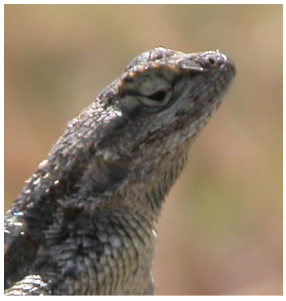
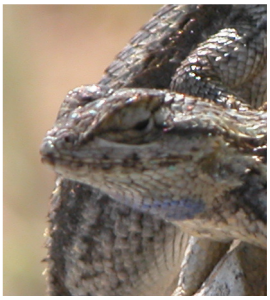
AUGUST 2005

THE GREEN VISIONS PLAN

for 21st century southern california





5. Terrestrial Target Species for Habitat Conservation Planning

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THE GREEN VISIONS PLAN

for 21st century southern california

The mission of the Green Visions Plan for 21st Century Southern California is to offer a guide to habitat conservation, watershed health and recreational open space for the Los Angeles metropolitan region. The Plan will also provide decision support tools to nurture a living green matrix for southern California. Our goals are to protect and restore natural areas, restore natural hydrological function, promote equitable access to open space, and maximize support via multiple-use facilities. The Plan is a joint venture between the University of Southern California and the San Gabriel and lower Los Angeles Rivers and Mountains Conservancy, Santa Monica Mountains Conservancy, Coastal Conservancy, and Baldwin Hills Conservancy.

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INTRODUCTION

One goal of the Green Visions Plan for 21st Century Southern California is "to protect and restore natural areas to ensure the persistence of native biodiversity and reintroduction of historically present natural communities" (Wolch et al. 2004). Several distinct approaches are necessary to achieve this goal. Among them is the use of a number of target species to guide reserve design and landscape connectivity that can serve as surrogates for biodiversity as a whole. This type of multispecies planning has been introduced as the template for conservation in California under the Natural Communities Conservation Planning Act.

This report provides the choice and rationale for terrestrial target species to be used in the Green Visions Plan. The first section is a literature review that discusses the use of target species in environmental and conservation planning, prepared by the lead author. Recommendations on the choice of target species are articulated from the literature review, and an approach to target species for the Green Visions Plan is established. A list of target species is then proposed, and followed by brief descriptions of each species.

This report does not address plants or aquatic species. Plants will be incorporated into the Green Visions Plan through two mechanisms: 1) the development of a map of the historical vegetation of the study area that can prioritize rare vegetation types and 2) the use of all species location data in the California Natural Diversity Database. Eventual parcel scorings will be based on presence of rare and endangered species in addtion to the target species selected here. Wholly aquatic species will be selected separately and presented in a complementary report, but amphibians and vernal pool specialists are included here.

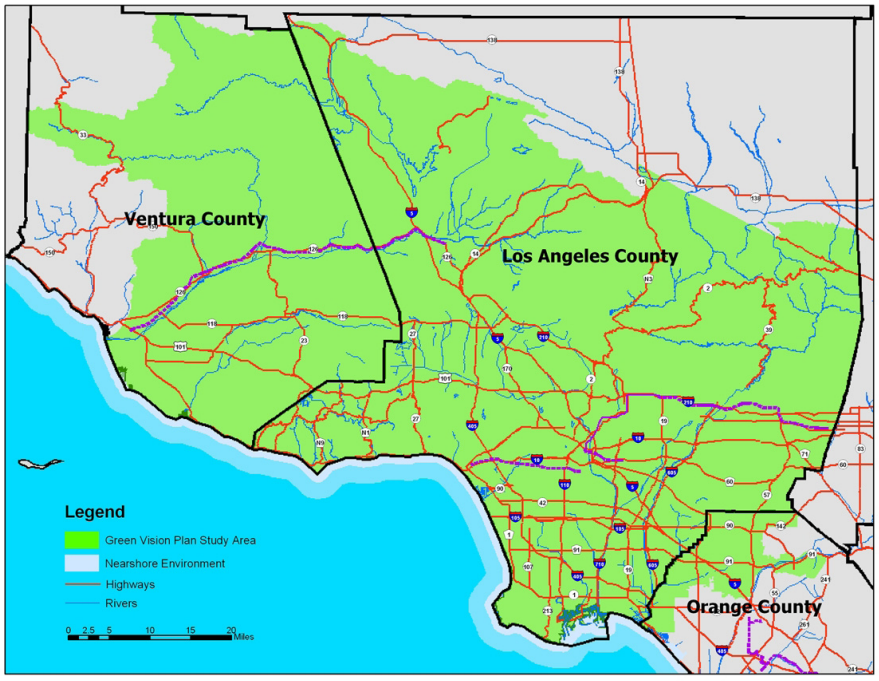

Figure 1. Green Visions Plan study area.

LITERATURE REVIEW

Target or surrogate species have been used in ecology and conservation for over a century in a variety of ways. Hall and Grinnell use target species to associate plants and animals to particular geographical areas in the 1910s (Carignan and Villard 2002). Earlier, Kolkwitz and Marsson had proposed the use of certain species as indicators of soil, climate, and the occurrence or other species, and Clements suggested use of species as surrogates for other species (Zacharias and Roff 2001). Since then, because of nature's complexity and a perpetual lack of scientific resources, conservation biologists have used target species as needed shortcuts for the understanding and management of ecosystems. Reviewing this literature revealed the existence of a variety of methodologies for the selection of target species, as well as a range of target species categories and different definitions for each category. This lack of consensus leads to two common points stressed in the literature, the need for clarity in the selection process, and for prudence in the use of target species – nature's complexity requires the use of surrogates, but also highlights the need for extreme caution in their use (Andelman and Fagan 2000; Caro 2000).

Categories of Target Species and Definitions

Many categories of target species can be found in the literature (Noss 1990; Lambeck 1997; Simberloff 1998; Lindenmayer et al. 2000; Noss 2004; O'Cousins 2004). The most comprehensive descriptions are provided by McGeoch (1998), Miller et al. (1998/1999), Caro and O'Doherty (1999) and Zacharias and Roff (2001). A review of these articles underscores the importance of clearly indicating which categories of target species will be used, for what reason, and with which objectives in mind.

McGeoch divides what she calls 'bioindicators' in three categories:

1. Environmental indicators.
    a. Sentinels
    b. Detectors
    c. Exploiters
    d. Accumulators
    e. Bioassay organisms
2. Ecological indicators.
3. Biodiversity indicators.

Miller et al. (1998/1999) define 4 categories of target species – keystone, umbrella, flagship and indicator species. Their conception of indicator species is in line with McGeoch's definition of ecological indicators. Caro and O'Doherty follow a similar categorization (1999). They recognize (1) indicator species, (2) umbrella species, and (3) flagship species. Indicator species are in turn divided into health, population and biodiversity indicators. Health indicator species are organisms or groups of organisms "so ultimately associated with particular environmental conditions that its presence indicates the existence of those conditions" (Patton 1987 cited in Caro and O'Doherty 1999: 807).

Finally, Zacharias and Roff (2001) define or identify the following categories of target species:

1. Indicator
    a. Composition indicator
        i. Community composition indicators (i.e. guild, taxon, assemblage)
        ii. Ecosystem composition indicators (abiotic structures, i.e. salinity, temperature)
    b. Condition indicator
2. Keystone
    a. Keystone predators
    b. Keystone mutualists
    c. Keystone modifiers
    d. Keystone prey
    e. Keystone diseases
3. Umbrella
    a. Single-species umbrellas
    b. Mesoscale species
    c. Umbrella groups
4. Flagship or charismatic
5. Economic and vulnerable species

Composition indicators can aid in the identification of land types, soils, or habitats. This was one of the first applications of indicators. On the other hand, condition indicators are used to "indicate the *condition* of a habitat, community, or ecosystem… [they] form the basis of biological monitoring of environmental change. (Zacharias and Roff 2004, emphasis added)

If we merge these four comprehensive reviews of target species we can present a list of categories that could be used to help us achieve our conservation objectives. Instead of building a new classification of target species categories, we should take advantage of the variety of definitions. After clearly determining our objectives we can select the categories of target species that more closely relate to those objectives and can therefore aid us in accomplishing of such goals. It is important to clearly identify both the definition of the categories being used and the objective of using each category and ultimately each target or group of target species.

Of the 10 categories outlined below, 1 to 6 are usually described as "indicators", examples for each category can be found in table 1 below:

1) Composition indicators: these include both community and ecosystem composition (Zacharias and Roff 2001). One example of composition indicator is the use of ground beetles as indicators of land type diversity (Rykken et al. 1997; see also Kremen et al. 1993; Heino 2001; Andersen et al. 2001; Kintsch and Urban 2002). The term 'composition indicator' is preferred over McGeoch's 'ecological indicator' because the latter implies species or group of species "characteristic or surrogate for a community or ecosystem"

(McGeoch 1998: 184), but also "sensitive to environmental stress factors, that demonstrates the effect of these stress factors on biota, and whose response is representative of the response of at least a subset of other taxa present in the habitat" (McGeoch 1998). A species or taxa could be used to identify habitat (Dufrene and Legendre 1997), but might not be a good surrogate for other taxa or species' reaction to stress. Therefore, composition indicators are categorized here as those that are used to "indicate a particular habitat, community or ecosystem" (Zacharias and Roff 2001: 61).

Indicator species can represent various elements of the environment (Miller et al. 1998/99), from the presence of specific contaminants, to wilderness quality or ecosystem health. Unlike other classifications (Miller et al. 1998/99; Caro and O'Doherty 1999; Zacharias and Roff 2001) McGeoch's classification of "environmental" and "ecological" indicators provides a fine distinction that can further clarify the use and objective of target species. We adopt these two of McGeoch's categories, however, because we choose to use Zacharias and Roff's (1999) composition indicators, our use of ecological indicators is restricted to the sensitivity to stress factors and the capacity of acting as surrogates of other taxa, leaving aside that the species or taxon could be "characteristic" of a particular habitat – this trait is covered under composition indicators.

2) Environmental indicators: "…a species or group of species that responds predictably, in ways that are readily observed and quantified, to environmental disturbance or to a change in environmental state" (McGeoch 1998: 153) For example, Bolger et al. (1997) conclude that some sparrow species are sensitive to fragmentation. The identified species could be used as environmental indicators of fragmentation (see Hager 1998 for reptiles and amphibians as indicators of fragmentation).

3) Ecological indicators: "An ecological indicator is… a characteristic taxon or assemblage that is sensitive to identified environmental stress factors, that demonstrates the effect of these stress factors on biota, and whose response is representative of the response of at least a subset of other taxa present in the habitat" (McGeoch 1998: 184; Hess and King 2002, but also see Fleishman et al. 2002, they do not recommend the use of birds and butterflies as indicators for other taxa).

There is a fine distinction between environmental and ecological indicators. As stated above, ecological indicators can be environmental indicators, but they also act as surrogates of other taxa or species, while environmental indicators do not do so.

