



RESEARCH PAPERS

The Condor 115(3):456–464
© The Cooper Ornithological Society 2013

CONSERVATION RELIANCE AMONG CALIFORNIA'S AT-RISK BIRDS

JOHN A. WIENS^{1,2,3} AND THOMAS GARDALI¹

¹*PRBO Conservation Science, 3820 Cypress Drive #11, Petaluma, CA 94954*

²*School of Plant Biology, University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia*

Abstract. Conservation-reliant species require continuing management to ensure their long-term persistence. We qualitatively assessed the extent of conservation reliance for 92 California bird taxa listed under federal or California endangered species acts or recognized as California bird species of special concern. Habitat loss and fragmentation are the major threats for over 90% of these taxa, whereas interactions with predators or brood parasites threaten less than half, and human actions imperil roughly 40%. Some form of habitat enhancement is proposed to reduce the threats for most taxa, reinforcing the value of habitat-conservation strategies. Protecting habitat for wetland taxa and restoring habitat for island taxa appear to be particularly costly actions. Importantly, the species of special concern are every bit as conservation reliant as are taxa listed as endangered or threatened; management of these yet-unlisted taxa may be especially effective in preventing them from slipping into a more precarious status. Consideration of the magnitude of threats together with the degree of conservation reliance may help in prioritizing taxa for conservation. The philosophy and practice of conservation and resource management must recognize that continuing actions will be required to maintain the viability of populations of a great many species.

Key words: *at-risk species, California, conservation, conservation reliance, habitat, management, prioritization.*

Dependencia de la Conservación de las Aves de California en Riesgo

Resumen. Las especies que dependen de la conservación requieren un manejo continuo para asegurar su persistencia a largo plazo. Evaluamos cualitativamente el grado de dependencia de la conservación de 92 taxa de aves de California incluidas en listas de especies en peligro federales o de California o reconocidas como especies de aves de California de interés especial. La pérdida de hábitat y la fragmentación son las principales amenazas para más del 90% de estos taxa, mientras que las interacciones con depredadores o parásitos de nidada amenazan menos de la mitad, y las acciones humanas ponen en peligro cerca del 40%. Se propone alguna forma de mejoramiento de hábitat para reducir la amenaza para la mayoría de los taxa, reforzando el valor de las estrategias de conservación de hábitat. La protección de hábitat para los taxa de humedales y la restauración de hábitat para los taxa de las islas parecen ser acciones particularmente costosas. Las especies de interés especial son tan dependientes de la conservación como lo son los taxa listados como en peligro de extinción o amenazados; el manejo de estos taxa aún no listados puede ser particularmente efectivo en prevenir que se deslicen a un estatus más precario. La consideración de la magnitud de las amenazas junto con el grado de dependencia de la conservación puede ayudar a priorizar los taxa para conservación. La filosofía y la práctica de la conservación y del manejo de los recursos deben reconocer que se requerirán acciones continuas para mantener la viabilidad de las poblaciones de muchas especies.

INTRODUCTION

Biodiversity is in a bind. Rates of extinction or imperilment are increasing and may become even greater as the effects of climate change amplify (Ricketts et al. 2005, Sekercioglu et al. 2008, Urban et al. 2012). Despite the growing awareness of the biodiversity crisis, conservation efforts are failing to

keep pace with the growing queue of species meriting attention. While thousands of species in the United States may currently be imperiled (Wilcove and Master 2005), government funding to support conservation has stagnated, and it becomes especially vulnerable during economic downturns.

Manuscript received 17 May 2012; accepted 31 January 2013.

³E-mail: jwiens@prbo.org

Nongovernmental support for conservation cannot cover the shortfall.

This situation is exacerbated by the recognition that many imperiled species will require continuing management to persist even after they have met mandated recovery goals—they are “conservation-reliant species” (Scott et al. 2005, Redford et al. 2011). Over 80% of the 1136 species listed under the Endangered Species Act (as of 2007) are likely to be conservation reliant, with only slight differences among taxa as diverse as plants, invertebrates, birds, or mammals (Scott et al. 2010). If this proportion is applied to the estimate of currently unlisted but imperiled species of Wilcove and Master (2005), then some 20 000 species in the United States may be conservation reliant. Clearly, the financial resources (not to mention the political will) to support the management needed to conserve all of these species are unlikely to materialize. Choices about how to allocate scarce conservation resources will have to be made (Mace and Purvis 2007, Briggs 2009); the notion of conservation triage is no longer heretical (Bottrill et al. 2008, Schneider et al. 2010, Rudd 2011, Wiens et al. 2012; but see Parr et al. 2009).

Ultimately, prioritization involves assessing costs, benefits, and risks (Murdoch et al. 2007, Goble 2009). A prioritization assessment should include an analysis of the components of conservation reliance, since species differ in their dependence on management, the magnitude and duration of actions required, and their responsiveness to management. As a first step, we present here a coarse-level, qualitative assessment of conservation reliance among California’s birds at risk. We ask:

- What factors threaten these taxa?
- How extensive is conservation reliance among these taxa?
- Does the extent of conservation reliance differ depending on listing status, migratory status, or habitat affinity?
- What management actions have been proposed?

We restrict our attention to California. California is a hot-spot of biodiversity in North America (Stein 2008), with 651 bird species recorded (http://www.californiabirds.org/ca_list.asp; accessed 27 January 2013). The distribution and status of birds in California are well known, and the federal and state listings of threatened and endangered species are complemented by a listing of 63 additional taxa that merit conservation attention in the state (Shuford and Gardali 2008). Determining how and to what extent these birds are conservation reliant is an essential step in prioritizing conservation. This approach can help to guide the implementation and continuing revision of the California Wildlife Action Plan (Bunn et al. 2007) and serve as a model for other states or regions.

