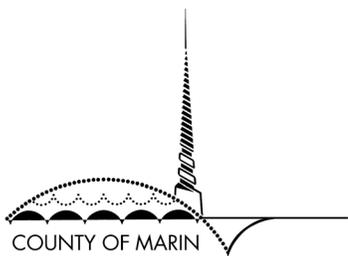


Oct 20 2022

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October 20, 2022

Alicia Bird, Environmental Scientist
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RE: MEMORIAL TRAIL IMPROVEMENT PROJECT

Dear Ms. Bird:

Thank you for providing comments on the Initial Study/Mitigated Negative Declaration (IS/MND) for the proposed Memorial Trail Improvement Project at Terra Linda/Sleepy Hollow Open Space Preserve. This correspondence summarizes the comments included in the California Department of Fish and Wildlife's (CDFW) letter dated July 13, 2022 and responses from the Marin County Open Space District (MCOSD). The MCOSD is scheduled to present the IS/MND to its Board of Directors on November 08, 2022 for adoption along with project approval. All comments received on the IS/MND and MCOSD's responses will be included in the material provided to the Board of Directors for their consideration.

Comment Summary 1 Summary: Northern Spotted Owl

The IS/MND concludes that northern spotted owl (NSO) is unlikely to utilize the project area due to habitat composition, proximity to development, and levels of public use however, the project area and a 0.25-mile radius appears to consist of potentially suitable nesting habitat for NSO, including coast live oak (*Quercus agrifolia*) forest and California bay (*Umbellularia californica* var. *californica*) forest, therefore nesting NSO may occur within the project area or a 0.25-mile radius and be disturbed. There are California Natural Diversity Database (CNDDB) documented NSO occurrences approximately 1.8 miles south of the project area and 2.5 miles to the east, which are well within the dispersal distance of NSO and in close proximity to development and areas of public use.

Given the potential for NSO to occur within the project area and 0.25-mile radius, Mitigation Measure (MM) BIO-1 would likely be insufficient to detect NSO presence. Additionally, the appropriate buffer distance for NSO is 0.25 mile (1,320 feet), as noted on page 51 of the MND, and therefore 100 feet, as proposed in Best Management Practice (BMP) Special-Status Wildlife-4: Avoidance and Protection of Northern Spotted Owl would be insufficient to avoid potential impacts to nesting NSO if they are present. If active NSO nests are not detected by the proposed surveys in MM BIO-1, nesting NSO could be disturbed by project activities resulting in nest abandonment and loss of eggs or reduced health and vigor and loss of young, thereby substantially reducing the number of the species. NSO is CESA listed as a threatened species and therefore is considered to be a threatened species pursuant to CEQA Guidelines section 15380. Therefore, if an active NSO nest is disturbed by the Project, the Project may result in a substantial reduction in the number of a threatened species, which is considered to be a Mandatory Finding of Significance pursuant to CEQA Guidelines section 15065, subdivision (a)(1).

For an adequate environmental setting and to reduce impacts to NSO to less than significant, CDFW recommends that the MND include the following mitigation measure for NSO.

MM BIO-2: A qualified biologist shall provide an assessment of potential NSO nesting habitat within the Project area and a 0.25-mile radius and obtain CDFW's written acceptance of the assessment. Alternatively, if the assessment is not completed, or if it concludes that NSO nesting habitat is present, then no Project activities within 0.25 miles of potential NSO nesting habitat shall occur between March 15 and August 31 unless a qualified biologist approved in writing by CDFW conducts NSO surveys following the U.S. Fish and Wildlife Service (USFWS) *Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls*, dated (revised) January 9, 2012.

Surveys shall be conducted in accordance with Section 9 of the survey protocol, *Surveys for Disturbance-Only Projects*. If breeding NSO are detected during surveys, a 0.25 mile no-disturbance buffer zone shall be implemented around the nest until the end of the breeding season, or a qualified biologist determines that the nest is no longer active, unless otherwise approved in writing by CDFW. The Project shall obtain CDFW's written acceptance of the qualified biologist and survey report prior to Project construction occurring between March 15 and August 31 each year.

Alternate buffer zones may be proposed to CDFW after conducting an auditory and visual disturbance analysis following the USFWS guidance, *Estimating the Effects of Auditory and Visual Disturbance to Northern Spotted Owls and Marbled Murrelets in Northwestern California*, dated October 1, 2020. Alternative buffers must be approved in writing by CDFW. If take of NSO cannot be avoided, the Project shall consult with CDFW pursuant to CESA and obtain an ITP, and also consult with USFWS pursuant to the federal Endangered Species Act.

CDFW considers the breeding season of NSO to be until August 31, not July 31, as young are still dependent on their parents and do not begin to disperse until September. Therefore, the project should consider the potential for impacts to NSO through August 31.

Would the Project have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFW or USFWS?

Response

The Marin County Open Space District recognizes that if preconstruction surveys do not detect a northern spotted owl nest that potential impacts from project implementation could occur. Potential impacts to northern spotted owl are not expected to result from implementation of the proposed project for a few primary reasons. The closest known northern spotted owl nest site to the project area is 1.5 miles away at a parcel of land owned by the City of San Rafael. The patchy forested areas within and surrounding the project area do not have a dense canopy, and the understory vegetation ranges from open to scrubby, and does not appear to be potential nesting habitat.

Point Blue Conservation Science previously surveyed the northern half of the preserve and did not find any NSO nests. A Point Blue Conservation Science Senior Avian Ecologist surveyed the project area on August 29, 2022 to ground-truth the habitat. This avian ecologist conducts United States Fish and Wildlife Service protocol-level surveys for northern spotted owls. The surveyed area included a 0.25-mile buffer around the project area. The survey found the vegetation consisted of smaller bays, with some oaks and scrub with grassy areas between the drainages, and the understory in the forested areas was not very open and therefore not suitable for northern spotted owl hunting. The conclusion is that the project area is not suitable for northern spotted owl nesting or hunting. No northern spotted owl nests were found. This survey supports the conclusions in the IS/MND and satisfies the survey included in the mitigation measure recommended in the comment. The Marin County Open Space District will provide information regarding the August 29, 2022 survey to the CDFW (attached to this letter).

A Biological Resources Assessment for the project area was completed by Prunuske Chatham, Inc. (PCI), in August 2019. PCI conducted botanical and wildlife surveys of the study area in spring 2019. The field surveys were conducted by PCI's senior wildlife biologist and vegetation ecologist. The primary purposes of the Biological Resources Assessment were to characterize biological communities and habitat conditions, to determine whether or not suitable habitat for special-status species is present, and to identify potential biological constraints. The potential for presence of special-status plants and wildlife and habitats was determined based on habitat conditions, presence or absence of unique habitat features, proximity of the Study Area to reported occurrences, and geographic ranges of relevant species. The surveys consisted of evaluating corridors along trails in the southeastern portion of the Preserve between Ridgewood Fire Road and Devon Drive including Memorial Trail and habitats in the interior of the Preserve. Habitats beyond these boundaries were not evaluated. The Biological Resources Assessment evaluated data collected and maintained by the Marin County Open Space District, a review of the California Natural Diversity Database (CNDDB), and other sources. PCI documented the presence of two special-status birds, oak titmice (*Baeolophus inornatus*) and Nuttall's woodpecker (*Picoides nuttalli*), within the Study Area. Additional special-status bird species and bat species have been documented within Terra Linda / Sleepy Hollow

Open Space Preserve but were not found during PCI's field surveys. The study area provides suitable habitat for these species and therefore there is potential for the species to exist within the project area even though PCI did not document presence. These include Cooper's hawk (*Accipiter cooperi*), Sharp-shinned hawk (*Accipiter striatus*), Grasshopper sparrow (*Ammodramus savannarum*), Golden eagle (*Aquila chrysaetos*), Burrowing owl (*Athena cunicularia*), Northern harrier (*Circus hudsonius*), White-tailed kite (*Elanus leucurus*), Pallid bat (*Antrozous pallidus*), Townsend's big-eared bat (*Corynorhinus townsendii*), and Hoary bat (*Lasiurus cinereus*).

Implementation of the proposed project would include ground-disturbing activities associated with trail decommissioning utilizing active methods and implementation of trail improvements however, this minimal disturbance would not result in habitat modifications that could cause potential impacts to special-status species that have the potential to occur within the project area. Implementation of the proposed project would remove one trunk of a multi-trunk California bay tree. The trunk to be removed is 8-inch diameter at breast height (DBH). This tree is located in the California Bay – Coast Live Oak plant community and is not associated with a stream crossing.

Implementation of Mitigation Measure BIO-1, along with implementation of applicable RTMP BMPs, would reduce potential impacts on special-status and nesting birds to a less than significant level. Mitigation Measure BIO-1, in conjunction with the August 29, 2022 survey completed by Point Blue Conservation Science, satisfies the recommendations included in the mitigation measure included in the comment. Point Blue Conservation Science's Senior Avian Ecologist conducts United States Fish and Wildlife Service protocol-level surveys for northern spotted owls and concluded the project area does not include suitable habitat for northern spotted owls.

Surveys conducted in accordance with Section 9 of the survey protocol, *Surveys for Disturbance-Only Projects*, is required for areas with suitable habitat. The project area does not support suitable NSO habitat, therefore the additional surveys required for Section 9 are not applicable for the proposed project. The Marin County Open Space District will commit to conducting nesting surveys through August 31st instead of July 31st, per CDFW's recommendation for birds other than northern spotted owl. For northern spotted owl, the following additional guidelines were developed between the Marin County Open Space District, the United States Fish and Wildlife Service, and Point Blue Conservation Science and apply to projects that involve disturbance only with no habitat modification, and would apply to the proposed project:

- No Effect: Action occurs August 1 through January 31
- Not Likely to Adversely Affect: Action occurs July 10 through July 31
- Likely to adversely affect: Action occurs March 1 through August 31

From 1992 to 2004, the United States Fish and Wildlife Service recommended that projects involving disturbance with no habitat modification should not take place between March 1 and August 31. In 2004, these dates were modified to February 1 through July 9. February 1 was selected based on data from coastal California sites showing earlier nesting behavior. The United States Fish and Wildlife Service agreed that the Marin County Open Space District could maintain a March 1 start date. July 9 was selected based on early fledging of young. This date gave fledgling northern spotted owls two-to-four weeks to acclimate to their surroundings. Point Blue Conservation Science recommends the more conservative approach of four weeks post-fledging based on site-specific data. The following documents are attached which provide details regarding the Marin County Open Space District's protocols:

- 2010 SF Bay Area NSO monitoring protocol
- 2008 guidance for NSO nesting season
- 2017 Marin County Parks bird nesting survey protocol, which were accepted by CDFW in 2019

The Marin County Open Space District has been utilizing the United States Fish and Wildlife guidance regarding NSO breeding season, which is February 1 - July 31. The Marin County Open Space District does not expect implementation of the proposed project would affect NSO because there is a lack of suitable habitat and no NSO nests have been located within the project area or the preserve.

The Marin County Open Space District will provide preconstruction surveys to CDFW for written acceptance prior to construction occurring between March 15 and August 31 each year of project implementation.

As documented in the IS/MND, implementation of the proposed project including implementation of the applicable RTMP BMPs and Mitigation Measure BIO-1, would not result in substantial adverse effects, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by CDFW or the United States Fish and Wildlife Service.

Comment Summary 2: Burrowing Owl

The MND identifies that western burrowing owl (*Athene cunicularia*) has been documented within the larger Terra Linda/Sleepy Hollow Open Space Preserve, the project area provides suitable habitat for burrowing owl, and there is the potential for burrowing owl to occur there. The project area is within the wintering range of burrowing owl. CDFW appreciates that surveys have been done within the preserve; however, it is unclear if any of the survey locations were within the project area and a sufficient buffer zone to detect wintering owls that may be disturbed. Furthermore, it appears the last time surveys were conducted was March 2018, which may not accurately reflect current conditions and occupancy.

If wintering burrowing owls are not detected by the appropriate surveys, the project may result in reduced health and vigor, or mortality, of owls resulting from removal of wintering burrows, or wintering burrow abandonment caused by audio and visual disturbances from Project construction activities. Burrowing owl is protected under Fish and Game Code sections 3503 and 3503.5 and the federal Migratory Bird Treaty Act. Therefore, if wintering burrowing owl occupy the Project area or adjacent habitat, Project impacts to burrowing owl would be potentially significant.

For an adequate environmental setting and to reduce impacts to wintering burrowing owl to less-than-significant, CDFW recommends that the MND include the following mitigation measure.

MM BIO-3: Prior to Project activities occurring during the burrowing owl wintering season from September 1 to January 31, a qualified biologist shall conduct a habitat assessment, and if warranted based on the habitat assessment, a survey pursuant to the CDFW *Staff Report on Burrowing Owl Mitigation* (CDFW 2012 Staff Report). The habitat assessment and surveys shall encompass the Project site and a sufficient buffer zone to detect owls nearby that may be impacted commensurate with the type of disturbance anticipated up to 500 meters or 1,640 feet, as outlined in the CDFW 2012 Staff Report, and include burrow surrogates such as culverts, piles of concrete or rubble, and other non-natural features, in addition to burrows and mounds. Time lapses between surveys or Project activities shall trigger subsequent surveys, as determined by a qualified biologist, including but not limited to a final survey within 24 hours prior to ground disturbance. Surveys shall occur each year of Project construction during burrowing owl wintering season if there is suitable habitat on or adjacent to the Project site (within up to 1,640 feet) where owls could be disturbed, as determined by a qualified biologist. The qualified biologist shall have a minimum of two years of experience implementing the CDFW 2012 Staff Report survey methodology resulting in detections. Detected burrowing owls shall be avoided pursuant to the buffer zone prescribed in the CDFW 2012 Staff Report unless otherwise approved in writing by CDFW, and any passive relocation plan for non-nesting owls shall be subject to CDFW review.

Please be advised that CDFW does not consider eviction of burrowing owls including passive removal of an owl from its burrow or other shelter, as a “take” avoidance, minimization, or mitigation measure; therefore, off-site habitat compensation shall be included in the eviction plan. Habitat compensation acreages shall be approved by CDFW, as the amount depends on site-specific conditions, and completed before Project construction. It shall also include placement of a conservation easement and preparation and implementation of a long-term management plan.

Response

Burrow surveys have been conducted across all potential grassland habitats within the preserve. The burrowing owl was observed in the northern part of the preserve (38.020429, -122.561295), which is well over the 500-meter buffer. The surveys were conducted in 2017, 2018 and again in 2022. In the 2017-2018 survey, only two inactive ground squirrel burrows were within the project area. No signs of western burrowing owls were observed. In the 2022 survey, no burrows larger than 3 inches, the average ground squirrel burrow size, were observed, nor were any other features a burrowing owl could use. Based on these results, the Marin County Open Space District has concluded there are no burrowing owls in the project area however, the Marin County Open Space District will include looking for habitat features during the preconstruction surveys and provide the results to the CDFW.

As required by Mitigation Measure BIO-1, the Marin County Open Space District would conduct pre-construction surveys. If state and/or federally listed birds are found breeding within the construction area, activities shall be halted until the chicks have fledged. If construction activities must continue and would incur take of the listed species, MCOSD would consult with the CDFW and USFWS prior to the initiation of work that would result in take.

Comment Summary 3: Special-status Herpetofauna

The project may impact the following special-status herpetofauna, which the MND identified have a low potential to occur: California giant salamander (*Dicamptodon ensatus*), foothill yellow-legged frog (*Rana boylei*) Northwest/North Coast clade, California red-legged frog (*Rana draytonii*), and western pond turtle (*Actinemys marmorata*). The California Natural Diversity Database (CNDDDB) identifies occurrences of all four species within two to five miles of the project. The project could impact stream or upland dispersal habitat or refugia for special status herpetofauna through vegetation

removal and grading activities, potentially injuring or killing them. Based on the above, if these special-status herpetofauna occur within the project area, project impacts to special-status herpetofauna would be potentially significant.

To reduce potential impacts to less-than-significant, CDFW recommends including the following mitigation measure in the MND.

MM BIO-4: For all Project activities that occur within 500 feet of stream or wetland habitat, prior to ground-disturbing activities, a qualified biologist shall conduct a pre-construction survey within 48 hours prior to the start of Project activities, focusing on the presence of foothill yellow-legged frog, California red-legged frog, California giant salamander and western pond turtle and their nests. If any of these special-status species are discovered during the survey, Project activities shall not begin until CDFW has been consulted and approved in writing measures to avoid and minimize impacts to special-status species, and the measures have been implemented. If California red-legged frog is encountered, the Project shall consult with USFWS pursuant to the federal Endangered Species Act and obtain any required authorization for impacts.

If an LSA Notification is submitted for Project activities affecting streams, CDFW may include in the LSA Agreement, if issued, additional protection measures for special status herpetofauna pending further analysis of the potential for their occurrence within the project area.

Response

Although the surrounding project area has small rodent burrows and shrubby habitat that may provide shelter, special status herpetofauna have not been observed within the preserve. The Biological Resources Assessment prepared by Prunuske Chatham, Inc. in August 2019 did not find presence of California giant salamander (*Dicamptodon ensatus*), foothill yellow-legged frog (*Rana boylei*) Northwest/North Coast clade, California red-legged frog (*Rana draytonii*), or western pond turtle (*Actinemys marmorata*) within the project area. Due to timing of the survey, no streams or wet seepy areas within 500 meters of the project area were observed. The project area and nearby areas do not contain other wet areas where these species could disperse to and therefore, implementation of the proposed project would not impact these species. The Marin County Open Space District would observe changes to the landscape from any winter/spring rains and would include any nearby habitat in a preconstruction survey.

The Marin County Open Space District submitted regulatory permit applications for the proposed project, including a Lake or Streambed Alteration Agreement to CDFW via EPIMs, on June 13, 2022 and is currently working through the permitting process.

Comment Summary 4: American Badger

The project is within the range of the American badger (*Taxidea taxus*) within grassland habitat and oak woodland habitat that may be suitable for American badger. Badgers range throughout most of California and can dig burrows in a single day; therefore, the species may occupy the project site and adjacent habitat prior to project construction. Additionally, the California Wildlife Habitat Relationships Predicted Habitat Suitability for the grassland portions of the site is High Suitability. American badger is an SSC and project impacts to American badger would be potentially significant.

For an adequate environmental setting and to reduce impacts to less-than-significant, CDFW recommends that the MND: (1) analyze the potential for American badger to occur on and adjacent to the project area, and (2) include mitigation measures to ensure impacts are reduced to less-than-significant. These measures may include a qualified biologist surveying for the species including adjacent habitat prior to construction, avoiding occupied burrows including a sufficient buffer approved by CDFW, and preparing and implementing a CDFW-approved relocation plan if badgers are found on or adjacent to the project site and cannot be avoided.

Response

Burrow surveys have been conducted across all potential grassland habitats within the preserve. The burrowing owl was observed in the northern part of the preserve (38.020429, -122.561295), which is well over the 500-meter buffer. The surveys were conducted in 2017, 2018 and again in 2022. In the 2017-2018 survey, only two inactive ground squirrel burrows were within the project area. In the 2022 survey, no burrows larger than 3 inches, the average ground squirrel burrow size, were observed. Based on these results, the Marin County Open Space District has concluded there are no American badgers in the project area however, the Marin County Open Space District will include looking for habitat features during the preconstruction surveys and provide the results to the CDFW.

Comment Summary 5: Special-Status Plants

It is unclear whether the project could impact special-status plants. The MND states that no special-status plants are expected to occur, given negative survey results. The MND notes that Prunuske Chatham, Inc. completed a Biological Resources Assessment (BRA) in August 2019, which included botanical surveys that were conducted in spring 2019. The BRA was not included as an appendix of the MND, and as such, CDFW cannot determine whether the BRA sufficiently addressed potential impacts to special-status plants. As outlined in CDFW's *Protocol for Surveying and Evaluating Impacts to Special-Status Native Plant Populations and Sensitive Natural Communities* failure to locate special-status plants during one field season may not adequately determine presence, and multiple years of surveys may be necessary depending on presence of adverse environmental conditions and species life history.

CDFW recommends including the BRA as an appendix to the MND and including the following mitigation measure.

MM BIO-5: The 2019 botanical survey report documenting absence of special-status plants within areas subject to Project direct and indirect impacts shall be provided to CDFW for written acceptance. If the survey report is not accepted in writing by CDFW, a qualified biologist shall conduct additional botanical surveys during the appropriate blooming period and conditions for all special-status plants that have the potential to occur prior to the start of construction. The survey area shall include the Project area and adjacent habitat where indirect impacts, for example hydrological modifications, may occur. More than one year of surveys may be necessary. Surveys shall be conducted following CDFW's *Protocol for Surveying and Evaluating Impacts to Special-Status Native Plant Populations and Sensitive Natural Communities* (<https://wildlife.ca.gov/Conservation/Survey-Protocols#377281280-plants>). Survey reports shall be submitted to CDFW for written approval prior to the start of construction. If any special-status plant species are observed, the Project shall fully avoid direct and indirect impacts to all individuals and prepare and implement a CDFW-approved avoidance plan prior to Project activities. If the Project cannot avoid impacts to special-status plants, the Project shall prepare and implement a CDFW-approved mitigation plan prior to project construction including: 1) compensatory habitat mitigation at a 3:1 mitigation to impact ratio, and 2) funding for management of mitigation land in perpetuity, unless otherwise approved in writing by CDFW.

Response

The Marin County Open Space District will provide the PCI Biological Resources Assessment to CDFW (attached to this letter). PCI conducted botanical surveys to characterize plant communities, compile an inventory of species observed, and to evaluate the potential for presence of special-status plant species. Surveys were conducted on April 16, 26 and June 18, 2019. Special-status species identified as having potential to occur based on the background review would typically be blooming and identifiable during those times. PCI conducted research to determine typical blooming periods and concluded that it would be unlikely for any rare plant species would be blooming later than June 18th. Surveys followed the protocol described in the California Department of Fish and Games (CDFW) *Protocols for Surveying and Evaluating Impacts to Special-status Native Plant Populations and Natural Communities* (CDFW 2009), as well as other survey guidelines. During each survey the existing trails and proposed general areas for future trails were traversed on foot and all habitats were surveyed. All plants observed were identified using the *Jepson eFlora* (Jepson Flora Project 2019) and *Marin Flora* (Howell et al. 2007) to the taxonomic level necessary to determine whether or not they were rare. Botanical nomenclature follows the *Jepson eFlora*.

A background literature and database search was conducted to determine the potential for special-status species and sensitive habitats to occur within or adjacent to the Study Area. The search focused on reported occurrences for the Novato and San Rafael 7.5' USGS quadrangles within a 5-mile buffer around the Preserve. General references, including aerial photographs, GIS maps, and soil survey reports were also consulted to evaluate the potential for unique biological communities and special-status species. The review included, but was not limited to, the following sources:

- California Natural Diversity Database (CNDDDB)4 (CDFW 2019)
- California Sensitive Natural Communities (CDFW 2018)
- A Manual of California Vegetation Online (CNPS 2019a)
- CNPS Inventory of Rare and Endangered Vascular Plants of California (CNPS 2019b)
- Calflora database (Calflora 2019)
- Information for Planning and Conservation (IPaC) Trust Resource List for the project area (USFWS 2019)

- Natural Resources Conservation Service Web Soil Survey (NRCS 2019)
- Marin County Open Space District Road and Trail Management Plan (MCOSD 2014);
- Marin County Open Space District Vegetation and Biodiversity Management Plan (MCOSD 2015); and
- Field guides and general references for plants, birds, mammals, reptiles, amphibians, and invertebrates.

The IS/MND on page 76 includes the following conclusion: “The botanical surveys conducted as part of the PCI Biological Assessment concluded that no special-status plant species were documented within the study area.”

The PCI Biological Resources Assessment included several recommendations to minimize potential impacts to biological resources. Most of these recommendations have been incorporated into the project design or are included in the RTMP BMPs however, one recommendation specifically addressed trail decommissioning in the sensitive serpentine habitat. The recommendation suggested avoiding any ground disturbance in serpentine habitat, and if ground disturbance could not be avoiding, conduct a focused botanical survey of the area prior to disturbance and develop a restoration plan.

Approximately 0.6 acre of serpentine grassland exists in the project area. Implementation of the proposed project would include decommissioning of Social Trail A, which includes approximately 0.04 acres in serpentine grassland. Decommissioning Social Trail A would involve passive methods, and no ground-disturbing activity would occur within serpentine grassland. The remaining trails proposed for decommissioning or improvement do not occur within serpentine grassland. Given that no ground-disturbing activity would occur within serpentine habitat, no impact would occur from implementation of the proposed project.

Comment Summary 6: Lake and Streambed Alteration and Riparian Habitat

The MND notes that “the proposed trail bridges would be located above the 100-year flood elevation spanning the banks of the ephemeral streams and would not be subject to regulatory permit authorizations.” However, bridges often cause permanent shading of the stream which may result in a substantial adverse impact to stream habitat. The MND also notes that the concrete foundations for these bridges will be set at the top of the stream banks. Depending on site-specific characteristics—such as slope of bank and adjacent lands, location and extent of riparian vegetation, and hydrological profile—installation of these bridges may have permanent or temporary impacts to the stream and its associated ecological communities and be subject to an LSA Notification. The MND mentions that multiple unnamed seasonal drainages occur throughout the project area, but it is unclear what level of impact, if any, the project will have on these drainages and if they are different than the streams where crossings will be installed. If permanent or temporary impacts to ephemeral drainages may be substantial the impacts would be subject to an LSA Notification. The project may result in permanent and temporary impacts to stream and riparian habitat. If the Project impacts stream and associated riparian habitat, impacts to these resources would be potentially significant.

For an adequate environmental setting, to comply with Fish and Game Code section 1602 et seq., and to reduce impacts to streams to less-than-significant, CDFW recommends including the following mitigation measure in the MND:

MM BIO-5: For Project activities that may substantially alter the bed, bank, or channel of on-site drainages or associated riparian habitat, including but not limited to bridge installation or modification, the Project shall consult with CDFW to determine if an LSA Notification is warranted, including providing CDFW with an aerial based map of aquatic features on the Project area. If CDFW determines that any of the Project impacts are subject to Fish and Game Code section 1600 et seq., the Project shall submit an LSA Notification to CDFW prior to Project construction. If CDFW determines that an LSA Agreement is warranted, the Project shall comply with all required measures in the LSA Agreement, including but not limited to requirements to mitigate impacts to the streams and riparian habitat. Permanent impacts to the stream and associated riparian habitat shall be mitigated by restoration of riparian habitat at a minimum 3:1 mitigation to impact ratio based on acreage and linear distance as close to the Project area as possible and within the same watershed and year as the impact, unless otherwise approved in writing by CDFW. Temporary impacts shall be restored on-site in the same year as the impact at a 1:1 ratio.

Please be advised that an LSA Agreement obtained for this Project would likely require the above recommended mitigation measures, as applicable.

Furthermore, while the MND states that work will be restricted to the dry season to the extent feasible, it also states work will occur March – May. CDFW considers the dry season to be June 15 to October 15, and an LSA agreement would likely limit work to this window, with the possibility to extend work on a week-to-week basis if conditions remain dry, unless additional justification for working in the wet season is provided.

Response

Each of the bridges are located on ephemeral streams in oak-bay woodlands under 100 percent canopy. The shading effect of these small trail bridges will have a less than significant impact on stream habitat. The footings will be set above and beyond the stream banks and out the influence of the streams. No riparian vegetation will be removed to construct the bridges. The hydrological profile will not be impacted by the bridges, and the ephemeral streams will not experience any temporary or permanent impacts from their placement.

Implementation of the rock armored ford crossings may alter the bed, bank, and/or channel of the ephemeral streams. The Marin County Open Space District submitted regulatory permit applications for the proposed project, including a Lake or Streambed Alteration Agreement to CDFW via EPIMs, on June 13, 2022 and is currently working through the permitting process.

No riparian vegetation would be removed to implement the proposed project.

The multiple unnamed seasonal drainages that occur throughout the project area are the same drainages where small trail bridges are proposed to improve water quality by reducing the existing erosion and sedimentation caused by visitors crossing through the bed of the drainages. Upslope work may occur as early as March, depending on weather, soil moisture, and the results of pre-construction surveys for special status species. Descriptions of the potential impact of the stream crossing are included in the IS/MND, and duplicated below:

Table 1: Trail Bridge Stream Crossings

CROSSING REFERENCE	LENGTH	TEMPORARY CONSTRUCTION IMPACT	PERMANENT IMPACT	CUT AND FILL VOLUME
Memorial Trail Social Trail 1	30 feet	80 feet	40 feet	3 cubic yards
Memorial Trail Social Trail 4	16 feet	40 feet	25 feet	2 cubic yards
Memorial Trail Social Trail 7	24 feet	80 feet	30 feet	4 cubic yards
Memorial Trail Social Trail 8	30 feet	80 feet	40 feet	6 cubic yards
Malone Trail Social Trail 10	18 feet	40 feet	28 feet	4 cubic yards
Malone Trail Social Trail 12	18 feet	40 feet	28 feet	2 cubic yards
TOTAL				21 cubic yards

Table 2: Rock Armored Stream Crossings

CROSSING REFERENCE	LENGTH	TEMPORARY CONSTRUCTION IMPACT	PERMANENT IMPACT	CUT AND FILL VOLUME
Memorial Trail Social Trail 2	10 feet	15 feet	10 feet	2 cubic yards
Memorial Trail Social Trail 3	10 feet	15 feet	10 feet	2 cubic yards
Memorial Trail Social Trail 5	12 feet	20 feet	12 feet	4 cubic yards
Memorial Trail Social Trail 6	16 feet	24 feet	16 feet	6 cubic yards
Malone Trail Social Trail 9	12 feet	20 feet	12 feet	3 cubic yards
Malone Trail Social Trail 11	8 feet	16 feet	8 feet	3 cubic yards
Malone Trail Social Trail 13	12 feet	20 feet	12 feet	3 cubic yards
TOTAL				23 cubic yards

Comment Summary 7: Editorial Comments

CDFW appreciates that the MND included Appendix A, which includes a list of Best Management Practices (BMP) utilized by the District as part of their Road and Trail Management Plan. However, it is not always clear which BMPs are being implemented for the project and it appears some BMPs should be designated as enforceable mitigation measures. For clarity, CDFW recommends that BMPs being implemented for the project that are necessary to reducing impact to less-than-significant be included as a mitigation measure in the MND.

Response

The IS/MND lists the applicable RTMP Policies and BMPs in the Setting section of each of the environmental checklist topic areas, under the sub-heading “Applicable RTMP Policies and BMPs.”

Comment Summary 8: Environmental Data

CEQA requires that information developed in environmental impact reports and negative declarations be incorporated into a database which may be used to make subsequent or supplemental environmental determinations. Accordingly, please report any special-status species and natural communities detected during project surveys CNDDDB. The CNDDDB field survey form can be filled out and submitted online at the following link: <https://wildlife.ca.gov/Data/CNDDDB/Submitting-Data>. The types of information reported to CNDDDB can be found at the following link: <https://www.wildlife.ca.gov/Data/CNDDDB/Plants-and-Animals>.

Response

The IS/MND describes the California Bay Forest, Valley Oak Woodland, Annual and Perennial Grasslands, and Serpentine Grassland which are considered sensitive plant communities per CDFW's List of California Terrestrial Natural Communities and the Manual of California Vegetation. The IS/MND describes two special-status birds documented within the study area including Oak titmouse (*Baeolophus inornatus*) and Nuttall's woodpecker (*Picoides nuttallii*). The Marin County Open Space District will ensure that any required CNDDDB reporting is completed. No special status plants were identified within the project area.

Comment Summary 9: Environmental Document Filing Fees

The project, as proposed, would have an impact on fish and/or wildlife, and assessment of environmental document filing fees is necessary. Fees are payable upon filing of the Notice of Determination by the Lead Agency and serve to help defray the cost of environmental review by CDFW. Payment of the environmental document filing fee is required in order for the underlying project approval to be operative, vested, and final.

Response

The Marin County Open Space District would pay the applicable CDFW filing fee when filing the Notice of Determination.

If CDFW would like to discuss the responses to comments, please contact Jason Hoorn, Natural Resources Planner at jhoorn@marincounty.org or 415 320 4610 (Office Cell).

Sincerely,



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Cc: Melanie Day, Senior Environmental Scientist (Supervisory)
Debbie Hultman, Assistant to the Regional Manager
Erin Chappell, Regional Manager

Attachments

- Biological Resources Assessment, Prunuske Chatham, Inc., August 2019.
- Northern Spotted Owl Ground-Truthing Survey Information, Point Blue Conservation Science, August 29, 2022.
- 2010 SF Bay Area NSO monitoring protocol
- 2008 Guidance for NSO nesting season
- 2017 Marin County Parks bird nesting survey protocol, which were accepted by CDFW in 2019



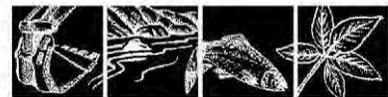
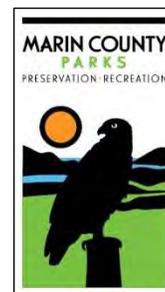
**Biological Resources Assessment
Terra Linda/Sleepy Hollow Open Space Preserve
Memorial Trail Project
August 2019 – revised January 2022**

Prepared for:

Marin County Open Space District
3501 Civic Center Drive, Suite 260
San Rafael, CA 94903

Prepared by:

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PRUNUSKE CHATHAM, INC.

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1. Introduction

Marin County Parks (MCP), which includes the Marin County Open Space District (MCOSD), manages and maintains the Terra Linda/Sleepy Hollow Open Space Preserve (Preserve), one of its 34 open space preserves in Marin County. The Preserve encompasses 1,172 acres of open space land covering the ridges above the Santa Margarita Valley. The lands were acquired from 1972 to 1989 through numerous parcel acquisitions. The Preserve supports a network of multiuse fire roads for hikers, bikers, dog walkers, and equestrians and several hiker and equestrian only trails. It also offers expansive views of Mount Tamalpais, Big Rock Ridge, and San Pablo Bay. The Mission Pass Path runs through the Preserve connecting the communities of Terra Linda and San Anselmo.

MCOSD retained Prunuske Chatham, Inc. (PCI) to complete a biological assessment of the southeastern portion of the Preserve. MCOSD is currently reviewing the trail network within this part of the Preserve; they are exploring opportunities to decommission sections of the Memorial Trail and multiple social trails and to establish one multiuse trail. The assessment was completed to 1) document existing plant and wildlife resources within the area and 2) provide recommendations for protection of biological resources. This report summarizes wildlife and botanical assessments and reviews the potential for special-status species occurrence. Upon completion of a final trail plan for this portion of the Preserve, PCI will update this report and provide recommendations to protect biological resources in accordance with the California Environmental Quality Act (CEQA).

2. Setting

The Preserve is located in central Marin County, northwest of the city of San Rafael (Figure 1). It encompasses 1,172 acres, mostly on the ridges surrounding the Santa Margarita Valley, and separates the neighborhoods of Sleepy Hollow (to the west) and Terra Linda (to the east). Undeveloped lands lie to the northwest; otherwise, the Preserve is surrounded by residential development. A narrow gap separates the northern and southern portions of the Preserve. Residential streets Fox Lane and Fawn Drive connect these two portions. The paved Mission Pass Path crosses a narrow point in the Preserve just north of this gap. Broad fire roads extend along most of the length of the Preserve's ridgelines, and smaller trails extend downslopes toward the residential areas. Elevations on the Preserve range from approximately 80 feet to 630 feet. Multiple small seasonal drainages originate below the ridge and flow north into the adjacent residential neighborhood, ultimately draining into the South Fork of Gallinas Creek and San Pablo Bay.

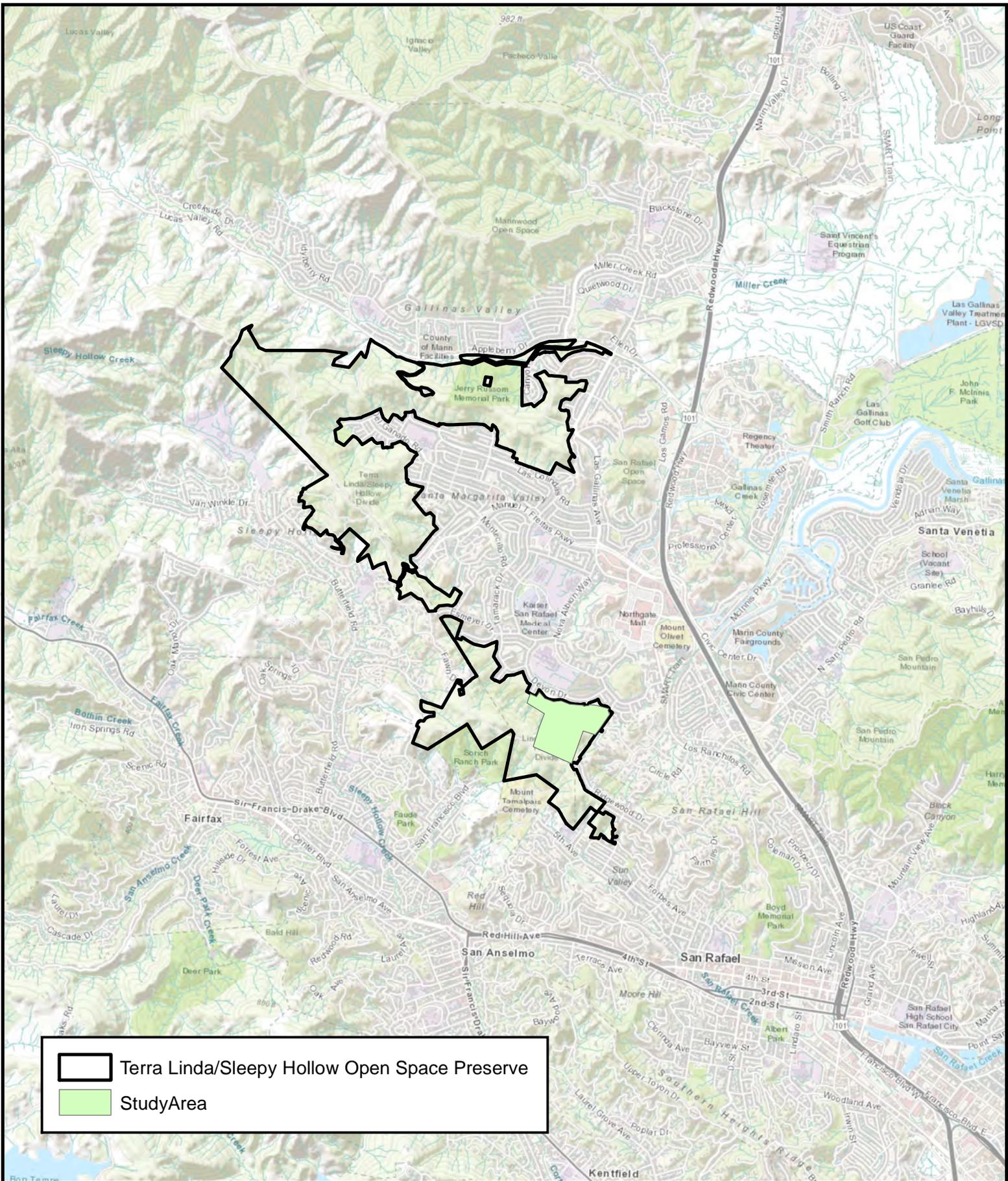
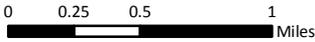


Figure 1. Project Location
 Biological Resources Assessment
 Terra Linda/Sleepy Hollow Open Space Preserve



August 2019
 Topography: ESRI
 Preserve Boundary: Marin County



3. Methods

Field surveys of the Study Area (see Figure 2) were conducted by PCI's senior wildlife biologist and vegetation ecologist. Surveys were conducted in spring 2019. PCI's assessment followed Marin County's *Preparation of Biological Site Assessments* (Marin County undated). The primary purposes of the assessment were to characterize biological communities and habitat conditions, to determine whether or not suitable habitat for special-status species is present, and to identify potential biological constraints. The potential for presence of special-status plants and wildlife and habitats was determined based on habitat conditions, presence or absence of unique habitat features, proximity of the Study Area to reported occurrences, and geographic ranges of relevant species. The surveys consisted of evaluating corridors along trails in the southeastern portion of the Preserve between Ridgewood Fire Road and Devon Drive including Memorial Trail and habitats in the interior of the Preserve; see Figure 2. Habitats beyond these boundaries were not evaluated. Representative site photographs taken during the biological field surveys are included in the plant and wildlife discussions below and at the end of this report; see Appendix A.

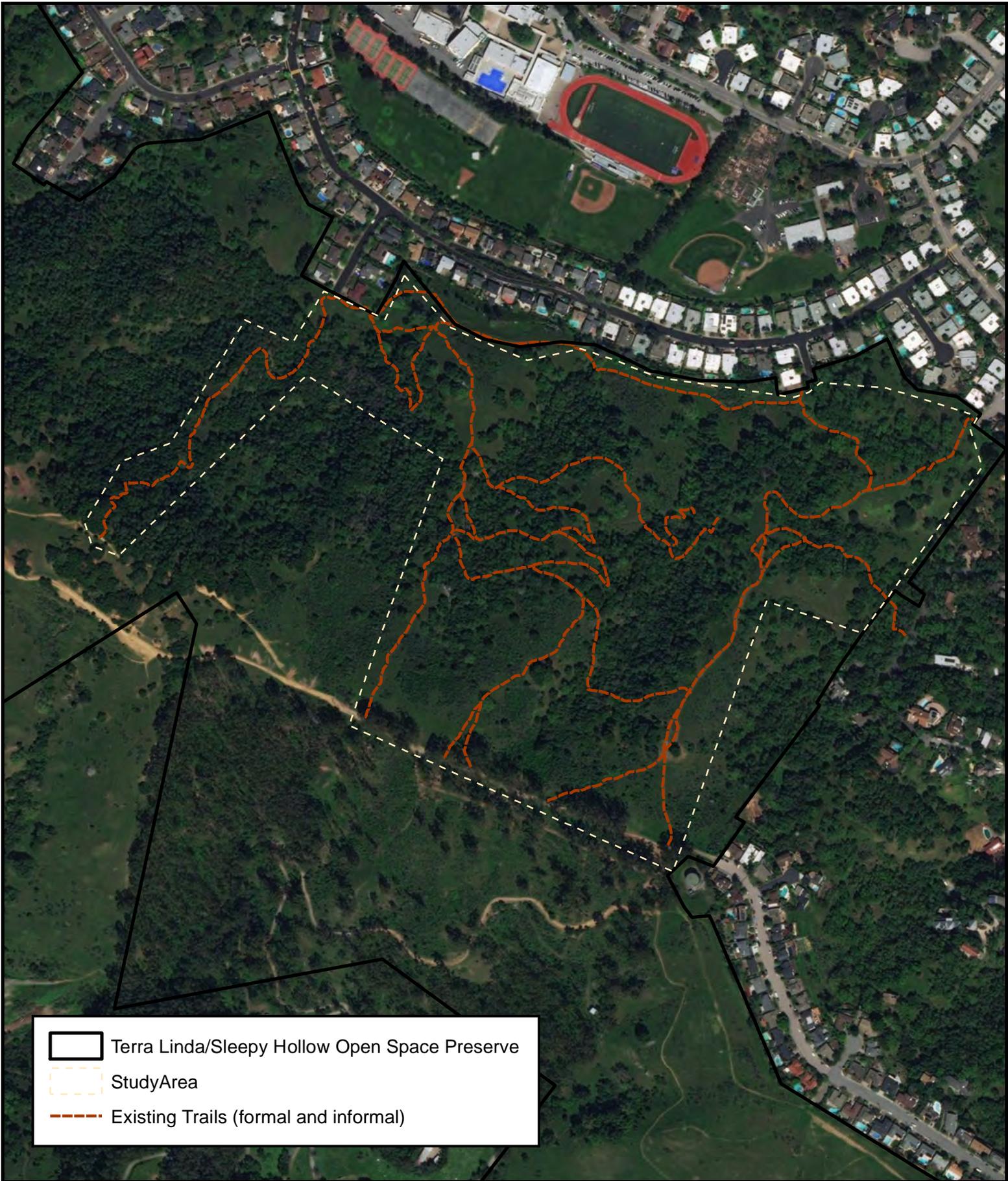
BOTANICAL SURVEYS. Botanical surveys were conducted to characterize plant communities, compile an inventory of species observed, and to evaluate the potential for presence of special-status plant species. Surveys were conducted on April 16, 26 and June 18, 2019. Special-status species identified as having potential to occur based on the background review would typically be blooming and identifiable during those times. Surveys followed the protocol described in the California Department of Fish and Games (CDFW) *Protocols for Surveying and Evaluating Impacts to Special-status Native Plant Populations and Natural Communities* (CDFW 2009), as well as other survey guidelines. During each survey the existing trails and proposed general areas for future trails were traversed on foot and all habitats were surveyed. All plants observed were identified using the *Jepson eFlora* (Jepson Flora Project 2019) and *Marin Flora* (Howell et al. 2007) to the taxonomic level necessary to determine whether or not they were rare. Botanical nomenclature follows the *Jepson eFlora*. Representative plant species observed within the Study Area are provided in the sections that follow. For a full list of all plant species observed within the Study Area, see Appendix B. Vegetation of this Preserve was mapped by consultants to the County in 2008 as part of a larger effort across multiple parklands; this existing mapping was reviewed by PCI in the field.

WILDLIFE SURVEY. A wildlife survey of the Study Area was conducted to evaluate the potential presence of special-status wildlife, compile an inventory of species observed and wildlife habitats, and complete an evaluation of existing habitats. A single full day survey was performed on April 16, 2019, in the morning through late-afternoon. Nocturnal surveys were not completed. During the survey, an inventory of all animal

species observed was compiled. The survey was conducted with the aid of binoculars. Visual cues (e.g., nests, tracks, scat, burrows, skeletal remains), calls, songs, and direct observations were used to identify wildlife. Unique habitat features (e.g., woody debris, water sources, etc.) and other plant materials were examined for presence of mammals, amphibians, reptiles, birds, and invertebrates. Representative wildlife species observed within the Study Area are provided in the sections that follow. For a full list of all vertebrate wildlife species observed within the Study Area, see Appendix C.

Figure 1 shows the Terra Linda/Sleepy Hollow Open Space Preserve and regional context. Figure 2 shows the Study Area. Figure 3 is a vegetation map of the Memorial Trail portion of the Preserve. Figure 4 illustrates the locations of known sightings of special-status plants and wildlife within the region (CDFW 2019). Figure 5 shows the areas of biological concern identified by PCI.

This biological assessment is specific to Memorial Trail portion of the Terra Linda/Sleepy Hollow Open Space Preserve identified above; impacts beyond these boundaries were not evaluated. It does not include an evaluation of the cumulative effects of the project at a local and regional scale. This report represents PCI's best professional effort to identify all sensitive habitats, species, and resources of concern within the Study Area.



- Terra Linda/Sleepy Hollow Open Space Preserve
- - - Study Area
- - - Existing Trails (formal and informal)

Figure 2. Study Area
Biological Resources Assessment
Terra Linda/Sleepy Hollow Open Space Preserve

0 250 500 1,000
Feet

August 2019
Aerial: ESRI
Trails and Preserve Boundary: Marin County



4. Soils

Soils in the Study Area are mapped as Tocaloma-Saurin association, extremely steep (NRCS 2019). These are well-drained loams and clay loams derived from residuum weathered from sandstone and shale. Typical slopes are 50-75%. Depth to bedrock is 20-40". Runoff is rapid and erosion hazard is considered high.

5. Existing Conditions

Botanical Assessment Results

The Study Area primarily supports bay and oak forest and woodlands, coyote brush scrub, and grassland. A small patch of serpentine grassland and a small rock outcrop are present at the western edge of the Study Area. A eucalyptus grove extends along Ridgewood Fire Road. The table below lists all vegetation types present. The table shows the nomenclature from the classification and mapping performed for Marin County (2008) by Aerial Information Systems (AIS) and California Native Plant Society, grouped into more general vegetation types. Figure 3 provides a general map of vegetation types, based on the 2008 mapping with field review by PCI.

Table 1. Vegetation Types within the Study Area

Vegetation Type - MCP Vegetation Map Nomenclature	CDFW Rank¹	Sensitivity²	Acres
<i>Forest and Woodland</i>			
California Bay Forest			
<ul style="list-style-type: none"> ▪ California Bay - Coast Live Oak Forest ▪ California Bay Alliance ▪ California Bay (pure) 	G4S3	Yes	23.5
Coast Live Oak Forest			
<ul style="list-style-type: none"> ▪ Coast Live Oak/(Grass-Poison Oak) 	G5S4	No	4.3

¹ Sensitivity based on federal (U.S. Army Corps of Engineers; Section 404), state (CDFW), and local (Marin County) regulations. Sensitive types highlighted in gray.

² Provided where map classes correlate to CDFW alliances. "G" indicates conservation priority at the global level, and "S" refers to the state level. 1 = critically imperiled; 2 = imperiled; 3 = vulnerable; 4 = apparently secure; 5 = secure. "?" indicates the need for further study. Alliances ranked 3 or lower are considered sensitive. Non-native alliances (i.e., semi-natural stands) are not ranked.

Vegetation Type - MCP Vegetation Map Nomenclature	CDFW Rank¹	Sensitivity²	Acres
Valley Oak Woodland <ul style="list-style-type: none"> ▪ Valley Oak - Coast Live Oak Mapping Unit ▪ Valley Oak/grass 	G3S3	Yes	9.3
Mixed Oak Forest <ul style="list-style-type: none"> ▪ Lower Elevation Mixed Broadleaf Forest – Coast Live Oak, Madrone, Black Oak or Oregon Oak Dominated 	G4S4	No	2.3
Eucalyptus Grove	N/A	No	2.6
Scrub			
Coyote Brush Scrub <ul style="list-style-type: none"> ▪ Coyote Brush - Mixed Shrub/Grassland ▪ Coyote Brush/Annual or Perennial Grasslands 	G5S5	No	14.1
Grasslands and Other			
Annual and Perennial Grasslands <ul style="list-style-type: none"> ▪ Grasslands (on well-developed soils). Per PCI observation includes complex mosaic of: <ul style="list-style-type: none"> ○ Wild oats grasslands ○ Needlegrass grasslands ○ California oat grass prairie 	Wild oats: N/A California oat grass: G4S3 Purple needlegrass: G4S3?	Yes, wherever significant component of CA oat grass or needlegrass is present— includes most of Study Area	16.5
Serpentine Grassland <ul style="list-style-type: none"> ▪ Upland Serpentine Grassland³ 	Varies	Yes	0.6
Cliffs/Rock Outcrop³	Varies	Varies	0.1

³ Locations not surveyed due to difficult access, and dominant plant species not determined; see text for discussion.

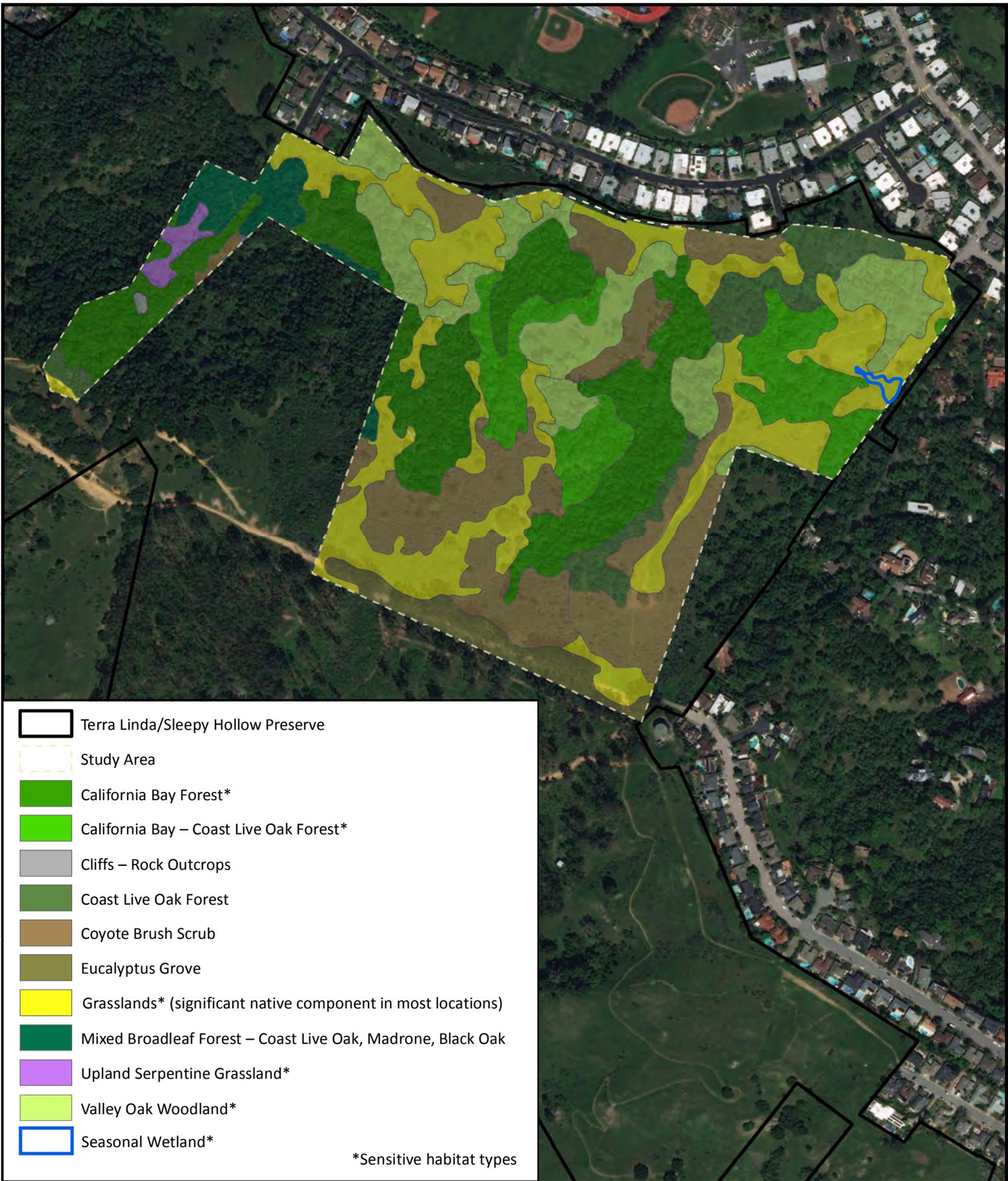


Figure 3. Vegetation Types
 Biological Resources Assessment
 Terra Linda/Sleepy Hollow Open Space Preserve

0 250 500 1,000 Feet

August 2019
 Aerial: ESRI
 Vegetation Types: Marin County 2008



California Bay Forest

California bay (*Umbellularia californica*) forest in the Study Area ranges from relatively pure stands to mixed stands of bay and coast live oak (*Quercus agrifolia*). It occurs primarily in the north-trending drainages. This vegetation type is dominated by evergreen species, creating a dense canopy that limits the understory. Bay is dominant, coast live oak is common, and madrone (*Arbutus menziesii*) is occasional. Sparse cover of shrubs, ferns,



grasses and forbs is present and primarily composed of native species. Typical species include poison oak (*Toxicodendron diversilobum*), honeysuckle (*Lonicera hispidula*), melic grass (*Melica* sp.), Pacific sanicle (*Sanicula crassicaulis*), Pacific pea (*Lathyrus vestitus*), goldenback fern (*Pentagramma triangularis*), lady fern (*Athyrium filix-fimina*), and maidenhair fern (*Adiantum jordanii*). Occasional non-native species including cotoneaster (*Cotoneaster* sp.) are present.

Habitat quality in the bay forests is high. Although less diverse than the oak woodlands, non-native species are still limited, and natural regeneration of trees is common. These forests line the drainages of the Study Area, protecting water resources and providing sheltered movement opportunities for wildlife along a topographic gradient. Other key ecosystem services provided by these bay forests include carbon sequestration, soil protection, and cooling and shading for humans and wildlife.

California bay forest is considered sensitive by CDFW, but is relatively common in Marin County.

Oak Woodland

Oak woodland in the Study Area includes valley oak (*Quercus lobata*) stands mapped at lower elevations in the north, coast live oak stands mapped in the northeast, and mixed oak stands mapped in the northwest. However, these types intermingle extensively and most stands include multiple species.

Canopy cover in the oak woodlands ranges from nearly continuous to relatively open and savanna-like. In addition to the dominant live oak and valley oak species, Oregon oak

(*Quercus garryana*), black oak (*Q. kelloggii*), madrone, and buckeye (*Aesculus californicus*) are common. Understory vegetation includes significant components of both native and non-native cover. In more open areas, non-native annual grasses (e.g., rattlesnake grass [*Briza maxima*], foxtail barley [*Hordeum murinum*]) are abundant, but scattered native grasses and forbs are commonly present in these areas as well (e.g., blue wild rye [*Elymus glaucus*], blue dicks [*Dicelostemma* spp.], sun cups [*Taraxia ovata*], ground iris [*Iris macrosiphon*], soaproot [*Chlorogalum pomeridianum*], checkerbloom [*Sidalcea calycosa* ssp. *calycosa*]). In areas of denser canopy, cover is reduced but dominated by native species including poison oak and hillside pea (*Lathyrus vestitus*), with lower cover by species such as hounds tongue (*Cynoglossum grande*), milkmaids (*Cardamine californica*), Torrey's melic (*Melica torreyana*) and California polypody (*Polypodium californicum*).

Habitat quality in these woodlands is high. Although annual grasses are dominant in the understory in open areas, a diversity of native grasses and herbaceous species are also present at lower cover in most locations. Highly invasive species are limited. Natural regeneration of trees is common. The woodlands provide important opportunities for movement and dispersal of plants and wildlife along a topographic gradient. Key



ecosystem services provided by these oak woodlands include habitat for a diversity of plants and wildlife (discussed below), carbon sequestration, soil protection, and cooling and shading for humans and wildlife.

Valley oak woodland is considered sensitive by CDFW.

Eucalyptus Grove

A stand of mature blue gum eucalyptus trees (*Eucalyptus globulus*) is present along the Ridgewood Fire Road. These represent a historic planting. Coyote brush and grassland forms the understory. This grove provides low native plant diversity but provides some wildlife habitat, shade for hikers, and carbon sequestration.



Coyote Brush Scrub

Coyote brush (*Baccharis pilularis*) scrub occurs in scattered exposed, sunny locations throughout the Preserve, especially on gentle upper slopes near the ridge. Cover is usually patchy. Other native shrubs are present including poison oak and sticky monkeyflower (*Mimulus aurantiacus*). A grassy understory is present, and is similar in composition to grassland found throughout the site: dominated by non-native annual grasses and forbs such as Italian thistle (*Carduus pycnocephalus*), but with a significant component of native perennial grasses and forbs as well. These native species include soaproot and small-flowered needlegrass (*Stipa lepida*).

Habitat quality in the coyote brush scrub patches is moderate. These may represent historically wooded areas recovering from human disturbance. Native understory species are present at low cover, and diversity is moderate. However, these stands provide valuable habitat diversity for wildlife, and the shrubs species may enable the gradual establishment of native trees and other native species. Other valuable ecosystem services



provided by these coyote brush stands include carbon sequestration and soil protection.

Grasslands

Grasslands occur in relatively narrow bands throughout uplands of the Study Area. Most of these are described by the 2008 mapping effort as “grasslands on well-developed soils.” In the Study Area, these grasslands are dominated by a mixture of non-native annual grasses and native perennial grasses, with occasional native forbs. A small area of serpentine grassland, and a nearby rock outcrop, are also mapped within the Study Area.



Dominant non-native species include wild oats (*Avena* sp.), rattlesnake grass, foxtail barley, and soft chess (*Bromus hordeaceus*). Non-native forbs are common and include flax (*Linum bienne*), vetch (*Vicia* sp.), cutleaf geranium (*Geranium dissectum*), English plantain (*Plantago lanceolata*), and Italian thistle. Native species present in most locations at moderate (5%-20%) cover are purple needlegrass (*Stipa pulchra*), California oatgrass (*Danthonia californica*), ground iris, and soaproot. Other natives present in scattered locations include sun cups, yarrow (*Achillea millefolium*), lupine (*Lupinus* spp.), and checkerbloom.

One stand of serpentine grassland, as well as a nearby rock outcrop, is mapped by the 2008 vegetation map on the western edge of the Study Area. PCI did not visit these stands because of limited access due to steepness and poison oak cover. No trails are proposed in this area; only trail decommissioning. Based on the mapping data, native plant diversity would be expected to be high in the serpentine area due to the effects of serpentine



chemistry. Rock outcrops also often support native grasses and forbs due to the limiting effects of thin soils. However, other smaller rock outcrops were observed elsewhere in the Study Area; species composition in these locations was similar to adjacent grassland areas.

A small seasonal wetland occurs along a swale within grassland near the northeastern edge of the Study Area (see Figure 3). Vegetation is dominated by common native wetland species including iris-leaf rush (*Juncus phaeocephalus*), gray rush (*Juncus patens*), dock (*Rumex* sp.), dense sedge and other sedge species (*Carex densa*, *Carex* sp.). Non-native annual grasses are also common.



Overall, habitat quality in the grasslands is moderate. Non-native species dominate, but a diversity of native grasses and forbs are present at low to moderate but consistent cover throughout the Study Area. In addition to supporting native plant biodiversity, key ecosystem services provided by these grasslands include wildlife habitat and soil protection.

Serpentine grassland, other grassland types with high cover of native species, and seasonal wetlands are considered sensitive. PCI recommends considering the native dominant grasslands as sensitive habitat.

Wildlife Assessment Results

Relatively few wildlife species are restricted to a single type, and, indeed, most species require more than one vegetation community. Therefore, wildlife communities are described in a larger context and across broader plant communities. These communities are described based on CDFW's *A Guide to Wildlife Habitats of California* (CDFW 1988) and the expertise of the preparer of this report. The following discussion includes a summary of each community's species associations based on field observations. Wildlife species' common names are used in the text because they are unequivocal. A complete list of wildlife species observed is provided in Appendix C.

Existing Wildlife Communities

The Terra Linda Sleepy Hollow Study Area supports extensive oak and California bay woodlands interspersed with patches of coyote brush scrub, grassland, wetland, and seasonal drainages. It is part of a continuous ridge extending from San Anselmo and Sleepy Hollow. The intact woodlands provide important wildlife corridors for species moving from east to west and along the lower drainages to the south. The absence of trails through portions of the woodlands buffers wildlife from recreation use, nearby development, and leave some habitats within the Preserve intact. The Study Area, and larger Preserve, provides key habitat for many of Marin County's wildlife species and can support a variety of wildlife through part or all of their life cycles.

Native bay and oak woodlands dominate the Study Area. These woodlands provide suitable habitat for a variety of terrestrial birds, mammals, amphibians, and reptiles. Birds represent the most abundant and prominent wildlife species within this habitat. Year-round resident birds observed included chestnut-backed chickadee, dark-eyed junco, northern flicker, special-status oak titmouse, western scrub-jay. Tree-climbing birds such as acorn woodpecker and special-status Nuttall's woodpecker were also seen. Summer residents included Pacific-slope flycatcher, tree swallow, orange-crowned warbler, and warbling vireo. Additional wintering species that may occur here, but were not seen due to the timing of the field survey, include ruby-crowned kinglet and yellow-rumped warbler. Red-shouldered and red-tailed hawks and turkey vulture were observed soaring over the wooded areas. Small vertebrates within the habitat are likely to serve as a food source for predatory birds. Nocturnal avian predators may also be present (e.g., western screech owl, great horned owl). Due to their nocturnal nature and timing of the field survey, no owls were observed. Based on the habitat composition, proximity to development, and levels of public use within the Study Area, the woodlands are not likely to support special-status northern spotted owl.

Native oaks and oak communities found within the Study Area serve as a significant resource for many wildlife species in the form of both food and shelter. Every part of the oak tree is utilized as forage for native species including acorns, leaves, twigs, pollen, roots, and sap. Perhaps the most widely recognized source of food is the acorn. This high-energy food is used heavily by acorn woodpeckers, western-scrub jays, and western gray squirrels; all three species were observed within the Study Area. Individual trees are also important food storage sites for acorn woodpeckers, which cache acorns for future consumption, particularly in dead and dying oak trees. Several acorn caches were observed in the Study Area. The use of acorns by a number of wildlife species is important for oak dispersal and regeneration. The entirety of an oak tree, from canopy to roots, also serves as shelter for wildlife. Even the layer of detritus around the base of an oak is utilized by amphibians and insects.

On the woodland floor, woody debris piles and layers of duff provide habitat for amphibians. Locally common California slender salamander were found in the duff under trees. Coast range fence lizard were abundant in areas of downed wood and rock outcrops.

Typically, woodland habitats support a variety of mammals. Isolated habitats free of human disturbance provide escape, cover, and nesting sites for a number of larger mammals. Black-tailed deer scat and a carcass were observed within the Study Area. Botta's pocket gopher and broad-footed mole mounds and tunnels were seen throughout the woodland. Bat species may forage over the habitats and roost in nearby larger trees. Native dusky-footed woodrats or their nest structures were not documented within the Study Area.

Grasslands and grassy openings are present within the woodlands throughout the Study Area. Grasslands provide important habitat for wildlife, but many species also require special habitat features (i.e., rocky outcroppings, woody cover, shrubs) and habitat margins to meet their needs. Grasslands provide foraging opportunities for a number of bird species who are attracted to seeds, other plant material, invertebrates, and small vertebrates. Species such as the western bluebird, American goldfinch, and golden-crowned sparrow were observed foraging in these open areas. The grassland openings among the more densely wooded areas provide foraging habitat for predatory hawks and owls (as noted above, both red-shouldered and red-tailed hawks were seen). Small vertebrates and invertebrates within the habitat are likely to serve as a food source for these birds and other predatory vertebrates. Patches of perennial grasses and forbs add to the habitat's complexity and provide additional foraging opportunities. Native butterflies observed included California buckeye and duskywings.

Coyote brush scrub occurs in the upper elevations near the ridgeline. Scrub provides habitat for a wide variety of wildlife adapted to shrub-dominated environments. Numerous rodent species inhabit scrub, and deer and other herbivores make extensive use of it for browse and protective cover. Shrubs are important to many mammals (e.g., bobcat, gray fox) as shade during hot weather. Scrub provides a variety of resources for birds in the form of seeds, fruits, insects, protection from predators and climate, as well as singing, roosting, and nesting sites. Wildlife observed in the scrub included California quail, western scrub-jay, wrenit, and spotted towhee.

The Study Area supports a small seasonal wetland near Del Haro Way and a number of seasonal drainages; however, these areas provides limited habitat for aquatic species due to their ephemeral nature. The wetland near Del Haro Way is fairly small and does not appear to support areas of standing water. Wildlife may use the wetland during the wetter months when the ground is saturated and the wetland may provide seasonal water. Steep ephemeral drainages flow from the ridge top and drain to northern edge of the Study Area. Due to the steep topography, these drainages may only flow during the wet winter months, but the north-facing drainages are likely to stay cool and moist throughout the year and provide the microclimate conditions required by many wildlife species. These cool, moist drainages are also important movement corridors for wildlife as they navigate from the lower elevations to the summit and across the Preserve, especially in areas that are currently undeveloped.

6. Special-status Species

Background Research

A background literature and database search was conducted to determine the potential for special-status species and sensitive habitats to occur within or adjacent to the Study Area. The search focused on reported occurrences for the Novato and San Rafael 7 ½' USGS quadrangles within a 5-mile buffer around the Preserve (Figure 4). General references, including aerial photographs, GIS maps, and soil survey reports were also consulted to evaluate the potential for unique biological communities and special-status species. The review included, but was not limited to, the following sources:

- California Natural Diversity Database (CNDDDB)⁴ (CDFW 2019)
- California Sensitive Natural Communities (CDFW 2018)
- A Manual of California Vegetation Online (CNPS 2019a)
- CNPS Inventory of Rare and Endangered Vascular Plants of California (CNPS 2019b)
- Calflora database (Calflora 2019)
- Information for Planning and Conservation (IPaC) Trust Resource List for the project area (USFWS 2019)
- Natural Resources Conservation Service Web Soil Survey (NRCS 2019)
- Marin County Open Space District Road and Trail Management Plan (MCOSD 2014);
- Marin County Open Space District Vegetation and Biodiversity Management Plan (MCOSD 2015); and
- Field guides and general references for plants, birds, mammals, reptiles, amphibians, and invertebrates.

Definition of Special-status Species

In California, special-status plants and animals include those species that are afforded legal protection under the federal and California Endangered Species Acts (ESA and CESA, respectively) and other regulations. These species must be considered during project evaluation to comply with CEQA, during consultation with state and federal resources

⁴ The California Natural Diversity Data Base (CNDDDB) is a repository of information on sightings and collections of rare, threatened, or endangered plant and animal species within California. It is maintained by CDFW. CNDDDB reports occurrences of special-status species that have been entered into the database and does not generally include inventories of more common animals or plants. The absence of a species from the database does not necessarily mean that they do not occur in the area, only that no sightings have been reported. In addition, sightings are subject to observer judgment and may not be entirely reliable as a result.

agencies, and in development of specific mitigation and avoidance measures for resource protection. Special-status species are defined as the following:

- Species listed or proposed for listing as threatened or endangered under the federal ESA;
- Species listed or proposed for listing as threatened or endangered under CESA;
- Species that are recognized as candidates for future listing by agencies with resource management responsibilities, such as U.S. Fish and Wildlife Service (USFWS), NOAA's National Marine Fisheries Service (NOAA Fisheries Service), and California Department of Fish and Wildlife (CDFW);
- Species defined by CDFW as California Species of Special Concern;
- Species classified as Fully Protected by CDFW;
- Plant species, subspecies, and varieties defined as rare or threatened by the California Native Plant Protection Act (California Fish and Game Code Section 1900, et seq.);
- Plant species listed by the California Native Plant Society (CNPS) as California Rare Plant Rank 1, 2 and 3 under CEQA (CEQA Guidelines Section 15380); and some list 4 plants based on CNPS guidelines;
- Species that otherwise meet the definition of rare, threatened, or endangered pursuant to Section 15380 of the CEQA Guidelines; and
- Mountain lions protected under the California Wildlife Protection Act of 1990 (Proposition 117) and designated as a "specially protected mammal in California."

Special-status Species Evaluation Criteria

Special-status species identified during the background review and field assessment were evaluated for the potential to occur within the Study Area. The potential for special-status species occurrence were classified as not present, low, moderate, high, or present. The criteria are described below:

Not Present – Suitable habitat is not present within the Study Area, species definitively not observed.

Low – One or more key habitat components is absent from the Study Area; no known occurrences in vicinity, or habitat present but species not observed during field surveys that would be expected to discover species, if present, based on season and level of effort. Species is unlikely to occur within the Study Area.

Moderate – Some of the habitat components required by this species are present within the Study Area and/or marginally suitable habitat is present within surrounding areas. Species may occur within the Study Area.

High – All of the habitat components required by this species are present within the Study Area and/or it is known to occur in surrounding areas. Species is likely to occur within the Study Area.

Present – Species has reported occurrences within the Study Area and/or was observed within the project site during field surveys.

Jurisdictional Areas

Wetlands and other waters of the U.S. and the state of California are considered jurisdictional areas. Wetlands and other waters include a variety of both permanent and ephemeral aquatic features. Regulations and policies that protect aquatic habitats have been enacted by a number of government agencies. Wetlands and waters fall under the jurisdiction of the U.S. Army Corps of Engineers, local Regional Water Quality Control Board, California Department of Fish and Wildlife, and Marin County. Any fill, removal of native riparian and wetland vegetation, or alteration of drainage patterns require permits and resource agency consultation.

Sensitive Natural Communities

CDFW maintains a list of natural communities (classified as vegetation alliances) present within the state, and ranks each in terms of their rarity and vulnerability on both the global (G) and state (S) level (CDFW 2018). Ranks range from 1 (very rare and threatened) to 5 (demonstrably secure). Natural communities with ranks of S1 to S3 are considered sensitive and are to be addressed in environmental review processes including CEQA. In addition, other communities may be considered sensitive based on regional or local policies.

California bay forest, valley oak woodland, serpentine grassland, other grassland stands of high native cover, and seasonal wetlands are considered sensitive based on CDFW ranking and/or wetland status. County-level oak woodland policies also protect native oak stands in general.

Map Not For Public Review. The occurrences shown on this map represent the known locations of the species listed here as of the date of this version. There may be additional occurrences or additional species within this area which have not yet been surveyed and/or mapped. Lack of information in the CNDDDB about a species or an area can never be used as proof that no special-status species occur in an area.

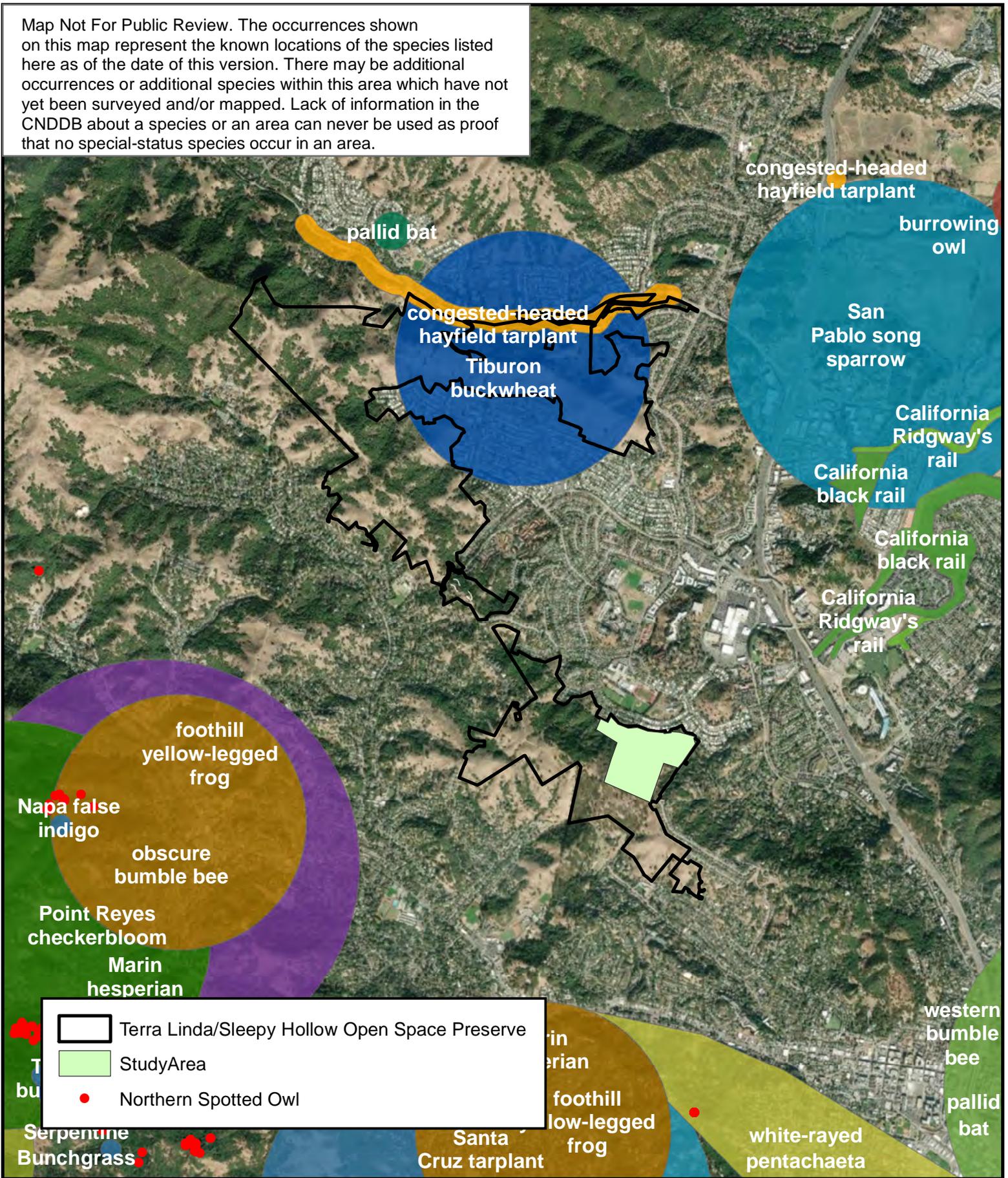


Figure 4. Reported Occurrences of Special-status Species
 Biological Resources Assessment
 Terra Linda/Sleepy Hollow Open Space Preserve

0 0.25 0.5 1 Miles

August 2019
 Aerial: ESRI
 Preserve Boundary: Marin County
 CNDDDB: CDFW



Special-status Plants

Based on the background literature review, a number of special-status plant species were identified as having potential to occur in the Study Area. Several CNPS-listed or locally rare species are identified as occurring within the Preserve by MCOSD's *Vegetation and Biodiversity Management Plan* (2015); most of these are associated with serpentine soils. If any work, including active decommissioning, is proposed within the serpentine area (see Figure 3), botanical surveys should be conducted in that location prior to disturbance. No special-status species were observed within the Study Area.

Species with reported observations in close proximity to the Study Area and/or in habitat types of relevance (e.g., oak woodland, grassland) are evaluated in Appendix D. Species that only occur in habitats not present within the Study Area or require specific microhabitat conditions not present within the area (e.g., marsh, coniferous forest, dunes) are not discussed further.

Special-status Animals

Based on the background literature review, a number of special-status animal species were identified as having the potential to occur in the Study Area or nearby. Species with reported observations in close proximity to the Study Area and/or in habitat types of relevance (e.g., woodland, grassland) were evaluated. Species that only occur in habitats not present within the Study Area (e.g., marine and freshwater aquatic habitats) or require specific microhabitat conditions not present within the Study Area are not discussed further. See Appendix E for a complete list of species evaluated and detailed species and listing status⁵ descriptions.

PCI documented the presence of two special-status birds, oak titmice and Nuttall's woodpecker, within the Study Area. Seven additional special-status birds have been documented within the larger Terra Linda/Sleepy Hollow Open Space Preserve by Marin County staff, but not necessarily confirmed within the Study Area (MCOSD 2015). Three special-status bat species have high potential to occur within or adjacent to the Study Area based regional occurrence data (CDFW 2019). These include the following:

- Cooper's hawk (*Accipiter cooperii*, WL)
- Sharp-shinned hawk (*Accipiter striatus*, WL)
- Grasshopper sparrow (*Ammodramus savannarum*, SSC)
- Golden eagle (*Aquila chrysaetos*, BCC, WL, FP)

⁵ Listing Status: FE-federally listed as endangered, FT-federally listed as threatened, BCC-Bird of Conservation Concern, SE-state listed as endangered, ST-state listed as threatened, Candidate SE-state candidate to be listed as endangered under CESA Candidate ST-state candidate to be listed as threatened under CESA, FP-State of California fully-protected species, SSC-California Species of Special Concern, and WL-Watch List.

- Burrowing owl (*Athena cunicularia*, BCC, SSC)
- Oak titmouse (*Baeolophus inornatus*, BCC)
- Northern harrier (*Circus hudsonius*, SSC)
- White-tailed kite (*Elanus leucurus*, FP)
- Nuttall's woodpecker (*Picoides nuttallii*, BCC)
- Pallid bat (*Antrozous pallidus*, SSC, Western Bat Working Group, high priority species; see *Special-status and Common Bat Species* below)
- Townsend's big-eared bat (*Corynorhinus townsendii*, SSC, Western Bat Working Group, high priority species; see *Special-status and Common Bat Species* below)
- Hoary bat (*Lasiurus cinereus*, Western Bat Working Group, medium priority species; see *Special-status and Common Bat Species* below)

Birds

The larger Preserve supports documented habitat for seven year-round resident, special-status bird species – Cooper's hawk, sharp-shinned hawk, golden eagle, oak titmouse, northern harrier, white-tailed kite, and Nuttall's woodpecker, seasonal breeding habitat for grasshopper sparrow, and overwinter habitat for burrowing owl. See *Protected Nesting Birds* for additional discussion.

Cooper's hawks are common in open woodlands and brushlands. This species forages for birds and mammals and nests in dense mixed forest, canyons, and riparian corridors. Cooper's hawks have been documented within the larger Preserve by Marin County staff (MCOSD 2015). This species may forage and nest within the Study Area in more densely wooded areas.

Sharp-shinned hawks occur known to nest in small numbers in oak woodland and mixed forests within Marin County. They forage over a variety of habitats, feeding primarily on small birds. Sharp-shinned hawks have been document within the larger Preserve by Marin County staff (MCOSD 2015). This species may forage and nest within the Study Area in more densely wooded areas.

Grasshopper sparrows are a common summer resident in grassland habitats. This species forages for insects and seeds. They nest in grass clumps. Grasshopper sparrow's have been documented within the larger Preserve by Marin County staff (MCOSD 2015). This species may forage and nest within the Study Area in limited grassland locations.

Golden eagles are found in open woodlands and mountainous habitats where they nest in large trees or on cliffs. Golden eagles are a year-round resident of Marin County, but are a rare, local nesting bird with a very small breeding population. They have been

documented within the larger Preserve by Marin County staff (MCOSD 2015). This species is not likely to use the Study Area with any frequency.

Burrowing owls are a ground-dwelling species found in grasslands, ranchlands, and open habitats. Historically, they nested along the baylands in Marin County, but now only occur seasonally, mostly as a winter resident. Burrowing owls have been documented within the larger Preserve by Marin County staff (MCOSD 2015). This species is not likely to use the Study Area with any frequency as suitable open habitats with underground burrows are largely absent; they may be found on a limited basis in winter.

Oak titmice are common in oak woodland habitats and urban areas. They typically forage for insects and seeds in trees and shrubs and nest in tree cavities and nest boxes. Oak titmice were documented within the Study Area by PCI. Suitable foraging and nesting habitat is present within the Study Area.

Northern harriers occupy wide-open habitats from grasslands to marshes. This species has been documented within the larger Preserve by Marin County staff (MCOSD 2015). However, limited open grassland habitat is present within the Study Area, mostly concentrated on the upper ridge line. Harriers may nest and forage within open habitats within the Study Area.

White-tailed kites occur in open woodlands and grassland habitats. They forage by hovering and diving for small rodents. Nests are constructed in trees and tall shrubs. White-tailed kites have been documented within the larger Preserve by Marin County staff (MCOSD 2015). Kites may forage and nest within the Study Area.

Nuttall's woodpeckers occur in oak woodlands and streamside habitats. This species probes for insects in tree bark and crevices. They nest in live or dead tree cavities. Nuttall's woodpeckers were documented within the Study Area by PCI. This species may forage and nest within the Study Area.

Special-status and Common Bat Species

There are approximately 15 bat species with known occurrences within Northern California, and a number of these species have a high probability of occurring within the Study Area and adjacent lands. Bats are highly mobile; many are migratory. Foraging habitats range from woodlands, forests, and grasslands to open water. All of Marin County's species are insectivorous and feed by echolocation. Bats use caves, mines, buildings, bridges, tree hollows, and other natural and man-made crevices for roosting. Focused surveys for bats were not performed as part of PCI's assessment. However, the Study Area supports suitable foraging and tree roosting habitat of a number of special-

status and common bat species. Three species (i.e., pallid, Townsend’s big-eared, and hoary bat) have been reported nearby and have a high likelihood of occurrence within the Preserve. Pallid bats may use tree hollows, Townsend’s big-eared bats may roost in crevices, and hoary bats may roost in trees and foliage. All three species have potential for forage over the Study Area and roost in suitable trees.

Protected Nesting Birds

Nesting native bird species are protected under both federal and state regulations. According to US Fish and Wildlife Service, under the federal Migratory Bird Treaty Act of 1918 (MBTA; 50 CFR 10.13,), “it is unlawful to pursue, hunt, take, capture, kill, possess, sell, purchase, barter, import, export, or transport any migratory bird, or any part, nest, or egg or any such bird, unless authorized under a permit issued by the Secretary of the Interior. Some regulatory exceptions apply. Take is defined as: ‘pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect.’” Bald and golden eagles are also protected under the federal Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) of 1940.

Birds and their nests are also protected under the California Fish and Wildlife Code (§3503 and §3513). Under §3503, “it is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto”. Under §3513, “it is unlawful to take or possess any migratory nongame bird as designated in the Migratory Bird Treaty Act or any part of such migratory nongame bird except as provided by rules and regulations adopted by the Secretary of the Interior under provisions of the Migratory Treaty Act”. The federal Endangered Species Act and California Endangered Species Act also protect nesting threatened and endangered bird species

Most bird species, with a few specific exceptions, are protected under the MBTA and California Fish and Game Code. Vegetation removal and/or construction activities in areas with suitable nesting habitat during the breeding period, typically mid-February to mid-August in this area, could result in nest abandonment or loss of native nesting birds unless appropriate actions are taken (e.g., preconstruction surveys, avoidance, monitoring, etc.; RHJV 2004).

7. Conclusions

MCOSD is exploring options to improve trail access and reduce social trails on the Terra Linda/Sleepy Hollow Open Space Preserve. They are assessing the feasibility of decommissioning sections of one formal (Memorial Trail) and multiple social trails and establishing a new multiuse trail in the southeastern portion of the Preserve. MCOSD retained PCI to complete a biological assessment of this section of the Preserve to inform the trail planning effort. The following is a summary of key biological resources identified by PCI within the Study Area. If further planning provides an opportunity for a multiuse trail, PCI will update this report and provide project specific recommendations to protect biological resources in accordance with the California Environmental Quality Act (CEQA); preliminary recommendations for trail planning are included below. Based on the botanical and wildlife background literature, data search, and field surveys, the Study Area supports the following resources:

- California bay forest, coast live oak forest, valley oak woodland, mixed oak forest, coyote brush scrub, grasslands (including significant native cover and one area of serpentine), one small seasonal wetland, and a eucalyptus grove are present in the Study Area. Habitat quality in all of the vegetation types except the eucalyptus grove is moderate to high.
- California bay forest, valley oak woodland, serpentine and other native grasslands, and seasonal wetlands are considered sensitive based on CDFW ranking and/or wetland status. County-level oak woodland policies also protect native oak stands in general.
- Habitat and wildlife corridors for a variety of native species (e.g., reptiles, amphibians, birds, mammals, and invertebrates) occur within the Study Area. The undeveloped woodlands provide an important wildlife corridor for species occupying the interior of the Study Area and allow them to move to and from the surrounding lands. The intact woodlands with limited interior trails buffer wildlife from recreational uses and leave some habitats within the Preserve intact.
- Breeding/wintering/foraging habitat is present for a number of native bird species, including several special-status species (i.e., Cooper's hawk, sharp-shinned hawk, grasshopper sparrow, oak titmouse, white-tailed kite, Nuttall's woodpecker).
- Potential roosting and foraging habitat is present for special-status and common bat species; special-status pallid bat, Townsend's big-eared bat, and hoary bat have been documented in the region and additional bat species may be present.

Preliminary Recommendations

Most habitats within the Study Area support moderate to high quality plant and wildlife communities. Any trail proposed within the Study Area would traverse through native habitat with significant native diversity and cover. Areas of biological concern are noted on Figure 5. To minimize impacts on biological resources as part of the trail planning, the following recommendations should be implemented:

- Whenever possible new trail construction should use sustainable segments of existing alignments.
- Minimize fragmentation of habitats from trail development. Maintain core areas of high-quality habitat undisturbed.
- Limit the number of stream crossings.
- Decommission informal trails, any trails that duplicate routes, and steep eroding trails; revegetate with native species appropriate to the habitat and of local provenance (see below).
- During trail decommissioning, ensure that nearby sensitive areas including serpentine habitat are protected. Avoid any ground disturbance in serpentine habitat. If ground disturbance cannot be avoided, a qualified botanist or restoration specialist should perform a focused botanical survey of the area prior to disturbance and develop a restoration plan.
- Where existing alignments are decommissioned, take adequate measures to encourage native plant establishment. This may require decompaction of soils, seeding, planting, and/or other restoration measures.
- Where existing alignments are decommissioned, take adequate measures to prevent ongoing use. This may require visitor management/education techniques. Long-standing neighborhood access routes and those indicated on Internet/Google maps (i.e., from Dias Way) are likely to be difficult to close.
- Undertake appropriate plant salvage and habitat restoration for decommissioned trails and areas disturbed by new trail construction. Robust native perennials such as grasses, irises, and soaproot are good candidates for salvage. Native seed could also be readily collected from areas adjacent to impact areas.
- Prevent the spread of invasive species; currently, highly invasive species are limited in the Study Area but trail construction and maintenance have high potential to spread the few existing stands, such as yellow star thistle, that occur along trails. Implement BMPs to avoid spreading invasive seed with equipment, and restore disturbed areas promptly.
- Avoid impacts to the wetland area identified in the northeast portion of the Study Area.
- To avoid potential losses of nesting native birds, preconstruction breeding bird surveys should be completed from February through August for any trail construction or vegetation disturbance.

- To avoid impacts on special-status and common bat species, prior to any tree removal or significant tree trimming, a qualified biologist should survey for bat roosts.

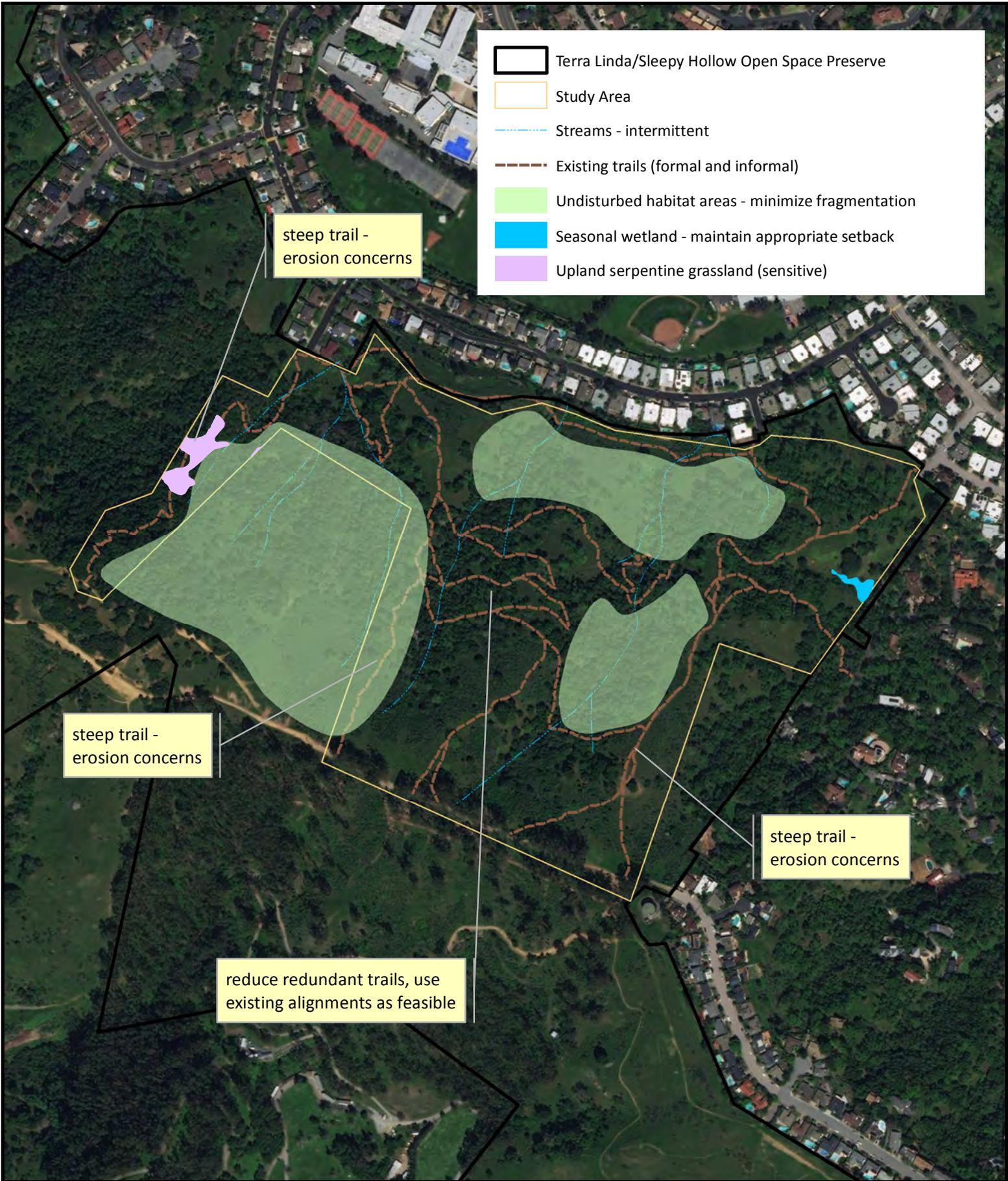
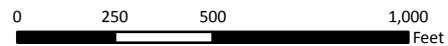


Figure 5. Areas of Biological Concern
 Biological Resources Assessment
 Terra Linda/Sleepy Hollow Open Space Preserve



August 2019
 Aerial: ESRI
 Trails and Preserve Boundary: Marin County



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Appendix A

Representative Photographs within the Study Area



Preserve entrance off Dias Way (above) and existing trail in northeast corner of Study Area (below).





Existing oak woodland and grassland habitat (above)
and non-native pines near Del Haro Way (below).





Wetland seep (above) and steep gradient trail (below); both near Del Haro Way.





Woodland habitat (above) and existing game trail (below)
in the northern portion of the Study Area.





Existing creek crossing and informal trail in northern portion of Study Area (above) and ridgetop trail leading to informal access point off Devon Avenue (below).





Scrub habitat in southern portion of the Study Area (above) and eucalyptus stand along Ridgewood Fire Road (below).





Informal trail off Ridgewood Fire Road (above) and existing Memorial Trail (below).



Appendix B: Plant Species Observed, Terra Linda/Sleepy Hollow Open Space Preserve Memorial Trail Project

Plant species observed on April 16, 26 and June 18, 2019.

Common Name	Scientific Name	Family - Common Name	Native (N) or Introduced (I)
annual ryegrass	<i>Festuca perennis</i>	Grass Family	I
bachelor's button	<i>Centaurea cyanus</i>	Sunflower Family	I
big squirreltail grass	<i>Elymus multisetus</i>	Grass Family	N
black oak	<i>Quercus kelloggii</i>	Oak Family	N
blue wildrye	<i>Elymus glaucus</i>	Grass Family	N
blue-eyed grass	<i>Sisyrinchium bellum</i>	Iris Family	N
brownhead rush	<i>Juncus phaeocephalus</i>	Rush Family	N
burclover	<i>Medicago polymorpha</i>	Legume Family	I
buttercup	<i>Ranunculus californicus</i>	Buttercup Family	N
California bay	<i>Umbellularia californica</i>	Laurel Family	N
California brome	<i>Bromus carinatus</i>	Grass Family	N
California buckeye	<i>Aesculus californica</i>	Soapberry Family	N
California gooseberry	<i>Ribes californicum</i>	Gooseberry Family	N
California melic	<i>Melica californica</i>	Grass Family	N
California oat grass	<i>Danthonia californica</i>	Grass Family	N
California polypody	<i>Polypodium californicum</i>	Polypody Family	N
California poppy	<i>Eschscholzia californica</i>	Poppy Family	N
celery weed	<i>Lomatium californicum</i>	Carrot Family	N
checkerbloom	<i>Sidalcea calycosa ssp. calycosa</i>	Checkerbloom Family	N
cleavers, goose grass	<i>Galium aparine</i>	Madder Family	N
coast live oak	<i>Quercus agrifolia</i>	Oak Family	N
coastal tarweed	<i>Madia sativa</i>	Sunflower Family	N
common fiddleneck	<i>Amsinckia intermedia</i>	Borage or Waterleaf Family	N
common maidenhair fern	<i>Adiantum capillus-veneris</i>	Brake Family	n
coyote brush	<i>Baccharis pilularis</i>	Sunflower Family	N
coyote mint	<i>Monardella villosa ssp. villosa</i>	Mint Family	N
cream cups	<i>Platystemon californicus</i>	Poppy Family	N
cudweed	<i>Pseudognaphalium sp.</i>	Sunflower Family	N
cut-leaf geranium	<i>Geranium dissectum</i>	Geranium Family	I
dense sedge	<i>Carex densa</i>	Sedge Family	N
dock	<i>Rumex sp.</i>	Buckwheat Family	
English plantain	<i>Plantago lanceolata</i>	Plantain Family	I
false brome	<i>Brachypodium distachyon*</i>	Grass Family	I
farmer's foxtail	<i>Hordeum murinum ssp. leporinum</i>	Grass Family	I
fennel	<i>Foeniculum vulgare*</i>	Carrot Family	I
goldenback fern	<i>Pentagramma triangularis</i>	Brake Family	N

Common Name	Scientific Name	Family - Common Name	Native (N) or Introduced (I)
graceful clarkia	<i>Clarkia gracilis</i>	Evening-Primrose Family	N
gray rush	<i>Juncus patens</i>	Rush Family	N
ground iris	<i>Iris macrosiphon</i>	Iris Family	N
hayfield tarweed	<i>Hemizonia congesta ssp. lutescens</i>	Sunflower Family	N
hedge nettle	<i>Stachys ajugoides</i>	Mint Family	N
hillside pea	<i>Lathyrus vestitus var. vestitus</i>	Legume Family	N
honeysuckle	<i>Lonicera hispidula</i>	Honeysuckle Family	N
hound's tongue	<i>Cynoglossum grande</i>	Borage or Waterleaf Family	N
Idaho fescue	<i>Festuca idahoensis</i>	Grass Family	N
Italian thistle	<i>Carduus pycnocephalus</i>	Sunflower Family	I
Ithuriel's spear	<i>Tritelaiea laxa</i>	Brodiaea Family	N
little hop clover	<i>Trifolium dubium</i>	Legume Family	I
milk maids, bitter cress, California toothwort	<i>Cardamine californica</i>	Mustard Family	N
miniature lupine	<i>Lupinus bicolor</i>	Legume Family	N
naked buckwheat	<i>Eriogonum nudum</i>	Buckwheat Family	N
narrowleaf flax	<i>Linum bienne</i>	Flax Family	I
needle goldfields	<i>Lasthenia gracilis</i>	Sunflower Family	N
ookow	<i>Dichelostemma congestum</i>	Brodiaea Family	N
Oregon oak	<i>Quercus garryana</i>	Oak Family	N
Pacific madrone	<i>Arbutus menziesii</i>	Heath Family	N
Pacific sanicle	<i>Sanicula crassicaulis</i>	Carrot Family	N
phacelia	<i>Phacelia sp.</i>	Borage or Waterleaf Family	N
purple needle grass	<i>Stipa pulchra</i>	Grass Family	N
purple sanicle	<i>Sanicula bipinnatifida</i>	Carrot Family	N
purple vetch	<i>Vicia benghalensis</i>	Legume Family	I
rattlesnake grass	<i>Briza maxima</i>	Grass Family	I
red fescue	<i>Festuca rubra</i>	Grass Family	N
ripgut brome	<i>Bromus diandrus</i>	Grass Family	I
rush	<i>Juncus sp.</i>	Rush Family	N
rusty popcornflower	<i>Plagiobothrys nothofulvus</i>	Borage or Waterleaf Family	N
scarlet pimpernel	<i>Anagallis arvensis</i>	Myrsine Family	I
shortspur seablush	<i>Plectritis congesta ssp. brachystemon</i>	Valerian Family	N
sky lupine	<i>Lupinus nanus</i>	Legume Family	N
slender cottonweed	<i>Micropus californicus</i>	Sunflower Family	N
small-flowered needlegrass	<i>Stipa lepida</i>	Grass Family	N
soap plant	<i>Chlorogalum pomeridianum var. pomeridianum</i>	Century Plant Family	N
spreading hedgeparsley	<i>Torilis arvensis</i>	Carrot Family	I
starflower	<i>Lysimachia latifolia</i>	Myrsine Family	N

Common Name	Scientific Name	Family - Common Name	Native (N) or Introduced (I)
sticky chickweed	<i>Cerastium glomeratum</i>	Pink Family	I
sticky monkeyflower	<i>Mimulus aurantiacus</i>	Lopseed Family	N
stone pine	<i>Pinus pinea</i>	Pine Family	I
subterranean clover	<i>Trifolium subterraneum</i>	Legume Family	I
sun cups	<i>Taraxia ovata</i>	Evening-Primrose Family	N
tomcat clover	<i>Trifolium willdenovii</i>	Legume Family	N
Torrey's melic	<i>Melica torreyana</i>	Grass Family	N
toyon	<i>Heteromeles arbutifolia</i>	Rose Family	N
valley oak	<i>Quercus lobata</i>	Oak Family	N
western lady fern	<i>Athyrium filix-femina</i>	Cliff Fern Family	N
wild hyacinth	<i>Dichelostemma capitatum</i>	Lily Family	N
wild oat	<i>Avena fatua</i>	Grass Family	I
wild plum	<i>Prunus cerasifera</i>	Rose Family	I
wood fern	<i>Dryopteris arguta</i>	Wood Fern Family	N
woodland star	<i>Lithophragma affine</i>	Saxifrage Family	N
yarrow	<i>Achillea millefolium</i>	Sunflower Family	N
yellow star-thistle	<i>Centaurea solstitialis</i> *	Sunflower Family	I
*invasive plant species of high concern			

Appendix C: Wildlife Species Observed, Terra Linda/Sleepy Hollow Open Space Preserve Memorial Trail Project

Wildlife species observed on April 16, 2019. Species listed in alphabetical order, not taxonomic order. Special-status species in bold.

Scientific Name	Common Name
Reptiles	
<i>Sceloporus occidentalis bocourtii</i>	Coast Range Fence Lizard
Amphibians	
<i>Batrachoseps attenuatus</i>	California Slender Salamander
Birds	
<i>Aphelocoma californica</i>	Western Scrub-jay
<i>Baeolophus inornatus</i>	Oak Titmouse
<i>Buteo jamaicensis</i>	Red-tailed Hawk
<i>Buteo lineatus</i>	Red-shouldered Hawk
<i>Callipepla californica</i>	California Quail
<i>Calypte anna</i>	Anna's Hummingbird
<i>Cathartes aura</i>	Turkey Vulture
<i>Chamaea fasciata</i>	Wrentit
<i>Colaptes auratus</i>	Northern Flicker
<i>Corvus brachyrhynchos</i>	American Crow
<i>Corvus corax</i>	Common Raven
<i>Empidonax difficilis</i>	Pacific-slope Flycatcher
<i>Haemorhous mexicanus</i>	House Finch
<i>Junco hyemalis</i>	Dark-eyed Junco
<i>Melanerpes formicivorus</i>	Acorn Woodpecker

Scientific Name	Common Name
<i>Melospiza melodia</i>	Song Sparrow
<i>Mimus polyglottos</i>	Northern Mockingbird
<i>Oreothlypis celata</i>	Orange-crowned Warbler
<i>Patagioenas fasciata</i>	Band-tailed Pigeon
<i>Picoides nuttalli</i>	Nuttall's Woodpecker
<i>Pipilo crissalis</i>	California Towhee
<i>Pipilo maculatus</i>	Spotted Towhee
<i>Poecile rufescens</i>	Chestnut-backed Chickadee
<i>Psaltriparus minimus</i>	Bushtit
<i>Sayornis nigricans</i>	Black Phoebe
<i>Sialia mexicana</i>	Western Bluebird
<i>Spinus tristis</i>	American Goldfinch
<i>Sturnus vulgaris</i>	European Starling (non-native)
<i>Tachycineta bicolor</i>	Tree Swallow
<i>Turdus migratorius</i>	American Robin
<i>Vireo gilvus</i>	Warbling Vireo
<i>Zonotrichia atricapilla</i>	Golden-crowned Sparrow
Mammals	
<i>Odocoileus hemionus</i>	Black-tailed Deer
<i>Scapanus latimanus</i>	Broad-footed Mole
<i>Sciurus griseus</i>	Western Gray Squirrel
<i>Thomomys bottae</i>	Botta's Pocket Gopher

Appendix D: Special-status Plant Species Evaluated for the Terra Linda/Sleepy Hollow Memorial Trail Project

The table below includes those plant species with CNDDDB occurrences on the Novato and San Rafael 7 ½' USGS quadrangles within a 5-mile buffer around the Preserve (CDFW 2019) and USFWS IPaC resource list (USFWS 2019).

