A Multispecies Approach to Ecological Valuation and Conservation

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Abstract: *The conservation of ecosystems focuses on evaluating individual sites or landscapes based on their component species. To produce a map of conservation values, we developed a method to weight habitat-suitability maps for individual species by species-specific extinction risks. The value of a particular site reflects the importance and magnitude of the threats facing the component species of the ecological community. We applied this approach to a set of species from the California Gap Analysis Project. The resulting map of multispecies conservation values identified the areas with the best habitat for the species most vulnerable to extinction. These methods are flexible and can accommodate the quantity and quality of data available for each individual species in both the development of the habitat-suitability maps and the estimation of the extinction risks. Additionally, the multispecies conservation value can accommodate specific conservation goals, such as preservation of local endemics, making it useful for prioritizing conservation and management actions. This approach provides an estimate of the ecological worth of a site based on habitat characteristics and quantitative models in terms of all the ecological components of a site, rather than a single threatened or endangered species.*

Una Aproximación Multiespecífica para la Valoración Ecológica y la Conservación

Resumen: *La conservación de los ecosistemas se enfoca en la evaluación de sitios individuales o paisajes en base a las especies que lo componen. Para producir un mapa de valores para la conservación, desarrollamos un método que valora mapas de aptitud del hábitat para especies a nivel individual en base a los riesgos de extinción especie-específicos. El valor de un sitio en particular refleja la importancia y la magnitud de las amenazas que enfrentan las especies que componen la comunidad ecológica. Aplicamos esta metodología a un grupo de especies del Proyecto de Análisis de Aberturas de California. El mapa de valores de conservación para múltiples especies resultante identificó las áreas con el mejor hábitat para las especies más vulnerables a la extinción. Estos métodos son flexibles y pueden abarcar la cantidad y calidad de los datos disponibles para cada especie individual tanto para el desarrollo de mapas de aptitud del hábitat, como para la eliminación de los riesgos de extinción. Además, los valores de conservación multi-especie pueden abarcar metas específicas de conservación, como lo es la preservación de endemias locales, haciéndolos útiles para priorizar las acciones de conservación y manejo. Esta metodología provee una estimación del mérito ecológico de un sitio en base a las características y modelos cuantitativos en términos de todos los componentes ecológicos de un sitio, y no en una sola especie amenazada o en peligro.*

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Introduction

There is an escalating conflict between economic development activities and the preservation of biodiversity. In the United States, the Endangered Species Act (ESA) of 1973 prohibits actions that might jeopardize the continued existence of threatened or endangered species. Section 10(a), a 1982 amendment, allows "taking" of listed species based on an approved habitat conservation plan (HCP) that must minimize and mitigate to the extent possible the adverse effects of the taking (Bingham & Noon 1997). In response to this legislation, an individual, conservation organization, or private company commonly sets aside some of the site in question as a protected reserve and develops the remaining area. Alternatively, a separate parcel may be purchased for conservation so that the entire site can be developed, a practice called mitigation banking. Therefore, methods to evaluate and rank sites in terms of their conservation value are needed to identify priority areas.

Habitat conservation plans provide one response to the conflict between conservation and development. Plans such as the Scrub Conservation and Development Plan of Brevard County, to protect scrub habitat and the threatened Florida Scrub-Jay (*Aphelocoma coerulescens*) (Swain et al. 1995; Root 1996, 1998), and the Natural Community Conservation Planning Program (NCCP) in southern California, to protect the California Gnatcatcher (*Polioptila californica californica*) and its habitat (Atwood & Noss 1994; Akçakaya & Atwood 1997), focus on a few threatened or endangered species and their habitat requirements. These HCPs provide a regional land-use plan for protecting essential habitat while allowing economic development on less essential habitat. This approach is driven by the specific requirements of the few focal species and potentially ignores those of other species.

Three serious issues confront conservation planners worldwide. First, entire communities rather than single species need to be the focus of conservation efforts. Second, empirical information about vulnerable communities and their constituent species may be sparse. Third, species may be interacting with one another in complicated ways.

There is a large number of methods for prioritizing sites for conservation. For example, the simplest method for determining the relative value of a set of sites is to rank them according to chosen criteria. Criteria for ranking sites may be intrinsic, such as floral and faunal diversity or rare species, or extrinsic, such as proximity to urban development or cost for acquisition (Margules et al. 1991). Ideally, the criteria chosen must be numerical and comparable across the landscape and should be independent. In some cases (e.g., index of biotic integrity; Karr 1981), the criteria are arbitrary, and the results are not comparable between or among different systems.

