DEVELOPMENT OF AN INDEX OF BIOLOGICAL INTEGRITY FOR RIPARIAN ECOSYSTEMS IN THE UPPER SANTA MARGARITA RIVER WATERSHED, RIVERSIDE AND SAN DIEGO COUNTIES, CALIFORNIA

FINAL REPORT

March 2004

Prepared by

James S. Wakeley
Michael P. Guilfoyle
Richard A. Fischer

U.S. Army Corps of Engineers
Engineer Research and Development Center
Environmental Laboratory
3909 Halls Ferry Road
Vicksburg, Mississippi 39180-6199

Table of Contents

List of Tables

List of Figures

INTRODUCTION

The Environmental Laboratory of the U. S. Army Engineer Research and Development Center (ERDC) is assisting the Los Angeles District of the U. S. Army Corps of Engineers and the U. S. Environmental Protection Agency, Region 9, 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 Riverside and San Diego Counties, 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 2003). 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: (1) the riparian reach, (2) the local drainage (i.e., the area contributing to tributary, groundwater, and overland flow that directly enters the riparian reach), and (3) 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 conclusions of the supplemental wildlife studies in the Santa Margarita River watershed. A previous report (Wakeley et al. 2003) described the supplemental wildlife studies in the San Jacinto River watershed.

This report characterizes the riparian bird communities using selected reaches of the Santa Margarita watershed during the breeding season, and describes the development of an Index of Biological Integrity (IBI) for riparian ecosystems based on bird utilization. Birds were chosen for this study because (1) they 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), (2) they are of considerable public and agency interest, and (3) the fate of many species in southern California is closely tied to the health of riparian ecosystems. Riparian habitats occupy a small fraction of the land area in the arid southwestern United States but play a critical role in maintaining regional biodiversity (Hubbard 1977; Johnson, Haight, and Simpson 1977; Brinson et al. 1981). Most bird species in arid areas use riparian habitats at some time of the year, and many are either riparian specialists (i.e., they prefer riparian habitats during some part of their annual cycles) or obligates (i.e., they require the presence of quality riparian habitats for survival) (Kozma and Mathews 1997, Yong et al. 1998, Ballard et al. 2000, Rich 2002). Habitat loss through urbanization, water diversion and impoundment, dredging and channelization of streams, livestock grazing, and other agricultural practices has contributed to the declines in numerous southwestern riparian bird species (Ballard et al. 2000, Guilfoyle 2001). Loss of riparian habitat has contributed to the decline of many Neotropical migrant species[1] in southern California (Ballard et al. 2000). Riparian habitats also support numerous short-distance migrants[2], Nearctic migrants[3], and resident species[4], many of which are also experiencing declines (Ballard et al. 2000, Lovio et al. 2002, Robinson et al. 2002, Zack et al. 2002).

The Santa Margarita watershed provides important seasonal habitats for a diversity of bird species (see http://www.friendsoftheriver.org/CaliforniaRivers/Rivers/SantaMargarita.html). Perhaps the most important habitat within the watershed occurs along the Santa Margarita River at the western end of the watershed. The Santa Margarita River is one of the last free-flowing rivers in southern California and its associated riparian vegetation contains the highest density and diversity of bird species in the south coastal river basin, including a large proportion of the nation's remaining population of endangered Least Bell's Vireos (*Vireo bellii pusillus*). Coastal wetlands associated with the lower portion of the river provide significant habitat for other

[1] Neotropical migrant bird species breed in the U.S. or Canada but migrate to wintering areas in southern Mexico, Central and South America, and the Caribbean Islands.
[2] Short-distance migrants generally migrate less than Nearctic migrants, with migration occurring altitudinally or simply in close proximity to the breeding areas. In southern California, short-distance migrants often winter just south of the study area, sometimes extending into northern Mexico.
[3] Nearctic migrants (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.
[4] Resident species are typically non-migratory bird species that breed and winter within the same general geographic area.

sensitive and endangered bird species, including the Light-footed Clapper Rail (*Rallus longirostris levipes*), Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*), and California Least Tern (*Sterna antillarum browni*).

Although the Santa Margarita watershed has no officially designated "Important Bird Areas" as does the San Jacinto watershed (see Wakeley et al. 2003), the undeveloped nature of substantial portions of the watershed provides a diversity of habitats used by a wide range of birds and other wildlife species.

The IBI Approach to Ecosystem Assessment and Monitoring

IBI was originally conceived as a method for assessing and monitoring the ecological health and integrity of streams through the direct characterization of their biological communities (Karr 1987, 1991). "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 factors, such as pollutant levels in water and sediments, with little regard to their biological consequences (Karr 1987, Karr and Chu 1999). In its original form, IBI was 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, and 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.

Objectives and Approach

The objectives of this study were (1) to characterize the species and guild composition of the bird communities that use riparian ecosystems in the San Jacinto and

Santa Margarita River watersheds during the breeding season and (2) to develop an avian community-based IBI that could be used to assess the biological integrity of riparian reaches in the two watersheds. These two rivers occupy adjacent watersheds in Riverside and San Diego Counties, California. Both river systems arise in the San Jacinto Mountains and foothills and flow generally westward toward the Pacific Ocean. The watersheds are similar in climate and topography. Each contains areas of relatively unaltered riparian habitats as well as areas impacted by agricultural and urban development. Therefore, the approach taken in this study was to develop a preliminary IBI based on data gathered in one watershed and to test that IBI by applying it in the second watershed.

In the first phase of this study, use of riparian reaches by breeding birds in the San Jacinto watershed was determined by direct sampling of birds in a stratified random sample of 95 reaches during March, April, and May of 2002. These data were used to develop a preliminary IBI based on seven community metrics: percent richness of bird species of conservation concern, percent richness of exotic species, percent abundance of tree and shrub nesters, percent abundance of canopy foragers, percent richness of ground foragers, percent richness of native cavity nesters, and native species richness (Wakeley et al. 2003). These metrics were identified through correlation and examination of plots of 65 potential metrics in relation to an index of human disturbance of each reach based on the extent of agricultural and urban development in the local drainage. Metrics with the best ability to discriminate different levels of human disturbance were selected as components of the IBI (Karr and Chu 1999, Wakeley et al. 2003).

This report describes the second phase of IBI development. The preliminary IBI was tested by applying it to a sample of 96 riparian reaches in the Santa Margarita watershed. Its performance was evaluated by comparing IBI scores with an index of human disturbance for each reach. Results were then used to refine the preliminary formulation and produce an improved IBI applicable to both watersheds. Details of the approach are presented in the Methods section.

METHODS

Study Area

The Santa Margarita River watershed encompasses more than 470,000 acres (190,000 ha), mostly within the western portion of Riverside County, CA (Figure 1). Towns and cities in the watershed include Murrietta, Temecula, and Fallbrook. The lower reaches of the Santa Margarita River flow through the U.S. Marine Corps Camp Pendleton, which was not included in the study area because of access restrictions. Elevations in the watershed range from approximately 350 ft at Camp Pendleton to over 5,000 ft in the San Jacinto Mountains in the northeastern portion of the watershed (Lichvar et al. 2003).