Scientific Name	Common Name	Listing Status ⁶ USFWS/CDFW/ CRPR	Life Form, Blooming Period, and General Habitat	Potential for Occurrence ⁷ within the Study Area
<i>Amorpha californica</i> var. <i>napensis</i>	Napa false indigo	--/--/ 1B.2	Perennial deciduous shrub. Blooms April-July. Broadleaved upland forest (openings), chaparral, woodland. 120-2000 m.	Low. Potentially suitable habitat present and historic occurrence within several miles but species not observed in Study Area.
<i>Amsinckia lunaris</i>	bent-flowered fiddleneck	--/--/ 1B.2	Annual herb. Blooms March-June. Coastal bluff scrub, cismontane woodland, valley and foothill grassland. Typically on gravelly slopes, grassland, openings in woodland, often serpentine. 3-500 m.	Low. One historic and one recent occurrence within 5 miles and potentially suitable habitat present but species not observed in Study Area.
<i>Arctostaphylos montana</i> ssp. <i>montana</i>	Mt. Tamalpais manzanita	--/--/ 1B.3	Perennial evergreen shrub. Blooms February-April. Serpentine, rocky chaparral or grassland. 160-760 m.	Low. Species not observed. No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.
<i>Arctostaphylos virgata</i>	Marin manzanita	--/--/ 1B.2	Perennial evergreen shrub. Blooms January-March. Sandstone or granite. Broadleaved upland forest, close-cone coniferous forest, chaparral, and North Coast coniferous forest.	Low. Species not observed in Study Area. Only marginally suitable habitat present.

⁶ Listing Status: FE-federally listed as endangered, FT-federally listed as threatened, SE-state listed as endangered, ST-state listed as threatened, Candidate SE-state candidate to be listed as endangered under CESA Candidate, ST-state candidate to be listed as threatened under CESA, CR-state listed as rare; California Rare Plant Rank (CRPR): 1A – Presumed extinct in California and rare/extinct elsewhere, 1B – Rare, threatened, or endangered in California and elsewhere, 2A – Presumed extirpated in California, more common elsewhere, 2B – Rare, threatened, or endangered in California, more common elsewhere, 3 - Plants for which we need more information, 4 – Plants of limited distribution. Suffixes: .1 Seriously endangered in California, .2 Fairly endangered in California, .3 Not very endangered in California.

⁷ See *Special-status Species Evaluation Criteria*.

Scientific Name	Common Name	Listing Status ⁶ USFWS/CDFW/ CRPR	Life Form, Blooming Period, and General Habitat	Potential for Occurrence ⁷ within the Study Area
<i>Dirca occidentalis</i>	western leatherwood	--/--/ 1B.2	Perennial deciduous shrub. Blooms January-March. Broadleaved upland forest, closed-cone coniferous forest, chaparral, woodland, North Coast coniferous forest. 50-395 m.	Low. No documented occurrences within 5 miles and species not observed in Study Area.
<i>Eriogonum luteolum var. caninum</i>	Tiburon buckwheat	--/--/ 1B.2	Annual herb. Blooms May-September. Serpentinite, sandy to gravelly locations in chaparral, woodland, coastal prairie, and grassland. 0-700 m.	Moderate. Species not observed in Study Area, but reported from serpentine in northern part of Preserve (CDFW 2019). No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.
<i>Helianthella castanea</i>	Diablo helianthella	--/--/ 1B.2	Perennial herb. Blooms March-June. Usually rocky, azonal (lacking well-developed horizons) soils, often in part shade. Broadleaved upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, valley and foothill grassland.	Low. Presumed extirpated in Marin County. Only marginally suitable habitat present, no documented occurrences within 5 miles, and species not observed in Study Area.
<i>Hemizonia congesta ssp. congesta</i>	white seaside tarplant (congested-headed hayfield tarplant)	--/--/ 1B.2	Annual herb. Blooms April-November. Valley and foothill grassland, sometimes roadsides. 20-560 m.	Low. Potentially suitable habitat present and historic occurrence along Lucas Valley Road but species not observed in Study Area.
<i>Hesperolinon congestum</i>	Marin western flax	FT/CT/ 1B.1	Annual herb. Blooms April-July. Serpentinite chaparral and grassland. 5-370 m.	Moderate. Species not observed. No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.

Scientific Name	Common Name	Listing Status ⁶ USFWS/CDFW/ CRPR	Life Form, Blooming Period, and General Habitat	Potential for Occurrence ⁷ within the Study Area
<i>Holocarpha macradenia</i>	Santa Cruz tarplant	FT/SE/ 1B.1	Annual herb. Blooms June-October. Coastal prairie, coastal scrub, valley and foothill grassland (often clay, sandy). 10-220 m.	Low. Historic occurrence within 5 miles and marginally suitable habitat present but species not observed in Study Area.
<i>Horkelia tenuiloba</i>	thin-lobed horkelia	--/--/ 1B.2	Perennial herb. Blooms May-July. Broadleafed upland forest, chaparral, valley and foothill grassland (mesic openings, sandy).	Low. No documented occurrences within 5 miles. Potentially suitable habitat present but species not observed in Study Area.
<i>Lessingia hololeuca</i>	woolly-headed lessingia	--/--/ 3	Annual herb. Blooms June-October. Broadleafed upland forest, coastal scrub, lower montane coniferous forest, and valley and foothill grassland (clay /serpentinite). 15-305 m.	Low. Reported occurrence on Preserve (Calflora 2019, MCOSD 2015) and marginally suitable habitat present but species not observed in Study Area.
<i>Lessingia micradenia</i> var. <i>micradenia</i>	Tamalpais lessingia	--/--/ 1B.2	Annual herb. Blooms July-October (sometimes June). Usually serpentinite, often roadsides, in chaparral and grassland. 100-500 m.	Low. Only known from Mt. Tam area. Species not observed. No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.
<i>Microseris paludosa</i>	marsh microseris	--/--/ 1B.2	Perennial herb. Blooms April-June (rarely July). Closed-cone coniferous forest, cismontane woodland, coastal scrub, valley and foothill grassland. 5-300 m.	Low. No documented occurrences within 5 miles. Potentially suitable habitat present but species not observed in Study Area.
<i>Pentachaeta bellidiflora</i>	white-rayed pentachaeta	FE/SE/ 1B.1	Annual herb. Blooms March-May. Woodland, grassland (often serpentinite). 35-620 m.	Moderate. Potentially suitable habitat present and extirpated historic occurrence within 1 mile to south but species not observed in Study Area. No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.

Scientific Name	Common Name	Listing Status ⁶ USFWS/CDFW/ CRPR	Life Form, Blooming Period, and General Habitat	Potential for Occurrence ⁷ within the Study Area
<i>Ranunculus lobbii</i>	Lobb's aquatic buttercup	--/--/4.2	Annual aquatic herb. Blooms February-May. Vernal pools. 15-470 m.	Low. Reported occurrences on Preserve (Calflora 2019, MCOSD 2015) but no vernal pools in Study Area.
<i>Sidalcea hickmanii</i> spp. <i>viridis</i>	Marin checkerbloom	--/--/ 1B.3	Perennial herb. Blooms May-June. Chaparral. 50-430m.	Low. Documented occurrence within 5 miles to west but typically on volcanic or serpentine soils.
<i>Stebbinsoseris decipiens</i>	Santa Cruz microseris	--/--/ 1B.2	Annual herb. Blooms April-May. Open areas, sometimes serpentine in broadleaved upland forest, closed-cone coniferous forest, chaparral, coastal prairie, and grassland. 10-500 m.	Low. Only marginally suitable habitat present. No documented occurrences within 5 miles. Species not observed in Study Area.
<i>Streptanthus glandulosus</i> var. <i>pulchellus</i>	Mt. Tamalpais bristly jewel-flower	--/--/ 1B.3	Annual herb. Blooms May-July. Serpentine in chaparral and grassland.	Moderate. Species not observed. No serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.
<i>Streptanthus glandulosus</i> var. <i>secundus</i>	one sided jewel flower	Locally rare per MCOSD (2015)	Annual herb. Blooms March-May. Rocky, open slopes and forest openings, usually on serpentine.	Moderate. Reported occurrences on Preserve (MCOSD 2015) but no serpentine present in proposed new trail areas. If decommissioning work occurs near serpentine area (see Figure 3), focused botanical surveys should be performed prior to any disturbance.
<i>Trifolium amoenum</i>	two fork clover	FE/--/ 1B.1	Annual herb. Blooms April-June. Coastal bluff scrub, valley and foothill grassland (sometimes serpentine). Open, sunny sites, swales. 5-415 m.	Low. Potentially suitable habitat present but species not observed in Study Area. Only records within 10 miles are historic.

Appendix E: Special-status Animal Species Evaluated for the Terra Linda/Sleepy Hollow Memorial Trail Project

The table below includes those animal species with CNDDDB occurrences on the Novato and San Rafael 7 ½' USGS quadrangles within a 5-mile buffer around the Preserve (CDFW 2019) and USFWS IPaC resource list (USFWS 2019). However, shore and marine birds (e.g., California least tern, short-tailed albatross, western snowy plover), fish (e.g., Delta smelt, longfin smelt, Sacramento splittail, tidewater goby), and other aquatic species (e.g., California freshwater shrimp, coho salmon, green sea turtle) were excluded from the table as suitable habitat is not present within the Study Area. Non-listed invertebrates reported as local interest species were also not included.

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
Amphibians			
California giant salamander <i>Dicamptodon ensatus</i>	--/SSC	Occur in wet coastal forests near permanent and semi-permanent streams and springs. This species is one of the largest terrestrial salamanders in North America. Breeding occurs mostly in spring, but sometimes fall. Eggs are laid in water and larvae exhibit an enlarged tail fin for swimming with external gills. They transform into land dwelling salamanders with lungs around 18 to 24 months. They consume a wide variety of animals from small invertebrates to salamanders, rodents, and lizard – they exhibit a sit and wait feeding style. Endemic to California.	Low. The Study Area does not support perennial or intermittent streams required for breeding by this species. Suitable habitat may be present downstream in perennial creeks, but salamanders are unlikely to migrate from these locations into the Study Area.
foothill yellow-legged frog <i>Rana boylei</i>	--/Candidate ST, SSC	In or near partly shaded rocky streams that are shallow, slow, and moderately size from sea level to 6,300 feet. Breeding occurs from spring to early summer after high flows have receded. Eggs are laid at downstream end of rocks. Tadpoles require 3 to 4 months to attain metamorphosis. During all season, never found far from water.	Low. The Study Area does not support perennial streams required by this species. Suitable habitat may be present in nearby watersheds, but frogs are unlikely to migrate from these locations into the Study Area. Nearby historical occurrences are assumed to be extirpated (e.g., San

⁸ Listing Status: FE-federally listed as endangered, FT-federally listed as threatened, BCC-Bird of Conservation Concern, SE-state listed as endangered, ST-state listed as threatened, Candidate SE-state candidate to be listed as endangered under CESA Candidate ST-state candidate to be listed as threatened under CESA, FP-State of California fully-protected species, SSC-California Species of Special Concern, and WL-Watch List.

⁹ See *Special-status Species Evaluation Criteria*.

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
			Anselmo Creek 1990s, near Hamilton Field 1940s).
California red-legged frog <i>Rana draytonii</i>	FT/ SSC	Breeding habitat includes marshes, streams, lakes, reservoirs, ponds, and other water sources with plant cover. Breeding occurs in deep, slow-moving waters with dense, shrubby, or emergent vegetation. Breeds November through April depending on location. During the non-breeding season, California red-legged frogs can remain at the breeding site (in the presence or absence of water) or move into surrounding non-breeding habitats.	Low. The Study Area does not support suitable perennial streams, ponds, or reservoirs required by this species for breeding. Suitable habitat may be present in nearby watersheds, but frogs are unlikely to migrate from these locations into the Study Area. The nearest reported occurrence on the west side of Highway 101 is 8 miles from the Study Area.
Reptiles			
northwestern pond turtle <i>Actinemys marmorata</i>	--/SSC	Found in or near permanent or semi-permanent water sources (e.g., ponds, lakes, rivers, streams) with suitable basking sites and underwater retreats. Eggs are laid in shallow holes dug by the female from April through August. Eggs hatch in late summer or fall. In northern California, hatchlings can remain buried until the following spring. Turtles may use uplands for overland migration (movements up to 5 km) and nesting sites (nesting can occur over 500 m from water).	Low. The Study Area does not support perennial streams, ponds, or reservoirs required by this species. No nearby ponds or reservoirs area visible on Google Earth™ within the immediate vicinity. Due to the lack of nearby suitable habitat, turtles are unlikely to use the Study Area.
Birds			
Cooper's hawk <i>Accipiter cooperii</i>	--/WL (nesting)	Forest hawk of open woodlands and brushlands. Forages for birds, chipmunks, and squirrels through forest and edge habitats. Nests in dense mixed forests, larger canyons, and riparian corridors typically in the fork of a tree. Cooper's hawks are a year-round resident in Marin County.	Present. Suitable habitat is present within woodlands in the Study Area. Species confirmed in Preserve by Marin County staff (MCOSD 2015).
sharp-shinned hawk <i>Accipiter striatus</i>	--/WL (nesting)	Nests in mixed forest and woodland habitats, typically in conifers within mixed forests. Forages over a variety of habitats, primarily on small birds. Sharpies are known to nest in small numbers in oak woodland and mixed forests within the county. Sharp-	Present. Suitable habitat is present within woodlands in the Study Area. Species confirmed in Preserve by Marin County staff (MCOSD 2015).

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
		shinned hawks are a year-round resident in Marin County, becoming more abundant in winter.	
grasshopper sparrow <i>Ammodramus savannarum</i>	--/SSC (nesting)	A small, open-country sparrow named for its buzzy insect-like song. Forages for insects and seeds and prefers “short to moderate-height, moderately open grasslands with scattered shrubs” (Shuford and Gardali 2008). Summer resident in Marin County in ungrazed or lightly grazed grasslands.	Present. Suitable habitat is present within limited grasslands locations within the Study Area. Species confirmed in Preserve by Marin County staff (MCOSD 2015).
golden eagle <i>Aquila chrysaetos</i>	BCC/WL, FP Protected by Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) of 1940.	Utilize open woodlands and mountainous habitats. Primarily solitary feeding on mammals. Nests in large trees or on cliffs. Breeds from late-January through August. Average clutch size is 2. Eggs are incubated for up to 45 days and nestling period of 65 to 70 days. A year-round resident of Marin County, but a rare, local breeding with a very small breeding population.	Present. Species confirmed in Preserve by Marin County staff (MCOSD 2015). Eagles are unlikely to nest within the Study Area. Limited foraging habitat is present. Eagles may occur in the area infrequently.
great egret <i>Ardea alba</i>	--/-- Not formally listed, rookies are considered a protected resource under MBTA and California Fish and Wildlife Code.	Occur in marshes, ponds, shores, and mudflats feeding primarily on fish, but also taking smaller animals. Nest in isolated pairs or colonies. Nests tend to be located in tall trees or shrubs. For herons and egrets, pre-laying and courtship can begin as early as January to March with the nesting season extending into June to August or later for the San Francisco Bay region in general.	Low (nesting). Foraging habitat is present within the Study Area; great egrets are known to feed on terrestrial wildlife and may feed in upland habitats within the Study Area. Suitable rookery (nesting) habitat is present within the Study Area, but there are no documented rookeries within the larger Preserve or the immediate vicinity. The nearest active rookery is located approximately 5 miles from the Study Area at Bel Marin Keys.
great blue heron <i>Ardea herodias</i>	--/-- Not formally listed, rookies are considered a protected	Large wading bird, commonly seen in freshwater and saline habitat and open grasslands where they feed primarily on fish and smaller animals. Courtship can begin in early January to March and breeding extends into June to August or	Low (nesting). Foraging habitat is present within the Study Area; great blue herons are known to feed on terrestrial wildlife and may feed in upland habitats

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
	resource under MBTA and California Fish and Wildlife Code.	later. Colonial nests are built in large trees or snags, often in association with great egrets.	within the Study Area. Suitable rookery (nesting) habitat is present within the Study Area, but there are no documented rookeries within the larger Preserve or the immediate vicinity. The nearest active rookery is located east of Highway 101 along San Pedro Road.
burrowing owl <i>Athene cunicularia</i>	BCC/SSC (burrowing sites and some wintering sites)	A small, ground-dwelling species of grasslands, prairies, rolling hills, and ranchlands. Subterranean nesters that utilize abandoned burrows of ground squirrels and other mammals. Feed on a variety of prey items, including ground insects and small vertebrates. Historically, this species bred in Marin County along the baylands, but now occurs seasonally, mostly as winter resident (Shuford and Gardali 2008).	Present. Species confirmed in Preserve by Marin County staff (MCOSED 2015). Suitable burrowing habitat was not documented within the Study Area, but the availability of burrowing habitat may change based on fossorial wildlife activity over time. This species may occur within the Study Area on limited basis in winter.
oak titmouse <i>Baeolophus inornatus</i>	BCC/--	Small, gray-brown bird of oak woodlands. Characterized by small pointed crest and nasal tsick-a-dee-dee call that resonates through woodland habitats. Forages for insects and seeds, hopping from branch to branch. Nests in cavities in trees or nest boxes. Oak titmice are a year-round resident in Marin County.	Present. Species documented within the Study Area by PCI in April 2019. Oak titmice may nest and forage year-round within the Study Area.
marbled murrelet <i>Brachyramphus marmoratus</i>	FT/SE (nesting)	Uncommon permanent resident of the west coast from California to Alaska. Permanent resident along the Marin Coast, but sightings are uncommon during the breeding season from May through July. This seabird forages for small fish and plankton in offshore areas and along the rocky coastline. It has an unusual nesting behavior. Unlike most alcids, it does not nest in burrows or cliff colonies, but uses old-growth forests dominated by conifers and redwoods. Nesting may occur as far as 45 miles inland. A single egg is laid on a platform	Not present. Suitable old-growth forest habitat not present within the Study Area.

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
		of lichen and moss on large tree limbs. Adult movements to and from the nest occur most often at dusk and dawn. Breeding success is very low. The decline of this species has been attributed to the loss of old-growth forests.	
northern harrier <i>Circus hudsonius</i>	--/SSC	Occupies wide-open habitats from grasslands to marshes. A slender, medium sized raptor. Fly low to ground hunting for small animals. Rely heavily of sense of hearing to detect prey. Nests are constructed on the ground in well concealed vegetation or clumps of vegetation. A year-round resident in Marin County.	Present. Suitable habitat is present within grasslands and open areas in the Study Area. Species confirmed in Preserve by Marin County staff (MCOSD 2015). Harriers may nest and forage year-round within open habitats within the Study Area.
snowy egret <i>Egretta thula</i>	--/-- Not formally listed, rookies are considered a protected resource under MBTA and California Fish and Wildlife Code.	Occur in marshes, swamps, ponds, and shores feeding primarily on fish, crustaceans, and insects. Nest in colonies with other egrets and herons. Nests tend to be located in tall trees or shrubs. For herons and egrets, pre-laying and courtship can begin as early as January to March with the nesting season extending into June to August or later for the San Francisco Bay region in general.	Low (nesting). Foraging habitat is present within the Study Area; snowy egrets are known to feed on terrestrial wildlife and may feed in upland habitats within the Study Area. Suitable rookery (nesting) habitat is present within the Study Area, but there are no documented rookeries within the larger Preserve or the immediate vicinity. The nearest active rookery is located on West Marin Island in San Rafael Bay.
white-tailed kite <i>Elanus leucurus</i>	--/FP	Raptor of semi-open areas. Forages for mostly small rodents by hovering and diving. Nests in trees and tall bushes. Year-round resident in Marin County in open woodlands, bottomlands, and agricultural grasslands. Kites are known to breed in lowland and grassland habitats in Marin County (Shuford 1993).	Present. Species documented within the Preserve by Marin County staff (MCOSD 2015). Kites may nest and forage year-round within the Study Area.
saltmarsh common yellowthroat	BCC/SSC	This subspecies of common yellowthroat is endemic to the greater San Francisco Bay region in wetland and riparian habitats. This species is	Low. Suitable wetland and riparian habitat is not present within the Study Area. Yellowthroats are not

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
<i>Geothlypis trichas sinuosa</i>		insectivorous and forages for insects and spiders. Breeding occurs from mid-March to late July. Open cup nests are constructed near the ground in grasses and herbaceous vegetation.	likely to be present within the Study Area.
California black rail <i>Laterallus jamaicensis coturniculus</i>	BCC/ST and FP	An elusive and seldom seen marsh bird. Occurs in tidal saltwater marshes dominated by pickleweed, cordgrass, and bulrush, and low-elevation freshwater marshes. Primarily occurs in marshlands around San Francisco Estuary and recently discovered (1994) in Sierra foothills. Constructs woven cup nest near ground. Consumes insects, seeds, and small crustaceans.	Not Present. Suitable habitat is not present within the Study Area. Rails are not likely to be present within the Study Area.
San Pablo song sparrow <i>Melospiza melodia samuelis</i>	BCC/SSC	This subspecies of song sparrow occurs in tidal marshes throughout the San Pablo Bay, including Richardson Bay. This species occurs year-round throughout its range. They are primarily associated with high marsh habitats dominated by pickleweed. This species feeds primarily on terrestrial invertebrates. Breeding occurs from early March to July, nests are constructed low to the ground in gum plants (<i>Grindelia</i> spp.).	Not Present. Suitable marsh habitat is not present within the Study Area. This subspecies of song sparrow is not likely to be present within the Study Area.
Nuttall's woodpecker <i>Picoides nuttallii</i>	BCC/--	Permanent, resident woodpecker of woodland habitats, prefers oak and streamside habitats. Characterized by black and white barring on backside. Probes for insects in tree bark and crevices. Nests in live or dead tree cavities excavated by males of the species, typically. Nuttall's woodpeckers are a year-round resident in Marin County.	Present. Species documented within the Study Area by PCI in April 2019. Nuttall's woodpecker may nest and forage year-round within the Study Area.
California Ridgway's rail <i>Rallus obsoletus obsoletus</i>	FE/SE, FP	Occupy salt and brackish marshes within the San Francisco and San Pablo Bays. Prefer habitat dominated by pickleweed (<i>Salicornia virginica</i>) and Pacific cordgrass (<i>Spartina foliosa</i>). Breeding occurs from mid-March through July, with peak activity in late June.	Not Present. Suitable habitat is not present within the Study Area. Rails are not likely to be present within the Study Area.

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
northern spotted owl <i>Strix occidentalis caurina</i>	FT/ ST, SSC	Dense forest habitats in northern California. Requires multi-layered canopy cover for roosting sites. Breeding sites include tree or snag cavities or broken tops of large trees. Nocturnal hunter eating mostly small mammals. Year-round resident in Marin County where it is known from breeding occurrences in old-growth and mixed forest habitats. Species occupies a large territory, approximately 5 square miles. A pair of owls may utilize the same breeding site for five to 10 year.	Low. Spotted owls have documented territories and nest sites approximately 1.5 miles southeast of the Study Area in the Southern Heights Ridge area in San Rafael. These sightings are reported in more densely wooded areas. Based on the habitat composition, proximity to development, and levels of public use within the Preserve, owls are not likely to establish nesting territories within the Study Area. They may migrate/ forage through the Study Area infrequently.
Mammals			
pallid bat <i>Antrozous pallidus</i>	--/SSC Western Bat Working Group high priority species	Grassland, shrubland, forest, and woodland habitats at low elevations up through mixed coniferous forests. A social species forming small colonies. Roosting sites include caves, mines, crevices, buildings, and hollow trees during day, more open sites used at night. Pallid bats feed on large flightless arthropods. A yearlong resident throughout most of its range. During non-breeding season, both sexes may be found roosting in groups of 20 or more individuals. One to three (typically twins) pups born from April to July.	High. Pallid bats have a reported occurrence within 2 miles of the Study Area (CDFW 2019). Suitable foraging and roosting habitat is present within the Study Area.
Townsend's big-eared bat <i>Corynorhinus townsendii</i>	--/SSC Western Bat Working Group high priority species	Low to mid-elevation mesic habitats including riparian, mixed forest, coniferous forest, prairies, and agricultural lands. Utilizes edge habitats for foraging. Roosting sites include caves, mines, tunnels, buildings, and other man-made structures. Mating typically occurs in winter with a single young born in May or June. Maternal roosts consist of a small number of females with young, typically less than 100 individuals.	High. There are no nearby reported occurrences of Townsend's big-eared bat, but bats are typically underrepresented in the CNDDDB (CDFW 2019). Suitable foraging habitat is present within the Study Area.

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
hoary bat <i>Lasiurus cinereus</i>	--/-- Western Bat Working Group medium priority species	Occur in open habitat or habitat mosaics. Requires medium to large trees for cover and habitat edges and/or open areas for foraging habitat. Tend to be solitary roosting in trees and foliage, and they are widespread in California except patchy in desert regions. Mating occurs during fall migration and young are born the following June. Favored food is moths.	High. Hoary bats have a historic occurrence within 3 miles of the Study Area (CDFW 2019). Suitable foraging and roosting habitat is present within the Study Area.
salt-marsh harvest mouse <i>Reithrodontomys raviventris</i>	FE/SE, FP	Salt marshes and adjacent diked wetlands. Prefers habitat dominated by pickleweed, their primary food source. Breeding occurs from spring through autumn. Nests constructed in wetland habitat with dense cover.	Not present. Suitable wetland/marsh habitat not present within the Study Area. Harvest mice are not likely to be present within the Study Area.
Invertebrates			
San Bruno elfin butterfly <i>Callophrys mossii bayensis</i>	FE/--	Coastal, mountainous areas with grassy ground cover. All known locations restricted to San Mateo County. Host plant is Pacific sedum (<i>Sedum spathulifolium</i>) (eggs laid on plant and caterpillars feed on sedum). Adult flight season is late February to mid-April.	Not Present. There are no nearby reported occurrences for this species in Marin County (CDFW 2019). The Study Area is outside the range of this species.
Mission blue butterfly <i>Plebejus icarioides missionensis</i>	FE/--	Historically, occupied grassland and chaparral habitats in seven counties surrounding the San Francisco Bay. The majority of butterflies are restricted to San Bruno Mountain. Small isolated colonies are also reported at Twin Peaks in San Francisco (possibly extirpated?) and Golden Gate National Recreation Area in the Marin Headlands. Host plant is silver lupine (<i>Lupinus albifrons</i>) (eggs laid on plant and caterpillars feed on lupine). Adult flight season is late March to early July. Adults are known to feed on buckwheat, golden aster, wild hyacinths, and other plants. Hilltops and ridges are important breeding grounds.	Not Present. The nearest reported occurrence for this species in Marin County is at Fort Baker (CDFW 2019). Suitable habitat is not present for this species within the Study Area.
Myrtle's silverspot butterfly <i>Speyeria zerene myrtleae</i>	FE/--	Historically, occupied coastal dune, prairie habitat, dunes, and bluffs from San Mateo County north to the Russian River in Sonoma County. Four remaining populations occur in western Marin	Not Present. There are no nearby reported occurrences for this species in Marin County (CDFW 2019). Suitable habitat is not

Common Name <i>Scientific Name</i>	Listing Status ⁸ USFWS/CDFW	Habitat Requirements	Potential for Occurrence ⁹ within the Study Area
		County and southwestern Sonoma County. Similar in appearance and life history to Behren’s silverspot butterfly. Larvae typically feed on violets (<i>Viola adunca</i>) where eggs are laid. Adult flight season from late June to early September. Adults known to use a number of nectar plants [i.e., gum plant, yellow sand verbena, mints (<i>Monardella</i> spp.), seaside daisy, and nonnative bull thistle and false dandelion].	present for this species within the Study Area.

MCP WILDLIFE BURROW SURVEY

Name:

Date:

Location/Project detail (including start date):

Start Time:

Weather/Wind/Cloud Cover:

End Time:

Weather/Wind/Cloud Cover:

Habitat Type:

Burrows Observed (width x height) Possible species use	Signs (tracks, scat, description of the mound, or anything else that helped determine the species)	Coordinates

Notes:



San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol

Version 6.4

Natural Resource Report NPS/SFAN/NRR—2010/245



ON THE COVER

Female northern spotted owl and fledglings in Point Reyes National Seashore, 2007.
Photo by Heather Jensen, NPS.

San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol

Version 6.4

Natural Resource Report NPS/SFAN/NRR—2010/245

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U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal, high-level peer review based on the importance of its content, or its potentially controversial or precedent-setting nature. Peer review was conducted by highly qualified individuals with subject area technical expertise and was overseen by a peer review manager.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the San Francisco Area Network Inventory and Monitoring website (<http://science.nature.nps.gov/im/units/sfan>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/NRPM>).

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	September 2003	D. Adams, K. Fehring, D. Hatch, S. Allen	First draft of monitoring protocol	Preparation for first peer review.	1.0
1.0	August 2004	D. Adams, K. Fehring, B. Merkle	Minor revisions to previous version.	Preparation for first peer review.	2.0
2.0	August 2004	D. Adams, K. Fehring, B. Merkle	Minor revisions to previous version.	Preparation for first peer review.	3.0
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5.0	May 2008	D. Adams, H. Jensen, K. Fehring, B. Merkle, D. Press, M. Koenen	Report format edits. Expanded and improved sections on monitoring history, previous research, barred owls, and reporting methods. Revised monitoring objectives. Added randomized study design based on new power analyses developed by SFSU.	To address peer review comments and meet current formatting guidelines.	6.3
6.3	April 2010	D. Press, D. Adams, H. Jensen, K. Fehring, B. Merkle, M. Koenen, L. Starcevich	Report format edits. Expanded NSO background info. Revised monitoring objectives. Added management triggers. New power analyses and sampling design recommendations from University of Idaho. Added documentation of SOD. Provided details on methods for long-term analyses.	To address peer review comments and meet current formatting guidelines.	6.4

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Executive Summary

This protocol and the attached standard operating procedures detail the background, field methods, data management, annual and long-term reporting and analyses, and operational requirements to monitor northern spotted owls (NSO) at Golden Gate National Recreation Area, Muir Woods National Monument, and Point Reyes National Seashore in California. The owls are listed as threatened under the Endangered Species Act and face a variety of threats in Marin County including loss of habitat due to development and catastrophic fire, displacement by barred owls (*Strix varia*), change in habitat due to Sudden Oak Death, human disturbances during the breeding season, and mortality due to West Nile Virus.

The parks included for monitoring by this protocol and surrounding Marin County compose the southernmost range of the NSO. Although NSO are typically found in old growth forests, in Marin NSOs reside in second growth Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), mixed conifer-hardwood, mixed evergreen hardwood forests, as well as remnant old-growth stands of coast redwood and Douglas-fir. The primary food source for the NSO is the dusky-footed woodrat (*Neotoma fuscipes*).

NSO density and fecundity monitoring began in 1993 after an infusion of funding associated with the Vision Fire at Point Reyes National Seashore. In 1999, the NPS and partners began regular long-term monitoring at 46 select NSO territories. Field methods follow those of the USDA Forest Service Pacific Northwest Research Station Protocol (PNW) with slight modification to reduce mousing and associated habituation to people. The monitoring program continues to the present using a new randomized sampling design that was initiated in 2007.

The long-term monitoring objectives are to:

1. Monitor long-term trends in NSO site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.
2. Monitor long-term trends in NSO fecundity (number of female young per territorial female) within NSO territories within the legislated NPS boundaries of Marin County, California.
3. Determine long-term trends in NSO nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

The sample design presented in this protocol includes an annual panel of 28 randomly selected sites with all remaining sites divided equally into four rotating panels of 8 sites each. That means a total of 36 sites will be monitored annually to determine occupancy. Fecundity determination will occur at every site occupied by a territorial female, no matter if the site is within the annual panel or one of the rotating panels. The selected sample design has a power of 99% to detect a 4% annual decline in occupancy in 5 years ($\alpha = 0.20$) and 80% power to detect a 10% annual decline in fecundity in 5 years ($\alpha = 0.20$). Nest tree characteristics will be recorded

for every nest detected during monitoring. In addition, a SOD Severity Index has been developed and will be calculated to track SOD around activity centers.

Surveys are conducted during the breeding season from March until the end of July. To determine occupancy, surveyors will make a minimum of 3 site visits before determining that a site is unoccupied. Given the relatively high detection probabilities, any combination of 3 day and night visits would provide a greater than 88% detection probability of either a single or pair. The initial visits are made during the day and if occupancy is not ascertained, follow ups are made during the night. Additional surveys will be conducted to determine fecundity.

Marin County monitoring mark-recapture data from 1998 to 2003 were included in a range-wide demographic analysis that estimated apparent survival rates for the Marin County study, which were stable relative to other study sites and the sex-specific fecundity. Data collected from 2004 suggest a stable populations and fecundity but statistical analyses have not yet been completed.

Research conducted by PRBO Conservation Science in Marin County using NSO data collected in part by this monitoring program looked at prey availability, habitat selection, and conservation threats. Habitat modeling suggested that protecting intact forested watersheds is a higher priority for protecting the NSO population in Marin County than managing for particular forest types or age classes in the region. In addition, a study on nest sites indicated that 91% of the nests in surveyed in Marin County were platform nests and 9% of nests were in cavities. In contrast, 80% to 90% of nests were in cavities in older forests in northwestern California and the Olympic Peninsula in Washington.

Barred owls (*Strix varia*) present a growing concern in Marin County. The first barred owls were documented in 2002. The first pair was noted in 2005 and the first successful breeding occurred in 2007 within the study area. Sudden Oak Death also presents a growing problem. A widespread die-off of native coast live oak and tanoak species throughout NSO habitat in Marin County may have long-term impacts on habitat, prey populations, and extreme fire behavior.

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S. Allen, Point Reyes National Seashore, and D. Hatch, Golden Gate National Recreation Area began this spotted owl monitoring program in the mid-1990s and have provided unflagging support, seeking NPS base and project funding sources to continue to the monitoring program and initiate studies to further explore the relationship of northern spotted owls to the Marin County landscape. PRBO Conservation Science, Marin Municipal Water District, and Marin Open Space District have been partners in the development and continuation of this monitoring program. T. Gardali and R. Cormier from PRBO have been valuable program members for the last several years.

M. Monroe has provided support for the monitoring through the Muir Woods National Monument's volunteer program and has been a liaison with the east Marin County communities and municipalities. D. George designed the initial database and database handbook. Numerous field techs, volunteers and interns have provided the dedication needed over the years.

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Preliminary sample design assistance was provided in 2006 through 2008 by G. LeBuhn and E. F. Connor, San Francisco State University, through the University of California CESU (Cooperative Ecosystems Study Unit) agreement.

University of Idaho completed the final power analyses and recommended sample design. We are grateful to Kirk Steinhorst and especially Leigh Ann Starcevich for the analyses, for reviewing sections of the protocol narrative, and for seeing this protocol through to this point.

1.0 Background and Objectives

The mission of the National Park Service (NPS) is “to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (NPS 1916). To uphold this goal, in 1992, the NPS began development of a national policy to better understand the dynamic nature and condition of natural resources, to detect or predict changes that may require intervention, and to serve as reference points for more altered parts of the environment (NPS 1992). In 1998, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) includes Eugene O’Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles National (PINN) Monuments, Point Reyes National Seashore (PORE), and Golden Gate National Recreation (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of SFAN is to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management and will also be able to accommodate unanticipated environmental conditions in the future.

In 2005, SFAN biologists and cooperators completed a vital sign selection process to rank the most important natural resources in the network of NPS units (Adams et al. 2006). The SFAN used four criteria to rank indicators: ecological significance, management significance, legal mandate, and cost and feasibility. Northern spotted owls (*Strix occidentalis caurina*: NSO) represent a vital sign for SFAN due to their ecological significance, a desire to augment to an already large data set on NSO (see Section 1.2), and high interest to the public (Adams et al. 2006). In addition, NPS Management Policies (NPS 2006), the Government Performance and Results Act (1993), strategic plan goals for the NPS, and the Northwest Forest Plan (NWFP; USDA and USDI 1994a, b) require that the NPS monitor long-term status and trends and maintain stable or increasing populations of species listed as threatened or endangered under the Endangered Species Act, such as the NSO.

1.1 Northern Spotted Owl Range-wide Status and Habitat Associations

NSOs were listed as federally threatened by the U.S. Fish and Wildlife Service on June 22, 1990 “due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms” (USFWS 1990). The owls are distributed in forested regions from southern British Columbia through Washington, Oregon, and northwestern California. They reach the southern limit of their range in coastal California north of San Francisco Bay, where they occur in GOGA, MUWO, PORE, and other parts of Marin County, California (Figure 1).

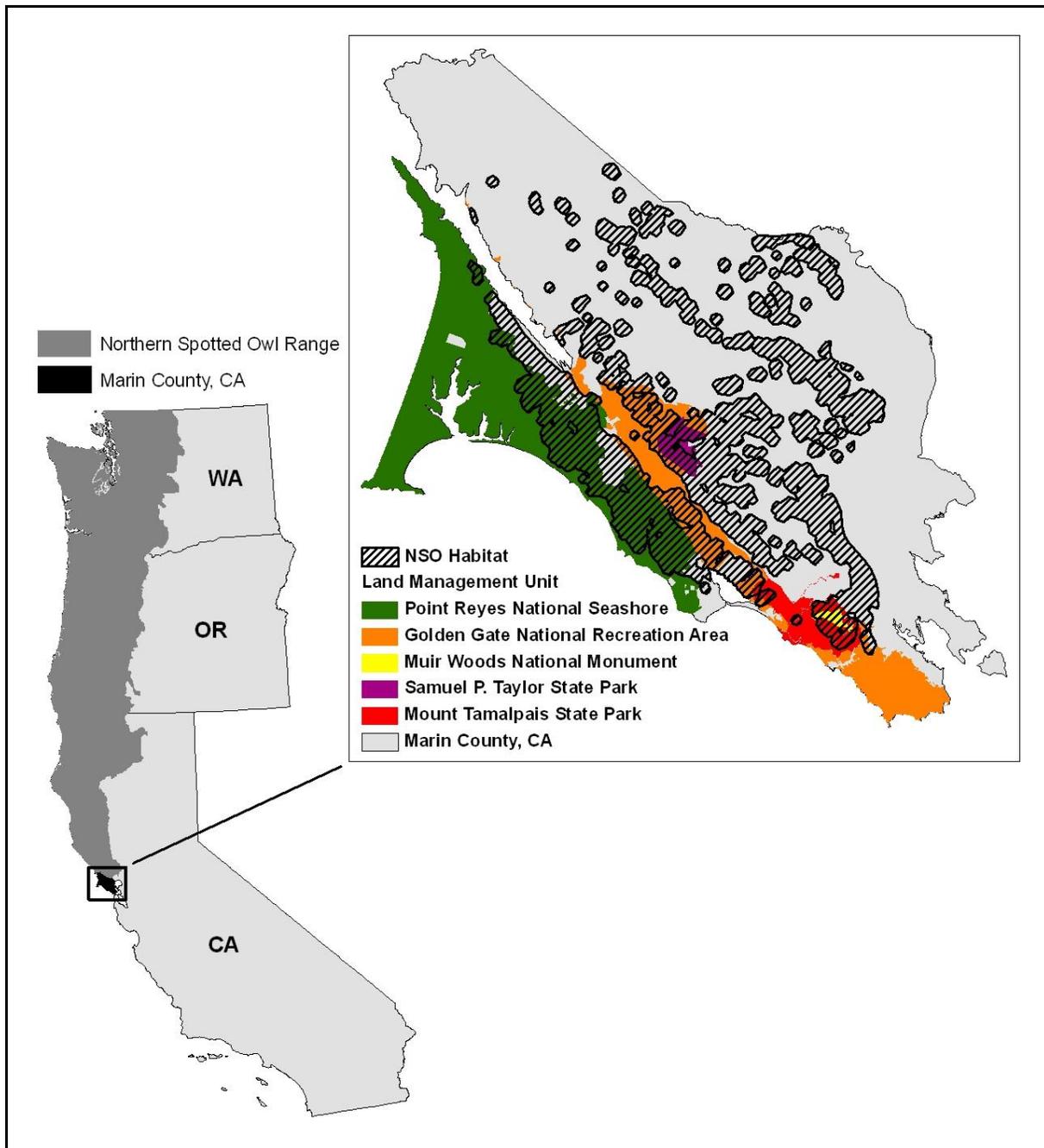


Figure 1. NSO suitable habitat (Stralberg et al. 2009) and land management units within Marin County, California.

NSOs are strongly associated with mature and old-growth coniferous forests throughout their entire range (Forsman et al. 1984; Thomas et al. 1990; Carroll and Johnson 2008) because these forests support the features necessary for successful nesting, roosting, foraging, and high prey densities. Important habitat features include a high canopy closure, a complex and multi-storied structure, botanical diversity, a high incidence of potential nest trees and structures, and large accumulations of forest floor woody debris (Thomas et al. 1990).

NSO annual home-range sizes generally increase from south to north, and can exceed several thousand acres in size (Thomas et al. 1990; Zabel et al. 1995). Carey et al. (1992) and Zabel et al. (1995) found that spotted owl habitat use and home range size is related to their primary prey species. In comparison to the northern populations, spotted owls in California may require a broad variety of habitats (Zabel et al. 2003). In the southern portion of the spotted owl range where the dusky-footed woodrat (*Neotoma fuscipes*) is the dominant prey, spotted owls appear to exhibit selective generalist behavior in habitat selection – that is, they select habitats containing a mix of old and younger forest stands that provide adequate nesting and foraging habitats (Zabel et al. 2003).

Several key studies have explored NSO habitat suitability, nest site occurrence, and life history traits (i.e., survival and fecundity) in relation to biotic and abiotic habitat variables at the landscape level. In northwestern California, Franklin et al. (2000) found that NSO survival is positively associated with levels of old-growth forests, and that both survival and reproductive output increase with the length of edge between old-growth forests and other vegetation types. Franklin et al. suggested that “a mosaic of older forest interspersed with other vegetation types promoted high fitness in Northern Spotted Owls”. Importantly, Franklin et al. (2000) documented nonlinear habitat relations for NSO, indicating that too much “suitable” habitat may actually have negative effects on NSO requirements, such as foraging. Olson et al. (2004) confirmed a nonlinear habitat relationship in the Oregon Coast Range, reporting that NSO survival was quadratically related to the amount of mid- and late-seral forests within 1,500m of activity centers. As with Franklin et al. (2000), edge effects between older forests and other habitat types also exerted a positive influence on NSOs in the Olson et al. (2004) study, furthering the notion that a mixture of older forests and other habitat types was important to NSO survival and reproduction. More recently, Carroll and Johnson (2008) again confirmed a quadratic relationship between owl sites and old-growth forests in the northern Californian subregion of the NSO range. In the northern regions of the NSO range, however, a more linear relationship between owl abundance and older forests was observed, underscoring the importance of old growth forest preserves in the recovery of NSO populations.

Within the NSO range, trends in NSO populations are evaluated through analyses of demographic data collected in key study areas on private, tribal, state, and federal lands, with some data sets extending back to 1985 (Anthony et al. 2006). Demographic studies include the banding of NSO adults and juveniles, resighting of banded owls, occupancy monitoring of known NSO territories, and reproductive monitoring of nesting NSOs.

The most recent demographic analysis of 14 study areas (Anthony et al. 2006) estimated and evaluated trends in age-specific survival and fecundity rates, and determined annual rates of population change within each study areas and across all study areas. NPS data from Marin County was included in the monograph but excluded from estimates of population change due to low sample size (see Section 1.2.2). Anthony et al. (2006) estimated that NSO populations across the 13 other long-term study areas decreased by an average of 3.7% each year from 1985 to 2003. Owl survival declined in 5 of the 14 study areas, with the sharpest declines reported from all four study areas in Washington. Reasons for these declines in survival and populations likely include, but are not limited to the high densities of barred owls (*Strix varia*) in Washington and

Oregon, loss of habitat due to timber harvest or wildfire, declines in prey abundance, poor weather conditions, and forest defoliation caused by insect infestations (Anthony et al. 2006).

1.2 History of Spotted Owl Monitoring in Marin County

The three NPS units in Marin County (GOGA, MUWO, and PORE) began a small-scale, joint NSO survey in the county in 1993. Previously, there had been informal surveys in the area, but only one pair was reported in the NWFP (USDA and USDI 1994a, b). In 1995, after the Vision wildfire, PORE was able to increase survey efforts and initiate monitoring of NSO sites in and around the fire because of an infusion of funds for rehabilitation and environmental compliance (Chow and Allen 1997). Additionally, following the fire, Chow studied NSO density and habitat associations as a graduate student at Humboldt State University (Chow 2001).

1.2.1 NSO Inventory

In 1997 and 1998, recognizing the need for more information about a sensitive species on NPS lands, the NPS conducted a formal NSO inventory study of most federal lands in Marin County using the U. S. Fish and Wildlife Service (USFWS) “Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls” (USFWS 1992) with national NPS funds. The NPS collaborated with PRBO Conservation Science (PRBO) in order to add to the inventory public lands adjacent to NPS boundaries, including Marin Municipal Water District (MMWD), Marin County Open Space District (MCOSD), and California State Parks. The inventory identified at least 80 different NSO territories, or activity sites, throughout Marin County. NSO were found in a variety of forested habitat types, including Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), and mixed hardwood forests comprised of tanbark oak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), and California bay laurel (*Umbellularia californica*). The results of the 1997 and 1998 inventory showed many more NSO activity sites than expected on public lands in the county.

1.2.2 NSO Long-Term Monitoring

In 1999, the NPS and partners began long-term monitoring at 46 of the 80 known NSO territories, identified during the inventory phase on the federal, state, and county managed lands (Hatch et al. 1999). The 46 territories were non-randomly selected based on accessibility, known management issues, and representation of different dominant forest types. Monitoring surveys were conducted to determine reproductive rates and population trends. Monitoring methods followed those of the USDA Forest Service Pacific Northwest Research Station Protocol (PNW) created for use in Northwest Forest Plan NSO demographic study areas (Forsman 1995). These survey methods include repeated calling and feeding of live mice (*Mus domesticus*; known as “mousing”) to enhance detection rates. It has been shown, however, that these methods can alter owl behavior. For example, owls habituated to people or food conditioning may be more vulnerable to disturbance and manipulation by park operations and visitors (Forsman 1995).

In 1999, the NPS modified the PNW demographic study monitoring protocol in response to observed behavioral changes in NSO apparently due to repeated mousing by biologists and photographers. All protocol deviations from the PNW protocol were intended to minimize the number of mice fed to owls by increasing search effort and observation time. The Modified Protocols for Spotted Owl Monitoring and Demographic Studies in Marin County, California

(Marin Modified Field Protocol; Fehring et al. 2001; see SOP 3: Status Designations) increased the search effort and number of visits in order to decrease the number of visits during which mice were offered to owls. Increased search effort was used to determine reproductive variables, including non-nesting status and number of young. Decreased mousing reduced the potential for NSO habituation to people.

The long-term monitoring included a demographic study using mark-recapture techniques to assess population trends. Between 1998 and 2003, the NPS individually marked NSOs at 26 of the 46 long-term monitoring territories using unique color bands and numbered U.S. Geological Survey (USGS) bands (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004). A total of 110 NSOs (37 adults, 23 subadults, 50 juveniles) were banded at the 26 sites. The Marin County study, however, suffered from a small sample size of capture-recapture data. The sample size was small due to banding owls at only 26 activity sites and a small time period of less than five years of recapture data for most banded owls. Despite the limitations of the study results, Marin County capture-recapture data from 1998 to 2003 were included in a range-wide demographic analysis workshop in January 2004 (Anthony et al. 2006). Due to the relatively small sample size compared to the other 13 sites examined in the demography study, the authors were not able to calculate the finite rate of population change (λ) for the Marin County data (Anthony et al. 2006). The analysis estimated apparent survival rates for the Marin County study, which were stable relative to other study sites (Figure 2) and the sex-specific fecundity (Figure 3).

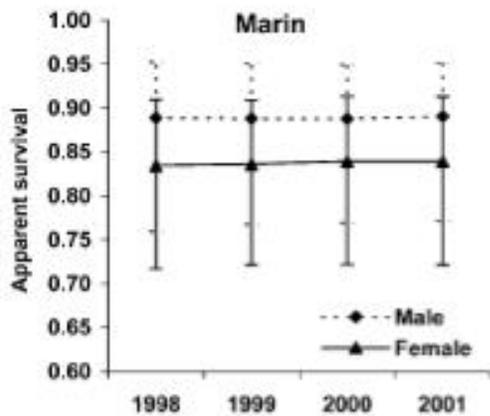


Figure 2. Model averaged apparent survival rates with 95% confidence intervals for male and female NSOs in Marin County (adapted from Anthony et al. 2006).

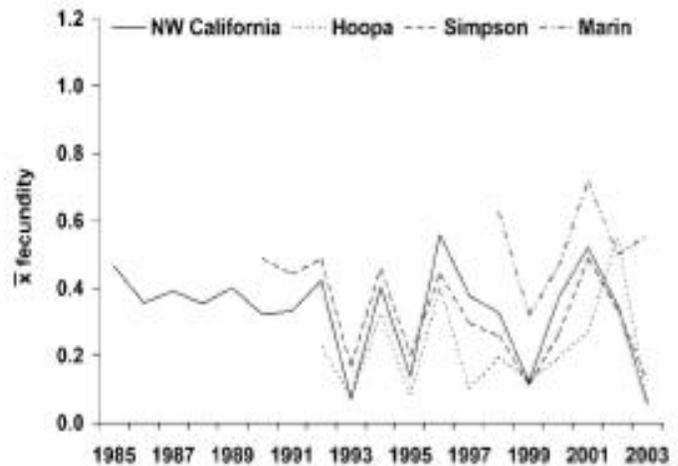


Figure 3. Annual fluctuations of mean fecundity (no. female young fledged per female) of NSOs in four study areas in California (adapted from Anthony et al. 2006).

The use of the Marin Modified Field Protocol may have affected estimates of fecundity values during the study, but since the annual fluctuations in fecundity appear to be similar to the other California study areas, we dismiss that as a measurable effect. In all NSO studies, a potential bias

in fecundity values is possible due to lower detectability of non-reproducing individuals (Franklin et al. 1996). The reduced use of mice to determine non-nesting in the Marin Modified Field Protocol may have decreased the probability of detecting non-reproducing owls because owls are less habituated to respond to observers. Multiple site visits, though, likely increased the probability of detection. Detection rates of Marin NSOs based on multiple visits were determined to be very high (Connor and LeBuhn 2007c).

Additionally, the Marin County site-based study, with almost 90% annual occupancy of monitored sites does not allow for much growth in occupancy rate to be measured. The general recommendation for the Marin County study from the 2004 range-wide workshop participants was to add more banding sites, add more demographic monitoring sites in suitable habitat, increase juvenile banding efforts and continue monitoring all the sites. Unfortunately, the demographic study ended in 2004 because of limited funding.

In 2004, the program was changed to reduce the level of reproductive monitoring to a random subset of 30 of the 46 long-term monitoring territories (Jensen et al. 2004). The remaining 16 territories were monitored for occupancy only. The number of 30 territories was suggested as a minimum number of sites in order to estimate population fecundity (PRBO, Nadav Nur, Theoretical Ecologist, pers. com. 2004).

Other protocol changes were initiated in 2006 as a result of peer review comments to an earlier version of this protocol. The reviewers emphasized that the selection process for the 46 long-term monitoring territories was not done randomly, which limited the ability to make inferences to the entire population on federal lands. In addition, the high occupancy rate and lack of unoccupied sites within suitable habitat in the sample population limited the ability to detect growth in occupancy.

To address peer review comments and begin modifications to the monitoring design, a formal study area was established and the entire area was inventoried for NSO occupancy in 2006 (Jensen et al. 2007). More details on the study area are provided in Section 2.1. Following the 2006 inventory, all sites were listed under a potential sampling frame for future occupancy monitoring. Only sites with a history of pair status for at least one breeding season between 1997 and 2006 were incorporated into a fecundity sampling frame. From 2007 to 2010, sites were randomly selected for full reproductive monitoring from the fecundity sampling frame (Jensen et al. 2008; Jensen et al. 2010). In 2007 and 2008, 25 random sites were monitored, while in 2009 and 2010 the sample size was increased to 30 random sites annually. The first non-nesting year for NSO was documented in 2007. Monitoring years 2007-2010 were interim years while the program sought statistical support for the occupancy and fecundity data, developed power analyses for the data, developed a final long-term sample design, and worked towards final protocol approval. The final sample design resulting from these efforts is presented in Section 2.0.

1.3 History of Spotted Owl Research in Marin County

The inventories and long-term monitoring conducted in Marin County have provided fertile grounds for opportunistic and complementary research.

1.3.1 Habitat Associations

Although typically associated with old growth or mature forests, NSOs can utilize a wide variety of habitat types. They exhibit flexibility in their use of different forested areas for nesting, roosting and feeding requirements, but typical habitat characteristics include a multi-storied structure and high canopy cover. In Marin County, NSOs reside in second growth Douglas-fir, second growth coast redwood, bishop pine, mixed conifer-hardwood, mixed evergreen hardwood forests, as well as remnant old-growth stands of coast redwood and Douglas-fir.

Chow (2001) studied NSO and habitat associations in Marin County between 1996 and 1998 in coordination with NPS inventory efforts (Section 1.2.1). Using a crude density estimate (number of owls per area surveyed), she detected 82 territorial owls at the highest density yet reported for the species (0.376 owls/ km²; Chow 2001; Blakesley et al. 2004). As with other areas within coastal California, NSOs were associated with habitats that had larger trees, greater number of potential nest trees, steeper slopes, and larger proportions of downed woody material. Chow speculated that the high density at the southern edge of the NSO range “reflected a relatively uniform distribution of suitable habitat” and that suitable habitat included mild climatic conditions (2001).

Between 1999 and 2002, PRBO and NPS conducted a more in-depth analysis of NSO occurrence and habitat distribution in Marin County (Stralberg et al. 2009). The study objectives were to apply and evaluate a habitat-based species distribution model, using a scaled approach that would be most useful to land managers.

Model development included a suite of point (i.e., nest location) and landscape features sourced from data collected on site and from locally available GIS layers. Point features included aspect and distances to the nearest stream and road. Landscape features were calculated for circular areas around activity centers at 200 m, 400 m, and 800 m intervals and included slope, elevation, forest cover proportion, proportion of various vegetation cover types (conifer versus hardwood, and specific dominant tree species), forest stand age, and total forest edge.

The analysis benefited from the NPS vegetation map for PORE, GOGA, and MUWO completed in 2003 (Schirokauer et al. 2003). The vegetation map represents an intensive effort involving initial pilot sampling of vegetation communities, manual GIS digitizing of vegetation polygons based on a set of 1994 aerial color photographs, and field verification at over 1,600 vegetation plots. Vegetation types were classified at a fine scale to the alliance/association level resulting in 87 identified plant communities. Classification accuracy of dominant forest and woodland cover types was uniformly robust at 80% or greater (Schirokauer et al. 2003).

Besides the importance of forest cover, the Stralberg et al. (2009) models indicated that forest connectivity and topographic conditions, such as slope position and stream proximity, were the strongest predictors of nesting owl presence. Topographic preferences may reflect a variety of factors, including favorable ambient temperatures, higher prey density, greater nest structure availability, and increased cover and protection from predators. In contrast to other studies within the NSO range, forest type (i.e., conifer-dominated versus hardwood-dominated), specific tree species composition, and mean stand size were not major influences on owl site suitability within the study area. Model results indicate that Marin County NSOs are generalists in this part

of their range and may benefit from a high interspersed of forest types within the study area, representing ideal conditions for high prey densities. The authors suggested that protecting intact forested watersheds is a higher priority for protecting the NSO population than managing for particular forest types or age classes in the region (Stralberg et al. 2009). A GIS-layer representing a model of the most likely NSO habitat in Marin County was produced in the study.

1.3.2 Nest Structures

Between 1999 and 2008, 101 unique nests were located within the NPS study area; 91% of the nests were platform nests and 9% of nests were in cavities (Jensen et al. 2010). The ratio of nest types in Marin County is similar to the ratio observed in other younger aged forests such as the Wenatchee National Forest on the east slope of the Cascade Mountains in Washington (Buchanan and Irwin 1993). In the Wenatchee study, 16.5% of nests were cavities, while in older forests in northwestern California and the Olympic Peninsula in Washington, 80% and 90% of nests were in cavities, respectively (Forsman and Griese 1997; LaHaye and Gutiérrez 1999). LaHaye and Gutiérrez (1999) hypothesized that nest type depends on the age of the forest and this is supported in Marin County where logging created a younger-aged forest habitat.

1.3.3 NSO Prey

In the northern portion of their range, NSOs feed on northern flying squirrels (*Glaucomys sabrinus*), but in the southern portion their diet is principally dusky-footed woodrats (*Neotoma fuscipes*). Additional prey items include mice (*Peromyscus* spp.), red tree voles (*Phenacomys longicaudus*), red-backed voles (*Clethrionomys* spp.), brush rabbits (*Sylvilagus bachmani*), pocket gophers (*Thomomys* spp.), and a variety of birds, amphibians and insects (Thomas et al. 1990). Pellet analyses indicate that spotted owls in Marin County forage primarily on dusky-footed woodrats, deer mice (*Peromyscus maniculatus*), and meadow voles (*Microtus californicus*) as well as other small mammals and forest-dwelling birds (Chow and Allen 1997, 2005; Fehring 2003; Fehring et al. 2003).

In the fall and winter of 2002, PORE and PRBO conducted a follow up study to confirm the relative importance of dusky-footed woodrats as a NSO prey species and to assess woodrat house densities in forested habitats. The results of the study showed an overall average of 0.95 woodrat houses per hectare across all plant communities, with California bay (*Umbellularia californica*) habitat having the highest density (1.19 houses/ha; Fehring 2003). Assuming a winter occupancy rate of 1:1 ratio of woodrats to houses, the house index would suggest that there were an average of 0.95 woodrats/ha in the Marin County study. The estimate is conservative since using woodrat houses may provide an underestimate of actual density, because not all houses are likely detected and woodrats will sometimes not use houses. The Marin County woodrat density values were similar to 0.9 woodrats/ha estimated from a density study based on direct woodrat trapping in late seral, mixed evergreen forests in northwestern California (Ward et al. 1998). The Marin County woodrat density estimates were higher than the 0.41 woodrats/ha density found in a woodrat trapping study in large, old growth habitat in northwestern California (Sakai and Noon 1993).

1.4 Conservation Threats

The NSO was originally listed as a threatened species because of loss of habitat, reduction in quality of habitat, and inadequate regulatory mechanisms (USFWS 1990). The 2004 status

review identified the effects of past and current timber harvest, loss of habitat to fire, and barred owls as current major threats, though the effects of barred owls on NSO remained uncertain (Courtney et al. 2004). In addition, Courtney and Gutiérrez (2004) identified West Nile Virus and Sudden Oak Death (SOD) as new potential threats. The 2008 NSO Recovery Plan acknowledged that protecting and managing NSO habitat alone is not adequate for NSO recovery and the USFWS prioritized barred owls as a significant and complex threat (USFWS 2008). Barred owls overlap in territory and diet with NSOs throughout much of their range, and barred owls are suspected of displacing the smaller NSO (Hamer et al. 1994, 2001; Leskiw and Gutiérrez 1998; Kelly et al. 2003).

In Marin County, the NSO population is subject to some of these same threats. The greatest concerns for the NSO population on federal lands in Marin County, include: (1) loss of habitat resulting from urban development along open space boundaries, (2) catastrophic wildfires, (3) interspecific competition due to the continued range expansion of the barred owl, (4) structural changes in forest heterogeneity due to SOD, (5) possible genetic isolation, (6) human disturbance due to intense recreational pressures, (7) use of rodenticides along the urban/wildland interface, and (8) West Nile virus.

1.4.1 Barred Owls

In May 2002, the first recorded barred owl observation for Marin County occurred within a monitored NSO territory at MUWO. The first barred owl pair was detected in 2005, and the first successful breeding by barred owls was documented in 2007, also in MUWO (Jensen et al. 2008). No spotted owl/barred owl hybrids have been documented to date. As of 2009, there are currently at least three known barred owls (one pair and a single male) within the NPS NSO study area in Marin County (Jensen et al. 2010). Four spotted owl sites selected for monitoring within the resident male barred owl's Olema Valley territory were determined to be unoccupied during the 2008 breeding season.

1.4.2 Sudden Oak Death

Of particular recent concern are the effects on NSO habitat of continuing die-off of tanoaks, coast live oaks and several other tree and shrub species due to a pathogen, *Phytophthora ramorum*, commonly known as Sudden Oak Death (SOD). This disease is widespread in coastal California and is commonly found in tanoaks, and in evergreen hardwood forests dominated by oaks, California bay, and madrone (*Arbutus menziesii*). Currently, Marin County is heavily infested by SOD. A recent study of PORE vegetation by researchers from University of California at Berkeley (Moritz et al. 2008) sampled SOD at 48 locations within three major vegetation types: redwood-tanoak, Douglas-fir, and California bay-coast live oak. Additionally, foliar samples were taken at 74 locations. Of these foliar sampling locations, 29 (39%) tested positive for *P. ramorum* and the pathogen was found in all three major vegetation types sampled. From the proportions of the randomly located plots that tested positive for infection, the researchers inferred that as much as 63% of redwood-tanoak forests, 45% of California bay-coast live oak forests, and 24% of Douglas-fir forests at PORE may be infected with *P. ramorum*. In several plots, tanoak mortality was greater than 95%. Finally, Moritz et al. (2008) stated that because tree species richness is low within their sampled locations, tanoak represents a substantial proportion of tree species richness and total woody species richness in both redwood

and Douglas-fir forests. Consequently, if tanoak is eliminated by SOD, as scientists predict, the tree species richness of redwood forests could be locally reduced by as much as one-third.

The die-off of native coast live and tanoak species is occurring throughout NSO habitat in Marin County, and this may have long-term impacts on habitat and prey populations. The major NSO prey species, the dusky-footed woodrat (Chow and Allen 1997, 2005; Fehring 2003), is dependent upon cover and food (acorns) provided by tanoaks (Sakai and Noon 1993). There are no published studies on the effects SOD on NSO prey base and this is a pressing research need for land management agencies in Marin County.

Oak mortality induced by SOD also causes changes in fuel loading, stand structure, and microclimate. As these changes occur, the potential for uncharacteristically extreme fire behavior and associated ecological impacts likely will increase. Anecdotal reports from fire fighters working in redwood forests infested with SOD during the 2008 Basin Fire in Big Sur, California indicated increases in fire intensity of approximately 25% (Lee et al. 2009).

1.4.3 Genetic Isolation

Feather samples collected in 1999 and 2000 from Marin County's NSO population were part of a study conducted at the Conservation Genetics Laboratory at San Jose State University. The Conservation Genetics Lab compared the Marin County NSO population with other populations of northern and California spotted owls (*Strix occidentalis occidentalis*). Their results indicated that the Marin County NSO population has very little gene flow with NSO populations farther to the north and shows no evidence of hybridization with California spotted owls (Henke et al. 2003; Barrowclough et al. 2005). Henke et al. (2003) did not find evidence of inbreeding effects in the Marin County NSO population, but Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's NSO population, the population warrants special management attention.

1.4.4 Predation

Predation is not believed to be an important threat within Marin County, but common ravens (*Corvus corvax*) and other corvids are suspected predators of NSO eggs. Range-wide NSO predators also occur in Marin County and include northern goshawk (*Accipiter gentilis*), Cooper's hawk (*Accipiter cooperii*), red-tailed hawk (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*) (Forsman et al. 1984; LaHaye 2004).

1.5 Measurable Monitoring Objectives

There are three current monitoring objectives for the SFAN NSO Monitoring Program. The methods are outlined in the sampling design and field methods sections below.

1. Monitor long-term trends in NSO site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.
2. Monitor long-term trends in NSO fecundity (number of female young per territorial female) within NSO territories within the legislated NPS boundaries of Marin County, California.

3. Determine long-term trends in NSO nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

Monitoring NSO population occupancy rates and fecundity will allow managers to accurately assess the status and trend of this isolated, potentially vulnerable NSO population, where it occupies a land use matrix strikingly different from that found throughout most of the NSO range. An analysis of historic fecundity data in the Marin County NSO monitoring program indicates that fecundity is a valuable parameter to measure for population size declines (Connor and LeBuhn 2007a, 2007b). Percent of occupied territories has been shown to be a good indicator of long-term declines in population size in a territory-based monitoring program for other raptors (Bart and Robson 1995; Katzner et al. 2007). Additional information collected at all activity sites will include sex and age of all NSOs. Concurrent monitoring of nest site characteristics may provide data on reasons for changes seen in reproductive success and also allow assessment of possible changes in nest site selection and/or differences in habitat quality.

Demographic monitoring to estimate rates of survival and population growth is occurring on late-seral stage forest reserves throughout the NSO range as part of the Northwest Forest Plan monitoring. While conducting demographic monitoring in Marin County would be ideal to better pinpoint changes in the NSO population, it is not feasible given current funding limitations.

1.6 Management Objectives

NSO monitoring provides critical data for land managers. Occurrence and nesting status information is frequently used by the parks to plan and mitigate for activities that may create potential nest or habitat disturbances. Fuel-load management, roads and trails maintenance, and other construction activities, for example, are generally not planned within 400 m of active nest sites or during the February 1 to July 31 seasonal restrictions window currently used by the USFWS (USFWS 1992).

Federal land in Marin County is included in the USFWS 2008 Recovery Plan as a Managed Owl Conservation Area (MOCA 2) which is defined as a small habitat block that can support between 1 and 19 NSO pairs based on the USFWS habitat modeling. USFWS Recovery Action 2 is to continue monitoring the population trend of NSO to determine if the population is decreasing, stationary, or increasing. While demographic monitoring is currently the primary action to assess the population status in other NSO areas, the monitoring methods in this protocol are designed to address the potential decline in the NSO population within the Marin County MOCA 2. The non-federal lands in Marin County (i.e., MMWD, MCOSED, and state parks) are identified as a Conservation Support Area (CSA). CSAs may function to provide demographic support to core NSO populations in the MOCA network or facilitate dispersal of juvenile NSO among MOCAs (USFWS 2008). In most cases, the CSA designation also recognizes existing land management that is compatible with the NSO recovery goals (USFWS 2008).

Given that NSO are a federally listed species, the Marin County NSO habitat is identified in the NSO Recovery Plan, and NSOs have high public interest, the SFAN parks have strong management interest in continuing NSO population trend monitoring on park lands in Marin County. Also, through monitoring NSO, biologists expect to also detect the presence of barred

owls within the study area. While the number of barred owls is still very low, increased detections are of great interest to park managers because of their potential threat to NSO.

1.7 Triggers for Management Activities

The target management triggers for the NSO are as follows:

- A 4% annual decline or greater in pair occupancy in 5 consecutive years of monitoring.
- A 10% annual decline or greater in fecundity in 5 consecutive years of monitoring.
- A decline in fecundity and/or occupancy of >50% in 2 consecutive years of monitoring.
- Reproductive failure for 3 out of 6 years.
- Barred owls are documented at >10 spotted owl sites in any given year.

Thresholds for NSO occupancy and fecundity reflect the results of power analyses of the long-term monitoring data (see Section 2.2). The threshold levels represent the number of years to detect 4% and 10% compounded annual changes with greater than 80% power. A 4% annual decline over 5 years therefore represents a 15% cumulative decline. A 10% annual decline over 5 years represents a 34% cumulative decline. The power analyses indicate that our current monitoring design has the ability to detect significant population changes in short periods of time, thus allowing for timely, reactive management actions if warranted.

Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol. In some cases, causes of declines in the NSO population, such as displacement by and competition with barred owls, may be easy to identify. If causes of population declines can be determined, managers may be able to act accordingly in a timely manner. In other cases, however, additional, specific research may be required. Depending on the management action(s), a procedural process under the National Environmental Policy Act may be instigated, requiring significant public input. Consultation with USFWS and other regulatory agencies may also be required especially when there are any catastrophic declines in fecundity and/or occupancy, repeated reproductive failure, or increases in barred owls. Although the SFAN will provide data and guidance, management actions will ultimately be decided by PORE, GOGA, and MUWO management staff, including, but not limited to, the park Wildlife Biologists, Science Advisors, Chiefs of Resource Management, and Superintendents.

2.0 Sampling Design

While demographic monitoring in Marin County would be ideal to detect a variety of changes in the NSO population, it is not feasible given current funding limitations. Occupancy monitoring, when combined with detection probabilities, may be the most cost-effective means to detect population trends, long-term effects of barred owls, or other threats to the NSO population on federal lands in Marin County. Measuring fecundity using the same methods as other NSO studies will provide some regional context to relate possible changes in Marin County to range-wide trends.

While annual monitoring is ideal for any long-term monitoring program and provides the most powerful sample design, limited resources require constrained field efforts. Decisions about monitoring efforts must be made within a framework that considers acceptable objectives in addition to funding, personnel, and management needs.

It is recognized that some additional monitoring may be needed annually to help answer management questions. For example, scheduling annual trail maintenance or periodic trail restoration may require repeated site surveys to determine NSO occupancy status before initiating work within NSO habitat. Surveys done for management purposes may be incorporated into the monitoring database and reported.

2.1 Study Area and Site Selection

The study area is approximately 13,890 hectares (34,320 acres; Figure 4) of federal lands in Marin County and includes sites at GOGA, MUWO, and PORE. The study area boundaries were created through a GIS analysis, using the area intersected by the 2003 buffered habitat model layer (Stralberg et al. 2009) and a 400 m buffer on federally legislative boundaries of GOGA, MUWO, and PORE. All NSO territories surveyed during inventory years in 1997, 1998, and 2006, regardless of results, were selected as the potential sample population or population of inference ($n=66$) for occupancy and fecundity monitoring.

A total of eight territories were removed from the potential sample population. The sites were eliminated due to private landownership (i.e., Drake's View Drive area, Inverness Valleys, Paradise Valley), unsafe access (i.e., steep terrain on slopes of Mount Tamalpais), or duplication of other sites (i.e., sites too close to be separate and distinct activity sites but which had been assigned different names).

Upon reviewing the list of sites not selected in the GIS analysis, two territories were added back into the potential sample population. These two territories had not been selected in the GIS analysis because the activity sites were outside of the buffered habitat model, but still within the buffered federal land boundary.

Note that locations of these sites are considered sensitive information and are not provided within the protocol and standard operating procedures. GPS locations of the selected sites, however, are maintained within the project database.

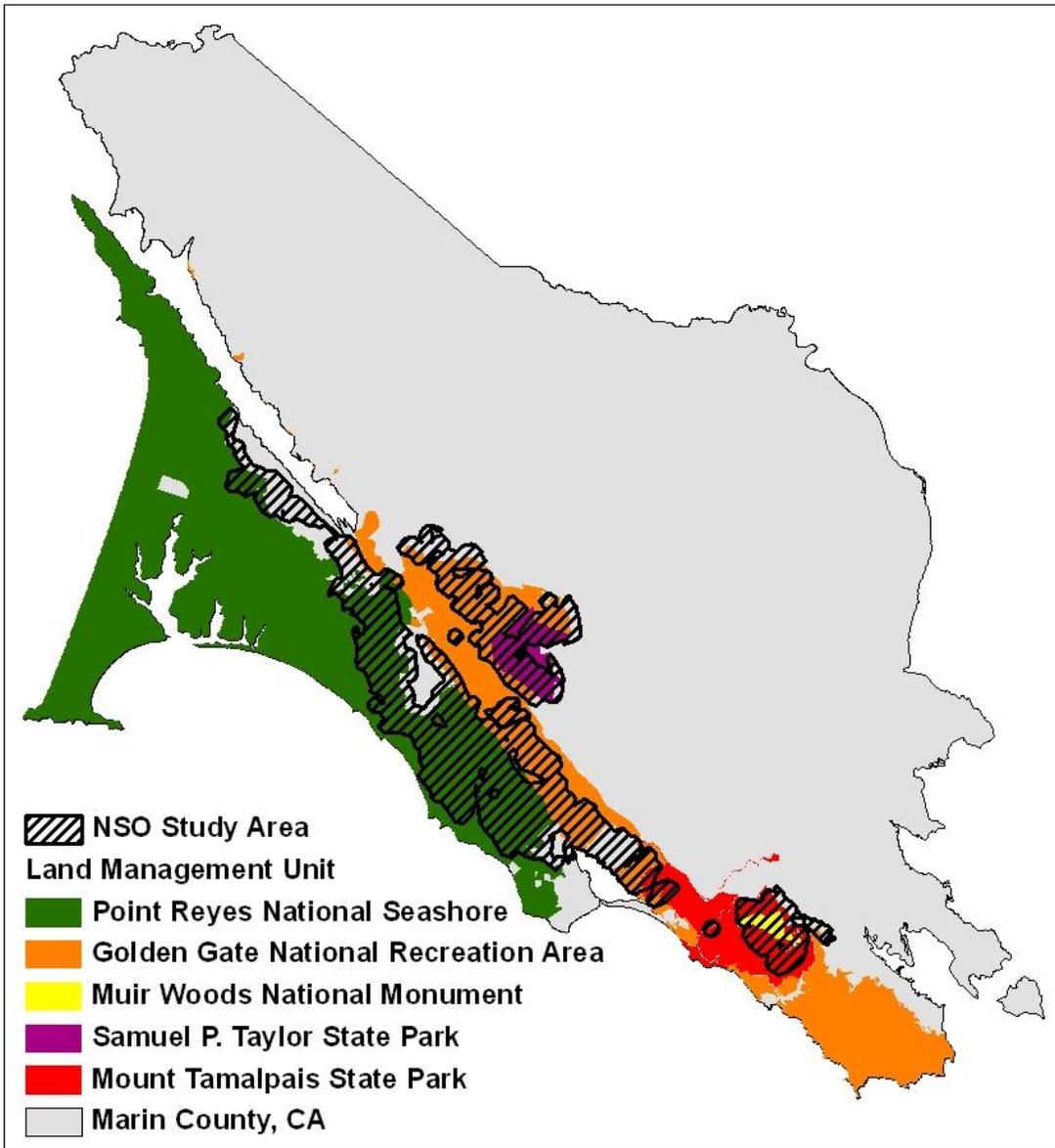


Figure 4. Northern spotted owl study area. Marin County land management units are color coded. The study area itself is shaded in black, diagonal lines.

2.2 Sample Design Power Analysis

Sample design analyses considered a broad range of options in order to evaluate different trend detection levels, sample sizes, cycling options, and staffing plans. The goal of the analyses was to determine the most cost-effective means to detect significant trends within a short-time frame and to provide inference to the entire study area rather than a fixed subset of the study area's NSO population. An initial review of our NSO monitoring data with recommendations for sample sizes needed to detect trends over time was conducted by San Francisco State University in 2007 (Connor and LeBuhn 2007a, 2007b, 2007c). In 2010, a more refined approach to our monitoring data was completed by the University of Idaho (Starcevich and Steinhorst 2010),

which incorporated additional years of data and barred owl presence as a covariate for occupancy and detection modeling. The final report of the power to detect trends in occupancy and fecundity in the study area's NSO populations is included within the protocol as Appendix A.

2.2.1 Occupancy Analysis

All locations within the final study area (see Section 2.1) that had an NSO detected at any time between 1997 and 2008 (60 sites) were included in the potential sample population for monitoring occupancy. These sites, known as the occupancy frame, were used to model the power to detect trends in occupancy over time for a series of sample designs (Appendix A). However, not all territories have been consistently or are currently occupied.

Occupancy was modeled with logistic regression as a function of related covariates, including site and year. The implicit dynamics occupancy model was assumed for the analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

The model for occupancy incorporated zero inflation. For occupancy, extra zeroes may result from imperfect detection. Analysis methods for zero-inflation apply mixture models that combine one distribution for the extra zeroes and another distribution for the remaining zeroes and non-zero outcomes so that measures of occupancy and fecundity can be accurately estimated (MacKenzie et al. 2006). The number of detections for occupancy analysis was modeled as a zero-inflated binomial random variable.

Maximum likelihood was used to estimate the logistic regression coefficients from the models for occupancy and detection rates. Detection probabilities were allowed to vary at each visit for each site and year, as covariates are often environmental or survey conditions that vary from visit to visit (MacKenzie et al. 2006). The models for NSO occupancy rate included covariates for year, and barred owl detections, and the detection rate model included covariates for the time of survey (day versus night), call method (yes versus no), and number of observers.

Model selection was conducted using the Akaike Information Criterion (AIC). Model output was examined to be certain that valid variance estimates are obtained. When valid estimates of the variance could not be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance was used for trend testing.

One of six possible occupancy status categories is assigned for each location monitored each year. These occupancy categories are mutually exclusive, with all locations falling into only one category each year. Ultimately, the most appropriate occupancy model would estimate occupancy trends for all status categories simultaneously so that the sum of occupancy estimates across categories is always one. However, the available literature has not incorporated techniques for estimating occupancy for more than two categories with methods for trend estimation. A univariate approach was taken to model the occupancy categories, however, only the pair occupancy category provided a meaningful ability to detect trends over time.

Fixed and random effects for location were examined in the modeling effort for occupancy and detection rates. Adding a fixed effect for location prohibitively reduced the number of degrees of freedom available for error estimation. Modeling the location effect as a random effect in the detection model produces the heterogeneous detection probability model which is often difficult to implement in a maximum likelihood approach (MacKenzie et al. 2006). In practice, this approach resulted in site-by-year level occupancy estimates very near 1 and with nearly zero variation and corresponding detection probabilities very near zero. Incorporating the random effect into the occupancy model produced similar problems.

The benefit of incorporating a fixed or random effect for location is that repeat visits to the same locations over time can reduce variance and provide more accurate trend estimation. Without a location effect, the data are treated like random samples taken independently each year (a [1-n] revisit design), no matter what revisit design is actually implemented in the field. The [1-n] revisit design has the lowest power for trend detection and therefore provides conservative power results.

Hypothesis testing for trend was conducted with the likelihood ratio test. The occupancy model that included a year term was compared to the occupancy model without a year term. A one-sided test for a decreasing trend was examined.

2.2.2 Fecundity Analysis

For the fecundity analysis, only territories that have had a pair of owls present at some time between 1999 and 2008 (48 sites) were included in the potential sample population for fecundity analysis. These sites, known as the fecundity frame, were used to model the power to detect trends in fecundity over time for a series of sample designs (Appendix A).

Fecundity was monitored with counts of NSO fledglings observed at each nest. As with the occupancy analysis, these outcomes were also modeled with the zero-inflated binomial model. When measuring fecundity, counts of fledglings might be subject to zeroes from nest failures due to non-nesting pairs, predation, or environmental factors.

Maximum likelihood estimation was used to obtain estimates of the regression coefficients in each model. To test for trend in fecundity, the year covariate was included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change probability of a fledgling at a site in a year over time.

2.2.3 Power Analysis

The occupancy and fecundity models with the lowest AIC scores and with a valid variance-covariance matrix were used in the power analysis. In both cases, power was computed via a parametric bootstrap. For each bootstrap sample, the likelihood ratio test of trend was conducted by applying the selected model with and without the term for trend. Power was then calculated as the proportion of times that the null hypothesis is rejected for the one-sided alternative hypothesis of decreasing trend.

Power must be approximated assuming that tests of trend are conducted at a specific Type I error rate. The Type I error rate, designated as α , is the probability of rejecting a true null hypothesis. For the one-sided test of trend, a Type I error would mean that the population was found to be declining when it was not. A Type II error occurs by failing to reject a false null hypothesis and thus concluding no change has occurred. For long-term monitoring, the cost of a Type I error may be far less than the cost of a Type II error. Mistakenly rejecting a true null hypothesis (Type I error) may trigger a management conservation action that is not actually needed. However, failing to detect a significant declining trend may have deleterious effects that cannot be reversed by the time the trend is actually detected. A conservative approach is to use a larger α value for higher power and reduced probability of a Type II error. For this power analysis, an α value of 0.20 was used.

2.3 NSO Monitoring Design

The SFAN I&M Program has selected a sample design for NSO occupancy and fecundity monitoring that surveys 36 sites each year. The design includes an annual panel of 28 randomly selected sites with all remaining sites divided equally into four rotating panels of 8 sites each (Table 1). Following the notation of MacDonald (2003), this revisit schedule of [(1-0), (1-3)] indicates that the annual panel is revisited every year and that the four panels are visited for one year then not visited for the following three years before being rotated back into the design. Under this revisit design, all 60 NSO territories with the SFAN study area will be monitored within a four-year time frame, or a single rotation of the sampling design.

Table 1. Selected sample design for NSO monitoring. The [(1-0), (1-3)] revisit design includes an annual panel of 28 sites with four rotating panels of 8 sites each. An example schedule for two monitoring cycles over eight years is displayed (Starcevich and Steinhorst 2010).

Panel	Revisit design	1	2	3	4	5	6	7	8
1	[1-0]	28	28	28	28	28	28	28	28
2	[1-3]	8				8			
3	[1-3]		8				8		
4	[1-3]			8				8	
5	[1-3]				8				8
ANNUAL TOTAL		36	36	36	36	36	36	36	36

Site occupancy will be established at all 36 territories monitored each year. Fecundity determination will occur at every site occupied by a territorial female, no matter if the site is within the annual panel or one of the rotating panels. Similarly, nest tree characteristics will be recorded for every nest detected during monitoring. Geographic coordinates of occupied sites, which default to nest locations for nesting pairs, in addition to nest tree and site measurements will provide a foundation for understanding NSO habitat relations over time.

No physical site stratification will be used in establishing the monitoring sites included in the annual panel. The selected territories are expected to represent a variety of forest types, slopes, watersheds, and soil types. Random selection of sites will be made by using a random number generator to assign a random number to each site, ordering the list, and selecting the first 28 sites for monitoring.

Starcevich and Steinhorst (2010) recommend that 20 to 25 locations with resident females must be surveyed annually to detect decreasing trends in fecundity of at least 10% within 5 years (Appendix A). Monitoring data indicates that from 1999-2009, approximately 70% of the NSO territories monitored resulted with a territorial female and a subsequent fecundity value for the monitoring season. The selected revisit design therefore oversamples for fecundity monitoring with the prediction that only 70% of sites will be available for fecundity analysis each year. With 36 sites monitored annually, a 30% reduction in available sites for fecundity monitoring results in approximately 25 available sites, which is still a large enough annual sample size to detect the targeted trend of a 10% annual decline over 5 years with at least 80% power.

To further ensure that the annual sample size is large enough to detect trends in fecundity over time, the annual panel of 28 sites will be comprised solely of locations included in the fecundity sampling frames, which are those sites occupied by a NSO pair during at least one breeding season from 1999-2008. We will randomly select the 28 annual panel sites from the list of sites within the fecundity sampling frame. The remaining sites within the study area will be randomly allotted to the four rotating panels. If needed, the sites included in the occupancy frame but not the fecundity frame could be balanced among years in the rotating panels, thus balancing the sites where NSO have been detected but where pair occupancy has not been established.

The power analysis conducted by Starcevich and Steinhorst (2010; Appendix A) indicates that the selected sample design has a power of 0.992 (99%) to detect a 4% annual decline in occupancy in 5 years with $\alpha = 0.10$, and 1.000 (100%) with $\alpha = 0.20$ (Table 2). Over 5 years, a 4% annual decline results in a total of a 15% loss.

Additionally, the results of the power analysis suggest that an annual sample of greater than 20 fecundity sites, as will be achieved with the selected sample design, will result in greater than 80% power to detect a 10% annual decline in fecundity in 5 years with $\alpha = 0.20$ (Figure 5). Over 5 years, a 10% annual decline results in a total of a 34% loss.

Table 2. Power of the likelihood ratio test to detect trends in spotted owl pair occupancy within five consecutive survey years for four revisit designs (Starcevich and Steinhorst 2010).

Revisit design	Power to detect a 4% annual decrease in occupancy		Power to detect a 10% annual decrease in occupancy	
	$\alpha = 0.10$	$\alpha = 0.20$	$\alpha = 0.10$	$\alpha = 0.20$
$[(1-0)^{15}, (1-3)^{1/2}]$	0.980	1.000	1.000	1.000
$[(1-0)^{26}, (1-3)^{1/2}]$	0.992	1.000	1.000	1.000
$[(1-0)^{28}, (1-3)]$	0.992	1.000	1.000	1.000
$[(1-0)^{40}, (1-3)]$	0.996	1.000	1.000	1.000

2.3.1 Sampling Frequency and Timing

Generally, survey visits must occur within the breeding season time period of March 1 to September 1 when NSOs demonstrate the highest degree of territoriality and vocal response to artificial calls (USFWS 1992; Forsman 1995). Technically, a survey area can be considered “occupied” if at any time throughout the year a NSO is detected, but assigning a level of occupancy, nesting, or reproductive status must occur within the breeding season. Standard operating procedure SOP 2: Field Survey Procedures describes more detailed timing guidelines

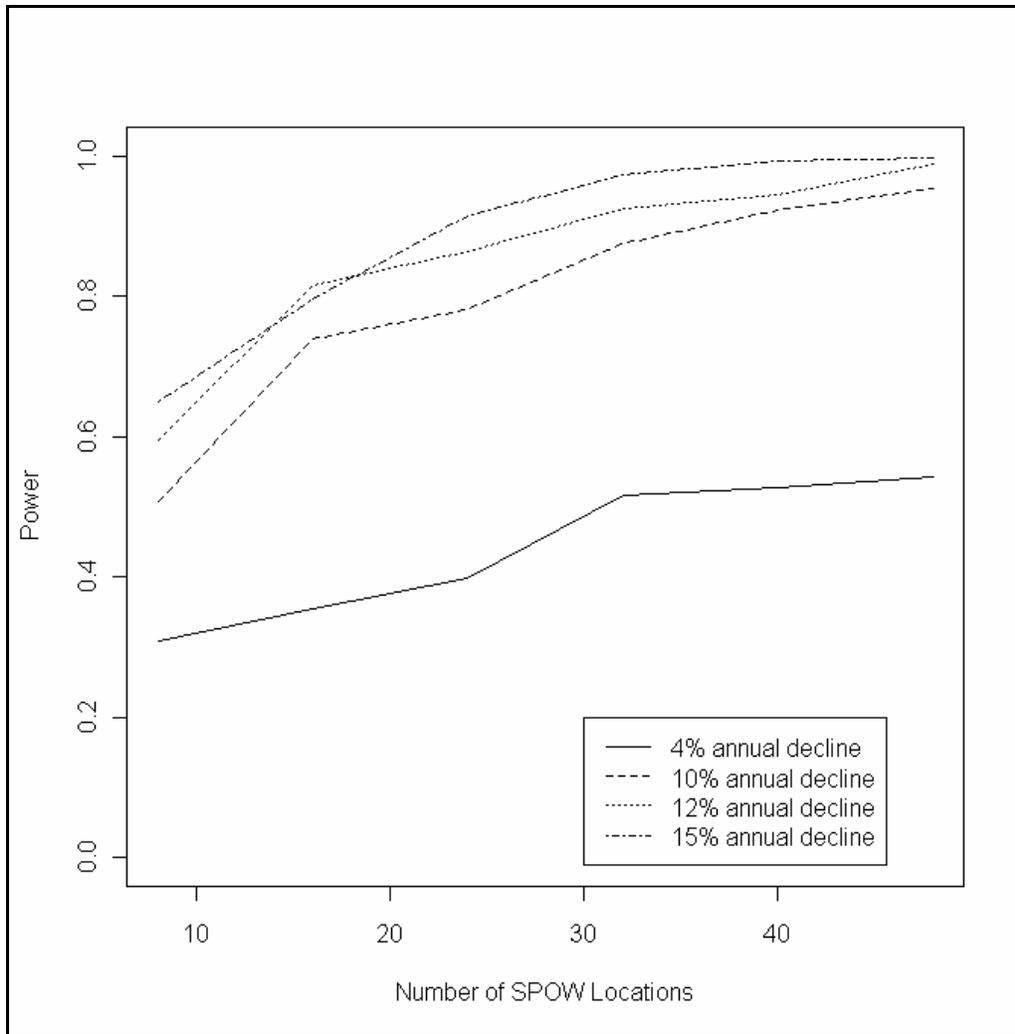


Figure 5. Power of the likelihood ratio test to detect trend in the binomial probability of spotted owl fecundity in 5 consecutive survey years for four rates of change (Starcevich and Steinhorst 2010).

and number of surveys required for ascertaining certain types of information (e.g., nesting status, fledgling counts) within the breeding season period.

In 2007, San Francisco State University conducted an analysis of day versus night detection of NSO singles and pairs using NPS data from 1999-2005 (Connor and LeBuhn 2007c). Using the lowest annual probabilities of single owl detection for day and night (night=0.67 and day=0.76), Connor and LeBuhn estimated that sampling NSO sites twice during the day and once at night provided a 98% probability of detection of at least one NSO. The probabilities of detecting a pair of owls were 0.50 for both day and night. Given the relatively high detection probabilities, any combination of 3 day and night visits would provide a greater than 96% probability of detection of at least one NSO and an 88% detection probability of an NSO pair.

2.4 Sample Design Review

The effectiveness of the NSO monitoring design to detect target trends in occupancy and fecundity will be evaluated through long-term trend reports produced by the SFAN, which are scheduled for completion at five-year intervals. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. In addition, the long-term effect of SOD is still unknown, but significant impacts on suitable NSO habitat are possible. A precipitous drop in site occupancy rate may suggest that owls are leaving the study area, moving further outside of their historic activity centers than our field monitoring protocols can capture, or are dying for reasons unknown. Reanalyzing the detection rates using new data, reassessing our current NSO habitat model (Stralberg et al. 2009), completing another full study area inventory, and revising the field methods are possible responses.

In a study of changes in NSO response to NSO playback calls, Crozier et al. (2006) found NSOs responded less frequently to NSO calls after being exposed to barred owl calls. As the barred owl population in Marin County is expected to increase, the annual sampling frequency and field protocols may need to be adjusted to increase the number of surveys per territory and widen the search area requirements. An interagency Barred Owl Work Group and its Survey Protocol Subcommittee, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

2.5 Additional Surveys

Each year, project staff or cooperators survey 15 to 30 additional NSO territories throughout Marin County, primarily to address specific management concerns. Most of these additional sites are outside the study area covered by this protocol and on lands owned by MMWD and MCOSD, who provide funding and support for the surveys conducted by PRBO staff. The NPS may include additional monitoring sites each year if sites with management concerns, for example sites that may be affected by road or trail maintenance, are not included in the annual monitoring sample. These sites also serve to expand the probability of resighting banded owls that have relocated out of the NPS study area, as well as detecting any barred owls, West Nile Virus or SOD in the areas. The core monitoring objectives do not include monitoring sites or areas strictly for direct management purposes, such as in preparation for trail or road work in NSO habitat. While these additional NSO surveys are outside of the parameters of this monitoring program, the results from outside of the study area may serve to provide an early warning to NPS managers of threats to the Marin County NSO population that have not yet manifested within NPS boundaries.

3.0 Field Methods

The NSO field season runs from approximately February to the end of August. Surveys are conducted March 1 to July 31. Data are entered into the database throughout the field season. Additional time at the end of the field season is used to analyze data and report results.

3.1 Field Season Preparations

Field technicians are hired and begin by February of each year. Their initial responsibilities will be to gather and check field equipment including binoculars, GPS, calling equipment, etc. All field equipment is listed in SOP 1: Preparations and Equipment Setup Procedures. In addition, a pre-season meeting convenes at the beginning of the field season for all members of field teams to discuss the season priorities, assign territories to field teams, and review protocols. If necessary to train interns or new technicians, a training day is scheduled to further review details of field techniques, protocols and safety procedures. New staff will also be sent out with trained staff until they are familiar with the monitoring protocol and study sites. Each field team is responsible for preparing field maps for each territory/activity center, which will be used in the field and attached to all final search form data sheets. The SFAN Data Manager provides copies of the satellite database to field teams. The satellite database is identical to the master database except that the field data tables are empty. Additional details about field season preparations are provided in SOP 1: Preparations and Equipment Setup Procedures.

3.2 Sequence of Events during Field Season

NSO surveys may be conducted from March 1 to September 1. For the purpose of this monitoring program, however, field crews are instructed to complete field work by July 31 to allow enough time to enter and analyze data and complete an annual report. The purpose of the surveys is to establish the occupancy status, presence of territorial pairs, and reproductive status. All monitoring sites in Marin County should be surveyed at least once by April 15 to determine occupancy. All monitoring sites selected for reproductive monitoring should be visited during the period of April 15 to May 1 to determine nesting status, and may require additional visits. Surveys to determine the number of young produced occur as needed during weekly nest checks between May 1 and July 31. Although it is anticipated that all field work will be complete by July 31, difficult sites may require surveys in August in order to finalize occupancy and reproductive status. The survey protocol and field methods are detailed in SOP 2: Standard Field Procedures and SOP 3: Status Designations,

3.3 Survey Protocols

Standard field survey protocols guide the primary data collection tasks for monitoring, which are: 1) to locate owls at individual activity centers, and to determine their sex, age and whether they are banded, and 2) determine status; that is, use behavioral observations to determine site occupancy and reproductive success for estimating fecundity rates. SOP 2: Standard Field Procedures provides more details on the standard procedures for night and day activity center monitoring surveys and data collection. SOP 3: Status Designations contains the guidelines for determining annual activity center status based on field data collection results.

3.3.1 Activity Center Monitoring

Activity centers are the focal points of NSO nesting and roosting activity. Within an occupied territory, the actual activity center location on the ground may change from year to year, but pairs of owls typically remain within the same sub-watershed or canyon. Activity center monitoring begins March 1 and continues until occupancy and reproductive success information has been obtained following the standard field procedures (SOP 2: Standard Field Procedures), but survey efforts should end by July 31. In some cases additional surveys may be needed through September 1. At sites that have been previously occupied by NSO pairs, surveyors initially attempt to visually locate the owls at their roost sites during the day without calling to minimize disturbance to the owls. Alternatively, owls are located using recorded playback or vocal imitations of their calls to elicit responses. Day or night surveys are used depending on site conditions. When necessary, surveyors utilize call routes along roads and trails with call points located a minimum of 400 m (0.25 miles) apart, or at the mouth or head of each forested drainage. Calling is conducted for at least 10 minutes at each call point. Off-trail calling is done at intervals along continuous transects.

For most monitoring site visits, it is preferable for efficiency and safety to have more than one person in the field. More eyes and ears allow for more thorough and efficient field visits. The responsibility for taking field notes is assigned to one member of the field team. If members of a team split up during a survey, both members are expected to take notes on their activity and combine the information at the end of the survey. Notes are taken either in field notebooks or directly on the Site Search Field Form (see SOP 2: Standard Field Procedures). The primary note taker is also responsible for entering the data from that site visit into the database and creating a map documenting the site visit. Maps are not required for subsequent nest checks following the first site search resulting in a nest discovery, unless there is a change in the occupancy or reproductive status (e.g., nest failure).

Variables measured annually for monitoring occupancy include number of owls, sex, age and presence/absence of a color band/tab combination. Between 1998 and 2003, 110 owls were captured and color-banded on NPS lands and surveyors continue to visually check and note presence or absence of USGS and color bands for all owls detected.

At the NSO territories selected for fecundity monitoring, the owls are monitored to determine nest success or failure, the number of young produced, and nest tree and habitat variables. All owl activity centers (either nest tree or roost tree location) are recorded in GPS (Global Positioning System) coordinates using a Garmin 3+ or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are later obtained by using ArcGIS 9.3.1 or higher (ESRI 2009).

3.3.2 Measuring Nesting Habitat

All nest trees, except those on private lands, are marked (site number and year) using aluminum tree tags (Forestry Suppliers, Inc.). The tags assist observers in determining old nest trees and tree reuse during monitoring. Nest site measurements include nest tree species, diameter at breast height (dbh), nest tree height, nest type, nest height, and aspect, slope, and relative slope position (low, middle, ridgetop). Dominant overstory and understory species are also recorded. In the

office using GIS, three additional habitat variables are calculated: distance to forest opening, distance to water, and distance to forest edge. Details on the procedures and data collection using the Nest Habitat Data Form are found in SOP 2: Standard Field Procedures.

3.4 Cooperation with Other Research Activities

NSO monitoring provides information to other ongoing research during regular field activities. Additional information is also in SOP 2: Standard Field Procedures.

3.4.1 Documenting West Nile Virus

Although West Nile Virus (WNV) has not been detected in a non-captive NSO as of May 2008 (USFWS 2008), the virus has been found in captive NSO and in wild barred owls. The likelihood of finding a dead or sick NSO with WNV is low given the brushy locations that are surveyed, but it is possible. Current procedures for handling a sick or dead NSO suspected of having WNV are similar to procedures for other birds except the initial contact would be made to the USGS National Wildlife Health Center (West Nile Virus Coordinator, Madison, WI (608) 270-2456). Additional directions on dealing with bird species found during field work that are suspected to have died from WNV are in SOP 2: Standard Field Procedures.

3.4.2 Documenting Sudden Oak Death

Sudden Oak Death (SOD) has been confirmed in all areas of the study area. *P. ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients (Moritz et al. 2008). Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death. Many other diseases cause similar symptoms; therefore, the presence of *P. ramorum* can only be confirmed by a laboratory test.

During field surveys, researchers should look for tanoaks or coast live oaks showing the symptoms of SOD. Researchers should be familiar with the document "How to recognize symptoms caused by diseases caused by *Phytophthora ramorum* causal agent of Sudden Oak Death" (Garbelotto et al. 2002). If symptoms are noted in previously undocumented areas, researchers should inform both the PORE and GOGA Supervisory Botanists who may conduct further testing to confirm SOD.

A SOD Severity Index will be established at each NSO site monitored each year adapted from rapid assessment methods developed by Moritz et al. (2008). The severity index evaluates affected tanoaks and coast live oaks on a scale of 0 (no SOD present) to 10 (>95% canopy cover). The severity index considers both overstory and understory trees within a circular plot (50 m radius) and includes both dead and symptomatic vegetation. The center point for the SOD severity index rating will be at the established activity centers, such as nest trees, for each NSO site monitored. For sites where a defined activity center is not found or is questionable, field staff may opt not to develop an SOD severity index. For example, this may occur at unoccupied sites or sites with single unknown status. SOP 2: Standard Field Methods provides detailed instructions for developing the SOD severity index at each site.

The SOD severity rating will compliment other anticipated SOD data sources. For example, in 2010, PORE submitted a USDA grant proposal to quantify the potential impacts of SOD on northern spotted owls within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests. Forty-eight SOD sample plots established by Moritz et al. (2008) were re-visited by the authors in 2009 and would be re-visited again under the USDA grant. We expect to benefit from other SOD research efforts in California led by universities and county, state, and federal land management agencies.

3.5 End of Season Procedures

At the end of the season, monitoring equipment is cleaned and stored at both PORE and GOGA. At PORE, storage of monitoring supplies is in the basement of the Resource Management building, Science office, and Lead Biological Technician's office. At GOGA, equipment is stored in Fort Cronkhite Building 1061 (Resource Management Building, Wildlife Ecologist's office) and in Fort Cronkhite Building 1063 (SFAN I&M Building, SFAN Data Manager's office and Dry Lab).

Following data entry and proofing (described in Section 4.0 below, SOP 4: Data Management Handbook), program and park staff analyze the data and produce a brief annual monitoring report with basic data summaries and any natural history items of note using the NPS Natural Resource Technical Report template (see SOP 5: Data Analysis and Reporting). The report provides pertinent updates to the park program managers and I&M Program Manager for inclusion in other reporting requirements (e.g., Annual Administrative Report and Workplan or for website updates). The report is posted to the SFAN I&M website.

The number of volunteers and the total volunteer hours spent on the owl program is summed by program staff and provided to the I&M Program Manager and to volunteer coordinators at GOGA and PORE for use in annual volunteers in parks reporting.

All digital photographs taken during the field season should be labeled with site name and date and collected by the Data Manager or Lead Biological Technician and put on a cd-rom to include with the final report and copy of master and satellite databases. Publication quality photographs should be submitted to the I&M Program Manager for use with the annual reporting along with a caption or explanation of the photograph.

Following all error-checking and proofing, all site survey forms are printed, attached to the corresponding field map for each site visit, and placed in a binder for that year. Included in the binder are a hardcopy of the annual report, any larger maps that were printed, and a CD containing a copy of the complete satellite and NSOMASTERXP databases and an electronic copy of the annual report. Any paper datasheets completed in the field are cataloged in a separate binder. The binders are submitted to the PORE Curatorial Manager two years after the field season to allow for ease of access to field maps by subsequent field staff (e.g., the 2007 data are archived in 2009).

The California Department of Fish and Game maintains the central repository for California NSO location information in the Biogeographic Information and Observation System (BIOS)

data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. The submission consists of a GIS shapefile with metadata of northern spotted owls activity centers monitored each year. The shapefile is an important annual product of the monitoring program, and a copy with associated metadata is saved to the PORE GIS server. Additional end of season procedures are detailed SOP 2: Field Methods, SOP 4: Data Management Handbook and SOP 5: Data Analysis and Reporting.

4.0 Data Handling, Analysis, and Reporting

4.1 Overview of Database Design

The Marin County Spotted Owl Database, created in 2000, is currently in MS Access XP format (NSOMasterXP.mdb). The SFAN Data Manager currently manages the database. The database remains in its original format with periodic updates or minor changes, which are documented in a separate revision log.

A full description of the major database tables, database design, and a data management handbook is in SOP 4: Data Management Handbook. The SOP describes the design, tables, forms, and queries critical to the database operation. SOP 4 contains additional guidelines for data entry procedures, error-checking procedures, database versioning, and data archiving. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the SFAN monitoring program are detailed in the program's Data Management Plan (Press 2005). MS Access XP is the primary software environment for managing the NSO monitoring data. ESRI ArcGIS serves as a tool for validation of spatial data residing in MS Access and for plotting site locations on park maps.

The program database consists of a single master database that contains the tables, forms, queries, and reports. Satellite databases are created at the beginning of each season and contain the structure of the master database, but with the field data tables left unpopulated. Data related to the area surveyed, which can be an existing territory or potential habitat, are entered into the SEARCH table. Multiple survey events can be associated with one territory location. If owls are observed during the survey, details are recorded in the DETECTIONS table. Detections information collected includes UTM coordinates (via GPS if possible) for each owl species. Data are also recorded if no owls are observed so that negative survey results are tracked. If mice are used during the survey, details on how long each mouse is offered and disposition of mouse is recorded in the MICE table, which is linked to the SEARCH table. If the survey is for inventory purposes or in a new territory, call points are used during the survey. Information on the call points and their UTM coordinates are recorded in the CALLPOINTS and CALLPTSLOCAs tables. If a nest is observed at a territory, details on the nest location and nest habitat are collected near the end of the season and entered in the NESTTREES table. Additional tables include OWLBANDS which stores data on all the banded owls within the survey area (approximately 110); and the STATUS table which is a summary table created at the end of the season after reviewing all the detection information gathered at a territory.

4.2 Data Entry, Verification, and Editing

An electronic Site Search data form is required for all field visits and the electronic entry of the Nest Site Habitat data field form is required for each nest with a known location. The blank Site Search data forms can be printed directly from the project database and filled out in the field, but if a field notebook is used, the electronic data form should be entered in the database within a week of the visit.

Two people participate in the data verification with one person reading the original out loud to another person looking at the computer monitor to verify that the two records match. If only one person is available, he or she should have any field notes or data forms in front of him or her.

They should then correct any mistakes and check the "error-checked" box on the form. Per the SFAN Data Management Plan, several quality assurance/quality control (QA/QC) procedures must be followed by the database user: 1) Have a familiarity with the database software, database structure, and any standard codes for data entry that have been developed; 2) enter or download data in a timely manner; and, 3) enter the data, one logical "set" at a time (Press 2005).

Field data should be entered into the satellite databases, verified and submitted to the Lead Biological Technician by August 15 of each year. The Lead Biological Technician will review the individual databases for missing data and other obvious inconsistencies before compiling them into an annual database. The annual database will undergo the standardized database error-checking procedures as outlined in SOP 4: Data Management Handbook. Field maps shall also be completed by August 15 and submitted to the Lead Biological Technician (SOP 2: Standard Field Procedures).

4.3 Metadata Procedures

Formal metadata has been completed for the program database and is provided on the NPS Data Store website (<http://science.nature.nps.gov/nrdata/index.cfm>). Each table and field in the project database was defined and documented using the NPS Metadata Tools and Editor (MTE) and Dataset Catalog. The database, and any GIS data resulting from the monitoring program, is considered sensitive information and is not available publicly, but distributed through data requests to the Data Manager. Further details on metadata development and distribution are provided in SOP 4: Data Management Handbook.

The complete protocol for this project (Protocol Narrative and SOPs) is an integral component of the project metadata. All narrative and SOP version changes are noted in the Master Version Table (MVT), which is maintained in SOP 7: Revising the Protocol. Any time the narrative or SOP versions are changed, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be interpreted and analyzed properly. The protocol narrative, SOPs, and data should not be distributed independently of this table.

4.4 Annual Data Summaries

At the end of each season, following data entry and proofing, each field team works with the Lead Biological Technician to determine the final season status for each territory using survey results and protocols. At least two people should review the data for each territory to make sure that the survey results provide necessary documentation for occupancy and reproductive determinations based on SOP 3: Status Determinations.

