DEVELOPMENT OF AN INDEX OF BIOLOGICAL INTEGRITY FOR RIPARIAN ECOSYSTEMS IN THE SAN JACINTO RIVER WATERSHED, RIVERSIDE COUNTY, CALIFORNIA

FINAL REPORT

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INTRODUCTION

The Environmental Laboratory at the U. S. Army Engineer Research and Development Center (ERDC) is assisting the Los Angeles District of the U. S. Army Corps of Engineers by providing technical information needed for the development of a Special Area Management Plan (SAMP) for the watersheds of the San Jacinto and Santa Margarita Rivers in western Riverside County, California. The purpose of the SAMP is to "develop and implement a watershed-wide aquatic resource management plan and implementation program, which will include preservation, enhancement, and restoration of aquatic resources, while allowing reasonable and responsible economic development and activities within the watershed-wide study area" (Los Angeles District Corps of Engineers 2000).

As part of the SAMP, riparian ecosystems in the two watersheds are being assessed at the riparian reach scale using a rapid, indicator-based assessment method (Smith 2002). The output consists of three indices that express the effects of human activities on hydrology, water quality, and wildlife habitat in each reach, in relation to the natural, undisturbed condition. The assessment is based on indicators that represent physical, chemical, and biological factors thought to influence riparian ecosystem integrity at three spatial scales: the riparian reach, the local drainage (i.e., the area contributing to tributary, groundwater, and overland flow that directly enters the riparian reach), and the drainage basin (i.e., the area contributing to main-stem inflow from upstream of a riparian reach). For the purposes of this study, riparian ecosystems are defined as linear corridors of variable width that occur along perennial, intermittent, and ephemeral streams (Williams 1978). They are recognized in the field by fluvial geomorphic features and by a plant community that differs in structure or species composition from that of the surrounding uplands, due to the increased availability and physical influence of water. Riparian reach assessment units are defined as discrete segments of the main-stem stream channel plus the adjacent riparian ecosystem and minor tributaries that are relatively homogeneous with respect to geology, geomorphology, channel morphology, substrate type, vegetation communities, and cultural alteration.

In addition to the indicator-based assessment, a number of supplemental technical studies were initiated to facilitate the decision-making process of the SAMP by providing more detailed information about the hydrologic, water quality, and wildlife habitat integrity of the two watersheds. Objectives of the supplemental technical studies were to (1) provide a more detailed characterization of baseline conditions in the study area, which is needed as a starting point to assess and predict future trends in riparian ecosystem integrity as a result of anticipated development, protection, and restoration activities, and (2) to provide data that can be used to test and refine the indicator-based assessment method, which, due to its relative simplicity, cost-effectiveness, and ease of use, is likely to be the primary tool for riparian ecosystem assessment and monitoring in the two watersheds. The purpose of this report is to describe the methods, results, and implications of the supplemental wildlife studies in the San Jacinto River watershed.

The supplemental wildlife studies for the SAMP have focused on the characterization of riparian bird and herpetofaunal (i.e., reptile and amphibian) communities in selected reaches of the San Jacinto River watershed, and the development of an Index of Biological Integrity (IBI) for riparian ecosystems in the study area. Birds and herps were chosen for study because they are of considerable public and agency interest, and the fate of many species in southern California is closely tied to the health of riparian and aquatic ecosystems. Throughout much of the arid southwestern United States, riparian habitats occupy <1 percent of the land area but have a critical role in maintaining regional biodiversity (Hubbard 1977; Johnson et al. 1977; Brinson et al. 1981). In California, many reptile and amphibian species are either restricted to riparian habitats year-round or must return to aquatic habitats to breed (Brode and Bury 1984). A number of avian species in the West are known to be either riparian specialists (i.e., they prefer riparian habitats during some part of their annual cycles) or riparian obligates (i.e., they require the presence of quality riparian habitats for survival) (Rich 2002). Furthermore, birds in general have been shown to be sensitive indicators and integrators of environmental change such as that brought about by human use and alteration of the landscape (Morrison 1986, Croonquist and Brooks 1991, O'Connell et al. 2000).

The IBI Approach to Ecosystem Assessment and Monitoring

IBI is a method for assessing and monitoring the ecological health and integrity of streams through the direct characterization of their biological communities. "Integrity," as applied to ecosystems, is a relatively new concept. In general, integrity is the state of being whole, complete, sound, and unimpaired. An ecosystem maintains its integrity, even in the face of significant disturbance, if it "preserves all its components as well as the functional relationships among the components" (De Leo and Levin 1997). Ecosystem integrity can be divided into physical, chemical, and biological components (Karr and Dudley 1981). Biological integrity has been defined as "the maintenance of the community structure and function characteristic of a particular locale . . ." (Cairns 1977) and "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having species composition, diversity, and functional organization comparable to that of natural habitats of the region" (Karr and Dudley 1981). IBI is specifically designed to integrate multiple sources of stress on aquatic ecosystems as a result of human activities, such as agricultural and urban development of watersheds (Karr and Chu 1999).

IBI was designed to supplement more traditional methods of in-stream monitoring that emphasize physical and chemical characteristics, such as pollutant levels in water and sediments, with little regard to their biological consequences (Karr 1987, Karr and Chu 1999). IBI is based on direct monitoring of the diversity and species composition of aquatic organisms, such as fish and aquatic invertebrates (Karr and Dudley 1981, Karr 1991). The index is composed of a number of separate measures of individual health, population and community structure, and is expressed in relation to values measured in relatively undisturbed, high-quality reference sites in the region. IBI is now well established as a tool for monitoring the integrity of aquatic ecosystems and recently has been adapted to terrestrial and riparian systems (O'Connell et al. 2000, Kimberling et al. 2001, Bryce et al. 2002). The National Research Council's (2002) Committee on Riparian Zone Functioning and Strategies for Management has endorsed the further development of IBI as a riparian assessment technique.

Supplemental Wildlife Studies in the San Jacinto River Watershed

Development of the IBI for the San Jacinto watershed required a community approach, potentially involving information on the full range of native bird, reptile, and amphibian species known to use riparian habitats in the watershed. Initially, we sought existing data on the presence and relative abundance of bird and herp species associated with one or more of the >600 designated riparian reaches in the study area. For birds, existing data tended to be limited to selected species of conservation and management concern (e.g., data compiled for the Western Riverside County Multiple Species Habitat Conservation Plan [Riverside County 2002]) or to particular portions of the watershed (e.g., U.S. Forest Service surveys in the San Bernardino National Forest). Existing information was not necessarily centered on riparian habitats, was derived from a variety of sources or sampling methods, or was not readily available to us for use in this study. Therefore, existing information could not provide the kind of watershed-wide, riparian-focused, methodologically standardized data sets that were needed to characterize riparian bird communities and develop a reliable IBI. Fortunately, birds are relatively easy to sample by standardized methods (e.g., Ralph et al. 1995). Therefore, we enlisted the assistance of a number of graduate students at the University of California, Riverside (UCR), under the direction of Dr. Tom Scott, to work with ERDC field personnel to sample avian communities in more than 100 riparian reaches across the San Jacinto watershed during spring of 2002. Details of bird survey methods and results are given in the section on Avian Studies.

Direct sampling for herps, on the other hand, can be difficult and problematic if the goal is to obtain information on the full suite of species present in an area. Species differ widely in their daily, seasonal, and annual activities, making it difficult to obtain reliable data on community composition without an extensive sampling effort. Some species are only active at night or after particular rainfall events. Furthermore, herps are generally more secretive than birds and require much more labor-intensive sampling methods (e.g., trapping, pitfalls, and active searches under rocks and logs) to detect their presence and determine relative abundance (Heyer et al. 1994). Because of these potential problems and associated costs, direct sampling for herps in this study was not practical in more than a handful of reaches. Therefore, we concentrated on existing sources of information about herp distributions in the watershed. Our goal was to evaluate the usefulness of existing data for characterizing riparian herp communities in the watershed and, if appropriate, use these data in developing the IBI. Details are given in the section on Herpetological Studies.

AVIAN STUDIES

Background

Riparian habitats in the southwestern United States constitute a small fraction of the habitat available to the indigenous biota, yet support highly diverse plant and animal communities. This is particularly true for the regional avifauna, where a large proportion of bird species rely solely, or in part, on riparian areas during the breeding season (Carothers et al. 1974, Gaines 1977, Hubbard 1977, Johnson et al. 1977, Kozma and Mathews 1997, Yong et al. 1998, Ballard et al. 2000). Habitat loss through urbanization, water diversion and impoundment, dredging and channelization, livestock grazing and other agricultural practices has contributed to declines in numerous southwestern riparian bird species (Ballard et al. 2000, Guilfoyle 2001). Recent estimates suggest that many southwestern states have lost over 50% of their original riparian habitats, while California and Arizona have lost over 90% (Dahl 1990). Loss of riparian habitat is considered the primary factor contributing to the decline of many Neotropical migrant species[1] in southern California (Ballard et al. 2000). Riparian habitats also support numerous Nearctic migrant species[2] and resident species[3], many of which are also experiencing declines (Ballard et al. 2000, Lovio et al. 2002, Robinson et al. 2002, Zack et al. 2002).

The San Jacinto River watershed (Figure 1) provides important seasonal habitats for a diversity of bird species. Several areas within the watershed have been designated as "Important Bird Areas," or IBAs. The IBA program is a global effort to identify areas that are most important for maintaining bird populations and focus conservation efforts. IBAs provide essential habitat for one or more bird species. An IBA may include breeding, wintering, and/or migrating habitats, and range in size from a few acres to thousands of acres. A site may be globally important, or important at the continental, national, or state level. To qualify as an IBA, a site must satisfy at least one of the following criteria:

1. Support species of conservation concern (e.g., threatened and endangered species)
2. Support range-restricted species (i.e., species that are vulnerable because they are not widely distributed)
3. Support species that are vulnerable because their populations are concentrated in one general habitat type or biome
4. Support species, or groups of similar species (such as waterfowl or shorebirds), that are vulnerable because they occur at high densities due to their congregatory behavior.

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[1] Neotropical migrant bird species breed in North America but migrate to wintering areas in Mexico, Central and South American, and the Caribbean Islands.
[2] Nearctic migrant bird species (also called temperate migrants) reside in North America year-round and typically breed in the northern U.S. and Canada and winter in the southern U.S.
[3] Resident species are typically non-migratory bird species that breed and winter within a general geographic area.

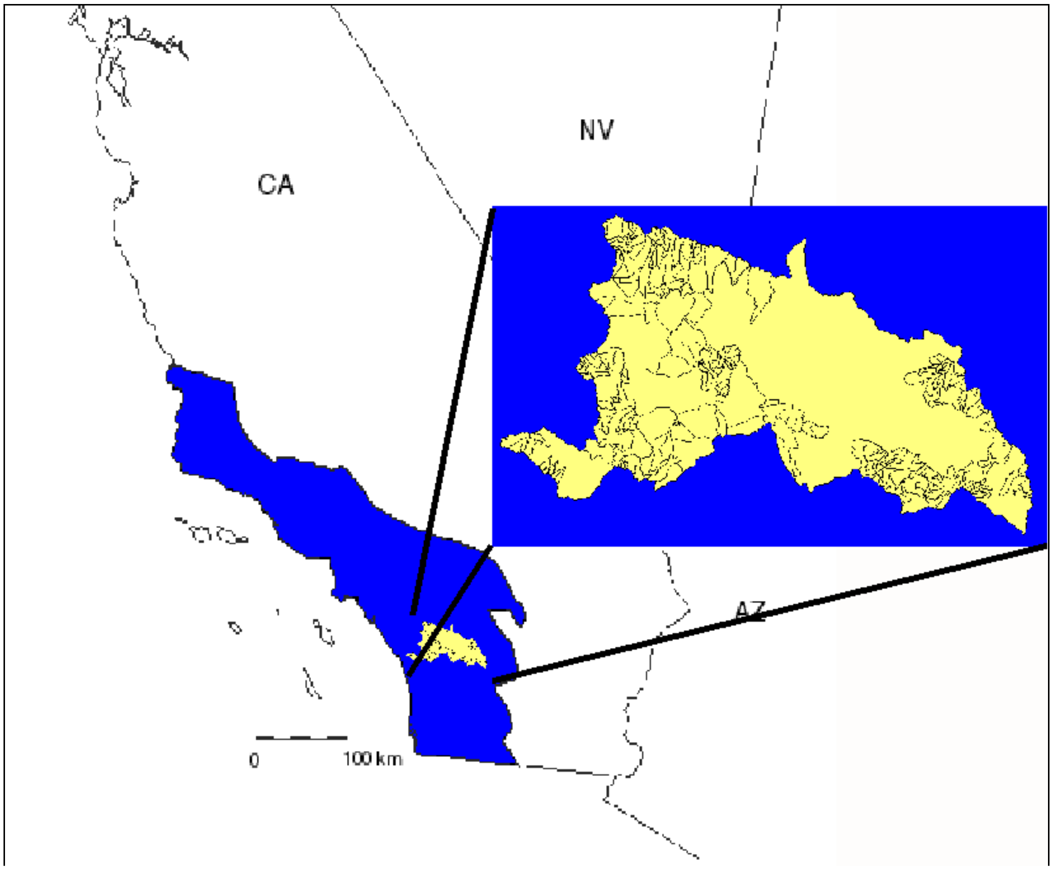


Figure 1. Location of the San Jacinto River watershed within the Central and Southern California Coast and Valleys physiographic region (Partners in Flight 2002).

The IBA program in California was initially established by BirdLife International, and is administered by the American Bird Conservancy and the National Audubon Society. Cooper (2001) compiled a state-wide list of IBAs in California. The following IBAs have been identified in the San Jacinto watershed. (Descriptions of each IBA below are quoted extensively from Cooper 2001.)

> **Bautista Creek**. Bautista Creek drains the northwestern San Jacinto Mountains, west of and parallel to the Garner Valley. This is a permanent stream that supports strong populations of foothill riparian and woodland bird species. Bautista Creek is apparently an important migration corridor for passerines moving up California from the Colorado Desert, specifically connecting the Anza-Borrego Region with the San Jacinto Valley. It supports a full compliment of breeding riparian species, including Least Bell's Vireo, Yellow Warbler, Yellow-breasted Chat and Blue Grosbeak. Sensitive species include Ferruginous Hawk, Golden Eagle, Prairie Falcon, Loggerhead Shrike, Bell's Vireo, Cactus Wren, California Gnatcatcher, Yellow Warbler, Yellow-breasted Chat, and Sage Sparrow.
>
> This region is to the east of the main housing boom area of western Riverside County, though plans to site Indian casinos in the area north and south of Bautista Creek are moving forward, with accompanying road-widening plans. The residential sprawl of

Hemet-San Jacinto will probably move southeast to affect this IBA, which currently receives no formal protection.

Garner Valley. This large, wet meadow at approximately 4500 feet in the San Jacinto Mountains lies in a broad valley south of Lake Hemet. The valley is dominated by rushes with stringers of montane willows, and is surrounded by an extensive, mature Yellow Pine Woodland and dense chaparral (esp. Manzanita and Chamise). The bird community here is unique in California, with this montane meadow supporting breeding populations of rails and grassland species (e.g., Northern Harrier, Savannah and possibly Vesper sparrows), as well as colonies of Tricolored and Yellow-headed blackbirds. Much of the riparian habitat is heavily grazed, and located on private land. An exceptionally high diversity of breeding birds is found in and around Garner Valley, with Pinyon Jays, Red Crossbills, and Cassin's and Purple finches nesting abundantly, along with chaparral species such as Mountain Quail, Green-tailed Towhee and Black-chinned Sparrow. Gray Vireo is known from chaparral. The area may also be the last stronghold of breeding Purple Martin south of the Tehachapi Mountains of Kern County, but their numbers are poorly known. Sensitive species include Ferruginous Hawk, Golden Eagle, Long-eared Owl, Loggerhead Shrike, Gray Vireo, Purple Martin, Sage Sparrow, and Tricolored Blackbird.

Lake Elsinore. Lake Elsinore is one of the largest natural lakes in southern California. It is surrounded on the east by arid, coastal sage scrub-covered hills, and on the west by the steep eastern escarpment of the Santa Ana Mountains, which are cloaked in chaparral and oak woodland. The lake is fed by Temescal Creek and the San Jacinto River, which enter from the Lake Mathews/Estelle Mountain IBA from the north. Though largely surrounded by trailer parks, campgrounds and marinas, the southern end features an extensive constructed wetland ("Wetland Habitat Area", City of Lake Elsinore) with small islets, mudflats, and freshwater marsh vegetation bounded by a large dike. More freshwater marsh and riparian habitat is found just north of the lake, associated with Temescal Creek, and accessible from Hwy. 74. South of the lake (though also separated from the lake by large dike) is the historic draw-down area of the lake, now a broad plain covered with alkali grassland (mainly exotic) and scattered clumps of mulefat-dominated riparian scrub. More intact grassland (mixed with coastal sage scrub) is found just west of Temescal Creek north of Hwy. 74, but is slated for development. Pockets of willow-cottonwood riparian woodland are also found along the lakeshore, particularly at the southwestern corner.

The drawdown area of Lake Elsinore supports a diverse raptor community, and several species of locally scarce waterbirds (incl. Caspian Tern) breed in the constructed wetlands. Currently, access limits thorough exploration of the wetlands (it's a 2-mile walk out to the habitat). Several heron rookeries are found in the riparian growth around the lake. The Riversidean Coastal Sage Scrub is especially lush on the east side of the lake, and supports high densities of California Gnatcatcher and Cactus Wren adjacent to residential areas (Cooper, pers. obs.). Human disturbance (ORV use, dumping) and arson threatens the remaining patches of coastal sage scrub, particularly those on the eastern side of the lake. The entire IBA is widely popular with ORV enthusiasts, and fences and signage are nearly impossible to maintain given current activities. Riparian thickets are especially at risk, both from vehicles and from serious infestation by exotic plants, especially Tamarisk, which was found to be completely lining the constructed wetlands and much of the draw-down area in 2001 (Cooper, pers. obs.). Sensitive species include Ferruginous Hawk, Caspian Tern, Loggerhead Shrike, Bell's Vireo, Cactus Wren, California Gnatcatcher, Yellow Warbler, Yellow-breasted Chat, Sage Sparrow, and Tricolored Blackbird.

San Jacinto Valley. The San Jacinto Valley is quite simply one of the most important bird areas in southern California. The Valley is dominated by the floodplain of the San Jacinto River, which runs northwest from the base of the San Jacinto Mountains. A portion of the river empties into Mystic Lake (a.k.a. "San Jacinto Lake"), just east of the community of Moreno Valley, while the rest is directed southwest from here toward the community of Perris and I-215. Low hills surround the valley on the north ("The Badlands"), west ("Bernasconi Hills") and south ("Juniper Flats"), which are covered with Riversidean Coastal Sage Scrub and, where frequently burned, by grassland. A series of impoundments with freshwater marsh on the southwest side of Mystic Lake is maintained as the San Jacinto Wildlife Area, and smaller areas of marsh are found at the Hemet-San Jacinto Water Treatment Plant (a.k.a. "San Jacinto Sewage Ponds") along Sanderson Rd. to the southeast, and locally elsewhere in the valley (around stock ponds). Large areas of pastureland, mostly sparse vegetation on alkaline soil, occur throughout. Finally, Motte-Rimrock Reserve (University of California, Riverside), just west of Perris, has been the site of numerous studies of the interior coastal sage scrub bird community.

The marshes of the San Jacinto Wildlife Area support one of the few remaining southern California breeding colonies of White-faced Ibis, as well as Least Bittern, rails and hundreds of pairs of Tricolored and Yellow-headed Blackbird. The pastureland, particularly the vast plowed fields southeast of Mystic Lake, are one of the few remaining areas left in southern California outside the Imperial Valley that support winter flocks of Mountain Plover, Long-billed Curlews, White-faced Ibis, and (until the 1990s) Sandhill Crane. Dozens of Ferruginous Hawks winter in this area, and virtually all of southern California's raptor community is represented here, perhaps concentrated by abundant rodent prey. A traditional roost of both Long-eared and Short-eared Owls exists in isolated olive groves along Davis Rd., within the San Jacinto Wildlife Area. Depending on water levels, thousands of shorebirds and waterfowl utilize the flooded fields of the Wildlife Area and at Mystic Lake to the north. The scrub on the hillsides surrounding the valley supports some of the highest densities of resident Bell's Sage Sparrow, which are here confined to undisturbed tracts of habitat, shared by California Gnatcatcher and Cactus Wren. The whole region appears to be a critical migration corridor between the desert and the coast for a wide variety of species: a sizable springtime migration of Sage Thrasher – nearly unique in coastal southern California – occurs in late winter, followed by a major push of Swainson's Hawks moving north toward the Central Valley.

This area . . . falls within the WRMSHCP planning area, and similar recommendations apply. The potential for habitat restoration in this area is enormous – the marshy shore of Mystic Lake was one of the last wintering areas for Yellow Rail and breeding Black Rail in southern California, and a Yellow Rail present here in the 1970s suggests that recolonization is not out of the question. The area has received attention from birders and ornithologists since the early 1900s. Conservation groups, including the State of California, have made the San Jacinto Valley a priority area for acquisitions and easements, with recent activity focusing on much of the regularly flooded lands in and around Mystic Lake. However, pressure to develop the surrounding uplands is intense; a new Indian casino is now (2001) being constructed less than a kilometer away from the shore of Mystic Lake. Sensitive species include Least Bittern, White-faced Ibis, Northern Harrier, Ferruginous Hawk, Golden Eagle, Prairie Falcon, Mountain Plover, Burrowing Owl, Short-eared Owl, Long-eared Owl, Loggerhead Shrike, Cactus Wren, California Gnatcatcher, Yellow Warbler, Yellow-breasted Chat, Sage Sparrow, Grasshopper Sparrow, and Tricolored Blackbird.

Objectives of the Avian Studies

The purpose of this work was to assist in the development of the SAMP by providing a detailed characterization of riparian breeding-bird communities in the San Jacinto River watershed. The information is needed in decisionmaking by the Los Angeles District and others involved in SAMP development, and will be used to test and refine a rapid, indicator-based approach for evaluating and monitoring riparian ecosystems. Specific objectives of the avian studies were:

1. To quantify the species composition and relative abundance of breeding bird communities associated with designated riparian reaches in the watershed

2. To evaluate bird community composition in relation to human disturbance of riparian reaches and their surrounding drainages

3. To integrate relevant bird-community metrics into an Index of Biological Integrity for riparian systems in the watershed

Methods

Study Area

The San Jacinto River watershed (Figure 1) is located approximately 7.5 miles (12 km) east of the city of Riverside in Riverside County, California, and encompasses approximately 1,489,820 acres (602,910 ha) within the western portion of the county (Lichvar et al. 2002). Towns and cities within the watershed include Perris, Lake Elsinore, Moreno Valley, Sun City, San Jacinto, and Hemet. The city of Temecula lies just southwest of the San Jacinto watershed. The watershed encompasses a large elevational gradient, from approximately 1,200 ft at Lake Elsinore to 10,804 ft on San Jacinto Peak on the northeastern edge of the watershed. The main watercourse within the watershed is the San Jacinto River, which begins in the San Jacinto Mountains and drains generally westward to Lake Elsinore. An intermittent channel connects Lake Elsinore to the Santa Ana River drainage to the north.

Climate in the region is characterized by hot, dry summers and mild winters. Average precipitation is approximately 12 in. (30 cm) annually at lower elevations, while higher elevations average as much as 26 in. (66 cm). At lower elevations, mean annual temperature is 64 ^{o}F, with a mean high of 81 ^{o}F and low of 47 ^{o}F. Mean annual temperatures are much cooler in San Jacinto Mountains, with an overall mean temperature of 53 ^{o}F, and a mean high of 68 ^{o}F and a low of 37 ^{o}F (Lichvar et al. 2002).

Bioregions

To facilitate sampling of the bird communities within the San Jacinto watershed, the study area was divided into 4 bioregions (Figure 2). Sampled reaches were chosen at random within each bioregion (Figures 3-6). Three of these bioregions, Lowlands, Foothills, and Mountains, generally followed bioregion designations described in the Riverside County Integrated Project: Multiple Species Habitat Conservation Plan (RCIP/MSHCP) (Riverside County 2002). The Badlands bioregion, originally a part of the RCIP/MSHCP's Riverside Lowlands bioregion, was designated separately after a field reconnaissance indicated that this area differed somewhat from the remainder of the Lowlands bioregion. Brief descriptions of each bioregion are provided below.

Lowlands. Corresponds to the Riverside Lowlands bioregion described in the RCIP/MSHCP (Riverside County 2002). This bioregion includes the San Jacinto, Perris, and Moreno Valleys, and generally occurs at an elevation below 2,000 ft (Figure 3). Common riparian trees include red and black willow (*Salix laevigata* and *S. gooddingii*) and sycamore (*Platanus racemosa*), with an understory of mulefat (*Baccharis salicifolia*). This area is relatively arid because of the rain shadow cast by the Santa Ana Mountains, and is characterized by a high degree of urbanization and habitat fragmentation (Figure 7). Some small, low-lying hills are found within this bioregion, yet these areas support plant communities typical of the lower elevation areas (Riverside County 2002). This region rarely receives any frost or snow during the winter months.

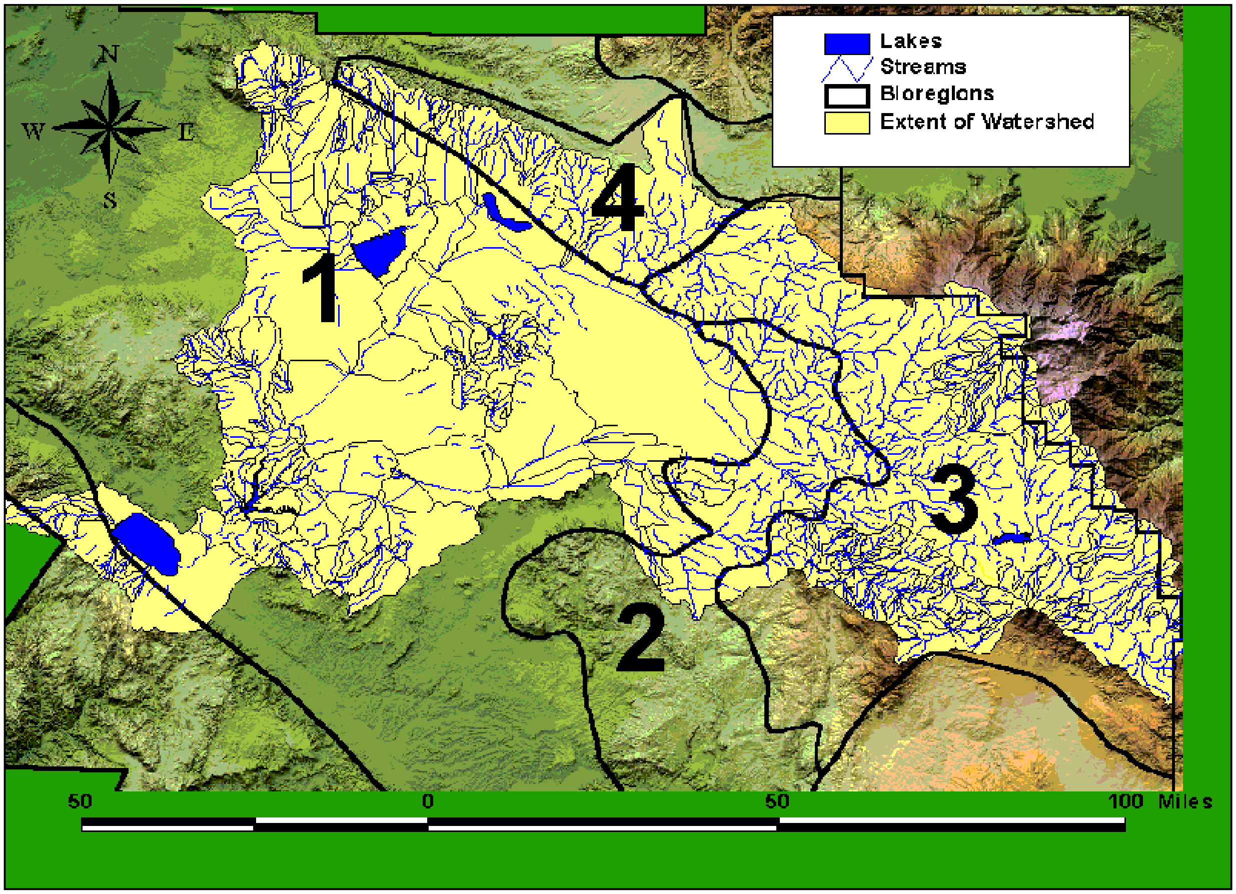


Figure 2. Distribution of the four major bioregions (1=Lowlands; 2=Foothills; 3=Mountains; 4=Badlands) within the San Jacinto River watershed, Riverside County, California.

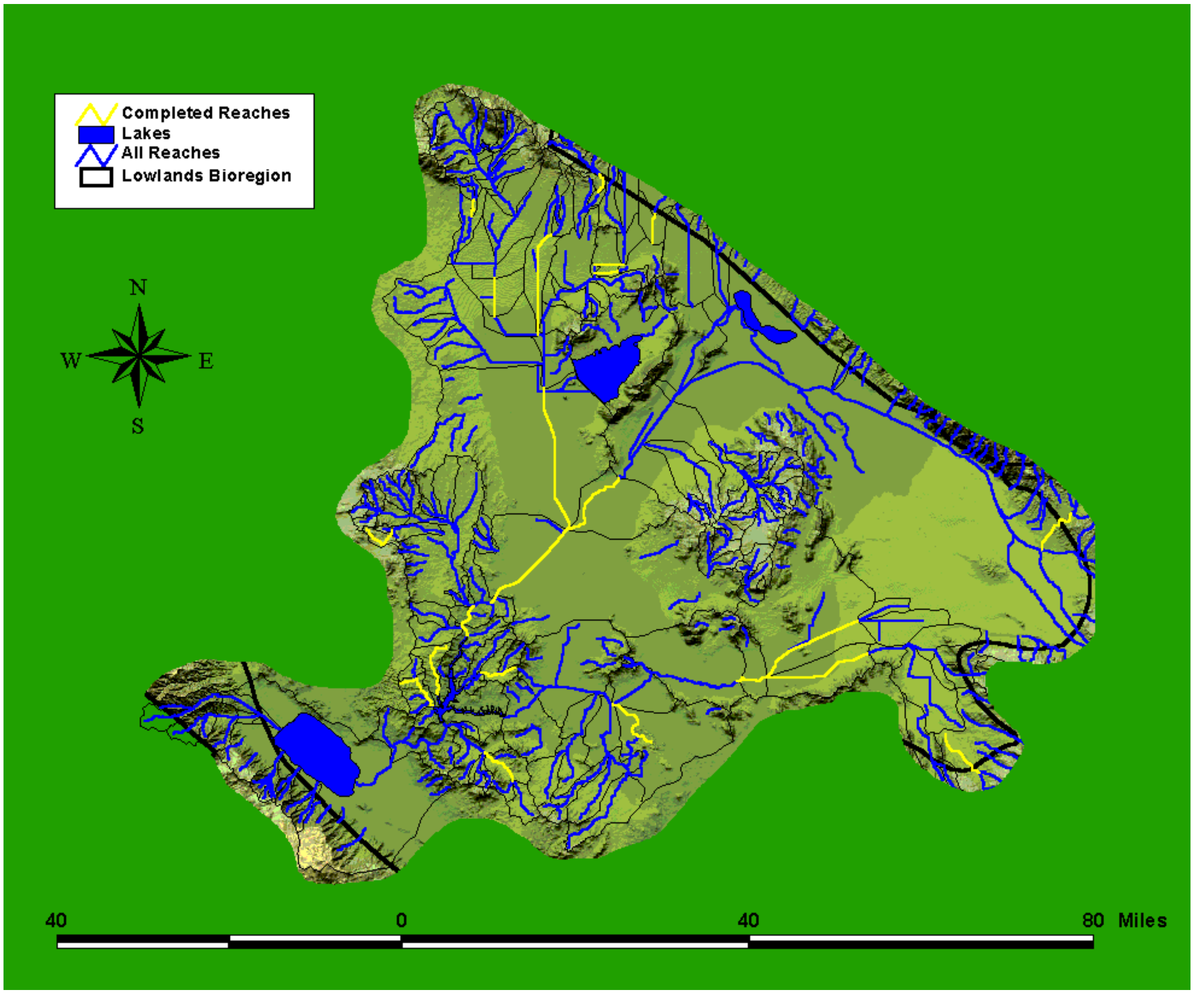


Figure 3. Distribution of sampled (yellow) and unsampled (blue) reaches within the Lowlands bioregion, San Jacinto River watershed, California.

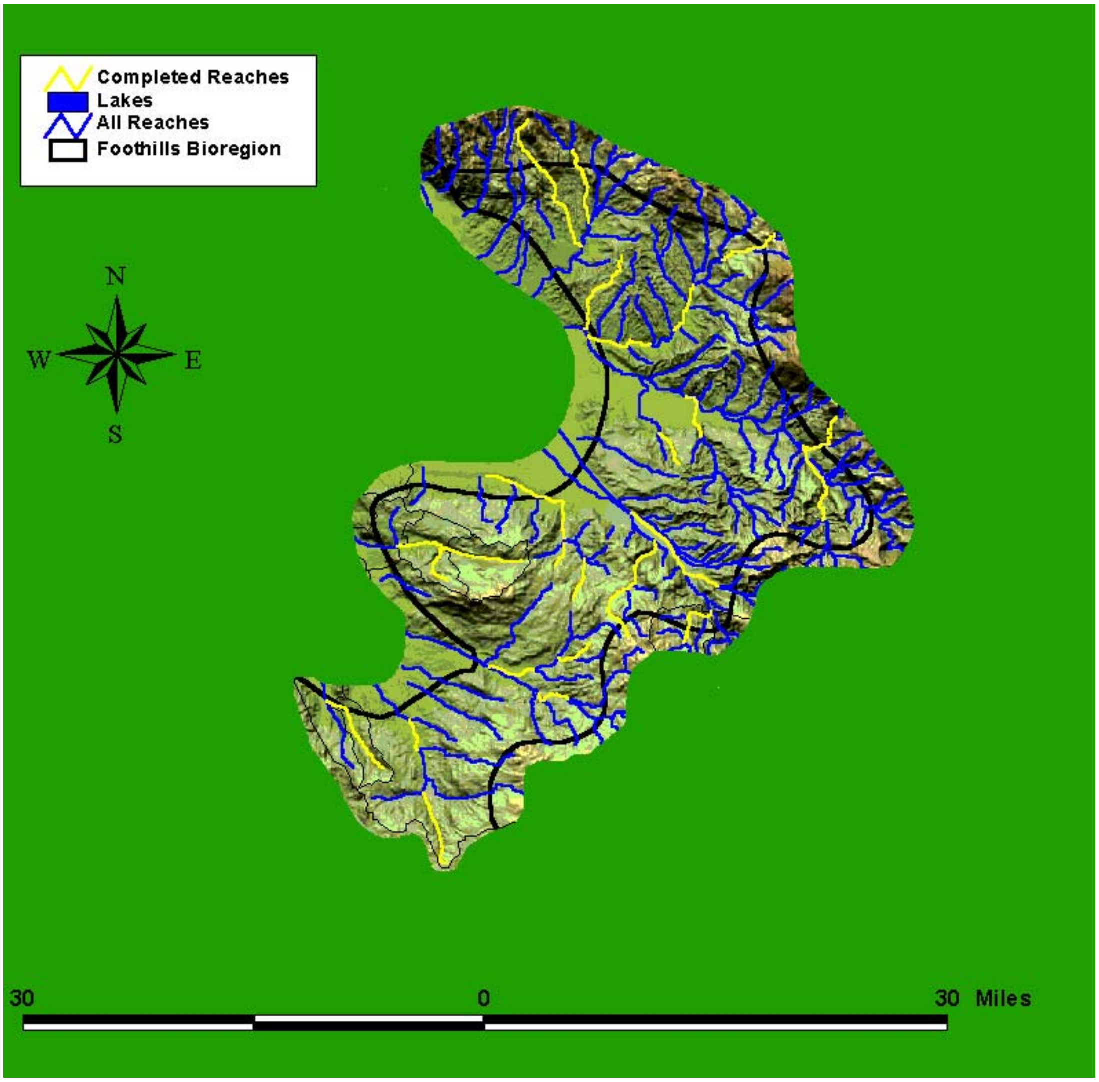


Figure 4. Distribution of sampled (yellow) and unsampled (blue) reaches within the Foothills bioregion, San Jacinto River watershed, California.