A common modification to simple ranking of sites is the minimum set algorithm approach. The goal of this iterative method is to determine the minimum set of sites that represents all attributes under a given set of conditions (Margules et al. 1988; Pressey & Nicholls 1989; Possingham et al. 2000). Both methods are usually based only on presence-absence data, however; they do not explicitly consider factors such as the size of populations, the viability of species in habitat patches, the quality of the habitat, or the interaction among populations in different habitat patches (e.g., metapopulation dynamics). The presence of a species in a particular patch does not necessarily indicate that the patch can support a viable population or that the population will persist regardless of the fate of the neighboring habitat patches. In addition, these methods depend on specifying the desired outcome or goal in advance, such as protection of 25% of habitat types or five populations of each species.

The GAP method is also common and uses geographic information system (GIS) maps of vegetation cover, species locations, existing reserves, and land ownership to determine which species are adequately protected in reserves and which need further protection. This approach considers both ecosystem-level information, such as vegetation coverage, and species information, such as presence and absence or density data (Noss & Cooperrider 1994; Kiester et al. 1996; Jennings 2000). The GAP method is particularly relevant for land-use decisions made on a landscape scale, but it may not be useful when smaller areas are under consideration. Although this method serves as a good starting point for prioritizing land acquisition and protection of biodiversity (Jennings 2000), it does not address the fundamental need for a conservation value, which incorporates extinction risk or some measure of viability, for all of the species of the ecosystem.

The method we describe incorporates aspects of single-species evaluation that apply to a suite of species. It has two important features: it assigns an ecological value to a parcel of land or section of a stream based on many species, and it facilitates multispecies assessments of ecological effects. The goal is to minimize extinction risk and maximize habitat quality for the component species; the viability of the populations, rather than just the species' presence, is considered. We applied our method to a set of California species included in the California Gap Analysis Project (Davis et al. 1998).

Methods

We combined maps of habitat suitability for each species with the extinction risk faced by each species in a single map of multispecies conservation values (MCVs). Using the risk of extinction as a weighting factor means that the more imperiled a species is, the more priority is given to its habitat requirements. A high MCV represents the highest-quality habitat for the set of species most at risk. We used two different measures of risk: endangerment indices and extinction risk probabilities from metapopulation modeling, which produced the index-based multispecies conservation value (iMCV) and the risk-based multispecies conservation value (rMCV), respectively.

Index-Based Multispecies Conservation Value

For each selected species we used the estimate of the habitat suitability across California and the species threat classification under one of four different endangerment indices. Using the data from the California Gap Analysis Project (Davis et al. 1998), we selected 40 species, including 19 birds, 11 mammals, and 10 reptiles (Appendix). Davis et al. (1998) determined habitat suitability for 455 species in California based on 1:100,000 landscape maps. These maps were developed for species, so in some cases we made the assumption that the species map was applicable to the listed subspecies. The 40 species we selected were federally listed, state listed, species of concern or species of interest in the Natural Community Conservation Planning Program. We chose 40 species to simplify the computations, but our method is not limited in the number of species that can be included. Based on the known habitat preferences and available distribution data for a species, each polygon on the landscape map was designated as 0, 1, 2, 3, 4, or 5 in habitat suitability for each of the 40 chosen species, with 5 being the most suitable (Davis et al. 1998).

In ArcView 3.1 (Environmental Systems Research Institute, Redlands, California), we developed a composite map of California that included the habitat suitability for each polygon for each of the 40 selected species. To combine the habitat suitability values for each of the species into a single value, we used a weighting factor based on one of four different indices of threat, which resulted in four different maps, one for each threat index. Ideally, the threat faced by a species is best characterized by its risk of extinction over some specified period based on detailed demographic data and simulation modeling. In the absence of such detailed data, a number of endangerment or threat indices account for a variety of contributing factors that can serve as reasonable proxies for extinction risk, such as the World Conservation Union (IUCN) Red List (IUCN 1994).

Each selected species was categorized by one of four listing classifications or imperilment indices (Appendix). The California listing status was obtained from the Department of Fish and Game (California Fish and Game Commission 1999). The federal listing status was obtained from the U. S. Fish and Wildlife Service (USFWS). The status as determined by The Nature Conservancy (TNC) and NatureServe (Master 1991) was taken from Davis et al. (1998). The IUCN listing status was determined from the IUCN Red List (IUCN 1994) or through use of RAMAS Red List software (Applied Biomathematics, Setauket, New York; Akçakaya & Ferson 1999; Akçakaya et al. 2000), which implements the IUCN classification rules.