METHODS

TAXA CONSIDERED

Using the listings of threatened and endangered birds and California Bird Species of Special Concern (BSSC) (Shuford

and Gardali 2008), we identified 92 species, subspecies, and distinct populations (“taxa”) for analysis (15 federally listed, 14 California listed [including 9 taxa listed by both], and 63 BSSC; we did not consider species that are candidates for listing as a separate category, although they are included among the BSSC). Drawing on information in recovery plans, species accounts in Shuford and Gardali (2008), *The Birds of North America* (<http://bna.birds.cornell.edu/bna/>), and personal experience, we evaluated each taxon in terms of key threats and proposed conservation actions.

A quantitative analysis of conservation reliance that could support a formal decision-support model (e.g., Korschgen et al. 2005, Bunnell et al. 2009) would be preferable. Unfortunately, the available data do not warrant such an approach. Instead, we developed categorical and qualitative information for each taxon (Appendix; available at <http://dx.doi.org/10.1525/cond.2013.120086>). Our results are therefore presented as simple tabulations. Because our categorizations are subjective, readers with different experiences or perspectives might differ somewhat in the assignments for taxa given in the Appendix. Because the extent and magnitude of conservation reliance among California bird taxa have not been quantified, however, even general, qualitative information can provide useful guidance for conservation and management.

THREATS

The persistence of a species may be threatened in multiple ways. To simplify our assessment, we categorized threats as habitat loss (combining habitat loss, degradation, and fragmentation), biotic interactions (predation, brood parasitism), and human effects (pollution, disturbance, direct exploitation). For each taxon, we assigned each threat a relative value (1 = high, 2 = medium, 3 = low). Because we evaluated federally listed species on the basis of recovery plans, in some cases these designations are based on a portion of the species’ range wider than California alone.

MANAGEMENT ACTIONS

To evaluate management, we considered four forms of habitat enhancement: maintenance (e.g., prescribed burning), protection (e.g., acquisitions, easements), restoration (e.g., reestablishment of riparian woodland), and creation of additional habitat (e.g., new islands as nesting areas); two categories of reducing harmful biotic interactions: controlling predators or brood parasites (the Brown-headed Cowbird, *Molothrus ater*); and reducing human effects: controlling pollution, reducing disturbance, and controlling exploitation such as hunting. In addition, we included two forms of population management (artificial breeding and introductions to unoccupied habitat). We assessed each action for each taxon in terms of its likely duration (continuous, intermittent, once or occasional) and its cost (high, medium, low). We evaluated threats and management separately, so each taxon could have multiple threats and/or multiple proposed actions. To assess whether there are

life-history or ecological correlates among taxa in their degree of conservation reliance, we also categorized each taxon by its migratory status in California (resident, breeding, or wintering) and by its general habitat association (marine/coastal, wetland, woodland, forest, riparian, and shrub/grassland/desert). Because several listed taxa are island endemics, we also considered threats and management for island taxa.

THREAT AND CONSERVATION-RELIANCE INDICES

We developed coarse indices to assess the overall level of threat and degree of conservation reliance for each of the taxa we considered. To calculate a threat index, we ranked each threat category for each taxon from 0 (none) to 3 (high) and summed the values. We then determined which taxon had the maximum threat value and divided the summed value for each taxon by that maximum value. The taxon facing the greatest number of threats of the greatest severity therefore had a threat index of 1.0.

We calculated the index of conservation reliance in a similar manner, rating actions as 0 (none), 1 (occasional, low-cost), 2 (intermittent low-cost or occasional medium-cost), 3 (intermediate medium-cost, continuous low-cost, or occasional high-cost), 4 (continuous medium-cost or intermittent high-cost) or 5 (continuous high-cost) (see Appendix). We summed the values across all categories of management for each taxon and divided the total by the value for the species with the maximum sum. Values of the conservation-reliance index thus ranged from 0 (no actions recommended or undertaken) to 1.0 (the most conservation-reliant taxon).

Bear in mind that these indices are only coarse approximations of the actual threat levels and degree of conservation reliance that might characterize a taxon. They provide a start, however, in comparing taxa as a basis for prioritizing conservation efforts.

RESULTS

THREATS

Listing status. By definition, taxa that are officially listed or recognized as species of special concern are threatened by one or more factors. Of the sources of threats we considered, habitat loss was identified as a threat for 97% of the 92 taxa and was ranked high for 84%; the percentages did not differ appreciably among the three categories of lists (threatened or endangered per the federal government, threatened or endangered per the state government, or BSSC (Fig. 1). Interspecific interactions and human actions were listed as threats for less than half of all taxa (Fig. 1). Such interactions were assigned high importance, however, for only 13% of the federally listed taxa, whereas this threat was ranked high for 33% of the state-listed taxa (Fig. 1), largely reflecting the vulnerability of several species (e.g., Scripps's Murrelet, Cassin's Auklet; see Appendix for scientific names) to predators or of others (e.g., Least Bell's Vireo) to cowbird parasitism. Human actions were considered highly important threats for half of the state-listed taxa and 40% of the federally listed taxa but for only 15% of the BSSC.