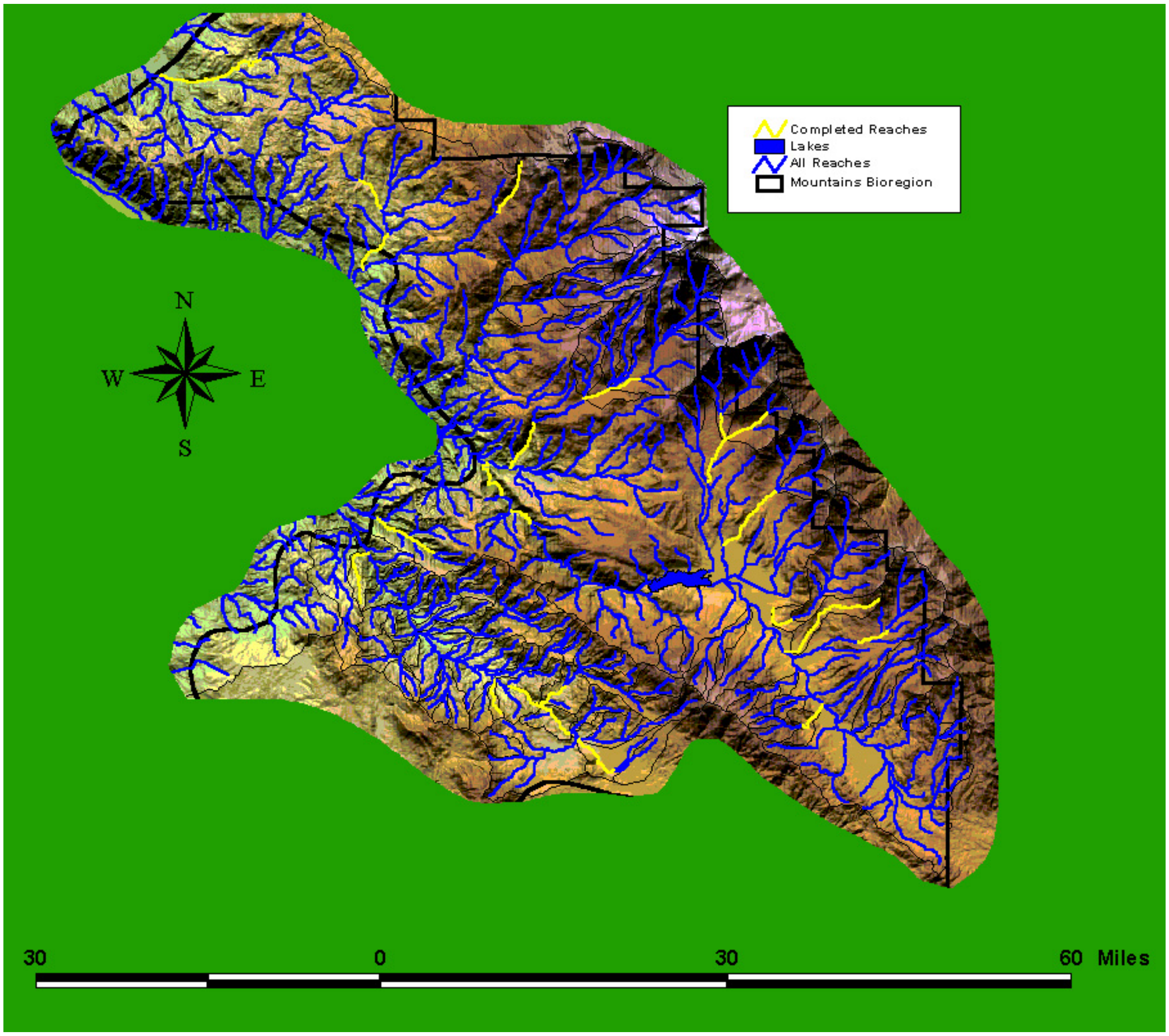


Figure 5. Distribution of sampled (yellow) and unsampled (blue) reaches within the Mountains bioregion, San Jacinto River watershed, California.

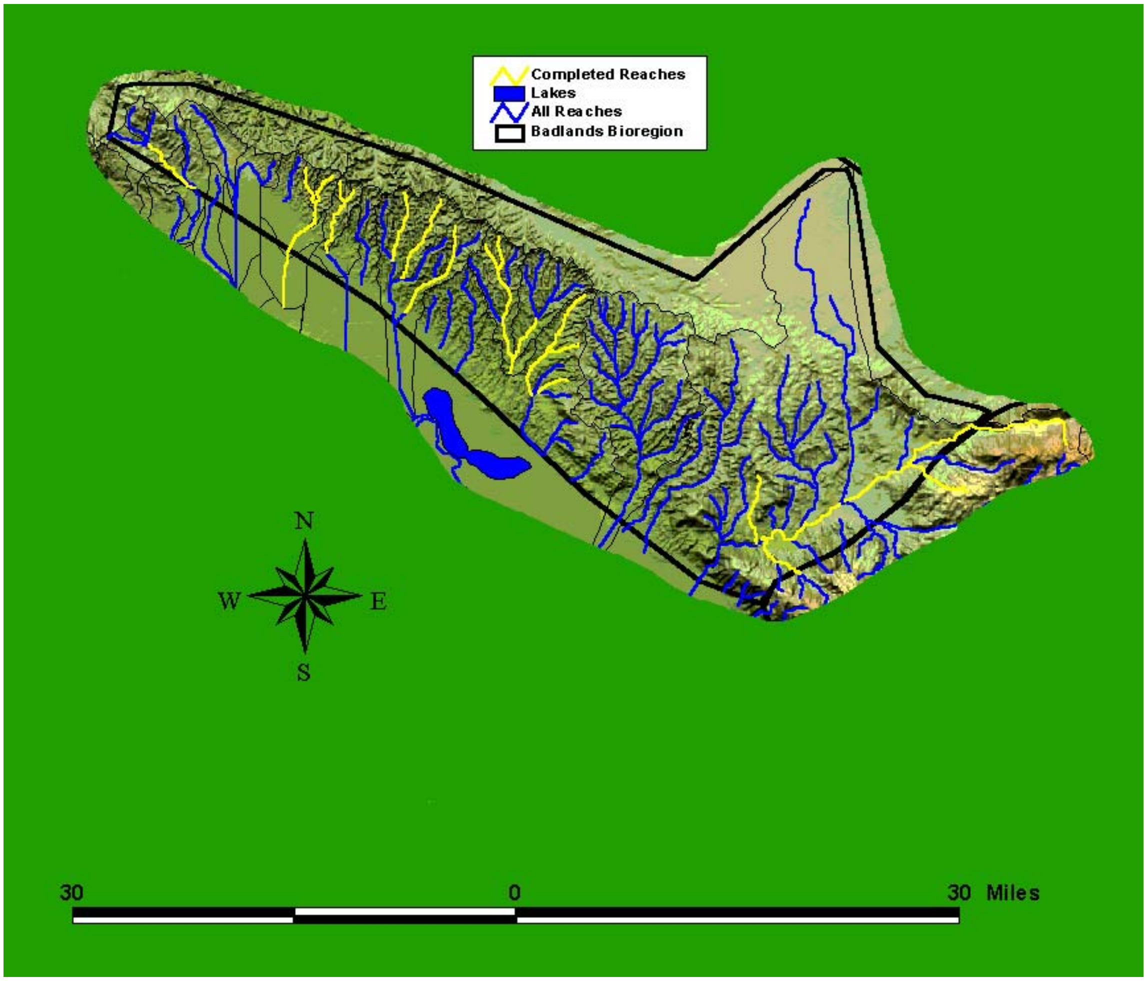


Figure 6. Distribution of sampled (yellow) and unsampled (blue) reaches within the Badlands bioregion, San Jacinto River watershed, California.

Figure 7. Reaches sampled within the Lowlands showed considerable variation, from highly agricultural areas (left) to small hills (right).

Figure 8. Reaches in the Foothills bioregion had generally steeper topography and were dominated by thickets of scrub oak and sage.

Foothills. Corresponds to the San Jacinto Foothills bioregion described in the RCIP/MSCHP (Riverside County 2002). This region ranges in elevation between 2,000 and 3,000 ft (Figure 4), and is characterized by overstory tree species including coast live oak (*Quercus agrifolia*), Fremont cottonwood (*Populus fremontii*), sycamore, and black willow. Understory vegetation is typically composed of mulefat, buckwheat (*Eriogonum fasciculatum*), scrub oak (*Q. dumosa*), and willows (Figure 8). This region receives occasional frost, but snow is rare.

Mountains. Corresponds to the San Jacinto Mountains bioregion described in the RCIP/MSCHP (Riverside County 2002). This bioregion is characterized by elevations exceeding 3,000 ft (Figure 5), with much more densely vegetated riparian communities (Figure 9), often supporting numerous evergreen trees including Jeffrey pine (*Pinus jeffreyi*), incense-cedar (*Calocedrus decurrens*), and canyon live oak (*Q. chrysolepsis*), plus broadleaved deciduous species including cottonwood, sycamore, and white alder (*Alnus rhombifolia*). Winters in this bioregion can be severe with considerable frost and snowfall.

Badlands. This bioregion was originally placed within the Riverside Lowlands bioregion (Riverside County 2002), but was separated for our study because of the higher elevations and the starkly contrasting vegetative communities (Figure 6). Unlike the Lowlands bioregion, little or no agriculture or urbanization exists within the Badlands. However, most reaches were highly disturbed by roads and frequent use by motorcycles and all terrain vehicles. This bioregion has elevations similar to the Foothills, but is much more arid and desert-like (Figure 10), with riparian vegetation comprised mainly of trees such as red and black willow, cottonwood, and sycamore, and understory species including mulefat, buckwheat, California sagebrush (*Artemesia californica*), and scale broom (*Lepidospartum squamatum*). This region rarely receives any frost or snow during the winter months.

Avian Community Sampling

Selection of Reaches. More than 600 riparian reaches and their local drainage areas were delineated previously as part of the indicator-based assessment of riparian ecosystems in the watershed (Smith 2002). Breeding bird communities were surveyed in a sample of these reaches. Reaches were selected at random from within each bioregion, with the constraint that the full range of human impacts to reaches had to be represented within the sample from each bioregion. The level of human disturbance was estimated by the percentage of land area in each reach's local drainage that consisted of urban, developed, or agricultural land uses. Detailed land-use coverages in ArcView® GIS format were provided by RBF Consulting, Inc., consultants to the RCIP. If we could not access a selected reach due to rough or inaccessible terrain, lack of landowner permission, or other logistical problems, another randomly chosen reach was substituted. We sampled a total of 102 reaches divided as follows among the bioregions: Lowlands (21), Foothills (29), Mountains (28), and Badlands (24) (Figures 3-6).

Figure 9. The Mountains bioregion was characterized by much higher elevation, steep slopes, and more densely vegetated riparian habitats, often supporting coniferous species, cottonwoods, and oaks.

Figure 10. The Badlands bioregion had elevations similar to the Foothills, yet was starkly more arid and desert-like. Habitat in this bioregion was characterized by sage scrub and dryland grasses.

Establishment of Sampling Points. Bird surveys and habitat measurements were made at 484 sampling stations established along the 102 stream reaches. Three to 5 sampling stations were established along each sampled reach depending upon reach length (Figure 11). The first station was established approximately 125 m from the downstream end of the reach, and subsequent stations were located upstream at approximately 250-m intervals. There were 95 sampling points in the Lowlands bioregion, 141 in the Foothills, 136 in the Mountains, and 112 in the Badlands. All sampling stations were marked with flagging and the position of each station was determined using a hand-held Garmin E-trex® GPS unit. Sampling locations were later entered into ArcView.

Point-count Surveys. Point-sampling methodology followed Hamel et al. (1996) (see Appendix A). All birds detected by sight or vocalization during a 5-min count were noted on a "bull's eye" field data form (see Appendix B). Bird surveys were conducted twice at all point-count sampling stations during the study, with the first round of surveys conducted from 20 March through 19 April, 2002, and a second round of surveys at each station conducted from 20 April through 29 May, 2002. Bird detections were recorded within 2 time categories (within 3 min and 5 min) and 3 distance categories ($\leq$25 m, $\leq$50 m, and >50 m from the observer). Bird surveys were conducted by 9 experienced birders (8 graduate students from UCR and 1 biologist from ERDC).

Habitat Sampling

During July 2002, sampling stations were revisited for collection of supplementary habitat data that might be used to refine the indicator-based riparian assessment (Smith 2002) in light of the IBI results. Habitat data collected at each station included channel width (bank to bank), riparian width (including the channel and riparian vegetation on both sides of the stream), stream gradient, and downstream compass bearing (Appendix C). The following data were estimated visually or measured (as noted) in the riparian zone within 50 m of the sampling point: height of the tallest riparian vegetation (clinometer), predominant height of the vegetation, diameter at breast height (dbh) of the largest riparian tree (diameter tape), and percent cover of woody vegetation, large trees (>20 ft tall), small trees (10-20 ft tall), shrubs (<10 ft tall), exotic trees, exotic shrubs, and rocks or logs. Finally, the coverage of the following land uses in a 100-m circle centered on the sampling point was estimated visually: agricultural crop or bare field, native or introduced grassland or herbs (including pasture), chaparral or shrubland, forest, urban/industrial/developed, and other. All percentages were recorded in one of the following cover classes: 0, trace (<1%), 1-5%, 5-25%, 25-50%, 50-75%, and 75-100%. Midpoints of cover classes were used in statistical analyses.

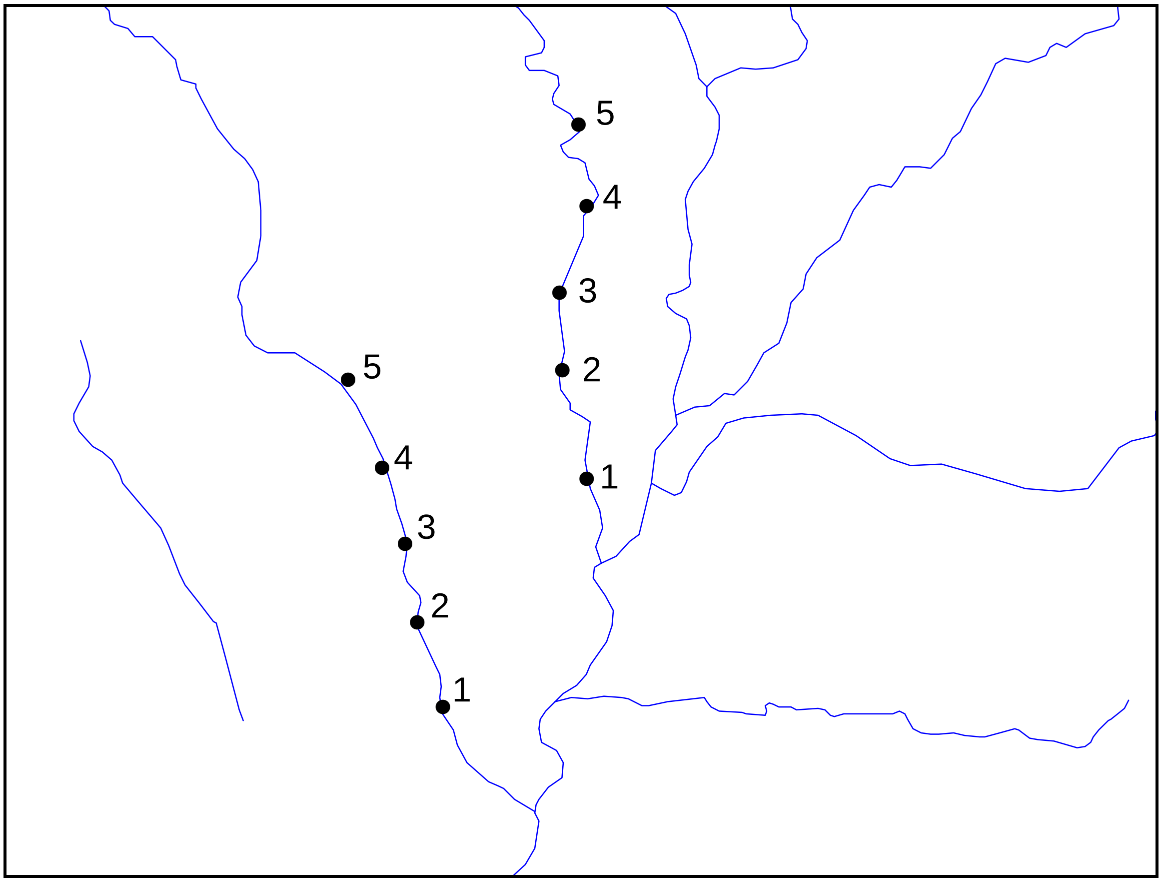


Figure 11. Example showing location of bird and habitat sampling points along reaches CASTILE-1 (left) and POPPET-T1A (right). Points are spaced approximately 250 m apart.

Bird Species Groupings for IBI Development

Previous studies involving development of IBIs for both aquatic and terrestrial systems (Karr and Chu 1999, Bryce et al. 2002) have shown that the most useful community metrics are those reflecting the species richness or relative abundance of animal guilds or other important groups. Therefore, it was necessary to identify appropriate groups and assign bird species to them.

We categorized bird species detected at sampling points by migratory status, predominant diet, foraging guild, conservation status, riparian dependence, native or exotic origin, and nest location (Table 1). Migratory status (e.g., Neotropical migrant, short-distance migrant, resident) was based on field guides and Birds of North America species accounts (Poole and Gill 2002). We followed DeGraaf and Rappole (1995) in classifying only those species that winter primarily south of the Tropic of Cancer as Neotropical migrants. We counted as residents those species whose breeding and wintering ranges overlapped in the study area even if considerable turnover of individuals may occur. We did not include nonbreeders or transients in subsequent analyses. Information on diets (e.g., insectivore, granivore, omnivore) and foraging guilds (e.g., aerial, bark, ground or low herbaceous plants, and woody canopies of shrubs and trees) was compiled from DeGraaf et al. (1985) and Ehrlich et al. (1988). We used our own judgment in resolving conflicts. The focus of this study was on riparian land birds; therefore, we did not include species listed as waterbirds (Table 1) in IBI development. We used Rich's (2002) classification of riparian obligates (i.e., species that place >90% of their nests or >90% of their abundance occurs in riparian areas; healthy riparian systems are required for their existence) and dependents (i.e., species that place 60-90% of their nests or 60-90% of their abundance is in riparian areas). Three species -- House Sparrow, European Starling, and Rock Dove (see Table 1 for scientific names of birds) -- were introduced to southern California. All other species were considered to be native. Nest locations (e.g., cavity, tree, shrub, ground) were based on Ehrlich (1988). We considered a bird species to be of conservation concern if it was (1) officially classified as threatened or endangered either at the Federal or State level, (2) recognized by the California Department of Fish and Game and the Point Reyes Bird Observatory (PRBO) as a Bird Species of Special Concern in California and included in priority lists 1, 2, or 3 (draft list dated 1 August 2002, http://www.prbo.org/BSSC/index.htm), or (3) classified in Tiers I or II of the Partners in Flight (PIF) priority system.

Table 1. Bird groups and guilds considered for IBI development. List includes all species detected during 2002 sampling in the San Jacinto watershed.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
Double-crested Cormorant	*Phalacrocorax auritus*	Resident	Piscivore	Water		Waterbird	Native	Ground
Black-crowned Night-Heron	*Nycticorax nycticorax*	Resident	Piscivore	Water		Waterbird	Native	Tree
Cattle Egret	*Bubulcus ibis*	Resident	Insectivore	Ground		Non-Dependent	Native	Tree
Snowy Egret	*Egretta thula*	Short Dist.	Crustaceavore	Water		Waterbird	Native	Tree
Great Egret	*Ardea alba*	Short Dist.	Carnivore	Water		Waterbird	Native	Tree
Great Blue Heron	*Ardea herodias*	Resident	Piscivore	Water		Waterbird	Native	Tree
Mallard	*Anas platyrhynchos*	Resident	Granivore	Water		Waterbird	Native	Ground
Turkey Vulture	*Cathartes aura*	Resident	Carnivore	Ground Scavenge		Non-Dependent	Native	Cavity
White-tailed Kite	*Elanus leucurus*	Resident	Carnivore	Ground Hawk		Non-Dependent	Native	Tree
Northern Harrier	*Circus cyaneus*	Resident	Carnivore	Ground Hawk	PRBO 2, PIF 2C	Non-Dependent	Native	Ground
Golden Eagle	*Aquila chrysaetos*	Resident	Carnivore	Ground Hawk		Non-Dependent	Native	Cliff
Bald Eagle	*Haliaeetus leucocephalus*	Nonbreed	Piscivore	Ground Hawk	SE, FT	Obligate	Native	Coniferous Tree
Sharp-shinned Hawk	*Accipiter striatus*	Resident	Carnivore	Air		Non-Dependent	Native	Coniferous Tree
Cooper's Hawk	*Accipiter cooperii*	Resident	Carnivore	Air		Dependent	Native	Tree
Red-shouldered Hawk	*Buteo lineatus*	Resident	Carnivore	Ground Hawk		Non-Dependent	Native	Tree
Red-tailed Hawk	*Buteo jamaicensis*	Resident	Carnivore	Ground Hawk		Non-Dependent	Native	Tree
American Kestrel	*Falco sparverius*	Resident	Insectivore	Ground Hawk	PIF 2A	Non-Dependent	Native	Cavity
Prairie Falcon	*Falco mexicanus*	Resident	Carnivore	Air	PRBO 3, PIF 1	Non-Dependent	Native	Cliff
California Quail	*Callipepla californica*	Resident	Granivore	Ground	PIF 2B	Non-Dependent	Native	Ground
Mountain Quail	*Oreortyx pictus*	Resident	Granivore	Ground	PIF 1	Non-Dependent	Native	Ground
American Coot	*Fulica americana*	Resident	Omnivore	Water		Waterbird	Native	Floating
Killdeer	*Charadrius vociferus*	Resident	Insectivore	Ground	PIF 2A	Non-Dependent	Native	Ground
American Avocet	*Recurvirostra americana*	Resident	Omnivore	Marsh	PIF 2C	Waterbird	Native	Ground
California Gull	*Larus californicus*	Short Dist.	Insectivore	Ground		Waterbird	Native	Ground
Western Gull	*Larus occidentalis*	Resident	Piscivore	Beach		Waterbird	Native	Cliff
Band-tailed Pigeon	*Columba fasciata*	Resident	Granivore	Canopy	PIF 1	Non-Dependent	Native	Ground
Rock Dove	*Columba livia*	Resident	Omnivore	Ground		Non-Dependent	Introduced	Cliff
Mourning Dove	*Zenaida macroura*	Resident	Granivore	Ground		Non-Dependent	Native	Tree
Greater Roadrunner	*Geococcyx californianus*	Resident	Insectivore	Ground		Non-Dependent	Native	Tree

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status	Riparian Use	Origin	Nest Location
Great Horned Owl	*Bubo virginianus*	Resident	Carnivore	Ground Hawk		Non-Dependent	Native	Tree
Burrowing Owl	*Athene cunicularia*	Resident	Carnivore	Ground Hawk	PRBO 1, PIF 2C	Non-Dependent	Native	Burrow
Black Swift	*Cypseloides niger*	Neotropical	Insectivore	Air	PIF 1	Obligate	Native	Cliff
Vaux's Swift	*Chaetura vauxi*	Transient	Insectivore	Air	PRBO 3	Non-Dependent	Native	Cavity
White-throated Swift	*Aeronautes saxatalis*	Resident	Insectivore	Air	PIF 2A	Non-Dependent	Native	Cliff
Black-chinned Hummingbird	*Archilochus alexandri*	Neotropical	Nectarivore	Flower	PIF 1	Dependent	Native	Tree
Costa's Hummingbird	*Calypte costae*	Resident	Nectarivore	Flower	PIF 1	Non-Dependent	Native	Shrub
Anna's Hummingbird	*Calypte anna*	Resident	Nectarivore	Flower	PIF 2B	Non-Dependent	Native	Tree
Allen's Hummingbird	*Selasphorus sasin*	Neotropical	Nectarivore	Flower	PIF 1	Non-Dependent	Native	Tree
Acorn Woodpecker	*Melanerpes formicivorus*	Resident	Omnivore	Canopy		Non-Dependent	Native	Cavity
White-headed Woodpecker	*Picoides albolarvatus*	Resident	Insectivore	Bark		Non-Dependent	Native	Cavity
Northern (Red-shafted) Flicker	*Colaptes auratus*	Resident	Insectivore	Ground		Non-Dependent	Native	Cavity
Ladder-backed Woodpecker	*Picoides scalaris*	Resident	Insectivore	Bark		Non-Dependent	Native	Cavity
Nuttall's Woodpecker	*Picoides nuttallii*	Resident	Insectivore	Bark	PIF 1	Non-Dependent	Native	Cavity
Downy Woodpecker	*Picoides pubescens*	Resident	Insectivore	Bark		Non-Dependent	Native	Cavity
Olive-sided Flycatcher	*Contopus cooperi*	Neotropical	Insectivore	Air	PRBO 2, PIF 2A	Non-Dependent	Native	Coniferous Tree
Western Wood-Pewee	*Contopus sordidulus*	Neotropical	Insectivore	Air	PIF 2A	Dependent	Native	Coniferous Tree
Willow Flycatcher (Southwestern)	*Empidonax traillii extimus*	Neotropical	Insectivore	Air	SE, FE	Obligate	Native	Shrub
Hammond's Flycatcher	*Empidonax hammondii*	Transient	Insectivore	Air		Non-Dependent	Native	Coniferous Tree
Gray Flycatcher	*Empidonax wrightii*	Transient	Insectivore	Air		Non-Dependent	Native	Shrub
Pacific-slope Flycatcher	*Empidonax difficilis*	Neotropical	Insectivore	Air	PIF 2B	Non-Dependent	Native	Cavity
Black Phoebe	*Sayornis nigricans*	Resident	Insectivore	Air	PIF 2B	Non-Dependent	Native	Cliff
Say's Phoebe	*Sayornis saya*	Resident	Insectivore	Air		Non-Dependent	Native	Cliff
Ash-throated Flycatcher	*Myiarchus cinerascens*	Neotropical	Insectivore	Canopy	PIF 2A	Non-Dependent	Native	Cavity
Western Kingbird	*Tyrannus verticalis*	Neotropical	Insectivore	Air		Non-Dependent	Native	Tree
Cassin's Kingbird	*Tyrannus vociferans*	Short Dist.	Insectivore	Air	PIF 2C	Non-Dependent	Native	Tree
Loggerhead Shrike	*Lanius ludovicianus*	Resident	Carnivore	Ground Hawk	PRBO 2, PIF 2A	Non-Dependent	Native	Tree
Bell's Vireo (Least)	*Vireo bellii pusillus*	Neotropical	Insectivore	Canopy	SE, FE	Dependent	Native	Shrub
Hutton's Vireo	*Vireo huttoni*	Resident	Insectivore	Canopy	PIF 1	Non-Dependent	Native	Tree
Warbling Vireo	*Vireo gilvus*	Neotropical	Insectivore	Canopy		Dependent	Native	Tree

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status	Riparian Use	Origin	Nest Location
Steller's Jay	*Cyanocitta stelleri*	Resident	Omnivore	Ground		Non-Dependent	Native	Coniferous Tree
Western Scrub-Jay	*Aphelocoma californica*	Resident	Omnivore	Ground	PIF 2B	Non-Dependent	Native	Tree
Pinyon Jay	*Gymnorhinus cyanocephalus*	Resident	Omnivore	Ground		Non-Dependent	Native	Coniferous Tree
American Crow	*Corvus brachyrhynchos*	Resident	Omnivore	Ground		Non-Dependent	Native	Tree
Common Raven	*Corvus corax*	Resident	Omnivore	Ground		Non-Dependent	Native	Cliff
Horned Lark	*Eremophila alpestris*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Violet-green Swallow	*Tachycineta thalassina*	Short Dist.	Insectivore	Air	PIF 2A	Non-Dependent	Native	Cavity
Bank Swallow	*Riparia riparia*	Neotropical	Insectivore	Air	ST	Obligate	Native	Bank
Cliff Swallow	*Petrochelidon pyrrhonota*	Neotropical	Insectivore	Air		Non-Dependent	Native	Cliff
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Neotropical	Insectivore	Air	PIF 2A	Non-Dependent	Native	Bank
Barn Swallow	*Hirundo rustica*	Neotropical	Insectivore	Air		Non-Dependent	Native	Cliff
Wrentit	*Chamaea fasciata*	Resident	Insectivore	Canopy	PIF 1	Non-Dependent	Native	Shrub
Oak Titmouse	*Baeolophus inornatus*	Resident	Omnivore	Canopy	PIF 1	Non-Dependent	Native	Cavity
Mountain Chickadee	*Poecile gambeli*	Resident	Insectivore	Canopy		Non-Dependent	Native	Cavity
Bushtit	*Psaltriparus minimus*	Resident	Insectivore	Canopy	PIF 2A	Non-Dependent	Native	Tree
White-breasted Nuthatch	*Sitta carolinensis*	Resident	Insectivore	Bark		Non-Dependent	Native	Cavity
Red-breasted Nuthatch	*Sitta canadensis*	Resident	Insectivore	Bark		Non-Dependent	Native	Cavity
Pygmy Nuthatch	*Sitta pygmaea*	Resident	Insectivore	Bark	PIF 2B	Non-Dependent	Native	Cavity
House Wren	*Troglodytes aedon*	Resident	Insectivore	Canopy		Dependent	Native	Cavity
Bewick's Wren	*Thryomanes bewickii*	Resident	Insectivore	Ground	PIF 2A	Dependent	Native	Cavity
Cactus Wren	*Campylorhynchus brunneicapillus*	Resident	Omnivore	Ground		Non-Dependent	Native	Cactus
Rock Wren	*Salpinctes obsoletus*	Resident	Insectivore	Ground		Non-Dependent	Native	Ground
Canyon Wren	*Catherpes mexicanus*	Resident	Insectivore	Ground	PIF 2B	Non-Dependent	Native	Cliff
Ruby-crowned Kinglet	*Regulus calendula*	Resident	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Blue-gray Gnatcatcher	*Polioptila caerulea*	Resident	Insectivore	Canopy		Non-Dependent	Native	Tree
California Gnatcatcher	*Polioptila californica*	Resident	Insectivore	Canopy	FT	Non-Dependent	Native	Shrub
Western Bluebird	*Sialia mexicana*	Resident	Insectivore	Ground Hawk	PIF 2B	Non-Dependent	Native	Cavity
Swainson's Thrush	*Catharus ustulatus*	Neotropical	Insectivore	Ground		Dependent	Native	Shrub
Hermit Thrush	*Catharus guttatus*	Resident	Insectivore	Ground		Non-Dependent	Native	Ground
American Robin	*Turdus migratorius*	Resident	Insectivore	Ground		Non-Dependent	Native	Tree

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status	Riparian Use	Origin	Nest Location
Northern Mockingbird	*Mimus polyglottos*	Resident	Omnivore	Ground		Non-Dependent	Native	Shrub
Sage Thrasher	*Oreoscoptes montanus*	Nonbreed	Insectivore	Ground		Non-Dependent	Native	Shrub
California Thrasher	*Toxostoma redivivum*	Resident	Omnivore	Ground	PIF 1	Non-Dependent	Native	Shrub
European Starling	*Sturnus vulgaris*	Resident	Omnivore	Ground		Non-Dependent	Introduced	Cavity
Cedar Waxwing	*Bombycilla cedrorum*	Nonbreed	Omnivore	Canopy		Non-Dependent	Native	Tree
Phainopepla	*Phainopepla nitens*	Resident	Frugivore	Canopy	PIF 2B	Dependent	Native	Tree
Orange-crowned Warbler	*Vermivora celata*	Resident	Insectivore	Canopy		Dependent	Native	Shrub
Nashville Warbler	*Vermivora ruficapilla*	Short Dist.	Insectivore	Canopy		Non-Dependent	Native	Ground
Yellow-rumped (Audubon's) Warbler	*Dendroica coronata*	Resident	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Black-throated Gray Warbler	*Dendroica nigrescens*	Neotropical	Insectivore	Canopy	PIF 2B	Non-Dependent	Native	Coniferous Tree
Townsend's Warbler	*Dendroica townsendi*	Nonbreed	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Yellow Warbler	*Dendroica petechia*	Neotropical	Insectivore	Canopy	PRBO 2	Obligate	Native	Shrub
MacGillivray's Warbler	*Oporornis tolmiei*	Neotropical	Insectivore	Canopy		Dependent	Native	Shrub
Wilson's Warbler	*Wilsonia pusilla*	Neotropical	Insectivore	Canopy		Obligate	Native	Ground
Common Yellowthroat	*Geothlypis trichas*	Resident	Insectivore	Canopy		Obligate	Native	Shrub
Yellow-breasted Chat	*Icteria virens*	Neotropical	Omnivore	Canopy	PRBO 3	Obligate	Native	Shrub
Western Tanager	*Piranga ludoviciana*	Neotropical	Omnivore	Canopy		Non-Dependent	Native	Coniferous Tree
California Towhee	*Pipilo crissalis*	Resident	Omnivore	Ground	PIF 2B	Non-Dependent	Native	Shrub
Spotted Towhee	*Pipilo maculatus*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Rufous-crowned Sparrow	*Aimophila ruficeps*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Chipping Sparrow	*Spizella passerina*	Resident	Omnivore	Ground		Non-Dependent	Native	Coniferous Tree
Brewer's Sparrow	*Spizella breweri*	Resident	Insectivore	Ground		Non-Dependent	Native	Shrub
Lark Sparrow	*Chondestes grammacus*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Black-chinned Sparrow	*Spizella atrogularis*	Short Dist.	Omnivore	Ground	PIF 1	Non-Dependent	Native	Shrub
Black-throated Sparrow	*Amphispiza bilineata*	Resident	Insectivore	Ground		Non-Dependent	Native	Shrub
Sage Sparrow	*Amphispiza belli*	Resident	Insectivore	Ground		Non-Dependent	Native	Shrub
Savannah Sparrow	*Passerculus sandwichensis*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Lincoln's Sparrow	*Melospiza lincolnii*	Resident	Omnivore	Ground		Obligate	Native	Ground
Song Sparrow	*Melospiza melodia*	Resident	Omnivore	Ground		Obligate	Native	Ground
White-crowned Sparrow	*Zonotrichia leucophrys*	Resident	Omnivore	Ground		Non-Dependent	Native	Shrub

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status	Riparian Use	Origin	Nest Location
Golden-crowned Sparrow	*Zonotrichia atricapilla*	Nonbreed	Omnivore	Ground		Non-Dependent	Native	Ground
Dark-eyed "Oregon" Junco	*Junco hyemalis thurberi*	Resident	Omnivore	Ground		Non-Dependent	Native	Ground
Black-headed Grosbeak	*Pheucticus melanocephalus*	Neotropical	Omnivore	Canopy	PIF 1	Dependent	Native	Tree
Blue Grosbeak	*Guiraca caerulea*	Neotropical	Omnivore	Ground		Obligate	Native	Shrub
Lazuli Bunting	*Passerina amoena*	Neotropical	Omnivore	Ground	PIF 1	Dependent	Native	Shrub
Western Meadowlark	*Sturnella neglecta*	Resident	Insectivore	Ground		Non-Dependent	Native	Ground
Red-winged Blackbird	*Agelaius phoeniceus*	Resident	Omnivore	Ground		Non-Dependent	Native	Reeds
Brewer's Blackbird	*Euphagus cyanocephalus*	Resident	Omnivore	Ground		Non-Dependent	Native	Coniferous Tree
Brown-headed Cowbird	*Molothrus ater*	Resident	Omnivore	Ground		Non-Dependent	Native	Tree
Hooded Oriole	*Icterus cucullatus*	Neotropical	Omnivore	Canopy	PIF 2B	Dependent	Native	Tree
Bullock's Oriole	*Icterus bullockii*	Neotropical	Omnivore	Canopy	PIF 1	Dependent	Native	Tree
Purple Finch	*Carpodacus purpureus*	Resident	Granivore	Canopy		Non-Dependent	Native	Coniferous Tree
Cassin's Finch	*Carpodacus cassinii*	Resident	Omnivore	Ground		Non-Dependent	Native	Coniferous Tree
House Finch	*Carpodacus mexicanus*	Resident	Granivore	Ground		Non-Dependent	Native	Tree
American Goldfinch	*Carduelis tristis*	Resident	Granivore	Ground		Dependent	Native	Shrub
Lesser Goldfinch	*Carduelis psaltria*	Resident	Granivore	Ground	PIF 2A	Dependent	Native	Tree
Lawrence's Goldfinch	*Carduelis lawrencei*	Resident	Granivore	Ground	PIF 1	Non-Dependent	Native	Tree
House Sparrow	*Passer domesticus*	Resident	Granivore	Ground		Non-Dependent	Introduced	Cavity

[1]F = Federal, S = State, E = Endangered, T = Threatened; PRBO Birds of Special Concern priority levels 1, 2, or 3; PIF Tiers 1 and 2 only.