We assigned an integer value to each threat level of the four indices (Table 1) such that the largest value indicates the greatest risk of extinction under that index and a value of 1 indicates that the species was assumed to have a negligible risk of extinction under that index. For example, species listed as federally endangered were assigned a risk value of 3, those listed as threatened were assigned a value of 2, and those with no federal status were assigned a value of 1. Under the IUCN criteria it is possible for a species to be classified as "data-deficient". Such a species cannot be classified because of the lack of data. For species classified as data-deficient, we assigned an integer value of 1, the same as for low-risk species. We did not assign values on the same scale because it is unclear how the categories of one index correspond numerically with the categories of any other index, so the comparisons of maps based on different indices were primarily qualitative.

The habitat suitability values were combined into a single aggregate value (conservation value) weighted by the extinction risk of each species. This final value, the iMCV, expresses the worth, in conservation terms, of each individual site based on a particular threat index. Therefore, the iMCV was calculated for each location j

Table 1. Threat categories and the integer value, which was used as an estimate of the species' risk of extinction for the multispecies conservation value, assigned to each category in four imperilment indices: California Department of Fish and Game (state), U.S. Fish and Wildlife (federal), The Nature Conservancy or NatureServe (TNC), and the World Conservation Union (IUCN).

	State		*Federal*		*TNC*		*IUCN*	
Threat	*threat*	*value*	*threat*	*value*	*threat*	*value*	*threat*	*value*
Highest	endangered	3	endangered	3	critically imperiled	5	critically endangered	4
	threatened	2	threatened	2	imperiled	4	endangered	3
	special concern	1.5	none	1	vulnerable	3	vulnerable	2
	none	1			apparently secure	2	lower risk	1
Lowest					secure	1	data deficient	1

in the region with the formula

$$\mathrm{iMCV}_j = \frac{\sum_{i=1}^{n} (S_{ij} \times E_i)}{\sum_{i=1}^{n} E_i}, \quad (1)$$

where n is the number of species, S_{ij} is the habitat suitability value for species i at location j, and E_i is the endangerment index value for species i. These values were then normalized so that they ranged from 0 to 1 for ease of presentation. Thus, the final map produced has a single multispecies conservation value (from 0–1) for each site for each threat index.

Risk-Based Multispecies Conservation Value

Ideally, we want to explicitly estimate the risk of extinction for each species based on simulation modeling, rather than use a proxy. A variety of models can be used to estimate the risk of extinction and the contribution of each cell, including individual-based models, unstructured simple population models, and spatially explicit metapopulation models. The model choice depends on the species and the data available. In our example we constructed spatially explicit population models, using RAMAS GIS (Applied Biomathematics, Setauket, New York; Akçakaya 1998), for a set of species in the 10 southern counties of California. More than 24% of the habitat was suitable (habitat suitability value of 2 or greater) for at least two of the six species we considered. Our method is not limited in the number of species or the size of the area that can be included; we chose only six species and a reduced area to simplify the computations.

Spatially explicit population models require data on demographic parameters, such as survival and fecundity, as well as spatial parameters, such as the location and size of populations. Such data exist for a number of the species we selected for the iMCV example, including California Gnatcatcher (scientific names in Appendix), Cactus Wren, California Spotted Owl, desert tortoise, Stephens' kangaroo rat, and San Joaquin kit fox. For this risk-based multispecies conservation (rMCV) index, we constructed detailed models to estimate species-specific risks and the contribution of each population to the overall risk, and we combined these values with a measure of habitat suitability across southern California.

For each species, we created a raster map of habitat suitability based on the California Gap Analysis database. These maps were imported into RAMAS GIS (Akçakaya 1998) and served as the basis of the spatial structure of the metapopulation or population. Each cell was assigned a suitability value of 0 through 5, with 5 being the most suitable (Davis et al. 1998). We assumed that only cells with a habitat suitability value of >2.5 were suitable for viable populations (i.e., could be occupied). The suitability maps were used to determine the location and size of populations and the distances among them.

Based on the available data, we constructed a female-only, stage-based, stochastic, spatially explicit model for each species. We used published data and models wherever possible. We assumed that populations were limited by both the quality and the quantity of habitat and that dispersal and correlation among populations was distance-dependent. The carrying capacity was assumed to be the maximum measured density in field studies, and the initial abundance was assumed to be the average density as measured in field studies.

For the gnatcatcher we used the demographic data from field studies and a metapopulation model (Bontrager 1991; Akçakaya & Atwood 1996, 1997). Akçakaya and Atwood (1996) also included data and a model for the Cactus Wren. Lahaye et al. (1994) presented a metapopulation analysis for the California Spotted Owl, and Call et al. (1992) provided information about the movement and home range characteristics of the owl. We developed a metapopulation model for the desert tortoise based on the models of Doak et al. (1994) and Root (1999) and data from Turner et al. (1986), Luke et al. (1991), Doak et al. (1994), and O'Connor et al. (1994). We modified the age-structured model of Price and Kelly (1994) for Stephens' kangaroo rat and incorporated the dispersal and home-range data of Price et al. (1994). The San Joaquin kit fox model was developed with data from White and Garrott (1997) and Disney and Spiegel (1992).