4) Biodiversity indicators: "A biodiversity indicator is a group of taxa (e.g. genus, tribe, family or order, or a selected group of species from a range of higher taxa), or functional group, the diversity of which reflects some measure of the diversity (e.g. character richness, species richness, level of endemism) of other higher taxa in a habitat or set of habitats" (1998: 184). Pearson and Cassola (1992) showed positive correlation between species richness of tiger beetles, birds and butterflies across North America, the Indian subcontinent and Australia (see also Chase et al. 2000 for southern California; Mac Nally and Fleishman 2004 for western North America).

5) Keystone species: One of the most accepted definitions of keystone species is Meffe and Carroll's (1997: 562), "species that have a disproportionately large effect on other species in a system". Keystone

species include ‘keystone predators’, ‘keystone food resource’, ‘keystone modifiers’; ‘keystone mutualists’, and ‘keystone diseases’ (Meffe and Carroll 1997; Zacharias and Roff 2001). Management of keystones has been suggested by Simberloff (1998) as a way to combine ‘single-species’ and ‘ecosystem’ management.

6) Umbrella species: Umbrella species differ from keystone species because theoretically the protection of the umbrella species protects the habitats and species under its range, but these habitats and species would not be significantly altered by the disappearance of the umbrella species (Zacharias and Roff 2001). Roberge and Angelstam define the term umbrella as “a species whose conservation confers protection to a large number of naturally co-occurring species” (2004: 77). Although there is uncertainty regarding the effectiveness of single umbrella species in conservation biology, the use of multiple species can enhance the effectiveness of this tool (Roberge and Angelstam 2004).

7) Focal species: Lambeck (1997) uses a combination of the umbrella and ecological indicator concepts, and refers to those species as “focal species” (see also Ryti 1992). According to Roberge and Angelstam “the focal species approach is consistent with the general definition of umbrella species. It simply goes beyond earlier approaches by addressing habitat quality and by proposing systematic criteria for the selection of a suite of umbrella (“focal”) species” (2004: 78). These criteria imply the selection of a species or group of species by type of threat. Each threat is then assigned the species or group of species most sensitive to that particular threat (Roberge and Angelstam 2004; Lambeck 1997). By doing this we can define species or groups of species as area limited species (area requirements), dispersal limited species (ability to connect patches), resource limited species (availability of certain food for example) or process limited species (need for fire) (Carignan and Villard 2002). This above sub-group classification might have some overlap with the use of “ecological indicator” described above, therefore clarity is needed at the time of selecting the indicator and the role the species will play. The focal species approach has been applied with relative effectiveness in fragmented landscapes in Australia (Watson et al. 2001; Brooker 2002), but has strong critics (Lindenmayer et al. 2000; Lindenmayer et al. 2002; Lindenmayer and Fisher 2003).

8) Flagship species: There are no strict criteria for the selection of flagship species (Caro and O’Doherty 1999), which are defined as “popular, charismatic species that serve as symbols and rallying points for major conservation initiatives” (Noss 1991: 361). Flagships are not good surrogates (Andelman and Fagan 2000), so flagship species used for purposes other than obtaining support for the project should be clearly identified in another category to avoid confusion.

9) Vulnerable species: Vulnerable or endangered species would generally be target species, particularly if they are endemic to our area of study. However, vulnerable species are generally not good indicators (but see Lawler et al. 2003, Tognelli 2005), so it needs to be clearly stated that these species are selected as targets due to their endangered status, independent of any use they might have as indicators, keystone, umbrella or any other above mentioned category.

One species can fall under several different categories of target species. A grizzly bear, for example, can at the same time act as an ecological indicator, a keystone, an umbrella, a focal, a flagship and a vulnerable species. This highlights the need to clearly define the objective of each species under each indicator (Miller et al. 1998/99).

History and Examples of Use of Target Species

There are numerous examples of the use of target species in the literature. In most cases the effectiveness of target species acting as surrogates has yet to be tested. However, a summary of the different experiences and results can provide ideas and suggestions that can aid our own selection process. Table 2 provides examples of use of target species. Due to the inconsistency on the use and definition of categories in the literature, the tables presented below were constructed using the categories outlined in the previous section. In many cases the category name used by the author is different than ours, we used the objective of the target species as described in the articles in order to classify them under our categories. Moreover, some authors have used “focal” or “indicator” species broadly defined and with various objectives. This causes the same e.g. “indicator species” to fall under several of our categories. In such cases we included them in all the suitable categories.

Table 1. Examples and effectiveness in the use of target species.

COMPOSITION INDICATOR				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Grasshoppers	Kakadu Region (Australia)		No	Andersen et al. 2001
Rare plant species	Amphibolite Mountains, North Carolina	Predict vegetation community	Yes (particularly when indicators are specialists)	Kintsch and Urban (2002)
ECOLOGICAL INDICATOR				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Birds and Carnivores	Lowland in Lombardy (Italy)	Indicators for connectivity	Not determined	Bani et al. 2002
Mammalian Carnivores	Coastal southern California	Determine potential indicators for fragmentation	Not determined for other areas	Crooks 2002
Birds and Butterflies	Great Basin of western North America	Surrogates of each other and/or other taxonomic groups	No	Fleishman et al. .2002
Bobcats and Mountain Lions	Coastal southern California	Determine potential indicators for connectivity	Not determined for other areas	Hunter et al. 2003
Terrestrial Arthropods		Early warning	Not determined	Kremen et al. 1993
Amphibians	Stockholm	Determine effect of fragmentation	Effective (time-lag of several decades)	Lofvenhaft et al. 2004

Table 1. Examples and effectiveness in the use of target species. (cont.)

ENVIRONMENTAL INDICATOR				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Grasshoppers	Kakadu Region (Australia)	Indicator of response to disturbance	Potentially useful	Andersen et al. 2002
Review	Review	Monitor ecological integrity	Useful with conditions, (1) Several species (2) Solid data (3) Caution in interpretation	Carignan and Villard 2002
Reptiles and Amphibians	Southeastern Great Lakes basin	Indicators of fragmentation	Indicators of insularization can be found among species of herpetofauna	Haer 1998
Multiple (Integrative Index Approach)	General	Index of Biological Integrity	Effective	Karr 1991
Terrestrial Arthropods		Indicator of disturbance	Not determined	Kremen et al. 1993
Bats	Neotropical Rainforests	Indicator of disturbance	Effective	Medellin et al. 2000
FLAGSHIP SPECIES				
Species/Group	**Location**	**Effectiveness**		**Authors**
Not specified	Southern California coastal sage scrub / Columbia Plateau / Continental USA	Limited as surrogates		Andelman and Fagan 2001
FOCAL SPECIES				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Land Birds	Western Australia wheat-belt	Design of conservation units	Not assessed	Brooker 2002

Table 1. Examples and effectiveness in the use of target species. (cont.)

Mammalian Carnivores	Rocky Mountain	Design of conservation units	Potential when using more than one species	Carroll et al. 2001
Birds	Southeastern Australia	Minimum patch size to accommodate existing woodland birds	Not assessed	Watson et al. 2001
VULNERABLE SPECIES				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Birds and small mammals	California coastal sage scrub	Indicators of species richness	No	Chase et al. 2000
Vulnerable species	Eastern United States	See table 2	See table 2	Lawler et al. 2003
BIODIVERSITY INDICATOR				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Birds and small mammals	California coastal sage scrub	Indicators of species richness	Some species (3 of 37)	Chase et al. 2000
Terrestrial Arthropods		Represent diversity of: (a)higher taxa (b)functional groups (c)functional groups within higher taxon	Not determined	Kremen et al. 1993
Number of Tiger beetle species	North America	Indicator of butterfly species diversity	Effective	Peason and Carroll 1998
Number of Tiger beetle species	Indian subcontinent	Indicator of bird species diversity	Effective	Pearson and Carroll 1998
Number of Tiger beetle species	Australia and North America	Indicator of bird species diversity	Not Effective	Pearson and Carroll 1998

Table 1. Examples and effectiveness in the use of target species. (cont.)

Number of Tiger beetle species	Australia	Indicator of butterfly species diversity	Not Effective	Pearson and Carroll 1998
Number of butterfly species	North America and Australia	Indicator of bird species	Effective	Pearson and Carroll 1998
UMBRELLA SPECIES				
Species/Group	**Location**	**Objective**	**Effectiveness**	**Authors**
Big carnivores	Southern California coastal sage scrub / Columbia Plateau / Continental USA		Limited	Andelman and Fagan 2001
Barred owl	Triangle Region of North Carolina, USA	Protection of invertebrate species	Ineffective	Rubino and Hess 2003
Barred owl	Triangle Region of North Carolina, USA	Protection of vertebrate species	75%	Rubino and Hess 2003
Vertebrate species (Gnatcatcher)	Southern California coastal sage scrub	Protection of invertebrates (3 species of Lepidoptera)	Ineffective	Rubinoff 2001

Table 2. Performance of indicator species or target group in protecting other species groups (Lawler et al. 2003: 879). The authors describe these as indicator species, but they determined whether the "coverage" needed to protect the "indicator species" will also protect other species. This approach fits better under the definition of umbrella species.

	Percentage of species covered [a]					
Indicator or target group (n)[b]	Fish	Reptiles	Amphibians	Mussels	Birds	Mammals
Fish (4)	91	65	62	73	83	81
Reptiles (100)	65	97	69	52	85	79
Amphibians (100)	72	71	95	53	76	81
Mussels (68)	73	62	62	96	74	79
Birds (95)	55	73	62	39	97	85
Mammals (99)	49	76	72	27	82	100
At-risk species (50)	74	72	74	74	81	82
All species (2)	85	81	81	78	91	87
Randomly-selected sites (100)	48	59	54	27	74	77

[a] Percentage of species in each of six taxa included in sets of 10 sites selected to cover members of each of seven indicator groups, sites selected to cover all species, and randomly selected sites. The mean percentage of species included by multiple unique sets of sites is reported.

[b] Number of unique sets of 10 sites used to calculate the mean percentage of species protected by each indicator or target group.

Number of Species Necessary/Correlation Between Taxonomic Groups

Biodiversity indicators are more effective when they involve a group of species from several taxonomic groups, this way it is easier to estimate "the relative number of species in one area compared to another" (Caro and O'Doherty 1999: 809). However, Noss (2003) warns about the possibility of superficial treatment if the group is too large, and recommends a set of 3 to 10 as optimal.

Based on their review of case studies using the umbrella category, Roberge and Angelstam (2004: 76) conclude that umbrella species are more effective when a group species rather than a single one is used, the reason being that "some species are inevitably limited by ecological factors that are not relevant to the umbrella species". For example, while birds and mammals might be good surrogates for species affected by factors occurring at landscape scales, they might need to be complemented by the use of invertebrates and nonvascular plants as indicators of threats occurring at finer scales. Another problem associated with the use of only one umbrella species is the lack of complete overlap between the umbrella species range and that of other species. Carroll et al, for example, suggest that to conserve carnivores in the Rocky Mountains the needs of several species should be considered to "accommodate factors such as winter habitat requirements" (2001: 976).