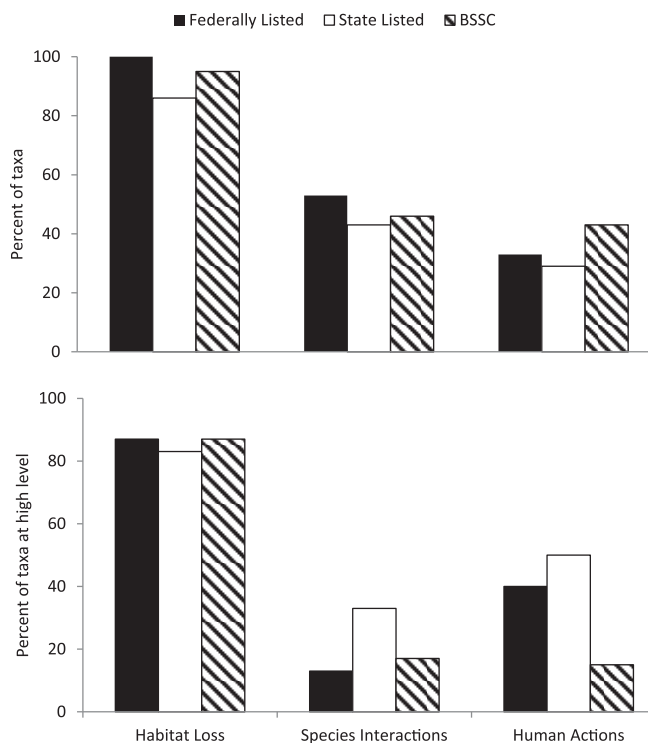


FIGURE 1. Top: percentages of federally and state-listed bird taxa and California Bird Species of Special Concern (BSSC) threatened by habitat loss, interactions with other species, or human actions. Bottom: percentages of species for which, when a threat is identified, the threat is ranked as high (i.e., habitat loss is identified as a threat for 95% of the BSSC taxa; for 87% of those taxa, this threat is ranked high).

There were also differences among the lists in the variety of factors threatening taxa. With respect to the three general threat categories, 43% of the federally and state-listed taxa were subject to a single identified threat, 54% to two threats. Fewer BSSC (29%) faced a single threat, whereas more faced threats from two (61%) or all three (10%) categories. Where only a single threat was identified, it was almost always (93%) habitat loss.

Migratory status and habitat association. The percentages of permanent residents and breeding summer visitors threatened by habitat loss and interspecific interactions did not differ from those for all species or the status groups (Fig. 2). Threats from human activities were lower for permanent resident species than for breeding summer visitors or winter visitors, and few wintering species were threatened by interspecific interactions (nest parasitism is not a threat in winter). Taxa of all habitat categories were threatened by habitat loss, although for marine and coastal taxa and taxa restricted to islands the fraction was somewhat less (Fig. 2). Few wetland or forest species were threatened by interspecific interactions, which were the dominant threat on islands (primarily because of predation). Human actions posed the greatest threat to taxa in marine and coastal environments, least in riparian habitats, where interspecific interactions (primarily nest parasitism) posed a greater threat.

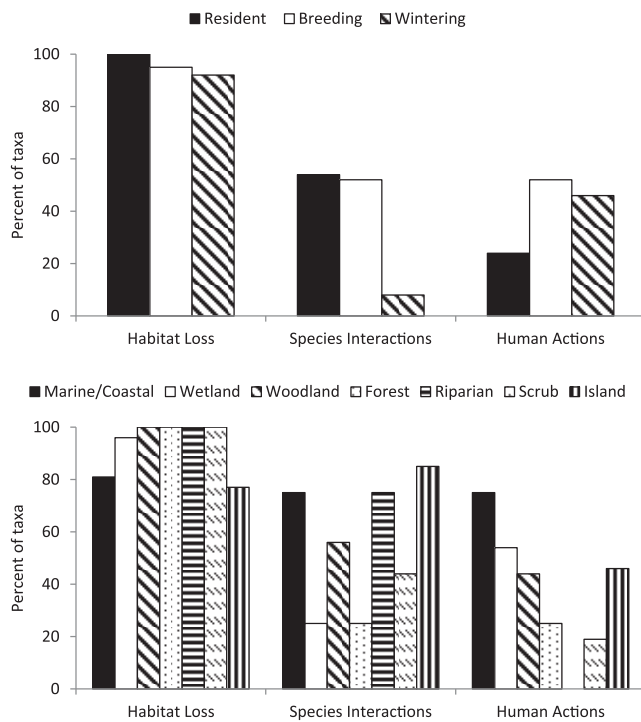


FIGURE 2. Top: percentages of California bird taxa at risk threatened by habitat loss, interspecific interactions, or human actions according to the migratory status of the taxon. Bottom: the same, partitioned by the primary habitat associations of the taxon.

MANAGEMENT AND CONSERVATION ACTIONS

Listing status. Because habitat loss was considered a major threat to most of the taxa, it is not surprising that habitat enhancement has been recommended for nearly all taxa (Fig. 3). Controlling interactions with other species or reducing human effects were recommended for roughly one-third of the taxa, while bolstering populations through introductions or captive breeding was suggested for few taxa. Even though interspecific interactions were considered a highly important threat to only a few of the federally listed taxa, controlling such interactions was suggested more than twice as often for

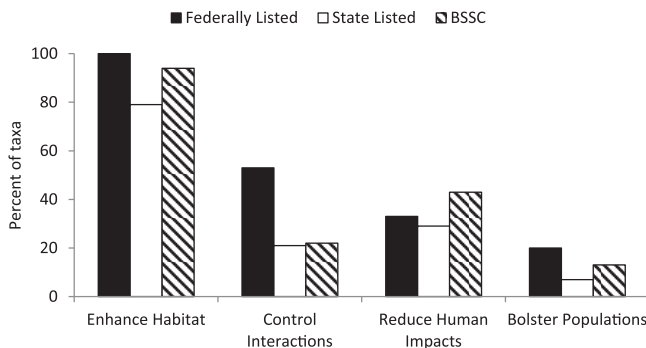


FIGURE 3. Percentages of California bird taxa at risk for which habitat enhancement, control of interspecific interactions, reduction of human effects, or bolstering of populations (e.g., captive breeding) are recommended to reduce threats.

these taxa as for the other groups (Fig. 3). This suggests that such threats may be associated with particular brood parasites or predators that can be targeted for management.