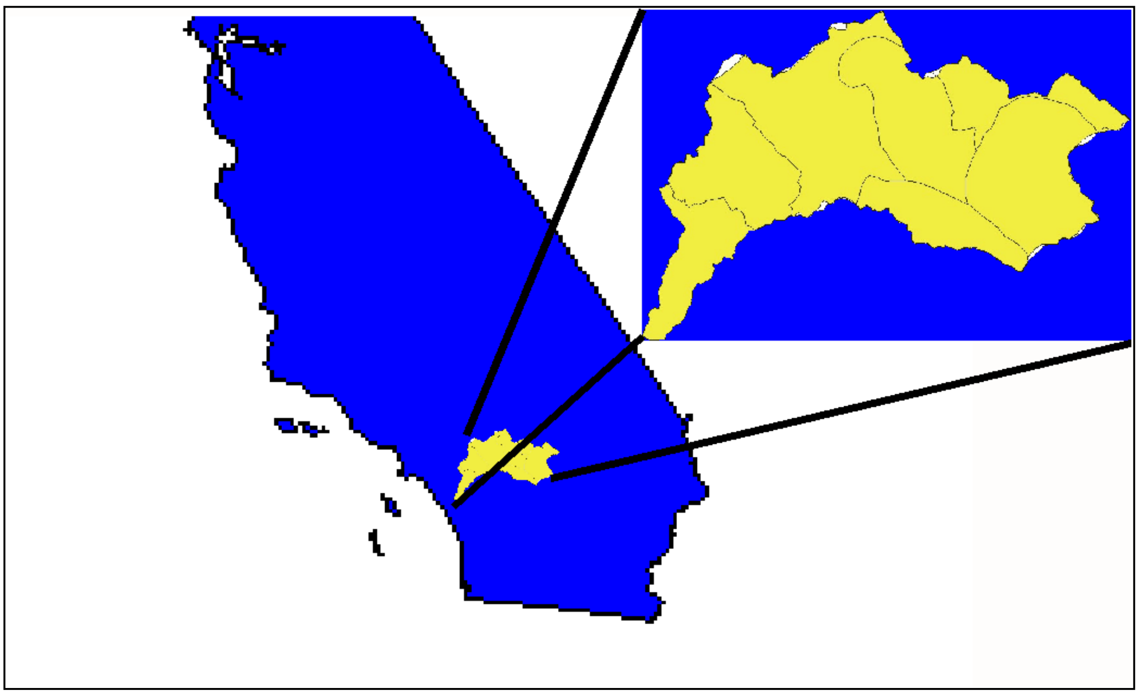


Figure 1. Location of the Santa Margarita River watershed within the PIF designated Central and Southern California Coast and Valleys physiographic region (Partners In Flight 2002).

Climate of the region is characterized by hot, dry summers and mild winters. Mean annual precipitation is approximately 12 in. (30 cm) at the lower elevations and as much as 26 in. (66 cm) at the higher elevations. Mean annual temperature is 64 °F at the lower elevations, with a mean high of 81 °F and low of 47 °F. Mean annual temperatures are much cooler in San Jacinto Mountains, with an overall mean of 53 °F, mean high of 68 °F, and mean low of 37 °F (Lichvar et al. 2003).

Bioregions

To facilitate sampling of bird communities, the watershed was divided into six bioregions (Figures 2-8). We used the same bioregion scheme developed for the

Riverside County Integrated Project: Multiple Species Habitat Conservation Plan (Riverside County 2002). Brief descriptions of each bioregion are provided below.

Riverside Lowlands. This bioregion encompasses the entire San Jacinto Valley, and generally occurs at an elevation below 2,000 ft (Riverside County 2002) (Figure 3). Common native trees in the bioregion include red, black, and arroyo willow (*Salix laevigata*, *S. gooddingii*, and *S. lasiolepis*), Fremont and balsam cottonwood (*Populus fremontii* and *P. balsamifera*), sycamore (*Platanus racemosa*), and coast live oak (*Quercus agrifolia*). Non-native species include eucalyptus (*Eucalyptus* spp.), tamarisk [or saltcedar] (*Tamarix* spp.), and European olive (*Olea europaea*). Understory and shrub species include mulefat (*Baccharus salicifolia*), tobacco tree (*Nicotiana glauca*), and sandbar willow (*S. exigua*). In open areas and grasslands, common species may include sunflower (*Helianthus* spp.), western ragweed (*Ambrosia psilostachya*), barley (*Hordeum leporinum*), cushion cryptantha (*Cryptantha circumscissa*), cocklebur (*Xanthium strumarium*), and the introduced hedgehog grass (*Echinochloa muricata*), black mustard (*Brassica nigra*), and giant cane (*Arundo donax*). In marsh habitats, common plants may include cattail (*Typha* spp.) and various species of rushes (*Scirpus* spp.). This region 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 9). Some small, low-lying hills are found within this bioregion, but these areas support plant communities typical of lower elevational areas (Riverside County 2002). This region rarely receives any frost or snow during the winter months.

San Jacinto Foothills. The San Jacinto Foothills bioregion (Riverside County 2002) (Figure 4) ranges in elevation between 2,000 and 3,000 ft, and is characterized by overstory tree species including coast live oak, Fremont cottonwood, sycamore, tamarisk, and red, black, and arroyo willow. Understory and shrub habitats typically contain willows, mulefat, chaparral broom (*B. pilularis*), buckwheat (*Eriogonum fasciculatum*), scrub oak (*Q. dumosa*), fourwing saltbrush (*Atriplex canescens*), sugar bush (*Rhus ovata*), barberry (*Berberis aquifolium*), elderberry (*Sambucus mexicana*), and scale broom (*Lepidospartum squamatum*) (Figure 10). Grasslands may contain the native dropseed (*Sporobolus* spp.) and non-native ryegrass (*Lolium* spp.). This region receives occasional frost, but snow is rare.

San Jacinto Mountains. This bioregion (Figure 5) is characterized by elevations exceeding 3,000 ft, with much more densely vegetated riparian communities (Figure 11), 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 willows, cottonwood, sycamore, and white alder (*Alnus rhombifolia*). Numerous understory trees and shrubs include willows, scrub oaks, mulefat, and brooms. Winters in this region can be severe with considerable frost and snowfall.

Santa Ana Mountains. This region (Figure 6) encompasses the Cleveland National Forest, and much of the valley north of the Santa Margarita River. This bioregion is relatively undisturbed, is characterized by elevations greater that 2,000 ft, and supports forests of balsam cottonwood, sycamore, coast live oak, interior live oak (*Q. wislizenii*), and Engelmann's oak (*Q. engelmannii*), with an understory of mulefat and red, black, and arroyo willow. Introduced species include the tobacco tree, and grassland species such as curly dock (*Rumex crispus*) and pampas grass (*Cortaderia selloana*) (Figure 12). This bioregion is influenced by coastal weather patterns, and typically experiences more fog, rainfall, and wind than the other bioregions.

Agua Tibia Mountains. The Agua Tibia Mountains bioregion (Figure 7) encompasses the boundary between Riverside and San Diego Counties, is characterized by elevations over 2,000 ft, and has experienced minimal urbanization pressure. This bioregion supports vegetative communities similar to the Santa Ana Mountains, yet does not experience the coastally influenced weather patterns. Hence, this bioregion has a somewhat drier climate (Figure 13). Common forest trees in this bioregion include coast live oak, black oak (*Q. kelloggi*), Fremont cottonwood, and black willow. Higher elevation evergreens include Jeffrey pine, ponderosa pine (*Pinus ponderosa*), bigcone spruce (*Pseudotsuga macrocarpa*), and white fir (*Abies concolor*). In grassland habitats, the introduced ryegrass is common. Winters in this region can be severe with considerable frost and snowfall.

Desert Transition. The Desert Transition (Figure 8) encompasses the far eastern portion of the Santa Margarita watershed, and includes the Cahuilla Indian Reservation and Lake Riverside Area. This bioregion is characterized by elevations >3,000 ft, and dry, desert-influenced climatic patterns. Vegetative communities found in this bioregion differ considerably from the other bioregions and include red shank chaparral, Big Basin sage scrub, and semi-arid succulent scrub habitat (Figure 14). Common forest tree species include canyon live oak, chaparral scrub oak (*Q. berberidifolia*), and red, black, and arroyo willow. Understory shrub and sage species include red shank (*Adenostoma sparsifolium*), broom snakeweed (*Gutierrezia sarothrae*), white sage (*Artemisia ludoviciana*) and Big Basin sage (*A. tridentata tridentata*). In open and grassland habitats, typical species may include black mustard, yerba santa (*Eriodictyon crassifolium*), slender wild oat (*Avena barbata*), deer grass (*Muhlenbergia rigens*), and the introduced red broom (*Bromus rubens*) and cheatgrass (*B. tectorum*). In isolated wetlands, Mexican rush (*Juncus mexicanus*) may be present. Despite the desert-like conditions, high elevations in this bioregion result in severe winters with considerable frost and snowfall.