Despite the increased effectiveness that results from the use of a group of species, Lindenmayer and Fischer remain skeptical on the grounds that "the total number of species present in any given landscape still outnumbers the three or so focal species by many orders of magnitude — so there are still likely to be numerous species whose requirements are not adequately capture by a limited suite of focal species" (2003: 150). They also challenge the assumption that taxa can be a good indicator for other species in the same or other assemblage or guild. The challenge is based on the dissimilar responses that species, even among members of the same guild or taxa, have to habitat change (Lindenmayer et al. 2002). Fleishman et al., for example, concluded that birds and butterflies are good "environmental indicators" (as defined above), but at the same time "urge restraint in using birds and butterflies as surrogates of other taxa for conservation planning" (2002: 78).

The use of a focal taxon, or group of species as indicators has shown mixed results (Ryti 1992; Chase et al. 2000; Carignan and Villard 2001; Carroll et al. 2002; Roberge and Angelstam 2004). These results call for caution when using focal species, but not even the harshest critics suggest that the use of surrogates should be completely left out (Simberloff 1999; Lindenmayer et al. 2002; Lindenmayer and Fischer 2003). Rather, a variety of approaches are recommended, including the use of focal species, for which rigorous field testing is recommended (Simberloff 1999; Lindenmayer et al. 2002; Lindenmayer and Fischer 2003; Freudenberger and Brooker 2004). However, there have been very few relational studies to demonstrate correlation and there is therefore "little evidence to suggest that any taxon or group of organisms can be expected to qualify as an ecological indicator" of other taxa (McGeoch 1998: 187).

Critics of Different Categories of Target Species

In general, criticism is not directed toward the indicator species tool per se (however, see Simberloff 1998; and Lindenmayer and Fischer 2003) but toward the applications, confusion in the use of criteria, erroneous assumptions, and lack of clarity that can be observed in the use of this tool (Landres et al. 1988; Caro and O'Doherty 1999; Caro 2000; Lindenmayer and Fischer 2003; Coppolillo 2004).

As we pointed out above, the concept of keystone species has been expanded and various subsets of keystones have been defined. This, added to the fact that "keystone status is based on human perception of a species' role" (Miller et al. 1998/99: 91), makes it difficult to point out keystone species (Simberloff 1998). Moreover, species might not act as a keystone throughout their entire life cycle, and a species might act as a keystone in one region and not do so in another (Zacharias and Roff 2001).

The umbrella species approach, particularly single-species, has been criticized for not offering enough protection to the species under the umbrella ("beneficiary species"; Roberge and Angelstam 2004). Often umbrella species are selected based either on their range-size demands, hoping that by protecting the target species all those included in its range will consequently receive protection. However, even a wide range, does not guarantee overlap with other species' habitat ranges. Berger (1997) found that several herbivores changed their ranges in response to precipitation and therefore they were not covered under the black rhino

umbrella. Another deficit of the umbrella species (singular) approach is that "conservation schemes based uniquely on area requirement will inevitably be flawed unless they also incorporate the needs of sensitive species requiring specialized habitat types" (Roberge and Angelstam 2004: 82). A single species umbrella approach is unlikely to effectively protect the species within its range, "multiple-species planning represents a more comprehensive way for umbrella-based conservation to overcome the array of known and unknown factors that limit or threaten population in reserves" (Rubinoff 2001: 1381–1382). The focal species approach directly addresses the issue of particularly sensitive species and provides a methodology for the use of a multi-species umbrella approach.

Focal species has been the most debated approach in the literature (Watson et al. 2000; Lindenmayer et al. 2000; 2002; Lambeck 2002; Brooker 2002; Lindenmayer and Fischer 2003). Critics have based their arguments on the fact that focal species are species or taxon-based surrogates, and none of these have proven to be effective indicators. They have also stressed that generally there is not enough information to reach a robust conclusion regarding which is the most sensitive species to a specified threat (Lindenmayer and Fischer 2003)[1]. Robust conclusions are hard to find in conservation biology, and the same criticism can be made of most other alternatives to focal species. It is important to clearly describe the assumptions, methods and objectives of focal and target species in general, and to, whenever possible, conduct field research to verify the accuracy of our assumptions and monitor both focal species and additional non-focal taxa (Lambeck 1997). The focal species approach advances the umbrella species concept by, for example, systematizing the selection criteria and therefore helping tackle the problem of lack of complete territorial overlap.

When evaluating the effectiveness of umbrella, focal or ecological indicators as surrogates it is important to keep in mind that species might be present but part of a non-viable population (Miller et al. 1998/99). This is particularly important in recently isolated fragments where existing population could be sinks (Roberge and Angelstam 2004).

Lindenmayer et al. (2000: 151; see also 2002, and Lindenmayer and Fischer 2003) base part of their argument against the use of indicators in concepts like "habitat and niche requirements… [which] lead to between-species differences in response to disturbance." On similar grounds they contest the use of guilds as indicators. They state that all members of the guild have different requirements and therefore are not good indicators. Carignan and Villard argue that these arguments do not invalidate the use of indicator species, but it highlights the importance of using "several species, representing different taxa and sensitivity to a variety of disturbances" (2002: 54).

General Recommendations Regarding Target Species

One of the most common recommendations throughout the literature — a clear statement of goals

[1] Some other challenges like the assumption of nestedness and independence of threatening process have been described as a "misrepresentation of the approach" (Lambeck 2002: 550).

— is a direct result of the confusion and misuse of target species in the past. Advance formulation and clear statements of the project goals is important for an appropriate use of target species, which in turn need to have their objective as target species clearly identified (Landres et al. 1988; Caro and O'Doherty 1999; Caro 2000).

Most authors who remain critical towards the use of surrogate species still recognize the need for caused by lack of time and resources to conduct more direct studies and management strategies. They also stress the importance of using target species only when other options are not available (Landres et al. 1988), or as one of several conservation strategies (Landres et al. 1988; Noss 1990; Noss et al. 1999; Kintsch and Urban 2002; Lindnenmayer et al. 2000, 2002; Lindenmayer and Fischer 2003; Freudenberger and Brooks 2004). Lindenmayer et al. consider the use of various strategies as a "risk-spreading strategy" in the management of something as complex as restoration (2002: 343).

Other authors suggest that focal species are complementary to other approaches (Noss et al. 1999; Kintsh and Urban 2002; Freudenberger and Brooks 2004). Kintsh and Urban (2002) propose the use of a combination of a focal species approach, community classification, and "conservation at the physical-proxy level." They consider the focal species approach as effective in the conservation of rare species but expensive and time consuming, therefore they suggest a combination with community classification, which requires less field time, and physical-proxy level conservation in order to ensure conservation at broader scales with limited time and resources.

The most important recommendation for umbrella species is that it should cover a large range, therefore it is usually suggested that umbrella species be large species. Being sensitive to disturbance (Caro and O'Doherty 1999) would be an added value for the umbrella species, but should not be considered a requirement since their main objective is not to serve as indicators. Miller et al. (1998/99) also recommend an excellent knowledge of the species' life history, a defined habitat association and the potential for reintroduction. They also state that the umbrella/wilderness indicator species is more suitable to the question of how much high-quality land is necessary" (Miller et al. 1998/99: 90). Given the nature of our study it is important to point out that this is not a common requirement throughout the literature. However, Miller et al. do provide specific recommendations for modified habitat. They recommend the use of males when using terrestrial carnivores as umbrellas and they stress that in highly fragmented or disturbed habitats "considering only female needs can result in low mating success" (Miller et al. 1998/99: 89).

When using a group of species it is recommended that each species is specialized in particularly narrow habitats to ensure sensitivity to degradation (Pearson and Cassola 1992) and because "it is less likely to be influenced by …natural variations in environmental conditions (Carignan and Villard 2002: 54). It is also important that the group covers the ecosystems of concern in the study area and that it represents different scales, from landscape to microhabitats (Pearson and Cassola 1992; Carignan and Villard 2002; Roberge and Angelstam 2004).

For obvious reasons, vulnerable, endangered and rare species are generally used as target species, however, case studies have shown conflicting results regarding the use of rare, vulnerable or endangered

species as indicators (environmental indicators or focal species). Chase et al. studied several species of birds and mammals, among which they had species of conservation concern, in California Coastal Sage Scrub and recommend "not to focus exclusively on rare species… but… on a diverse suite of species" (2000: 474). Cousins and Lindborg state that species that are too rare are difficult and expensive to monitor, and Lindenmayer and Fischer argue that rare species can lead to an under-appreciation of small patches because they will "typically be located in larger patches — in part because greater sampling effort has taken place there" (2003: 153). On the other hand, Lawler et al. (2002) found that species at risk were good indicators, and suggest this is due to the taxonomic diversity of the group. These results are in line with Carignan and Villard (2002), who suggest the use of indicators from all functional guilds, and with Kintsch and Urban's conclusion that specialists are better indicators (2002). Finally, Miller et al. (1998/99) suggest caution in the use of endangered species for reserve design and recommend not using only endangered species as flagships to avoid public conflict.

Compiling the recommendations found in the literature we suggest the recommendations listed below (Table 3) as broad guidelines for the project.

Table 3. Recommendations for the use of target species.

Recommendation	Reference
Advance and clear formulation of goals	Landres et al. 1988; Caro and O'Doherty 1999; Caro 2000; Lindenmayer and Fischer 2003
Clear specification of criteria for the selection of target species	Landres et al. 1988; Caro and O'Doherty 1999; Caro 2000; Noss 2003
Extensive a priori knowledge of species selected	Landres et al. 1988; Pearson and Cassola 1992; McGeoch 1998;
Target species approach needs to be complemented with other approaches	Landres et al. 1988; Noss 1990; Noss et al. 1999; Kintsch and Urban 2002; Lindnenmayer et al. 2000, 2002; Lindenmayer and Fischer 2003; Freudenberger and Brooks 2004
Peer review	Landres et al. 1988
Suite of species should represent a broad range of scales and habitats.	Noss 1990; Pearson and Cassola 1992; Roberge and Angelstam 2004;
Easy and cost effective to monitor	Noss 1990; Pearson and Cassola 1992; McGeoch 1998; Carignan and Villard 2002;
Confirm effectiveness of target species as surrogates	Landres et al. 1988; McGeoch 1998; Caro and O'Doherty 1999; Lindenmayer et al. 2000; Lindenmayer and Fischer 2003

SELECTION OF TARGET SPECIES FOR GREEN VISIONS PLAN

In this section, we apply the recommendations of the literature about the use of target species as a conservation planning tool to the Green Visions Plan.

1) Clear formulation of goals. The goal of the Green Visions Plan is to provide a planning tool and reserve design that protects and restores the biodiversity of the project region. The Plan also seeks to restore nature in urban areas as part of providing equitable access to passive recreational activities to all segments of society. The purpose of using target species is to a) act as surrogates for biodiversity, either directly or indirectly (e.g., as a keystone species), b) provide guidelines for the spatial configuration (e.g., size, connectivity, and habitat types) of a reserve system to maintain biodiversity in wild to urban situations, c) be useful to evaluate the effectiveness of the plan over time.