PIF is a voluntary, international coalition of government agencies, conservation groups, academic institutions, private businesses, and everyday citizens dedicated to "keeping common birds common." PIF's goal is to direct resources toward the conservation of birds and their habitats through cooperative efforts in North America and the Neotropics. The foundation of PIF's bird conservation strategy is a series of Bird Conservation Plans. These plans identify species and habitats most in need of conservation, and establish objectives for the bird populations and habitats in physiographic areas (ecoregions) and states. The plans identify the general habitat requirements of priority species at the site level, and then identify the quantity and quality of habitat required by birds at the landscape scale. These plans are being drafted for each of the 58 physiographic regions in the conterminous United States. The San Jacinto watershed occurs within the Central and Southern California Coast and Valleys physiographic region (physiographic region #90) (Partners in Flight 2002) (Figure 1). The California PIF has written detailed bird conservation plans for the entire state based on habitat types. Bird conservation plans pertinent to the San Jacinto watershed include the California PIF Oak Woodland Bird Conservation Plan (Zack et al. 2002), the California PIF Coastal Scrub and Chaparral Bird Conservation Plan (Lovio et al. 2002), the California PIF Coniferous Forest Bird Conservation Plan (Robinson et al. 2002), and the California Riparian Bird Conservation Plan (Ballard et al. 2000).

A PIF Species Prioritization Scheme was developed to determine which species in each region are the most in need of conservation attention (Carter et al. 2000, Partners in Flight 2001). The scheme ranks each species of North American breeding bird by physiographic region based upon seven measures of conservation "vulnerability." The factors include (1) relative abundance (interspecific), (2) size of breeding range, (3) size of non-breeding range, (4) threats to the species on the breeding grounds, (5) threats to the species on the wintering grounds, (6) current known population trends, and (7) relative density (intraspecific) in a given planning unit compared to the maximum reached within its range. To highlight those species most warranting conservation attention in a given area, PIF generated a Priority Species Pool using various combinations of the vulnerability factors.

Tier IA. Extremely High Priority
Tier IB. High Priority
Tier IIA. High Regional Concern
Tier IIB. High Regional Responsibility.
Tier IIC. High Regional Threats.
Tier III. Additional Watch List Species
Tier IV. Additional Federally listed Species
Tier V. Additional Species of Local Management Interest

Species with relatively high overall scores are considered most in need of conservation attention (although they are often not endangered at present) and need at least to be carefully monitored throughout their ranges. Scores for PIF species are posted on the internet at http://www.rmbo.org/pif/pifdb.html under “Partners in Flight priority setting process” (Carter et al. 2000).

Data Handling and Analysis

All field data were entered into Microsoft Excel® spreadsheets and checked for accuracy. Most data handling and analysis was accomplished with Statistical Analysis System (SAS) software (SAS Institute, Inc. 1988). Differences in mean counts for species groups (Neotropical migrants, short-distance migrants, resident species, and all species) and for selected species between first and second visits to sampling points were tested using t-tests. Analysis of variance (ANOVA) and Tukey’s Multiple-Range Test were used to determine differences in mean counts for species groups and selected individual species, and mean species richness for species groups, among the four bioregions. Data on eight individual species were selected for closer study and illustration. These consisted of two Neotropical migrants (Ash-throated Flycatcher and Bullock’s Oriole), and six residents (White-crowned Sparrow, Yellow-rumped [Audubon’s] Warbler, Spotted Towhee, House Finch, Wrentit, and Bushtit), each with at least 40 detections recorded (Burnham et al. 1980).

Development of the IBI involved calculating 65 potential bird-community metrics for each riparian reach and evaluating each metric’s relationship to the level of human disturbance in the reach (Karr and Chu 1999). Any metric having a strong empirical relationship with human activity was a potentially useful component of the IBI. Bird metrics included the total species richness and total number of individual birds detected in each reach. In addition, for each bird guild or group (e.g., granivores) (Table 1), three different metrics were calculated for each reach: (1) species richness (i.e., number of species of guild members), (2) percent richness (i.e., number of species of guild members / total number of species detected in the reach x 100), and (3) percent abundance of individuals (i.e., number of individual birds in that guild detected / total number of birds counted in the reach x 100). These three metrics were calculated for each of the following groups or guilds: Neotropical migrants, short-distance migrants, all migrants, residents, insectivores, frugivores, granivores, omnivores, granivores and omnivores combined, ground foragers (not counting ground hawkers), bark foragers, aerial foragers, canopy foragers (in trees and shrubs combined), species of conservation concern, riparian obligates, riparian obligates and dependents combined, native species, exotic (introduced) species, cavity nesters, ground nesters, and nesters in trees or shrubs combined.

Individual metrics were evaluated first by calculating the Pearson correlation coefficient between the metric and an index to human disturbance of each reach. The index to human disturbance was estimated as the mean of two percentages: (1) the percentage of land area in the reach’s local drainage that was in agricultural, urban, or developed land uses according to the land-use coverage in the GIS and (2) the average percentage of the area within 100-m radius circular plots around each sampling point that was in agricultural or developed land uses according to on-site sampling in July 2002. Therefore, the disturbance score was based on a combination of landscape-scale and immediate streamside land use.

Any bird-community metric that was significantly ($P < 0.05$) correlated with the reach disturbance index was evaluated further by plotting the value of the metric versus the disturbance index across all sampled reaches in a bioregion or in the entire watershed. These "ecological dose-response curves" reflect measured biological response to the cumulative effects of human use of the landscape (Karr and Chu 1999). Metrics showing strong responses and good separation between relatively undisturbed and highly disturbed reaches were potential components of the IBI. Final selection was made after checking to see that none of the identified metrics was highly correlated ($|r| > 0.80$) with another selected metric.

Dose-response curves for each selected metric were then examined again to divide the metric into intervals that would be given a numeric score of 1, 3, or 5, where 1 indicated the disturbed or impacted condition, 5 represented the relatively pristine or undisturbed condition, and 3 was intermediate. This step put all metrics on a common scoring basis despite differences in original measurement units (Karr and Chu 1999). Scoring was based on natural breaks in the plots. In addition, historical or pre-settlement characteristics of bird communities in the watershed were also considered in assigning the top score to each metric. For example, historical bird communities did not contain introduced species (House Sparrow, European Starling, Rock Dove), but probably did contain some species now rare or extirpated in southern California. The final IBI was the sum of scores for the selected metrics and reflected the difference between existing and historical bird communities.

Results

During the 2002 breeding season, we detected more than 11,500 birds of 137 identified species in riparian habitats in the San Jacinto River watershed. There were 33 species of Neotropical migrants, 7 short-distance migrants, 5 Nearctic migrants, and 93 year-round residents (Table 2). During the first visit to each sampling point, we counted 5,458 birds of 121 species, including 25 Neotropical migrants, 7 short-distance migrants, 4 Nearctic migrants, and 85 resident species (Table 3). During the second visit to the sampling points, we detected 6,101 birds of 122 species, with 27 Neotropical migrants, 6 short-distance migrants, 3 Nearctic migrants, and 86 resident species (Table 4).

Mean counts of Nearctic migrants, short-distance migrants, and resident species did not differ significantly between the two visits; however, higher mean counts were observed for Neotropical migrants and total number of birds during the second round of visits (Figure 12). Several Neotropical species, including the Ash-throated Flycatcher and Bullock's Oriole, had higher mean counts during the second round of surveys (Figure 13). No significant differences in mean counts were observed for most resident species, including House Finch, Wrentit, and Bushtit; however, higher mean counts were observed for the Audubon's Warbler and White-crowned Sparrow during the first visits to the points, while the Spotted Towhee had significantly higher mean counts during the second round of surveys (Figure 13).

As a group, neither Neotropical nor Nearctic migrant species showed any significant differences in mean counts among the bioregions. However, higher mean counts for short-distance migrants were observed in the Lowlands and Mountains bioregions (Figure 14). Higher mean counts for resident species and total species were observed in the Lowlands and Foothills bioregions (Figure 15). Differences in mean counts among bioregions were observed for most species tested (Figure 16). Four species (Spotted Towhee, Wrentit, Bushtit, and Ash-throated Flycatcher) had higher mean counts in the Foothills and Mountains, while 2 species (House Finch and White-crowned Sparrow) had higher mean counts in the Lowlands, Foothills, and Badlands. Bullock's Oriole had higher mean counts in the Foothills, while Audubon's Warbler showed no differences among bioregions (Figure 16). Neither Neotropical nor Nearctic migrants exhibited any significant difference in mean species richness per reach among the bioregions; however, higher mean species richness for short-distance migrants was observed in the Mountains bioregion (Figure 17). Both resident and total species had higher mean species richness in the Foothills and Mountains bioregions and lower species richness in the Badlands (Figure 18).

Thirty-four PIF Priority species were detected during point-count surveys in the San Jacinto watershed (Table 5). Highest total counts and numbers of priority species were observed in the Foothills and the Mountain bioregions, while the Lowlands had the fewest priority species and the lowest counts (Table 5). Of the four PIF-designated habitat types within the watershed, highest total counts of priority species were observed in the Coastal Scrub / Chaparral and the Oak Woodlands. The most common priority

Table 2. Total number of detections by species and number of points at which each species was detected during spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, March-May 2002

Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
House Finch	681	213	Lawrence's Goldfinch	16	9
Brewer's Blackbird	665	72	*Nashville Warbler*	16	9
Mourning Dove	644	302	Sage Sparrow	16	9
Spotted Towhee	636	308	Say's Phoebe	16	14
Lesser Goldfinch	581	237	Band-tailed Pigeon	13	9
California Towhee	515	264	**Hutton's Vireo**	13	9
American Crow	502	157	**Western Wood-pewee**	13	11
European Starling	468	99	*Cassin's Kingbird*	11	8
Common Raven	427	152	**Hooded Oriole**	11	7
Wrentit	409	209	**Common Yellowthroat**	10	9
Bewick's Wren	347	213	Turkey Vulture	10	7
Scrub Jay	336	172	Lincoln's Sparrow	9	4
Bushtit	329	148	American Robin	8	5
House Wren	266	126	**Empidonax** spp.	8	6
House Sparrow	244	44	Ladder-backed Woodpecker	8	8
Western Meadowlark	241	88	Red-breasted Nuthatch	8	6
White-crowned Sparrow	214	71	Cooper's Hawk	7	6
Anna's Hummingbird	186	129	Great Blue Heron	7	7
Oak Titmouse	184	107	<u>Townsend's Warbler</u>	7	7
California Quail	175	73	**Black-chinned Hummingbird**	6	5
Northern Mockingbird	156	98	Hermit Thrush	6	5
Rock Dove	143	28	**Olive-sided Flycatcher**	6	6
Acorn Woodpecker	142	55	American Coot	5	1
Song Sparrow	140	84	**Gray Flycatcher ***	5	4
Ash-throated Flycatcher[1]	123	93	Northern Harrier	5	5
Black-headed Grosbeak	100	65	Sharp-shinned Hawk	5	5
Costa's Hummingbird	98	85	Cassin's Finch	4	3
Stellar's Jay	98	41	Great-horned Owl	4	3
Brown-headed Cowbird	95	58	**Lazuli Bunting**	4	4
Cliff Swallow	95	17	Red-shouldered Hawk	4	3
Red-winged Blackbird	94	36	<u>Sage Thrasher</u>	4	3
Bullock's Oriole	88	51	Savannah Sparrow	4	2
Red-tailed Hawk	85	66	**Blue Grosbeak**	3	2
California Thrasher	83	67	Cattle Egret	3	3
Mallard	80	27	California Gnatcatcher	3	2
Lark Sparrow	77	44	Greater Roadrunner	3	3
Black-chinned Sparrow	76	49	Snowy Egret	3	2
Red-shafted Flicker	74	53	**Swainson's Thrush**	3	3
Nuttall's Woodpecker	72	54	White-headed Woodpecker	3	2
Audubon's Warbler	70	36	American Avocet	2	1
Violet-green Swallow	70	15	Black-throated Sparrow	2	2
Mountain Chickadee	65	40	Burrowing Owl	2	2
Northern Rough-winged Swallow	64	28	Cactus Wren	2	1
Pygmy Nuthatch	57	25	Downy Woodpecker	2	2
Wilson's Warbler	54	43	Purple Finch	2	2
Double-crested Cormorant	50	1	Western Gull	2	2
Pinyon Jay	50	7	<u>Bald Eagle</u>	2	1
Loggerhead Shrike	46	28	Black-crowned Night-heron	1	1
Pacific-slope Flycatcher	45	34	**Bell's Vireo**	1	1
Rock Wren	45	29	**Black Swift**	1	1
Black Phoebe	39	35	Brewer's Sparrow	1	1
American Kestrel	38	32	*California Gull*	1	1
<u>Cedar Waxwing</u>	38	3	<u>Golden-crowned Sparrow</u>	1	1
Great Egret	37	13	Golden Eagle	1	1
Rufous-crowned Sparrow	36	26	**Hammond's Flycatcher ***	1	1

Table 2. Total number of detections by species and number of points at which each species was detected during spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, March-May 2002					
Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
Killdeer	30	21	**MacGillivray's Warbler**	1	1
Western Kingbird	29	23	Prairie Falcon	1	1
Barn Swallow	28	7	**Vaux's Swift ***	1	1
Mountain Quail	28	18	**Willow Flycatcher**	1	1
White-breasted Nuthatch	27	15	White-tailed Kite	1	1
Chipping Sparrow	26	7	**Yellow-breasted Chat**	1	1
Horned Lark	25	15			
Oregon Junco	25	17			
White-throated Swift	25	7			
Ruby-crowned Kinglet	24	22	**Total**	11,559	
Bank Swallow	23	5			
Western Tanager	23	16			
Phainopepla	21	12			
Western Bluebird	21	13			
American Goldfinch	20	13			
Black-throated Gray Warbler	20	13			
Allen's Hummingbird	19	12			
Orange-crowned Warbler	19	15			
Canyon Wren	18	14			
Yellow Warbler	18	16			
Blue-gray Gnatcatcher	17	13			
Warbling Vireo	17	15			

[1]Neotropical migrants are denoted in **bold**; short-distance migrants are in *italics*; and Nearctic migrants are underlined.
* Transient (non-breeder on the study area) Neotropical migrant species.

Table 3. Number of detections by species and number of points at which each species was detected during the first visit of early spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, March to mid-April 2002.

Early Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
House Finch	337	126	White-breasted Nuthatch	10	8
Brewer's Blackbird	303	31	Lincoln's Sparrow	9	4
Mourning Dove	266	167	*Nashville Warbler*	9	5
Spotted Towhee	266	184	**Western Kingbird**	9	2
Lesser Goldfinch	256	103	Sage Sparrow	8	5
American Crow	244	107	Say's Phoebe	8	7
European Starling	236	66	**Wilson's Warbler**	8	8
White-crowned Sparrow	211	70	Turkey Vulture	7	5
California Towhee	205	147	American Robin	6	3
Bewick's Wren	187	151	Great Blue Heron	6	6
Wrentit	186	122	Lawrence's Goldfinch	6	2
Common Raven	181	88	Phainopepla	6	4
Scrub Jay	166	105	American Coot	5	1
Bushtit	141	82	Cooper's Hawk	5	4
Western Meadowlark	128	68	**Gray Flycatcher** *	5	4
House Wren	127	84	Red-breasted Nuthatch	5	4
Oat Titmouse	112	78	**Empidonax** spp.	4	3
Anna's Hummingbird	89	78	**Hooded Oriole**	4	2
House Sparrow	85	28	Ladder-backed Woodpecker	4	4
California Quail	80	33	Northern Harrier	4	4
Acorn Woodpecker	74	33	Savannah Sparrow	4	2
Audubon's Warbler	70	36	**Black-chinned Hummingbird**	3	3
Northern Mockingbird	68	59	*Cassin's Kingbird*	3	3
Song Sparrow	65	45	Chipping Sparrow	3	2
Stellar's Jay	65	33	Common Yellowthroat	3	3
Red-winged Blackbird	59	21	Hermit Thrush	3	3
California Thrasher	55	46	Horned Lark	3	3
Rock Dove	55	10	**Hutton's Vireo**	3	2
Double-crested Cormorant	50	1	Sage Thrasher	3	2
Mountain Chickadee	44	31	Sharp-shinned Hawk	3	3
Pinyon Jay	41	7	Townsend's Warbler	3	3
Violet-green Swallow[1]	41	11	**Warbling Vireo**	3	3
Mallard	39	16	Band-tailed Pigeon	2	2
Cedar Waxwing	38	3	Cassin's Finch	2	1
Lark Sparrow	37	22	Great-horned Owl	2	6
Red-shafted Flicker	37	29	Western Gull	2	2
Red-tailed Hawk	37	32	**Western Tanager**	2	2
Great Egret	33	9	**Western Wood-pewee**	2	2
Nuttall's Woodpecker	33	30	Bald Eagle	1	1
Pygmy Nuthatch	30	15	**Bell's Vireo**	1	1
Ash-throated Flycatcher	28	24	Brewer's Sparrow	1	1
Brown-headed Cowbird	28	16	Cactus Wren	1	1
Black Phoebe	25	23	Cattle Egret	1	1
Rock Wren	25	18	California Gnatcatcher	1	1
Mountain Quail	24	16	*California Gull*	1	1
Ruby-crowned Kinglet	24	22	Golden Eagle	1	1
Bank Swallow	23	5	Greater Roadrunner	1	1
Costa's Hummingbird	23	19	**Lazuli Bunting**	1	1
Black-chinned Sparrow	22	17	**Olive-sided Flycatcher**	1	1
Bullock's Oriole	22	12	Red-shouldered Hawk	1	1
Barn Swallow	21	4	*Snowy Egret*	1	1
Oregon Junco	21	14	**Swainson's Thrush**	1	1
American Kestrel	20	19	White-headed Woodpecker	1	1
Pacific-slope Flycatcher	19	17	**Yellow-breasted Chat**	1	1

Table 3. Number of detections by species and number of points at which each species was detected during the first visit of early spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, March to mid-April 2002.

Early Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
Rufous-crowned Sparrow	19	13	**Yellow Warbler**	1	1
Northern Rough-winged Swallow	18	8			
Cliff Swallow	17	6	**Total**	5,458	
Loggerhead Shrike	17	14			
Allen's Hummingbird	16	9			
American Goldfinch	15	8			
Black-headed Grosbeak	15	10			
Killdeer	14	9			
Western Bluebird	14	9			
Black-throated Gray Warbler	12	6			
Blue-gray Gnatcatcher	11	9			
Canyon Wren	11	10			
Orange-crowned Warbler	11	9			

[1]Neotropical migrants are denoted in **bold**; short-distance migrants are in *italics*; and Nearctic migrants are <u>underlined</u>.
* Transient (non-breeder on the study area) Neotropical migrant species.

Table 4. Number of detections by species and number of points at which each species was detected during the second visit of spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, mid-April to late May 2002.

Late Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
Mourning Dove	378	235	***Barn Swallow***	7	4
Spotted Towhee	370	251	*Canyon Wren*	7	6
Brewer's Blackbird	362	54	**Common Yellowthroat**	7	6
House Finch	344	151	***Hooded Oriole***	7	5
Lesser Goldfinch	325	194	Nashville Warbler	7	4
California Towhee	310	197	*Western Bluebird*	7	6
American Crow	258	104	*Blue-gray Gnatcatcher*	6	4
Common Raven	246	99	American Goldfinch	5	5
European Starling	232	62	***Olive-sided Flycatcher***	5	5
Wrentit	223	159	**Empidonax** spp.	4	4
Bushtit	188	95	*Great Egret*	4	4
Scrub Jay	170	118	Ladder-backed Woodpecker	4	4
Bewick's Wren	160	125	Mountain Quail	4	4
House Sparrow	159	33	Oregon Junco	4	4
House Wren	139	90	*Townsend's Warbler*	4	4
Western Meadowlark	113	63	Allen's Hummingbird	3	3
Anna's Hummingbird	97	71	***Black-chinned Hummingbird***	3	2
Ash-throated Flycatcher[1]	95	78	***Blue Grosbeak***	3	2
California Quail	95	50	Hermit Thrush	3	2
Northern Mockingbird	88	67	***Lazuli Bunting***	3	3
Rock Dove	88	20	*Red-breasted Nuthatch*	3	2
Black-headed Grosbeak	85	58	*Red-shouldered Hawk*	3	2
Cliff Swallow	78	11	*Turkey Vulture*	3	2
Costa's Hummingbird	75	68	White-crowned Sparrow	3	3
Song Sparrow	75	56	*American Avocet*	2	1
Oak Titmouse	72	51	American Robin	2	2
Acorn Woodpecker	68	41	Black-throated Sparrow	2	2
Brown-headed Cowbird	67	46	Burrowing Owl	2	2
Bullock's Oriole	66	44	*Cattle Egret*	2	2
Black-chinned Sparrow	54	35	Cassin's Finch	2	2
Red-tailed Hawk	48	42	California Gnatcatcher	2	1
Northern Rough-winged Swallow	46	23	Cooper's Hawk	2	2
Wilson's Warbler	46	35	Downy Woodpecker	2	2
Mallard	41	16	Great-horned Owl	2	2
Lark Sparrow	40	26	Greater Roadrunner	2	2
Nuttall's Woodpecker	39	34	Purple Finch	2	2
Red-shafted Flicker	37	30	Snowy Egret	2	1
Red-winged Blackbird	35	18	Sharp-shinned Hawk	2	2
Stellar's Jay	33	23	***Swainson's Thrush***	2	2
Loggerhead Shrike	29	19	White-headed Woodpecker	2	1
Violet-green Swallow	29	6	Black-crowned Night-heron	1	1
California Thrasher	28	24	***Black Swift***	1	1
Pygmy Nuthatch	27	17	Cactus Wren	1	1
Pacific-slope Flycatcher	26	24	California Gull	1	1
White-throated Swift	25	7	Golden-crowned Sparrow	1	1
Chipping Sparrow	23	6	Great Blue Heron	1	1
Horned Lark	22	12	**Hammond's Flycatcher** *	1	1
Mountain Chickadee	21	18	MacGillivray's Warbler	1	1
Western Tanager	21	14	*Northern Harrier*	1	1
Rock Wren	20	16	Prairie Falcon	1	1
Western Kingbird	20	16	*Sage Thrasher*	1	1
American Kestrel	18	14	Vaux's Swift*	1	1
Rufous-crowned Sparrow	17	13	***Willow Flycatcher***	1	1
White-breasted Nuthatch	17	11	*White-tailed Kite*	1	1

Table 4. Number of detections by species and number of points at which each species was detected during the second visit of spring point-count surveys in riparian habitats, San Jacinto River watershed, CA, mid-April to late May 2002.

Late Spring 2002					
Species	# Detected	# Points	Species	# Detected	# Points
Yellow Warbler	17	15			
Killdeer	16	13			
Phainopepla	15	8			
Black Phoebe	14	13	**Total**	6,101	
Warbling Vireo	14	12			
Band-tailed Pigeon	11	7			
Western Wood-pewee	11	10			
Hutton's Vireo	10	8			
Lawrence's Goldfinch	10	7			
Pinyon Jay	9	3			
Black-throated Gray Warbler	8	7			
Cassin's Kingbird	8	5			
Orange-crowned Warbler	8	6			
Sage Sparrow	8	4			
Say's Phoebe	8	8			

[1]Neotropical migrants are denoted in **bold**; short-distance migrants are in *italics*; and Nearctic migrants are underlined.
* Transient (non-breeder on the study area) Neotropical migrant species.

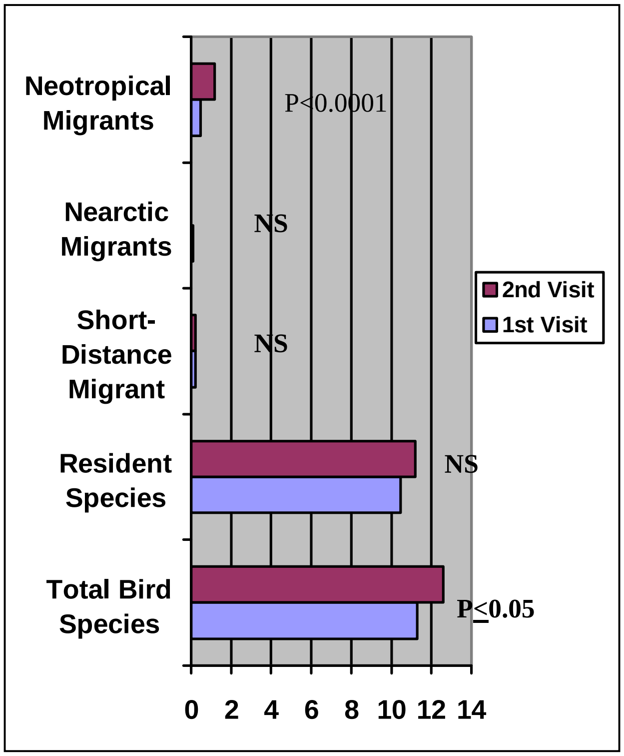


Figure 12. Comparisons (t-tests) of mean counts per reach for species groups between the two visits to each sampling station during spring bird surveys in the San Jacinto watershed, 2002**.**

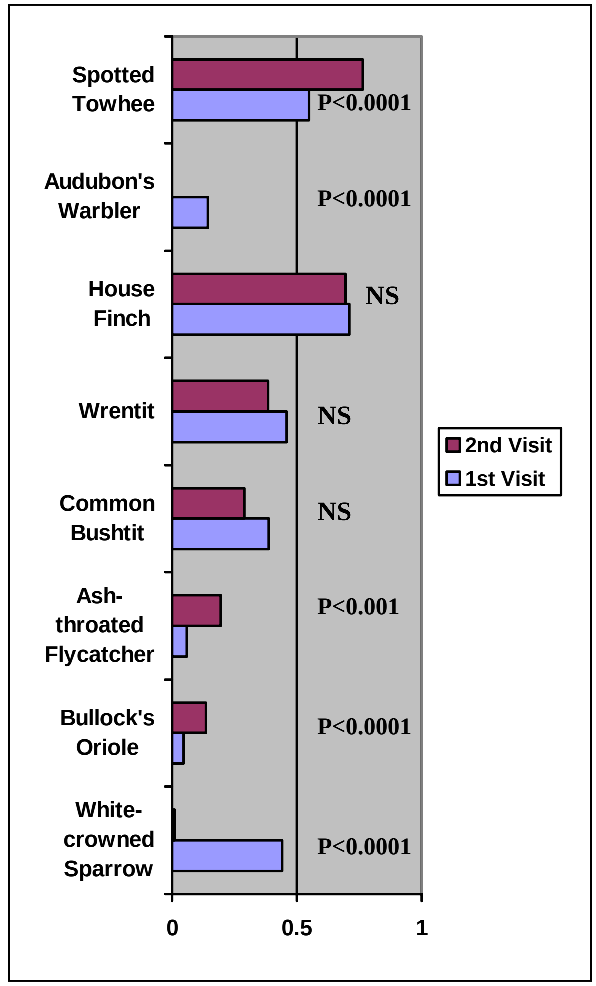


Figure 13. Comparisons of mean counts per reach for selected species between the two visits to each sampling station during spring bird surveys in the San Jacinto watershed, 2002**.**

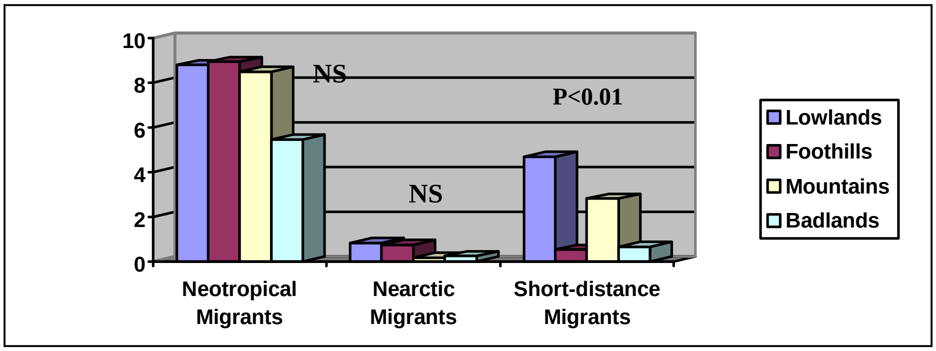


Figure 14. ANOVA on mean counts per reach for Neotropical, Nearctic, and short-distance migrant species groups among the four bioregions during spring bird surveys in the San Jacinto watershed, 2002**.**

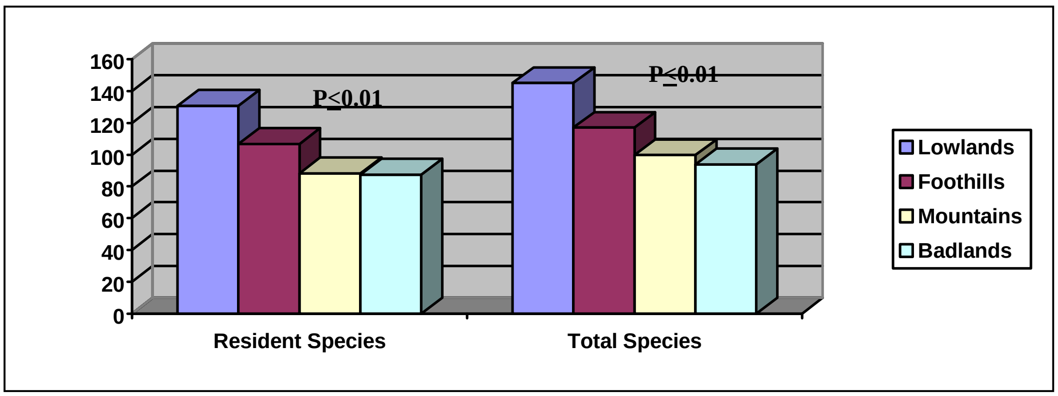


Figure 15. ANOVA on mean counts per reach for resident and total species groups among the four bioregions during spring bird surveys in the San Jacinto watershed, 2002.

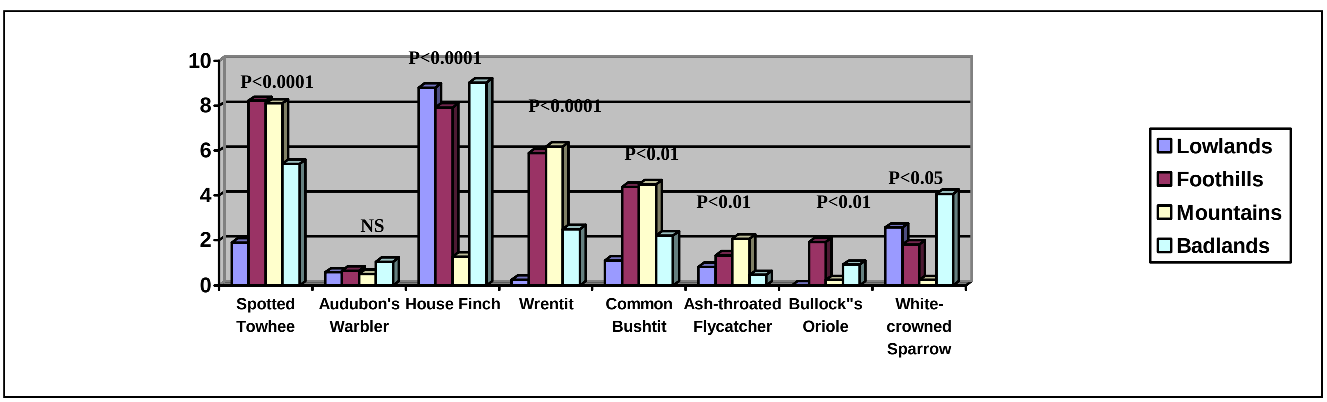


Figure 16. ANOVA on mean counts per reach for selected species among the four bioregions during spring bird surveys in the San Jacinto watershed, 2002**.**

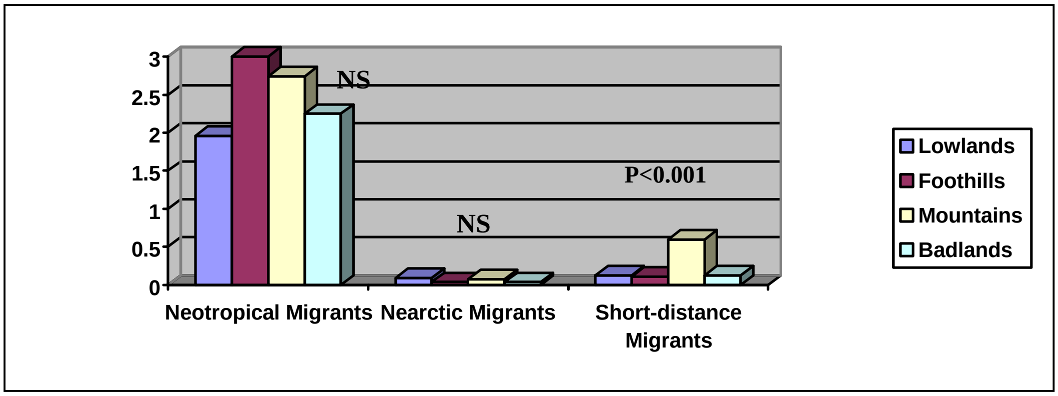


Figure 17. ANOVA on mean species richness per reach for species groups among the four bioregions during spring bird surveys in the San Jacinto watershed, 2002**.**

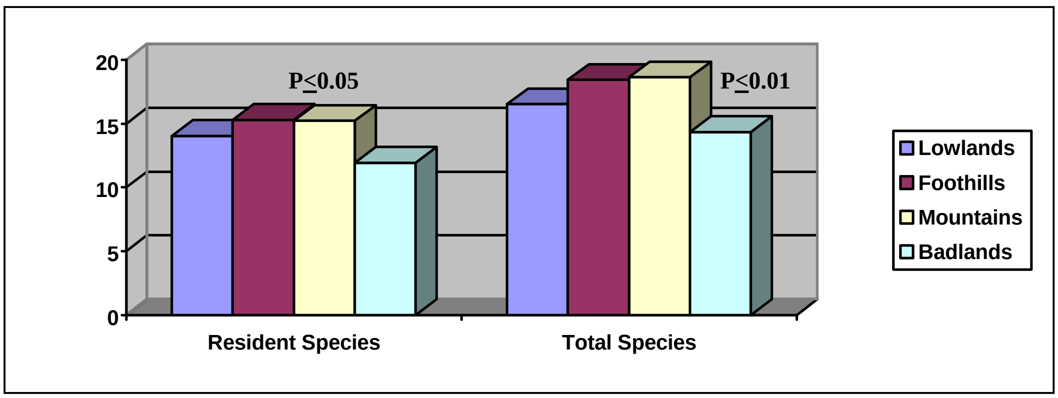


Figure 18. ANOVA on mean species richness per reach for resident species and total species groups among the four bioregions during spring bird surveys in the San Jacinto watershed, 2002.