Because actions to enhance habitat were suggested so often, we examined these suggestions in greater detail (Table 1). Among all taxa for which habitat enhancement was recommended, habitat protection was listed for three-quarters, maintenance or restoration of existing habitat for somewhat more than half, and creation of new habitat for only 15%. Most of these actions would incur medium costs. Where habitat protection was a recommended action, it was more often at greater cost—purchasing land for conservation is generally expensive.

Habitat protection was considered to be important to management of all three categories of lists, but especially the BSSC (Table 1). Creation of new habitat was suggested more often, and habitat restoration less often, for the state-listed taxa than for the other groups, with a correspondingly higher cost.

The duration of management is an important component of conservation reliance. Habitat restoration or creation may need to be undertaken only once, occasionally (e.g., once a decade), or frequently (e.g., annually), depending on the nature of the action, but once the habitat is restored or created often it requires little long-term investment (Table 2). On the other hand, maintaining existing habitat, which was suggested substantially more often as management for BSSC (Table 1), requires frequent or continuous action. Controlling interacting species, such as the Barred Owl (*Strix varia*) that competes with the Spotted Owl or the Brown-headed Cowbird that parasitizes Least Bell's Vireos, may require continuing intervention.

Migratory status and habitat association. The proposed management of taxa of different migratory status was generally similar, although reducing human effects was less important for resident taxa, while controlling interspecific interactions and bolstering populations were not proposed for any wintering taxa (Fig. 4). Among the habitat-management actions, restoration was somewhat less important and maintenance and habitat creation somewhat more important for breeding summer visitors than for permanent residents or wintering taxa. Habitat protection was proposed for nearly all wintering taxa. Costs of habitat actions were high only for protection of habitat for some breeding and wintering taxa (Table 1).

Habitat enhancement was proposed less often for marine/coastal taxa, and even less often for island taxa, than for taxa of other habitats (Fig. 2). Control of interspecific interactions was proposed most often for riparian, island, and marine/coastal taxa, whereas reducing human effects figured importantly for marine/coastal, wetland, and island taxa. Bolstering populations through introductions or captive breeding was recommended for less than a third of the taxa on islands and even less for those of other habitats.

Among the habitat-management actions, restoration was proposed most often for island and marine/coastal taxa, less often for woodland taxa, and not at all for forest taxa (probably reflecting the greater availability of woodland and forest that can be maintained or protected) (Table 1). Habitat

TABLE 1. Habitat enhancement proposed for conservation-reliant species (grouped by listing status, migratory status, and major habitat affinity) for which habitat loss/fragmentation is identified as a primary threat to long-term persistence. The first number in each column indicates the percent of taxa in a group for which the action is proposed; the number in parentheses is the percent of that action that may demand a medium level of investment; the number in brackets is the percent requiring a high level of investment.

Group (% with habitat as threat)	Habitat-enhancement action			
	Restoration	Maintenance	Protection	Creation
All taxa (93)	56(54)[6]	58(45)[6]	74(70)[12]	15(14)[5]
Federally listed (100)	74(73)[13]	34(27)[7]	73(67)[7]	7(7)[0]
State listed (79)	42(42)[8]	33(8)[0]	75(58)[0]	33(33)[33]
BSSC (94) ^a	65(61)[4]	83(67)[8]	85(85)[18]	18(18)[6]
Permanent resident (97)	64(61)[11]	53(47)[8]	76(69)[8]	12(11)[3]
Summer breeding (93)	49(49)[3]	67(44)[5]	69(69)[13]	24(21)[8]
Wintering (85)	54(45)[0]	45(27)[0]	91(73)[18]	0(0)[0]
Marine/coastal (81)	85(77)[8]	46(39)[8]	93(77)[8]	16(15)[0]
Wetland (96)	56(56)[0]	60(48)[9]	78(78)[22]	21(21)[4]
Woodland (100)	33(33)[0]	33(0)[0]	55(44)[0]	0(0)[0]
Forest (100)	0(0)[0]	75(63)[13]	88(88)[0]	13(13)[13]
Riparian (100)	63(63)[13]	63(38)[0]	26(25)[0]	25(13)[13]
Scrub (93)	64(60)[12]	64(56)[4]	80(76)[16]	12(12)[4]
Island (69)	88(88)[22]	44(44)[0]	55(55)[11]	11(11)[0]

^aCalifornia Department of Fish and Game's Bird Species of Special Concern (Shuford and Gardali 2008).

protection was also frequently recommended for marine/coastal, scrub/grassland/desert, and wetland taxa, least often for riparian taxa. Creation of new habitats was suggested substantially less often than were other types of habitat enhancement. The greatest frequencies of high-cost actions were associated with habitat protection for wetland taxa and habitat restoration for island taxa. A need for continuous

maintenance of habitat was identified for nearly half of the marine/coastal taxa (Table 2).

INTEGRATING THREATS AND CONSERVATION RELIANCE

The challenge of conserving species at risk is to reduce threat levels and, consequently, the degree of conservation reliance.

TABLE 2. Duration of habitat-enhancement actions proposed for conservation-reliant species (grouped by listing status, migratory status, and major habitat affinity) for which habitat loss/fragmentation is identified as a primary threat to long-term persistence. Values are percentages of taxa requiring an action to be applied once or occasionally (O), intermittently or frequently (I), or continuously (C).