2) Clear specification of the criteria for selection of target species. We established the following categories for the evaluation of target species. Species that fit in one or more of these categories were considered. Species fitting into more than one category are preferred.

Connectivity indicator. Species that represent a range of sensitivity to the presence of corridors (e.g., that have a range of dispersal distances), and are therefore sensitive to the distance between appropriate habitat patches. Species should also represent a range of habitat types within the study area. Species known to be keystones or to serve as umbrellas for movement of other species between habitat patches ranked more highly.

Biodiversity indicator. Species that are known to be correlated with high species diversity of either their own taxonomic group or other groups.

Vulnerable species. Species that are vulnerable are preferred over those that are not, but species so rare that they only have a few occurrences within the study are excluded.

Keystone species. Species that play a recognized keystone role in the ecosystem are preferred.

Umbrella species. Species that have been shown to behave as umbrella species are preferred – that is, their habitat and life cycle requirements encompass those of many other species.

Fragmentation indicator. Species with a range of sensitivity to fragment size are desired.

Habitat quality indicator. Species that indicate high habitat quality are desired.

Existing knowledge. A thorough body of scientific literature is desired for each species.

3) Adequate a *priori* knowledge of the species. This practical aspect was incorporated into the selection criteria and resulted in an under-representation of invertebrates in the focal species list. While many invertebrate species might be useful target species, detailed geographic data and useful habitat descriptions are lacking for most taxa.

4) Target species approach needs to be complemented with other approaches. As outlined in the Analytic Frameworks for the Green Visions Plan (Wolch et al. 2004), the target species approach will be accompanied by other methods to identify and rank valuable habitat to maintain regional and local biodiversity. For example, potential natural vegetation will be mapped and high conservation values assigned to vegetation types that have suffered the greatest percent loss, or are not well represented in protected lands.

5) Peer review. This report will be circulated for peer review, both among academic scientists for formal

assessment and among resource experts within the regulatory and nonprofit community.

6) Suite of species should represent a broad range of scales and habitats. Our scheme explicitly seeks to ensure representation of species that use the breadth of natural habitats within the study area.

7) Easy and cost effective to monitor.

8) Confirm effectiveness of target species as surrogates. Because the scope of the project does not allow for investigations of all target species in detail, we have attempted to provide scientific literature that documents where species are to be used as surrogates.

Based on these guidelines, we ranked species within the Green Visions Plan area in each of these categories. Target species were selected to represent each of the major habitat types in the study area, as defined under the CALVEG mapping scheme (dune, chaparral/sage, grassland, hardwood (riparian) forest, coniferous forest, and wet grassland) for terrestrial species; aquatic species will be considered separately. We sought to have representation of major taxonomic groups — mammals, birds, reptiles, insects, and plants — within each habitat type, as appropriate. We reviewed species lists of all birds, reptiles, and mammals with distributions within our study area, and reviewed lists of more well-known invertebrate groups, and selected species that fit these overall criteria. Each criterion was evaluated as “yes” or “no” with special attention paid to the issue of sensitivity to connectivity and fragmentation. It would have been possible to develop a quantitative method for the selection of target species. This was avoided because of its time-consuming nature and ultimately subjective decisions made in selecting among several candidates for a particular combination of taxa, habitat, and sensitivity.

PROPOSED TARGET SPECIES

Proposed target species for the Green Visions Plan are listed in Table 4. The 41 species are divided among different taxonomic groups, with an overemphasis on vertebrates. The number of vertebrates out of proportion with their abundance in the environment reflects the increased knowledge about these species. Plants will be analyzed in another portion of the Green Visions Plan that concentrates on vegetation community representation. Each taxonomic group, and each major habitat type contains species that are both highly sensitive and moderately sensitive to human disturbance. In this manner, rankings of the value of habitats in the Plan area based on the number of target species present will show highest value for the areas least disturbed by humans, but still show value for habitats within the urban matrix that still support moderately sensitive native species.

Table 4. Target species for conservation in the Green Visions Plan.

Birds	**Major Vegetation Division**
1. Belding's Savannah Sparrow	Tule/pickleweed/wet meadow
2. Burrowing Owl	Dune, Grassland
3. California Quail/Mountain Quail	Chaparral/Sage, Hardwood Forest (riparian)/Conifer Forest
4. Lark Sparrow	Chaparral/Sage
5. Loggerhead shrike	Dune, Grassland
6. Marsh Wren	Tule/pickleweed/wet meadow
7. Northern Harrier	Grassland
8. Redwinged Blackbird/Tricolored Blackbird	Tule/pickleweed/wet meadow
9. Rufous-crowned Sparrow	Chaparral/Sage
10. Sage Sparrow	Chaparral/Sage
11. Spotted Owl	Conifer Forest
12. Western Meadowlark	Dune, Grassland
13. White-tailed Kite	Grassland
14. Yellow-breasted Chat	Hardwood Forest (riparian)
Reptiles and Amphibians	
15. California Tree Frog	Riverine, Chaparral/Sage, Grassland
16. Coast Horned Lizard	Chaparral/Sage, Dune
17. Coast Range Newt	Chaparral/Sage, Conifer Forest, Grassland, Hardwood Forest (riparian)
18. Two-striped Garter Snake	Hardwood Forest (riparian), Tule/pickleweed/wet meadow
19. Western Pond Turtle	Dune, Hardwood Forest (riparian),
Mammals	
20. American Badger	Grassland, Chaparral/Sage
21. Bighorn Sheep	Conifer Forest
22. Bobcat	Chaparral/Sage, Conifer Forest, Hardwood Forest (riparian)
23. California Meadow Vole	Grassland
24. Coyote	Chaparral/Sage, Conifer Forest, Dune, Grassland, Hardwood Forest (riparian)
25. Dusky-footed and Desert Woodrats	Chaparral/Sage, Conifer Forest, Grassland, Hardwood Forest (riparian)

Table 4. Target species for conservation in the Green Visions Plan. (cont.)

26. Gray Fox	Chaparral/Sage, Conifer Forest, Grassland
27. Big Brown Bat	Chaparral/Sage, Conifer Forest, Conifer Forest, Hardwood Forest (riparian)
29. Long-tailed Weasel	Chaparral/Sage, Conifer Forest, Dune, Hardwood Forest (riparian)
30. Perognathus mice	
31. Pacific and Delzura Kangaroo Rats	Chaparral/Sage, Conifer Forest, Grassland, Hardwood Forest (riparian)
32. Puma	Chaparral/Sage, Conifer Forest, Hardwood Forest (riparian)
33. San Diego Black-tailed Jackrabbit	Grassland
Invertebrates	
34. Behr's metalmark	Chaparral/Sage
35. California dogface	Hardwood Forest (oak)
36. Comstock's fritillary	Grassland
37. El Segundo blue butterfly	Dune
38. Lorquin's admiral	Hardwood Forest (riparian)
39. Riverside fairy shrimp	Tule/pickleweed/wet meadow (vernal pool)

SPECIES ACCOUNTS

For each proposed target species, we have compiled preliminary species accounts from the scientific literature. Each species account contains an assessment of the species in nine categories.

1. Sensitive – is the species sensitive to human disturbance or is it human tolerant?
2. Connectivity – is the species sensitive to the distance between habitat patches?
3. Biodiversity – is there evidence that the species is an indicator of biodiversity in its or another taxonomic group?
4. Rare – is the species rare in the study area?
5. Keystone – is the species disproportionately important to its ecosystem relative to its abundance?
6. Umbrella – will protection of the species result in the protection of other species?
7. Fragment – is the species sensitive to the size of habitat fragments?
8. Habitat quality – is the species sensitive to degradation of habitat quality?
9. Knowledge – do we have sufficient scientific knowledge about the species to use it effectively?

In addition to these categories, we further indicate whether the species would serve as an indicator of connectivity at the regional (high-level) or local (low-level) scale. The account itself contains information about habitat, food, ecology/behavior, the rational for its use as a target species, and a bibliography.

These species accounts will be combined with other natural history information to construct distribution maps of the target species within the Green Visions Plan area. These predictive distribution maps will then be used to identify conservation value by overlaying the distributions. This, combined with additional analysis on wildlife movement, will provide the basis for the design of an ideal reserve and corridor system for the region.

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**Y**	**N**	**Y**

Belding's Savannah Sparrow *(Passerculus sandwichensis)*

Distribution and abundance: Coastal portion of the area of study and it is listed as endangered in California.

Habitats: Grasslands, salt marshes, wet meadows, beaches and coastal dunes. "Breeds in semi-open areas along the coast and in grasslands in lowland areas" (Fisher and Clarke 1997: 129).

Food: Grass, insects, snails.

Ecology / Behavior: Home Range: Research from other subspecies includes the following. In Georgia, Norris (1960) estimated a short-term winter home range at 3.2 ha (8 ac). Winter density averaged 10–12 individuals per ha (4–5 per ac) and varied up to 74 per ha. They adapt well to restored grasslands in which they are up to 9 times more dense, possibly due to the fact that these grasslands have less vegetation and more bare ground (Fletcher and Koford 2002; see also Horn and Koford 2000). A study by O'Leary and Dennis (2000) found a minimum area requirement of 15 ha. Walk and Warner (1999) had previously determined minimum area requirement in Illinois at 75 ha. Swanson in a study in Ohio classified savannah sparrows as area sensitive with a minimum area requirement of 50 ha. Finally, a study in Maine determined its minimum area requirement to be 10 ha (Vickery et al. 1994).

Rationale for its use as target species: Sensitive to coastal habitat destruction (Small 1994). Sensitive to fragmentation (Bakker et al. 2002; Douglas 2001; but see also Johnson and Lawrence 2001).

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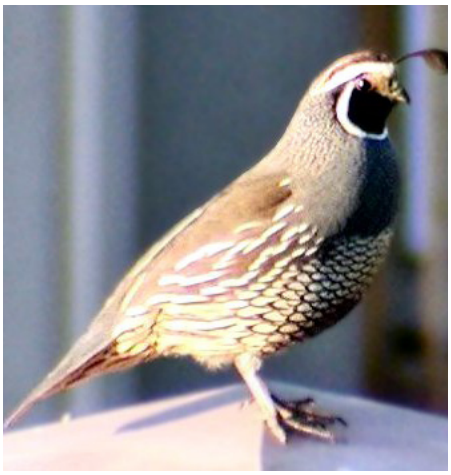
Credit for photograph: http://mywebpages.comcast.net/pavlik/Savannah%20Sparrow.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

California Quail (*Callipepla californica*) and Mountain Quail (*Oreortyx pictus*)



Distribution and abundance: Common in low elevations (Ahlborn n/d). Fairly common to uncommon in montane areas, typically found between 2000 and 9000 ft (Ahlborn n/d; Small 1994; Penrod et al. n/d).

Habitats: Mainly chaparral, sagebrush scrub, grassland oak and open stages of conifer and deciduous habitats. Also in the margins of grasslands and some croplands (Ahlborn n/d; Calkins et al. 1999). Higher range of desert scrub, conifer and deciduous forests, and woodlands (Small 1994; Ahlborn n/d).

