Landowner Incentive Program

California Bird Species of Special Concern in the Central Valley and Decision Support Tools

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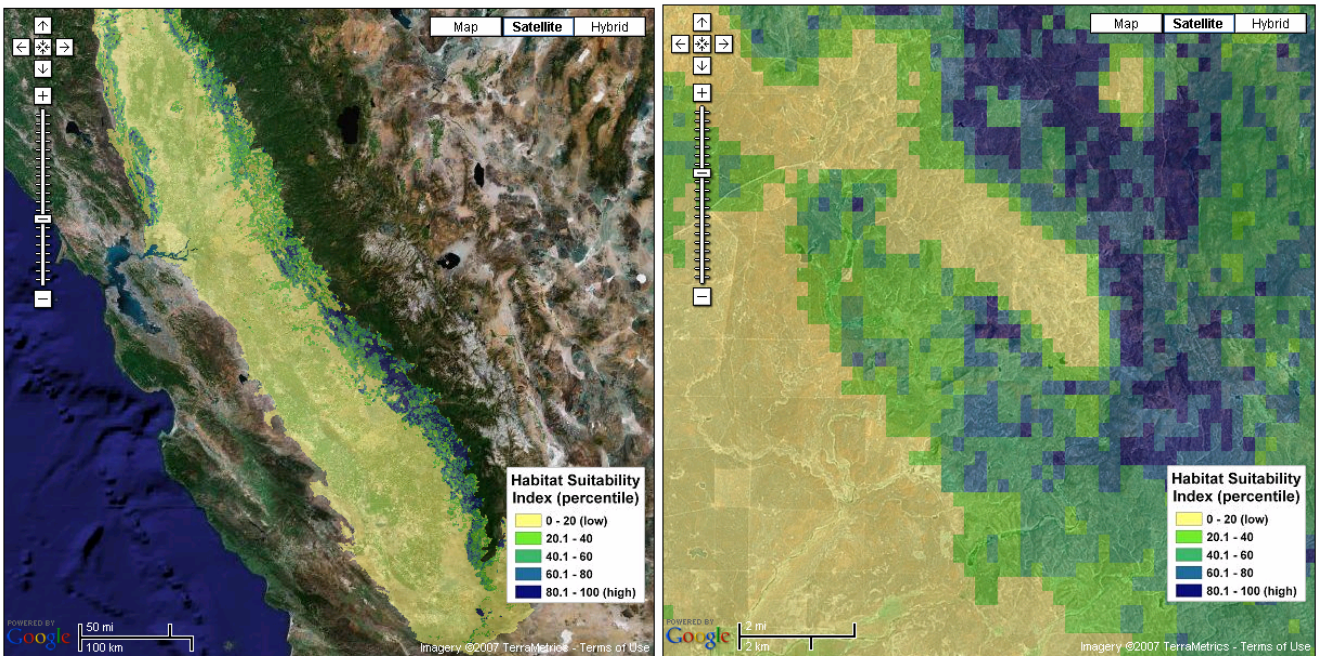

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EXECUTIVE SUMMARY

An objective of the current California Landowner Incentive Program (LIP) is to expand priorities for privately owned habitat in the Central Valley from investments primarily in seasonal wetlands to include semi-permanent and permanent wetlands, riparian, native grassland, and other upland habitats. The LIP thereby provides a unique opportunity to restore and enhance populations of over 27 Bird Species of Special Concern (BSSC) and other special-status species in California's Central Valley. To assist LIP landowners and managers with habitat restoration and enhancement decisions, we developed a suite of biologically based decision support tools (DST) that will increase the effectiveness of project selection and "on the ground" habitat improvements for these and other species. Because biological and/or spatial data are lacking for many special-status species, we included California Partners in Flight (CalPIF) 'focal species' from three of the most common habitat types in the Central Valley (riparian, oak woodland, and grassland). Using the best available avian occurrence and spatial habitat data, we developed spatial models for bird species distributions and basin-specific estimates of current and potential species densities for selected BSSC and CalPIF focal species. Also included in the DST are current distribution maps for BSSC, habitat management recommendations, and conservation actions specific to BSSC in the Central Valley of California. These data form the basis of a new password-protected, interactive website (www.prbo.org/cadc/lip) that can spatially guide conservation actions to help make the Central Valley 'great' again.

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CHAPTER 1. CALIFORNIA BIRD SPECIES OF SPECIAL CONCERN IN THE CENTRAL VALLEY

Background and Introduction

California supports exceptional biodiversity because of its large size, diverse habitats and environmental heterogeneity, and relative isolation from the rest of the continent (Stein et al. 2000, Stein 2002). In terms of its flora and fauna, California leads the nation in overall species richness, number of state endemics, and rare species. Along with the possession of such a rich and diverse bird fauna comes the responsibility for its conservation. Californians must overcome daunting problems to maintain the state's biodiversity in the face of severe and ongoing habitat loss and degradation, which has led to population declines of many native species. California's Bird Species of Special Concern (BSSC) list is one of several tools that can be used to help meet stewardship responsibility for the state's incredible birdlife, and the habitat it depends on, and to foster conservation of its at-risk birds.

The BSSC list was first published in 1978 by California Department of Fish and Game (CDFG) and has been revised two times since (see CDFG 1992), with the most recent revision being the most substantial. In this most recent permutation, the California BSSC list is based on a scientifically defensible and repeatable method to set objective standards for inclusion of birds on the list, for assigning them to different levels of conservation priority, and for forming the basis for assigning them research priority. The revision also incorporated over twenty years of data to enable identification of currently declining or vulnerable birds that may warrant listing as state threatened or endangered if present trends continue. For a definition of a BSSC as well as detailed explanation of variables considered for listing and special status categorization, see Shuford and Gardali *in press*.

As a regulatory tool, the special concern list is intended to guide state, federal, and local governments in defining the "sensitive" species under the California Environmental Quality Act (CEQA) for which analysis of project impacts is required. The special concern list is also meant to stimulate further research, conservation actions, and prevent future listing under state and federal endangered species acts.

For ease of access to BSSC 2006 information and recommendations that are relevant to future Landowner Incentive Program (LIP) planning efforts in the Central Valley, we have

synthesized threats and habitat recommendations for each species regularly occurring in the Valley. These are grouped by general habitat type (Table 1) and are derived primarily from individually authored species accounts. We also include brief summary information for other special status species regularly occurring in the Central Valley, specifically those federally or state listed, on the U.S. Fish and Wildlife Service's (USFWS) list of Birds of Conservation Concern 2002 (USFWS 2002), or on The International Union for the Conservation of Nature and Natural Resources' (IUCN) Red List (see Table 2 for full list). The species highlighted in this document are those that we believe have great potential to benefit from targeted conservation activities of private lands habitat programs.

Needs and Challenges

Estimates indicate that California has lost over 90% of its original wetlands (Dahl et al. 1991), 95% of its riparian habitat (RHJV 2004), and 60% of its grasslands (CPIF 2000). Although biologists frequently emphasize these high rates, the percentages hide the true extent and complexity of the loss both in terms of structure and function. Habitat degradation and fragmentation can also have profound effects on biodiversity (Saunders et al. 1991, Debinski and Holt 2000). Severity of threats affecting BSSC taxa are listed in Table 3.

Among the greatest losses of ecosystem function affecting birds in California is that of natural hydrology, which before human intervention greatly enhanced biological productivity both in space and time. The periodic flooding of areas such as the Central Valley formerly formed a diverse mosaic of permanent and ephemeral wetland and riparian habitats that depended on such perturbations for renewal (Rosenberg et al. 1991, Shuford et al. 2001). Restoring natural functions to such habitats will be among the greatest conservation challenges in the state, though models exist for ways to meet human needs and also conserve the ecological integrity of riverine ecosystems (Richter and Richter 2000).

The conservation of biodiversity in California faces great challenges because regions of the state with high numbers of special concern taxa also have the highest human population densities and projected future growth rates. In the Central Valley, projected growth will be particularly high in the Sacramento-Yolo county area, qualifying it as a "hotspot of vulnerability," i.e., an area with both restricted-range species and high projected rates of human population growth and development (Abbitt et al. 2000). Likewise, urbanization continues to

reduce agricultural lands in the Central Valley at a rate among the highest in North America (American Farmland Trust 1995, Sorensen et al. 1997).

Protection, restoration, and enhancement of habitats for at-risk species will of necessity take a multi-faceted approach. A high priority should be placed on protecting natural processes and species, subspecies, and distinct populations that are nearing endangerment because of declining populations or vulnerability to threats. The identification of such taxa by California's BSSC 2006 list provides a starting point from which to work regardless of the method of protection selected. Success will be enhanced if efforts are intensified before populations decline further and if they emphasize voluntary rather than regulatory measures. Such methods include public and private land acquisition, conservation easements, tax incentives, and cost-share programs for habitat enhancement (Bean 2000). Cooperative and proactive efforts among agencies and other groups and between habitat managers and scientists tend to be the most effective in sensitive species protection (Squires et al. 1998).

Management Recommendations

Except where noted, the following management recommendations are derived from the California BSSC 2006 species accounts (Shuford and Gardali in press).

WETLANDS

Fulvous Whistling-Duck (Fig. 1; figures begin on page 42**)**

This species is currently so rare (and irregular) in the San Joaquin Valley that it will be challenging to manage effectively for it on private lands in that region.

- Protect occupied and potentially suitable nesting and foraging areas and restore or create additional habitat. Requirements are freshwater marshes with dense stands of emergent vegetation and open-water areas with floating aquatic plants.
- Maintain water in semi-permanent wetlands until at least mid-August to accommodate this late-nesting species.
- Consider flooding additional wetlands in the San Joaquin Valley, particularly on federal and state refuges, through the spring and summer, while identifying and preserving areas suitable for foraging and nesting.
- Investigate the feasibility of implement Peters' (2000) proposal to transplant Fulvous

Whistling-Ducks from Louisiana to sites in the San Joaquin Valley over a three-year period, after determining the best potential release sites. Future management of such sites should emphasize the actions specified above that promote the maintenance of viable whistling-duck populations into the future.

Tule Greater White-fronted Goose (Fig. 2)

- Protect or enhance relatively deep marshes dominated by tules and bulrushes (*Scirpus* spp.) and cattails (*Typha* spp.) in the known range of the tule greater white-fronted goose in the Sacramento Valley. Protect areas with a mosaic of harvested rice fields, used early in fall and during hunting season (late Oct-late Jan), and winter-flooded uplands and marshes with an abundance of Alkali Bulrush (*Scirpus robustus*) and some open water, used later in the season.
- Provide some open water ponds with some emergent vegetation where Tule Geese can roost and loaf.
- Identify additional habitat outside the federal and state refuges for possible protection.
- Continue restrictive hunting regulations in the core wintering range with mid-December closures until the population levels and trends are better known.

Redhead (Fig. 3)

- Where feasible, increase the extent of permanent and semi-permanent, deep-water (>1 m) marshes to provide suitable Redhead breeding habitat. Optimally, such wetlands should be >0.4 ha in extent and offer a mosaic of about 75% open water interspersed with dense emergent vegetation.
- Work for allocation of adequate water supplies to allow for management of suitable wetlands; use state and federal incentive programs to promote permanent and semi-permanent wetlands on private lands.

American White Pelican (Fig. 4)

Because this species has not bred in the Central Valley since the early 1950s, it would take extraordinary efforts to restore isolated, fish-productive wetlands of sufficient size to reestablish a nesting colony in this region. Still, restoration or enhancement of large wetlands might benefit pelicans in the region during winter and migration.

Least Bittern (Fig. 5)

- Preserve, protect, and improve shallow marshes (>10 ha in size) that contain dense emergent vegetation.
- Protect existing patches of habitat used by Least Bitterns at sites identified as occupied habitat on the basis of recent records or future monitoring efforts.
- Manage summer wetlands to increase the availability of suitable bittern habitat by extending, where feasible, the current four-year cycle for refuge marsh management to one of about seven years.
- Minimize disturbance to Least Bitterns during their nesting season.

Snowy Plover (Fig. 6)

- Focus on protecting and enhancing important breeding sites by first determining source areas for the overall population that produce young above the levels needed to replace adult mortality. In the meantime, protect or enhance all sites that currently support at least five pairs of breeding plovers and evaluate the feasibility of enhancing habitat at sites holding fewer pairs.
- Ensure that breeding areas receive adequate high-quality water (lacking high levels of contaminants or selenium) and that water diversions do not eliminate or degrade important nesting habitats.
- Protect, enhance, or restore habitats that may be negatively impacted or threatened by water management practices, such as spring draw downs that remove foraging areas needed by breeding plovers.
- Ensure that regional efforts to restore wetlands in the southern San Joaquin Valley include creation of some playa lake habitats suitable for plovers, not just freshwater wetlands.
- Protect key stopover and wintering areas for Snowy Plovers, such as San Joaquin Valley evaporation ponds, or provide suitable alternative habitat nearby using water with low selenimum concentrations.

Black Tern (Fig. 7)

- Focus on restoring, enhancing, and providing long-term protection for suitable early successional wetlands and on maintaining isolation of colonies from humans and ground predators.
- Consider eliminating early-season draw downs in rice fields to reduce the likelihood of predation of tern nests.
- Consider enhancing tern habitat primarily in years of exceptional runoff, when it will do the most good, thereby exploiting the tendency of seabirds to exhibit boom and bust cycles of productivity. In such years, try to increase limited breeding on newly restored wetlands on refuges near Los Banos by spreading water over larger areas within the Eastside Bypass near Los Banos and the James Bypass/Fresno Slough south of Mendota Wildlife Area or by drawing water from upstream, circulating it through refuge ponds, and draining it back into the bypass downstream. Maintain a slow but steady flow to reduce the chances of botulism.
- When possible, flood fields containing residual vegetation or crop stubble for use as breeding habitat. Explore retiring fields with marginal crop yields and putting them in a conservation bank to be flooded when water is available. Weigh such flooding against possible mortality of waterbirds from botulism disease outbreaks, which might be reduced by rotating fields to be flooded and choosing areas with no prior evidence of disease.

Modesto Song Sparrow (Fig. 8)

- Protect and create suitable emergent freshwater marshes dominated by tules (*Scirpus* spp.) and cattails (*Typha* spp.), early successional riparian willow (*Salix* spp.) thickets, young Valley Oak (*Quercus lobata*) forests with a sufficient understory of blackberry (*Rubus* spp.), and vegetated irrigation canals and levees.
- To counteract the sparrows' low dispersal capabilities, create new habitat close to currently occupied habitat.
- If possible, implement measures to reduce predation and parasitism of nests such as increasing plant understory volume.
- Focus management and restoration efforts primarily on identifying and maintaining source populations capable of producing young in excess of adult mortality.

Yellow-headed Blackbird (Fig. 9)

- Protect large, deep-water marshes, particularly those managed with water depth of at least 30 cm under emergent stands of *Typha* or *Scirpus*.
- Focus on the enhancement and restoration of suitable wetlands for breeding, particularly within important historical nesting areas such as the Tulare Basin.
- Manage deepwater marshes to increase or maintain sufficient habitat edges and patchiness important for nest sites.

WETLANDS AND GRASSLANDS

Northern Harrier (Fig. 10)

- Maintain a mosaic of large undisturbed habitats for nesting and foraging, particularly those with an abundant prey base, e.g., freshwater marshes, abandoned fields, active alfalfa fields, wet grasslands, and fields with dense green and residual vegetation.
- Minimize human disturbance near nesting areas, restricting public access as necessary during the breeding season.
- Reduce livestock impacts on nesting success by limiting their access to harrier nesting areas, especially during the breeding season.
- Practice rest-rotational range management, leaving some sections idle each year.
- Delay haying and plowing when possible until after nestlings have fledged (~ mid July).
- Avoid raising wetland water levels during the nesting season to prevent flooding nests of harriers and other ground-nesting species.

Lesser Sandhill Crane (Fig. 11)

The following recommendations will also benefit the Greater Sandhill Crane (G. c. tabida), a state threatened species. However, Greaters are more constrained by distance of foraging sites from their roost sites (Ivey and Herziger 2003) - on average traveling less than 2 miles to forage. For specific locations of conservation priority in regions of the Central Valley, see Ivey 2005. Additionally, CDFG is required to implement a Greater Sandhill Crane Recovery Strategy and Pilot Program by 2009.

- Protect and enhance favorable grain crops and provide unharvested corn and milo plots on

federal, state, and other conservation lands used by Lesser Sandhill Cranes in the Central Valley. Consider purchase or easements on major feeding areas in Merced, San Joaquin, and other counties where major crane use areas are discovered or established.

- Encourage farmers to delay discing grain crop stubble until after February, as deep discing buries waste grains.
- Similarly, encourage farmers and wildlife agency personnel to delay burning or flooding of grain stubble until late February.
- Encourage management of row crops to provide nut sedge, a highly desired food resource in row crops, in the fall and winter.
- Protect and enhance shallow, sparsely vegetated wetlands within 2-4 km of major crane feeding areas to provide favorable roosting and loafing sites.
- Minimize disturbance to crane roosting and foraging habitats and prioritize sites with minimal or no disturbance for conservation efforts.
- Limit all hunting activities within 0.4 km of crane roost sites and other use areas, and, where possible, restrict human access.
- Manage 20%-40% of grasslands in major crane use areas with cattle grazing to provide foraging sites for cranes.
- To avoid collisions, reroute any utility corridor proposed through crane use areas.

Short-eared Owl (Fig. 12)

Management for voles or other cyclic prey needed by these owls may take experimentation and hence may be difficult to implement on private lands in the short term.

- Protect freshwater marshes and grasslands.
- Implement and monitor management practices on wildlife refuges and agricultural lands that are conducive to both vole and Short-eared Owl productivity, realizing that, because of the cycles of both, obvious benefits may not be realized every year.
- Maintain a mosaic of habitats with lush herbaceous vegetation, including sufficient areas of weedy abandoned fields and wet grasslands; as appropriate, leave some areas ungrazed.
- Implement predator control programs where necessary, particularly to eliminate non-native ground predators such as the Red Fox.
- Avoid flooding fields or wetlands where owls are known or suspected to be nesting.

- Encourage rest-rotational schemes on cattle-grazed or agricultural fields that leave some land in lush herbaceous vegetation each spring.
- Minimize hay mowing and crop harvesting during the breeding season (particularly March-May) in fields that have sufficient cover (30-60 cm high) to support breeding owls, or mow around known nests if they are found.

Tricolored Blackbird (Fig. 13)

In addition to the management recommendations from the BSSC, a "Conservation Strategy for the Tricolored Blackbird" document has been produced by the Tricolored Blackbird Working Group (2007). More detailed recommendations are included in that report, which should be consulted to direct conservation action.

- Restore habitat by promoting the growth of secure nesting substrates (e.g., nettles, thistles, and other naturally armored native plants) near productive foraging habitats to increase the potential carrying capacity for this species. Restored nesting habitats should be situated on protected public and private lands, especially in agricultural areas of the Central Valley and surrounding foothills.
- On refuges and other public lands that support Tricolored Blackbird colonies in irrigated pastures, manage irrigation to permit a sequential flooding regime in adjacent land parcels at the time they are breeding to enhance insect productivity. Incorporate carefully managed grazing of these parcels to maintain an average vegetation height of 15 cm to provide optimal Tricolored Blackbird foraging habitat.
- Lure nesting Tricolored Blackbirds, when possible, away from dairies and other agricultural operations to secure habitats where they are more likely to succeed; where colonies establish, defer harvest of grain and silage crops, if feasible, until after the breeding season.

GRASSLANDS

Mountain Plover (Fig. 14)

- Protect traditional wintering sites and high-quality wintering habitat from urban development and other incompatible land use changes by securing conservation easements and property acquisition as part of regional conservation planning efforts. Prime sites are short-grass prairie habitats, or their equivalents, that are flat and nearly devoid of vegetation; in winter

these include fallow, heavily grazed, or recently burned sites.

- Manage grassland habitat, where possible, to maintain low stature and cover of grass. Time controlled burns to accommodate mid-winter Mountain Plover use.

Burrowing Owl (Fig. 15)

The following recommendations pertinent to non-breeding habitat also would likely benefit Ferruginous Hawk – an IUCN "near threatened" species:

- Place sizeable tracts of grassland under conservation easements or agreements with agricultural (grazing) operations to maintain populations through best management practices, such as the elimination or restriction of small mammal poisoning.
- Conservation agreements should also be sought with landowners of row crop agriculture, to encourage appropriate management of water conveyance structures, roadsides, and field margins. It will be necessary to work closely with landowners to alleviate concerns that maintaining owls on their property is a liability in terms of flexibility in land management practices necessary to maintain economic viability.
- Maintain suitable vegetation structure through mowing, revegetate with low-growing and less dense native plants, or controlled grazing, as appropriate.
- Where nesting burrows are lacking, enhance habitat by using artificial burrows or encouraging the presence of ground squirrels.
- Control off-road vehicles and unleashed pets within occupied Burrowing Owl habitat.
- Develop prescriptions that mimic natural processes and that preferably do not require ongoing management for maintaining Burrowing Owls.

Oregon Vesper Sparrow (Fig. 16)

- Preserve grassland areas known to support high numbers of Vesper Sparrows in winter, using purchase, easements, and incentives as necessary or possible. Prime areas typically have open ground with little vegetation or are grown to short grass and low annuals; these include stubble fields, meadows, and road edges.

Grasshopper Sparrow (Fig. 17)

Because this species is extirpated as a breeding bird in the southern San Joaquin Valley, and generally is a very rare and local breeder in grasslands in the rest of the Central Valley, it

likely will be difficult to manage for it on private lands in California until future research can identify the characteristics of grassland that are needed to support this species in this region.

- Protect or restore large tracts of short to middle-height, moderately open grasslands with scattered shrubs.
- Negotiate conservation agreements (allowing limited grazing, for example, but preserving grassland) or favorable zoning on private land.
- Redirect urbanization away from native and non-native grasslands.
- Manage as native grassland significant tracts of Grasshopper Sparrow habitat that come into public ownership.
- Minimize or prevent disturbance of the ground surface in native grassland, as this favors exotic weeds at the expense of native grasses. Develop means for restoring native grassland.

GRASSLANDS AND RIPARIAN HABITAT

Swainson's Hawk (from Woodbridge 1998)

The primary management issues currently facing Swainson's Hawks in California are: 1) loss of preferred nesting habitat in mature riparian forest; 2) loss or adverse modification of high-quality foraging habitat to development or conversion to incompatible crop types; and 3) high mortality due to pesticide use on migration route and wintering areas. Over 95% of the known nest sites are on private lands and are vulnerable to changes in the agricultural environment and development. The Swainson's Hawk Technical Advisory Committee (SWTAC) has been particularly active in the three primary Swainson's Hawk population centers in the Central Valley – Sacramento, San Joaquin, and Yolo counties. The SWTAC is currently developing a recovery plan for the species, which should provide more specific habitat management recommendations for the Valley. In the interim, general recommendations include:

- Ensure the availability of suitable nesting and foraging habitat through preservation of riparian systems and groves of, or lone, mature trees in agricultural fields.
- Maintain compatible agricultural practices in grasslands, pastures, and croplands.
- Optimize adjacency of the above two elements.
- Protection and restoration of riparian forests may provide nesting habitat superior to other sources of trees such as roadsides and field margins.

- Protection and restoration of riparian systems even along smaller drainages (e.g., Willow Slough – Woodland, and Red Bridge Slough – Vernalis) would provide numerous nesting opportunities.
- Provide incentives for Swainson's Hawk friendly agricultural practices (e.g., maintain fallow lands, lightly grazed pastures) or to grow specific crops (e.g., alfalfa and other hay crops) vs. unsuitable crops (e.g., vineyards, orchards, and cotton).

RIPARIAN HABITAT

Yellow-breasted Chat (Fig. 18)

- Preserve existing, and restore degraded, riparian habitat, particularly early successional habitats, with a well-developed shrub layer and an open tree canopy, that are restricted to the narrow border of streams, creeks, sloughs, and rivers.
- Manage riparian habitat to maintain and/or promote a dense shrub layer; install a shrub layer in the early stages of restoration projects.
- Time removal of exotic plants from riparian areas used by nesting chats to avoid disturbance during breeding(April-August), and proceed only after careful assessment and mitigation for any potential detrimental effects to chats.

Yellow Warbler (Fig. 19)

- Protect, manage, and restore dynamic riparian systems that provide the mechanisms (e.g., seasonal flooding) to create early successional as well as more structurally complex vegetative components (e.g., herbaceous cover, shrub cover, and riparian tree canopy).
- Eliminate or manage cowbird feeding sites near Yellow Warbler breeding habitat.
- Cowbird trapping may be a viable option to aid warblers in some areas, but criteria outlined by experts (Smith 1999, NACAC 2003) should be met prior to the initiation of any trapping program.

Yellow-billed Cuckoo (from Laymon 1998)

- All existing habitat should be preserved regardless of present habitat quality, and low quality habitat should be enhanced to reach suitable or optimal levels.
- Sites capable of producing optimal habitat should receive highest priority for restoration.