We ran each species model 10,000 times for 50 years each time. Next, we successively removed each individual population and reran the metapopulation model another 10,000 times. The result was a value for each cell on the map of the habitat suitability of each species and the probability of extinction for each species. The contribution of each cell to the risk of extinction was estimated as the difference between the risk of extinction with all populations included, minus the risk with the population (that the cell belonged to) removed. The contribution value is set under the assumption that all other patches in the population would remain except the patch of interest. Therefore, the rMCV for each cell (j) in the map was estimated with the following equation (a modification of Eq. 1):

$$\mathrm{rMCV}_j = \frac{\sum_{i=1}^{n} (S_{ij} \times P_i \times C_{ji})}{\sum_{i=1}^{n} P_i}, \quad (2)$$

where n is the number of species (in this case 6), S_{ij} is the habitat suitability value for species i at location j, P_i is the probability of extinction or decline of species i, and C_{ji} is the contribution of location j to the viability of species i. Using these models, we also examined an alternative measure of risk, the risk of a 50% decline in abundance in 50 years. Similarly, the C_{ji} is the contribution of that location, j, to the overall risk for the entire species, i.

Results

In each of the four resulting iMCV maps (Fig. 1), areas with a higher conservation value were those with the best habitat suitability for the most vulnerable species based on the state listing status, federal listing status, TNC listing status, or the IUCN listing status. Areas that had a low multispecies conservation value had little suitable habitat for the most vulnerable species. Only 6.4% of the polygons (3.9% of the total area) were in the top 10% of iMCV values for all four threat indices, although 15.3% (11.1% of the total area) of the polygons were in the top 10% of iMCV values for at least one threat index. Approximately 29% of the polygons (23.1% of the total area) were in the top 20% of iMCV values for at least one index, and 14.6% of the polygons (10.2% of the total area) were in the top 20% of iMCV values for all four indices.

Each of the four threat indices yielded a slightly different spatial configuration. A correlation analysis using Kendall's correlation coefficient (Sokal & Rohlf 1981) revealed that the federal listing status most closely corresponded with the IUCN listing status (coefficient of rank correlation, τ, was 0.716), but there was low correspondence among the other indices (τ was 0.225–0.408). Several regions had a high conservation value under all four of the weighting schemes. In particular, sites around the Great Central Valley and several large blocks of habitat in the southern one-third of California all had high multispecies conservation values.

Explicitly modeling the risks of extinction for the six species produced an rMCV map (Fig. 2a) that incorporated the habitat suitability and the risk of extinction for each species. The rMCV map revealed valuable habitat patches scattered across the 10 southern counties of California. Nine percent of the polygons (5.3% of the total area) had a value in the top 10% of the rMCV values, and 24.1% (12.4% of the total area) were in the top 20% of the rMCV values. Approximately 29% of the polygons (38.9% of the area) had an rMCV value of <0. This is possible because a particular location may increase the overall risk of extinction (e.g., a sink population), and the contribution value (Cij) would then be a negative value.

Alternatively, using the risk of a 50% decline as our risk measure for weighting the habitat-suitability maps produced a slightly different map (Fig. 2b). In this case there were fewer negative rMCV values. Only 7.7% of the polygons (9% of the total area) had a negative rMCV value. The top 20% of the rMCV values included 19% of the polygons (7.9% of the total area), and the top 10% included 18% of the polygons (7.7% of the total area).

Discussion

These results of the iMCV approach highlighted a number of regions that are important for the conservation of biodiversity in California. This was true whether the problem was examined from a local (California only) or global (IUCN) perspective. In both cases, the assessment was made at the local or regional scale. When global (IUCN) threat categories were used, however, the assessment reflected the importance of habitat patches for the whole species rather than just for the population in California. Depending on the goals, this iMCV method could be tailored to address many different scales of concern. For example, habitat suitability could be developed at an appropriate scale that is different for each species, and the measure of extinction risk could be tailored to a specific goal such as the preservation of species endemic to California.

There are a few limitations to our approach. First, we selected only 40 species, which may not be representative of California's faunal diversity. Most of the remaining 455 species included in the California Gap Analysis Project were not listed as endangered or threatened at the state or federal levels. Therefore, it is unlikely that the resulting map would change in overall pattern even if these additional species were included, because their assigned risk value would be 1. Also, this is not a limitation of the method itself but of its particular application in this paper for the purpose of demonstrating the method. Although this method does not ignore unlisted species (they are assigned a risk value of 1), they are given little weight in the overall MCV value. These rankings might need to be adjusted if there is a desire to increase the value of the unlisted species.