Table 5. Distribution among bioregions and habitat types of Partners in Flight Priority species detected during spring surveys in the San Jacinto River watershed, California, 2002.

PIF California Habitat Type	PIF Priority Species	Lowlands	Foothills	Mountains	Badlands	Total Counts
Riparian	Bank Swallow	23	0	0	0	371
	Bell's Vireo	0	1	0	0	
	Black-headed Grosbeak	6	40	44	10	
	Blue Grosbeak	3	0	0	0	
	Common Yellowthroat	5	2	2	1	
	Song Sparrow	44	52	37	7	
	Swainson's Thrush	0	1	2	0	
	Warbling Vireo	1	8	7	1	
	Willow Flycatcher	0	0	0	1	
	Wilson's Warbler	8	15	15	16	
	Yellow-breasted Chat	0	0	0	1	
	Yellow Warbler	2	7	5	4	
Coastal Scrub / Chaparral	Black-chinned Sparrow	0	38	38	0	643
	Cactus Wren	0	2	0	0	
	California Gnatcatcher	3	0	0	0	
	Costa's Hummingbird	14	24	18	42	
	Greater Roadrunner	1	2	0	0	
	Rufous-crowned Sparrow	3	17	4	12	
	Sage Sparrow	8	3	0	5	
	Wrentit	5	183	161	60	
Oak Woodland	Acorn Woodpecker	2	51	89	0	849
	Blue-gray Gnatcatcher	0	6	8	3	
	Lark Sparrow	4	15	3	55	
	Nuttall's Woodpecker	12	31	27	2	
	Oak Titmouse	5	72	101	6	
	Western Bluebird	0	0	20	1	
	Western Scrub Jay	11	188	123	14	
Coniferous Forest	Black-throated Gray Warbler	0	4	10	6	83
	Oregon Junco	0	1	17	7	
	MacGillivray's Warbler	0	0	0	1	
	Olive-sided Flycatcher	0	0	6	0	
	Red-breasted Nuthatch	0	0	8	0	
	Vaux's Swift	0	1	0	0	
	Western Tanager	1	11	8	2	
Total counts		161	775	753	257	1,946
Total number of species		20	25	23	22	34

species were the Wrentit and the Western Scrub Jay, both common in the Foothills and the Mountain bioregions within the Chaparral and Oak Woodland habitat types. Other relatively common priority species include the Oak Titmouse, Song Sparrow, Nuttall's Woodpecker, Acorn Woodpecker, and the Black-headed Grosbeak (Table 5).

IBI Development

To calculate bird community metrics for each reach, we first summed bird counts made during the first and second visits to each sampling point. Therefore, the bird data used in IBI development accounted for both early and later breeders. Reaches differed in the number of points sampled due to different reach lengths and the difficulty of accessing portions of some reaches. Eighty-three sampled reaches contained 5 points each, 12 reaches had 4 points, and 7 reaches had 3 points. Because certain bird-community metrics depended on the cumulative area sampled (e.g., overall and guild species richness) (Rosenzweig 1995), it was necessary to standardize bird counts across reaches by using equal numbers of samples per reach. To determine the appropriate number of sampling points per reach, we calculated the average number of species detected in each reach using data from the first point in each reach, the first two points, the first three points, and so forth (Table 6). This analysis indicated that the number of species detected increased with number of sampling points. Species were still being accumulated with a fifth sampling point but, judging by the overlapping confidence intervals, the increase in number of species counted after the fourth point was not significant. Therefore, four points appeared to be sufficient to account for most species present in a reach. Based on this analysis, IBI development was based on the 95 reaches for which we had at least four sampling points per reach, and data from a fifth point were not used.

Table 6. Effect of number of sampling points on the number of bird species detected in each riparian reach (n = 83).

Number of Sampling Points	Mean Number of Species / Reach	95% Confidence Interval
1	10.25	9.60 - 10.91
2	15.10	14.17 - 16.03
3	17.71	16.61 - 18.81
4	20.55	19.27 - 21.84
5	22.48	21.11 - 23.85

Correlation coefficients between bird metrics and the disturbance index were calculated for individual bioregions, combinations of bioregions, and for the entire watershed. In general, the highest correlations were found in the Lowlands bioregion, Badlands bioregion, and Lowlands and Badlands combined (maximum $|r| = 0.78$, 0.73, and 0.81, respectively), where bird communities and habitats were fairly similar and where sampled reaches represented a wide range of human disturbance from nearly undisturbed to highly impacted. In the Foothills bioregion, Mountains bioregion, and Foothills and Mountains combined, maximum correlation coefficients were $|r| = 0.60$, 0.46, and 0.60, respectively. These reaches were more similar to each other in bird communities and habitats than they were to either the Lowlands or Badlands. Furthermore, there were fewer highly impacted reaches in the Foothills and Mountains and, therefore, samples tended to be clustered at one end of the disturbance gradient and correlation coefficients as a result were low. For IBI development, we decided to focus on the combined Lowlands and Badlands area. The resulting bird IBI was then applied to the Foothills and Mountains area and checked for logic and reliability. Analysis of variance (PROC GLM; SAS Institute, Inc. 1988) was used to check for differences in the relationship between bird IBI values and disturbance scores across bioregions. One advantage of the IBI approach is that it is based on community-level metrics rather than individual species. Therefore, a given IBI formulation is more likely to be applicable across a wide area despite internal variations in species composition of bird communities.

Twenty five of the 65 potential bird-community metrics were significantly correlated ($P < 0.05$) with the disturbance score in the combined Lowlands and Badlands bioregions (Table 7). In general, reaches with higher disturbance scores had fewer (or lower percentages of) species of conservation concern, tree and shrub nesters, canopy foragers, insectivores, riparian obligates and dependents, and cavity nesters. On the other hand, highly disturbed reaches had more (or larger percentages of) exotic species, granivores, omnivores, and ground foragers. Dose-response curves (Figure 19) were plotted for all 28 significant metrics and used to make a final selection for the bird IBI. Those selected did not necessarily have the highest correlation coefficients but gave the best separation of disturbed and undisturbed reaches. For each bird guild or group, only one metric was chosen for the final IBI (e.g., for bird species of conservation concern, percent richness was chosen but not percent abundance or overall richness), and care was taken to avoid high correlations ($|r| > 0.80$) among the final metrics.

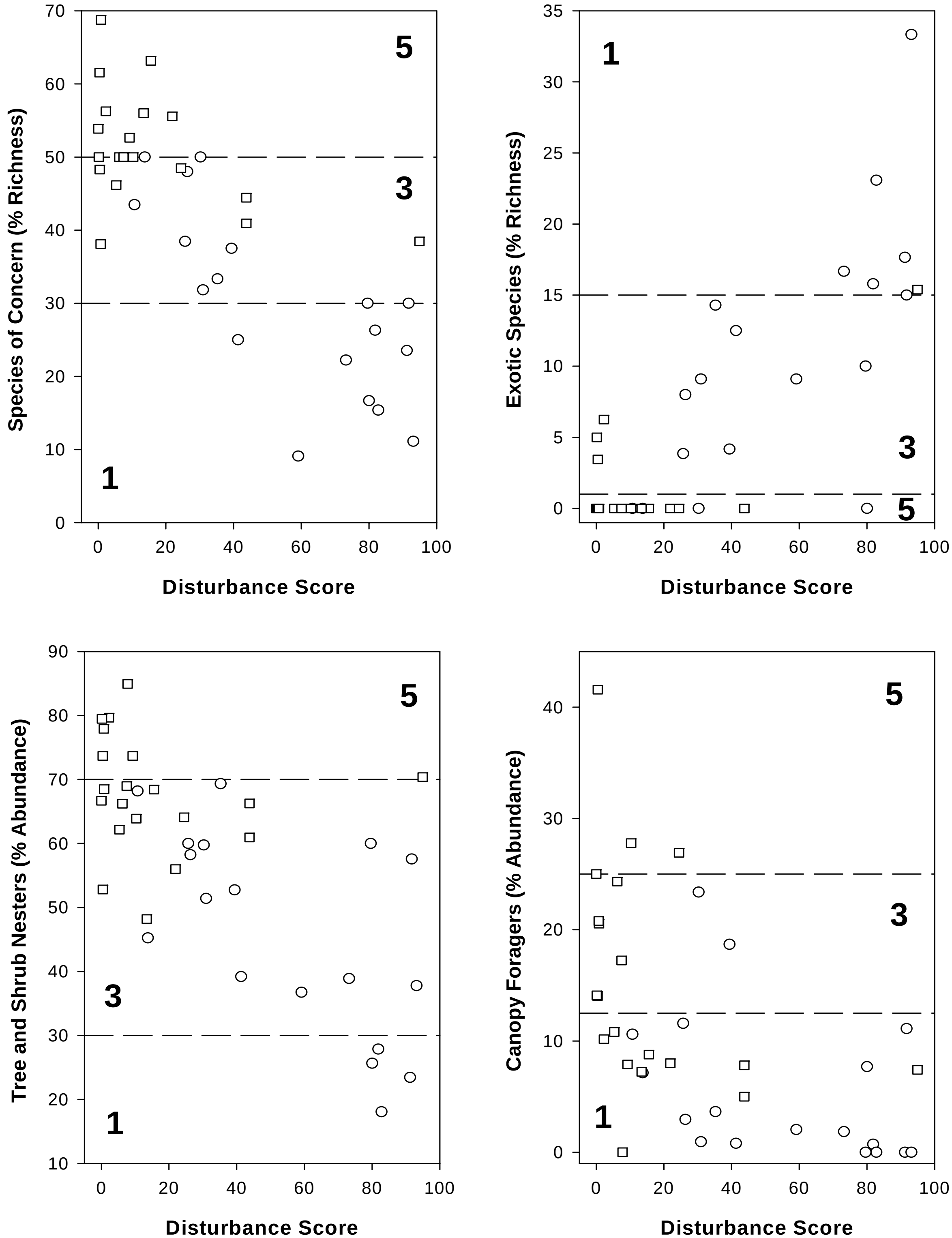
The final bird-community IBI consisted of seven metrics reflecting native species richness, the percentage of total species richness that consisted of exotic species, species of concern, ground foragers, and native cavity nesters, and the percentage of total bird abundance that consisted of tree and shrub nesters and canopy foragers (Table 7). Each metric was divided into three intervals that were assigned scores of 1, 3, or 5 (Table 8 and Figure 19). Metric scores for each reach were then summed to calculate IBI (Table 9). For an IBI consisting of seven metrics, the possible range of IBI scores was 7 to 35. Sampled reaches in the Lowlands and Badlands scored from 7 to 29. None of the sampled reaches achieved the maximum IBI score, indicating that bird communities in all reaches in the Lowlands and Badlands were impacted by human activity to some degree.

A plot of the bird IBI versus the reach disturbance score (Figure 20) showed excellent discrimination between highly disturbed and relatively undisturbed stream reaches in the combined Lowlands and Badlands regions. The correlation coefficient was $r = -0.84$, and there was complete separation between relatively impacted (disturbance score > 80, IBI <18) and unimpacted (disturbance score < 20, IBI > 20) reaches. Many of the Badlands reaches were less disturbed and had higher biological integrity than those in the Lowlands, where a greater proportion of the land has been converted to agricultural and developed uses, with predictable effects on riparian ecosystems.

Table 7. Correlation coefficients, listed in decreasing order of absolute value, between bird-community metrics and the disturbance score for Lowlands and Badlands reaches (n = 38).

Bird Metric	Correlation (*r*)	*P*
Species of concern (% richness)[1]	-0.81	<0.0001
Exotic species (% richness)	0.77	<0.0001
Native species (% richness)	-0.77	<0.0001
Species of concern (% abundance)	-0.74	<0.0001
Exotic species (% abundance)	0.72	<0.0001
Native species (% abundance)	-0.72	<0.0001
Exotic species richness	0.71	<0.0001
Tree/shrub nesters (% abundance)	-0.67	<0.0001
Species of concern richness	-0.67	<0.0001
Tree/shrub nesters (% richness)	-0.58	0.0001
Canopy foragers (% abundance)	-0.56	0.0003
Granivores and omnivores (% richness)	0.55	0.0004
Ground foragers (% richness)	0.51	0.0012
Tree/shrub nester richness	-0.50	0.0012
Canopy foragers (% richness)	-0.47	0.0028
Native cavity nesters (% richness)	-0.42	0.0092
Native species richness	-0.42	0.0094
Canopy forager richness	-0.41	0.0101
Ground foragers (% abundance)	0.41	0.0107
Native cavity nesters (% abundance)	-0.41	0.0109
Insectivores (% richness)	-0.41	0.0113
Granivores (% richness)	0.39	0.0156
Riparian obligates and dependents (% abundance)	-0.38	0.0189
Insectivore richness	-0.35	0.0299
Native cavity nester richness	-0.34	0.0344

[1]Metrics in bold type were selected for the final IBI.


Species of Concern (% Richness)
Disturbance Score
5
3
1
Exotic Species (% Richness)
Disturbance Score
1
3
5
Tree and Shrub Nesters (% Abundance)
Disturbance Score
5
3
1
Canopy Foragers (% Abundance)
Disturbance Score
5
3
1

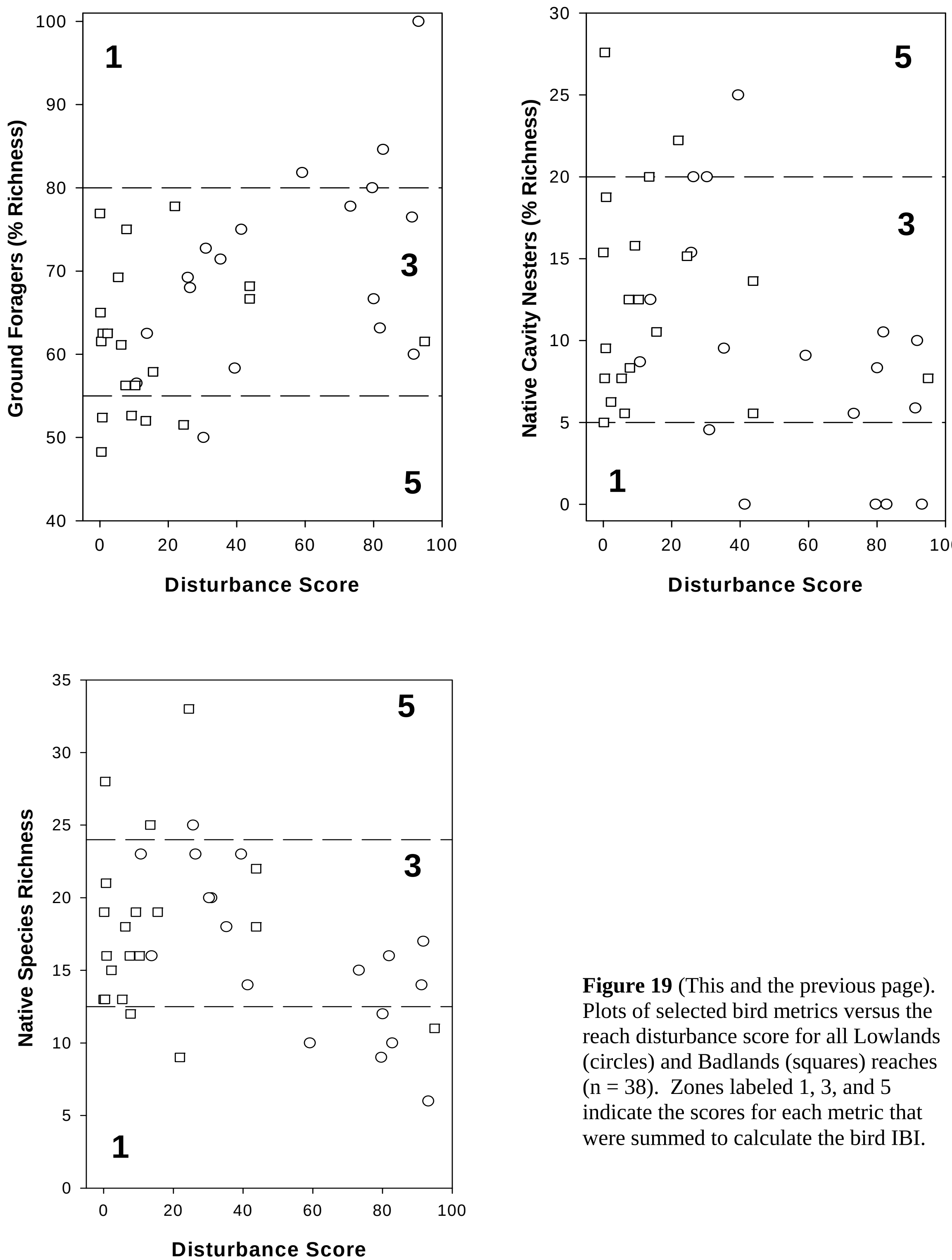


Figure 19 (This and the previous page). Plots of selected bird metrics versus the reach disturbance score for all Lowlands (circles) and Badlands (squares) reaches (n = 38). Zones labeled 1, 3, and 5 indicate the scores for each metric that were summed to calculate the bird IBI.

Table 8. Scoring criteria for metrics selected as part of the bird IBI.

Metric	**Assigned Score**		
	1	**3**	**5**
Species of concern (% richness)	<30%	Intermediate	≥50%
Exotic species (% richness)	>15%	Intermediate	= 0%
Tree/shrub nesters (% abundance)	<30%	Intermediate	≥70%
Canopy foragers (% abundance)	<12.5%	Intermediate	≥25%
Ground foragers (% richness)	≥80%	Intermediate	<55%
Native cavity nesters (% richness)	<5%	Intermediate	≥20%
Native species richness	<13 species	Intermediate	≥24 species

Table 9. Measured bird-community metrics, metric scores, reach disturbance scores, and calculated bird IBIs for sampled riparian reaches in the San Jacinto River watershed.

Reach Identifier	Bioregion	Disturbance Score	Species of Concern (% Richness)		Exotic Species (% Richness)		Tree/Shrub Nesters (% Abundance)		Canopy Foragers (% Abundance)		Ground Foragers (% Richness)		Cavity Nesters (% Richness)		Native Species Richness		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
STJOHNS-T1A	Foothills	7.7	62.5	5	0.0	5	68.3	3	32.7	5	50.0	5	25.0	5	24	5	33
BLKBRN-4	Mountains	0.0	61.9	5	0.0	5	71.9	5	51.6	5	42.9	5	23.8	5	21	3	33
HIXON-1	Mountains	0.0	62.5	5	0.0	5	63.8	3	31.3	5	45.8	5	29.2	5	24	5	33
INDIAN-8	Mountains	1.1	52.0	5	0.0	5	35.8	3	37.0	5	52.0	5	40.0	5	25	5	33
LION-1	Mountains	0.0	54.2	5	0.0	5	35.2	3	34.1	5	45.8	5	37.5	5	24	5	33
MELLOR-T1B	Mountains	0.0	77.8	5	0.0	5	70.1	5	51.9	5	44.4	5	22.2	5	18	3	33
SFSJ-4	Mountains	0.0	64.5	5	0.0	5	51.5	3	42.6	5	45.2	5	22.6	5	31	5	33
AVERY-4	Foothills	2.4	60.0	5	3.3	3	53.4	3	34.0	5	46.7	5	23.3	5	29	5	31
CHOLLA-3	Foothills	0.5	60.0	5	0.0	5	49.4	3	53.2	5	40.0	5	20.0	5	15	3	31
FAIRVIEW-T1B	Foothills	1.4	60.0	5	0.0	5	60.9	3	43.5	5	53.3	5	26.7	5	15	3	31
WASHBURN-1	Foothills	79.0	52.0	5	4.0	3	76.7	5	26.2	5	56.0	3	24.0	5	24	5	31
BAUCK-12	Mountains	0.0	66.7	5	0.0	5	41.0	3	41.0	5	44.4	5	33.3	5	18	3	31
BLKBRN-3	Mountains	0.0	62.5	5	0.0	5	74.0	5	54.5	5	50.0	5	12.5	3	16	3	31
HERKEY-3	Mountains	1.6	54.5	5	0.0	5	39.4	3	46.5	5	36.4	5	40.9	5	22	3	31
HERKEY-2	Mountains	0.2	50.0	5	0.0	5	51.1	3	44.4	5	40.9	5	40.9	5	22	3	31
MELLOR-1	Mountains	0.0	60.0	5	0.0	5	77.9	5	37.7	5	45.0	5	15.0	3	20	3	31
MORRIS-3	Mountains	2.2	41.7	3	0.0	5	51.5	3	41.2	5	45.8	5	33.3	5	24	5	31
SFSJ-3	Mountains	0.4	48.1	3	0.0	5	42.1	3	33.7	5	51.9	5	29.6	5	27	5	31
STRAWBERRY-1	Mountains	1.4	59.1	5	0.0	5	63.2	3	59.6	5	45.5	5	31.8	5	22	3	31
BALA8-2	Badlands	13.4	56.0	5	0.0	5	48.2	3	7.2	1	52.0	5	20.0	5	25	5	29
POTRERO-6	Badlands	0.5	48.3	3	3.4	3	52.8	3	41.6	5	48.3	5	27.6	5	28	5	29
POTRERO-5	Badlands	24.5	48.5	3	0.0	5	64.1	3	26.9	5	51.5	5	15.2	3	33	5	29
BLKBRN-1	Foothills	22.1	70.6	5	0.0	5	74.4	5	32.1	5	58.8	3	11.8	3	17	3	29
BROWN-T2A	Foothills	0.4	72.2	5	0.0	5	48.3	3	31.0	5	55.6	3	27.8	5	18	3	29
FAIRVIEW-4	Foothills	0.0	57.1	5	0.0	5	64.5	3	43.5	5	57.1	3	28.6	5	14	3	29
INDIAN-2	Foothills	0.8	46.7	3	3.3	3	41.6	3	37.0	5	50.0	5	26.7	5	29	5	29

Table 9. Cont.

Reach Identifier	Bioregion	Disturbance Score	Species of Concern (% Richness)		Exotic Species (% Richness)		Tree/Shrub Nesters (% Abundance)		Canopy Foragers (% Abundance)		Ground Foragers (% Richness)		Cavity Nesters (% Richness)		Native Species Richness		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
SFSJ-1	Foothills	0.1	54.2	5	4.2	3	45.5	3	42.9	5	50.0	5	29.2	5	23	3	29
SJMS-04	Lowlands	30.2	50.0	5	0.0	5	59.7	3	23.4	3	50.0	5	20.0	5	20	3	29
APPLECYN-2	Mountains	1.9	54.5	5	4.5	3	49.3	3	29.9	5	54.5	5	31.8	5	21	3	29
BAUCK-11	Mountains	0.0	52.4	5	0.0	5	57.1	3	37.1	5	57.1	3	33.3	5	21	3	29
BAUCK-T7A	Mountains	0.4	80.0	5	0.0	5	54.8	3	48.4	5	50.0	5	20.0	5	10	1	29
HERKEY-T2B	Mountains	0.0	35.3	3	0.0	5	38.9	3	42.6	5	41.2	5	47.1	5	17	3	29
HERKEY-T2A	Mountains	0.0	43.3	3	3.3	3	32.7	3	29.8	5	43.3	5	36.7	5	29	5	29
THOMAS-1	Mountains	0.0	48.1	3	0.0	5	63.6	3	20.8	3	48.1	5	29.6	5	27	5	29
BALA2-T1A	Badlands	0.0	53.8	5	0.0	5	66.7	3	25.0	5	76.9	3	15.4	3	13	3	27
BALA5-4	Badlands	0.4	61.5	5	0.0	5	73.7	5	14.0	3	61.5	3	7.7	3	13	3	27
BALA8-T1A	Badlands	9.3	52.6	5	0.0	5	73.7	5	7.9	1	52.6	5	15.8	3	19	3	27
EDEN-4	Badlands	10.3	50.0	5	0.0	5	63.9	3	27.8	5	56.3	3	12.5	3	16	3	27
POTRERO-T4B	Badlands	0.7	38.1	3	0.0	5	77.9	5	20.8	3	52.4	5	9.5	3	21	3	27
AVERY-3	Foothills	18.9	46.2	3	2.6	3	64.1	3	36.6	5	43.6	5	17.9	3	38	5	27
BAUCK-02	Foothills	48.7	55.6	5	0.0	5	79.5	5	15.9	3	50.0	5	0.0	1	18	3	27
CASTILE-1	Foothills	0.0	50.0	5	0.0	5	61.3	3	17.3	3	75.0	3	16.7	3	24	5	27
INDIAN-6	Foothills	0.0	60.0	5	0.0	5	56.0	3	24.0	3	53.3	5	13.3	3	15	3	27
SANDCYN-1	Foothills	0.0	57.1	5	4.8	3	48.2	3	28.6	5	52.4	5	19.0	3	20	3	27
STJOHNS-2	Foothills	33.3	48.3	3	6.9	3	42.1	3	31.6	5	58.6	3	24.1	5	27	5	27
XEROX-1	Foothills	3.0	45.5	3	0.0	5	65.0	3	35.0	5	45.5	5	27.3	5	11	1	27
XEROX-2	Foothills	0.0	50.0	5	0.0	5	69.6	3	26.1	5	64.3	3	14.3	3	14	3	27
BAUCK-14	Mountains	5.4	75.0	5	0.0	5	41.5	3	32.3	5	68.8	3	18.8	3	16	3	27
BAUCK-04	Mountains	0.0	72.2	5	0.0	5	52.9	3	19.6	3	55.6	3	22.2	5	18	3	27
POTRERO-T5E	Mountains	0.4	57.9	5	5.3	3	71.8	5	35.9	5	68.4	3	5.3	3	18	3	27
POTRERO-T5D	Mountains	0.0	50.0	5	0.0	5	54.8	3	23.8	3	58.3	3	16.7	3	24	5	27
STRAWBERRY-4	Mountains	43.6	47.4	3	0.0	5	51.9	3	15.6	3	47.4	5	36.8	5	19	3	27
BALA3-2	Badlands	0.8	68.8	5	0.0	5	68.5	3	20.5	3	62.5	3	18.8	3	16	3	25

Table 9. Cont.

Reach Identifier	Bioregion	Disturbance Score	Species of Concern (% Richness)		Exotic Species (% Richness)		Tree/Shrub Nesters (% Abundance)		Canopy Foragers (% Abundance)		Ground Foragers (% Richness)		Cavity Nesters (% Richness)		Native Species Richness		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
BALA5-T1C	Badlands	6.2	50.0	5	0.0	5	66.2	3	24.3	3	61.1	3	5.6	3	18	3	25
EDEN-3	Badlands	7.5	50.0	5	0.0	5	69.0	3	17.2	3	56.3	3	12.5	3	16	3	25
POTRERO-T4C	Badlands	0.2	50.0	5	5.0	3	79.5	5	14.1	3	65.0	3	5.0	3	19	3	25
BROWN-1	Foothills	0.8	51.9	5	3.7	3	61.5	3	16.5	3	63.0	3	14.8	3	26	5	25
FAIRVIEW-1	Foothills	18.2	44.8	3	3.4	3	70.2	5	16.1	3	65.5	3	6.9	3	28	5	25
GOODHART-2	Foothills	0.4	50.0	5	0.0	5	46.5	3	12.7	3	55.6	3	11.1	3	18	3	25
INDIAN-1	Foothills	1.5	36.0	3	4.0	3	49.7	3	20.3	3	56.0	3	20.0	5	24	5	25
NFORK-1	Foothills	0.6	52.4	5	4.8	3	55.7	3	37.7	5	57.1	3	19.0	3	20	3	25
ORCHARD-2	Foothills	48.9	65.0	5	0.0	5	72.9	5	8.3	1	65.0	3	15.0	3	20	3	25
POPPET-T1A	Foothills	0.0	45.5	3	4.5	3	56.3	3	23.8	3	50.0	5	31.8	5	21	3	25
GARNER-T2A	Mountains	0.0	54.2	5	4.2	3	65.9	3	18.3	3	58.3	3	25.0	5	23	3	25
STRAWBERRY-5	Mountains	50.3	35.7	3	3.6	3	58.2	3	14.3	3	57.1	3	28.6	5	27	5	25
BALA6-1	Badlands	2.3	56.3	5	6.3	3	79.7	5	10.2	1	62.5	3	6.3	3	15	3	23
BALA8-3	Badlands	15.5	63.2	5	0.0	5	68.4	3	8.8	1	57.9	3	10.5	3	19	3	23
BALA8-T1C	Badlands	7.8	50.0	5	0.0	5	84.9	5	0.0	1	75.0	3	8.3	3	12	1	23
EDEN-T1B	Badlands	21.9	55.6	5	0.0	5	56.0	3	8.0	1	77.8	3	22.2	5	9	1	23
BAUCK-02	Foothills	76.8	47.1	3	0.0	5	71.4	5	2.6	1	76.5	3	5.9	3	17	3	23
CC-3	Lowlands	39.4	37.5	3	4.2	3	52.7	3	18.7	3	58.3	3	25.0	5	23	3	23
SJMS-05	Lowlands	13.7	50.0	5	0.0	5	45.2	3	7.1	1	62.5	3	12.5	3	16	3	23
BALA8-T1D	Badlands	5.4	46.2	3	0.0	5	62.2	3	10.8	1	69.2	3	7.7	3	13	3	21
POTRERO-T3A	Badlands	43.8	40.9	3	0.0	5	66.3	3	5.0	1	68.2	3	13.6	3	22	3	21
POTRERO-T2A	Badlands	43.8	44.4	3	0.0	5	60.9	3	7.8	1	66.7	3	5.6	3	18	3	21
SJMS-14	Foothills	64.2	40.0	3	0.0	5	70.4	5	5.6	1	66.7	3	0.0	1	15	3	21
STJOHNS-1	Foothills	20.4	33.3	3	3.7	3	57.9	3	6.1	1	59.3	3	18.5	3	26	5	21
ELLIS-3	Lowlands	10.7	43.5	3	0.0	5	68.2	3	10.6	1	56.5	3	8.7	3	23	3	21
RRCYN-T3A	Lowlands	25.7	38.5	3	3.8	3	60.0	3	11.6	1	69.2	3	15.4	3	25	5	21
RRCYN-T2A	Lowlands	26.3	48.0	3	8.0	3	58.2	3	2.9	1	68.0	3	20.0	5	23	3	21

Table 9. Cont.

Reach Identifier	Bioregion	Disturbance Score	Species of Concern (% Richness)		Exotic Species (% Richness)		Tree/Shrub Nesters (% Abundance)		Canopy Foragers (% Abundance)		Ground Foragers (% Richness)		Cavity Nesters (% Richness)		Native Species Richness		IBI
			Metric	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	
FOBES-1	Mountains	0.0	31.8	3	4.5	3	37.3	3	7.8	1	63.6	3	31.8	5	21	3	21
RCC-3	Lowlands	35.2	33.3	3	14.3	3	69.3	3	3.6	1	71.4	3	9.5	3	18	3	19
BALA2-1	Badlands	94.9	38.5	3	15.4	1	70.4	5	7.4	1	61.5	3	7.7	3	11	1	17
POPPET-1	Foothills	37.2	29.2	1	4.2	3	45.7	3	5.0	1	66.7	3	16.7	3	23	3	17
FS-3	Lowlands	91.7	30.0	3	15.0	1	57.6	3	11.1	1	60.0	3	10.0	3	17	3	17
RRCYN-T4C	Lowlands	30.9	31.8	3	9.1	3	51.4	3	0.9	1	72.7	3	4.5	1	20	3	17
SJMS-06	Lowlands	80.0	16.7	1	0.0	5	25.6	1	7.7	1	66.7	3	8.3	3	12	1	15
STAFE-3	Lowlands	73.2	22.2	1	16.7	1	38.9	3	1.9	1	77.8	3	5.6	3	15	3	15
STAFE-2	Lowlands	41.3	25.0	1	12.5	3	39.2	3	0.8	1	75.0	3	0.0	1	14	3	15
BELL-2	Lowlands	81.9	26.3	1	15.8	1	27.9	1	0.7	1	63.2	3	10.5	3	16	3	13
DOMPKY-1	Lowlands	59.1	9.1	1	9.1	3	36.7	3	2.0	1	81.8	1	9.1	3	10	1	13
HS-1	Lowlands	91.2	23.5	1	17.6	1	23.4	1	0.0	1	76.5	3	5.9	3	14	3	13
SJMS-07	Lowlands	79.6	30.0	3	10.0	3	60.0	3	0.0	1	80.0	1	0.0	1	9	1	13
KITC-2	Lowlands	93.1	11.1	1	33.3	1	37.8	3	0.0	1	100.0	1	0.0	1	6	1	9
PVSD-1	Lowlands	82.8	15.4	1	23.1	1	18.1	1	0.0	1	84.6	1	0.0	1	10	1	7

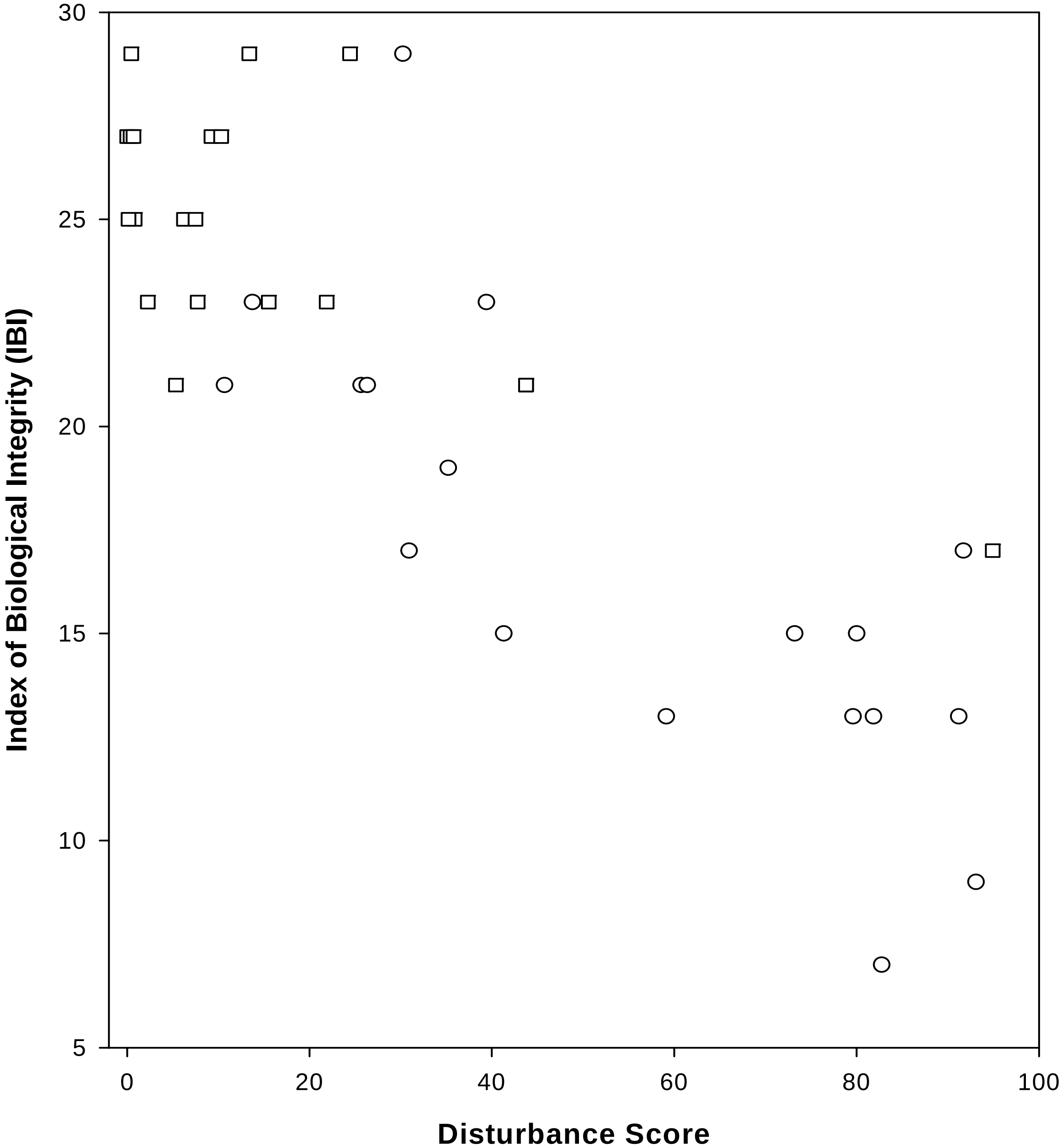


Figure 20. Plot of bird-community IBI versus the reach disturbance score (*r* = -0.84) for Lowland (circles) and Badland (squares) reaches (n = 38).