- The best habitats for nesting are at large sites with high canopy cover and foliage volume, and moderately large and tall trees. Specifically:
    - ✓ Sites >80 ha in extent and wider than 600 m are optimal habitat. Sites 41-80 ha in extent and wider than 200 m are suitable, and sites 20-40 ha and 100-200 m-wide are marginal.
    - ✓ Sites with greater than 65% tree canopy closure are optimal. Sites with 40-65% are marginal to suitable.
    - ✓ Sites with foliage volume from 30,000 m3/ha to 90,000 m3/ha are optimal. Sites with 20,000 m3/ha to 30,000 m3/ha, and over 90,000 m3/ha are suitable.
    - ✓ Sites with mean canopy height 7-10 m may be optimal. Sites with mean canopy height from 4-7 m and from 10-15 m appear to be suitable.
    - ✓ Nest sites with basal area (cross-sectional area of all the trees at breast height per hectare of forest) between 5 m2/ha and 20 m2/ha appear to be optimal. Sites with basal area 20 m2/ha to 55 m2/ha are suitable. Sites with basal area less than 5 m2/ha and greater than 55 m2/ha are marginal.
- Restoration efforts should be concentrated in areas adjacent to existing habitat patches, or in areas of sufficient extent to create comparatively larger tracts of habitat.
- Restoration efforts in the southern portion of the nesting range should be higher priority (e.g., South Fork of the Kern River) but northern sites also essential (e.g., Sacramento River from Red Bluff to Colusa; RHJV 2000).
- Restore and protect adjacent upland refugia habitats for foraging in wet years, as primary prey species hibernate underground and are not available in wet years with late spring flooding.

Least Bell's Vireo

This species is currently so rare (perhaps only a single pair) in the Central Valley that it may be extremely difficult to manage effectively for it on private lands in that region. However, riparian habitat restoration has the potential to increase the vireo population and further expansion into the Valley. Least Bell's Vireos prefer early successional riparian areas (RHJV 2000).

Bank Swallow (from Garrison 1998)

A recovery plan has been written for the Bank Swallow in California (Schlorff 1992). The most significant management issue affecting the Bank Swallow in California is the direct loss of suitable colony sites through bank protection and flood control projects, particularly on the Sacramento River (Garrison et al. 1987).

- Conservation of extensive amounts of suitable nesting sites throughout large areas is important for success.
- Integrating Bank Swallow habitat protection with larger scale riparian ecosystem conservation efforts is promising.
- Cycles of flooding and erosion should be allowed to continue in as naturally cycle as possible.
- Local breeding populations benefit greatly from annual erosion to create new nesting habitat and maintenance of suitable banks, cliffs, and bluffs where nesting colonies already occur.
- Artificial habitat enhancement is not very cost-effective and may not be necessary in areas where considerable amounts of suitable habitat exist.

RIPARIAN AND OAK WOODLAND

Long-eared Owl (Fig. 20)

Because this species has declined and is now a very scarce and irregular breeder in the Central Valley, it likely will prove difficult currently to effectively manage for this species on private lands. As with Short-eared Owls, management for voles or other cyclic prey needed by Long-eared Owls may take experimentation and hence may be difficult to implement on private lands in the short term.

- Protect and enhance riparian forests and oak woodlands adjacent to grasslands, meadows, or shrublands, particularly areas of known breeding occurrence with suitable adjacent foraging habitat giving special attention to appropriate vegetative cover and configuration and considering the surrounding landscape out to 3 km from core nesting areas.

Purple Martin (Fig. 21)

Before the arrival and increase of European Starlings, fierce competitors for nest cavities, Purple Martins formerly nested in buildings and riparian habitats from Stockton in the

Delta north through the Sacramento Valley. Martins now breed in this region only in the city of Sacramento, where they have persisted by nesting in hollow-box bridges. Hence, management for martins in this region is likely to be effective only by protecting, enhancing, or creating artificial nesting sites.

- Protect occupied and suitable bridge sites from uses that restrict air space and martin access or that cause excessive human disturbance.
- Establish nest box programs to diversify nesting habitats where nest-site competition threatens or has eliminated martins and where commitment to long-term management is certain. Do not foster complete conversion to nest boxes for populations that are successfully nesting in trees, bridges, or power poles.

SHRUBLANDS

Loggerhead Shrike (Fig. 22)

- Maintain and increase suitable breeding habitat of shrublands or open woodlands with tall shrubs or trees (also fences) for hunting perches; open areas of short grasses, forbs, or bare ground for prey capture; and large shrubs or trees for nest placement.
- Continue efforts to curb conversion of native shrub habitats to exotic plant communities or agricultural fields.

San Joaquin Le Conte's Thrasher (Fig. 23)

- Protect and maintain all existing Le Conte's Thrasher habitats in the San Joaquin Valley. These typically are on gentle to rolling, well-drained slopes bisected with dry washes, conditions found most often on bajadas or alluvial fans. Occupied habitats are generally moderately to sparsely-vegetated by saltbush with bare ground or patches of sparse low-growing grass. Foraging areas are well-drained and have extensive bare ground and a well-developed litter layer near shrubs; nesting areas require at least a few larger, dense shrubs for nest placement.
- Target habitat restoration toward lost or degraded sites, particularly saltbush habitat in large areas destroyed by fire (e.g., Lokern Natural Area).
- Create habitat corridors within and among subpopulations.
- Maintain, at a minimum, corridors of intact habitat through oil fields along properly

functioning drainages in the McKittrick-Maricopa and Lost Hills areas.

- Allow grazing by livestock for part of the year to benefit saltbush habitat by reducing fire, which otherwise can spread and intensify non-native annual plant matter. Set livestock stocking rates at a level such that the majority of shrubs maintain a near hemispherical shape. Restrict the season of use to when there is adequate green vegetation for livestock to select grasses, thereby minimizing use of saltbush. Do not allow grazing of saltbush habitat during prolonged drought, or for a year following a significant recruitment of seedlings.

Table 1. Broad-scale Habitat Affinities of Taxa on the List of California Bird Species of Special Concern 2006 Occurring in the Central Valley[a]

Taxon	WE[b]	RI[c]	OW[d]	SC[e]	GR[f]
Fulvous Whistling-Duck	X				
Tule Greater White-fronted Goose	X				
Redhead	X				
American White Pelican	X				
Least Bittern	X				
Northern Harrier	X				X
Lesser Sandhill Crane	X				X
Snowy Plover	X				
Mountain Plover					X
Black Tern	X				
Burrowing Owl					X
Long-eared Owl		X	X		
Short-eared Owl	X				X
Loggerhead Shrike			X	X	X
Purple Martin		X	X		
San Joaquin Le Conte's Thrasher				X	
Yellow Warbler		X			
Yellow-breasted Chat		X			
Oregon Vesper Sparrow					X
Grasshopper Sparrow					X
Modesto Song Sparrow	X				
Tricolored Blackbird	X				X
Yellow-headed Blackbird	X				

[a]Species classified on the basis of their primary use of various broad classes of habitats; some species classified as having more than one primary habitat.

[b]WE, wetlands (freshwater marsh, wet meadows, vernal pools, flooded agricultural fields, and riverine and lacustrine waters).

[c]RI, riparian forest and woodland.

[d]OW, oak woodland and oak savanna.

[e]SC, scrub habitats (chaparral and saltbush scrub).

[f]GR, grassland (native grassland, pastureland, grass-like crops, weedy fields, and sparsely-vegetated cultivated fields).

Table 2. Status Designations of Conservation Concern for Birds in the Central Valley from Various State, Regional, Continental, and Global Assessments[a]

Species	BSSC 2006[b]	T & E[c]	USFWS 2002[d]	IUCN 2006[e]
Fulvous Whistling-Duck	1	–	–	–
Tule Greater White-fronted Goose	3	–	–	–
Redhead	2	–	–	–
American White Pelican	1	–	–	–
Least Bittern	2	–	–	–
Bald Eagle	–	SE, FT	–	–
Northern Harrier	3	–	–	–
Swainson's Hawk	–	ST	R, 32	–
Ferruginous Hawk	–	–	–	NT
American Peregrine Falcon	–	SE	R, 32	–
Prairie Falcon	–	–	R, 32	–
California Black Rail	–	ST	R, 32	–
Lesser Sandhill Crane	3	–	–	–
Greater Sandhill Crane	–	ST		–
Snowy Plover	3	–	R	–
Mountain Plover	2	–	R, 32	VU
Whimbrel	–	–	R, 32	–
Long-billed Curlew	–	–	R, 32	NT
California Least Tern	–	SE, FE	–	–
Black Tern	2	–	–	–
Western Yellow-billed Cuckoo	–	SE	R, 32	–
Burrowing Owl	2	–	R, 32	–
Long-eared Owl	3	–	–	–
Short-eared Owl	3	–	–	–
Lewis's Woodpecker	–	–	R, 32	–
Loggerhead Shrike	2	–	R, 32	–
Least Bell's Vireo)	–	SE, FE	–	–
Purple Martin	2	–	–	–
Bank Swallow	–	ST	–	–
San Joaquin Le Conte's Thrasher	1	–	32	–
Yellow Warbler	2	–	–	–
Yellow-breasted Chat	3	–	–	–
Oregon Vesper Sparrow	2	–	–	–
Grasshopper Sparrow	2	–	–	–
Modesto Song Sparrow	3	–	–	–
Kern Red-winged Blackbird	2	–	–	–
Tricolored Blackbird	1	–	R, 32	EN
Yellow-headed Blackbird	3	–	–	–
Lawrence's Goldfinch	–	–	R, 32	–

[a]Conservation status designations are provided for comparison of widely cited assessments at various scales, regional to global. Taxa included on other lists are not included here if they occur in the Central Valley only as vagrants or rare migrants or visitors, unless they formerly were much more numerous in the region and subsequently have been greatly reduced in numbers by human activities. For some taxa, rankings may apply to different seasonal or breeding roles on different lists.

[b]Species, subspecies, and distinct populations on the 2006 list of California Bird Species of Special Concern (Shuford and Gardali *in press*) that occur in the Central Valley. Numbered designations indicate priority levels within the list (1, 2, or 3; highest to lowest).

[c]Species listed as threatened or endangered by state or federal law. ST, state threatened; SE, state endangered; FT, federally threatened; FE, federally endangered.

[d]Species or subspecies on the USFWS list of Birds of Conservation Concern 2002 (USFWS 2002); includes taxa of lesser concern than those listed as Federally threatened or endangered (see footnote [c] above). R, USFWS Region 1 (states of CA, HI, ID, NV, OR, and WA, plus other Pacific islands). The number 32 refers to Bird Conservation Region 32 (Coastal California), which includes the Central Valley.

[e]Central Valley species with IUCN Red List global conservation status ranks (listed here in descending order of conservation concern): CR, critically endangered; EN, endangered; VU, vulnerable; and NT, near threatened (IUCN 2006).

Table 3. Severity of Known Historic and Current Threats in California Affecting Taxa on the List of California Bird Species of Special Concern 2006 Occurring in the Central Valley[a]

Taxon	Habitat Loss[b]	Alien Species[b]	Pollution[b]	Over-exploitation[b]	Disease[b]
Fulvous Whistling-Duck	X			x	X
Tule Greater White-fronted Goose	X				
Redhead	X			x	
American White Pelican	X		X	x	X
Least Bittern	X				
Northern Harrier	X		x		
Lesser Sandhill Crane	X			x	x
Snowy Plover	X			x	
Mountain Plover	X				
Black Tern	X	x			
Burrowing Owl	X		x		
Long-eared Owl	X				
Short-eared Owl	X				
Loggerhead Shrike	X		x		
Purple Martin	X	X			
San Joaquin Le Conte's Thrasher	X	X			
Yellow Warbler	X				
Yellow-breasted Chat	X				
Oregon Vesper Sparrow	X	x			
Grasshopper Sparrow	X	X			
Modesto Song Sparrow	X	x			
Kern Red-winged Blackbird	X	X			
Tricolored Blackbird	X		X		
Yellow-headed Blackbird	X		x		

[a]Severity of threats: X, a major realized threat known or strongly thought to have caused a substantial population decline or range retraction; x, a minor realized or potential threat that is not yet known or thought to have caused a substantial population decline or range retraction (see Shuford and Gardali *in press*).
[b]Categories of threats are those of Wilcove et al. (1998, 2000; see Shuford and Gardali *in press*); habitat loss also includes habitat degradation.

CHAPTER 2. DECISION SUPPORT TOOLS

Introduction

An objective of the current California LIP is to expand habitat priorities in the Central Valley from primarily seasonal wetland investments to semi-permanent and permanent wetlands, riparian, native grassland, and other upland habitats (e.g., oak woodland) and thereby expand the program's benefits to the multitude of special status species known to occur throughout the Central Valley. Building on the numerous partnerships currently being established between private landowners, state and federal agencies, and non-governmental organizations, this LIP program provides the opportunity to restore and enhance populations of over 27 Bird Species of Special Concern (BSSC) and other special status species. BSSC species, as described above, are from the most recent list revised in 2006, which was based on a scientifically defensible and repeatable methodology. These species warrant immediate conservation action to prevent further regulatory actions. For more information see Shuford and Gardali (*in press*).

Because current biological data on which to base management and planning decisions are often lacking for many species of concern, we also addressed 'focal species' from three of the most common habitat types in the Central Valley (riparian, oak woodland, and grassland). These species represent various stages of vegetative succession, habitat characteristics and/or critical ecosystem elements and have been used previously by California Partners in Flight (CalPIF) to develop statewide habitat based bird conservation plans (BCPs, *http://www.prbo.org/calpif/plans.html*). Thus the implementation of conservation actions that benefit multiple focal species is assumed to enhance the biodiversity of the habitat in question, including species of special concern (Chase and Geupel 2005).

By focusing on BSSC species such as Tricolored Blackbird and Burrowing Owl that are precariously close to being listed as threatened or endangered, and CalPIF focal species such as Song Sparrow and Common Yellowthroat that may respond rapidly to restoration and enhancement, we anticipate an increase in the popularity of the LIP program. Private landowners will be able to achieve measurable and noticeable population increases, thus preventing the regulatory polarizations that often accompany endangered species regulations.

In this chapter we use current information on BSSC and CalPIF focal species to assist the planning and implementation of the California LIP program in the Central Valley. We achieve this by 1) presenting spatially explicit distribution models that predict probability of occurrence of BSSC and CalPIF focal species, 2) providing current basin-specific focal species density estimates (birds per hectare) to provide a measurable baseline and potential target for evaluation of project success, and 3) providing comparative values of nest survivorship for a subset of focal species to provide insight on population health and potential growth.

Species Distributions Models as Planning Tools

INTRODUCTION

Program effectiveness may be greatly enhanced by using a consistent and biologically based method for evaluating and prioritizing actions on the ground. Models of species habitat associations and spatial predictions of species occurrence ('species distribution models') are a defensible and valuable method to guide where projects should be implemented and what management prescriptions are needed.

The recent development of sophisticated species distribution modeling techniques provides an opportunity to greatly improve the value and usefulness of species occurrence data (Guisan and Zimmermann 2000, Austin 2002). While GIS-based, empirical species distributional models have been developed at broad spatial scales for over a decade (Lindenmayer et al. 1991, Pereira and Itami 1991, Aspinall and Veitch 1993), the increasing availability of comprehensive and detailed vegetation and land use GIS layers has improved our ability to develop more accurate and detailed models of species occurrence for local and regional conservation purposes. Species distribution models can provide significant improvements in predictive abilities over the simple habitat suitability index (HSI) or wildlife habitat relationship (WHR) models, which are often based on broad-scale habitat associations that are not necessarily applicable throughout a species' range. Individual species distribution models can also be combined in an index of multi-species habitat value.

Furthermore, new and sophisticated modeling algorithms have improved our ability to predict species distributions based on presence-only occurrence data such as that found in the California Natural Diversity Database (CNDDB) (Elith et al. 2006, Hernandez et al.

2006). Using new statistical and machine learning approaches, point occurrence data can be related to GIS-based environmental data layers to generate robust, spatially continuous predictions of species occurrence.

METHODS

Our approach was to use a powerful machine learning algorithm called Maxent (Phillips et al. 2006) to predict species distributions based on species occurrence locations and GIS-based environmental data layers. Maxent is based on the principle of maximum entropy, and uses information about a known set of species occurrence points, compared with environmental "background" data, to develop parsimonious models of species occurrence. The method accommodates several different types of non-linear relationships and is similar to generalized additive models (Hastie and Tibshirani 1990) in its outputs and interpretation.

Species occurrence data came from two different datasets: (1) the California Natural Diversity Database (CNDDB), and (2) PRBO's long-term avian point count survey database, including over 7,000 points throughout California (Fig 47). We used the CNDDB data to model many of the BSSC species that are not well-captured by point count surveys (i.e., non-passerine species). For other species of interest—CalPIF BCP focal species[1]—we combined the two data sources, but PRBO point count data comprised the large majority of data points. While PRBO point count survey data also contains species absence information, only species presence locations were used for Maxent modeling. Any location at which a species was detected at least once was considered a presence location. CNDDB records from throughout California were filtered by spatial accuracy and by season (only breeding season records were used). PRBO point count records, which have high spatial accuracy, were filtered only by season.

Predictors of species distributions were GIS-based environmental data layers (100-m by 100-m pixels) covering the entire state of California (Table 4). A variety of vegetation, climate, hydrology, and land use data layers were manipulated to create input data layers of hypothesized importance for each species of interest (Appendix 1). Manipulation of input data was performed using ArcGIS 9.2 (ESRI 2006) and Fragstats 3.3 (McGarigal and Marks

[1] Two grassland focal species (Grasshopper Sparrow, Savannah Sparrow) are not known to be regular breeders on the valley floor (<300 feet) and so were not included.

1995). Resulting metrics included moving window averages (average pixel value within a circle of a given radius), linear densities (i.e., stream density), and Euclidean distances (i.e., distance to nearest stream or lake). Climate parameters were obtained from PRISM 800-m grid cell climate datasets (http://prism.oregonstate.edu/); vegetation parameters were based on a 100-m composite landcover dataset developed by the California Department of Forestry's Fire and Resource Assessment Program (FRAP) (http://frap.cdf.ca.gov/projects/frap_veg/index.asp); freshwater emergent and seasonal wetland vegetation were derived from polygon data from the U.S. Fish and Wildlife Service National Wetlands Inventory dataset (http://www.fws.gov/nwi); land use parameters were derived from multi-year land use polygon data from the Department of Water Resources (http://www.landwateruse.water.ca.gov/basicdata/landuse/landusesurvey.cfm); topographic and hydrologic parameters were derived from the USGS's national elevation dataset (http://ned.usgs.gov/) and national hydrographic dataset (http://nhd.usgs.gov/), respectively.

The "background" against which presence locations were compared in Maxent consisted of the entire state of California. However, due to larger uncertainties associated with predictions in some areas with sparse data, final predictions were clipped to the Central Valley, which contained ample data for the species of interest. The boundary used to clip final predictions was created by merging the spatial extents of the selected California Central Valley hydrologic units (see http://cain.nbii.gov/calwater/calwfaq.html) and The Nature Conservancy's Great Central Valley ecoregion (see www.nature.org). We chose this merged boundary as it allowed complete overlap with the Central Valley's 12 largest hydrologic units while providing some coverage of the foothills to the east.

Model predictions were cross-validated using a subset of the data points (25%) selected at random by the Maxent program. Model performance was assessed using the area under the curve (AUC) of receiver operating characteristic (ROC) plots (Fielding and Bell 1997).

Table 4. GIS-based environmental predictors of species distribution and sources covering the entire state of California (100-m by 100-m pixels).

Environmental Variable	Description	Original Source
Habitat		
Wildlife habitat types (unless listed below).	Categorical vegetation types and percent within 1 or 5 km radius using the California Wildlife Habitat Relationships (CWHR) classification scheme.	CA Department of Forestry and Fire Protection (Fire and Resource Assessment Program).
Combined wildlife habitat types.	Categorical land cover classes aggregated from CWHR classes.	CA Department of Forestry and Fire Protection (Fire and Resource Assessment Program).
Emergent wetland	Percent combined freshwater and seasonal emergent wetland types within 1 km radius.	U.S. Fish and Wildlife Service (National Wetland Inventory)
Emergent wetland distance	Distance (km) to combined freshwater and seasonal emergent wetland types.	U.S. Fish and Wildlife Service (National Wetland Inventory)
Agriculture types	Percent orchard, field crops, pasture, rice, vineyards within 1or 5 km radius.	Department of Water Resources, Land Use Program
Weather		
Temperature monthly minimum/maximum	Average monthly minimum and maximum temperatures for Jan, March, June, Oct.	Oregon State University (PRISM climate mapping system)
Precipitation monthly average	Average monthly precipitation for Jan, March, June, Oct.	Oregon State University (PRISM climate mapping system)
Topography		
Elevation	Elevation at point in meters.	U.S. Geological Survey (Teale GIS Solutions Group)
Slope	Slope at point derived from elevation data.	U.S. Geological Survey (Teale GIS Solutions Group)
Perennial and intermittent stream density	Stream density (km/km^2) within 1 km radius.	U.S. Geological Survey (National Hydrography Dataset)
Perennial and intermittent stream distance	Distance (km) to nearest stream.	U.S. Geological Survey (National Hydrography Dataset)
Canal/ditch density	Canal/ditch density (km/km^2) within 1 km radius.	U.S. Geological Survey (National Hydrography Dataset)
Lake habitat	Percent lake within 1 km radius.	U.S. Geological Survey (National Hydrography Dataset)
Lake distance	Distance (km) to nearest lake.	U.S. Geological Survey (National Hydrography Dataset)

RESULTS

Model validation statistics (ROC AUC) indicated good model performance for most species, with scores ranging from fair to excellent (Table 5). AUC values represent the

predictive ability of a distribution model and are derived from a plot of true positive against false positive fractions for a given model. Higher values (up to 1.0) characterize higher accuracy models. An AUC value of 0.5 is the equivalent of a random prediction. As a general guideline, AUC values of 0.6 – 0.7 indicate poor accuracy, 0.7 – 0.8 is fair, 0.8 - 0.9 is good, and values greater than 0.9 represent excellent accuracy (Swets 1988). Graphs depicting the nature of the relationship between each species and each environmental variable, as well as graphs showing the relative importance of each variable for each species are available on the website (http://data.prbo.org/cadc/tools/lip/).

Predicted Central Valley distributions for BSSC and other special status species are shown in Figures 24-42. Suites of species including Bird Species of Special Concern (BSSC) Species, grassland species and oak woodland species and riparian species are depicted in figures 43-46. Predicted distributions generated by Maxent represent cumulative percents of occurrences. That is, at a given location, the value of that pixel represents the percent of that species' distribution that is contained within all of the pixels of equal or lower value. Thus higher values represent a higher probability of a species' occurrence. These maps may be used to evaluate a specific location, watershed or region's potential to benefit a particular species. These maps can also identify and guide which species-specific management recommendations (presented in chapter 1 and elsewhere) should be implemented.

Table 5. Model Diagnostics (ROC AUC values) indicating model performance for each species

Species	AUC value	Model Performance
Acorn Woodpecker (ACWO)	0.874	Good
Ash-throated Flycather (ATFL)	0.765	Fair
Black-headed Grosbeak (BHGR)	0.708	Fair
Blue Grosbeak (BLGR)	0.905	Excellent
Burrowing Owl (BUOW)	0.992	Excellent
Common Yellowthroat (COYE)	0.869	Good
Lark Sparrow (LASP)	0.92	Excellent
Northern Harrier (NOHA)	0.946	Excellent
Nuttall's Woodpecker (NUWO)	0.762	Fair

Table 5 (cont.)

Oak Titmouse (OATI)	0.797	Fair
Song Sparrow (SOSP)	0.815	Good
Spotted Towhee (SPTO)	0.696	Poor
Swainson's Hawk (SWHA)	0.965	Excellent
Tri-colored Blackbird (TRBL)	0.968	Excellent
Western Bluebird (WEBL)	0.881	Good
Western Meadowlark (WEME)	0.878	Good
Yellow-breasted Chat (YBCH)	0.917	Excellent
Yellow-billed Magpie (YBMA)	0.944	Excellent
Yellow Warbler (YWAR)	0.865	Good

Estimates of current and potential breeding density

INTRODUCTION

In addition to representation of ecosystem attributes, many of California PIF focal species were selected because they are relatively easy and cost effective to monitor (Chase and Geupel 2005). As a result, a wealth of current and comparable information has been generated across the Central Valley (see Ballard et al. 2003). This replicable information provides the scientific foundation for the development of population objectives that can guide conservation efforts (Pashley and Geupel 2003).

Most songbirds are territorial and vocal during their breeding seasons. Thus, data collected from standardized surveys or 'point counts' using audible and visual cues during the breeding season are more reliable and repeatable than data collected at other times of the year. These data allow for calculations of a quantifiable metric (relative breeding density) that allows comparisons over time and between sites. Furthermore the use of standardized protocols allows comparisons at multiples scales (project, region, state). Current density estimates provide a quantitative measure of current population status and a baseline to gauge future conservation actions. Potential density estimates provide a target to determine when conservation actions have succeeded. By incorporating geospatial analysis we can use these current and potential estimates to identify where on the landscape projects and conservation

actions have the highest potential to be effective. Furthermore these estimates allow an objective assessment of how a particular project is contributing to regional (CVJV 2006) or continental population objectives (Rich et al. 2004).

We present current density estimates for 12 California PIF focal species in each of the 12 hydrological units (basins) representing the 4 most common broad habitat types in the Central Valley. These species include Song Sparrow, Yellow-breasted Chat, Black-headed Grosbeak, and Common Yellowthroat (wetland/riparian); Lark Sparrow and Western Meadowlark (grassland); and Acorn Woodpecker, Nuttall's Woodpecker, Ash-throated Flycatcher, Yellow-billed Magpie, Oak Titmouse, and Western Bluebird (oak woodland). We did not include Blue-gray Gnatcatcher, Savannah Sparrow, and Grasshopper Sparrow because of poor sample size and very limited breeding at lower elevations in the valley.