Avian Community Sampling

Selection of Reaches and Establishment of Sampling Points. During spring and early summer of 2003, 470 point-count stations were established and sampled along 96 riparian reaches within the Santa Margarita watershed. These reaches were selected through a stratified random procedure from a list of over 500 reaches identified, mapped, and sampled during a broader indicator-based assessment of riparian habitats within the watershed (Smith 2003). The number of reaches sampled in each bioregion was allocated approximately in proportion to the area of each bioregion. The number of reaches sampled per bioregion was: Riverside Lowlands (28), San Jacinto Foothills (18), San Jacinto Mountains (7), Santa Ana Mountains (16), Agua Tibia Mountains (7), and Desert

Transition (20). Within each bioregion, reaches were initially ranked according to an index of human disturbance based on land use in the local drainage (LD) as indicated in the project geographic information system (GIS). The initial index of human disturbance was calculated as follows:

$$LD = ((2 \times \%\ \text{urban}) + (\%\ \text{low-density urban}) + (\%\ \text{agricultural})) / 2$$

This index utilized the two categories of urban land indicated in the GIS, giving double weight to full urban conditions compared with the dispersed residential areas categorized as low-density urban. Agricultural land consisted of land dominated by crops, groves, and pastures but did not include native rangeland. To ensure that the full range of human disturbance was sampled within each bioregion, reaches in a bioregion were divided into three groups representing the upper 25%, middle 50%, and lower 25% of disturbance scores, and approximately equal numbers of reaches were selected at random from each group. If a selected reach was too difficult to access or if landowner permission could not be obtained, another randomly selected reach from the same group was substituted.

The first point-count station was established approximately 125 m from the downstream end of the reach, and subsequent stations were located upstream at approximately 250-m intervals to reduce the probability of detecting the same individual birds at different stations. Four to five point-count stations were established along each sampled reach depending upon reach length and accessibility (Figure 15). Following the protocol established for the San Jacinto watershed, data from only the first four points were used for IBI development (Wakeley et al. 2003). The total number of points sampled in each bioregion was: Riverside Lowlands (137), San Jacinto Foothills (88), San Jacinto Mountains (34), Santa Ana Mountains (78), Agua Tibia Mountains (34), and Desert Transition (99).

Point-count sampling stations were marked with flagging and the position of each station was recorded using a hand-held GPS unit (Garmin E-trex®). As a backup, all surveyors recorded the UTM coordinates on field data sheets while conducting the bird surveys. GPS coordinates will allow points to be relocated in the future for evaluation of trends in avian communities or habitat characteristics. Position data were imported into ArcView® GIS for display and spatial analysis.

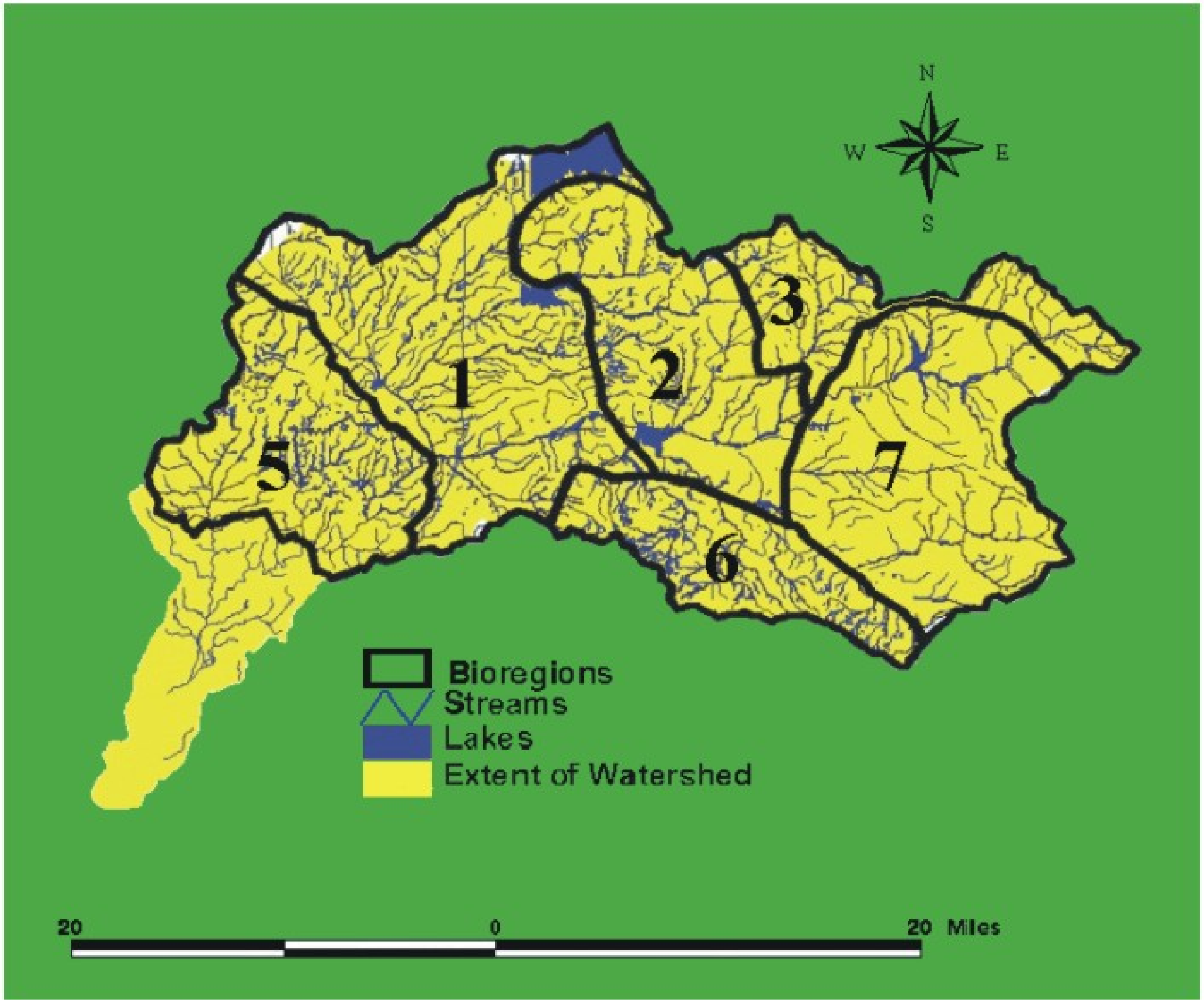


Figure 2. Locations of the six bioregions (1=Riverside Lowlands, 2=San Jacinto Foothills, 3=San Jacinto Mountains, 5=Santa Ana Mountains, 6=Agua Tibia Mountains, and 7=Desert Transition) within the Santa Margarita River watershed, Riverside and San Diego Counties, California.