Food: Seeds, green vegetation, flowers, fruits and insects (Ahlborn n/d; Calkins et al. 1999).

Ecology / Behavior: Non-migratory. Home range in California estimated at 10.5 ha average. May migrate to different elevations (Penrod et al. n/d; Ahlborn n/d). Home range is not well known, in Idaho an average of 2.6 km^2 was recorded as well as a lack of individuals in fragments smaller than 1 km^2 (Penrod et al. n/d; Ahlborn n/d).

Rationale for its use as target species: Flagship? Sensitive to habitat fragmentation (Penrod et al. n/d). Good for low level connectivity analysis due to its relative tolerance to residential areas (Farrand 1988; but see Fisher and Clarke 1997 regarding sensitivity to feral cats) and long dispersal range.

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Credit for photograph: http://home.earthlink.net/~birdutah/h_quailca1.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Lark Sparrow (*Chondestes grammacus*)

Distribution and abundance: Common in lowlands and foothills (Granholm n/d; Small 1994).

Habitats: Open woodlands, foothill hardwood and hardwood-conifer, chaparral, grasslands with trees, meadows with low bushes or trees (Granholm n/d; Small 1994).

Food: Seeds and insects.

Ecology / Behavior: Non migratory. Home ranges for Kansas reported at 6.1 ha (Grahnolm n/d).

Rationale for its use as target species: Sensitive to edge effect and fragmentation (Bolger et al. 1997). It is declining in most of its range (Lusk et al. 2003).

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Credit for photograph: http://www.imperial.cc.ca.us/birds/lark-spw.htm

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

Loggerhead Shrike (*Lanius ludovicianus*)

Distribution and abundance: Present in suitable habitat throughout the state.

Habitats: Foothills, deserts, open country, grassland, woodlands, structurally heterogeneous vegetation with dead plant cover, widely spaced shrubs and short trees and grasses (Cade and Woods 1997; Michaels and Cully 1998)

Food: Insects and various invertebrates, also carrion, small birds, mammals and amphibians (Granholm n/d; Yosef 1996.

Ecology / Behavior: Although sensitive to fragmentation and habitat modification, a study from Tucson showed that loggerheads take advantage of some aspects of the urban ecosystem (e.g. abundance of certain prey; golf courses) and might be relatively tolerant to some aspects of urbanization (Boal et al. 2003). Studies in Missouri show that they are relatively sensitive to roads (Esely and Bollinger 2001; but they are known to use mowed road verges). In Texas they are also sensitive (i.e. less shrike abundance) to the presence of exotic fire ants (Allen et al. 2001). Mean dispersal distance was found to be 14.7 km for juveniles in Alberta, and a 3.5 km natal dispersal was reported in North Dakota (Collister and De Smet 1997; Haas 1995).

Rationale for its use as target species: Sensitive to pesticides, human disturbance, but still relatively tolerant to urbanization. Good knowledge of dispersal, they disperse preferentially along corridors rather than through isolated patches (Haas 1995). Due to its particular needs regarding dispersal it is an excellent target species for local connectivity analysis.

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Credit for photograph: http://www.inhs.uiuc.edu/chf/pub/ifwis/birds/loggerhead-shrike.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**N**	**N**	**N**	**N**	**N**	**Y**	**Y**	**?**

Marsh Wren (*Cistothorus palustris*)

Distribution and abundance: Common breeeder in appropriate habitat, but extirpated from urban areas.

Habitats: Freshwater and salt marshes. Hides in dense vegetation and nests in cattails and flooded willow thickets. Densities and nest success are higher in denser vegetation and deeper water (Leonard and Picman 1987).

Food: Small invertebrates, seeds and grains.

Ecology / Behavior: Benoit and Askins (2002) found that because they are not short grass meadow specialists they are not as affected by fragmentation as other marsh species, and therefore can survive in smaller patches. Studies in Iowa suggest they are less abundant in restored than in natural wetlands (Delphey and Dinsmore 1993).

Rationale for its use as target species: Indicator of rare habitat type in region, but more tolerant than other specialists.

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Credit for photograph: http://animaldiversity.ummz.umich.edu/site/resources/washtenaw_audubon/bird1_005.jpg/medium.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

Northern Harrier (*Circus cyaneus*)

Distribution and abundance: Uncommon in the area of study but can be abundant in undisturbed habitat throughout the state. Fairly common winter visitor.

Habitats: Wetlands, open and agricultural fields, desert sinks (RCIP 2000; Polite n/d)

Food: Small and medium sized mammals, small reptiles, frogs, birds, insects, crustaceans (RCIP 2000; Polite n/d).

Ecology / Behavior: Home range average varies in different locations from approximately 400 ha in Utah and Michigan to 890 ha in Wisconsin. A minimum area requirement of 55 ha was determined in one study in Illinois (Walk and Warner 1999). Johnson and Igl (2001) found a positive association with patch size in a study in Montana, Minnesota and North and South Dakota.

Rationale for its use as target species: Numbers are down due to decrease of marshland habitat (Clarke 1989) and destruction of nests and nest habitat by agriculture, overgrazing, chemicals and reduced prey availability.

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Credit for photograph: http://www.degrauwegans.nl/Fotos/Foto's_Waarn/Blauwe_Kiekendief_KMA.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**N**	**N**	**Y**	**N**	**N**	**N**	**Y**	**Y**

Red winged and Tricolored Blackbird (*Agelaius phoeniceus* and *Agelaius tricolor*)

Distribution and abundance: Common throughout the area of study and abundant in suitable habitat. Extirpated through large urban areas.

Habitats: Fresh and saline wetlands, particularly those with dense stands of cattails, grain fields, riparian woodlands, ponds and lakes.

Food: Seeds and cultivated grains, insects, suburban birdfeeders.

Ecology / Behavior: Frequent in several urban environments (e.g. golf courses, gardens, cemeteries). Beletsky and Orians (1993) determined dispersal between natal and breeding sites at 1.4 km, with most males breeding in their area of study having been born at no more than 5 km from it. Another study (Moore and Dolbeer 1989) estimates dispersal at almost 100 km.

Rationale for its use as target species: Numbers are decreasing due to the reduction of breeding, nesting and foraging habitat.

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Credit for photograph: http://www.mbr-pwrc.usgs.gov/id/framlst/i4980id.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y?**

Rufous-crowned Sparrow (*Aimophila ruficeps*)

Distribution and abundance: Common to abundant resident in appropriate habitat (Dobkin n/d; Small 1994)

Habitats: Mixed chaparral and coastal scrub (Dobkin n/d).

Food: Seeds, insects, spiders and grass (Dobkin n/d).

Ecology / Behavior: Non migrant. Home range for southern California estimated at 1.5 ha (Dobkin n/d)

Rationale for its use as target species: Because it is an abundant generalist species that becomes rare near edges and small fragments it is a good indicator of fragmentation (Bolger et al. 1997).

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Credit for photograph: http://www.birdphotography.com/species/rcsp.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**Y**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Sage Sparrow (*Amphispiza belli*)

Distribution and abundance: Varies from common to uncommon in different seasons in its different suitable habitats (Dobkin and Granholm n/d; Small 1994).

Habitats: Interior chaparral with dense chamise, coastal sage scrub and arid chaparral and sagebrush (Small 1994).

Food: Seeds, insects and spiders (Dobkin and Granholm n/d).

Ecology / Behavior: Migratory. Home range in other states (Oregon and Nevada) reported at 40 ha (Dobkin and Granholm n/d).

Rationale for its use as target species: The Sage Sparrow is sensitive to fragmentation (Bolger et al. 1997; Knick and Rotenberry 2002), and although the Rufous-crowned sparrow is more common and appears to be more sensitive to fragmentation (Bolger et al. 1997), the Sage Sparrow is still an important target species in other respects. It is strongly associated with chamise chaparral and inland communities (Small 1994; Bolger et al. 1997; Chase et al. 2000), and it is an indicator of mammal species diversity (Chase et al. 2000).

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**?**	**Y**	**N**	**?**	**Y**	**Y**	**Y**

Spotted Owl (*Strix occidentalis*)

Distribution and abundance: Uncommon in southern California.

Habitats: In southern California associated with oak and oak-conifer habitats (Polite n/d)

Food: Small mammals, birds and large arthropods (Polite n/d). In one study in San Bernardino, dusky-footed woodrats compromised 74% of the owl's diet in biomass (Smith et al. 1999).

Ecology / Behavior: Prefers old growth densely wooded areas but forages in young forests, particularly if dusky-footed woodrats are present (Carey and Peeler 1995). Dispersal in the San Bernardino Mountains has been reported between 0.4 and 35.7 km. Dispersal for *Strix occidentalis caurina* in Oregon and Washington ranged from 0.6 to 111.2 km. Only 9% of individuals dispersed more than 50 km (Forsman et al. 2002).

Rationale for its use as target species: Sensitive to habitat modification and fragmentation. Flagship species. Important for analysis of connectivity between mountain ranges through riparian corridors.

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**N?**	**N**	**N**	**N**	**N**	**Y**	**N**	**Y**

Western Meadowlark (*Sturnella neglecta*)

Distribution and abundance: Common in suitable habitat throughout the state.

Habitats: Open country and grasslands.

Food: Carrion, insects, snails, grass and forb seeds.

Ecology / Behavior: Moderate sensitivity to fragmentation and appears to be more common in fragments of more than 10 ha (Swanson 1996). Not sensitive to landscape features (Knick and Rotenberry 1995). Occupancy related to the amount of grassland or shrub cover (Knick and Rotenberry 1995). Although a generalist that is abundant in open space grasslands, its numbers diminish closer to urban edges (Jones and Bock 2002). Bakker et al. (2002) also found that they are sensitive to patch edges with trees.

Rationale for its use as target species: Although adaptable and common in suitable habitat it is still sensitive to fragmentation and relatively sensitive to modification of natural habitat.

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

White-tailed kite (*Elanus leucurus*)

Distribution and abundance: Uncommon resident with fluctuating population size. Most of the population occurs and breeds in lowlands and foothills west of the Sierra Nevada (Small 1994).

Habitats: Open grasslands, agricultural areas (except "clean" agriculture), wetlands, woodlands and riparian areas adjacent to open areas (RCIP 2000).

Food: Voles and other small mammals, reptiles, birds and large insects.

Ecology / Behavior: Population size related to abundance base prey (RCIP 2000). Minimum area required was estimated at 20 ha of a combination of habitats (Ibid). Dispersal distance of up to 160 km has been reported (Ibid).

Rationale for its use as target species: Sensitive to the transformation of natural and farm areas to clean farming and urbanization.

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Credit for photograph: http://www.birdphotography.com/species/wtki.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**N**	**?**	**Y**	**Y**

Yellow-breasted chat (*Icteria virens*)

Distribution and abundance: Rare to uncommon in the area of study. Summer resident in coastal California

Habitats: Relatively wide dense riparian thickets of willows near water, dense brush and nesting areas associated with water.

Food: Insects (ants compromised 82% of their diet in a study in Arizona; Yard et al. 2004), berries and fruits.