Finally, the IBI formulation developed for the Lowlands and Badlands bioregions was applied to the Foothills and Mountains bioregions (Table 9). In general, Foothill and Mountain reaches and their local drainages were less disturbed by human activity than those in the Lowlands and Foothills. This was reflected in calculated IBIs, with 19 of the Foothill and Mountain reaches scoring higher than the best of the Badland and Lowland reaches. IBI scores for Foothill and Mountain reaches ranged from 17 to 33 (maximum possible score = 35).

A plot of the bird IBI versus the reach disturbance score for all sampled reaches in the San Jacinto River watershed (n = 95) (Figure 21) showed good separation of IBI scores between highly impacted and relatively unimpacted reaches. Scores for Foothill and Mountain reaches followed the same general trend as those for Lowland and Badland reaches, with the exception of one outlier (reach WASHBURN-1) that had a high IBI despite a relatively high disturbance score. ANOVA based on all 95 reaches indicated that the slope of IBI versus the disturbance score may not be homogeneous across bioregions ($P = 0.049$). However, elimination of the outlier produced a nonsignificant result ($P = 0.291$). Therefore, the analysis indicated that there were no fundamental differences in the way bird communities in each bioregion responded to increased human disturbance, at least for the metrics we selected as part of the bird IBI. Thus there was no need to develop separate IBI formulations for each bioregion. However, this result needs to be examined further through an independent test of this IBI formulation in a second watershed.

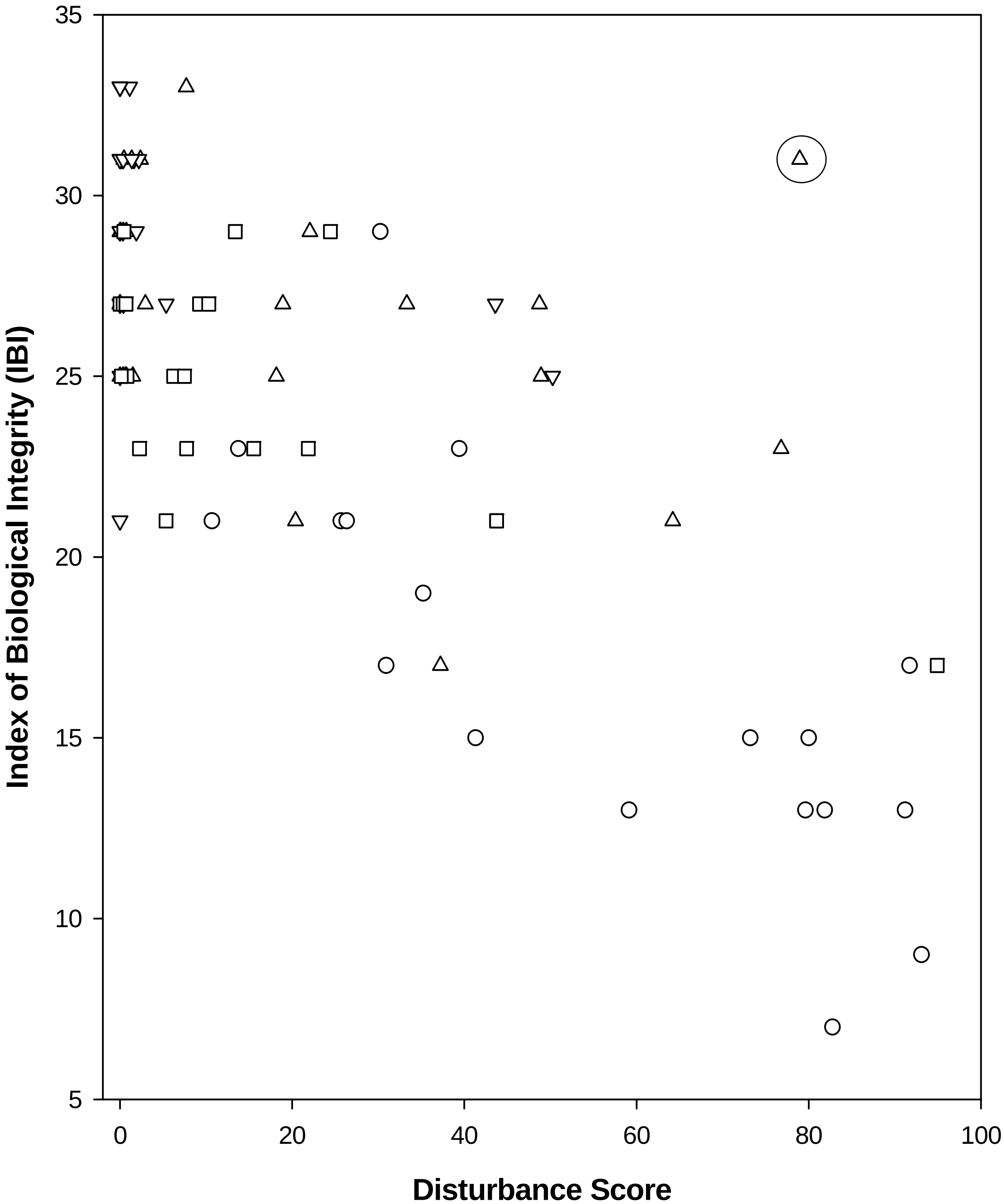


Figure 21. Plot of the bird-community IBI versus reach disturbance score for all Lowland (circles), Badland (squares), Foothill (triangles pointing up), and Mountain (triangles pointing down) reaches (n = 95). Overall r = -0.74. Circled outlier is reach WASHBURN-1. Elimination of the outlier resulted in r = -0.79.

HERPETOFAUNAL STUDIES

Background

Herpetofauna (reptiles and amphibians) use riparian and wetland habitats primarily for reproduction, although some species depend on wet habitats more for foraging or cover. Amphibians are linked to water during their egg and larval stages and many reptiles are functionally tied to wetlands (Harris and Gosselink 1990). With few exceptions, the approximately 190 species of amphibians in North America north of Mexico require wetlands and aquatic habitats at least for breeding purposes (Clark 1979, Conant and Collins 1991). Many of the reptiles associated with riparian and wetland habitats in the United States are the opposites of amphibians in life history strategy. They use wet areas for food and cover, but move to the habitat edge or to more xeric land to deposit eggs (Clark 1979, Szaro and Belfit 1986). Ecosystem support roles of wetland herpetofauna include (1) serving as links in food chains, (2) processing dead organic matter and making it available to detrital food chains, (3) physically modifying the wetland habitat so that it supports a more diverse or abundant fauna, and (4) controlling populations of nuisance organisms. Pauley et al. (1999) reviewed amphibian and reptile ecology in riparian habitats and provided species listings for riparian habitat types.

Because the majority of North American herpetofauna inhabit riparian/wetland habitats at some time in their life cycles, they are potentially excellent indicator species for these ecosystems (Lowe 1989, Wake 1991). The diversity of wetland amphibians varies with latitude and annual rainfall (Clark 1979). Species richness is very high in southern swamps, even in temporary ponds, and decreases to the north and west. In the southwestern deserts of the United States, 60% of the herpetofauna inhabits riparian and wetland areas (Lowe 1989). In California, riparian ecosystems provide habitat for 83% of the amphibians and 40% of the reptiles known from the State (Brode and Bury 1984). Amphibians and reptiles are often abundant in aquatic and streamside zones in the Pacific Northwest, and most have distinct habitat preferences. Bury (1988) showed that 30 to 60% of the Pacific Northwest herpetofauna was associated with riparian zones of small streams.

Terrestrial and aquatic amphibians and reptiles are excellent bioindicators of the environmental health in ecosystems (Jones 1986). Many herpetofaunal species are sensitive to pollution, loss of aquatic habitat, and other anthropogenic influences (Hall 1980). Amphibians are particularly sensitive because of their highly permeable skins that can rapidly absorb toxic substances present in both aquatic and terrestrial pollution (Blaustein and Wake 1990, Lannoo 1998). The egg stage is extremely susceptible to chemical pollutants, and exposure in high concentrations can result in developmental abnormalities. Herpetofauna are important in food chains and make up a large proportion of the vertebrates in certain ecosystems (Bury and Raphael 1983). It may be that the herpetofaunal community of an ecosystem, particularly amphibians, signals environmental stress earlier than do most other organisms.

These attributes of herpetofaunal communities made them an obvious choice for consideration as a component of an IBI designed to assess the health and integrity of riparian ecosystems in the San Jacinto River watershed. Compared with birds, however, it is much more difficult, laborious, and costly to obtain meaningful information about herp diversity and abundance across many different riparian reaches in a short period of time. Characterizing the full suite of herp species that use an area generally requires multiple sampling methods (e.g., pit traps, timed searches, auditory surveys) carried out at various times (e.g., diurnal, seasonal, and annual) (Heyer et al. 1994). Herp activity and, therefore, the probability of detecting a particular species, may also be influenced by recent rainfall, particularly in arid regions. For community-level studies, it is often necessary to accumulate data over a number of years to compensate for extreme year-to-year variability in herp activity. Therefore, rather than directly sampling the herp communities that used riparian reaches in the San Jacinto watershed, our approach involved the use of an existing, cumulative database of herpetological records compiled for Riverside County (Beaman et al., in prep.). We used these historical records to characterize the herp communities of selected reaches and build portions of a combined bird/herp IBI.

Objectives of the Herpetofaunal Studies

Specific objectives were:

1. Use the historical database to compile herpetological records for each of the 102 riparian reaches in the San Jacinto River watershed that were sampled for birds in 2002

2. Use the compiled records to identify herpetofaunal community metrics for inclusion in a combined bird/herp IBI

Methods

As with the avian studies, the study area was the San Jacinto River watershed in Riverside County, CA. We used the same 102 riparian reaches for herp work that had been randomly selected and sampled for avian use in the spring of 2002. Selected reaches were distributed among the four bioregions as follows: Lowlands (21), Badlands (24), Foothills (29), and Mountains (28). Table 10 provides the site codes used throughout this section to identify the sampled reaches.

Herp Distribution Records

All historical records for the herpetofaunal communities in the watershed were compiled from the electronic database developed by Beaman et al. (in prep.). Beaman et al. (in prep.) is an ongoing project to compile historical herpetofaunal records for Riverside and San Bernardino Counties, California, into a searchable database using Microsoft Access® software. Collection data from the following institutions were used to construct the database:

American Museum of Natural History
Brigham Young University
California Academy of Sciences
California Department of Fish and Game, Natural Diversity Data Base
California Polytechnic University, Pomona
Field Museum of Natural History
Florida Museum of Natural History
Illinois Natural History Survey
Marjorie Barrick Museum, University of Nevada, Las Vegas
Museum of Comparative Zoology
Museum of Natural History, University of Kansas
Museum of Natural Science, Louisiana State University
Museum of Southwestern Biology, University of New Mexico
Museum of Vertebrate Zoology, University of California, Berkeley
Museum of Vertebrate Zoology, University of California, Santa Barbara
Museum of Zoology, University of Michigan
National Museum of Natural History, Smithsonian Institution
Natural History Museum of Los Angeles County
Oklahoma Museum of Natural History, University of Oklahoma
San Bernardino County Museum
San Diego Natural History Museum
Santa Barbara Natural History Museum
The Carnegie Museum of Natural History
The Chicago Academy of Sciences
University of Arizona
University of Colorado, Boulder
U.S. Department of the Interior, Bureau of Land Management, Desert District Office, Riverside, CA
Other sources: individual field notes, published records, and unpublished data from pitfall trap surveys.

Table 10. Site codes used for sampled reaches in subsequent tables.

LOWLANDS		BADLANDS		MOUNTAINS		FOOTHILLS	
1	BELL-2	1	BALA2-3	1	APPLECYN-2	1	AVERY-3
2	CC-3	2	BALA2-T1A	2	BAUCK-14	2	AVERY-4
3	DOMPKY-1	3	BALA2-2	3	BAUCK-12	3	BAUCK-02
4	ELLIS-3	4	BALA2-1	4	BAUCK-11	4	BAUCK-02
5	FS-3	5	BALA3-2	5	BAUCK-T7A	5	BLKBRN-1
6	HS-1	6	BALA3-T1A	6	BAUCK-04	6	BROWN-1
7	IRWO-T1A	7	BALA5-4	7	BLKBRN-4	7	BROWN-T2A
8	IRWO-2	8	BALA5-T1C	8	BLKBRN-3	8	CASTILE-1
9	KITC-2	9	BALA6-1	9	FOBES-1	9	CHOLLA-3
10	PVSD-1	10	BALA8-3	10	GARNER-T2A	10	FAIRVIEW-4
11	RCC-4	11	BALA8-2	11	HERKEY-3	11	FAIRVIEW-1
12	RCC-3	12	BALA8-T1C	12	HERKEY-2	12	FAIRVIEW-T1B
13	RRCYN-T3A	13	BALA8-T1D	13	HIXON-1	13	GOODHART-2
14	RRCYN-T2A	14	BALA8-T1A	14	HERKEY-T2B	14	INDIAN-6
15	RRCYN-T4C	15	EDEN-3	15	HERKEY-T2A	15	INDIAN-2
16	SJMS-07	16	EDEN-4	16	INDIAN-8	16	INDIAN-1
17	SJMS-06	17	EDEN-T1B	17	LION-1	17	NFORK-1
18	SJMS-05	18	POTRERO-6	18	MELLOR-1	18	ORCHARD-2
19	SJMS-04	19	POTRERO-5	19	MELLOR-T1B	19	POPPET-1
20	STAFE-3	20	POTRERO-T4B	20	MORRIS-3	20	POPPET-T1A
21	STAFE-2	21	POTRERO-T3A	21	POTRERO-T5E	21	SANDCYN-1
		22	POTRERO-T2A	22	POTRERO-T5D	22	SFSJ-1
		23	POTRERO-T4C	23	SFSJ-4	23	SJMS-14
		24	RCC-5	24	SFSJ-3	24	STJOHNS-2
				25	STRAWBERRY-5	25	STJOHNS-T1A
				26	STRAWBERRY-4	26	STJOHNS-1
				27	STRAWBERRY-1	27	WASHBURN-1
				28	THOMAS-1	28	XEROX-1
						29	XEROX-2

Utilizing the searchable format of this database, herpetofaunal species lists were compiled for the San Jacinto watershed. Data on the location of each of the 102 stream reaches from the avian surveys were imported into ArcView® GIS and Map Source® mapping programs. Locality data for species records from the herpetofauna database were also plotted on these maps to identify the historical species richness for each stream reach. Species records often did not include a precise geographic position. Positions relative to our selected riparian reaches were estimated based on written descriptions given in the database. A species was assumed to occur in a particular reach if the described location was within 2.5 miles of the designated stream reach. Since an accurate herpetofaunal species list for a given area typically takes many years to compile, we believe that this database represents the best available information on species richness in the sampled riparian reaches. However, the database was limited to records of species presence or absence (i.e., not detected). Therefore, no analysis of historical abundance was possible.

Standardized species codes are not typically used for herpetofauna as is done with avian species. For this study, numerical species codes were assigned to amphibian and reptile species based on Collins (1997).

Herp Metrics for IBI Development

Life history requirements as described by Stebbins (1985) and Brown (1997) were used to classify species for development of potential herp community metrics. Herp species were assigned to the following guilds or groups: major taxa (salamanders, frogs/toads, turtles/tortoises, crocodilians, lizards, snakes), riparian use (obligate, dependent, associate, incidental), diet (herbivore, insectivore, carnivore, omnivore), habitat use (aquatic/semiaquatic, fossorial, surfacorial, arboreal), nesting strategy (aquatic, terrestrial ground, terrestrial vegetation, live bearer), conservation priority (included species that are threatened or endangered at the State or Federal levels, those determined to be of special conservation concern, and those for which restricted collection limits are in place), and introduced (exotic) status. For each guild or group, we calculated the following potential IBI metrics: (1) species richness (i.e., number of species) for that guild or group in the reach, and (2) percent richness (i.e., number species of group members / total species richness x 100). Twenty five herp metrics were evaluated, including total herp species richness.

Herp metrics were evaluated for inclusion in the IBI by the same procedure used to evaluate bird metrics. The relationship between each herp metric and the index to human disturbance of riparian reaches was first determined by calculating Pearson correlation coefficients, both by bioregion and for the watershed as a whole. For those with significant correlations ($P < 0.05$), plots were examined visually for strong empirical relationships and good separation between relatively impacted and unimpacted reaches (Karr and Chu 1999). The range of each selected metric was divided into intervals based on visual examination of plots, and was scored 1 (low integrity), 3 (intermediate), or 5 (high integrity). Selected metrics were then added to the IBI formula derived earlier for birds alone. None of the selected bird/herp metrics were highly correlated with one another ($|r| < 0.80$). The final bird/herp IBI was the sum of scores for all selected metrics.

Results

Beaman et al. (in prep.) contained a total of 18,513 herpetofaunal records for Riverside County. The earliest records dated from the late 1800s but the majority were from the 1950s, 1960s, and 1970s. These records were sorted to construct historical species lists and subsequent IBI herp metrics. Appendix D lists the 100 species (9 salamanders, 15 frogs/toads, 4 turtles, 36 lizards, and 36 snakes) identified for Riverside County. Forty-four species (48 subspecies) of amphibians (3 salamanders, 8 frogs/toads) and reptiles (1 turtle, 13 lizards, 19 snakes) were documented from the San Jacinto River watershed (Table 11). The distribution of amphibians and reptiles by bioregion shows higher species richness in the Lowlands (39 species) and Mountains (36 species) and lower species richness in the Foothills (28 species) and Badlands (27 species) (Tables 12 and 13). Each list was comprised predominantly of reptile species.

Tables 14-17 provide the historical species lists for each stream reach by bioregion. Stream reaches within the Lowlands bioregion had the widest range of documented species richness (0 to 27 species per stream reach, mean 8.6 species) (Table 14). Stream reaches within the Badlands bioregion had the smallest range of species richness (1 to 12 species per reach). The mean number of species per reach was similar across the Badlands (7.5 species), Mountains (7.4 species), and Foothills (7.9 species) bioregions (Tables 15-17). Herp occurrence records were available for 92 of the 102 target riparian reaches. No historical records were identified within 2.5 miles of 10 stream reaches (BELL-2, BAUCK-14, BAUCK-12, BAUCK-11, BAUCK-T7A, HERKEY-3, HERKEY-T2B, HERKEY-T2A, LION-1, and SANDCYN-1).

As a group, lizards and snakes were the most numerous taxa in the database. Herpetofauna are not generally considered to be riparian obligates but many species are associated with riparian habitat during portions of their life history. A higher number of insectivores and carnivores than herbivores and omnivores is a reflection of species at a higher trophic level in an ecosystem. This was consistence for all four bioregions. The majority of species throughout all the stream reaches were surfacorial users of the habitat and terrestrial ground nesters. Of the 102 stream reaches, 84 of the reaches had documented historical records of species with some status of conservation priority. Fourteen of the reaches had records of an introduced exotic species (Bullfrog). Species assignments to various guilds and groups are shown in Table 18 for amphibians, Table 19 for turtles and lizards, and Table 20 for snakes. Documented herp species richness for each reach is shown in Table 21 for Lowlands reaches, Table 22 for Badlands reaches, Table 23 for Mountain reaches, and Table 24 for Foothills reaches. Metrics expressed as percent richness are given for each bioregion in Tables 25-28.

Table 11. Historical herpetofaunal occurrence (with species codes in bold) within the San Jacinto River watershed, Riverside County, California. (Database source: Beaman et al., in prep.)

Caudata (Salamanders)			
(A4.2)	***Batrachoseps attenuatus*** California Slender Salamander		
(A8.1)	***Ensatina eschscholtizii*** Ensatina		
(A23.3)	***Taricha torosa*** California Newt		
Anura (Frogs and Toads)			
(B3.4)	***Bufo boreas*** Western Toad	**(B12.2)**	***Rana aurora*** Red-legged Frog
(B3.5)	***Bufo californicus*** Arroyo Toad	**(B12.15)**	***Rana muscosa*** Mountain Yellow-legged Frog
(B6.4)	***Hyla cadaverina*** California Treefrog	**(B16.2)**	***Spea hammondii*** Western Spadefoot
(B6.10)	***Hyla regilla*** Pacific Treefrog	**(B12.8)**	***Rana catesbeiana*** Bullfrog (Introduced species)
Testudines (Turtles and Tortoises)			
(C6.3)	***Clemmys marmorata*** Western Pond Turtle		
Squamata-Lacertilia (Lizards)			
(F1.1)	***Anniella pulchra*** California Legless Lizard	**(F18.2)**	***Phrynosoma coronatum*** Coast Horned Lizard
(F4.8)	***Cnemidophorus hyperythrus*** Belding's Orangethroat Whiptail	**(F21.3)**	***Sceloporus graciosus*** Sagebrush Lizard
(F4.18)	***Cnemidophorus tigris*** Western Whiptail	**(F21.8)**	***Sceloporus occidentalis*** Western Fence Lizard
(F5.4)	***Coleonyx variegates*** Western Banded Gecko	**(F21.10)**	***Sceloporus orcutti*** Granite Spiny Lizard
(F9.3)	***Elgaria multicarinatus*** Southern Alligator Lizard	**(F26.1)**	***Uta stansburiana*** Side-blotched Lizard
(F10.5)	***Eumeces gilberti*** Gilbert's Skink	**(F27.1)**	***Xantusie henshawi*** Granite Night Lizard
(F10.12)	***Eumeces skiltonianus*** Western Skink		
Squamata-Serpentes (Snakes)			
(G2.2)	***Arizona elegans*** Eastern Glossy Snake	**(G26.1)**	***Lichanur trivirgata*** Rosy Boa
(G6.1)	***Charina bottae*** Rubber Boa	**(G28.2)**	***Masticophis flagellum*** Coachwhip
(G13.4)	***Crotalus exsul*** Red Diamond Rattlesnake	**(G28.3)**	***Masticophis lateralis*** Striped Racer
(G13.7)	***Crotalus mitchellii*** Speckled Rattlesnake	**(G36.1)**	***Pituophis catenifer*** Gopher Snake
(G13.12)	***Crotalus viridis*** Western (Pacific) Rattlesnake	**(G39.1)**	***Rhinocheilus lecontei*** Longnose Snake
(G14.1)	***Diadophis punctatus*** Ringneck Snake	**(G40.3)**	***Salvadora hexalepis*** Western Patchnose Snake
(G22.1)	***Hypsiglena torquata*** Night Snake	**(G47.8)**	***Tantilla planiceps*** Western Black-headed Snake
(G23.3)	***Lampropeltis getulus*** Common Kingsnake	**(G48.9)**	***Thamnophis hammondii*** Two-striped Garter Snake
(G23.6)	***Lampropeltis zonata*** California Mountain Kingsnake	**(G49.1)**	***Trimorphodon biscutatus*** Lyre Snake
(G25.2)	***Leptotyphlops humilis*** Western Blind Snake		

Table 12. Historical occurrence of amphibians by bioregions in the San Jacinto River watershed, Riverside County, California (X = documented historical record). (Database source: Beaman et al., in prep.).

Amphibians	Lowlands	Badlands	San Jacinto Mountains	Foothills
Caudata (Salamanders)				
Batrachoseps attenuatus California slender salamander	X	—	—	—
Ensatina eschscholtizii eschscholtzii Monterey ensatina	—	—	X	—
Ensatina eschscholtzii klauberi large-blotched ensatina	—	—	X	—
Taricha torosa torosa coast range newt	X	—	—	—
Anura (Toads and Frogs)				
Bufo boreas halophilus California toad	X	X	X	X
Bufo californicus Arroyo toad	—	—	X	X
Hyla cadaverina California treefrog	X	—	X	X
Hyla regilla Pacific treefrog	X	X	X	—
Rana aurora draytoni California red-legged frog	—	—	X	X
Rana muscosa mountain yellow-legged frog	—	—	X	—
Spea hammondii western spadefoot	X	X	—	X
Rana catesbeiana (Introduced Species) bullfrog	—	—	X	—
TOTAL AMPHIBIAN SPECIES	6	3	8	5

Table 13. Historical occurrence of reptiles by bioregions in the San Jacinto River watershed, Riverside County, California (X = documented historical record). (Database source: Beaman et al., in prep.).				
Reptiles	**Lowlands**	**Badlands**	**Mountains**	**Foothills**
Testudines (Turtles and Tortoises)				
Clemmys marmorata pallida southwestern pond turtle	X	—	—	—
Squamata - Lacertilia (Lizards)				
Anniella pulchra silvery legless lizard	X	X	X	—
Cnemidophorus hyperythrus beldingi Belding's orangethroat whiptail	X	X	—	X
Cnemidophorus tigris multiscutatus coastal whiptail	X	X	X	X
Cnemidophorus tigris tigris Great Basin whiptail	X	X	X	X
Coleonyx variegatus abboti San Diego banded gecko	X	X	—	X
Elgaria multicarinatus webbii San Diego alligator lizard	X	—	X	X
Eumeces gilberti rubricaudatus western redtail skink	X	—	X	—
Eumeces skiltonianus western skink	X	X	X	X
Phrynosoma coronatum blainvillii San Diego horned lizard	X	X	X	X
Sceloporus graciosus sagebrush lizard	X	—	X	—
Sceloporus occidentalis biseriatus San Joaquin fence lizard	X	X	X	X
Sceloporus occidentalis longipes Great Basin fence lizard	X	X	X	X
Sceloporus orcutti granite spiny lizard	X	X	X	X
Uta stansburiana side-blotched lizard	X	X	X	X
Xantusie henshawi granite night lizard	X	X	X	X

Reptiles - (Continued)	Lowlands	Badlands	Mountains	Foothills
Squamata - Serpentes (Snakes)				
Arizona elegans occidentalis California glossy snake	X	—	—	—
Charina bottae umbratica southern rubber boa	—	—	X	—
Crotalus exsul ruber northern red rattlesnake	X	X	X	X
Crotalus mitchellii pyrrhus southwestern speckled rattlesnake	X	—	X	—
Crotalus viridis helleri southern Pacific rattlesnake	X	X	X	X
Diadophis punctatus modestus San Bernardino ringneck snake	X	X	X	X
Hypsiglena torquata deserticola desert night snake	X	—	X	—
Lampropeltis getulus californiae California kingsnake	X	X	X	—
Lampropeltis zonata parvirubra San Bernardino mountain kingsnake	—	—	X	—
Lampropeltis zonata pulchra San Diego mountain kingsnake	—	—	X	—
Leptotyphlops humilis humilis southwestern blind snake	X	X	X	X
Lichanura trivirgata roseofusca coastal rosy boa	X	X	—	X
Masticophis flagellum piceus red coachwhip	X	X	—	—
Masticophis lateralis lateralis California striped racer	X	X	X	X
Pituophis catenifer annectens San Diego gopher snake	X	X	X	X
Rhinocheilus lecontei lecontei western longnose snake	X	—	—	X
Salvadora hexalepis virgultea coast patchnose snake	X	X	—	—
Tantilla planiceps western black-headed snake	X	X	X	X
Thamnophis hammondii two-striped garter snake	X	—	X	X
Trimorphodon biscutatus vandenburghi California lyre snake	X	X	—	X
TOTAL REPTILE SPECIES	33	24	27	23

Table 14. Cumulative historical species list for surveyed reaches of the San Jacinto Lowlands. (Database source: Beaman et al., in prep.)

Species Code	**Reach Codes**																				
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
A4.2																					
A8.1																					
A23.3																					
B3.4							X	X	X			X									
B3.5																					
B6.4		X											X	X	X						
B6.10		X					X		X				X	X	X				X		
B12.2																					
B12.8																					
B12.15																					
B16.2							X		X												
C6.3										X						X	X				
F1.1																					
F4.8		X		X			X	X	X	X	X	X	X	X	X	X	X				
F4.18			X				X	X	X			X								X	X
F5.4			X				X	X	X			X								X	X
F9.3					X		X		X												
F10.5							X		X												
F10.12							X		X												
F18.2			X	X			X	X	X	X		X				X	X			X	X
F21.3							X	X				X									
F21.8		X	X		X						X	X	X	X	X					X	X
F21.10			X		X	X	X	X	X	X		X				X	X			X	X
F26.1		X	X		X	X	X		X	X						X	X			X	X
F27.1							X		X												
G2.1							X		X	X						X	X				
G6.1																					
G13.4			X				X	X	X	X		X				X	X			X	X
G13.7							X		X												
G13.12										X			X	X	X	X	X	X	X		
G14.1																					
G22.1							X		X												
G23.3			X				X		X											X	X
G23.6																					
G25.2							X		X												
G26.1			X				X		X	X						X	X			X	X
G28.2							X	X	X												
G28.3		X					X	X	X			X	X	X	X						
G36.1					X		X		X	X			X	X	X	X	X	X	X		
G39.1							X		X												
G40.3										X						X	X				
G47.8							X		X												
G48.9																					
G49.1							X	X	X	X		X				X	X				
Total	0	6	9	2	5	2	27	11	26	12	2	11	7	7	7	12	12	2	3	9	9

Table 15. Cumulative historical species list for surveyed reaches of the San Jacinto Badlands. (Database source: Beaman et al., in prep.)

Species Code	**Reach Codes**																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
A4.2																								
A8.1																								
A23.3																								
B3.4	X	X	X	X	X																			
B3.5																								
B6.4																								
B6.10	X	X	X	X	X																			
B12.2																								
B12.8																								
B12.15																								
B16.2	X		X	X	X		X	X	X	X	X	X	X	X										
C6.3																								
F1.1																		X	X		X	X		
F4.8	X	X	X	X	X	X				X	X	X	X	X	X	X	X							X
F4.18	X	X	X	X	X													X	X		X	X		
F5.4	X	X	X	X	X					X	X	X	X	X	X	X	X							
F9.3																								
F10.5																								
F10.12																								
F18.2										X	X	X		X	X	X	X							
F21.3																								
F21.8																		X	X	X	X	X	X	X
F21.10																								
F26.1											X				X		X							
F27.1																								
G2.1																								
G6.1																								
G13.4	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X							
G13.7																								
G13.12																								
G14.1																								
G22.1																								
G23.3	X	X	X	X	X	X	X	X	X									X	X		X	X		
G23.6																								
G25.2										X	X	X	X	X	X	X	X							
G26.1																								
G28.2	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X		
G28.3	X	X	X	X	X					X	X	X	X	X	X	X	X	X	X		X	X		
G36.1	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X							
G39.1																								
G40.3																								
G47.8										X	X	X	X	X	X	X	X							
G48.9																								
G49.1	X	X	X	X	X	X																		
Total	12	11	12	12	12	4	5	5	5	10	11	10	8	10	10	9	10	6	6	1	6	6	1	2

Table 16. Cumulative historical species list for surveyed reaches of the San Jacinto Mountains. (Database source: Beaman et al., in prep.)

Species Code	Reach Codes																										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
A4.2																												
A8.1	X								X							X		X	X						X	X		
A23.3																												
B3.4	X					X						X	X												X	X	X	
B3.5						X		X					X															
B6.4						X							X			X												
B6.10																									X	X		
B12.2																												
B12.8																X		X	X									
B12.15	X					X						X	X			X		X	X						X	X	X	
B16.2																												
C6.3																												
F1.1																												
F4.8																												
F4.18	X								X	X										X	X							X
F5.4																												
F9.3									X	X						X			X	X	X				X	X	X	X
F10.5																												
F10.12	X								X			X				X								X	X	X	X	
F18.2	X					X	X	X	X	X		X	X			X		X	X	X	X							X
F21.3	X								X	X		X				X		X	X		X				X	X	X	X
F21.8	X					X			X	X		X	X			X		X	X	X	X	X		X	X	X	X	X
F21.10	X								X	X		X				X		X	X	X		X		X	X	X	X	X
F26.1	X					X			X	X			X							X	X				X	X	X	X
F27.1																X			X						X	X		
G2.1																												
G6.1																									X	X		
G13.4																								X				
G13.7																X		X	X	X								
G13.12						X	X	X	X	X			X							X	X				X	X	X	X
G14.1																									X	X	X	
G22.1																									X	X	X	
G23.3	X								X																			
G23.6																									X	X	X	
G25.2																							X	X			X	
G26.1						X	X	X																				
G28.2																												
G28.3	X								X	X		X								X	X				X	X	X	X
G36.1	X					X	X	X	X	X		X	X							X	X		X	X	X	X	X	X
G39.1																												
G40.3																												
G47.8																							X	X			X	
G48.9	X					X			X	X			X			X				X			X	X	X	X	X	X
G49.1																												
Total	14	0	0	0	0	11	4	5	14	11	0	9	10	0	0	13	0	8	10	11	9	2	4	8	19	19	17	11

Table 17. Cumulative historical species list for surveyed reaches of the San Jacinto Foothills. (Database source: Beaman et al., in prep.)