All NSO monitoring data are entered into the database, including submissions from PRBO of other Marin County territories monitored for management purposes. For the annual reports, only NPS occupancy and fecundity data collected within the NSO study area are summarized and presented. The exception is the nesting habitat and nest structures section of the annual report, which includes data gathered on all nests located in the Marin County since 1998.

Site occupancy and reproductive status are reported directly as percentages of different occupancy and reproductive status classes. Annual population fecundity is determined by calculating an average fecundity of territorial females within the monitored sample. Fecundity is the number of female young (# of fledglings/2) per territorial female (Franklin et al. 1996). Standard error of the sample is also reported.

Other metrics included in the annual summary:

- Age composition of pairs
- Survey effort (mean and range of number of visits per site)
- Nest tree measurements (nest type, height, aspect, tree species, dbh)
- Habitat characteristics (dominant overstory, elevation, slope, distance to water, etc.)
- Breeding season weather metrics

Incidental data collected are also reported, including:

- Barred owl statistics (number of detections, number of NSO sites with barred owls detected)
- Medium to large scale changes in NSO habitat (e.g., wildfires)

Further details for the contents of the annual summary including sample tables and figures are provided in SOP 5: Data Analysis and Reporting.

4.5 Annual Reporting Schedule

An annual report is produced for the long-term monitoring sites and is prepared by the Lead Biological Technician in coordination with the project lead(s). The report is reviewed by the project staff from PORE and GOGA. The first draft of the report is produced in the late-summer or fall following the field season once the data has all been error-checked. Peer-review and completion of the report are the responsibilities of the NSO program managers and should be finalized before the start of the next field season.

The annual report summarizes the field and data collection activities from the season and includes the data summaries listed above in the context of data from previous years. The most recent 2008 Annual Report (Jensen et al. 2010) is available online at:

http://science.nature.nps.gov/im/units/sfan/vital_signs/Spotted_Owl/birds.cfm

The 2008 annual report, which went through a formal peer review process, will serve as a template for future annual reports. Report figures are formatted in a MS Excel spreadsheet and can be updated each year and inserted into the report. Additional details on reporting are in SOP 5: Data Analysis and Reporting.

4.6 Long-term Trend Analysis Reporting

Every 5 years, the program will undergo a larger trend analysis and protocol review. The focus of the trend assessments will be on the key parameters in the study design (territory occupancy rate and fecundity).

Occupancy and fecundity estimates will be obtained annually and will provide measures of status. When more than three years of monitoring data are available, linear trends in the logged odds of occupancy may be estimated and tested for significance. The number of detections is modeled as a zero-inflated binomial random variable (MacKenzie et al. 2006). To test for trends in occupancy and fecundity, the year covariate is included as a predictor in the occupancy and fecundity models and then tested for significance with likelihood ratio tests.

The methods for detecting long-term trends in the NSO occupancy and fecundity data were developed by Starcevich and Steinhorst (2010; Appendix A), which used 10 years of NPS NSO monitoring data to estimate the power to detect trends in preparation for this protocol (see Section 2.2 Sample Design Power Analysis). Methodology for trend analysis of occupancy and fecundity rates is provided in SOP 5: Data Analysis and Reporting, with pilot data provided in SOP 5 Appendix B. Instructions are given for the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

Additional factors will be analyzed in the trend reports such as differences in occupancy and fecundity rates between age classes of females and males, different nesting habitat factors, effects of climatic and weather conditions, and presence of barred owls. The analyses will also show the NPS NSO population within the context of Marin County, by including data collected on MMWD and MCOSS lands, and within a regional context, by comparing NSO trends in other parts of California.

Information about NSO habitat associations from this region could have important management and ecological implications and will therefore be explored by the SFAN monitoring program as a component of long-term trend analyses. SOP 5: Data Analysis and Reporting outlines our approach to analyzing nest site measurements collected in the field and developing NSO habitat models in GIS that incorporate both field measurements and landscape variables.

As described in SOP 5: Data Analysis and Reporting, data collected on barred owl presence and SOD severity at the NSO monitoring sites will be incorporated as important covariates in our long-term occupancy, fecundity, and habitat analyses. The significance of these effects may be assessed with likelihood ratio tests of regression coefficients in the models for occupancy, fecundity, or detection rates.

4.7 Report Formats

All documents produced by the NSO monitoring program will be published in either the Natural Resource Report Series or the Natural Resource Technical Report Series following guidance from the NPS Natural Resource Program Center in Fort Collins, CO. Published reports will adhere to a set of strict formatting standards and are peer-reviewed to ensure that information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. The Natural Resource Publications Management home page hosts a list of all documents published in the NRR and NRTR Series. The home page can be found at: <http://www.nature.nps.gov/publications/NRPM/>

4.8 Other Reporting Requirements

Information is reported through a variety of other means detailed in the SOP 5: Data Analysis and Reporting. These reports include annual updates for the SFAN Annual Administrative Report and Workplan, updated resource briefings, informal updates through the SFAN Natural Resources and Science Monthly Update, park presentations, and online updates to the public internet site.

4.9 Report and Data Dissemination

In order for the NSO monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the NSO monitoring documents and data will be the Internet. The NSO monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website: <http://science.nature.nps.gov/im/units/sfan/>

The annual reports generally do not contain sensitive owl information and, therefore, can be distributed to the public. Any maps created are done in large scale and without specific landscape details and no owl locations are mentioned by name in the report.

Although the NSO monitoring database will not be posted for public download, metadata records for the master database will be maintained at the NPS Data Store. The metadata records will direct interested parties to the SFAN Data Manager for further inquiries.

In addition to the NPS Data Store of the NPS I&M Program maintains an on-line natural resource bibliographic database known as NatureBib. NatureBib records will be created for all of the NSO monitoring documents, including the protocol, annual reports, and any resulting publications.

The California Department of Fish and Game maintains BIOS data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program (see SOP 5: Data Analysis and Reporting). BIOS is the preferred central contact for dissemination of NSO data to appropriate parties.

4.10 Data and Report Archival Procedures

Annually following data proofing and error checking, the project database located on the PORE network (inppore04\Resources\Natural_Databases\Spotted Owl\NSOMasterXP.mdb) is archived onto a CD-ROM with a copy of the annual report and project protocols. All database related files reside on a secure server at PORE with regular backup routines and off-site storage rotation. All GIS related files reside at PORE (inppore07\GIS\vector\Wildlife\Spotted Owl). A mirror copy of the PORE spotted owl folder sits on the Network Drive (inpgogamahe1\Divisions\Network I&M\Individual Vital Signs\SpottedOwl) maintained by GOGA.

5.0 Personnel Requirements and Training

5.1 Roles and Responsibilities

The GOGA Wildlife Ecologist, the SFAN Data Manager, and the Lead Biological Technician are the program managers for the long-term monitoring program. Additional assistance for planning and coordination comes from an additional biological technician, the SFAN I&M Program Manager, PORE Science Advisor, PORE Chief of Resource Management, and GOGA Chief of Resource Management. PRBO works under contracts with the MMWD and MCOSD for monitoring and inventorying NSO on their lands and submits data to the NPS NSO database.

In general, the GOGA Wildlife Ecologist and SFAN Data Manager are responsible for managing the project database, training, and supervising the Lead Biological Technician (GS-07, term, subject to furlough position). The Lead Biological Technician is responsible for monitoring selected NSO sites, supervising the Biological Technician, providing field training to interns, communicating with the other field staff, providing project updates during the course of the season, consulting with field staff on protocol and database questions, data entry and error-checking, and writing the annual report. The Biological Technician (GS-05, term, subject to furlough position) is responsible for field monitoring at selected sites, data entry, error-checking the data, and other data management tasks. The GOGA Wildlife Ecologist and SFAN Data Manager assist with the monitoring of selected sites as needed. The Project Lead duties are currently assigned to the SFAN Data Manager (as of 5/12/08).

Tasks for Project Lead:

- ◆ Supervise the biological technicians
- ◆ Develop and conduct performance review (to be reviewed by I&M Program Manager)
- ◆ Manage owl monitoring program budget
- ◆ Provide or coordinate training for the biological technicians
- ◆ Conduct annual QA/QC field checks
- ◆ Present issues for consultation with the Technical Steering Committee
- ◆ Review and provide comments on annual report
- ◆ Initiate and complete long-term analysis and synthesis report
- ◆ Update protocol as needed
- ◆ Provide field assistance as needed to ensure coverage

Tasks for the Lead Biological Technician (GS-07):

- ◆ Coordinate logistics for field work
- ◆ Coordinate field assistance for protocol implementation and provide training to field assistants such as interns
- ◆ Maintain equipment in good working order and keep maintenance records
- ◆ Collect field data and implement field QA/QC measures
- ◆ Coordinate data entry, verification, and validation in consultation with SFAN Data Manager
- ◆ Perform summary statistical analyses on data; present and interpret results in annual reports
- ◆ Communicate results through a variety of media and channels including Annual Administrative Report and Workplan, executive briefing, I&M Update, and online websites

- ◆ Coordinate with Project Lead regarding staff and training needs, budget and equipment needs, vehicle, data analysis and data interpretation
- ◆ Production of annual hard copy binders

Tasks for the Biological Technician (GS-05):

- ◆ Provide training to field assistants such as interns
- ◆ Maintain equipment in good working order and keep maintenance records
- ◆ Collect field data and implement field QA/QC measures
- ◆ Perform data entry, verification, and validation in consultation with SFAN Data Manager
- ◆ Production of annual hard copy binders

Tasks for the Project Intern or Volunteer:

- ◆ Assist biological technicians with field work, data entry, and reporting

Tasks for SFAN Data Manager:

- ◆ Provide assistance to the biological technicians regarding data management, archiving, reporting
- ◆ Assist with GIS needs
- ◆ Assist with compilation of metadata for past and current monitoring programs
- ◆ Review protocol, annual reports, long-term trend analyses
- ◆ Assist with field work at selected monitoring sites

Tasks for the GOGA Wildlife Ecologist and PORE Science Advisor:

- ◆ Be well-versed in all aspects of the NSO Monitoring Protocol
- ◆ Provide technical assistance to the biological technicians
- ◆ Review protocol, annual reports, long-term trend analyses
- ◆ Assist with field work at selected monitoring sites

Broad tasks for I&M Program Manager:

- ◆ Broad programmatic oversight and review
- ◆ Coordinate guidance on data management, data analysis and reporting
- ◆ Provide information related to I&M program requirements, including reporting requirements and deadlines
- ◆ Review protocol, annual reports, long-term trend analyses
- ◆ Plan program budget in coordination with Project Lead
- ◆ Coordinate peer review of analysis and synthesis reports

5.2 Qualifications

Field personnel are required to have normal hearing abilities and either one season of experience doing NSO surveys, including field data collection, or training in NSO survey techniques. In addition, personnel must also be skilled with the use of GPS equipment for navigation and data collection. Observers should be well-organized, be able to make decisions in the field (based on a monitoring protocol), and work methodically under sometimes difficult conditions.

Because of the amount of training involved in attaining adequate experience required for consistent and accurate field data collection, the project employs few volunteers. Volunteers work under the supervision of project staff at all NPS sites.

5.3 Training Procedures

Training procedures are outlined in the attached SOP 1: Preparations and Equipment Setup Procedures and SOP 2: Standard Field Procedures. New and returning personnel are required to read this protocol and all SOPs, and the USFWS Protocol (1992) prior to field data collection.

In particular, all field personnel need to be familiar with:

- band colors and tabs (SOP 2),
- owl aging techniques (SOP 2 and 3),
- spotted, barred and hybrid owl plumage and calls (SOP 2),
- field safety considerations (SOP 6), and
- use of mice and mice management (SOP 2 and 3).

New full-time personnel are accompanied by returning field staff for on-the-job training typically until June. New part-time personnel and volunteers are paired with another more experienced field staff member throughout the season.

6.0 Operational Requirements

6.1 Annual Workload and Field Schedule

Field work is accomplished by two biological technicians with the support of interns and volunteers, from March 1 until approximately July 31. The SFAN Data Manager and the GOGA Wildlife Ecologist may take the lead on monitoring a few sites each year if needed. Monitoring may require 4-6 visits per territory in a season (up to four hours per visit). Surveys can be accomplished by a single observer, although two observers are recommended for efficiency and safety.

Immediately following the field season, the biological technicians will proof and error-check the database, produce the annual report and maps, and report results to federal, state and county agencies. General monitoring program tasks are listed with the target due date and lead person in Table 3.

Procedures for making changes to and archiving previous versions of the protocol and SOPs are described in SOP 7: Revising the Protocol. All personnel should be familiar with the revision requirements and naming schemes.

Table 3. Annual NSO program tasks.

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Advertise technician vacancy (as needed)												
Technician season												
Field training (as needed)		Late Feb	Early Mar									
Satellite copies of database to field crews			Mar 1									
Field surveys and nest habitat sampling												
Satellite database data entry							Due July 31					
Data error-checking, merge with master database.								Aug 15				
Site summaries, GIS layer production								Aug 31				
Data hardcopy binders									Sept 30			
BIOS annual reporting									Sept 30			
Annual report production (draft)									Sept 30			

6.2 Facility and Equipment Needs

Office space with computers for the biological technicians along with equipment storage space and a place to house live mice is provided by PORE. SOP 1: Preparations and Equipment Setup Procedures, lists field equipment needs for each field team.

6.3 Budget

Estimated costs for conducting NSO monitoring are shown in Table 4. The budget is based on FY10 cost estimates with costs expected to increase annually by approximately 4%. Personnel expenses for fieldwork are based on the biological technicians doing the majority of the fieldwork with assistance from permanent the GOGA Wildlife Ecologist, SFAN Data Manager, interns, and volunteers. The Lead Biological Technician is also responsible for preparing the annual monitoring report. The initial annual budget for the project is estimated to be \$83,850, which includes salaries of permanent NPS staff supporting the project. The estimate does not include in-kind services of volunteers. Field costs may vary from year to year depending on the skill level and experience of the biological technicians.

Table 4. Estimated annual SFAN NSO monitoring program budget based on FY10 cost estimates.

	Description	Cost
Funding Source	Park contribution (PORE)	-0-
	Park contribution (GOGA)	\$4,500
	SFAN I&M contribution	\$79,350
	Sub-total	\$83,850
Expense Type	Biological Tech GS-7 – 16 pp	\$47,000
	Biological Tech GS-5 – 14 pp	\$24,000
	SFAN Data Manager GS-11 – 1pp	\$3,900
	Wildlife Ecologist – GOGA GS-12 – 1pp	\$4,500
	Vehicle	\$3,000
	Equipment and supplies	\$750
	Travel, training, meetings	\$700
	Sub-total	\$83,850
	Balance	-0-

Additional periodic costs may be incurred if new equipment (e.g., spotting scopes and binoculars) are needed beyond those allowable by the annual budget. If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports.

6.4 Permit Requirements

Neither an Endangered Species Act Recovery Permit nor a USGS banding permit is required for calling or monitoring NSO surveys. Using a caller to attract wildlife is prohibited within the NPS lands though, and does require permission from the Superintendent and/or an NPS research and collecting permit. This permit will be obtained through the NPS Research Permit and Reporting System: <https://science1.nature.nps.gov/research/ac/ResearchIndex>.

7.0 Glossary

Abundance – In this context, abundance refers to the mean number of adult NSOs at the activity centers monitored or mean number of NSOs located during an inventory effort.

Activity center – Interchangeable term with ‘known and/or historic site center’. This area represents the area surrounding concentrations of ‘the best of’ detections such as nest stands, stands used by roosting pairs or territorial singles, or areas of concentrated nighttime detections.

Adult: A northern spotted owl ≥ 2 years old.

Breeding season – The time period that includes pair initiation, nesting, and fledging of young. The window is considered to be March 1 to September 1 for the purposes of conducting surveys to detect NSO (USFWS 1992; Forsman 1995); and considered to be February 1 to July 31 by USFWS for the purposes of limiting management activities that may affect nesting NSO.

Breeding years – Typical years when spotted owls breed during the nesting season; see also non-breeding years.

Fecundity – A measure of reproductive success typically reported as the number of female young fledged per territorial female (e.g., Anthony et al. 2006)

Home range – The area annually traversed by spotted owls that provide important habitat elements for breeding, feeding, and sheltering

Inventory – A large scale survey of suitable NSO habitat to detect the number and occupancy status of activity centers within a designated area.

Mousing – Mousing describes the act of offering prey items to spotted owls. The purpose of mousing spotted owls is to determine pair status and/or reproductive status. A male spotted owl may take a prey item to an unseen female, likewise, adult owls may take prey items to unseen young.

Nest – Northern spotted owls use broken-topped trees, old raptor nests, witches broom, cliff ledges, mistletoe brooms, and tree cavities for nests. A spotted owl must be observed using the structure or have mice taken to a nesting female positively identified in the structure to designate a nest tree.

Nestling – A young owl that is still in the nest.

Non-breeding years – Non-breeding years refers to breeding seasons when NSOs did not breed across a large landscape. This occurrence was documented in Marin County in 2007 when there were no breeding pairs on federal lands.

NSO – Northern spotted owl.

Occupancy – Determination that an area or activity center contains an owl or owls. A survey area can be considered “occupied” if at any time throughout the year a NSO is detected. Assigning a level of occupancy, nesting, or reproductive status must occur within the breeding season.

Productivity – A measure of reproductive success reported as the number of young fledged per territorial pair (e.g., Anthony et al. 2006).

Reproductive status – Determination that nesting owls have laid eggs or have nestlings/fledglings.

Reproductive success – Measures used to describe the amount of reproduction that occurred annually. See fecundity and productivity.

Roost – Typically a tree used by a spotted owl for extended daytime rest periods. A roost site consists of the roost itself and the immediate vicinity. Roost areas are identified by observations of spotted owls, and/or the presence of pellets, whitewash and other evidence.

Spotted Owl Site - See Territory.

Subadult – A spotted owl in the first or second years of life.

Territory – Area defended and used by a territorial NSO single or pair for foraging, roosting, and nesting; often referred to as a NSO “site” and includes an activity center.

Vital Signs – As used by the National Park Service, are the subset of indicators chosen a by park or park network as part of the vital signs monitoring program. They are defined as any measurable feature of the environment that provides insights into changes in the state of the ecosystem. Vital signs are intended to track changes in a subset of park resources and processes that are determined to be the most significant indicators of ecological condition of those specific resources that are of the greatest concern to each park. This subset of resources and processes is part of the total suite of natural resources that park managers are directed to preserve “unimpaired for future generations,” including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on these resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic levels, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

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SOP 1. Preparations and Equipment Setup Procedures

Version 1.3

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
1.0	12/8/07	D. Adams	Format, slight content revisions	Respond to reviewer comments.	1.1
1.1	05/18/08	D. Adams, Paul Johnson, Marcus Koenen	Minor content revision to equip list and volunteer mgmt	Incorporate staff edits	1.2
1.2	03/04/10	D. Press	Minor content revision. Added more detail on volunteers. Added section on training new staff.	In response to peer review comments.	1.3

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This SOP outlines the basic activities carried out at the onset of each field season (March).

1.0 Prepare Field Maps

Each field team should have field maps for each site for navigation to the designated activity sites and for preparing site search maps for each visit. Maps for each of the monitoring sites are created using GIS and facilitate finding past Northern Spotted Owl (NSO) nests and activity centers in the field. Use topographic maps as a base layer with the addition of labeled roads, trails and past NSO nest site occurrences. Create the 8-1/2x11 field map using no greater than a 1:18,000 scale, include a scale bar, north arrow and title with the minimum of the area identified.

2.0 Pre-season Meeting

Project leader or Lead Biological Technician schedules a pre-season meeting in February or early March to bring together all the project personnel and plan for the year's activities. Identify roles and responsibilities during the meeting if they are unclear or new personnel will be participating.

1. Assign NSO survey sites to field personnel including biological technicians, intern, GOGA Wildlife Ecologist, SFAN Data Manager, volunteers, or other staff.
2. Provide annual satellite databases for all field crews.
3. Review Training Topics:
 - Protocols and SOPs
 - Band colors and tabs
 - NSO aging techniques
 - Spotted, barred and hybrid owl plumage and calls
 - Field safety considerations (See SOP 6: Safety Procedures)
 - Mice maintenance

4. Review Equipment Needs

Review the condition and location of equipment needed for the season. Generally, four-wheel drive government vehicles are used for accessing NSO owl sites via park roads and trails. Where and when possible though, biologists should hike and use mountain bikes on park trails.

Monitoring equipment is stored at both PORE and GOGA. At PORE, storage of monitoring supplies is in the basement of the Resource Management building, Science office, and Lead Biological Technician's office. At GOGA, equipment is stored in Fort Cronkhite Building 1061 (Resource Management Building, Wildlife Ecologist's office) and in Fort Cronkhite Building 1063 (SFAN I&M Building, SFAN Data Manager's office and Dry Lab).

Domestic or pet mice used for baiting NSOs are typically purchased at area pet stores and one person from the field team is responsible for feeding and caring for them. Generally, 8-20 mice are needed on hand depending on the time period in the season. Small cages are used to carry the mice (4-6 at a time) into the field.

Each field team needs:

- Megaphone, tape player, owl tape, and/or hoot flute
- Batteries (AA, C, and D for megaphones)
- Spotting scope and tripod
- Datasheets (site search and nest forms)
- Watch
- Thermometer
- Specimen collecting envelopes and bags
- Field clothing
- Mouse lure and mice, if necessary
- Aluminum tree tags and nails
- Flagging
- Park radio and/or cell phone
- Binoculars
- Field notebook
- Compass
- Field maps
- GPS unit
- Headlamps/flashlights
- Extra water and food.
- Banding list
- Monitoring protocol

3.0 Volunteer and Intern Management

During the pre-season meeting it is important to identify which long-term and new volunteers or interns will participate in the NSO monitoring field work, the range of work they are authorized to do (e.g., visit sites independently and collect data or only accompany a trained field crew member). SFAN staff must determine who will be scheduling their work and supervising their activities. Volunteers may assist long-term monitoring efforts covered by this protocol when accompanying other assigned field staff. At the SFAN staff's discretion, volunteers may be permitted to conduct surveys on their own. This has been particularly helpful in the past with simple nest checks. Volunteers will not be permitted to work independently until their abilities to follow proper procedures and accurately record data consistent with the monitoring protocol are confirmed by SFAN staff. Volunteer supervisors should track each volunteer's hours and provide them to the Lead Biological Technician for the annual report and to the individual park Volunteers in Parks Coordinators.

4.0 Training New Staff

New field observers hired by the SFAN for the NSO monitoring program will require significant training by existing staff. If possible, the SFAN should try to hire biologists with previous experience monitoring northern spotted owls. New hires will be required to become intimately familiar with field procedures and must accompany existing staff into the field on numerous surveys in order to orient themselves to the monitoring sites and learn field techniques first hand. New staff will not be permitted to work independently until their abilities to follow proper procedures and accurately record data consistent with the monitoring protocol are confirmed by SFAN staff.

SOP 2. Standard Field Procedures

Version 1.4

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
1.1	12/8/07	D. Adams	Format, slight content revisions	Respond to reviewer comments.	1.2
1.2	02/19/08	D. Adams	Content corrections	Response to internal review comments	1.3
1.3	04/19/10	D. Press	Re-organization of figures. Format edits. Added SOD severity methods. Mention of USFWS 2010 protocol. Added Literature Cited section.	To meet current formatting guidance and respond to peer review comments.	1.4

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This standard operating procedure (SOP) outlines basic field survey procedures and guidelines, data collection, and documentation for the SFAN Northern Spotted Owl (NSO) monitoring program. The sections on survey methods, data collection and documentation, and specific field procedures were adapted from other existing monitoring protocols including those by Forsman (1995), the USFWS (1992), and Fehring et al. (2001).

Research on spotted owls over the last decade has raised concerns regarding the effectiveness of the USFWS 1992 survey protocol, particularly those which do not result in spotted owl detections, most likely due to barred owl presence. An interagency Barred Owl Work Group and its Survey Protocol Subcommittee, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

1.0 Survey Period

Informal surveys or incidental detections may occur any time during the year, but data involving occupancy and reproductive status designation as well as valid band confirmations must occur within specified time periods as described in this SOP. In general, surveys to establish the presence of territorial pairs or singles and to establish reproductive status will take place between March 1 and July 31 for the purposes of this monitoring protocol. All designated monitoring sites in Marin County should be surveyed at least once by April 15 to determine occupancy. In addition, the sites should be visited between April 15 and May 1 to determine nesting status.

2.0 Survey Area

The first survey of the season at each site should be an abbreviated search of the most recent activity center. The first day search can be expanded to include known roost areas and historic nest cores, especially if evidence of whitewash or pellets is found and/or there is easy access to past activity centers. If the first day visit is conducted in April, a more extensive search of past activity centers is justified. The shortened survey effort is due to the fact that owls at reliable territories (e.g., those with solid occupancy histories) will often appear in the historic core area in April.

If owls are not detected on the first visit, the second visit will entail an extensive search of all historic activity areas. Depending on evidence found and site history, the second visit could be a night survey. For example, if no evidence of owl presence was located on the first visit and the history of owl occupancy is unknown, a night survey is probably the best option for the second visit. If no response is heard on a second day visit, switch to night surveys to locate owls. It is a good idea to be ready to call at the activity site core at dusk when completing a night survey. This increases the chances of locating the area where the owls are roosting during the day before they start moving throughout the territory at night. If night access is limited to one effective call

point to cover the area, complete a 30+ minute call station from that location. Follow-ups to night surveys with NSO detections should be substantial; plan on spending several hours searching the area where the owl was heard.

3.0 Survey Methods

3.1 Scheduling Field Surveys

All sites that will be surveyed to determine occupancy status may take a minimum of one (if a pair is detected) and up to five visits to maximize detectability based on previous monitoring data (Connor and Lebuhn 2007c). Band identification, age, sex, and species verification should be determined for all NSO detected. Sites that are monitored for reproductive status will likely need additional visits after occupancy status is determined to locate the nest and confirm the number of young produced and fledged.

Do not survey under inclement weather conditions, such as high winds (>10 mph), rain, or high noise levels (stream noise, machinery, etc.) that would prevent you from hearing a response that would be heard under better conditions.

3.2 Sites with Recent Spotted Owl History

Initial attempts to determine occupancy status at sites with reliable histories within the previous two years should be conducted during daylight for the first two visits. If no owls or a single owl is detected during the initial day visits, subsequent surveys should occur during dusk, night, or predawn hours to determine pair status. If necessary, at least one night visit should occur before the end of April and an attempt should be made to complete two night visits before June 1. Sites with recent history, but no detections for the season should receive three night visits.

3.3 Sites with Inconsistent or No Recent Spotted Owl History

Sites with no recent owl history should be visited three times at night if no response is detected. Two of the night visits should occur before the end of June. An historic site will be considered unoccupied if it receives three night visits with no response. If owl response is heard during a night survey, follow-ups need to be conducted the next day except in the case of extreme circumstances or inclement weather. If a response is detected numerous times on night surveys, but owls cannot be located during day survey efforts, switch efforts to pre-dawn surveys so that a search can be conducted as soon there is sufficient light to safely enter forest.

Early season work is important because locating a nest or definitively determining non-nesting may reduce the need for further site visits.

3.4 Day Surveys

- 1) Day surveys should be the first visit for all sites with a well-established activity center. They are also used to follow up on any night survey response. The additional search effort can minimize the amount of calling required to locate owls in the daytime.
 - a) Conduct a search of the known nest/roost area for at least 30 minutes, documenting all owls seen or heard as well as whitewash, pellets or other evidence.

- b) If no owls are located, initiate calling and continue an expanded search for at least an additional hour and covering up to ½ mile radius around the historic activity center. Focus expanded searches around any observed evidence. If no evidence is found, conduct a night survey covering the potential habitat.
- 2) If owls are located, record the species, sex, age, and band color as well as completing all of the fields in the datasheet. Indicate the methods used to determine species, sex and age in the narrative (4-note calls, appearance of tail tips, color bands, behaviors etc.)

3.5 Night Surveys

The intent is to obtain complete coverage of the area of interest such that owls will be able to hear the surveyor and the surveyor will be able to hear the owls.

- 1) Establish calling stations and survey routes to achieve complete coverage of the area. Calling stations should be spaced 400 to 800 m (0.25 to 0.5 mile) apart, depending on topography. Take advantage of prominent points within the calling area when establishing calling stations.
- 2) Conduct night surveys between sunset and sunrise. Be sure not to call the same section of a survey route at the same time on each survey effort (i.e., vary the time that you start and the point from which you start your route).
- 3) Systematically survey the area of interest until an owl responds, or if no response, until a minimum of three complete night visits are conducted each year. Survey effort should be spread out over two to three months to avoid survey efforts concentrated in a short period of time (e.g., in a three-week period at the start of the survey season).
- 4) Follow the survey methods listed below (spot calling is the recommended method). Whatever method you use, be sure you cover all potential areas within the historic activity site area.
 - a) **Spot calling:** Set up a series of calling stations approximately 400 m (0.25 mile) apart along a road. When possible, pick prominent points that cover large areas. Spend at least 10 minutes at each station, more if the topography prevents you from hearing owls that might respond from the previous calling point (e.g., you cross a major ridge). If the topography lends itself to fewer, prominent calling points, spend more time at each station. If a response is elicited, stop calling immediately and listen carefully to identify the owl's species, gender and location. A complete 10 minutes of calling is not required if a response has been elicited.
 - b) **Continuous walking or leapfrog surveys:** Walk the designated route, stopping at frequent intervals to call and listen for responses. If two people are involved, you may use a leapfrog method (see Forsman 1983).
- 5) If owls are heard during a survey:

- a) Estimate the original and final location of the owl(s). The best method is to triangulate on the owl's calls, taking compass bearings from two to three locations. Be sure to record on the survey form the method used to estimate the location.
 - b) Record the location on a map attached to the survey form. The triangulation and accompanying map provide a means for verification of the location.
- 6) If an owl responds at any station, record the data as required. If no response is heard, proceed to the next station calling point. Continue until the defined area is completely covered.
 - 7) If an owl responds at night, return to the area during the day as soon as possible (see Day Surveys) to verify status as described below.
 - 8) If a response occurs during dusk or pre-dawn hours and there is sufficient time and light to complete status verification, do so.
 - 9) If the survey is for inventory purposes, once a owl responds at night, complete the survey route for the remaining stations points that are beyond earshot of the responding owl. Beyond earshot is generally over a ridge or at least 800 m to 1200 m (0.5 to 0.75 mile) away. Completing the route will provide an opportunity to detect any other owls in the area.

4.0 Data Collection and Documentation

In order to establish consistency among the various Marin County survey units, a minimum set of information is required to be collected. Whether or not owls are located, a Site Search Form form (Figure SOP 2.1) is required for all field visits. All fields on the Site Search Form should be filled out and a written narrative completed documenting all relevant events. For all field visits you should record the site name, weather, start and end time, a description of the area covered, the purpose of survey (e.g., “Purpose of visit is to locate male and determine his band and age” or “Purpose of visit is to confirm reproductive success with second fledgling count”) and results of visit (see detailed Site Search Form section below).

Be aware of the current status of the site you are visiting and know what data are needed. Since we don't regularly use “mousing” to determine status it is of the utmost importance to record detailed and accurate field notes. Take notes in chronological order using specific times to indicate notable events. For all daytime observation you should note the time you get both an audio and any visual responses from an owl.

Note how you knew it was a NSO versus a barred owl. Note where you located the owl(s). Indicate the sex and types of NSO responses observed. Note the age of the owls and how it was determined. Always note band and tab color and leg, determination of no band if you can determine it, or if leg observation is not possible that the band is unknown (see Reading Color Bands section below). Always make an effort to determine this information. Never record age, sex, and band determination in the detection table if you did not observe it and are not 100% positive of your determination. Describe the behavior of the owls. During non-nesting visits make sure to note the length of time that a female is observed roosting in view.

Northern Spotted Owl Site Search Form

Crew:

Form I.D.#: Site Name: Owl Site #: Date:

Recorder: Lead Observer: Other Observers' Initials: #Observers:

Visit Times Visit Start Time:

Call Start Time: Call Method: (V,T,B,N) Visit End Time:

Conditions Summary

Wind: Precipitation: Temp. (F.): Clouds%: Light:

Visit Summary Formal Survey? Purpose of Visit: SPOW Response?

Other Raptor or Corvid Species Detected: Were mice offered? Total # SPOW Detected On This Visit Of:

Was an effort made to see bands? Mousing Purpose: Mature owls:

View into the nest was adequate to see all owls that might be in it? Total #Mice Taken: Nestlings:

Mice taken to nest? Branchers:

Fledglings:

Owl and Other Raptor Detections

species	sex	tail	age	time	A/V	band color	tab	leg	UTM-E	UTM-N	meth	acc

Mousing Effort

mouse#	time out	time taken	fate	fate time	sex	age	notes

Evidence	Non-Nesting Indicators	Nesting Indicators	Reproduction
<p>check up to 6</p> <input type="checkbox"/> None <input type="checkbox"/> Pellets <input type="checkbox"/> Feathers <input type="checkbox"/> Whitewash <input type="checkbox"/> Dead Owl <input type="checkbox"/> Eggshell(s)	<p>check the most significant</p> <input type="checkbox"/> 0=None <input type="checkbox"/> 1=No Brood Patch on Female 4/15 thru 6/15 <input type="checkbox"/> 2=Female Roosting 60+ min. 4/15 thru 4/30 <input type="checkbox"/> 3=Prey taken, but not to nest 4/1 thru 6/15	<p>check the most significant</p> <input type="checkbox"/> 0=None <input type="checkbox"/> 1=Nestlings Seen <input type="checkbox"/> 2=Female on Nest <input type="checkbox"/> 3=Prey Taken to Nest <input type="checkbox"/> 4=Brood Patch on Female <input type="checkbox"/> 5=Regenerating Brood Patch	<p>check what is known about this site</p> <input type="checkbox"/> 1=Unknown <input type="checkbox"/> 2=Non-Reproducing <input type="checkbox"/> 3=Confirmed Nest Failure <input type="checkbox"/> 4=Reproduced

NARRATIVE (Record all information that justifies your data sheet and describe details.)

Figure SOP 2.1. Site Search Form used for monitoring spotted owls in the San Francisco Bay Area Network.
 For multiple or moving owls, record and number each response or observation. Make note of

types of vocalizations heard, movements of owls (toward or away from you), or situations such as when one response is received and the owl is quiet thereafter. This will give the person(s) analyzing the data and determining activity centers additional information to consider. Be especially cognizant of the possibility that you may hear hybrid owls, and make careful notes of unusual vocalizations.

When owls are detected on a night survey, you should note the species, response time, compass bearing, approximate distance, and a description of calls. For all spotted owl responses also note the sex and any movement the owl makes. Use triangulation to pinpoint location of night auditory detections.

If nesting is detected, be sure to record detailed notes regarding the location of nest tree and nesting structure so that return visits can be made to collect nest habitat measurements. Record any visual cues that may aid in identifying the tree on a subsequent visit. Make an effort to obtain a GPS location. Record enough detail so that someone else can easily locate the nest tree if needed.

The Site Search Forms can be printed directly from the project database. Ideally, data forms are filled out in the field, but if a field notebook is used instead, forms should be filled out as soon as possible upon returning to the office. As a general rule, data forms should be completed and entered into the database within a week of the visit. This way the information is still fresh in your mind and you may be to provide additional details to your notes, but most importantly it is insurance that if you lose the datasheet or field notebook the visit is documented elsewhere.

4.1 Field Survey Map

A field survey map is required for all field visits other than nest checks (because the location is known from a previous map). The field survey map templates should be created for each area or site at the beginning of the season by each field team. Previous years' maps are acceptable as long as the documentation on the map is clear.

Noted on the field survey map should be the owl site, date, time period of visit using military time (e.g., 1300 – 1550), form id number for database form, outcome of visit (e.g., nest/FA/MA), location of nest and owls detected including sex, age, and bands, any call points used, and area searched. For both day and night surveys, field maps should also represent route surveyed and stations called and should correspond to the narrative text in the Site Search Form.

All spotted, barred, great horned, barn, saw-whet, pygmy, screech owl and accipiter response or observation locations should be noted on the field survey map and Site Search Form. For multiple or moving owls, map all response or observation locations and number each location to correspond with survey results and narrative.

5.0 Specific Field Procedures

5.1 Ageing Owls

Always make an attempt to look at an owl's tail tips on every survey. If it is perched high or obscured by foliage, a lure (rat toy) can be used to entice an owl to move to allow a visual of its

legs for bands and tail tips. An owl cannot be recorded as an adult unless the tail tips are seen, because there is no plumage difference between an adult and subadult except for the tail tips. Adults have mottled and rounded tail tips. First year subadults (S1) and juveniles have white pointed tail tips. Second year subadults (S2) have white rounded tail tips. In the situation when the tail is clearly not an adult tail, but the surveyor is unable to differentiate further, the code (SA) is used to indicate a subadult, age unknown. It can be very difficult to determine between an S1 and S2, but it is especially difficult if the tail tips are wet or if there is a mix between white and plump rectrices and white and pointy rectrices, or if you have limited experience aging subadults. As long as a surveyor can determine an owl is a subadult (SA) and not an adult, it is not necessary to differentiate between S1 and S2. Molting of the rectrices can also occur during the breeding season, which can leave the owls temporarily tailless or with a mix of shorter and longer tail feathers or a mix of a subadult/adult tail tips or S1/S2 tail tips. Describe any odd tail observations in the comments section of the data form. If the surveyor is unable to achieve a good view of the tail tips, the age should be recorded as unknown. NSO and barred owls have similar terminal tail band patterns and the same characteristics can be used to age barred owls.

5.2 Identifying Calls

All surveyors should be very familiar with the range of calls that could be heard in the field from NSO, barred owls, great horned owls, western screech owls, saw-whet owls and other area raptors and corvids. As part of the early season training, each surveyor will receive an audio recording of owl calls to review.

5.3 Reading Color Bands

Always carry the list of banded owls in the field. Always note band color and leg or determination of no band if you can determine it. Always make an effort to determine this information. Do not assume that you will have another opportunity to see the owl. Never record age, sex, and band determination in the detection table if you did not observe it and are not 100% positive of your determination. For example, if you saw a flash of orange on the right leg, record band color as “present” in the detection table and explain what you saw in the comments field. If you saw only one leg and it was unbanded, include the information in the comments field, but select band color as “unknown”. Make sure you have a view of both legs, before determining a owl as unbanded and using the “none” category in the band color field. If you confirm a banded owl that is not a historic owl to that site refer to the banding list to identify where it originated and document this in the comment field of the Site Search Form and also in the final status summary. Make an extra effort to confirm bands on owls during the early season, particularly females. Females can prove to be more challenging to confirm and can elude confirmation even when nesting. If a nest fails or when a pair is non-nesting, the pair may not spend much time in the core area as the season progresses.

5.4 Collecting Feathers

If a surveyor locates a NSO feather during a survey, it should be collected and placed in a resealable bag, for potential future use in a genetic study. On the outside of the bag record the species, site name, date, collector’s name, UTM’s of the feather’s location, and sex, age, and band ID of the owl the feather came from, if known. Record sex and age as unknown unless the surveyor actually witnesses the feather fall off of the owl or it is collected from the remains of a fledgling or nestling (in this case only the sex would be unknown). If you are unsure of the owl

species from which the feather came from, collect it and the corresponding collection information and show it to the Lead Biological Technician for determination. At the end of the season, turn in all feathers to the Project Lead for storage.

5.5 Using a Compass

5.5.1 Compass Basics

The magnetic declination for Point Reyes Station is 14° 52' E and changes by 0° 6' W/year. All compasses used in the owl monitoring program should have the ability to preset declination and should be set to this value.

5.5.2 Compass Components

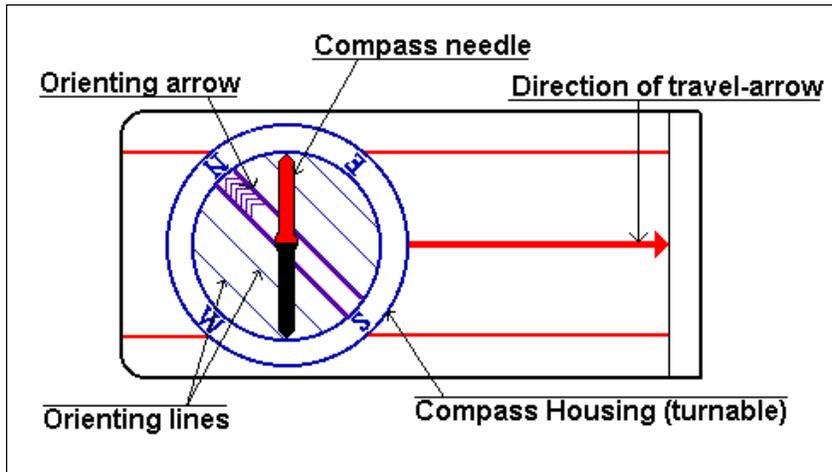


Figure SOP 2.2. Compass components.

5.5.3 How to Use a Compass

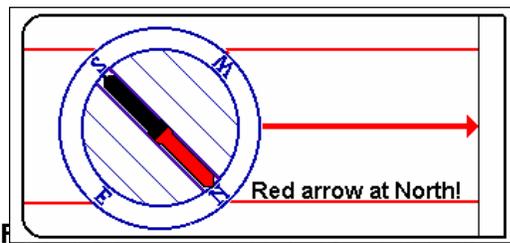
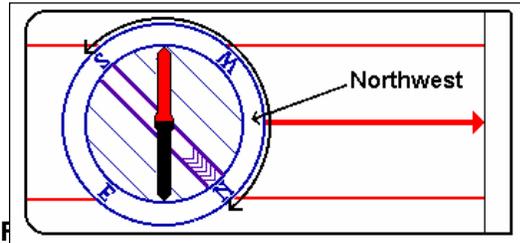
“Dial it up.” Use the compass housing to dial up a given compass bearing. In this case use 315 degrees (NW). See Figures SOP 2.2 and 2.3.

1. “Plug it in.” Act like you are plugging the compass into your body so that your shoulders and entire body turns with the compass and not just your arms. This will ensure you and the compass are pointed in the right direction.

“Put the red in the shed” by turning until the compass needle (the red) is in the orienting arrow (the shed). See Figure SOP 2.4.

Once you have the “red in the shed” look in front of you and find a landmark (tree, rock, etc.) the direction of travel arrow is pointing you.

- Walk to the landmark and put the “red in the shed” again. Locate your next landmark and walk to it. Keep repeating this process until you reach your destination.



5.5.4 How to Triangulate on a Location

Triangulation is used for identifying the point where two bearings intersect. We use triangulation to locate owls at night so that we can follow-up on that location the next day. In Figure SOP 2.5, “C” would be the owl’s location and “A” and “B” would be calling or listening stations.

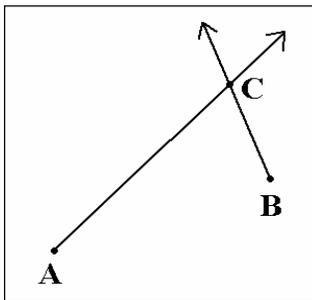


Figure SOP 2.5. Triangulation.

The same steps as described above would be used to achieve this. You would “dial up” a compass bearing on the owl’s auditory from two different locations along the trail or road. (While fine-tuning your bearing on the owl you should also estimate the distance the owl is away from your location in case the owl moves and you only get one bearing on it). The next step would be to transfer the compass bearings to a map by plotting your call stations on the map and then lining the orienteering lines on your compass with a north/south line on the map. Using the edge of the compass, draw the intersecting bearing lines on the map and place a dot at the point of intersection to represent the owl’s location. The final step is to obtain UTM coordinates from ArcView/ArcGIS and plug them into a GPS unit if you have one. You can use the “Go to” function on the GPS unit to lead you to the point of detection and hopefully the owl!

6.0 Completing Data Forms

6.1 Site Search Data Form

The Site Search Form (Figure SOP 2.1) is filled out for each visit to an owl site, regardless of outcome. Fields on the Site Search Form are described below.

General Information

Form ID #: This eight-digit number is sequentially assigned to each form filled out based upon the year and which crew performed the site search. The first four numbers correspond to the year. The fifth number corresponds to the crew (PRBO=1 PORE=2 MUWO=3 GOGA=4 MMWD=5 and MCOSD=6). The final three numbers should correspond to the order in which surveys were performed. It is not necessary for the numbers to relate precisely to the sequence of searches, so long as every data sheet is given a unique number. It is advisable to keep a log of the numbers you have already used and how they correspond to dates and locations. This allows a means to track stray data.

Site Name: Fill out the complete name of the site visited. Be sure to distinguish between sites with similar names, e.g., Barnabe Creek and Barnabe North. A look-up table will prompt you with the correct spelling of most locations during data entry.

Owl Site #: "MRN" followed by four numbers. Most sites have been designated with a unique number. This field is automatically filled in from the Site Name selection based on the assigned number in the SitesLUT. Official MRN numbers are assigned and distributed by the CA Department of Fish and Game.

Date: Indicate the date numerically in the format of month/day/year.

Crew: indicate the four or five letter acronym for the survey crew that you are a part of. A look-up table will prompt you.

Recorder: Record your initials here. This allows data managers to efficiently ask the appropriate owler any questions regarding the data. The data recorder identified in the field and in the database should be the same person. If it is not, indicate this in the narrative. Add new initials by clicking on the "Update Initials LUT" button below this field.

Lead Observer Last Name: Record the last name of the site search's most experienced observer.

Other Observer's Initials: Record three letter initials strings separated by spaces for observers other than the lead. Include the recorder. Use consistent initials sequences for each observer. Use prompt to see initials previously used.

#Observers: record the total number of observers that were on the site search.

Conditions Summary

Visit Start Time: Indicate the time at which you began actively searching for owls by visually searching, calling, or listening.

Call Start Time: Indicate the time at which you began either playing a tape or simulating spotted owl calls with your voice.

Method: Indicate whether you used voice simulations, a cassette recording broadcast, both of these, or if no call simulations were done. Never leave this field blank. A look-up table prompts for appropriate answers.

Visit End Time: Indicate the time at which you ceased any kind of searching for spotted owls within your search radius of the activity site.

Wind: Use the one adjective that most accurately describes weather conditions typical of the search.

Precipitation: Use the one adjective that most accurately describes weather conditions typical of the search.

Temp: Indicate the most characteristic Fahrenheit scale temperature experienced during the search.

Clouds (%): Estimate the average percentage of the sky obscured by clouds during the site search.

Light: Indicate whether the survey was performed primarily during daylight or during hours of darkness.

Visit Summary

Formal Survey: If the effort was part of regular monitoring or inventory, record “yes.” If information was gathered opportunistically, e.g., while camping, hiking, or represents an unofficial visitor’s report, record “no.”

NSO Response: Indicate whether there was a positively identified spotted owl heard or seen during the site search. Do not indicate yes for barred owl detections. Do not indicate yes for “possible” spotted owls. Only record "possible" owls in the narrative.

Other Owl Species Detected: Note the four letter AOU codes for other owl, corvid, or raptor species heard or seen during the survey, e.g., BDOW for Barred Owl, GHOW for Great Horned Owl, WSOW for Western Screech Owl, BNOW for Barn Owl, NPOW for Northern Pygmy Owl, NSWOW for Northern Saw-Whet Owl, etc. If a barred owl is detected, document it as fully as possible, preferably with photography. DO NOT INCLUDE 'POSSIBLE' DETECTIONS. These are only appropriate in the narrative.

Was an effort made to see bands?: Please indicate whether observers attempted to look for bands. Indicate "NA" for visits without owls. Indicate "yes" if an attempt was made, even if the view was poor and no bands were seen.

Were owls banded on this visit?: Answer yes only if new bands were placed on an owl's legs during the visit.

Were Mice Offered?: Indicate "yes" if live mice were offered to owls during the visit, regardless of mouse fate.

Mousing Purpose: Indicate why mice were offered to the owls. A look-up table provides appropriate responses.

Total #Mice Taken: Indicate the total number of mice which did not make it back into the cage. Do not include mice offered but which were not taken. Include only the number "added" to the forest.

Bait taken to nest?: Check here if any of the bait mice that you offered were taken to a spotted owl nest.

Total # Detected: Note total number of mature NSO, Nestlings, Branchers, and Fledglings: These fields allow data managers to quickly quantify detections and verify referenced data in the detections subforms. Enter "0" where necessary rather than leave fields blank.

Nest View: Was the view into the nest adequate to see all owls that might be present in it? If you have any doubt, answer "no."

Owl and Other Raptor Detections

Species: Use only one row for each individual detected. Record all owl species and all noteworthy diurnal raptors. Use the AOU four letter codes to indicate the species, e.g., SPOW for spotted owl or COHA for Cooper's Hawk.

Sex: Indicate "F" for Female, "M" for Male, or "U" for Unknown.

Tail: Describe NSO tail feathers using "P" for an acuminate point with a white band, "T" for the terminus being worn into a plump triangle, "R" for round and mottled, "S" for tips which are undoubtedly subadult but which you are unable to differentiate further, or "U" for unknown.

Age: Describe NSO age using "A" for Adult, "S1" for 1st year subadult, "S2" for 2nd year subadult, "SA" for a subadult of unknown age, "U" for an unknown adult or subadult, "N" for Nestling, "B" for Brancher, "F" for fledgling, or "J" for unknown age juvenile. For other species "I" may be used for immature.

Time: Indicate the time the raptor was first detected.

Type: Indicate the kind of detection with “A” for Auditory, “V” for Visual. Both may be inscribed in this field in the order of occurrence.

Band Color: Always fill in this field. Include newly banded owls. Write in the color or pattern of the band only if it was positively identified. Write “PRESENT” if you are certain there was a band but were unable to definitely determine the color. Write “NONE” if you gained a good view of both legs and positively confirmed the absence of a color band on both legs. Write “UNKNOWN” if the legs were not adequately seen or if only one leg was seen. DO NOT ENTER PARTIAL COLORS, e.g., only enter "RED" if it was solid.

Tab: Always fill in this field. Indicate the color, “UNKNOWN” if the tab was not definitively identified, "PRESENT" if you were certain there was a tab but could not identify it, or "GONE" if the owl has definitely removed its tab.

Leg: Always fill in this field. Indicate “R” for the owl’s right leg, “L” for the owl’s left leg, "U" for cases where information is unknown, "N" for neither leg (in the case of "NONE" as color).

UTM E: Record the Universal Transverse Mercator Easting, NAD 83 Zone 10. For the Marin County study area this number should be between 499600 and 545700.

UTM N: Record the Universal Transverse Mercator Northing, NAD 83 Zone 10. For the Marin County study area this number should be between 4184500 and 4236000.

Meth: Indicate the method used to derive the UTM coordinates. Review the look-up table for options.

Acc: Indicate your estimate of the accuracy of your map or the accuracy given by your GPS unit. Use “80” for accuracy at or below 80 m, use “150” for accuracy at or below 150 m, use “300” for accuracy at or below 300 m, or another figure for higher numbers.

Mousing Effort

Mousing Table: Record one row for each mouse offer. Changing mice or changing mouse locations do not constitute a new mouse offer.

Mouse #: Indicate which mouse in the sequence of offers the row represents.

Time Out: Indicate the time at which the mouse was placed within striking range of the owl.

Time Taken: Indicate the time at which the NSO captured the mouse. If the mouse was never captured, place a line through the field to indicate a negative response.

Fate: Always fill in this field. Use the following codes: “E”=ate mouse; “H”=held mouse until observer left or for 1 hour; “C”=cached mouse; “T”=took mouse to owl of opposite sex; “Y”=took mouse to young; “A”=took mouse to owl of opposite sex who took it to young; “N”=took mouse to nest; “I”=ignored mouse until observer left or for 1 hour; “L”=left with mouse, returned or was relocated without it; “X”=left with mouse, not relocated; “W”=left with

mouse, was relocated without it but with certainty did not deliver to young or mate “D”=dropped mouse w/o retrieving; or “B”=Bander prevented owl from capturing the mouse. This final field is an important distinction from “I” or “D.”

Fate Time: Indicate the time at which the above fate code became apparent. For "Held" mice this will be the time you last saw the owl with the mouse.

Sex: Indicate the gender of the NSO that either interacted with the mouse or was offered the mouse.

Age: Indicate the age of the NSO that either interacted with the mouse or was offered the mouse.

Behavior/Notes: Briefly indicate exceptional circumstances of any mice. Lengthy details may be included in the Narrative.

Observational Information

Place a check mark in all the small white boxes which correspond to events or evidence which happened, were seen, or became apparent during this site search under the categories of Visit Status, Evidence, Nesting Indicators, and Reproductivity.

Narrative

This is the most important field in the record of your site search. Narratives are especially important at the end of the season when site status is designated. Write an account of all relevant events which took place during the site search. Include the time of all significant moments of the day. Include directions, landmarks, reasons and reasoning, tools used, unusual circumstances, suggestions and questions. Presume that your audience is someone 20 years into the future who may not understand owl research. Here you are able to document any nuances of your effort which are not captured by the above data fields and explain why your site search was performed in the manner that it was and how the results came about. Also by telling the story of your effort, data managers have a way to double-check the above data entry and solve any difficulties. Consider the narrative as a means by which to avoid a telephone call later in the season asking you to explain why or how you came to the conclusions you came to.

6.2 Nest Habitat Data Form

The Nest Habitat Data Form (Figure SOP 2.6) is filled out for each known nest site each year. The measurements and form take about 45 minutes to complete per site and can be filled out at any time after a nest is found, but should be done after the young have fledged if possible to avoid any disturbance. In addition, the nest trees are tagged with aluminum tags (Forestry

Northern Spotted Owl Nest Habitat Data Form
(attach map location and any photos)

Location

Site Name: _____ Owl Site #: _____ Year: _____

Observers: _____ Measurement Date: _____ Tree Tagged? yes / no Tag # _____

New Location (never described before)? Yes / No

First Year Used: _____ Total # of Seasons SPOW Documented Nesting in this Tree: _____

Number of SPOW Fledged From This Tree (this season): _____ Is This Number Definitive? Yes / No

GPS Unit Used: _____ UTM E _____ UTM N _____ Accuracy _____ Elevation: _____ meters / feet

Physical Features

Aspect: _____ (degrees) Magnetic or True

Slope: _____% Slope Position: bottom / mid-slope / ridgeline / ridgetop

Distance to Water: _____m (permanent or ephemeral present during breeding season)

Forest Opening: _____m Kind _____ (windfall, glade, outcrop, shrub, etc.)

Forest Edge: _____m Kind _____ (meadow, road, reservoir, etc.)

Dominant Vegetation at Site (circle all that are >33% of the overstory or understory layer)

Overstory: redwood / Douglas fir / bishop pine / bay / live oak / other _____

Understory: fern / hazelnut / coffeeberry / tan oak / huckleberry / herbaceous / other _____

Nest Features

Nest Tree Species: redwood / Douglas fir / bishop pine / bay / live oak / other _____

Nest Type: cavity (top entry or side entry) / platform Nest Tree Alive? _____

Nest height: _____m Tree height: _____m Diameter at breast height (dbh): _____cm

How was the info gathered? (circle any/all used) ArcView/topo map/compass/clinometer/altimeter/dbh tape

Description of Site (general habitat, stand description, proximity to main or alternate roosts, nests, etc.): _____

Direction to Roost / Nest (access trails, gates, landmarks, flagging, distance, etc.): _____

Continue on Back if Necessary

4/5/04

Figure SOP 2.6. Nest Habitat Data Form used for recording nest and habitat characteristics for spotted owl monitoring in the San Francisco Bay Area Network.

Suppliers, #25331), stamped to indicate site number and year. Fields on the nest habitat data form are described below.

Location

Site Name: Official site names are assigned in the office. If it is a new site, you can suggest a name based on a local geographic feature. If you are unsure whether it is an existing site or a new site, record detailed notes of location and accurately map your location. Cross reference your mapped location against a comprehensive territory map upon returning from the field.

Owl Site #: Official MRN number assigned and distributed by the CA Department of Fish and Game. Some sites have yet to receive a MRN # and are recorded as “None”.

Year: Record the current year.

Observers: Record initials of individuals present.

Measurement Date: Record the date the nest tree measurements were collected.

Tree Tagged: Yes, if it was a reused tree that was tagged previously or if you tagged it as a new tree that year. Tag tree at face height on the most accessible side unless nest tree is located directly on a trail. If the latter is the case, tag on side away from trail. Remember to color the aluminum tag black using a permanent marker to reduce its visibility. If it is a reused nest tree, use a nail to etch the last two digits of the new year of use on the old tag or add a new tag. Enter the new tag # in the Tag # field, and describe both tags in the data form comments section.

Tag #: Tag includes MR# then a space followed by the last two digits of the year it was first located, for example: MR001_04. Check trunk of tree at eye level for previous nest tags.

New Location (never before described): Refers to the nest tree not the site. Yes, if it is the first year the nest tree was identified. No, if it is a subsequent year of use.

Total # of Seasons NSO Documented Nesting in this Tree: You can read nest tree tag for this information or check the nest tree forms in the database.

Number of NSO Fledged From This Tree (this season) and Is this Number Definitive?: This is an attempt to avoid underestimating number fledged. If you saw two fledglings on one visit, but only one after that you should note that one fledgling is not definitive and the fledge number is ‘1’, with a note in the comments field about why the number was not definitive. If site was monitored for occupancy and management purposes, the number of fledglings may not be definitive due to the reduced number of surveys these sites receive.

GPS Unit Used: Confirm GPS unit and refer to drop down list on nest form.

UTM E and UTM W: Record UTM coordinates of the nest tree.

Accuracy: Record accuracy of UTM coordinates. The measure of accuracy can be found on GPS unit and will be meters on most units. Record accuracy value in meter units.

Elevation: Obtain elevation from USGS topographic map and use meters as units.

Physical Features

Aspect: The compass bearing at which water would flow if you dumped a bucket at the nest tree. Average this over the 50 m around the nest to avoid measuring tiny landscape features. Record whether this bearing is magnetic (no declination set on compass) or true (declinated compass).

Slope: Determined using a clinometer. Crouch down to fern height and look across the tops of the ferns noting the % slope. Take percentages looking downslope and upslope and average them. Double check scales on clinometer by tipping it way up, ensuring that percent scale is recorded and not the degrees scale.

Slope Position: (bottom, mid-slope, ridgeline, or ridgetop). Slope position is general overall location on slope. It is often mid-slope. If the slope drops down from the nest site in all directions, you are on the ridgetop (rare). If the slope goes up from your position in one direction and down in the other three directions, you are on the ridgeline (uncommon).

Distance to water: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. Record whether water is present throughout season or only present during the wet season.

Forest Opening: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. A forest opening for this purpose is defined as an area the sun reaches the ground over a minimum patch of 5 m radius..

Forest Edge: Can estimate distance in field, but may have to refer to topographic map or ArcGIS for accurate distance. Record distance in meters. Defined as a larger scale change in habitat that creates a forest border.

Dominant Vegetation at Site

Overstory and Understory: Identify and record all dominant species that compose >33% by cover of the overstory and understory within 50 m of the nest tree. Overstory classification assumes that a tree receives direct sunlight, and thus its loss will increase light penetration to the forest floor. Understory vegetation may occur at any height secondary to the upper canopy layer, and includes secondary trees, shrubs, and herbs.

Nest Features

Nest Tree Species: Determine and record.

Nest Type: Should be either a platform or cavity (also note: top or side entry).

Nest Tree Alive: Yes or No.

Nest Height and Tree Height: Obtained using a clinometer, 50 m tape or pacing, and trigonometry. Directions are included with clinometer. One way is to measure your distance

from the tree using either 50 m tape or counting paces far enough so that you are even horizontally with base of the tree. (You can use the clinometer to check this. This distance is your first “side”.) Take a clinometer reading at the nest and the top of the tree to get the angles to each from your known distance from the tree. Use the known distance and these to calculate the other “sides” (heights). Remember to add your height to the side/angle/side math. Record an ocular estimate of tree height and nest height to double check your math.

Diameter at breast height (dbh): Measured using dbh tape and recorded in centimeters.

How was the information gathered: Circle all that apply from the list.

Description of Site: General description of general habitat, stand description, proximity to main or alternate roosts, nests, etc. Provide all details needed to orient future field staff to the site.

Direction to Roost/ Nest: Description of access trails, gates, landmarks, flagging, distance, etc. Include detailed descriptions of nesting structure, nest aspect (general bearing of which side of the tree the platform/cavity is on), and state if the platform has disintegrated.

6.3 Cooperating with Other Research Activities

6.3.1 Documenting West Nile Virus

Although West Nile Virus has not been found in a non-captive NSO as of May 2008, the virus has been found in captive NSO and in wild Barred Owls. The likelihood of finding a dead or sick NSO with West Nile Virus is low given the brushy locations that are surveyed, but it is possible. Current procedures for handling sick or dead spotted owls suspected of having West Nile Virus are similar to procedures for other birds except the initial contact would be made to the USGS National Wildlife Health Center (West Nile Virus Coordinator, Madison, WI (608) 270-2456).

Any other bird species found during field work that are suspected to have died from West Nile Virus are reported to the California Department of Health Services using their toll-free hotline (877-WNV-BIRD). Since fecal material, saliva, and blood are the most likely sources of viral infection from handling an animal, latex gloves should be worn and if necessary, eye protection. If field staff has been in contact with infected animals or contaminated materials, flushing and washing the exposed area with soap and water is the recommended treatment. All birds should be submitted for testing as soon as possible following discovery and should not be frozen prior to testing. The Centers for Disease Control and Prevention (CDC) website (<http://www.cdc.gov/ncidod/dybid/westnile/index.htm>) provides basic information about the disease, maps and statistics on human cases, and links to other government websites for additional information such as county maps and the list of affected bird species.

6.3.2 Documenting Sudden Oak Death

Sudden Oak Death (SOD) has been confirmed in all areas of the study area. *Phytophthora ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree’s flow of nutrients (Moritz et al. 2008). Other secondary decay organisms such as beetles and fungi often move in after the tree is infected.

Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death. Many other diseases cause similar symptoms; therefore, the presence of *P. ramorum* can only be confirmed by a laboratory test.

During field surveys, researchers should look for tanoaks or coast live oaks showing the symptoms of SOD. Researchers should be familiar with the document “How to recognize symptoms caused by diseases caused by *P. ramorum* causal agent of Sudden Oak Death” (Garbelotto et al. 2002). If symptoms are noted in previously undocumented areas, researchers should inform both the PORE and GOGA Supervisory Botanists who may conduct further testing to confirm SOD.

An SOD Severity Index will be established at each NSO site monitored each year adapted from rapid assessment methods developed by Moritz et al. 2008. The severity index evaluates affected tanoaks (*Lithocarpus densiflorus*) and coast live oaks (*Quercus agrifolia*) on a scale of 0 (no SOD present) to 10 (>95% canopy cover). The severity index considers both the overstory and understory within a circular plot (50 m radius) and includes both dead and symptomatic vegetation. Ratings of 8-10 consider larger plots at 75 m to 100 m in radius.

Oak trees classified within the overstory may be a dominant or minor component of the overstory or co-dominant with other tree species, such as redwood or Douglas fir. Overstory classification assumes that a tree receives direct sunlight, and thus its death will increase light penetration to the forest floor. Understory trees may occur at any height secondary to the upper canopy layer. Both overstory and understory trees must be ≥ 1 inch dbh for consideration in the rating evaluation.

The center point for the SOD severity index rating will be at the established activity centers, such as nest trees, for each NSO site monitored. The SOD severity index will be entered into the STATUS table of the NSO monitoring database (see SOP 4: Data Management Handbook). Final status records are entered for each NSO site monitored each year and include geographic UTM coordinates of nest trees or activity centers. The center point for each SOD severity index rating should match the UTM coordinates in the corresponding STATUS record.

For sites where a defined activity center is not found or is questionable, field staff may opt not to develop an SOD severity index. For example, this may occur at unoccupied sites or sites with single unknown status.

A detailed guide to the SOD severity index rating is presented in Table SOP 2.1.

Table SOP 2.1. Guide to SOD severity index rating on 0-10 scale. Data is collected within a circular plot (50 m radius) unless otherwise noted.

Rating	Overstory			Understory			
	Dead ¹		Sympt / Dead ²		Dead		Sympt / Dead
0	none	AND	None	AND	none	AND	none
1	none	AND	None	AND	1-2 tr ³	OR	1-4 tr
2	none	OR	< 5% CC ⁴	AND/OR	3-4 tr	OR	5-6 tr
3	< 5% CC	OR	≥ 5% CC	AND/OR	≥ 5 tr	OR	≥ 7 tr
4	≥ 5% CC	OR	≥ 25% CC		NA		
5	≥ 25% CC	OR	≥ 50% CC		NA		
6	≥ 50% CC	OR	≥ 75% CC		NA		
7	≥ 75% CC	OR	≥ 95% CC		NA		
8	≥ 95% CC	OR	≥ 95% CC in area ≥ 75 m r		NA		
9	≥ 95% CC in area ≥ 75 m r	OR	≥ 95% CC in area ≥ 100 m r		NA		
10	> 95% CC in area ≥ 100 m r		NA		NA		

1. Dead is standing dead or fallen, stump sprouting ignored.
2. Sympt / Dead includes the total of both dead and symptomatic trees.
3. Trees (tr) are defined as woody stems ≥ 1 inch DBH.
4. CC is canopy cover

7.0 Literature Cited

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SOP 3. Status Designations

Version 1.3

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
July 2001	12/8/07	D. Adams	Format, slight content revisions	Respond to reviewer comments and format standards	1.1
1.1	5/4/08	D. Adams, H. Jensen, D. Press	Format, content revisions, additions	Respond to reviewer comments and format standards	1.2
1.3	4/19/10	D. Press	Format revisions and minor edits. Mention of USFWS 2010 protocol. Added Literature Cited section.	To meet current formatting guidelines and peer review comments.	1.3

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This standard operating procedure (SOP) document describes the protocol used to determine the annual occupancy, nesting, and reproductivity status of northern spotted owls based on data collected during surveys on federal lands in Marin County, California. Survey methods are described in SOP 2: Standard Field Procedures. This SOP was adapted from existing monitoring protocols, including the “Spotted Owl Monitoring Protocols for Demographic Studies” (PNW Protocol; Forsman 1995), the USFWS “Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls” (USFWS Protocol; USFWS 1992), and the Marin Modified Field Protocol (Fehring et al. 2001).

In 2001, the Marin County spotted owl monitoring program designed a monitoring protocol, the “Marin Modified Field Protocol”, in response to observed behavioral changes in northern spotted owls due to repeated mousing. The modified protocol was based primarily on the PNW Protocol and used the advantage of the accessibility of the owl sites to increase the search effort and the number of visits in order to decrease the number of mice fed to owls, while striving to obtain the same accurate measure of owl reproductive status and success in other monitored areas. This SOP formally replaces the Marin Modified Field Protocol as the standard followed by the SFAN NSO monitoring program.

Modifications to the standard, range-wide protocols (PNW and USFWS Protocols) are identified as underlined text. Some original text has been lined out but is retained for comparison purposes. All modifications are noted with a number corresponding to the endnote. Because some of the text is taken directly from the range-wide protocols, there are references to different survey periods in Washington, Oregon, and California, which is also retained for comparison purposes.

The two-letter codes following each status designation refer to the codes used in the program database in the status table and form. All sites or areas where management concerns are paramount and are not part of the long-term monitoring program should be surveyed according to the USFWS Protocol. Occupancy and reproductive status requirements differ, so refer to the appropriate protocol.

The PNW Protocol emphasizes the need to differentiate spotted owls from barred owls and spotted/barred hybrids. As this need increases in Marin County, the vigilance is important to document the continuing range expansion of the barred owl.

Research on spotted owls over the last decade has raised concerns regarding the effectiveness of the USFWS 1992 survey protocol, particularly those which do not result in spotted owl detections, most likely due to barred owl presence. An interagency Barred Owl Work Group and its Survey Protocol Subcommittee, a sub-group of NSO managers conducting demographic monitoring under the Northwest Forest Plan, has evaluated the effectiveness of the current NSO demographic survey protocol in the presence of barred owls. The findings and recommendations from the Barred Owl Work Group were adopted by the USFWS in the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010). Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

1.0 Survey Site Status Determination

Figure SOP 3.1 illustrates the five levels of status that must be determined at each NSO territory in each year that a territory is monitored.

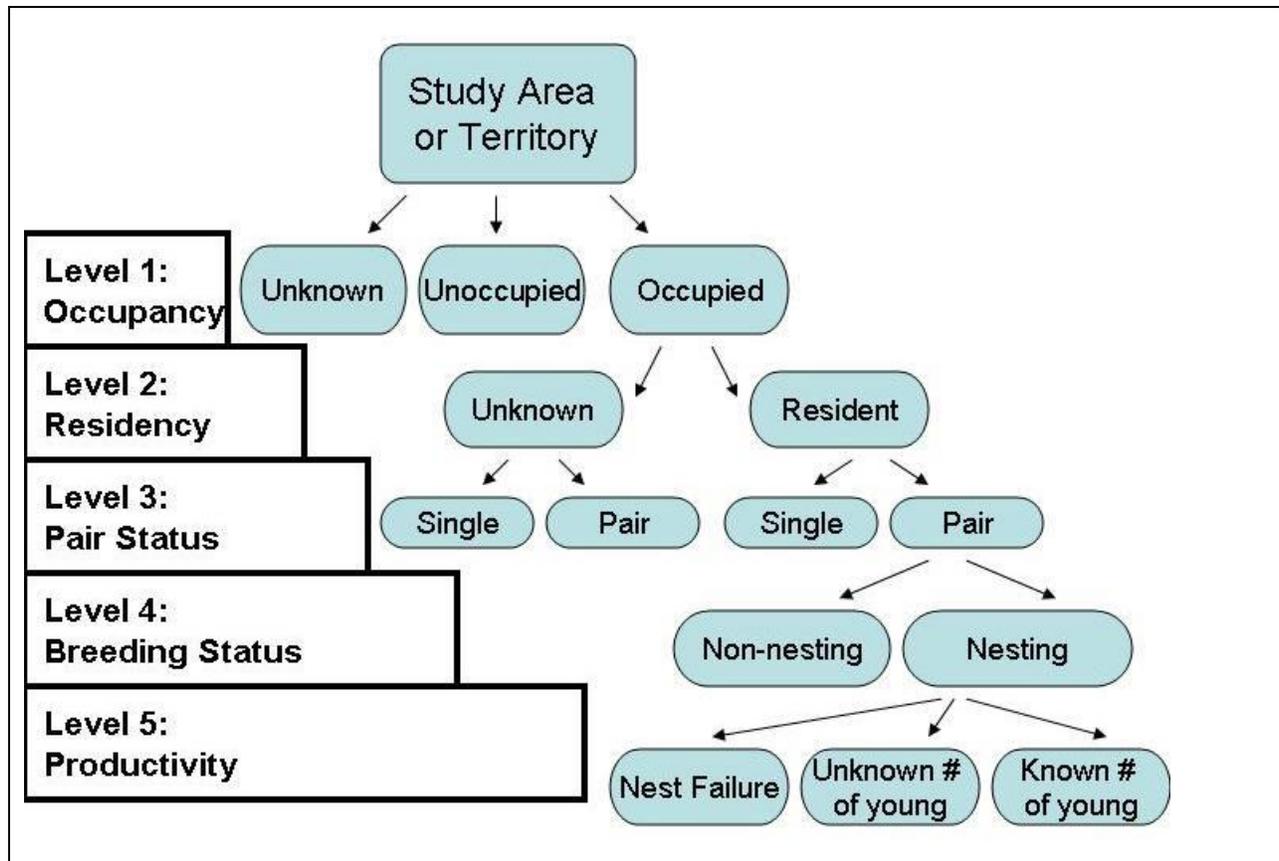


Figure SOP 3.1. The five levels of NSO territory status and study area designation.

1.1 Level 1 Occupancy Status

OCCUPIED: A survey area or site will be considered Occupied if at any time (within or outside of breeding season) a spotted owl is detected within the survey area or site (see Level 2).

UNOCCUPIED (UO): A minimum of 3 visits per year are required to establish that an area is Unoccupied (two-year survey; Marin Modified and PNW Protocol). This determination is based on a two-year survey. For example, if spotted owls are not detected at a site without previous historical data or the site has a gap in historical data, a two-year survey (min. three visits/yr) is needed. If no spotted owls are detected the first year, the site Occupancy status would remain Unknown (UK) until a second year of surveys confirmed that the site is Unoccupied.

UNKNOWN (UK):
Two definitions apply:

Definition 1: Applied to areas or territories with no historical site data in which no spotted owls were detected during the minimum three visits/breeding season. An Unknown status should be applied to the area until a second consecutive year of surveys has been completed. A second year of surveys (minimum three visits/breeding season) with no owl detections needs to be completed before the site is determined Unoccupied (UO).

Definition 2: Areas that have no spotted owl detections and that meet the minimum of three visit/year during the second year of surveys, but have an incomplete (<3 visits/breeding season) survey effort the previous year will be considered Unknown.

INCOMPLETE (IC): Applied to areas where fewer than three surveys occurred during a single breeding season and no spotted owls were detected. In these cases the overall status code would be Incomplete, Unknown (UK) would be used for pair status and Not Applicable (NA) for Nesting status and Reproduction status.

NOT SURVEYED (NS): Applied to areas that were not surveyed during the breeding season. Pair, nesting, and reproductive status would be Not Applicable (NA). Since status forms are not frequently completed if a site was not surveyed during the breeding season, a status of Not Surveyed is rarely used.

1.2 Level 2 Residency and Level 3 Pair Status

Occupied Resident:

PAIR (PR): A site will be considered occupied by a **Pair** if any of the following occurs:

1. Two marked individuals that have been paired in previous years are found alive on one or more occasions between March 1 and September 30 anywhere within a 1 mile radius of the traditional site center. There is no requirement that they be seen near each other, as long as they appear to be occupying the historical site. In cases where both pair members are confirmed alive within the historic range, but where one or both members are occasionally found roosting with other owls (not unusual in non-nesting years) we will usually classify the two historic pair members as a Pair.*
2. In cases where owls are unmarked or their bands are not seen, owls will be classified as a Pair if a male and female are heard and/or observed within 0.5 mile of each other on one or more day visits or on two or more night visits. Male and female locations do not need to occur on the same visit. For example, Pair status would be assumed if a male and female were heard one night, a female was heard another night, and a male on another night.*
3. A male takes a mouse to a female. To be called a spotted owl Pair the female must be either: 1) seen or, 2) heard giving definite spotted owl calls. Otherwise the site should be listed as occupied by a Pair of undetermined species composition.

4. A female is detected on a nest. If both she and the male are not seen (or heard giving definite spotted owl calls), then it should be called a Pair of undetermined species composition.
5. One or both adults are seen with young. To be called a spotted owl Pair, both adults must be seen, or the young must be seen late enough in the season to examine their plumage to insure they are not hybrids.
6. If juveniles in advanced stages of plumage development are observed such that you are sure as to their species (a trained observer can identify hybrids once the feathers on the breast and abdomen develop in late July and August).

Because of the potential for hybridization, it is becoming increasingly important to confirm the identity of both pair members. In the case of females heard on the nest, you need to be aware that the contact calls of female barred owls and spotted owls are essentially identical. Thus, if there is any suspicion that barred owls are in the area, you should definitely return to the site to confirm the species of the female. (Marin Modified and PNW Protocol)

**NOTE that USFWS protocol defines pair status a little differently in terms of the first and second criteria of the PNW and Marin Modified Protocols (USFWS below):*

1. *A male and female are heard and/or observed (either initially or through their movement) in proximity (<1/4 mile apart) to each other on the same visit....*

RESIDENT SINGLE (RS):

Resident Single status is established by the presence or response of a single owl within the same general area on three or more occasions during a breeding season, with no response by an owl of the opposite sex after at least three complete surveys. Multiple responses by single owls in the same general area over several years are also acceptable for defining Resident Singles. (two or more responses in one year and one or more responses in another year should constitute a Resident Single). Determining if responses occur within the same general area should be based on topography and the locations of adjacent owl activity areas.

If a single owl is detected, at least two additional visits should be conducted to determine if a pair is present. These visits should all take place during the breeding season in which the first response is heard. (Marin Modified, PNW, and USFWS Protocol)

Occupied Unknown

PAIR UNKNOWN (PU): Two owls, pair status unknown. The presence or response of two owls of the opposite sex where pair status cannot be determined and where at least one member must meet the resident single requirements *or site had pair occupancy the previous breeding season*. (USFWS protocol; *Marin 2007 addition*)

SINGLE UNKNOWN (SU): The response of a male and/or female which does not meet any of the above category definitions (USFWS protocol for Unknown Status). Also included would be

cases where owls could not be sexed based on responses and/or unbanded non-vocal owls. Owls cannot be positively sexed based on barking and contact calls. Sex should be considered unknown until a sexable call such as a four note location call or series hoot is detected.

1.3 Level 4 Breeding/Nesting Status

Nesting status surveys may be conducted from April 1 - May 31 in Oregon and California and April 1 - June 15 in Washington or at high elevations in Oregon. However, if females are detected on the nest prior to these dates, then those visits can be counted as well. To avoid missing a late nesting attempt it is important that visits not all take place in early April. If early visits do not provide evidence of nesting, at least one visit should take place after April 15 in California and Oregon and May 1 in Washington and at higher elevations in Oregon. Species of the male and female must be clearly established to avoid any possibility of confusing hybrids and spotted owls.

To minimize mousing use additional visits, extensive searching and careful observation of owl behavior to locate nests. Inspect likely platforms and look for feathers plucked from the brood patch which are often visible around the edge of the nest. If nesting is suspected but the nest cannot be located, use the mousing protocol to locate the nest.¹

Mousing: One of the techniques used to assess nesting status will be to feed live mice to owls and then observe the owls to see what they do with the mice. Protocol for this procedure is as follows:

1. Locate one or both members of a pair during the day and offer them at least four mice. Allow at least a 5-minute pause between mousing attempts. Describe what the owls do with each mouse (eat, ignore, cache, carry to nest, etc.). If only a single owl is located, the same protocol is followed. If you are unsure whether a mouse was eaten or cached, but are sure that it was not carried to a nest or young, be sure to so indicate. In other words, don't just record that you have no idea what happened to a mouse when you are sure that it was not taken to a nest or to young owls.
2. If the owl(s) cache mice or simply roost with a mouse for prolonged periods, then it is okay to stop mousing after three mice are fed.
3. If an owl takes a mouse and flies away, follow it as closely as possible to determine where it takes the mouse. If you are unable to follow the owl, and don't know if it took the mouse to a nest or fledged young then that mouse should not be counted towards the requirements of the protocol. Be ready to run, as owls sometimes carry mice several hundred yards to reach their nests or young.

In order to avoid habituating owls to humans, do not feed any more mice than necessary to determine nest location and nest status.

NESTING PAIR (NP): Owls will be classified as a Nesting Pair if any of the following are observed:

¹ This statement is added to clarify the methods for locating nests.

1. A female is detected on a nest or either a male or female carries prey into a nest on two or more occasions within the dates specified above. After April 15 in California and Oregon and May 1 in Washington, nesting may be confirmed on the basis of only one occasion where a female is observed on a nest or when a male or female carries prey into a nest. The two-visit protocol for confirmation of nesting is dropped after the specified dates because there is little chance owls will continue to "play house" (i.e., sit in the nest without actually laying eggs) after the first two or three weeks of the nesting period. All fecundity monitoring sites in Marin County should be should be visited between April 15 and May 1 to determine nesting status.²
2. A female possesses a well-developed brood patch when examined in hand during April 1 - June 30. Presence of a small bare area or molting feathers on the abdomen should not be counted as a brood patch. This is a judgment call. When in doubt use other criteria such as results of mousing or observations of roosting. Describe the brood patch, including dimensions and visual appearance of skin.
3. Young owls are observed in the presence of at least one adult. Because of the possibility of hybridization, an effort should be made to confirm identity of both parents, although this will not be absolutely required if the species of juveniles can be conclusively determined. Always examine juveniles carefully to make sure that they are not juvenile barred owls or hybrids.
4. Spotted owl eggs, eggshells or remains of nestlings are found in or under a nest.

NON-NESTING (NN): Confirmation of Non-Nesting status must take place before June 1 in California and Oregon and June 15 in Washington. The June 15 cutoff may also be used at higher elevations in Oregon if deemed biologically appropriate. With these cutoffs, some pairs will inevitably be classified as Non-Nesting, when they in fact nested and failed. This means that estimates of the proportion of the population that nests may be somewhat underestimated because the estimate will include some pairs that nested and failed early in the season.

To classify a pair/female as Non-Nesting, the four-mouse protocol should be conducted on one or both members of the pair with no evidence of nesting on at least two occasions. At least two mice must be taken to be considered a valid mousing attempt.

If visits to document nesting are made in April they should be at least 3 weeks apart so that late nesting attempts will not be overlooked. Visits to determine nesting status in May or early June may be done at any interval, including consecutive days. One-day intervals between nesting visits are permissible later in the season because there is little chance that a late nesting attempt will be overlooked during that period.

² This statement is added for Marin County surveyors in order to maximize our chances of determining Non-Nesting status based on observing roosting females (See #3 under Non-Nesting Status).

Pairs or single females that are not checked at least twice before June 1 in California and Oregon and June 15 in Washington should be listed as "nesting status unknown". Exceptions to this two-visit protocol are:

1. Female does not possess a brood patch when examined in hand between April 1 and June 15. (If this occurs, non-nesting status can be confirmed based on 1 visit.)
2. Females believed to be Non-Nesting based on one visit between April 15 and June 1, and which then cannot be located despite repeated return visits to the area. Cases like this are not uncommon in poor nesting years, when pairs briefly return to their traditional nest areas, then split up and become difficult to locate.
3. Females observed roosting for 60 minutes or more between April 15 and May 1³, showing no sign of attachment to a nest or young, may be classified as Non-Nesting based on a single visit. Females should normally be incubating eggs or brooding young during this period. This technique should not be used for confirmation of nesting after May 1, as it is common for females with well-developed nestlings to remain out of the nest for prolonged periods. When possible complete a second non-nesting confirmation visit to make sure.

NEST FAILURE (NF): (No young are produced)

All nesting outcomes in Marin County are based on the view into the nest. Nests where the female is visible when incubating eggs are classified as “visible nests”. Nests with no view into the nest are called “non-visible nests”. Once a nest is located, weekly visits are required to observe activity on the nest such as females incubating or nestling activity. Visits near the expected fledge date are especially important. Spotting scopes and extended periods of observation are used on all nests. Detailed notes about the presence or absence of whitewash at the base of the nest tree are needed to support the following conclusions.

- A **visible** nest is classified as a Nest Failure if, after positive confirmation of nesting there is no female incubating or nestling activity observed at the nest. Two additional visits are required to ensure that no nestlings were obscured and that no nestling fledged between visits.
- A **non-visible** nest is classified as a Nest Failure if the nest is visited on 3 occasions near the expected fledge date and no fledglings are observed. The third visit should be a mousing visit (4 mouse protocol with at least 2 mice taken to qualify as a test).⁴

³ The PNW Protocol requires that a female be observed for 30 minutes between April 15 and May 15. The length of observation has been changed to 60 minutes because nesting females have been observed off the nest for longer than 30 minutes in the mild climate of Marin. The dates have been changed to April 15 - May 1 because it appears that this is the 2-week window in Marin when all females will be either incubating eggs or brooding chicks that are less than 2 weeks old. Both changes are attempts at being as conservative as possible because we are relying mainly on this method for determining non-nesting.

⁴ The PNW protocol requires that failed nests are confirmed with either two mousing visits (at least two mice eaten or cached), previously nesting owls cannot be relocated, or a combination of the two. The modification to this is an effort to capitalize on the fact that most of the nests in Marin County are platform nests and can be observed with a

1.4 Level 5 Productivity

NESTING: YOUNG PRODUCED (NY):

This measure of reproduction is the most important measure, as it is the basis for estimates of fecundity. The Number of Young produced is averaged for all females whether they are paired or not. Because fecundity is sometimes subdivided by age class (S1, S2, adult) it is critical that age of each male and female be determined, even if that requires repeated visits to document.

The measure of reproduction is the number of young which leave the nest. It is not permissible to count "branchers" (i.e., young owls sitting on branches in the nest tree) unless you are sure that there are no other young hidden in the nest. The concern with counts of branchers is that you may overlook young that are still hidden in a nest.

Pairs or single females (visible and non-visible nests) will be classified as producing no young if:

1. They are confirmed to be non-nesting based on protocols for determination of nesting status (above).
- ~~2. They are moused to protocol on 2 or more occasions before 31 August, with no sign of young. This may include any combination of reproductive status visits and/or fecundity visits. For example, if a single visit in late May suggests no young produced (e.g., adults eat or cache all mice) this could be combined with a single visit later in the summer which also indicates no young produced.~~
3. Female is observed and designated as non-nesting on one or more occasions in April-May (April 1 -June 15 in Washington), but neither she nor her mate can be relocated later in the summer, despite repeated attempts (minimum of two) to relocate them. As a result, they cannot be moused to determine numbers of young produced. This change to the protocol is needed to address the behavior of some non-nesting owls or owls that nest and fail - they sometimes become difficult to locate and cannot be confirmed as having produced no young.

The number of young produced is determined as follows:

A pair is classified as producing young if at least one fledgling owl is observed; observations of nestlings or branchers do not count. For pairs that produce young, brood counts may take place anytime after the young fledge until August 31. However, a determined effort should be made to count the number of young produced as early as possible after broods fledge, preferably before June 30 in Oregon and July 15 in Washington. The objective is to document the number of young produced before any mortality occurs.

scope. In addition, our required weekly visits to visible nests make it less likely that young can fledge without being observed. The requirement to search under the nest tree for evidence is based on observations that there is usually a large amount of whitewash produced by the young before they can fly well and move away from the nest tree. Note there is still a mousing requirement for non-visible nests that are suspected of failing.

~~After the first occasion when young are counted, at least one follow up visit should be made to insure that all young were observed on the first visit. If owlets are found under a known or suspected nest tree in late May or June, then the follow up visit to confirm the number of young fledged should take place at least 3 days later to make sure that all young have time to leave the nest. In all other situations, the 3 day interval between the first and second visit is not required (i.e., visits can be as close as 1 day apart).~~

~~To estimate the number of young produced you should offer 4 mice to one or both adults on both visits, and count the maximum number of owlets that are seen or heard. A visit counts for determination of number of young produced, as long as an adult takes at least 1 of the 4 mice offered.~~

For pairs that produce young, brood counts occur during the weekly nest visit which first detects all nestling owls out of the nest. The objective is to document the number of young produced before any mortality occurs. All young owls observed in visible nests should be located again once they are out of the nest. Use prompt timing of visits and extensive search efforts to locate young close to the nest tree. Look for evidence such as whitewash trails or parental behavior to provide clues about the location of recently fledged owls. Listen for the fledgling begging whistle which can be very helpful for locating and clarifying the number of fledglings. The closer to the expected fledge date, the closer the fledglings will be to the nest tree and the smaller the search area.

For **visible** nests, the brood count will be defined as the number of young observed both in the nest and after they leave the nest. This number must match on two visits or a mousing visit is required.

For **non-visible** nests, visit the nest as close as possible to the estimated fledging date and follow the guidelines below. If a definitive fledgling count cannot be obtained from observation, use mousing to verify.

If **zero** fledglings are observed, a total of three visits are required near the estimated fledging date with mousing on the third visit (four-mouse protocol).

If **one** fledgling is observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.

If **two** fledglings are observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.

If **three** fledglings are observed, this number must be verified on another visit. The highest number of fledglings between the two visits will be the number fledged.⁵

⁵ The PNW Protocol requires that both counts of fledglings are estimated by offering the adult(s) 4 mice. The modification to this is again an effort to capitalize on the large number of visible platform nests. It is possible that we could undercount fledglings without the use of mice. However, the fact that we are checking the nests weekly

If dead owlets are found under a known nest tree they will not be counted as fledged unless there is some flight feather development.⁶

2.0 Status Designation Database Fields

For each spotted owl site monitored, Occupancy status, Nesting status, and Reproductive status designations are assigned in the database to represent the highest level of knowledge of that site for that year for each category. A Final status determination represents the highest degree of each of these three categories. The status designations are entered into the master database using two letter codes, noted below in parentheses.

Final Status (database field “Status”) possibilities include:

- Survey Incomplete (IC)
- Not Surveyed (NS)
- Unoccupied (UO)
- Unknown (UK)
- Resident Single (RS)
- Single Unknown (SU)
- Pair (PR)
- Pair Unknown (PU)
- Nesting Pair (NP)
- Non-Nesting Pair (NN)
- Nesting Failure (NF)
- Nesting: Young Produced (NY)

Occupancy Status (database field “PAIRSTAT”) possibilities include:

- Not Surveyed (NS)
- Unoccupied (UO)
- Unknown (UK)
- Resident Single (RS)
- Single Unknown (SU)
- Pair (PR)
- Pair Unknown (PU)

Nesting Status (database field “NESTSTAT”) possibilities include:

will allow us to locate more fledglings before mortality occurs. Note that mousing is used if multiple counts are not matching or if the second count is less than either the first count or the number of nestlings.

⁶ The PNW Protocol Addendum states that all young found dead on the ground are to be counted as fledged regardless of their position relative to the nest tree. The modification is added to address immature young which have either fallen or been preyed upon and ended up under the nest tree. The majority of nests in Marin County are platform nests and more young may fall from these nests before fledging. These young have no chance of survival (and may have been dead when they hit the ground) and should not be counted as fledged.

- Not Applicable (NA) – Survey Incomplete (IC) or Occupancy status is determined as Not Surveyed (NS), Unoccupied (UO), Resident Single (RS) (male), or Single Unknown (SU)
- Unknown (UK) – Nesting Status of owls cannot be determined according to protocol or Occupancy status is Unknown (UK) or Pair Unknown (PU)
- Nesting Pair (NP)
- Non-Nesting Pair (NN) – applicable for owl pairs and Resident Single (RS) females

Reproductive Status (database field “REPROSTAT”) possibilities include:

- Not Applicable (NA) –Occupancy status is determined as Survey Incomplete (IC), Not Surveyed (NS), Unoccupied (UO), Resident Single (RS) (male), or Single Unknown (SU)
- Unknown (UK) –nesting is confirmed but reproductive status of owls cannot be determined according to protocol or when Nest Occupancy status is unknown
- Nesting Pair (NP)
- Non-Nesting Pair (NN) – applicable for owl pairs and Resident Single (RS) females
- Nesting Failure (NF)
- Nesting: Young Produced (NY) – fledglings must be observed; nestlings and branches do not count

The database status records also note the annual status for each site as determined by the USFWS and PNW protocols. Determinations of the USFWS and PNW status designations may differ from the status designation determinations based on this SOP and therefore must be referenced for accuracy. Database codes are not used for these status designation fields.

Available status designations according to the USFWS protocol (database field “USFWSSTAT”) include:

- Survey Incomplete
- Not Surveyed
- Unoccupied
- Unknown
- Resident Single
- Pair
- Pair Unknown
- Nesting Pair
- Non-Nesting Pair
- Nesting: Young Produced

Available status designations according to the PNW protocol (database field “PNWSTAT”) include:

- Survey Incomplete
- Not Surveyed
- Unoccupied
- Unknown

- Resident Single
- Pair
- Nesting Pair
- Non-Nesting Pair
- Nesting Failure
- Nesting: Young Produced

Note that Single Unknown is not a permissible status designation for the USFWS and PNW protocols. Nesting Failure is not an option under the USWFS protocol, and Pair Unknown is not an option under the PNW protocol. The field “MARINSTATUS” is the text equal to the code in the “Status” field and may be used as a comparison to the USWFS and PNW status designations.

During spotted owl inventory years, the USFWS protocol has been and will be used for all status determinations.

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SOP 4. Data Management Handbook

Version 1.2

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
	Aug. 2000	Daniel George			
	Aug. 2004	Dawn Adams			
	Sept. 2007	Dawn Adams	Reformatted	To meet new formatting guidelines.	1.0
1.0	May 2008	David Press	Edited and updated	More thorough documentation and implementation of new data management strategies	1.1
1.1	March 2010	David Press	Minor text and formatting edits. Added Literature Cited section. Converted database object descriptions to table.	In preparation for final protocol submission	1.2

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Two critical long-term goals of the San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program (I&M) are to:

- integrate natural resource inventory and monitoring information into National Park Service (NPS) planning, management, and decision making
- share NPS accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives

For the northern spotted owl (NSO) monitoring program to meet I&M Program goals, a detailed management plan is needed to ensure data quality, interpretability, security, longevity and availability.

This SOP describes how the monitoring protocol meets these data management objectives through data entry specifications, database design, quality assurance and control measures, metadata development, data maintenance, data storage, and data archiving. In this SOP, particular attention is paid to the procedures all project staff must follow to learn how to enter, update, and manage data for the NSO monitoring database. Procedures for data handling and quality assurance/quality control for all monitoring protocols implemented by the SFAN monitoring program are detailed in the program's Data Management Plan (Press 2005).

1.0 Database Design

The NSO monitoring program has continued the use of a monitoring database developed in 2000 prior to incorporation within the I&M Program. The database is maintained in MS Access XP with similarities to the design concept of the Natural Resource Database Template (NRDT), an application developed by the NPS Natural Resource Inventory and Monitoring Program. As with the NRDT, data organization is based on the concept of a survey, or event, occurring at a specified date, time, and location, in this case a spotted owl territory, which is further described in a locations table. The project database does not comply with NRDT standards because not all core tables and naming conventions are utilized. However, the database has served the project staff well, and there are no current plans to convert the database to meet NRDT compliance.

The program database consists of a single master database, titled NSOMASTERXP, which contains all tables, forms, queries, and reports. Satellite databases are created at the beginning of each season for each project team, including Golden Gate National Recreation Area (GOGA), Point Reyes National Seashore (PORE), and PRBO Conservation Science (PRBO). The satellite databases retain the structure of the master database, but with the field data tables left empty. At the end of the field season, the satellite data are uploaded into the master database, archived, and copies of the master database are distributed back to the project teams.

Figure SOP 4.1 shows the relationships among the core tables in the database. Data related to the area surveyed, which can be an existing territory or potential habitat, are entered into the SEARCH table. The SEARCH table is the primary data table, equivalent to tbl_Events in the NRDT. Multiple survey events can be associated with one territory location. If owls are observed

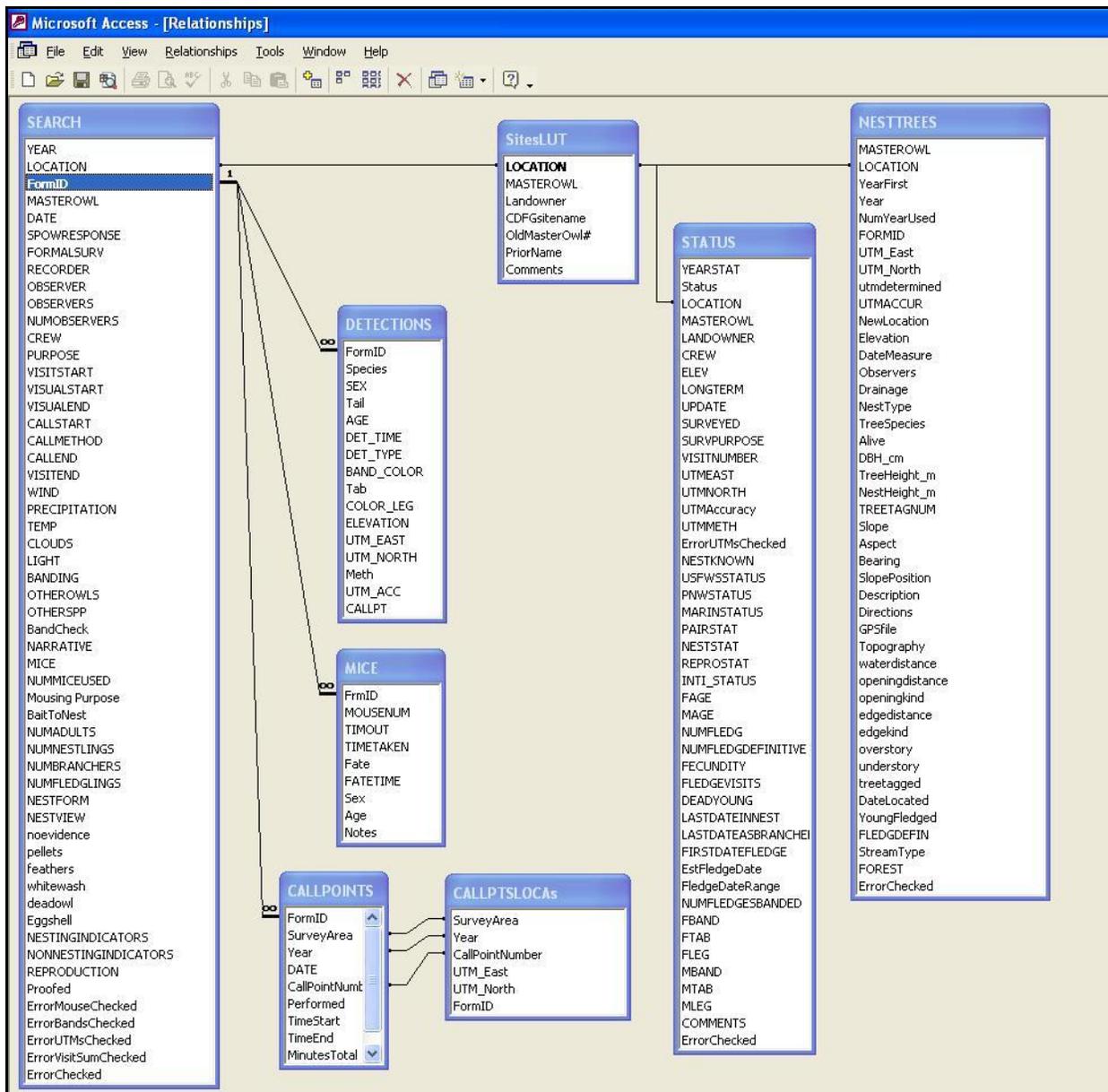


Figure SOP 4.1. Relationships among the NSOMASTERXP.mdb database core tables.

during the survey, details are recorded in the DETECTIONS table. Detection information collected includes UTM coordinates (via GPS if possible) for each owl species. Data are also recorded if no owls are observed so that negative survey results are tracked. If mice are used during the survey, details on how long each mouse is offered and disposition of mouse is recorded in the MICE table, which is linked to the SEARCH table. If the survey is for inventory purposes or in a new territory, call points may be used during the survey. Information on call points and their UTM coordinates are recorded in the CALLPOINTS and CALLPTSLOCAs tables. The SEARCH table is linked to the DETECTIONS, MICE, and CALLPOINTS tables by the unique FormID field in one-to-many relationships. The FormID is an eight-digit number

sequentially assigned to each field form based upon the survey year and the crew that performed the survey. See SOP 2: Standard Field Procedures for more details.

If a nest is observed at a territory, field data collected at the end of the season on the nest location and nest habitat are entered in the NESTTREES table. Nest tree data are entered for each site where nests were located each year, even if a nest is re-used within a particular territory.

Additional tables include OWLBANDS which stores data on all the banded owls within the survey area (approximately 110); and the STATUS table which stores site and year summary data created at the end of the season after reviewing all the detection information gathered at each activity site.

1.1 Tables

If a table's title is in all capital letters it is a core table essential to the operation of the database. Look-up table are noted with "LUT" at the end of each table name. Altering the title or field names will require additional edits to associated forms, queries, and possibly macros. Additionally, any changes made to table design within a satellite database may cause errors in the process of appending records to the master database. As such, only the SFAN Data Manager should perform edits to the core database structure, with thorough documentation of the changes made. Complete database table descriptions are provided in Table SOP 4.1.

1.2 Queries

If a query's title is in all capital letters it is a core table essential to the operation of the database. Altering the title or field names will require additional edits to associated forms, queries, and possibly macros. If the core queries are edited or deleted, the database may no longer be able to group data in ways that some forms require. Additionally, any query with the word "ERROR" in the title may depend on other queries with the word "ERROR" in the title or may be used by a macro, and making changes may require changes in other queries or macros. As such, only the SFAN Data Manager should perform edits to the core queries, with thorough documentation of the changes made. Database query descriptions are provided in Table SOP 4.2.

1.3 Macros

Macros represent custom strings of commands. Almost all of the macros in the database are commands performed when different buttons in the database are used. Database macro descriptions are provided in Table SOP 4.3.

1.4 Forms

All of the forms in the database are essential to the operation of data entry. Those in all capital letters are primary forms, those in lowercase either provide functions within the primary forms or perform secondary functions like printing. Database form descriptions are provided in Table SOP 4.4.

Table SOP 4.1. NSO monitoring database table descriptions.

Database Table Name	Description
BandColorLUT	Look-up Table which has all Band Colors already entered. Used by the Detection subform within the SITESEARCH form and by the BANDING and STATUS forms.
BlankDatasheet	Used to create dummy fields for PrintBlank forms.
CALLPOINTS	Where data are stored for call points which are performed. Data entered into the CallPtPerformSubForm, a subform of the SITESEARCH form, are stored in this table.
CALLPTSLOCAs	Where data are stored for the UTM locations of call points. Data entered into the CallPointSubForm, a subform of the InventoryCallPoints form, are stored in this table.
DETECTIONS	Where data for individual “Owl and other raptor detections” are stored.
InitialsLUT	Where data are stored for observer initials. New records are created from the “Initials” form which comes up when the “Update Observers’ Initials LUT” button is used.
LandownerLUT	Lists codes for Marin County landowners. Used by the Combo-box for the “Landowner” field on the STATUS form and in the SitesLUT table.
LookUp	Home for a series of codes used by many combo-boxes in all forms.
MICE	Where data are stored when mouse offer records are entered in the “MouseSub” within the SITESEARCH form
NESTTREES	Where data are stored for all nest tree records entered in the NESTTREES form.
OWLBAND	Where all band records are stored when data are entered in the BANDING form.
SEARCH	Where data entered into the SITESEARCH form are stored. The SEARCH table is the database’s primary data table. It contains the FormID number, location, date and observer information, visit times, conditions summary, visit summary and narrative fields. Data entered into the subforms are stored in DETECTIONS, MICE, and CALLPOINTS sub-tables. The SEARCH table has a one-to-many relationship to the sub-tables, joined by the FormID, allowing variable numbers of records in the sub-tables to be associated with one site visit.
SitesLUT	A list of locations and owl activity site numbers (MRN#) used by several combo-boxes. The MRN# site numbers are assigned by the California Department of Fish and Game. Also contains records for previous names or numbers used at the activity site. Assists in keeping records standard.
STATUS	Where data entered into the STATUS form are stored. Contains a summary of an activity site’s survey results for a given year.
StatusLUT	Contains a list of Status codes used by combo-boxes in the STATUS form. Assists in keeping records standard.
Suggestions	Contains a memo field for database users to record suggestions or observations about the database. Used by the “Suggestions” form.

Table SOP 4.2. NSO monitoring database query descriptions.

Database Query Name	Description
1IDFINDER	Used by the "idchooser" combo-box on the WELCOME form to query all FormID numbers in the database and order them in descending order to allow the database user to choose which form to print.
2RECORDREVIEW	This is the record source for the "SiteSearchByDate" form. It sorts records by ascending dates for ease of viewing.
3STATUSBYYEAR	This is the record source for the STATUS form. It sorts records by location in ascending order and by year in descending order for ease of viewing in the master database
CALLPTSLOCASORTED	This is the record source for the CALLPTSLOCAs form and sorts records by the survey area, year, and station number for ease of viewing.
ERRORCHECK	Any query with a title that begins with these letters is a key component of standardized error-checking procedures. ERRORCHECK queries are described in detail in Section 4.0 Data Verification and Validation Procedures.
JOINER	Any query that begins with these letters joins tables together in preparation and for use in another query.
SUM	Any query which begins with these letters is designed to summarize data.

Table SOP 4.3. NSO monitoring database macro descriptions.

Database Query Name	Description
AutoExec	This macro automatically executes on the opening of the database. It opens the WELCOME form, closes all form toolbars and maximizes the WELCOME form.
Close	All macros in the owl database which begin with the word "close" perform commands to close forms when buttons in the associated form called "Close" are clicked.
InitialsNew	Forces the Initials form to go to a new record when it is first opened.
Open	All macros in the owl database which begin with the word "open" perform commands to open forms when buttons such as those in the header of forms called "All Visits," "Band Data," "Nest Info," or "Status" are clicked.
RefreshWelcome	This macro is run when the small button on the right of the idchooser on the WELCOME form is clicked. It closes the WELCOME form and reopens it, forcing the query which generates the list of FormID numbers available to re-run.
REVIEW	When macros with this in the title are run, forms will open with records, which need to be error-checked.