Group	Restoration			Maintenance			Protection			Creation		
	O	I	C	O	I	C	O	I	C	O	I	C
All taxa	15	41	0	7	34	17	17	52	5	6	8	1
Federally listed	7	67	0	7	7	20	7	53	13	0	7	0
State listed	8	33	0	0	25	8	25	42	8	8	17	0
BSSC	22	43	0	10	53	20	22	63	0	8	8	2
Permanent resident	6	58	0	14	25	14	3	67	6	6	6	0
Summer breeding	18	31	0	3	46	18	28	36	5	8	13	3
Wintering	36	18	0	0	27	18	27	64	0	0	0	0
Marine/coastal	31	54	0	0	0	46	23	54	16	8	8	0
Wetland	17	39	0	0	43	17	17	57	4	4	13	4
Woodland	33	0	0	0	22	11	22	22	11	0	0	0
Forest	0	0	0	25	25	25	25	63	0	0	13	0
Riparian	13	50	0	0	63	0	13	13	0	0	25	0
Scrub	4	60	0	16	40	8	12	68	0	12	0	0
Island	44	44	0	22	11	11	11	33	11	11	0	0

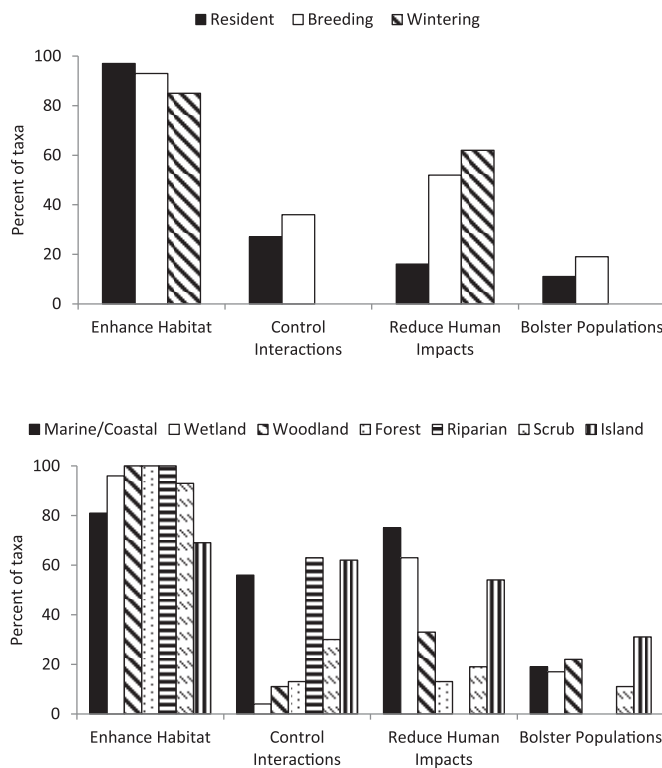


FIGURE 4. Percentages of conservation actions proposed to reduce primary threats to California bird species at risk. Top: species categorized by migratory status. Bottom: species categorized by primary habitat association.

One way to prioritize conservation-reliant taxa for management attention is by arranging them according to the level of threat and their degree of conservation reliance (Fig. 5A). The objective is to move taxa into the lower-left box (“low priority”). Taxa that currently experience a high threat level but require relatively little management to alleviate the threat may represent good returns on investments, whereas taxa that require substantial management but are not highly threatened may be problematic investments for conservation. The taxa perhaps warranting the closest attention are those at the upper right in Figure 5A, which are highly threatened and will require large and/or continuing investments in management to reduce the threats.

To see how this prioritization framework might apply to the taxa we assessed, we developed coarse indices to rate the taxa according to the aggregate of threats and the array of management proposed (i.e., conservation reliance). In Figure 5B we show how the taxa we considered are distributed in this threat/conservation-reliance space. (Because the index values are relatively coarse, derived from our qualitative categorizations of threats and actions [Appendix], we show only which taxa are placed in the four sectors to avoid false impressions of quantitative precision.) Although the subdivision of the graph

space is arbitrary (based on median values of the threat and conservation-reliance indices), it nonetheless helps to relate the taxa to the sections of Figure 5A. Excluding the taxa that fall on boundaries between sectors (see caption for Fig. 5), 29 taxa fall in the “low priority” sector, 9 in the “good return on investment” sector, 23 in the “consider carefully” sector, and 11 in the “problematic” sector.

Most of the federally listed taxa fall in the “consider carefully” sector, while most of the state-listed taxa are in the “low priority” sector. Only the state-listed Gila Woodpecker falls in the “good return on investment” sector. Two federally listed taxa (the Coastal California Gnatcatcher and Inyo California Towhee) fall in the “problematic” sector. There appear to be real differences in the threat level and degree of conservation reliance between the federally and state-listed taxa. Of the BSSC, 21 are placed in the “low priority” sector, while 14 fall in the “consider carefully” sector.

DISCUSSION

It is easy to get lost in the details summarized in Figures 1–5 and Tables 1 and 2 (let alone the Appendix!), so it may be worthwhile to step back and ask, “what general conclusions can be drawn?” There are several:

- Nearly all of the taxa we considered are to some degree conservation reliant. This result emerges not just for the taxa that are officially listed as threatened or endangered but for the larger assemblage of taxa of special conservation concern.