METHODS

Density estimates for each of the eight basins were derived from fixed radius and variable point count surveys (Ralph et al. 1993) conducted from 1994-2005 (Small et al. 1999, Gardali et al. 2006, Hickey et al. 2006) (Fig. 47). Point count locations were assigned a habitat type (e.g., riparian, grassland) based on the FRAP composite landcover layer (Table 6) and included density calculations for all focal species associated with that habitat type (Table 7).

Current densities (individuals per 10 hectares) were estimated by dividing the mean number of detections within 50 m by the area of the 50-m radius circle (0.785 hectares) and multiplying by 10. Densities were averaged across years at each point, and across points within each basin. Mean densities were only calculated for basins that contained ten or more transects. To address potential sources of bias in these estimates (e.g., detection probability, time of day, annual variation, etc.), we calculated standard error values representing variability across points within basins but not across years.

Estimates of target densities were calculated as the upper 75th percentile of site-level mean density values from current point count data, excluding all sites with zero detections. This percentile was used on the assumption that most current populations are degraded and could be enhanced with habitat enhancement and specific management prescriptions as presented above.

Table 6. Habitat Groups and Associated WHR Types

Habitat	WHR Name
Grassland	Perennial Grassland
	Annual Grassland
	Pasture
Oak Woodland	Blue Oak-Foothill Pine
	Blue Oak Woodland
	Coastal Oak Woodland
	Valley Oak Woodland
	Montane Hardwood-Conifer
	Montane Hardwood
Riparian	Aspen
	Montane Riparian
	Valley Foothill Riparian
	Desert Riparian
Wetland	Wet Meadow
	Freshwater Emergent Wetland

Table 7. Focal bird species and associated habitat groups.

Habitat Group	Species
Grassland	Burrowing Owl
	Grasshopper Sparrow
	Savannah Sparrow
	Western Meadowlark
Oak Woodland	Acorn Woodpecker
	Ash-throated Flycatcher
	Blue-gray Gnatcatcher
	Lark Sparrow
	Nuttall's Woodpecker
	Oak Titmouse
	Western Bluebird
	Yellow-billed Magpie
Riparian and Wetland	Black-headed Grosbeak
	Blue Grosbeak
	Northern Harrier
	Song Sparrow
	Swainson's Hawk
	Tricolored Blackbird
	Yellow-breasted Chat
	Yellow Warbler

RESULTS

Current density (Table 8) and potential density (Table 9) estimates for 12 species by hydrological unit (basin) are presented below. Variation by unit may reflect differences in sample size, bird distribution, habitat suitability and quality, and intrinsic variation in bird habitat selection.

Current population estimates from a specific area can be derived from these densities by multiplying appropriate estimates (birds per hectare) by the area of available habitat to be enhanced or restored. Population targets may be derived by multiplying the target density by the amount of area to be restored or enhanced. This process was used to derive population estimates for riparian focal species in the Central Valley Joint Venture's current implementation plan (CVJV 2006).

On the website (http://data.prbo.org/cadc/tools/lip/), current and potential density estimates are also presented at the site level, thus increasing the applicability of these estimates for individual projects.

Table 8a. Density estimates (birds per 10 hectares) and standard errors (SE) for select focal bird species. Estimates were calculated from point count surveys where at least 10 points existed within a given habitat within each Hydrologic Unit. Points were only included if there was at least 1 detection for a given species. Densities were calculated for each point count site using a 50 meter survey radius. For riparian focal species, density estimates were calculated separately for riparian and wetland habitats.

		Redding		Tehama		Colusa Basin		Delta-Mendota Canal	
Species	Habitat	Mean	SE	Mean	SE	Mean	SE	Mean	Standard Error
ACWO	Oak Woodland	5.6870	0.8692	4.9003	0.6677	NA	NA	NA	NA
NUWO	Oak Woodland	2.1558	0.3773	3.2979	0.7461	NA	NA	NA	NA
ATFL	Oak Woodland	4.3623	0.7276	5.1958	0.5546	NA	NA	NA	NA
OATI	Oak Woodland	11.7752	1.1501	6.7410	0.8595	NA	NA	NA	NA
WEBL	Oak Woodland	NA	NA	3.3845	0.4758	NA	NA	NA	NA
LASP	Oak Woodland	NA	NA	5.2940	0.8053	NA	NA	NA	NA
YWAR	Riparian	5.5754	1.3540	1.1291	0.2052	NA	NA	NA	NA
YBCH	Riparian	6.0661	0.7763	3.8854	1.2869	NA	NA	NA	NA
SOSP	Riparian	6.6812	1.2040	NA	NA	NA	NA	9.2969	1.1003
BHGR	Riparian	3.8987	0.9997	6.6169	0.7907	11.6495	1.1894	2.8741	0.5582
BLGR	Riparian	NA	NA	1.5557	0.2435	NA	NA	NA	NA
YWAR	Wetland	NA	NA	NA	NA	NA	NA	NA	NA
SOSP	Wetland	NA	NA	NA	NA	12.5973	1.6507	12.6371	2.1330
BHGR	Wetland	NA	NA	8.3502	1.0760	8.2413	0.6593	NA	NA
BLGR	Wetland	NA	NA	NA	NA	NA	NA	NA	NA
WEME	Grassland	NA	NA	4.4007	0.8883	NA	NA	7.9560	1.3053

Table 8b. Density estimates (birds per 10 hectares) and standard errors (SE) for select focal bird species. Estimates were calculated from point count surveys where at least 10 points existed within a given habitat within each Hydrologic Unit. Points were only included if there was at least 1 detection for a given species. Densities were calculated for each point count site using a 50 meter survey radius. For riparian focal species, density estimates were calculated separately for riparian and wetland habitats.

		North Valley Floor		San Joaquin Delta		San Joaquin Valley Floor		South Valley Floor	
Species	Habitat	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ACWO	Oak Woodland	NA	NA	NA	NA	NA	NA	NA	NA
NUWO	Oak Woodland	NA	NA	NA	NA	4.5382	0.5115	NA	NA
ATFL	Oak Woodland	NA	NA	NA	NA	6.7675	1.2514	NA	NA
OATI	Oak Woodland	NA	NA	NA	NA	8.2618	1.5888	NA	NA
WEBL	Oak Woodland	NA	NA	NA	NA	NA	NA	NA	NA
LASP	Oak Woodland	NA	NA	NA	NA	NA	NA	NA	NA
YWAR	Riparian	NA	NA	NA	NA	NA	NA	NA	NA
YBCH	Riparian	NA	NA	NA	NA	NA	NA	NA	NA
SOSP	Riparian	NA	NA	NA	NA	7.8230	0.9048	NA	NA
BHGR	Riparian	NA	NA	NA	NA	4.3524	0.7186	NA	NA
BLGR	Riparian	NA	NA	NA	NA	NA	NA	NA	NA
YWAR	Wetland	NA	NA	0.9073	0.1569	NA	NA	NA	NA
SOSP	Wetland	NA	NA	17.9444	2.9737	NA	NA	19.9768	3.5730
BHGR	Wetland	NA	NA	3.1857	0.6859	NA	NA	NA	NA
BLGR	Wetland	NA	NA	1.8203	0.4049	NA	NA	NA	NA
WEME	Grassland	NA	NA	NA	NA	NA	NA	NA	NA

Table 9. Target Density Estimates for each species by hydrological unit (basin)

Species	Habitat	Redding	Tehama	Colusa Basin	Delta-Mendota Canal	North Valley Floor	San Joaquin Delta	San Joaquin Valley Floor	South Valley Floor
ACWO	Oak Woodland	7.9618	6.3694	NA	NA	NA	NA	NA	NA
NUWO	Oak Woodland	1.7693	3.8217	NA	NA	NA	NA	6.3694	NA
ATFL	Oak Woodland	6.0510	6.3694	NA	NA	NA	NA	7.9618	NA
OATI	Oak Woodland	14.3312	8.4926	NA	NA	NA	NA	12.7389	NA
WEBL	Oak Woodland	NA	4.2463	NA	NA	NA	NA	NA	NA
LASP	Oak Woodland	NA	8.4926	NA	NA	NA	NA	NA	NA
YWAR	Riparian	10.2619	1.6985	NA	NA	NA	NA	NA	NA
YBCH	Riparian	8.0502	4.6709	NA	NA	NA	NA	NA	NA
SOSP	Riparian	8.9349	NA	NA	12.7389	NA	NA	10.5096	NA
BHGR	Riparian	7.0771	7.4310	15.3043	3.3970	NA	NA	6.3694	NA
BLGR	Riparian	NA	2.1990	NA	NA	NA	NA	NA	NA
YWAR	Wetland	NA	NA	NA	NA	NA	1.0616	NA	NA
SOSP	Wetland	NA	NA	12.7389	17.1975	NA	22.9830	NA	28.3970
BHGR	Wetland	NA	11.2703	9.9080	NA	NA	3.7951	NA	NA
BLGR	Wetland	NA	NA	NA	NA	NA	2.9193	NA	NA
WEME	Grassland	NA	5.7325	NA	12.7389	NA	NA	NA	NA

Future Directions

We have constructed an interactive version of the songbird-habitat models that uses Google Maps as a faster alternative to ESRI's internet map server (ArcIMS) as a web hosting service. Interactive maps are currently available to interested parties across the internet (http://www.prbo.org/cadc/lip). The project will continue to be updated using data sharing protocols and extensive data resources (such as eBird and the Breeding Bird Survey) being developed in conjunction with our partnership in the Avian Knowledge Network (www.avianknowledge.net), and we foresee being able to combine data from multiple sources in the next 2-3 years in order to increase the models' predictive power.

Figure 1 Fulvous Whistling-Duck

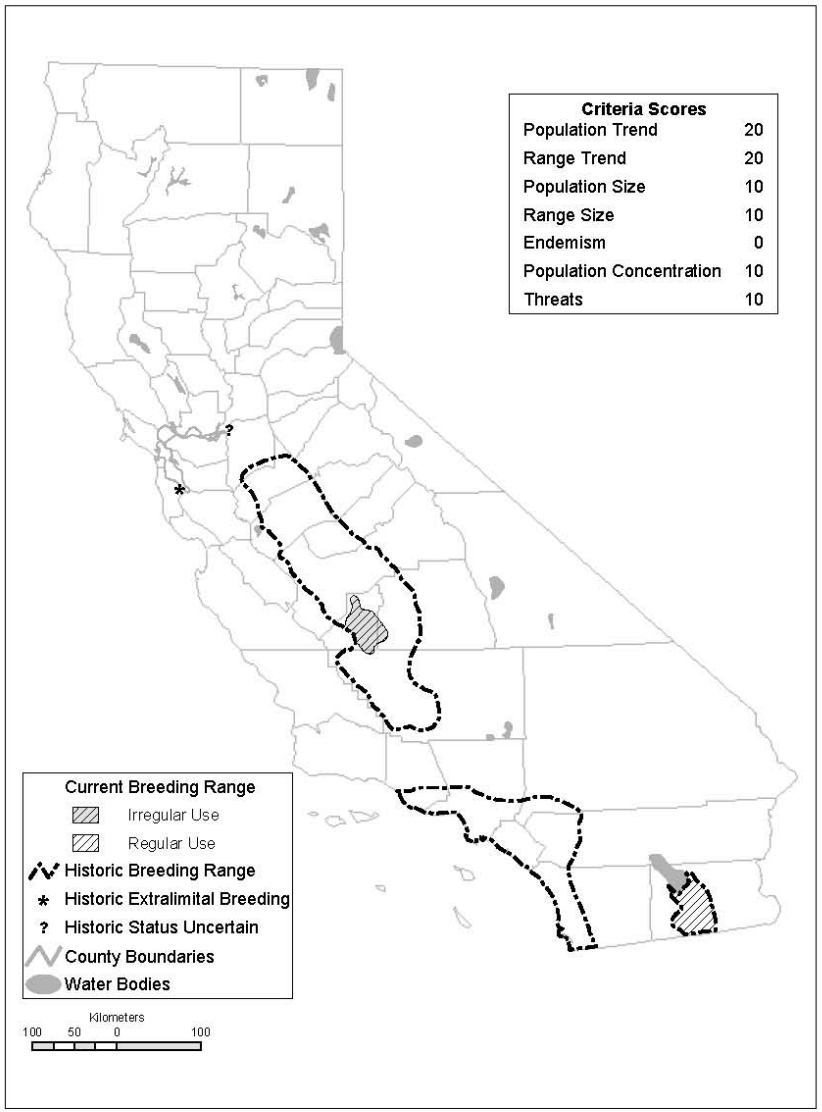


Figure 2 Tule Greater White-fronted Goose

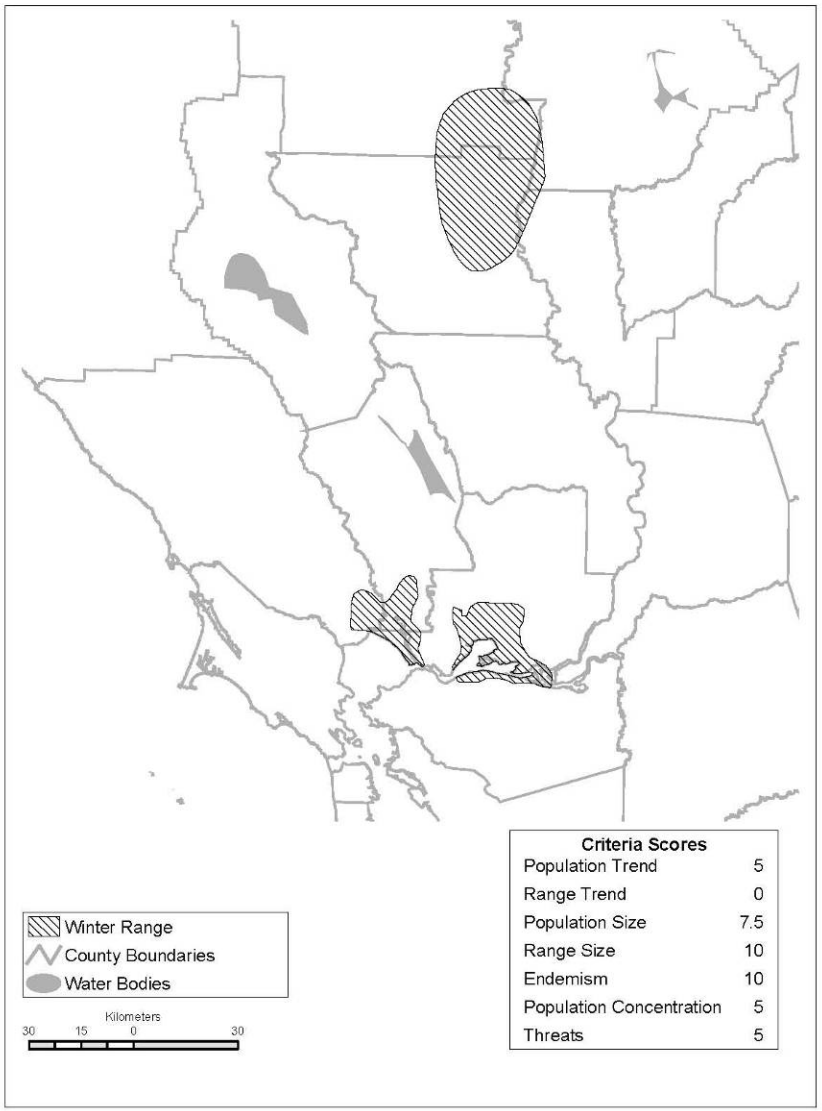
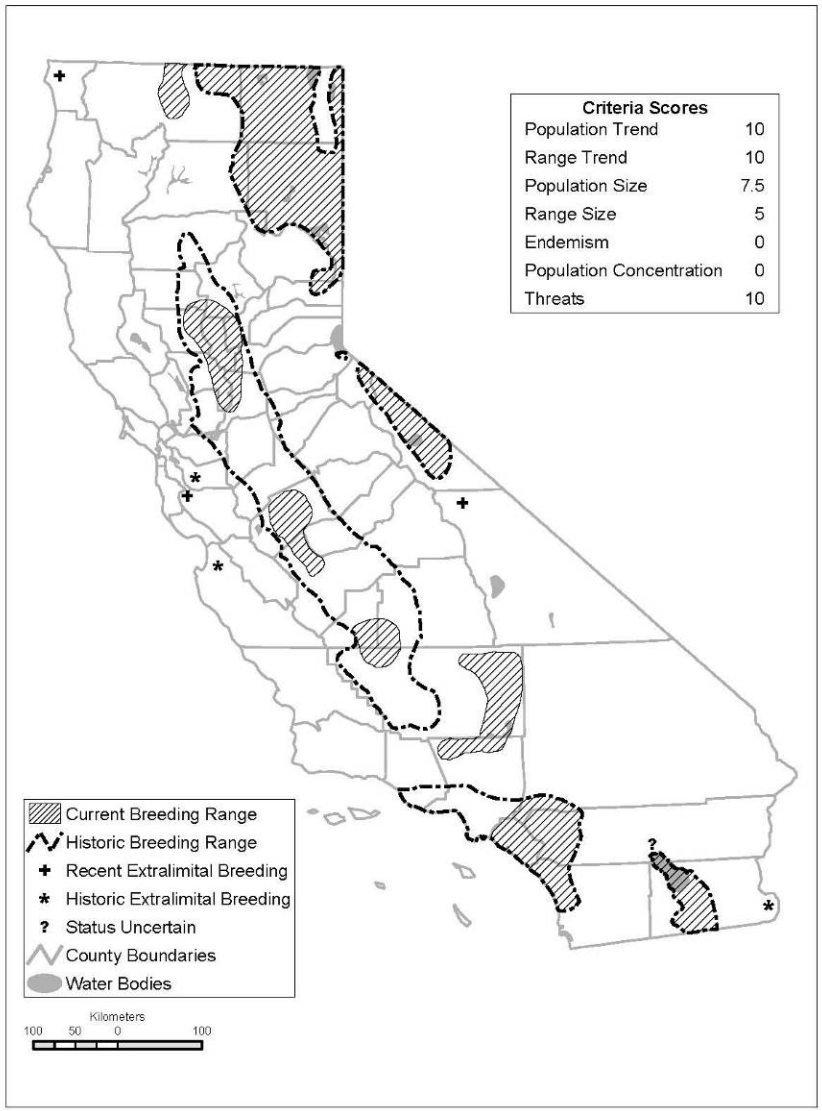