A more fundamental limitation is that the threat indices are only an approximate estimate of the extinction risk of each species, and they did not agree completely with one another (Appendix). For example, 16 out of the 40 species we selected were federally listed as endangered. Only 9 of these species were also listed as endangered under the state classification, only 1 fell into the highest threat category of the TNC classification, and 6 were in the highest threat category under the IUCN classification. Additionally, 30% of the species were not listed by USFWS criteria or were considered data-deficient under IUCN criteria. It is unclear how the categories in one threat index correspond quantitatively to those in any of the other threat indices (Burgman et al. 1999).

Another fundamental limitation is that the method does not consider interactions among the species con-

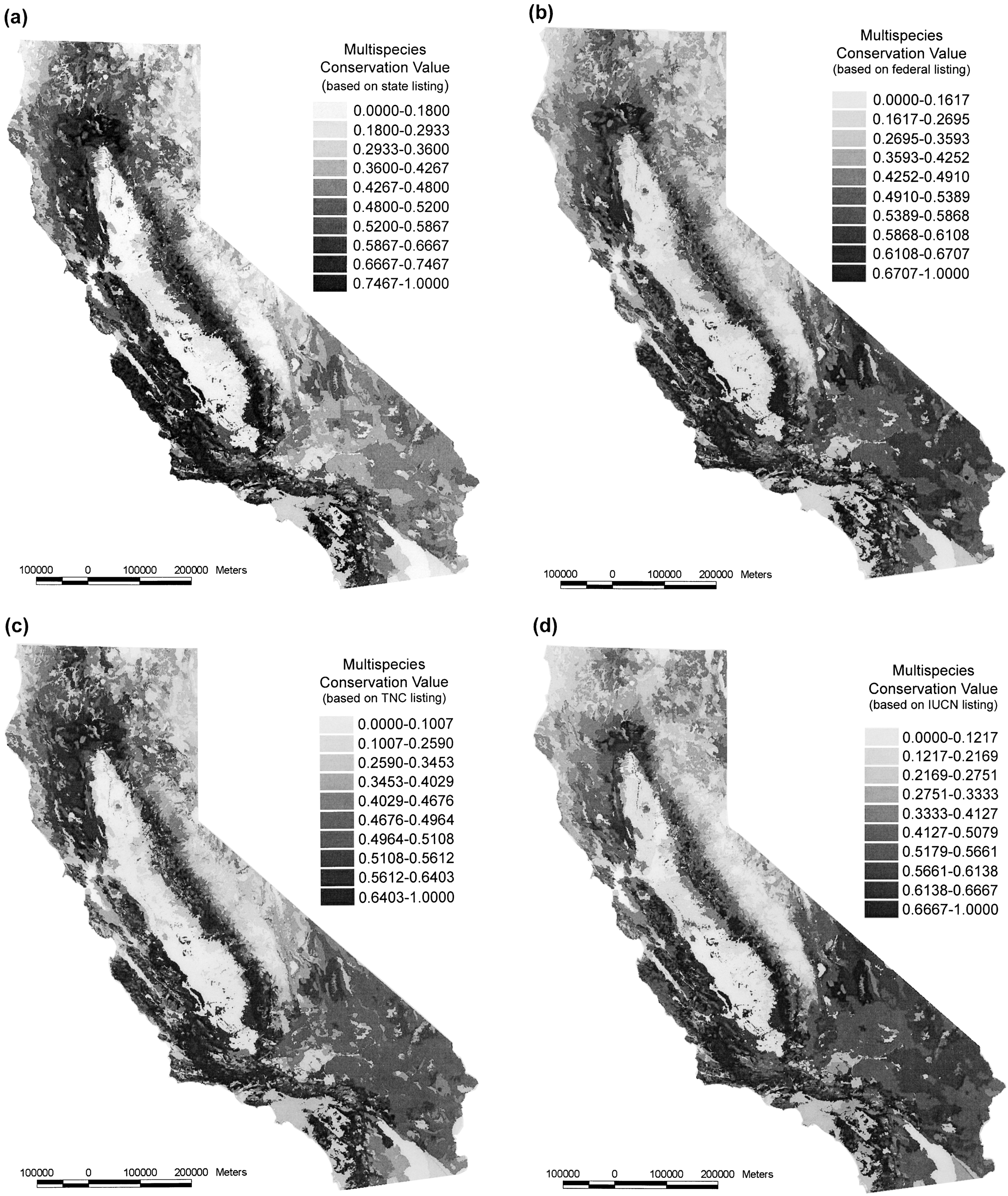

Figure 1. Maps of multispecies conservation values for 40 species based on their habitat suitabilities from the California Gap Analysis Project (Davis et al. 1998), weighted by (a) the state listing status from the California Fish and Game Commission, (b) the federal listing status from the U. S. Fish and Wildlife Service, (c) The Nature Conservancy or NatureServe classification, or (d) the World Conservation Union (IUCN) Red List classification. The categories shown represent 10 intervals of equal area; a larger value indicates a higher conservation value.