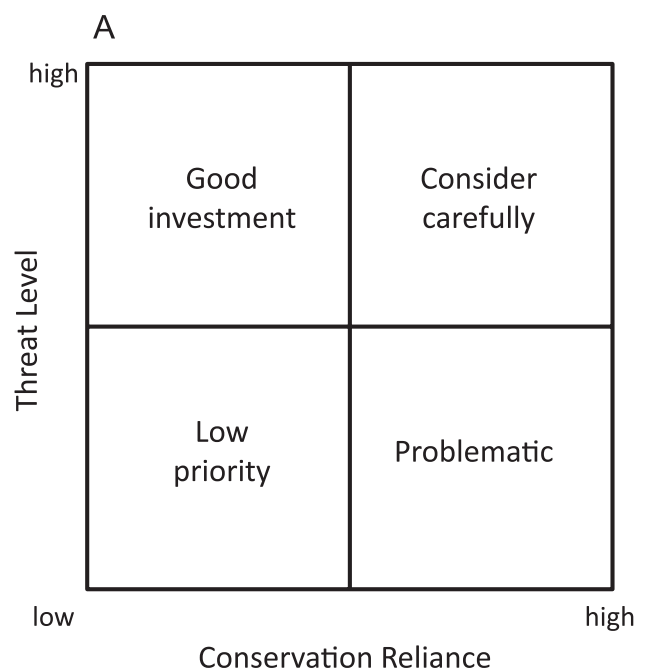


FIGURE 5. *Continued*

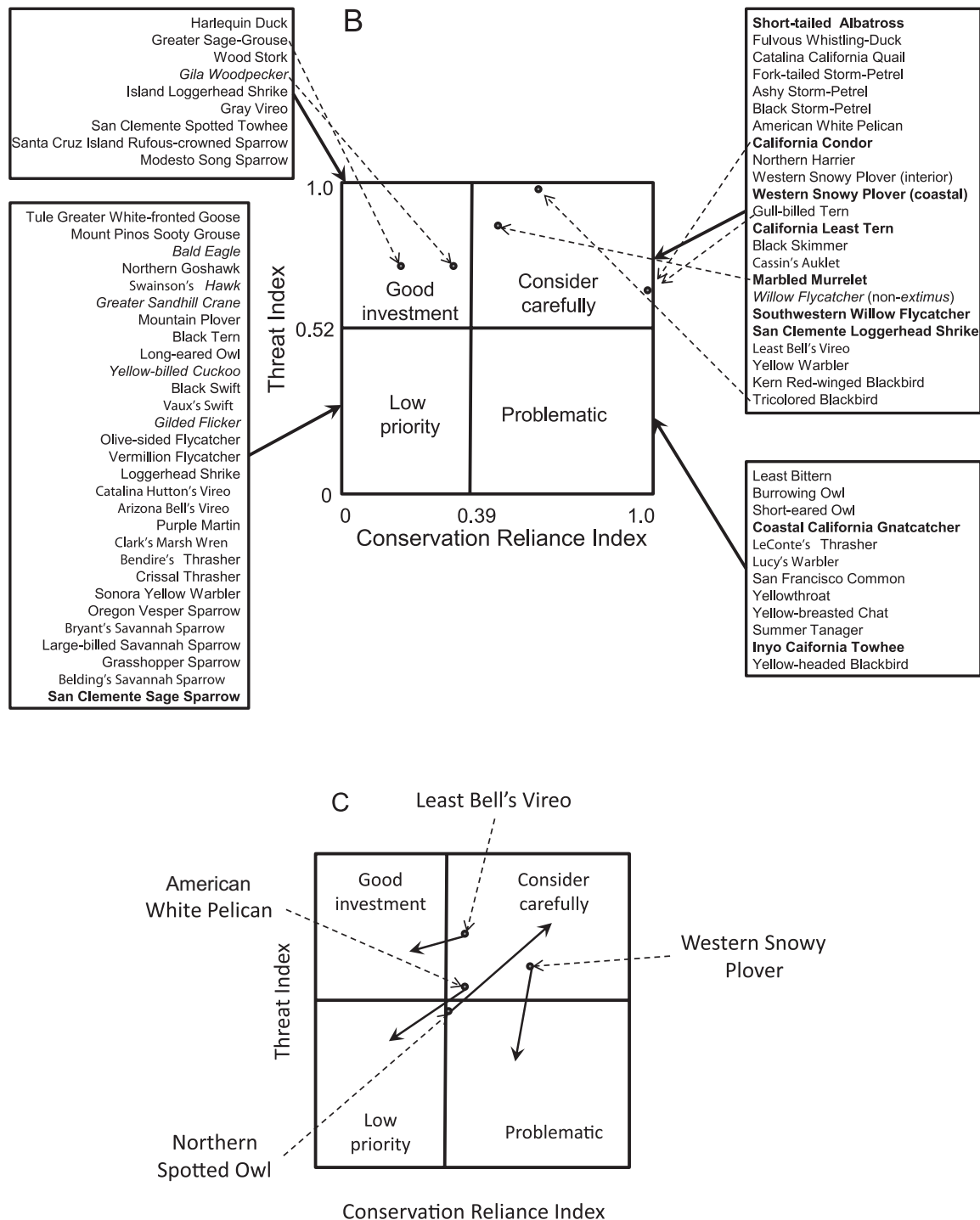


FIGURE 5. (A) A generalized framework for prioritizing conservation-reliant species based on the threat level and the degree of conservation reliance. (B) Placement of the taxa considered in this study in the four sectors of Fig. 5A. Federally listed taxa are shown in **bold**, state-listed taxa in italics, and BSSC in normal font. The taxa were positioned according to their values for the threat index and conservation-reliance index; the sectors are defined by the median values of the threat index and conservation-reliance index for all taxa. Taxa whose value(s) fell on the median values are not shown (boundary between the "low-priority" and "problematic" sectors: **California Clapper Rail**, **Light-footed Clapper Rail**, **Yuma Clapper Rail**, Lesser Sandhill Crane, Tufted Puffin, **Northern Spotted Owl**, *Great Gray Owl*, *Elf Owl*, *Bank Swallow*, San Diego Cactus Wren, Alameda Song Sparrow; boundary between the "good investment" and consider carefully sectors: Brant, Redhead, *Scripps's Murrelet*, Yellow Rail, *Black Rail*, California Spotted Owl, Suisun Song Sparrow, Samuels' Song Sparrow, Channel Island Song Sparrow). Dots show the locations of taxa mentioned in the text. (C) Potential trajectories of future change in threat level or degree of conservation reliance for selected taxa. See text for details.