Figure 3 Redhead Figure



4 American White Pelican

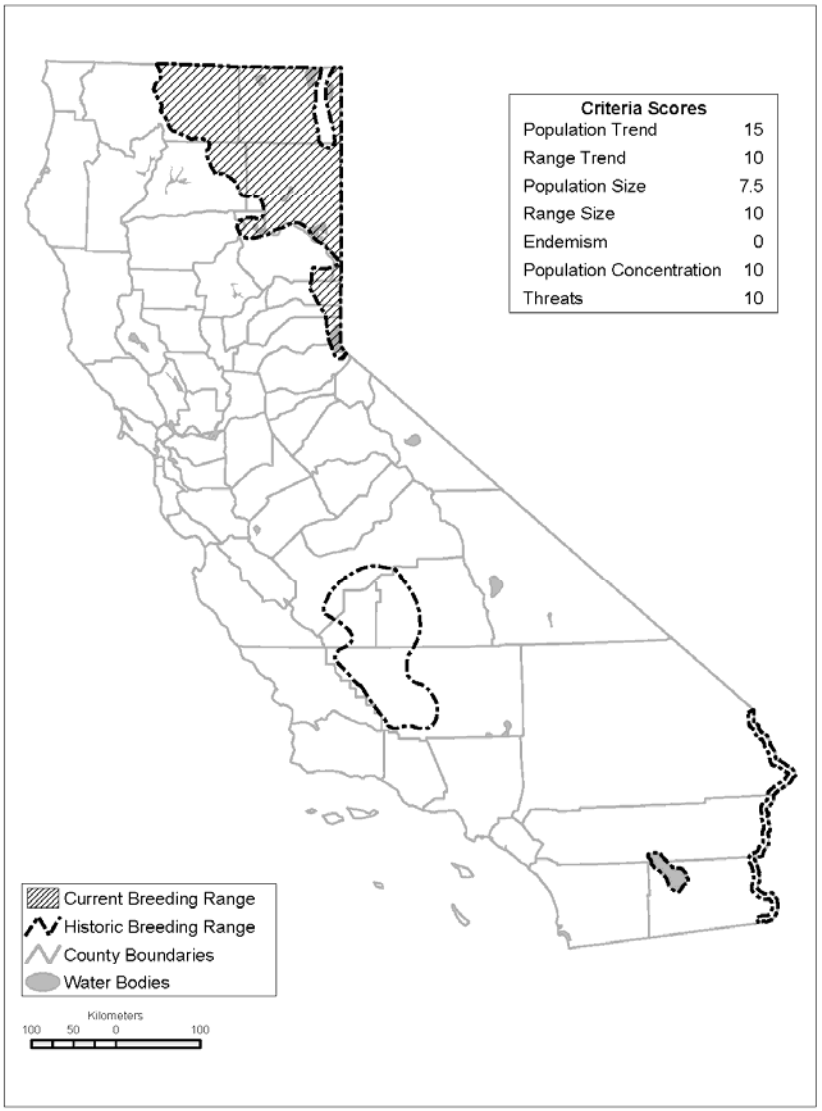


Figure 5 Least Bittern

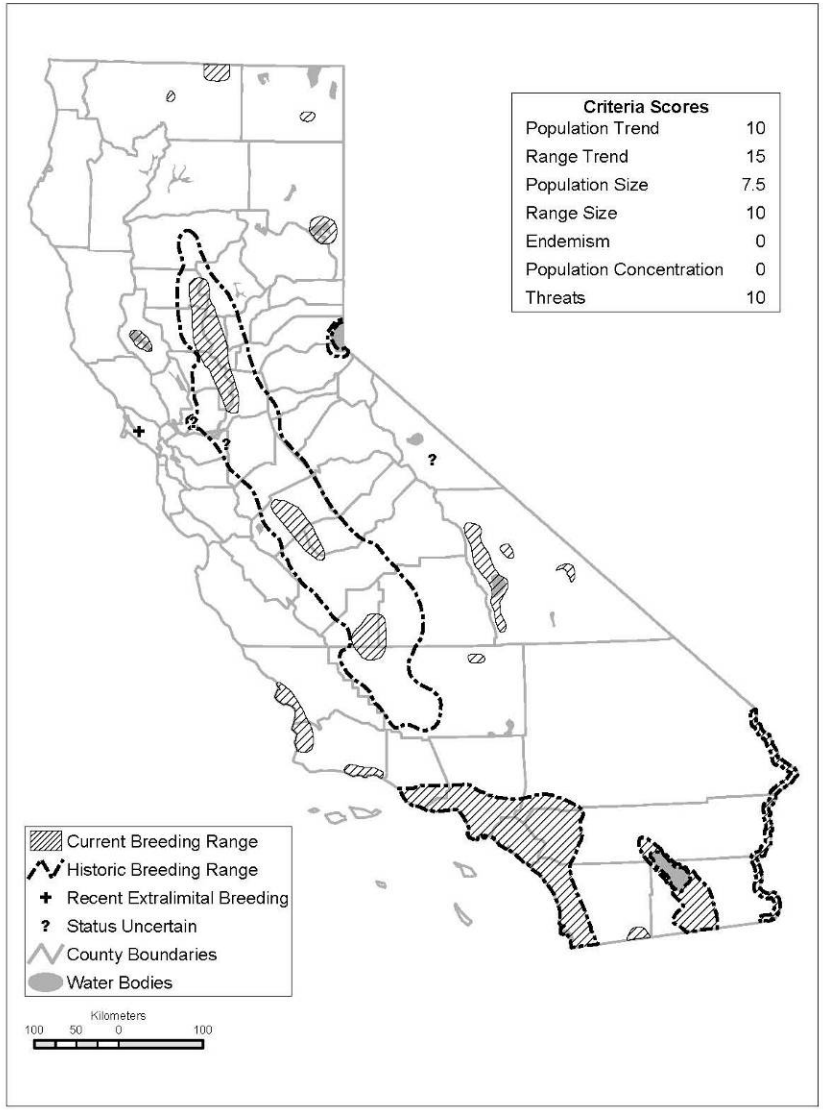


Figure 6 Snowy Plover

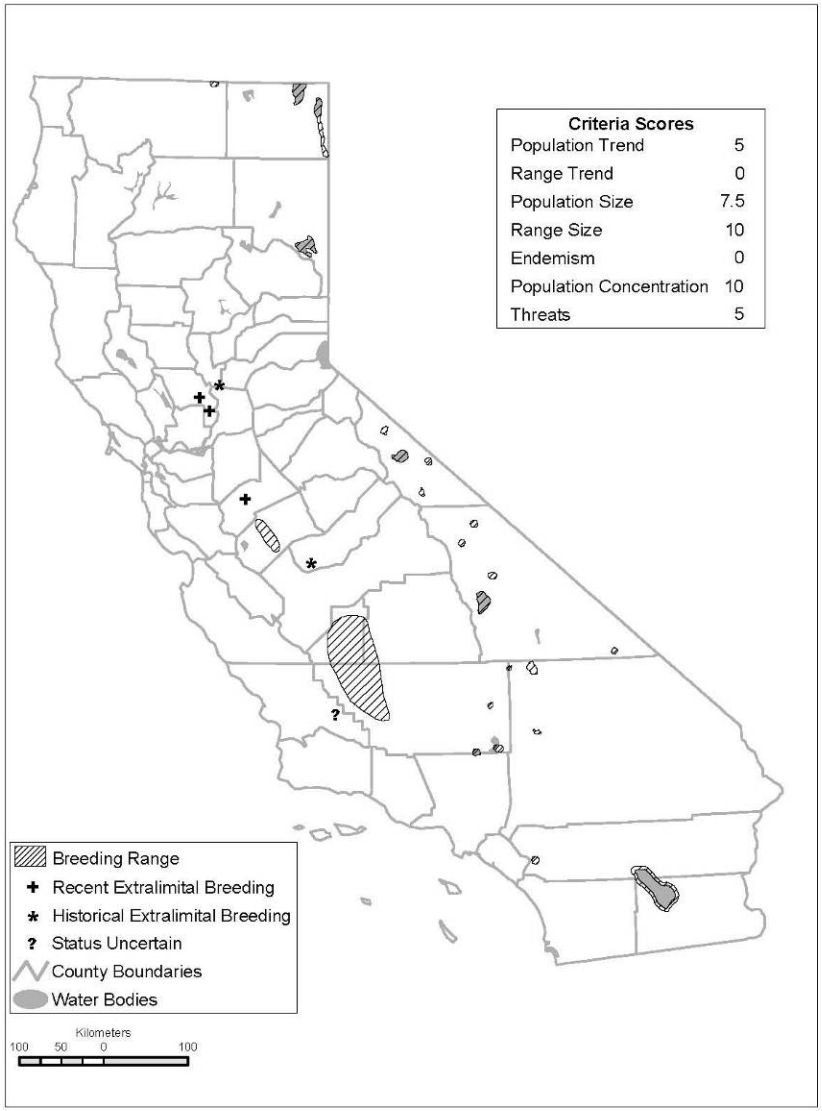


Figure 7 Black Tern

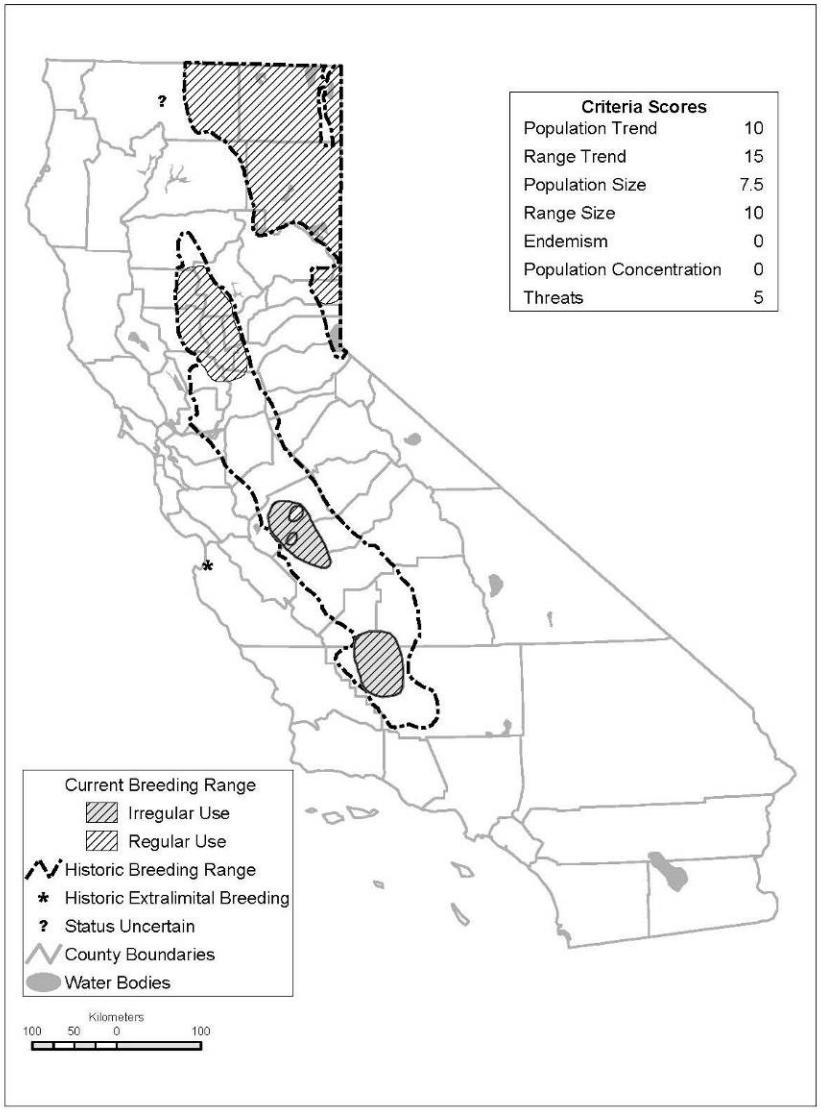


Figure 8 Modesto Song Sparrow

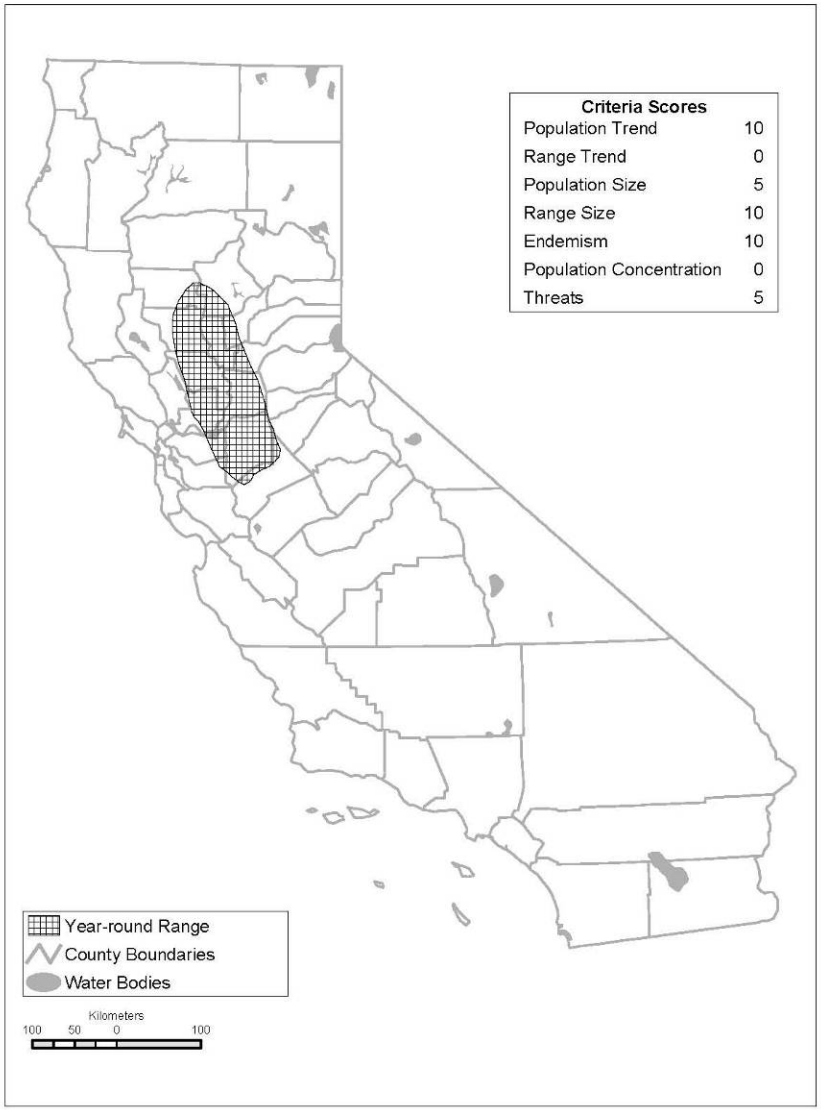


Figure 9 Yellow-headed Blackbird

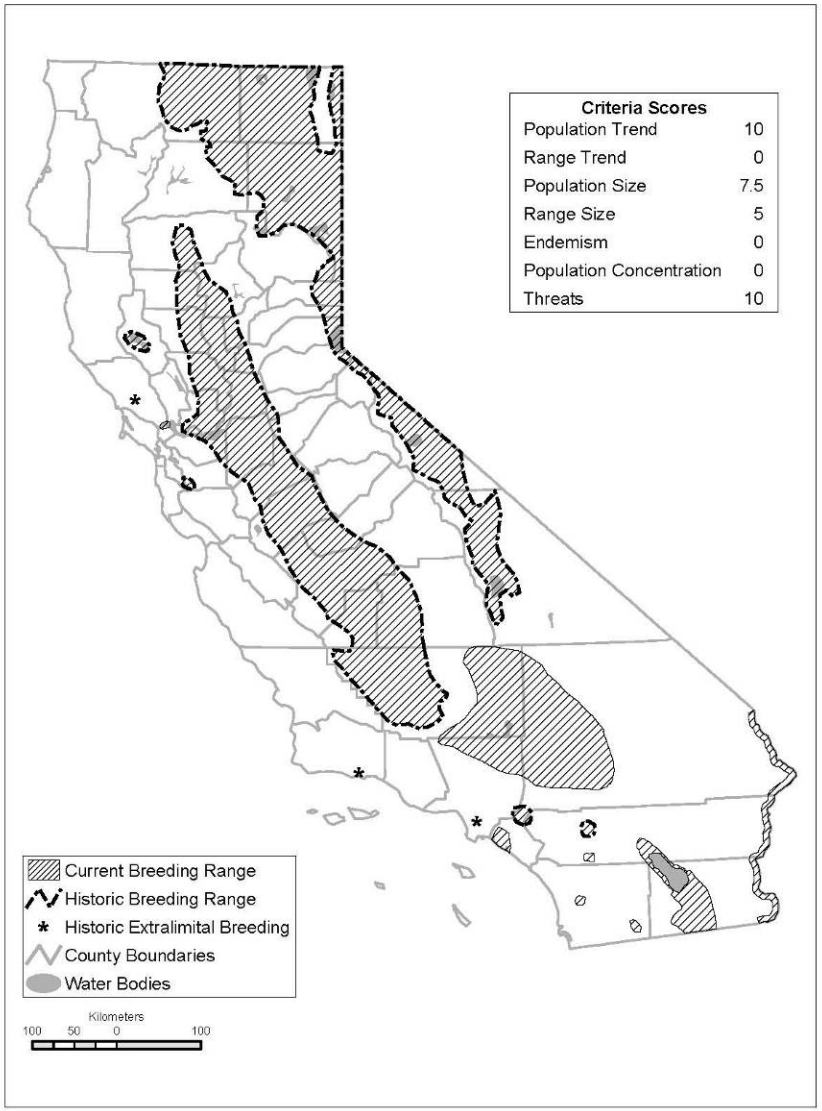


Figure 10 Northern Harrier

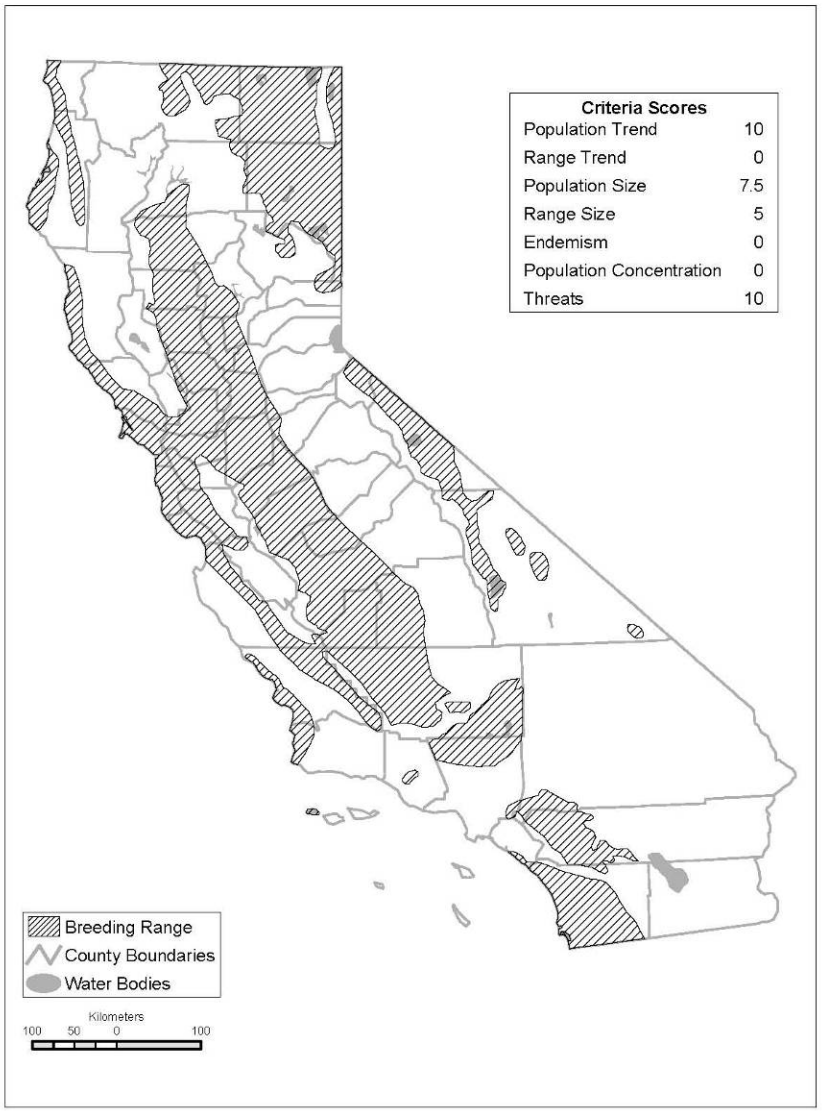


Figure 11 Lesser Sandhill Crane

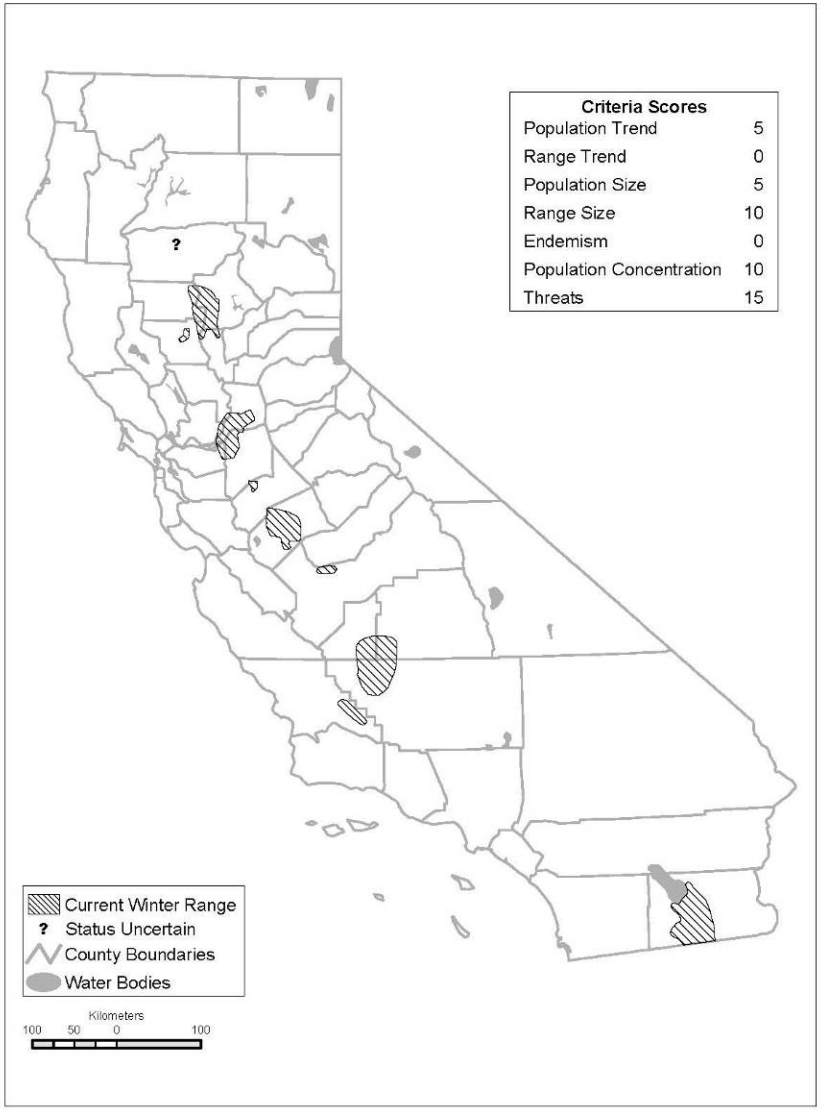


Figure 12 Short-eared Owl

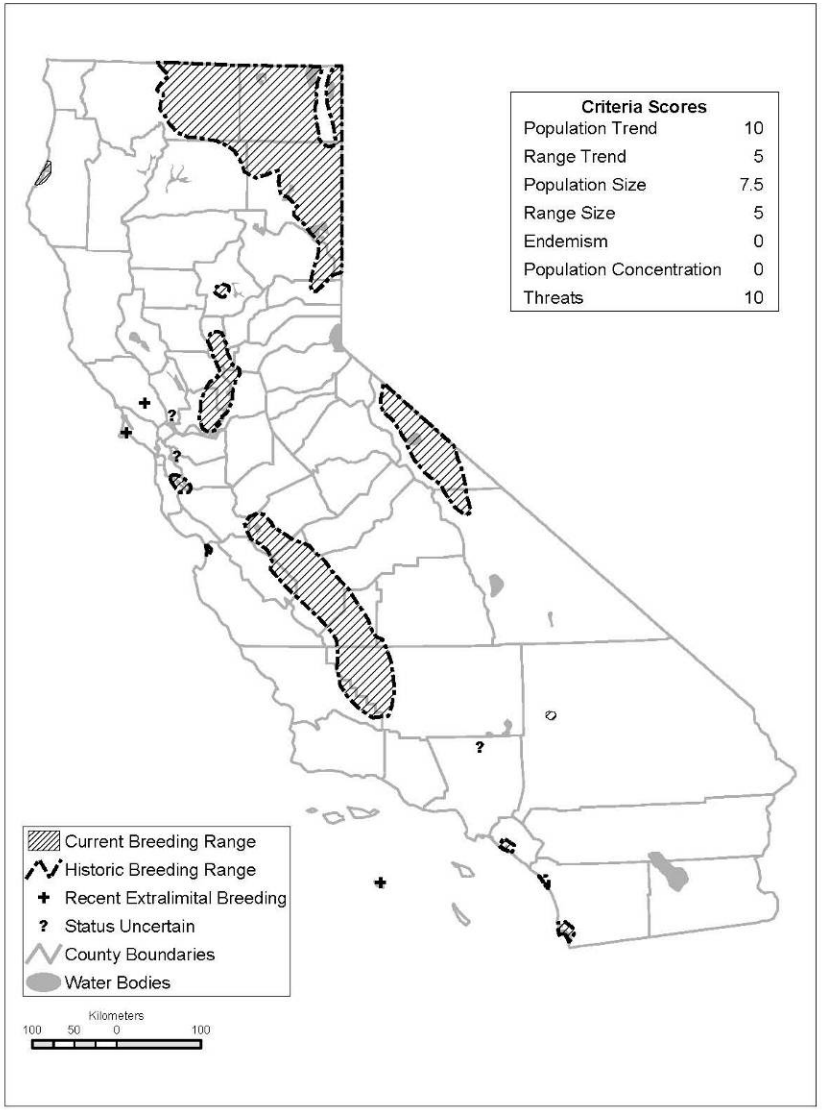
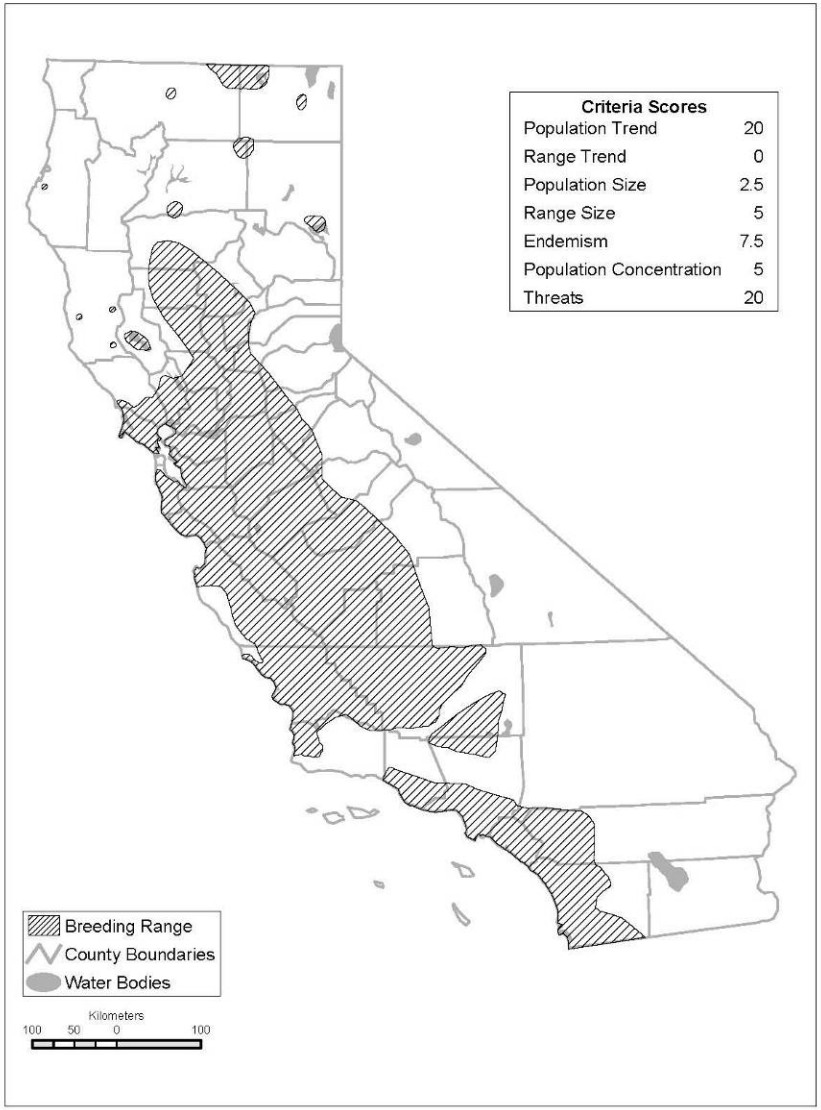