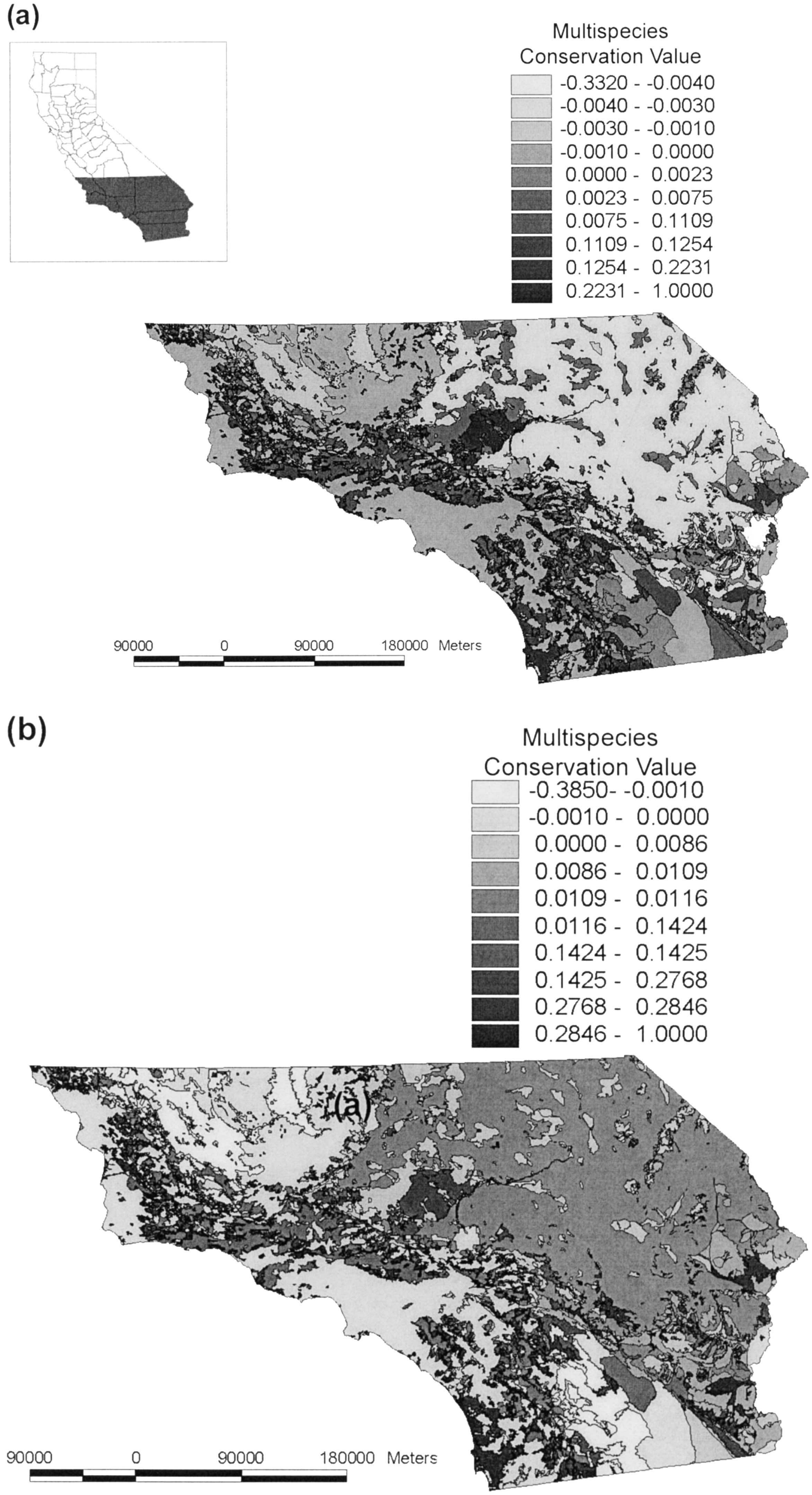

Figure 2. Map of multispecies conservation values of the southern 10 counties of California for six species based on their habitat suitabilities from the California Gap Analysis Project (Davis et al. 1998), weighted by (a) the probability of extinction for each species and (b) the probability of a 50% decline in abundance for each species estimated from population models. The categories shown represent 10 intervals of equal area; a larger value indicates a higher conservation value.

sidered. The MCV is based on the habitat suitability and extinction of the individual species included in the index, regardless of the type of competitive or trophic (predator-prey) relationship that might exist among some of the species in the list. This is partly by necessity. Explicitly incorporating such interactions is difficult because of lack of data and because of the difficulty in modeling the dynamics of complex community-level interactions. If information about trophic interactions was available, however, the interactions could be incorporated at the level of habitat maps, for example, by making the distribution of the prey one of the variables that contribute to the habitat suitability function of the predator.