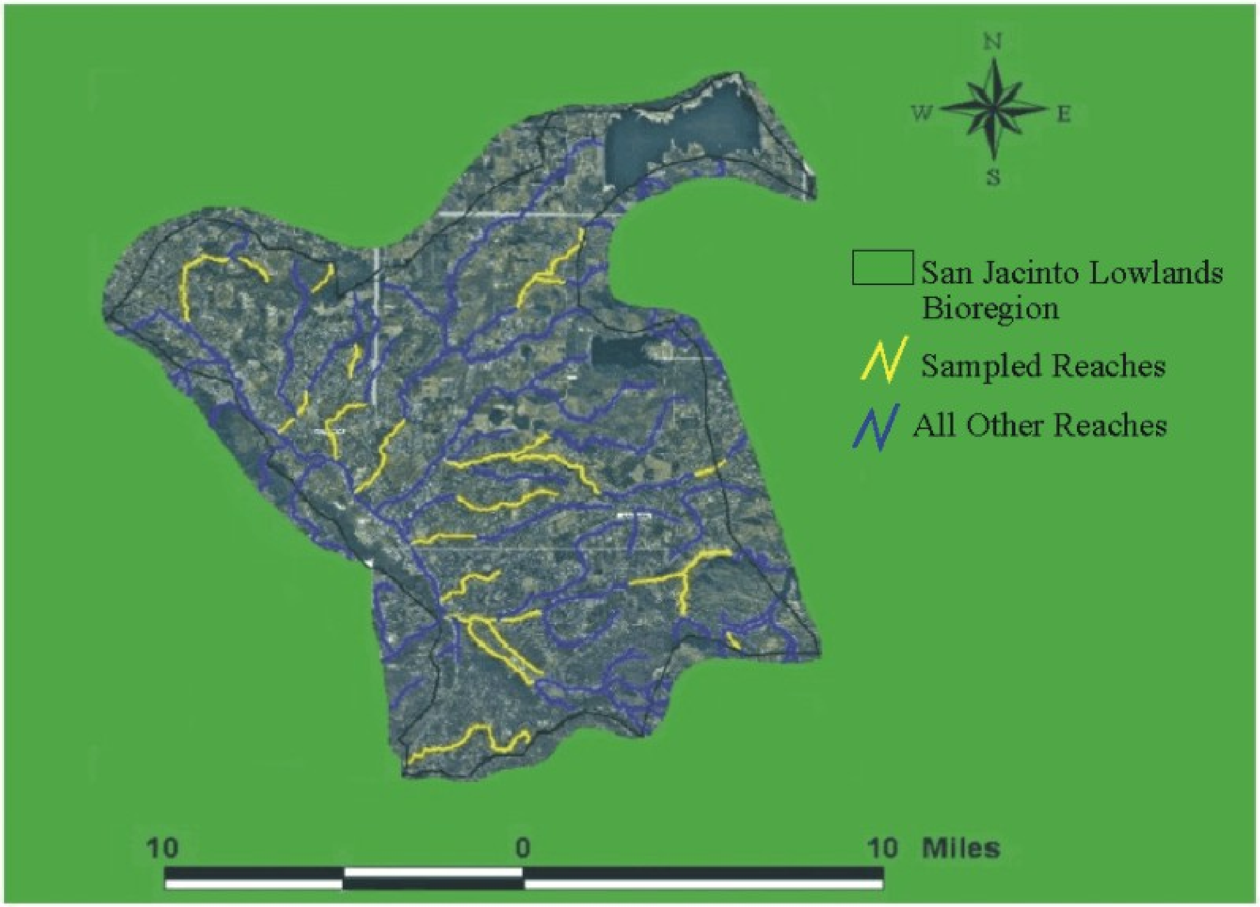


Figure 3. Distribution of sampled (yellow) and unsampled (blue) stream reaches in the Riverside (San Jacinto) Lowlands bioregion, Santa Margarita watershed, California.

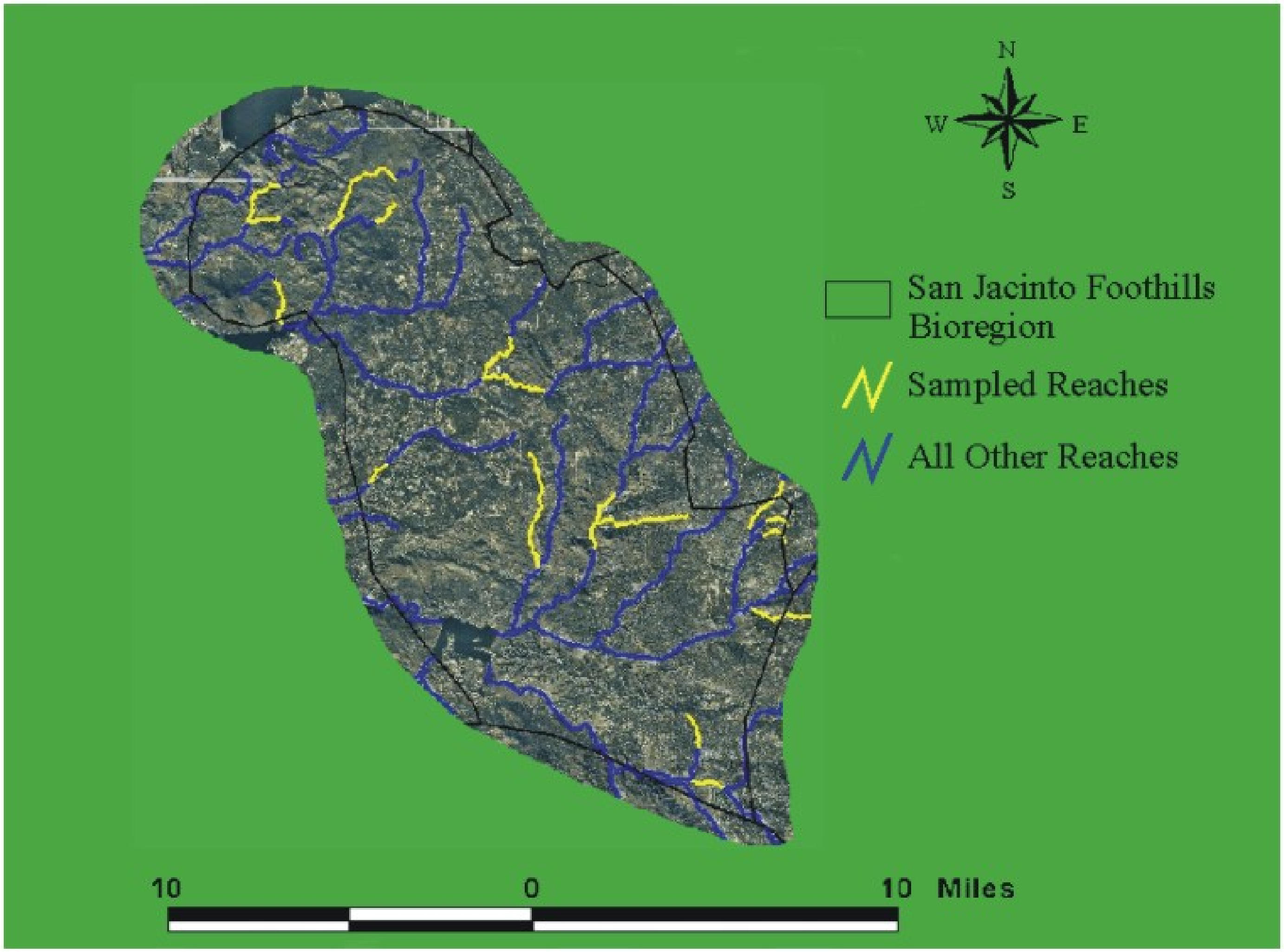


Figure 4. Distribution of sampled (yellow) and unsampled (blue) stream reaches in the San Jacinto Foothills bioregion, Santa Margarita watershed, California.