Table SOP 4.4. NSO monitoring database form descriptions.

Database Table Name	Description
AboutSSF	This form describes the fields and appropriate entries for the SITESEARCH form. Opened by the "About Site Search Form" at the top left of the SITESEARCH form.
AboutSSF2	A continuation of the "AboutSSF" form. Opened by the "More Descriptions/Definitions" button at the bottom of the "AboutSSF" form.
AboutStatus	This form describes the fields and appropriate entries for the STATUS form. Opened by the "About Status Form" button at the top left of the STATUS form.
BANDING	Form for the entry of Banding data sheets (not used since termination of banding program in 2003).
blanksheets	This form is a menu of options for printing blank forms.
CallPointSubForm	Form with the title "Spotted Owl Inventory Call Point Location UTM's" at the top. Data entered into this form are stored in the CALLPTSLOCAs table.
CallPtPerformSubform	Used within the SITESEARCH form for the entry of the level of effort performed at inventory call points on a given visit. Data entered into this subform are stored in the CALLPOINTS table.
Detection Subform	Used within the SITESEARCH form for the entry of owl and other raptor detections. Data entered here are stored in the DETECTIONS table.
Initials	The form in which the names and associated initials of observers can be entered. Data entered into this form are stored in the "InitialsLUT" table.
InventoryCallPoints	The form into which inventory call point UTM's can be entered and which appears when the "Enter Point UTM's" button is used on the SITESEARCH form. Data entered into this form are stored in the CALLPTSLOCAs table.
MouseSub	This is the subform within the SITESEARCH form into which "Mousing Effort" records can be entered. Data entered into this form are stored in the MICE table.
NESTTREES	The form into which the Nest Site Habitat Data field form can be entered. Data entered into this form are stored in the NESTTREES table.
PrintBlankInventory	This form is designed to generate a blank inventory form when printed.
PrintBlankSiteInvestigation	This form is designed to generate a one-page blank site search form when printed. This form may be used for incidental records and informal surveys
PrintBlankSiteSearch	This form is designed to generate a two-page blank site search form when printed. This form may be used for times when surveys are performed by those without ready access to a computer with the database installed.
PrintNarrative	This form is designed to print out the narrative of a given record and is only opened from the WELCOME form.
PrintSiteInvestigation	This form is designed to print out a one-page version of a given record. It can only be used for site visits during which there was no mousing effort and is only opened from the WELCOME form.
PrintSiteSearch	This form is designed to print out a two-page version of a given record. It has enough space for the mousing records and is only opened from the WELCOME form
PrintSub	These forms are used by the "PrintBlank" forms to generate empty fields within the detections, mouse, and call point sub-forms.
SITESEARCH	The form with the heading "Northern Spotted Owl Site Search Form." Data entered into this form are stored in the SEARCH table. The form contains master fields (FormID at a minimum) which are automatically entered into child fields in the subforms. Records are ordered by FormID each time the form is opened.
RECORDREVIEW	The form with the heading "All Records For One Location." This is essentially the same form as the SITESEARCH form, but its record source is the query SEARCHBYDATE. The query sorts records by the date field. This form is opened by the button for Site Search Records within the "RECORD REVIEW" section of the WELCOME form, allowing the database user to see all records for one site in

Database Table Name	Description
	the order of the visits.
STATUS	The form with the heading "Site Status and Activity Center." Its record source is the query STATUSBYYEAR and data entered into the form are stored in the table STATUS.
Suggestions	A simple form allowing database users to record problems or suggestions in their use of the database. Data entered into this form are stored in the "Suggestions" table.
WELCOME	The form with the heading "Marin County Spotted Owl Database" from which the user can navigate to different forms within the database.

2.0 Data Recording and Entry

2.1 Data Recording

Data recording procedures are detailed in SOP 2: Standard Field Procedures, including data form examples and database field descriptions (Site Search Form, Nest Habitat Data Form, and Status Form). Primarily, recording is done in the field using a Site Search data form (preferred) or field notebook. Although the observer should complete the site search data form, if time constraints occur, a minimum set of information is required for all field visits: the location or site name, weather, start and end time, a description of the area covered, annotated field map, purpose of survey (e.g., "Purpose of visit is to locate male and determine his band and age" or "Purpose of visit is to confirm reproductive success with second fledgling count"), and results of visit.

A Nest Site Habitat data form should be filled out for each nest found during the season. Although the nest site form can be filled out at any point during the season, observers should consider the nesting activities before embarking on the habitat survey since it can take up to 30 minutes to complete depending on the site.

2.2 Additional Spotted Owl Data Files

Additional temporary data files which are useful to program administration, site visit tracking, and site status, should be created annually in either MS Excel or MS Word:

2.2.1 Site Visit Table

This table is used throughout the season to keep track of the progress at each site. The chart will indicate the number of visits performed, the basic outcomes, and the accumulated knowledge about each site.

2.2.2 Form ID# Table

This table is used throughout the season to keep track of the FormID numbers assigned. Having this table will not only avoid duplicating or skipping numbers, but will become an excellent resource at the end of the year for tracking down stray data.

2.2.3 Band Tracking Table

This table is used to keep track of which bands are documented at which sites. This tool will help identify sites which require additional visits in order to read band combinations. Checking owls each visit will also help track if or when a new owl moves into a site.

2.2.4 Project Contacts

This table tracks program contacts including phone numbers and email addresses. Hard copies should be carried into the field at all times.

2.3 Data Entry

An electronic Site Search data form is required for all field visits and the electronic entry of the Nest Site Habitat data form is required for each nest with a known location. The blank Site Search data forms can be printed directly from the project database and filled out in the field, but if a field notebook is used, the electronic data form should be entered in the database within a week of the visit. This ensures that the information is still fresh and the observer can provide additional details to their notes, but most importantly it is insurance that if a field notebook is lost, the visit is documented elsewhere.

Per the SFAN Data Management Protocol, several QA/QC procedures must be followed by the database user (Press 2005). The database user must:

- Have a familiarity with the database software, database structure, and any standard codes for data entry that have been developed. Know how to open the data entry form, create a new record, and exit the database properly. Also, learn how to commit both a "field" entry and a complete record entry and correct mistakes made while typing.
- Enter or download data in a timely manner. All data should be entered or downloaded into the project database as soon as possible, preferably no less than once a week.
- Enter the data, one logical "set" at a time. Record in your notebook errors you know you have made or any questions that arise about the data content; these will be useful during data verification. Initial and date each paper form or field notebook entry as it is completed to avoid confusion about what has been entered and what has not with a different color than the data. Interrupt your data entry only at logical stopping points.

3.0 Annual Data Work Flow

The master database (NSOMASTERXP.MDB) contains all the site search, nest habitat and banding data collected since 1998. The SFAN Data Manager is responsible for managing the owl database and assisting the project biological technicians with any database issues.

3.1 Satellite Databases

Satellite databases are created at the beginning of each season and parallel the structure of the master database. The satellite data tables are blank except for the STATUS, NESTTREES and OWLBAND tables, which should contain the entire available project data collected thus far for reference purposes. The Welcome Form is renamed for the year to help indicate that it is a satellite copy. Satellite databases are provided to GOGA, PORE, and PRBO Conservation Science for use in entering data during the owl field season. The databases are provided in MS Access XP format.

Satellite databases should be backed up regularly during the course of the season. CDs or zip disks are a great option if available. If the database is located on a local area network, regularly copy the database to an archive on the network, on your hard drive, or both. File names of back-up databases should include the date of the back-up, such as:
GOGA_SPOW_2010_Satellite_040110_BackUp

Each team entering data into a satellite database is responsible for proofing their database entry and sending their complete satellite database and hardcopies of all field forms and maps for each site visit to the Lead Biological Technician by August 15th of each season for final review. See Section 4.0 Data Verification and Validation Procedures for more information.

3.2 Uploading Annual Data to the Master Database

The SFAN Data Manager incorporates all the satellite databases, including the PRBO database, into a single annual database and completes additional error-checking queries at the end of the season in coordination with the biological technicians. When complete, the Data Manager imports the annual dataset into the master database, appends the data to the appropriate tables, archives the annual dataset, and distributes the updated master database back to PORE, GOGA, and PRBO Conservation Science.

3.3 Archiving the Annual Data

Following all error-checking and proofing, all site survey forms are printed, attached to the corresponding field map for each site visit, and placed in a binder for that year. Included in the binder are a hardcopy of the annual report, any larger maps that were printed, and a CD containing a copy of the complete satellite and NSOMASTERXP databases and electronic annual report. Any paper datasheets completed in the field are cataloged in a separate binder. The binders are submitted to the PORE Curatorial Manager two years after the field season to allow for ease of access to field maps by subsequent field staff (e.g., the 2007 data are archived in 2009).

3.4 NSO GIS Shapefile

Each year a GIS shapefile of point data is created for all NSO activity centers monitored in all years in Marin County, including the data collected that field season by both the NPS and PRBO. The shapefile includes year, location name, MRN#, occupancy status, reproductive status, and other fields. The attributes are taken from the STATUS table of the monitoring database. A metadata record for the shapefile is created as described in Section 6.0 of this SOP.

3.4.1 Creating a GIS Shapefile

Using the project database (NSOMasterXP.mdb), a make-table query is used to begin records for a new shapefile for all monitoring years. The make-query query transfers fields from the STATUS table into a new database table titled "BIOS REPORT", which can then be exported in DBF format. In ArcMap (ESRI 2009), select the Add XY Data option under the Tools menu, then navigate to the DBF file containing the BIOS REPORT table fields. In the Add XY Data window, choose UTM EAST for the X field and UTM NORTH for the Y field. Set the coordinate system (Projected Coordinate Systems>UTM>NAD 1983>NAD 1983 UTM Zone 10N.prj), and select OK. The table will now appear as a data source.

To create a new shapefile from the imported table, right click on the SPOW data layer in the display window. Select Data>Export data. In the Saving Data window, keep the default options, select a location for the shapefile, and rename the file (e.g., marin_spow_sites_1999_2009.shp). The shapefile can now be queried for different years, status outcomes, etc.

Use the previous year's XML metadata record and text metadata record to create both metadata records in both formats for the current year's shapefile. Make sure that dates and contact information are up-to-date. The XML file may be edited by using ArcCatalog or the NPS Metadata Tools and Editor.

3.5 Annual Report and Data Submission

Once the annual report has been completed, the report is posted to the SFAN website and a record is cataloged in NatureBib. See SOP 5: Data Analysis and Reporting for more information. All project data are also submitted to the Biogeographic Information and Observation System (BIOS) data access system, maintained by the California Department of Fish and Game. Directions for creating the BIOS GIS shapefile and associated metadata records are provided in Section 3.4.1. The annual GIS shapefile and metadata should be copied to the PORE GIS directory for internal NPS use.

4.0 Data Verification and Validation Procedures

Ideally two people can participate in the data verification with one person reading the original out loud to another person looking at the computer monitor to verify that the two records match. If only one person is available, they should have any field notes or data forms in front of them.

4.1 Site Search Form

4.1.1 Data Verification

The first step in the process of assuring quality data is to have the recorder re-read the data. This should be done either on the same day that the data were entered or just before beginning new data entry. The field teams should review their data prior to submitting the satellite databases to the Database Manager.

General Procedure:

- 1) Scan all fields to make sure all have been filled in.
- 2) Review date field for accuracy.
- 3) Sort search times in sequential order to make sure they do not contain unlikely values.
- 4) Ensure that "SPOW Response" matches evidence in the detections.
- 5) Ensure that the total #s of different ages of owls correspond to the detections.
- 6) Review the # of mice used and mousing effort for symmetry and logical sequence.
- 7) Review detections for completeness and correlation with field notes.
- 8) Review Observational Information check-boxes to ensure the appropriate boxes have been checked.
- 9) Spell-check the narrative and review for completeness and logic.

4.1.2 Form ID Number Sequence Completeness

Before error-checking data, review the Form ID numbers to check for gaps in the sequence. If there is a complete string of numbers for a crew, ensure that the final number is the last number for which there are data. If there is a gap, inquire whether there are data for that number or if it was not used. This process should be done periodically through the season. In some cases, multiple field staff working for the same agency can use different sets of numbers (i.e., 1-100 and 100-200).

At the end of the season, all crews should submit copies of their FormID logs as part of the permanent record. These can be used in future years to compare to existing data sequences.

4.1.3 Site Numbers

Run the following query:

ERRORCHECK10sitenumbers: This query, in conjunction with the ERRORjoinersites query, generates a list of location names which have had different values entered for the MASTEROWL (MRN#) field. If sites are listed when this query is run, then the number in the CountOfMASTEROWL1 field indicates the number of different values in SEARCH records for that site. The correct site number appears next to the Location name.

4.1.4 Dates

Open the SEARCH table and promote the date field to ascending order. Review the top dates to see if there are any outliers. Review and correct any dates occurring in the wrong year or in a month outside of the study protocol. Then promote the date field in descending order and review in the same manner.

4.1.5 Recorder Initials

Run the following query:

ERRORCHECK11recorder: This query will display SEARCH table records where there are no matching [RECORDER] initials in the table InitialsLUT. Records will be displayed either because new initials were not added to InitialsLUT or initials were entered incorrectly in the [RECORDER] field. The appropriate additions or corrections should be made.

4.1.6 Visit Times

Run the following queries:

ERRORCHECK26callendtimes: Use this query to generate a list of call end times which occur before call start times. Check narratives and originals and correct.

The visit time ERRORCHECK queries below apply to the visual search start/end time fields, which were part of the survey protocol until 2004 when they were discontinued. Only visit start and end are currently used. These error check queries remain in the database, however, and so are described here as part of the administrative record.

ERRORCHECK27visitstarttimes: Use this query to generate a list of all visit start times which occur after visual search start time. Check narratives and originals and correct.

ERRORCHECK20visualendtimes: Use this query to generate a list of empty “visual search end time” entries where there should be a value entered. Enter the value of the call start time into empty fields. If there was no calling, enter the value of the visit end time field.

ERRORCHECK21visualendtimes: Use this query to generate a list of inappropriate “visual search end time” entries. Running the query will produce a list of records in which the visual search end time was recorded as being after the call start time. Change all visual end times to the value of the call start time. Running the query again should produce an empty table.

ERRORCHECK22visualendtimes: Use this query to generate a list of inappropriate “visual search end time” entries. Running the query will produce a list of records in which the visual search end time was recorded before the visit end time, but during which there was no calling. Change all the “Visitend” values to the values of “Visitend.” Running the query a second time should produce an empty table.

ERRORCHECK23visualendtimes: Use this query to generate a list of remaining inappropriate visual search end time entries. The query generates a list of all visual search end times which do not match either the call start time or the visit end time. Adjust all Visitend fields to match Callstart fields, unless there are any null values in the Callstart field. Use the value in the Visitend field if there is no value in Callstart.

ERRORCHECK24visualendtimes: Use this query to generate a list of detections where there was no calling, but in which the visual end time and the detection time are the same. Check the narrative of the record and verify that the record is accurate.

ERRORCHECK25visualendtimes: Use this query to generate a list of visual search end times that were recorded as times that occurred before or equal to the visual search start times. The call start time is listed for reference. For records where visual search start and end and call start times are all the same, erase the times entered in visual search times, since there was no visual search. For records where the time of visual search end time occurred before visual search end time, review the narrative and original of the record for the correct time.

4.1.7 Visit Summary

Run the following queries:

ERRORCHECK30formalsurvey: This query generates a list of all visits for which "No" was the response to the "Formal Survey?" question. Review these records to assure that this was the correct response.

ERRORCHECK31spowresponse: This query will generate a list of records for which "No" was recorded in the Visit Summary to the "SPOW Response?" question, but for which there was a detection recorded. Check any records listed to assure that the detection is meant to be associated with the visit and change the SPOWRESPONSE field appropriately.

ERRORCHECK32otherowls: This query generates a list of records for which the visit summary indicates that no other owls were seen, but for which there exists a non-SPOW detection record. Review the listed site visits and make corrections if needed.

ERRORCHECK33nestlings: This query will generate a list of records for which the visit summary indicates that there were a different number of nestlings than the number of nestling detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK34branchers: This query will generate a list of records for which the visit summary indicates that there were a different number of branchers than the number of brancher detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK35fledglings: This query will generate a list of records for which the visit summary indicates that there were a different number of fledglings than the number of fledgling detections recorded for the site visit. Review the record(s) and make appropriate changes.

ERRORCHECK36mature: This query will generate a list of records when an entry for the visit summary's "mature SPOW" field is different from the number of entries in the "Owl Detections" field (for adult and subadult SPOW). Review the record(s) and make appropriate changes.

ERRORCHECK37viewofnest: This query generates a list of records for which the recorder stated that there was an adequate view into the nest to see all owls that were present within it, but for which no young were recorded, no female was stated to have been on the nest, and the record does not indicate that the site is non-reproducing or a confirmed nest failure. If you discover many records generated from this query, run the "REVIEWviewofnest" macro to review all of them in form view. Review the records and change whichever field is inaccurate. NOTE: This field did not exist prior to 2000 data.

ERRORCHECK38mice: This query will generate a list of records for which the recorder stated that there was no mousing, but for which 1 or more mice were used.

ERRORCHECK39mice: This query generates a list of records in which the field for "Total #Mice Used:" does not match the number of records of mice which were taken. The query works in conjunction with the two queries with "ERRORjoinermice" in the titles.

4.1.8 Indicate Completion

Once all of the above queries have been run and all fields in the visit summary fields have been error-checked, ensure that the "ErrorVisitSumChecked" and "ErrorMouseChecked" checkboxes in the SEARCH table are checked, or set to True. Alternatively, one can check the "Summary Checked" and "Mice Checked" boxes in the related Site Search Form.

4.2 Detections Form

4.2.1 Band Resightings

Partial band color observations do not count as a band color, but should rather be noted as “PRESENT”. For example, if you see orange on a band but are not certain of the absence or presence of a pattern, record “orange” only in your notes and in the narrative and “PRESENT” in the data field “band color.”

Check for standard use of field terms: while checking all band records, make certain that the following terms are used appropriately:

PRESENT: used when a band was known to be present, but the color is not known. For example, if observer recorded a color for a tab, but nothing for band color, record "present" as band color.

NONE: used only when it was verified that no band was present on the owl. Both legs must be seen. If such records are found at sites where owls of that sex were already banded, make certain from the field notes that the observer verified the absence of bands on the owl.

UNKNOWN: used in all situations where both legs could not be seen or the observer failed to record the color of a band or whether bands were looked at.

GONE: This value should be used for tabs which have been removed by the owls wearing them.

Error-Check: Several steps will be required to complete error-checking. Check the "Bands Checked" box in the Site Search form or the “ErrorBandsChecked” field directly in the SEARCH table only when all steps have been completed.

Run the following queries:

ERRORCHECK0referencebands: This query generates a list of all the band colors of owls banded in the study area. The query may be printed and used for reference in other error-checking queries.

ERRORCHECK40nonspowbands: This query generates a list of all non-NSO detections for which a band color was recorded. Check to see if this unusual event actually happened.

ERRORCHECK41nullbandvalues: This query will generate a list of all NSO detections for which no information was recorded for band colors. Review all of the records to assure that the appropriate value is "UNKNOWN" and change accordingly.

ERRORCHECK42owlsthatmoved: This query will generate a list of all NSO band combinations which were given (banded) at one location and then recorded as observed at another location. Check the narratives and other records to verify, make appropriate changes,

then print up the remaining verified relocated owl records and use for reference during next queries.

ERRORCHECK43ifybands: This query generates a list of questionable band colors. Review to make sure that these represent owls that moved or for which there was a justifiably unknown "Band leg" value recorded. Change partial colors, e.g., "green" for "green white triangle" to "PRESENT." Only true values of band colors should be entered in the band color field. This query runs in conjunction to the ERRORjoinerBcolors and ERRORjoinerBdetecombos queries.

ERRORCHECK44ifyband+tabs: This query will generate a list of sex/band/tab/leg combinations that were recorded for detections which do not exist in the banding records. Some records should include the owls that have removed their tabs. Check these and all others to verify accuracy and make appropriate changes if possible. This query works with the ERRORjoinerBcombos query and the ERRORjoinerBdetecombos2 query.

ERRORCHECK45bandedleg: Run this query to generate a list of all records for which the recorder stated that there were no bands on the owl (NONE as color) but for which they recorded a leg. Because "NONE" is meant to indicate that there were no bands on either leg of the owl, review the records that show up and change the band color to "UNKNOWN" and the leg to U if the narrative indicates that only one leg was seen. If the narrative indicates that both legs were seen, change the leg field to "N" to represent that neither leg bore a band.

ERRORCHECK45bandedleg2: Run this query to generate a list of all records for which the recorder stated that the band color was UNKNOWN, but for which they specified a leg. Review the records to see if this was meant to indicate that no colored band was seen on the other leg, but that this leg remained unknown.

ERRORCHECK45bandedleg3: Run this query to generate a list of all records for which the recorder stated "PRESENT" as the band color and for which they indicated a leg. Review to make sure that the narrative indicates that the band was known to be on that leg.

4.2.2 UTMs

Before reviewing the UTM's for accuracy, the dataset must be complete. Open the DETECTIONS table and sort the UTM_EAST field ascending. Null values should appear on top. Record the FormID numbers, location and dates and review the original maps to generate UTM's. Repeat for the UTM_NORTH field.

The first step in reviewing the UTM's is to correct those which erroneously fall outside of Marin County by running the ERRORCHECK51utmeast and ERRORCHECK52utmsnorth queries. Check the original maps and correct.

Use the query ERRORCHECK53utms to create a GIS event theme of NSO detections by completing the following steps:

1. Temporarily change the ERRORCHECK53utms query to a make-table query and run the query to create a new table.
2. Open ArcMap and begin a new empty map.
3. Select the Add XY Data option under the Tools menu, navigate to the NSOMASTER database and select the temporary table you just created.
4. In the Add XY Data window, choose UTM_EAST for the X field and UTM_NORTH for the Y field.
5. Set the coordinate system (Projected Coordinate Systems>UTM>NAD 1983>NAD 1983 UTM Zone 10N.prj), and select OK. The table will now appear as a data source in the map.

For comparison, add the previous year's shapefile to the map (see Section 3.4). Loading the current year of data and the shapefile of the previous year's activity site centers, one can visually see what lies at unusual distances from the activity center. These detections should be reviewed against the original field maps for accuracy. While zoomed out to the extent of the study area, scan the map to look for unusually large clusters. Zoom into these and use the identify feature to look for mismatched site names. Measure the distance between distant points bearing the same site name. Verify that anything over 250 m apart is appropriate.

To identify outliers within each activity site, perform an auto-label by site name to all the points while zoomed in fairly closely. Contrary names which overlap in the same activity area need to be examined to see which were incorrectly entered.

When complete, be sure to delete the temporary table used to create the GIS theme from the database. Check the "UTMs Checked" box in the Site Search form or the "ErrorUTMsChecked" field directly in the SEARCH table only when all steps have been completed.

4.3 Status Form

The status form is the last form to be completed for each site each year and summarizes the survey results for each site. Complete descriptions of each status level (occupancy, residency, pair status, nesting status, and reproductive status) and descriptions of determinations are found in SOP 3: Status Designations. Directions for entering data into status form fields and available values are described in detail in SOP 3.

Due to the complexities of the survey protocol, nothing can replace repeated review of the Site Search records in comparison to the STATUS table for accuracy. However, some queries have been built to locate potential errors. These procedures are not comprehensive however, and it is recommended that the entire set of STATUS records are reviewed at least three times, reviewing each field against supporting evidence. See SOP 2: Standard Field Procedures for details on field descriptions as well as the database help text available from the STATUS form. Run the following queries to verify that the status entered in the STATUS form has evidence supporting

it in the site search records. When error checking is complete, select the “Error Checked” box in the STATUS form for all records.

ERRORCHECK71statusNY: This query generates a list of all sites which were designated as Nested with Young (NY) produced, but for which there are no SEARCH records which have detections of branchers or fledglings.

ERRORCHECK72statusNF: This query generates a list of all sites which were designated as a Nest Failure (NF), but for which there are no associated SEARCH records with the NONNESTINGINDICATORS field. The field represents surveys in which mice were taken, but were not brought to the young. Review to make sure that the nest failures listed in this query were confirmed by adequate follow-up visits to visible nests after initial nesting confirmation.

ERRORCHECK73statusN: This query generates a list of STATUS records which were not designated Nested with Young (NY), but for which there was a fledgling record. Review and make appropriate changes.

ERRORCHECKstatusNN+: This query generates a list of STATUS records with Non-Nesting (NN) or Unknown (UK) Nesting status codes, but for which there is a positive response in the SEARCH records to the NESTINGINDICATORS field.

Additional error-checking queries such as these can be added to the database to more comprehensively check for likely problems.

To check the UTM's in the STATUS table for accuracy, view the table as a GIS event theme in a new ArcMap project following the directions given in Section 4.2(b) for checking the accuracy of UTM's in the DETECTIONS table. Add the theme of the preceding year's shapefile. Set unique symbols for the two different layers to compare the locations and look for large movements or incorrect UTM's. Review all UTM's which emerged in unlikely or suspiciously far points. Correct any UTM's that need correcting in the database.

Reminder: Do not edit the table in the previous year's shapefile because the changes will be made to the associated DBF file immediately.

4.4 Nest Tree Habitat Form

Error-check all of the Nest Tree Habitat forms by reading the original physical datasheet and comparing this to the data that was entered into the database. Correct any mistakes and check the "Error Checked" box on the form. See SOP 2: Standard Field Procedures for detailed description of data form/database fields.

5.0 Version Control Guidelines and Database History

Version control guidelines for the MS Access Northern Spotted Owl Monitoring Database will follow those presented in the SFAN's Data Management Plan (Press 2005). Prior to any major changes to the database design, a back-up copy of the database should be made. Once the database design changes are complete, the database should be assigned the next incremental

version number. The final copy of the previous database version should be archived with the version closing date incorporated into the database title. Version numbers should increase incrementally by hundredths (e.g., version 1_01, version 1_02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2_0, 3_0, 4_0 ...). With proper controls and communication, versioning ensures that only the most current database version is used for queries and analyses. Significant database re-design may require approval by the project manager, review by other data management staff, and revisions to this data management SOP. The database version number should be included in the file title of the database, for example, NSOMASTERXP_v1_00.

The SFAN Data Manager maintains a history of the Northern Spotted Owl Monitoring Database in a MS Word document titled *NSOMASTER_Database_History* located at:

Inppore04\Resources\Natural_Databases\Spotted Owl

All design modifications to the database are tracked within this document and are referenced to changes in database version numbers. Major changes to the data themselves are also noted in this document, such as when a new set of annual data is uploaded. It is especially important to note edits to the data that will result in changes to final data summaries previously published in annual reports or other media. This will prove invaluable to data users attempting to understand differences in data between years.

The database history may also be used each year to summarize anything that was unique or changed about the year's methodology and is therefore reflected in the annual dataset. Notes on techniques for collection and review of data are also very helpful.

Data related administrative records previously stored within the database in the YEARMetainfo table have been transferred to the *NSOMASTER_Database_History* document.

6.0 Metadata Procedures

The NPS GIS Committee recently required all NPS GIS data layers be described with the NPS Metadata Profile, which combines the FDGC standard, elements of the ESRI metadata profile, the Biological Data Profile, and NPS-specific elements. Although no standard has been applied to natural resource databases and spreadsheets, the SFAN completed the NPS Metadata Profile to the greatest extent possible to document the master MS Access NSO Monitoring Database.

The metadata record for the Northern Spotted Owl Monitoring Database was initially developed in Dataset Catalog v3.0, an MS Access metadata development and catalog tool developed by the NPS I&M Program. Dataset Catalog is currently the preferred tool to begin metadata records for MS Access databases because of its ability to harvest entity and attribute information from this database format.

The metadata record was exported from Dataset Catalog as an XML file and completed in NPS Metadata Tools and Editor v1.1 (NPS MTE), thus allowing for all NPS-specific elements in the metadata record to be completed. When completed, the metadata record, but not the data themselves, was posted to the NPS Data Store for public discovery and consumption. The

database, and any GIS data resulting from the monitoring program, is considered sensitive information and is not available publicly, but distributed through data requests to the Data Manager. Contact information within the metadata record directs interested parties to the SFAN Data Manager for further inquiries. The metadata record posted to the NPS Data Store will be updated annually after the annual data have been uploaded or following database revision to a new version whole number (i.e., v1_3 to v2_0, but not v2_0 to v2_1).

The location data for this project are stored as UTM coordinates within the MS Access master database. Because GIS spatial data layers are generated from the database for internal use only, only simplified metadata records will be developed for these data layers using ArcCatalog and the NPS MTE. The metadata records will be saved as XML files and should be stored with the spatial data files, but not posted to the NPS Data Store.

At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. A complete and thorough metadata record for the BIOS submission has been created in ArcCatalog and the NPS MTE and may simply be updated annually prior to submission. See SOP 5: Data Analysis and Reporting for detailed instructions.

The complete protocol for this project is an integral component of the project metadata. All narrative and SOP version changes are noted in the Master Version Table (MVT), which is maintained in SOP 7: Revising the Protocol. Any time the narrative or SOP versions are changed, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The Version Key number is essential for project information to be properly interpreted and analyzed. The protocol narrative, SOPs, and data should not be distributed independently of this table.

7.0 Data Storage

NPS IT specialists keep servers at both PORE and GOGA locked and secure, perform regular server maintenance and upgrades, and ensure that frequent server back-up procedures are functioning properly with weekly off-site storage.

All master data files for the NSO monitoring project are housed at PORE. NSOMASTERXP, the master database, currently in version 1_0, resides at:

Inppore04\Resources\Natural_Databases\Spotted Owl

Inppore04\Resources must always be mapped as the U drive. The following folders reside within the above directory:

SPOW_BackUps

Back-up copies of the master database or of annual satellite databases should be stored here. File names of back-up databases should include the date of the back-up, such as: NSOMASTERXP_v1_00_040110_BackUp.

Archived_Master_Dbase_Versions

When the master database is converted to a new version number, the final previous database version should be archived here.

Archived Annual Data

Separate folders for each year (i.e., Archived 2009 Data) store final satellite databases and other final annual data products.

BIOS Submission

Separate folders for each year (i.e., BIOS Submission 2009) store correspondence and final data products submitted to the BIOS data access system.

GIS Files

GIS files are housed on a separate server at:

Inppore07\GIS\vector1\wildlife\spottedowl\covers

Inppore07\GIS must always be mapped to the S drive.

Documents

Protocol documents, annual reports, seasonal documents or temporary data files (see Section 2.2), and all other project related files are located at:

Inppore04\Resources\Science\Spotted Owls

At the SFAN offices at GOGA, copies of all final documents and data relating to the spotted owl monitoring program are archived at:

Inpgogamahe1\Divisions\Network I&M\IM_Archive\VS_Indicators\Spotted_Owl

Data and documents are stored in separate folders. The master database will be copied and archived here annually after that year's field data have been error-checked and uploaded. All final documents relating to the NSO monitoring program, including the protocol and all annual reports, will also be stored in the NSO archive directory. All files in the archive directory are stored in read-only format.

8.0 Literature Cited

ESRI (Environmental Science Research Institute, Inc.). 2009. ArcGIS 9.3.1. ESRI, Redlands, CA.

Press, D.T. 2005. Data management plan for the San Francisco Bay Area Network inventory and monitoring program. USDI National Park Service. San Francisco, CA. 113 pp.

SOP 5. Data Analysis and Reporting

Version 1.3

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
1.0	Nov. 2007	Dawn Adams	Reformatted	To meet new formatting guidelines.	1.1
1.1	March 2008	Dawn Adams, Dave Press, Marcus Koenen, Bill Merkle	Updating analysis section	New analysis	1.2
1.2	March 2010	D. Press, L.A. Starcevich	Significant expansion of section on long-term analytical techniques and reporting. Added Literature Cited section. Added two appendices.	New analytical methods. Response to peer review comments.	1.3

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This SOP details the formal reports (e.g., annual reports) and informal reports (e.g., web updates) produced through the I&M Program. For each report, content is described and analyses are presented. Additional information on analyses is also presented in SOP 4: Data Management Handbook.

1.0 Annual and Long-Term Trend Reports

This section provides instructions for: 1) annual data analysis and reports, and 2) periodic trend analysis and reporting for northern spotted owl (NSO) monitoring in the San Francisco Bay Area Network (SFAN). For the annual reports and long-term trend analysis, only NPS occupancy and fecundity data collected within the NSO study area are analyzed and presented. The exception is the nesting habitat and nest structures section of the annual report, which includes data gathered on all nests located in the county since 1998.

1.1 Annual Reports

The purpose of the annual report is to summarize the data for the current year, as well as to provide for some comparison with data from previous years. The report is prepared by the Lead Biological Technician and reviewed by the project staff from Point Reyes National Seashore (PORE) and Golden Gate National Recreation Area (GOGA). The first draft of the report is produced in the late-summer or fall following the field season once the data has all been error-checked. Peer-review and completion of the report are the responsibilities of the NSO program managers and should be finalized before the start of the next field season. The report summarizes occupancy, fecundity, and any other relevant information. The 2008 annual report, which went through a formal peer review process, will serve as a template for future annual reports.

1.1.1 Data Summaries

In each annual report, statistics are presented for the following standard survey parameters at a minimum:

- Site occupancy
 - Number and percentage of occupied territories*
 - Occupancy status summary (number of single, pair, unoccupied sites)*
- Reproduction
 - Reproductive status summary (number of nesting and non-nesting pairs, number of nest failures, number of nests that fledged young, and number of young)*
 - Fecundity (average number of female young per territorial female with standard error)*
 - Productivity (average number of young per occupied territory with standard error)*
- Age composition of pairs*
- Survey effort (mean and range of number of visits per site)
- Nest tree measurements
 - Nest type, height, and aspect
 - Nest tree species, height, and diameter at breast height
- Habitat characteristics (presented as average for the season)
 - Dominant understory and overstory vegetation types (general description)
 - Elevation*

- Slope*
 - Slope position
 - Distance to forest opening*
 - Distance to forest edge*
 - Distance to water*
- Weather metrics from Mt. Barnabe and/or Bear Valley weather stations
 - Average monthly precipitation*
 - Monthly wind speed (number of days per month with high wind speed of 20 mph or higher)*

* Values with asterisk are also presented in a report figure to help visualize trends.

Incidental data collected is also reported, including:

- Barred owl statistics
 - Number of detections
 - Number of NSO sites with barred owls detected
 - Barred owl occupancy status at sites
 - Estimate of number of barred owls in study area
- Medium to large scale changes in NSO habitat (e.g., wildfires)

Report figures are formatted in a MS Excel spreadsheet and can be updated with current year values and inserted into the report.

An example table summarizing annual monitoring results is shown in Table SOP 5.1. Site occupancy and reproductive status are also reported as percentages of different occupancy (Figure SOP 5.1) and reproductive status classes (Figure SOP 5.2) for comparison with other monitoring years. Annual population fecundity is determined by calculating an average fecundity of territorial females within the monitored sample. Fecundity is the number of female young (# of fledglings/2) per territorial female (Franklin et al. 1996). Standard error of the sample is also reported.

The annual reports generally do not contain sensitive owl information and, therefore, can be distributed to the public. Any maps created are done in large scale and without specific landscape details and no owl locations are mentioned by name in the report.

Table SOP 5.1. Summary of the spotted owl monitoring results for the 2008 breeding season.

Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nests located	Number of young produced	Fecundity
25	20	15	13	6	18	0.69

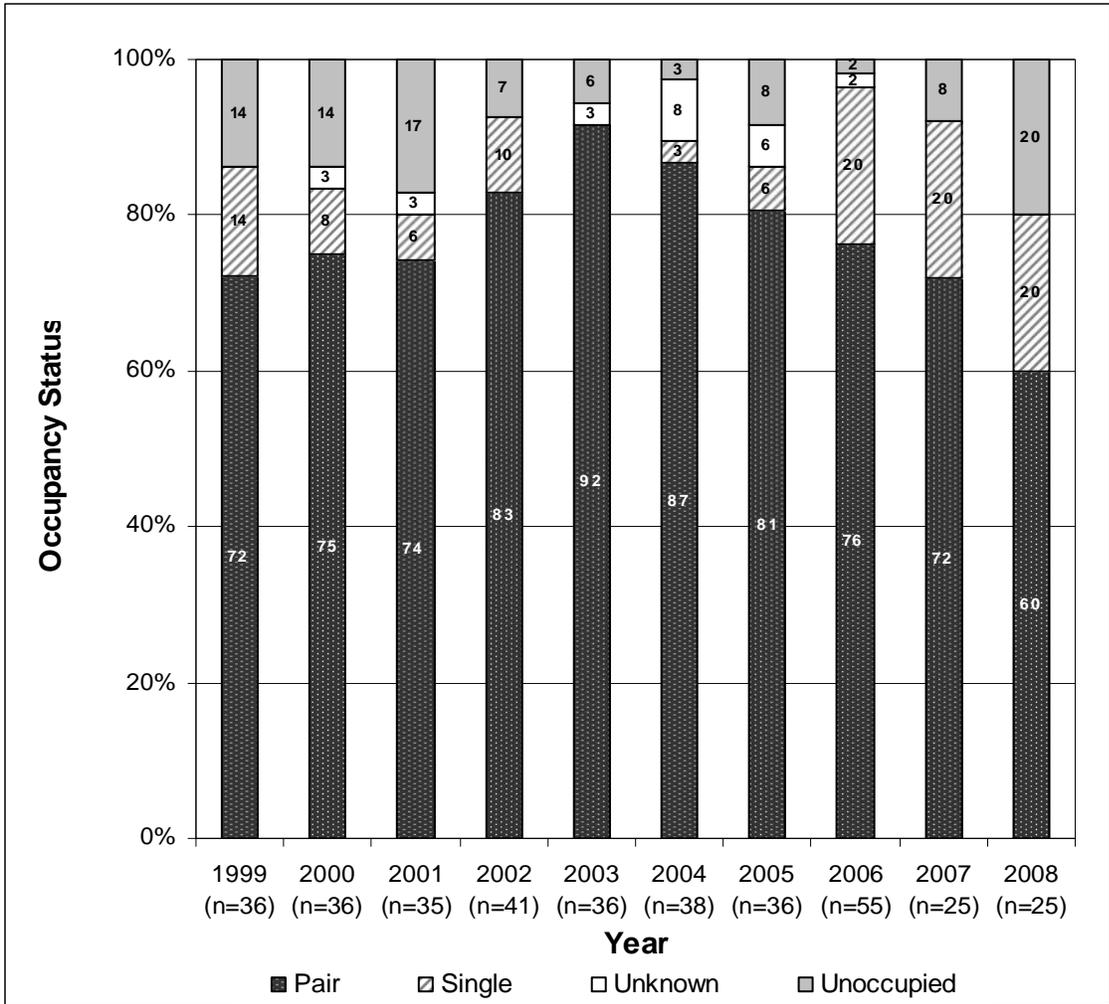


Figure SOP 5.1. Occupancy status for all NPS study sites (1999-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories.

1.2 Long-Term Trend Reports

Every 5 years, the program will develop a larger trend analysis and protocol review. Long-term trend reports would be produced by the project leads and other network staff or through cooperative agreements or contracts depending on funding availability. The focus of the trend assessments will be on the key parameters in the study design, specifically territory occupancy rate and fecundity. The report will include examining patterns and trends in nesting habitat selection. At that time, additional factors will be considered for analysis, especially as they relate to NSO occupancy and fecundity. Some examples of potential analyses are examining differences in occupancy and fecundity rates between age classes of females and males, factors associated with differences in habitat quality, different nesting habitat factors (e.g., distance to water, forest edge, and dominant forest structure). A long-term trend assessment is also an appropriate point to analyze the effects of climate and weather conditions, the presence of barred owls, and the presence and severity of Sudden Oak Death (SOD). The significance of these

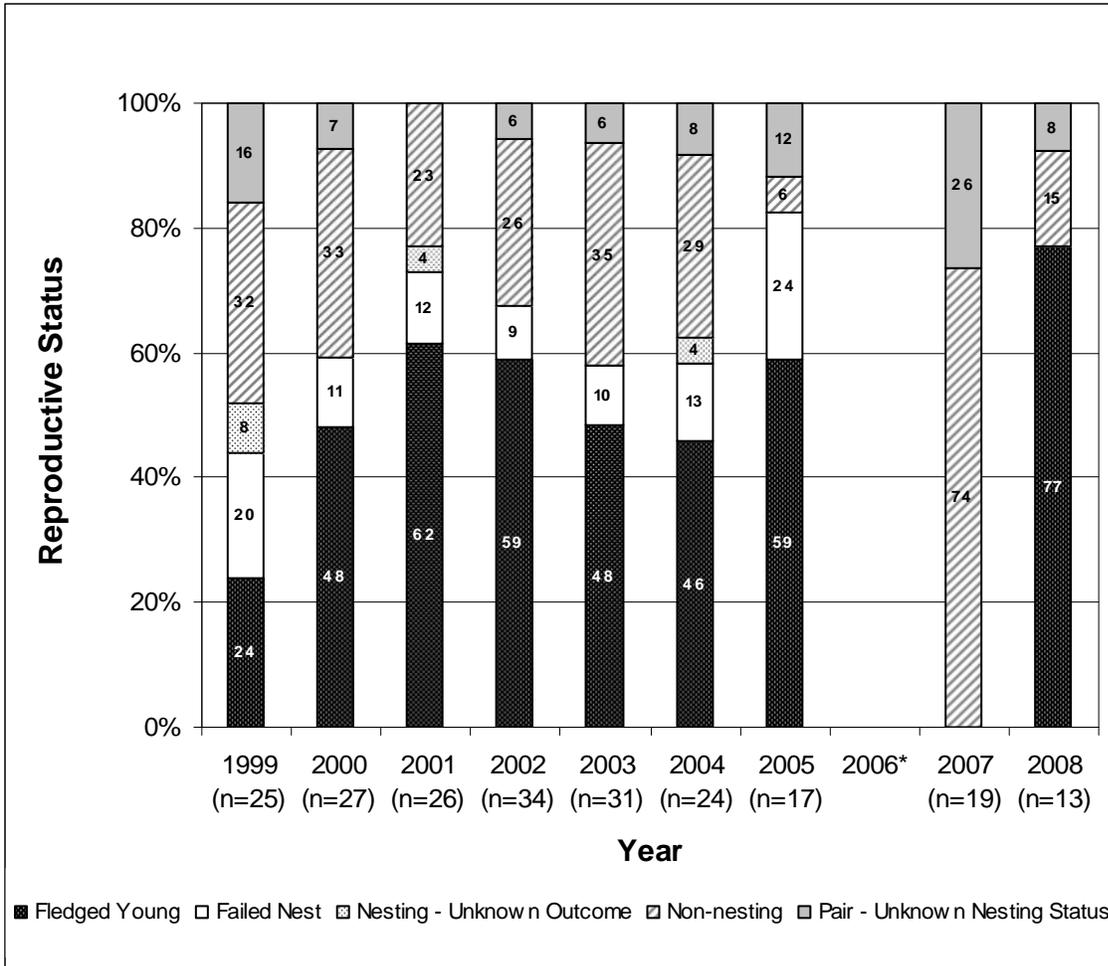


Figure SOP 5.2. Reproductive status for owl pairs monitored in the NPS study area (1999-2005 and 2007-2008). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories. *2006 inventory data was excluded from this analysis.

effects may be assessed with likelihood ratio tests of regression coefficients in the models for occupancy, fecundity, or detection rates. Results will be discussed within the context of the Marin County NSO population, by including data collected on MMWD and MCOSD lands, and within a regional context, by comparing NSO trends in other parts of California.

1.2.1 Occupancy Analysis

Methods for detecting long-term trends in the NSO occupancy data were developed by Starcevich and Steinhorst (2010; Appendix A), which used 10 years of NPS NSO monitoring data to estimate the power to detect trends in preparation for this protocol. The methods in Starcevich and Steinhorst (2010) will serve as a roadmap for future long-term trend analyses and are summarized here. Our statistical approach may evolve over time allowing us to include new covariates into the analysis, such as climatic factors or SOD, and to keep up to date with the latest analytical techniques.

Analysis code for estimating trends in occupancy rate is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. Instructions are given to conduct the occupancy and fecundity trend analysis with the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

The spotted owl monitoring program employs six mutually exclusive northern spotted owl site occupancy categories (Table SOP 5.2). Occupancy will be estimated independently for each category.

Table SOP 5.2. Northern spotted owl occupancy categories.

Occupancy Code	Description
PR	Resident pair detected
PU	Pair detected but pair occupancy not confirmed
RS	Resident single
SU	Single detected but occupancy not confirmed
UK	Occupancy status unknown
UO	Unoccupied

When more than three years of monitoring data are available, linear trends in the logged odds of occupancy may be estimated and tested for significance. The number of detections is modeled as a zero-inflated binomial random variable (MacKenzie et al. 2006). Let y_{ijk} be the outcome for site i , year j , and visit k , and let y_{ijk} take a value of 1 if a spotted owl is detected and 0 otherwise. Since the outcome is either 0 or 1, the outcome actually has a zero-inflated Bernoulli distribution. Let y_{ijk} be the number of detections made at site i and year j during the k^{th} visit. The zero-inflated Bernoulli distribution is expressed as:

$$P(Y = y_{ijk}) = \pi_{ij} p_{ij}^{y_{ijk}} (1 - p_{ij})^{1 - y_{ijk}} + (1 - \pi_{ij}) I(y_{ij} = 0),$$

where π_{ij} is the occupancy rate in site i and year j , and p_{ij} is the detection rate for site i and year j . There are S sites; T years, and K visits to a site each year. Define the indicator function as $I(y_{ij} = 0)$ as 1 when $y_{ij} = 0$ and 0 otherwise. This model assumes an equal number of visits to a site within a year, but K can vary among sites and/or years.

Occupancy (π) is modeled with logistic regression as a function of related covariates:

$$\log\left(\frac{\pi_{ij}}{1 - \pi_{ij}}\right) = \gamma_0 + \gamma_1 x_{ij}.$$

To test for linear trend in the logged odds of occupancy, the year covariate, x_j , should be included as a predictor in the occupancy model. The likelihood ratio test is used to assess the significance of the trend coefficient.

The probability of zero inflation (p) is simultaneously estimated by logistic regression:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta'_1 x_{ij}.$$

Maximum likelihood is used to estimate the parameter values from the models for occupancy and detection rates and the zero-inflated Bernoulli distribution. Occupancy can be modeled at the site-by-year level so predictors should be collected at the site level, year level, or site-by-year level. Detection probabilities are allowed to vary at each visit for each site and year, so covariates are often environmental covariates that vary from visit to visit (MacKenzie et al. 2006). However, if detection rates are also changing over time, a model that includes a year covariate may be needed for accurate occupancy estimation.

The implicit occupancy model is assumed for this analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

Model selection is conducted using the Akaike Information Criterion (AIC). Model output is examined to be certain that valid variance estimates are obtained. When valid estimates of the variance cannot be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance is used.

For the pilot data, the occupancy model selected by AIC included site-level, year-level, and visit-level covariates (Table SOP 5.3). Possible detection models were based on covariates collected within each site and year such as month, an indicator for a day vs. night survey, an indicator for whether a call method was used, and the number of observers. The detection model with the lowest AIC for the NSO pilot data collected from 1999 to 2008 includes the indicator for day survey, the indicator for call use, and the number of observers.

Table SOP 5.3. Covariate information available for occupancy and detection modeling (Starceвич and Steinhorst 2010).

Covariate Code	Level	Description
Year	Year	Year of the survey
Month	Visit	Month of the survey
Barred	Site	Indicator of barred owl detection at a site for a given year
Daytime	Visit	Indicator that survey occurred during the day
Call	Visit	Indicator that a call method was used
ObsNum	Visit	Number of observers present during the survey

The process of model selection was problematic for the spotted owl pilot data. Because occupancy analysis is based on a nonlinear model, obtaining a positive-definite Hessian matrix was not possible for some models. The Hessian matrix affects the estimates of variance for

occupancy and detection regression parameter estimates which affects trend testing. Model selection was conducted using AIC as the model selection criterion (Bayes Information Criterion was also examined but selected similar models). However, models chosen with AIC often did not provide positive-definite Hessian matrices. The model with the lowest AIC and a positive-definite Hessian matrix was used in the power analysis for trend testing. The final occupancy and detection models are provided for each status category in Table SOP 5.4. The final models were often a reduced version of the model with the lowest AIC indicating that simpler models are more stable for occupancy estimation. The occupancy estimates by category are provided in Table SOP 5.5.

Table SOP 5.4. Final occupancy and detection models for each spotted owl occupancy category (Starcevich and Steinhorst 2010).

Status Category	Occupancy Model $\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)$	Detection Model $\log\left(\frac{p_{ij}}{1-p_{ij}}\right)$
PR	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij} + \beta_3 \text{ObsNum}_{ij}$
PU	γ_0	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
RS	γ_0	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
SU	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
UK	γ_0	$\beta_0 + \beta_1 \text{Month}_{ij} + \beta_2 \text{Call}_{ij}$
UO	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Call}_{ij}$

Table SOP 5.5. Occupancy estimates (and standard errors) from the final model for each spotted owl occupancy category (Starcevich and Steinhorst 2010).

Status Category	Est. Occupancy Rate for Sites with Barred Owls (SE)	Est. Occupancy Rate for Sites without Barred Owls (SE)	Est. Occupancy Rate (SE)
PR	0.9197 (0.0505)	~ 1.000 (0.00001)	-
PU	-	-	0.0301 (0.0146)
RS	-	-	0.1614 (0.0428)
SU	0.2562 (0.0960)	0.1127 (0.0384)	-
UK	-	-	0.0208 (0.0058)
UO	0.1172 (0.0371)	0.0601 (0.0124)	-

Analysis code using the R software package is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. For each status category, occupancy estimates are provided either for the model including the indicator of barred owl presence (estimates of occupancy with and without barred owl presence are provided in the second and third columns) or the model without a factor for barred owl presence (occupancy estimates given in the fourth column).

Columns for the unused model contain a "-" to indicate that this model was not used. Due to the complexities of estimating trend with a multi-category occupancy classification, a univariate approach was used and occupancy estimates do not sum to 1. Notice that the presence of barred owls in a site and year decreases pair occupancy but increases the single-unknown and unoccupied status categories. This result suggests that the effect of barred owl presence is to reduce pair occupancy and inhibit territorial behavior as evidenced by the positive effects observed in the SU and UK status categories.

1.2.2 Fecundity Analysis

Methods for detecting long-term trends in the NSO fecundity data were developed by Starcevich and Steinhorst (2010; Appendix A; Appendix SOP 5A), which used 10 years of NPS NSO monitoring data to analyze re-visit designs and to estimate the power to detect trends in preparation for this protocol. The methods in Starcevich and Steinhorst (2010) will serve as a roadmap for future long-term trend analyses and are summarized here. Our statistical approach may evolve over time allowing us to include new covariates into the analysis, such as barred owl presence or SOD, and to keep up to date with the latest analytical techniques.

Analysis code for estimating and testing trends in fecundity rates is provided in Appendix SOP 5A, and pilot data are provided in Appendix SOP 5B. Instructions are given for the VGAM package of the R Project for Statistical Computing. The VGAM package is used for obtaining maximum likelihood estimates from zero-inflated mixture distributions.

Let y_{ij} be the number of fledglings per territorial female detected in occupied site i and year j . Let n be the number of occupied sites and T be the number of years monitored for fecundity. The probability mass function of Y is:

$$P(Y = y_{ij}) = \pi_j \binom{M}{y_{ij}} p_{ij}^{y_{ij}} (1 - p_{ij})^{M - y_{ij}} + (1 - \pi_j) I(y_{ij} = 0),$$

where π_j is the probability that an extra 0 is **not** observed at site i in year j , p_{ij} is the probability of a fledgling at site i in year j , M is the maximum number of fledglings seen in any nest, and $I(y_{ij} = 0)$ is 1 when $y_{ij} = 0$ and is 0 otherwise. Similarly to the occupancy analysis, the parameters, π_{ij} and p_{ij} , are estimated with maximum likelihood estimation. To test for trend in fecundity, the year covariate is included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change in p_{ij} over time. We assume that M is 5 based on historical data and recommendations from the SFAN ecologists.

Fecundity of spotted owls is measured by the number of fledglings per territorial female. Nesting spotted owls can produce 0 to 3 fledglings, though a maximum of two fledglings was observed from the pilot data. The 1998-2008 pilot data indicate that zero inflation may be an issue (Figure SOP 5.3). Zero inflation may result from a high number of non-nesting pairs or nest failures related to predation or environmental factors.

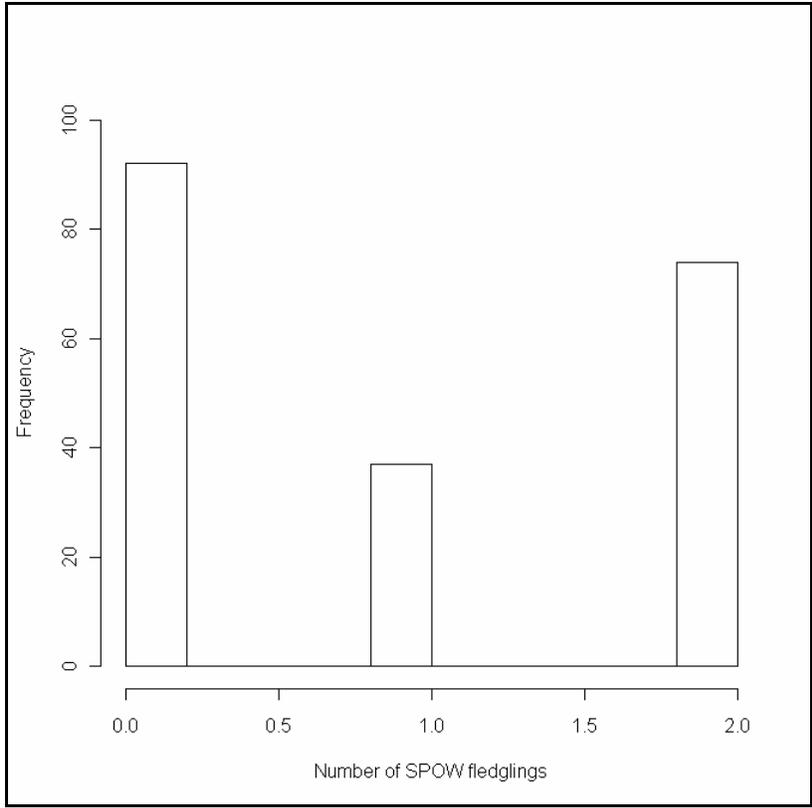


Figure SOP 5.3. Histogram of spotted owl fledglings across years, 1998-2008.

Fecundity is measured as the binomial probability for fledglings. These estimates are provided in Table 5.6 by year. While the estimates indicate an increasing trend (Figure SOP 5.4), the increase is not significant (LRT test statistic: 0.0043, p-value: 0.9479). The probability of not detecting an extra zero is estimated as 0.6396 (SE 0.0466).

Table SOP 5.6. Estimated binomial probabilities for fledgling.

Year	Estimated Binomial Probability for Fledglings (SE)
1999	0.4715 (0.0686)
2000	0.4724 (0.0574)
2001	0.4732 (0.0473)
2002	0.4741 (0.0393)
2003	0.4750 (0.0349)
2004	0.4758 (0.0353)
2005	0.4767 (0.0405)
2006	0.4776 (0.0490)
2007	0.4784 (0.0593)
2008	0.4793 (0.0707)

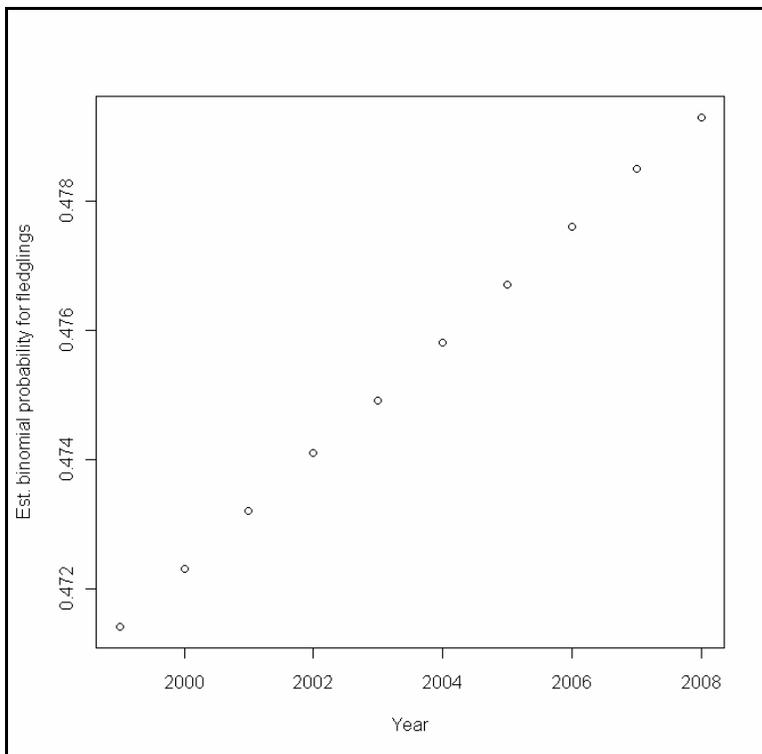


Figure SOP 5.4. Estimated binomial probabilities for spotted owl fledglings by year.

1.2.3 Habitat Analysis and Modeling

Nest site measurements collected in the field will provide ample opportunities for data exploration. Trends in NSO nest type and habitat features may be analyzed by testing whether mean parameter values differ by year using ANOVA analysis. Post-hoc tests and graphical analysis will be used to examine significant test results. Tests of specific parameters will help to confirm patterns observed in the field, such as shifts in elevation, towards forest edges, or changes in nest tree species. Broader understanding of NSO habitat associations, however, must

take a more unified approach that incorporates both field measurements and landscape variable derived from other sources.

New information about NSO habitat associations from this region could have important management and ecological implications and will therefore be explored by the SFAN monitoring program as a component of long-term trend analyses. A GIS modeling approach that relates NSO nest site occurrence and reproductive success to important habitat variables may help to explain any long-term trends detected in the monitoring data. The SFAN has already developed a GIS model for nest site occurrence in a collaborative effort with PRBO (Stralberg et al. 2009). The SFAN approach to modeling NSO habitat associations within the project area in future modeling efforts is outlined below.

Analyzing spatial relationships can be instrumental in determining many aspects in the lives of wildlife including their distribution and abundance. Wildlife-habitat models are an important tool in wildlife management for describing habitat selection and habitat quality. Almost any wildlife-habitat model that can be described in terms of mapable habitat features can be developed with GIS. To accurately describe a relationship between wildlife and habitat variables, model development should be a well thought out and well documented process and modeling results should be viewed with skepticism. The accuracy and biological meaningfulness of the inferences ultimately depends on the models included in the candidate set (Johnson and Omland 2004). With that in mind, the increase of GIS technology and model selection techniques provides an opportunity to spatially investigate otherwise latent biological patterns.

A critical component in evaluating habitat selection is to include the influences of spatial and temporal scale on ecological processes (Wiens 1989). Multiple years of data can be incorporated into analyses to provide insight into processes over time and data can be evaluated at multiple spatial scales. A subset of the dataset should be withheld for the purpose of model validation.

In the case of northern spotted owls, the concept of habitat selection extends beyond the physical attributes of vegetation and topography to incorporate the influence of the environmental variation associated with climate, prey, intraspecific and interspecific interactions (e.g., competitors, predators, parasites, disease), and time lags (e.g., delayed response to changing habitat conditions due to site fidelity). Factors affecting spotted owl demographic rates have been related to vegetation, weather, barred owls, prey, density-dependent factors, and interaction among factors (Franklin et al. 2000; Courtney et al. 2004; Olson et al. 2004; Dugger et al. 2005).

Biotic and abiotic information collected at nest tree locations used in conjunction with GIS derived layers provides an opportunity to evaluate third-order habitat selection (Johnson 1980) of spotted owl territories. One approach to evaluate third-order habitat selection would be to compare occupied nest sites with an equal, but random sampling of unused, available sites within an individual's home range or a specified spatial scale to evaluate selection at a fine spatial scale using the resource selection function (RSF) approach (McDonald et al. 1990).

The spotted owl location data can be created using our northern spotted owl master database for Marin County. The general work flow for model development is a multiple step process that includes: 1) identification of variables to include in the model 2) gathering and assembling

spotted owl data and GIS data, 3) processing and prepping the variables in GIS, 4) construction of *a priori* models, and 5) regression analysis and AIC_c ranking to evaluate model performance.

Step 1: Variable identification

The selection of variables will be based on a review of existing literature describing factors influencing habitat associations of spotted owls and the spotted owl's primary prey (dusky-footed woodrat) in the study area (Table SOP 5.7). A majority of the variables likely to be included were identified in a nest site occurrence model for Marin County (Stralberg et al. 2009).

Step 2: Gathering and assembling spotted owl and GIS data

To create a spotted owl dataset for the analysis, the selection criteria would be based on the objective of the model. Appropriate information can be queried from master database and assembled in a spreadsheet. Existing slope, aspect, elevation, aerial imagery, vegetation (Schirokauer et al. 2003), hydrology (i.e., streams), boundary, and infrastructure (i.e., roads and trails) data layers for the San Francisco Bay area are available from the GIS drives at PORE and GOGA.

Step 3: Process and prep the variables in GIS

For each variable, the spotted owl activity centers (i.e., nest or roost location) would be the focal location for calculating spatial conditions. The shape and size of the analysis area will be based on purpose of the analysis. For each focal location, a set of spatial metrics would be calculated from GIS layers representing the habitat variables. Point metrics would reflect conditions at a specific location (e.g., nest site). Landscape metrics would be calculated around focal locations using a predefined radius or radii. The pixel size used in GIS analysis would be based on accuracy and specificity needs; however it would likely be completed using a 10m x 10m resolution. Point and landscape metrics would be calculated using ArcGIS 9.3.1 and standard extensions (ESRI 2009; Table SOP 5.7). Before processing any GIS data, all layers would be projected in the same geographic coordinate system (North American Datum 1983), all layers would have the same projection (UTM Zone 10), and the analytical environment would be set to the pixel size chosen to best represent the data.

Step 4: Construction of a priori models

A priori models would be constructed based on the variables hypothesized to be important based on literature support. Once all GIS values are obtained and entered in a spreadsheet, then the data table could be converted to a text file and imported into the statistical program R. To test for redundancy in explanatory power among habitat variables, a correlation analysis would be completed to identify variables with moderate to high correlation ($r \geq 0.60$) within each of the hypothesized models. The models including correlated variables would be removed from the analysis. An information-theoretic approach would be used to evaluate competing models (Burnham and Anderson 2002). The goal is to build the simplest model that describes the relationship between the habitat variables and the response variable.

Step 5: Complete regression analysis and AIC ranking to evaluate model performance

Akaike's Information Criterion adjusted for small sample size (AIC_c; Akaike 1973; Burnham and Anderson 2002) would likely be used to compare and select among candidate models. The goal would be to include the smallest number of predictor variables necessary to make good

predictions. Model ranking and selection of “best” models within the study area would be based on AIC_c (Akaike 1973; Burnham and Anderson 2002). If ΔAIC among the top tier of models is <2, model averaging will be considered. Otherwise, the most parsimonious model will be selected (Burnham and Anderson 2002).

Table SOP 5.7. Point and landscape metrics to be considered in *a priori* habitat models.

Point Variables	Reasoning for Variable Consideration
Slope position (proportion)	nest sites found in watershed are more likely to occur on lower portions of slope (Blakesley 1992; LaHaye and Gutierrez 1999; Folliard 2000; Stralberg et al. 2009)
South aspect (degrees)	important variable in Stralberg et al. (2009) for nest site occurrence; highest densities of woodrat houses on south facing aspect (136 – 270 degrees; Willy 1992)
Distance to nearest stream (m)	woodrat (primary prey species) live near small streams due to higher amounts of food resources (English 1923)
Distance to forest edge (m)	measure of fragmentation and possible effects on prey densities
Distance to nearest road (m)	measure of fragmentation and possible source of nest site disturbance
<u>Sudden Oak Death severity index (0-10)</u>	impacts to canopy closure, acorn production for woodrats (NSO prey), and increased fire risk
Landscape Variables	Reasoning for Variable Consideration
Mean elevation (m)	productivity was greatest at lower elevations (LaHaye et al. 1997, Bart and Forsman 1992); important variable in Stralberg et al. (2009) for nest site occurrence
Elevational position in watershed	important variable in Stralberg et al. 2009 for nest site occurrence
Proportion of edge	measure of forest fragmentation; increased food resources; influenced habitat fitness potential (Franklin et al. 2000; Dugger et al. 2005)
Total forest edge length (m/ha)	increased food resources (Franklin et al. 2000; Dugger et al. 2005)
Mean slope (degrees)	variable in Stralberg et al. 2009 for nest site occurrence
Percent canopy cover	associated with high canopy cover (Forsman et al. 1984); possible variable in future; data not available at this time
Proportion of old growth trees	Possible variable in future; need LIDAR imagery to tease out residual trees
Forested proportion	important variable in Stralberg et al. (2009) for nest site occurrence
Conifer proportion	variable in Stralberg et al. (2009) for nest site occurrence
Hardwood proportion	variable in Stralberg et al. (2009) for nest site occurrence
Douglas-fir proportion	variable in Stralberg et al. (2009) for nest site occurrence
Redwood proportion	variable in Stralberg et al. (2009) for nest site occurrence

Landscape Variables (cont.)	Reasoning for Variable Consideration
Bishop pine proportion	variable in Stralberg et al. (2009) for nest site occurrence
Oak (tanoak/coast live) proportion	important forage and cover for prey (Atsatt and Ingram 1983; Sakai and Noon 1993)
California bay laurel proportion	variable in Stralberg et al. (2009) for nest site occurrence; Willy (1992) found that California bay laurel was a plant of local importance to woodrats harbor abundant prey base; Willy (1992) found links to plant species associated with shrub species. However, this might be a result of forest/shrub edge effect.
Shrub proportion	variable in Stralberg et al. (2009) for nest site occurrence
Grass proportion	variable in Stralberg et al. (2009) for nest site occurrence
Urban proportion	variable in Stralberg et al. (2009) for nest site occurrence
Coarse woody debris (CWD)	Possible variable in future; woodrats use CWD in house construction; Chow (2001) roosts were associated with large, downed woody material
Sudden Oak Death proportion	Quantify tree mortality with aerial imagery
Covariates	Reasoning for covariate consideration
Weather	Timing of weather patterns (temperature and precipitation) influences reproductive success (Franklin et al. 2000)
Barred owl	Competitor and possible predator
Great-horned owl	Competitor and predator
Female age	Effects of female age on productivity (e.g., Anthony et al. 2006)

1.2.4 Barred Owls

The increasing numbers of barred owls in Marin County are anticipated to have significant, long-term impacts on the NSO population within the NPS study area. Long-term trend reports will summarize our current knowledge of barred owls within the study area and their perceived impacts on the NSO population. Reported barred owl information will include the following and may be expanded upon:

- Number of barred owl resident singles and pairs
- Location of barred owl resident singles and pairs (map)
- Known reproductive outcomes of nesting barred owls
- Number of banded barred owls (if applicable)
- Percentage of NSO territories where barred owls have been detected
- Percentage of NSO territories where barred owls have been detected that are now unoccupied
- Average proximity of NSO activity centers to barred owl activity centers
- Summary of observations of barred owl and NSO interactions

Barred owl presence will play an important role in the long-term analyses of the NSO occupancy and fecundity data and habitat selection models. As described in the previous sections of this

SOP, barred owl presence will be included as an explanatory covariate in occupancy, fecundity and habitat analyses.

1.2.5 Sudden Oak Death

The long-term effects of SOD on NSO are unknown. However, with more openings in the forest canopy from fallen trees, reduced acorn crops affecting woodrat populations, and increased fuel load for wildfire, the potential effects of SOD on NSO populations is significant. SOD presence and severity may be an explanatory variable in the long-term trends of NSO occupancy, fecundity, and habitat selection. As described in the previous sections of this SOP, SOD will be included as an explanatory covariate in occupancy, fecundity, and habitat analyses.

SOD severity data will be collected at each nest or established activity center monitored each year (see protocol narrative Section 3.4.2 and SOP 2 Section 6.3.2). Additional SOD data available for inclusion in our analyses would come from other sources. For example, in 2010, PORE submitted a US Department of Agriculture grant proposal to quantify the potential impacts of SOD on NSO within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests.

1.3 Report Formats

All documents produced by the NSO monitoring program will be published in either the Natural Resource Report Series or the Natural Resource Technical Report Series following guidance from the NPS Natural Resource Program Center in Fort Collins, CO. Published reports will adhere to a set of strict formatting standards and are peer-reviewed to ensure that information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. The Natural Resource Publications Management home page hosts a list of all documents published in the NRR and NRTR Series. The home page can be found at:

<http://www.nature.nps.gov/publications/NRPM/>

4.0 Other Reporting

4.1 USFWS Permit Reporting

The SFAN NSO monitoring program is currently not required to operate under a USFWS Endangered Species Act Recovery Permit, because the monitoring study is largely observational (with calling). The monitoring program does not include banding, otherwise handling owls, or climbing to nests, so a “take” is not expected as a result of typical monitoring activities.

4.2 Annual Administrative Report and Workplan

The Lead Biological Technician provides annual administrative updates to the I&M Program Manager in August of each year for inclusion in the Annual Administrative Report and Workplan. The update includes project highlights, summary of work completed, volunteer hours summarized by park, budget, and expected budget for the next fiscal year.

4.3 SFAN Natural Resource and Science Monthly Updates

Interesting findings and project highlights are disseminated once or twice per season through the monthly SFAN update. This one-page monthly report series is distributed by email to park and network staff. Highlights are presented in short paragraphs with photographs. The update is developed and distributed by the I&M program, and includes information from I&M and from the park Natural Resources and Science divisions.

4.4 Resource Briefing

At the end of the field season, a resource briefing should be updated and reposted to the I&M website. The briefing is a two-page summary of NSO monitoring and provides information to park and network staff.

4.5 Website Updates

The SFAN I&M program maintains a public website with a page devoted to the NSO monitoring program. At the beginning and end of the field season, the public website should be updated with any new reports or information about the monitoring.

4.6 Project Presentations

Annually, results should be presented formally to park staff at GOGA and PORE. Presentations in the past, for example, have been given through the PORE lunch-time seminar series, the GOGA educator's symposium, or the SFAN Natural Resource and Science Symposium. Posters or presentations are also encouraged at scientific meetings such as The Wildlife Society, Conservation Biology, Ecological Society of America or other meetings of regional or national scope.

5.0 Report and Data Dissemination

For the NSO monitoring program to inform park management and to share its information with other organizations and the general public, guidance documents, reports, and data must be easily discoverable and obtainable. The main mechanism for distribution of the NSO monitoring documents and data will be the Internet. The NSO monitoring protocol, accompanying SOPs, and all annual reports will be made available for download at the SFAN website:

<http://science.nature.nps.gov/im/units/sfan/>

Following review and approval by the NPS region's key official, the finalized NSO documents will be distributed as soon as possible. After new postings to the SFAN website, each cooperator will be notified of newly available documents. Cooperators include PORE, GOGA, Muir Woods National Monument, PRBO Conservation Science, Marin Municipal Water District, Marin County Open Space District, and the State Park Ecologists at Tomales Bay and Samuel P. Taylor State Parks.

The NPS I&M Program maintains an on-line natural resource bibliographic database known as NatureBib. NatureBib records will be created for all of the NSO monitoring documents, including the protocol, annual reports, and any resulting publications. The public version of NatureBib is in development by the NPS I&M program.

5.2 Data Dissemination

All data collected are public property and subject to requests under the Freedom of Information Act (FOIA). However, sensitive data, such as the location of rare species, must be withheld. While the NSO monitoring database will not be posted for public download a metadata record for the database will be maintained at the NPS Data Store. The metadata record will direct interested parties to the SFAN Data Manager for further inquiries. Metadata requirements and distribution detail are included in SOP 4: Data Management Handbook.

NSO activity site locations and status information are provided to a number of agencies. This way we ensure that our work is available to county and state planners and contractors as they plan for projects in and around Marin County. Sharing of electronic information should only occur after all the data have been proofed and error-checked, and all site status determinations are complete. Ideally, the data dissemination would be accompanied by the annual report, but that may not always be possible, depending on the length of time required for report review and approval.

All areas surveyed and owl detections are mapped using GIS software programs, and GIS layers and metadata are provided to agencies involved in land management and planning in Marin County. Map layers are made available to park staff for park planning and compliance projects.

5.2.1 BIOS Data Submission

The California Department of Fish and Game maintains the central repository for California NSO location information in the Biogeographic Information and Observation System (BIOS) data access program. At the end of each season or prior to the next season, the SFAN Data Manager and the Lead Biological Technician are responsible for submitting the project monitoring data to the BIOS program. BIOS is the preferred central contact for dissemination of NSO data to appropriate parties. All sites surveyed for any purpose are included in the reporting to California Department of Fish and Game.

The BIOS data submission will include:

- GIS shapefile (must include prj, sbn, shx, sbx, and shp files)
- associated metadata record in both XML and TXT format

A zipfile should be created to package these products prior to distribution. SOP 4: Data Management Handbook provides detailed directions for developing the GIS shapefile and metadata records.

Instructions for submitting data to BIOS are available on-line:

http://bios.dfg.ca.gov/submitting_data.asp

Email electronic copies of a cover letter, GIS shapefile, and metadata files to:

Ray McDowell, BIOS Database Coordinator
Department of Fish and Game
rmcdowell@dfg.ca.gov

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Appendix SOP 5A. R code for occupancy and fecundity estimation and trend analysis.

1. Download and open R.

Go to <http://www.r-project.org/> and click on "CRAN" in the left-hand menu. Choose a CRAN mirror site. Under "Download and Install R," select the appropriate platform then click on "base." From here, the installation files may be downloaded and run. Load the version of R that matches the version under which the VGAM package was written (currently version 2.9.2). Unfortunately, you will not know if they match until you install R and run the VGAM package, but an error message will occur if the versions do not match.

Open R and install the VGAM package. Click on the menu item "Package" then select "Install package(s)." Select a CRAN mirror site then scroll to the bottom of the drop-down list and select VGAM. Load the package by typing "library(VGAM)" (without the quotes) at the R prompt. After an R package is installed, it must be loaded every time it is used in a new R session.

2. Read the data file.

To read a data file into R, first change the working directory to the directory in which the data are stored by selecting "File\Change dir..." and selecting the appropriate directory. The data should be saved as a tab-delimited text file with a header in the first row to use the following command:

```
SPOWOcc<- read.table("SPOWOcc.txt", header=TRUE, sep = "\t")
```

For this example, the pilot data for the occupancy and fecundity analyses are provided in Appendix SOP 5B. Copy and paste the two commands into R to obtain the pilot data.

3. Obtain models for occupancy and detection.

Model selection is conducted using AIC as the selection criterion. Use site-level, year-level, and site-by-year level predictors for the occupancy model and use variables measured at the visit level for detection models. Compare each pair of occupancy and detection models and obtain the set that provides the lowest AIC value. The R code provided in the next step may serve as a template for coding occupancy and detection models for the VGAM package. AIC values may be obtained with the following function call for a model names "fit": `AICv1m(fit)`.

If a fit generates a warning message like the following, then a regularity condition has been violated and the standard errors may be calculated in error:

Warning messages:

```
1: In checkwz(wz, M = M, trace = trace, wzeps = control$wzepsilon) :  
213 elements replaced by 1.819e-12
```

The standard errors of the predicted values may be quite large, which can be checked by examining the output of the `predict.vglm` function. If this warning message is obtained, this model may produce erroneous standard errors. Select a different model that meets regularity conditions.

4. Estimate occupancy and obtain confidence intervals.

```
# The following function is used for the estimation of occupancy and detection  
# rates with the models obtained by comparing AIC values. The occupancy  
# model contains terms for the year and an indicator of core sites. The detection  
# model depends only on the month in which the survey was conducted.
```

```
SPOWlik.implicit <-function(parms,vars, data){  
  
  tmp<-rep(0,7)  
  names(tmp)<-c("pconst","psiconst", "year.o", "barred", "daytime",  
  "call", "obsnum" )  
  tmp[vars]<-parms  
  
  OccData<-data.frame(unique(cbind(data$Year, data$Barred)))  
  names(OccData)<-c("Year", "Barred")  
  M<-dim(OccData)[1]  
  
  DetData<-data.frame(unique(cbind(data$Daytime, data$Call,  
  data$ObsNum)))  
  names(DetData)<-c("Daytime", "Call", "ObsNum")  
  T<-dim(DetData)[1]  
  
  Rows<- dim(data)[1]  
  ones.Occ<-rep(1,M)  
  ones.Det<-rep(1,T)  
  year.o<- OccData$Year  
  barred<- OccData$Barred  
  daytime<-DetData$Daytime  
  call<- DetData$Call  
  obsnum<- DetData$ObsNum  
  
  # Model detection probs:  
  pmat<-expit(tmp[1]*ones.Det + tmp[5]*daytime + tmp[6]*call +  
  tmp[7]*obsnum)  
  # Model occupancy rates  
  psi<-expit(tmp[2]*ones.Occ + tmp[3]*year.o+ tmp[4]*barred)  
  
  LogLik<-rep(NA,M)  
  ymat<-data$PR  
  
  for(i in 1:M){  
    prob<-rep(1,T)  
    for (t in 1:T) {  
      # Site loop  
      # YEAR loop
```

```

index<-(1:Rows)*as.numeric((data$Year== OccData[i,1]) & (data$Barred==
OccData[i,2]) & (data$Daytime== DetData[t,1]) & (data$Call==
DetData[t,2]) & (data$ObsNum== DetData[t,3]))
index<-index[index!=0]
m<-length(index)
  if(m>0) {
    yvec<-ymat[index]
    ysum<-sum(yvec)
    nodet<-as.numeric(ysum==0)

# Calc Log likelihood

prob[t]<- ((psi[i]* pmat[t])^ysum)*((1- (psi[i]*pmat[t]))^(m-ysum))

    }
  }
# Calc prob of occurrence for each site
  LogLik[i]<-log(prod(prob))
}
sum(-1*LogLik)
}

```

Copy and paste these general functions into R for summarizing results:

```

expit<-function(x) ifelse(x>700,1,exp(x)/(1+exp(x)))
logit<-function(x) log(x/(1-x))

```

Obtain the occupancy and detection models. Analysis of the pilot data indicated # that more accurate estimates were obtained by obtaining reasonable starting # values for the regression parameters. Initial parameter estimates are obtained # for the full occupancy model from a simple logistic regression fit that assumes # perfect detection. Note that the intercept estimate is used as the initial estimate # for the intercepts of both the occupancy model and the detection model.

```

fit.full.logreg<-glm(PR~ Year + Barred + Daytime + Call + ObsNum,
family = binomial, data=SPOWOcc)
summary(fit.full.logreg)

```

Partial output:

```

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  4.29133    0.74572   5.755 8.69e-09 ***
Year         -0.10688    0.02479  -4.312 1.62e-05 ***
Barred       -0.37174    0.22689  -1.638  0.1013
Daytime      1.75383    0.13030  13.460 < 2e-16 ***
Call        -4.02091    0.71337  -5.636 1.74e-08 ***
ObsNum       0.19897    0.08109   2.454  0.0141 *

```

```
# Obtain maximum likelihood estimates for the regression parameters.
```

```
v= c("pconst","psiconst", "year.o", "barred", "daytime", "call",  
"obsnum" )  
x<-nlm(SPOWlik.implicit, p=c(4.29133, 4.29133, -0.10688, -0.37174,  
1.75383, -4.02091, 0.19897),vars=v, data=SPOWOcc, hessian=TRUE)
```

```
# Note that the output includes two warnings that "NA/Inf" replaced by maximum  
# positive value." This indicates that the Hessian matrix is not positive-definite  
# and the standard errors may be inaccurate. This model is used for trend testing  
# with the likelihood ratio test which is not affected by the Hessian matrix. The  
# model that excludes the year term was found to have lowest AIC and a positive-  
# definite Hessian matrix.
```

```
# Examine the fitted values of occupancy and detection rates:
```

```
phat<-expit(data.matrix(cbind(1, SPOWOcc[,6:8]))%% data.matrix(x  
$estimate[c(1,4:6)]))  
pihat<-expit(data.matrix(cbind(1, SPOWOcc[,c(1,5)]))%%  
data.matrix(x$estimate[c(2:4)]))  
unique(cbind(Barred=SPOWOcc$Barred, Daytime=SPOWOcc$Daytime,  
Call=SPOWOcc$Call, ObsNum=SPOWOcc$ObsNum,  
pihat=round(pihat,4),phat=round(phat,4)))
```

```
# Obtain estimated occupancy probabilities and CI's using the invariance property of  
# MLEs. Account for the fact that VGAM predicts the probability that site is  
# unoccupied:
```

```
X.Occ<- data.matrix(cbind(1, SPOWOcc[,c(1,5)]))  
Beta.Occ<- data.matrix(x$estimate[2:4])  
Var.Beta.Occ<-solve(x$hessian)  
yhat<- X.Occ%% Beta.Occ  
SE.yhat<-sqrt(diag( X.Occ%% Var.Beta.Occ[2:4,2:4] %% t(X.Occ)))
```

```
# Estimated occupancy near 1 and estimated SE's near 0 generate a Hessian matrix  
# that is not positive-definite.
```

```
alpha<-0.20  
Z.alpha<- qnorm(1-alpha/2)  
OccCILow.Untrans<- yhat - Z.alpha* SE.yhat  
OccCIHigh.Untrans<- yhat + Z.alpha* SE.yhat  
OccCILow <-expit(OccCILow.Untrans) # CI low of prob occupied  
OccCIHigh <-expit(OccCIHigh.Untrans) # CI high of prob occupied  
Occ.Ests<-data.frame(round(cbind(Year=SPOWOcc$Year+1999,  
Barred=SPOWOcc$Barred, Daytime=SPOWOcc$Daytime, Call=SPOWOcc$Call,  
ObsNum=SPOWOcc$ObsNum, pihat= expit(yhat), OccCILow, OccCIHigh),4))  
names(Occ.Ests)<-c("Year", "Barred", "Daytime", "Call", "ObsNum", "pihat",  
"pihat.CI.Low", "pihat.CI.High")  
unique(Occ.Ests[order(Occ.Ests$Year, Occ.Ests$Barred, Occ.Ests$Daytime,  
Occ.Ests$Call, Occ.Ests$ObsNum),])
```

5. Test for decreasing trend in occupancy.

Plot occupancy estimates by year:

```
PiByYr<-data.frame(unique(cbind(Yr= SPOWOcc$Year+1999,Barred= SPOWOcc$Barred,
pihat=pihat)))
names(PiByYr)[2:3]<-c("Barred", "pihat")

plot(PiByYr$Yr, PiByYr$pihat, ylim=c(0,1), pch="")
points(PiByYr$Yr[PiByYr$Barred==1], PiByYr$pihat[PiByYr$Barred==1], pch=1)
points(PiByYr$Yr[PiByYr$Barred==0], PiByYr$pihat[PiByYr$Barred==0], pch=2)
legend(2000, .3, pch=1:2, legend=c("Barred owl presence", "Barred owl
absence"))
```

The plot indicates that sites with barred owl presence exhibited substantially
lower occupancy levels in the most recent three years.

To conduct the likelihood ratio test for trend, a reduced model that excludes the
year term in the occupancy model is fit and compared to the full model to
determine if the year coefficient is significantly smaller than zero.
Obtain starting values for the reduced occupancy model from a simple logistic
regression fit that assumes perfect detection.

```
fit.red.logreg <-glm(PR~ Barred + Daytime + Call + ObsNum, family =
binomial, data=SPOWOcc)
summary(fit.red.logreg)
```

Partial output:

```
Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)  3.69101    0.73203   5.042 4.60e-07 ***
Barred       -0.58602    0.22111  -2.650 0.008042 **
Daytime      1.80314    0.12919  13.958 < 2e-16 ***
Call        -4.12134    0.71308  -5.780 7.49e-09 ***
ObsNum       0.28480    0.07892   3.609 0.000307 ***
```

```
v2= c("pconst","psiconst", "barred", "daytime", "call", "obsnum" )
x2<-nlm(SPOWlik.implicit, p = c(3.69101, 3.69101, -0.58602, 1.80314, -
4.12134, 0.28480),vars=v2, data=SPOWOcc, hessian=TRUE)
```

```
chisq.test<- 2*( x2$minimum-x$minimum)
p.value<-pchisq(chisq.test, 1, lower.tail=FALSE)
c(chisq.test, p.value)
```

We reject null hypothesis of a one-sided test of decreasing trend if the p-value is
greater alpha and if the coefficient for the trend from the full fit is negative.
Here we are testing at the 0.20 level so this p-value <0.0001 indicates that
a significant decline has occurred in the occupancy trend.

6. Estimate detection rates and obtain confidence intervals.

```
X.Det<- data.matrix(cbind(1, SPOWOcc[,6:8]))
Beta.Det<- data.matrix(x$estimate[c(1,5:7)])
Var.Beta.Det<-solve(x$hessian)
yhat.Det <- X.Det %*% Beta.Det
SE.yhat.Det <-sqrt(diag( X.Det %*% Var.Beta.Det [c(1,5:7), c(1,5:7)] %*%
t(X.Det)))

DetCILow.Untrans<- yhat.Det - Z.alpha* SE.yhat.Det
DetCIHigh.Untrans<- yhat.Det + Z.alpha* SE.yhat.Det
DetCILow <-expit(DetCILow.Untrans)
DetCIHigh <-expit(DetCIHigh.Untrans)
Det.Ests<-data.frame(round(cbind(Year=SPOWOcc$Year+1999,
Daytime=SPOWOcc$Daytime, Call=SPOWOcc$Call, ObsNum=SPOWOcc$ObsNum,
phat=expit(yhat.Det), DetCILow, DetCIHigh),4))
names(Det.Ests)<-c("Year", "Daytime", "Call", "ObsNum", "phat",
"phat.CI.Low", "phat.CI.High")
unique(Det.Ests[order(Det.Ests$Year, Det.Ests$Daytime, Det.Ests$Call,
Det.Ests$ObsNum),])
```

7. Estimate fecundity and obtain confidence intervals.

The VGAM package allows the separate modeling for occupancy and detection rates. A list of matrices, denoted as H, is used to indicate in which model each term occurs. An intercept falls into both the occupancy and the detection model, so the H matrix for the intercept term is a 2x2 matrix with rows indicating regression terms and columns indicating occupancy and detection model inclusion, respectively. The Year and Barred terms were included in the occupancy model only and the Daytime, Call, and ObsNum terms were used to predict detection rates, so each of these terms includes only one column. For more help with model specification in VGAM, use `help(constraints)` or see the following link:

<http://www.stat.auckland.ac.nz/~yee/VGAM/doc/VGAM.pdf>.

```
# Load the VGAM library.
```

```
library(VGAM)
```

```
# Create "H" matrices to specify the models for fecundity rate and the probability
# of not obtaining a zero:
```

```
H1<-matrix(c(1,0,0,1),2,2)      # Intercept terms
H2<-matrix(c(0,1),2,1)         # Year term
Hlist<-list("(Intercept)"=H1, YEAR=H2)
fit.full = vgam(NUMFLEDG/3 ~ YEAR, zibinomial(zero=NULL),
constraints=Hlist, data= SPOWFec, maxit=1000,
weight=rep(3,dim(SPOWFec)[1]))
```

Obtain the estimates of the regression coefficients:

```
Coefs<-Coef(fit.full)
Coefs
```

Obtain estimates of the fledgling fecundity rate:

```
Fec.Ests<-predict.vglm(fit.full, se.fit=TRUE)
alpha<-0.20
Z.alpha<- qnorm(1-alpha/2)
FecCI.Low.Untrans<-Fec.Ests$fitted.values[,2]- Z.alpha* Fec.Ests$se.fit[,2]
FecCI.High.Untrans<-Fec.Ests$fitted.values[,2]+ Z.alpha* Fec.Ests$
se.fit[,2]
FecCI.Low <-expit(FecCI.Low.Untrans)          # CI low
FecCI.High <-expit(FecCI.High.Untrans)       # CI high
Fec.Ests.CI<-data.frame(round(cbind(Year=SPOWFec$YEAR+1999,
phat=expit(Fec.Ests$fitted.values[,2]), phat.CI.Low =FecCI.Low,
phat.CI.High =FecCI.High),6))
unique(Fec.Ests.CI[order(Fec.Ests.CI$Year),])
```

Obtain estimates of the probability of not observing an extra zero:

```
ProbZero<-1-expit(Coefs[1])
ProbZero.CI.Low.Untrans<- Fec.Ests$fitted.values[,1]- Z.alpha* Fec.Ests$
se.fit[,1]
ProbZero.CI.High.Untrans <-Fec.Ests$fitted.values[,1]+ Z.alpha* Fec.Ests$
se.fit[,1]
ProbZero.CI.Low <-expit(ProbZero.CI.Low.Untrans)
ProbZero.CI.High <-expit(ProbZero.CI.High.Untrans)
unique(round(cbind(ProbZero, CI.Low=ProbZero.CI.Low,
CI.High=ProbZero.CI.High),4))
```

8. Test for decreasing trend in fecundity.

Compute the likelihood ratio test for trend:

```
H1<-matrix(c(1,0,0,1),2,2)      # Intercept terms
H2<-matrix(c(0,0),2,1)         # Year term - excluded
Hlist2<-list("(Intercept)"=H1, Year=H2)
fit.red = vgam(NUMFLEDG/3 ~ 1, zibinomial(zero=NULL),
constraints=Hlist2, data= SPOWFec, maxit=1000,
weight=rep(3,dim(SPOWFec)[1]))
```

Compute the p-value for LRT statistic:

```
chisq.test<- -2*(logLik(fit.red)- logLik(fit.full))
p.value<-pchisq(chisq.test, 1, lower.tail=FALSE)
c(chisq.test, p.value)
```

Reject null hypothesis of a one-sided test of decreasing trend if p-value < alpha
= 0.2 and if the coefficient for the trend is negative. Here we fail to reject the
null hypothesis with a p-value of 0.9479.

Appendix SOP 5B. Example pilot data for occupancy and fecundity analysis

Occupancy data

```
SPOWocc <-  
structure(list(Year = c(1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 7, 1, 3,  
2, 3, 2, 2, 1, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 6, 3,  
4, 4, 4, 5, 5, 6, 6, 6, 7, 7, 7, 7, 9, 7, 7, 7, 6, 9, 9, 8, 8,  
8, 6, 7, 1, 6, 3, 6, 6, 6, 5, 5, 5, 4, 4, 4, 4, 4, 4, 3, 3,  
4, 2, 0, 0, 0, 2, 2, 2, 0, 2, 2, 2, 2, 3, 3, 1, 3, 3, 0, 0, 0,  
0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 7, 7, 7, 7, 7, 1, 8, 8, 8, 9, 9,  
1, 9, 9, 1, 8, 9, 3, 9, 8, 8, 8, 8, 2, 2, 2, 6, 6, 3, 3, 3, 3,  
5, 5, 5, 8, 6, 3, 7, 7, 7, 7, 7, 8, 2, 1, 1, 1, 2, 1, 1, 1, 2,  
2, 2, 2, 1, 2, 2, 2, 3, 2, 2, 2, 2, 2, 3, 3, 3, 3, 6, 3, 3, 7,  
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7, 7, 7, 7, 7, 8, 8, 7, 8, 5, 9, 9, 9, 9, 9, 9, 0, 8, 0, 7, 1,  
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8, 8, 8, 9, 9, 9, 9, 9, 8, 3, 3, 2, 3, 3, 3, 2, 2, 2, 2, 2,  
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2, 3, 3, 3, 4, 0, 5, 5, 5, 5, 5, 6, 6, 6, 6, 7, 7, 7, 7, 4, 0, 3,  
4, 3, 0, 0, 0, 1, 1, 1, 2, 2, 2, 3, 9, 3, 4, 3, 3, 3, 3, 4, 4,  
4, 4, 4, 4, 4, 6, 4, 6, 4, 4, 4, 4, 5, 5, 5, 5, 5, 6, 9, 6, 6,  
6, 6, 6, 7, 8, 8, 8, 8, 8, 9, 1, 8, 8, 1, 9, 9, 0, 0, 0, 0, 0,  
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0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0, 4, 6, 7, 2, 9, 9, 9, 9,  
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8, 1, 4, 3, 3, 4, 4, 4, 4, 4, 4, 6, 4, 3, 4, 4, 4, 5, 5, 6, 4, 1,  
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7, 6, 6, 6, 6, 6, 8, 6, 6, 7, 7, 7, 8, 8, 6, 6, 4, 4, 0, 9, 9,  
9, 9, 0, 9, 0, 0, 0, 1, 1, 1, 0, 1, 6, 9, 3, 3, 3, 3, 3, 3, 4,  
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5, 5, 5, 6, 5, 1, 2, 7, 7, 7, 7, 7, 7, 7, 7, 1, 1, 1, 1, 1,  
1, 1, 0, 0, 0, 2, 5, 9, 5, 4, 5, 4, 4, 4, 2, 3, 3, 3, 3, 2, 5,  
6, 6, 6, 6, 6, 6, 7, 6, 5, 5, 5, 9, 5, 7, 7, 7, 7, 7, 8, 8,  
8, 9, 7, 7, 7, 7, 7, 7, 7, 0, 7, 0, 0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 7, 0, 3, 2, 2, 2, 2, 2, 2, 0, 1, 1, 1, 1, 0, 4, 5, 3, 3,  
3, 3, 3, 3, 3, 3, 3, 4, 7, 4, 3, 5, 6, 6, 6, 6, 7, 7, 7, 7,  
7, 9, 9, 9, 9, 9, 7, 9, 5, 5, 5, 6, 6, 6, 9, 7, 9, 9, 9, 0, 9,  
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4, 3, 4, 4, 3, 3, 3, 3, 7, 3, 6, 6, 6, 6, 6, 6, 6, 6, 6,  
6, 6, 5, 2, 7, 7, 7, 7, 7, 8, 9, 9, 9, 9, 8, 5, 1, 2, 2, 0, 0,  
0, 1, 7, 6, 6, 5, 5, 5, 1, 1, 7, 7, 3, 7, 3, 3, 7, 7, 7, 7,  
7, 7, 7, 2, 7, 2, 0, 0, 1, 1, 1, 1, 9, 2, 6, 3, 3, 3, 3, 4, 5,  
5, 6, 3, 7, 8, 6, 6, 6, 6, 6, 7, 7, 7, 9, 6, 8, 8, 9, 9, 9, 9,  
9, 9, 9, 9, 9, 9, 9, 9, 7, 9, 8, 8, 8, 8, 8, 8, 3, 7, 7, 3,  
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0, 7, 6, 1, 1, 1, 1, 2, 2, 1, 0, 0, 7, 7, 7, 7, 7, 7, 7, 7,
```


3L, 7L, 3L, 4L, 4L, 5L, 5L, 5L, 4L, 5L, 6L, 7L, 3L, 4L, 5L, 5L,
5L, 5L, 4L, 5L, 5L, 3L, 3L, 6L, 6L, 6L, 6L, 4L, 5L, 5L, 6L, 6L,
3L, 4L, 5L, 4L, 3L, 5L, 3L, 5L, 4L, 4L, 4L, 5L, 6L, 3L, 5L, 5L,
5L, 5L, 5L, 6L, 7L, 3L, 4L, 4L, 4L, 6L, 4L, 5L, 5L, 5L, 6L, 3L,
3L, 6L, 4L, 5L, 5L, 5L, 5L, 5L, 5L, 6L, 4L, 3L, 3L, 7L, 4L, 4L,
4L, 5L, 5L, 5L, 7L, 7L, 5L, 7L, 3L, 3L, 3L, 4L, 4L, 6L, 4L, 4L,
4L, 4L, 3L, 4L, 6L, 4L, 4L, 4L, 4L, 5L, 5L, 4L, 5L, 6L, 6L, 6L,
5L, 5L, 5L, 4L, 3L, 4L, 5L, 3L, 3L, 4L, 3L, 6L, 6L, 5L, 5L, 3L,
7L, 6L, 3L, 5L, 5L, 4L, 3L, 3L, 4L, 5L, 5L, 5L, 4L, 4L, 7L, 6L,
6L, 5L, 5L, 4L, 4L, 3L, 4L, 3L, 4L, 3L, 5L, 3L, 7L, 7L, 5L, 4L,
5L, 5L, 4L, 5L, 5L, 3L, 4L, 4L, 4L, 5L, 6L, 6L, 7L, 6L, 4L,
3L, 4L, 4L, 5L, 5L, 5L, 6L, 6L, 7L, 4L, 3L, 4L, 5L, 5L,
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SOP 6. Safety Procedures

Version 1.2

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
	Nov. 2007	Dawn Adams	Created	To meet new formatting and content guidelines.	1.0
1.0	Feb. 2008	Dawn Adams	Layout, added emergency #s	Edited for peer review	1.1
1.1	March 2010	David Press	Added Section 3.0 on check in / check out procedures.	To formalize these procedures	1.2

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This SOP provides safety information related to monitoring spotted owls at Golden Gate National Recreation Area (GOGA), Muir Woods National Monument (MUWO), and Point Reyes National Seashore (PORE). Also see SFAN Field Safety SOP maintained on the GOGA network drive: inpgogamahe1\Divisions\Network I&M\Shared\Standard Operating Procedures\SFAN Field SOPs\Standard Operating Procedures.

1.0 Weather and Field Attire

Summer conditions are often mild (between 60 - 80°F), but when conducting fieldwork along the coastal environment, it is important to dress appropriately for a range of weather conditions. Because of the possibility of encountering poison oak and general uneven terrain found off-trail, field personnel should wear long pants and high-topped hiking boots. Leg gaiters are also recommended to reduce the exposure to poison oak and the risk of tick bites during surveys. Since surveys can last longer than anticipated, field personnel are encouraged to take extra food and drinking water into the field.

2.0 Field Hazards

Biting or stinging invertebrates (wasps, spiders, ticks) may be encountered. The bites or stings from these animals can be painful, but usually not fatal. If bitten or stung and painful swelling or an allergic reaction occurs, seek medical attention immediately. Check your clothing and exposed skin frequently when in the field for ticks and upon returning from the field, do a more thorough body search for ticks.

Poison oak is found throughout the owl habitat in the study area. Before doing any fieldwork personnel should become familiar with the dangers associated with exposure to this native plant. If exposure occurs wash thoroughly with soap and rinse with plenty of water upon returning from the field and then apply Tecnu® ointment (provided at headquarters). If a strong reaction occurs, seek medical attention and alert your supervisor as soon as possible.

Appendix SOP 6A is the Job Hazard Analysis (JHA) for the spotted owl monitoring program. The JHA analyzes the duties, tasks, and potential hazards associated with the program, and addresses the hazards through safe work behaviors and procedures.

3.0 Check Out / Check In Procedures

When working in the field solo, whether during the day or at night, field staff should inform a supervisor, co-worker, or other responsible party of field plans and check back in at the end of the survey. At the beginning of the season, a list of field sites to be monitored should be developed that contains the geographic coordinates of the most recent activity centers. Coordinates should be in both UTM (NAD83, Zone 10) and Lat/Long (WGS 84). Detailed directions to the activity centers should be included, with trail and road names, distances, and off-trail landmarks. A copy of the site directions should be retained by all project staff and a copy should be given to park dispatch. If a spouse or housemate will be responsible for ensuring the safe return of staff after hours, a copy of the site directions should be left at home and should include pertinent phone numbers to call in case of emergency. Phone numbers should include

those for other project staff (work, home, and cell), park dispatch, Marin County Sheriff, and 911.

At the beginning of the season, project staff should meet with NPS law enforcement staff to discuss possible safety concerns with any of the NSO sites planned for monitoring that year. If necessary, law enforcement staff may accompany the project staff on initial visits to sites of concern.

Appendix SOP 6A. Job hazard analysis (JHA) for northern spotted owl monitoring activities.

POINT REYES NATIONAL SEASHORE Job Safety Analysis	Job Title: Spotted Owl Monitoring	Date: June 7, 2006
	page 1 of 3	Analysis by: Heather Jensen, Dawn Adams
Division: SCIENCE	Title of person	Reviewed by: Sarah Allen
Location: PORE, GOGA, MUWO	who does job: Biotechnician- Wildlife	Approved by:
	Supervisor: Program Lead	
Personal Protective Equipment: Long-sleeved shirt, thick pants, sturdy boots, eye protection		
Training and/or certifications		Permits

A. SEQUENCE OF BASIC JOB STEPS	B. POTENTIAL JOB HAZARDS	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT
Identify steps and sequence of work activities	Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	Determine specific controls and safe behaviors for each hazard.
Office Work- Computer use for email and data entry	Muscle and eye strain, repetitive stress injury	Proper posture and use of ergonomic furniture Take breaks every hour
Mouse care and use	Mouse bites	Handle mice gently, lifting by the tails unless tails have injuries; use greater care when mice are agitated
Owl capture and handling	Talon cuts while handling owls Being struck by adult owls when near juvenile owls	After capture, control owl's legs at all times Keep talons and beak at a safe distance from face Communicate location of adults clearly with your field partner, and have one person watching owls at all times Wear a hat and/or glasses to protect face and eyes
Travel to Field Locations in Vehicle	Driving hazards such as accident	Use defensive driving techniques Expect oncoming traffic on one-lane roads in park Be alert for foggy conditions

A. SEQUENCE OF BASIC JOB STEPS Identify steps and sequence of work activities	B. POTENTIAL JOB HAZARDS Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT Determine specific controls and safe behaviors for each hazard.
		Watch for deer, elk and other wildlife, and adjust speeds to safely operate around areas of high use Obey traffic laws and wear seatbelt at all times Do not drive when fatigued, be familiar with route or prepare for unknown route Do not talk on radio or cell phone while driving Do not put hot drinks on your lap Be familiar with the vehicle and its operation Check gauges, tires, wipers, fluids and replace when necessary Check vehicle has spare tires, jumper cable and jack with all parts.
Hiking to work areas on trails, routes or off trail navigation	Working off trail Getting lost or confused as a group Losing a crew member	Consult with law enforcement staff about areas that may be unsafe to travel off trail. If needed, arrange to have law enforcement staff join the initial site visits and clear the area. Have map and compass and other navigational aids and know how to use them. Travel together when off-trail Make sure both members of the team are aware of location, and can find route out if they are separated. When trail hiking, plan stops at trail junctions to regroup. Arrange meeting places and times -- all crewmembers must wear a watch. Have a travel plan for each day and make sure it is understood by all crewmembers Stay in communication via radio or stay in sight Carry cell phone, radio and spare batteries If lost or disorientated, stay calm, assess location by consulting map and landmarks, and proceed to

A. SEQUENCE OF BASIC JOB STEPS Identify steps and sequence of work activities	B. POTENTIAL JOB HAZARDS Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT Determine specific controls and safe behaviors for each hazard.
	<p>Working at night</p> <p>Loose footing</p> <p>Lightning storms</p> <p>Wind storms</p> <p>Exposure to cold, wet conditions</p> <p>Exposure to heat and sun Overexertion and dehydration</p> <p>Injuries due to hiking (aches, sprains and blisters)</p>	<p>nearest road or trail.</p> <p>Do not panic -- Have a mental plan for what to do if lost If injured, stay put and call dispatch. When possible, conduct night work in pairs. If working alone, leave a travel/survey plan with a supervisor, co-worker, or responsible party who will notify proper authorities in the event of a disappearance. Carry a light source and extra batteries.</p> <p>When traveling in areas with steep or unstable terrain, stagger your positions so that you are not immediately below someone, yell "rock" if you dislodge one.</p> <p>In the event of a lightning storm, turn your radio off, if near a vehicle, get entirely inside. If in the outdoors try to do the following: separate the group, get off ridge tops and away from trees, get as low as possible and if possible lie on non-conductive material.</p> <p>If it is windy enough to blow small twigs and branches out of the trees, try to get out of the woods or find an area away from hazard trees Wear proper equipment- and bring extra layers. Recognize the signs of hypothermia in yourself and others Carry and eat high-calorie foods, stay well-hydrated Have hat, sunscreen and sunglasses Recognize the signs of dehydration Take frequent rest stops (15 min per every 2 hours) and stay hydrated Pay attention to footing- plan ahead for the route to avoid steep, unstable terrain</p>

A. SEQUENCE OF BASIC JOB STEPS Identify steps and sequence of work activities	B. POTENTIAL JOB HAZARDS Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT Determine specific controls and safe behaviors for each hazard.
	<p>Injuries due to falling (lacerations, broken bones, head injuries)</p> <p>Injuries due to carrying a heavy pack</p>	<p>Use appropriate footwear, boots and socks. Prevent blisters and have blister treatments (moleskin, tape etc) accessible. Pay particular attention to traveling on steep slopes, unstable terrain, through dense vegetation, and in foggy conditions. Practice fall- arrest techniques (roll on to stomach, dig elbow, feet and knees in). Have first aid kit, stabilize injured person, treat for shock and know how to initiate rescue via radio Reduce pack weights when possible Pay attention to how you put your pack on (avoid twisting motions- get help or place pack on surface or against tree) Make sure your pack is properly fitted and balanced</p>
Hiking to work areas- Stream and river crossings	Exposure, sprains, broken bones, drowning	<p>Avoid swift or deep water crossings by using foot or automobile bridges. Be careful on slippery logs and watch footing on either side of stream crossing.</p>
Working in the outdoors	<p>Exposure to allergy-causing plants and insects</p> <p>Exposure to toxic plants</p>	<p>Alert crew members to possible problems with allergens. Be alert for toxic plants and alert to common bee and wasp nesting habitat and activity- especially the person in front. Carry Benadryl, epi-pen or other antihistamine Avoid poison oak when possible. Wear long-sleeved shirts, long pants, and hiking boots. Wash skin exposed to poison oak with Tecnu or other appropriate cleaner and change clothes if necessary at end of day/survey. Do not eat any fungus or plant unless you are 100% sure it is edible.</p>

A. SEQUENCE OF BASIC JOB STEPS Identify steps and sequence of work activities	B. POTENTIAL JOB HAZARDS Task: Identify hazards in each basic step. Site: Identify site hazards that could affect workers	C. SAFE BEHAVIORS- SAFE WORK PROCEDURES REQUIRED TO COMPLETE THE JOB/PROJECT Determine specific controls and safe behaviors for each hazard.
	<p>Exposure to ticks</p> <p>Exposure to giardia, E. coli and other pathogens</p> <p>Improper nutrition due to inappropriate food choices</p> <p>Loss of food to ravens, raccoons, small animals</p> <p>Cougar attack</p> <p>Strange or aggressive human interactions</p>	<p>Wear proper attire (long-sleeved shirts and long pants) and do frequent tick checks. If bitten by black legged tick, properly remove tick, save tick, send tick in for lab analysis, and monitor general health condition.</p> <p>Do not drink any water unless it has been filtered, boiled or treated in some fashion</p> <p>Do not create more contaminated areas- urinate away from streams and water, dig a cathole for solid waste and bury toilet paper.</p> <p>Wash hands when possible and carry hand cleaner</p> <p>Bring a variety of healthy, nutritious food that will give you good energy during travel and work. Do not rely on sugar snacks.</p> <p>Prevent animals from getting into your food by not leaving you backpack open or accessible to animals.</p> <p>If approached by cougar make yourself large and noisy, wave arms, yell, grab a stick. Back away from cougars but do not turn and run, ever. If attacked, fight back.</p> <p>Terminate contact with visitor and leave the area, contact dispatch (GOGA: 415-561-5656; PORE: 415-464-5170 or emergency numbers (911)</p>

SOP 7. Revising the Protocol

Version 1.2

Revision History Log

Previous Version #	Revision Date	Author	Changes Made	Reasons for Change	New Version #
	Sept. 2007	Marcus Koenen	Adapted from SFAN Water Quality Protocol		1.0
1.0	May 2008	Dawn Adams	Added App. A with reviewers comments and response	In prep for submitting to PWR.	1.01
1.01	March 2010	David Press	Added App. B with reviewers comments and response. Added App. C and App. D also. Changed this SOP from SOP 8 to SOP 7.	In prep for submitting protocol for final approval. Removed SOP 7 After the Season from protocol.	1.2

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This standard operating procedure (SOP) explains how to make changes to the Northern Spotted Owl (NSO) Monitoring Protocol Narrative for the San Francisco Bay Area Network (SFAN) and accompanying SOPs, and tracking these changes. Editors of the Protocol Narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data is collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

1.0 Revision Procedures

The NSO Monitoring Protocol Narrative for the SFAN and accompanying SOPs has attempted to incorporate sound methodologies for collecting and analyzing spotted owl data. However, all protocols regardless of how sound require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken. The Protocol Narrative is a general overview of the protocol that gives the history and justification for doing the work and an overview of the sampling methods, but that does not provide all of the methodological details. The Protocol Narrative will only be revised if major changes are made to the protocol. The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.