Figure 13 Tricolored Blackbird Figure



14 Mountain Plover

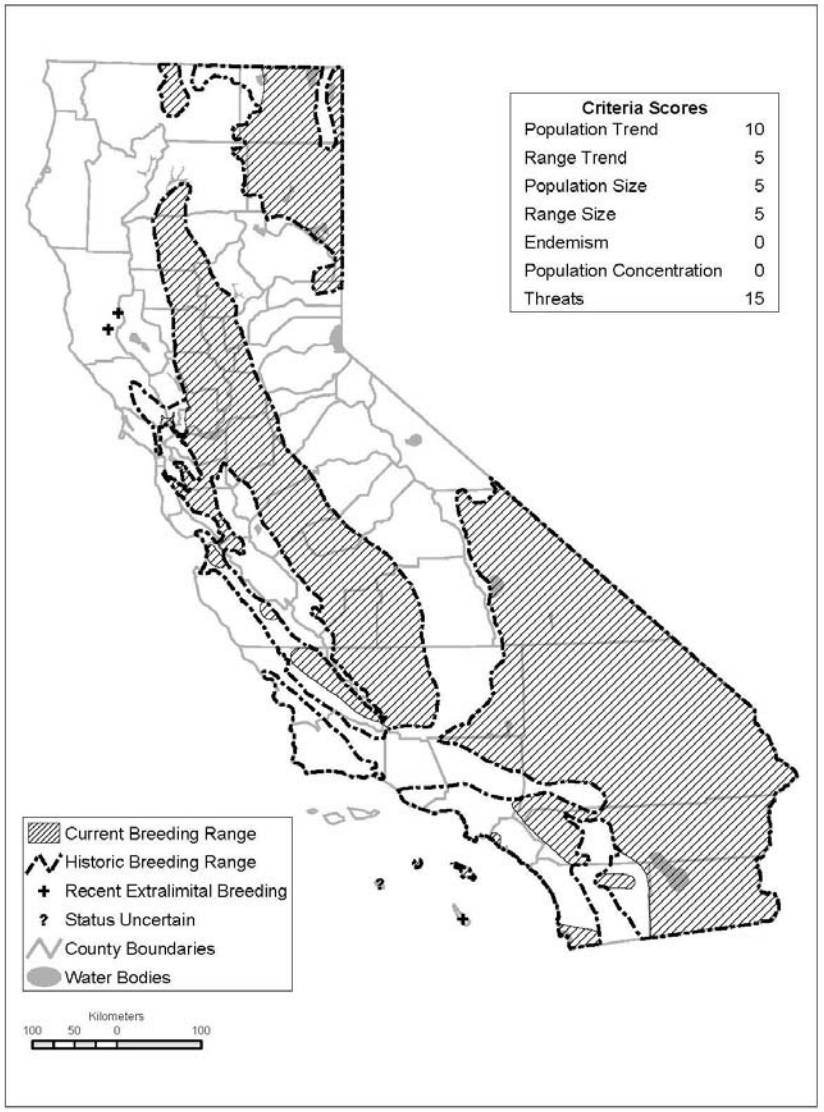


Figure 15 Burrowing Owl

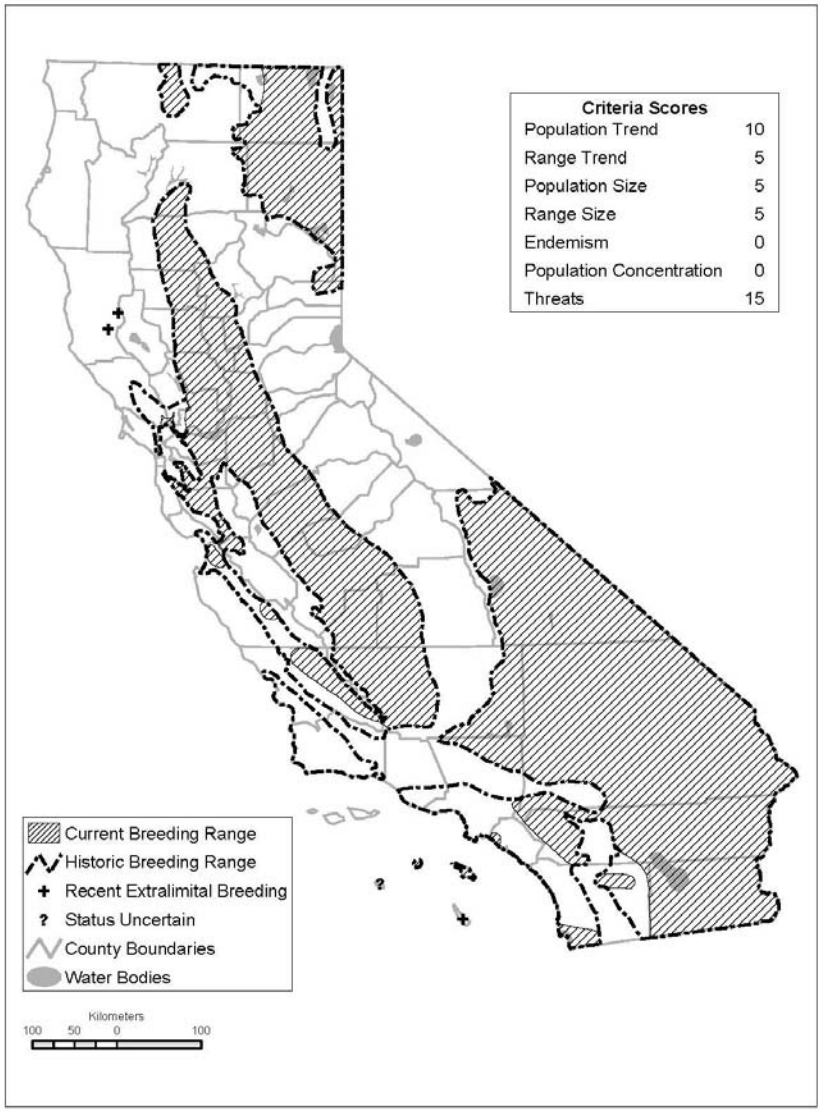


Figure 16 Oregon Vesper Sparrow

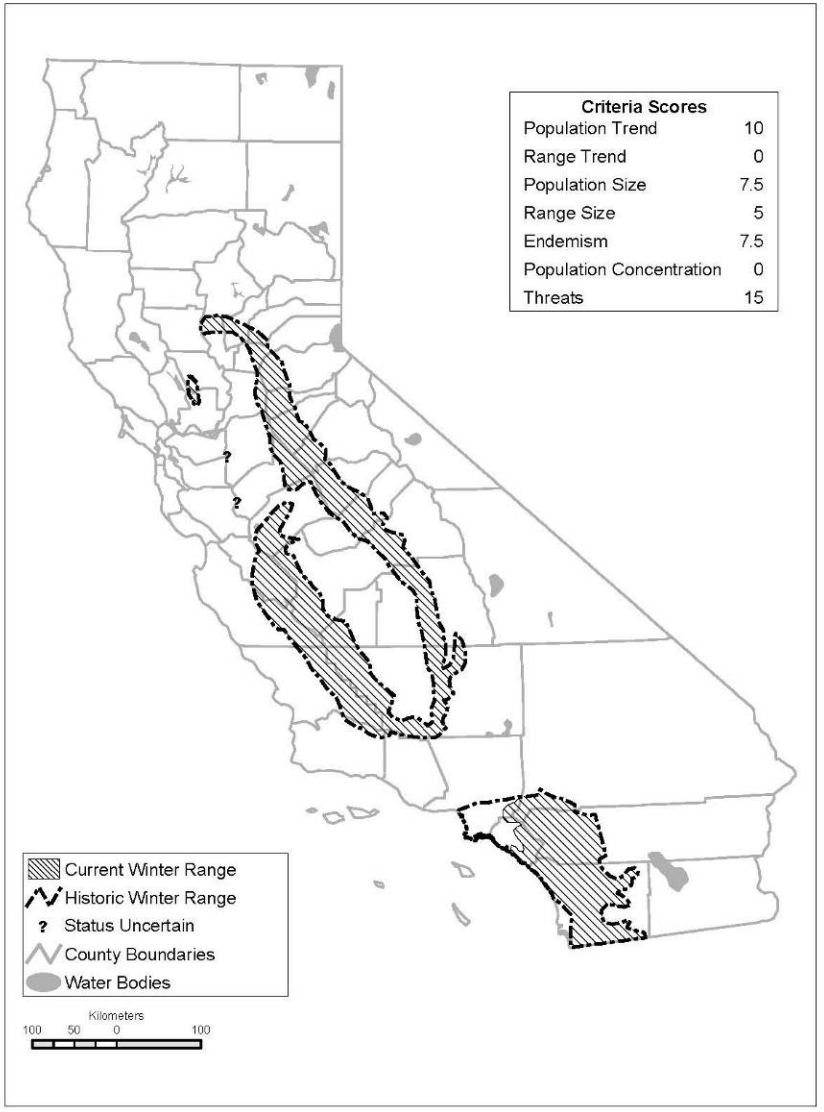


Figure 17 Grasshopper Sparrow

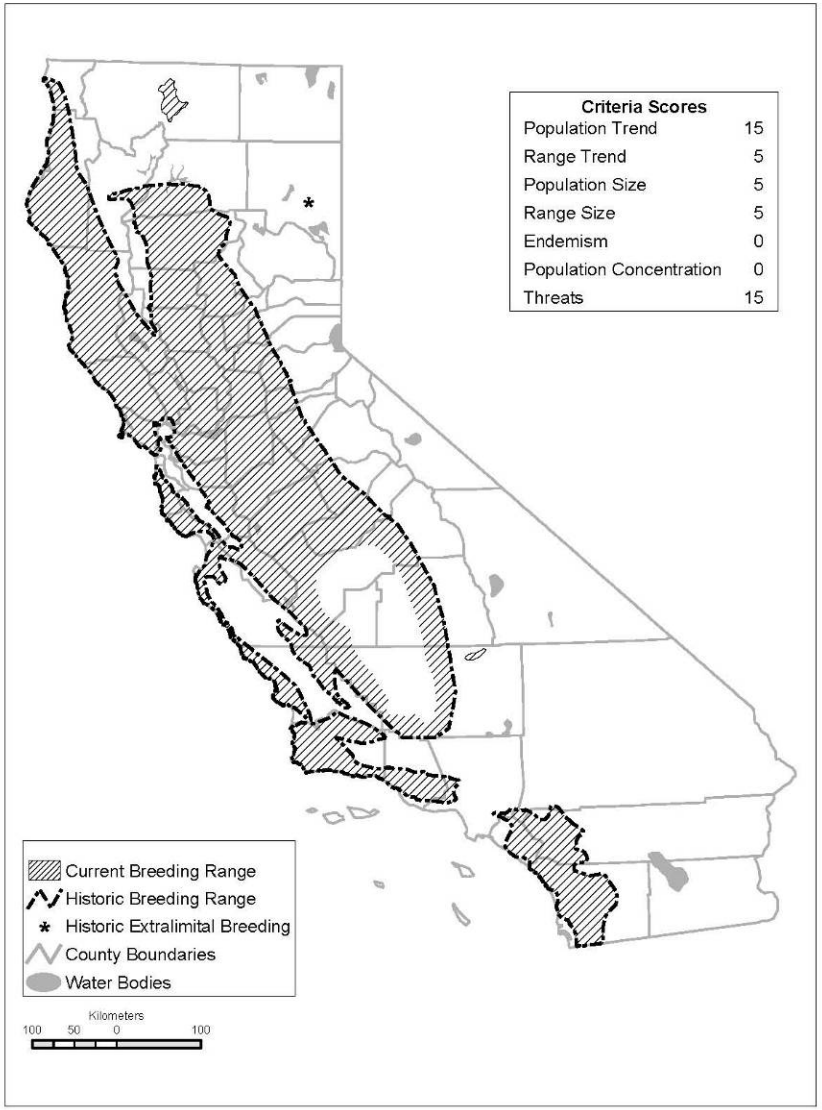


Figure 18 Yellow-breasted Chat

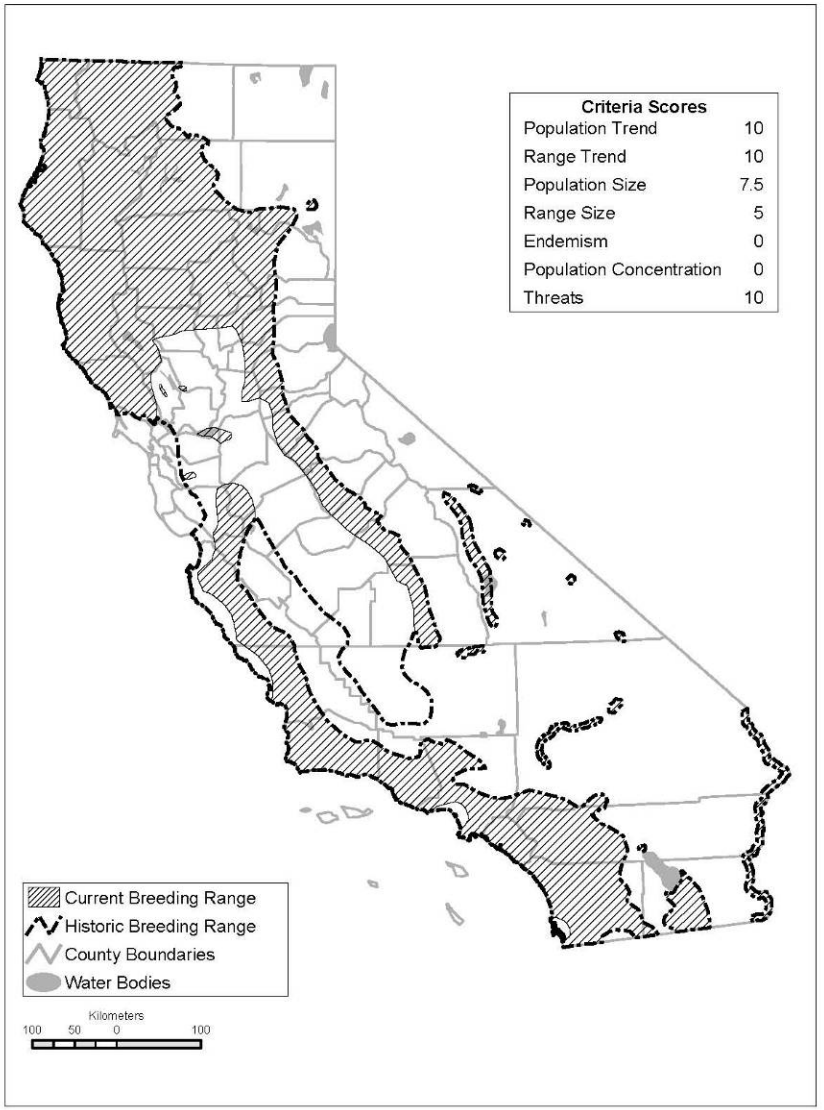


Figure 19 Yellow Warbler

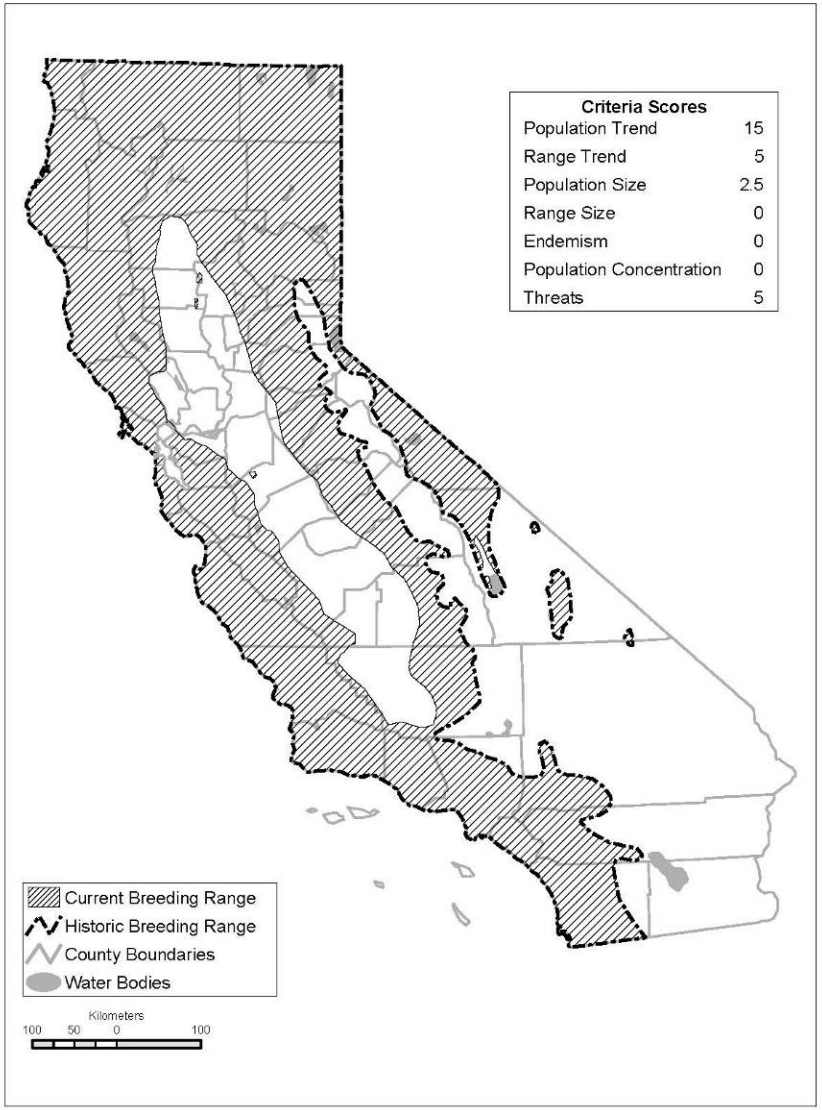


Figure 20 Long-eared Owl

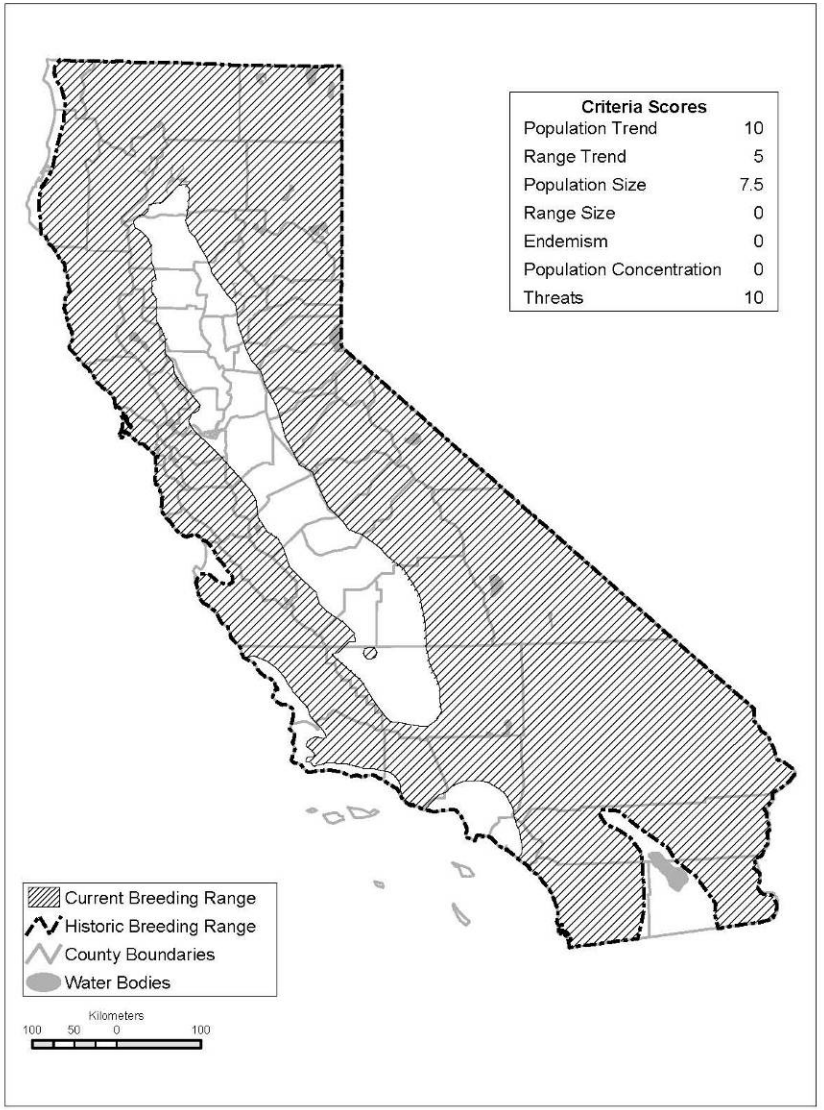


Figure 21 Purple Martin

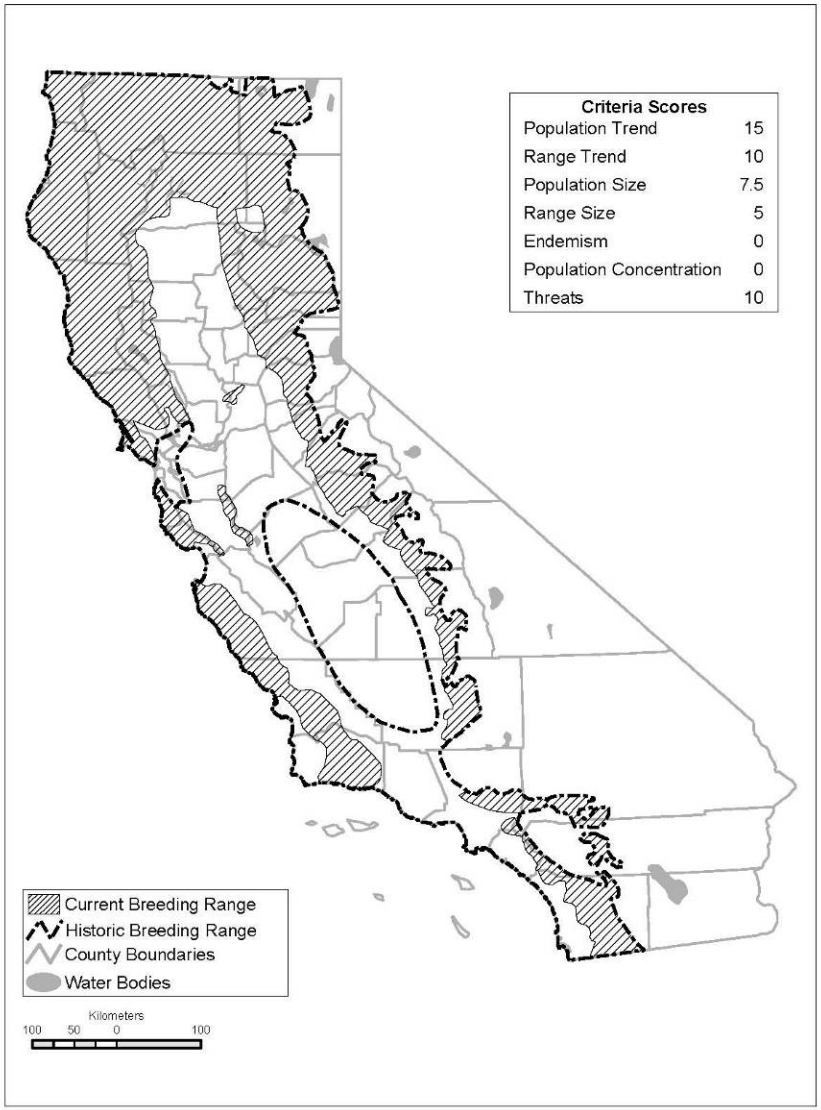


Figure 22 Loggerhead Shrike

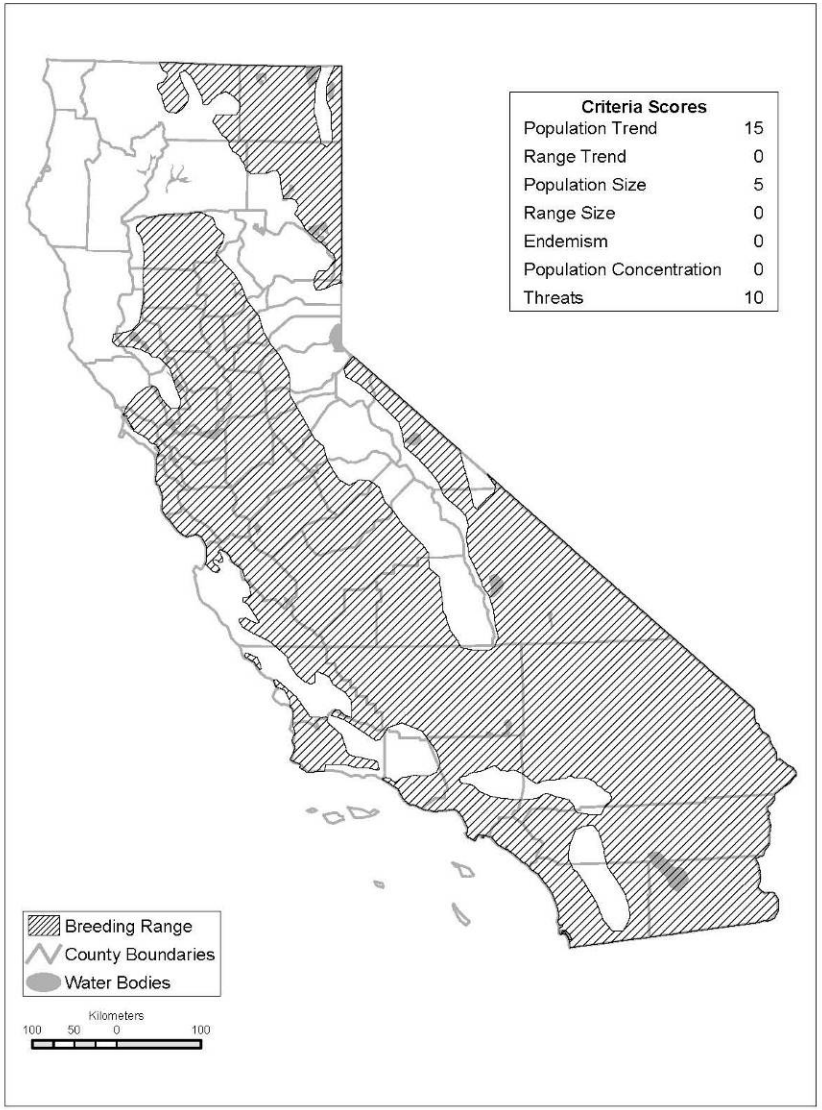