Species Code	Reach Codes																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
A4.2																													
A8.1																													
A23.3																													
B3.4	X	X				X	X		X		X	X			X	X		X					X				X		X
B3.5			X	X	X		X			X	X	X						X										X	X
B6.4						X	X		X						X		X	X				X					X		X
B6.10															X			X				X	X				X		
B12.2																													
B12.8																													
B12.15						X	X		X						X			X				X	X				X		X
B16.2																													
C6.3																													
F1.1																													
F4.8	X	X									X		X		X	X		X					X	X		X	X		
F4.18											X				X	X		X					X				X		
F5.4	X	X																											
F9.3											X				X	X		X					X				X		
F10.5																													
F10.12	X	X						X								X	X		X	X			X				X		
F18.2	X	X	X	X	X	X	X		X	X	X	X		X	X	X		X		X		X	X			X	X	X	X
F21.3																													
F21.8						X	X		X						X		X	X				X					X		X
F21.10	X	X									X					X	X		X			X	X	X	X		X		
F26.1	X	X				X	X		X		X				X	X		X					X				X		X
F27.1	X	X								X	X	X	X						X					X		X			
G2.1																													
G6.1																													
G13.4	X	X				X	X				X	X			X		X	X				X					X		
G13.7																													
G13.12			X	X	X		X			X	X	X			X	X		X					X				X	X	X
G14.1	X	X								X	X	X																	
G22.1																													
G23.3																													
G23.6																													
G25.2																	X					X							
G26.1	X	X	X	X	X	X	X			X	X	X						X	X									X	X
G28.2																													
G28.3						X					X		X		X	X		X					X	X		X	X		
G36.1			X	X			X	X		X	X	X			X	X	X	X	X	X		X	X					X	X
G39.1						X							X											X	X	X			
G40.3																													
G47.8																	X					X							
G48.9						X	X		X													X							
G49.1	X	X																											
Total	12	12	5	5	4	11	12	2	7	7	15	9	4	1	14	11	8	16	5	3	0	11	13	5	2	5	15	5	10

Table 18. Herp guild/group assignments for salamander and frog/toad species historically occurring within the surveyed reaches of the San Jacinto watershed.

Herp Category	**Species Codes**										
	Salamanders			**Frogs/Toads**							
	A4.2	**A8.1**	**A23.3**	**B3.4**	**B3.5**	**B6.4**	**B6.10**	**B12.2**	**B12.8**	**B12.15**	**B16.2**
Riparian Obligates	X	X	X					X	X		X
Riparian Dependents				X	X	X	X			X	
Riparian Associates	X		X								
Riparian Incidentals		X									
Herbivores											
Insectivores	X	X	X	X	X	X	X	X	X	X	X
Carnivores											X
Omnivores											
Aquatic/Semi-aquatic						X		X	X		X
Fossorial											
Surfacorial	X	X	X	X	X	X	X			X	
Arboreal											
Aquatic Nesters			X	X	X	X	X	X	X	X	X
Terrestrial Ground Nesters	X	X									
Terrestrial Vegetation Nesters											
Live Bearers											
Conservation Priority			X		X			X	X	X	
Introduced Species											X

Table 19. Herp guild/group assignments for turtle and lizard species historically occurring within the surveyed reaches of the San Jacinto watershed.

Herp Category	**Species Codes**													
	Turtles	**Lizards**												
	C6.3	**F1.1**	**F4.8**	**F4.18**	**F5.4**	**F9.3**	**F10.5**	**F10.12**	**F18.2**	**F21.3**	**F21.8**	**F21.10**	**F26.1**	**F27.1**
Riparian Obligates	X													
Riparian Dependents														
Riparian Associates		X	X	X		X	X	X					X	X
Riparian Incidentals					X				X	X	X	X		
Herbivores														
Insectivores		X	X	X	X	X	X	X	X	X	X		X	
Carnivores				X		X								
Omnivores	X											X		X
Aquatic/Semi-aquatic	X													
Fossorial		X												
Surfacorial			X	X	X	X	X	X	X	X	X	X	X	X
Arboreal						X								
Aquatic Nesters														
Terrestrial Ground Nesters	X		X	X	X	X	X	X	X	X	X	X	X	
Terrestrial Vegetation Nesters														
Live Bearers		X												X
Conservation Priority	X	X						X	X	X				X
Introduced Species														

Table 20. Herp guild/group assignments for snake species historically occurring within the surveyed reaches of the San Jacinto watershed.

Herp Category	**Species Codes** Snakes																		
	G2.1	**G6.1**	**G13.4**	**G13.7**	**G13.12**	**G14.1**	**G22.1**	**G23.3**	**G23.6**	**G25.2**	**G26.1**	**G28.2**	**G28.3**	**G36.1**	**G39.1**	**G40.3**	**G47.8**	**G48.9**	**G49.1**
Riparian Obligates																		X	
Riparian Dependents									X										
Riparian Associates						X		X		X	X						X		
Riparian Incidentals	X	X	X	X	X		X					X	X	X	X	X			X
Herbivores																			
Insectivores						X				X		X	X	X			X		
Carnivores	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X
Omnivores																			
Aquatic/Semi-aquatic																		X	
Fossorial	X					X				X					X		X		
Surfacorial		X	X	X	X	X	X	X	X		X	X	X	X	X	X			X
Arboreal																X			
Aquatic Nesters																			
Terrestrial Ground Nesters	X					X	X	X	X	X		X	X	X	X	X	X		X
Terrestrial Vegetation Nesters																			
Live Bearers		X	X	X	X						X							X	
Conservation Priority		X	X			X		X	X		X			X		X		X	
Introduced Species																			

Table 21. Cumulative herp species richness for surveyed reaches of the San Jacinto Lowlands.

Herp Category	Lowland Reaches																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Total Herp Species	0	6	9	2	5	2	27	11	26	12	2	11	7	7	7	12	12	2	3	9	9
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	0	2	0	0	0	0	3	1	3	0	0	1	2	2	2	0	0	0	1	0	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	0	3	6	2	4	2	11	6	10	4	2	7	2	2	2	4	4	0	0	6	6
Snakes	0	1	3	0	1	0	13	4	13	7	0	3	3	3	3	7	7	2	2	3	3
Riparian Obligates	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0
Riparian Dependents	0	2	0	0	0	0	2	1	2	1	0	1	2	2	2	0	0	0	1	0	0
Riparian Associates	0	3	3	1	2	1	11	2	10	3	1	2	1	1	1	3	3	0	0	5	5
Riparian Incidentals	0	1	6	1	3	1	14	8	13	8	1	8	4	4	4	8	8	2	2	4	4
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	0	6	5	2	4	1	17	8	16	4	2	8	6	6	6	4	6	1	2	5	5
Carnivores	0	1	4	0	2	0	15	5	13	7	0	5	3	3	3	7	7	2	2	5	5
Omnivores	0	0	1	0	1	1	2	1	2	2	0	0	0	0	0	2	2	0	0	1	1
Aquatic/Semi-aquatic	0	1	0	0	0	0	1	0	1	1	0	0	1	1	1	1	1	0	1	0	0
Fossorial	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	1	1	0	0	0	0
Surfacorial	0	6	9	2	5	2	24	11	22	10	2	11	7	7	7	10	10	2	3	9	9
Arboreal	0	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	1	0	0	0	0
Aquatic Nesters	0	2	0	0	0	0	3	2	3	0	0	1	2	2	2	0	0	0	1	0	0
Terrestrial Ground Nesters	0	4	7	2	5	2	20	8	19	9	2	9	4	4	4	9	9	1	1	7	7
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	0	0	2	0	0	0	5	1	4	3	0	1	1	1	1	3	3	1	1	2	2
Conservation Priority	0	0	2	1	1	0	9	3	7	6	0	3	1	1	1	6	6	1	1	4	4
Introduced Species	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 22. Cumulative herp species richness for surveyed reaches of the San Jacinto Badlands.

Herp Category	Badland Reaches																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Total Herp Species	12	11	12	12	12	4	5	5	5	10	11	10	8	10	10	9	10	6	6	1	6	6	1	2
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	3	2	3	3	3	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	3	3	3	3	3	1	0	0	0	3	4	3	2	3	4	3	4	3	3	1	3	3	1	2
Snakes	6	6	6	6	6	3	4	4	4	6	6	6	5	6	6	6	6	3	3	0	3	3	0	0
Riparian Obligates	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Riparian Dependents	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riparian Associates	3	3	3	3	3	2	1	1	1	3	4	3	3	3	4	4	5	3	3	0	3	3	0	1
Riparian Incidentals	6	6	6	6	6	2	3	3	3	6	6	6	4	6	6	5	5	3	3	1	3	3	1	1
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	9	8	9	9	9	2	3	3	3	9	10	9	7	9	9	9	9	5	5	1	5	5	1	2
Carnivores	8	7	8	8	8	3	5	5	5	5	5	5	4	5	4	2	5	4	4	0	4	4	0	0
Omnivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic/Semi-aquatic	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Fossorial	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2	2	2	1	1	0	1	1	0	0
Surfacorial	11	11	11	11	11	4	4	4	4	7	8	7	5	7	8	7	8	5	5	1	5	5	1	2
Arboreal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic Nesters	3	2	3	3	3	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
Terrestrial Ground Nesters	8	8	8	8	8	4	3	3	3	8	9	8	6	8	9	8	9	5	5	1	5	5	1	2
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0
Conservation Priority	3	3	3	3	3	2	3	3	3	3	3	3	1	3	3	3	3	2	2	0	2	2	0	0
Introduced Species	1	0	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0

Table 23. Cumulative herp species richness for surveyed reaches of the San Jacinto Mountains.

Herp Category	Mountain Reaches																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Total Herp Species	14	0	0	0	0	11	4	5	14	11	0	9	10	0	0	13	0	8	10	11	9	2	4	8	19	19	17	11
Salamanders	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	1	0	0
Frogs/Toads	2	0	0	0	0	4	0	1	0	0	0	2	4	0	0	2	0	2	2	0	0	0	0	0	3	3	2	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	7	0	0	0	0	3	1	1	8	7	0	5	3	0	0	7	0	4	6	6	6	2	0	3	7	7	6	7
Snakes	4	0	0	0	0	4	3	3	5	4	0	2	3	0	0	2	0	1	1	5	3	0	4	5	8	8	9	4
Riparian Obligates	1	0	0	0	0	1	0	0	1	1	0	0	1	0	0	2	0	1	1	1	0	0	1	1	1	1	1	1
Riparian Dependents	2	0	0	0	0	4	0	1	0	0	0	2	4	0	0	2	0	1	1	0	0	0	0	0	4	4	3	0
Riparian Associates	5	0	0	0	0	1	1	1	6	3	0	1	1	0	0	4	0	1	3	3	3	0	2	3	6	6	6	3
Riparian Incidentals	6	0	0	0	0	5	3	3	7	7	0	6	4	0	0	5	0	5	5	7	6	2	1	4	8	8	7	7
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	11	0	0	0	0	8	2	3	10	8	0	8	8	0	0	9	0	6	7	7	8	1	3	5	12	12	12	8
Carnivores	5	0	0	0	0	4	3	3	7	6	0	2	3	0	0	3	0	1	2	7	5	0	2	3	10	10	9	6
Omnivores	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	2	0	1	2	1	0	1	0	1	1	1	0	1
Aquatic/Semi-aquatic	1	0	0	0	0	2	0	0	1	1	0	0	2	0	0	2	0	1	1	1	0	0	1	1	1	1	1	1
Fossorial	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	2	1	1	3	0
Surfacorial	12	0	0	0	0	10	4	5	13	10	0	9	9	0	0	11	0	7	9	10	9	2	1	5	18	18	14	10
Arboreal	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	1	1	0	0	0	1	1	1	1
Aquatic Nesters	1	0	0	0	0	4	0	1	0	0	0	2	4	0	0	3	0	2	2	0	0	0	0	0	3	3	2	0
Terrestrial Ground Nesters	12	0	0	0	0	4	2	2	12	4	0	7	4	0	0	7	0	5	6	8	8	2	3	6	12	12	13	9
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	1	0	0	0	0	3	2	2	2	2	0	0	2	0	0	3	0	1	2	3	1	0	1	2	4	4	2	2
Conservation Priority	7	0	0	0	0	6	3	4	6	4	0	5	5	0	0	7	0	4	5	3	3	0	2	4	9	9	7	4
Introduced Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 24. Cumulative herp species richness for surveyed reaches of the San Jacinto Foothills.

Herp Category	Foothill Reaches																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
Total Herp Species	12	12	5	5	4	11	12	2	7	7	15	9	4	1	14	11	8	16	5	3	0	11	13	5	2	5	15	5	10
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	1	1	1	1	1	3	4	0	3	1	2	2	0	0	4	1	1	5	0	0	0	3	3	0	0	0	4	1	4
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	7	7	1	1	1	3	3	1	3	2	7	2	2	1	6	7	3	6	3	2	0	3	7	3	1	3	8	1	3
Snakes	4	4	3	3	2	5	5	1	1	4	6	5	2	0	4	3	4	5	2	1	0	5	3	2	1	2	3	3	3
Riparian Obligates	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Riparian Dependents	1	1	1	1	1	3	4	0	3	1	2	2	0	0	4	1	1	5	0	0	0	3	3	0	0	0	4	1	4
Riparian Associates	6	6	1	1	1	2	2	1	1	3	7	3	2	0	4	5	3	5	3	1	0	2	5	2	0	2	5	1	2
Riparian Incidentals	5	5	3	3	2	5	5	1	2	3	7	4	2	1	6	5	4	6	2	2	0	5	5	3	2	3	6	3	4
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	7	7	3	3	2	7	8	2	6	4	9	5	2	1	12	9	6	13	2	3	0	8	11	2	0	3	12	3	8
Carnivores	4	4	3	3	2	5	5	1	1	4	9	6	2	0	6	6	2	7	2	1	0	3	5	2	1	2	6	3	3
Omnivores	2	2	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	2	0	0	1	1	2	1	1	0	0	0
Aquatic/Semi-aquatic	0	0	0	0	0	2	2	0	1	0	0	0	0	0	1	0	1	1	0	0	0	2	0	0	0	0	1	0	1
Fossorial	1	1	0	0	0	1	0	0	1	1	1	1	1	0	0	0	2	0	0	0	0	2	0	1	1	1	0	0	0
Surfacorial	12	12	5	5	4	10	11	2	6	7	15	9	4	1	14	11	6	16	5	3	0	8	13	5	2	5	15	5	10
Arboreal	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0	1	0	0
Aquatic Nesters	1	1	1	1	1	3	4	0	3	1	2	2	0	0	4	2	1	4	0	0	0	3	3	0	0	0	4	1	4
Terrestrial Ground Nesters	8	8	2	2	1	5	4	2	3	3	9	3	3	1	8	8	6	9	3	3	0	6	9	3	2	4	9	2	4
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Live Bearers	3	3	2	2	2	3	4	0	1	3	4	4	1	0	2	1	1	3	2	0	0	2	1	1	0	1	2	2	2
Conservation Priority	6	6	4	4	3	5	7	2	3	6	7	7	1	1	5	3	3	6	4	3	0	5	4	1	0	2	4	4	5
Introduced Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 25. Percent species richness of herp categories in surveyed reaches of the San Jacinto Lowlands

Herp Category	Lowland Reaches																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Total Herp Species	0	6	9	2	5	2	27	11	26	12	2	11	7	7	7	12	12	2	3	9	9
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	0	33	0	0	0	0	11	9	12	0	0	9	29	29	29	0	0	0	33	0	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	8	8	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	0	50	67	100	80	100	41	55	38	33	100	64	29	29	29	33	33	0	0	67	67
Snakes	0	17	33	0	20	0	48	37	50	58	0	27	43	43	43	58	58	100	67	33	33
Riparian Obligates	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	8	8	0	0	0	0
Riparian Dependents	0	33	0	0	0	0	7	9	8	8	0	9	29	29	29	0	0	0	33	0	0
Riparian Associates	0	50	33	50	40	50	41	18	38	25	50	18	14	14	14	25	25	0	0	56	56
Riparian Incidentals	0	17	67	50	60	50	56	73	50	67	50	73	57	57	57	67	67	100	67	44	44
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	0	100	56	100	80	50	62	73	62	33	100	73	86	86	86	50	50	50	67	56	56
Carnivores	0	17	44	0	40	0	56	45	50	58	0	45	43	43	43	58	58	100	67	56	56
Omnivores	0	0	11	0	20	50	7	9	8	17	0	0	0	0	0	17	17	0	0	11	11
Aquatic/Semi-aquatic	0	17	0	0	0	0	4	0	4	8	0	0	14	14	14	8	8	0	33	0	0
Fossorial	0	0	0	0	0	0	15	0	15	0	0	0	0	0	0	8	8	0	0	0	0
Surfacorial	0	100	100	100	100	100	89	100	85	83	100	100	100	100	100	83	83	100	100	100	100
Arboreal	0	0	0	0	20	0	4	0	4	8	0	0	0	0	0	8	8	0	0	0	0
Aquatic Nesters	0	33	0	0	0	0	11	18	12	0	0	9	29	29	29	0	0	0	33	0	0
Terrestrial Ground Nesters	0	67	78	100	100	100	74	73	73	75	100	82	57	57	57	75	75	50	33	78	78
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	0	0	22	0	0	0	19	9	15	25	0	9	14	14	14	25	25	50	33	22	22
Conservation Priority	0	0	22	50	20	0	33	27	27	50	0	27	14	14	14	50	50	50	33	44	44
Introduced Species	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0

Table 26. Percent species richness of herp categories in surveyed reaches of the San Jacinto Badlands

Herp Category	Badland Reaches																							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Total Herp Species	12	11	12	12	12	4	5	5	5	10	11	10	8	10	10	9	10	6	6	1	6	6	1	2
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	25	18	25	25	25	0	20	20	20	10	9	10	13	10	0	0	0	0	0	0	0	0	0	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	25	27	25	25	25	25	0	0	0	30	36	30	25	30	40	33	40	50	50	100	50	50	100	100
Snakes	50	55	50	50	50	75	80	80	80	60	55	60	63	60	60	67	60	50	50	0	50	50	0	0
Riparian Obligates	8	0	8	8	8	0	20	20	20	10	9	10	13	10	0	0	0	0	0	0	0	0	0	0
Riparian Dependents	17	18	17	17	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riparian Associates	25	27	25	25	25	50	20	20	20	30	36	30	38	30	40	44	50	50	50	0	50	50	0	50
Riparian Incidentals	50	55	50	50	50	50	60	60	60	60	55	60	50	60	60	56	50	50	50	100	50	50	100	50
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	75	73	75	75	75	50	60	60	60	90	91	90	88	90	90	100	90	83	83	100	83	83	100	100
Carnivores	67	64	67	67	67	75	100	100	100	50	45	50	50	50	40	22	50	67	67	0	67	67	0	0
Omnivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic/Semi-aquatic	8	0	8	8	8	0	20	20	20	10	9	10	13	10	0	0	0	0	0	0	0	0	0	0
Fossorial	0	0	0	0	0	0	0	0	0	20	18	20	25	20	20	22	20	17	17	0	17	17	0	0
Surfacorial	92	100	92	92	92	100	80	80	80	70	73	70	63	70	80	78	80	83	83	100	83	83	100	100
Arboreal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic Nesters	25	18	25	25	25	0	20	20	20	10	9	10	13	10	0	0	0	0	0	0	0	0	0	0
Terrestrial Ground Nesters	67	73	67	67	67	100	60	60	60	80	82	80	75	80	90	89	90	83	83	100	83	83	100	100
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	8	9	8	8	8	0	20	20	20	10	9	10	13	10	10	11	10	17	17	0	17	17	0	0
Conservation Priority	25	27	25	25	25	50	60	60	60	30	27	30	13	30	30	33	30	33	33	0	33	33	0	0
Introduced Species	8	0	8	8	8	0	20	20	20	10	9	10	13	10	0	0	0	0	0	0	0	0	0	0

Table 27. Percent species richness of herp categories in surveyed reaches of the San Jacinto Mountains

Herp Category	Mountain Reaches																											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Total Herp Species	14	0	0	0	0	11	4	5	14	11	0	9	10	0	0	13	0	8	10	11	9	2	4	8	19	19	17	11
Salamanders	7	0	0	0	0	0	0	0	7	0	0	0	0	0	0	8	0	13	10	0	0	0	0	0	5	5	0	0
Frogs/Toads	14	0	0	0	0	36	0	20	0	0	0	22	40	0	0	15	0	25	20	0	0	0	0	0	16	16	12	0
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	50	0	0	0	0	27	25	20	57	7	0	56	30	0	0	54	0	50	60	55	67	100	0	38	37	37	35	64
Snakes	29	0	0	0	0	36	75	60	36	4	0	22	30	0	0	15	0	13	10	45	33	0	100	63	42	42	53	36
Riparian Obligates	7	0	0	0	0	9	0	0	7	1	0	0	10	0	0	15	0	13	10	9	0	0	25	13	5	5	6	9
Riparian Dependents	14	0	0	0	0	36	0	20	0	0	0	22	40	0	0	15	0	13	10	0	0	0	0	0	21	21	18	0
Riparian Associates	36	0	0	0	0	9	25	20	43	3	0	11	10	0	0	31	0	13	30	27	33	0	50	38	31	31	35	27
Riparian Incidentals	43	0	0	0	0	45	75	60	50	7	0	67	40	0	0	38	0	63	50	64	67	100	25	50	42	42	41	64
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	79	0	0	0	0	73	50	60	71	8	0	89	80	0	0	69	0	75	70	64	89	50	75	63	63	63	71	73
Carnivores	36	0	0	0	0	36	75	60	50	6	0	22	30	0	0	23	0	13	20	64	56	0	50	38	53	53	53	55
Omnivores	7	0	0	0	0	0	0	0	7	1	0	11	0	0	0	15	0	13	20	9	0	50	0	13	5	5	0	9
Aquatic/Semi-aquatic	7	0	0	0	0	18	0	0	7	1	0	0	20	0	0	15	0	13	10	9	0	0	25	13	5	5	6	9
Fossorial	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	50	25	5	5	18	0
Surfacorial	86	0	0	0	0	91	100	100	93	10	0	100	90	0	0	85	0	88	90	91	100	100	25	63	95	95	82	91
Arboreal	0	0	0	0	0	0	0	0	7	1	0	0	0	0	0	8	0	0	10	9	11	0	0	0	5	5	6	9
Aquatic Nesters	7	0	0	0	0	36	0	20	0	0	0	22	40	0	0	23	0	25	20	0	0	0	0	0	16	16	12	0
Terrestrial Ground Nesters	86	0	0	0	0	36	50	40	86	4	0	78	40	0	0	54	0	63	60	73	89	100	75	75	63	63	76	82
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Live Bearers	7	0	0	0	0	27	50	40	14	2	0	0	20	0	0	23	0	13	20	27	11	0	25	25	21	21	12	18
Conservation Priority	50	0	0	0	0	55	75	80	43	4	0	56	50	0	0	54	0	50	50	27	33	0	50	50	47	47	41	36
Introduced Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 28. Percent species richness of herp categories in surveyed reaches of the San Jacinto Foothills

Herp Category	Foothill Reaches																												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
Total Herp Species	12	12	5	5	4	11	12	2	7	7	15	9	4	1	14	11	8	16	5	3	0	11	13	5	2	5	15	5	10
Salamanders	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Frogs/Toads	8	8	20	20	25	27	33	0	43	14	13	22	0	0	29	9	13	31	0	0	0	27	23	0	0	0	27	20	40
Turtles/Tortoises	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crocodilians	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lizards	58	58	20	20	25	27	25	50	43	29	47	22	50	100	43	64	38	38	60	67	0	27	54	60	50	60	53	20	30
Snakes	33	33	60	60	50	45	42	50	14	57	40	56	50	0	29	27	50	31	40	33	0	45	23	40	50	40	20	60	30
Riparian Obligates	0	0	0	0	0	9	8	0	14	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0
Riparian Dependents	8	8	20	20	25	27	33	0	43	14	13	22	0	0	29	9	13	31	0	0	0	27	23	0	0	0	27	20	40
Riparian Associates	50	50	20	20	25	18	17	50	14	43	47	33	50	0	29	45	38	31	60	33	0	18	38	40	0	40	33	20	20
Riparian Incidentals	42	42	60	60	50	45	42	50	29	43	47	44	50	100	43	45	50	38	40	67	0	45	38	60	100	60	40	60	40
Herbivores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insectivores	58	58	60	60	50	64	67	100	86	57	60	56	50	100	86	82	75	81	40	100	0	73	85	40	0	60	80	60	80
Carnivores	33	33	60	60	50	45	42	50	14	57	60	67	50	0	43	55	25	44	40	33	0	27	38	40	50	40	40	60	30
Omnivores	17	17	0	0	0	0	0	0	0	14	7	0	25	0	0	0	13	0	40	0	0	9	8	40	50	20	0	0	0
Aquatic/Semi-aquatic	0	0	0	0	0	18	17	0	14	0	0	0	0	0	7	0	13	6	0	0	0	18	0	0	0	0	7	0	10
Fossorial	8	8	0	0	0	9	0	0	14	14	7	11	25	0	0	0	25	0	0	0	0	18	0	20	50	20	0	0	0
Surfacorial	100	100	100	100	100	91	92	100	86	100	100	100	100	100	100	100	75	100	100	100	0	73	100	100	100	100	100	100	10
Arboreal	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7	9	0	6	0	0	0	0	8	0	0	0	7	0	0
Aquatic Nesters	8	8	20	20	25	27	33	0	43	14	13	22	0	0	29	18	13	25	0	0	0	27	23	0	0	0	27	20	40
Terrestrial Ground Nesters	67	67	40	40	25	45	33	100	43	43	60	33	75	100	57	73	75	56	60	100	0	55	69	60	100	80	60	40	40
Terrestrial Vegetation Nesters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Live Bearers	25	25	40	40	50	27	33	0	14	43	27	44	25	0	14	9	13	19	40	0	0	18	8	20	0	20	13	40	20
Conservation Priority	50	50	80	80	75	45	58	100	43	86	47	78	25	100	36	27	38	38	80	100	0	45	31	20	0	40	27	80	50
Introduced Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Development of a Combined Bird/Herp IBI

Correlation coefficients between herp community metrics and the index to human disturbance of reaches were calculated for the combined Lowlands and Badlands reaches, and for the combined Foothills and Mountains reaches. Analyses were based on 85 reaches across all bioregions – the 95 reaches used in the analysis of bird data minus 10 reaches that had no herp records. As with the analysis of bird community metrics, higher correlations were achieved in the Lowlands and Badlands reaches, probably because of the limited number of highly impacted reaches in the Foothills and Mountains. For the Foothills and Mountains (n = 48), two correlations were significant but were very low: percent richness of obligate riparian species was negatively correlated with the disturbance score (r = -0.30, P = 0.036) and species richness of surfacorial species was positively correlated with disturbance level (r = 0.30, P = 0.039).

For the Lowlands and Badlands reaches (n = 37), 16 herp metrics were significantly correlated with the disturbance score (Table 29). Some of these correlations could not be explained easily (e.g., higher numbers of arboreal species in highly disturbed reaches?) and may have been due to small numbers of species in some guilds or groups, and the exaggerated effects of outliers. Visual examination of plots led to the selection of only two metrics for inclusion in the IBI – percent richness of omnivore species and percent richness of insectivores (Figure 22). These two metrics were not highly correlated with each other (r = -0.57), nor were they highly correlated with any of the previously selected bird metrics ($|r|$ < 0.80). The percentage of insectivorous herp species declined with increasing human disturbance of riparian reaches. Many amphibians and reptiles in the San Jacinto watershed are insectivorous (Tables 18-20). The decline in percentage richness of insectivores probably reflected the loss of microhabitat diversity for these species in highly developed reaches. The increase in percentage of omnivores with disturbance was due entirely to the presence of one or more of the three omnivorous species (i.e., Western Pond Turtle, Granite Spiny Lizard, and Granite Night Lizard) in relatively impacted Lowland reaches.

Herp-community metrics and metric scores were calculated for all 85 sampled reaches in the San Jacinto River watershed for which herp records were available (Table 30). For the percent richness of insectivores, a score of 1 was assigned if the metric was <45% and a score of 5 if the metric was $\geq$87.5%. Intermediate values were scored a 3. For the percent richness of omnivores, a metric value of 0% was assigned a 5, values $\geq$15% were assigned a 1, and intermediate values a 3. Combined bird/herp IBI values were calculated as the sum of metric scores for the seven bird metrics (Table 9) and two herp metrics. The maximum possible bird/herp IBI was 45 and the minimum possible was 9. Actual values ranged from 9 to 41 (Table 30). Highest values were mainly from relatively undeveloped Foothill, Mountain, and Badland reaches, and lowest values were from highly impacted Lowland reaches.

A plot of bird/herp IBI versus the disturbance score (Figure 23) showed good discrimination between highly disturbed and relatively undisturbed reaches, and the overall correlation was strong (r = -0.86). This correlation was reduced to r = -0.73 when Foothill and Mountain reaches were included (Figure 24).

Table 29. Correlation coefficients, listed in decreasing order of absolute value, between herp-community metrics and the disturbance score for Lowlands and Badlands reaches (n = 37).

Herp Metric	**Correlation (*r*)**	***P***
Omnivore species richness	0.77	<0.0001
Omnivores (% richness)[1]	0.69	<0.0001
Arboreal species richness	0.66	<0.0001
Arboreal species (% richness)	0.58	0.0002
Insectivores (% richness)	-0.55	0.0005
Lizard species richness	0.53	0.0008
Turtles (% richness)	0.45	0.0050
Turtle species richness	0.45	0.0050
Live-bearer species richness	0.45	0.0051
Surfacorial species richness	0.44	0.0062
Species of concern richness	0.38	0.0191
Herp species richness	0.38	0.0213
Terrestrial nester species richness	0.37	0.0249
Riparian incidental species richness	0.37	0.0255
Riparian associate species richness	0.35	0.0327
Exotic species (% richness)	-0.34	0.0374

[1]Metrics in bold type were selected for inclusion in the bird/herp IBI.

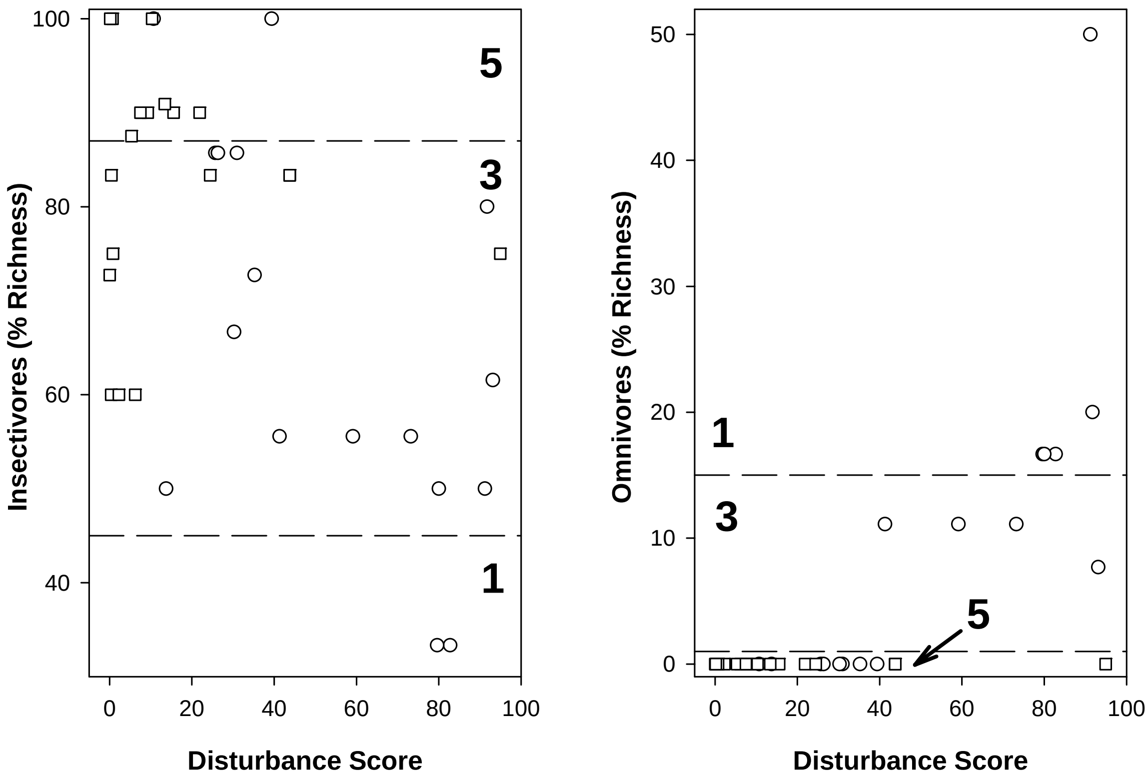


Figure 22. Plots of selected herp metrics versus the reach disturbance score for Lowlands (circles) and Badlands (squares) reaches (n = 37). Zones labeled 1, 3, and 5 indicate the scores for each metric that are summed, along with the seven selected bird metrics, in the bird/herp IBI.

Table 30. Herp-community metrics (based on historical records), metric scores, reach disturbance scores, and calculated bird/herp IBIs for sampled reaches in the San Jacinto River watershed.							
Reach Identifier	**Bioregion**	**Disturbance Score**	**Insectivores (% Richness)**		**Omnivores (% Richness)**		**Bird/Herp IBI**
			Metric	**Score**	**Metric**	**Score**	
BAUCK-14	Mountains	5.4	NA	NA	NA	NA	NA
BAUCK-12	Mountains	0.0	NA	NA	NA	NA	NA
BAUCK-11	Mountains	0.0	NA	NA	NA	NA	NA
BAUCK-T7A	Mountains	0.4	NA	NA	NA	NA	NA
BELL-2	Lowlands	81.9	NA	NA	NA	NA	NA
HERKEY-3	Mountains	1.6	NA	NA	NA	NA	NA
HERKEY-T2B	Mountains	0.0	NA	NA	NA	NA	NA
HERKEY-T2A	Mountains	0.0	NA	NA	NA	NA	NA
LION-1	Mountains	0.0	NA	NA	NA	NA	NA
SANDCYN-1	Foothills	0.0	NA	NA	NA	NA	NA
BLKBRN-4	Mountains	0.0	50.0	3	0.0	5	41
HIXON-1	Mountains	0.0	80.0	3	0.0	5	41
SFSJ-4	Mountains	0.0	75.0	3	0.0	5	41
BALA8-2	Badlands	13.4	90.9	5	0.0	5	39
BLKBRN-3	Mountains	0.0	60.0	3	0.0	5	39
CHOLLA-3	Foothills	0.5	85.7	3	0.0	5	39
FAIRVIEW-T1B	Foothills	1.4	55.6	3	0.0	5	39
HERKEY-2	Mountains	0.2	88.9	5	11.1	3	39
STRAWBERRY-1	Mountains	1.4	70.6	3	0.0	5	39
WASHBURN-1	Foothills	79.0	80.0	3	0.0	5	39
BALA8-T1A	Badlands	9.3	90.0	5	0.0	5	37
BLKBRN-1	Foothills	22.1	50.0	3	0.0	5	37
BROWN-T2A	Foothills	0.4	66.7	3	0.0	5	37
CASTILE-1	Foothills	0.0	100.0	5	0.0	5	37
EDEN-4	Badlands	10.3	100.0	5	0.0	5	37
INDIAN-6	Foothills	0.0	100.0	5	0.0	5	37
INDIAN-2	Foothills	0.8	85.7	3	0.0	5	37
INDIAN-8	Mountains	1.1	69.2	3	15.4	1	37
MELLOR-1	Mountains	0.0	75.0	3	12.5	3	37
MELLOR-T1B	Mountains	0.0	70.0	3	20.0	1	37
MORRIS-3	Mountains	2.2	63.6	3	9.1	3	37
POTRERO-6	Badlands	0.5	83.3	3	0.0	5	37
POTRERO-5	Badlands	24.5	83.3	3	0.0	5	37
POTRERO-T4B	Badlands	0.7	100.0	5	0.0	5	37
POTRERO-T5E	Mountains	0.4	88.9	5	0.0	5	37
SFSJ-3	Mountains	0.4	62.5	3	12.5	3	37
SJMS-04	Lowlands	30.2	66.7	3	0.0	5	37
APPLECYN-2	Mountains	1.9	78.6	3	7.1	3	35
AVERY-4	Foothills	2.4	58.3	3	16.7	1	35

Table 30. Cont.