All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by SFAN staff. However, if a complete change in methods is sought, than an outside review is required. Regional and national staff of the National Park Service (NPS) with familiarity in spotted owl monitoring and data analysis will be utilized as reviewers. Also, experts in spotted owl research, monitoring, and statistical methodologies outside of the NPS can be utilized in the review process.

Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by tenths (e.g., version 1.1, version 1.2, etc.) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0, etc.) Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.

Narrative and SOP updates may occur independently. That is, a change in one SOP will not necessarily invoke changes in other SOPs; a narrative update may not require SOP modifications. The program tracks the narrative and SOP version numbers in a Master Version Table (MVT; Table SOP 7.1), which is maintained in this document (SOP 7). Anytime a narrative or an SOP version change occurs, a new Version Key number (VK#) must be created and recorded in the MVT, along with the date of the change and the versions of the narrative and SOPs in effect. The VK number increments by whole integers (e.g., 1, 2, 3, 4, 5). The protocol narrative, SOPs, and data should not be distributed independently of this table.

Updates to the MVT and changes to the Protocol Narrative or SOP must be provided to the SFAN Data Manager for inclusion in the master version table database and the metadata record.

In addition, the database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.

Post new versions on the website and forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP, including spotted owl project staff from Golden Gate National Recreation Area and Point Reyes National Seashore. Archive older versions of the protocol narrative and SOPs on the network archive server under the Spotted Owl vital sign folder.

Table SOP 7.1. Master version table and current SFAN northern spotted owl protocol documents.

Version Key #	Date of Change	Protocol Narrative	SOP 1	SOP 2	SOP 3	SOP 4	SOP 5	SOP 6	SOP 8
VK1	May 2008	6.3	1.2	1.3	1.2	1.1	1.2	1.1	1.01
VK2	July 2010	6.4	1.3	1.4	1.3	1.2	1.3	1.2	1.2

2.0 Protocol Reviews

A draft of the Northern Spotted Owl (NSO) Monitoring Protocol was submitted and reviewed by three reviewers in 2004 and to two additional reviewers in 2008. Appendix SOP 7A summarizes the major deficiencies and suggested corrective actions noted by the reviewers along with the authors' responses. The summary does not include layout, grammatical, spelling or table/figure change edit recommendations. Appendix SOP 7B documents all review comments with the authors' specific responses for the 2008 review. The authors' responses are documented in italics in both appendices. Hard copies of reviewer comments are on file at the San Francisco Bay Area Network Inventory and Monitoring office.

Appendix SOP 7A: 2004 peer review comments and response from protocol authors.

A draft of the Northern Spotted Owl (NSO) Monitoring Protocol was submitted and reviewed by three reviewers in 2004. In 2007 and 2008, review comments were incorporated into the protocol. This appendix summarizes the major deficiencies and suggested corrective actions noted by the reviewers. This summary does not include layout, grammatical, spelling or table/figure change edit recommendations. The text in italics represents the changes made to the document based on the reviewer's comments. Hard copies of reviewer comments are on file at the San Francisco Bay Area Network Inventory and Monitoring office.

Review #1: Dr. Patti Happe, Wildlife Branch Chief, Olympic National Park
patti_happe@nps.gov, Phone 360-565-3065

Reviewer expressed concern over dropping the demography study and banding program and consequent loss of survival information, which she values the more than reproductive metrics and sees the Marin population as an important contribution to a range-wide study.

Due to funding and personnel constraints for overall SFAN vital signs monitoring program, the monitoring program could not continue the additional effort spent on banding at this time.

Needs a better description of sample population and area of inference, how sample was selected.
Revised protocol narrative included a better description of previous study design and its limitations. The revised study design and subsequent reselection of study sites was described in detail.

Needs a better description of monitoring history.

Revised protocol included information from additional monitoring studies and expanded on those previously described.

Use more descriptive maps, include NSO range-wide map.

Revised map included in protocol narrative: increased size, included NSO range inset, improved NSO habitat and park boundaries delineations, and provided better description in text. Authors desired the protocol to be a public document, so did not represent sites selected for monitoring in smaller scale maps.

Data management section is missing metadata procedures.

Metadata information included in revised protocol.

Include more about why the NSO was federally listed, primary threats, and which threats apply to this population. Note absence of recovery plan and how it would apply to the SFAN area.

Information from draft recovery plan (made available in August 2007) was included in narrative background section.

Need support for 15% change threshold and description of what it means.
Revised study design and power analysis used previous data to determine specific probabilities and length of time needed to detect 10% declines in fecundity and occupancy.

Needs a better description of satellite database processes.
Included in narrative and SOP.

Is it necessary to continue nest characterization? Do we expect changes and would it change management actions?
Authors determined that due to potential changes in nesting habitat from sudden oak death and ease of collecting the nest and habitat data warranted continuing the nest characterization.

Review #2: Dr. Rocky Gutiérrez, Ph.D., University of Minnesota
gutie012@tc.umn.edu, Phone 612-624-2720

This reviewer provided the most extensive review comments throughout the protocol. Every comment is not addressed but some (e.g., sample design comments) are lumped into a single comment.

Details of sample design (randomization) and data analysis are unclear. The sampling and experimental design is not appropriate and sufficient to answer the monitoring questions and ensure statistical validity. The key issues are that no stratified random sampling design was employed and no specific analysis discussed. The current sample can be used but it limits inference to the sites monitored and not to the parks in general. Consider using MacKenzie detectability models or correct for survey effort when looking at changes in occupancy.
Corrected through SFSU sample design analysis, reselection of random sample populations for occupancy and fecundity monitoring. SFSU analyzed past data to determine probability of detection (both day and night) for at least one owl and a pair of owls, and incorporated the detectability values into a power/sample size analysis for occupancy populations. The data analysis section and SOP was expanded and more detail provided.

Need to expand discussion of the barred owl issue, and references to NSO Status review 2004. Barred owls should be a major reason for continued monitoring of spotted owls.
Included additional results from status review and draft recovery plan, which expanded the barred owl issues range-wide and within Marin County.

Relevant research on spotted owls in Marin County is not cited (Chow thesis).
Additional information provided in narrative on Marin County owl studies including Nola Chow's thesis. Rearranged background sections on history of inventory, monitoring, and research.

Protocol does not include clear and specific objectives for management action such as thresholds and or trends.
Expanded information on management objectives and triggers for management actions, but specific thresholds and subsequent management actions have not been identified. If causes of

population declines can be determined, managers may be able to act accordingly or request additional research.

Reporting section of protocol is incomplete, not well organized, and needs improvement.
Reporting section revised to make clear the types of reports and reporting schedule.

Protocol is missing example field forms, training manual, and facility and office needs section.
Missing pieces included in revised protocol and expanded SOPs.

Marin County NSO population is almost a closed population so if banding a large proportion of the small population, it is a powerful assessment of a population's status.
Due to funding and personnel constraints for overall SFAN vital signs monitoring program, the monitoring program could not continue the additional effort spent on banding at this time. A new demography study is a research option if declines are detected.

Overly ambitious set of monitoring objectives.
Monitoring objectives were reduced and remaining ones were narrowed in scope.

Reviewer suggested that the SFAN field season methods include having different monitoring teams check the same activity site as a check and balance.
Not possible because of limited field staff and site access logistics, but instituted periodically and when possible.

Emphasize need for hearing tests or adequate hearing ability in field personnel.
Addressed in personnel requirements.

Reviewer felt that survey stations set only 0.25 miles apart would lead to excessive survey stations and a 0.5 mile distance is suitable.
Unlike other NSO areas, Marin has smaller canyons and terrain features, and prominent points are not as common. In addition, the area has a higher amount of vehicle and plane traffic which the authors felt necessitated more dense survey points. Protocol text was changed to "survey stations a minimum of 0.25 mile apart".

Each member of a survey team should keep notes for future cross-referencing.
Authors changed the protocol to indicate that if members of a field team split up during a survey, both are required to take notes with the designated survey notetaker responsible for compiling the notes at the end of the survey.

Reviewer suggests collecting larger scale habitat metrics like size of patch, edge, etc.
Larger scale habitat metrics were identified through GIS during the habitat model preparation, but data is not analyzed on an annual basis and would be part of a long-term trend analysis.

Describe formal procedures for proof reading data.
Description of quality assurance/quality control procedures were expanded in data management SOP and data entry, verification and editing sections of protocol.

Reviewer questioned the purpose of the conceptual model appendix included in the original draft, which suggested that SFAN was developing a comprehensive model.

Authors decided to remove model from protocol as it was no longer a requirement and apparently was not a critical piece of information needed to understand the monitoring objectives.

Review #3: Dr. Reginald H. Barrett, University of California, Berkeley,
rbarrett@nature.berkeley.edu, Phone 510-642-7261

Reviewer generally thought the protocol met all the requirements of the protocol checklist, but had a couple additional suggestions:

Add an organizational chart of all the staff and relationships.

Revised protocol provides an expanded list of staff member involved in NSO monitoring and responsibilities, but authors felt that an organizational chart was not warranted.

Provide a chart of all the data sets (files, etc.) with names and contact information for responsible staff.

Additional network pathways for specific files were included in revised protocol. Due to expected turnover of staff, names and contact information were not included in protocol, but are provided on an annual basis to program staff and other cooperators.

Appendix SOP 7B: 2008 peer review comments and response from protocol authors.

A draft of the Spotted Owl Monitoring Protocol was submitted to Dr. James Agee, PWR Protocol Review Coordinator, and Dr. Penny Latham, PWR Regional I&M Coordinator in May 2008. Dr. Agee forwarded the protocol to two anonymous peer reviewers (R1 and R2). In 2009 and 2010, review comments were incorporated into the protocol. This appendix summarizes the deficiencies and suggested corrective actions noted by the reviewers. The text in italics represents the authors' changes to the document based on the reviewers' comments. Hard copies of reviewer comments are on file.



College of Forest Resources Box 352100
University of Washington, Seattle, Washington 98195

James K. Agee, Emeritus Professor of Forest Ecology
Ph: 206-543-8242 Fax: 543-3254
112 Winkenwerder Hall
email: jagee@u.washington.edu

October 1, 2008

The scientific review for “**Northern Spotted Owl Monitoring Protocol**” for the San Francisco Bay Area Network Inventory and Monitoring Program is complete. The protocol receives the following decision:

Needs Major Revision

Attached to this letter are review and informational documents: (1) a PWR Protocol Review Checklist. Each question is addressed in the left column; if scientific, it is addressed by me and the word is in bold, and if administrative is addressed in normal font, as a “yes”, “no”, “in part”, or N.A. [not applicable]. (2) The individual reviews are included with author's names erased, and reviewers are identified in this cover letter as R1 or R2. The reviews are self-explanatory, but what I attempt to do here is place them in an integrated context beyond the abbreviated response in the PWR Protocol Review Checklist.

The protocol is well-written and given the limited sample design, is presented well, with appropriate power analyses. Many of the earlier review comments (by NPS-selected reviewers) were addressed in the revision. Nevertheless, due to the high profile of the Northern Spotted Owl, I chose to send the protocol out for a blind peer review. While the protocol appears sufficient to “generally” inform managers from the San Francisco Network of national parks about the status and trends of Northern Spotted Owl breeding in these parks, both reviewers were in consistent agreement that this “general” protocol was insufficient. This is due to funding

limitations that significantly limit the number of sites and visits, and possible incompatibility with data collected by other agencies.

Due to the high profile of this particular vital sign, the review was forwarded in mid-August to assigned NPS personnel (Drs. David Graber and Steve Fancy, together with Penny Latham) to evaluate its political status. Their response is that all NPS monitoring protocols will be exempt from the “highly influential” criterion, as these are just study plans, so that issue is now moot.

As I read the protocol, it does deviate from the Forest Service PNW Station standards, which I believe are those used by the other Federal agencies. If true, then more funding would be required to bring the protocol into compliance. The small sample size is less an issue if the methods are compatible with those of other agencies, so that this protocol can be part of a larger dataset. On its own, it will need a larger sample size. This is the most critical issue to be addressed in a response. If the plan is to be part of larger sample, then objectives will have to be revised to reflect that the monitoring will be less to draw conclusions about park owls and more to draw conclusions about larger geographic populations.

The comments of reviewers are attached here, and major points include:

A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

Methods are well-described but are unlikely to be effective in establishing no occupancy (R2).

There is a pressing need to correlate change in owl populations with causes, but neither sudden oak death nor barred owls will be monitored in sufficient detail to establish cause (R1, R2)

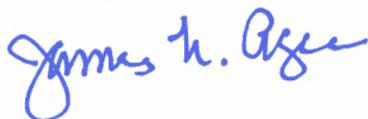
There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2)

Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

Long-term trend analysis needs more definition

Upon receipt of the protocol, due to the complex nature of the comments, I will send this out for another review to at least one reviewer. Please address each comment of the reviewers in detail.

Sincerely,



James K. Agee
National Park Service, Pacific West Region, Protocol Review Coordinator

PWR PROTOCOL REVIEW CHECKLIST

Protocol Name: SFAN Spotted Owl

Science Reviewer: **J.K. Agee** Admin. Reviewer: Mark Huff

	Overall Organization and Presentation of Protocol Narrative
Yes	1. Is the overall monitoring protocol well-organized with sections clearly delineated?
Yes	2. Does the protocol have a title page with authors' names, protocol version number and date? (Protocol version numbers should be constructed to allow for both major and minor changes.) Is there a Table of Contents, abstract, and the three basic sections: 1-Narrative, 2-Standard Operating Procedures (SOPs), and 3-Supplementary Materials or Appendices recommended in the NPS standards published by Oakley et al. 2003 (http://science.nature.nps.gov/im/monitor/protocols/ProtocolGuidelines.pdf).
Yes	3. Is there a complete and accurate table of contents with page numbers? (Chapters should be paginated consecutively, i.e. Chap. 1 (pp. 1-20), Chap. 2 (pp. 21-28), Chap. 3 (pp. 29-44), etc. to allow for modular updates.)
Yes	4. Are the tables and figures clearly labeled and understandable?
Yes	5. Is the protocol bound so that it lies flat, preferably in a 3-ring binder?
Section 1	A. Background and Objectives (Chapter 1)
Yes	1. Does the protocol narrative provide a rationale or justification for why a particular resource or resource issue was selected for monitoring? Is the history and background for this resource issue well-referenced with supporting literature cited?
Yes	2. Does the protocol narrative discuss the linkages between this and other monitoring projects? --Monitoring NSO in Marin County --Sudden Oak Death
Yes	3. Does the protocol narrative describe how monitoring results will inform management decisions?
Yes	4. Does the protocol narrative contain careful documentation of the monitoring objectives or monitoring questions being asked?
No	5. Does the protocol narrative identify specific measurable objectives such as thresholds or trigger points for management actions?
Section 1	B. Sampling Design (Chapter 2)
Unclear	1. Is there a clear and logical rationale for selecting the sampling design over others?
Yes	2a. Were the criteria for site selection clearly discussed including stratification, spatial design, and whether this monitoring will be co-located and/or integrated with other VS monitoring protocols? (See Checklist, Section 1A2.)
Yes, but questionable	2b. Has the target population or "sampling frame", and the sampling units, been identified? In other words, is the desired level of inference clear?
Yes	3. Is the sampling frequency and replication identified?
Yes	4. Is the timing of sampling defined?
No, but	5. Are the location of sampling sites clearly identified?

justified	
Yes	6. Is the level of change that can be detected for the amount or type of sampling being instituted identified? (See Checklist, Section 1A5.)
Section 1	C. Field Methods (Chapter 3)
Yes	1. Are preparations for the field season and equipment setup included? Are requirements for permitting and compliance discussed?
Yes	2. Does the protocol include clear and detailed information on taking measurements with example survey forms included? (Protocol variables and measurements may be discussed in detail in a SOP. A complete set of forms should be included in either the supplementary materials or a SOP.)
Yes	3. Is the method of access for sampling sites provided?
N.A.	4. Is there an overview of procedures for establishing, monumenting, and maintenance of plots discussed in one or more SOPs?
N.A.	5. Does the protocol include details for the post-collection processing of samples or vouchers?
Yes	6. Does the protocol include procedures to be followed at the end of the field season?
Section 1	D. Data Handling, Analysis and Reporting (Chapter 4)
Yes	1. Does the protocol provide an <i>overview</i> of the process for entering, editing, and storing data, identification of database software, and whether the database is consistent with the recommended I&M database template structure? (For water quality protocols, see specific water quality guidance in Part B or WRD's General Comments 15, and checklist items in Section 2, items 8-10, below.)
N.A.	2. Are quality assurance (QA) and quality control (QC) procedures presented for the various levels of data collection and analysis? (See water quality Part B guidance or General Comments 15 as appropriate.)
Yes	3. Is the data structure clearly presented and sufficient to capture the required information to meet the stated goal? Is there an overview of the database design?
Yes	4. Are there recommendations for routine data summaries and statistical analysis to detect change?
Yes	5. Is there a recommended reporting schedule? --the word "style" is misspelled (staylor) in Reporting Section 4.5
Yes	6. Is there a recommended report format with examples of summary tables and figures?
In part	7. Is there a recommendation for long-term trend analysis (e.g. every 5 or 10 years)?
Yes	8. Does the protocol narrative include an adequate description of metadata and data archival procedures?
Yes	9. Does the protocol narrative describe the frequency of testing and review of protocol effectiveness?
Section 1	E. Personnel Requirements and Training (Chapter 5)
mostly	Does the narrative include a listing of the personnel and describe their roles and responsibilities, and qualifications? --The Network used outside experts to develop the analytical parts of the protocol. Expertise for population trends reporting is not defined.

Yes	2. Does the protocol include a discussion of training procedures for personnel?
Section 1	F. Operational Requirements (Chapter 6)
Yes	1. Are facility, vehicle and equipment needs identified?
Probably n/a	2. Is there a summary of key partnerships with agencies, organizations and individuals that are part of the monitoring program and a description of their contribution? Is there a list of relevant cooperative agreements and other partnership agreements, if applicable?
Yes	3. Is a schedule for the annual fieldwork and administrative needs required to implement this protocol included?
Yes	4. Is there an overall budget that summarizes the annual and periodic costs of implementation of the protocol? Does it seem reasonable?
mostly	5. Does the staffing plan and budget demonstrate that adequate resources have been allocated to data management, analysis, and reporting activities (ca. 30% are recommended)? Only 1-2 pp allocated to Wildlife Ecologist; may be insufficient.
Section 1	G. Literature Cited (Chapter 7)
Yes	1. Are the literature citations relevant, sufficient and consistently formatted?
Section 2	Standard Operating Procedures (Selected essential SOPs in addition to those mentioned in the narrative outline are identified in the checklist below. For Water Quality protocols, Part B Guidance or WRD's General Comments 15 should be consulted when developing SOPs.)
Yes	1. Is there a table of contents for the SOPs?
Yes	2. Are changes to each SOP clearly identified with a title, version number or revision date, and page numbers? Changes to protocol modules (Chapters or SOPs) should be reflected in the overall protocol version number and protocol revision history log either through a minor or major revision; however, you may also wish to develop a numbering scheme for SOPs, e.g. SOP 1.00, 1.01...
Yes	3. Is there a SOP with instructions for revising the protocol and a revision history log?
Yes	4. Is there a SOP with instructions for preparation before the field season? Is there a SOP with instructions for procedures and equipment storage during and after the field season? (Also see numbers 10 and 11 below.)
Yes	5. Is there a SOP for training field personnel?
Yes	6. Is there a SOP that clearly defines protocol variables and how to measure them? (See Checklist, Section 1C2.)
	7. Are there clear and detailed driving and other navigational instructions to sampling sites?
Yes	8. Are the details of Data Management identified in one or more SOPs? Topics to be included are at minimum identified in Section 1D and may include customized data management routines. Specifically for water quality monitoring data, does the SOP specify how data will be reported to WRD for entry into the Environmental Protection Agency's STORET database?
NA	9. For water quality monitoring and other monitoring as appropriate, is there a quality control SOP associated with each protocol that adequately documents QC objectives for measurement sensitivity (detection limits), measurement precision, measurement systematic error (bias as percent recovery), data

	completeness (including adequacy of planned sample sizes and statistical power – this topic may be in the SOP on Sampling Design), and (if applicable for lab measurements only) blank control? Are instrument calibration details included either in the QC SOP or in a separate calibration SOP?
NA	10. For water quality protocols, is there a SOP that includes an explanation of how data comparability (a quality assurance basic) was considered in choosing which protocols and chemical labs to utilize? Do protocol SOPs contain enough field and lab method details to allow others to determine if data produced is comparable enough to other regional data sets to be considered credible by regulatory agencies interested in the data?
NA	11. Do aquatic protocol SOPs adequately describe the details of all Sampling Protocols (Field and Laboratory), as well as equipment needs and operation, sampling techniques, sample preservation and handling and logistics?
Yes	12. Are all major procedures required for the protocol sufficiently explained? Are any SOPs missing?
Yes	13. Are the literature citations with the SOP relevant, sufficient and consistently formatted?
Section 3	Supplementary Materials or Appendices
NA	1. Is there a table of contents with Section 3 – Supplementary Materials that clearly identifies the materials provided in this section of the protocol?
NA	2. Are the supplementary materials relevant, sufficient and consistently presented? Consistent formatting is desirable, but not always possible.
Yes	3. Are data collection forms provided either in this section or in an SOP?
Yes	4. Is there a section for the Administrative Record that provides the history of protocol development and refinement? A summary event table is highly recommended in addition to the supporting materials required in the Protocol Review File Checklist, e.g. the initial study plan or protocol development summary, the results of protocol development studies, peer review comments and responses during the development phase, and/or any published protocol on which a major portion of the methodology included in this protocol is based. (The published protocol may be presented either in Section 2 or Section 3 depending upon its contribution to the current protocol.)

PRC (Agee) Comments

This is a well-written and concise protocol. Specific comments by page number, paragraph, and line number:

Xiii, par 1 1 6: the owl is threatened, not endangered (as noted page 1 line 1).

Fixed.

P3, par 3. If there were 80 known sites before state and county lands were added, why did not that number increase when the other lands were added (Patti Happe made same comments in earlier draft).

The 1997-1998 inventories included NPS and adjacent lands, including Marin Municipal Water District, Marin County Open Space, and California State Parks. The inventory identified at least 80 different NSO activity sites throughout Marin County. The 80 sites were not just on federal lands. The paragraph noted has been revised to be clearer.

P6, par 2, 1 7: If the Stralberg analysis was done in 1999-2002, how is it not published 6 years later?

Stralberg's habitat model was published in 2009. The full citation is noted here and has been updated in the Literature Cited section of the protocol.

Stralberg, D., K. E. Fehring, N. Nur, L. Y. Pomara, D. B. Adams, D. Hatch, G. R. Geupel, and S. Allen. 2009. Modeling nest-site occurrence for the Northern Spotted Owl at its southern range limit in central California. Landscape and Urban Planning 90:76-85.

P8, par 2, 1 3 from bottom. If tanoak represents one species, how can its loss represent a "substantial proportion" of tree species richness (defined as number of species)?

Average species richness was low in the plots studied for Sudden Oak Death. In redwood forests, for example, average tree species richness was 3.2, which included tanoak. The authors wrote:

"Tanoak represents a substantial proportion of tree species richness and total woody species richness in both redwood and Douglas-fir forests. In our redwood plots, which are species-poor in comparison to our Douglas-fir plots, tanoak accounts for an average of one third of tree species richness and one fifth of total woody species richness. If tanoak is eventually eliminated by SOD, the species richness of redwood forests will be severely reduced."

We have modified the section referenced (page 8, paragraph 2) to more accurately reflect the study's findings.

P9, par 4 (Mgt objectives). Given the comments of two reviewers, I question that NSO monitoring will actually provide "critical data for land managers".

The sentence is in reference to the annual needs that park managers have for NSO data in order to perform regular park operations and maintenance. Consultation with NSO biologists has become a routine element when planning for fuel reduction projects, trail re-routes, and law enforcement actions. In this sense, the NSO monitoring data has proven itself to be a critical planning tool year after year. We hope that with revisions to our sampling design the SPOW data will prove equally as critical in determining the long-term trends in the status of the species in the parks.

P26, par 2, l 7: comparison, not comparision

Fixed.

P 26, last par, l 6: Style not Stayle

Fixed.

SFAN Spotted Owl Reviewer #1.

Process of Vial Signs Protocol Review: Summary

San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol v6.3

Background and Objectives

A good background of previous work was presented. The protocol represents significant work and thought. However, I am concerned that the objectives of the protocol will not meet the objectives of the Vital Signs monitoring. Some specific objectives were presented. The objectives of the protocol are limited to addressing long-term trends in occupancy and reproduction of a subset of documented “activity sites”. It seems improbable that there will be timely information to inform managers about emerging problems. There are no firm monitoring plans for the threats that seem most imminent: increasing barred owls and declining forest health due to sudden oak death. The objectives and the rest of the protocol seem excessively bounded by lack of funds and personnel. Even if a decline is noted, the reasons for the decline in spotted owls will be obscure.

Sampling Design

The sample design is limited by funding and personnel. I am concerned that the selection of 20-25 permanent monitoring sites results in a too narrow sample and that will not allow inferences to be drawn without pseudo-replication. Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon. The 3 years on/3years off sampling is efficient in terms of cost:benefit ratios, but very inefficient in timely detection of changes.

Sampling Methods

Methods are well described and based on a power analysis, for number of visits. But I am concerned that the number of visits is still too low (3) to establish no occupancy, particularly with increasing barred owl presence. Establishing occupancy is easy (you see one and it’s occupied), reproduction is more time consuming, but vacancy (proving a negative) is the most difficult.

It is not clear if the detailed measurements around nest trees will help meet overall objectives or if they will prove redundant.

Analytical Techniques

The analytical techniques are well developed and adequate given the design. As stated above, statistical rigor was used in developing sampling frequency using power analyses. Long-term trend analysis (5-10 yr) will be problematic with a 3yr on/3yr off design.

R1 Specific Comments

p. xiii: threats: put in order of importance; habitat loss due to anthropogenic and natural causes is probably number 1 (if within this broad category a more specific threat is paramount it should be identified; e.g., wildfire), barred owl is probably number 2, human disturbance is probably number 3. Is there any local data on sudden oak death? Other introduced plant diseases? WNV? How about other mosquito-borne diseases (e.g., the equine encephalitis group of arboviruses, avian malarias, etc.)? My concern here is that real threats be identified, new potential threats be identified along with some likelihood, etc. and not just a “bandwagon” list of threats. My concern goes beyond the bandwagon idea: we are likely going to experience a variety of new threats due to introduction of pests and diseases and exacerbation of endemic pests and diseases due to climate and land-use changes.

The sentence has been re-arranged, but we do not believe, nor do we suggest, that the list of potential threats is complete or that it represents the order of importance. At this point, we do not have enough information to accurately place these threats in order of importance. We consider all of these as real threats until proven otherwise. More detail on threats is provided in the protocol narrative, specifically in section 1.4.

The objectives apply to “activity sites” suggesting a limited subset of already identified locations available in the sampling universe within the legislated NPS boundaries will be monitored; the evaluation of changes in nesting “habitat” (there is no such thing as nesting habitat; there is habitat, and there are nest sites) within the boundaries is a non-sequitur if sampling is limited to existing activity sites.

We have modified our use of the terms “territory” and “activity site” within our monitoring objectives and throughout the remainder of the protocol and SOPs. We will be monitoring occupancy and fecundity of NSO territories. All known territories within the study area have been identified through exhaustive inventory efforts. Each year, surveys are focused on the activity site, or activity center, within each territory. The activity site is defined as the area occupied during a single breeding season by a territorial NSO resident single or pair, which would include a nest and/or roost site. Activity sites may, or may not, change from year to year.

Page 1, line 1: what was the reason for listing?

*Sentence revised to read: Northern spotted owls (*Strix occidentalis caurina*: NSO) were listed as federally threatened by the U.S. Fish and Wildlife Service on June 22, 1990 “due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms” (USFWS 1990).*

Page 3, 1.2.2: what was the basis for the choice of the 46 of the 80 known activity sites?

As noted on pg. 5, par. 2, the 46 sites were based on accessibility, management issues, and forest type. The selection was non-random, leading the NPS to modify its sampling

design during the course of developing this protocol. The selection criteria of the 46 sites have been moved to page 3, section 1.2.2.

Owls habituated to food may be less vulnerable to disturbance by park visitors and recreationists and other people because they are habituated—the presence of people is no longer novel or threatening. Mousing/habituation could also reduce the stress of repeated playback/imitated calls during surveys. Foster et al. found negative effects of research on owls they attributed to radios, but which could have as easily been attributed to repeated calling, capture, and handling for banding and for attaching radios as to the radio itself—improper attachment leading to injury to the owl, especially sores and lacerations is, of course, very serious (Foster, C. C., E. D. Forsman, E. C. Meslow, G. S. Miller, J. A. Reid, F. F. Wagner, A. B. Carey, and J. B. Lint. 1992 . Survival and reproduction of radio-marked adult spotted owls. *Journal of Wildlife Management* 56(1): 91-95). In my talks with Forsman, he has often discounted the negative impacts of normal forest operations (from maintenance to recreation) on owls and cites the case of an owl nest in a spar tree in a logging operation. Habituation can be a good thing.

The SFAN protocol limits the amount of mousing to the bare minimum needed to successfully determine occupancy and reproductive status. Mousing is used as a last resort only. Our approach to mousing and our concern for habituating a listed T&E species is consistent with NPS management policies. We have no intention of modifying our approach to mousing. In a response letter to the SFAN (Appendix SOP 7D), reviewer 4 wrote that in regards to mousing, “We don’t have any concerns with the consistency of SFAN methods.”

Page 5: dismiss the protocol as a measurable effect because other sites also used same protocol?

In the sentence referenced, “fluctuations” has been modified to read “annual fluctuations in fecundity”. We simply noted that during the demography study we observed fluctuations similar to other CA study sites, leading us to believe that our modified monitoring protocol did not have a measurable effect on fecundity determinations.

Paragraph 2 suggests highly biased sampling.

We agree and modified our site selection accordingly following our 2006 inventory. See next paragraph in narrative.

Paragraph 3 is circular: habitat is *defined* as the space(s) occupied by the species. Growth in occupancy must follow growth in habitat space. Yes, of course, there is some fluctuation around carrying capacity due to random demographic and environmental (e.g., weather) effects.

In the paragraph, we use the term “suitable habitat”, meaning the forested areas within the park boundaries where we would expect spotted owls to occur. The reviewer is correct that occupancy must follow growth in habitat space, but only if occupancy is already at carrying capacity. We simply noted a previous reviewer’s concerns that we are at carrying capacity, making occupancy growth impossible to measure.

1.3.1. I suggest rigorous use of terminology. When using “habitat” use it to refer to the areas actually occupied by spotted owls or the types of areas routinely occupied by owls. Use other language (forest types, forest seral stages, plant community classification, etc. such as provided in Wildlife-Habitat relationships manuals) when referring to the biotic environment in a more general way.

Old-growth and mature forests is a particularly annoying combination of terms. What is mature: generally when trees reach their asymptotic height or when they become economically “mature”. You can just say older forest or late-seral stage forest, etc. Similarly “multi-storied structure and high canopy cover” is over-used. You could say botanically diverse forests with complex structure and be more accurate and more descriptive.

We should be moving away from jargon and shibboleths if we want to advance our understanding of animal-environment relationships.

I'll skip further comments on language and terminology as it could get tedious.

Our use of terminology is consistent with that in the published NSO literature. Some minor changes were made throughout the protocol as suggested.

Page 7, 1.4, 1st sentence; yes, well written, and should be place up front in any discussion of threats. Nice discussion in this section.

Page 8, line 1 suggests that BAOW are now the major potential threat within the area to be monitored? The next paragraph documents a major forest health problem with SOD. Does this also create increased fire danger? Any quantitative information on effects on prey base? Might this be a threat that has to be monitored?

Oak mortality induced by SOD likely causes changes in fuel loading, stand structure, and microclimate. As these changes occur, the potential for uncharacteristically extreme fire behavior and associated ecological impacts may increase. Anecdotal reports from fire fighters working in redwood forests infested with SOD during the 2008 Basin Fire in Big Sur, California indicated increases in fire intensity of approximately 25% (Lee et al. 2009).

We are not aware of any quantitative studies in the published literature that have investigated the effects of SOD on NSO prey base. However, PORE has submitted a grant request to USDA to research effects of SOD on NSO, including prey base.

We have added an additional component to our field methods that establishes a SOD severity rating at each activity center identified during our monitoring efforts. Please refer to Section 3.4.2 of the protocol narrative and Section 6.3.2 in SOP 2: Standard Field Methods.

1.5: Would it not be necessary to include BAOW and SOD in your objectives given the massive

potential for impacts on owls? Again it is not clear if only existing activity sites are being monitored or if new activity sites can be recruited.

Measures of barred owl populations or SOD as causal factors for changes in spotted owl populations is beyond the scope of this monitoring protocol. In a response letter to the SFAN (Appendix SOP 7D), Dr. Agee, the PWR Protocol Review Coordinator, wrote, "As these are likely research topics, they should not be required as part of a monitoring protocol."

As mentioned, we have added a severity rating for SOD occurrence at activity centers to our field methods. Focused efforts beyond the incidental detections of barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Rather than add extensive monitoring of BAOW and SOD to the NSO protocol, we propose to use these simple measures of BAOW and SOD presence as covariates when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starcevich and Steinhorst (2010). See SOP 5: Data Analysis and Reporting for details.

We anticipate that additional SOD data sources within the study area will become available over time from other research projects. For example, in 2010, PORE submitted a USDA grant proposal to quantify the potential impacts of SOD on northern spotted owls within PORE and GOGA. The project would develop detailed GIS layers of SOD presence and severity, quantify the effects of SOD on dusky-footed woodrat populations, and model fire behavior within SOD affected forests.

All known territories within the study area were identified during inventory efforts in 1997-1998 and 2006. A few areas with suitable habitat but where NSO were not detected may be re-inventoried as time allows. Newly discovered territories will be added into the sampling design.

Page 9.Para 1: I don't believe owl demographic data can be used to accurately assess status and trend in the short- to medium term unless there is understanding of the factors underlying the demography. Nest-site characteristics may prove less important than foraging area characteristics.

Status and trends in NSO occupancy and fecundity can be assessed given our proposed sample design, as outlined in Section 2.0 Sample Design. The reviewer is correct, however, that the protocol may not have the ability to identify the underlying factors resulting in significant changes to occupancy and fecundity. The NSO monitoring program is unfortunately unable to collect meaningful data on all factors that may influence the NSO population within the study area. In a response letter to the SFAN (Appendix SOP 7D), reviewer 4 wrote, "My understanding is that vital signs monitoring is to detect change, and if change is detected, we are to do targeted research to understand what is going on. Monitoring foraging habitat and prey base is way beyond what the program is supposed to do."

We propose to collect information on nest site characteristics, activity center Sudden Oak Death presence and severity, and barred owl presence within the territories that are monitored. These factors may prove valuable in determining the cause of declines in occupancy and fecundity and will not tax the program with extensive, additional data collection. In addition, the SFAN has access to a broad range of additional abiotic and biotic data sources which may be employed when trying to understand long-term trends in the NSO data. For example, weather and climate data, both local and regional, are readily accessible. In addition, we have outlined in SOP 5: Data Analysis and Reporting our approach to NSO habitat modeling within the study area using nest site measurements and a suite of available landscape variables. On a final note, NSO monitoring may identify future, critical research needs, such as woodrat density, to help explain trends in the data.

Lack of funding may preclude effective monitoring and evaluation if the methods chosen deviated markedly from the more widespread use of more intensive methods—you lose the ability for comparing local demographic performance to regional and universal performance.

Without the ability to fund a rigorous banding program, our monitoring efforts are less intensive than the demography monitoring areas within the northern spotted owl's range. However, our occupancy and fecundity methods and data are comparable and could be compared at regional and range-wide spatial scales. For example, data from our study area was incorporated into Anthony et al. (2006) which analyzed demographic data from 14 study areas in Washington, Oregon, and California for the time period of 1985–2003.

Data from our monitoring effort will also contribute towards Recovery Action 3, to conduct occupancy inventory or predictive modeling, of the NSO Recovery Plan (USFWS 2008). The recovery plan notes, “Periodic assessment of the distribution of spotted owls is important because the demographic study areas may not be representative of range-wide conditions.”

1.6. para 1: so at least 1 purpose of the monitoring is to keep people away from active nest sites?

Yes – this is an important management objective of the program.

The presence of BAOW is not only a potential threat to SPOW but also may affect the efficacy of monitoring of SPOW; SPOW may become harder to detect in the presence of BAOW. It may be necessary to make provision for some additional methods if BAOW increasingly respond to SPOW playback calls.

Spotted owl detections within the presence of barred owls is a difficult issue faced by all agencies monitoring spotted owls range-wide. While the reviewer is correct that we may need to make provisions for additional methods to monitor spotted owls as our barred owl population increases, we will seek guidance in this matter to ensure that new methods are compatible with range-wide recommendations.

The USFWS released the draft “2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls” (USFWS 2010) in February 2010. The revised protocol addresses the effectiveness of the USFWS 1992 survey protocol, particularly those surveys which do not result in spotted owl detections, most likely due to barred owl presence. Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

Page 10, 1.7: trigger points not identified—therefore no planned response to changes in owl populations? Kind of abrogates the need for monitoring. If causes of declines can be determined ... that is not built into the monitoring. The failure to obtain funding for BAOW and SOD studies may very undercut the value of any SPOW monitoring.

Management triggers have been identified and added to the protocol under Section 1.7. Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol. In some cases, causes of declines in the NSO population, such as barred owls, may be easy to identify. In other cases, however, additional, specific research may be required. Depending on the management action(s), the NEPA process may be instigated, requiring significant public input. Although the SFAN will provide data and guidance, management actions will ultimately be decided by PORE, GOGA, and MUWO management staff, including, but not limited to, the park Wildlife Biologists, Science Advisors, Chiefs of Resource Management, and Superintendents.

Measures of barred owl populations or sudden oak death as causal factors for changes in spotted owl populations is beyond the scope of this monitoring protocol. In a response letter to the SFAN (Appendix SOP 7D), Dr. Agee, the PWR Protocol Review Coordinator, wrote, “As these are likely research topics, they should not be required as part of a monitoring protocol.” As previously explained, however, barred owl and SOD data can be used as covariates in our long-term trend analyses.

Page 12, 2.1: One has to wonder that with 3 years on and 3years off, what might actually be gained by monitoring other than documenting population stability or population collapse ... would there be opportunity for management intervention at all?

During revisions of this protocol, we developed new occupancy and fecundity power analyses under contract with the University of Idaho (Starcevich and Steinhorst 2010), which is included in the protocol as Appendix A. Starcevich and Steinhorst (2010) reviewed the power to detect trends for a variety of sample sizes and re-visit designs. The resulting sample design that we propose to implement is detailed in Section 2.0 of the protocol narrative. The SFAN will not implement a 3 years on 3 years off monitoring design.

Page 2.3.1.: By choosing a limited set of permanent sites have you limited your inference to these sites and these sites alone? In other words, you have one unique sample that you will study

repeatedly, allowing no inference to other areas beyond the 1st sample in time, and allowing no calculation of error without using pseudo-replication.

Our revised sample design overcomes the short comings of the previous sample design noted by the reviewer. We propose an annual panel of 28 sites and four rotating of panels of 8 sites each. A total of 36 sites will be monitored each year. Over a four year period, all territories within the study area will be surveyed.

Page 14, Para 2: increasing presence of BAOW may change these probabilities. I assume you are limiting samples to days without unusual weather or disturbances. No or low breeding obviously changes these probabilities; don't you have to assume some no/low breeding years and a priori adjust effort? 1 detection is sufficient; 3 failure to detect might well be insufficient.

The SFAN must re-visit the NSO detection rate within the study area on a regular basis to ensure that the monitoring design it still capable of meeting the monitoring objectives. We expect to review the entire monitoring design, which incorporates the detection rate, approximately every 5 years when trend reports are prepared. Conditions in the field, such as a significant increase in barred owl detections, may warrant more immediate evaluation of the monitoring design.

The USFWS released the draft "2010 Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls" (USFWS 2010) in February 2010. The revised protocol addresses the effectiveness of the USFWS 1992 survey protocol, particularly those surveys which do not result in spotted owl detections, most likely due to barred owl presence. Among other protocol revisions, the draft 2010 protocol, currently under review by the NPS, details increased survey effort over a 2-year period in order to determine unoccupied NSO status at survey areas. The SFAN anticipates adoption of the draft 2010 protocol following NPS approval.

Page 15, 2.5.: accepting an increased likelihood to detect catastrophic decline is perhaps a fatal flaw in this plan, if, as stated, monitoring results are to be feedback to management.

Our revised sample design has more than the ability to simply detect catastrophic declines. The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater. See Section 2.0 Sampling Design for details.

Page 19, 3.1: Will new survey members be formally "certified" as competent (or not) by trusted, experienced staff during field familiarization?

With a limited budget and staff, monitoring efforts would lose significant ground if a newly hired survey member proves to be incompetent in the field. However, even with rigorous hiring procedures and thorough reference checks, the SFAN may inadvertently hire someone that is inadequate in the field. New hires will undergo significant training and thorough review of field notes, datasheets, and maps. New staff will not be permitted

to conduct solo surveys until supervisory staff is confident in their abilities. If a new hire proves incompetent, the SFAN staff will be forced to fill in as needed until an adequate replacement arrives. Training requirements for new staff have been added in a new section of SOP 1.

Page 20: What provision is there for field observers to report any problems or doubts they have about the protocol so that these can be addressed immediately?

While there is no formal method for reporting problems outlined in the protocol, our staff is small, works together very closely during the field season, and checks-in almost daily. Field observers are traditionally supervised by others that are actively participating in the monitoring. The staff holds a pre-season, organizational meeting, and there are several follow-ups during the course of the season, both via email and during face-to-face meetings. Field observers are always encouraged to report problems or doubts regarding their work.

3.3.2. To what use will these detailed measurement of nest trees be put? It doesn't seem to address the monitoring objectives.

Nest site measurements directly address monitoring objective 3. Other studies have detailed similar nest characteristics (i.e., Buchanan and Irwin 1993). Nest site measurements are very simple to conduct in the field with virtually no extra cost to the field crew. They also provide us with good indications of major changes in nest site selection and habitat around the nest sites. Some nest site variables may be incorporated into modeling approaches to assess NSO habitat relationships within the study area.

Page 21, 3.4.1: are there other diseases as likely or more likely to affect the owls, such as those in the equine encephalitis group?

Unknown. The NSO Recovery Plan (USFWS 2008) indicates that, "At this time, no avian diseases are significantly affecting spotted owls. It is unknown whether avian diseases such as West Nile Virus (WNV) or avian flu will significantly affect spotted owls."

3.4.2: I would think a more careful reporting for SOD would be employed; all SOD could be GPS'd and reported.

SOD is widespread throughout much of the NSO study area. A GPS point of all SOD occurrences would take away from much of the limited field time available for NSO monitoring. An independent effort to develop GIS layers of SOD presence and severity is a more suitable approach. The NPS submitted a proposal to USDA in 2010 to develop these GIS layers as part of an SOD research project. In addition, a SOD Severity Index has been added to the protocol that will provide an assessment of SOD around NSO activity centers.

Page 29: certification procedures for biotechs and volunteers should be developed.

Although no formal certification procedures exist, training requirements for volunteers and new staff are outlined in SOP 1.

SOP 2, Page 24: define overstory and understory very specifically. 33% by cover? By Biomass? Count overstory foliage in the understory as in the understory. Be very specific.

We have added specific details to this section, including clarification that we are recording species that compose >33% by cover. Overstory classification assumes that a tree receives direct sunlight, and thus its loss will increase light penetration to the forest floor. Understory vegetation may occur at any height secondary to the upper canopy layer, and includes secondary trees, shrubs, and herbs.

SOP 2, Page 25: description of site is too vaguely worded, too subject to interobserver variability.

This portion of the nest habitat form has no set guidelines. However we have added the following guidance to this section, "Provide all details needed to orient future field staff to the site."

SOP 5, Page 4: I may have missed it, but all the data collected around nests—how do you avoid duplicate measurements or do you intend them? I'm confused about how you value "trends" in slope, distance to opening, distance to edge, water, etc.

During the course of this study, we have documented owls re-using nest trees, sometimes even the same platform or cavity nest structure. As of 2008, of the 274 nests located, approximately 12% of those were re-used nest trees. For each year that a nest tree is used, we re-measure nest tree DBH, nest height, slope, aspect, distance to water, etc. at the nest tree. During analysis, it will be easy to filter the data for nest trees used in more than one year and avoid adding duplicate measurements into the analysis.

A suite of habitat variables will be employed to evaluate NSO habitat relationships within the study area over time. Some measures will be collected on site whereas others will be based on available GIS layers. If models that predict NSO nest site occurrence or reproductive success shift over time, the data can be further explored to see what habitat variables are driving model variances. For example, we could explore an interaction between year and distance to edge to see if there has been a significant movement of NSO towards forest edge habitats over time. The root cause of such a shift, however, may not be explained by the data and could require additional research.

Nice Job Hazard Analysis.

SFAN Spotted Owl Reviewer #2

The three reviewers who reviewed an earlier version of this protocol in 2004 affirmed many of the checklist items. I agree with those assessments and did not cover them in this review. Key comments made by 2004 reviewer R. J. Gutiérrez are referenced below as *RJG*.

1. Is the overall monitoring protocol well organized, clearly written and will it produce scientifically sound results?

RJG stated that *the basic protocol is fine*, which I agree, but he also stated that *the details of analysis are sufficiently unclear to allow answering the question will it produce “scientifically sound results?”* The key issues are the randomization design for the sampling and the explicit analysis to be used for different types of data gathered. The randomized design issue was addressed by the authors. Analyses to assess long term trends are too hypothetical. It’s still unclear if the monitoring data are capable of delivering statistically significant trends. While the analytical methods for occupancy rate and fecundity are described briefly in SOP 5, it seems that the details of the methods are in an unpublished report by Connor and LeBuhn 2007. In SOP 5, the analytical methods are not linked back to the sampling design to demonstrate that detecting trends are feasible in such small landscapes. Also, the Narrative needs to succulently describe the analyses used to assess long-term trends.

During revisions of this protocol, we developed new occupancy and fecundity power analyses under contract with the University of Idaho (Starcevich and Steinhorst 2010), which is included in the protocol as Appendix A. Starcevich and Steinhorst (2010) reviewed the power to detect trends for a variety of sample sizes and re-visit designs. The resulting sample design that we propose to implement is detailed in Section 2.0 of the protocol narrative. The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater. Our methods for long-term occupancy and fecundity analyses are entirely derived from Starcevich and Steinhorst (2010) and are described in SOP 5: Data Analysis and Reporting.

It is not clear how the authors are addressing long-term effects of barred owls relative to the listed three measureable objectives in the Narrative.

Narrative 2.1: *Occupancy monitoring, when combined with detection probabilities, may be the most cost-effective means to detect population trends, long-term effects of barred owls, or other threats to the NSO population on federal lands in Marin County.*

Olson et al. (2005) recommend the use of a site-specific barred owl covariate in NSO detectability analyses to prevent false conclusions about NSO occupancy decreases.

Issues surrounding the sampling of Barred Owls need to be addressed.

A systematic protocol for sampling barred owl occupancy within the study area is beyond the scope of this monitoring protocol. Focused efforts beyond the incidental detections of

barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Our approach instead will be to use BAOW as a covariate when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starceвич and Steinhorst (2010). SOP 5: Data Analysis and Reporting details our approach to incorporating barred owls presence into occupancy, fecundity, and habitat analyses.

5. Does the monitoring protocol include a good and thorough summary of existing and previous monitoring work in the parks, the network of parks, and region relative to the indicator

Key research/monitoring findings on spotted owls in CA and from the broader perspective-- Anthony et al. 2006--needs to be included (providing a range-wide context for work in Marin County).

Section 1.1 has been re-organized and re-titled as “Northern Spotted Owl Range-Wide Status and Habitat Associations”. The rationale for monitoring initially contained in Section 1.1 has been expanded and moved to just before Section 1.1. A summary of key research findings from the NSO literature, including Anthony et al. 2006, has been included in Section 1.1.

7. Does the monitoring protocol include clear and specific objectives for management action such as thresholds and or trends?

The authors acknowledge that *trigger points for management have not been identified*. Not clear what management can do. Removal of barred owls from national parks is not a viable option.

Management triggers have been identified and added to the protocol under Section 1.7. Identifying or providing examples of specific management actions that may be employed under different scenarios is beyond the scope of this monitoring protocol.

4. Is the sampling and experimental design appropriate and sufficient to answer the monitoring questions and ensure statistical validity?

Details are missing for long-term analyses and habitat relations.

Detailed statistical methods for detecting changes in occupancy and fecundity over time have been added to SOP 5: Data Analysis and Reporting. We have also drafted a detailed GIS modeling approach that will be used to investigate how occupancy and reproductive success may be related to important habitat variables.

1. Is planning and project management (e.g., staffing, budgeting, scheduling) clearly described, logical, and likely to ensure that the project objectives will be met?

Budget/staffing time commitment for analyses and reports not clear.

Annual reporting is built into the annual project schedule as indicated in Table 3. The Lead Biological Technician is responsible for report preparation in coordination with the project lead(s), as indicated in Section 4.5 and Section 5.1. We have added to Section 6.3 to clarify that the annual budget for the Lead Biological Technician includes completion of the annual report. Section 5.1 clarifies that long-term trend reports are initiated and completed by the project lead(s). Budget needs for long-term trend reports are unknown at this time. However, Section 6.3 states, “If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports.”

7. Does the plan discuss the need for periodic reviews of the overall monitoring program as well as individual protocols or other components?

Protocol revisions are discussed in several places in the protocol narrative and SOPs. Section 2.4 of the protocol narrative discusses the need to periodically review the effectiveness of the NSO monitoring design to detect target trends in occupancy and fecundity in a timely manner. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. Section 4.6 and SOP 5: Data Analysis and Reporting note that a review of the sampling design, field methods, and analytical techniques will be explored in detail as a component of the long-term trend reports produced every 5 years. Finally, SOP 7: Revising the Protocol addresses the need to revise methodologies for collecting and analyzing monitoring data as new information becomes available. The SOP provides detailed instructions on protocol revisions to ensure that edits are reviewed, well-documented, and that current protocol versions are adequately distributed.

1. Are the literature citations relevant, sufficient and consistently formatted?

A succinct, broader literature review is needed of the NSO, especially (1) habitat studies that might guide objective 3 and (2) summarize 2006 Anthony et al. results.

Section 1.1 has been re-organized and re-titled as “Northern Spotted Owl Range-Wide Status and Habitat Associations”. The rationale for monitoring initially contained in Section 1.1 has been expanded and moved to just before Section 1.1. A summary of key research findings from the NSO literature, including Anthony et al. 2006, has been included in Section 1.1. Section 1.3.1 has been expanded and discusses research on NSO habitat relationships within the I&M study area.

2. Does the literature reflect current scientific understanding of the target indicator(s)?

Agree with RJG’s 2004 comment: *Was insufficient to determine this.*

Relevant citations from the scientific literature have been expanded.

Additional comments and suggestions:

A. Sample Design

The protocol appears sufficient to “generally” inform managers from San Francisco Network National Parks about the status and trends of the NSO breeding in these Parks. For this species, high-profile and threatened, the NPS needs to be extraordinarily careful in developing a protocol that will stand up in the courts. The reality is that the NSO is among the most litigated species in North America. The context surrounding the NSO, unfortunately, raises the bar for developing a monitoring protocol--beyond simply informing status and trends to managers that have few, if any options to take management actions for this species.

It is plausible that NSO monitoring results from Marin County National Parks could find its way into court cases. If so, would the trend analyses of occupancy and fecundity rates used in this protocol stand up in court? Statistical inferences that can be drawn from the protocol design/methods seem weak.

The protocol states: *there is a 78% probability in capturing a 10% annual decline over 8 years n=20.*

A 10% annual decline is an extraordinarily steep decline. Detecting this steep decline comes at a moderate probability, too, 78% at $\alpha=0.2$. Any decline less than a very rapid local extinction will not be detected effectively. It seems evident: for this protocol to be effective, the monitoring sample size needs to be increased substantially, perhaps doubled, and the sample frequency needs to be annual rather than periodic. The budget is well below what is needed to monitor this species effectively.

Our revised sampling design, presented in Section 2.0 of the protocol narrative, addresses the reviewers concerns. We are proposing to monitor an annual panel of 28 sites for occupancy and fecundity. The remaining 32 sites within the study area are split into four panels of 8 sites each, which will be visited over a four year period. With 8 additional sites monitored each year, we reach a total of 36 sites monitored annually (28 + 8). The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater.

B. Barred Owls

A systematic protocol for reliably sampling Barred Owl occupancy was not presented in the protocol. The following outputs are expected in the protocol using what is assumed to be an opportunistic sampling scheme for Barred Owls:

- *Barred owl*
 - *Number of detections*
 - *Number of NSO sites with barred owls detected*
 - *Barred owl occupancy status at sites*
 - *Estimate of number of barred owls in study area*

To test for barred owl effects, correlations between number of barred owls on NSO territories can be made with NSO territory occupancy or fecundity. Barred owl presence on a territory could be used as a covariate in a logistic regression analysis of NSO reproductive success. Effects of barred owls could be determined through examining whether barred owl presence is associated with changes in NSO nest site characteristics at different scales (ANOVA).

A systematic protocol for sampling barred owl occupancy within the study area is beyond the scope of this monitoring protocol. Focused efforts beyond the incidental detections of barred owls would likely require calling for barred owls within spotted owl territories, which may greatly hinder our abilities to detect trends in the spotted owl population. Our approach instead will be to use BAOW as a covariate when analyzing long-term trends in the spotted owl data. BAOW presence was included as a covariate in the occupancy power analysis developed by Starcevich and Steinhorst (2010). See SOP: 5 Data Analysis and Reporting for details.

C. Effects of Periodically Changing the Study Design

The authors suggested that the sample design would have to change as Barred Owl populations increased (inevitable?) (text shown below). Yet, no assessment was given on the effects that drawing new samples would have on future analyses and the ability to detect trends in a reasonable timeframe. If new samples are inevitable, does it make sense to commit a long-term monitoring program to this species?

Narrative 2.3.1: Sample sites will be permanent, unless there are biological reasons to review the protocol, reassess the sample population, and reselect a sample. Scenarios that would trigger a reassessment of the current study design include a change in detectability rates, which could be due to a stronger barred owl influence, and broad population-wide biological changes, such as multiple non-breeding seasons. In addition, a precipitous drop in the occupancy rate may suggest that owls are leaving the study area, moving further outside of their historic activity centers than our field monitoring protocols can capture, or are dying for reasons unknown. Reanalyzing the detection rates using new data, completing a full study area inventory, and revising the field methods are possible responses.

Narrative 2.5.3: A random sample that is initially representative of a larger sample population can lose this ability with long-term, large-scale population changes, such as what has been seen in the effects of barred owls on the NSO populations in the Pacific Northwest. While the best sampling design is spatially and temporally balanced enough to reflect these large-scale shifts, in some cases, the shift is not captured. Knowing that the Marin County NSO population has the potential for a large change with an expansion of barred owl numbers, another inventory may be needed to in the near future to avoid the problem of missing such shifts in distribution or abundance of NSO or barred owls. Depending on findings, a new random fecundity and/or occupancy monitoring sample could be selected from this inventoried population, which may avoid any research bias that could develop by surveying the same sample of sites each year.

Our newly proposed sampling design visits all sites within our study area within a 4 year time-frame. A random sample that is not representative of the entire population is no

longer an issue with this protocol. The protocol narrative reflects this change, and the second paragraph quoted above has been removed.

As with other monitoring protocols, we will still need to review our sample design and field methods on a periodic basis to ensure that we are still able to meet our monitoring objectives. Protocol review will be a component of our long-term trend reports. We have added Section 2.4 Sample Design Review to the protocol narrative which outlines the need to review the sample design and field methods on a periodic basis.

D. Inconsistencies

1. Narrative 4.4: *For the annual reports, only NPS occupancy data from the 25 long-term monitoring sites and NPS fecundity data from the 25 fecundity sites are summarized and presented.*

Narrative 2.3.1: *The process was repeated for the fecundity monitoring using the fecundity potential sample population and selecting the first 20 sites.*

This was an unintentional inconsistency in the draft protocol we submitted for review. The error is irrelevant at this point since we have increased our sample size. We will monitor 36 sites each year for occupancy and fecundity. Both sections noted above have been revised to reflect our currently proposed sample design.

2. Inconsistent when long-term trend reports will be produced:

SOP 5 2.0: every 9-13 years

Narrative 4.6: every 10 years.

This was an unintentional inconsistency in the draft protocol we submitted for review. With our current proposal of annual monitoring, we now suggest that long-term trend reports should be produced every 5 years.

E. Budget

Narrative 6.2: Not clear from the budget where/how analyses and report production are being funded?

Annual reporting is built-into the annual project schedule as indicated in Table 3. The Lead Biological Technician is responsible for report preparation in coordination with the project lead(s), as indicated in Section 4.5 and Section 5.1. We have added to Section 6.3 to clarify that the annual budget for the Lead Biological Technician includes completion of the annual report. Section 5.1 clarifies that long-term trend reports are initiated and completed by the project lead(s). Budget needs for long-term trend reports are unknown at this time. However, Section 6.3 states, "If these needs cannot be met by park or SFAN staff, periodic costs may also include technical assistance through cooperative agreements (e.g., through a CESU) or contracts to assist with data analysis during development of long-term trend reports."

F. Peer Review Reconciliation

Comment from 2004 reviewer RJG: "...need to clarify the style. I would write this as if it were a proposal. We will do this and we will do that style. or this will be done and that will be done by this group in this manner."

Style still needs work.

For example from SOP 5.2: *Some examples of potential analyses are examining differences in occupancy and fecundity rates between age classes of females and males, factors associated with differences in habitat quality, different nesting habitat factors (e.g., distance to water, forest edge, and dominant forest structure).*

Improvements to the writing style were made throughout the protocol narrative and accompanying SOPs.

Long-term Trend Analysis Reporting

Narrative section 4.6 lacks any explanation of what kind of analyses will be done to determine statistically significant long-term trends. This is the most important analysis of the monitoring project.

Detailed statistical methods for detecting changes in occupancy and fecundity over time have been added to SOP 5: Data Analysis and Reporting. We have also drafted a detailed GIS modeling approach that will be used to investigate how occupancy and reproductive success may be related to important habitat variables. The approach to trend detection tiers off of the power analyses performed by Starcevich and Steinhorst (2010) which is described in detail in protocol Section 2.2, Section 2.3, and is included as Appendix A. Protocol Section 4.6 directs readers to the detailed step-by-step guidance to methods for long-term analytical techniques presented in SOP 5.

Appendix SOP 7C: December 2008 letter from SFAN to PWR Protocol Review Coordinator.

In December 2008, SFAN and park staff associated with the northern spotted owl monitoring protocol drafted a series of questions and clarifications following the formal peer review comments received in October 2008. A letter was sent to Dr. Jim Agee, PWR Protocol Review Coordinator, via email. The SFAN letter is included below and Dr. Agee's response is included as Appendix SOP 7D.

12/18/2008

Dear Dr. Agee,

Thank you for the response and comments from yourself and two reviewers on the SFAN Spotted Owl Monitoring Protocol. We greatly appreciate the reviewers' time and their high level of scrutiny. Many of the comments will be relatively easy to address in a subsequent draft. For example, we agree that we made inconsistent use of the term "habitat" and were unclear about the number of sample sites in different sections of the protocol and SOP.

We are writing, however, to seek additional feedback from you and the reviewers which would greatly help us in addressing the peer review comments. In particular we seek further input on the issues of sample size and cycling. Below, we respond to the six main issues that you pointed out in your cover letter with questions and requests for guidance. Given that this was an anonymous review, they may want to respond in writing but we would also welcome a dialogue, perhaps even a conference call, with our project team to allow for in-depth discussion and to reduce the amount of time needed for back and forth correspondence. Also, on several comments below we note that they run counter to the guidance from NPS. These may require additional conversations between you and Penny to give us additional guidance.

Review Point 1.

- A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

The Northwest Forest Plan suggests that more than 50 pairs should be monitored or ideally more than 75-100 (Lint, Joseph et al. 1999, Northern Spotted Owl Effectiveness Monitoring Plan). If this were applied to the SFAN spotted owl population, it would require a complete census of our study area and even then, may not be possible because of the available number of pairs and site access.

For occupancy, the sample size (n=20) selected in our protocol was based on a 78% probability of capturing a 10% annual decline over 8 years. For fecundity, the sample size (n=20) selected in our protocol was based on a 74% power of detecting a 10% annual decline in fecundity over

12 years. It appears that the main concern is the level of decline that we can detect in not adequate (we would only be able to detect a catastrophic change). This is a good issue to bring up, but we would like additional guidance on what level of change would be considered acceptable. If, for example, we increased our sample size to $n=30$, it would increase power to 88% power of detecting a 10% annual decline over 12 years, would reviewers find that to be adequate?

Related to this issue, reviewers also pointed out that the current sample size of 20 would be adequate if data can be rolled up with regional studies. It should be noted that our data currently contribute to a county-wide data set on spotted owls in this region. PRBO Conservation Science, for example, annually monitors spotted owls on up to 25 sites on non-federal lands. These lands include those managed by Marin County and the Marin Municipal Water District. The focus of their monitoring is tracking site occupancy and reproductive success in areas with management concerns. While their monitoring objective is different, their field methods are identical so that occupancy and fecundity can be compared.

Also, in the past, data collected through this monitoring program were incorporated into the 5-year review (Anthony et al. 2006. Status and Trends in Demography of Northern Spotted Owls: 1985-2003. Wildlife Monograph 163). While we are still collecting occupancy and fecundity data, we did drop banding. The field methods for determining occupancy and fecundity are still compatible with those of the Northwest Forest Plan (NWFP) and can be rolled up with future analyses. Barrowclough et al (page 1117; 2005) notes that monitoring the spotted owl in this region continues to be of interest to the NWFP because it is geographically distinct. Data from our monitoring effort will also contribute towards Recovery Action 3 (conduct occupancy inventory in areas outside of the demographic study areas; USFWS 2008. Spotted Owl Recovery Plan). The question for reviewers is then if we highlighted how data are compatible with the data collected by PRBO and the NWFP, would reviewers view the proposed sample size as adequate or would sample size continue to be problematic?

Related to sample design, in the protocol we proposed a 3-year on 3-year off rotation. We have also considered a 1 year on and 2 year off or a 1 year on 1 year off that would provide us with similar power. We selected the 3/3 design anticipating that it would be easier to hire a technician for 3 consecutive years than to hire and train a new person every other year or every 3rd year. Similarly, the design proposed for landbird monitoring would fall in 3 years on 3 years off and we could cycle these two programs. If the 3/3 design, however is insufficient, we would like thoughts from the reviewers if either of the two other designs 1/1 or 1/2 would be sufficient. We note also that even in our "off" years, PRBO will continue to monitor sites and NPS will also monitor some sites to address park management needs. These sites will not be randomly selected and may not include all monitoring described in the protocol. However, the effort will help us determine if unusual events may be occurring during a year (such as the non-nesting year in 2007). Guidance on cycling will be very helpful because if cycling of any kind is unacceptable, then our board and steering committee must make serious decisions that would require us to drop the spotted owl or another monitoring program.

Review Point 2.

- Methods are well-described but are unlikely to be effective in establishing no occupancy (R2).

We are using the same standard as in the NWFP to determine site occupancy including day visits to look for signs of use (white wash and pellets), night calling, and in some cases pre-dawn visits or searches of a larger area around previous sites. Occupancy analyses of our 1999-2005 data indicate that surveying a site twice during the day and once at night within a season would give a 98% probability of detection. In addition, we are awaiting the release of the updated USFWS northern spotted owl protocol (expected in 2009) that will help define the probability of detecting spotted owl presence or absence given the presence or absence of a barred owl. If the reviewer has something else in mind can they point us to acceptable standards?

Review Point 3.

- There is a pressing need to correlate change in owl populations with causes, but neither sudden oak death nor barred owls will be monitored in sufficient detail to establish cause (R1, R2).

We agree that this is a pressing issue but this is a research topic rather than a component of the monitoring protocol. Golden Gate NRA has received funding in 2007 to conduct a barred owl study to evaluate effects on spotted owls. The study did not get implemented because of the small population of barred owls in our study area (1 pair). Funding has been requested again for the years 2010-11. In regards to incorporating barred owl monitoring into spotted owl monitoring, according to the Northern Spotted Owl Recovery Plan (May 2008), there is no consensus on how to monitor barred owls within areas inhabited by spotted owls.

Similarly, there has been recent research on the prevalence and distribution of Sudden Oak Death (SOD) at Point Reyes NS and Golden Gate NRA. Not all of the results were presented in the protocol and the research is on-going and is a coordinated effort by several agencies and universities. This work is also continuing into 2009. In addition, we note that spotted owls exhibit site tenacity that can result in a time lag (delayed response to habitat change). This may confound the immediate effects of SOD on spotted owl biology. In the near future, we may be able to determine a correlative effect by evaluating our long-term spotted owl occupancy and reproductive data with current and available SOD monitoring data.

Although research is ongoing or planned, the main point is that while long-term monitoring should be able to detect trends, monitoring may not necessarily determine cause and effect. The direction we received from the national program is that once trends are detected, it is reasonable that additional research may be triggered to look for causal links. While we can strengthen the section of the protocol dealing with triggers for more research or management (see Review Point 4 below), the request to expand monitoring to SOD and barred owls or the myriad of other potential threats listed by R1, is outside of the scope of vital signs monitoring. As far as we know, the NWFP has not done this either.

Review Point 4.

- There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2).

While we agree that this section can be enhanced, determining specific management actions are difficult if not impossible without knowing causal links. We expect that once a “trigger” is met, additional research will be needed to determine causal links. Only after that can management actions be seriously considered.

Reasonable triggers for more research that we are considering include:

- a. a decline in productivity and/or occupancy of > 50% in one year,
- b. reproductive failure for 3 out of 6 years, and
- c. barred owls are documented at >10 spotted owl sites in any given year.

If the reviewers have other reasonable triggers in mind, we would greatly appreciate their input.

Review Point 5.

- Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

As in the Review Point 3, research on prey base and a foraging area are outside of the scope of this monitoring effort. The reason nest site characteristics have been incorporated into the study is because it is very simple to do with virtually no extra cost to the field crew. It also provides us with a good indication of major habitat changes that may be occurring around the nest sites. The reviewers are correct that if owl numbers change for other reasons (such as foraging area characteristics), research will be needed. Foraging research has been conducted in the park by PRBO Conservation Science (see Fehring et al. 2003) and could be conducted again if owl productivity changes. Similarly, if the extent or intensity of SOD increases, additional foraging or habitat research may be warranted.

Review Point 6.

- Long-term trend analysis needs more definition.

We can add more information here. Connor and Lebuhn (quantitative ecologists at San Francisco State University working with the spotted owl team) suggest that trend analyses can be conducted by fitting the appropriate ANOVA model or occupancy model to the respective fecundity and occupancy data, and examining tests for linear or quadratic trends and for temporal differences in the fecundity data, and a likelihood ratio test for a year effect on occupancy in the occupancy data. Such analyses could be updated each year after data are obtained for the current year.

Other Points

Mousing: R1 notes a concern about reduced mousing in our protocol. Early in the monitoring program, we followed the standard NWFP protocol. However, staff noted that owls were frequenting campgrounds, following hikers and roosting on deck railings of homes. Park managers decided at the time that causing habituation to spotted owl was **not acceptable** in this study area. Staff began to field test a modified approach that would reduce habituation of owls to people. The modified protocol relies on increased survey effort over mousing. This often succeeds because nests are generally platform types and not cavity types. Mousing is still conducted as a last result. When developing the modified approach in 1999, field staff tested the methods and compared results to the standard NWFP methods. Park staff also consulted with NWFP biologists to ensure data consistency while still meeting park expectations for reduced mousing. Given that data were comparable with our monitoring effort, they were included in the 5-year review (Anthony et al. Status and Trends in Demography of Northern Spotted Owls: 1985-2003. Wildlife Monograph 163).

Banding: While the reviewers expressed concern that we were not banding we would like more guidance about the reason for this. As noted above, we believe that our methods are compatible with the NWFP for occupancy and fecundity monitoring. Banding would initially increase the work load but may provide increased efficiency in the field. We would have to determine if banding for the sake of increasing our efficiency is a good justification. Additional insight from the reviewers on why we should band would be helpful.

Protocol: R1 noted that, “Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon.” As noted above, our methods are consistent. If the reviewer can provide specifics as to what aspect of our field methods the reviewer is most concerned with, it would be very helpful.

Thank you for your help. We look forward to your and/or the reviewers' response.

Happy Holidays,
Marcus

Marcus Koenen
Inventory and Monitoring Coordinator
San Francisco Bay Area Network (SFAN)

Appendix SOP 7D: April 2009 PWR response to SFAN peer review clarification letter.

In April 2009, Dr. Jim Agee responded to the letter from the SFAN and park staff presented in Appendix SOP 7C. Dr. Agee's letter is included below as Appendix SOP 7D. Responses from the SFAN are included in italics.



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April 20, 2009

The review of the SFAN network response to the initial peer review of the Northern Spotted Owl protocol has been completed. We sent the 2008 version of the protocol, the 2008 peer review, and the network's response to two reviewers familiar with northern spotted owl issues. We'll call them here reviewer 3 and reviewer 4. Note that reviewer 3 was reviewer 2 in the 2008 review. The 2008 peer review raised five major issues, and these are addressed by each reviewer below. The review is organized as follows:

- Issue raised by 2008 peer review
- Network response
- Reviewer 3 comments
- Reviewer 4 comments
- PRC (Agee) conclusions

At the end of this letter is a summary of findings.

Review Point 1. A sample of 20-25 sites is too narrow to be effective (R1). And, if increased sampling will be needed in the future this will complicate analyses (R2). Why not increase sample size now?

Network response. The Northwest Forest Plan suggests that more than 50 pairs should be monitored or ideally more than 75-100 (Lint, Joseph et al. 1999, Northern Spotted Owl Effectiveness Monitoring Plan). If this were applied to the SFAN spotted owl population, it would require a complete census of our study area and even then, may not be possible because of the available number of pairs and site access. Related to sample design, in the protocol we

proposed a 3-year on 3-year off rotation. ...Guidance on cycling will be very helpful because if cycling of any kind is unacceptable, then our board and steering committee must make serious decisions that would require us to drop the spotted owl or another monitoring program.

Reviewer 3 response. Noted above, 50 pairs are recommended by Northern Spotted Owl experts, which likely would require a complete census. It is not clear to me why the Network is asking the peer reviewers to find a solution for achieving something less than what experts have already tested and recommended (from 8 demography locations studied for more than 20 years). If documenting long-term trends of the Northern Spotted Owl is a high priority Vital Sign for this network, then the Network needs to provide effective design and sufficient resources to achieve what experts are recommending. There is a reality check that the Network seems unwilling to address; that is, rare, wide-ranging vertebrates are expensive to monitor effectively, and there are few, if any, short cuts. The question on the table is less about science and reconciling comments by peer reviewers and more about whether or not the Network is capable or willing to provide sufficient resources to monitor this species effectively.

Dr. Agee's October 1, 2008 letter stated the following: "The small sample size is less an issue if the methods are compatible with those of other agencies, so that this protocol can be part of a larger dataset. On its own, it will need a larger sample size." Dr. Agee stated the problem and solution, succinctly. Building on this point: increase the sample size by forming a "regional" partnership (agreement) to monitor trends of the Owl at a broader geographic scale than the parks alone. To achieve this, the Network's monitoring objectives, analyses, and interpretations would need to be revised, to project trends broader than at a multi-Park scale. While the design, analytical methods, and reporting would shift to a larger scale, monitoring implemented on NPS land could continue to inform land managers of the Owl's status locally. A partnership approach has its risks, however. If partners pull out, then implementation of the protocol is in jeopardy.

Reviewer 4 response. We agree with the reviewers that the sample size is pretty small. In addition, we question the value of doing just a portion of the demographic monitoring protocol, fecundity monitoring. The demographic meta-analyses has illustrated that the main driver of spotted owl lambda is adult female survival, not fecundity. Although fecundity is interesting, if the main question is spotted owl population trends, and you can't measure survival (which you can't without banding) then I think the network would be better served, and have a more powerful monitoring program if their effort focused solely on occupancy monitoring. Given the level access and spotted owl density, I suspect that they could get to almost all of the 60 sites. Occupancy monitoring would require fewer visits per site, and consequently for the same level of effort, more sites could be sampled, the area of inference would be greater, as would the power to detect trend.

I understand all too well the financial constraints with the I&M program, and do not have serious reservations with an on and off cycle of NSO monitoring, especially if the sample size is increased. However, I am a bit concerned about a 3 on and 3 off cycle. In many other NSO monitoring areas an every other year breeding cycle is prevalent. If the SFAN gets into that cycle, data would may hard to interpret because you could be in a situation where the trends would be either biased high (2 good years and one bad) or low. I suggest it might be better to a 2 year cycle.

PRC Conclusions. The reviewers agree that the sample size is too small, and there just are not short cuts to solve this problem. It's the network's call on whether you want to focus on fecundity or occupancy, and whether a 3-on/3-off or 2-on/2-off yearly sampling cycle is best (Reviewer 4 seems to have a good justification for 2-on/2-off).

This protocol includes a revised sample design that includes annual sampling and increases the number of sites sampled. Details are presented in Section 2.0. We are proposing to monitor an annual panel of 28 sites for occupancy and fecundity. The remaining 32 sites within the study area are split into four panels of 8 sites each, which will be visited over a four year period. With 8 additional sites monitored each year, we reach a total of 36 sites monitored annually (28 + 8). The sample design allows us to detect a 4% annual decline in occupancy within 5 years with 99% power. In addition, we will be able to detect a 10% annual decline in fecundity within 5 years with 80% power or greater.

Review Point 2. Methods are well-described but are unlikely to be effective in establishing no occupancy (R2).

Network response. We are using the same standard as in the NWFP to determine site occupancy including day visits to look for signs of use (white wash and pellets), night calling, and in some cases pre-dawn visits or searches of a larger area around previous sites. Occupancy analyses of our 1999-2005 data indicate that surveying a site twice during the day and once at night within a season would give a 98% probability of detection. In addition, we are awaiting the release of the updated USFWS northern spotted owl protocol (expected in 2009) that will help define the probability of detecting spotted owl presence or absence given the presence or absence of a barred owl. If the reviewer has something else in mind can they point us to acceptable standards?

Reviewer 3 response. The approaches provided are okay.

Reviewer 4 response. I agree with the SFAN network, their methods are well documented to do well in detecting NSO's, and with a formal occupancy analysis, with a proportion of the sites being revisited, one would be able to assess detection probability and possible changes in detection over time. We suggest that SFAN model occupancy as Gail Olson did using the MacKenzie et al 2003 methods, where changes in detect ability would be accounted for in the estimation of occupancy rate, regardless of the cause (breeding status, weather, barred owls, habituation, etc).

PRC conclusions. Network approach is acceptable.

Review Point 3. Correlate changes in owl populations with causes.

PRC conclusions. There was no network response to review point #3. It dealt with measures of barred owl populations or sudden oak death as causal factors for changes in spotted owl

populations. As these are likely research topics, they should not be required as part of a monitoring protocol. However, if the nest tree part of the protocol is retained, it seems that SOD could be monitored in the vicinity of nest trees quite easily.

A SOD severity index has now been included to rapidly assess the state of SOD in around activity centers. Details for SOD data collection are provided in SOP 2: Standard Field Procedures.

Review Point 4. There are no trigger points for management actions, and no suggestions of what actions might include (R1, R2).

Network response. While we agree that this section can be enhanced, determining specific management actions are difficult if not impossible without knowing causal links. We expect that once a “trigger” is met, additional research will be needed to determine causal links. Only after that can management actions be seriously considered.

Reasonable triggers for more research that we are considering include:

- a. a decline in productivity and/or occupancy of > 50% in one year,
- b. reproductive failure for 3 out of 6 years, and
- c. barred owls are documented at >10 spotted owl sites in any given year. If the reviewers have other reasonable triggers in mind, we would greatly appreciate their input.

Reviewer 3 response. The triggers provided are okay, as long a brief rationale is provided. Re: management actions: Recommend providing additional information by reviewing known management actions or proposed management actions (published and unpublished) (e.g., the ongoing USFWS Barred Owl removal study was a management action). The best sources are the Recovery Plan(s) and USFWS 5-year reviews, as well as, contacting the USFWS directly on this topic, then adapt accordingly as NPS management actions to consider.

Reviewer 4 response. I have always struggled with this issue, especially for a species that is a regional management issue. SFAN management team needs to decide what they will do under what situations. One suggestion would be management actions to take if there is an increase in barred owls and decrease in spotted owl occupancy. Because they are at the beginning phase of the invasion, they most likely can take effective action, or at least try, if the Park (s) decide that is something the can and should do.

PRC conclusions. Reviewer 3 is clear and reviewer 4 somewhat less so, but the management triggers appear reasonable and acceptable. Make sure they are presented in the protocol revision not as triggers to be “considered” but triggers that will be employed.

Two key management triggers have been added that are closely linked with our ability to detect trends.

- *A 4% annual decline or greater in pair occupancy in 5 consecutive years of monitoring.*
- *A 10% annual decline or greater in fecundity in 5 consecutive years of monitoring.*

The thresholds for these management triggers are a product of the power analysis conducted by Starcevich and Steinhorst (2010; Appendix A) and the adopted sample design for the monitoring program (see Section 2.0 Sample Design)

The previously identified management triggers were left in because they will serve to help identify unexpected, yet catastrophic changes that could occur and would trigger immediate consultation with USFWS.

Review Point 5: Nest site characteristics are well done, but what if changes in owl numbers is associated with foraging area characteristics (R1)?

Network response. As in the Review Point 3, research on prey base and a foraging area are outside of the scope of this monitoring effort. The reason nest site characteristics have been incorporated into the study is because it is very simple to do with virtually no extra cost to the field crew. It also provides us with a good indication of major habitat changes that may be occurring around the nest sites. The reviewers are correct that if owl numbers change for other reasons (such as foraging area characteristics), research will be needed.

Reviewer 3 response. No response.

Reviewer 4 response. I do question the value of continuing to measure nest tree characteristics. If the network is concerned about habitat changes, then that should be measured or assessed either through this or another (vegetation monitoring ?-) protocol. If nest trees are being monitored for management and compliance (e.g., to protect all known nest sites) that that should be just stated. My understanding is that vital signs monitoring is to detect change, and if change is detected, we are to do targeted research to understand what is going on. Monitoring foraging habitat and prey base is way beyond what the program is supposed to do.

PRC conclusions. Network response is acceptable.

Review Point 6. Long-term trend analysis needs more definition

Network response. We can add more information here. Connor and Lebuhn (quantitative ecologists at San Francisco State University working with the spotted owl team) suggest that trend analyses can be conducted by fitting the appropriate ANOVA model or occupancy model to the respective fecundity and occupancy data, and examining tests for linear or quadratic trends and for temporal differences in the fecundity data, and a likelihood ratio test for a year effect on

occupancy in the occupancy data. Such analyses could be updated each year after data are obtained for the current year.

Reviewer 3 response. The protocol authors seem to be struggling with this section, nibbling around the edges without taking it on directly. I will repeat my original comment because I believe the intent at that time was clear:

“Narrative section 4.6 lacks any explanation of what kind of analyses will be done to determine statistically significant long-term trends. This is the most important analysis of the monitoring project.”

The protocol is incomplete without addressing this point sufficiently. I recommend that authors contact one or more NPS or I&M quantitative ecologists who have completed this section of a protocol for a vertebrate species and/or contact Tom Philippi, I&M Quantitative Ecologist, to assist and provide more comprehensive perspective on the expectations for this section of the protocol.

Reviewer 4 response. Unfortunately, given our recommendations above, the network will need to go back to their statisticians. However, occupancy analysis is becoming fairly common, so I don't think this should be too hard to do (I hope).

PRC conclusions. The network needs to more specifically address the issue of long-term trends.

Additional information has been added to both the narrative, specifically in Section 4.4 and 4.6, and in detail in SOP 5: Data Analysis and Reporting for conducting the long-term occupancy and fecundity trend analyses. Instructions are also provided for the occupancy and fecundity trend analysis using the VGAM package of the R Project for Statistical Computing in the appendix to SOP 5.

Other review comments made by reviewer 4:

Mousing: We don't have any concerns with the consistency of SFANs methods.

Banding: There are advantages to banding, but in the original review it was decided that they were outweighed by cost and impact to the owls. We don't have concerns about the impacts of capture. They might have less overall impact if the monitored owls were banded and could be quickly identified this way, in fact it might save costs overall. This is a decision they should make with input from the field crew. However, if SFAN switches to occupancy monitoring, banding would not be required.

Protocol: R1 noted that, “Of further concern is the departure of the protocol from monitoring on other federal lands making it impossible to interpret results in the light of more widespread geographic phenomenon.” I agree with SFAN. I'm not sure what is this reviewer's intent, except to perhaps have SFAN do full blown demographic monitoring, which they are not required to do, nor do they have the resources to do. In addition, as they state above, the

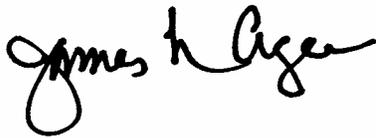
recovery plan does call for occupancy monitoring outside of the demographic areas, which is what they will be doing.

Summary of conclusions.

On review points 1 and 6, the reviewers agreed that the sample size was too small and that long-term trend analysis needs to be more specifically defined. On review points 2, 4 and 5, the reviewers agreed that the approach taken by the network for site occupancy and management thresholds is adequate. Reviewer 5 questioned the need for measuring nest tree characteristics, but if it can be afforded I see no reason that it should not be acceptable.

I hope this additional review has provided adequate guidance to the network to complete an acceptable protocol for northern spotted owl. Please remember to address not only the comments in this supplementary review but also those made in the 2008 review before resubmitting the protocol.

Sincerely,

A handwritten signature in black ink that reads "James K. Agee". The signature is written in a cursive style with a large, looped initial "J".

James K. Agee

PWR Protocol Review Coordinator

**Appendix A: Analysis of power to detect trends in
occupancy and fecundity in prairie falcon and spotted owl
populations**

**San Francisco Bay Area Network
of the
National Park Service**

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1. INTRODUCTION

The San Francisco Bay Area Network (SFAN) of the National Park Service (NPS) has identified prairie falcon and spotted owl populations as two of the network's Vital Signs for long-term monitoring. Specifically, trends in occupancy and fecundity will be monitored so that detrimental changes in the population can be identified to inform timely management decisions. The analysis approaches for measures of occupancy and fecundity are first discussed, and then power to detect trends in occupancy and fecundity is computed for all metrics of interest for the two species.

2. GENERAL ANALYSIS APPROACH

The models for both occupancy and fecundity incorporate zero inflation. For occupancy analysis, extra zeroes may result from imperfect detection. When measuring fecundity, counts of hatchlings or fledglings might be subject to zeroes from nest failures due to non-nesting pairs, predation, or environmental factors. Analysis methods for zero-inflation apply mixture models that combine one distribution for the extra zeroes and another distribution for the remaining zeroes and non-zero outcomes so that measures of occupancy and fecundity can be accurately estimated (MacKenzie et al. 2006). The number of detections for occupancy analysis and the number of hatchlings or fledglings for fecundity analysis are modeled as zero-inflated binomial random variables.

2.1 *Occupancy and trend modeling*

Let y_{ijk} be the outcome for site i , year j , and visit k , and let y_{ijk} take a value of 1 if a prairie falcon is detected and 0 otherwise. Let y_{ij} be the number of detections made at site i and year j during the k^{th} visit. The zero-inflated binomial distribution is expressed as:

$$P(Y = y_{ijk}) = \pi_{ij} p_{ij}^{y_{ijk}} (1 - p_{ij})^{1 - y_{ijk}} + (1 - \pi_{ij}) I(y_{ijk} = 0),$$

where π_j is the occupancy rate in year j and p_{ij} is the detection rate for site i and year j . Assume that there are S sites, T years, and K visits to a site each year. Define the indicator function as $I(y_{ij} = 0)$ as 1 when $y_{ij} = 0$ and 0 otherwise. This model assumes an equal number of visits to a site within a year, but K can vary among sites or among years.

Occupancy (π) is modeled with logistic regression as a function of related covariates:

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \gamma_0 + \gamma_1 x_{ij},$$

where x_{ij} represents a covariate for the i^{th} site and the j^{th} year. Multiple site-level or year-level covariates may be incorporated. To test for linear trend in the logged odds ratio of occupancy, the year covariate should be included as a predictor in the occupancy model. The probability of zero inflation (p) is simultaneously estimated by logistic regression:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta'_1 x_{ijk},$$

where x_{ijk} represents a covariate collected at the i^{th} site and k^{th} visit during the j^{th} year.

The implicit dynamics occupancy model is assumed for this analysis. In contrast to the explicit dynamics model, estimates of colonization and local extinction are not explicitly measured in the implicit dynamics model (MacKenzie et al. 2006). The net effect of extinction and colonization rates on occupancy is monitored rather than estimating the parameters separately since monitoring net change over time is the primary goal.

Maximum likelihood is used to estimate the regression coefficients from the models for occupancy and detection rates. Occupancy can be modeled at the site-by-year level so predictors should be collected at the site level, year level, or site-by-year level. Detection probabilities are allowed to vary at each visit for each site and year, so covariates are often environmental covariates that vary from visit to visit (MacKenzie et al. 2006). However, if detection rates are also changing over time, a model that includes a year covariate may be needed for accurate occupancy estimation. Model selection is conducted using the Akaike Information Criterion (AIC). Model output is examined to be certain that valid variance estimates are obtained. When valid estimates of the variance cannot be acquired for the model with the lowest AIC, then the model with the lowest AIC and valid variance is used.

2.2 Fecundity and trend modeling

Fecundity is monitored with counts of hatchlings or fledglings observed at each nest. These outcomes are also modeled with the zero-inflated binomial model. Let y_{ij} be the number of hatchlings or fledglings detected in occupied site i and year j . Let n be the number of occupied sites and T be the number of years monitored for fecundity. The probability mass function of Y is:

$$P(Y = y_{ij}) = \pi_{ij} \binom{M}{y_{ij}} p_{ij}^{y_{ij}} (1-p_{ij})^{M-y_{ij}} + (1-\pi_{ij}) I(y_{ij} = 0),$$

where π_{ij} is the probability that an extra 0 is **not** observed at site i in year j , p_{ij} is the probability of a hatchling/fledgling at site i in year j , M is the maximum number of hatchlings/fledglings seen in any nest, and $I(y_{ij} = 0)$ is 1 when $y_{ij} = 0$ and is 0 otherwise. Maximum likelihood estimation is used to obtain estimates of the regression coefficients in each model, and the invariance property of maximum likelihood estimates is used to obtain estimates of π_{ij} and p_{ij} . To test for trend in fecundity, the year covariate is included as a predictor in the binomial probability model and then tested for significance with a likelihood ratio test. In contrast to the occupancy analysis, fecundity inference is made on the change in p_{ij} over time.

2.3 Power approach

Power is often calculated assuming large-sample properties for hypothesis tests of significance. However, the assumptions necessary for assuming asymptotic normality are extensive and often difficult to verify (Sumathi and Aruna Rao, 2009). Ridout et al. (2001) observed that the normal approximation to the score test underestimates the true test size for testing the significance of the dispersion parameter when comparing the zero-inflated negative binomial and zero-inflated Poisson distributions. Jung et al. (2005) corrected this problem with a parametric bootstrapping approach to significance testing, which provided uniformly higher power. For both prairie falcon and spotted owl monitoring, trend is tested with the likelihood ratio test, which demonstrates power equal to or higher than that provided by the Wald test (Lyles et al. 2006).

Model selection for occupancy and fecundity is conducted using the pilot data for prairie falcons and spotted owls. In each case, the model with the lowest AIC score with a valid variance-covariance matrix is used in the power analysis. In all four cases, power is computed via a parametric bootstrap. For each bootstrap sample, the likelihood ratio test of trend is conducted by applying the selected model with and without the term for trend. Power is calculated as the proportion of times that the null hypothesis is rejected for the one-sided alternative hypothesis of decreasing trend, i.e.

$$H_o : \beta = 0 \text{ vs. } H_a : \beta < 0 .$$

Power must be approximated assuming that tests of trend are conducted at a specific Type I error rate. The Type I error rate, designated as α , is the probability of rejecting a true null hypothesis. For two-sided tests of trend, a Type I error would mean that the population was found to be changing when it was not. A Type II error occurs by failing to reject a false null hypothesis and thus concluding no change has occurred. For long-term monitoring, the cost of a Type I error may be far less than the cost of a Type II error. Mistakenly rejecting a true null hypothesis (Type I error) may trigger a management conservation action that is not actually needed. However, failing to detect a significant trend may have deleterious effects that cannot be reversed by the time the trend is actually detected. A conservative approach is to use a larger α value for higher power and reduced probability of a Type II error (Buhl-Mortensen 1996; Gibbs, et al. 1998; Mapstone 1995). For this power analysis, an α value of 0.20 is used. Power does not fall below the α value assumed for the trend test.

2.4 Revisit designs

Revisit designs specify the schedule of sites visitations by year for the duration of the monitoring period. Revisit design allow balance over space and time of available survey effort. The notation of MacDonald (2003) is used to describe the revisit designs.

The notation employs a string of numbers, dashes, and commas to identify the revisit design among panels. The numbers in odd-numbered positions will designate the number of consecutive visits to a panel before it rotates out of the revisit schedule. Digits in the even-numbered positions indicate the number of sampling occasions that the panel will not be revisited. Therefore, a revisit schedule of [1-0] indicates that the panel will be revisited each year and never rotated out of the schedule. This revisit schedule is equivalent to taking a random sample of sites and visiting them every year. The [1-n] revisit design represents a sampling design in which independent random samples are taken every year. A [2-2] revisit design consists of one panel visited for two consecutive years and then rested for two consecutive years before beginning the cycle again. Differing revisit schedules among panels are indicated by separating the digits in parentheses by commas within the brackets. For example, a revisit schedule of [(1-0), (1-3)] indicates that the revisit design includes an annual panel that is revisited every year and four panels that are visited for one year then not visited for the following three years before being rotated back into the design.

A random site effect may be incorporated in the occupancy or detection model to account for variation among sites. However, implementing the appropriate correlation structure in a mixed model approach may be problematic with maximum likelihood estimation (MacKenzie et al. 2006). Incorporating numerous fixed site effects may exhaust available degrees of freedom making variance estimates unreliable and trend testing inaccurate. Without fixed or random site effects, the data are treated as if collected from a [1-n] revisit design. This revisit design has the lowest power for trend detection (Urquhart and Kincaid, 1999), so power results are conservative. Since site effects are difficult to incorporate, MacKenzie et al. (2006) suggest using a [1-0] design so that unexplained variation among sites is minimized for more accurate tests of trend. Incorporating relevant site-level covariates into the occupancy model will also help explain differences in occupancy from site-to-site.

3. PRAIRIE FALCON POWER ANALYSES

SFAN, in cooperation with Pinnacles National Monument (PINN), has monitored the occupancy rate and fecundity measures of the prairie falcon population in PINN since 1984. SFAN personnel are interested in monitoring trends in occupancy and fecundity measures. This section will address the power to detect changes in prairie falcon occupancy and fecundity measurements over time.

3.1 Survey design

The target population includes 36 territories historically used by prairie falcon in PINN. Of the 36 territories in the target population, 18 of these territories fall into the "core" area. The core area consists of territories that are more accessible to climbers and hikers. These areas have been surveyed more consistently and frequently over the last 22 years to assess hiking/climbing pressure during the breeding season. Eighteen non-core areas were identified and added to the sample over time. Due to the added monitoring importance of the core areas, the core and non-core areas will be treated as separate strata with core territories censused annually. Depending on survey resources and the results of the power analysis, the non-core territories will be either censused or allocated to a set of panels that are visited on an alternating cycle.

Sites are visited at least 3 times each year with visits lasting 1 to 4 hours. At least 3 visits to a site are needed to determine that a site is unoccupied, and visits are spaced 21 to 28 days apart. In sites where prairie falcon detections are made, territorial occupancy is assessed by examining the behavior of each detected prairie falcon. Territorial behavior is verified by observing courtship or reproductive behavior or by evidence of offspring.

Pilot data collected since 1984 are available with a more consistent effort made since 2002. Detections from Ball Pinnacle and Central High Peaks were excluded because these territories are near other historic territories and are not considered independent territories. Some survey records for territories in which no detections were made were omitted from the database prior to the 2008 survey, potentially causing invalid inference on occupancy and detection rates from the incomplete data set. For this reason, only the 2008 and 2009 data are used for the power analysis. This database problem does not affect the fecundity data set because the subset of pair-occupied sites is the target population for fecundity monitoring. Fecundity monitoring data were collected from 2002 to 2009. While fecundity data are available since 1984, the data collected since 2002 represent the current methodology and are thought to be more consistent.

SFAN is interested in approximating the power to detect trends in occupancy and fecundity measures. For a Type I error rate of 0.2, the power to detect a 50% decline in each indicator of interest over a 10-year period in a one-sided alternative hypothesis is examined for several sample sizes and revisit designs.

3.2 Occupancy analysis

The definition of occupancy requires a verification of territorial behavior. A prairie falcon detection does not necessarily imply that occupancy has been established. Designation of site occupancy requires multiple site visits within a year and evidence of territorial behavior. To estimate occupancy according to the SFAN definition of occupancy, only detections verifying territorial behavior should be used. Detection probabilities from this analysis would reflect the detection of an individual or pair displaying territorial behavior. However, the current data set reflects all detections regardless of behavior. Therefore, occupancy may be overestimated in this analysis. Data analysis may be improved by recording an indicator that the detection provides proof of territorial occupancy. This field could be recorded as a 0/1 binary field rather than a descriptive field for easier data analysis.

The pilot data are examined to determine if the estimated detection rates for prairie falcon are substantially less than one, indicating that occupancy estimates should be calculated assuming imperfect detection. In the next section, the occupancy analysis approach and concurrent estimation of trend over time are discussed. All occupancy estimates relate to pair occupancy since no single prairie falcons were observed in 2008 or 2009.

3.2.1 Evaluation of detection probabilities

Maximum likelihood estimation was used to obtain estimates of regression coefficients for models of occupancy and detection rates. Occupancy models were based on a site-level covariate (an indicator for core area) and the survey year. Detection models were based on covariates collected within each site and year such as month, high temperature, low temperature, average wind speed, cloud cover, and level of precipitation. The occupancy model selected from the modeling exercise contained covariates for the year and core area inclusion. The three detection models with the lowest AIC are given in Table 3.1. The lowest detection probabilities from the first model were obtained for the relatively-few PRFA surveys conducted when precipitation was present. Because the AIC for the month-only detection model is only slightly larger, this more parsimonious model is used for model stability.

Table 3.1: Best detection models from 2008-2009 pilot data

Detection model variables	AIC	Range of estimated detection rates	2008 estimated occupancy rate (SE)	2009 estimated occupancy rate (SE)
Hi_TempF, CCPct, Precip_Code	518.31	0.3011 – 0.6965	0.9271 (0.1020)	1.0000 (0.0031)
Month, Precip_Code	519.84	0.3281 – 0.6511	0.8788 (0.0957)	1.0000 (0.0016)
Month	520.27	0.3305 – 0.6513	0.8787 (0.0956)	1.0000 (0.0010)

Plotting the estimated detection probabilities against the month predictor (Figure 3.1), one may observe that detection probabilities for PRFA are highest later in the season. A t -test of the two-sided hypothesis that the mean detection rate is equal to 1 is highly significant (p -value < 0.0001). There is no evidence that PRFA detection probabilities are so high as to warrant conducting a trend analysis that assumes perfect detectability. Therefore, the zero-inflated Bernoulli distribution is assumed.

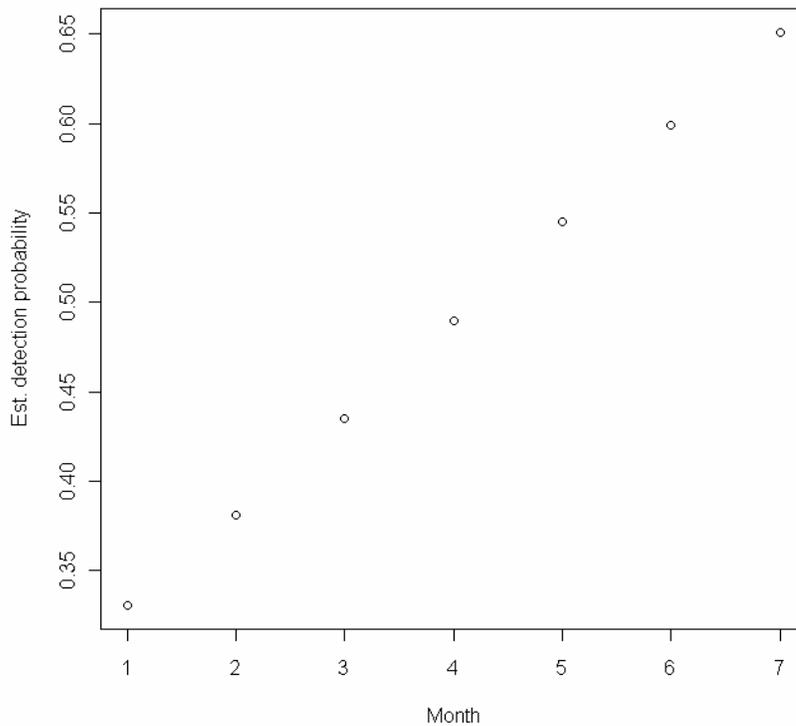


Figure 3.1: Estimated detection probabilities by month

3.2.2 Power analysis

The power analysis is conducted using the parametric bootstrapping approach. The models for occupancy and detection obtained from the pilot data are used. The month covariate is randomly selected from the pilot data so that months in which prairie falcon surveys are more common will occur more frequently in the bootstrap samples.

Power is examined for a range of sample sizes that are visited using several revisit designs. Figures 3.2 through 3.5 provide illustrations of several possible revisit designs for a range of annual sample sizes. For each revisit design, the set of core territories is visited annually and all territories are visited at least once over the course of the revisit cycle. Notice that, for the [(1-0), (1-4)] revisit design, 10 years are required to obtain complete replication at all territories. For the [(1-0), (1-1)] design, all sites are visited at least twice in four survey years. When the [1-0] revisit design is used, all sites are visited annually and a complete replicate is obtained after the second survey year.

An issue that arose in the occupancy modeling exercise is the difficulty in obtaining stable maximum likelihood estimates from occupancy and detection models that incorporate an effect for the territory. Fixed effects for each site require considerable degrees of freedom that can result in erroneous variance estimation. Incorporating a random effect into the detection model for a heterogeneous detection probability model generated occupancy estimates very close to 1 in every case. Furthermore, occupancy and detection models with any complexity generally produced Hessian matrices that were not positive-definite, so standard errors for trend estimation could be wrong. Since neither a fixed nor a random effect for territory can be incorporated into the models, the sample is treated as if were collected in a [1-n] design. The revisit designs cannot be distinguished from another because the benefits of sampling the same sites annually cannot be integrated into the model. However, the [1-n] revisit design has lowest power for trend detection, so the power results provided here are conservative.

MacKenzie et al. (2006) suggest that the heterogeneous detection probability model, while difficult to implement in a maximum likelihood setting, may be conducted with a Bayesian approach. When incorporating a fixed or random site effect is not possible, including site-level covariates that are related to occupancy will help explain site-to-site differences in occupancy estimates. Unexplained site-to-site variation is included in the residual error term which increases the standard error of the estimate of the trend coefficient and decreases power to detect trend.