Figure 23 San Joaquin Le Conte's Thrasher

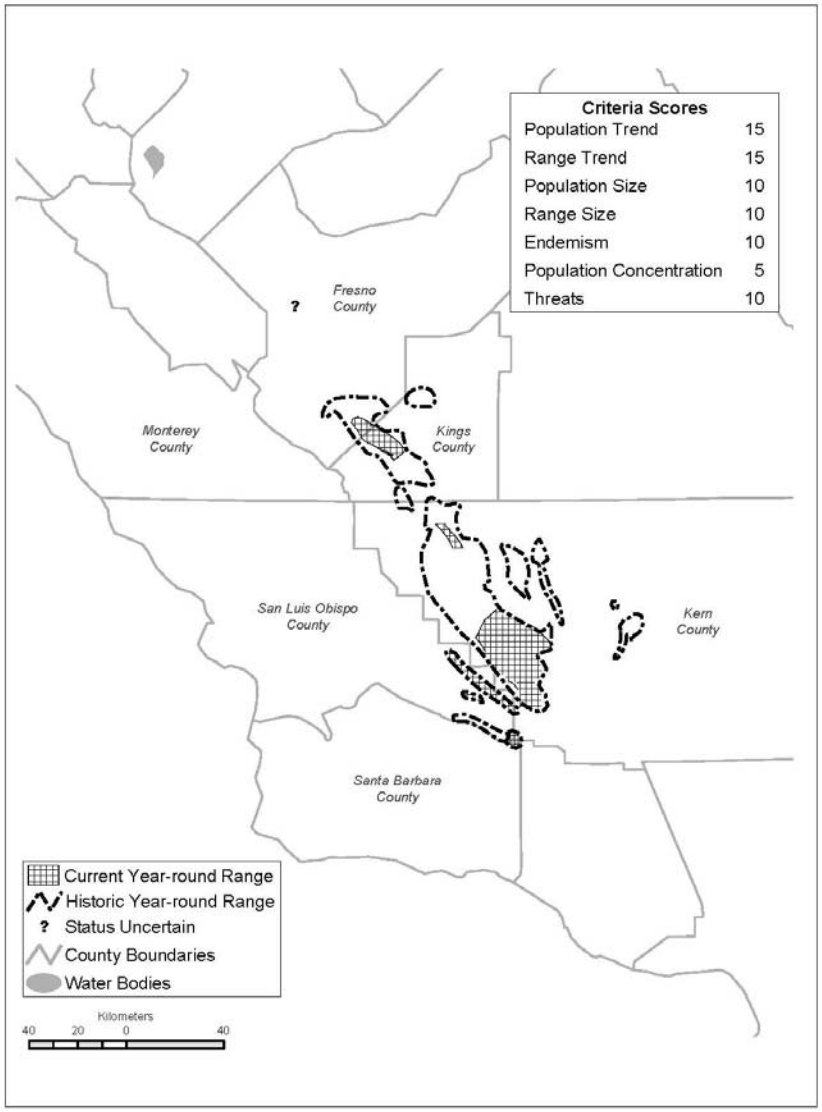


Figure 24 Acorn Woodpecker

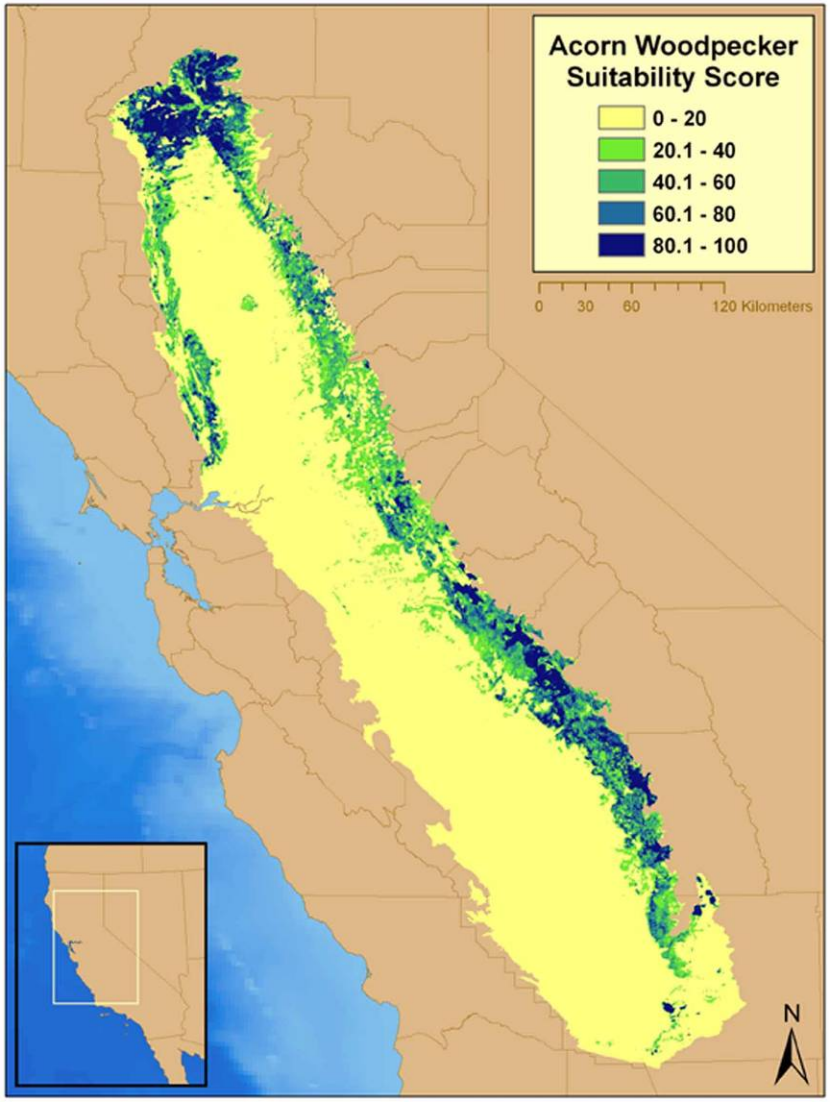


Figure 25 Ash-throated Flycatcher

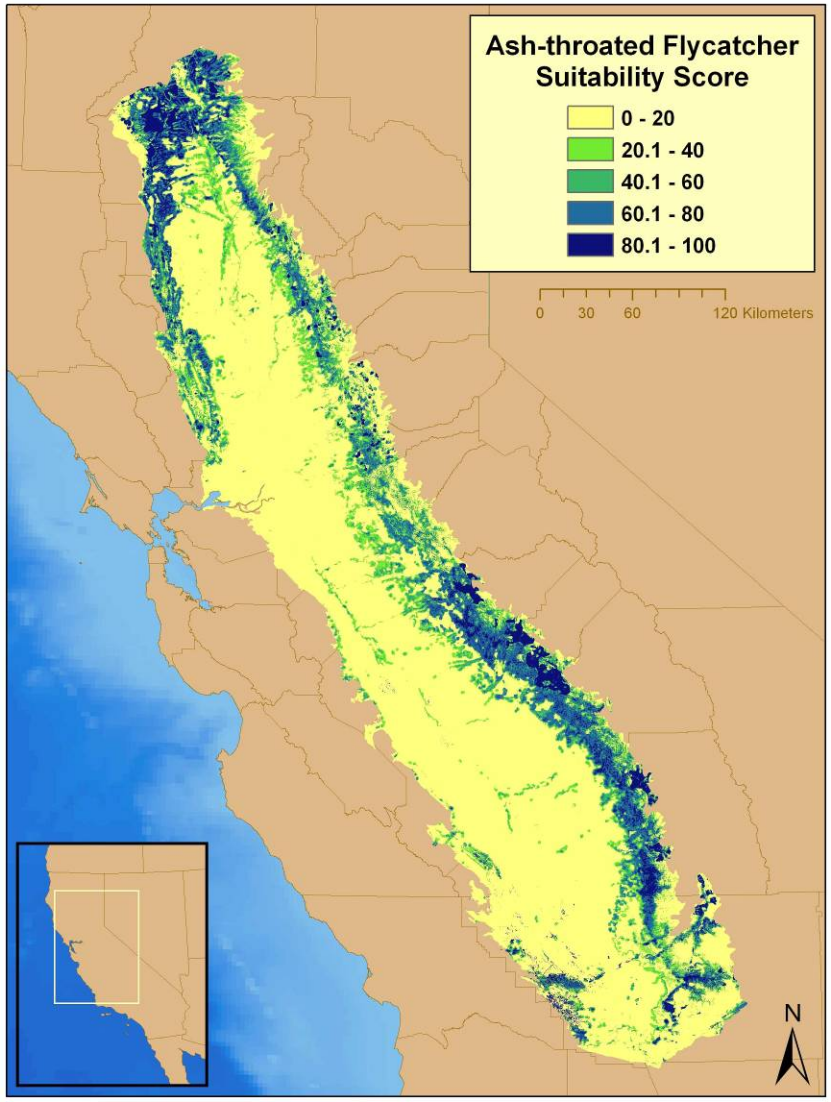


Figure 26 Lark Sparrow

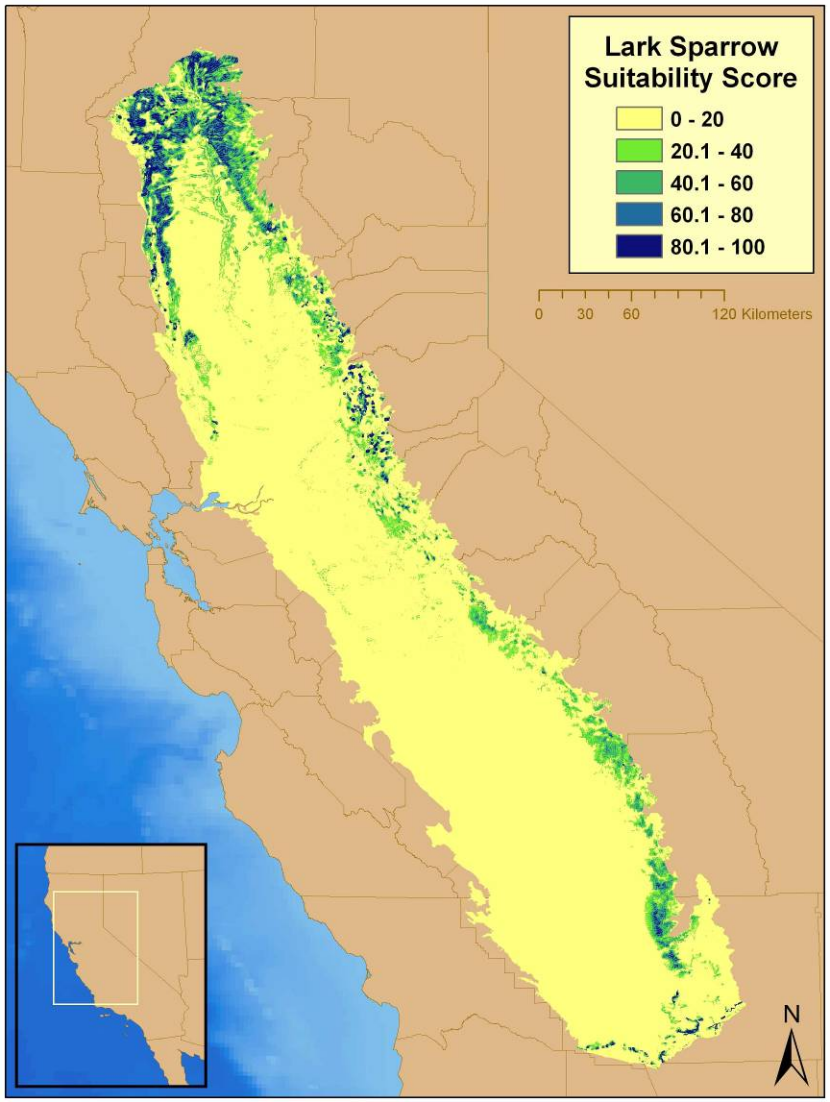


Figure 27 Nuttall's Woodpecker

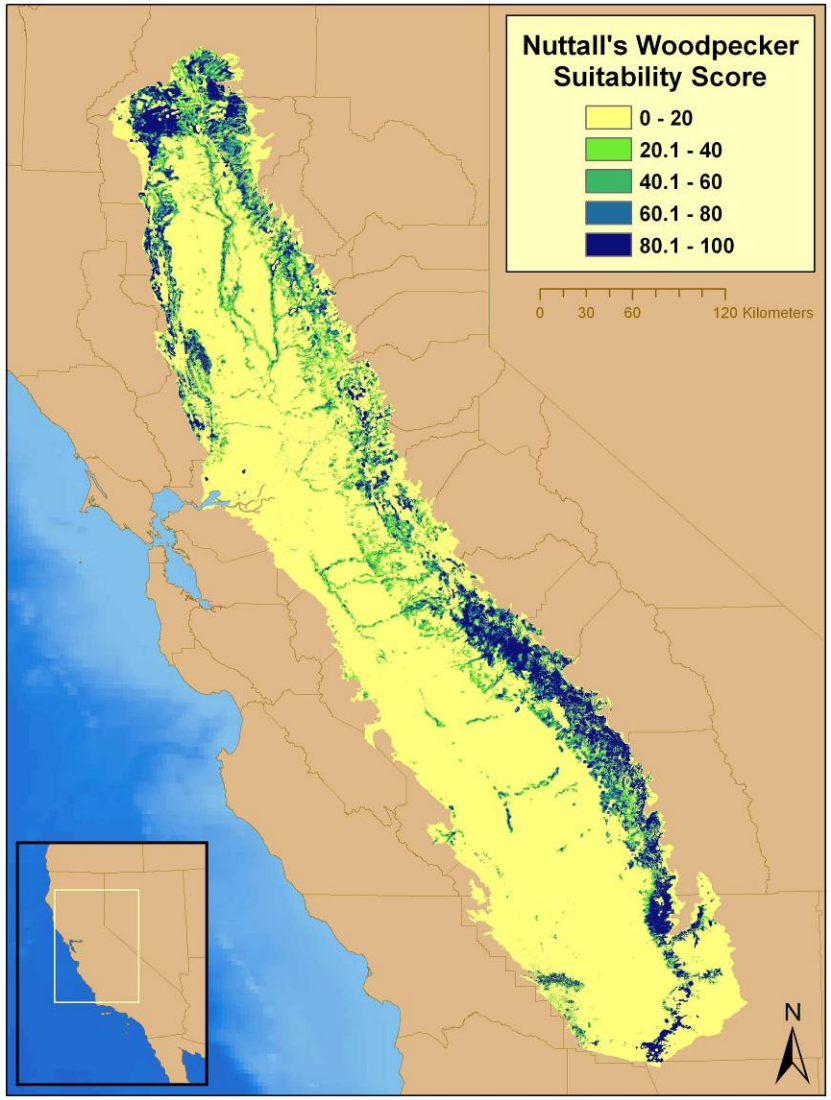


Figure 28 Oak Titmouse

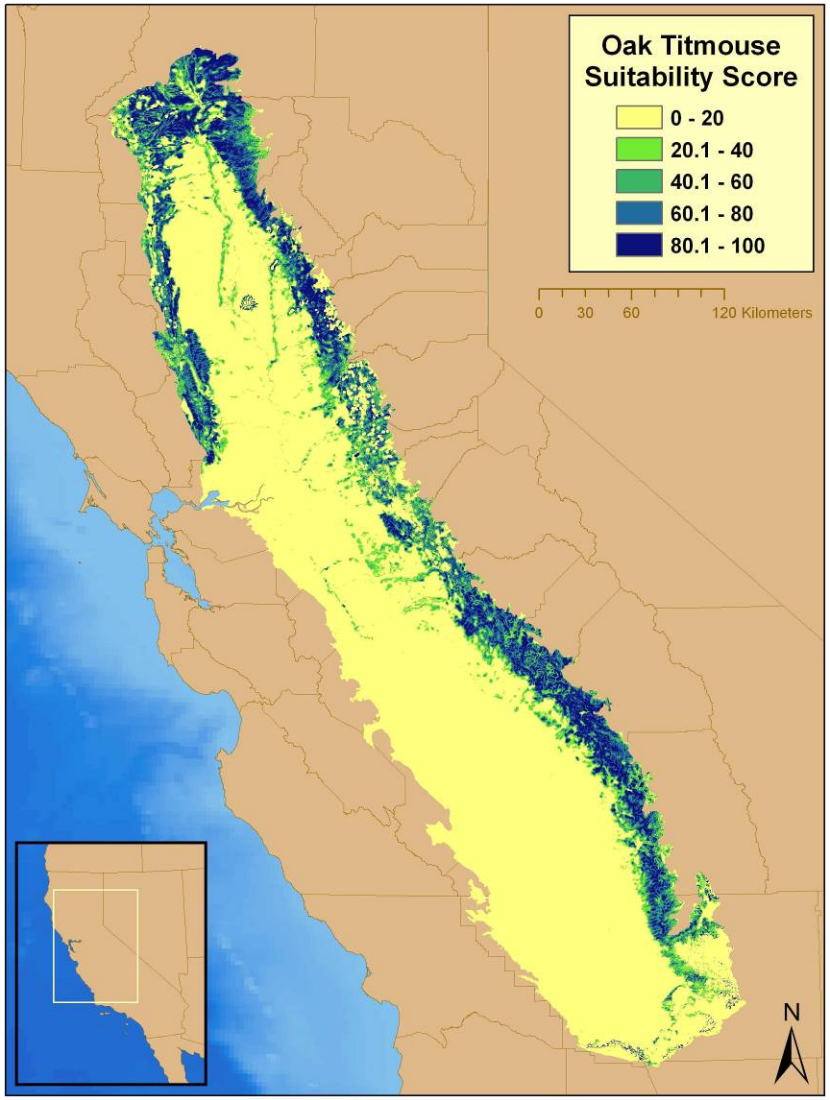


Figure 29 Western Bluebird

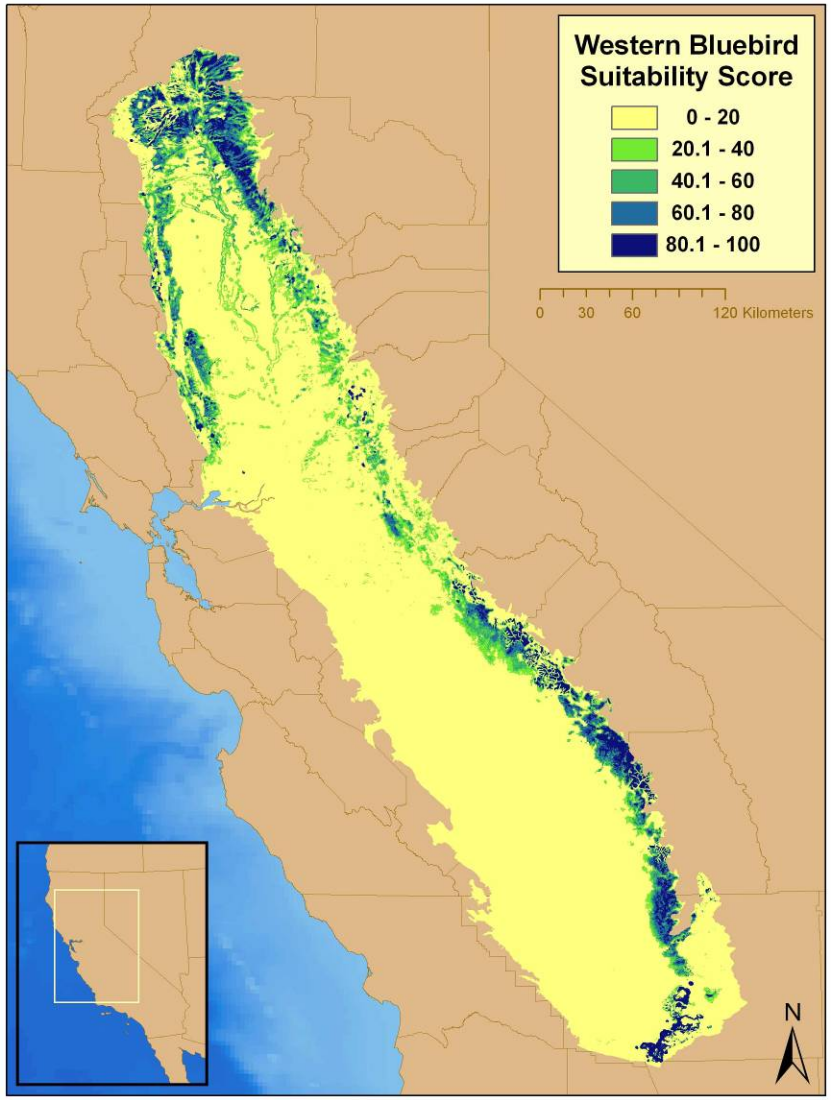


Figure 30 Yellow-billed Magpie

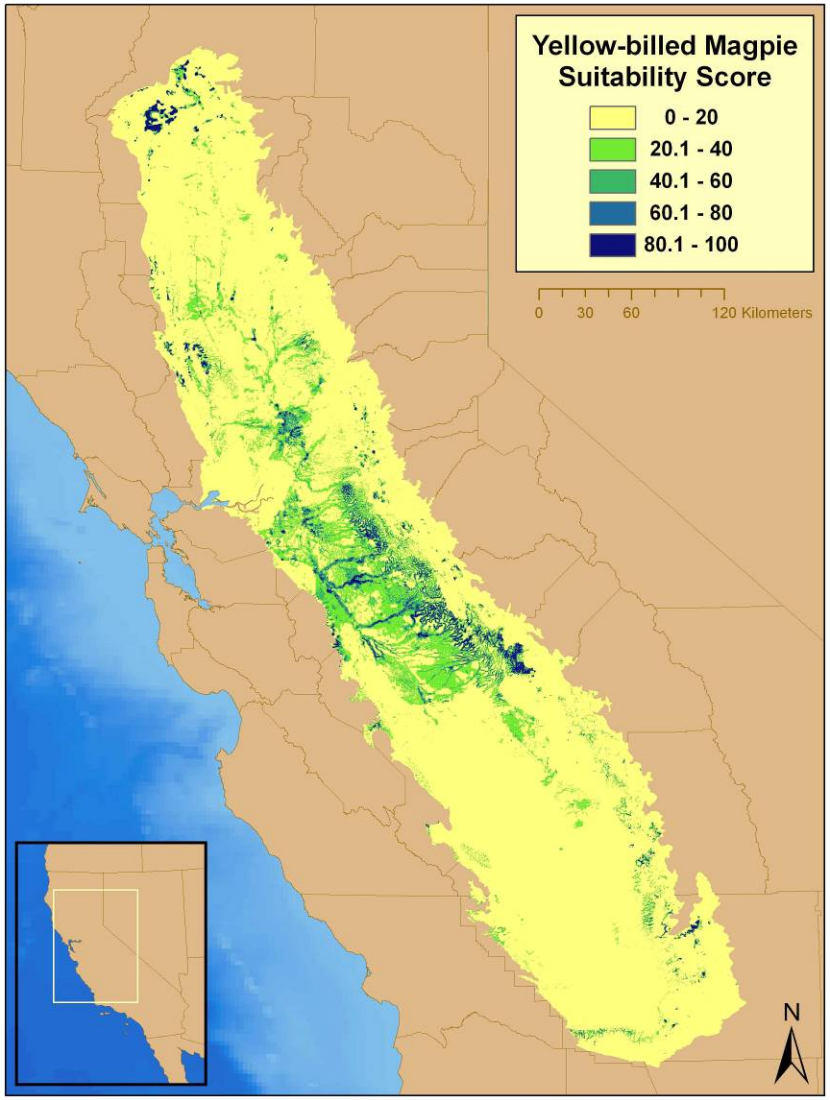


Figure 31 Burrowing Owl

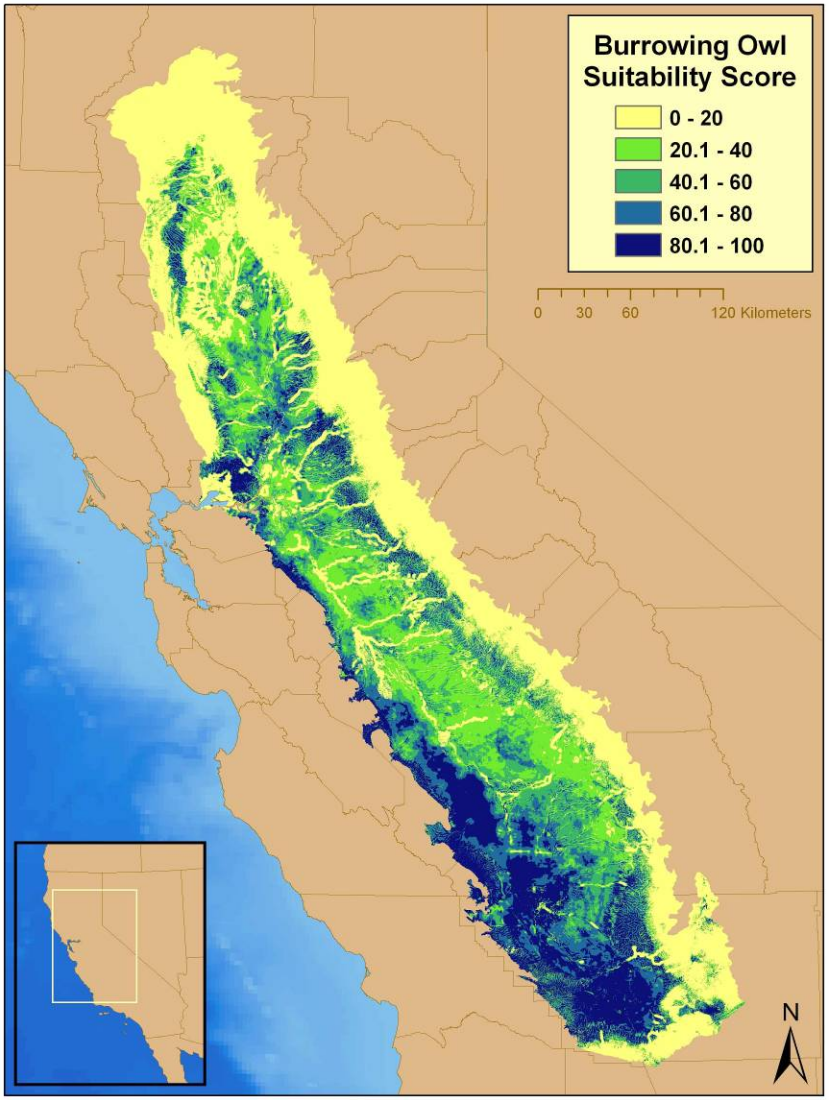


Figure 32 Northern Harrier

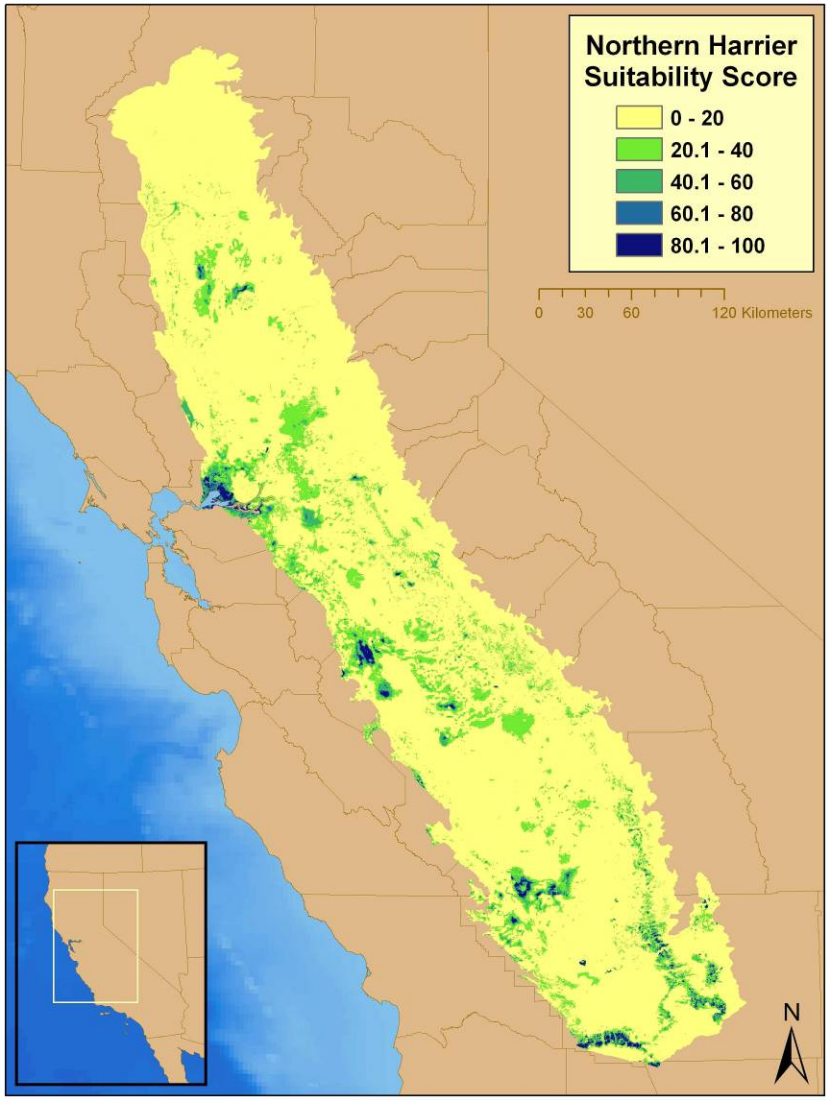