Reach Identifier	Bioregion	Disturbance Score	Insectivores (% Richness)		Omnivores (% Richness)		Bird/Herp IBI
			Metric	Score	Metric	Score	
BAUCK-02	Foothills	48.7	60.0	3	0.0	5	35
BAUCK-04	Mountains	0.0	72.7	3	0.0	5	35
BALA2-T1A	Badlands	0.0	72.7	3	0.0	5	35
BALA5-4	Badlands	0.4	60.0	3	0.0	5	35
EDEN-3	Badlands	7.5	90.0	5	0.0	5	35
FAIRVIEW-4	Foothills	0.0	57.1	3	14.3	3	35
POPPET-T1A	Foothills	0.0	100.0	5	0.0	5	35
POTRERO-T4C	Badlands	0.2	100.0	5	0.0	5	35
SFSJ-1	Foothills	0.1	72.7	3	9.1	3	35
STJOHNS-T1A	Foothills	7.7	0.0	1	50.0	1	35
THOMAS-1	Mountains	0.0	72.7	3	9.1	3	35
XEROX-1	Foothills	3.0	60.0	3	0.0	5	35
XEROX-2	Foothills	0.0	80.0	3	0.0	5	35
BALA3-2	Badlands	0.8	75.0	3	0.0	5	33
BALA5-T1C	Badlands	6.2	60.0	3	0.0	5	33
BALA8-3	Badlands	15.5	90.0	5	0.0	5	33
BALA8-T1C	Badlands	7.8	90.0	5	0.0	5	33
BROWN-1	Foothills	0.8	63.6	3	0.0	5	33
CC-3	Lowlands	39.4	100.0	5	0.0	5	33
EDEN-T1B	Badlands	21.9	90.0	5	0.0	5	33
INDIAN-1	Foothills	1.5	81.8	3	0.0	5	33
ORCHARD-2	Foothills	48.9	81.3	3	0.0	5	33
STRAWBERRY-4	Mountains	43.6	63.2	3	5.3	3	33
AVERY-3	Foothills	18.9	58.3	3	16.7	1	31
BAUCK-02	Foothills	76.8	60.0	3	0.0	5	31
BALA6-1	Badlands	2.3	60.0	3	0.0	5	31
BALA8-T1D	Badlands	5.4	87.5	5	0.0	5	31
ELLIS-3	Lowlands	10.7	100.0	5	0.0	5	31
FAIRVIEW-1	Foothills	18.2	60.0	3	6.7	3	31
GARNER-T2A	Mountains	0.0	72.7	3	9.1	3	31
NFORK-1	Foothills	0.6	75.0	3	12.5	3	31
POTRERO-T5D	Mountains	0.0	50.0	3	50.0	1	31
SJMS-05	Lowlands	13.7	50.0	3	0.0	5	31
STRAWBERRY-5	Mountains	50.3	63.2	3	5.3	3	31
GOODHART-2	Foothills	0.4	50.0	3	25.0	1	29
POTRERO-T3A	Badlands	43.8	83.3	3	0.0	5	29
POTRERO-T2A	Badlands	43.8	83.3	3	0.0	5	29
RRCYN-T3A	Lowlands	25.7	85.7	3	0.0	5	29
RRCYN-T2A	Lowlands	26.3	85.7	3	0.0	5	29
STJOHNS-2	Foothills	33.3	40.0	1	40.0	1	29
FOBES-1	Mountains	0.0	71.4	3	7.1	3	27

Table 30. Cont.

Reach Identifier	Bioregion	Disturbance Score	Insectivores (% Richness)		Omnivores (% Richness)		Bird/Herp IBI
			Metric	Score	Metric	Score	
RCC-3	Lowlands	35.2	72.7	3	0.0	5	27
SJMS-14	Foothills	64.2	84.6	3	7.7	3	27
BALA2-1	Badlands	94.9	75.0	3	0.0	5	25
RRCYN-T4C	Lowlands	30.9	85.7	3	0.0	5	25
STJOHNS-1	Foothills	20.4	60.0	3	20.0	1	25
FS-3	Lowlands	91.7	80.0	3	20.0	1	21
STAFE-3	Lowlands	73.2	55.6	3	11.1	3	21
STAFE-2	Lowlands	41.3	55.6	3	11.1	3	21
DOMPKY-1	Lowlands	59.1	55.6	3	11.1	3	19
POPPET-1	Foothills	37.2	40.0	1	40.0	1	19
SJMS-06	Lowlands	80.0	50.0	3	16.7	1	19
HS-1	Lowlands	91.2	50.0	3	50.0	1	17
KITC-2	Lowlands	93.1	61.5	3	7.7	3	15
SJMS-07	Lowlands	79.6	33.3	1	16.7	1	15
PVSD-1	Lowlands	82.8	33.3	1	16.7	1	9

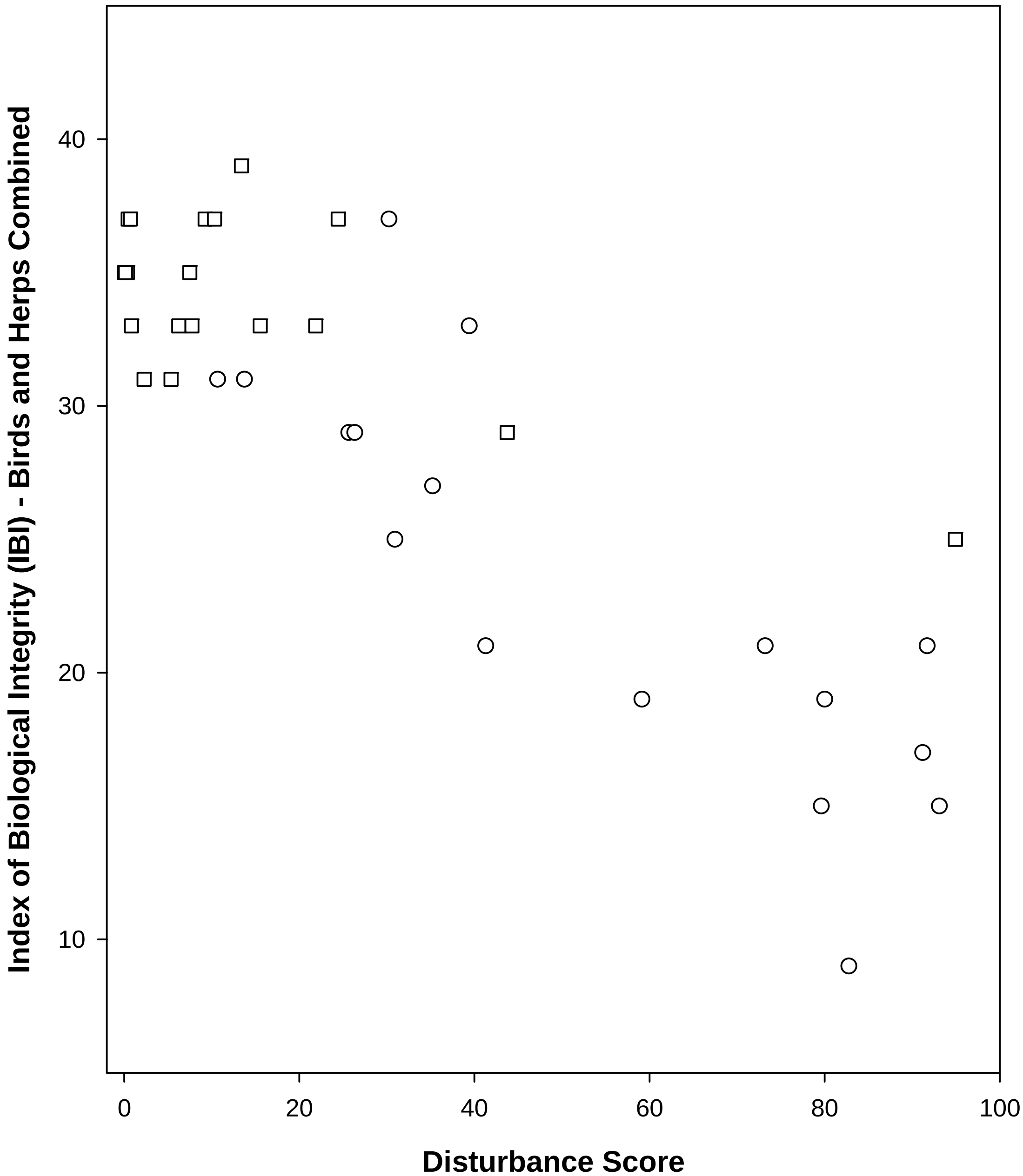


Figure 23. Plot of the bird/herp IBI versus the reach disturbance score (r = -0.86) for Lowland (circles) and Badland (squares) reaches (n = 37).

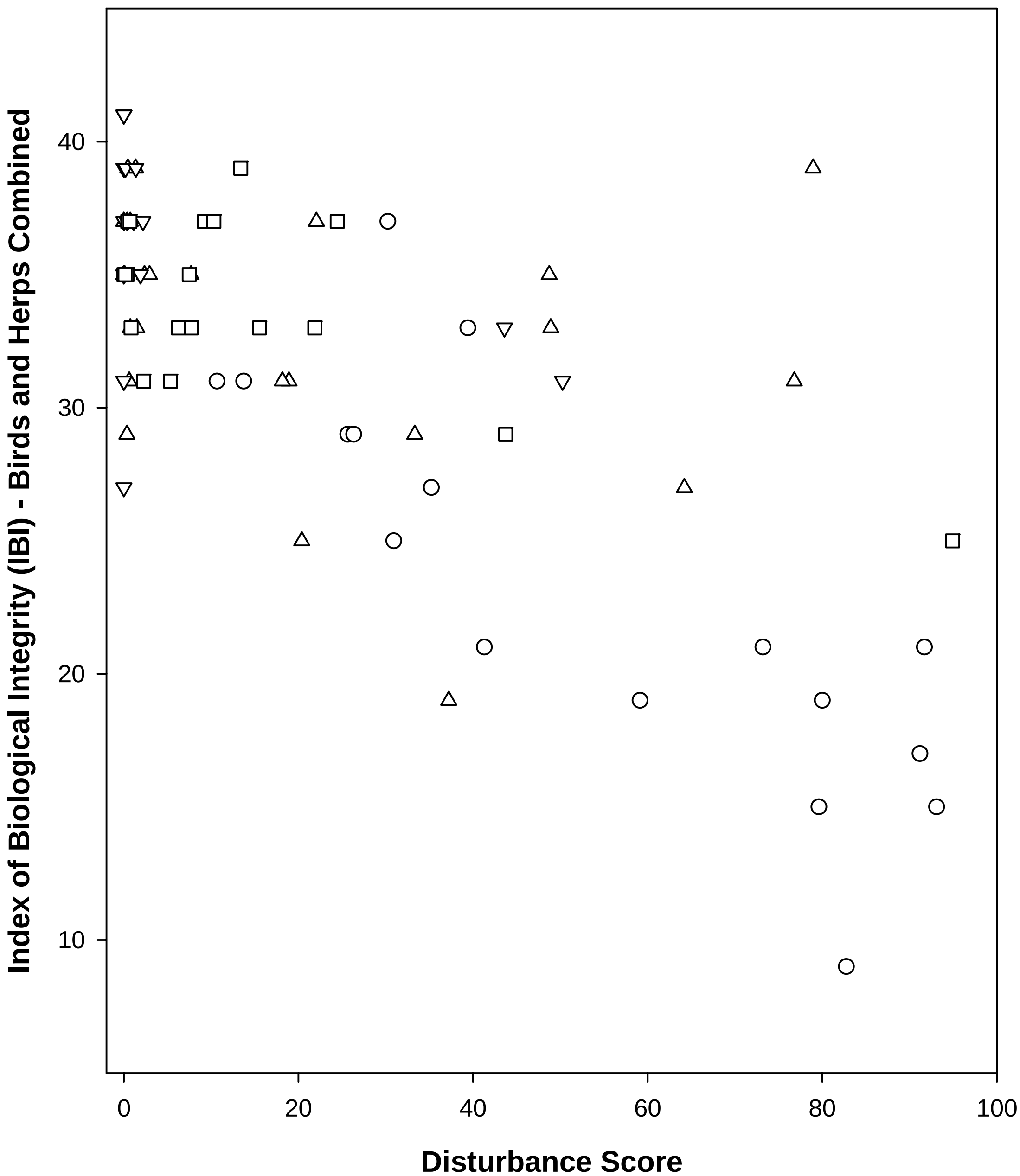


Figure 24. Plot of the bird/herp IBI versus the reach disturbance score (r = -0.73) for all Lowland (circles), Badland (squares), Foothill (triangles pointing up), and Mountain (triangles pointing down) reaches (n = 85).

DISCUSSION

Avian Studies

The search for bird-community metrics in this study that were potentially useful components of a riparian IBI echoed findings from previous studies of the effects of urbanization on avian communities. For example, McKinney (2002) reviewed the literature on changes in biotic communities along rural-to-urban gradients and noted that increasing urbanization often results in a decline in native species richness and an increase in the number and proportion of non-native species that may be better adapted to exploit human-altered environments. Fragmentation and loss of native plant communities, especially forests, can result in the loss of insectivores and other foliage gleaners, Neotropical migrants, and ground nesting species sensitive to human activity. Species that are able to adapt to high levels of human disturbance tend to be ground-foraging omnivores, granivores, and exploiters of cultivated crops and garbage (McKinney 2002).

In riparian reaches within the San Jacinto River watershed, the percentage of the bird community that consisted of species deemed to be of conservation concern declined with increasing levels of human disturbance. Species of concern included those listed as threatened or endangered on State of California or Federal lists, Bird Species of Special Concern identified by the California Department of Fish and Game, and Priority Species listed by Partners in Flight. Criteria used to prioritize species varied with the organization and purpose. In general, vulnerable-species designations were based on long-term declining population trends, initial rarity or limited distribution in the region, or dependence upon threatened habitat types (e.g., Carter et al. 2000). The demonstrated decline in species of concern with increasing human disturbance of riparian reaches simply confirmed the vulnerability of these species to widespread development and other human disturbance of the San Jacinto watershed. Percent richness of species of concern was, therefore, a strong metric for evaluating riparian ecosystem integrity.

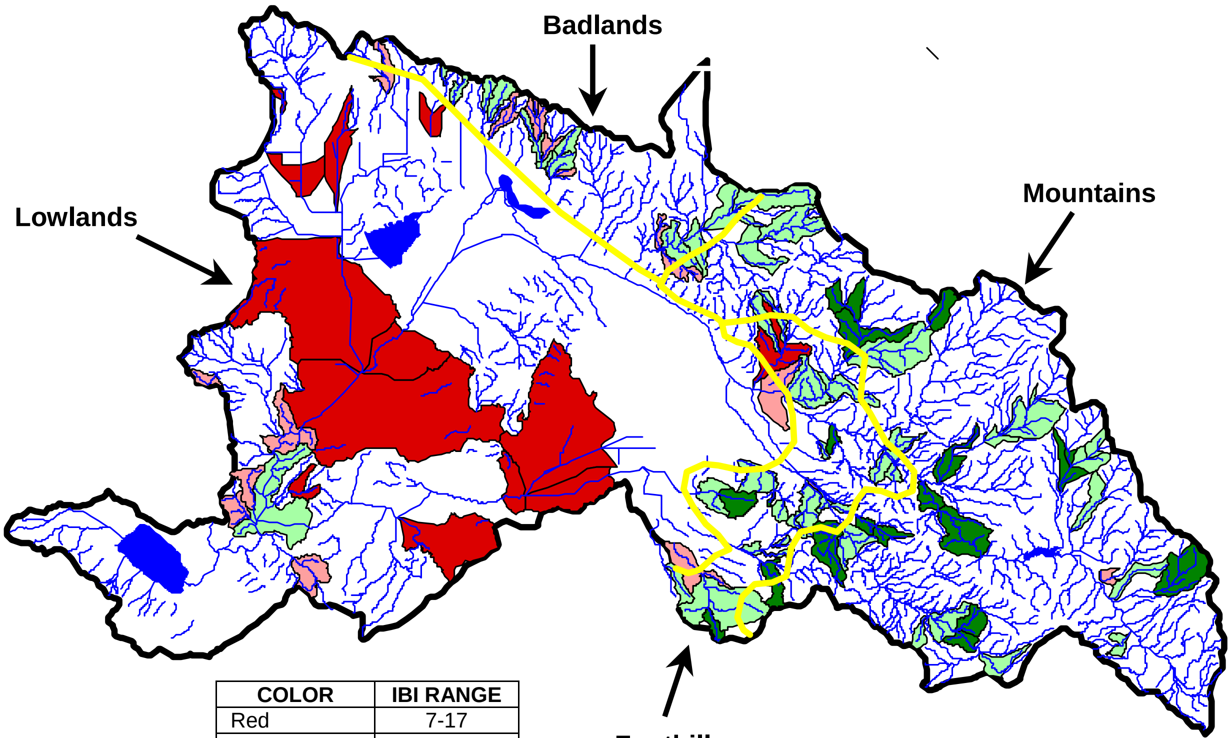
The increase in non-native, introduced species (i.e., House Sparrows, European Starlings, and Rock Doves) with disturbance in the watershed reflected their strong affinities for agricultural, suburban, and developed environments (McKinney 2002) and was another useful metric for assessing riparian integrity. Declines in overall native species richness, tree and shrub nesters, woody canopy foragers, and native cavity nesters likely reflected the fragmentation and loss of riparian woodlands and the general decline in habitat diversity in reaches dominated by humans. As a result, bird communities in these areas contained a larger proportion of ground-foraging omnivores and granivores, and fewer insectivores, than did less disturbed reaches.

In general, we found that riparian bird communities had the highest integrity and, therefore, were likely to be more similar to their unimpacted, presettlement condition, in the San Jacinto Mountains, Foothills, and some of the less disturbed Badlands reaches.

Lowlands reaches, where agricultural and urban development were greatest, had some of the lowest IBI scores and the most impacted bird communities (Figure 25). However, IBI was sensitive to variations in community integrity within bioregions. For example, the Strawberry Creek drainage through the community of Idyllwild scored lower than most of the undeveloped drainages in the Mountains bioregion, and the rapidly urbanizing Poppet Creek drainage achieved the lowest IBI of any Foothills reach. Within the Badlands, some of the lowest integrity scores were in reaches that were heavily used by people and recreational vehicles. In the highly developed Lowlands bioregion, IBI scores were uniformly low. The exception was the San Jacinto River in the vicinity of Railroad Canyon Reservoir. This reach was sampled above the lake, thus avoiding the area of greatest suburban development adjacent to the reservoir.

Some bird-community metrics that we ultimately did not select to be part of the IBI were metrics that we predicted *a priori* were likely to be important. For example, none of the potential metrics based on migratory status (e.g., species richness of Neotropical migrants) was significantly correlated with the reach disturbance score. Apparently, migratory status by itself did not make some species more vulnerable to human activity than others. Instead, vulnerability was related more to the species' functional roles in the community, as reflected in foraging and nesting guilds. Only one metric based on Rich's (2002) designations of riparian dependency (i.e., % abundance of riparian obligates and dependents combined) was significantly related to the reach disturbance score. However, the correlation coefficient was so low (r = -0.38) that inclusion of the metric in the IBI simply reduced its overall correlation with the disturbance score. Therefore, the metric was not included in the final bird IBI.

Bryce et al. (2002) used similar techniques to develop an IBI based on bird community composition for 13 riparian reaches in the Willamette Valley of Oregon. Their final IBI consisted of 13 metrics, including some that were also important in the San Jacinto watershed. Metrics that were negatively correlated with a reach disturbance index included native species richness, number of Neotropical migrant species, % warbler species, % insectivore species, number of native cavity nesters, number of foliage gleaning species, and number of "intolerant" individuals. Metrics that were positively correlated with disturbance included % omnivore or granivore species, % ground gleaning species, and % "tolerant" species. Intolerant species were those in decline or otherwise vulnerable to human impacts, similar to the species of conservation concern used in the San Jacinto study. Tolerant species included House Sparrows, Starlings, and Rock Doves as well as a number of native species that may have benefited from human activities (e.g., American Goldfinch, Brown-headed Cowbird).



COLOR	IBI RANGE
Red	7-17
Pink	18-23
Light green	24-30
Dark green	31-35

Figure 25. Spatial distribution of bird IBI scores across the San Jacinto River watershed. For display purposes, the entire local drainage of each sampled reach is highlighted (n = 95). Color categories are arbitrary and are only intended to show where relatively high and low values of the integrity index were determined. Bioregion boundaries are shown in yellow. See Table 9 for a complete data listing.

O'Connell et al. (2000) took a somewhat different approach to develop an IBI-like index based on the proportion of bird species in 16 behavioral and physiological guilds at 34 sites in central Pennsylvania. They then used the index to assess the condition of 126 sites across the central Appalachian region. Bird guilds selected for the index included functional guilds (e.g., ground gleaners, upper canopy foragers), compositional guilds (e.g., exotic species, resident species), and structural guilds (e.g., canopy nesters, forest generalists).

Our bird IBI formulation was based on community-level metrics that reflected the taxon richness, trophic structure, and behavioral diversity of riparian bird communities. Such metrics are likely to be more stable both temporally and geographically than metrics based on indicator species whose populations may vary greatly from year to year (Karr and Chu 1999). We used ANOVA to check for differences in the behavior of our IBI across bioregions, and found no reason to develop separate IBI formulations for different portions of the San Jacinto watershed. This is an important advantage for biologists and regulators who need only use a single IBI formula across the entire watershed. However, reaches with significant human impacts were relatively uncommon in the Foothills and Mountains bioregions, making ecological dose-response relationships difficult to assess and contributing to the variability seen in plots of IBI versus reach disturbance scores. To assure its reliability, the IBI formula we developed for the San Jacinto watershed needs to be tested in another similar watershed, such as the Santa Margarita watershed to the south.

Our disturbance score likely failed to capture some kinds of human activity that had measurable impacts on bird communities, which provided another source of variability in the plots. The reach disturbance score was based on land-use/land-cover information at two spatial scales – the local drainage of the riparian reach and the area within 100 m of each bird sampling point – and reflected the percentage of the area in agricultural, urban, and developed land uses. In general, low disturbance scores were shown to be associated with high values of the IBI. However, several Badlands reaches that had been given low disturbance scores (e.g., BALA6-1, BALA8-T1C, BALA8-T1D) also had lower than expected bird IBIs. These reaches were heavily impacted by off-road vehicles, a form of disturbance that was not reflected in the reach disturbance score. However, the IBI, which integrates the effects of multiple stressors on biological communities (Karr and Chu 1999), gave each reach an appropriately reduced integrity index.

IBI is specifically designed to assess human impacts (Karr and Chu 1999) but natural variability, such as vegetation development following a fire, can also affect the value of the index, at least temporarily. Arid-land riparian systems are especially prone to low-frequency, high-discharge flooding events that may remove woody cover and alter sediment distributions within the floodplain (Goodwin et al. 1997, National Research Council 2002). Changes in habitats as a result of catastrophic natural events may depress the IBI in the same way that human activities do. Knowledge of recent natural events and the presence or absence of direct indicators of human disturbance (e.g., agricultural or urban land uses, roads, off-road vehicle damage) can be used to distinguish between natural and human-caused changes in IBI.

Herpetofaunal Studies

The majority of North American reptiles and amphibians are functionally tied to riparian or wetland habitats either as obligate or seasonal inhabitants. Anthropogenic factors have been implicated in many of the reported declines and extinctions of herp populations (Bury and Busack 1974, Barclay 1980, Szaro et al. 1985, Vickers et al. 1985, Bury and Corn 1988, Jones 1988; Blaustein and Wake 1990, 1995; Pechmann et al. 1991, Livermore 1992, Wigley and Roberts 1994). One problem with documenting herpetofaunal declines is that for most regions and species, there are few or no historical data with which to compare. A second problem is that amphibian and reptile populations fluctuate and environmental conditions vary (e.g., wet years favor reproduction whereas droughts do not). What may look like an extirpation of a species could instead be a temporary absence because of hibernation or dormancy. Therefore, species richness for a given area is best determined by compiling the most comprehensive list of historical records possible. This study was unusually fortunate to have access to an assimilated, long-term database of herpetofaunal records for the watershed area.

Both macrohabitat and microhabitat features are important determinants of herp activity in an area. The xeric conditions, rocky terrain, and vegetation composition of the sampling areas in the San Jacinto River watershed generally provided habitat more suitable for lizards and snakes than amphibian species. The distribution and abundance of certain herpetofaunal species in wetland ecosystems is controlled by several macrohabitat factors including wetland size and location, relationship to adjacent terrestrial and aquatic systems, flooding regime, water quality, substrate, and vegetation structure (Pianka 1966, Clark 1979, Jones 1981). Stream size determines the characteristics of the adjacent riparian zone and associated wildlife (Bury 1988). Along small headwaters, the herpetofauna consists primarily of amphibians. As creeks and streams become larger, both amphibians and reptiles may co-exist. Reptiles are found mostly along larger streams and rivers. Habitat structure is also known to influence amphibian and reptilian community structure. Higher abundance of amphibians and reptiles is found in streamside zones associated with a closed canopy and abundant leaf litter (Dickson 1989, Rudolph and Dickson 1990).

Amphibians and reptiles are ectothermic; body temperatures are not derived from metabolic processes but rather from the surrounding environment. Therefore, behavioral adaptations and use of different microhabitats by amphibians and reptiles are diverse. Jones (1986) demonstrated that changes in microhabitats within a riparian ecosystem influences the distribution, abundance, and diversity of herpetofauna. Unaltered riparian ecosystems generally contain more abundant and diverse microhabitats, especially in regard to surface litter and trees. Herpetofauna are not nearly as common in riparian ecosystems with little surface litter and vegetation structure.

The most important factor affecting amphibian and reptile distribution and habitat use is horizontal and vertical habitat availability. Jones (1986) identified nine microhabitat components and attributes that are important determinants of amphibian and reptile abundance: lotic water, permanent lentic water, temporary lentic water, rock, plant litter and debris, live vegetation, dead vegetation, plant species, and soil. Microhabitat components are site-specific, physical entities that provide environmental conditions necessary for a wide variety of ecological functions such as reproduction, foraging, predator avoidance or escape, thermoregulation, and resting.

Litter (e.g., fallen logs, leaves), plant root structure, horizontal vegetation structure, substrate moisture, pH, and light intensity, as well as soil depth, texture, and diversity are critical elements for amphibians and reptiles to utilize an area. Thus, riparian reaches in the San Jacinto River watershed likely differ in herp abundance and diversity mainly due to natural and man-induced variations in macro- and microhabitat characteristics. Thus, herp abundance and community composition are potentially valuable indicators of habitat degradation and useful components of IBI, if appropriate data on herp use of riparian reaches is available. Appendix E discusses herp sampling techniques that can be employed if existing data are inadequate.

We used an existing database of herp collections and other distributional records (Beaman et al., in prep.) to estimate herp community composition in selected riparian reaches. Potential shortcomings of this database for our purposes included (1) the lack of consistent sampling effort across reaches and (2) the cumulative nature of the database, which may or may not reflect current herp distributions. As discussed previously for birds, the number of species detected in an area depends upon the level of effort expended in searching for them. Uneven sampling intensity could have affected estimates of species richness of herp groups and guilds in a reach, independent of human disturbance. More than half of the records in the database were accumulated during the 1950s, 1960s, and 1970s. Some cultural alteration of the watershed had undoubtedly occurred by then (e.g., widespread agricultural use, expanding towns) but the level of urban and suburban development is certainly greater today.

Only two herp-community metrics were selected for inclusion in a bird/herp IBI – percent richness of insectivores (negatively correlated with the disturbance score) and percent richness of omnivores (positively correlated with the disturbance score). Insectivore richness probably reflected overall macrohabitat and microhabitat diversity available to herps in each reach. Human activity tends to homogenize landscapes (Karr and Chu 1999), reducing the diversity of habitats and richness of herp communities. A higher proportion of omnivore species may have been due to the loss of other trophic groups (e.g., insectivores, carnivores, herbivores) or to environmental conditions that benefited the generalist omnivore species at the expense of specialists.

Conclusions and Recommendations

This study showed that IBI can be a useful tool for assessing and monitoring terrestrial ecosystems, just as it has proved to be for aquatic systems (Karr and Chu 1999). We identified several bird and herp metrics that were significantly associated with the level of human impact of riparian reaches in the San Jacinto watershed. The resulting IBI appeared to discriminate well between highly impacted and relatively pristine reaches. The next step is to test the IBI formulation with an independent data set derived by sampling additional reaches within the San Jacinto watershed or applying the same techniques in another similar watershed.

We believe that the further development and use of the riparian IBI can be simplified by focusing solely on birds. Little was gained by adding the two herp metrics to the seven metrics derived from bird sampling alone. In general, reaches that had high scores for the herp metrics also scored highly for birds. Furthermore, birds are more easily and efficiently sampled and, therefore, are more conducive to real-time monitoring of ecosystem integrity in a rapidly developing landscape. In contrast, a single estimate of herp community composition may require multiple sampling techniques and accumulation of data over a period of years (Appendix E), making routine monitoring difficult. Using existing herp distribution data for western Riverside County (Beaman et al., in prep.) was problematic due to the lack of consistent sampling effort across reaches. We could not tell whether low herp species richness in a particular reach was due to habitat degradation or an inadequate sample. Furthermore, this unusual database is unlikely to be available for other areas where the IBI might be applied or tested. Therefore, an IBI formulation based on birds alone is more likely to be transferable to other watersheds or other regions.

Although as yet untested, the bird-based IBI developed in this study may be useful immediately to assess the biological integrity of other riparian reaches in the San Jacinto watershed or in similar habitats in nearby watersheds. Investigators should follow the same sampling procedures used to develop the IBI. Experienced birders able to identify all species by sound or sight are essential. In each reach, the investigator should establish four sampling points spaced at 250-m intervals along the stream, beginning approximately 125 m from the downstream end of the reach, and sample all points using 5-minute, unlimited-distance point counts, twice during the spring and early summer. Bird metrics then can be calculated from the field data, scored as shown in this report, and summed to estimate the final IBI for that riparian reach.

IBI is a complete assessment tool that was developed originally to monitor temporal and spatial trends in the biological integrity of streams (Karr and Chu 1999). The bird-based IBI developed for riparian ecosystems in the San Jacinto River watershed also could be used directly to monitor changes in riparian integrity over time and as a result of specific human activities in the watershed. However, the approach may not be practical or cost effective in all situations due to the specialized personnel required, the need to sample twice at prescribed times of the year, and the need for foot access to nearly one full kilometer of each selected stream reach. Therefore, another important role for IBI is to serve as the standard of comparison for testing and validating more rapid, indicator-based assessment methods. The IBI derived in this study will be used to test the habitat-integrity index developed by Smith (2002) for southern California watersheds, which is based on habitat characteristics that are readily measured on site or estimated from aerial photography or GIS data. The goal is to improve the accuracy and reliability of the indicator-based method so that it can be used with confidence to monitor ecological changes in this rapidly developing region.

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APPENDIX A

Bird Sampling Protocol

San Jacinto River Watershed, Spring 2002

Bird Sampling Protocol

Sampling stations and general data collection:

1. Establish five sampling stations along a transect that follows on or near the centerline of the main channel of the stream in each randomly selected riparian reach.
2. Establish the first sampling point 125 m from the downstream end of the reach, and subsequent stations at 250-m intervals (total transect length is 1,125 m). The sampling scheme can be modified as needed to take advantage of secondary roads, trails, or other convenient access to the stream.
3. Record bioregion, reach name, sampling station number, GPS position, and downstream compass bearing for each station. The four bioregions can be denoted using '1' for Lowlands, '2' for San Jacinto Foothills, '3' for San Jacinto Mountains, and '4' for Badlands.
4. Other pertinent information to record: month, day, year, time of day, and visit number (1 or 2). Be sure to note the observer, the temperature if known, and describe the wind and sky conditions using the following codes:

   Wind:
   1) 0 - $\leq$ 2 mph.
   2) 1 - 2-5 mph.
   3) 2 - 5-10 mph
   4) 3 - 10-20 mph.
   5) 4 - $\geq$ 20 mph.

   Sky:
   1) 0 - Clear
   2) 1 - Partly cloudy
   3) 2 - Cloudy (broken or overcast)
   4) 3 - Drizzle or light rain
   5) 4 - Intermittent showers or rain

Bird counts:

5. During the breeding season (mid-March to late May), count all birds seen or heard at each station using a 5-minute, unlimited-distance point count.
6. Divide the count into 3 and 5 minute intervals by noting a superscript ^{1}for birds detected during the first 3 minutes, and ^{2}for birds detected between 3 and 5 minutes.
7. Denote on the 'bull's eye' data form the estimated distance band where each bird was located. Use 4-letter AOU bird codes to denote each species detected. In front of each code, note the number of individuals detected if more than 1. The small circle represents a 25-m distance band and the large circle represents a 50-m distance band. All birds outside of 50 m should be noted outside of the large circle. Flyovers should be noted in the space provided at the bottom of the data sheet.

8. Sample each reach and sampling station twice, once during March-April and again during April-May.
9. Perform point counts during the first 4 hours after sunrise.

Supplementary habitat characteristics:

10. For each sampling station, record 5 pertinent habitat characteristics by writing or circling the character that best describes the conditions. Responses to all 5 habitat characteristics should take less than 1 minute.
11. Riparian Width: Estimate to the nearest 1 m the width of the riparian zone where the bird surveys are being conducted.
12. For the next 3 characteristics (Dominant Vegetation, Vertical Cover, and Ground Cover), circle the best response that describes the immediate riparian area. The response should provide a broad characterization of the riparian area within the designated riparian width noted earlier. (Ground cover refers cover percent vegetative cover $\leq$ 1 m in height. Vertical cover refers to the percentage vegetative cover $\geq$ 1 m to the top of the existing vegetation.)
13. Under Surrounding Land Use, circle the response that best describes the dominant land use outside of the riparian zone. If time permits, and especially if the landscape is mixed, provide estimated percentages of the various land uses under each option.