Ecology / Behavior: Arrives in April and departs in late September. More abundant in regenerating clearcuts (Annand and Thompson 1997). Prefers nest sites at more than 20 m from habitat edges (Woodward et al. 2001)

Rationale for its use as target species: Sensitive to habitat destruction due to channeling, development and agriculture, particularly the clearance of dense riparian thickets (RCIP 2000). Indicator of larger blocks of riparian habitat.

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Pacific Tree Frog (*Hyla regilla*)

Distribution and abundance: West coast of North America. Locally common.

Habitats: Wide range of habitats, but requires water bodies for breeding.

Food: Wide variety of aquatic and terrestrial invertebrates.

Ecology / Behavior: Predominantly nocturnal. Males form breeding choruses to attract mates. Eggs laid in marshes, ponds, lakes, and slow-moving streams; tadpoles take up to 2 1/2 months until metamorphosis. Species is important food source for garter snakes.

Rationale for its use as target species: Indicator of functioning wetland habitat; excluded by exotic bullfrogs. Important ecological role as prey species. Sensitive to water quality.

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**?**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

Coast Horned Lizard (*Phrynosoma coronatum*)

Distribution and abundance: Uncommon to common in appropriate habitat (Morey n/d).

Habitats: Coastal sage scrub, riparian habitats, oak woodlands, annual grasslands (Morey n/d; IHRMP and CSB n/d).

Food: Mainly native harvester ants, opportunistically will consume other insects (Morey n/d; IHRMP and CSB n/d).

Ecology / Behavior: Diurnal most of the year with some nocturnal activity in mid-summer. Little information on their range is available, but a range of 9–91 m was reported. (Morey n/d; IHRMP and CSB n/d).

Rationale for its use as target species: Sensitive to habitat loss and disturbance. Roads, houses, and landfills aid the invasion of Argentine ants and displacement of native ants (negatively correlated [Fisher et al. 2002]). A diet based on Argentine ants affects horned lizard growth rates (Suarez et al. 2000; Suarez and Case 2002)

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Credit for photograph: http://www.sdnhm.org/fieldguide/herps/phry-cor.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**N**	**N**	**Y**	**N**	**N**	**N?**	**Y**	**Y**

Coast Range Newt (*Taricha torosa*)

Distribution and abundance: Common in coast ranges (Morey n/d).

Habitats: Woodlands, grasslands and forests, coastal scrub and mixed chaparral, slow moving streams (IHRMP and CSB n/d; Morey n/d).

Food: Earthworms, snails, slugs and insects (IHRMP and CSB n/d; Morey n/d).

Ecology / Behavior: Diurnal feeding activity. They migrate up to 1 km between breeding and terrestrial habitat (IHRMP and CSB n/d; Morey n/d).

Rationale for its use as target species: Species of concern. Breeding habitat has been degraded and is particularly sensitive to two exotic predator species: crayfish and mosquito fish (IHRMP and CSB n/d). Crayfish prey and alter newt's behavior, resulting in displacement and population declines (Gamradt et al. 1997).

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Credit for photograph: http://arnica.csustan.edu/jacklin/Big_basin_1/

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y?**	**N**	**N**	**N**	**Y**	**N**

Two-striped Garter Snake (*Thamnophis hammondii*)

Distribution and abundance: Common to uncommon in the area of study (Kucera n/d; IHRMP and CSB n/d).

Habitats: Streams, creeks and other permanent and semi-permanent bodies of water, also occurs in coastal slopes chaparral, mixed oak and oak woodlands. (Kucera n/d; IHRMP and CSB n/d).

Food: Fish, amphibians, fish eggs, earthworms and occasionally small mammals and invertebrates (Kucera n/d; IHRMP and CSB n/d).

Ecology / Behavior: Mainly diurnal, but becomes nocturnal during hot weather. It also uses uplands during the winter, while it is found mainly by streamside habitats during the summer. Summer range calculates as 1500 m^2 average and winter range as 3400 m^2 average (Kucera n/d; IHRMP and CSB n/d).

Rationale for its use as target species: Sensitive to urban development, loss of wetland habitat, and modification of riparian habitat (Kucera n/d; IHRMP and CSB n/d).

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Credit for photograph: http://www.werc.usgs.gov/fieldguide/thha.htm

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**

Pond Turtles (Southwestern and Western) (*Clemmys marmorata pallida* and *Clemmys marmorata*)

Distribution and abundance: Uncommon in suitable habitat in the area of study (Morey n/d).

Habitats: Permanent and intermittent streams, ponds, marshes, reservoirs, permanent and shallow wetlands.

Food: Omnivorous. Aquatic plants, invertebrates, fishes, frogs and carrion (Morey n/d)

Ecology / Behavior: Loss and alteration of aquatic habitat is threatening the species, particularly in southern California. Habitat fragmentation has resulted in reduction of genetic variability (IHRMP and CSB n/d). Females are reported to have traveled more than a mile along a waterway in order to find suitable nesting sites (Ibid). Linear home ranges of up to 4 km were found in southern California (Goodman and Stewart 2000). They also are capable of moving at least 3 miles to adjacent water bodies. Although they survive well in artificial channels they have serious difficulty basking and finding appropriate nest sites in the surrounding aquatic habitat (Spinks et al. 2003).

Rationale for its use as target species: Sensitive to habitat quality in adjacent riparian areas. Due to their long linear home range they could act as umbrellas for other species requiring good habitat quality close to riparian habitats. Potentially useful for connectivity analysis.

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Credit for photograph: http://www.werc.usgs.gov/fieldguide/clma.htm

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**

Western Spadefoot Toad (*Spea hammondii*)

Distribution and abundance: Central Valley, adjacent foothills and Coast Ranges (Morey n/d).

Habitats: Coastal sage scrub, chaparral, grasslands. Common in grasslands with vernal pools (IHRMP and CSB n/d).

Food: Adults consume butterfly and moth larvae, insect worms and other invertebrates (Morey n/d; IHRMP and CSB n/d).

Ecology / Behavior: Mainly nocturnal, most movements occur during rainy nights. They spend up to 10 months per year underground, and movements are very limited.

Rationale for its use as target species: Indicators of vernal pools and other ephemeral wetland habitats.

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Credit for photograph: http://www.werc.usgs.gov/fieldguide/scha.htm (Chris Brown)

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N?**	**N**	**Y**	**Y**	**Y**

American Badger (*Taxidea taxus*)

Distribution and abundance: Present throughout the area of study and the state. Common in Sacramento Valley but fluctuating with food sources (Jameson and Peeters 1988). Uncommon in the area of study (Jameson and Peeters 1988; Penrod et al. n/d; Ahlborn n/d).

Habitats: Mainly grasslands, prairies and open stages of shrub and forest (Penrod et al. n/d; Ahlborn n/d). Apps et al. (2002) found a negative association with forest cover and wet vegetation in British Columbia.

Food: Mostly ground squirrels and pocket gophers, but also insects, reptiles, eggs, and birds.

Ecology / Behavior: Mates in late summer and young are born in March or April. Home range has a strong seasonal (larger summer ranges) and geographical variation, home ranges of up 2100 ha have been reported in Wyoming (Penrod et al. n/d), and radio collared data determined 850 ha for a female (Long 1973), smaller territories were reported in British Columbia (Apps et al. 2002). A dispersal distance of 110 km was documented for a male (Penrod et al. n/c). Active yearlong, nocturnal and diurnal. The probability of occurrence of badgers is positively related to fragment area, and isolation is not a predictor of probability of occurrence (Crooks 2002).

Rationale for its use as target species: Keystone species in certain circumstances. They control small mammal populations, particularly squirrel and pocket gophers. Red-tailed Hawks observe them to catch fleeing squirrels. Sensitive to fragment size.

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Credit for photograph: http://www.death-valley.us/modules.php?name=News&file=article&sid=47

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

Bighorn Sheep (*Ovis canadensis nelsoni*)

Distribution and abundance: Present in favorable habitat but not common.

Habitats: Uses desert, perennial grassland, montane chaparral, oak and conifer habitats (Penrod et al n/d; Hopkins n/d). Perennial water sources an important factor (Turner et al. 2004). One population in Santa Rosa Mountains reportedly uses urban areas for resting and feeding (Rubin et al. 2002).

Food: Grasses and forbs; browse all year

Ecology / Behavior: They have smaller home ranges in the San Gabriel Mountains, with approximately 4 km2 for ewes and 18 for rams (Penrod et al n/d). Escape terrain is crucial in use of habitat. Possible positive association with wildfires (Holl et al. 2004; but see Smith et al. 1999).

Rationale for its use as target species: Very sensitive to habitat degradation and fragmentation. Endangered species. Used by Angeles National Forest and the San Bernardino National Forest as a "management indicator species to track the status of forest management goals" (Holl et al. 2004: 413).

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Credit for photograph: http://www.imagesofcolorado.com/wildpix/guanellabighorn30eeea2r3.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**Y**	**N**	**Y**	**Y**	**Y**

Bobcat (*Lynx rufus*)

Distribution and abundance: Present throughout the area of study and the state, and common in favorable habitat.

Habitats: Rocky terrain with brush cover, forests, and foothill chaparral (Ahlborn n/d; Jameson and Peeters 1988). Wood related habitat important in studies in Illinois (Clayton et al. 2002). Negative association with areas of high topographic complexity (Carroll et al. 2001). Fedriani et al. (2000) provide more specific information regarding habitats for the Santa Monica mountains.

Food: Wide variety, including fruits and grass.

Ecology / Behavior: Mates in winter and young are born in spring (particularly in California). Home range in California was reported at 2.46–4.64 km^2, and a study in San Diego's chaparral reported home ranges between 0.8 and 6.4 km2, but with a mean of less than 2 km^2 (Lembeck 1978). Has a strong seasonal and geographical variation, with large territories reported in British Columbia. Active yearlong. Adult female home ranges averaged 1.7 km^2 in an urban southern California study, but males and young females utilize fragments of 0.4 km^2 (Riley et al. 2003). Home ranges might be lower in non-natural areas due to opportunistic food or difficulty in movement (Ibid. but see Tigas et al. 2002). Road kill might be increased by the presence of suitable habitat (thornshrub) in road verges or median (Cain et al. 2003). Moreover, studies in southern California indicated that culverts were not particularly effective (Tigas et al. 2002).

Rationale for its use as target species: Bobcats act as keystone species in other states (Mallow n/d; Awake 2003). Their numbers are negatively correlated with coyotes (Ahlborn n/d). Studies in Mendocino show different dietary preferences and no territorial conflicts (Neale and Sacks 2001), but Fedriani et al. (2000) report that predation of bobcats by coyotes is an important source of mortality. They could complement coyotes as keystone species in our study. They are more sensitive than coyotes to fragmentation and habitat quality, particularly due to adult female sensitivity, which could compromise population persistence.

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Credit for photograph: http://www.buckshotscamp.com/A-Bobcat-Picture.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**N**	**Y**	**N**	**N**	**N**	**N**	**N**	**Y**

California Meadow Vole (*Mycrotus Californicus*)

Distribution and abundance: Abundant in appropriate habitats, but some subspecies declining.