Figure 33 Western Meadowlark

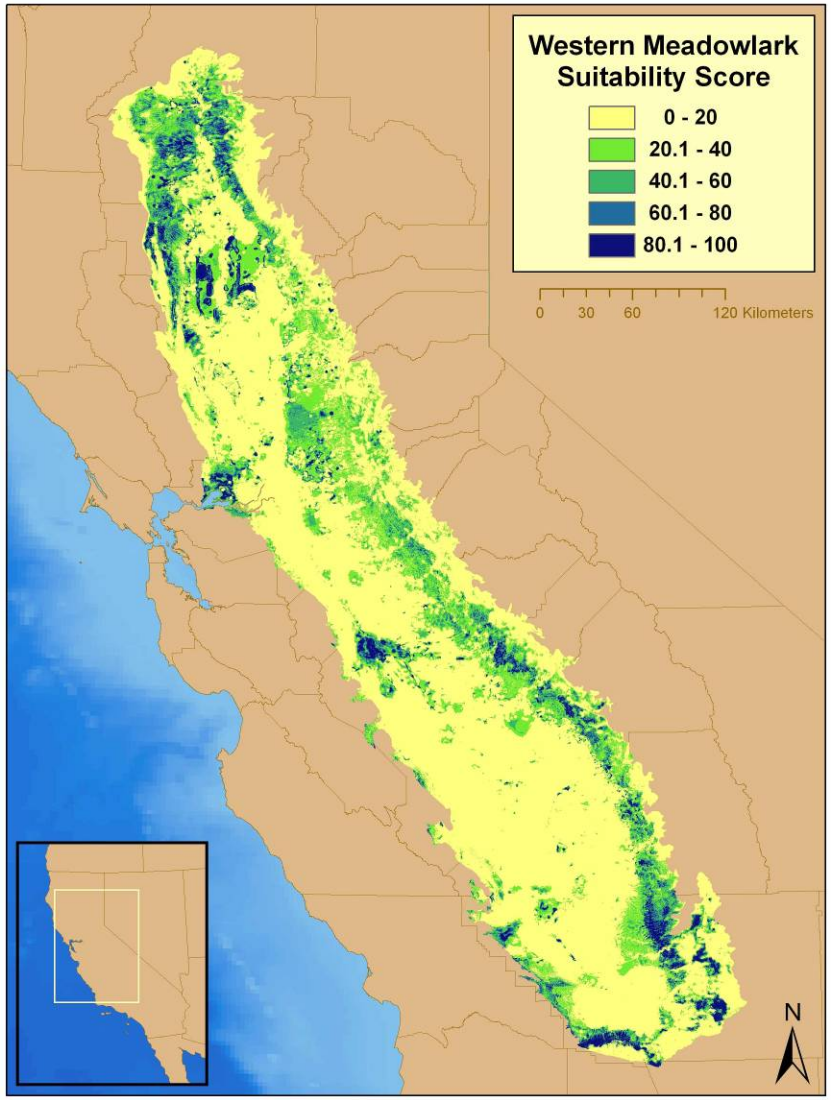


Figure 34 Black-headed Grosbeak

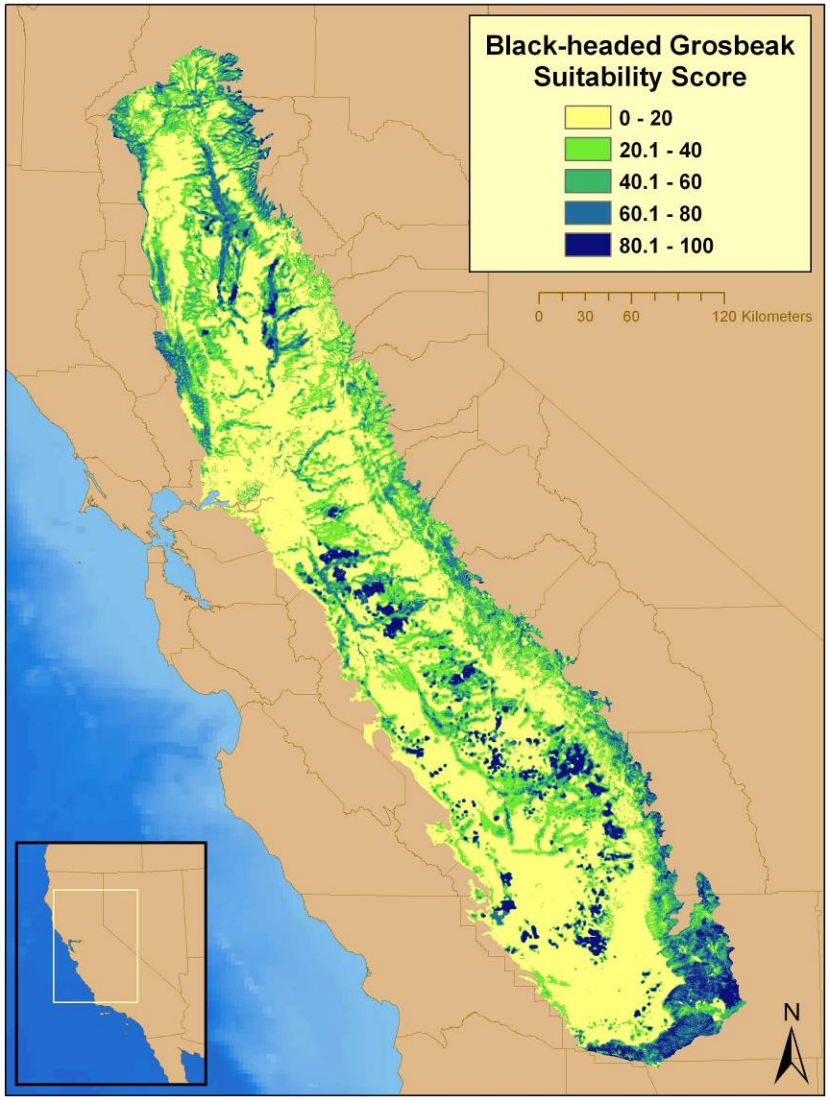


Figure 35 Blue Grosbeak

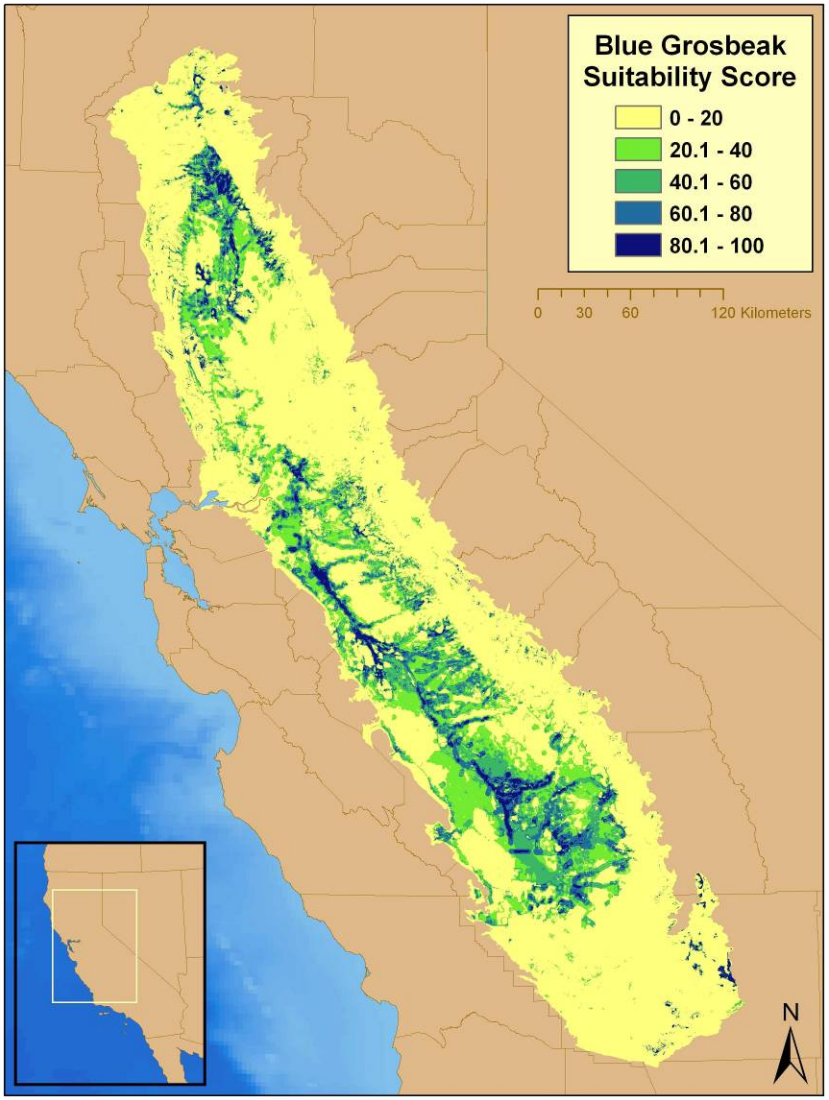


Figure 36 Common Yellowthroat

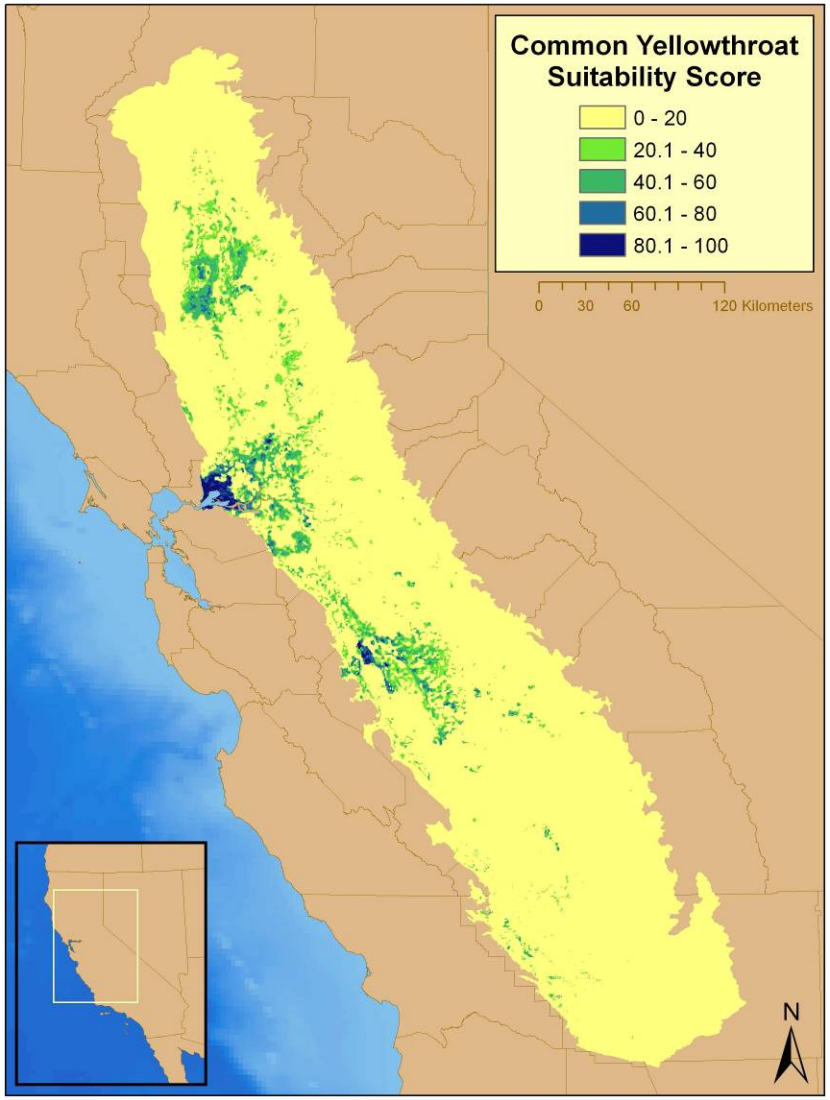


Figure 37 Song Sparrow

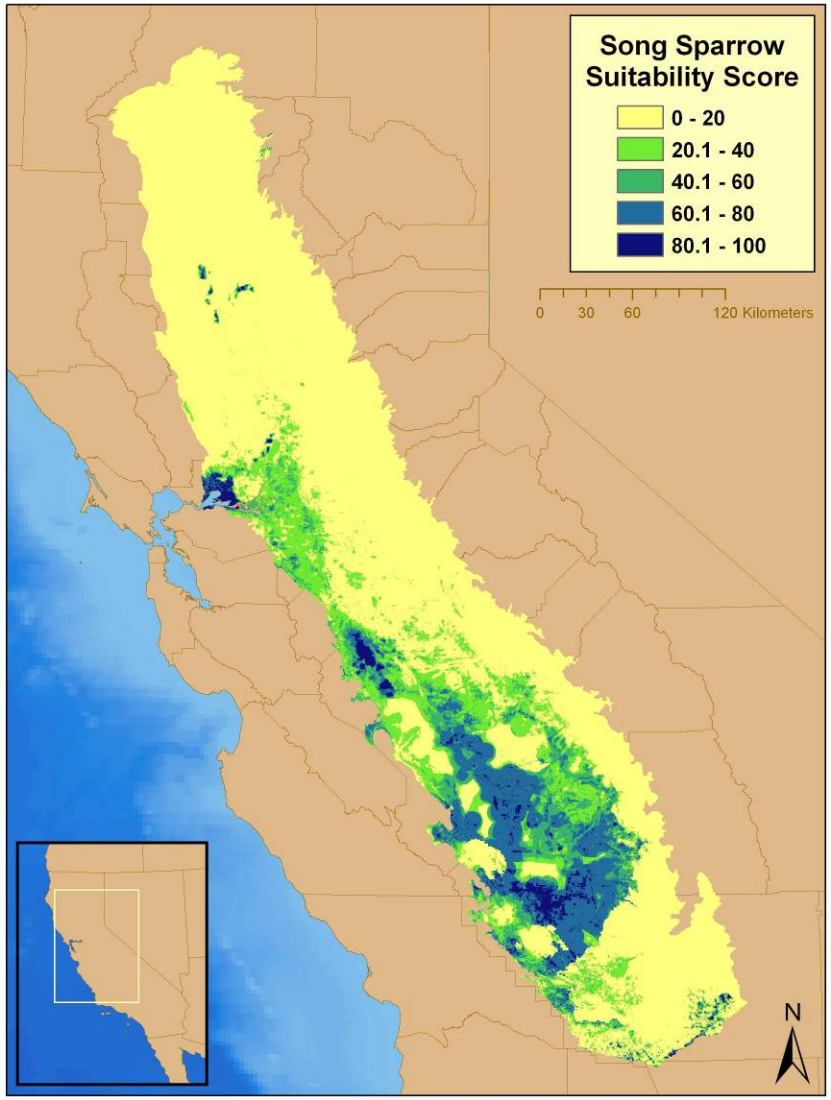


Figure 38 Spotted Towhee

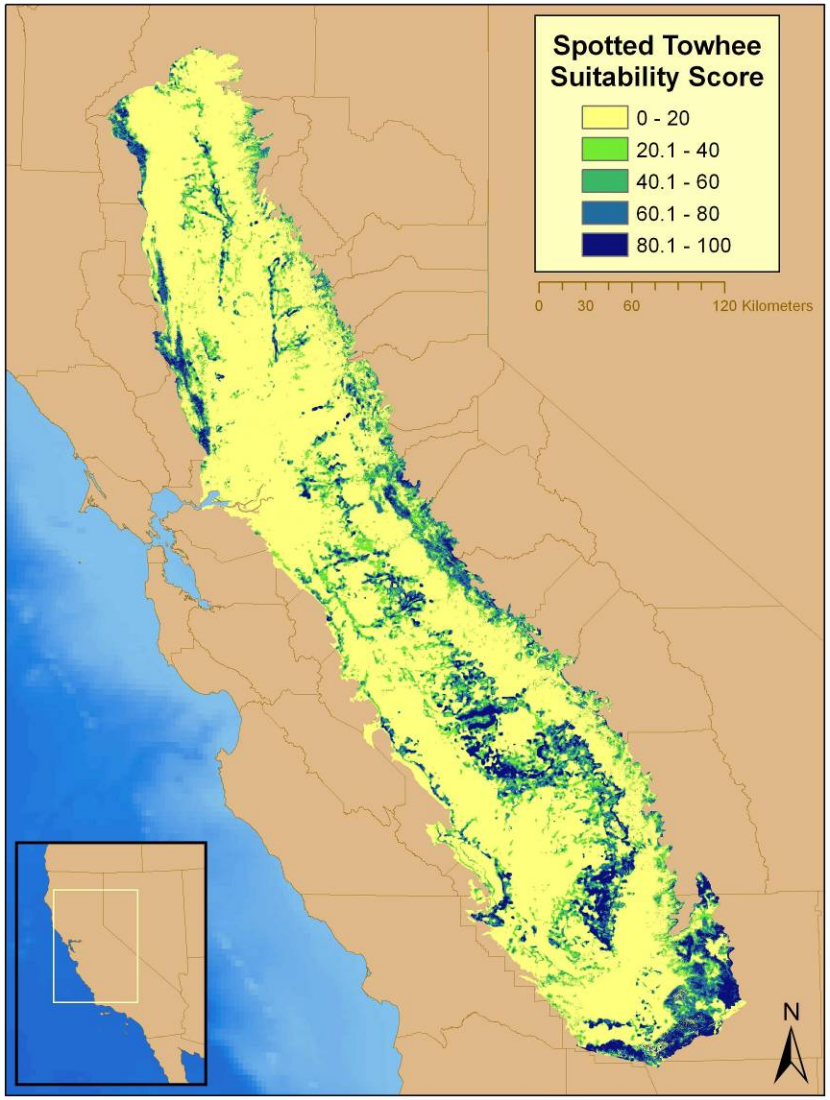


Figure 39 Swainson's Hawk

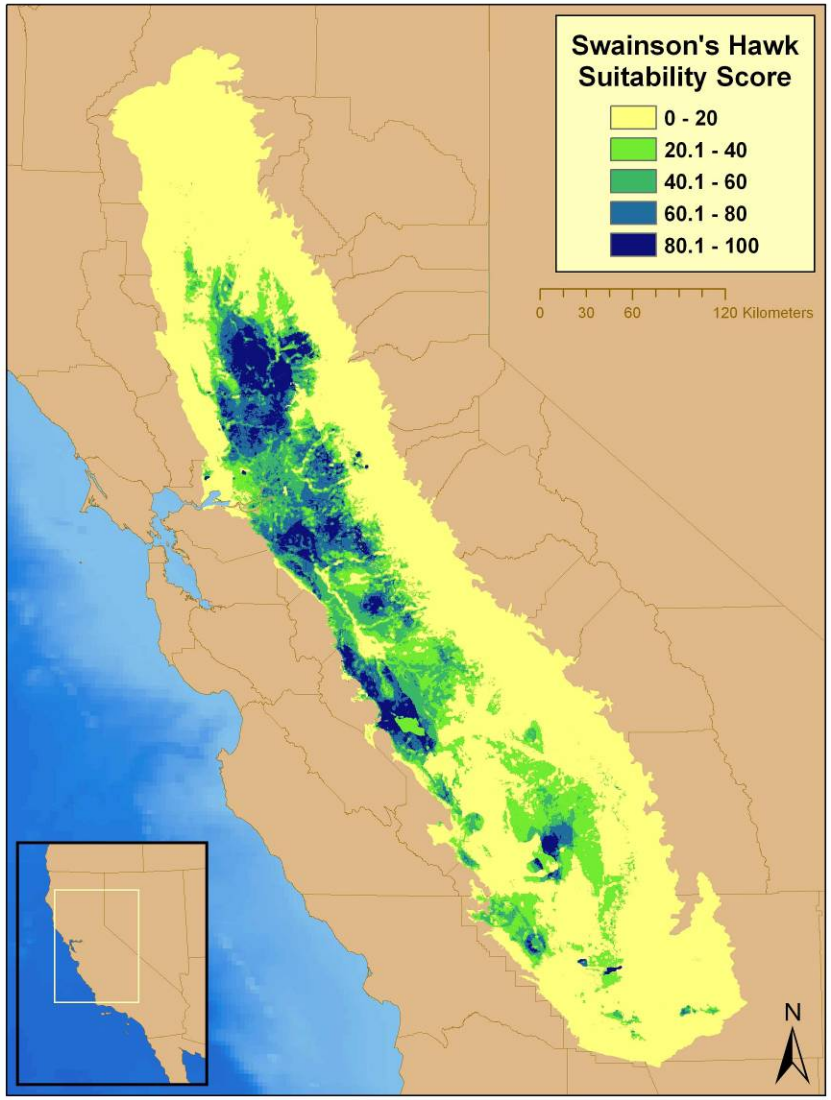


Figure 40 Tricolored Blackbird

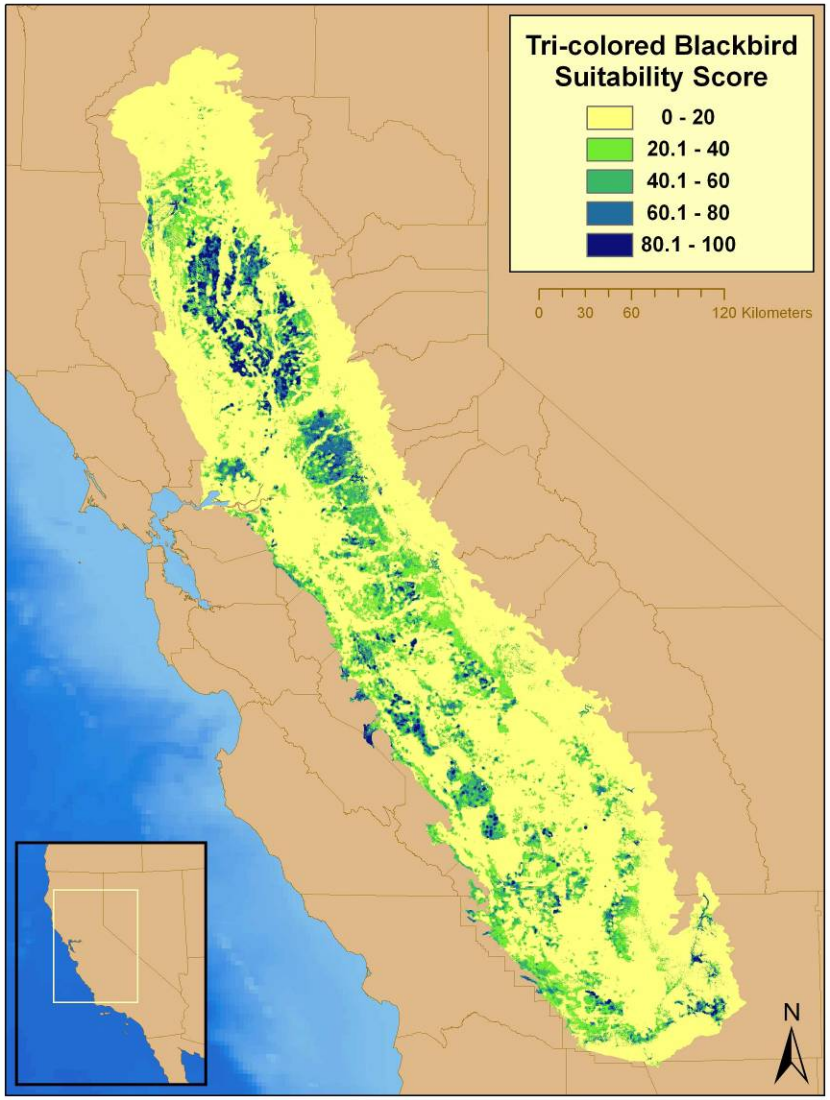


Figure 41 Yellow-breasted Chat

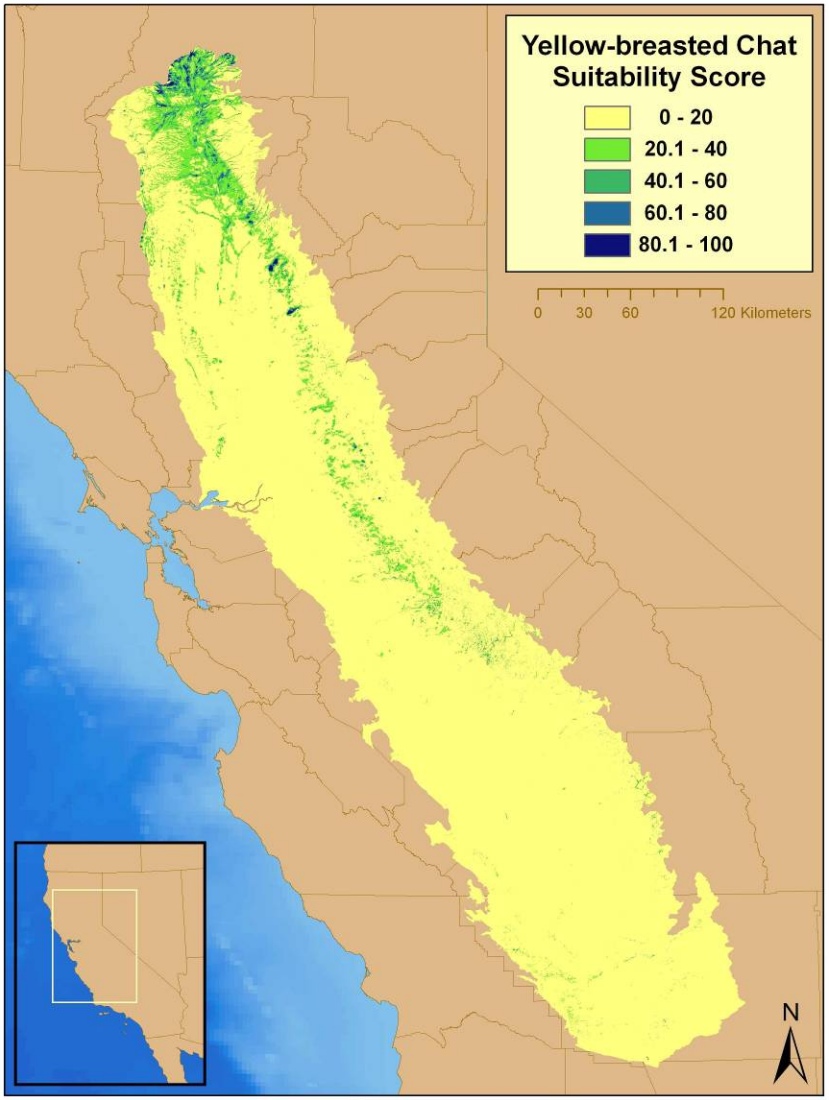


Figure 42 Yellow Warbler (BSSC)