Panel	Core/ non-core	Year	
		1	2
1	Core	18	18
2	Non-core	3	3
ANNUAL TOTAL		21	21

Figure 3.2: [(1-0)] revisit design for annual census of core sites and sample of 3 non-core sites

Panel	Core/ non-core	Year									
		1	2	3	4	5	6	7	8	9	10
1	Core	18	18	18	18	18	18	18	18	18	18
2	Non-core	3	3	3	3	3	3	3	3	3	3
3	Non-core	3					3				
4	Non-core		3					3			
5	Non-core			3					3		
6	Non-core				3					3	
7	Non-core					3					3
ANNUAL TOTAL		24	24	24	24	24	24	24	24	24	24

Figure 3.3: [(1-0),(1-4)] revisit design

Panel	Core/ non-core	Year			
		1	2	3	4
1	Core	18	18	18	18
2	Non-core	6	6	6	6
3	Non-core	6		6	
4	Non-core		6		6
ANNUAL TOTAL		30	30	30	30

Figure 3.4: [(1-0),(1-1)] revisit design

Panel	Core/ non-core	Year	
		1	2
1	Core	18	18
2	Non-core	18	18
ANNUAL TOTAL		36	36

Figure 3.5: [(1-0)] revisit design for annual census of all sites

The power to detect a 50% decline in occupancy after 10 consecutive survey years is provided in Table 3.2 for the revisit designs described in Figures 3.2 through 3.5. The [1-0] revisit design is known to have the highest power to detect trend (Urquhart and Kincaid, 1999). As discussed previously, the default revisit design is assumed to be a [1-n] design since the effect of territory cannot be explicitly modeled. Therefore, the difference among the power calculations presented in Table 3.2 is a function of annual sample size rather than an artifact of the revisit design.

Table 3.2: Power to detect occupancy trends for different sample sizes and revisit designs

Annual sample size of territories	Number of core sites surveyed annually	Number of non-core sites surveyed annually	Revisit design	Power to detect a 50% decrease after 10 consecutive survey years
18	18	0	[1-0]	0.953
21	18	3	[1-0]	0.973
24	18	6	[(1-0),(1-4)]	1.000
30	18	12	[(1-0),(1-1)]	1.000
36	18	18	[1-0]	1.000

Because the core sites must be censused each year to monitor high-use areas, the power to detect trends in non-core sites is examined separately (Table 3.3). The samples will be stratified by core and non-core areas, so trends may be estimated separately for each subpopulation. Comparisons of Tables 3.2 and 3.3 indicate that the high power to detect trends across the set of territories is largely due to the census of core sites. The pilot data did not indicate a significant difference in occupancy between core and non-core sites ($p=0.1413$). However, if future prairie falcon trends occur at different rates between core and non-core areas or if inference to the subpopulation of non-core sites is of interest, then results for trends in prairie falcon occupancy at PINN may be misleading unless at least between 9 and 12 non-core territories are surveyed each year. If historic data are corrected so that non-detections are included in the data set, the pilot data may be helpful in determining if sample sizes for non-core areas should be considered independently from the annual census of core sites.

Table 3.3: Power to detect occupancy trends for non-core sites only

Number of non-core sites surveyed annually	Revisit design	Power to detect a 50% decrease after 10 consecutive survey years
3	[1-0]	0.559
6	[1-0]	0.754
9	[1-0]	0.773
12	[1-0]	0.852

3.3 Fecundity power analysis

Fecundity will be monitored by examining trends in the binomial probability of hatchlings and fledglings. Histograms of prairie falcon hatchlings and fledglings per nest from data pooled over the years 2002 to 2009 indicate a large number of zeroes in each outcome (Figures 3.6 and 3.7, respectively). The additional zeroes may be a result of mechanisms such as imperfect detection rates, predation, or environmental factors and are accounted for using a zero-inflated binomial model. The maximum number of eggs observed in the pilot data is 5, so this is assumed to be the maximum number of hatchlings or fledglings per nest in PINN.

Assuming that the numbers of hatchlings and fledglings follow zero-inflated binomial distributions and assuming that a random sample of occupied sites are visited each year, the power to detect a 50% decline in fecundity after 10 consecutive survey years is provided for hatchlings (Table 3.4) and fledgling (Table 3.5). The results of the power analysis indicate that annual surveys of at least 10 pair-occupied sites provides power of at least 0.8 to detect a 50% decline over 10 years in hatchling or fledgling rates.

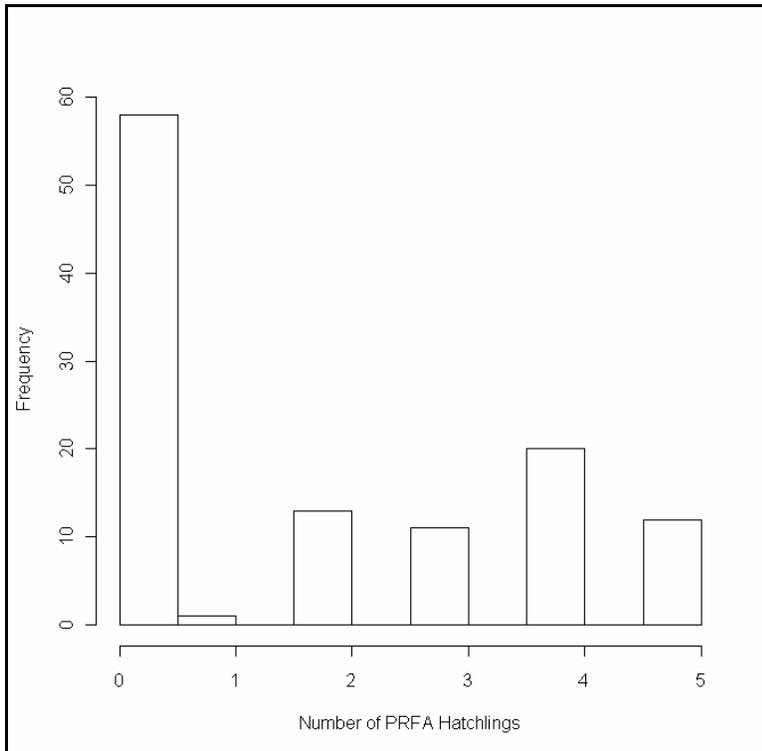


Figure 3.6: Histogram of hatchlings across years, 2002 - 2009

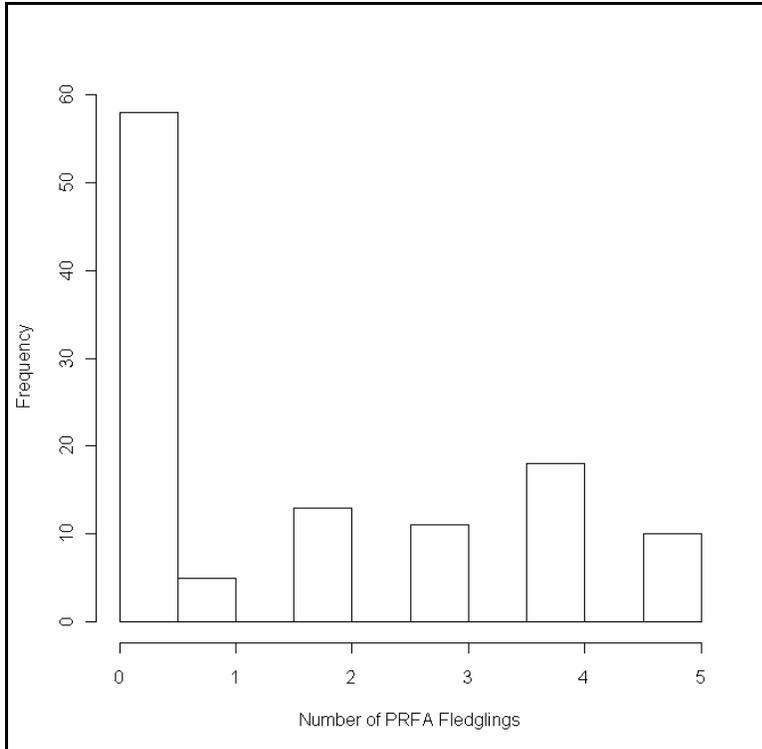


Figure 3.7: Histogram of fledglings across years, 2002 - 2009

Table 3.4: Power to detect a 50% decline in the probability of hatchlings

Annual sample size of occupied nests	Power to detect a 50% decrease after 10 years (based on 2002-2009 pilot data)
5	0.609
10	0.910
15	1.000
20	1.000
25	1.000

Table 3.5: Power to detect a 50% decline in the probability of known fledglings

Annual sample size of occupied nests	Power to detect a 50% decrease after 10 years (based on 2002-2009 pilot data)
5	0.645
10	0.922
15	0.977
20	1.000
25	1.000

Core sites are visited annually so that hiking and climbing pressure can be assessed throughout the breeding season. Given that the set of core sites is censused annually, power is examined for samples that contain all core sites and a range of non-core sites each year. For counts of both hatchlings (Table 3.6) and fledglings (Table 3.7), the power to detect trend in the binomial probability for each outcome is one. This level of power is attained even when no non-core sites are surveyed. However, if inference to non-core sites is of interest, then this subpopulation should be sampled with sufficient effort. Power to detect a 50% decline over 10 consecutive years exceeds 0.8 for as few as three sites each year for hatchlings (Table 3.8) and fledglings (Table 3.9).

Table 3.6: Power to detect trend in the binomial probability for **hatchlings** for a census of core sites and a sample of non-core sites

Annual sample size of territories	Number of core sites surveyed annually	Number of non-core sites surveyed annually	Power to detect a 50% decrease after 10 consecutive survey years
18	18	0	1.000
21	18	3	1.000
24	18	6	1.000
30	18	12	1.000
36	18	18	1.000

Table 3.7: Power to detect trend in the binomial probability for **fledglings** for a census of core sites and a sample of non-core sites

Annual sample size of territories	Number of core sites surveyed annually	Number of non-core sites surveyed annually	Power to detect a 50% decrease after 10 consecutive survey years
18	18	0	1.000
21	18	3	1.000
24	18	6	1.000
30	18	12	1.000
36	18	18	1.000

Table 3.8: Power to detect trend in the binomial probability for **hatchlings** for non-core sites only

Number of non-core sites surveyed annually	Revisit design	Power to detect a 50% decrease after 10 consecutive survey years
3	[1-0]	0.875
6	[1-0]	0.957
9	[1-0]	1.000
12	[1-0]	1.000

Table 3.9: Power to detect trend in the binomial probability for **fledglings** for non-core sites only

Number of non-core sites surveyed annually	Revisit design	Power to detect a 50% decrease after 10 consecutive survey years
3	[1-0]	0.816
6	[1-0]	0.969
9	[1-0]	0.988
12	[1-0]	0.996

3.4 Conclusions

Annual surveys of 27 to 30 territories consisting of a census of the 18 core sites and 9 to 12 of the non-core sites for occupancy surveys and at least 10 occupied territories for fecundity surveys should provide power greater than 0.80 for trend detection. Stratified random sampling within the non-core subpopulation will allow inference to that subpopulation of territories. MacKenzie et al. (2006) recommend the [1-0] revisit design so that the additional variation from alternating territories in and out of the survey will not affect variance estimates and therefore the power to detect trends. However, management goals may necessitate the use of serially-alternating revisit designs so that all territories may be visited intermittently.

Gavin Emmons stated that some territorial pairs arrive in the spring rather than in the late winter, so territories designated as "occupied" for that year may actually be unoccupied early in the survey season. This would cause underestimation of detection rates. The pilot data indicate that detection probabilities are lowest in January and gradually increase over the course of the survey season (Figure 3.1). Most of these late-winter visits occur in core territories which are visited throughout the hiking and climbing season. The occupancy model used in this application applies the assumption that occupancy is consistent throughout the monitoring period. Defining the monitoring window so that this assumption is true will allow accurate and precise estimation of occupancy and detection rates. Determining the occupancy sampling time frame *a priori* will not bias the results but will provide more accurate estimation of detection and occupancy rates from a more balanced data set.

4. SPOTTED OWL POWER ANALYSES

The monitoring goals of the spotted owl protocol are to detect substantial long-term trends in spotted owl occupancy and fecundity rates at activity sites within NPS boundaries in Marin County, California. The methods described in Section 2 are used to calculate the power to detect trend in spotted owl metrics. Some background on the sampling design is followed by discussions of the power to detect trend in spotted owl occupancy and fecundity rates. For a Type I error rate of 0.2, the power to detect declines of 4%, 10%, 12%, and 15% in each indicator of interest over 5- and 10-year periods in a one-sided alternative hypothesis is examined for several sample sizes of sites and revisit designs. Results from an initial analysis provide the basis for further power analysis to inform survey design choices.

4.1 Sampling design

The spotted owl study area consists of all federal lands within Marin County and includes Golden Gate National Recreation Area, Muir Woods National Monument, Point Reyes National Seashore, and Samuel P. Taylor State Park, as well as a 400m buffer around these parks. The sampling frame consists of all sites within the study area where a spotted owl has been observed in any survey conducted between 1997 and 2006. A total of 66 sites were initially identified from this list. Eight sites were removed due to inaccessibility (on private land or unsafe to access) or close proximity to another site. Two sites were added to the frame that fell just outside of the GIS buffer. The final 60 sites serve as the sampling frame for occupancy monitoring. Occupancy surveys are conducted between March 1 and August 31.

Between March 1 and May 31, nesting status is assessed. From May 1 to August 31, nests are monitored and fecundity measurements are collected. Fecundity surveys are only conducted at sites containing territorial females, including resident single females and both nesting and non-nesting pairs. Sites that do not meet these criteria of a territorial female are omitted from fecundity estimation based on a "non-target" assessment. Inclusion probabilities may be adjusted to account for changes in the sampling frame so that unbiased estimation is achieved. The number of locations monitored for fecundity is given for the pilot data collected from 1999 to 2008 (Table 4.1). For fecundity monitoring, the subset of 48 sites containing a nesting pair during at least one year is used as the sampling frame.

Since fecundity measurements are conditional on territorial female at a monitored territory, the target population can change from year to year. Furthermore, locations that had not previously hosted a territorial female could later be colonized, thus meeting the definition of the target population for fecundity monitoring. Unfortunately, some nests cannot be evaluated for occupancy by territorial females until later in the survey season, so selecting a sample from the set of sites meeting the criteria for fecundity sampling is not possible. Therefore, a random sample from the sampling frame of 48 sites will be used for monitoring. The fecundity sample should be larger than necessary given that roughly 70% of the sites are eligible for fecundity surveys (David Press, personal communication).

Table 4.1: Number of locations sampled for SPOW fecundity monitoring by year

Year	Number of locations	Number of fecundity locations
1999	34	19
2000	34	25
2001	34	25
2002	41	27
2003	34	28
2004	24	24
2005	21	21
2006	NA	NA
2007	25	12
2008	25	12
2009	30	26

One of six possible occupancy status categories is assigned for each location each year (Table 4.2). These occupancy categories are mutually exclusive, with all locations falling into only one category each year. Ultimately, the most appropriate occupancy model would estimate occupancy trends for all status categories simultaneously so that the sum of occupancy estimates across categories is always one. However, the available literature has not incorporated techniques for estimating occupancy for more than two categories with methods for trend estimation. Given the instability of occupancy and detection models in the univariate case (discussed in the next section), the multivariate case was not explored.

Table 4.2: Occupancy categories

Occupancy code	Description
PR	Resident pair detected
PU	Pair detected but pair occupancy not confirmed
RS	Resident single
SU	Resident single detected but occupancy not confirmed
UK	Occupancy status unknown
UO	Unoccupied

To estimate occupancy according to the SFAN definition of occupancy, only detections verifying territorial behavior are used. The proportion of detections falling within each status category is provided in Table 4.3. The majority of detections occurred within locations with a resident pair. Resident single occupancy is rare in comparison. Status categories for which territoriality is unknown (PU, SU, and UK) also occur less frequently. Without adjusting for imperfect detection, observed detection rates imply high occupancy rates for resident pairs. However, some of the categories are quite rare and estimates of the binomial probabilities may be unstable because they are close to 0 (Olkin, et al., 1981).

Table 4.3: Observed status category frequency among all detections by year

Year	PR	PU	RS	SU	UK	UO
1999	0.82	0.03	0.03	0.03	0.02	0.06
2000	0.81	0.00	0.05	0.04	0.01	0.09
2001	0.85	0.00	0.02	0.00	0.01	0.13
2002	0.89	0.00	0.04	0.02	0.00	0.05
2003	0.96	0.01	0.00	0.00	0.01	0.02
2004	0.92	0.00	0.05	0.00	0.02	0.01
2005	0.88	0.00	0.04	0.00	0.04	0.03
2006	0.67	0.00	0.16	0.11	0.05	0.02
2007	0.79	0.07	0.06	0.04	0.00	0.04
2008	0.79	0.02	0.04	0.07	0.01	0.08

4.2 Occupancy analysis

The pilot data for occupancy modeling are taken from the set of sites chosen for monitoring. Sites outside the SFAN monitoring area were excluded because they do not represent the target population for which trends will be estimated. Covariate information available for occupancy and detection modeling is described in Table 4.4. These variables represent all modeling variables included by SFAN personnel in the pilot data set.

Table 4.4: Covariate information available for occupancy and detection modeling

Covariate code	Description
Year	Year of the survey
Month	Month of the survey
Barred	Indicator of barred owl detection at a site for a given year
Daytime	Indicator that survey occurred during the day
Call	Indicator that a call method was used
ObsNum	Number of observers present during the survey

The process of model selection was problematic for the spotted owl pilot data. Because occupancy analysis is based on a nonlinear model, obtaining a positive-definite Hessian matrix was not possible for some models. The Hessian matrix affects the estimates of variance for occupancy and detection regression parameter estimates which affects trend testing. Model selection was conducted using AIC as the model selection criterion (Bayes Information Criterion was also examined but selected similar models). However, models chosen with AIC often did not provide positive-definite Hessian matrices. The model with the lowest AIC and a positive-definite Hessian matrix was used in the power analysis for trend testing. The final occupancy and detection models selected with this approach are provided for each status category in Table 4.5. The final models were often a reduced version of the model with the lowest AIC indicating that simpler models are more stable for occupancy estimation.

The occupancy estimates by category are provided in Table 4.6. For each status category, occupancy estimates are provided either for the model including the indicator of barred owl presence (estimates of occupancy with and without barred owl presence are provided in the second and third columns) or the model without a factor for barred owl presence (occupancy estimates given in the fourth column). Columns for the unused model contain a "-" to indicate that this model was not used. Due to the complexities of estimating trend with a multi-category occupancy classification, a univariate approach was used and occupancy estimates do not sum to 1. Notice that the presence of barred owls in a site and year decreases pair occupancy but increases the single-unknown and unoccupied status categories. This result suggests that the effect of barred owl presence is to reduce pair occupancy and inhibit territorial behavior as evidenced by the positive effects observed in the SU and UK status categories.

Table 4.5: Final occupancy and detection models for each spotted owl occupancy category

Status category	Occupancy model $\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right)$	Detection model $\log\left(\frac{p_{ij}}{1-p_{ij}}\right)$
PR	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij} + \beta_3 \text{ObsNum}_{ij}$
PU	γ_0	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
RS	γ_0	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
SU	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Day}_{ij} + \beta_2 \text{Call}_{ij}$
UK	γ_0	$\beta_0 + \beta_1 \text{Month}_{ij} + \beta_2 \text{Call}_{ij}$
UO	$\gamma_0 + \gamma_1 \text{Barred}_{ij}$	$\beta_0 + \beta_1 \text{Call}_{ij}$

Table 4.6: Occupancy estimates (and standard errors) from the final model for each spotted owl occupancy category

Status category	Est. occupancy rate for sites with barred owls (SE)	Est. occupancy rate for sites without barred owls (SE)	Est. occupancy rate (SE)
PR	0.9197 (0.0505)	~ 1.000 (0.00001)	-
PU	-	-	0.0301 (0.0146)
RS	-	-	0.1614 (0.0428)
SU	0.2562 (0.0960)	0.1127 (0.0384)	-
UK	-	-	0.0208 (0.0058)
UO	0.1172 (0.0371)	0.0601 (0.0124)	-

Fixed and random effects for location were examined in the modeling effort for occupancy and detection rates. Adding a fixed effect for location prohibitively reduced the number of degrees of freedom available for error estimation. Modeling the location effect as a random effect in the detection model produces the heterogeneous detection probability model which is often difficult to implement in a maximum likelihood approach (MacKenzie et al. 2006). In practice, this approach resulted in site-by-year level occupancy estimates very near 1 and with nearly zero variation and corresponding detection probabilities very near zero. Incorporating the random effect into the occupancy model produced similar problems. A Bayesian approach may be more appropriate for a random effects modeling approach (MacKenzie et al. 2006).

The benefit of incorporating a fixed or random effect for location is that repeat visits to the same locations over time can reduce variance and provide more accurate trend estimation. Without a location effect, the data are treated like random samples taken independently each year (a [1-n] revisit design). MacKenzie et al. (2006) argue that the [1-0] revisit design is best for trend estimation because the models cannot distinguish between variation among different locations and that observed over time. However, the implicit occupancy model used in this analysis does not require that the same sites are visited annually because the local extinction and colonization parameters are not explicitly estimated. MacKenzie et al. (2006) recommend that the [1-0] revisit design be used unless destructive sampling occurs. However, the needs of the monitoring program may dictate that all sites be visited periodically, making a revisit design that accommodates those requirements more desirable.

The revisit designs initially under consideration were the [1-0], [2-2], [(1-0)⁵,(2-2)], and [(1-0)¹⁰,(2-2)] designs (Figures 4.1 – 4.4, respectively, are provided for a set annual sample of 40 sites). The difference in the latter two designs is that an annual panel of 5 sites is used in the [(1-0)⁵,(2-2)] design while an annual panel of 10 sites is used in the [(1-0)¹⁰,(2-2)] design. As discussed, the trend analysis treats the data as if a [1-n] design has been used. The [1-n] revisit design has the lowest power for trend detection and therefore provides conservative power results. The replication within a location cannot be used to induce a correlation within a location over time to reduce the variance of the trend estimate. The results of the power analysis for the six spotted owl occupancy status categories, monitoring periods of 5 and 10 years, and all revisit designs are provided in Appendix A. Power is given for a one-sided hypothesis test of no change

versus a decreasing trend over time. The results of the initial power analysis demonstrate that the revisit designs are indistinguishable when neither the occupancy nor the detection model includes an effect for location.

The detection model exhibited considerable influence on the final estimates of occupancy. Estimated occupancy could vary widely depending on what covariates were included in the detection model. The problems described above indicate that detection models might perform best when they are simple and covariates uncorrelated with predictors used in both the occupancy and detection models are used.

	Year							
Panel	1	2	3	4	5	6	7	8
1	40	40	40	40	40	40	40	40
ANNUAL TOTAL	40	40	40	40	40	40	40	40

Figure 4.1: $[(1-0)]$ revisit design for an annual sample of 40 sites

	Year							
Panel	1	2	3	4	5	6	7	8
1	40	40			40	40		
ANNUAL TOTAL	40	40	0	0	40	40	0	0

Figure 4.2: $[(2-2)]$ revisit design for an annual sample of 40 sites

	Year							
Panel	1	2	3	4	5	6	7	8
1	5	5	5	5	5	5	5	5
2	35	35			35	35		
ANNUAL TOTAL	40	40	5	5	40	40	5	5

Figure 4.3: $[(1-0)^3, (2-2)]$ revisit design for an annual sample of 40 sites

	Year							
Panel	1	2	3	4	5	6	7	8
1	10	10	10	10	10	10	10	10
2	30	30			30	30		
ANNUAL TOTAL	40	40	10	10	40	40	10	10

Figure 4.4: $[(1-0)^{10}, (2-2)]$ revisit design for an annual sample of 40 sites

Power to detect trends in pair occupancy over time (Figures A.1 and A.2) is nearly 1 for trends over either 5 or 10 years. For pairs whose occupancy status is unknown (Figures A.3 and A.4), power is considerably lower, only reaching 0.8 for annual declines of over 10% and censuses over 10 consecutive years. Power to detect declines in resident single occupancy within 5 years is below 0.8 unless all of the sites in the population are visited and declines are at least 15% annually (Figure A.5). However, the power to detect trend in resident single status is at or above 0.8 for annual samples of as few as 20 locations per year when the annual decline is 10% or greater over 10 years (Figure A.6). Power for trend detection within 5 years is consistently below 0.8 for the single unknown, unknown, and unoccupied categories, but power to detect

trends within 10 years are near 0.8 for the single unknown and unoccupied categories when declines are at least 10% annually.

Overall, the power to detect trend in pair occupancy is excellent at the $\alpha = 0.2$ level. However, higher levels of effort or change are required for trend detection in other status categories because of their relative rarity. Maximum likelihood estimates of binomial probabilities that are close to 0 are generally unstable (Olkin et al., 1981). This may explain the decrease in power for an increasing number of sites in the power plot of unoccupied status (Figure 4.16).

Based on the results of the initial power analysis, the spotted owl workgroup determined that monitoring the occupancy of spotted owl pairs is of greatest importance. The relative rarity of the other status categories causes trend estimation to be more difficult unless changes are extreme. Data collection will continue for the other status categories so that baseline information is available for monitoring any future changes, but trends will only be calculated for spotted owl pairs.

In addition to focusing inference on the occupancy of spotted owl pairs, the results of the initial occupancy power analysis indicated that power to detect trend was adequate for a 5-year monitoring period. The final sampling design for occupancy and fecundity sampling needed to meet some additional criteria, including visiting all occupancy and fecundity sites at least once within one revisit cycle, obtaining an adequate fecundity sample size given that about 70% of occupancy sites are eligible for fecundity surveys, and possible restrictions on annual funding. Two possible funding scenarios were proposed: annual funding and funding for two consecutive years of high survey intensity followed by two years with low survey intensity. Based on these two funding scenarios and two proposed sample sizes from the fecundity analysis, four revisit designs were examined (Figures 4.5 to 4.8).

The four proposed revisit designs provide options for sampling designs given different levels and cycles of funding and for annual samples of 35 and 43 locations so that 25 and 30 fecundity sites may be visited in fully-funded years. The revisit design notation $(1-3)^{1/2}$ indicates that only half of the [1-3] panels are visited, so there are two [1-3] panels visited and no sites from this revisit design are surveyed in the other two years.

		Year							
Panel	Revisit design	1	2	3	4	5	6	7	8
1	[1-0]	15	15	15	15	15	15	15	15
2	[1-3]	20				20			
3	[1-3]		20				20		
ANNUAL TOTAL		35	35	15	15	35	35	15	15

Figure 4.5: $[(1-0)^{10}, (1-3)^{1/2}]$ revisit design for an annual sample of 35 sites

		Year							
Panel	Revisit design	1	2	3	4	5	6	7	8
1	[1-0]	26	26	26	26	26	26	26	26
2	[1-3]	17				17			
3	[1-3]		17				17		
ANNUAL TOTAL		43	43	26	26	43	43	26	26

Figure 4.6: $[(1-0)^{26}, (1-3)^{1/2}]$ revisit design for an annual sample of 43 sites

		Year							
Panel	Revisit design	1	2	3	4	5	6	7	8
1	[1-0]	28	28	28	28	28	28	28	28
2	[1-3]	8				8			
3	[1-3]		8				8		
4	[1-3]			8				8	
5	[1-3]				8				8
ANNUAL TOTAL		36	36	36	36	36	36	36	36

Figure 4.7: $[(1-0)^{28}, (1-3)]$ revisit design for an annual sample of 36 sites

		Year							
Panel	Revisit design	1	2	3	4	5	6	7	8
1	[1-0]	40	40	40	40	40	40	40	40
2	[1-3]	5				5			
3	[1-3]		5				5		
4	[1-3]			5				5	
5	[1-3]				5				5
ANNUAL TOTAL		45	45	45	45	45	45	45	45

Figure 4.8: $[(1-0)^{40}, (1-3)]$ revisit design for an annual sample of 45 sites

If location effects could be incorporated into the model, we would expect power to be lowest for the revisit design represented in Figure 1 and the highest for Figure 4 based on the increasing size of the annual revisit panel. The [1-0] annual panel sites will be selected from the list of sites that fall in both the occupancy and fecundity sampling frames. Then the remaining sites could be ordered randomly and allotted to the other panels. If needed, the sites included in both the occupancy and fecundity frames could be balanced among years in the remaining panels, thus also balancing the sites that historically have not contained successful nests.

The power for each revisit design is provided in Table 4.7. The power to detect trend is very high because the estimated occupancy rate is near 1, making declines easy to detect. Power was estimated to be near or equal to one for all revisit scenarios and both levels of change given a Type II error of 0.20, so power was also examined at the $\alpha = 0.10$ level. At this level, power is at or above 0.98 for all revisit designs. Because site-level effects are not incorporated in this occupancy analysis, power is conservative for trend detection. Furthermore, power calculated from this model is a function of the total sample size rather than of panel sample sizes.

Table 4.7: Power to detect trends in spotted owl pair occupancy within five consecutive survey years for four revisit designs

Revisit design	Power to detect a 4% annual decrease in occupancy		Power to detect a 10% annual decrease in occupancy	
	$\alpha = 0.10$	$\alpha = 0.20$	$\alpha = 0.10$	$\alpha = 0.20$
$[(1-0)^{15}, (1-3)^{1/2}]$	0.992	1.000	1.000	1.000
$[(1-0)^{26}, (1-3)^{1/2}]$	0.992	1.000	1.000	1.000
$[(1-0)^{28}, (1-3)]$	0.992	1.000	1.000	1.000
$[(1-0)^{40}, (1-3)]$	0.996	1.000	1.000	1.000

4.3 Fecundity analysis

Fecundity of spotted owls is measured by the number of fledglings per territorial female. Nesting spotted owls can produce 0 to 3 fledglings, though a maximum of two fledglings was observed from the pilot data. The 1998-2008 pilot data indicate that zero inflation may be an issue (Figure 4.5). Zero inflation may result from a high number of non-nesting pairs or nest failures related to predation or environmental factors.

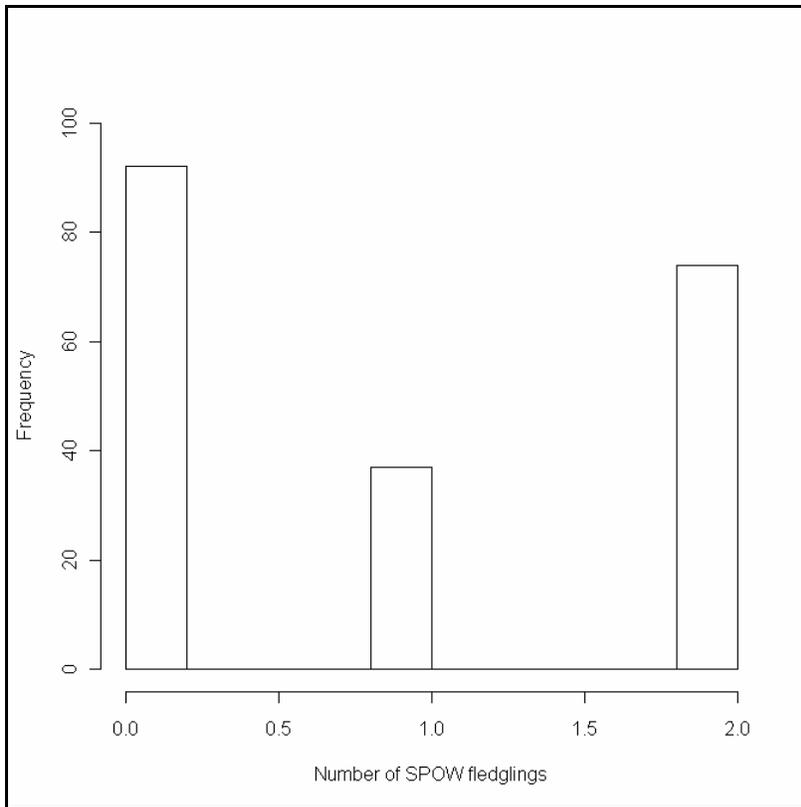


Figure 4.5: Histogram of detected spotted owl fledglings across sites and years from the pilot data

Fecundity is measured as the binomial probability for fledglings. These estimates are provided in Table 4.8 by year. While the estimates indicate an increasing trend (Figure 4.6), the increase is not significant (LRT test statistic: 0.0043, p-value: 0.9479). The probability of not detecting an extra zero is estimated as 0.6395 (SE 0.0466).

Table 4.8: Estimated binomial probabilities for fledgling

Year	Estimated binomial probability for fledglings (SE)
1999	0.4715 (0.0686)
2000	0.4724 (0.0574)
2001	0.4732 (0.0473)
2002	0.4741 (0.0393)
2003	0.4750 (0.0349)
2004	0.4758 (0.0353)
2005	0.4767 (0.0405)
2006	0.4776 (0.0490)
2007	0.4784 (0.0593)
2008	0.4793 (0.0707)

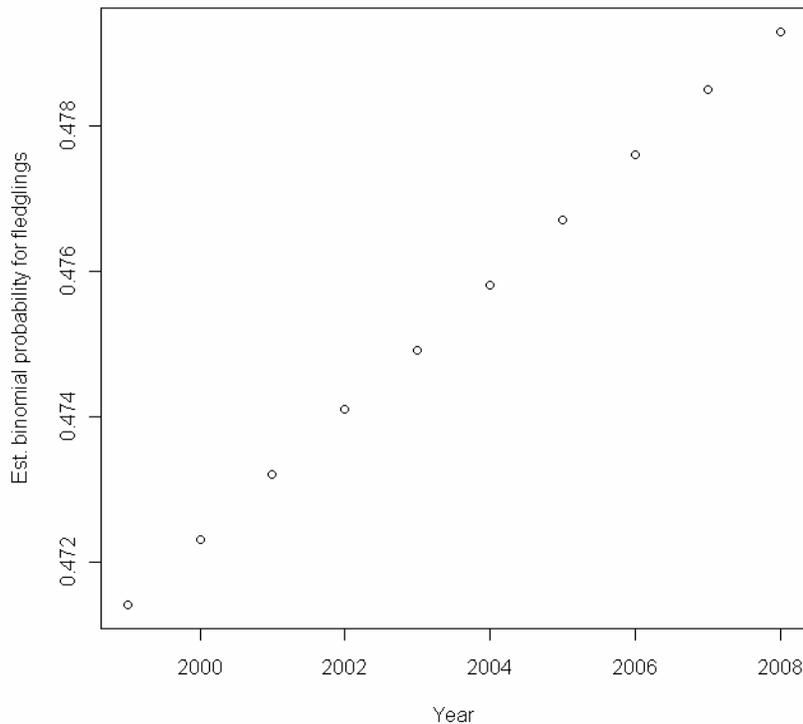


Figure 4.6: Estimated binomial probabilities for spotted owl fledglings by year

The power to detect trends in fledgling rates is calculated as described in section 2.2. The intercept-only model for zero-inflation is constant across all locations and years. The fledgling rate model is allowed to change linearly across years for trend testing. The power to detect decreasing trends in spotted owl fecundity is based on the likelihood ratio test for monitoring periods of 5 years (Figure 4.7) and 10 years (Figure 4.8). Twenty to 25 locations with resident females must be surveyed annually to detect decreasing trends of at least 10% within 5 years. Power to detect a 4% decline within 5 years never exceeds 0.5. For a 10-year monitoring period, power to detect decreasing trends of at least 10% is at least 0.8 for samples as low as 10 occupied locations per year. Around 30 nests must be visited annually to detect a 4% decline with power of 0.8 within 10 years. Out of 25 sites selected for fecundity monitoring, the 2007 and 2008 surveys resulted in 12 sites with territorial females for fecundity analysis. At this level of effort, longer monitoring time frames are required to achieve adequate power for trend detection.

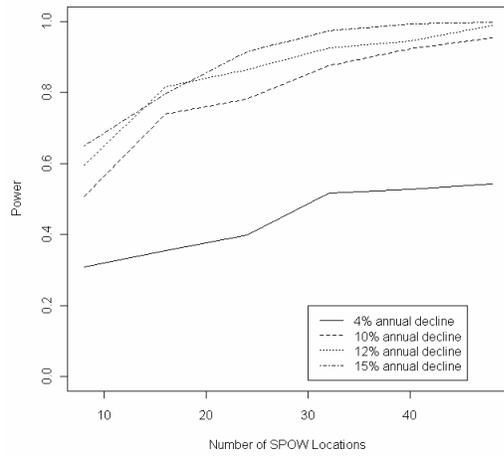


Figure 4.7: Power to detect trend in the binomial probability of spotted owl hatchling success in 5 consecutive survey years for four rates of change

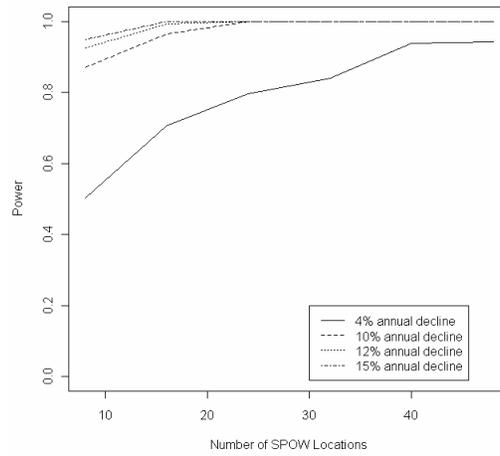


Figure 4.8: Power to detect trend in the binomial probability of spotted owl hatchling success in 10 consecutive survey years for four rates of change

4.4 Conclusions

The power to detect decreasing trends in spotted owl occupancy is nearly 1 for the pair occupancy status. Power to detect declines in sites with resident singles, sites with single spotted owls with unknown status, and in unoccupied sites exceeds 0.8 when annual declines are at least 10% for monitoring of at least 10 years. Power to detect trends in the pair unknown and unknown categories is uniformly low based on the rarity of these status categories.

The power to detect trends in spotted owl fecundity within 5 years is at least 0.8 when the annual decline is at least 10% and at least 25 to 30 sites with known reproductive outcomes are visited annually. Given that roughly 70% of the sites visited qualify for fecundity monitoring, an initial sample of 35 to 43 sites is needed to obtain the desired sample size. For a 10-year monitoring window, power is around 0.9 even for annual fecundity samples as small as 10 territories when annual declines are at least 10%. When the annual decline is 4% over 10 years, at least 30 territories must be surveyed annually to achieve power of 0.8 or more.

5. CONCLUSIONS

Overall, power for trend detection is high for prairie falcon and spotted owl monitoring. For prairie falcon monitoring, 27 to 30 (18 core and 9 to 12 non-core) territories should be visited annually to achieve power of 0.8 to detect a net decline in pair occupancy of 50% in 10 years. Power to detect a similar trend in fecundity measures may be obtained by monitoring fecundity in at least 10 pair-occupied sites.

A preliminary power analysis indicated that power to detect trends in spotted owl pairs exceeds 0.9 at the $\alpha = 0.2$ level. Because other status categories were relatively rare and power for trend detection was low, these categories will be tracked over time but not monitored for trend. Four possible revisit designs at various levels of effort in a five-year period are proposed, each provided power of about 1.00 for trend detection in pair occupancy at the $\alpha = 0.2$ level.

The power analysis was ultimately based on a [1-n] design because a fixed or random site effect could not be incorporated into the zero-inflated binomial models. Therefore, the benefits of sampling the same sites through time could not be used to reduce the estimate of the trend variance for higher power. However, this restriction means that the power analysis is conservative. MacKenzie et al. (2006) suggest that a Bayesian analysis might resolve this problem encountered in maximum likelihood estimation. If maximum estimation is to be used to trend estimation and testing, then MacKenzie et al. (2006) recommend using a [1-0] revisit design so that additional sites do not rotate into the sample from year to year and increase site-to-site variation. This additional variation cannot be explained by the model, and the additional unexplained error reduces power to detect trend. Site-level covariates related to occupancy could be incorporated into the occupancy model to account for some site-to-site differences in occupancy.

From panel design theory, it is known that revisiting the same sites each year provides the highest power for trend detection and visiting an independent random sample each year gives the lowest power to detect trend (Urquhart and Kincaid, 1999). Skipping survey years increases the amount of time required to detect trends, but adding a panel of sites visited annually can increase the power to nearly that of the always-revisit design. Without specific information to compare revisit designs, SFAN personnel may need to rely on management needs to determine what revisit design is best. If all prairie falcon territories or spotted owl locations need to be visited in a cycle, then incorporating a revisit design that visits a majority of the same sites annually will help reduce site-to-site variation. Visiting the remaining sites with a serially-alternating revisit schedule will ensure that all sites are evaluated regularly.

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APPENDIX A: Power to detect trends in spotted owl occupancy status categories by revisit design

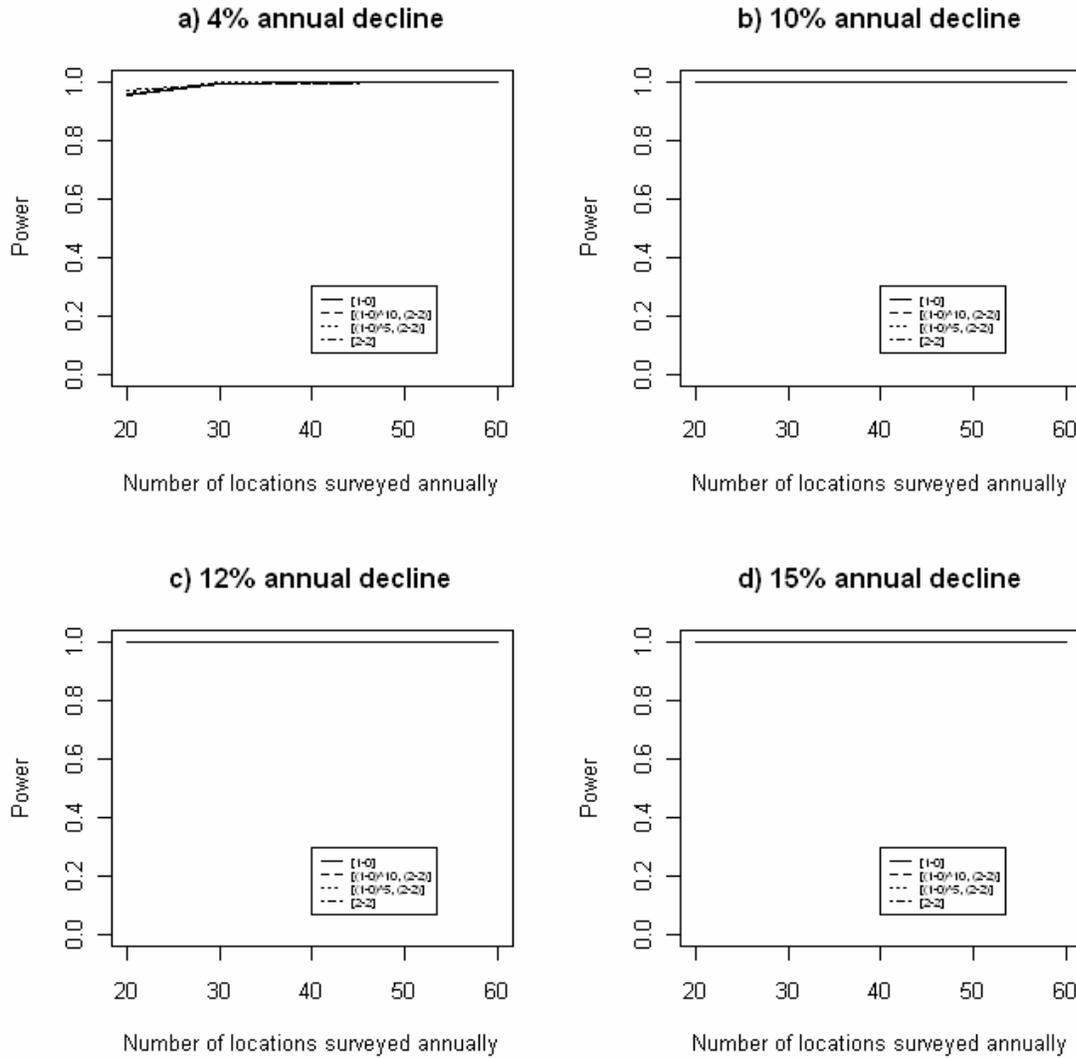


Figure A.1: Power to detect population declines in PR occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

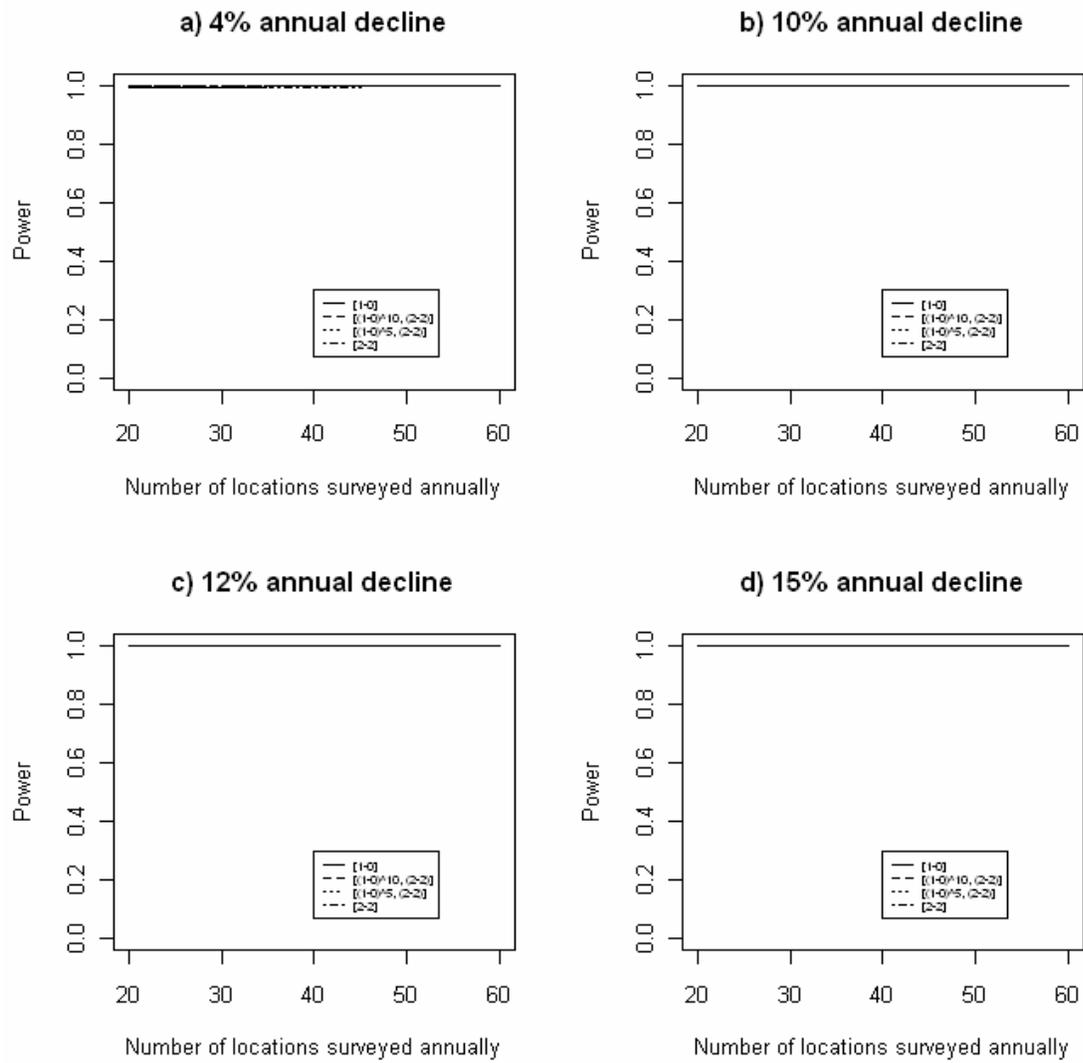


Figure A.2: Power to detect population declines in PR occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

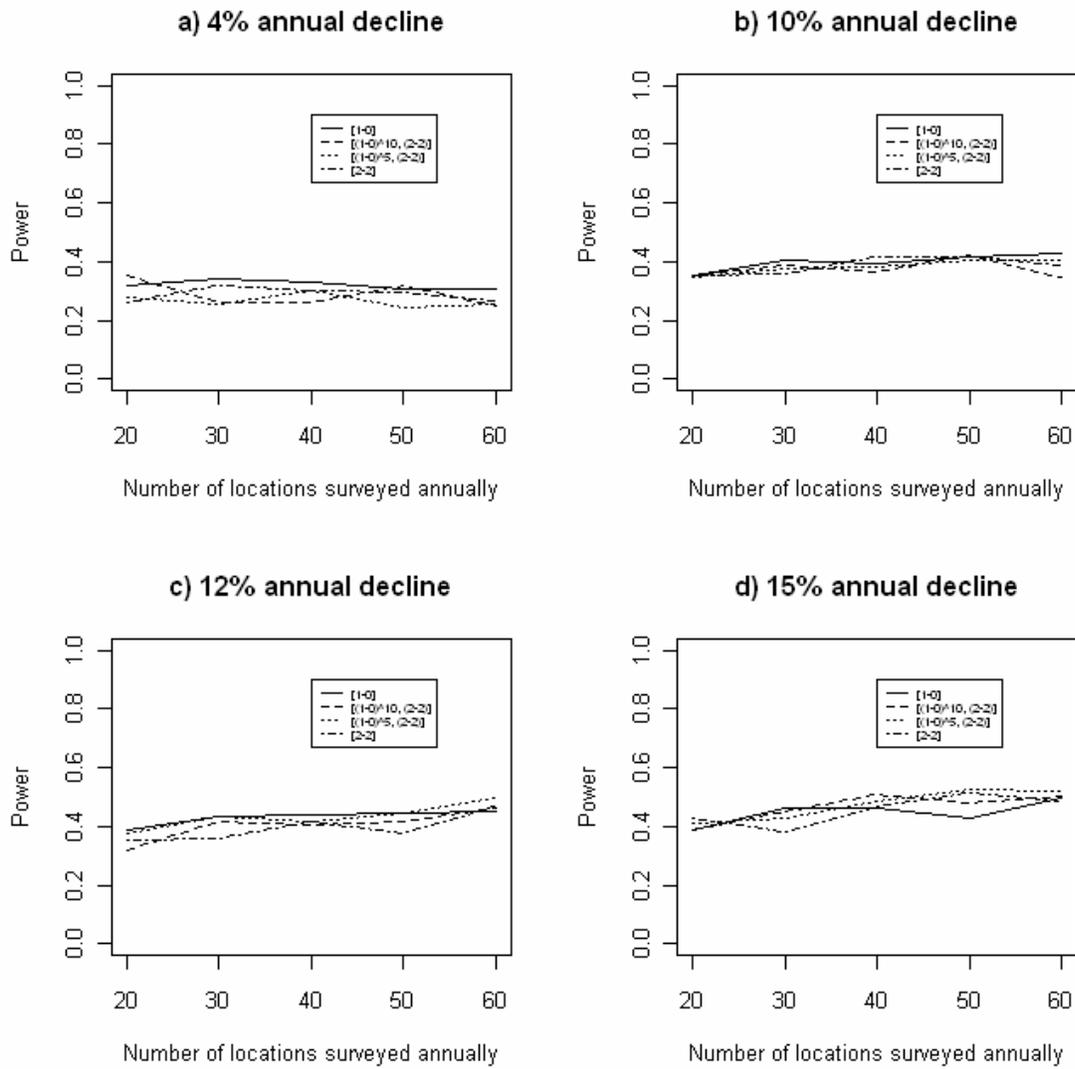


Figure A.3: Power to detect population declines in PU occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

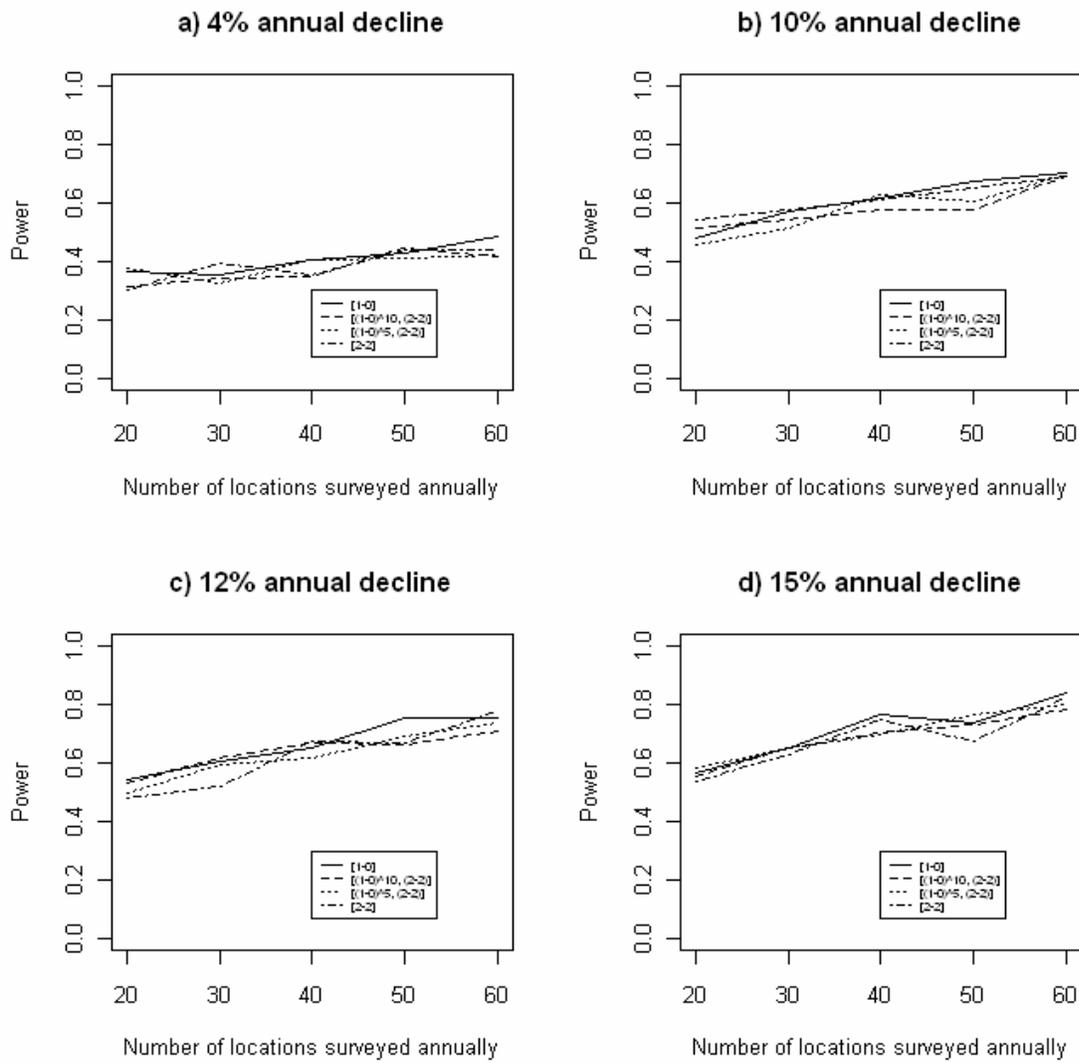


Figure A.4: Power to detect population declines in PU occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

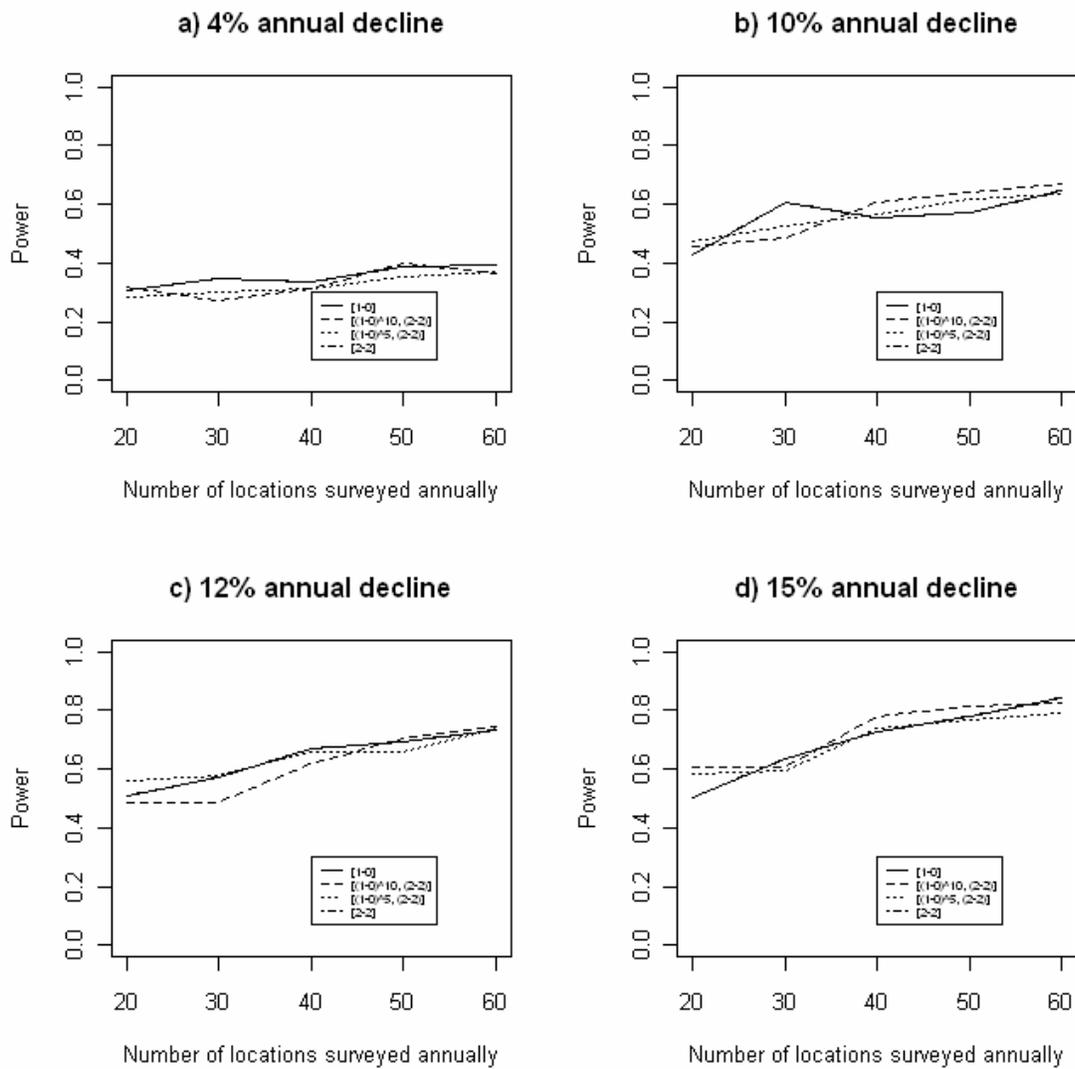


Figure A.5: Power to detect population declines in RS occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

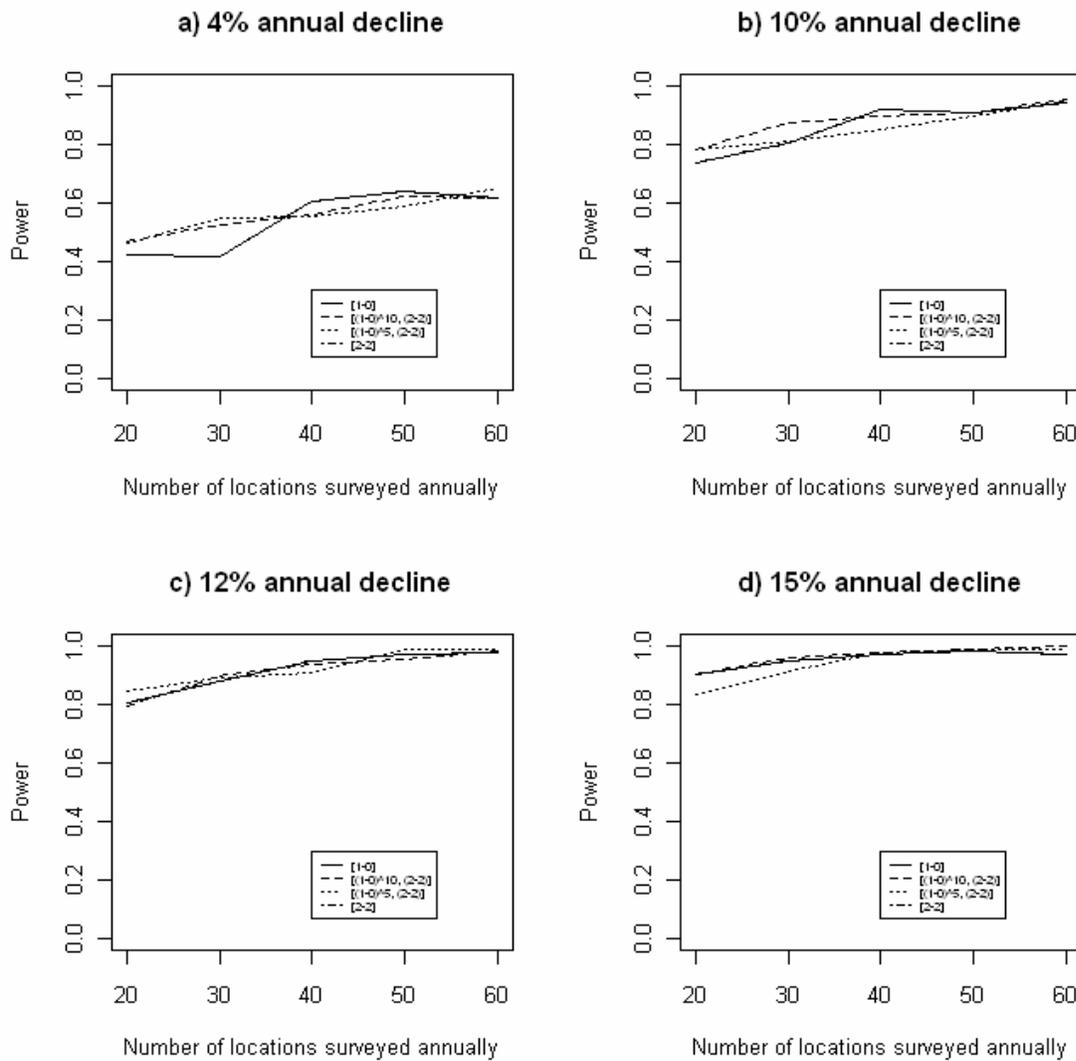


Figure A.6: Power to detect population declines in RS occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

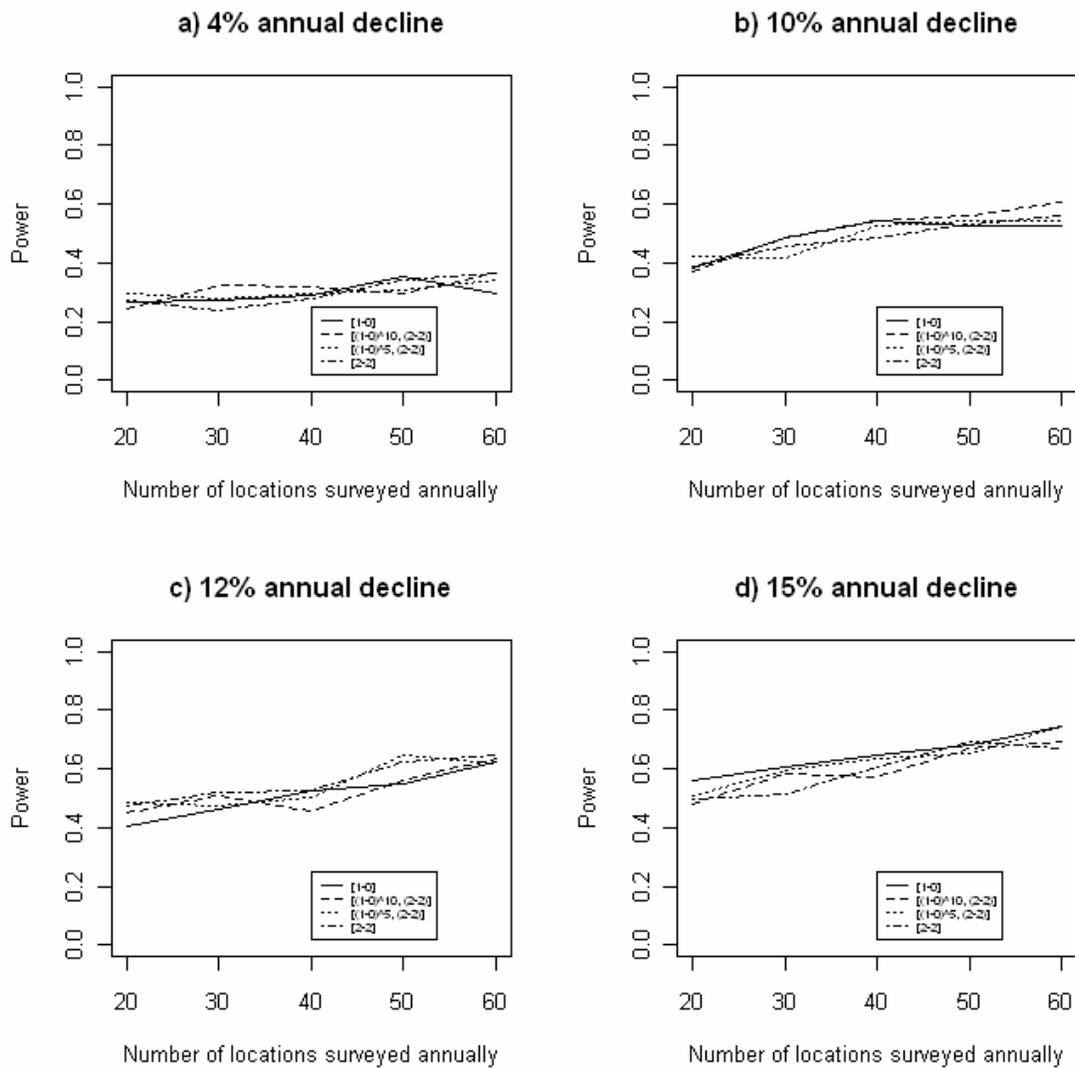


Figure A.7: Power to detect population declines in SU occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

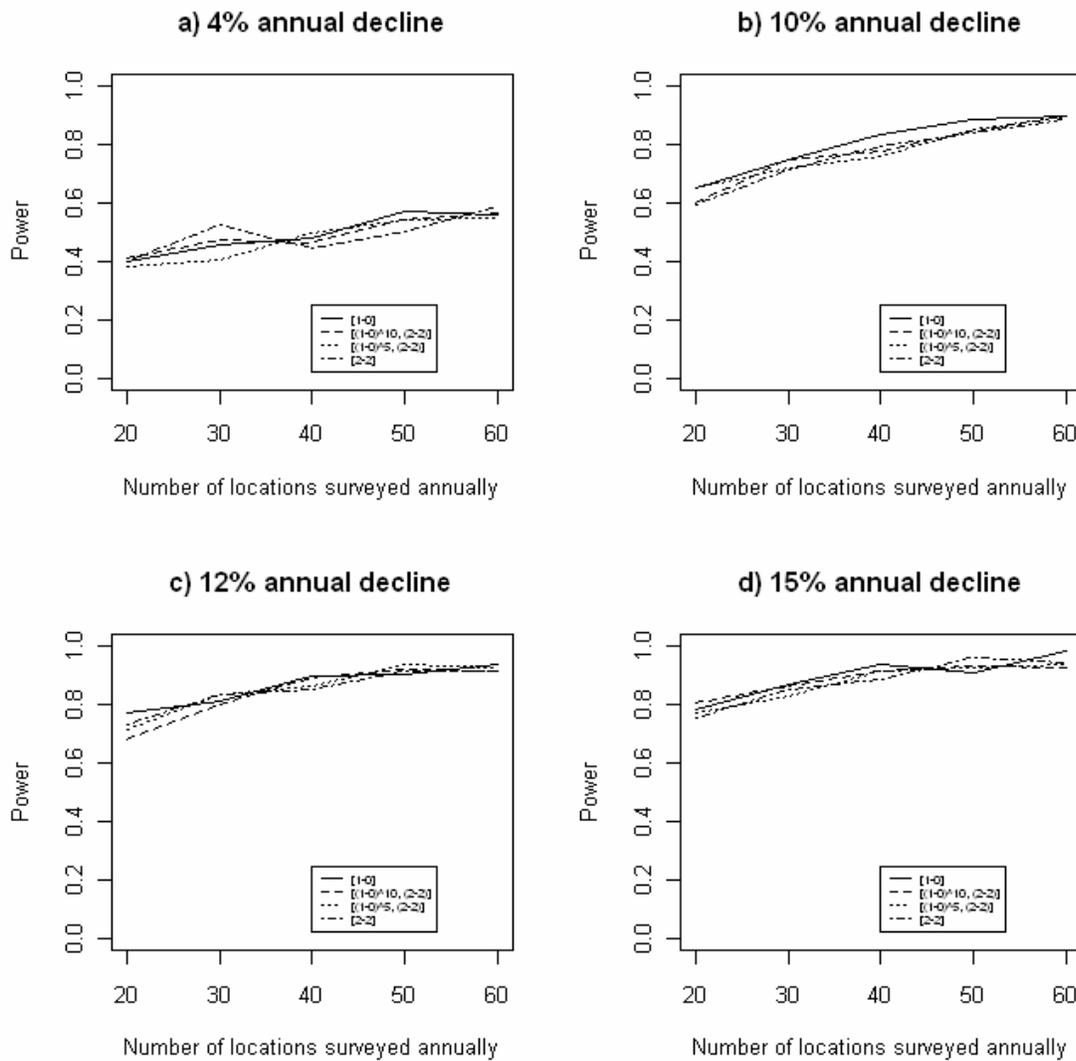


Figure A.8: Power to detect population declines in SU occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

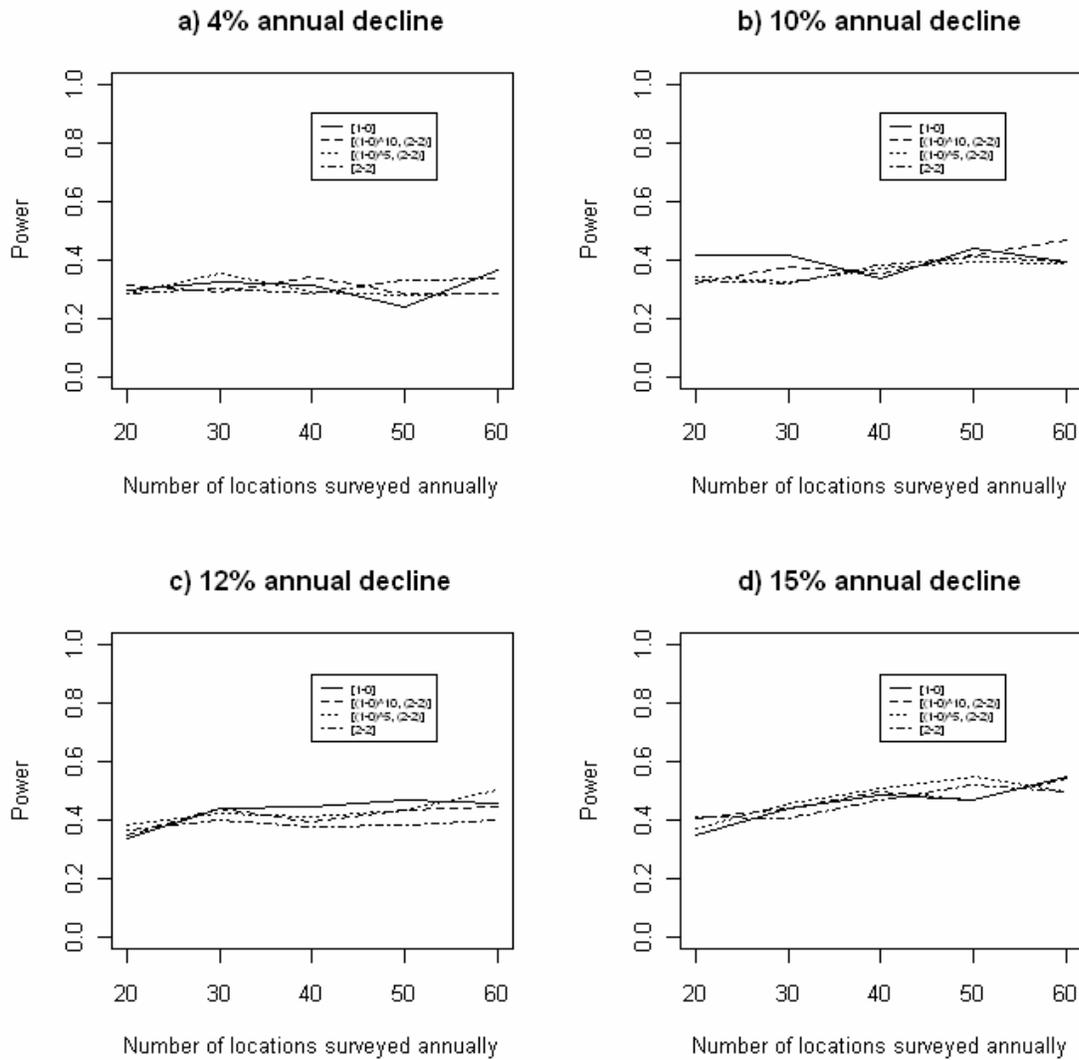


Figure A.9: Power to detect population declines in UK occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

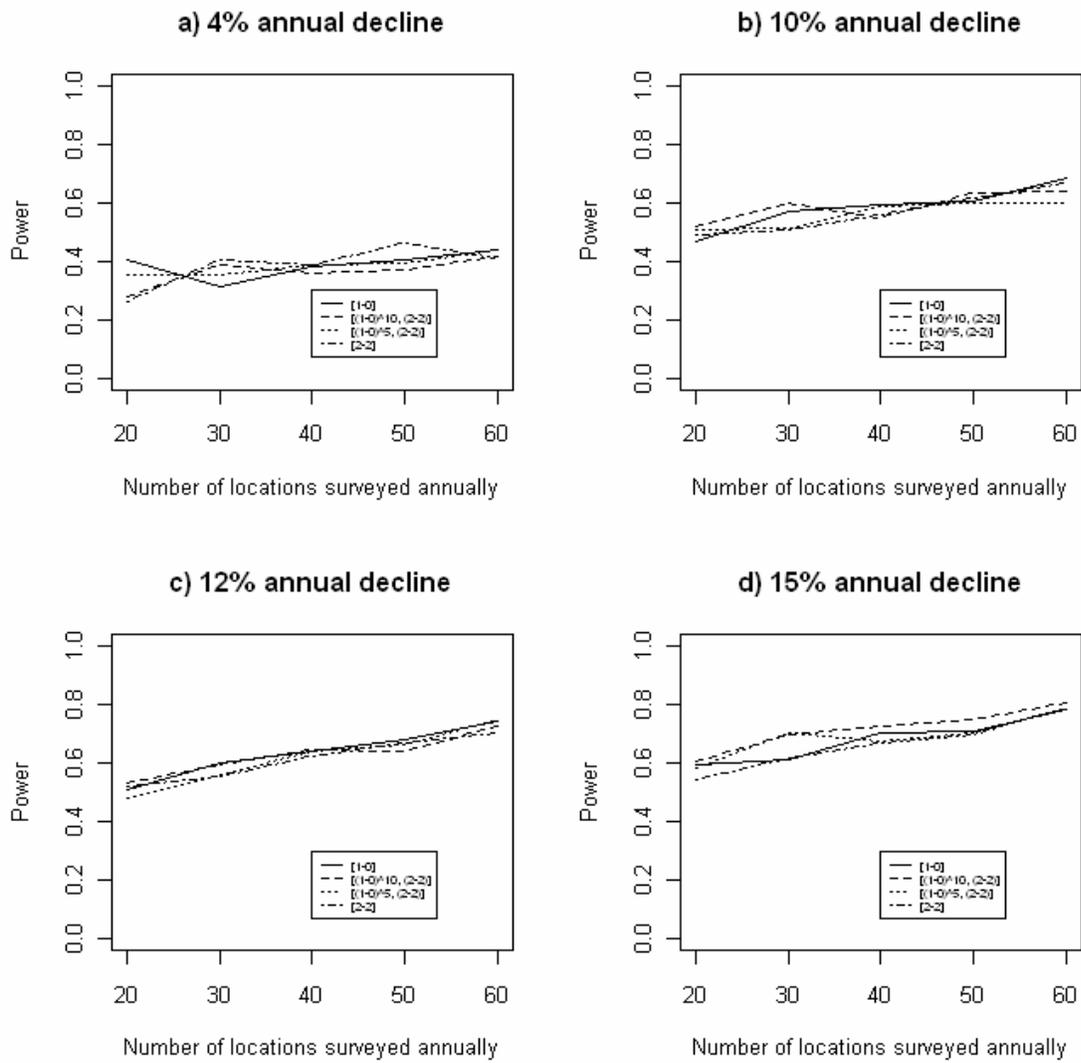


Figure A.10: Power to detect population declines in UK occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

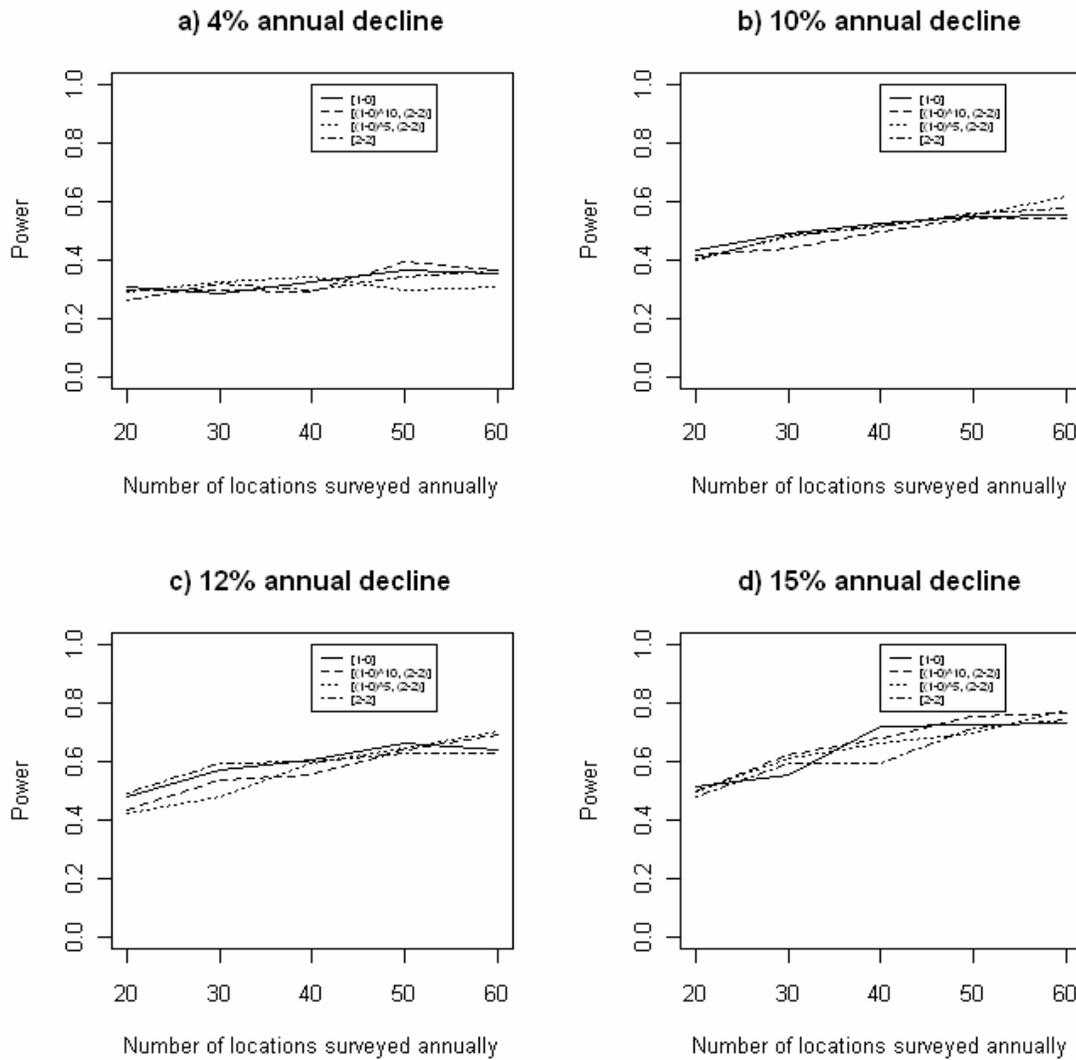


Figure A.11: Power to detect population declines in UO occupancy in tests of trend over 5 consecutive survey years for the $\alpha=0.20$ significance level

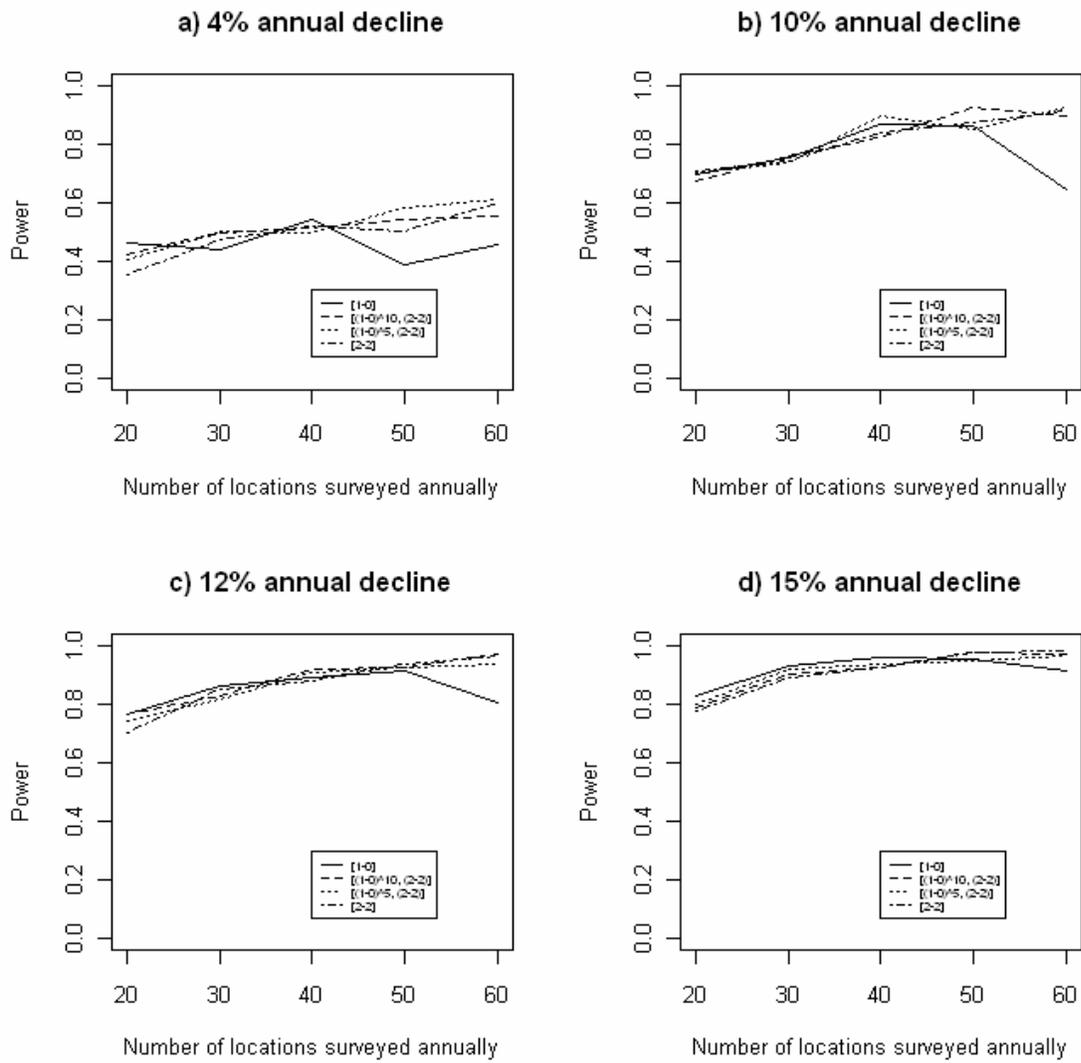


Figure A.12: Power to detect population declines in UO occupancy in tests of trend over 10 consecutive survey years for the $\alpha=0.20$ significance level

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 963/105610, September 2010

National Park Service
U.S. Department of the Interior



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Northern Spotted Owl

The following guidelines apply to projects involving disturbance only, no habitat modification. Changes and clarifications were made to this document on May 14, 2008 based on a phone conversation between USFWS (Amy Fesnock), MCOSED (Mischon Martin and Matt Sagues) and PRBO (Renée Cormier):

No effect: Action occurs August 1 through January 31.

***Not likely to adversely affect:** Action occurs July 10 through July 31.

***Likely to adversely affect:** Action occurs March 1 through August 31.

*** From 1992 to 2004, USFWS service recommended that projects involving disturbance with no habitat modification should not take place between March 1 and August 31. In 2004, these dates were modified to February 1 through July 9. February 1 was selected based on data from coastal CA sites showing earlier nesting behavior. Amy Fesnock agreed that MCOSED could keep their March 1 start date. July 9 was selected based on early fledging of young. This date gave fledgling Spotted Owls 2-4 weeks to acclimate to their surroundings. PRBO recommends the more conservative approach of 4 weeks post-fledging based on site-specific data.**

The following guidelines apply to projects involving modification of suitable habitat:

No-cut buffers should be instated at a 500ft radius of all nest trees and activity centers. Cutting within 500ft of a nest tree or activity center could reduce long-term breeding success. Although some limbing may be permissible after consultation with USFWS, it will never be permissible to cut large swaths of trees within the 500ft boundary.

Historic nest sites and activity centers are also awarded the same 500ft no-cut protection. If owls move more than 1000ft and the historic site has not been occupied for >3 years, USFWS can be consulted. If the historic area shows connectivity to the new nesting sites, it will continue to have protection.

Not likely to adversely affect:

- 1) Habitat modification occurs in occupied or unsurveyed suitable nesting habitat September 16 through January 31; and
- 2) Post-project, at least 500 acres of suitable habitat remains within 0.7 mile of the activity center (AC); and at least 1,336 acres of suitable habitat remain within 1.3 miles of the AC; and no suitable habitat is degraded or removed in the nest grove.

Likely to adversely affect:

- 1) Habitat modification occurs in occupied or unsurveyed suitable nesting habitat February 1 through September 15; or
- 2) Post-project, less than 500 acres of suitable habitat remains within 0.7 mile of the AC; and/or less than 1,336 acres of suitable habitat remain within 1.3 miles of the AC; or

<p><u>Critical Habitat</u></p>	<p>3) Suitable habitat is degraded or removed in the nest grove.</p> <p><u>Critical Habitat</u></p> <p>No effect: Actions that do not degrade or remove PCE's (nesting, roosting, foraging, or dispersal habitat, or stands that are capable of becoming suitable habitat).</p> <p>Not likely to adversely affect: Based on site-specific basis, but generally activities remove or degrade less than 0.25 acre of PCE's (nesting, roosting, foraging, or dispersal habitat; or stands that are capable of becoming suitable habitat) and do not remove potential nest trees.</p> <p>Likely to adversely affect:</p> <ol style="list-style-type: none">1) Actions that remove or degrade nesting, roosting, foraging, or dispersal habitat; or2) Actions that prevent or appreciably slow the development of habitat in stands capable of becoming nesting, roosting, foraging, or dispersal habitat.
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MARIN COUNTY
PARKS
PRESERVATION · RECREATION



BIRD NESTING SURVEY TRAINING MANUAL

Marin County Parks



Originally prepared in 2015 by S. Abercrombie; R. Hendrickson, and N. Cullen

Edited in 2017 by L. Michl

Note: Updates to buffers being species-specific were accepted by CDFW in 2019

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Introduction:

The purpose of this training manual is to familiarize Marin County Parks (MCP) staff, specifically the Biological Monitors (bio-monitors), with the laws and regulations that protect birds and the procedures to follow to protect birds. In 2015, the MCP Resource Division fully implemented measures to avoid impacting bird nests. These measures were initiated to fulfil two obligations: (1) protect natural resources and (2) conduct vegetation maintenance activities associated with fuel reduction, recreation activities, or projects.

Laws and Regulations

Both federal and state laws protect birds, mostly during the bird nesting season. This section is not an exhaustive list of all the laws that protect birds, but focuses on the laws that protect birds during the nesting season. Other laws that need to be considered (but are not included in this training manual) are the Endangered Species Act, California Endangered Species Act, California State Full Protected Species, and California Species of Special Concern.

Migratory Bird Treaty Act of 1918

The Migratory Bird Treaty Act (MBTA) of 1918 is a “federal statute that was implemented in the 1916 Convention between the U.S. and Great Britain (for Canada) for the protection of migratory birds. Later amendments implemented treaties between the U.S. and Mexico, the U.S. and Japan, and the U.S. and the Soviet Union (now Russia). Specific provisions in the statute include: Establishment of a Federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this Convention . . . for the protection of migratory birds . . . or any part, nest, or egg of any such bird." (16 U.S.C. 703).” For the complete law and amendments, visit <https://www.fws.gov/laws/lawsdigest/migtrea.html>. The U.S. Fish and Wildlife Service (USFWS) is the agency tasked with enforcing the MBTA. A list of species protected under the MBTA can be found in the Federal Register Vol. 78 No. 212:

<https://www.fws.gov/migratorybirds/pdf/policies-and-regulations/MBTAListofBirdsFinalRule.pdf>.

Fish and Game Code

The California Department of Fish and Wildlife (CDFW) has several Fish and Game Codes that protect migratory birds:

3053 - “It is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto. (*Amended by Stats. 1971, Ch. 1470.*)”

3053.5 – “It is unlawful to take, possess, or destroy any birds in the orders Falconiformes or Strigiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird

except as otherwise provided by this code or any regulation adopted pursuant thereto. (*Added by Stats. 1985, Ch. 1334, Sec. 6.*)”

3513 – “It is unlawful to take or possess any migratory nongame bird as designated in the Migratory Bird Treaty Act or any part of such migratory nongame bird except as provided by rules and regulations adopted by the Secretary of the Interior under provisions of the Migratory Treaty Act. (*Amended by Stats. 1977, Ch. 1208.*)”

Marin County Parks

In addition, MCP’s Vegetation and Biodiversity Management Plan (VBMP; MCOSD 2015) outlines several best management practices (BMPs) to follow, including:

BMP-Special-Status Wildlife Species-1 (Implement Seasonal Restrictions During Bird Nesting Season; Avoid Active Nests or Obtain and Comply with section 3503 and 3503.5 with DFW):

- **Identify potential habitat for nesting birds and survey to determine if active nests are present before initiating vegetation management actions.** Surveys will include the proposed vegetation management footprint and a ¼ mile buffer area (for raptors) or a 150 foot buffer area (for other birds). Surveys will be conducted within 14 days of the start of active ground disturbing activities.
- **If any active nests of protected bird species are found, prohibit brushing, mowing and tree removal vegetation management activities at the nest site and within a buffer area until the young birds have fledged and left the site, and/or the nest has been abandoned.** The buffer area will be 150-250 feet, or as determined through a consultation with the Department of Fish and Wildlife, pursuant to section 3503 and 3503.5 of the state Fish and Wildlife Code and the federal Migratory Bird Treaty Act. In general, a line-of site buffer of at least 150 feet between the nest site and vegetation management activities is recommended. For raptors, buffer distances may be increased to 250 feet or more, depending on the visual distance from the nest to the vegetation management work area, and the sensitivity of the raptor species to vegetation management activities. In addition a 5MPH speed limit will be enforced in and near bird nesting habitats and other sensitive habitat areas.
- **If impacts to nesting birds cannot be avoided, contact the USFWS and the DFW to obtain the necessary permits before initiating vegetation management activities.**

Due to discrepancies in the VBMP (i.e. the first bullet point recommends a ¼ mile buffer for raptors and the second bullet point recommends a 250 ft. buffer for raptors, which is a difference of 1,070 feet), changes and adaptations to the avoidance measure protocols over time, and consultation with both the USFWS and CDFW, a 250 ft. buffer around raptor nests has been established.

Other BMPs in the VBMP that protect nests or particular species include: BMP-Special-Status Wildlife Species-2 (Avoid and Protect Northern Spotted Owls); BMP-Special-Status Wildlife Species-3 (Avoid and Protect Double Crested Cormorant Nests, Heron, and Egret Rookery

Sites); and BMP-Special-Status Wildlife Species-4 (Avoid and Protect California Clapper Rail, California Black Rail, and Salt Marsh Harvest Mouse). See the VBMP (MCOSD 2015) for the exact wording of these BMPs.

Avoidance Measures

Bird nesting season dates vary throughout the United States and throughout California. In the San Francisco Bay area, the generally agreed upon dates are January 1 – July 31 for raptors and March 1 – July 31 for passerines (i.e. song birds). In addition, northern spotted owls (NSO; *Strix occidentalis caurina*) have their own restrictions that must be followed (in compliance with both the federal and state Endangered Species Act). NSO nesting season takes place from February 1 – July 31. During this time, noise restrictions are in place in NSO suitable habitat (i.e. redwood forests, redwood/bay forest, etc.). Noise restrictions include the use of all power tools. Once NSO nests have been identified, a quarter-mile buffer of noise restriction around the nest is enforced during the nesting season. In addition, Ridgeway's Rail (*Rallus longirostris obsoletus*) have their own guidelines since they use brackish marshland and are both a federally and state listed endangered species. Ridgeway's rail season is from February 1 – August 31. Mowing within 250 feet of brackish marshland requires work to occur between 8 am and 4 pm and occur outside of high tide. Only the tops of levees should be mowed. For a summary of the restrictions for Ridgeway's rail, see Appendix A.

A bird nesting survey by a qualified and trained person is required for any vegetation maintenance involving power tools on shrubs/trees and grass over eight inches tall. These restrictions are only in place during bird nesting season (see above for dates).

Marin County Parks Vegetation Management

There are a variety of activities that occur on MCP lands that require vegetation management. These activities can generally be divided into three categories (1) Regular Maintenance Mowing, which includes most of the annual flashy fuel mowing and fuel break maintenance that is performed by Rangers and/or contract crews; (2) Trail Maintenance, which includes clearing trails for ingress and egress; (3) and Project Sites, which is a broader category that includes maintenance activities required for activities and projects that are by definition limited in scope and duration (i.e. Stafford Lake Bike Park, Road and Trail Management Plan [RTMP] projects), but can also include various other fuel reduction projects.

Regular Maintenance Mowing

Regular Maintenance Mowing includes all of the mowing that takes place on an annual basis by either MCP Rangers or contract crews. Regular Maintenance Mowing primarily includes efforts to reduce flashy fuels behind houses, along frontages, and along fire roads.

In 2014, as preparation for the 2015 season, multiple MCP staff persons, including resource staff and operations staff, contributed to an effort to review and better document all of the annual mowing sites that MCP has maintained over the years. Each site was scrutinized, and the need for continued annual maintenance was determined at each site by looking at factors including 1) contribution to fire safety, 2) impact to natural resources, and 3) the degree to which we are

obligated (legally, conditionally, or otherwise) to maintain fuel breaks in the area. The result was a refined list of sites and locations where annual maintenance mowing will take place, as well as an updated and improved record of those locations (mowing areas were digitized and stored in our GIS database).

Most of the sites that remained in our list of Regular Maintenance obligations consist of mowing strips 30 feet wide that run between the edge of our preserves and the property boundary of private residences. These sites also include road frontages, where county and municipal ordinances require a 30 foot clearance for ignition prevention. Finally, these sites include mowing fire roads, both within the road prism and the road shoulder, to prevent ignition from the underside of vehicles.

Trail Maintenance

‘Trail maintenance,’ for the purpose of this manual, can broadly be described as vegetation removal to maintain a safe and passable corridor for trail users. This involves mowing tall, overhanging grass, trimming encroaching shrubs (such as poison oak and blackberry), and limbing tree branches.

Trail maintenance varies throughout MCP because of the many trails we are responsible for maintaining and for the variety of user groups that use our trails. MCP is working on designing trail maintenance standards for the different user groups.

Project Sites

This includes vegetation removal work that does not fall under Trail Maintenance or Regular Maintenance Mowing, and does not occur regularly every year. RTMP projects will fall in this category and other projects not related to the RTMP (i.e. Stafford Lake Bike Park). ‘Project’ sites, by definition, will be unique and vary from season to season. Bird nesting surveys for projects will follow the same protocol but may also include other permit requirements for that specific project. When there is conflict between MCP protocol and the permit requirements, the more stringent requirements will be used.

Survey Protocol

Organization and Scheduling

The protocol for the nesting bird surveys is a multifaceted, ever-improving effort. One of the most important components of the survey and maintenance efforts is the communication and collaboration between Operations and Resource staff. The first steps before initiating fuel maintenance and vegetation removal activities should therefore include pre-season planning discussions between Operations staff and the Natural Resources staff. Before the outset of the annual Phase 1 fuels reduction (Regular Maintenance mowing typically starting in May) and trail maintenance implementation, both parties need to meet and create a season-long list of priority projects and mowing areas, along with an estimated timeline for when these projects will occur. As the maintenance season begins, Operations staff will fill in an Excel spreadsheet to relay to the Natural Resources team the expected date of the operation. This Excel spreadsheet should

continually be updated as new projects are planned. The bio-monitors will check this spreadsheet every day to ensure they are aware of all projects that are expected to occur. Projects should be entered into the spreadsheet at a minimum of two-weeks before the start date. The two-week window will allow Natural Resources staff enough lead time to survey maintenance sites ahead of the mowing or trail crews without slowing down the implementation schedule.

Communication between the Natural Resources staff and Operations staff should continue to occur as priorities change or projects are delayed to ensure that areas are not surveyed multiple times before a project begins. The Natural Resource team will be responsible for relaying any information regarding natural resources restrictions to Operations staff, including the location of bird nests, northern spotted owl nest locations and their quarter mile buffer, rare plant locations, and active badger dens.

Bio-Monitor/Observer Nest Searching Protocol

The following is a generalized summary of survey methods, based on the most recent iteration of the nest survey protocol.

Surveys for nesting birds are to be carried out a *maximum* of two weeks (14 days) before the initiation of maintenance activities that may cause impact to nesting birds. The observers use both sight and sound, along with some knowledge of local bird species in order to detect and locate active nests and/or breeding birds. While there are many ways an observer can detect nesting birds, we have split them into two categories; (1) Active Flushing and (2) Active Observation. Active Flushing involves the use of a 1-1.5meter flushing stick (wooden pole, PVC pipe, or adjustable hiking poles), and sweeping the vegetation at a height of at least 6” off the ground in order to flush any nesting birds hidden in the vegetation, which causes parent birds to flush and effectively reveals locations of nests. Active Observation involves the surveyor moving through the project footprint, trying to detect birds by sight or sound and watching for a period of time, using knowledge of bird behavior (as outlined later on in this training manual) to determine if the bird is breeding, building a nest, defending a nest, or provisioning its young with food. While surveying, if the observer suspects that any bird may be nesting in the area, they are to continue observing that individual until they can confirm whether or not that bird is in fact building or tending to a nest.

Areas dominated by certain vegetation types require the surveyors to emphasize one survey method over another because of the habitat they provide for birds. These site types and their respective protocols are as follows:

Open Grassland

Open grassland habitats are defined as areas dominated by grasses with little to no robust, woody vegetation. Open grasslands are to be surveyed primarily by active flushing, as birds in open grasslands are more difficult to locate purely by observation. Many fuel breaks behind houses are categorized as open grasslands.

Shrubs/Scrubland

Shrubby areas are primarily treeless habitats, and may include a spectrum of scrub dominance, from scattered to dense. Typically, the interstitial spaces between shrubs tend to be grassy, and the extent of these grassy regions is correlated to the degree of shrub dominance. In areas dominated by shrubs the surveyors should use a mix of reduced-intensity active flushing (careful, non-vigorous flushing in order to prevent destroying nests) and active observation in order to locate nests. In the grassy regions, surveyors should use active flushing as normal.

Scattered Trees

While this is a somewhat vague distinction, areas with scattered trees should be treated differently than other habitat types encountered during surveys. Occurring amongst open grassland or in shrubby areas, 'scattered tree' habitat contains singular trees or small groups of trees that are not canopy-forming. When surveyors encounter scattered trees, they are to observe the tree or group of trees until they can confirm whether or not birds are nesting in the tree. Special attention should be paid to tree cavities and the distal and proximal portion of branches. In the grassy regions, surveyors should use active flushing as normal.

Forested

Forested areas are defined as areas that are dense enough with trees that those trees form a relatively unbroken canopy. In forested areas, surveyors are to move through the survey site using Active Observation methods to detect both the physical presence of birds, but also the specific behavior of the birds, in order to determine whether there is active nesting or breeding activity in the area. In the interest of efficiency, surveyors are encouraged to move on from an area if birds are not detected. If birds are detected and surveyors suspect potential nesting breeding activity, the surveyors are to observe the individual birds until they can confirm or refute nesting or breeding status.

Figure 1 features a diagram which illustrates how observers choose the most appropriate surveying strategy based on the spectrum of habitat types that will be encountered in Marin County. On one end of the spectrum is 'Pure Active Flushing,' and at the other end is 'Pure Active Observation.' The observer will need to decide the appropriate usage and combination of active flushing and observation to carry out the most effective survey based on the type and scope of work that will be performed and the vegetation that dominates the impacted areas.

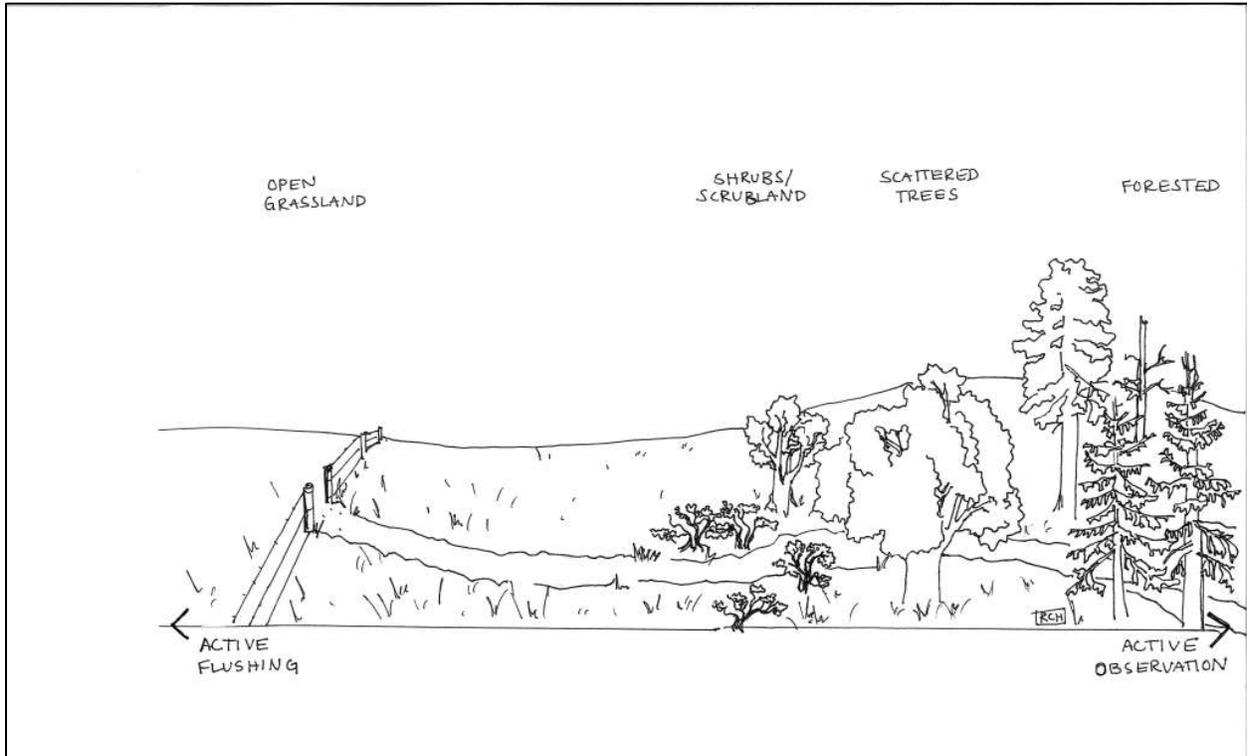


Figure 1. Different Habitat Types Where Birds May Be Found

Marking and Reporting a Nest

Upon locating a nest, the surveyors should make note of the nesting species or at least the larger group to which the bird belongs (i.e. songbird, raptor, shorebird, etc.), determine what stage of nesting that bird is in (nest construction, incubation, rearing, or fledging), and flag the buffer area around the nest. For raptor nests the flagging should occur at a 250 foot radius, or if the nest is directly adjacent to a path, 250 feet from the nest in either direction on the path. For songbird nests and nests of any other avian order, flagging is set up at a 150 foot radius, or if the nest is directly adjacent to a path, flagging is set up 150 feet from the nest in either direction on the path. In both cases, flagging should be placed at the appropriate distance, depending on the bird order, and located in areas where maintenance crews will clearly see the flags and know to avoid the buffered area. Specific identification of the species of nesting bird should be made as accurately as possible, as species identification aids in both establishing an appropriate buffer area and in determining an appropriate return date on which to check the nest to see if the young have fledged. A range finder or tape measure can be used to mark the buffer distances. The location of the nest is then recorded in a GPS unit and the person who made the request will be notified both by email and through the MCP tracking Excel spreadsheet.