Despite these limitations, the index-based approach is flexible. Additional species could be easily incorporated into the calculations. There are extensive listing data for many species of interest for conservation and management, which makes these threat indices useful as proxies for extinction risk. Multiple scales could be incorporated readily. For this method, habitat suitability could be estimated at different scales, depending on the species, with variables appropriate to the individual species (e.g., vegetation, area, prey species). Additional factors that might be important, such as roads, human density, or current level of protection, can be incorporated into the habitat suitability analysis or the estimation of risk. Also, the risk can be estimated based on a threat index that is appropriate for planning (e.g., local, regional, national). Our iMCV method provided a quantitative and spatially explicit conservation value that would be useful for such applications as a multispecies recovery plan or a regional habitat conservation plan. Additionally, land acquisition or conservation could be prioritized by selecting, for example, the sites in the top 25% of the MCV values.

The results from the risk-based approach were also informative. The regions where there was the greatest overlap among the six species were also where many of the highest rMCV values were found. In general the most valuable locations were along the eastern side of the state, which closely reflects the higher risk of extinction for the species found in these areas. The valuable sites along the eastern side correspond with the highly endangered coastal sage scrub habitat included in reserve designs of the Natural Community Conservation Planning Program (Akçakaya & Atwood 1997; Davis et al. 1998). It is important to emphasize, though, that the MCV maps shown here are intended as a demonstration on a large scale and are not directly comparable to the detailed planning maps developed at the local or county scale.

Interestingly, the map based on the risk of a 50% decline rather than the risk of extinction shows a slightly different pattern. Areas on the western side of the state had a higher rMCV value under the risk of decline than they did an rMCV value under the risk of extinction. This suggests that species such as the desert tortoise, which occurs in this region, have a higher risk of a large decline. The risk of a decline may provide an important early warning for species that are not currently considered threatened or endangered but may be quite vulnerable to changes in their environment.

When data are available, explicitly measuring the risk of extinction with a model is preferable to using an index. When the models can be detailed and reflect species-specific, life-history characteristics, the results reflect a more accurate estimation of risk than simple classification as an endangered or threatened species. The major disadvantage of a method that uses risk-based, multispecies conservation value is that parameterizing the simulation models usually requires more data, although we had little difficulty finding published data and models for many of these species. There are also methods for estimating the risk of extinction of a species that use only presence-absence or siting data (Solow 1993*a*, 1993*b*; Burgman et al. 1995, 2000). The amount of data needed is driven by the model chosen for estimating the risk of extinction and the contribution of each location; a simple unstructured population model requires far less data than an individual-based simulation model. Importantly models can highlight which parameters have the most influence on the risk of extinction, warranting further study and guiding future research efforts. Models also facilitate the use of various measures of risk such as the risk of extinction or quasi-extinction, the risk of a specified percent decline, or the risk of decline to a certain threshold, which may be tailored to a specific set of species and conservation goals.

There are some important advantages to this risk-based method compared with methods based on simple indices. The population model facilitates the estimation of the contribution of each population to the overall risk for the species. Rather than making an assumption about the value of each population to the whole, the difference in the risk of extinction with and without a specific population or region can be estimated. This approach takes into account such aspects as location, area, and distance to other populations in the context of the viability of the overall metapopulation. In this way, one can select a subset of sites and evaluate the risks of extinction or decline for the species being considered. For the index-based method in this example, we assumed that all populations had equivalent contributory value or that all cells were weighted equally, which may or may not be true.

The risk-based multispecies conservation value is also flexible in terms of scale. Both the habitat suitability analysis and metapopulation models can be developed at a scale appropriate to the individual species. Many more species can be readily accommodated with this method than the six we used in this test case. Also, this method, with sufficient data, allows one to estimate and compare the effects of fire, timber harvest, drought, and other factors. One can incorporate a potential effect into the metapopulation model, estimate the risk, and compare the resulting MCV map to the map without an effect. Potential changes also can be incorporated into the habitat suitability maps that reflect planning choices so that the outcomes of different plans can be compared. This method provides a quantitative and spatially explicit conservation value useful for such applications as a multispecies recovery plan, a regional habitat conservation plan, or an evaluation of local management alternatives.