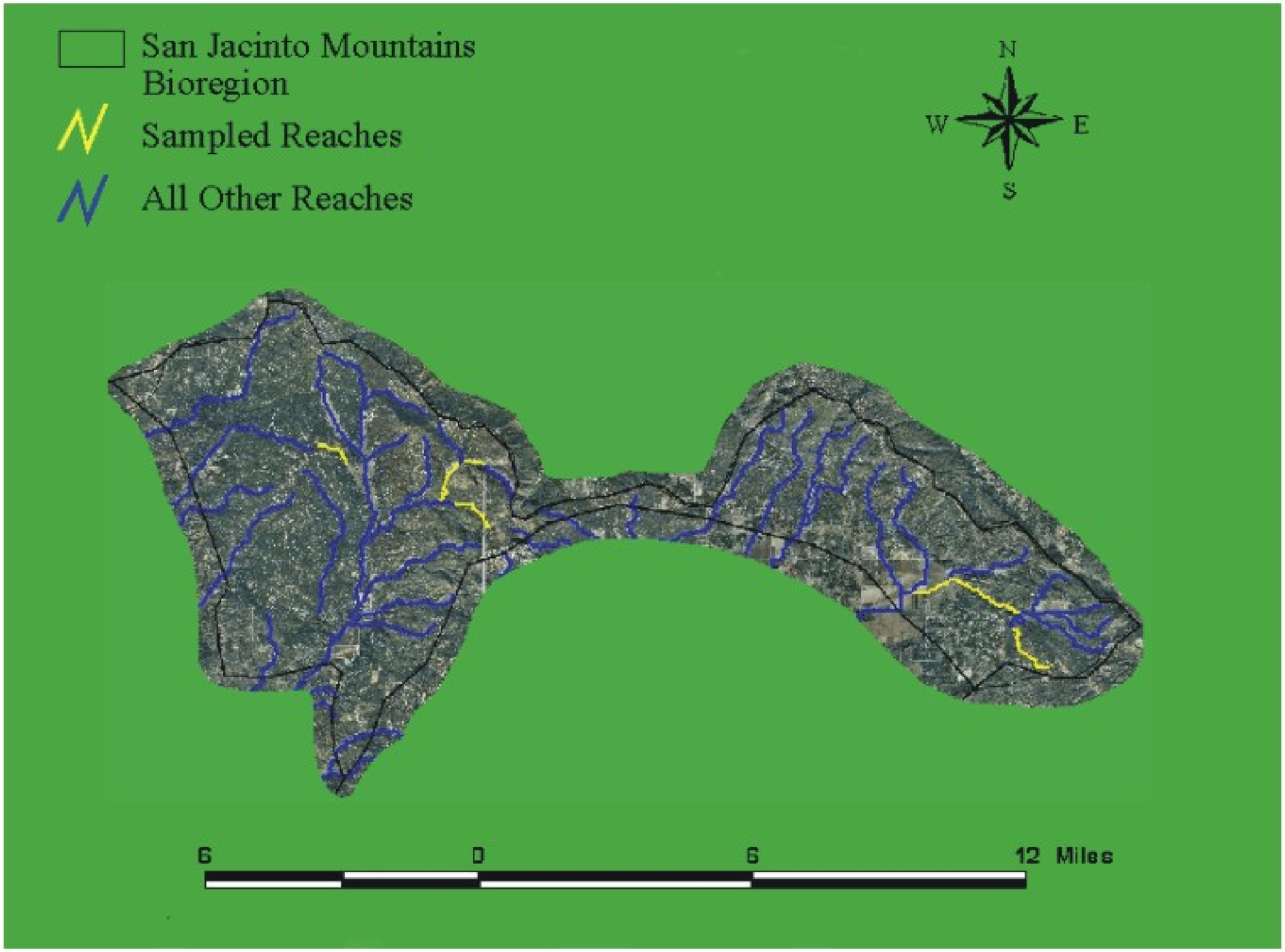


Figure 5. Distribution of sampled (yellow) and unsampled (blue) stream reaches in the San Jacinto Mountains bioregion, Santa Margarita watershed, California.

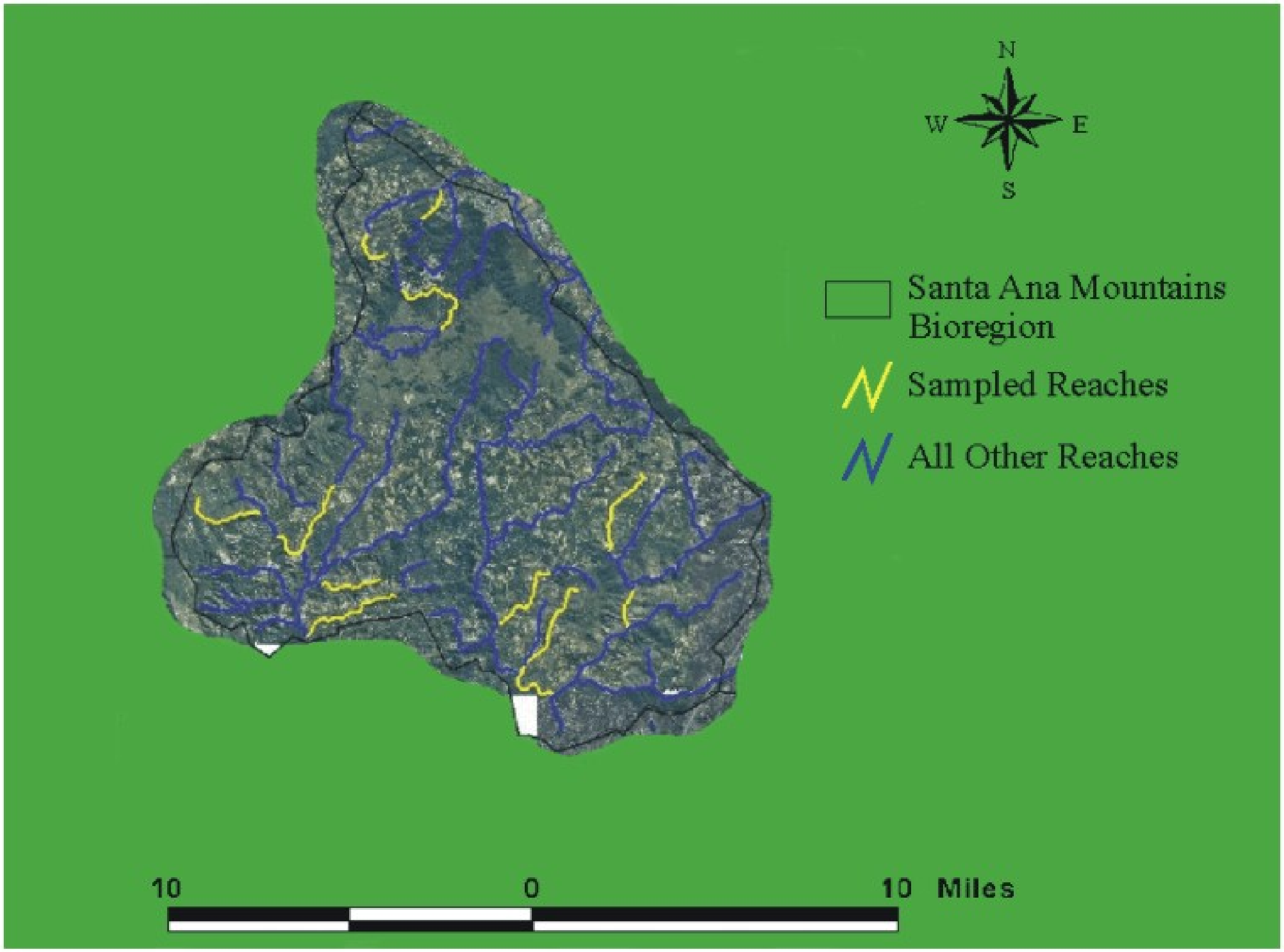


Figure 6. Distribution of sampled (yellow) and unsampled (blue) stream reaches within the Santa Ana Mountains bioregion, Santa Margarita watershed, California.