Techniques and Tips:

Learning to identify and locate birds can be a daunting task, especially if you have a limited background in wildlife/natural resources. However, there are many ways to go about overcoming the immense volume of information about these curious feathered critters. This section of the

training manual will give you some basic practical tools to both identify and locate birds in the field.

How to Learn to ID Birds

Learning birds is not an endeavor that can be accomplished quickly, and in fact learning birds is a hobby that many people practice for their entire lives. Even the most seasoned birders are constantly learning how to identify birds by both song and sight. In other words: there is no finish line, so just learn what you can and enjoy the experience.

Below are several basic methods/ideas that one can employ to begin learning to identify birds:

Learn to Identify Birds One at a Time

When you are in the field you will be battered by a barrage of avian sights and sounds, which can make picking a single bird out a difficult task. To simplify this sensory overload, choose the bird that is most visible and sitting still long enough to get your binoculars focused on and learn what you can about that single species. (Once you have the most obvious birds learned you can then focus in on the more difficult ones.) Learning birds by their songs/calls can be accomplished in a similar fashion. Listen for the bird with the simplest, loudest or most memorable vocalization. When learning a vocalization it is helpful to actually see the bird open its bill and vocalize. Again, once you've learned the simple vocalizations you can then move on to the more complex or subtle ones. To summarize: learn what is easiest to see or hear, and build your mental database of birds one at a time from there.

Qualify your observations

It is easy to simply look at a bird and see that it big or small and has a certain pattern on the feathers. However to make the most of each observation, you must be deeply engaged each time you observe a bird. It is surprising how much your memory can warp what you have observed in the time it takes to put down the binoculars and flip through your bird guide. To build an accurate representation of a bird you have observed it is easiest to break the bird down into different features. Some of these features that are most effective in accurately recounting a bird are *bill size and shape, tail length, posture, general color scheme*, as well as the more dramatic markings on its plumage such as an *eye-ring, "eye brow"*, or other *markings that stand out*. Try to make a list of these in your head, to your coworker/birding companion, or in a field notebook. While you are observing a bird, especially one that is particularly flitty (i.e. can't sit still), don't be too eager to begin searching your bird guide – your guide isn't going to fly away (but the bird will!), so observe as long as you can to try to gain as much information as possible while you have the bird in your sights. After the bird leaves, you can begin putting your list of observations back together and make a more accurate attempt at identifying the bird. Consult your bird guide and/or record all observations in your field notebook to reinforce your knowledge. Figure 2 shows the part of a bird that can aid in identification.

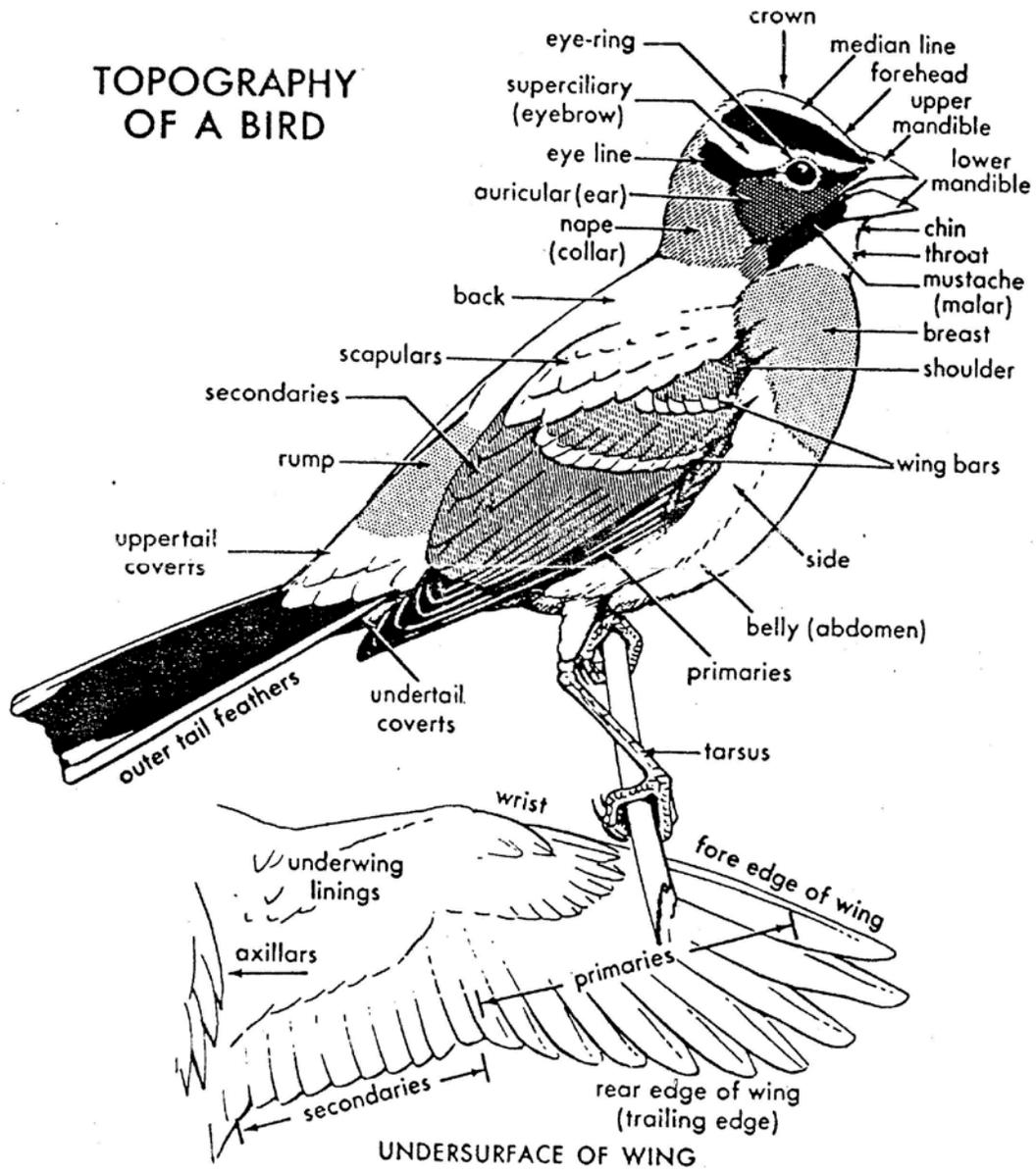


Figure 2. Bird Anatomy

Take a Guess

Once you have built up a small baseline of information about the local bird species, attempt to identify each bird that you come across while you are conducting nesting bird surveys. Many novice birders (and inexperienced individuals in just about any field) are afraid to make an attempt in displaying their knowledge, in the fear of being wrong. However making mistakes can be an effective way to learn. If you do *not* guess the identity of a bird, then you have nothing to measure your learning progress of that bird's identification against. Incorrectly guessing the species of a bird often moves you a step closer to remembering the correct identification. Additionally, if you are able to correctly identify a bird to species, it will reinforce and solidify your ID knowledge of that species. Taking a stab at identifications is best when you are with a more experienced birder, so that they can confirm whether or not you have made the correct identification.

Make a list

Another way to learn is to test yourself, or assess the progress of your training. The easiest way to do this is to make a list of birds as you go about your field duties as a bio-monitor, even when you are not conducting nesting bird surveys. Making a list of the birds that you see and hear in the field can strengthen your identification skills of birds you know and recognize, as well as elucidate those birds or songs you are less familiar with. Additionally, MCP has an eBird account in order to enter bird lists from observations made at our parks or preserves (<http://ebird.org/> **Account info:** Username: MarinParks, Password: MarinBirds415).

How to Find Birds

Some birds are far more bold than others and don't mind going about their daily activities out in the open (birders refer to these birds as being 'cooperative') where they can be seen with relative ease. Most water birds (e.g. wading birds, shorebirds, and waterfowl) are not concerned with being hidden as their defense from predators takes form either by feeding in large groups or by retreating to the water where a terrestrial predator would not pursue them. Songbirds and many other birds who reside in upland habitats avoid predators altogether by hiding in vegetation. Most of the birds you will observe during nesting bird surveys will be these upland-dwelling individuals who make themselves quite hard to see. However, because birders are driven by an otherworldly force to find birds, there *are* methods to discern the locations of these cryptic little animals.

Visually

One way you can observe a bird, initially the most obvious, is by seeing them. However, as described above, most songbirds do not like to be seen and will do whatever they can to remain hidden. There are two main methods to overcome a tiny bird's desire to not be seen: (1) by the virtue of patience and (2) by flushing the bird out of its hiding place. Both methods are useful in their own ways and should be employed under appropriate circumstances (see *Bio-Monitor/Observer Nest Searching Protocol*). Being patient, still, quiet, and waiting for a bird to show itself can be highly effective. However it is not always the most expedient way to observe a

bird, especially in grassland habitats where birds can stay concealed in tall grasses, moving about on foot rather than on the wing. Alternatively, you can actively (or passively) flush birds out from their hiding spots both by employing the use of flushing sticks, or simply by walking through an area.

Aurally

Another method of locating (and identifying birds) is by listening to their calls and songs and allowing the birds to reveal themselves. The majority of pre-mowing surveys occur mid spring through summer, making locating birds by sound during that time period incredibly effective, as spring and summer tends to be the peak breeding season for songbirds (songbirds are the most vocal during breeding season to attract mates and defend territories). Locating birds by listening to their calls and songs is a powerful tool, because even if they are hiding you can determine where to look to identify the individual. With training and practice, you can tell an adult bird from a juvenile, as well as identify most birds to species. A disadvantage of locating birds by sound is that it must be done in the morning when songbirds are the most active (aural surveys become significantly less accurate and thereby less useful later in the day when songbirds go quiet), effectively limiting the amount of time that the bio-monitors have to complete surveys.

How to Find Bird Nests

Once you have located a bird and identified the species or group in which it belongs, the next step is to determine whether or not the bird is nesting. Fortunately, there are a number of behaviors associated with nesting in many bird species, and knowing these behaviors will allow you to determine whether the bird is constructing a nest, incubating eggs, tending to young, or defending a nest (occasionally males will do this). Observing behavior associated with nesting does not always mean that a bird is nesting, however it will provide evidence for which to continue observing a bird until the bio-monitor can build a substantial case indicating that the bird is actually nesting. Below is a list of behaviors associated with nesting songbirds and what stage of nesting the behavior might indicate:

- **Alarm Calls:** The most obvious behavior associated with nesting, which can even be identified by birders with limited experience. Alarm calls will vary greatly from bird to bird. However, after spending enough time in the field listening to birds vocalize, alarm calls will stand out from the typical sonic landscape for that habitat type. Though alarm calls tend to be different from species to species, they can be generalized as being quicker and harsher than typical calls of said species, as well as being repeated incessantly until the threat to the nest is gone. If you hear an alarm call it can be used as fairly powerful evidence for determining that a bird is nesting. However, alarm calls can be used at any stage of nesting, so while they may alert you of a nesting bird, they will not indicate the nesting status of a bird, and further investigation of the bird should proceed.
- **Carrying Nesting Material:** If you can locate a bird visually always attempt to see if the bird is carrying any non-food items including, but not limited to: leaves, feathers, twigs, hair, aster pappus, string, or any other number of items. If a bird *is* carrying a non-food item in its bill, continue to watch the bird as long as you can see it and if its nest is

nearby, it will likely fly directly to the nest to continue building its nest. Clearly, carrying nesting material indicates that a bird is in the construction stage of nesting.

- **Repeated Location Perching:** You will often observe this behavior under the canopy of a forest, however it can occur elsewhere as long as perches are available. Observing repeated location perching often begins either with a bird flying from undergrowth to a perch or from a perch to undergrowth. Upon continued observation, you will eventually notice that the individual is flying from undergrowth to perch, then off into the forest, returning anywhere from 30 seconds to a few minutes later, to perch in the same spot, then drop into the same location in the undergrowth. This can either indicate nest construction or that a bird is bringing food to its young (very young nestlings are fed regurgitated food; therefore you will not see the adult carrying anything unless you notice that the adult has a bulging crop).
- **Carrying Food:** When you observe a bird carrying whole food items, keep your binoculars focused on that individual as long as you can, for the bird will either land on a perch to consume the food, or it will fly to a nest where it is provisioning its young with food. If the bird does bring the food into undergrowth, into a cavity, or occasionally into a simple cup nest suspended between branches, then you can determine not only that the bird is in the nest tending stage of nesting, but is actually relatively far along in that stage. Young nestlings must consume regurgitated food, where nestlings that are nearing fledging can consume whole food items.
- **Guarding:** Guarding can be defined as a bird remaining within a small area, and not flushing a significant distance even in the presence of humans. Typically, birds guarding an area will be defending a nest and will be creating alarm calls in an attempt to ward off the disturbance. Birds will display guarding behavior at all stages of nesting, so to determine nesting status, continue to observe the guarding bird, but move away from the bird slowly and quietly, in hopes that the bird will resume its regular activities and reveal the location of its nest.

This list is by no means a complete list of behaviors associated with nesting. In fact, there are many other behaviors that can indicate that a bird is nesting, many of which are species specific and must be learned by closely observing a particular species. In general, any bird that is exhibiting behavior that would be considered unusual for that species is a bird that is worth watching until you can determine whether or not that individual is nesting.

How to Find and Identify Raptor Nests

While behavior can be useful for locating the nests of many birds, raptor nests are often observed before the nesting individual, shifting the focus from displayed behavior to a simple visual search for a nest (if you do happen to observe a raptor behaving strangely, by all means pay attention to it, however this is much less common to observe in raptors than it is in songbirds). Because raptors build such large nests (and often in the tops of poorly leaved trees) it is relatively easy to spot a raptor nest in the canopy by simply walking along the area that is to be mowed while paying attention to nearby trees. This can be difficult in a forest as the bio-monitor must also pay attention to birds beneath the canopy. For this reason, spotting raptor nests is easiest either by walking the same route twice (looking for non-raptor nests during the first pass,

and looking for raptor nests during the second). Though it is easy to see something that *might* be a raptor nest, it can be difficult to both determine if that nest actually belongs to a raptor, and if the nest is active.

Nests that are most commonly mistakenly identified as belonging to a raptor are those of squirrels. With a little bit of training you can quickly learn to tell a squirrel nest from a raptor nest. Raptor nests tend to be built on sturdy or large branches high in a tree, and raptors will often reuse nests because of their structural integrity. Raptor nests are generally shaped like a dish, wide and somewhat concave on the top side, and have a mass of sticks extending below the dish shape.

Squirrel nests on the other hand are built in a huge variety of locations, including the ends of flimsy branches where it seems that a strong gust might blow it away. Squirrel nests also vary dramatically in shape from being wide and flat-ish (appearing similar to a raptor nest), to a near-perfect sphere, to a tall misshapen ovoid mass. In general, the way to tell them apart is that squirrel nests typically do not have a flat top to the nest, and instead have some amount of nest material piled on top of what would otherwise be a flat nest. The nesting material used is another way to tell if a nest belongs to a squirrel. Squirrels tend to use mostly leaves (especially eucalyptus and bay leaves) in their nest construction.

Once you have identified a large nest as belonging to a raptor, you must then determine whether it is active or not, as many raptor nests are built strong enough to withstand many seasons unoccupied before being used again or falling apart. To figure out if the nest is actively being used there are a few methods that can be employed. If the nest is being used, built, or refurbished (in the case of a reused nest) you will have to be patient and observe the nest for up to 10 minutes to see if an adult returns to the nest with nest material. If the adult is incubating, it may not move for long periods of time. However, looking at the nest for the presence of downy feathers or looking below the nest for whitewash (raptor droppings), are both methods that would provide reason to continue watching the nest until you can observe the adult in the nest. The same methods should be employed to determine if there are fledglings in the nest, with the addition of searching for an adult returning to the nest with food items or a full crop.

Conducting a Survey

Now that you are familiar with how to learn to identify birds, identify nesting behavior and locate nests, it is time to go conduct a survey. The following section describes the step-by-step process of what actions must be taken to complete a survey (Figure 3 provides a general overview of the survey process).

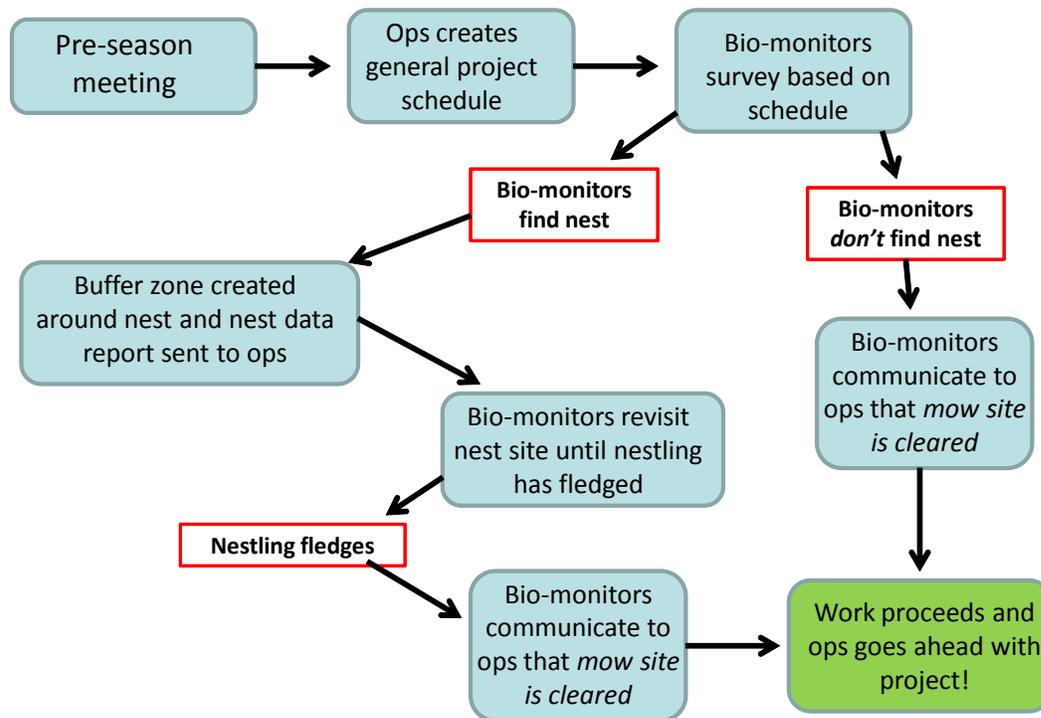


Figure 3. A simple flow chart illustrates the process for arranging and conducting nest surveys, as well as communicating the survey results.

Pre-Season Meeting

Before the bird nesting/project season begins (typically projects begin in May), a meeting will need to be held for all staff involved with implementing the project work (mowing, trail maintenance, etc.) to inform them of the purpose of conducting nesting bird surveys, and of the steps that need to be taken to carry out a survey and clear a trail or project site for operations work. The pre-season meeting will also be a good time for non-resources staff to ask questions about the bird nesting surveys. The bio-monitors will become familiar with the presentation material and the content it covers in order to give the presentation at the pre-season meeting.

Project Scheduling

Following the meeting, operations staff will need to create a broad schedule that outlines where they will be doing work over the course of the season and in what order they will be doing the work. Detailed schedules should be created before the work will actually be performed and should consist of a list of trails or fire roads and a date that the operations staff will begin the work at each preserve. Operations will designate point-people in charge of communicating the schedule and schedule changes with the bio-monitors/resource specialist.

Keeping in mind that the bio-monitors must survey a project site *no more than two weeks ahead of the project start*, Operations staff will communicate through an Excel document that includes the requestor, the request date, the operations date (date the project is expected to begin), a map, the preserve name, and the nearest trail/road. Mowing maps have been created for most of the

open space preserves and can be used every year to indicate where the work will occur. The bio-monitors or surveyors will fill in if there are owl restrictions, the survey crew, the survey date, if the area is OK to mow or clear vegetation, and the mow by date (the two week window after the survey is completed when vegetation maintenance can be conducted). See Attachment B for a summary of how to request a bird nesting survey.

What to do Before Surveying

Before you run out of the office to go survey for nesting birds, you must first know where you're going and be properly equipped. The day before you survey a site or series of sites, print out maps or load digital maps on to the Nexus tablet and find the trails or areas that you will be surveying. Gather together any equipment (and charge all electronics) you may need ahead of time in order to get out on the trail and begin surveying as soon as possible the following morning. Below is a list of all the equipment that you may need while you are surveying:

- Binoculars
- Binders containing reference material
- Bird books and other references
- Camera
- Flagging tape and pinflags
- Meter tape
- GPS unit
- Maps (paper or tablet [Nexus 7])
- Notepad/notebook

Surveying a Site

Finally you can go survey and get your binoculars on some birds! In order to optimize your potential to detect birds while you are surveying, it is important that you begin your surveys early. To perform the most effective surveys it is best to begin your day early, usually at first light when you can see birds. The earlier the better, because birds are much more active during the mornings than later in the day, so all surveys should be completed **NO LATER THAN 11:00 am**.

As for the survey itself, use the methodology described above to make the best choice of survey method given the habitat type you find yourself in. While some of the methods encourage you to take your time, you should be aware of how much time you have to devote to a certain set of trails or project sites, and prioritize your time appropriately. Be thorough and efficient in your surveys and you will likely find most, if not all of the nests in the project sites.

You Found a Nest

When you are out surveying, and you identify an active nest, there are a few steps that you need to follow in order to ensure the safety of the nest. First, follow the methodology described above to properly flag the nest and mark it in the Trimble GPS unit. Before leaving the survey site, make sure you have done your best to identify the species of the owner of the nest so you can accurately estimate when to return.

More often than not, however, you will not find a nest, which is fine as long as you followed the appropriate methods and were as thorough as possible. Many survey locations are mowed annually, so these habitats provide less than favorable locations as nesting sites. The absence of nests is also valuable data to record, so be sure to fill out the data sheet (Appendix C) for each project area. A summary of how to conduct a bird nesting survey can be found in Appendix D.

External Resources:

Identification

- Common Breeding Songbirds of Marin Open Space Preserves (Appendix E)
- Nests (Appendix F)
- Sibley's Guide to Birds (book/App)
- Peterson Field Guide to Birds of Western North America (book)
- Allaboutbirds.org (website by Cornell Lab of Ornithology)
- Merlin Bird ID (free app)
- California Birds – Audubon Society (free app)
- iBird Lite: North America (free app)

Behavior and Nesting

- Handbook of Field Methods for Monitoring Landbirds (Appendix G)
- The Birder's Handbook (book)
- The Marin County Breeding Bird Atlas (book)

Other Bird Information

- ebird.org (website)

References

Marin County Open Space District (MCOSD). 2015. *Draft Vegetation and Biodiversity Management Plan*, April.

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Appendix A
Maintenance Around Ridgeway's Rail Habitat

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Marin County Parks Maintenance around Ridgeway's Rail Habitat

Ridgeway's rail (*Rallus longirostris obsoletus*) is both a federally and state listed species (endangered). Presence should be assumed in salt or brackish marshland during the breeding season which is **February 1 – August 31**, and these protocols will help to avoid impacting them.



Identification tips:

- Ridgeway's rail is a medium-sized bird with a compact body, a long, orange bill that curves down slightly, and a short, squared tail
 - Color varies, but is often reddish or grey with dull stripes on flanks
- Nests are built in clumps of vegetation or shrubs, near the upper reaches of high tide or on bank near water
 - Nest is a cup of grasses and sedges, lined with finer material and often with vegetation woven into a canopy over nest
 - Frequently a ramp of plant material leads from ground up to nest

All maintenance within 250' of salt or brackish marshland:

- Should occur 8am – 4pm
- Should avoid periods of high tide (2 hours before or after extreme high tides, defined as 6.5 or above)
- Should occur as quickly as possible to reduce disturbance from noise, dust, etc.
- **Mowing levees should only include the tops of levees** – not the side slopes down to the marsh

The entire site must be walked prior to mowing to determine presence of rails or nests.

- If rails are observed, birds will be allowed to leave the area on their own before work begins (you can not physically remove or chase a bird)
- If nests are observed, work will be rescheduled after the young have fledged
- If no nests are observed, the surveyor will walk at a safe distance in front of the mower to ensure that all avoidance and minimization measures are followed

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Appendix B
How to Request a Bird Nesting Survey

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Marin County Parks How to Request a Bird Nesting Survey

Requesting the survey

1. **Open up the Internet Shortcut named "VegManagment".**

It should be in this folder:

<H:\Resource Mngt\BirdNestingSurveys\Request a Survey>

The shortcut will take you to [THIS](#) Google Sheet (so fancy!), where you can enter your requests.

2. **Click into the tab that best houses your project.**

There are 4 tabs under the table, labelled [Preserves](#), [Parks](#), [ProjectsTrails](#), and [EmergencyWork](#). Regular maintenance projects for preserves and parks should go into their respective tabs, while planned road and trail projects should go into the [ProjectsTrails](#) tab. Resource projects go into the [ProjectsTrails](#) tab. Emergency or response projects go into the [EmergencyWork](#) tab.

3. **Fill in all columns to the LEFT of the GREEN HEADINGS.**

- a. For [Preserves](#), [Parks](#), and [ProjectTrails](#), provide:

- **Preserve** name
- **Project** name or code of **mow zone**
- **Type** of zone to be mowed ([Preserves](#) ONLY)*
- Name of the **requesting party** (your first and last name)
- **Date** you are making the **request**
- **Date** of the **operation or when the work is planned on taking place**
- A **map** (see below for description)
- Any helpful **details** regarding access, location, challenges, etc.

* Please make a separate entry row for each mow zone. Please reuse past mow zones when entering relevant requests.

- b. For [EmergencyWork](#), provide:

- **Number** of project (first project on list is 1, second is 2, etc.)
- Brief description of the **work to be done**
- **Preserve** name
- **Nearest trail or fire road** to the emergency work
- **Equipment** needed
- Name of the **requesting party** (your name)
- **Date** you are making the **request**
- **Date** of the **operation**

- A **map** (see below for description)
- Any helpful **details** regarding access, location, challenges, etc.
- **Photos** of the emergency work

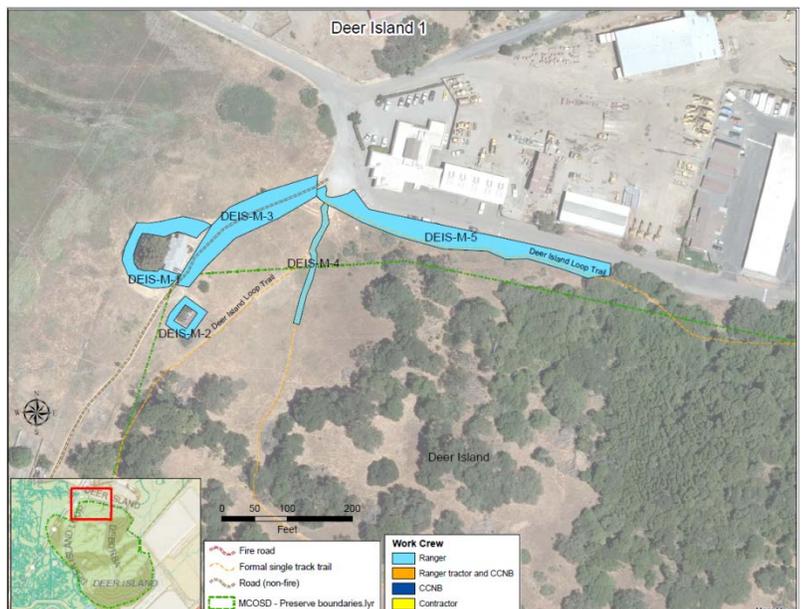
4. **Provide a map using the “MowMaps” Internet Shortcut**

- Upload maps to Google Drive by first clicking on the MowMaps shortcut, which can be found the same folder:
<H:\Resource Mngt\BirdNestingSurveys\Request a Survey>
- Click into the appropriate sub-folder ([Preserves](#), [Parks](#), [ProjectsTrails](#), or [EmergencyWork](#)), and drag-and-drop the map file straight into the drive.
- Right-click the map file once it’s loaded into the folder and select “Get Shareable Link”.
- Copy the provided link, and paste it into the **Map** column of your request entry.

Please provide a map that includes:

- A satellite view
- Clearly marked project locations
- A scale bar
- A compass or north arrow
- Relevant street and fire road names for navigation

Here are some examples of super helpful maps:



Aren't they beautiful?

Results of the Survey

Congratulations! You've submitted a Bird Nesting Survey Request! Now what?

1. **Keep an eye out for an email from the Biomonitors (biomonitor@marincounty.org)**
We'll make sure to let you know after we've had a chance to survey, as well as the results of the survey and any restrictions.

2. **Check the GREEN columns for the official results from the survey**

The columns tell you the following:

- **Owl Restriction?:** Whether or not the project area is within 0.25 mi of a Northern Spotted Owl nest or if the project is in suitable NSO habitat.
- **Survey Crew:** The **survey crew** that conducted the survey
- **Survey Date:** The **date** the survey was conducted
- **OK to mow?:** Whether or not the project/zone is **OK to mow/proceed**
- **Mow by date:** The last day the bird survey is still good (2 weeks from survey date), and therefore the last day you can still mow/work. If the project persists after this date, another bird survey **MUST** be conducted.
- **Return survey date:** If a nest is found or suspected, the survey crew will return on this date to check back on the status on the nest (usually 2 weeks later).

If the buffer zone for the nest impedes partially but not completely into the project area, the survey crew will mark the extent of the buffer with flagging.

Frequently Asked Questions

Once the Bird Nesting Survey is clear, how long do I have to complete my project?

You have **2 weeks** from the survey date. After that, the area will have to be resurveyed.

How will I know when the surveys are done?

When we've completed a survey, we'll communicate the results via email. After that, all information regarding dates and results can be found on the Google Sheet, under the **GREEN** columns.

Can I conduct a Bird Nesting Survey on my own?

Unless you've been given direct permission from Lisa Michl or have been trained by Sam Abercrombie or Bill Kuhn, we ask that you **do not** conduct your own bird surveys.

Do I need a Bird Nesting Survey for projects that don't require motorized tools or tractor mowers?

No. The nesting surveys are intended to protect nesting birds from being destroyed by power tools since the operator usually cannot tell (by sight or sound) if there is a nearby nest. If you are using hand tools, such as hand saws or weed wrenches, you don't need a formal survey. However, please still check the project area for nests or activity to ensure no nests are damaged or displaced.

Why did we switch from using the Excel spreadsheet to a Google Sheet?

The Google Sheet allows anyone with the link to edit information on the document, and multiple people can view and edit the document at once. Additionally, Google Sheets offers accessibility both off of our network drives and in the field. Not everyone was able to access the old Excel spreadsheet, and nobody could check it in the field.

Do I really have to include a map?

Yes please! An accurate map significantly increases the efficiency of the survey by cutting down on the guesswork of navigation. Verbal or written directions are difficult to interpret in the field, so a clear map can get us to the correct area that needs to be surveyed in a timely manner.

Further questions can be sent to biomonitor@marincounty.org and lmichl@marincounty.org

Appendix C
MCP Nesting Bird Survey Data Sheet

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MCP NESTING BIRD SURVEY DATA SHEET

Name:

Date:

Location/Project detail (including start date):

Start Time:

Weather/Wind/Cloud Cover:

End Time:

Weather/Wind/Cloud Cover:

Habitat Type:

Species	Behavior	Bird Location	Nest Location

Notes: (ie. any flagging? is this a repeat survey? Birds observed)

(Draw map on reverse if necessary or attach map)

Submit Original to Lisa Michl, 415-473-2128

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Appendix D
Bird Nesting Survey Guide

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Marin County Parks Bird Nesting Survey Guide

**** Only conduct bird nesting surveys if you have already been trained in the past by Sam Abercrombie or Bill Kuhn. Otherwise, please request a survey with resources staff. ****

Surveys are to be conducted between dawn and should be finished **no later than 11am**. They are good for two weeks after the survey date. Additionally, surveys cannot be done in the rain.

Field gear:

- Binoculars
- Datasheet on H drive: [PARKSFIELD\Resource Mngt\BirdNestingSurveys\DataSheets\BlankBirdSurveyDataSheet.pdf](#)
- Kestrel wind and weather meter (or other means to get wind speed and temperature)
- Rangefinder, measuring tape (250 ft.), or phone with map/app that measures distance
- 1 – 1.5 meter pole/PVC pipe
- Survey flags or flagging tape
- Sibley field guide book/app or Merlin Bird ID app (free)

Use both active flushing and observation when searching for nests:

- Active flushing: sweeping vegetation off the ground in order to flush and nesting birds hidden in the vegetation, which causes parent birds to flush and effectively reveals locations of nests
- Active observation: moving through the project footprint, trying to detect birds by sight or sound and watching for a period of time, using knowledge of bird behavior to determine if the bird is breeding, constructing a nest (carrying non-food items in bill like twigs, lichen, string, etc., repeated location perching), defending a nest (alarm calls, flying aggressively towards or near you), or tending to its young (carrying food, repeated location perching)
- If the surveyor suspects that a bird may be nesting in the area, they are to continue observing that individual until they can confirm whether or not that bird is building/tending to a nest

You found a nest! Now what?

- Identify species and stage of nesting (construction, incubation, nestlings) or if nest is non-active
- If active, measure and flag off a buffer where nesting impacts the project area (150 ft. for songbirds, 250 ft. for raptors, ¼ mile for northern spotted owls)
- Check back on nest every two weeks to confirm it is still active

Fill out the datasheet when surveying, and keep a bird list for all species observed on site.

After surveying:

- Update the [vegetation management database](#) with your findings
- Contact whoever requested the survey with the results
- Scan in your datasheet and save to the [H drive](#) using the following format:
BirdNestingSurvey_PreserveName_2017.month.day

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Appendix E
*Common Breeding Songbirds of Marin Open
Space Preserves*

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COMMON BREEDING SONGBIRDS OF MARIN OPEN SPACE PRESERVES

Unless otherwise shown or noted, males and females look similar.

Oak Titmouse

Voice: Many vocalizations – *skip it! skip it! skip it!* – *doy de doy, doy de doy* – hoarse scold etc.



- Year-round resident
- Oak woodlands
- Cavity nester
- Pairs mate for life
- Maintain stable territories year after year
- Pry small invertebrates out of bark crevices
- Also use small bill to hammer open acorns and other nuts

Chestnut-backed Chickadee

Voice: *chick-a-dee dee* – variable, high, buzzy notes



- Year-round resident
- Moist woodlands/ forests/canyons
- Cavity nester
- In fall and winter join mixed-species flocks which move and forage together – usually making constant chattering noises
- Agile, acrobatic – often hang upside down while foraging
- Opportunistic feeders depending on season and area (invertebrates, seeds, buds, fruit etc.)

Bushtit

Voice: very high, soft, constant chatter



- Year-round resident
- Most habitats with shrubs and trees
- Long, sock-like nests hang from branches of shrubs and trees
- Very social year-round, even during breeding season
- In fall and winter form flocks of 10-50 birds, constantly chattering as move through areas
- Very small – only weigh as much as 3-4 paperclips
- Eat up to 80% of body weight in food each day
- Forage on leaves and flowers for insects and spiders

Oregon Junco (subspecies of Dark-eyed Junco)

Voice: many vocalizations – metallic trills – short kissing sound, etc.



- Year-round resident, plus winter migrants
- Woodlands with good ground cover
- Usually nest on ground, hidden by overhanging vegetation – often on road banks
- Male has black head, female dark gray head
- Form winter flocks of 10 – 30 birds
- Forage on ground – diet is mainly small seeds with an increase in invertebrates when raising young

California Towhee

Voice: high, quick notes – sounds like a ball dropping and dribbling



- Year-round resident
- Shrubby habitats with open ground
- Nest in dense shrubs, low trees
- Frequently parasitized by Brown-headed Cowbirds
- Pairs mate for life and remain on territory year-round
- Highly territorial –often resulting in injury
- Few adults survive for more than 3 years
- Forages on ground by hopping/scratching in leaf litter
- Diet: invertebrates (more in the breeding season), seeds, berries

Spotted Towhee

Voice: many vocalizations – harsh, metallic trills – nasal squawks – *gaar-et* – etc.



- Year-round resident
- Shrubby habitats with layered leaf-litter
- Usually nest on ground, hidden by overhanging vegetation
- Non-migratory in western U.S. but migratory in other areas
- Forages on ground by hopping/scratching in leaf litter
- Diet: invertebrates (more in the breeding season), seeds, acorns, berries

Song Sparrow

Voice: song vocalizations vary widely, calls include sharp chips and *chimp* calls



- Year-round resident
- Open shrubby habitats, but can occupy many other habitats as well
- Forage on the ground or low in shrubs or grass
- Nest close to or on the ground in grass, weeds or shrubs
- Diet: Seeds and fruits with an inclusion of invertebrates into their diet during the summer
- Sing from exposed perches where they can be easily viewed

White-Crowned Sparrow

Voice: Call – rising sharp *seep*,



- Year-round resident in California
- Open or shrubby habitat, especially coastal chaparral
- Forage low or on the ground, and will hop and scratch like the California and Spotted towhee
- Diet: seeds of weeds and grasses, supplemented with invertebrates during the summer
- Nest a foot to several feet off the ground, typically in shrubs

Lark Sparrow

Voice: Song is a mix of clear notes and trills with buzzes and churrs. Like many sparrow songs it is best to hear it rather than read about it.



- Year-round resident in Marin
- Open habitats with scattered trees or shrubs, commonly on poor soils
- Nest on the ground or low in shrubs or trees
- Diet: seeds and vegetation, supplemented with invertebrates in the spring and summer
- Commonly found sitting or walking on open ground
- Easily distinguished from other sparrows by the harlequin coloration on its face

Lesser Goldfinch

Voice: The male's breeding song is a jumble of clear notes mixed in with wheezes, trills, and stutters, lasting up to 10 seconds. When in a flock goldfinches make a short, wheezy, descending contact call.



- Year-round resident in Marin
- Open habitats with scattered trees or shrubs, or in openings in forest
- Nest in a variety of trees. Builds a cup nest in a fork of branches
- Diet: seeds mostly from the aster family, fruits of many other plants. Occasionally eats insects.
- Often seen and heard flying in flocks with other lesser goldfinches, or sometimes in mixed flocks with house or purple finches.
- Can be distinguished from the American goldfinch by the smudged olive color between its head and wings.

Orange-crowned Warbler

Voice: undulating trill, sounds like a thumb run over a comb (he combs his orange crown)



- Mar – Nov, with small numbers during the winter
- Shrubby, wooded habitats
- Usually nest on ground, hidden by overhanging vegetation
- Migrants arrive mid-March as oak leaves emerge and there are high numbers of Oak Moth caterpillars to feed on – sustain adults and hungry young
- Usually forage high in tree canopy for invertebrates
- Drink from Sapsucker wells and occasionally hummingbird feeders

Black-throated Gray Warbler

Voice: Ratcheting up “*busy busy busy bee*” (he's striped like a bee)



- Apr – Oct
- Dry woodlands
- Nest in shrubs or trees
- Males sing continuously throughout the day
- Forage on leaves for invertebrates

Wilson's Warbler

Voice: rapid, staccato, choppy notes, speeding up at end



- Apr – Sept
- Moist riparian or forested areas with dense, low-growing vegetation
- Nest in tangled vegetation (often blackberry vines) near ground
- Males tend to stop singing once they secure a mate, then sing again for a short period once nest-building is complete
- Once nestlings leave the nest, parents split them up, each feeding their share of the young for ~3 weeks
- Forage on leaves for invertebrates and fly out to catch insects in mid-air

Bewick's Wren

Voice: highly variable, usually 3-parted song with buzzes, trills and repeated notes.



- Year-round resident
- Open woodlands with dense understory
- Cavity nester
- Remains on territory year-round
- Each male has ~13 – 20 different songs – repeating each song 40 – 50 times before switching to next.
- White eyebrow
- Diet: invertebrates

House Wren

Voice: rapid, bubbling song with a combination of buzzes, clear notes and nasal *shjoo, shjoo*



- Apr – Sept with very small numbers during the winter
- Open woodlands with sparse understory
- Cavity nester
- Male builds multiple twig nests – female chooses one then lines it with soft feathers, grass, hair etc.
- Highly aggressive during breeding season
- Each male has ~20 – 50 different songs
- Female sings back to male for the first few days, then stops unless male tries to attract another female – in which case she starts singing again
- No white eyebrow
- Diet: invertebrates

Brown Creeper

Voice: "trees beautiful trees!" (he's always found climbing up trees)



- Year-round resident
- Moist, well-shaded forests
- Nest is tucked behind loose bark, usually on dead trees, close to the ground
- Birds characteristically 'creep' up tree trunks with sharp claws and stiff tail
- Forage for invertebrates by prying into bark crevices with long, curved bill

Pygmy Nuthatch

Voice: Shrill staccato piping. Vocalizations are highly variable.



- Year-round resident
- Coniferous forest – Long needled Pines
- Cavity nester
- Able to cling to bark at any angle - even head-down (vs. creepers and woodpeckers)
- Often wedge food into bark crevices and hammer to pieces with bill
- Diet: invertebrates, nuts, acorns (harvested in the fall – some are cached to eat during the winter)

Red-breasted Nuthatch

Voice: Series of singular notes sounding like a toy car – *yank-yank-yank*



- Year-round resident
- Coniferous forest
- Cavity nester
- Will often vocalize during the middle of the day (when other songbirds are quiet)
- Able to cling to bark at any angle - even head-down (vs. creepers and woodpeckers)
- Often wedge food into bark crevices and hammer to pieces with bill
- Diet: invertebrates, nuts, acorns (harvested in the fall – some are cached to eat during the winter)

White-breasted Nuthatch

Voice: many vocalizations – husky single notes – nasal, rapid yelping – etc.



- Year-round resident
- Oak woodlands
- Cavity nester
- Smear noxious secretions of crushed insects around cavity entrance to deter predators
- Able to cling to bark at any angle - even head-down (vs. creepers and woodpeckers)
- Often wedge food into bark crevices and hammer to pieces with bill
- Diet: invertebrates, nuts, acorns (harvested in the fall – some are cached to eat during the winter)

Warbling Vireo

Voice: *rosita rosita rosita rozeet!* – voice is pretty, clear and bubbly



- Mar – Sept
- Woodlands and riparian areas
- Nest – a deep cup suspended in the fork of tree branches, well hidden.
- Males sing constantly – even while sitting on nest.
- Common Cowbird host – doesn't attempt to destroy eggs.
- Very abundant but usually heard rather than seen
- Diet: mostly invertebrates (40-80% caterpillars), some berries

Hutton's Vireo

Voice: continuous repetition of single or double notes (“Chinese water torture bird”)



- Year-round resident
- Mixed evergreen forests – especially Live Oaks
- The nest is a well hidden, deep cup suspended in the fork of tree branches (usually Coast Live Oak)
- Nest very early (as early as late January)
- Live Oaks keep leaves year-round, supporting a high number of insects, which provides a continuous food source
- Glean invertebrates off leaves and flowers – also eat some berries

Tree Swallow

Voice: metallic chirps, watery warbles



- Year-round, numbers increase Feb – Oct
- Usually found near a water source (pond, marsh etc.)
- Cavity nester
- May aggressively, sometimes fatally, compete with Chickadees, Bluebirds and other swallows for nest sites
- Doesn't have white around eye, barely on rump
- Female more brown
- Catch flying insects in air – also eat berries and seeds in winter

Violet-green Swallow

Voice: electric – sounds like light sabers



- Mar – Oct
- Usually found in open oak woodlands
- Cavity nester
- Has white around eye and on rump
- Female more brown with less white around eye
- Catch flying insects in air

Barn Swallow

Voice: squeaky chatter, interspersed with buzzes



- Mar – Oct
- Open areas: grasslands, marshes, ponds, estuaries, beaches
- Nests almost exclusively on man-made structures (e.g. barns)
- Nest is a half cup of mud and grasses hidden under eaves of buildings
- World's most abundant and widely distributed swallow
- Female has shorter forked tail, paler underside
- Catch flying insects in air – also eat berries and seeds in winter

Black Phoebe

Voice: *phoe-bee, pha-boo, phoe-bee, pha-boo...* (he says his name)



- Year-round residents
- Many habitats, but usually near fresh water
- Nest almost exclusively on human structures
- The nest is attached to a vertical surface by mud and is made up of mud, dried grass and hairs
- Very adapted to human environments (city parks, suburban yards, etc.) but also found in open spaces
- Sit on low, exposed perch and fly out to catch insects in air

Pacific -slope Flycatcher

Voice: 2-part whistle - sounds like calling a dog



- Mar – Oct
- Shaded forests
- Nest is a small cup found in a variety of situations: ground, banks, trees, cavities
- Often reuse nest site for second brood or in subsequent year
- Perch on leafy branch (vs. exposed perch) and fly out to catch insects
- Diet: insects, including a high number of bees, wasps and ants

Ash-throated Flycatcher

Voice: sounds like a referee whistle



- Apr – Sept
- Dry woodlands and open brushy areas (tolerant of hot, dry conditions – more than other flycatchers)
- Cavity nester
- Active foragers - perch and make short flights to catch insects off leaves or the ground (vs. mid-air like other flycatchers)
- Broad diet: mostly insects, including bees, wasps, caterpillars, grasshoppers etc. – also some berries, reptiles and rodents

Lazuli Bunting

Voice: "sweet sweet sweet, I'm so super sweet sweet sweet"



male



female

- May – Sept
- Edge habitats with both brushy and grassy areas
- Nest in low vegetation
- Males form small groups for several days when first arrive, increasingly singing and fighting as establish territory
- Singing drops off dramatically once mated
- Female is very plain with a faint wash of blue on wings and tail
- Diet: invertebrates, seeds, fruits

Black-headed Grosbeak

Voice: melodic, sounds like a "drunken robin"



male



female

- Apr – Sept
- Woodlands
- Loose nests in outer branches of low trees and shrubs
- Males continuously sing – at each other until eggs are laid, then at mate, even while incubating eggs and helping with nestlings
- Once young have fledged females sing to keep family group together
- Diet: invertebrates, seeds, fruit, leaf and flower buds

Brown-headed Cowbird

Voice: variable – 1 very high note – slur of 4 notes that sounds like water – quick, quack notes



male



female

- Year-round, numbers increase Mar – Oct
- Varied habitats
- A "brood parasite" – lays eggs in the nests of other species
- The young cowbird out-competes the host's own young, usually resulting in mortality
- Lays up to 70 eggs in one season
- Historically followed buffalo herds – now livestock
- Eat grain in dung and insects stirred up by feet
- Diet: invertebrates and seeds

Red-winged Blackbird

Voice: variable calls, though classic call goes *conk-la-ree!* sung in a harsh metallic tone



- Year-round, numbers increase Mar – Oct
- Varied habitats
- A “brood parasite” – lays eggs in the nests of other species
- The young cowbird out-competes the host’s own young, usually resulting in mortality
- Lays up to 70 eggs in one season
- Historically followed buffalo herds – now livestock
- Eat grain in dung and insects stirred up by feet
- Diet: invertebrates and seeds

Acorn Woodpecker

Voice: variable – laughing, raucous *uh-oh, uh-oh, uh-oh*



male



female

- Year-round residents
- Any area with mature oaks
- Cavity nester
- Colonial – individuals work cooperatively to forage for food, guard granary and raise young
- Granaries are passed down from generation to generation with an average of 500 holes added each year
- All species of acorns are used but Valley and Blue Oaks are preferred because they have lower tannins
- Female has black band between white and red on head
- Diet: prefer flying insects (especially flying ants) but acorns allow to remain on territory year-round

Downy Woodpecker

Voice: High pitched *pik* call, and a raspy whinny. Drum is medium speed (quicker than Acorn, slower than Hairy)



Male



Female

- Year-round residents
- Lives in open woodlands or urban-woodland interface areas
- Cavity nester
- Male has red spot on back of head
- Diet: Beetle larvae, ants, caterpillars and other insects
- Looks nearly identical to the hairy woodpecker, but is about 1/3 smaller and the bill is smaller in proportion to its head
- Distinguished from hairy woodpecker by black spots on the white, outer tail feathers (apparent when using the tail feathers to prop themselves up against a tree)

Hairy Woodpecker

Voice: High pitched *pik* call, and a clean whinny. Drum is very quick (faster than the downy woodpecker)

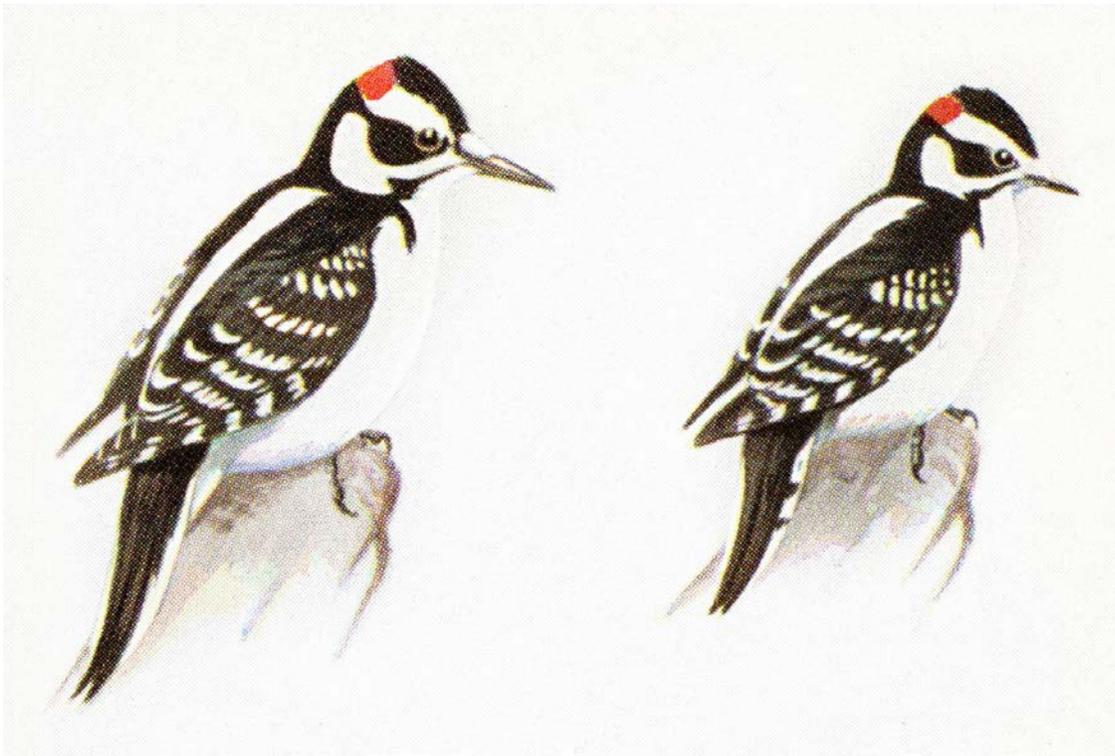


Male



Female

- Year-round residents
- Lives in a wide variety of woodland habitats as well as urban edges
- Cavity nester
- Male has red spot on back of head
- Diet: Beetle larvae, ants, caterpillars and other insects
- Looks almost identical to downy woodpecker, but is a bit larger, and its bill is proportionally larger
- Distinguished from downy woodpecker by clean, white, outer tail feathers (apparent when using the tail feathers to prop themselves up against a tree)



Hairy woodpecker

Downy woodpecker

****Notice the relative bill size and the spots on the outer white tail-feathers****

Hairy:

Hairy:

- Hairy woodpecker is relatively larger
- Hairy woodpecker's call is static – same pitch
- Hairy woodpecker's call is scratchy
- Hairy woodpecker's bill is about as large as its head

Downy:

- Downy woodpecker is relatively smaller
- Downy woodpecker's call descends
- Downy woodpecker has a piercing call
- Downy woodpecker's bill is about ½ size of its head

Nuttall's Woodpecker

Voice: high, quick, chirpy trills – *chirp, chirp, chhhiiirrrrrppp*



male



female

- Year-round resident
- Any area with mature oaks
- Cavity nester
- Have a harder time excavating cavities than other woodpeckers so often create cavities in the softer wood of riparian trees, surrounded by oaks
- Mated pairs remain on territory year-round
- No red on female
- Diet: invertebrates – also some berries (e.g. poison oak berries), sap, acorns etc.

Anna's vs. Allen's Hummingbird



Anna's:

- No noise when flying
- Males have a red head
- Females have a red patch on neck



Allen's:

- Make noise when flying
- Orange neck
- J flying pattern
- Jetsons' song

Black Phoebe vs. Dark-eyed Junco



Black Phoebe:

- Return to regular perch after fly-catching
- Often wags or pumps tail
- Black bill
- White belly only (back extends feather tuft)



Dark-eyed Junco:

- Often forages for seeds on ground
- White outer tail feathers
- Short, pink, conical bill
- Black reminiscent of executioner's head

American Goldfinch vs. Wilson's Warbler



American Goldfinch:

- Black cap, forehead, and wings
- White spot on underwing
- Eats seeds
- Heard in flight



American Goldfinch:

- Black cap only
- Eats insects

References/Further reading:

Bay Area Birds. David Lukas

The Marin County Breeding Bird Atlas. W. David Shufford

The Birder's Handbook. Paul R. Ehrlich, David S. Dobkin, Darryl Wheye

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Appendix F

Nests

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NESTS

RAPTOR NESTS

Red-tailed Hawk

Large (~29" wide x 6-20" deep)

Usually in large tree; at fork of trunks or junction of large branch with trunk; upper canopy; with an expansive view. Nests often reused for multiple years.

Sticks and twigs with a few fresh leaves mixed in.



Red-shouldered Hawk

Medium (~21" wide x 10" deep)

Usually in main fork; below canopy crown; occasionally in conifers. Nests often reused for multiple years.

Sticks, twigs, bark strips, dry leaves, moss, conifer needles.



White-tailed Kite

Medium (~20" wide x 8" deep)

Usually in treetop, in slender branches; camouflaged from below but open above; flimsy to well-made. Nests usually not reused.

Twigs.



Eagles – Golden and Bald

Very large (3-8' wide x 3-12' deep)

Cliffs; often in fork of tall trees, especially conifers. Nests often reused for multiple years.

Large sticks.



Great-horned Owl

Don't build their own nests but take over nests previously built by hawks, ravens, crows, squirrels etc. Nests often reused for multiple years.



Barn Owl

Usually nest in cavities, especially coast live oak; will often use owl boxes. Nests often reused for multiple years.



NON-RAPTOR NESTS (which can be easily mistaken for raptor nests)

Raven

Large (~15-60" wide x 8-24" deep)

Usually in conifers, also eucalyptus and deciduous trees. Nests often reused for multiple years. Sticks, twigs, wire.



Squirrel

Large (~2' wide x 2' deep)

Usually in upper canopy.

2 types of nests – both built of twigs and leaves

1. Round, covered with roof: used for birthing, rearing young, protection in winter
2. Cup, no roof: used as day rests, warmer seasons



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Appendix G
*Handbook of Field Methods for Monitoring
Landbirds*

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Ralph, C. John; Geupel, Geoffrey R.; Pyle, Peter; Martin, Thomas E.; DeSante, David F. 1993. **Handbook of field methods for monitoring landbirds**. Gen. Tech. Rep. PSW-GTR-144-www. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 41 p.

This handbook is a compilation of methods that can be used to assay population size, demographics, and status of many species of birds occurring in a wide variety of habitats. The handbook will prove useful to field biologists, managers, and scientists anywhere in the New World from the arctic through the tropics. The methods include four types of censuses for determining population size and trends, mist-netting and nest searches to determine demographic parameters, and other methods that will be useful in operating a monitoring station, including habitat and weather observations, and suggestions for training personnel and possibilities for detailed studies. Suggestions of specific methods and data forms are included.

Retrieval Terms: bird populations, census, mist-nets, monitoring, nesting birds

Acknowledgments:

The late L. Richard Mewaldt was the first among equals in setting high standards and maintenance of accurate records. His contributions are detailed by Ralph (1992). We take great pleasure in dedicating this handbook to him.

This handbook is a direct outgrowth of the landbird program started more than 25 years ago at the Point Reyes Bird Observatory to monitor landbird populations in coastal California, and much of this handbook is the result of the methods developed and adapted there. Over this period, many people contributed to the development of this landbird monitoring program.

The handbook benefitted greatly from discussions and correspondence by Bruce Bingham, Grant Ballard, Danny Bystrak, Barbara Carlson, Brenda Dale, Sam Droege, John Faaborg, Kevin J. Gutzwiller, Denise Hardesty, Kimberly Hollinger, Bill Howe, David W. Johnston, Stephanie Jones, Cherry Keller, Kathy Klimkiewicz, Rolf R. Koford, Karin Kozie, Borja Milá, Sherri Miller, Michael Morrison, Barry R. Noon, Nadav Nur, Raymond J. O'Connor, Will Peach, Carol Pearson Ralph, Martin Raphael, Dan Reinking, Christopher C. Rimmer, Sharon Ritter, John T. Rotenberry, John R. Sauer, Tom Sherry, Sue Sniado, John Tautin, Jared Verner, Dennis Vroman, George E. Wallace, Dan Welsh, and Joseph M. Wunderle, Jr.

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May 1993

Handbook of Field Methods for Monitoring Landbirds

C. John Ralph Geoffrey R. Geupel Peter Pyle Thomas E. Martin David F. DeSante

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In Brief . . .

Ralph, C. John; Geupel, Geoffrey R.; Pyle, Peter; Martin, Thomas E.; DeSante, David F. 1993. **Handbook of field methods for monitoring landbirds**. Gen. Tech. Rep. PSW-GTR-144. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 41 p.

Retrieval Terms: bird populations, census, mist-nets, monitoring, nesting birds

The increased attention devoted to the status and possible declines of populations of smaller species of terrestrial birds, known collectively as “landbirds,” has resulted in an immediate need for specific methodology for monitoring their populations. This handbook is derived from several sources and is based on the authors’ collective experiences in operating monitoring stations. Presented here are a compilation of methods that can be used to assay population size, demographics, and status of virtually all species of landbirds in a wide variety of habitats, from grassland and tundra to temperate and tropical rain forests. Rare species, or those with unusual habits, will require some modifications. The handbook will prove useful to field biologists, managers, and scientists anywhere in the New World. The handbook

first suggests priorities for selecting a monitoring method and determining station locations. Then, general tasks that determine which species can be monitored, and methods of establishing and maintaining a study plot, journal keeping, and training of personnel are presented. Two demographic methods are described, one involving mist nets, and the other finding nests during the breeding season. Detailed suggestions are given for both methods which should allow a trained person to successfully operate a station. Both methods involve monitoring at a station at regular intervals during the breeding season. The handbook also includes descriptions of four types of censuses for determining population size and trends: spot mapping of territories, area searches of specific sites, strip transects along predetermined routes, and point counts. The latter method has been accepted as the standard method, is treated in most detail, and involves a person standing in one spot for 3 to 10 minutes and recording all birds seen or heard. In addition, methods are suggested for measuring habitat, recording weather, and color-banding individuals to determine specific demographic parameters. Throughout the handbook, sources of materials are given that are needed for each method, as well as specific references to published works.

Introduction

Throughout the New World attention is now being focused on the status of populations of landbirds, which are the many species of smaller birds, sometimes referred to as “non-game” birds. Landbirds have not usually been the focus of management activities except in a few cases of threatened or endangered species, such as the Kirtland’s Warbler. Recent evidence suggests that some landbird species are declining in abundance, fueling much speculation upon the causes of these declines, the species involved, and their habitat preferences. Hypotheses about the causes of these declines are varied, ranging from tropical deforestation to nest parasitism by the cowbird. However, part of the difficulty in determining the status of landbirds results from problems in monitoring these small birds, as compared to larger, more easily-studied species. To determine population changes, and to hypothesize possible causes of these changes, more basic information needs to be gathered.

Much of the evidence for these population declines in the New World has come from the results of the Breeding Bird Survey coordinated by the U.S. Fish and Wildlife Service and the Canadian Wildlife Service (Robbins and others 1986, 1989). These roadside counts provide excellent baseline data. However, they do little to identify the factors contributing to changes in landbird populations, and are limited to areas with major roads.

The use of population size as a measure of health of a species has been a common tool of biologists for many years (Hutchinson 1978; Lack 1954, 1966). Methods for surveying population size have been detailed by Ralph and Scott (1981), in the excellent compendium by Cooperrider and others (1986), and the manual by Koskimies and Vaisanen (1991). Population size, however, is only a retrospective tool. It tells only after the fact that a species has enjoyed an increase or suffered a decline. To ponder causes of changes, the biologist must couple information on population size with data on the internal composition of a population—its demographics (Temple and Wiens 1989). For example, data on sex ratio, age distribution, nesting success, survivorship, average weight, and population movements can all give valuable cues to factors or events regulating a population. Moreover, such primary population characters can provide early warning signals of population problems prior to actual declines. Many studies have used data such as these to describe the dynamics of various populations (DeSante and Geupel 1987, Hutchinson 1978).

Several other efforts have been under way to document changes in adult populations and in productivity. For example, in the late 1970’s, the Germans and Austrians started the “Mettnau-Reit-Ilmlitz-Programm” (Berthold and Scherner 1975). Since 1981, the British Trust for Ornithology has conducted their Constant Effort Sites (CES) Scheme (Baillie and others 1986; Baillie and Holden 1988;

Peach and Baillie 1991; Peach and others 1991). Martin has started a program involving nest searches (Martin and Geupel in press). DeSante (1991, 1992a,b) has started a cooperative mist-netting program in North America known as “Monitoring Avian Productivity and Survivorship” (MAPS) along these same lines. The Point Reyes Bird Observatory has been monitoring landbird populations in coastal California for more than 25 years (Ralph 1967, Geupel and DeSante 1990b).

In this handbook we outline the steps that might be followed in monitoring many species of landbirds. We cover methods used in monitoring of population size, productivity, age and sex ratios, survivorship, habitat relationships, and other parameters. We provide details of four methods that estimate population size, two methods that measure demographic factors, and two suggestions for conducting habitat assessment. We have tried to give the land manager, biologist, and others complete information on basic requirements, tools, resources, and methods to carry out a successful landbird monitoring program. Depending on funding and staffing, any combination of the techniques we describe is applicable to virtually any site and budget. This handbook does not provide the objectives of each study that might be conducted, or what analyses can be conducted. These both must be examined carefully before monitoring begins. We hope that this handbook will generate interest in monitoring programs using methods that can give insight into causes, as well as the facts, of population changes.

Objectives of a Monitoring Program

A monitoring program ideally should provide three types of data. One is an estimate of the population size and trends for various species of birds. The second is an estimate of the demographic parameters for at least some of those populations. The third is habitat data to link the density and demographic parameters of bird populations to habitat characteristics. Ideally a monitoring program should take a community approach and monitor all avian species in the area.

We have recently seen a marked increase in interest in monitoring, far outstripping available personnel, training, and resources. Indeed, this increase is the impetus for this handbook. While this has been gratifying, we think that it is essential that people first determine why they might want to establish a census, mist netting, or nest searching program. Not everyone requires a monitoring program to meet their goals. We have sometimes seen the establishment of a monitoring program first, followed by an attempt to decide what type of information can be obtained. We very strongly suggest that, before a monitoring program is put in place, the following steps be carried out: (1) decide the objectives and goals desired; (2) determine whether monitoring is the way to accomplish these; (3) with the goals firmly in mind, write

down the questions being asked, clearly and objectively; (4) determine which monitoring methods most directly answer the questions posed; (5) review the types of data that can be obtained from these methods, and outline exactly how these data will answer the questions; (6) outline the analytical methods that can be employed; (7) determine the cost, logistics, availability of personnel, and probable length of commitment to the project; and (8) write a study plan and have it reviewed by a person competent in research and statistics. This procedure is vital, because accumulation of a data base does not itself lead to meaningful analyses later.

Participants in a monitoring program can include private, state, provincial, and federal groups. Our premise is that the basic entity for this exercise is an administrative unit, such as a Forest Service District or a State Park. Not all such units will want or need such a program. Each unit should outline its needs and goals before starting, suggest monitoring programs to meet those needs, and have them reviewed by a competent biostatistician. We do believe, however, that our recommendations below have generality among many types of administrative units. These units can be very heterogeneous, and thus a variety of methods may be needed.

Glossary

Landbirds: the general term used for the generally smaller birds (usually exclusive of raptors and upland game birds) not usually associated with aquatic habitats. By contrast, waterbirds include seabirds and other aquatic species.

Region: an area of several thousand acres, often including several drainages, that the biologist wishes to sample. Here, extensive point counts are conducted on roads to monitor overall population sizes and their changes.

Administrative unit: the basic entity that conducts monitoring. Examples are a Forest Service District or Forest, a State Park, a National Wildlife Refuge, a private nature center, or a commercial forest.

Monitoring station: an area of usually less than about 50 ha (125 acres) within a region. Here, intensive censuses, nest searching, and mist netting are conducted.

Capture array: the generally rectangular or circular configuration of mist net locations at a station.

Nest search or census plot: an area of, preferably, a single habitat type where spot mapping or area searches are conducted.

Census grid: the arrangement of intensive point counts overlaying a demographic mist net array or nest search plot.

Census point: the place where a single point count census is taken.

Net location: the place where a single net is placed.

Nest site: the place where a single nest is found.

A 10-day time: **interval** is the basis for most monitoring and analyses.

Selecting Monitoring Methods and Location of Monitoring Stations

Before beginning work, careful attention should be given to selecting the appropriate method for the questions being asked, and great care should be given to selecting locations of monitoring stations to best answer these questions.

Selection of Methods

The standardized set of methodologies described below should be followed closely to ensure compatibility with those of other monitoring stations. These methodologies are integrated and hierarchic, so as to allow a region's sampling schemes to complement other programs and to allow comparisons between monitoring stations in a region, and between regions.

Methods recommended should be employed for a minimum of three years, and preferably longer. However, depending on individual objectives, some results may be obtainable in a year or two.

What Will the Data from This Program Provide?

These data will be used at two geographic scales. At the level of the managed forest, for instance a large National Forest District, they will provide a local assessment of the status and trends of landbirds. The scheme below samples the landscape as a whole within the unit and will permit statements such as: "Scarlet Tanagers have significantly increased on the sampled units in the forest," "Hermit Thrushes have had high mortality during migration or the winter in the past two years," or "15 of 20 neotropical migrants have increased over the past 3 years." Such a local scheme will permit some investigation of patterns of population change (e.g., "are declining trends more prevalent in units of the northern half of the forest?", "do increasing trends appear to be associated with certain forestry practices?"). Their primary purpose, however, is to estimate the status and trends of the population. Assessment of the *cause* of population change, or associations with environmental factors such as cutting practices, are more efficiently studied by other research programs with more appropriate techniques.

At the larger scale, perhaps a Forest Service Region, a state, or a province, the program will permit evaluation of geographic patterns of various attributes of landbirds. It is important to realize that the program cannot evaluate the population status of birds of the entire geographic area, whether regional, state, federal, or continental. If, for example, samples are only from forested environments, only statements about birds using forested lands can be made. Additionally, because sites are chosen by the unit, and are not a random sample of all available units or sites, the program can investigate only the *patterns* of population change, rather than the population's overall status. Questions

this approach can answer, for example, are: “are population increases or reproductive failures in a group of species more prevalent in some regions or states?”; “what is the association between forest management and population status of a group of species?”; “do some forest types have more neotropical migrants than others?”; or “are populations increasing in some forest types, but not in others?”

Coverage

While it would be best to have complete coverage of any state, province, or region, we do believe that it is acceptable and inevitable that gaps will exist. These gaps will occur within habitat types, forests, states, provinces, or regions. At a minimum, we hope to have several units involved in each state, province, or region. We strongly urge that each unit have both population and demographic methods in operation, and cover anything from a few hundred to several thousand acres. Further, we suggest that sampling within a unit should be stratified by at least general habitat type, such as “mixed coniferous forests,” “tropical thorn forest,” or “coastal chaparral.” Samples in an analysis, in general, should not be pooled across habitat types. The data from these units would be searched for large-scale patterns, e.g., species showing consistent declines over the entire region or within a given habitat type. Results from these investigations will identify patterns that need further research or greater intensity of monitoring to determine their causes. The overall program could be considered a large-scale hypothesis-generating mechanism.

Table 1—Census and demographic monitoring methods

Variables and characters	Census			Demographic	
	Point count	Spot map	Area search	Mist nets	Nest search
<i>Variables measured</i>					
Index to abundance	yes	yes	yes	yes	partly
Density	no	yes	no	no	partly
Survivorship (adult)	no	no	no	yes	no
Survivorship (juvenile)	no	no	no	yes	partly
Productivity	no	no	no	yes	yes
Recruitment	no	no	no	yes	no
Habitat relations	yes	yes	yes	little	partly
Clutch size	no	no	no	no	yes
Predation/parasitism	no	no	no	no	yes
Individuals identified	no	no	no	yes	yes
Breeding status known	no	yes	no	partly	yes
<i>General characters</i>					
Habitat types measured	all	some	most	some	few
Habitat specificity	good	good	good	fair	good
Rare species measured	many	few	many	some	few
Canopy species measured	all	all	all	some	few
Area sampled known	partly	yes	yes	partly	yes
Size of area sampled	moderate	small	small	large	small
Training necessary	much	much	moderate	much	much
Observer error potential	high	high	moderate	moderate	moderate
Use in non-breeding	yes	no	yes	yes	no
Cost per data point	low	high	low	high	very high
Applicable scale	broad	local	broad	broad	local

Priorities

Methodologies are compared in *table 1*. At a minimum we recommend that the following programs of demographic and population monitoring be implemented in each unit, in the following order. Although this handbook describes three censusing methods, the point count method has been adopted as the recommended standard, and its implementation is suggested below. Each recommended method is in segments of 10 person-days, other than the first which takes one person-day. For example, if funding is available for 21 person-days of field work, then only Priorities I through III (outlined below) would be implemented. These estimates of time do not include set-up or training. These will vary depending upon qualifications of personnel. The minimum numbers of counts or netting sites, noted below, are derived from our experiences with many such population monitoring programs. We believe they are useful, but not restrictive, minima for a unit’s effort.

Priority I. Breeding Bird Survey—If the unit is in North America and has an unsurveyed Fish and Wildlife Service Breeding Bird Survey route within or near it, we recommend that the standard survey be conducted. This involves 50 3-minute point counts along roads at 0.5-mile (1-km) intervals. The effort takes one person-day at the height of the breeding season, usually in early June. The surveyor must know all of the vocalizations of species likely to be encountered. This Survey will help detect regional trends in many species in the unit, or its vicinity.

Priority II. On-Road Point Counts—As a second priority, we recommend that the unit put in point-counting stations in multiples of about 250 stations to monitor overall population changes and responses to habitats. We suggest that the stations be in habitats representative of the unit, stratified by these major habitats, systematically placed, and placed primarily along secondary roads. This level of effort will require about 10 person-days during the early breeding season, usually in May or June. It is based on the assumption that in the 10-day period, an average of about 25 stations can be censused in each day. While we acknowledge the fact that an on-road monitoring program is not without bias, the benefits are considered by most workers to outweigh the disadvantages, and are at least partly offset by Priority IV, below.

Priority III. Demographic Monitoring—We recommend that the unit establish at least one site to measure demographic parameters. Either constant-effort mist netting or nest searches (both, if possible) should be conducted on usually about six plots within each unit. These monitoring stations will estimate demographic variables that influence the density estimates.

Constant-Effort Mist-Netting Sites—Operating mist nets through the breeding season, at most North American stations, will require about 10 person-days per site, beginning about June and continuing through the end of August. In Latin America, the season would be longer. The program will provide information on productivity, survivorship, and movement of many species. Mist netting involves capturing birds, banding them, and taking data on age, sex, breeding

status, molt, and survivorship. At a minimum each monitoring station should operate 8-12 nets at least once every 10 days throughout the breeding season. It has become well established that results from constant-effort mist netting provide excellent indexes of productivity and recruitment for a variety of species (e.g., DeSante and Geupel 1987, Peach and others 1990, Peach 1992). It is the only method that estimates survivorship and recruitment using mark and recapture. Its major weakness is that the recruitment data are not habitat specific, especially late in the summer. The survivorship data are excellent, and all data are most habitat specific for adults, especially early in the breeding season. As the season progresses, influx of peripheral birds and young from other areas dilutes this specificity.

Nest Searching Sites—Nest searches involve intensively finding nests in a plot. Typically, one plot can be done in about 20-40 person-days, beginning about May and continuing to about August. Nest searching involves finding nests, monitoring their outcome, and measuring associated vegetation. A study plot needs to be visited at least once every four days to find and check nests. Nest searches provide direct measures of reproductive success (rather than an index) and can provide direct data on influences of habitat on reproductive success and the incidence of nest parasitism. Nest searching, however, is quite labor intensive and is applicable to fewer species than mist netting.

A drawback to both demographic methods is that they will assay the population health of only certain species in an area. As a general rule of thumb, usually about 10 species at any one station will be monitored. However, when data from several stations are combined over a larger geographical area, meaningful insights may be gained on many species.

In addition, within each demographic plot, at least 9-16 intensive point count censuses should be conducted at least twice during the peak of the breeding season. Other census methods (i.e., spot mapping, area search) may also be employed, depending on objectives, size of study area, and availability of personnel. Vegetation measures should also be made at each census point and within each demographic plot.

Priority IV. Off-Road Point Counts—As a fourth priority, we recommend that the unit conduct point counts in segments of approximately 100 points off-roads in habitats not covered by the on-road point counts. Each segment of 100 points will require up to 10 person-days during the same period as on-road counts, and assumes about 10 stations per day are covered along trails or cross-country.

Priority V. Additional Work—When resources are available, we recommend that the unit add programs, in increments of 10 person-days, of the three programs (II-IV) above. We do encourage additions of programs in the order they are recommended. However, local conditions, variety of habitat types, length of sampling season, areas of management concern, and consultation with biostatisticians will modify the order and magnitude of additional work in each unit. Additionally, at some point a unit will be best served collecting information other than that outlined above.

Selection of a Station Location

A monitoring station should be located in representative habitat for a given region, or in a habitat of concern. A station may have a variety of habitat types, and some will have a higher density of birds than others. Because the derived population and demographic parameters are likely to be highly sensitive to successional changes in the habitats sampled, stations should not be placed in very young habitats. However, young habitats are acceptable if they are held in a lower successional stage by active management.

If the census methods involve extensive point counts, the points can be spread out along a road or trail network, over a fairly large area of the region. This makes for a robust data set, because each point is at a location somewhat representative of the habitats in the region. In spot mapping and nest searches, a plot is usually established in a single habitat type, and is usually square or rectangular. Plots in heterogeneous habitat are often not as useful because they are more difficult to generalize about.

For constant-effort mist netting, we suggest the capture array be placed where a high rate of capture can be achieved. By contrast, extensive census points and the nest search plot should be placed in the representative habitats of the region.

Permanent Stations

While the need for broad-scale monitoring is of vital importance, in-depth studies in small, protected areas, such as natural areas, nature reserves, and parks, can contribute greatly to our knowledge of landbird populations. In-depth studies of bird life histories (normally using individually color-banded birds) can provide important insights into vulnerability and management of species. Other biological studies concurrently conducted at the station can add greatly to our knowledge of the factors affecting local landbird populations. Monitoring stations with active field programs or living quarters for biologists are ideal for intensive programs in remote areas and can often attract volunteers.

Obtaining institutional sponsorship of permanent stations can provide long-term commitment over many years. A monitoring program with such a commitment will continue despite turnover in personnel and can provide some stability in funding. Furthermore, by using local volunteers to collect data in such a program, a community outreach and education program can be established. Bird observatories and some university field stations in North and Latin America have been conducting programs similar to this for many years.

General Monitoring Procedures

Species To Be Covered

Although many species will be censused at a single station, fewer will be captured, and still fewer species will have their nests found. However, biologists at a single station should get a good sample of the population size of perhaps 30 species and

some indication of demographics on about 10 species. In a region with perhaps six stations, more species will be monitored. Over a wide geographic area, these data can be combined to produce patterns of the population sizes and demographics of many species.

Monitoring Period

Breeding Season

The period of study for the breeding season differs, depending upon the individual species, latitude, rainfall pattern, temperature, elevation, or even year. Therefore, each region should establish its own monitoring period on the basis of the local breeding season and the criteria described below.

Demographic monitoring, by mist nets or nest searches, should span the entire breeding season. Censusing, by contrast, is usually conducted only during approximately the first half of the breeding season, when birds are most active, paired, on territories, and vocal.

For all monitoring, we recommend the use of the sampling interval time period of 10 days, as used in the British CES project, for several reasons. This interval allows at least one weekend for making up for inclement weather, and divides the month into three approximately equal portions. It also provides a basis for direct comparison between stations.

Operation of the demographic monitoring station by mist netting or nest searching should begin no sooner than the 10-day interval when virtually all of the breeding birds have established territories, but before many have begun laying eggs. For most lower elevation areas in temperate North America this will be about May 1 or May 11. The date, however, should be adjusted to conform with the local situation. For example, in the more northern parts of the United States, the first period can begin May 21 or May 31. In Alaska or northern Canada, or at high altitudes, the first period may begin as late as June 10. In the southwestern United States or coastal southern California, where 90 percent of the species have begun nesting activities by mid to late March, the starting date could be April 1 or 10. In Mexico, it could be even earlier, and in much of Latin America it could be much earlier. It is considered important by some investigators to avoid netting before migrant individuals of breeding species have finished moving through. Early netting might result in later net avoidance during the breeding season, thus biasing a few of the demographic estimates. However, some adjustment for this factor can be made during analysis and many stations do this with good results.

A good measure of the establishment of territories is increased singing. Also, captured males will show a pronounced cloacal protuberance. Individuals carrying nesting material is another excellent indication that the breeding season is under way. The best measure of the start of the breeding season is the beginning of egg laying. Females normally develop a brood patch when the first egg is laid.

The termination of the demographic monitoring should be no earlier than when the local population begins to be augmented by fall migrants, or by an increase of dispersing individuals

known to have not bred in the local area. In most of temperate North America, this will usually be about the second or third 10-day interval of August.

For uniformity, May 1 of each year should be considered the first 10-day period. If a season in a region begins earlier, it should be backdated from May 1. In fact, the season of monitoring for most areas in temperate North America will begin May 1 and continue for a maximum of twelve 10-day intervals until August 28. If a station begins before May 1, it should continue until late August, unless a pilot project's data indicate that all breeding individuals and their young have left earlier.

For most of temperate North America, we recommend, therefore, the following periods: May 1-10, May 11-20, May 21-30, May 31-June 9, June 10-19, June 20-29, June 30-July 9, July 10-19, July 20-29, July 30-August 8, August 9-18, and August 19-28.

Censuses conducted on demographic study stations, such as mist netting stations, need be done only in the first five 10-day intervals when birds are on territory and actively singing. In temperate North America, this will be usually from May 1 through June 19. In northern latitudes or higher elevations, the period could be as late as June 1 to July 9. Point censuses, and also area searches, should be done once on each plot in each of the five 10-day intervals, and preferably about the midpoint of the interval.

Migration Operation

Operating a monitoring station in the spring or fall is an option in many areas. Spring and fall migration data from mist nets and censuses are confounded by many factors, particularly local weather, and the questions migration data can answer are different from those netting during the breeding season can answer. The data can provide interesting and insightful information about the timing, composition, and extent of migration (e.g., Ralph 1978, 1981a; Robbins and others 1959). The fall migration in particular gives a measure, derived from many source areas, of the overall productivity of a species. As mentioned previously, if a mist net program is operated in the spring in the same area as a breeding mist net array, a few demographic measures may be altered somewhat.

Nonbreeding Season

The value of winter studies is quite high. Winter is a time when populations are resident and relatively stable, thus providing excellent data on survivorship and mortality. It is very likely that habitat associations, for example, are much more defined in the winter than in the summer (e.g., Huff and others 1991, Manuwal and Huff 1987). The methods outlined here have full applicability in the non-breeding seasons, both in North America and Latin America. In the tropics, mist netting throughout the year at the same site would clarify many questions about molt, skull, and plumage patterns.

Maintenance of a Study Plot

Plots should be permanently marked with stakes, markers, or flagging that will survive over at least one winter. Rebar

(steel reinforcing bar), rock cairns, or tags driven into landmarks all work well. Tags are available from biological supply companies. In general, markers should be laid out along a compass direction, be placed at regular intervals, and be visible at any point between the markers. Each marker should correspond to a numbered grid point on a map. In colder areas, be aware that in years with heavy snowfall, plot markers can still be buried in the spring. Net and census points should also be permanently marked. Be sure to record in your journal net height and angle of placement (use stakes or give a compass direction).

Customized maps of the study area should be traced from a large scale map or from aerial photographs. Landmarks, grid points, and net and census points should also be sketched. Blank maps can be used for spot mapping censuses, vegetation mapping, and other figures.

Each monitoring station ideally should be operated indefinitely. Although objectives will vary, we suggest that at a minimum, capture arrays of nets and nest searches should be operated for four consecutive years, and census plots for three years.

Journal Keeping

Journal keeping is an essential tool of all field biologists. The importance of regular, accurate journal keeping cannot be overemphasized. It is not uncommon for journals to be subpoenaed in court. The Grinnell method (Herman 1989) is the most widely used by vertebrate ecologists and is extremely detailed. Here we provide guidelines for basic information that may be useful for monitoring landbird populations.

As a minimum we recommend recording the following on a daily basis:

- Netting information: (a) the number and location of each net operated; (b) the exact hours of each net operated; and (c) the total capture and recapture rate for each species at each monitoring array.
- Censuses and nest searches: the number, location, and timing of each census conducted and the hours of nest searches.
- Personnel information: list the activities of each biologist conducting field work, including areas censused, net locations operated, and other activities.
- List of all birds seen or heard: basically presence/absence data; provide any interesting notes on potential breeding or other behavior of note.
- Weather data: in addition to the basic weather data that should be taken (see below), a general one- or two-sentence statement on the day's weather is also helpful.
- Plant phenology: a list of what is blooming or in seed may help interpret changes in bird distribution.
- Interesting observations of mammals, herptiles, insects, and other natural history observations should also be included.

Training and Numbers of Personnel

Training is extremely important because the level of training and experience will greatly affect the reliability of the data collected. Training *must* be something that is continuous throughout the field season. It is necessary to transmit expectations early and often in data taking or responsibilities

for certain tasks.

The length of time to train personnel will vary greatly depending upon the quality and interest of recruits. For many census procedures, the mechanical aspects can be taught in two or three 2-hour sessions. However, for a person who has minimal skill in identification of plant or animal taxa, it can take a week or longer, depending upon the taxon, and the person's previous experience. The suggestions for censusers in Kepler and Scott (1981) are especially relevant. For a completely untrained person to learn to remove birds from mist nets takes at least 2-3 weeks of intensive training. This training should include at least 3-4 hours of removing birds from nets each day. Training for nest searching requires a similar time commitment.

Probably the most important aspect of training is the testing of the observer. This should be done regularly in the field by the most experienced personnel available to make sure that data are accurate, and of high quality. This can also be accomplished by regularly checking data sheets *as they come in from the field*. Any delay prevents feedback to the field crews.

The number of persons required to operate a monitoring station depends upon several factors. If nets are the method of choice, we suggest a minimum of two people, one of whom is well-trained in removing birds from mist nets, and one of whom is well-trained in identification of birds by sight, song, and call. The less skilled person can be of great assistance, and with proper training can contribute much to the monitoring. Censuses and netting are both morning activities, and under some circumstances they can be conducted concurrently if the censuser's position is known to the netter and he or she can be called upon for help if capture rate is moderately high. The health of the birds is of paramount importance, and all efforts to prevent injury must be taken. Nest searches can be conducted throughout the day, although it is most productive in the morning.

When conducting censuses, it is best to rotate observers, if at all possible, so that no observer censuses any given point more than the others.

Syllabi for training in the methods contained in this handbook have been prepared. These are for the use of persons experienced in the methods, so that they can efficiently pass on the methods to others. The syllabi are available from the senior author.

Data To Be Taken

Below we outline several types of data to be taken and provide sample forms for each. We have also prepared data entry programs using IBM compatible computers for these forms. Clean forms for reproduction and these programs can be obtained by contacting the senior author. These programs can use either standard entry systems such as dBASE or simple BASIC compilers.

For each point count census point, mist net location, and nest site, we suggest that the "Location and Vegetation Form" be filled out. It is described in detail in the Habitat Assessment section and contains important location information for data base files. At the minimum, for all monitoring programs, this

location data should be taken.

All the data forms have constant the following information, to help relate between data bases:

- State or province—The 2-column code for each.
- Region—An 8-column code, designated by the investigator. Often, the name of the USGS quad, a prominent landmark, or a nearby town will provide the best code name.
- Station/Location—This is a 6-column unique identifier designated by the investigator to separate, within each region, the location of the various data points. We recommend that the station be a 4-letter code. The net location, point count census point, or nest number will be a 2-number code.

Constant-Effort Mist Nets and Banding

Scope

The capture of birds in nets can give the biologist an insight into the health and demographics of the population of the birds being studied. For instance, the proportion of young birds captured in mist nets has been shown to be a good measure of the productivity of birds during the previous few weeks (Baillie and others 1986). The sex ratio of a population can be used to assess the species' differential survivorship the previous year and the ability of the population to increase. The mist net capture rate gives a measure of the number surviving during the previous winter. The marking of individuals gives the biologist insight into degree of dispersal between different habitats and survivorship between years (e.g., Peach and others 1991). Finally, weight, when compared to measures of body size such as wing length, can give a measure of individual fitness.

Mist nets have been used for a long period to capture birds. Recently they have been used to monitor populations. Although some have used them to assay population size (e.g., Karr 1981), for most species, censuses are the best method for this, as netting provides relatively fewer data points per unit time. Netting, however, is the method of choice to provide information about the various attributes of the population, for instance, age and sex ratios and physiological condition.

Over the years numerous aids have been developed for field workers, with an emphasis on capture techniques and data taking (e.g., Baldwin 1931, Bub 1991, Lincoln 1947, Lincoln and Baldwin 1929, Lockley and Russell 1953, McClure 1984). O.L. Austin introduced mist nets to North American biologists in 1947 (Keyes and Grue 1982), and he, Low (1957), and Bleitz (1957) were all pioneers in their use.

The procedure detailed below is essentially identical to the "Constant Effort Sites" (CES) Scheme of the British Trust for Ornithology (Baillie and others 1986). The standards of operation are also identical to those of the Monitoring Avian Productivity and Survivorship Program (MAPS) (DeSante 1992a). We suggest the use of a series of mist net arrays, as in

the British program, to be operated on 10 to 12 intervals during the breeding season, coupled with point count censuses. These data will provide an index of **adult population** size and changes at each station. The proportion of young birds in the catch will provide a measure of post-fledgling **productivity**. And finally, between-year recaptures can provide a sensitive measure of adult **survivorship** and **recruitment**. With these data, managers will have information on the possible causes of landbird declines or their remedies.

The monitoring of populations with mist nets is no more complicated than other techniques, but placement and operation should be done rather uniformly; thus we present below more details about this method than about others.

Net Placement

Operating a capture array of mist nets is a complex undertaking, but very rewarding. Much useful information can be gained from reading Bleitz (1970), Keyes and Grue (1982), or McClure (1984). We outline below some guidelines for operation of nets and their placement (*fig. 1*).

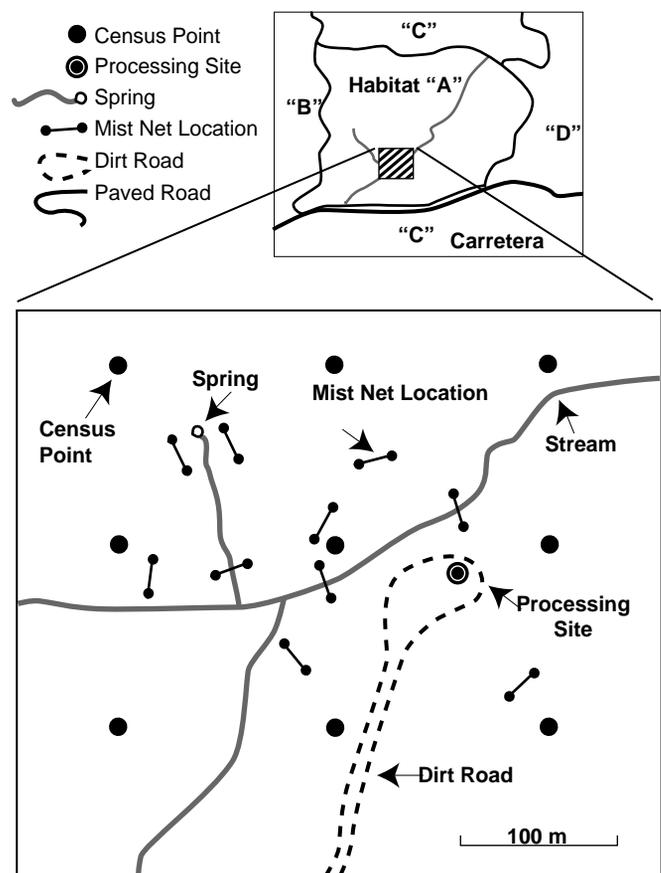


Figure 1—An idealized capture station of about 40 acres (16 ha) set in an area of more than 250 acres of habitat "A." Nine census points are set at uniform spacing of about 150 m to estimate population levels. Ten net locations are placed in sites where high capture rates are likely, along a stream, near a spring, and other areas where vegetation is dense, in order to monitor population and demographic parameters.

A field crew of two people can usually set up and monitor an array of 8-12 mist nets quite easily. We suggest 10 as an appropriate number. If the biologists are especially skilled, or the bird density quite low, a few more nets may be operated. However, if too many nets are established in an array early in the season when capture rates are relatively low, the likely influx of post-breeding birds later in the season, in July and August, may severely tax the crew's resources.

Distance between nets is a very important consideration because of the effect of net dispersion on the precision of data from capture-recapture analyses. In order to increase the probability of capturing a bird banded the previous year, one should place the nets as far apart as possible, thus intersecting the most territories. However, it is absolutely critical that nets also be close enough to each other that a person can visit all net locations in a maximum of 10-15 minutes walking, preferably less, if no birds are caught. On flat, level terrain, this array would be about 0.5-0.6 miles (800-1000 m) in length. If 10 nets are placed in a circle or rectangle, this would allow about an average of 75-100 m between nets, and would cover approximately 5-10 ha. In steep or rough terrain, nets should be closer, and the area covered less. In all cases, nets should be spread out as uniformly as possible.

Nets should be placed at the same location and orientation for all 10-day intervals in each year and preferably between years. In the event the vegetation changes between years at a given location, the nets will measure this change, rather than changes in population of the birds. For this reason, care should be exercised in placing nets in locations where the vegetation will remain relatively stable through the life of the study. For example, successional changes, for instance, from a clear-cut to pole-sized trees over 10 years, would be unacceptable for a site. However, when the changes over a decade would be much less marked, the site would be permitted. If, due to unforeseen circumstances, the vegetation is changed markedly at one or two net locations of an array, the nets can be moved to locations with similar vegetation to allow better between-year comparisons. This should be a last resort, and only done after consultation with knowledgeable participants in the program.

Although few problems arise from placement of census points in areas of relatively high human impact, capture arrays must be located with more care. In some areas nets can be left in place (but closed) between capture days if the chance of encounter by visitors is extremely low. In most areas, it is advisable to rig the nets to allow easy removal at the close of a day's effort.

Baiting, artificial water, or taped vocalizations should not be used at any time to attract birds to the nets.

Net Locations

The best locations for the nets are usually on an edge of a habitat. Examples of edges include the boundary between a forest and a field, the boundary between two forests types (e.g., an upland pine and a pine/alder association in a valley), brushy portions of wooded areas, at the edge of a pond, and along a riparian corridor. Especially productive are areas where a

habitat type has a narrow section, for instance a hedgerow, that narrows at a gate or where a natural gap funnels the vegetation along a watercourse. Birds, especially shrub species, will naturally be funneled into a net at that spot. Observations of bird movements will often suggest appropriate net locations.

The highest rate of capture is usually found in wetter areas within a given habitat type. If at all possible, natural running or pooled water should be available throughout the summer in the capture array, as it will draw birds from the immediate area. An array aside a major watercourse with a well-developed and wide riparian corridor will tend to monitor this habitat, but will also monitor the surrounding habitats. In many regions of the country, the riparian zone is the only place where sufficient numbers of birds can be captured.

The major goal of a mist net array is to capture birds, not to monitor the birds of a specific habitat. Census methods or nest search are more appropriate for this. An array set in a uniform habitat, such as an old-growth stand of coniferous trees, will usually catch relatively few birds, even if located along a watercourse in that habitat. There are possible exceptions to this, such as eastern deciduous forests (T. Sherry, pers. comm.).

A reasonable goal for capture rate is approximately two birds per net per day. This would result in the capture of approximately 200 or more birds during the season. Typically, the capture rate in the breeding season will be high during the first 10-day period, decline thereafter, and usually increase again during post-breeding dispersal, in July and August in temperate North America.

Erecting and Operating Nets

In order to operate nets properly, the trammels (the horizontal shelf strings that support the net) should be taut horizontally. Except with 6-m nets, this usually involves the use of tie cords bracing the pole upright. These can be arranged at 120° angles to the net, with one end secured to the pole and the other to nearby rocks, bushes, or stakes. When operated, the netting material should not be stretched apart to its full extent, but should allow some slack between the trammel lines; otherwise birds will bounce off the tight net.

If the habitat is higher than the typical net height of 2.5 or 3 meters above the ground, a stacked net can be considered. Although some birds may be missed, it is better to use single nets, rather than to stack them one above another, unless a particular location has a great abundance of birds. Even canopy-dwelling species invariably spend at least some time at lower levels, whether to nest, take water, or forage. The additional time spent putting up a stacked net can usually be better employed by establishing another net in the array. McClure (1984) describes several plans to stack nets; the simplest is to use a strong metal pole, perhaps 8-10 feet long, such as metal electrical conduit pipe. Connect two lengths together with a sleeve (a 10-cm section of conduit slipped over a 20-cm long pipe and glued in place), and tether the pole with a rope. The net can be easily lowered and raised using this method.

For single nets, we suggest the following simple method of putting them in place, adapted from Dennis P. Vroman (pers.

comm.). Clear all vegetation from a net lane 2 m wide to prevent vegetation from becoming entangled in the net. Drive one piece of 1-m by 3/8-inch piece of steel reinforcing bar (rebar) into the ground with a small hand sledge hammer at one end of the net lane on a slight backward angle to the net. Insert a 5-foot section of sawn 10-foot, 0.5-inch or larger, galvanized steel conduit over the rebar. Repeat at the other end of the net lane.

A single net can be kept on a round metal spool (used to hold bulk electrical wire), with a 6.5-inch diameter rim and 3.5- to 4-inch long axle or shaft. Place the loops of the net over the top of the upright conduit; then unroll the net towards the second pole, being careful to keep the loops in order. A second 5-foot section can be placed on each pole in a conduit connector or a sleeve atop the first conduit to allow the net to be fully opened.

When a net is to be closed, it should be spun to keep it from unraveling. To do this most effectively (preferably with two people from both ends simultaneously), leave the topmost trammel separated from the others on the pole, and spin the net on the lower trammels into a tight roll. Then quickly bring the top trammel down atop the roll to keep it from unraveling. This will allow the net to be opened much more quickly than if the net had been spun around all the trammel lines.

To roll up the net, keep all the support cords together and centered on the axle as the net is rolled up to allow easy unrolling. Use a rubber band to hold the loops in place at the end of the rolled net. Poles and rebar can be hidden under vegetation near the net location to save set-up time.

Nets are also commonly put in cloth bags. To take down the net, it is rolled up on small folds and put into the bag, as the biologist moves from one end towards the other.

Net Specifications and Maintenance

A variety of net types can be purchased, but we strongly suggest that the same type be used throughout the life of the study. The net color should be black in forest or brush habitats. The net mesh should be either 30 mm or 36 mm in stretched diameter. The larger net catches more thrush-sized birds, but smaller birds can become more severely tangled. Nets 12 m in length are preferred, although in certain sites a half-net of 6 m long can prove useful. (If a 6-m net is used, its use for one hour equals a half net-hour.) In addition, some suppliers offer “extra-full” nets that provide more capture area. They also offer “tethered” nets that are resistant to bunching by the wind because they are fastened to the trammels. If a nontethered net is obtained, it can easily be tethered by placing drops of a liquid cement along the top trammel.

A net should be replaced when it fades badly or becomes degraded by the sun so that it breaks very readily. A net can be tested by putting two fingers into the net and gently parting them. Nets sustain damage from branches, misuse, large birds, and from the rare occasions when a badly tangled bird must be cut out of the netting. The life can be prolonged by repairs with a strong black nylon twine or thread. Holes should be repaired promptly, or the net replaced, as they affect the efficiency of capture, and make it difficult to figure out how to extract a bird.

Operation of Nets

Net Hours

To minimize variability and make comparisons from different locations, standardization of the number of nets and the number of hours nets are operated has long been advocated. It is extremely important that nets be operated on the same schedule between years, so as to allow direct comparisons. A standard “net” is considered to be 12 m long and 2.5 m high. For calculating effort, one standard mist net operated for one hour is a “net-hour.” Two nets stacked atop one another would be considered two nets, although one net location. If operated for one hour, they would total two net-hours.

Although there are methods of compensating for varying number of nets operated in different time periods (Ralph 1976), these are best implemented during migratory periods when there is a high turnover of individuals between days. During the breeding season, when populations are more stable, it is best to operate nets on as regular a schedule as possible. This includes the number of nets, the number of hours, the time of day, the number of days, and the number of days between operations.

We recommend that biologists use the “Record of Net-Hours” form (*fig. 2*). The data are recorded on a daily basis, as follows:

- State or province—The 2-column code for each.
- Region—An 8-column code, designated by the investigator. Often, the name of the USGS quad, a prominent landmark, or a nearby town will provide the best code name.
- Station—A 4-letter code for the station that contains the mist net array.
- Year.
- Operator(s).
- Net location—Place a 2-column number identifying each net location. Most arrays will have no more than 10 locations, and thus would be numbered 1-10.
- Number of nets—This number is usually one, but if a stacked net is used, or if a net is within 10 m of another, they are considered the same location, and the number of nets is entered here.
- Month and day—One line for each day of operation, but if a net location is operated for more or less time than the other nets, it should get a line to itself.
- Open and close times—Using the 24-hour clock, record the time of starting to open and the time of starting to close the nets.
- Hours open—Calculate the number of hours open to the nearest tenth of an hour (e.g., 4 hours, 20 minutes is 4.3 hours).
- Number of net-hours—Multiply the number of nets by the hours open, and enter here.
- Total net-hours—For each day, total the number of net-hours.

Time of Day and Number of Checks

Nets should be opened within 15 minutes of local sunrise and operated for a minimum of 4, and preferably 6, hours per

from ideas of Shreve (1965), and were later modified and augmented by Ralph (1967, 1988). Practice and careful review of these techniques are essential. Most importantly, be careful. The life and health of the birds are of primary concern.

As you work on a badly tangled bird, it is important to remember that the bird can usually be backed out easily, unharmed, in the direction from which it entered the net. You *must first* take the time necessary to figure out exactly how the bird went into the net. Observe carefully from which side the bird entered the net, and between which trammels it went, in order to find the opening of the pocket the bird made. Do not just grab the bird, tempting as it may be. Start on the side of the net which the bird entered; part the trammels and netting loosely, and look into the pocket caused by the weight of the bird. Because the tail is the last to enter, look at its position to get a clue about how the bird entered the net. Back the bird out the way it went in, step by step. A light touch is the most important prerequisite for all methods. After determining where the bird entered, several standard procedures are used for removing birds, but different species and different problems will require some improvisation.

We describe the various methods used to remove birds from nets below. No one method will suffice for all birds, because each bird flies into a net differently. Combinations of methods will often be necessary. In all methods it is often desirable to know where the strands of net are amongst the bird's feathers. This knowledge can help you decide where to move your fingers next. By far the best method is to pull gently at the exposed netting and see where feathers move on the bird. This will tell you where the net strands are binding, leading to quicker removal.

Body Grasp Method

This method has recently been used by some stations, and it has been found to surpass other methods in ease of learning, reduced injury to the birds, and speed of removal. About 9 of 10 birds can be removed with this method.

1. Find out from which side of the net the bird entered. Find the opening of the pocket caused by the weight of the bird.

2. You have three choices at this point. (1) If the bird's body is accessible, without any netting in the way, and the net free of the back and head, just put the bird into the "bänder's grip," with your palm against its back, your index and middle fingers on either side of the neck, the left wing held with your thumb, and the other fingers curled around the body and the right wing. Then proceed to step #7 below. (2) If the net is tangled around the head and wing, just slip your fingers over the body and under the wings. This usually involves your thumb around the breast and your fingers over the bird's back, and down over its sides and under the wings and carefully around the curve of the body. (3) If the body is too tangled to be available for a body grasp, then one of the other methods below must be used.

3. With the body now firmly secured, back the body out of the net to expose at least the bend of one of the wings. Then, remove the net from the wings. Flick net threads from the bend of the wings, working from the underside. Generally your

thumb should be placed under the thread(s) on the underside of the wing and your forefinger placed on the outer bend of the wing as a fulcrum to flick the thread over. Often at this stage it is helpful to pull gently on the exposed portions of the still tangled threads in order to free them or to see where they are caught.

4. When one wing is free, slip your fingers over the now-exposed wing, securing it against the bird's body. Then, pull remaining loops from around the neck, working from the back of the head forward, in the manner of removing a T-shirt.

5. Remove the net from the other wing, as above.

6. The bird should now have gradually been put into the "bänder's grip."

7. Pull the bird up and away from the net, and it will usually free its own feet in an effort to fly. If the toes are caught, untangle them by pulling strands gently. You will notice that if the heel joint is straightened out, the bird's toes have a tendency to relax, so that the netting can be more easily removed. If the bird is clutching the net firmly, extract the feet by (1) first freeing the opposable toe (the "thumb") by sliding the threads over it and lifting it away from the other toes; (2) with the fingers, straightening the other three toes out; and (3) sliding the netting over the toes with repeated strokes.

This method, when administered with a nimble hand and a light touch, is very easy on the bird because the only firm contact is on the sides of the neck. It is also a time saver, because feet untangle themselves. The method works best with a recently caught bird that has had little time to entangle itself, but is applicable to most birds.

Feet First Method

The original, and perhaps still the most widely used method, is somewhat slower but is usually the way that beginners are taught. Its main disadvantage is that it requires holding the legs, sometimes causing injury or breakage. It involves the following steps:

1. As before, find the side of the net the bird entered.

2. If you (the bänder) are right-handed, grasp both tibiae (the tibia is the feathered part of the leg above the bare tarsus) from the rear of the bird using your left hand so that your fingers point towards the bird's head. The bird should be upside down in the net when you have your grip.

3. Put your index finger between the tibiae, and press your thumb against the bird's right tibia and your middle finger against the left tibia. This leaves your right hand free to remove net strands from the entangled legs and feet.

4. Most importantly, make certain that all threads are pulled down and off tibiae and thighs below the heel joint, the prominent joint between the tibia and tarsus. These threads are sometimes high up on the thigh at the flank.

5. Untangle the toes by the method described in the body grasp method above.

6. Pull the bird up and away from the net, still holding the bird upside down by the feathered tibiae, above the bare tarsus. Flick net threads from the bend of the wings, working from the underside. Generally the thumb should be placed

under the thread(s) on the underside of the wing and the forefinger placed on the outer bend of the wing as a fulcrum to flick the thread over. Often at this stage it is helpful to pull gently on the exposed portions of the still tangled threads in order to free them or to see where they are caught.

7. When both wings are free, pull remaining loops from around the neck, working from the back of the head forward. Be sure to secure the bill by placing the thumb against the tip while pulling the net over the head in order to protect the delicate neck.

Rollover Method

A third method requires a little practice but is applicable to almost every situation:

1. As always, determine the side of the net entered.
2. Grasp the left (or right) leg above the tarsus and release the foot.
3. Release the left (or right) wing; release the head, then the other wing. Grasp the bird normally with the “bander’s grip.” Finally, free the right foot.

This method requires an experienced “feel”—the bird is rolled over and released in order of foot, wing, head, wing, and foot. This method is especially recommended when one of the legs is particularly badly tangled. Work so as to free that leg last.