These methods produce a quantitative rather than a qualitative estimate of value. The conservation value provides an objective measure of the ecological worth of a particular site based on quantitative models that can be validated. Second, this approach is multivariate and incorporates in a single value as many factors as possible about the species of interest. Third, this methodology is flexible. The conservation value takes advantage of all the available data for each species, including presence-absence, density, habitat requirements, and spatial data. Fourth, and probably most important, these indices evaluate a site in terms of all component species of its ecosystem rather than in terms of a single threatened or endangered species.

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Appendix. Forty selected species from California and their vulnerability status as assigned by the California Fish and Game Commission (state), the U. S. Fish and Wildlife Service (federal), The Nature Conservancy or NatureServe (TNC), and the World Conservation Union (IUCN).

Common name	*Scientific name*	*State*	*Federal*	*TNC*	*IUCN*
California Condor	*Gymnogyps californianus*	endangered	endangered	critically imperiled	critical
White-tailed Kite	*Elanus leucurus*	none	none	secure	data deficient
Bald Eagle	*Haliaeetus leucocephalus*	endangered	threatened	apparently secure	low risk
Northern Harrier	*Circus cyaneus*	special concern	none	secure	data deficient
Sharp-shinned Hawk	*Accipiter striatus*	none	none	secure	data deficient
Cooper's Hawk	*Accipiter cooperri*	none	none	apparently secure	low risk
Golden Eagle	*Aquila chrysaetos*	none	none	secure	low risk
American Peregrine Falcon	*Falco peregrinus anatum*	endangered	endangered	apparently secure	low risk
Prairie Falcon	*Falco mexicanus*	special concern	none	secure	data deficient
Northern Spotted Owl	*Strix occidentalis caurina*	none	threatened	vulnerable	low risk
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	none	endangered	secure	endangered
California Horned Lark	*Eremophila alpestris actia*	none	none	secure	endangered
Cactus Wren	*Campylorhynchus brunneicapillus*	none	none	secure	low risk
San Clemente Loggerhead Shrike	*Lanius ludovicianus mearnsi*	none	endangered	apparently secure	critical
Least Bell's Vireo	*Vireo bellii pusillus*	endangered	endangered	secure	endangered
Inyo California Towhee	*Pipilo crissalis eremophilus*	endangered	threatened	apparently secure	critical
Southern California Rufous-crowned Sparrow	*Aimophila ruficeps canescens*	special concern	none	secure	data deficient
San Clemente Sage Sparrow	*Amphispiza belli clementeae*	none	threatened	secure	vulnerable
Coastal California Gnatcatcher	*Polioptila californica californica*	none	threatened	imperiled	endangered
Pacific pocket mouse	*Perognathus longimembris pacificus*	none	endangered	secure	critical
Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*	endangered	endangered	secure	critical
Giant kangaroo rat	*Dipodomys ingens*	endangered	endangered	imperiled	critical
Stephens' kangaroo rat	*Dipodomys stephensi*	endangered	endangered	imperiled	endangered
San Bernandino Merriam's kangaroo rat	*Dipodomys merriami parvus*	none	endangered	secure	endangered
Fresno kangaroo rat	*Dipodomys nitratoides exilis*	special concern	endangered	vulnerable	critical
San Diego desert woodrat	*Neotoma lipida intermedia*	special concern	none	secure	data deficient
Armagosa vole	*Microtus californicus scirpensis*	endangered	endangered	secure	vulnerable
Coyote	*Canis latrans*	none	none	secure	low risk
San Joaquin kit fox	*Vulpes macrotis mutica*	threatened	endangered	apparently secure	vulnerable
Bighorn sheep	*Ovis canadensis*	threatened	endangered	secure	endangered
Desert tortoise	*Gopherus agassizii*	threatened	threatened	vulnerable	vulnerable
Coachella Valley fringe-toed lizard	*Uma inornata*	endangered	threatened	critically imperiled	endangered
Blunt-nosed leopard lizard	*Gambelia silus*	endangered	endangered	imperiled	endangered
Coronado skink	*Eumeces skiltonianus interpaniefalis*	none	none	secure	data deficient
Orange-throated whiptail lizard	*Cnemidophorus hyperythrus*	special concern	none	secure	data deficient
Coastal western whiptail lizard	*Cnemidophorus tigris multiscutatus*	special concern	none	secure	data deficient
Coastal rosy boa	*Lichanura trivirgata rosafusca*	special concern	none	secure	data deficient
San Bernandino ringneck snake	*Diadophis punctatus modestus*	none	none	secure	data deficient
San Francisco garter snake	*Thamnophis sirtalis tetrataenia*	endangered	endangered	secure	endangered
Red diamond rattlesnake	*Crotalis ruber ruber*	special concern	none	secure	data deficient