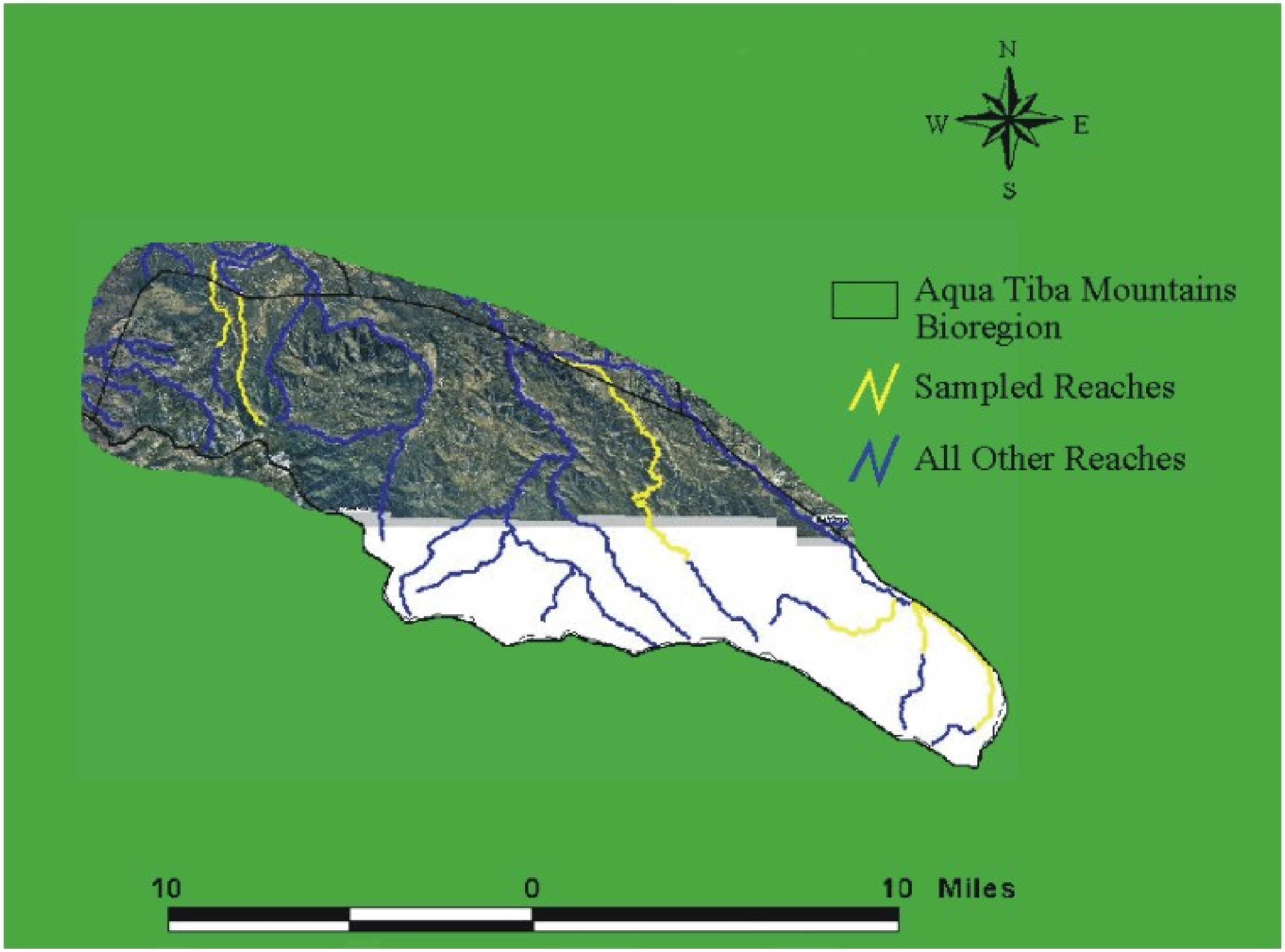


Figure 7. Distribution of sampled (yellow) and unsampled (blue) stream reaches in the Agua Tibia Mountains bioregion, Santa Margarita watershed, California.

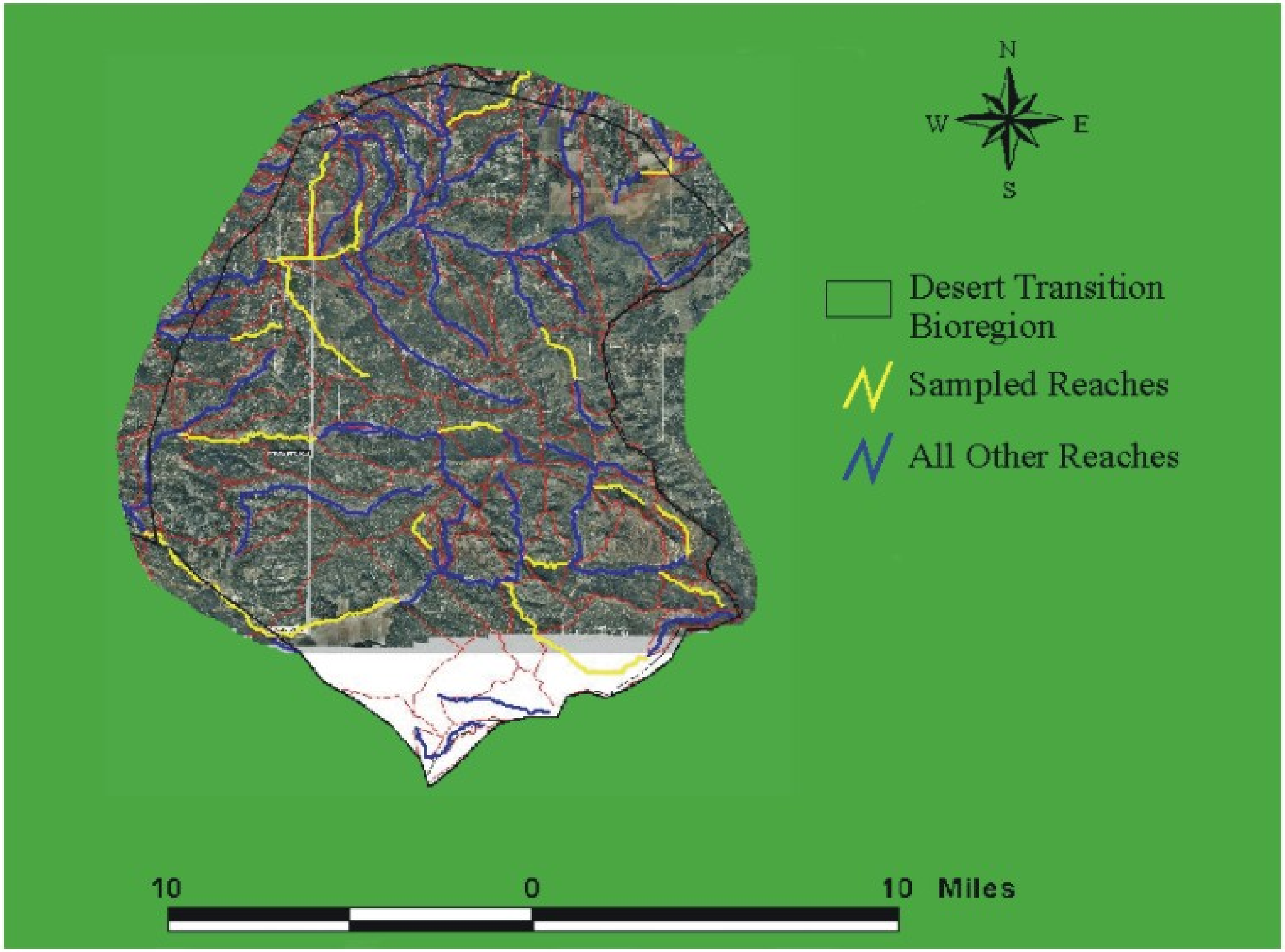


Figure 8. Distribution of sampled (yellow) and unsampled (blue) stream reaches in the Desert Transition bioregion, Santa Margarita watershed, California.

Figure 9. Reaches sampled within the Riverside Lowlands bioregion were the most impacted by urban development (left), yet some densely vegetated, high quality areas were available (right) that supported diverse bird communities.

Figure 10. Reaches in the San Jacinto Foothills bioregion generally had steeper topography and were dominated by thickets of scrub oaks and sage (left), but some areas were composed largely of open sage and shrub habitat (right).