Processing

Once the birds are removed from the nets, put each individual in a separate, small cloth bag, and transport to the processing site. It is probably best to have a central processing site, rather than to process birds at each net as they are captured, because: (1) a biologist rapidly circulating around the nets can better monitor the captures, in case of an influx of birds that might necessitate shutting down some nets temporarily; and (2) it lessens the disturbance in the vicinity of the nets. Further, if processing becomes delayed, it is always preferred to have the birds out of the nets and stored in bags. Bags should be made from opaque cloth, and sewn so that the seams (and possible loose threads that can catch toes) are outside. Hang bags from hooks or branches to prevent them from being stepped on, and out of direct sunlight. They should be washed often.

Birds should be released at the processing site except for females (indicated by a brood patch) and dependent juveniles (indicated by a frizzy appearance and a growing tail). They should be released at the point of capture.

Recaptures provide the most important data in a constant-effort mist netting program. We suggest, if some birds have to be released without processing, that recaptures have a much higher priority for processing than unbanded birds. If birds have to be released without complete processing, we suggest that the following be regarded as the priorities, in order: (1) band number (if a recapture); (2) species; (3) age (usually involves skulling, or diagnostic plumage characters); (4) new band number (if previously unbanded); (5) sex; and (6) other measurements or data. Please notice that the species and age are the two variables which are considered absolutely critical. If these are not accurately and completely recorded, the time and money spent in the monitoring has minimal value to the objectives.

Special Problems Tongue Caught in Net

The mouth structure of birds, especially thrushes, thrashers, and woodpeckers, allows net threads to catch behind the tongue. While the bird’s head is held between your index and middle finger, your third and fourth fingers and thumb can hold the net near the side of the mouth and relieve pressure on the tongue by pulling the net backward along the side of the head. A pencil, crochet hook, or a sharp twig can be manipulated with your free hand to lift the thread from behind the cleft of the tongue. Until one becomes deft at releasing the tongue in this manner, a small pair of scissors is invaluable. Usually, clipping a single strand of mesh will do the trick.

Badly Caught Birds

As a last recourse, to remove a strand from a tongue, or to rapidly extract a bird in distress it is sometimes necessary to cut a few threads with a scissors, a stitch ripper (sewing tool that cuts threads along seams), or a sharp knife. The most rapid method is to find an area with few (or only one if possible) layers of netting. Clip as few strands as possible, just enough to bring the bird through the net. Then free the bird in the normal manner. It should be very rare to need to cut more than three strands. Before releasing such a bird, look carefully to ensure that no net remains on the bird.

Data Collection

One of the first steps a biologist must take to make the capture work more meaningful is to properly record the data presented each time that a bird is caught. Much of the following was extracted from Pyle and others (1987) and Ralph (1967, 1988). The identification guide by Pyle and others (1987) should be included in all netting kits.

At each net location, we suggest that the Location and Vegetation Form (*fig. 15*, discussed in detail below) be filled out. The Location information on the first three lines of the form is vital to data base management.

For each individual captured or recaptured, we recommend that the following data be recorded. In addition to date, time, and location, it is imperative that the species be accurately identified. It is also vital that the age and the sex of the birds be determined. We highly recommend that determining the amount of skull pneumatization be a top priority, as essentially all analyses depend upon accurate ageing. Age and sex determinations are generally complicated by the highly variable nature of size, plumage, and molt patterns in each species. We recognize that a certain percentage of individuals cannot be reliably aged, sexed, or identified with any one or even all of the published criteria. Remember that with age and sex it is better to be cautious than inaccurate. If the bander is unsure of an age/sex class, we recommend that the record be conservative, by recording the age or sex as unknown, and separately noting which class seems likely. By using the skull pneumatization and the literature carefully, determinations can be made with above 99 percent confidence. Information on how the bander aged and sexed the bird can be used to screen improperly

processed birds. We also highly recommend that the breeding condition of adults, the extent of juvenal plumage and molt, and the wing chord also be recorded.

For the various attributes below we suggest a letter or numeric code. We strongly suggest that whatever codes are used at a station should be used consistently between years, or certainly within a year. Alpha (letter) codes have the advantage of being mnemonic in nature, increasing accuracy. Numeric codes have the advantage of retaining the order of progression from small, none, or few, to large or many.

Plumage Attributes

The first plumage (subsequent to the natal down) acquired by the nestling and retained by the juvenile fledgling is called the juvenal plumage (note the difference in spellings). The body feathers of this plumage are replaced during the first prebasic molt, which almost always occurs within three months of fledging and usually takes place on the breeding grounds. Juveniles are readily aged by many criteria and are generally sexually indistinguishable by plumage. The juvenal plumage is usually more streaked or spotted than that of the adult, and juveniles will often have wing bars where the adult has none. Juvenal feathers also have a more loosely structured contour (*fig. 3*), most evident in the feathers of the nape, back, and undertail coverts. In addition, many nestling characteristics are evident in young juveniles which can also be helpful in separating them from adults. The gape of nestlings and early juveniles is swollen and more brightly colored than that in adults, and the inside of the mouth is also brighter in tone, or paler in hue, or both, in juveniles than in adults. Several characters useful for separating first-year birds from adults can be applied to juveniles. In particular, summer adults in alternate (breeding) plumage should show very worn flight feathers while those of juveniles should be relatively much fresher. And, of course, the pneumatization process is just beginning in juveniles, whereas it should be complete (or nearly so) in adults. Finally, eye color is useful for separating juveniles of many species, being generally grayer and paler in juveniles and redder and darker in adults. In summary, biologists

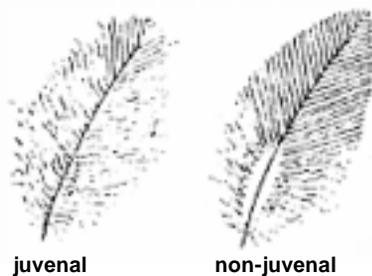


Figure 3—The contrast between juvenal and nonjuvenal body feathers. The differences are most apparent with undertail coverts and feathers of the nape and back. Taken from Pyle and others (1987).

should have no trouble with the separation of juveniles from adults during the summer months, when all criteria are used.

In most passerine species, however, birds in juvenal plumage cannot be reliably sexed by in-hand criteria alone. Only in a few species, in which differences occur in the color pattern of the flight feathers, can juveniles be sexed by plumage.

As juvenile birds go through their first molt, normally in the fall, they assume a plumage that is often similar to that of adults, especially to that of the adult female in sexually dimorphic (having a male and female plumage) species. Inspecting the skull is now recognized as being the most reliable technique for ageing these birds.

Age Classes

The various age codes suggested below follow, for the most part, the system used by the U.S. Fish and Wildlife Bird Banding Laboratory and the Canadian Wildlife Service Bird Banding Office, as listed in the North American Bird Banding Manual (CWS and USFWS 1991). The system is based primarily on the calendar year. Following are the age designation, the alpha code used by the Services, a suggested one-letter abbreviation (or optional numeric code) for purposes of this handbook (where different from the Services' code), and a definition of the age class.

Unknown (U or 0). Age cannot be determined with absolute confidence.

Local (L or 4). A young bird incapable of sustained flight.

Hatching Year (HY) (H or 2). A bird in its juvenal or first basic plumage during its first calendar year (i.e., from its fledging until December 31 of the year that it fledged).

Second Year (SY) (S or 5). A bird in its second calendar year (i.e., January 1 of the year following fledging through December 31 of the same year).

After Hatching Year (AHY) (A or 1). A bird in *at least* its second calendar year. This code is more significant after the breeding season, when it implies an adult. Before the breeding season, it essentially means “unknown” (either SY or ASY).

After Second Year (ASY or 6) (O [older]). An adult in at least its third calendar year (i.e., a bird in at least the year following its first breeding season and second prebasic molt). A bird known to be in its third year, or older, should be indicated by “O,” and a note should be made in the Notes columns.

Skull Pneumatization

Determining the amount of skull pneumatization, also known as ossification, is the best method of ageing most species of birds during the summer and fall months and, for some species, is proving useful through the early winter and even into spring. The importance of this method cannot be understated. If you take only one datum besides species, skull pneumatization is quite probably the next most important.

This technique came into common usage in the late 1960's. Biologists are strongly urged to become proficient at skulling and to skull most passerine species throughout the year. When a fledgling passerine leaves the nest, the section of the skull overlaying the brain (frontals and parietal) consists of a single

layer of bone. From fledging until the bird is four to 12 months old (depending mostly on the species), a second layer of bone develops underneath the first. The two layers are then separated slightly by spaces or air pockets and joined by small columns of bone. This process is called skull pneumatization.

The pattern generally follows one of the two progressions illustrated in *figure 4*, but may show other variations. Smaller species tend to show the peripheral pneumatization pattern, and larger species the median line pattern. Individuals of certain species may show either pattern, however, and the exact shapes of the unpneumatized areas or “windows” will also show substantial individual variation.

Any passerine found with a partially pneumatized skull (*fig. 4a-c*) can be reliably aged as a hatching year bird, with the exception perhaps of occasional summer or early fall birds with small windows (*fig. 4d*). In most North American passerine species, the skulls of the earliest hatching year birds become completely pneumatized in October and November, and the latest birds become complete between November and January, but for purposes of this monitoring effort during the breeding season, all hatching year birds will have incomplete pneumatization.

In some (perhaps many) species, small unpneumatized windows may normally be retained until spring and even early summer. This is most commonly seen in the longer distance migrants such as certain flycatchers, swallows, thrushes, and vireos. Birds with windows greater than one millimeter in diameter (*fig. 4d*) are probably reliably aged as Second-years through June of their second year. Birds with smaller windows are not necessarily in their hatching year, because some small proportion (probably less than 1 percent) of individuals will never show complete pneumatization. Birds with small windows in July and August are most likely to be advanced young of that year.

The Process of Determining the Extent of Skull Pneumatization

Unpneumatized areas of the passerine skull usually appear pinkish or dull reddish, whereas pneumatized areas appear grayish, whitish, or pinkish-white, with small white dots indicating the columns of bone. The color or contrast between these two color patterns, or both, can usually be seen through the skin of the head, especially after the head has been wetted to allow parting of the feathers, and to make the skin more transparent.

To skull a passerine, start by holding the bird in the position shown in *figure 5*. This hold facilitates skulling because the skin can more readily be moved around the skull, allowing a large area of the skull to be viewed through a small area of skin. In order to see the skull, the feathers need to be parted such that a small opening of bare skin is created. This can be accomplished without wetting the feathers, but is much more easily done if a small amount of water is applied to the head (do not apply detergent or alcohol solutions). During cold weather, the few drops of water used to make the skin more transparent should have no effect on the bird’s ability to

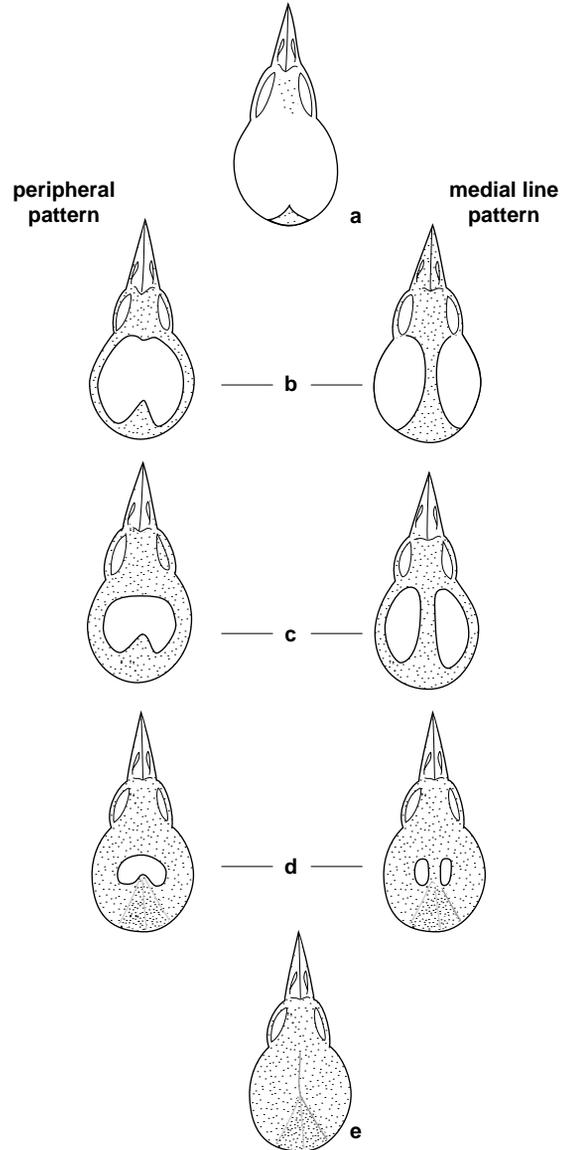


Figure 4—The two common patterns of skull pneumatization, from a very young bird (“a”), to a completely pneumatized bird (“e”). Taken from Pyle and others (1987).

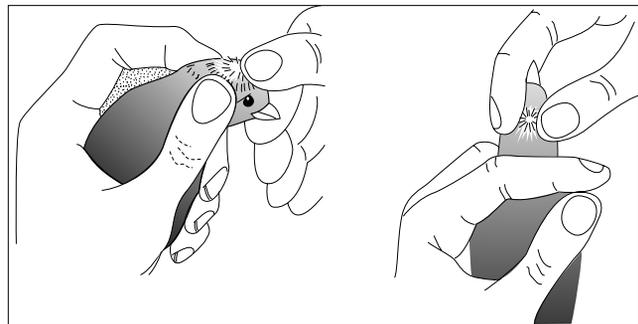


Figure 5—Two good holds for skulling a bird. It is best to look to the side of the mid-line of the skull. Taken from Pyle and others (1987).

maintain its temperature. If there is concern about this, simply put the bird out of the wind in a dry bag for a few minutes before releasing it.

It is usually easiest to part the feathers by running your thumb or finger forward over the crown, against the direction in which the feathers lie, and then moving the feathers off to each side. In the summer and early fall, when most young birds are just beginning the pneumatization process, it is good to start at the rear and the side of the skull and work up towards the crown. Later in the fall, the parting should be made higher up on the crown (in the areas just above and behind the eyes), where the last unpneumatized windows usually occur. With thicker-skinned birds, one can improve viewing by parting the feathers on the side of the head or neck (where the skin is more transparent) and moving the skin up to the crown. When the skulling process is finished, the feathers can be smoothed back into place.

It is usually best to hold the bird under a fairly strong lamp or in indirect sunshine to achieve the best lighting conditions for viewing. Very bright light often creates a glare off the skin. It is often helpful to move the head around, because different angles of light can make it easier to see through the skin. We strongly recommend using a magnifying device such as a visor that slips over your head.

Move the skin back and forth—the spots will be stationary, and thus visible. *If the tiny white dots are not visible, one is not properly viewing the skull*, or the bird is a very young juvenile with an entirely pinkish skull. “Seeing” a boundary between whitish and pink areas is not enough, because one might be seeing only bone structure unrelated to pneumatization. Start looking at the skull at a point at its base and slightly to one side. Continue looking forward until just halfway between the eye and the top of the crown. If at no point the dots disappear and are replaced by a clear pink area, the skull is fully pneumatized. Because the pneumatization usually proceeds centripetally and anteriorly, be sure to examine the area between the eyes of all birds with pneumatized skulls, to make sure that they are not “advanced” immatures.

Also look for entirely pinkish skulls in very young birds (*fig. 4a*) in June–July and for contrasts between the pneumatized and unpneumatized areas in older birds (most frequently after August). Small windows (*fig. 4d*) should be carefully looked for at all times.

Any of several factors may make it difficult or impossible to see the pneumatization of the skull. These include: the skin of the head being too thick; large amounts of fat in the skin during fall migration and winter; and dark, or otherwise opaque, skin (especially in molting or injured birds). It is especially difficult to see the pneumatization of the skull in molting birds, because of the thickening and the excessive flaking of the skin.

We suggest codes for categories of skull pneumatization. Because the critical differences are often in the 0–5 percent or 95–100 percent categories, care should be taken. It can make a great deal of difference in evaluating the age during the breeding season to know that a skull had only small windows

(e.g., 98 percent pneumatized) and could have been either a second-year bird or perhaps a young bird, as opposed to one that was perhaps 70 percent and almost assuredly a young bird.

The codes we suggest are:

N or 0 - No white spots showing, only a single, thin layer of bone covers the entire brain.

T or 1 - Trace of pneumatization at the very back of the skull, usually appearing as an opaque, grayish crescent or a very small triangular area. Between 1 and 5 percent of the skull is pneumatized.

L or 2 - Less than one-third pneumatized, but some is obvious. Generally the posterior part of the cranium has a triangular or circular area of small white dots, usually distinctly contrasting with the nonpneumatized area.

H or 3 - Half the skull pneumatized, between one-third and two-thirds complete. Typically, most of the rear half is complete, as well as part of the front, extending back to the eyes. The front is usually difficult to see, because of dense, short feathers.

G or 4 - Greater than two-thirds pneumatized, but at least a small area not complete, less than 95 percent complete.

A or 5 - Almost complete pneumatization, between 95 percent and 99 percent complete. These birds show a tiny dull, pinkish area or “windows.”

F or 6 - Fully complete pneumatization.

U - Unknown, skull examined, but extent of pneumatization not determinable.

Sex Determination

The best method for determining the sex of sexually monomorphic passerine birds during the breeding season is by the presence or absence of the cloacal protuberance in the male, and the brood patch, which primarily occurs in females. All North American landbirds develop at least one of these characteristics, at least partially, and most are reliably sexed by them during the late spring and summer months. Latin American birds are less well-known, but these guidelines should generally apply.

Cloacal Protuberance—In order to store sperm and to assist with copulation, external cloacal protuberances, or bulbs, are developed by male passerine birds during the breeding season. They usually begin to develop early in the spring and reach their peak size in 3–5 weeks. Depending on the species and the number of clutches attempted during the breeding season, cloacal protuberances will recede from mid to late summer.

Although the cloacal regions in females will sometimes swell slightly, or show a small protuberance, it rarely approaches the size of those in the males (the Wrentit appears to be an exception). If the swelling forms a gradual slope on the abdomen ending with the cloacal opening pointing towards the tail, then it is probably a female in breeding condition. When the female is most swollen in this area, she will usually also have a brood patch. A typical male protuberance essentially forms a right angle to the abdomen and is somewhat larger at the top than at the bottom.

To view the protuberance, blow the feathers apart in the region of the vent. The shape of the protuberance can be somewhat variable, and nonbreeding males may not always develop one. After a little experience with the shape of the cloacal region during the nesting season, biologists should have no problem separating breeding males from females.

We have categorized cloacal protuberances into four size categories (*fig. 6*): none (**N** or 0), small (**S** or 1), medium (**M** or 2), and large (**L** or 3). As one becomes familiar with the various extents of protuberances, one can make a judgment on the relative size.

Brood Patch—Incubation or brood patches are developed

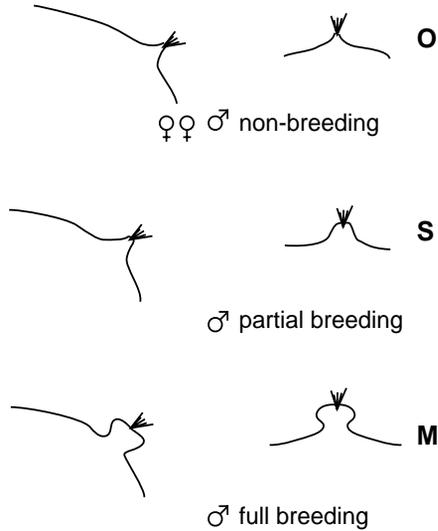
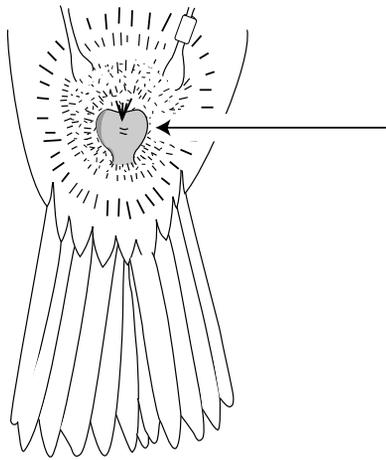


Figure 6—On the left, a cloacal protuberance at its peak in a male passerine. On the right a nonbreeding male (class = 0), a male beginning to be in breeding condition (class = S), and a male in full breeding condition (class = M). Class “L” would show a more prominent protuberance. Taken from Pyle and others (1987).

by incubating birds as a means of transferring as much body heat as possible to eggs or young in the nest. In most landbirds, females perform all or most of the incubating, and develop more substantial brood patches. The presence of a distinct brood patch can thus be used to reliably sex breeding females of almost all passerine species.

The development of the brood patch begins with the loss of the feathers of the abdomen, about 3-5 days before the first eggs are laid (Blake 1963). Shortly thereafter, the blood vessels of the region begin to increase in size, and the skin becomes thicker and filled with an opaque, whitish fluid. *Figure 7a* illustrates a full brood patch as viewed by blowing

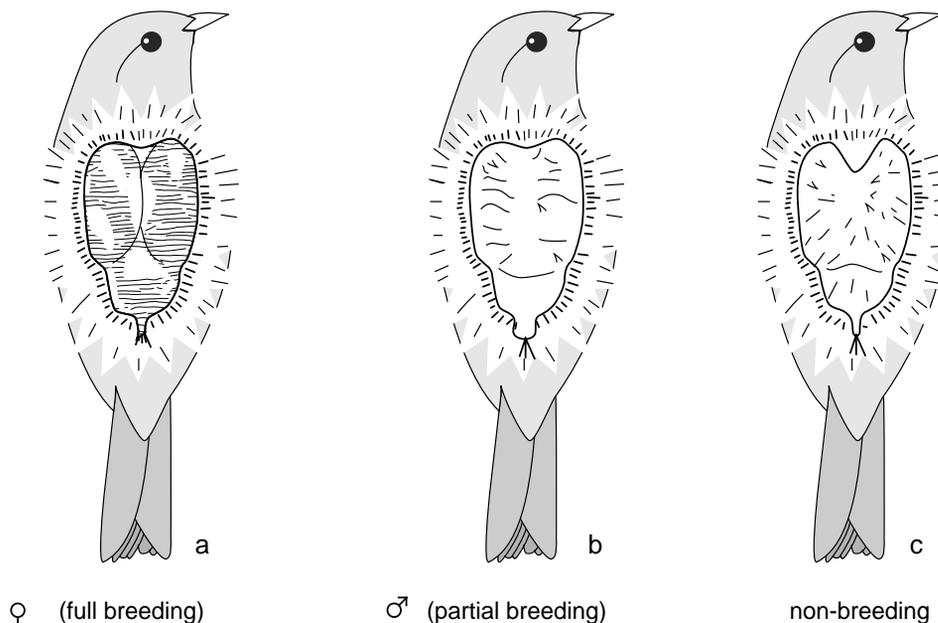


Figure 7—Brood patches in different stages of development. Taken from Pyle and others (1987).

the feathers of the breast aside. A few days after the fledglings leave the nest, the swelling and blood vascularization will begin to subside. If a second clutch of eggs is laid, the process (except for defeathering) will be repeated. A new set of feathers on the abdomen are usually not grown until the prebasic molt, after completion of breeding. Between the end of nesting and the onset of molt, the skin of the abdomen will often appear grayish and wrinkled. Many young, and especially juvenile, passerine birds have little or no down or feathers on the belly; therefore the belly of some young look much like that of an adult who is just beginning to develop a brood patch, but the area will be quite smooth and usually a pink or dark red.

In most North American passerine birds, the male does not develop a brood patch in the breeding season. Slightly fewer feathers may be present on the abdomen than are found in the winter, but the breast retains a feathered appearance. In a few groups, in North America, notably the mimids, vireos, *Myiarchis* flycatchers, and a few other species (see Pyle and others 1987), the male will assist with incubation and develop an incomplete brood patch. This will include partial or complete feather loss and slight to moderate vascularization and swelling, which rarely or never approaches the extent of development typically found in females of the same species. Only in the Wrenit and the woodpeckers does the male develop a full brood patch.

We suggest recording brood patch in the order of its development as follows:

N or 0 - No brood patch present—Breast more or less feathered.

Nonfeathered areas of the breast and abdomen smooth without evident vascularization. In some species such as hummingbirds, and in most young birds, the breast is normally not feathered.

S or 1 - Smooth skin—A loss of breast and some abdomen feathers, but most of the area is still rather smooth and dark red.

V or 2 - Vascularized—Abdominal skin thickened with increased fluid and vascularization. This is the peak of incubation.

W or 3 - Wrinkled—Abdomen skin thinning, wrinkly, and scaly.

M or 4 - Molting—New pin feathers are coming in on the abdomen. Nesting is usually completely over by this point.

Measurements

The standard reference for measuring birds is Baldwin and others (1931), which outlines virtually every possible measurement. Although old, it is commonly listed as available in catalogs of used natural history books.

Size, as indicated by specific measurements such as wing, tail, or tarsus length, is often a useful characteristic for identifying, ageing, and especially, for sexing passerine birds in the hand. In almost all passerine species, the size of males of a given population will average larger than that of the females by about 5-10 percent. The extent to which the sexes overlap in size depends on both the species and the particular

measurement being considered. Measurements also vary with age, but to a lesser extent than with sex. For example, juvenal primaries tend to be slightly (2-5 percent) shorter than adult primaries. Within each sex class, immature birds with juvenal primaries will have shorter wing lengths than adults. When coupled with weight and fat, size can also give a strong indication of the health of a bird.

When identifying, ageing, or sexing passerine birds it is important to use measuring techniques that are strictly standardized with those of published samples. In the following sections we recommend standardized methods for obtaining the measurements. All linear measurements should be recorded in millimeters (mm).

Wing Length—Although various methods of measuring wings are employed, we recommend that you measure the wing chord, because this is the length most frequently used and most widely published for North American birds, and is the most consistent between measurements. The wing chord is measured from the bend of the wing to the tip of the longest primary, across the natural arc of the primaries (*fig. 8*). While taking the wing measurement, avoid the tendency to flatten the natural curve of the wing, thus getting a measurement that is 2-5 percent longer than proper.

To measure the wing chord it is best to have a thin ruler with a perpendicular stop at zero. Insert the ruler under the wing, and place the bend of the wing (carpal joint or “wrist”) snugly against the stop. To avoid differences due to carpal compression, we recommend that the bend of the wing be pushed against the stop with no more pressure than the wing itself applies when the ruler is moved up to the wing. Once the wing is in place, make sure that the line between the carpal joint and the tip of the longest primary is parallel with the edge of the ruler, gently lower its tip to the ruler so that it touches it, and read the wing chord length (*fig. 8*).

When measuring the wing it is important to make sure that the longest primary is not broken, bent, or molting. Bent primary tips should be straightened. Older and more worn primaries will result in a shorter wing measurement and should be noted.

Weight—Because bird weight varies substantially with geographic population, condition of the individual, and season or period within the life cycle of each particular species, this measurement is not as useful for ageing, sexing, or identifying birds as is the wing chord. Weight, however, is an important indicator of the health of the bird, especially when coupled with wing length and fat content. It should always be recorded, when possible, to the nearest tenth of a gram.

Molt

Types of Molt—Relatively little is known about the timing, sequence, and extent of molt in many species, especially in Latin America. A proper understanding of molt can be extremely helpful in the accurate ageing and sexing of passerine birds in the hand. With a few known exceptions, molting is confined to two periods within the annual life cycle of North American passerine birds, just before and just after the breeding season.

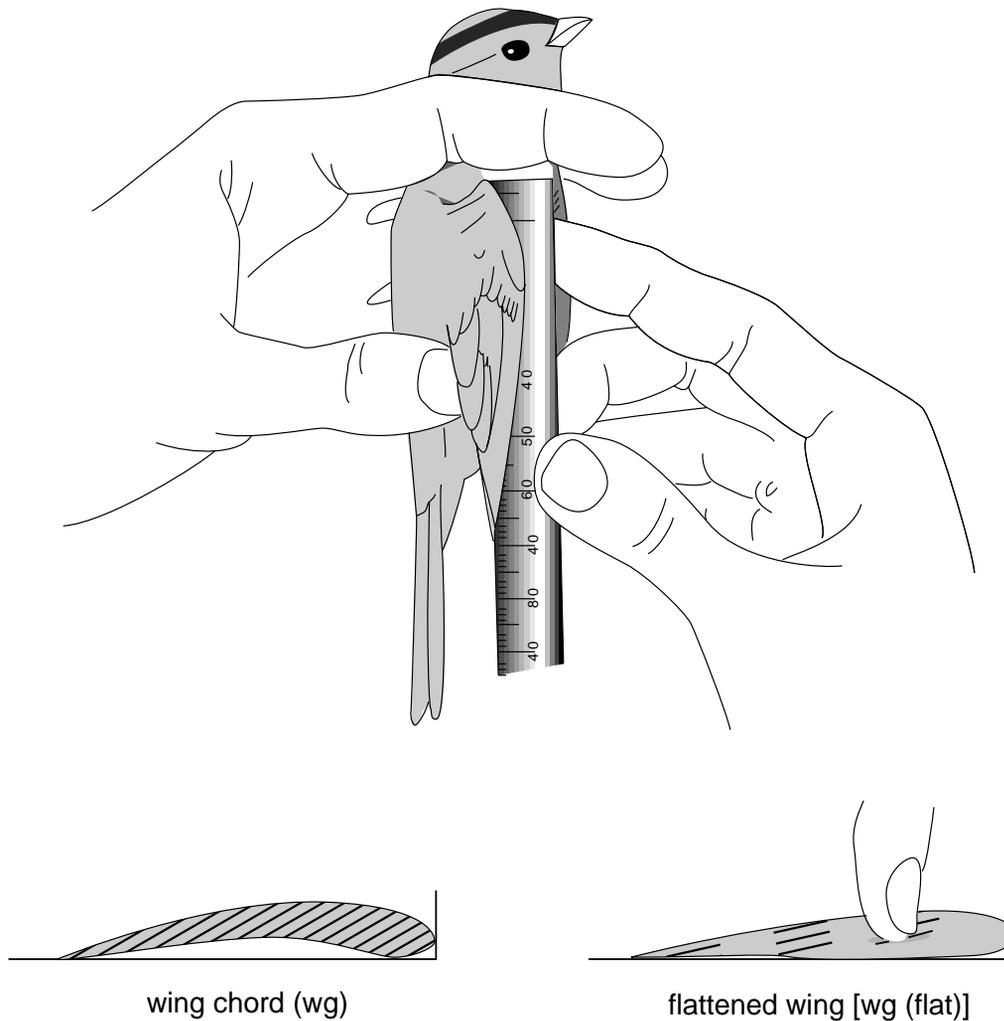


Figure 8—Above, a good hold for measuring the wing chord, and below, the measurement of the wing chord and flattened wing. The wing chord is preferred in North America. Taken from Pyle and others (1987).

Thus, most adult passerine birds display two plumages, the basic (winter) plumage and the alternate (summer or breeding) plumage. The molt that occurs just before the breeding season is called the prealternate molt; that occurring just after the breeding season is the prebasic molt. All North American passerine birds have a prebasic molt, and just over half (predominantly migratory species) have a prealternate molt.

The prebasic molt usually occurs from July to September on the breeding grounds and occurs in both recently fledged birds and adults that have completed nesting activities for the year. With one or two exceptions, the prebasic molt in adult passerine birds is “complete” (*fig. 9*; includes all body and flight feathers), whereas hatching year birds of most species typically replace the body feathers and some coverts, but not the primary coverts, and flight (wing and tail) feathers (except the central two tail feathers) during a “partial” first prebasic molt.

As you blow apart the feathers on the various areas of the body, you can easily determine which feathers are molting by the presence of a cylindrical sheath around the base of the molting feather. When the feather is fully grown, this sheath

is preened off and the feather ceases its traffic with the body and is thus fully grown.

Birds have three types of flight feathers: the rectrices, or tail feathers, and the outer (primary) and inner (secondary) wing feathers. The rectrices are numbered in pairs, beginning with the central ones (the “decks”) as #1, and proceeding outward in both directions usually to #5 or #6, depending upon the taxon. In some species the decks are sometimes molted by the young at the same time as their body feathers. The remaining rectrices molt in an ascendant sequence from #2 through #6.

The secondaries are long flight feathers attached to the skin at the ulna, the bone of forearm. These are numbered by all authors beginning at the bend of the wing and proceeding inward toward the body. This is the usual order of molt, except that the three innermost secondaries (tertials) molt like body feathers and may be molted by juveniles. They are also often molted concurrently with the longer secondaries.

The primaries are the long flight feathers attached to bones of the “hand.” These are numbered in most of the North American literature from the wrist-joint (bend of the

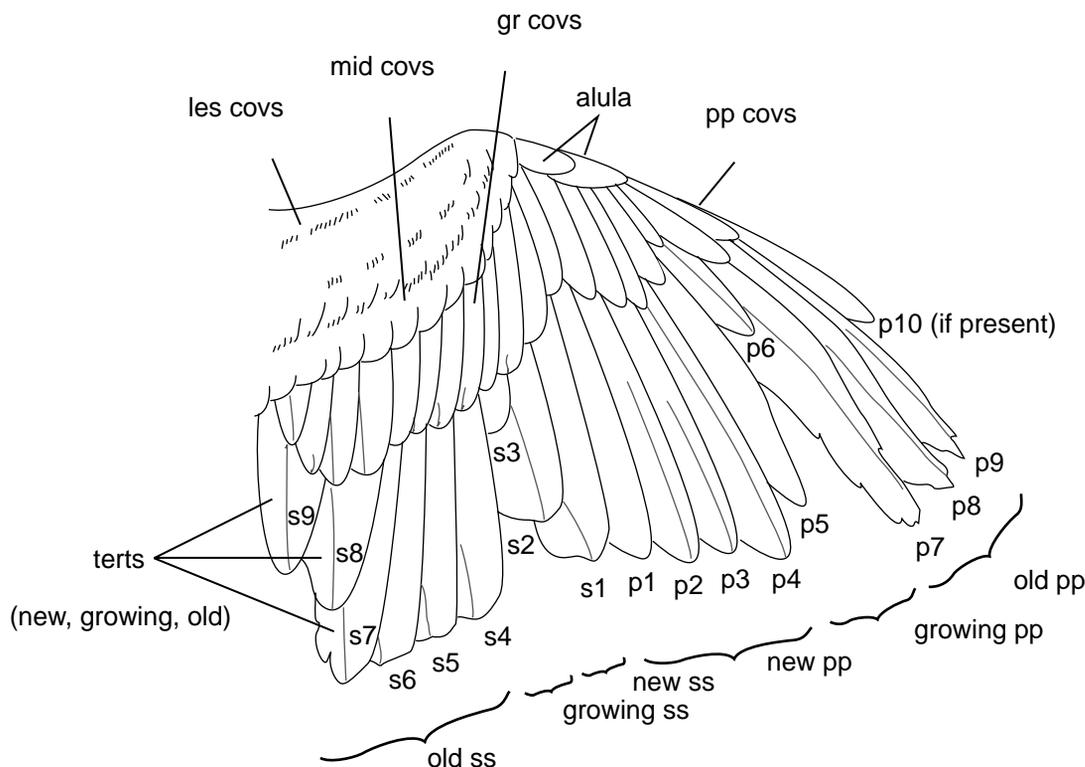


Figure 9—An example of a wing during complete molt of an adult. Notice the worn primaries 7-9 and secondary 7. Taken from Pyle and others (1987).

wing) outward, which is the sequence that nearly all birds molt these feathers.

Pyle and others (1987) have provided a complete enumeration of the numbers of flight feathers of passerine birds in North America.

Recording Molt—A basic system of recording molt in the flight feathers is to record presence or absence of molt in the primary feathers or the secondaries (except the innermost three). We suggest that the molt in the tail feathers not be recorded, except as a note. You should always check both wings, because birds often lose feathers accidentally (“adventitious molt”). Flight feather molt is “**S**” if symmetrical and normal, “**A**” if adventitious, and “**N**” or “**0**” if none.

More detailed recording of molt can be conducted using the British Trust for Ornithology’s method (Ginn and Melville 1983).

Body molt can be recorded by a subjective determination of none (**N** or 0), trace (**T** or 1) (a few, perhaps adventitious molting feathers), light (**L** or 1) (involving more than one feather tract), medium (**M** or 2), or heavy (**H** or 3) molt.

Extent of Juvenal Plumage

We suggest that the extent of juvenal plumage be recorded, because it is a good indicator of the age of a young bird and the timing of breeding. Juvenal plumage can be coded in the following: **N** or 0 = no juvenal body plumage; **L** or 1 = less than

half of juvenal plumage remains; **H** or 2 = more than half of the juvenal plumage remains, some first basic plumage is visible; **F** or 3 = full juvenal plumage, bird has not started first prebasic molt. For a more objective measure, the bander could estimate the percent of juvenal plumage.

Primary Feather Wear

Feather wear could be a useful indicator of age, because it seems likely that the juvenal generation of flight feathers may wear faster, and thus show more wear at any given time, than later, adult generations of feathers. Faster wear results from the rapid growth of juvenal feathers resulting in weaker feathers, and the protracted molt of adults. In some species during especially the early breeding season, adult flight feathers, molted after the previous breeding season, are much older than juvenal feathers and can help age birds.

Examine the outer four or five primaries to determine wear, and classify them according to the following scale: **N** or 0 = No wear, the feather edges are perfect, and the entire edge is light, including the tips; **S** or 1 = Slight wear, the feather edges are slightly worn with no fraying or nicks, and the edge is often light-colored, except at the tips; **L** or 2 = Light wear, the feathers are definitely worn, but with little fraying and few nicks; **M** or 3 = Moderate wear, considerable wear with definite fraying, and nicks and chips are obvious along the edges; **H** or 4 = Heavy wear, feathers very heavily worn and

frayed, and the tips often worn completely off; and **X** or 5 = Excessive wear, feathers are extremely ragged and torn, the shafts are usually exposed well beyond the vane, and all the tips are usually completely worn or broken off (one wonders how well the bird can fly).

Fat

The amount of fat on a bird may indicate periods of stress, low availability of food, low fledging weight, and other conditions that give insight into the viability of an individual. Especially as birds prepare for migration, subcutaneous fat is accumulated and is visible beneath the skin as white, yellow, or light orange areas easily seen in contrast to the red muscular areas. The fat can be most easily seen on the abdomen and the furculum. The furcular or interclavicular region is the depression formed between the attachments of the pectoralis muscles to the furculum (the “wish-bone”) and coracoids, forming a “V” running toward the spinal cord and pectoral girdle, through which the neck protrudes. You can assign a fat class on the basis of how much fat you can find:

<u>Fat Class</u>	<u>Furculum</u>	<u>Abdomen</u>
N or 0	No fat, the region is concave	No fat
T or 1	Trace, deeply concave, scattered patches, less than 5 percent filled.	None, or a trace
L or 2	Thin Layer, less than a third filled.	Trace or thin layer filled.
H or 3	One-Half filled in small patches covering some areas.	Small patches, not covering some areas.
F or 4	More than 2/3 Filled, level with clavicles	Covering pad, slightly mounded
B or 5	Slightly Bulging	Well mounded
G or 6	Bulging Greatly	Greatly distended mound
V or 7	Very large fat pads of furculum and abdomen meet	

Data Entry

We include a standard data form (*fig. 10*) that we encourage you to use. Fill in all the information, and print neatly in soft, black pencil. For codes not shown, and for exact definitions, see CWS and USFWS (1991). Right justify data in appropriate fields. Do not use ditto marks. If data are repeated on the next line, use a slanting line in the field from upper left to lower right, or a vertical line in the center of each column. If data are not collected, leave the column blank, or enter 9’s for numerical data. If a band is lost or destroyed, indicate this in the code column and also in the species column. On any one sheet place only the records for one band size or the recaptured birds. When starting a new series of bands, or a new calendar year, **always** start a new banding sheet. The sheet is broken into the following categories:

- Heading material: State code, region code, band size (“R” for recaptures, entered on a separate sheet), page number (for each band size), and year of banding or capture.
- Recorder and bander—Place the initials of the recorder and bander here, and their full names at the bottom of the page (these are not entered into the data base).
- Code—This column tells if it is a: new banding (**N**); recapture (**R**) (a bird previously banded); unbanded bird (**U**) (place 9’s in the band number columns); destroyed band (**D**);

lost band (**L**); or a changed band (**C**) (a band that replaced an old or worn band—make a note of the old band number).

- Band number—The full, right-aligned number of the first band on the first line. Thereafter, the final three digits of new bands only. Do not use dashes in this field to separate prefix; rather, right align all numbers. On recapture pages, the full band number should be entered each time.

- Species—An abbreviation of the species name (e.g., Bl-cap Chick, for Black-capped Chickadee). The abbreviation is not entered into the data base, but is a check against the error-prone species codes below, such as Barn Swallow (BARS) and Bank Swallow (BANS).

- Species Code—The four-letter code of species name (e.g., BCCH). The list of these for North America is in CWS and USFWS (1991). A Latin American version has not yet been prepared, but biologists can use the first two letters of the genus and the first two letters of the species names. This will suffice for many species.

- Age—The single letter or numeric codes as indicated above.

- How aged—Use the following codes: **A**, adult plumage; **B**, brood patch; **C**, cloacal protuberance; **E**, eye color; **F**, feather wear; **H**, hatching year (first winter) plumage; **I**, inside of mouth or any part of bill; **J**, juvenal plumage; **M**, molt; **P**, plumage in general; **S**, skull; **T**, tail length; **W**, wing length; or **O**, other (explain this code in the Notes section). Write the codes in their order of importance to your age determination.

- Sex—Use M for male, F for female, and U for unknown.
- How sexed—Use the codes as in “how aged.”
- Skull—Record the code above that indicates the percent of skull pneumatized.

- Cloacal protuberance—Use the code described previously
- Brood patch—Use the code described previously.
- Fat—Use the codes described previously.
- Body molt—Use the codes described previously.
- Flight feather molt—Use the codes described previously.
- Flight feather wear—Use the codes described previously.
- Juvenal plumage—Record the extent of this plumage, using the codes described previously.

- Wing length—Record to the nearest millimeter.
- Weight—Record to the nearest tenth of a gram.
- Status—Among the most common are: 300, normal and released; 301, color-banded; and 615, injured and released. The full list of status codes is in CWS and USFWS (1991).

- Date—Month, day, and year, all in numbers.
- Capture time—Using the 24-hour clock, record to the nearest 10 minutes, e.g., 6:24 a.m. is 062, 4:48 p.m. is 165, etc.
- Station/location—Record an abbreviation using four letters for the station’s name and two numbers for the net location; a total of six columns used.

- Notes—Record any useful additional data, such as: sequence of color bands, if present; suspected ages or sexes of birds coded “U”; information on unusual wing lengths; or why an “other” code was used for how aged. If additional data are taken, such as an unusual age category, they should be placed in the “Notes” columns, in order to keep primary data consistent.

STATE REGION: **MT** **SA** **5** **1** **A**
 BAND NUMBER: **113187501**
 CODES: New band N, Band destroyed D, Repeat R, Band lost L, Unbanded U, Band changed C
 AGE: Unknown U, Local L, After hatch year A, Hatch year H, Older O
 HOW AGED & SEXED: M M, P Plumage, J Juvenile, A Adult, S Sexed, F Skull, T Tail length, W Wing length
 SEX: Male M, Female F, Unknown U
 STATUS: 300 Normal, 301 Color tag band, 613 Injured, 626 Injured in 08/20/07
 YEAR: **1997**

RECORDER	SDR	CODE	BAND NUMBER	SPECIES	SPECIES CODE	AGE	SEX	WEIGHT	STATUS	MO	DAY	YR	CAP TIME	STATION / LOC	NOTES
JTB	KLP	N	113187501	MI. W. C. Spar	WWS	U	M	27.2	301	06	12	97	0915	BEVA	3 R 6 5 V
			503	Hermit Thr.	WETA	U	M	30.1	300						
			503					29.8					1.00		
			504					28.9		06	14	97	0725	SLCR	2
			505	BAND LOST											
			506	Br-hd. Cowb.	BHC	U	M	32.1	300					SLCR	3
			999					99.9							
			999					99.9							
JTB	KLP	N	113187507	Na. Oriole	NOO	U	M	34.0					0.95		5 R 6 L U M B A N D E D
			508	MI. W. C. Spar	WWS	U	M	25.4	301						10 R 6 Y 5

Names: _____ PAGE NO _____

Figure 10—An example of a form for recording data from captures.

Sources of Equipment¹

Advertisements for supplies and good articles on capture techniques can be found in the publication "North American Bird Bander." Persons doing mist netting or banding should join their regional Association and receive this, the joint publication of the Western Bird Banding Association (BBA), 1158 Beechwood St., Camarillo, CA 93010 (Colorado and west); Eastern BBA, R.D. #2, Box 436A, Hellertown, PA 18055 (Appalachians and east); or the Inland BBA, 81 Woodshire Drive, Ottawa, IA 52501.

Mist Nets

Nets can be purchased in the United States at the following: Association of Field Ornithologists, c/o Manomet Bird Observatory, Box 936, Manomet, MA 02345 [telephone (508) 224-6521]. A wide assortment of nets.

Avinet, P.O. Box 1103, Dryden, NY 13053 [telephone and FAX: (607) 844-3277]. They have a wide selection of nets, banding tools, scales, poles, color bands, and other material.

Eastern Bird-Banding Association, Gale W. Smith, R.D. #2, Box 131, Kempton, PA 19529. An assortment of nets.

Color Bands

The only source of split-ring plastic color bands for landbirds that we have found is A.C. Hughes, Ltd., 1 High Street, Hampton Hill, Middlesex TW12 1NA, England. Avinet (see above) carries a limited supply of Hughes' bands.

The best bands for most species are the "Plastic Split Rings" in solid colors. We have found their five most visible and separable colors are Red, Yellow, Light Blue, Dark Blue, and Orange. If more colors are needed, some investigators have found White reasonably separable from the standard aluminum band, and the Black and the Dark Green separable from the Dark Blue. Hughes' sizes (and their Fish and Wildlife Service approximate equivalents) are: XF (0), XCS (1), XCL (1B), XB (1A), and X3 (2).

Optical Device for Skulling

An excellent one is OptiVisor, a binocular magnifier available in 2.5, 2.75 and 3.5 powers. Available from the manufacturer Donegan Optical Company Incorporated, P.O. Box 14308, Lenexa, Kansas 66285-4308, or call them at (913) 492-2500 for a distributor near you.

Wing Rulers

Rigid tempered steel rules with a stop at the end are very good for measuring wings. Sizes are 15 cm, 30 cm, and 60 cm. Available from Chris N. Rose, 98 Lopez Rd., Cedar Grove, NJ 07009.

¹The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Banding Pliers

The best have holes in jaws to fit standard U.S. band sizes, with a split pin on top for even band opening. Three pliers are available: one will open all of band sizes 0, 1, 1B, and 1A; another for sizes 2 and 3; and one for sizes 3B, 3A, and 4. These are available from Roger N. MacDonald, 850 Main St., Lynnfield, MA 01940, (617) 334-3448.

Scales for Weighing

Electronic scales are widely available for under \$300, and Pesola scales and a spring balance field scale are available through Avinet (see above). A good general purpose one has a capacity of 300 g and a readability of 0.1 g. The Ohaus C-Series costs under \$200 and Acculab has one under \$150. With a capacity for most birds, Acculab has a pocket balance with 80 g capacity for under \$100. These are available from many scientific supply houses, such as Markson, P.O. Box 3944, Houston, Texas 77253 (800-528-5114).

Bags for Holding Birds

Washable bags can be made, or cotton mailing bags can be purchased. An ideal size for most small birds is 6 by 9 inches, or somewhat larger. U.S. Government agencies can purchase excellent cotton mailing bags from the General Services Administration.

Bird Banding Laboratory and Office

All capture work must be done under very strict regulations and permits. Permit applications in the United States can be obtained from the Bird Banding Laboratory, U.S. Fish and Wildlife Service, Laurel, Maryland 20708. In Canada, the address is Canadian Bird Banding Office, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A 0H3. Special permits are also needed from most states and provinces, and the above offices can supply information on them. Many Latin American countries also require permits.

The Bird Banding Laboratory and Office provide excellent support for all activities relating to capture, and permittees receive bands at no cost. However, they have limited resources for supporting banding work and cannot honor all requests for permits. Applicants for permits must show evidence of qualifications and must have a well-justified need to band. Permittees are expected to provide accurate and timely reports of birds banded.

Nest Searches

Nest searches provide the most direct measurement of nest success in specific habitats. They also allow identification of important habitat features associated with successful nests and insight into habitat requirements and species coexistence. Knowledge of the appropriate cues and techniques for finding nests allows large numbers to be found, thereby providing vital information about many species. Nest searches have an

advantage over constant-effort mist netting, in that the measures of success are direct and habitat-specific. However, they are more limited as to the area surveyed and do not measure individual survivorship. Mist nets sample birds from a larger area, and the data derived may therefore have wider applicability, but are not habitat specific.

In this section we describe aids and standardized techniques for locating and monitoring success of nests, adapted from Martin and Geupel (in press).

Nest Sites

Nest finding is labor intensive (DeSante and Geupel 1987, Ricklefs and Bloom 1977), but most observers can improve their ability to locate nests in a matter of days with training and practice.

The behavioral observations and clues described below work effectively for a variety of species. However, our experience includes a small subset of species and habitats and, in particular, is largely restricted to forest and shrub habitats. Other methods may be more effective in other habitats. For example, cable-dragging (Higgins and others 1969) and rope-dragging (Labisky 1957) may be more effective for many grassland species. In particular, all species, and even some individuals, differ in nest placement and behaviors near the nest. The patience and alertness of observers, and their familiarity with the habitat and behavior of individual species, are the most important influences on effectively locating nests.

Nest finding can be a frustrating task; patience is an important asset. It is a good idea to set a goal of finding at least one nest daily. More than one nest will be found on many days, but if at least one nest can be consistently found every day, the numbers of nests over the season will rapidly accumulate.

Methods

The particulars of plot sizes and numbers will vary according to the purpose of the study or activity, the habitat involved, and the density of birds. As a general guideline, we recommend that two study plots be established for each person that searches for nests. The searchers should work alternating days on these two plots for the entire nesting season. This provides consistent monitoring and allows the person to become familiar with the plot. In general, eight plots, each 40-50 ha, would usually be necessary to be established in forest habitat to find sufficient numbers of nests (ca. 20 nests per species) for the range of species typically found in any given forest, but smaller plots (ca. 10 ha) can be established in areas with higher densities.

In general, one should try to develop as quickly as possible a search image for the nests of various species. T. Sherry (pers. comm.) notes that he routinely finds 25-50 percent of his nests by constantly scanning appropriate potential nest locations in the vicinity of an active female.

During Nest Construction

Ideally, nests should be located during construction to provide the best estimates of nest success. This is also usually the easiest time to find nests because of the high level of

activity and, in some areas, forests are not leafed out, making the task of following the female much simpler (T. Sherry, pers. comm.). We advise biologists to spend the maximum amount of time early in the season when the finding rate is maximum. Nest building begins by May in most areas of North America, although permanent residents and some ground-nesting species will begin earlier. Only the female constructs the nest and incubates the eggs for most small terrestrial birds (Kendeigh 1952, Silver and others 1985). Exceptions include woodpeckers, vireos, and wrens. Thus, the most effective way of finding most nests is by locating and following females, although males may provide some cues. Some nests in the shrub layer can be found by random search. Ground nests in forests are usually the most difficult to find. It is best to watch the female as she is gathering nesting material without using binoculars, because when she flies, she can be followed more easily with the naked eye.

Females tend to be extremely furtive during nest building. A mated female can be recognized by copulations or by her movements around the territory unharassed by the male. Females should always be checked with binoculars, especially during and after long, direct flights, to determine whether nesting material is being carried. Many birds will carry very fine material, not obvious upon casual inspection, such as spider webbing and hair for lining nests.

Sitting near sources of nesting material (e.g., failed nests, thistles) or open areas with a good view of the territory can help detection of nest-building females. Observers should use different paths across plots to increase the probability of randomly encountering females near undiscovered nests.

Follow a bird with nesting material from a distance to avoid disturbance. Do not interrupt a long flight. If the bird disappears in a patch of vegetation, begin to scan for potential nest sites. Be patient and wait for another visit by the bird. If the area where the female disappears is near the nest, the female will spend time in the area. At the same time, be aware that the female may move out of the back side of the patch to another patch that contains the nest.

Some individuals tolerate nearby observers and behave normally, but most species are very wary of observers. If the observer is too close to the nest, the bird often will sit on a perch somewhere near the nest site until the observer leaves. Eventually the bird will drop the nesting material if the observer does not move away. Thus, such behavior is an indication that the observer is too near the nest and should move quickly away. Obtain a new position at some distance (ca. 15 m) hidden by vegetation. Observe the female arrive with nest material and leave without it from the same location several times. Be aware that a female can skulk into one patch of vegetation and leave unobserved to move to a different patch, then return the same way, to give the appearance of nesting in the first patch. Some species such as MacGillivray's Warbler, Hooded Warblers, and Sage Sparrows will walk on the ground for several meters to approach the nest secretly. Birds can often be detected by watching for movement of the vegetation where they are otherwise hidden. Where the vegetation stops moving is usually the nest site.

Mapping the male's position as he sings around the territory can often reveal a center of activity from which the male can often see the nest (T. Sherry, pers. comm.). The observer then can scan appropriate nest sites nearby, or at least increase the chance of catching a glimpse of a wary female.

Once the suspected nest site has been identified, back away quickly. Verify the status and location a few hours later, being careful that the female is absent. Do not approach the nest while the female is watching; disturbance at this early stage can cause abandonment. After quick verification, the area should be left and not visited for four days.

During Egg-Laying

This is the most difficult stage for finding nests because the female may visit the nest only when she lays an egg, and most species lay one egg per day. The female will sometimes sit on the nest during egg-laying when weather is particularly harsh. Nest visitation becomes more frequent with more eggs in the nest (Kendeigh 1952).

Behavioral cues are useful at this stage. When either parent gets near the nest, they will look at it. If an egg-laying female detects a predator in the area, such as an observer following her, she will sometimes check the nest. Another good cue is a female staying in an area without actively feeding. She will often look at the nest site repeatedly, aiding location of the nest.

Finally, copulatory behavior can be used during both nest-building and egg-laying. Copulation often occurs in the same tree above a nest, on the same branch, or in the next tree. Examine carefully the area immediately adjacent to copulatory activity.

During Incubation

The beginning of incubation can be estimated as when females suddenly "vanish," and males increase singing. Some behavioral cues can help locate nests. Females start foraging fast during the incubation and nestling stages, probably because their time is more limited. Females that are making rapid hops, quick short flights, and rapid wing flicks will probably return to the nest soon. On average, most passerine females are off the nest for 6-10 minutes and on for 20-30 minutes (e.g., Zerba and Morton 1983).

Observers can find females by alertly moving through the study plot, but sitting down in a spot for 20-30 minutes is also useful. A female leaving a nearby nest can thereby be detected. Females can also be detected by call notes, although species differ in the types of sounds. Females of many taxa (e.g., gnatcatchers, warblers, Emberizine finches) chip or call just before leaving, or just after leaving, the nest. This behavior seems to be a communication note to the mate. Females of other species use other vocal signals, e.g., thrushes give a chuck or mew sound; tanagers often give a characteristic sound near the nest or during copulation; and some taxa (e.g., Emberizine finches and icterines) have a nest departure call (McDonald and Greenberg 1991), often answered by the male. If you detect, follow, but then lose a vocalizing female,

immediately return to the original location where she was detected, and you may often find her again before she returns to the nest.

Males can also be of some help. When the female is off the nest, some males quietly guard the nest or follow her (for example, the Gray Catbird) (Slack 1976). A quiet male may indicate presence of a foraging female or a nest nearby. In many species, especially cavity-nesters, males will feed incubating females (e.g., Lyon and Montgomerie 1987; Martin and Geupel, unpubl. data; Silver and others 1985). Males of some species (e.g., Chestnut-sided Warbler) use singing perches that are in direct view of the nest. Males sitting on a perch, looking towards the same spot, may indicate a nest.

Males can sing anywhere in the territory while a female is incubating, but he can become silent when the female is about to leave, or has left, the nest (T. Sherry, pers. comm.). When this occurs, he will often make a long flight over to where the female is starting to forage (and sometimes will incite her to leave the nest). Sherry suggests being alert to these flights because they provide valuable clues to where the nest vicinity is, and can also help the observer detect females, which are often difficult to find considering how long they stay motionless during incubation.

A female foraging off the nest is fairly tolerant of people, but observers should be inconspicuous. As she returns to the nest, she is more cautious. This can be used to an observer's advantage. First, a relatively long flight after foraging is probably a return to the nest, and is often along the same route. Quickly running in her direction for about 25 m may often result in a resighting, because the disturbance will keep her from returning to the nest, giving more time to relocate her. If she is near the nest, but cautious about approaching, she will bounce between a few branches, and may also forage rapidly. Eventually, she will start to move down toward the nest several times and then suddenly fly back up, apparently indecisive. If the observer is too close to the nest, the bird will continue to bounce, and will sometimes fly off, only to return within a few minutes. The observer should then back off and watch. If it is cold, do not keep her off the nest for too long. If the female has been followed for more than 30 minutes without results, then she probably is not on a nest, unless both sexes incubate.

If a female disappears into a tree or shrub, the nest is probably in or next to it. Memorize the area where the female disappeared and choose potential nesting sites before approaching. Moving quietly, begin tapping potential nest shrubs with a stick. Listen for the flush of the female off the nest. If unsuccessful, the site can be revisited for careful searches.

In many species, nest site preference seems to be an evolutionarily conservative trait (Martin 1992). Some birds greatly prefer their nest to be in or under certain plant species, or in particular patch types (Martin and Roper 1988, Martin unpubl. data). Describe and visit nest sites from previous years to aid new observers in finding nests.

During the Nestling Stage

Finding nests during the nestling period is the easiest,

because both males and females commonly bring food and remove fecal sacs. Males are normally the easiest to follow, as they tend to be less cautious. Nests can usually be found from a distance using binoculars because of the constant activity of the parents.

In some species a singing male can indicate the nest location. He may sing, for example, less and less as he starts to gather food to carry to the nest, become silent when he is about to approach the nest, and then resume loud song immediately after leaving the nest (T. Sherry, pers. comm.). Additionally, Sherry notes that birds will often become reticent to go to a nest with a human nearby, so that if a bird becomes relatively inactive (hopping around, not taking long flights) in a particular area, or dropping prey, then the nest is probably nearby. In this case, the observer should either search intensively in the vicinity, if likely nest spots are nearby, or back away to give the bird a chance to become calm and go to the nest.

Knowledge of the nesting cycle allows an observer to anticipate when to start looking for a new nest. Most species will renest after a nesting failure, although this varies among and within species (Geupel and DeSante 1990a, Martin and Li 1992). Reconstruction usually begins within 10 days, and the earlier in the nesting cycle that failure occurred, the farther apart the nests are likely to be (citations in Martin 1992). Multi-brooded species may renest in as little as 8 days after fledging. Sometimes the female will begin nesting while the male is still tending the fledglings of the previous brood (Burley 1980).

Nest Monitoring

Each nest found needs to be checked every 3 to 4 days to determine its status. Careful attention to checking nests is critical for data quality, because the number of days that nests have eggs or young is used to calculate daily mortality rates, the most effective measure of nest success (Mayfield 1961, 1975). Nests should be checked from a distance the day before expected fledging, and every other day thereafter. A chart showing nests as they are found and the expected date of fledging is extremely helpful. If nestlings appear ready to fledge before the next scheduled visit, then the next visit should be sooner. Calculations of nest success should terminate with the last day that young were observed in the nest. Nests should also be checked more frequently about the time of hatching, if the length of the incubation period is desired.

With canopy nests, mirrors attached to telescoping aluminum poles can check contents of nests. These are available from stores stocking swimming pool supplies, and are commonly up to 4-5 m. A window-washing pole to 12 m is also available (Tucker Manufacturing Company, 613 Second Ave. S.E., Cedar Rapids, Iowa 52406; 319 363-3591). T. Sherry (pers. comm.) suggests a convex mirror to allow views from a variety of angles from the ground. Mounting a small flashlight next to the mirror can illuminate the nest contents in cloudy or rainy weather. Often binoculars must be used to view the nest in the mirror.

Careful and detailed observations should be recorded if a nest predation event is observed. If the nest appears inactive from a distance, it should be approached to verify. If the eggs or young appear to be gone, then check the nest structure and immediate area, perhaps up to 6-10 m (T. Sherry, pers. comm.) for evidence. Any evidence (e.g., shell fragments, hole in nest, nest torn up) should be fastidiously noted. When the young fledge, they commonly perch on the edge, flattening it, and leave fecal droppings in (or on the edge of) the nest. These would indicate possible successful fledging. Observers should try to verify success by seeing fledglings or by hearing adult alarm calls or begging calls of the young. Fledglings normally do not move very far in the first couple of days, although some, such as Rufous-sided Towhee, may move 100 m in a few hours. Some species or individuals may carry food up to 24 hours or longer after predation of their nest, including to unrelated fledglings from neighboring territories.

Nestlings may be banded when the primaries first break sheath. Banding may provide valuable information on juvenile survival and dispersal. Always have an assistant with you to record data, and be careful the nestlings do not jump out as you try to remove them (use two hands). Avoid banding in the morning or during cold or wet periods.

Filling Out the Forms

Two types of data sheets are used to record data about the nest site and nest activity. One set ("Nest Check Form"—*fig. 11*) is used in the field to record information when nests are checked. To prevent loss, and serve as a backup and summary record for each nest, the "Nest Record Form" (*fig. 12*) should be maintained at some permanent location. The Record Form should be updated daily, to prevent data loss.

All observations should be recorded on the Check Form and transferred to the Record Form, including visits with no activity. This is particularly critical for canopy or cavity-nests where nest contents cannot be viewed.

Nest Check Form

Data are collected in the field and are recorded on the Check Form. One to several nests can be recorded on a single form. When a new nest is found, its location is carefully noted at the bottom of the form, and the form may be needed in the field over the next few visits to relocate the nest. The data taken should include:

- State or province—The 2-column code for each.
- Region—An 8-column code, designated by the investigator. Often, the name of the USGS quad, a prominent landmark, or a nearby town will provide the best code name.
- Station—A 4-letter code for the station that contains the nest search plot.
- Year.
- Observer's initials.
- Nest number—A unique, identifying 2-column number for the nest site. We would expect that at each station, for each species, no more than 100 nests would be found.

NEST RECORD FORM

1.

STATE
 REGION
 STATION
 SPECIES
 YEAR
 NEST NO.
 ATTEMPT

2. NEST CHECKS

DATE		CONTENTS					COMMENTS
Month	Day	Build- ing	Adult on	obs- ved	Number of eggs	Number of young	
6	6	X					entering hole
6	9	X		X			3/4 th built
6	12		X	X	3	0	flushed off nest
6	15			X	3	0	
6	18			X	0	0	empty

3. DATES and PERIOD

Month Day Contents
 Found start of nest
 1st egg Number
 Clutch completion eggs
 Hatched nestl.
 Fledged or failure fledg.
 Last date active

Outcome predation - jay?
 Cause of failure

Period	Number of days observed	Success
Egg laying	<input type="text" value="4"/>	<input type="text" value="5"/>
Incubation	<input type="text" value="3"/>	<input type="text" value="D"/>
Nestling	<input type="text" value="0"/>	<input type="text"/>

4. NEST SITE

Measurements in cm unless otherwise designated

Plant common name Alder
 Genus A C N U S
 Plant height Nest height above ground
 Plant dbh Nest dist. from edge
 Canopy cover (denso.) Nest dist. from center/stem
 Number support branches Diameter support branches
 Concealment from above from below
 Concealment from side N S E W
 Compass direction Total % cover nest substrate

Band numbers of young

Figure 12—An example of a Nest Record Form that is kept at a permanent location for recording data from the Nest Check Form, as well as the nest site and characteristics data.

- Species name—The 4-letter code, based on CWS and USFWS (1991).
- Date—Month, Day, Year.
- Time—Use the 24-hour clock.
- The activity of an adult if either building (“build.”) or incubating (“on”), by putting an “X” in the blank.
- The observer should record the contents of the nest whenever it is approached close enough for careful observation. If the contents are actually observed, this should be noted by an “X” in the observed box (“obs.”). If the contents are counted accurately, the number of eggs, young, or both, are noted. Age of the nestlings should be estimated when possible because it can help determine the nest fate by providing information on length of time that nests were active. Age estimates should be recorded in Notes.

The form also includes space for a description of one or more nest sites that the observer finds on this day. The description should be sufficiently detailed to allow anyone to locate the nest. Take compass readings from a fixed point (e.g., a stake or grid point) to establish a reference location.

Nest Record Form

This form is filled out each day upon return from the field, and should contain the following data:

- Header data
 - State or Province
 - Region
 - Species code
 - Year
 - Nest number

The number of attempts at nesting that this record represents for that pair for that season.

- Nest Checks. These are the data transcribed from the Check Form, and are the same as for that form.
- Dates and Period

The following dates should be tabulated, as they become available: date of finding of nest (and contents when found), date of first egg laid, date of clutch completion (and number of eggs laid in final clutch), date of hatching of last egg (and number of nestlings produced), date of fledging (and the number of fledglings), or nest failure, and date when last active.

Outcome, a written description of the fate of the nest.

Cause of failure (codes: UN = unknown because not revisited; FY = fledged, with at least one young seen leaving or in vicinity of nest; FP = fledged young, as determined by parents behaving as if dependent fledgling(s) nearby, FU = Suspected fledging of at least one young, but uncertain (e.g., no adult behavior observed); FC = fledged at least one host young with cowbird parasitism; PO = predation observed; PE = probable predation, nest empty and intact; PD = predation, damage to nest structure; AB = nest abandoned prior to eggs; DE = deserted with egg(s) or young; CO = failure due to cowbirds; WE = failure due to weather; HA = failure due to human activities; and OT = other).

Period = the number of days nest was observed for the following: days during the egg laying, incubation, and nestling period.

Success = for each period, based on the following codes: S = Successful, D = Depredated, N = status unknown/nest not occupied, U = status Unknown/nest occupied fate unknown, M = Mortality other than predation, A = Abandoned, F = Female died, Z = abandoned, no (zero) eggs laid.

Predation Risk from Monitoring

Locating and monitoring nests have potential to increase predation (Major 1989, Picozzi 1975, Westmoreland and Best 1985). With proper precautions, such biases can be eliminated or minimized (Gottfried and Thompson 1978, Willis 1973). Finding the nest normally creates the most distress to adults and disturbance to the nest site because subsequent visits are brief. Some evidence suggests that predation rates are higher on the first or early visits than subsequent visits (Bart 1977, but see Bart and Robson 1982).

Therefore, we suggest the following when locating nests:

- Minimize distress calls by adults; never allow them to continue for more than five minutes;
- Do not approach a nest when any potential nest predators, particularly visually-oriented predators (e.g., corvids), are present;
- Minimize disturbance to the area around the nest; and
- Do not get close to nests during nest building, as birds will abandon if disturbed before egg-laying, particularly during the early part of a season.

To lower the probability of predation or brood parasitism from checks, we recommend that you

- Check from as great a distance as possible, using binoculars to look into the nest or climb up to look from above;
- Approach nests on different paths on subsequent visits, using paths that are quick, quiet, and that minimize vegetation disturbance;
- Never leave a dead-end trail to the nest, but continue walking in a different direction;
- If avian predators are common, check other bushes without nests, and always assume a predator is watching;
- Be quick and accurate during nest checks and nestling banding;
- Minimize the number of observers;
- Use a pen or stick to check nests to prevent human scent from being left on or near a nest.

Vegetation Measurement

We suggest two methods of vegetation measurement: (1) the nest and the plant containing it; and (2) the nest site and random points in the plot. The entire plot should be measured with a series of points, as outlined in the section “Methods of habitat assessment” below.

The Nest and Nest Plant

Measurement of the vegetation of the nest site is an important research tool and has some application to monitoring. If you wish to determine this aspect of habitat, we suggest that you measure the vegetation as soon as a nesting attempt terminates. Be careful at the beginning of the season, as an empty nest may not yet have eggs. Some species or individuals will delay laying as long as eight days after completing nests. Do not delay measuring the vegetation, because foliage density around the nest changes rapidly.

We suggest the following measurements (*fig. 12*), of the plant containing the nest. All measurements should be in centimeters.

- Plant species common name.
- Plant species genus.
- Plant height.
- Nest height.
- Plant “dbh” (diameter at breast height), stem diameter of the nest substrate, usually measured at 0.25 m above the ground, because many nests are in substrates less than “breast height.”
- Nest distance from edge—Distance from edge of plant, inward to the nest.
- Canopy cover—The canopy cover at chest height should be measured using a densiometer. This is a measure of the tree canopy, and should be measured as close to the nest as possible, but not under the canopy of the nest plant if it is a shrub.
- Nest distance from center/stem—Distance of the nest laterally from the main stem.
- Number of support branches—The number of branches actually supporting the nest.
- Diameter support branches—Average diameter of stems supporting the nest.
- Nest concealment—Measured by estimating percent of the nest concealed by foliage cover in a 25-cm circle centered on the nest from a distance of 1 m from above (overhead cover), from below, and from the side (side cover) in each of the four cardinal directions.
- Compass direction—Direction from the nest to the main stem of the substrate.
- Total percent cover nest substrate—The percent cover of the plant containing the nest, using the outer margin of the plant as the boundary. This is most useful in shrubs.

The Nest Site and Random Points

Vegetation in the patch surrounding the nest can provide information on differences in microhabitat choice among species.

We recommend using vegetation sampling methods based on a series of points, as outlined in the section “Methods of habitat assessment,” below, or those described in Martin and Roper (1988) with some modifications (obtainable from Martin). The point method involves measuring habitat features in the nest patch in circular releves of 11.2-m radius centered on the nest, smaller than the 25- to 50-m releves for general

habitat assessment, detailed below. In addition, non-use sites should be sampled with the same protocol at 35 m from the nest in a direction parallel to the contour of the plot (to stay within the same microhabitat type when possible). The sampling plot should be centered on the plant stem nearest to the 35-m point that is of the same species and size as that used for the nest. Random plots can also be established in a grid to obtain a stratified random sample of the vegetation. Comparisons of random versus nest plots can indicate choice of microhabitat types. Comparisons of nest versus non-use plots then provide information on choice of habitat patches within a microhabitat type. These sampling protocols keep the methods relatively compatible with other sampling schemes (e.g., James and Shugart 1970), but also allow tests of hypotheses about the interactions between choice of nest site and predation risk or habitats chosen for nesting.

Censusing

The assessment of population size should be an integral part of any monitoring program. Various methods have been employed and thoroughly tested (see Ralph and Scott 1981). Abundance of birds has long been used to measure habitat suitability but is often retrospective, giving trends without any possibility of determining causation, and can even be misleading (van Horne 1983).

It is desirable to use a method that allows the biologist to census as many points as possible in the time available, thus gaining as many independent data points as possible. That is, it is much better statistically to census five points in a 10-day interval, than to count at one point five times. The farther apart each of the five points, the more likely the data can be extrapolated to a larger region.

Below we outline four major methods. Two of these, the point counts and the spot mapping methods, are the most common ones used (for definitions see Ralph 1981b). The point count is probably the best for most surveys and has been adopted as the standard method for monitoring (Ralph and others, in press). The methods for both are taken in part from the excellent book by Koskimies and Vaisanen (1991). In addition, a strip transect count and an area search method are also presented. The latter is especially popular with volunteers.

General Considerations

Time of Day

The best time for censusing at most temperate latitudes during the breeding season is usually between 5 and 9 a.m. Under most circumstances, no counts should be done after 10 a.m. Exceptions could be in the non-breeding period. It is best to start within 15 minutes of local sunrise. Examining pilot data is the best way to determine when detection rates are the most stable. In general, the period between official sunrise and the ensuing 3-4 hours is usually relatively stable. For most species, during the period between dawn (first light) and

sunrise, the number and rate of birds singing is somewhat higher than the rest of the morning. For maximum comparability in detection probabilities for species among points, it will be best to start at sunrise rather than at first light.

Census Period

Breeding season point counts should be run during the time of year when the detection rates of the species being studied are most stable. Within the breeding season, the months of May, June, and the first week in July are best for counting most passerines in North America. However, stable counting periods, when the rate of singing of the various species has stabilized, are as early as April in the Southeast and Southwest and may extend later in the boreal zones. In Latin America the breeding season will be longer, and censuses can profitably be conducted throughout the year.

Weather

Birds should not be surveyed when rain or wind interfere with the intensity or audibility of bird sounds, when fog or rain interfere with visibility, or when cold weather shuts down bird song activity.

Point Counts

We suggest two levels of point counts. **Extensive point counts** are intended for a series of points, placed at a minimum of 250 m apart, largely on roads or trails over an entire region. **Intensive point counts** are placed within a mist net or nest search plot.

The account below is based on Hilden and others (1991), and the standards are taken from Ralph and others (in press), as adopted by the Point Count Workshop of the Monitoring Group of the Neotropical Migratory Bird Conservation Program, held in Beltsville, Maryland, November 1991.

Background and Aims

In many countries point counts are the main method in monitoring the population changes of breeding landbirds. With the point count method it is possible to study the yearly changes of bird populations at fixed points, differences in species composition between habitats, and abundance patterns of species. The point count method is probably the most efficient and data-rich method of counting birds. It is the preferred method in forested habitats or difficult terrain. Point counts involve an observer standing in one spot and recording all the birds seen or heard at either a fixed distance, or unlimited distance. This method can be conducted one or many times at a given point. The North American Breeding Bird Survey of the U.S.D.I. Fish and Wildlife Service is such a method.

The point count method applied to landbirds does not provide reliable data on waterfowl; however, rails and waders are counted well. Some landbirds also pose problems as they are particularly quiet, loud, nocturnal, or flocking. If these species are of particular interest, the method may be modified to accommodate them.

Equipment and Time Needed

One should not start point counts without good identification skills, including a knowledge of the songs and calls of birds. Details on training for distance estimates are given in Kepler and Scott (1981). In the tropics, learning all the songs and calls of all species at all times of the year is difficult in practice. In many areas it takes an experienced observer 4-8 weeks to identify 80-90 percent of the species. In temperate zones, this can often be done in less than 2 weeks.

For the census one needs a map, a pencil, notebook, a watch that shows seconds, and binoculars. The route and the points are marked on a survey map and, if necessary, in the field with plastic tape or streamers to ensure that the same points are found in the following years. The observer may move from one point to another by foot or with a vehicle.

The time needed for censusing one point count route is usually no more than four morning hours, depending on the distance between the points and the method of travel.

Choosing a Counting Route for Extensive Point Counts

An extensive point count route should encompass all the habitats of a region, if possible. In addition, it should include any mist net or nest searching plots in the region. In choosing a route and laying out the points for census, use a systematic rather than random sampling design, either on roads or off roads. Systematic gridding of points is preferable to the random placement of points in most cases. Systematic placement can include placing points at designated distances along roads. Do not stratify by habitat, unless separate estimates for a habitat are required. If the goal is to estimate population trends for an entire management unit, then point counts should be spaced evenly throughout that unit, or along the road system in an area, without regard to current habitat configurations.

Observers should attempt to carry out censuses primarily on tertiary roads, then secondary roads, and should avoid wide, primary roads. Off-road censuses should be carried out on trails, if possible, in major habitats not covered by road systems. Using roads, travel time can be reduced to as little as 1-2 minutes between sampling points. Under optimal road conditions, up to 25 5-minute point counts can be conducted in one morning. In an off-road situation, the number of point counts one observer can conduct during a morning varies between 6 and 12. Roadside habitats usually do not sample all of the available habitats. In this situation, a collection of both on- and off-road surveys can be created that best fits local conditions. Although a road modifies the surrounding habitats, we feel that tertiary road systems (i.e., narrow dirt roads) allow for birds to be counted in approximately the same proportions as off-road surveys.

The minimum distance between point counts in wooded habitats is 250 m. Birds previously recorded at another sampling point should not be recorded again. In virtually all habitats, more than 99 percent of individuals are detected within 125 m of the observer. In open environments, this minimum distance

should be increased because of the greater detectability of birds. Along roads, where travel by vehicle is possible, distances of 500 m or more should be used.

Choosing Points for Intensive Point Counts

The intensive point counts are conducted within a study plot for mist nets or nest searches. We suggest between 9 and 16 points in a grid of 3 by 3, 3 by 4, or 4 by 4 points. For most analyses, the birds counted from these points will be combined into a single mean. Therefore, the distance between points is less critical than for extensive point counts where each point is intended to be statistically independent. The points on an intensive census grid should be adjusted to fit within the netting array or nest search plot so as to fully census the area. It is very important not to include areas much beyond the array or plot boundaries. These are covered by the extensive point count censuses. For example, a census grid of nine points, 100 m apart, would cover 4 ha. Allowing for an effective radius of censusing of perhaps 50 m outside this grid, the area covered expands to about 9 ha. A grid of 12 points 150 m apart would have an effective area of about 22 ha. Thus a census grid should have points that are between 75 and 150 m apart, depending upon the area to be covered and the number of points to be included. Under most circumstances 9-12 points should be more than adequate.

Field Work

The censuser should approach the point with as little disturbance to the birds as possible. Counts should begin immediately when the observer reaches the census point. Time spent at each count point should be 5 minutes if travel time between counting points is less than 15 minutes (for greater efficiency) and 10 minutes if travel time is greater than 15 minutes. If a survey is primarily for inventory and few points will be surveyed, then 10 minutes is appropriate. Data should be separated into those individuals seen or heard during the first 3 minutes (for comparison with Breeding Bird Surveys) and those additional individuals heard in the remaining 2 and 8 minutes.

The details of each point are recorded: the reference number, name of the point, date, and the time. The species are written down in the order they are observed. For each species, the number of individuals is recorded separately for those within a circle of 50 m around the censuser and for all those outside the circle, out to an unlimited distance. In noisy environments, dense foliage, or in tropical forests, observers have found that 25 m was preferred. The distance is that at which the individual was first observed. For birds near the 50-m border, the category may be confirmed by measuring paces to the border when the counting is over. If a bird flees when the censuser arrives at the point, the bird should be included according to its take-off place. Birds that were detected flying over the point, rather than detected from within the vegetation, should be recorded separately.

Estimating distances requires experience, so a new censuser should measure the length of steps in different terrain, and

then check the distance to several singing birds in order to make the estimating of distances routine. Estimating may be eased by either natural or artificial landmarks.

If there are several males of the same species around a point, one may sketch in the margin the directions and distances of each singing male with an arrow to ensure that they are not confused. Juvenile birds or birds that fledged during the current breeding season should be recorded separately.

A bird flushed within 50 m of a point's center as an observer approaches or leaves a point should be counted as being at the point if no other individual is seen during the count period. It is advisable that this be recorded separately.

If a flock is encountered during a census period, it may be followed after the end of the period to determine its composition and size. An observer should follow such a flock for no more than 10 minutes. This is especially useful during the winter. A bird giving an unknown song or call may be tracked down after the count period for confirmation of its identity.

No attracting devices or records should be used, except in counts for specialized groups of birds.

Filling in the Forms

The data taken at point counts are of two types, the location information and the census data. The location data are contained in the first three lines of the "Location and Vegetation Form" (fig. 15, described below) and contain information about each census point. We also suggest that the vegetation data be taken (see Habitat Assessment, below). We suggest two types of census data forms. One involves mapping and the other direct recording.

Mapping Point Counts—This method of taking data involves the recorder placing on a map (fig. 13) the location of each bird detected (D. Welsh, pers. comm.). We suggest that species codes be used on the map, with a single letter for the most common species, and the full 4-letter code for other species. The birds' activities can be recorded by the various mapping symbols given in figure 13. The circle on the map can be the 50-m radius, enabling the observer to keep track of individuals easily. The orientation of the observer ("DIR") should be entered on each form by placing the compass direction in the box at the top. Separate time periods are easily kept by using different colored pencils, e.g., birds seen in the first 3 minutes in black, and those seen within 3-5 minutes in red.

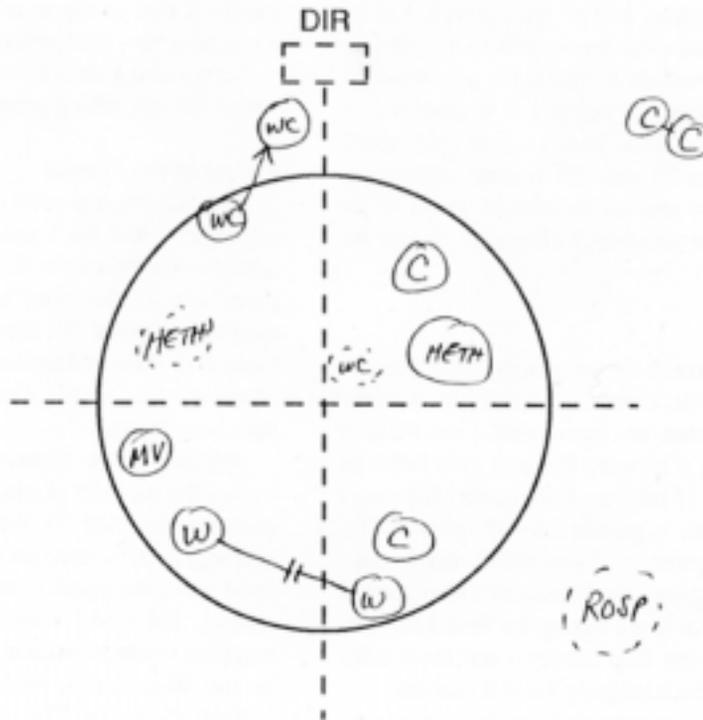
The data are then transcribed onto the Point Count Data Form (fig. 14), described below.

Direct Recording Point Counts—This method involves a single-step process of the observer recording the observations directly on the Point Count Data Form (fig. 14). Many observers do not think that it is necessary to map the location of birds in order to keep track of individuals. Using this method, an observer tallies in pencil each individual detected by placing a "tick" mark (a single line), or another code, in the appropriate column. Codes, for example, can be used to separate out singing vs. visual-only birds (S and V) and age categories. When field work is over, the actual number in each distance and time category can be written in ink for data entry.

POINT COUNT LOCATION MAPPING

CA	M T S H A S T A	B E V A	6	17	1992	2
STATE	REGION	STATION	MONTH	DAY	YEAR	POINT

TIME			



MAPPING SYMBOLS

CODE

- S Position of singing male
- S Approximate position of singing male
- S Simultaneous song of 2 males
- S Known change in position
- S Assumed change in position
- N **MAWA *** Nest

CODE

- M Male observed
- F Female observed
- C Calling, sex unknown
- P Pair together assumed mated
- O **MAWA** Observed, sex unknown

Figure 13—A recording form for mapping the location of birds during point counts with some mapping symbols. Taken from Welsh (pers. comm.)

Observer _____

POINT COUNT DATA FORM

CA
MTSHASTA
BEVA
6
17
1992
2
 STATE REGION STATION MONTH DAY YEAR VISIT NUMBER

PT. NUMBER	TIME	SPECIES	0 - 3 MIN			3 - 5 MIN		
			≤ 50 M	> 50 m	fly -overs	≤ 50 M	> 50 m	fly -overs
1	0540	MTCH	" 2	" 2			" 2	
		HETH	" 2					
		MWSP	" 3					
		ROSP				' 1	' 1	
		BEWR	" 2					
2	0552	RTHA	" 5		' 1			' 1
		MTCH	" 2			' 1	' 1	
		RCKI	" 3			' 1		
		RECR		' 1				
		MWSP	' 1					
3	0559	FOSP				" 2		
		HETH	" 3					
		SSHA						' 1
		MWSP	" 2				' 1	

Figure 14—An example of a data form for recording point count data. Birds are recorded separately within or outside a 50-m circle around the observer, and in the first three minutes or later in the

census. The data are recorded as "tick" marks in each box; then later the actual numbers of birds, as derived from the data, are summarized and recorded.

4/17/92

The specific data suggested are as follows:

- State or province—The 2-column code for each.
- Region—An 8-column code, designated by the investigator. Often, the name of the USGS quad, a prominent landmark, or a nearby town will provide the best code name.
- Station—For intensive point counts, we suggest a 4-letter code, the same as that used for the mist net array or nest search plot. For extensive point counts, we suggest a code relating to the general area or road. In general, we expect that a given station will have no more than 50 points.
 - Month, day, and year.
 - Observer
 - Visit number—Indicate how many visits this year will have been made to these points at the end of this day's census.
 - Point Number—The 2-column census point number.
 - Time—Using the 24-hour clock.
 - Species—The 4-letter species code.
 - Tally of individuals—This is a series of five fields. The major subdivisions are those birds detected at less than, and more than, 50 m, and those birds flying over, but not landing within detection of, the observer. Within the two distance categories, observers can separate out those detected in the first three minutes, and the next two minutes. Observers wishing to separate out behavioral, age, or sex categories can note them with an appropriate letter code. Otherwise, "tick" marks (e.g., 3 = ///) can be used.

Repeating the Count

In general, a station should be sampled only once each season. Counts can be repeated if the goal is good estimates of the community at certain, specific points, such as a small area of rare wetland habitat.

The timing of the census of each route should be kept constant from year to year; it should not differ by more than seven days from the date of the first count. If the phenology of the spring differs, then the date can be changed. The start of the count should not differ by more than 30 minutes from that of the first year. If possible, the same observer should census the route every year.

Strip Transects

Strip transects are very similar to point counts, but the observer records all birds seen or heard while traversing each section of a trail. Each section is then the unit of measurement, and can be 100 m or 250 m long. This method is best used in very open terrain where the observer can devote his or her full attention to the birds, and not worry about footing.

In this method the observer should attempt to cover a given amount of trail in a fixed amount of time, e.g., 100 m in ten minutes.

Area Search

Background and Aims

The area search method has been adopted for a nation-wide survey, the Australian Bird Count (Ambrose 1989), and was chosen over several others because of its appeal to volunteers.

It uses a method that, while quantitative, mimics the method that a birder would use while searching for birds in a given area. Essentially this is a series of three 20-minute point counts in which the observer can move around in a somewhat restricted area. In this way unfamiliar calls can be tracked down and quiet birds can be found.

Preparation

The observer should be reasonably familiar with most (if not all) bird species likely to be encountered at the plot. This method allows the observer to track down unfamiliar birds, but walking the plot before a survey with a person familiar with the birds allows the observer to be more efficient.

Choosing a Plot

The plot should allow relatively easy detection and identification of birds (by sight or calls) and allow the observer to move about freely. The plot should be sufficiently large to provide three separate search areas (or plots), each about 3 ha in forest or dense woodland, but larger areas of 10 ha or more can be used in more open habitats. In very dense forest, smaller areas of 1-2 ha can be used. The search areas can have adjoining boundaries or can be in completely separate regions of the plot. More than three search areas can be established within a plot, but the same search areas must be used on each visit.

Time of Day

Because of the intensive nature of this method, it can be carried out longer into the morning than other methods. However, it should continue no later than five hours after dawn.

Field Work

Walk throughout the plot for exactly 20 minutes in each search area, stopping or moving to investigate sightings or calls when appropriate. Record numbers of birds of each species seen, heard, or both seen and heard in the search area during this time. Record birds outside the search area separately, but concentrate on finding as many birds as possible within the plot. The observer may find it easier to tape record observations and then transfer results onto paper soon after the survey. An accompanying person can serve as a recorder. A single survey is completed after at least three areas have been searched at a plot.

Filling in the Form

A standard form is suggested, listing the species found and a running tally of the number of birds, both on and off the area. These tallies can be totaled on the right of each area for each species.

Spot Mapping

Background and Aims

The mapping method is based on the territorial behavior of birds. By marking the locations of observed birds on a detailed map during several visits within a breeding season, it is possible to count the number of territories in an area and estimate the density of birds. Spot mapping is not usually used

as a general method for broad-scale monitoring of breeding landbirds, because it requires more time and field work than single-visit point counts and line transects. However, the method should be applied when fairly precise pair numbers and densities as well as the distribution of territories in small study areas or patchy habitats are to be studied. The standard mapping method is less suitable for species that live in colonies or loose groups, or species with large or no territories.

In general, one or two observers make repeated visits (a minimum of 8) to specific plots during the breeding season. Some habitat analysis is also required. Standard methodology as described by Robbins (I.B.C.C. 1970) is also used by The Cornell Laboratory of Ornithology's (CLO) resident bird counts. The latter program, known as the "Breeding Bird Census" (BBC), is a continent-wide program that welcomes contributors and publishes results of North American plots annually in the *Journal of Field Ornithology*. The CLO also encourages "Winter Bird Population Studies" (WBPS) on the same plot. For more information, write to: CLO, Resident Bird Counts, 159 Sapsucker Woods Road, Ithaca, NY 14850; Telephone (607) 254-2441. The basics of the method are contained in Koskimies and Vaisanen (1991). We present here enough information for a biologist to evaluate the technique. The methods of especially data recording, evaluation, and analysis are complex and detailed.

Equipment and Time Needed

One needs 30-40 copies of a very detailed map (preferably 1:2000, or, in open areas, 1:3000 may be acceptable), a compass, and flagging for marking the area.

The time needed depends on the size and terrain of the census area as well as on bird density, with higher densities requiring the mapping of more individuals. Usually about 10-30 hectares in a wooded area or 50-100 ha in an open area may be counted in one morning. Thus, in forest it takes 10 mornings to census 30 ha by the ordinary 10-visit version of the mapping method (about 50-60 hours of field work). In addition, it can take as many as 40 hours (4 hours per census morning) to prepare the species maps, and about 5-10 hours to analyze them. In total, one could spend as many as 100 hours censusing 30 ha of forest during one breeding season. Marking the 50-by-50-m plot in the field takes about 25 hours before the first census season.

Drawing a Map and Marking the Area

The census area should be as round or square as possible in order to minimize border length, because territories along edges are difficult to analyze. After the area has been chosen, a detailed map (known as a visit map) is drawn of it before the first census. The recommended scale for the map is 1:2000. A survey map (1:20,000) and field experience should be used in drawing. Boundaries of the area and landmarks such as edges between habitats, streams, roads, paths, buildings, big rocks, and trees are marked on the map. There should be enough landmarks on the map so that the observer can locate the positions of birds accurately on the map. One copy of the map

is needed for each visit, and enough copies should be reserved for making the species maps. If there are only a few natural landmarks, a grid of 50-m squares can be established with the corners of the squares marked with plastic flagging with coordinates written on them.

Census Period and Number of Visits

Because of differences in phenology of arrival and nesting, the visits should cover a period long enough to ensure that each species is easily observable on at least three visits. There should be 10 visits in a standard mapping of forest birds. If the bird density is very high and the nesting period of the community is long, 12 visits are recommended. The visits ought to be evenly distributed over the census period. Fewer visits can suffice in open habitats, where bird densities are usually lower than in forests, or where the season is short (e.g., tundra or alpine grasslands).

Time of Day

The main census time is 5 a.m. to 10 a.m. when the birds sing most actively. After a very cold night counting can be delayed. During very warm weather it should be prolonged because of the lower activity of birds. Two visits should be made in the evening: the first in the beginning of the census period (especially for counting thrushes), the second about two or three weeks later (especially for counting nocturnal singers). If there are several nocturnal or dusk-active species breeding in the area, these two censuses should be added to the ordinary program of 10 morning visits, for a total of 12. In northern temperate zones, owls, woodpeckers, and crossbills breed early and should be censused by extra visits in March and April.

Field Work

A clean map is reserved for each visit. Each visit should cover the area as evenly as possible, and no place should be farther from the route than 25 m (dense vegetation or high density of birds), 50 m (sparse vegetation, few birds) or 100 m (open habitats). The route you follow through the plot should be on a grid twice the size of the distances above, for example, 50 m in dense habitat. Successive visits should be started at different points, especially if you think that a part of the area is getting attention at the expense of the rest. Simultaneous observations of two individuals of the same species singing or seen must always be recorded carefully so that birds can still be separated from their neighbors after they have moved, which frequently happens during a census visit.

Even while you are busy censusing, you should not walk very slowly, because then, for example, a bird uttering alarm calls may attract other birds to congregate nearby. Therefore, walk with moderate speed and record the birds all the time. Stop frequently to "hunt" for simultaneous observations of different individuals of the same species, to listen, and to mark the birds on the map. If you are not sure whether there is only one bird or two, you can return to the area censused already to make sure which is the case. In open areas it is often useful to search for the birds with binoculars.

The ordinary speed of censusing is 10-12 min/ha, or 5-6 ha/hour when the bird density is about 300-500 pairs/km². If the density is very high, the censusing speed slows down to 3-4 ha/hour (15-20 min/ha). When the density is very low or only some of the species are being censused early in the spring, one may walk a little more rapidly; however, at least eight minutes should be allowed for each hectare.

There are many advantages to slow and thorough censusing: (1) one can gather simultaneous observations effectively by following the movements of individual birds in different parts of their territories; (2) one can pay special attention to species difficult to detect; and (3) one can search for nests and check those found earlier. All observations are marked on a map using standard codes which are given in the detailed instructions in Koskimies and Vaisanen (1991). All observations are transferred from the field maps to exactly the same locations on the species-specific maps. There should be a separate map for each species.

Other Considerations

Color Banding Individuals

Observer variability can be a great problem in many of the censusing schemes described above (Verner and Milne 1989). The color banding of individuals allows field identification and survival estimates of individuals without recapture and can greatly enhance spot mapping efficiency, the ability to find nests, and basic life history information. Furthermore, it allows more detailed observation of behavior including breeding biology, survival, and foraging ecology. Color-banding and other auxiliary markers must be authorized by the Bird Banding Laboratory.

Methods of Habitat Assessment

Many applications of habitat analysis are in the literature (e.g., Verner and others 1986). It is not our intention to outline what analyses can be done, but to emphasize that, at the least, vegetation information should be taken at each of the stations. Objectives of vegetation assessment can be many, but among the most common are to relate, in one way or another, the changes in bird composition and abundance to differences in vegetation. These vegetation changes can be either changes over time, or differences between habitats. Two adequate, but relatively time-consuming, methods of habitat assessment are those of James and Shugart (1970), used primarily in forested habitats, and Noon (1981). An excellent and rapid method which could be substituted for the method of estimating stand characteristics below is that of MacArthur and MacArthur (1961) which involves estimating foliage density. The technique uses horizontal measurements to estimate density by relating the percentage of a board that is obscured by foliage. This method has been tested and found reliable by Conner and O'Halloran (1986) and Conner (1990).

If managers wish to characterize the interactions of birds and habitat in a region, then some kind of habitat classification with sampling in proportion to the relative abundance of habitat in that region is the optimal design. This sampling, stratified by habitat, should be done with the guidance of a biometrician.

We present two alternatives here. One is that used to type vegetation into broad habitat classifications, as the Constant Efforts Site vegetation assessment technique does, or a more specific one, involving estimation of stand characteristics. We strongly suggest the latter method, as being more useful for monitoring.

Broad Habitat Classification

Objectives—This method provides brief, overall classification of vegetation and a map that allows other investigators to evaluate the habitat of your station. These data should be the minimum collected on vegetation at any monitoring station. If more detailed vegetation data are collected, then this level need not be taken.

Considerations—The information collected should provide enough data to determine the vegetation types. The method will not provide quantitative information for correlative analyses and ordinations.

Procedures—It is best to make a map of the main areas of habitat within the station on a yearly basis, sometime in June. Prepare it on the scale of approximately 1:2000 (approximately 1 foot to a half mile [1 m to 2 km]). Include the major vegetation types, extending it at least 100 meters beyond the outermost net or capture location. Indicate on the map: trails, roads, ditches, streams, marshy areas, net or census points, open water, and broad habitat boundaries. Also on the map should be a reference point identifiable on a U.S. Geological Survey topographic map or equivalent.

Use colored lines to separate habitat types, and record the following on a form:

- Habitat type: broad category such as forest, brush, marsh, field, etc.
- Shrubby vegetation: list the shrub species comprising more than 10 percent cover in order of their percent cover in each type.
- Trees: list the tree species comprising more than 10 percent cover in order of their percent cover in each type.
- Height of vegetation: record the approximate average height of the canopy of forest or brush to the nearest meter.
- Ground layer: describe the vegetation of the ground layer in terms of the common name of the main species groups present, e.g., ungrazed grass, bare ground with nettle, rushes, etc.
- For wet areas: indicate the water depth in June, or for temporary ponds and streams, give the period that water was present.

Estimation of Stand Characteristics

Objectives—This is a system for assessing habitat characteristics in an efficient and timely fashion at vertebrate

monitoring stations. It is taken from a method developed by Bruce Bingham and C.J. Ralph.

Considerations—The information collected will provide enough data to determine the vegetation formation, association, and major structural characteristics. The types of data are those which have some logical relationship with bird requirements for feeding or nesting. The method provides enough quantitative information for correlative analyses and ordinations. It is flexible so that it can be applied to any vegetation formation, including deserts, grasslands, and forests.

Procedures—Establish a releve, a variable radius plot centered, for example, on a census point. The size of the plot will vary, depending on the homogeneity of the vegetation composition, and the density of the vegetation. Generally, this would be a radius of less than 50 m, and often about 25 m. Walk around the point for no more than 5-10 minutes, or until you stop adding new species, whichever is less. Once the search is stopped, the distance from the stopping point, or the outermost boundary of vegetation that the observer can see from the point center, is the radius of the plot and is treated as a boundary for estimating relative abundance.

If the point has more than one vegetation type, then establish two releves. An example would be along a road, with a clear cut on one side, and a mature forest on the other. No more than two releves should be established at a point.

Determine the number of major layers of vegetation within your releve by their dominant growth form: tree layer (T), shrub layer (S), herb (H), and the ground cover (moss and lichen) layer (G).

In a forest with all layers, the tree layer is the uppermost stratum, dominated by mature trees. It may be a single layer, or consist of two or more sublayers recognizable by changes in density and canopy status (see below). The shrub layer is dominated by shrubs or small trees. The herb layer is dominated by low-growing plants, typically nonwoody, although seedlings and other reproduction of trees and shrubs may be present. The ground layer is dominated by such plants as mosses, lichens, and liverworts. Bare ground and litter are ignored for this classification scheme.

We recommend the use of the following height classes for each stratum, if they are appropriate, because they can make the process less subjective. For example, the tree layer could include any plants taller than 5 m (In shorter forests, this might be lowered to 3 or 4 m, as appropriate). The shrub layer could then be established at between 50 cm to 5 m. The herb layer includes any plants less than 50 cm tall. The moss/lichen layer refers to a ground-appressed, low carpet, less than 10 cm high.

For purposes of bird-habitat association, only species of trees and shrubs need be identified and recorded in the data below. For other plants, a common name such as FERN, HERB, MOSS, or LICH will suffice for most purposes. Plant ecologists have used some species in the herb or ground cover layers as indicative of a particular plant association. In this case, the species should be recorded.

Determine the average height of each major layer present and dominant plant species. It is desirable to have additional

information on structure, such as the maximum and minimum d.b.h. of canopy trees and total percent cover value of each layer.

Determine relative importance of species in each layer present. Importance can be expressed as either abundance or cover. Percent cover is probably the most common, and we suggest using it.

Below is a detailed description of the data we suggest be taken and recorded as on *figure 15*. The data are separated into Location Data and Vegetation Data.

Location Data:

State or province—The 2-column code for each.

Region—An 8-column code, designated by the investigator.

Often, the name of the USGS quad, a prominent landmark, or a nearby town will provide the best code name.

Site data.

- Latitude and longitude—For each point, latitude and longitude should be recorded as the southeast corner of the 1-minute block containing the point, as determined from accurate topographic maps. For example, 40°53'20"N, 124°08'45"W would be reduced to 4053-12408.

- Elevation to nearest meter, by using an altimeter.

- Aspect of the slope (the compass direction the observer faces when looking down hill) to the nearest degree, with a compass.

- Percent slope, with a clinometer.

- Presence (+) or absence (-) of water within the releve.

- Plot radius, distance from the center to the edge of the releve.

Vegetation Data:

Vegetation Structure and Composition

- Total cover—Estimate the cover of each of the four layers, according to the established scale such as Braun-Blanquet (Mueller-Dombois and Ellenberg 1974) or Daubenmire (1968). We recommend the Braun-Blanquet Cover Abundance Scale, which is: 5 = >75 percent cover; 4 = 50-75 percent cover; 3 = 25-50 percent cover; 2 = 5-25 percent cover; 1 = numerous, but less than 5 percent cover, or scattered, with cover up to 5 percent; + = few, with small cover; and r = rare, solitary, with small cover.

- Height—Record to the nearest decimeter (0.1 m) the *average* height of the lower and upper bounds of each of the four layers.

- Species—Record the species by a 4-letter code (using the first two letters of the genus and the first two of the species) with the greatest cover (foliage or crown cover) within each layer's boundary.

- D.b.h.—For each layer where trees are present, record the diameter at breast height to the nearest centimeter of the largest tree in the layer and also for the smallest trees.

- Species—Record the species of trees used for minimum and maximum d.b.h. measurements

- Number of sublayers—Sublayers are useful to give the plant ecologist a quick overview of the structure of a layer, and

are primarily relevant to the tree layer, although sometimes seen in the shrub layer. Record the number of sublayers visible in each primary layer. Record “1” if the layer is uniform and “2” or more if more than a single layer is divided into sublayers. In a primary layer, sublayers are sometimes obvious because of one or more species with shorter heights than the dominant species of the upper portion of the layer. In addition, sublayers are sometimes formed by cohorts of one or more size classes, possibly related to some event. For example, the tallest trees in a stand may form an open (low-density) layer of emergent individuals. Beneath that may be a denser layer of trees forming the main body of the tree layer. Below this denser layer may be another open or closed layer of trees that are intermediate to the main body of the canopy. This layer may consist of shade tolerant species or reproduction. Biologists should be cautioned that extreme precision is not required for this estimation, and unless sublayers are very obvious, they should not be recorded.

Species composition data

- **Sublayer**—For layers where sublayers have been recognized, record the sublayers with a letter designating the primary layer, followed by a number (e.g., T1, T2, T3, S1, etc.), indicating the sublayers by decreasing heights.

- **Cover or cover abundance value**, as above, using the Braun-Blanquet method—Because of the difficulty of determining crown covers independently for species of trees in a canopy, sometimes basal area cover of stems (trunks) has been used for tree layer species and crown cover for species in other layers. We suggest the cover abundance value for consistency.

- **Species**—Record the species’ name for each plant species making up at least 10 percent of the cover.

Additional/optional information can be integrated into the method, if desired:

Snags: list layers with snags present; separate into those with a d.b.h. of less than 10 cm and those larger.

Logs: list those less than 10 cm diameter at large end by abundance or cover class, and those greater than 10 cm.

Comments—This type of vegetation assessment is limited by the size of the plot and the amount of estimation required. For example, a plot of even 50 m in radius obviously does not include all vegetation inhabited by birds heard or seen from a census point. This would require a plot of 200 m or more radius. However, most birds detected at a point are within 100 m, and many are within 50 m. Further, time limitations would require much more time spent monitoring vegetation than spent counting birds.

When observers are required to estimate, a substantial amount of error is introduced. What effect the degree of observer error likely with estimation would have on conclusions should be established. The principal source of error in this method of vegetation assessment is the determination of percent cover and heights. Intensive training can moderate this source of error, enabling each vegetation assessment to be placed into at least broad categories or plant associations.

Weather Monitoring

We suggest the following weather measurements three times per day, at the beginning, midpoint, and end of the census or capture period in a day. The maximum high and low temperature from each 24-hr period should also be recorded. Data from nearby weather stations may also be used. However, some measurements from the immediate area are more valuable.

- **Weather**—Use RAIN, DRIZZLE, SLEET, SNOW, or FOG. (If it is raining and foggy, put down RAIN.) If the above conditions do not apply, use: OVC (overcast), more than 90 percent cloud cover over entire sky; BRK (broken), 50-90 percent cloud cover; SCT (scattered), 10-50 percent cloud cover; or CLR (clear), less than 10 percent cloud cover.

- **Wind Direction**—Using an anemometer, stand facing into the wind and record the direction to the nearest 1/16th of the compass, i.e., N, NNE, NE, etc. If winds are variable, record predominate direction.

- **Wind Speed**—Record both the average and maximum speeds.

- **Visibility**—Estimate visibility to the nearest 250 m if less than 2 km, otherwise to the nearest kilometer.

- **Barometric pressure.**

- **Temperature**—Dry bulb temperature. Record to the nearest 1 degree centigrade.

- **Relative humidity.**

- **Rain**—Record from a rain gauge to nearest 0.1 mm.

We suggest a continuous strip chart recorder to measure temperature and a somewhat permanent station to measure rainfall.

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