Habitats: Montane riparian, dense annual grassland and wet meadow (Brylski n/d).

Food: Grasses, sedges and herbs, fresh tender leaves and developing seeds (Brylski n/d; Jameson and Peeters 1988).

Ecology / Behavior: Home range between 0.1 to 1.0 ha (Brylski n/d), males have a larger home range and are territorial, females have smaller home range and are not territorial (Salvioni and Lidicker 1995).

Rationale for its use as target species: Important prey. Compromises, with two other rodents, 73% of the great gray owls diet (Fetz et. al. 2003); their abundance is positively correlated with mallards nest success (Ackerman 2002). They have been associated with plant species richness in grasslands of coastal California. They do not locate themselves in richer areas but rather create the conditions for this richness with their burrow entrances (Fehmi, J and Bartolome 2002). Population growth rates are benefited by use of both grassland (source) and marsh (sink) habitat (Harding 2002).

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Credit for photograph: http://kaweahoaks.com/html/vole.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**Y**	**Y**	**N**	**Y**	**N**	**Y**	**N**	**Y**

Coyote (*Canis latrans*)

Distribution and abundance: Common to abundant resident throughout the state, common in the area of study.

Habitats: Occurs in almost all habitats (Ahlborn n/d). Fedriani et al. (2000) provide more specific information regarding habitats for the Santa Monica Mountains.

Food: Omnivorous, prays on cottontails and jackrabbits but primarily eats smaller mammals, some insects, reptiles, amphibiasns, birds and fruits (Ahlborn n/d; Jameson and Peeters 1988).

Ecology / Behavior: Home range between 8 and 100km^2 (Ahlborn n/d). Way et al. (2004) reported daily movements in a suburban area averaging 26 km for males and 20 km for females. Grinder and Krausman (2001b) studied coyotes in Tucson and found home ranges from 1.7 to 59.7 km^2, averaging 12.6 km^2. Movements occurred more than expected in altered areas and areas such as golf courses or dumps were used to travel, rest and hunt (Way et al. 2004; see also Grinder and Krausman 2001a). Railtracks and power lines were also used by coyotes as connecting corridors, and the authors suggest that natural areas are still needed to provide rest, travel and forage habitat for their could be a threshold for coyotes tolerance to human development (Way et al. 2004; see also Quinn 1997; Crooks 2002). Riley et al. (2003) found that males were more urban-associated than females, but urban areas were used by most individuals in their case study. There is a positive relationship between the use of developed areas and their nocturnal patterns and home range (Riley et al. 2003; see also Tigas et al. 2002; but see Grinder and Krausman 2001a).

Rationale for its use as target species: Considered a keystone species in certain ecosystems. Regulates micro-mammals and mesopredators (Henke and Bryant 1999). Controls populations of smaller predators (Soule et al. 1988). Can be used for low level connectivity analysis and reserve design (Crooks 2002). Good knowledge of behavior in urban areas.

“Coyotes have… persisted in developed areas in southern California. The remarkable behavioral plasticity of coyotes and their ability to succeed in disturbed areas limits their utility as an indicator of connectivity across much of coastal southern California. Nevertheless, coyote occupancy, residency, and relative abundance declined with fragment area and isolation, to the point of local extinctions of coyote populations in the smallest, more isolated urban remnants. Coyotes can therefore serve as useful indicators of functional connectivity in highly fragmented areas, particularly those sites that have already lost more vulnerable predators such as bobcats and mountain lions” (Crooks 2002: 500).

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Credit for photograph: http://www.delta.dfg.ca.gov/ gallery/coyote.asp

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**Y**	**Y**	**N**	**N**	**Y**	**N**	**Y**

Dusky footed woodrat (*Neotoma fuscipes*)

Distribution and abundance: Present and common in appropriate habitats throughout the area of study and the state. Abundant in forest habitats (Brylski n/d). Common in appropriate habitat.

Habitats: Hardwood forests and brushland. Prefers "moderate canopy and moderate to dense understory" (Brylski).

Food: Woody plants, flowers, fungi, berries, grasses and acorns (Brylski n/d; Jameson and Peeters 1988).

Ecology / Behavior: A study in northern California shows that they move across a variety of habitats even though risks increase substantially in the process. The same study found an average home range size of more than 5000 square meters for adult males and more than 2500 square meters for adult females (Sakai and Noon 1997). Dispersal (217 and 134 meters) of two individuals was documented and one happened across an 8 meter dirt road (Sakai and Noon 1997).

Rationale for its use as target species: Associated with low small-mammal species richness (Chase et al. 2000), also important prey species for spotted owls (Sakai and Noon 1997)

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Credit for photograph: http://sacramento.fws.gov/images/woodrat.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Gray Fox (*Urocyon cinereoargenteus*)

Distribution and abundance: Common in suitable habitat throughout the state.

Habitats: Chaparral, brush stages of conifer and woodland habitats, adapts well to farmland (Ahlborn n/d; Jameson and Peeters 1988; but see Gehring and Swihart 2003 regarding farmland). Fedriani et al. (2000) provide more specific information regarding habitats for the Santa Monica mountains.

Food: Omnivorous. Small rodents and rabbits are an important part of their diet, also eats fruits and insects. Can climb some trees. Needs a permanent water source (Ahlborn n/d; Jameson and Peeters 1988)

Ecology / Behavior: Home range varies in different locations. An average of 1.2 km^2 was recorded near Davis, California; more than 7 km^2 in Florida (Ahlborn n/d); and an average of 2.3 km^2 in South Carolina, where dispersal of almost 10 km was confirmed (Weston and Brisbin 2003). Home range structure is more complex and its use less uniformed in residential areas (Harrison 1997). Nighttime activity and diet is also significantly different in residential areas. Seeds ingested by the fox germinate significantly earlier than fresh seeds (Wilson and Barry 1999). According to Fedriani et al. (2000) they behave as specialists in brushy habitats in the Santa Monica Mountains area. Coyotes are an important source of mortality in the Santa Monica Mountains, and their abundance is negatively correlated (Fedriani et al. 2000).

Rationale for its use as target species: Sensitive to high-density residential subdivisions (Harrison 1997), but can persist in moderately-sized urban parks.

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Credit for photograph: http://animaldiversity.ummz.umich.edu/site/resources/corel_cd/gray_fox.jpg/view.html

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**N**	**Y**	**N**	**N**	**Y**	**Y**

Big Brown Bat (*Eptesicus fuscus*)

Distribution and abundance: Ranges from Canada to South America. Common. (Jameson and Peeters 1988, Kurta and Baker 1990).

Habitats: Habitat generalist, but decreased abundance in urban areas (Agosta 2002; Geggie and Fenton 1985).

Food: Feeds on a variety of flying insects, primarily beetles and flies (Jameson and Peeters 1988).

Ecology / Behavior: Commonly roosts in structures, tree hollows, caves, uand under bridges (jameson and Peeters 1988). Rears young in maternity colonies of 5-700 individuals while males roost elsewhere (Novak 1994). Forages with echolocation under streetlights that attract insect prey (Geggie and Fenton 1995).

Rationale for its use as target species: Bats are declining world-wide (Agosta 2002). It plays a significant role in controlling insect populations as the most abundant bat specialezed to hard-bodied insects (Agosta 2002). Despite broad niche and abudance, it is being elminated from urban areas in study area. Susceptible to accumulation of toxins because of long life (~20 years) and trophic level and therefore potential indicator of toxins (Agosta 2002).

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Credit for photograph: Dr. Merlin Tuttle, Bat Conservation International (used with permission)

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

White-footed mice (*Peromyscus* spp.)

Distribution and abundance: Several species common within study area.

Habitats: Wide range of habitats: scrub, chaparral, oak woodlands, forests.

Food: Insects, fruits, seeds, leaves, and fungi (Jameson and Peeters 1988)

Ecology / Behavior: Mostly nocturnal and semi-arboreal to arboreal. Can be territorial. Multiple litters per year, with 2-8 young per litter. Can use highway underpasses (Ng et al. 2004). Decreased abundance with vegetation disturbance (Sauvajot et al. 1998).

Rationale for its use as target species: Likely to be found in larger fragments, but susceptible to vegetation degradation. Indicator of prey base for larger predators.

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Credit for photograph: http://wotan.cse.sc.edu/perobase/systematics/p_calif.htm

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Long-tailed Weasel (*Mustela frenata*)

Distribution and abundance: Common in most parts of the state, but avoids streamside areas (Ahlbron n/d; Jameson and Peeters 1988).

Habitats: Conifer and deciduous forests, woodlands and shrubs. (Ahlbron n/d)

Food: Mainly small mammals, but also insects, small birds and fruit (Ahlbron n/d; Jameson and Peeters 1988; (see Edwards and Forbes (2003) for detailed diet of Mustela erminea in forested landscape).

Ecology / Behavior: Home range depends on prey availability, habitat type and matrix (Gehring and Swihart 2004). Range includes a radius of 511 m (Gehring and Swihart 2003)

Rationale for its use as target species: Their populations respond to small mammal population numbers (Ahlbron n/d; Gehring and Swihart 2003). Sensitive to fragmentation (Gehring and Swihart 2003), but Crooks found that although patch size positively correlates with occurrence of long tailed weasels, isolation is not a predictor of probability of occurrence (Crooks 2002). Could be important to control small mammal numbers, but not to the point of being considered keystone.

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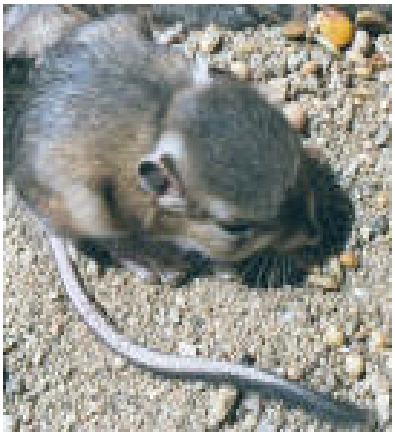
Credit for photograph: http://www.washington.edu/burkemuseum/collections/mammalogy/mamwash/Images/must_fr.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**N**	**N**	**N**	**Y**	**Y**	**Y**

Pacific and Delzura Kangaroo Rats (*Dipodomys agilis* and *Dipodomys simulans*)



Distribution and abundance: Pacific Kangaroo Rat found in chaparral and woodlands, Delzura Kangaroo Rat found in grassland and scrub. D. agilis relatively common, while D. simulans restricted and in decline.

Habitats: Species split in 1997, so prior work reflects both species together (Sullivan and Best 1997). Sagebrush, chaparral, and desert scrub habitats (Ahlbron n/d; Penrod et al. n/d; Jameson and Peeters 1988). A study conducted in a coastal sage scrub community near Irvine showed a strong preference of high sand/bare ground cover (Meserve 1976).

Food: Grasses, forbs and shrubs, also feeds on some insects (Ahlbron n/d; Jameson and Peeters 1988).