Figure 11. The San Jacinto Mountains bioregion was characterized by high elevations, steep slopes, and densely vegetated riparian habitats, and was generally undisturbed compared to other bioregions. The Hamilton 4 reach (right), was one of only two reaches that supported Brewer's Sparrows.

Figure 12. Subjected to coastal weather patterns, stream reaches within the Santa Ana Mountains bioregion received more rainfall than other bioregions (left). High elevations and steep slopes (right) made access to some reaches in this bioregion difficult.

Figure 13. The Agua Tibia Mountains bioregion varied from densely vegetated oak woodlands (left) to open sage scrub habitats (right). Although some areas within this bioregion were subject to agriculture or ranching, this bioregion was largely undisturbed.

Figure 14. The Desert Transition bioregion was distinctly drier than the other bioregions (top left), with scattered areas of large boulders (top right), and several reaches with sandy or rocky substrates (bottom left); however, several reaches possessed dense vegetation (bottom right) and supported diverse bird communities.

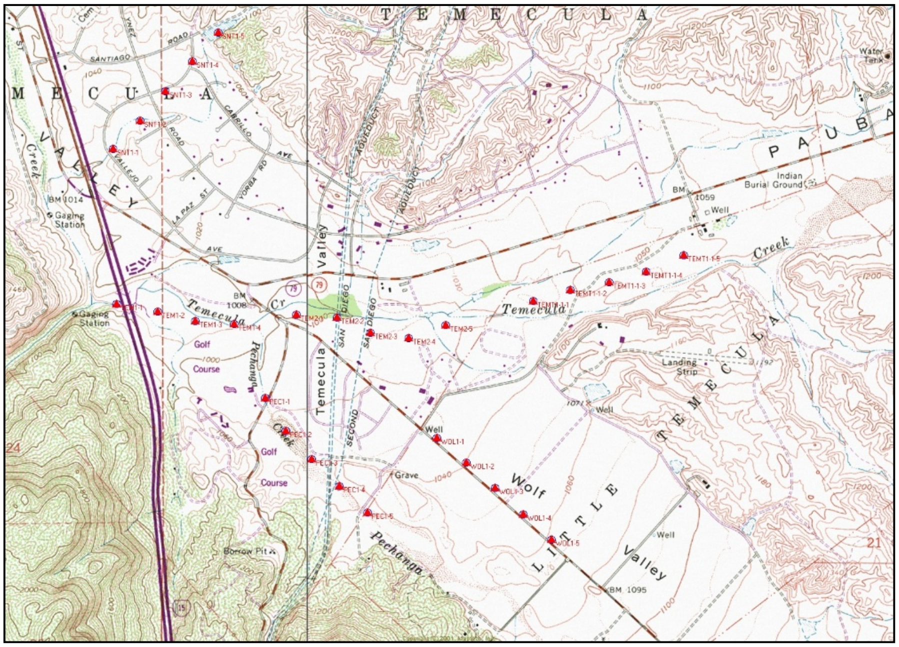


Figure 15. Example showing locations of bird and habitat sampling points along the Temecula, Pechanga, and Wolf Creek drainages in the Santa Margarita watershed. Points are spaced approximately 250 m apart.

Point-count Surveys. Point-sampling methodology followed Ralph et al (1995) and Hamel et al. (1996) (see Appendix A), and consisted of 5-min survey counts with all birds detected by sight or vocalizations noted on a "bull's eye" field data form (see Appendix B). We conducted bird surveys twice at all point-count stations in an effort to sample both early and later nesting species. Survey points were first sampled from 22 March through 29 April and resampled from 29 April through 2 June 2003. We recorded bird detections in two time categories (the first 3 min and next 2 min of the 5-min count period) and three distance categories (<25 m, 25-50 m, and >50 m from the observer); however, subsequent analyses were based on all birds detected within 5 min and unlimited distance. Surveys were conducted by seven locally experienced birders. We attempted to reduce observer bias by spending the first morning in the field together as a group.

Habitat Sampling and the Index to Human Disturbance. During mid-April to early June 2003, we revisited sampling stations to collect habitat data (see Appendix C). The coverage of the following land uses in a 100-m circle centered on each sampling point was estimated visually: agricultural crop or bare field; native or introduced grassland or herbs (including pasture); chaparral or shrubland; forest; and urban, industrial, or developed land. We recorded all percentages in one of seven cover classes: 0, trace (<1%), 1-5%, 5-25%, 25-50%, 50-75%, and 75-100%, and used midpoints of cover classes in subsequent analyses. In addition, we visually rated the level of human activity within or immediately adjacent to the riparian zone as 0=none, 25=light, 50=moderate, 75=heavy, or 100=severe. Types of human activities were recorded and included all-terrain vehicle (ATV) trails, dirt road, secondary paved road (≤2 lanes), main paved road (>2 lanes), livestock grazing, mowing or clearing, presence of a house or other structure, and presence of a public park or picnic area.

Habitat data gathered on site were used to supplement the land-use data in the GIS to create a final index of human disturbance (IHD) for each sampled reach that accounted for human activity at different spatial scales. IHD was based on (1) land use in the local drainage of the reach, (2) land use in the immediate vicinity of bird sampling points, and (3) other human activity within or immediately adjacent to the riparian zone. The initial disturbance index attributable to human use of the local drainage (LD) was described previously in the section on Selection of Reaches and Establishment of Sampling Points. This component of the IHD ranged from 0-100%. Sampled local drainages ranged in size from 91 to 6,030 acres (37 to 2,440 ha); therefore, LD reflected human environmental alteration at a landscape scale. The second component of IHD, disturbance attributable to land use in the vicinity of the riparian reach (RR), was determined by averaging the midpoints of land-use cover classes within 100 m of the first four sampling points in each reach, including only agricultural land use or urban/industrial/developed land use as significantly disturbed. This component ranged from 0-87.5%. The third component, an index of direct human activity in the riparian zone (HA), was calculated as the mean of the visual ratings of human activity across the four sampling points. Mean values ranged from 0-100. IHD was calculated as the largest of these three components:

IHD = Maximum of LD, RR, or HA.

This formula for the human disturbance index was different from that used previously in the San Jacinto watershed (Wakeley et al. 2003). In the San Jacinto watershed, land-use data in the GIS did not distinguish between low-density urban and full urban conditions. We took advantage of the added information in the Santa Margarita analysis by giving full urban conditions greater weight in the index. In addition, it became clear during the analysis of the San Jacinto data that land-use coverage alone, even combining the local drainage and riparian reach scales, did not capture all of the types of human disturbance that potentially impacted riparian bird communities. For example, several reaches were used heavily by ATV riders and, consequently, had lower-than-expected IBI values for the apparent level of disturbance indicated by land-use coverages alone. For the Santa Margarita study, we devised the HA to account for these additional human impacts.

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 relevant groups. Therefore, it was necessary to identify appropriate groups and assign bird species to them. For the Santa Margarita work we used the same groupings developed previously for the San Jacinto watershed (Wakeley et al. 2003).

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 IBI development. 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 excluded species listed as water or marsh birds from IBI development (see Table 1 under Riparian Use). Captive domestic birds were also dropped from the dataset. 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 et al. (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 lists dated 17 October 2003, http://www.prbo.org/cms/docs/terre/List_17_Oct_2003.pdf), or (3) classified in Tiers I (high overall priority) or II (high regional priority) of the Partners in Flight (PIF) priority system (Carter et al. 2000, Panjabi 2001, http://www.rmbo.org/pif/pifdb.html).