- In most instances, the risk stems primarily from habitat degradation or loss, but most taxa face threats from multiple sources.
- Correspondingly, recommendations for management of these taxa emphasize some form of habitat enhancement, although the multiplicity of threats means that multiple management responses may often be needed.
- The recommended management actions vary in potential cost and duration, both by taxon and action. Some actions, such as protecting habitat or creating new habitat, may have high initial costs that diminish (but do not completely disappear) once the action is completed, whereas others, such as maintaining existing habitat or removing interacting species, may continue.
- Although most taxa in all major habitat groups are conservation reliant, there are differences among the groups in the actions proposed to address threats. Habitat restoration, for example, does not figure importantly in the habitat enhancement proposed for forest birds, but is a core strategy for marine/coastal and island taxa.
- Over half of the taxa are categorized as “low priority” or “good return on investment,” suggesting that conservation investments in these taxa may have good prospects of success. Nearly one-third of the taxa, however, are categorized as “consider carefully”; success for these taxa, even with considerable investment, may be far from certain.

Although the categorization of taxa in Figure 5 is coarse and based on our qualitative assessments of threats and conservation actions, it does serve to draw attention to those taxa for which the efficacy of conservation measures is not a foregone conclusion. In particular, the taxa positioned at the extremes in the “consider carefully” sector are especially worthy of note (Fig. 5B). One of these is the California Condor. Recent studies have indicated that chronic lead pollution poses a severe threat that is likely to require long-term, high-cost management (Finkelstein et al. 2012), leading some (e.g., Bottrill et al. 2008, Wiens et al. 2012) to suggest that conservation triage be given serious consideration. Interestingly, the Gull-billed Tern occupies the same position in the threat/conservation-reliance space as the condor, largely because of the variety of actions proposed to deal with threats. The federally threatened Marbled Murrelet and the BSSC-listed Tricolored Blackbird are the most highly threatened taxa, and for both the conservation-reliance index is higher than average. On the other hand, several other taxa (e.g., the Gila Woodpecker, a state-listed species, and Greater Sage-Grouse, a BSSC) stand out in the “good investment” sector as highly threatened but with low conservation-reliance scores (Fig. 5B). In these cases, undertaking single management actions intermittently could yield substantial benefits.

We can extend the application of this framework to consider potential future trajectories of taxa in the threat/conservation-reliance space (Fig. 5C). For example, although huge investments in management and protection of old-growth forests over the past several decades have reduced the level of threat to the Northern Spotted Owl, it now faces a new and growing threat from competition with the Barred Owl (Wiens 2012). Additional management is being proposed, escalating the Spotted Owl’s degree of conservation reliance. Along the coast, the level of threat to the Western Snowy Plover has been reduced as the population has approached full recovery in some regions, but this has been accomplished through intensive efforts to control predators and restrict human access to breeding locations. Because these efforts must continue to maintain the population gains, conservation reliance will remain high. The Least Bell’s Vireo could move from a position of being highly threatened and moderately conservation reliant to a more favorable position as efforts to control the nest parasite and restore riparian habitat bear fruit and can be lessened. The American White Pelican may always require some management of water levels in breeding areas, but infrequent modifications of nesting islands (e.g., installing antipredator fences) could make it less threatened and less conservation reliant.

Our analysis suggests that active management of species and ecosystems may become the norm rather than the exception. The philosophy and practice of conservation and resource management must embrace a situation in which continuing action will be required to maintain the viability of populations of a great many birds in California and elsewhere. The financial resources needed to address these threats across the breadth of conservation-reliant taxa considered here (or by Scott et al. 2010) are not available now, nor are they likely to be available in the future (Underwood et al. 2009). The magnitude and extent of conservation reliance just among California birds make it clear that hard decisions must be made about how best to invest limited conservation resources. The Endangered Species Act dictates that federally listed taxa must receive attention (although attention is clearly greater for a salmon than for a butterfly). Our analysis suggests that the BSSC may be every bit as demanding of conservation attention, even though most are less immediately imperiled. In fact, investments in species that are not poised on the brink of extinction may yield a greater return, in terms of the probability of long-term population persistence (Possingham et al. 2002). The “low-hanging fruit” for conservation investment may be those conservation-reliant species that are still abundant enough to support functioning populations and that require only infrequent and inexpensive management of habitat or the other factors that threaten their persistence, which may include most of the taxa in the “good investment” sector of Figure 5B.

Conservation is challenging, and the task will only become more formidable as the environmental changes now unleashed play out. Recognizing that conservation reliance extends well

beyond the species formally recognized as endangered or threatened is an essential first step toward the difficult task of prioritizing and optimizing our conservation actions. It will not be easy. But we must begin.

ACKNOWLEDGMENTS

We thank the California Department of Fish and Game, especially Lyann Comrack, for funding the California Bird Species of Special Concern project, which made our analyses possible. Two anonymous reviewers provided unusually helpful comments. This is PRBO publication 1940.