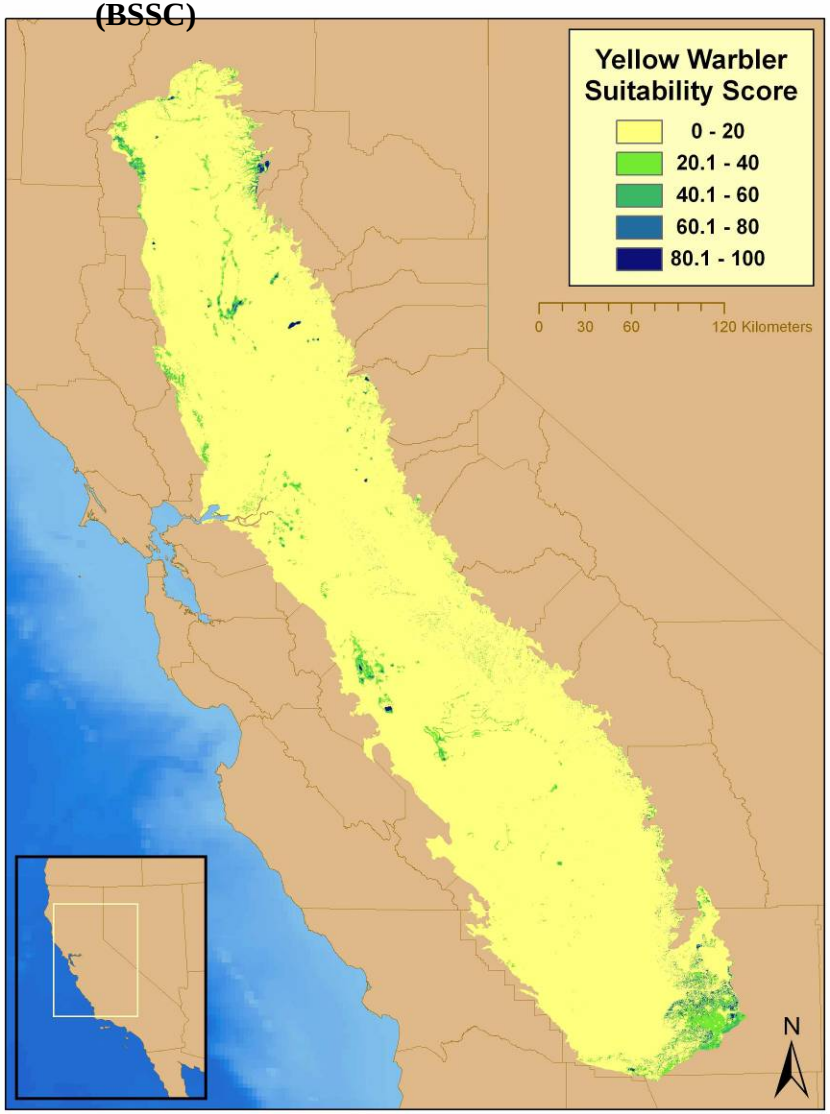


Figure 43 Bird Species of Special Concern

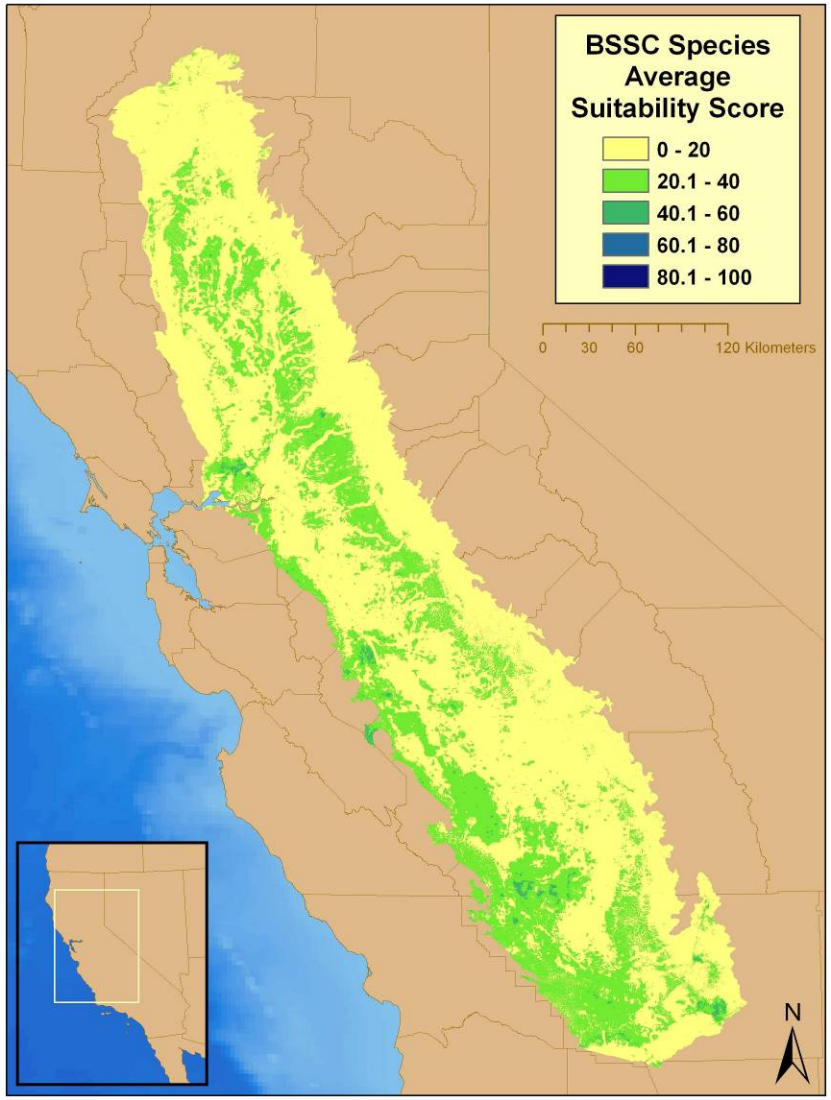


Figure 44 Grassland Species

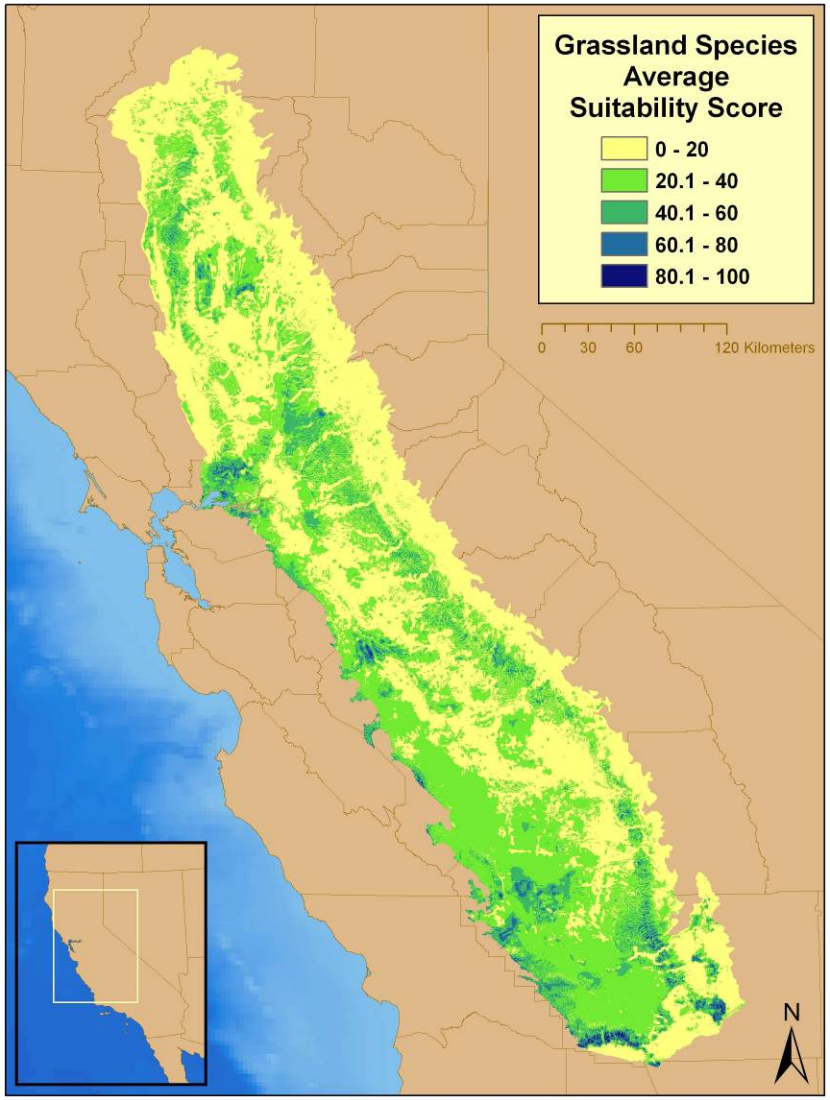


Figure 45 Oak Woodland Species

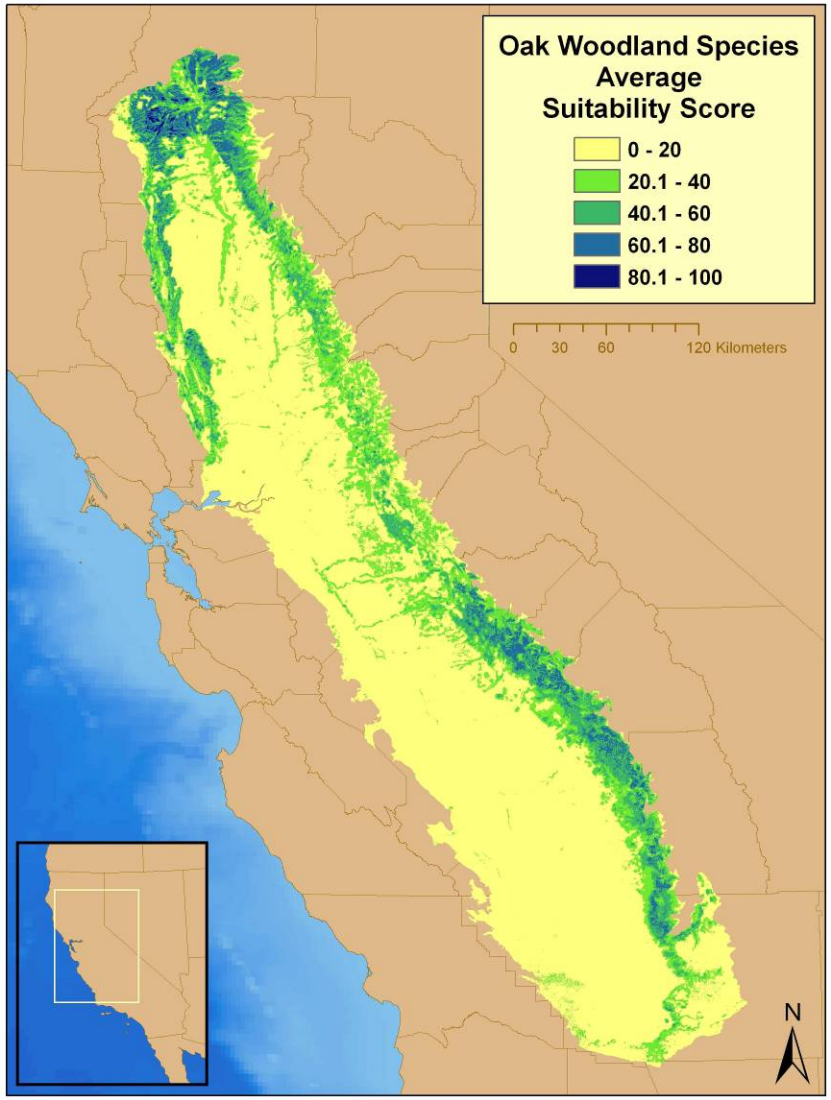


Figure 46 Riparian Species

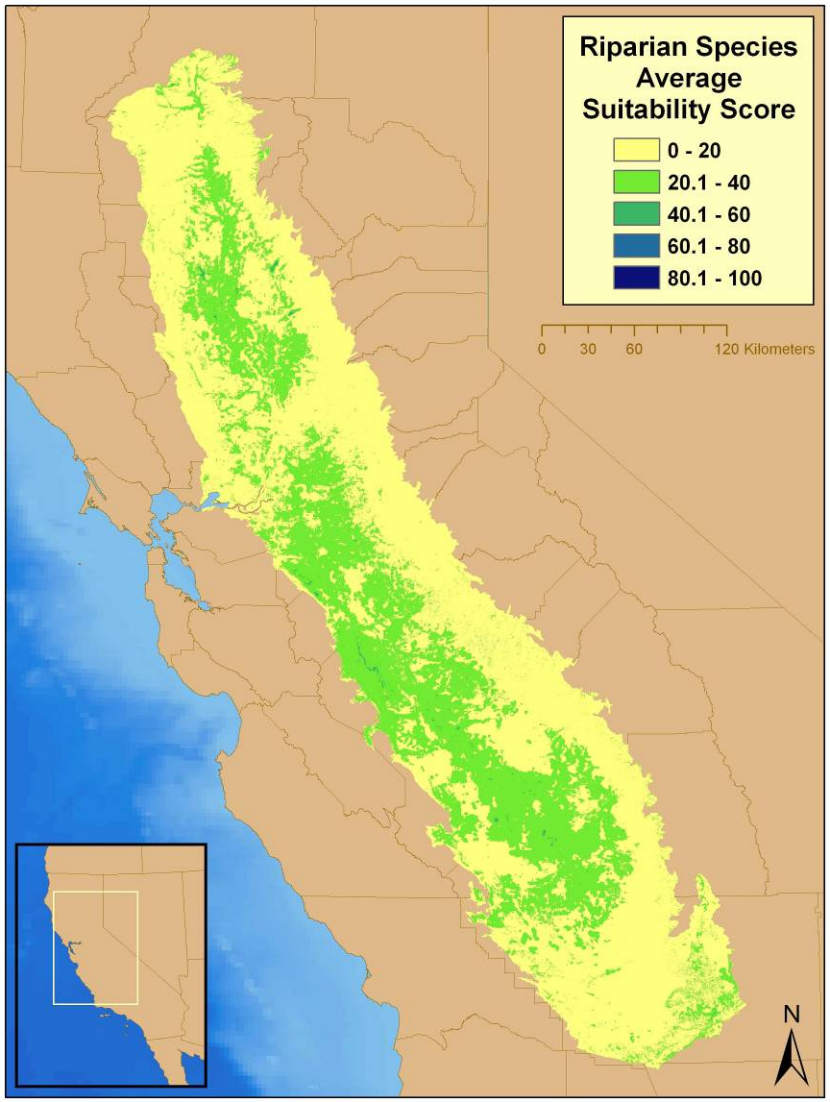
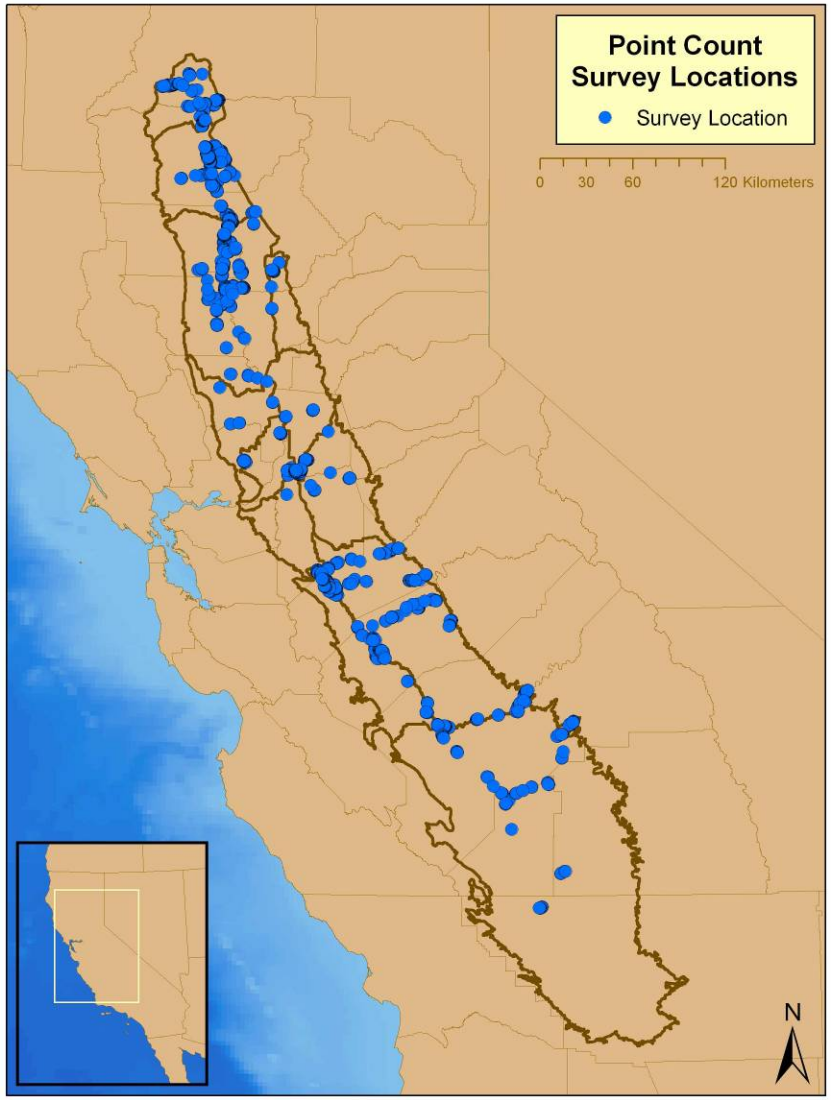


Figure 47 PRBO Point Count Locations



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Appendix 1

List of variables selected *a priori* for each species and used in the distribution model. Variable selection was based on habitats listed as important during the breeding season in BSSC and CalPIF species accounts as well as expert opinion. For all species, the following variables were used which are not included in the tables below: minimum and maximum average temperature and average precipitation for January, March, June, October, density of intermittent streams and perennial streams (km/km^2), distance (km) to stream, elevation, slope.

Acorn Woodpecker

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Ash-throated Flycatcher

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Black-headed Grosbeak

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Blue Grosbeak

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Burrowing Owl

Variable	Description
Density of canals	Linear density of canals in km/ km^2
Distance to canals	Distance (km) to nearest canal
Combined agriculture	Percent of all combined agriculture within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
5k annual grassland	Percent annual grassland vegetation within 5 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
1k Field crop	Percent field crop within 1 km radius
5k Field crop	Percent field crop within 5 km radius
Idle cropland	Percent idle cropland within 1 km radius
Pasture	Percent pasture within 1 km radius

Common Yellowthroat

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Lark Sparrow

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Northern Harrier

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined agriculture	Percent of all combined agriculture within 1 km radius
Combined wetland	Percent of all combined wetland vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
5k annual grassland	Percent annual grassland vegetation within 5 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Sagebrush	Perecent sagebrush vegetation within 1 km radius
Saline emergent wetland	Percent saline emergent wetland within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Wet meadow	Percent wet meadow vegetation within 1 km radius
1k Field crop	Percent field crop within 1 km radius
5k Field crop	Percent field crop within 5 km radius
Idle cropland	Percent idle cropland within 1 km radius
Pasture	Percent pasture within 1 km radius
Distance to lakes	Distance (km) to lake
Distance to emergent wetland	Distance (km) to emergent wetland

Nuttall's Woodpecker

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Oak Titmouse

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Song Sparrow

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Spotted Towhee

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Swainson's Hawk

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined agriculture	Percent of all combined agriculture within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
1k Field crop	Percent field crop within 1 km radius
5k Field crop	Percent field crop within 5 km radius
Idle cropland	Percent idle cropland within 1 km radius
Pasture	Percent pasture within 1 km radius

Tricolored Blackbird

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined agriculture	Percent of all combined agriculture within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
5k annual grassland	Percent annual grassland vegetation within 5 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
1k Field crop	Percent field crop within 1 km radius
5k Field crop	Percent field crop within 5 km radius
Idle cropland	Percent idle cropland within 1 km radius
Pasture	Percent pasture within 1 km radius
Lakes	Percent lake within 1 km radius
Distance to lakes	Distance (km) to lake
Distance to emergent wetland	Distance (km) to emergent wetland

Western Bluebird

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Western Meadowlark

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined agriculture	Percent of all combined agriculture within 1 km radius
Combined wetland	Percent of all combined wetland vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius
1k Field crop	Percent field crop within 1 km radius
5k Field crop	Percent field crop within 5 km radius
Idle cropland	Percent idle cropland within 1 km radius
Orchards	Percent orchards within 1 km radius
Pasture	Percent pasture within 1 km radius

Yellow-breasted Chat

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland

Yellow-billed Magpie

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Perennial grassland	Percent perennial grassland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Blue oak woodland	Percent blue oak woodland vegetation within 1 km radius
Blue oak foothill pine	Percent blue oak foothill pine vegetation within 1 km radius
Coastal oak woodland	Percent coastal oak woodland vegetation within 1 km radius
Valley oak woodland	Percent valley oak woodland vegetation within 1 km radius

Yellow Warbler

Variable	Description
Combined shrub	Percent of all combined shrub vegetation within 1 km radius
Combined hardwood	Percent of all combined hardwood vegetation within 1 km radius
Combined conifer	Percent of all combined conifer vegetation within 1 km radius
Annual grassland	Percent annual grassland vegetation within 1 km radius
Freshwater/seasonal emergent wetland	Percent freshwater/seasonal emergent wetland vegetation within 1 km radius
Montane riparian	Percent montane riparian vegetation within 1 km radius
Valley foothill riparian	Percent valley foothill riparian vegetation within 1 km radius
Orchard	Percent orchard within 1 km radius
Pasture	Percent pasture within 1 km radius
Urban	Percent urban land within 1 km radius
Vineyard	Percent vineyard within 1 km radius
1k Fieldcrop	Percent fieldcrop within 1 km radius
Distance emergent wetland	Distance (km) to freshwater or seasonal emergent wetland