Ecology / Behavior: Home range sizes from 0.1 to 0.6 ha have been reported (Ahlbron n/d). Densities of up to 45/ha were reported for San Diego County (McClenaghan 1984).

Rationale for its use as target species: Sensitive to fragmentation and habitat loss. Has difficulty crossing physical barriers such as roads, some grasses and artificially lighted areas (Penrod et al. n/d).

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Credit for photograph: http://natureali.org/images/mammals/panamint%20kangaroo%20rat.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**

Puma (*Felis concolor*)

Distribution and abundance: Uncommon and found in most habitats (Ahlbron n/d).

Habitats: Prefers open areas like grasslands and woodlands, but it is also common in shrublands and mixed conifer forests (Ahlbron n/d; Jameson and Peeters 1988).

Food: Carnivorous, eats other carnivores, and from small mammals to deer, of which mule deer are an important part of their diet (Ahlborn n/d).

Ecology / Behavior: Home ranges are 40km^2 as minimum and up to 250 km^2 were reported for Idaho (Ahlborn n/d). A study in the Santa Ana Mountain Range shows that cougars do not avoid roads, they prefer riparian habitats and are reluctant to use grasslands (Dickson and Beier 2002)

Rationale for its use as target species: Keystone species. Excellent for high level connectivity analysis. Very sensitive to habitat destruction, fragmentation and isolation (Crooks 2002).

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Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**Y**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**Y**

San Diego Black-Tailed Jackrabbit (*Lepus californicus*)

Distribution and abundance: Common throughout the state.

Habitats: Prefers desert shrub areas and open stages of forest and chaparral (Polite n/d; Jameson and Peeters 1988).

Food: Prefers herbs and grasses, but also feeds from forbs, cultivated crops and other vegetation.

Ecology / Behavior: Home range size was estimated in 1 to 3 km^2 in Utah (Smith 1990), earlier studies in California estimated them in 18.5 ha (Polite n/d). Group movements of up to 35 km in less than 10 days were recorded also in Utah, but the average is 5 km in a 2–10 day period (Smith et al. 2002).

Rationale for its use as target species: Important prey for large raptors (see Marzluff et al. 1997 and Kochert et al. 1997 for golden eagle). Indicator of open habitat (grassland) in the basin.

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Smith, G; Stoddart, L; and Knowlton, F 2002. Long-distance movements of black-tailed jackrabbits. *Journal of wildlife Management* 66 (2): 463–469.

Credit for photograph: http://www.nenature.com/BlackTailedJackrabbit.htm

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**Y**	**N**	**Y**	**N**

Behr's Metalmark (*Apodemia virgulti*)

Distribution and abundance: Locally distributed in appropriate habitat throughout coastal central and southern California into Baja California.

Habitats: Sage scrub, chaparral, and dunes with foodplant.

Food:. Larval foodplant is flat-top buckwheat (Eriogonum fasciculatum), adults nectar at buckwheat and other flowers.

Ecology / Behavior: One to two generations per year in March through September. Maximum dispersal in one subspecies is 600 m.

Rationale for its use as target species: Sensitive species in decline as hostplant lost to invasive weeds and urbanization.

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Credit for photograph: http://www.npwrc.usgs.gov/resource/distr/lepid/bflyusa/pic/apodvirg.jpg (Paul Opler)

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**Y**	**N**	**Y**	**N**

California dogface (*Colias eurydice*)

Distribution and abundance: North-central California to Baja California, west of Sierra Nevada and deserts. Very rare or local throughout range.

Habitats: Oak woodlands, chaparral, or coniferous woodlands with foodplant present.

Food: Larval foodpalnt is false indigo (*Amorpha californica*; Fabaceae). Adults nectar at many species of flowers.

Ecology / Behavior: Two flights of adults per year (Spring and Summer). Males patrol for females within habitat.

Rationale for its use as target species: Indicator of intact herb understory in oak woodlands. Declining in lowlands because of degradation of oak woodland habitats.

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Credit for photograph: http://www.sdnhm.org/fieldguide/inverts/californiadogface.html (Bob Parks)

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**Y**	**N**	**Y**	**N**	**N**	**Y**	**Y**	**N**

Comstock's Fritillary (*Speyeria callippe comstocki*)

Distribution and abundance: Southern California subspecies of wide-ranging species. Near extirpation in Santa Monica Mountains and status uncertain in San Gabriel Mountains.

Habitats: Grasslands supporting larval host of native *Viola* spp. Adults fly May through June.

Ecology / Behavior: Restricted to grassland habitat. Females lay eggs near but not on foodplants. Diapause occurs as first instar larvae. Larvae develop following season, pupate, and eclose as adults. Nectars at available nectar sources. Other subspecies require relatively large, open grasslands (tens of ha).

Rationale for its use as target species: Sensitive to degradation, fragmentation, and connectivity of grassland habitats. Probable surrogate for grassland species, as is the nominate subspecies in the San Francisco Bay region.

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Credit for photograph: http://mamba.bio.uci.edu/~pjbryant/biodiv/lepidopt/nymph/Comstock1.jpg (Peter J. Bryant)

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**N**	**Y**	**N**

El Segundo Blue Butterfly (*Euphilotes bernardino allyni*)

Distribution and abundance: Localized in El Segundo dune system, currently at Los Angeles International Airport, Chevron refinery, and private property in Torrance.

Habitats: Found exclusively associated with seacliff buckwheat (*Eriogonum parvifolium*) in coastal dune and bluff habitats in Los Angeles County.

Food: Larval forms consume flowerheads of seacliff buckwheat, adults nectar at flowers of seacliff buckwheat

Ecology / Behavior: Life cycle closely associated with seacliff buckwheat. Adults fly in summer (late June through August), mate and lay eggs on flowerheads of buckwheat. Larvae develop within flowerheads and pupate in soil below plants. Sensitive to competition from other Lepidoptera and removal of foodplant. Can persist on small patches of foodplant, but unlikely to be recolonized over distances greater than a few hundred meters.

Rationale for its use as target species: Indicator of very rare habitat type (coastal dune); indicator of connectivity within coastal dune habitat because of extremely sedentary nature.

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Credit for photograph: Rudi Mattoni © 1992

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
N	**Y**	**N**	**N**	**N**	**Y**	**N**	**N**	**N**

Lorquin's Admiral (*Liminitis lorquini lorquini*)

Distribution and abundance: West coast of United States north to Canada. Increasingly rare in Los Angeles Basin (Mattoni 1990).

Habitats: Riparian forest

Food: Willows (*Salix* sp.) are larval foodplant.

Ecology / Behavior: Two broods per year. Adults are relatively sedentary and aggressively defend territories.

Rationale for its use as target species: Sedentary nature and declining habitat (riparian forest) make it indicator of connectivity at local scales.

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Credit for photograph: http://www.laspilitas.com/butterflies/Butterflies_and_Moths/Lorquin's_Admiral/Admiral.jpg

Sensitive	Connectivity	Biodiversity	Rare	Keystone	Umbrella	Fragment	Habitat Quality	Knowledge
Y	**N**	**N**	**Y**	**N**	**N**	**N**	**Y**	**N**

Riverside Fairy Shrimp (*Streptocephalus wootoni*)

Distribution and abundance: Southwestern California through Baja California. Distribution limited greatly by urbanization, now listed as endangered.

Habitats: Found in deep, long-lived vernal pools, ephemeral pools and stock ponds (Eng et al. 1990).

Food: Detritus, algae and other small particles are filtered out of the water by fairy shrimp.

Ecology / Behavior: Life cycle begins when cysts hatch after warm late spring rains. Only a proportion of cysts hatch each year to spread risk over years (Simovich and Hathaway 1997). Adults grow and reproduce in pools, but face mortality if pools dry before new cysts are produced. Cysts can survive desiccation for long periods. Movement between pools presumably by vertebrate vectors.

Rationale for its use as target species: Indicator of very rare habitat type.

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Credit for photograph: Guy Bruyea, Bruyea Biological Consulting http://ecoregion.ucr.edu/fullpictures.asp?sp_num=2&image_id=1

The proposed focal species evenly represent the major habitat divisions of the study area (Table 5). The species also fit the many different roles described for focal species in this report. Some species are useful for many reasons (e.g., puma) and across many habitat types (e.g., coyote). The next step will be the production of range maps for each of the focal species. These range maps will then be used to identify those areas of the region that would need to be conserved to ensure the long-term persistence of the focal species and the habitats that they represent.

Table 5. Characteristics of focal species by major habitat type and focal species role.

	Chaparral	Conifer	Dune	Grassland	Hardwood	Lacustrine	Riverine	Wetland
Birds								
Belding's savannah sparrow								EN V FO?
Burrowing Owl			EN FL	EN FL				
California Quail/Mountain Quail	EN V	EN V			EN V			
Lark Sparrow	EN V				EN V		EN V	
Loggerhead Shrike			EN B? V	EN B? V				
Marsh Wren								EN
Meadowlark			EN	EN				
Northern Harrier				EN V				
Redwinged/Tricolored Blackbird								EN
Rufous-crowned Sparrow	EN FO							
Sage Sparrow	EN EC B							
Spotted owl		EN EC U V			EN EC U V			
White-tailed Kite				EN V				
Yellow-breasted Chat					EN V		EN V	
Reptiles and Amphibians								
Coast Horned Lizard	EN V		EN V					
Coast range Newt	EN V	EN V		EN V	EN V		EN V	
California Tree Frog							EN V	
Spadefoot Toad	EN V		EN V	EN V	EN V		EN V	EN V
Western Pond Turtle			EN U F V			EN U F V	EN U F V	
Two-striped Garter Snake					EN		EN	EN
Mammals								
American Badger	EN K							

Composition indicators	C	Umbrella	U
Environmental indicators	EN	Focal	FO
Ecological indicators	EC	Flagship	FL
Biodiversity indicators	B	Vulnerable	V
Keystone	K		

	Chaparral	Conifer	Dune	Grassland	Hardwood	Lacustrine	Riverine	Wetland
Bighorn Sheep		EN V						
Bobcat	EN K FL	EN K FL			EN K FL		EN K FL	
California Meadow Vole				B				
Coyote	K	K	K	K	K		K	
Dusky-footed Woodrat	B(-) V	B(-) V		B(-) V	B(-) V		B(-) V	
Gray Fox	EN	EN		EN				
Big Brown Bat	EN	EN			EN		EN	
Long-tailed Weasel	EN B	EN B	EN B		EN B			
White-footed Mice	EN	EN	EN	EN	EN			
Pacific/Delzura Kangaroo Rat	EN	EN		EN	EN		EN	
Puma	EN EC K U V FL FO	EN EC K U V FL FO			EN EC K U V FL FO		EN EC K U V FL FO	
San Diego Black-tailed Jackrabbit				EC EN V				
Invertebrates								
Behr's Metalmark	EN							
California Dogface					EC C V			
Comstock's Fritillary				EN U				
El Segundo Blue Butterfly			EN U V FL					
Lorquin's Admiral							EN	
Riverside Fairy Shrimp								EN V

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