LITERATURE CITED

- BRIGGS, S.V. 2009. Priorities and paradigms: directions in threatened species recovery. *Conservation Letters* 2:101–108.
- BOTTRILL, M.C., L.N. JOSEPH, J. CARWARDINE, M. BODE, C. COOK, E.T. GAME, H. GRANTHAM, S. KARK, S. LINKE, E. McDONALD-MADDEN, R.L. PRESSEY, S. WALKER, K.A. WILSON, AND H.P. POSSINGHAM. 2008. Is conservation triage just smart decision making? *Trends in Ecology and Evolution* 23:649–654.
- BUNN, D., A. MUMMERT, M. HOSHOVSKY, K. GILARDI, AND S. SHANKS. 2007. California wildlife: conservation challenges. California Department of Fish and Game, Sacramento, CA.
- BUNNELL, F. L., D. F. FRASER, AND A. P. HARCUMBE. 2009. Increasing effectiveness of conservation decisions: a system and its application. *Natural Areas Journal* 29:79–90.
- FINKELSTEIN, M. E., D. F. DOAK, D. GEORGE, J. BURNETT, J. BRANDT, M. CHURCH, J. GRANTHAM, AND D. R. SMITH. 2012. Lead poisoning and the deceptive recovery of the critically endangered California Condor. *Proceedings of the National Academy of Sciences USA* 109:11449–11454.
- GOBLE, D. D. 2009. The Endangered Species Act: what we talk about when we talk about recovery. *Natural Resources Journal* 49:1–44.
- KORSCHGEN, C. E., M. G. KNUTSON, T. J. FOX, L. HOLLAND-BARTELS, H. C. DEHAAN, C. H. THEILING, J. J. ROHWEDER, K. KENOW, L. E. LEAKE, AND T. WILL. 2005. Natural resource assessment and decision support tools for bird conservation planning. USDA Forest Service General Technical Report PSW-GTR-191.
- MACE, G. M., AND A. PURVIS. 2007. Evolutionary biology and practical conservation: bridging a widening gap. *Molecular Ecology* 17:9–19.
- MURDOCH, W., S. POLASKY, K. A. WILSON, H. P. POSSINGHAM, P. KAREIVA, AND R. SHAW. 2007. Maximizing return on investment in conservation. *Biological Conservation* 139:375–388.
- PARR, M. J., L. BENNUN, T. BOUCHER, T. BROOKS, C. A. CHUTAS, E. DINERSTEIN, G. M. DRUMMOND, G. EKEN, G. FENWICK, M. FOSTER, J. E. MARTINEZ-GÓMEZ, R. MITTERMEIER, AND S. MOLUR. 2009. Why we should aim for zero extinction. *Trends in Ecology and Evolution* 24:181.
- POSSINGHAM, H. P., S. J. ANDELMAN, M. A. BURGMAN, R. A. MEDELLÍN, L. L. MASTER, AND D. A. KEITH. 2002. Limits to the use of threatened species lists. *Trends in Ecology and Evolution* 17:503–507.
- REDFORD, K. H., G. AMATO, J. BAILLIE, P. BELDOMENICO, E. L. BENNETT, N. CLUM, R. COOK, G. FONSECA, S. HEDGES, F. LAUNAY, S. LIEBERMAN, G. M. MACE, A. MURAYAMA, A. PUTNAM, J. G. ROBINSON, H. ROSENBAUM, E. W. SANDERSON, S. N. STUART, P. THOMAS, AND J. THORBJARNARSON. 2011. What does it mean to successfully conserve a (vertebrate) species? *BioScience* 61:39–48.
- RICKETTS, T. H., E. DINERSTEIN, T. BOUCHER, T. M. BROOKS, S. M. BUTCHART, M. HOFFMAN, J. F. LAMOREUX, J. MORRISON, M. PARR, J. D. PILGRIM, A. S. L. RODRIGUES, W. SECHREST, G. E. WALLACE, K. BERLIN, J. BIELBY, N. D. BURGESS, D. R. CHURCH, N. COX, D. KNOX, C. LOUCKS, G. W. LUCK, L. L. MASTER, R. MOORE, R. NAIDOO, R. RIDGELY, G. E. SCHATZ, G. SHIRE, H. STRAND, W. WETTENGEL, AND E. WIKRAMANAYAKE. 2005. Pinpointing and preventing imminent extinctions. *Proceedings of the National Academy of Sciences USA* 102:18497–18501.
- RUDD, M. A. 2011. Scientists' opinions on the global status and management of biological diversity. *Conservation Biology* 25:1165–1175.
- SCHNEIDER, R. R., G. HAUER, W. I. ADAMOWICZ, AND S. BOUTIN. 2010. Triage for conserving populations of threatened species: the case of woodland caribou in Alberta. *Biological Conservation* 143:1603–1611.
- SCOTT, J. M., D. D. GOBLE, J. A. WIENS, D. S. WILCOVE, M. BEAN, AND T. MALE. 2005. Recovery of imperiled species under the Endangered Species Act: the need for a new approach. *Frontiers in Ecology and the Environment* 3:383–389.
- SCOTT, J. M., D. D. GOBLE, A. M. HAINES, J. A. WIENS, AND M. C. NEEL. 2010. Conservation-reliant species and the future of conservation. *Conservation Letters* 3:91–97.
- SEKERCIOGLU, C. H., S. H. SCHNEIDER, J. P. FAY, AND S. R. LOARIE. 2008. Climate change, elevational range shifts, and bird extinctions. *Conservation Biology* 22:140–150.
- SHUFORD, W. D., AND T. GARDALI [EDS.]. 2008. California bird species of special concern. *Studies of Western Birds* 1. Western Field Ornithologists, Camarillo, CA, and California Department of Fish and Game, Sacramento, CA.
- STEIN, B. A. 2008. Biodiversity and the military mission, p. 2–33. *In* N. Benton, J. D. Ripley, and F. Plowledge [EDS.], *Conserving biodiversity on military lands: a guide for natural resources managers*. NatureServe, Arlington, VA.
- UNDERWOOD, E. C., K. R. KLAUSMEYER, S. A. MORRISON, M. BODE, AND M. R. SHAW. 2009. Evaluating conservation spending for species return: a retrospective analysis in California. *Conservation Letters* 2:130–137.
- URBAN, M. C., J. J. TEWKSBURY, AND K. S. SHELDON. 2012. On a collision course: competition and dispersal differences create no-analogue communities and cause extinctions during climate change. *Proceedings of the Royal Society B* 279:2072–2080.
- WIENS, J. A., D. D. GOBLE, AND J. M. SCOTT. 2012. Time to accept conservation triage. *Nature* 488:281.
- WIENS, J.D. 2012. Competitive interactions and resource partitioning between Northern Spotted Owls and Barred Owls in western Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, OR.
- WILCOVE, D. S., AND L. L. MASTER. 2005. How many endangered species are there in the United States? *Frontiers in Ecology and the Environment* 3:414–420.