APPENDIX B

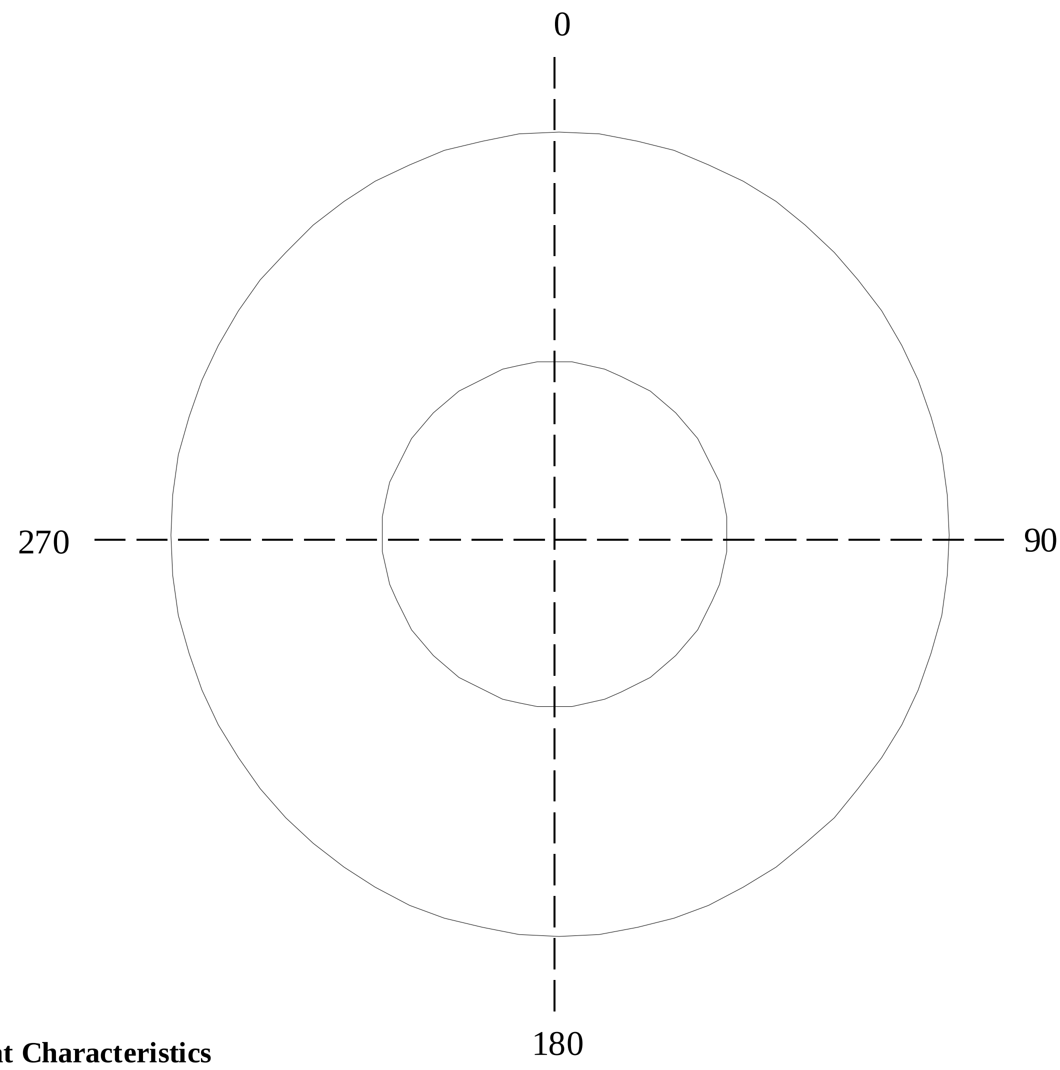
Sample Point-Count Data Form

SAN JACINTO WATERSHED
POINT COUNT SURVEYS
SPRING 2002

Observer

Bioregion Reach Month Day Year Time Point Visit

Temp Wind Sky UTM Northing UTM Easting Compass Bearing (down stream)



Habitat Characteristics

Riparian Width:

Dominant Veg.: Grass/herb. Shrubs Trees None/Soil

% Vertical Cover: ≤ 10% 10-25% 25-50% 50-75 % ≥ 75%

% Ground Cover: ≤ 10% 10-25% 25-50% 50-75 % ≥ 75%

Surrounding Land Use: Open/Agr. Chaparral/Shrubs Forest Urban

FLYOVERS:

APPENDIX C

Sampling Protocol for Vegetation Characterization

Vegetation Sampling Protocol for the San Jacinto Watershed, Summer 2002

Measured at each bird sampling point:

Active channel width (m) – The active channel measured from bank to bank. The channel is defined as the area of the generally unvegetated stream bottom during normal flows, characterized usually by sand-and-gravel substrate having little or no vegetation.

Riparian width (m) – Total width of the riparian zone, including the channel and riparian vegetation, measured perpendicular to the channel (include riparian vegetation on both sides of the channel). The riparian zone is indicated by vegetation of different structure and/or species composition than that on the surrounding uplands as a result of the action or increased availability of water in the drainage. For incised channels, include riparian vegetation on former terraces.

Downstream compass bearing (degrees).

Estimated for the Riparian Zone within 50 m of the point (not counting adjacent habitats; if for example, the riparian zone is only 20 m wide, then estimate variables only within the riparian zone along the 20-m strip within 50 m each side of your sampling point):

Height of tallest riparian vegetation (m) - Visual estimate (check w/ clinometer on occasion to ensure accuracy and consistency).

Predominant vegetation height (m) – Predominant height of the uppermost layer of riparian vegetation (Visual estimate – check with clinometer or measuring tape on occasion to ensure accuracy and consistency). The predominant height should disregard occasional trees, if not fairly continuous. For example, the predominant height of a shrubby habitat having 1 or 2 taller trees should be the height of the shrub layer.

Estimated DBH of the largest riparian trees (cm)

Percent cover of all woody riparian vegetation combined (cover class) – Use cover classes given below.

Percent cover of riparian trees (cover class) – Trees are defined as >6 m (>20 ft) tall.

Percent cover of riparian "shrubs" (cover class) – Shrubs are <6 m (<20 ft) tall.

Percent cover of rocks and logs in the riparian zone (cover class) – Select only those structures and cobble sizes that could be used as herp cover (e.g., escape, thermal/shade cover)

Percent cover of exotic tree species (cover class) – Provide a list of those present and their approximate percent cover by species

Water in reach – Note the presence and mean depth of any water in the sampling reach within 50 m of the point

Within a 100-m circle surrounding the sampling point: (Take these data when cover classes can be assessed directly from the sampling point – don't spend time climbing to higher ground to gain a vantage point.)

Adjacent non-riparian land use (cover in each of the following classes):

- Agricultural (bare or cropped at time of bird sampling, if possible)
- Native or introduced grass/herb (including pasture)
- Chaparral/shrubland
- Forest
- Urban/industrial/developed
- Other (specify)

Cover classes to use for all percent cover estimates:

0 = None present
T = Trace (<1%)
1 = 1-5%
2 = 5-25%
3 = 25-50%
4 = 50-75%
5 = 75-100%

APPENDIX D

Historical Herpetofaunal Occurrence
in
Riverside County, California

Appendix D. Historical herpetofaunal occurrence in Riverside County, California (Database source – Beaman et al. In prep.).

Historical occurrence of Caudata (salamanders) in Riverside County, California				
Species	**#Records in Database**	**Range in County**	**Habitat**	**Notes**
Aneides lugubris (A3.5) arboreal salamander	6 records	West	Chiefly coastal live-oak woodland	Found in rotting logs, rock crevices, under bark
Batrachoseps aridus (A4.1) desert slender salamander	40 records	Small spot Central	Palm oasis of Hidden Palm Canyon	**FE, CE**
Batrachoseps attenuatus (A4.2) **California slender salamander**	199 records	Isolated West	Riparian; Along streams in coastal & valley oak woodlands	Locally common yearlong resident
Batrachoseps major (A4.5) garden slender salamander	8 records	West	Earthworm burrows, crevices, various undergound retreats	**CP**
Batrachoseps nigriventris (A4.6) blackbelly slender salamander	17 records	Isolated West	Chiefly oak woodland	Found under rocks and logs in scattered colonies
Ensatina eschscholtzii (A8.1) Ensatina				
E. e. croceater yellow-blotched ensatina	3 records (old dates)	Isolated central	Deciduous and evergreen forest	Rotting logs
E. e. eschscholtzii **Monterey ensatina**	51 records	West - localized concentrated populations	Oak & pine woodlands	Nocturnal uncommon
E. e. klauberi **large-blotched ensatina**	43 records	West - localized concentrated populations	Oak & pine woodlands Woody debris From 1500-5400'	**FSC, CSC, R5** Nocturnal uncommon
Taricha torosa (A23.3) California newt **T. t. torosa** **coast range newt**	54 records	West - localized populations	Along creeks & streams; close to water especially in rocky areas; hardwood-conifer habitat	**CSC** Require water or moist area under cover

Historical occurrence of Anura (Toads and Frogs) in Riverside County, California				
Species	**#Records in Database**	**Range in County**	**Habitat**	**Notes**
Bufo boreas (B3.4) Western toad ***B. b. halophilus*** **California Toad**	373 records	West	Widely distributed	Common species Nocturnal Scarce or common depending on habitat quality
Bufo californicus (B3.5) **Arroyo Toad**	43 records	West - fragmented populations	Upland and riparian; Sandy or cobbly washes	**FE, CSC, CP, CE** **Critical habitat designated** uncommon
Bufo cognatus (B3.7) Great Plains Toad	228 records	Far East	Prairies or deserts	Breeds after heavy rains in shallow pools
Bufo punctatus (B3.15) Red-spotted Toad	309 records	East	Desert streams, oases, open grassland, and scrubland	Nocturnal. Breeds in temporary pools
Bufo woodhousii (B3.21) Woodhouse's Toad	39 records	Limited Central	Varied habitats. Prefers sandy areas.	May not be common; west tip of its range
Hyla cadaverina (B6.4) **California Treefrog**	396 records	West - Spotty and localized	Along streams with abundant boulders and cobbles	Nocturnal
Hyla regilla (B6.10) **Pacific Treefrog**	468 records	West	All types of habitats	Nocturnal
Rana aurora (B12.2) Red-legged Frog ***R. a. draytoni*** **California Red-legged Frog**	29 records	West - isolated areas	Plunge pools of foothills; riparian	**FT, CSC, CP, CT** Some ref. state may be extirpated from county. Uncommon
Rana muscosa (B12.15) **Mountain Yellow-legged Frog**	112 records	Isolated Central	850-7500'	**PE, CSC, CP, R5, SBNF** Uncommon, rare
Rana yavapaiensis (B12.27) Lowland Leopard Frog	2 records (old dates)	Far East	Montane streams and riparian >6000'	Usually stays close to water
Scaphiopus couchii (B14.1) Couch's Spadefoot	2 records	Far East	Arid and desert	Breed after heavy rains

Spea hammondii (B16.2) **Western Spadefoot**	75 records	West - Populations localized but widespread	Grassland, scrub, chaparral	**CP** Activity limited to wet season; summer storms
Rana catesbeiana (B12.18) **Bullfrog**	173 records	Introduced various locations	Wide range aquatic habitats	Introduced Species
Rana pipiens (B12.19) Northern Leopard Frog	2 records	Introduced various locations	Wide range aquatic habitats	Introduced Species
Xenopus laevis (BE.CF) African Clawed Frog	421 records	Introduced various locations	Wide range aquatic habitats	Introduced Species

Historical occurrence of Testudines (turtles and tortoises) in Riverside County, California				
Species	**#Records in Database**	**Range in County**	**Habitat**	**Notes**
Clemmys marmorata (C6.3) Western Pond Turtle ***C. m. pallida*** **Southwestern Pond Turtle**	33 records	West	Permanent or near perm. water w/basking sites; to 8000'	**FSC, CSC, CP, R5**
Gorpherus agassizii (C11.1) Desert Tortoise	245 records	East	Desert, semi-arid	**FT, CT, CP**
Apalone spinifera (C1.3) Spiny Softshell	6 records	Introduced various locations	Riverine with mud, sand, or gravel bottom	Introduced species
Trachemys scripta (C20.2) Slider sp.	2 records	Introduced various locations	Wide range of aquatic habitats with basking sites	Introduced species

Historical occurrence of Squamata - Lacertilia (Lizards) in Riverside County, California				
Species	**#Records in Database**	**Range in County**	**Habitat**	**Notes**
Anniella pulchra (F1.1) **California Legless Lizard**	35 records	West	Moist, loose soil associated w/drainage & valley bottoms	**FSC, CSC, R5** Burrower, secretive, seldom seen
Callisaurus draconoides (F3.1) Zebratail Lizard	690 records	East	Deserts; washes & alluvial plains, prefers flats	Common
Cnemidophorus hyperythrus (F4.8) Orangethroat Whiptail ***C. h. beldingi*** **Belding's Orangethroat Whiptail**	185 records	West	Low elevated coastal scrub, chaparral, valley-foothill hardwoods	**CP** Fairly common
Cnemidophorus tigris (F4.18) Western Whiptail				
C. t. multiscutatus **Coastal Whiptail**	1283 records	West	Variety of habitats including riparian. Abundant in desert regions	Widely distributed but uncommon in non-desert regions. Hard to catch
C. t. tigris **Great Basin Whiptail**		East	Desert and semi-arid sparse plants	Common in desert regions
Coleonyx variegates (F5.4) Western Banded Gecko				
C. v. abboti **San Diego Banded Gecko**	*C. variegatus* 443 records *C. v. abboti* 9 records *C. v. variegatus* 11 records	West	Primarily desert sandy flats & desert washes; to 5000'	Nocturnal
C. v. variegatus Desert Banded Gecko		East	Primarily desert sandy flats & desert washes; to 5000'	Nocturnal

Crotaphytus (F7) Collared Lizards				
C.s bicinctores (F7.1) Great Basin Collared Lizard	80 records	East	Prefers rocky areas particularly washes	Very uncommon Confusing nomenclature and maps in Stebbins
C. collaris (F7.2) Eastern Collard Lizard		East	Prefers rocky areas particularly washes	Confusing nomenclature and maps in Stebbins
C. insularis (F7.3) Desert Collared Lizard		East	Prefers rocky areas particularly washes	Confusing nomenclature and maps in Stebbins
C. vestigium (F7.6) Baja California Collard Lizard		East	Prefers rocky areas particularly washes	May be *C. insularis* Confusing nomenclature and maps in Stebbins
Dipsosaurus dorsalis (F8.1) Desert Iguana	440 records	East	Sandy flats & hammocks of the creosote woodlands of Mojave & Sonoran deserts	Tolerates extreme heat better than other desert lizards
Elgaria multicarinatus (F9.3) Southern Alligator Lizard ***E. m. webbii*** **San Diego Alligator Lizard**	89 records	West	Valley-foothill habitats, mixed chaparral, open areas of mixed conifer forest; to 7500'	Common in suitable habitats. Active during cooler temps.
Eumeces gilberti (F10.5) Gilbert's Skink ***E. g. rubricaudatus*** **Western Redtail Skink**	72 records	West Central	Wide variety of habitats. Commonest in successional stages or open areas within habitats. Avoids heavy brush or dense forest; up to 6500'	Common but seldom observed
Eumeces skiltonianus (F10.12) **Western Skink**	106 records	West	Most terrestrial habitats but not deserts. Avoids heavy brush or dense forest; up to 7000'	**Bag limit (CP)** Common but seldom seen in the open; secretive
Gambelia wislizenii (F11.3) Longnose Leopard Lizard	110 records	East	Desert woodland and scrub; up to 5900'	Uncommon. Difficult to approach.
Petrosaurus mearnsi (F17.1) Banded Rock Lizard	223 records	Isolated spot West Central	Associated w/boulder hillsides, rock outcrops.	Uncommon west of desert slope.

Phrynosoma coronatum (F18.2) Coast Horned Lizard ***P. c. blainvillii*** **San Diego Horned Lizard**	294 records	West	Open areas of valley-foothill hardwoods, conifer & riparian; < 8000'	**FSC, CSC, CP, R5** Common to uncommon in suitable habitat
Phrynosoma mcalli (F18.4) Flat-tail Horned Lizard	100 records	Isolated East Central	Desert washes & desert flats in central Riverside	**CP** Present range reduced by human activities
Phrynosoma platyrhinos (F18.6) Desert Horned Lizard	183 records	East	Great Basin and desert habitats. San Jacinto River wash. Prefer sparse open habitats. To 6000'	Common year long
Phyllodactylus xanti (F19.1) Peninsula Leaf-toed Gecko	2 records (1941, 1960)	Isolated Central	Rock dweller. Likely in vicinity of streams and springs.	**CP** Nocturnal May be *P. n. nocticolus*
Sauromalus obesus (F20.1) Chuckwalla *S. o. obesus* Western Chuckwalla	750 records	East	Desert rock-dwelling	Widely distributed in desert
Sceloporus graciosus (F21.3) **Sagebrush Lizard**	800 records	Isolated West	Primarily chaparral and montane species. Between 3000-10,400'	**Bag limit (CP)** Widely distributed in preferred habitats.
Sceloporus magister (F21.6) Desert Spiny Lizard	236 records	East	Desert, usually rocky areas; up to 6000'	Good climber of trees and rocks
Sceloporus occidentalis (F21.8) Western Fence Lizard				
S. o. biseriatus **San Joaquin Fence Lizard**	*S. occidentalis* 689 records *S. o. biseriatus* 112 records *S. o. longipes* 77 records (1917-1951)	West	Found throughout CA except true desert	**Bag limit (CP)** CA most common reptile. Blue belly lizard (Western Fence Lizard)
S. o. longipes **Great Basin Fence Lizard**		West	Found throughout CA except true desert.	CA most common reptile. Western Fence Lizard
Sceloporus orcutti (F21.10) **Granite Spiny Lizard**	544 records	West	Chaparral & forest; arid more than desert; prefer rocks	Rarely found away from rocks

Uma inornata (F24.1) Coachella Valley Fringe-toed Lizard	355 records	Very isolated East	Fine, loose, wind-blown deposits	**FT, CE** Isolated area
Uma notata (F24.2) Colorado Desert Fringe-toed Lizard	49 records	Small area East	Desert sand dunes	“Swims” through sand
Uma scoparia (F24.3) Mojave Fringe-toed Lizard	221 records	Small area East	Desert sand dunes	Fast, ground dweller
Urosaurus graciosus (F25.1) Brush Lizard	193 records	East	Desert	Fast, ground dweller
Urosaurus ornatus (F25.3) Tree Lizard	13 records	Far East	Ranges from desert to lower edge of spruce-fir zone	Fast, ground dweller
Uta stansburiana (F26.1) **Side-blotched Lizard**	1804 records	All County	Open habitat w/ rock or sand; arid & semi-arid; to 7000'	Common species year round. Frequents highly disturbed areas.
Xantusia henshawi (F27.1) **Granite Night Lizard**	671 records	West	Arid/semi-arid with rocky areas; 660-4000'	**CP** Nocturnal, secretive
Xantusia vigilis (F27.3) Desert Night Lizard	206 records	Central	Arid/semi-arid with rocky areas; 990-5900	**Bag limit (CP)** Nocturnal, secretive
Hemidactylus turcicus (FE.MG) Mediterranean Gecko	4 records	Introduced various locations	Near human dwellings, lights. Nocturnal	Introduced species

Historical occurrence of Squamata - Serpentes (snakes) in Riverside County, California				
Species	**#Records in Database**	**Range in County**	**Habitat**	**Notes**
Arizona elegans (G2.1) Eastern Glossy Snake *A. e. eburnata* Desert Glossy Snake	*A. elegans* 332 records *A. e. eburnata* 26 records	East	Open areas with sandy or loose, loamy soil.	Generally prefers open areas. Burrower, nocturnal.
Arizona occidentalis (G2.2) Western Glossy Snake ***A. o. occidentalis*** **California Glossy Snake**	*A. o. occidentalis* 52 records	West	Open areas with sandy or loose, loamy soil.	Not likely riparian
Charina bottae umbratica (G6.1) **Southern Rubber Boa**	10 records	Small spot in West	Montane habitats near water	**FSC, CT, CP, R5, SBNF** Nocturnal, crepuscular; Burrower, much time underground
Chionactis occipitalis (G8.1) Western Shovelnose Snake *C. o. occipitalis* Mojave Shovelnose Snake	386 records	East	Moves through sand	Nocturnal
Coluber mormon (G10.2) Western Racer	4 records	West-Bottom tip of its range	Found in semiarid and moist habitats but not in dry areas of southern CA	Frequent riparian habitat for food.
Crotalus atrox (G13.2) Western Diamondback Rattlesnake	71 records	East	Arid & semi-arid desert region	Mostly nocturnal or crepuscular
Crotalus cerastes (G13.3) Sidewinder *C. c. laterorepens* Colorado Desert Sidewinder	495 records	East	Desert	Mostly nocturnal
Crotalus exsul (G13.4) Red Diamond Rattlesnake ***C. e. ruber*** **Northern Red Rattlesnake**	210 records	West	Desert scrub, open chaparral, grassland, woodland, rocky hillsides and outcrops	**CSC** Mostly nocturnal or crepuscular Rare on coast side of mountains
Crotalus mitchellii (G13.7) Speckled Rattlesnake ***C. m. pyrrhus*** **Southwestern Speckled Rattlesnake**	146 records	All County	Mostly rock-dweller; hilly or mountainous areas	Active diurnal or nocturnal depending on temp.; uncommon in most habitats

Crotalus viridis (G13.12) Western (Pacific) Rattlesnake ***C. v. helleri*** **Southern Pacific Rattlesnake**	71 records	West	Not desert; wide range of habitats up to 10,000'	Tolerant of disturbed areas; diurnal or nocturnal depending on temp.; occurs in moister habitats than other rattlesnakes
Diadophis punctatus (G14.1) Ringneck Snake				
D. p. modestus **San Bernardino Ringneck Snake**	35 records	West	Moist habitat with abundant ground cover	Secretive
D. p. similis San Diego Ringneck Snake	3 records (1935-1948)	Southwest corner May not be inside county	Open rocky areas, moist habitat with abundant ground cover; to 7000'	**FSC, CSC, R5** Secretive Found in areas of their food of slender salamanders
Hypsiglena torquata (G22.1) Night Snake				
H. t. deserticola **Desert Night Snake**	91 records	East - isolated localities	Varied habitats, including riparian	Active crepuscular & nocturnal Rear fanged
H. t. klauberi San Diego Night Snake		West - isolated localities	Many habitats including riparian; prefer rocky; to 8700'	Active diurnal & nocturnal Rear fanged
Lampropeltis getulus (G23.3) *Common Kingsnake* ***L. g. californiae*** **California Kingsnake**	97 records	All county	Many habitats including riparian; most abundant in valley-foothill riparian to 7000'	**Bag limit (CP)** Very common snake; diurnal
Lampropeltis zonata (G23.6) California Mountain Kingsnake				
L. z. parvirubra **San Bernardino Mountain Kingsnake**	29 records	Small area West Central	Rocky areas near streams, 1400-10,000'	**FSC, CSC, R5** Primarily diurnal but may be nocturnal depending on temp.; uncommon
L. z. pulchra **San Diego Mountain Kingsnake**		Small area West	Rocky areas near streams, to 7000'	**FSC, CSC, CP, R5** Primarily diurnal but may be nocturnal depending on temp.; uncommon

Leptotyphlops humilis (G25.2) Western Blind Snake ***L. h. humilis*** **Southwestern Blind Snake**	83 records	West	Widely distributed; found around plant roots, beneath rocks, inside ant and termite nests	Burrower, rarely seen
Lichanura trivirgata (G26.1) Rosy Boa				
L. t. gracia Desert Rosy Boa	185 records	East	Rocky shrublands and desert	Nocturnal/crepuscular
L. t. roseofusca **Coastal Rosy Boa**		West - scattered populations	Rocky shrublands, Chaparral, Desert scrub; up to 3800'	**FSC, R5, CSC** Active above ground; Nocturnal/crepuscular; Difficult to detect
Masticophis flagellum (G28.2) Coachwhip ***M. f. piceus*** **Red Coachwhip**	149 records	All County	Arid regions below 6000'; open terrain	Common to uncommon; usually avoid dense vegetation
Masticophis lateralis (G28.3) Striped Racer ***M. l. lateralis*** **California Striped Racer**	83 records	West	Ecotone between chaparral and riparian; streamside woodland up to 6000'	Diurnal; uncommon to common
Phyllorhynchus decurtatus (G35.2) Spotted Leafnose Snake *P. d. perkinsi* Western Leafnosed Snake	365 records	East	Sandy or gravely desert areas	Nocturnal; rarely encountered
Pituophis catenifer (G36.1) Gopher Snake				
P. c. affinis Sonoran Gopher Snake	235 records	East	Many habitats	One of the common snakes in CA; mostly diurnal
P. c. annectens **San Diego Gopher Snake**		West	Many habitats	**Bag limit (CP)** One of the common snakes in CA; mostly diurnal
Rhinocheilus lecontei (G39.1) Longnose Snake ***R. l. lecontei*** **Western Longnose Snake**	148 records	All County	Rocky or brushy arid regions; up to 4000'	Nocturnal; secretive/burrower; common only in desert region

Salvadora hexalepis (G40.3) Western Patchnose Snake				
S. h. hexalepis Desert Patchnose Snake	159 records	East	Brushy desert, sagebrush flats	Diurnal; not much known about natural history
S .h. virgultea **Coast Patchnose Snake**		West	Brushy desert, sagebrush flats	**CSC** Diurnal; not much known about natural history
Sonora semiannulata (G44.1) Ground Snake	3 records	East	Semi-arid area with hiding places; favor river bottoms	Not rare but seldom encountered; secretive; burrower
Tantilla hobartsmithi (G47.5) Southwestern Blackhead Snake	7 records	Very small area East but may not be within Co	Many habitats	Mainly nocturnal or crepuscular; little known about; rear fanged
Tantilla planiceps (G47.8) **Western Blackhead Snake**	30 records	West	Many habitats	Mainly nocturnal or crepuscular; little known about; rear fanged
Thamnophis hammondii (G48.9) **Two-striped Garter Snake**	75 records	West	Found in streamside vegetation of Perennial/intermittent streams to 8000'	**FSC, CSC, CP, R5** Mostly diurnal but sometimes nocturnal; takes to water when disturbed; population decline due to loss of habitat
Thamnophis marcianus (G48.10) Checkered Garter Snake	5 records	Far East	Found along lowland aquatic areas	Feeds on species found in riparian areas.
Thamnophis sirtalis (G48.16) Common Garter Snake *T. s. infernalis* California Red-sided Garter Snake	3 records	North West corner Bottom point of range	Many habitats including riparian	**CSC** Rare
Trimorphodon biscutatus (G49.1) Lyre Snake				
T. b. lambda Sonoran Lyre Snake	65 records	Far East	Rocky areas of many habitats	Nocturnal; secretive; rear fanged
T. b. vandenburghi **California Lyre Snake**		West	Rocky areas of many habitats	Nocturnal; secretive; rear fanged

Protection Status Code:

Federal

FE	= Federally Listed Endangered
FT	= Federally Listed Threatened
PE	= Federally Proposed Endangered
PT	= Federally Proposed Threatened
FC	= Candidate species for federal listing; taxa for which the USFWS has substantial information to support listing as threatened or endangered
FSC	= Federal Species of Special Concern; a term for former Category 2 Candidates; taxa that may warrant listing but for which substantial information to support a proposed rule is lacking

State

CE	= State Listed Endangered
CT	= State Listed Threatened
CSC	= State Species of Special Concern; species that appear to be vulnerable to extinction because of declining populations, limited ranges, and/or continuing threats
CP	= State Protected; may not be taken or possessed at any time except with permit for scientific collecting or scientific purposes

Other

R5	= USDA Forest Service Region 5 Sensitive
SBNF	= San Bernardino National Forest Sensitive

Darkened species names = known to occur within San Jacinto River watershed sampling area.

APPENDIX E

Recommended Techniques for Onsite Herp Inventories

Recommended Techniques for Onsite Herp Inventories

Presence/absence (i.e., not detected) studies are recommended when field sampling is necessary to estimate herp species richness. In general, the goal of presence/absence sampling is to determine the number of species in an area (species richness) and document species geographic ranges. Habitat associations may also be a secondary objective for these types of studies. The most direct approach is to systematically search the study area by turning over natural and/or artificial cover and searching specific microhabitats during appropriate weather conditions. This is much more complicated than it might first appear. Herp species, especially amphibians, can be very secretive and virtually impossible to find when conditions of temperature or moisture are unfavorable. Not finding a particular species at a site does not necessarily mean that the species is absent. If none are found after intensive searches several times during a season in appropriate microhabitats and weather conditions, it may be unlikely that a species is present. However, it is still more appropriate to note these species as not detected rather than absent.

The type and amount of data collected during herp surveys will depend on the scale of the survey, the objectives of the inventory, and the natural history requirements of any target species. Data collection and data sheets must be customized for the specific study, study site, and personnel. Most amphibians and reptiles are secretive and difficult to find. They are generally active only during specific times such as foraging, or when migrating to and from breeding areas. Although some species are more mobile than others, most remain hidden, and some fossorial species spend days or even months in underground burrows. Survey techniques should be designed to locate species when they are active and are on or near the surface. The following questions should be considered in designing a survey for specific target species: a) What time of day is the target species most active? b) Does the target species migrate to and from breeding areas, and if so, how far? c) Does the target species use the same habitat year round for all activities? Unfortunately, many aspects of the natural history of herp species are poorly known.

Since amphibians and reptiles are ectotherms, their daily and seasonal activities are constrained by environmental temperatures. The timing of a herp survey frequently coincides with seasonal or daily movement activities such as migrating to and from breeding sites or emerging to bask. Amphibians are extremely susceptible to desiccation. Consequently, amphibians generally become more active after a rainfall and their activity may temporarily cease during dry seasons. Reptile skin is impervious to water and can tolerate dryer conditions than amphibians. In general, the best time to survey for amphibians is after a rainfall, during wet weather in spring or fall. The best time to survey for reptiles is during warm, sunny days of late spring, summer, and early fall.

Many amphibians and reptiles exhibit wide natural fluctuations in numbers from year to year (Gibbons and Semlitsch 1981, Vogt and Hine 1982). These natural fluctuations are not clearly understood, but tend to be cyclical and may be weather related. Therefore, long-term monitoring may be required to determine whether declines in species numbers are due to human-influenced disturbances or natural population fluctuations.

In general, the preferred method for determining presence of herp species is hand-collecting. This method can be labor-intensive, but it is more versatile and productive than trapping techniques that require much more equipment and set-up time. Field crew size depends on the size of the area to be surveyed, time allotted, and budget limits. A minimum of 2 people should be used for safety purposes. Field personnel used when collecting snakes should be experienced with identification and safe handling of the species in the area. Presence/not-detected studies utilizing hand-collecting techniques can include randomized or non-randomized sampling methods, time-constrained searches, quadrat and/or transect searches, habitat searches on foot, or road surveys with vehicles.

A time-constrained search involves hand-collecting over a specific amount of time. Non-timed, informal opportunistic searches of a study area may reveal species presence but provide poor data for quantitative comparisons. By fixing the survey effort, comparisons can be made between surveys to provide some indication of relative abundance, and spatial and temporal trends. Results are usually expressed in terms of number of species or individuals detected per number of person-hours spent searching.

Quadrat sampling and transect searches are more systematic approaches for hand-collecting herps. Quadrat sampling of a study area consists of thoroughly searching for herp species within selected quadrat sampling units. Quadrats are squares of fixed area that are placed within the study area at random. A major problem with this technique is that important habitat features for a particular species may be excluded from a quadrat unit because of the random selection process. Species density and distribution are also important considerations. Optimal quadrat size may be specific to a particular species at a particular study site.

Transect searches address the problem that herp species may be difficult to locate, have patchy populations, or occur in areas where they might easily be overlooked. Transect searches consist of walking in a straight line for a specific distance and recording all the herps found within a set distance on either side of the line. The width of the transect may vary depending on the habitat it passes through and the detectability of the herp within the sampled habitat. The transect width should be set at the start of each survey. Before surveys begin, the transect locations are plotted on aerial photos or maps using start points and compass bearings chosen at random. This method provides a measure of relative abundance of herps in the study area as a function of the area surveyed (transect length times width). Heavily vegetated habitats in wetter areas are usually more difficult to survey intensively than are drier, more sparsely vegetated areas. Accessibility of a study area is a serious logistical consideration when choosing a monitoring method. Sampling bias may result from lack of accessibility to critical habitats.

A typical transect for salamander surveys might be 2 m wide, whereas a transect for snakes or lizards may be wider. Transects should be parallel to each other and approximately 20 m apart. Each transect is generally 100 m long, but may be longer or shorter depending on the size of the study area. The transects should extend across as much area as possible so that all habitats are well represented. This general scheme may need to be modified for linear habitats such as riparian zones. Transects should be marked with string so that the transect is straight and does not deviate into "better" habitat. The ends of the transect should be marked with stakes and flagging tape for future reference. The number of person-hours spent searching should be recorded. The actual search of the transect involves turning over potential cover objects, searching through leaf litter, and tearing bark off logs as done in other hand-collecting methods. Care should be taken not to count animals found outside the transect. These animals may be noted for indication of species presence but not included in transect computations for relative abundance.

Artificial cover objects are generally easier and less disruptive to install than arrays of traps. These are frequently pieces (approximately one or two meters) of untreated wood but may be of plastic or even metal. Cover boards can be placed directly on the soil or slightly elevated. Herps use these structures as hiding shelters. Artificial cover objects are well suited to studies that require repeated sampling, are relatively easy to sample once in place, result in little or no damage to the natural habitat, and can attract species that are difficult to trap in pitfall or funnel traps. Unlike traps, cover objects present no risk of specimen mortality from failure to check frequently and movements of individuals are not limited. Because the artificial cover objects can be checked repeatedly over long periods, some rare species can eventually be found without habitat damage that would result from repeated searches of natural cover.

Road surveys (also known as night driving or road cruising) have been used in many studies to sample herp populations. This method may be thought of as a type of transect in which the transect is a road. By traveling sections of roads by car, bicycle, or on foot, it is possible to record at least the presence of species and possibly a rough index of relative abundance of species for a particular area over time. Paved roads with little vehicle use are best. Roads are driven at slow speeds, using low headlight beams, flashlights or headlamps to detect road kills and animals moving across the road. The efficiency of this method will be affected by the weather, time of day, and the amount of vehicular traffic on the road. Personnel and traffic safety should always be of primary concern. Road surveys may be biased as a sampling technique because some herp groups or species avoid crossing roads. Because of this, the absence of certain species on roads does not mean that they are not present in the surrounding habitat. Quantitative comparisons can be made between surveys when systematic data are kept such as time spent surveying, distance surveyed, and number of people involved in the survey. Environmental conditions should also be recorded.

Despite the biases and limitations of road surveys, many herps can be found along roads, basking at the edges during the day, or on the road itself. The presence of snakes and some other reptiles on roads is likely associated with thermoregulation. Because of this, it is unlikely to find reptiles basking on an extremely hot road in the middle of a hot sunny day. It is more likely to find reptiles basking on a road during the early morning as the pavement heats up and in the afternoon or evening while heat is still retained in the pavement. It should be noted that movement patterns of reptiles may vary depending on whether a species is diurnal or nocturnal and sampling for a particular species must be conducted at the appropriate time. Road surveys for amphibians are usually most successful when done just after dark on wet, warm, and dark nights. Amphibians are frequently found during spring migrations to breeding pools.

Auditory surveys are used for determining presence/not detected inventories of male frogs and toads during the breeding season. This method is also known as “aural site transect,” “spring road transect,” and “audio strip transect.” Auditory surveys can be used on road transects or at discrete listening sites (terrestrial or aquatic). The observer records the species calling along the route (by vehicle, boat, bicycle, or foot). Systematic tape recordings can also be made for additional confirmation of species identification. Approximately 3 to 5 minutes should be spent listening or recording per survey station or site. A minimum of 3 to 5 visits is recommended during the breeding season. Auditory surveys are most effective after 1 to 2 days of rainfall or during moderately wet weather. Sampling with this method will be biased toward species that call frequently, loudly, and over a wide range of climatic conditions.

Future efforts to conduct field herp surveys in riparian reaches within the San Jacinto River watershed, if desired, should include combinations of the techniques described above. Ideally, bird and herp surveys should be made in the same sample of reaches. However, it is likely that fewer reaches could be surveyed for herps due to the higher level of effort required for sampling. Randomized subsampling of reaches would be appropriate. Transect surveys should be done both parallel and perpendicular to the stream within the riparian zone for the most complete coverage of the macrohabitats and microhabitats available. No trapping techniques are recommended but the use of artificial cover is suggested. Diurnal sampling should concentrate on hand-collecting efforts along transects and nocturnal sampling should utilize road and auditory survey techniques. A minimum of two sampling efforts, spring and fall, should be conducted to increase the chances of encountering species at optimal times.