Table 1. Bird groups and guilds considered in IBI development. List includes all species detected during 2003 sampling in the Santa Margarita River watershed.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
Eared Grebe	*Podiceps nigricollis*	Nonbreed	Crustaceavore	Water		Water bird	Native	Floating
Pied-billed Grebe	*Podilymbus podiceps*	Resident	Crustaceavore	Water		Water bird	Native	Floating
Clark's Grebe	*Aechmophorus clarkii*	Resident	Piscivore	Water		Water bird	Native	Floating
Western Grebe	*Aechmophorus occidentalis*	Resident	Piscivore	Water		Water bird	Native	Floating
American White Pelican	*Pelecanus erythrorhynchos*	Nonbreed	Piscivore	Water	PRBO 1	Water bird	Native	Ground
Double-crested Cormorant	*Phalacrocorax auritus*	Resident	Piscivore	Water		Water bird	Native	Ground
Black-crowned Night-Heron	*Nycticorax nycticorax*	Resident	Piscivore	Water		Water bird	Native	Tree
Snowy Egret	*Egretta thula*	Short Dist.	Crustaceavore	Water		Water bird	Native	Tree
Great Blue Heron	*Ardea herodias*	Resident	Piscivore	Water		Water bird	Native	Tree
Domestic Goose	*Anser domesticus*	Resident	Granivore	Ground		Captive	Introduced	Ground
Canada Goose	*Branta canadensis*	Resident	Omnivore	Ground		Water bird	Native	Ground
Mallard	*Anas platyrhynchos*	Resident	Granivore	Water		Water bird	Native	Ground
Gadwall	*Anas strepera*	Resident	Herbivore	Water		Water bird	Native	Ground
Cinnamon Teal	*Anas cyanoptera*	Resident	Granivore	Water	PIF 2A	Water bird	Native	Ground
Redhead	*Aythya americana*	Resident	Crustaceavore	Water	PRBO 2	Water bird	Native	Floating
Ruddy Duck	*Oxyura jamaicensis*	Resident	Herbivore	Water		Water bird	Native	Ground
Turkey Vulture	*Cathartes aura*	Resident	Carnivore	Ground Scavenge		Non-Dependent	Native	Cavity
Osprey	*Pandion haliaetus*	Resident	Piscivore	Water		Water bird	Native	Tree
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
Sharp-shinned Hawk	*Accipiter striatus*	Resident	Carnivore	Air		Non-Dependent	Native	Coniferous 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
Domestic Peacock	*Pavo cristatus*	Resident	Granivore	Ground		Captive	Introduced	Ground
Domestic Chicken	*Gallus gallus*	Resident	Granivore	Ground		Captive	Introduced	Ground
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

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
Sora	*Porzana carolina*	Resident	Insectivore	Ground		Marsh bird	Native	Floating
American Coot	*Fulica americana*	Resident	Omnivore	Water		Water bird	Native	Floating
Killdeer	*Charadrius vociferus*	Resident	Insectivore	Ground	PIF 2A	Non-Dependent	Native	Ground
Long-billed Dowitcher	*Limnodromus scolopaceus*	Resident	Insectivore	Water		Water bird	Native	Ground
Ring-billed Gull	*Larus delawarensis*	Nonbreed	Omnivore	Ground		Water bird	Native	Ground
California Gull	*Larus californicus*	Short Dist.	Omnivore	Ground		Water bird	Native	Ground
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
Common Ground-Dove	*Columbina passerina*	Resident	Granivore	Ground		Non-Dependent	Native	Ground
Greater Roadrunner	*Geococcyx californianus*	Resident	Insectivore	Ground		Non-Dependent	Native	Tree
Barn Owl	*Tyto alba*	Short Dist.	Carnivore	Ground Hawk	PIF 2B	Non-Dependent	Native	Tree
Burrowing Owl	*Athene cunicularia*	Resident	Carnivore	Ground Hawk	PRBO 1, PIF 2C	Non-Dependent	Native	Burrow
Lesser Nighthawk	*Chordeiles acutipennis*	Neotropical	Insectivore	Air		Non-Dependent	Native	Ground
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
Belted Kingfisher	*Ceryle alcyon*	Resident	Piscivore	Water		Obligate	Native	Bank
Acorn Woodpecker	*Melanerpes formicivorus*	Resident	Omnivore	Canopy		Non-Dependent	Native	Cavity
Northern (Red-shafted) Flicker	*Colaptes auratus*	Resident	Insectivore	Ground		Non-Dependent	Native	Cavity
Red-breasted Sapsucker	*Sphyrapicus ruber*	Short Dist.	Insectivore	Bark		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
Hairy Woodpecker	*Picoides villosus*	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
Gray Flycatcher	*Empidonax wrightii*	Transient	Insectivore	Air		Non-Dependent	Native	Shrub

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
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		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
Cassin’s Vireo	*Vireo cassinii*	Neotropical	Insectivore	Canopy	PIF 2C	Non-Dependent	Native	Coniferous Tree
Warbling Vireo	*Vireo gilvus*	Neotropical	Insectivore	Canopy		Dependent	Native	Tree
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
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
Tree Swallow	*Tachycineta bicolor*	Resident	Insectivore	Air		Dependent	Native	Cavity
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
Verdin	*Auriparus flaviceps*	Resident	Insectivore	Canopy		Non-Dependent	Native	Shrub
Bushtit	*Psaltriparus minimus*	Resident	Insectivore	Canopy	PIF 2A	Non-Dependent	Native	Tree
Brown Creeper	*Certhia americana*	Resident	Insectivore	Bark		Non-Dependent	Native	Coniferous 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

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
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
Marsh bird Wren	*Cistothorus palustris*	Resident	Insectivore	Ground	PIF 2C	Marsh bird	Native	Reeds
Golden-crowned Kinglet	*Regulus satrapa*	Resident	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Ruby-crowned Kinglet	*Regulus calendula*	Nonbreed	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Blue-gray Gnatcatcher	*Polioptila caerulea*	Resident	Insectivore	Canopy		Non-Dependent	Native	Tree
Western Bluebird	*Sialia mexicana*	Resident	Insectivore	Ground Hawk	PIF 2B	Non-Dependent	Native	Cavity
California Swainson's Thrush	*Catharus ustulatus oedicus*	Neotropical	Insectivore	Ground	PRBO 3	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
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
Crissal Thrasher	*Toxostoma crissale*	Resident	Insectivore	Ground	PRBO 1, PIF 1	Non-Dependent	Native	Shrub
European Starling	*Sturnus vulgaris*	Resident	Omnivore	Ground		Non-Dependent	Introduced	Cavity
American Pipit	*Anthus rubescens*	Short Dist.	Insectivore	Ground		Non-Dependent	Native	Ground
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
Hermit Warbler	*Dendroica occidentalis*	Short Dist.	Insectivore	Canopy		Non-Dependent	Native	Coniferous Tree
Yellow Warbler	*Dendroica petechia*	Neotropical	Insectivore	Canopy	PRBO 2	Obligate	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

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
Western Tanager	*Piranga ludoviciana*	Neotropical	Omnivore	Canopy		Non-Dependent	Native	Coniferous Tree
Green-tailed Towhee	*Pipilo chlorurus*	Short Dist.	Insectivore	Ground		Non-Dependent	Native	Shrub
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
Grasshopper Sparrow	*Ammodramus savannarum*	Short Dist.	Insectivore	Ground	PRBO 2	Non-Dependent	Native	Ground
Fox Sparrow	*Passerella iliaca*	Short Dist.	Insectivore	Ground		Obligate	Native	Ground
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
Vesper Sparrow	*Pooecetes gramineus*	Nonbreed	Omnivore	Ground		Non-Dependent	Native	Ground
White-crowned Sparrow	*Zonotrichia leucophrys*	Nonbreed	Omnivore	Ground		Non-Dependent	Native	Shrub
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
Yellow-headed Blackbird	*Xanthodephalus xanthocephalus*	Resident	Insectivore	Ground	PRBO 2	Marsh bird	Native	Reeds
Red-winged Blackbird	*Agelaius phoeniceus*	Resident	Insectivore	Ground		Non-Dependent	Native	Reeds
Tricolored Blackbird	*Agelaius tricolor*	Resident	Insectivore	Ground	PRBO 1, PIF 1	Marsh bird	Native	Reeds
Great-tailed Grackle	*Quiscalus mexicanus*	Resident	Omnivore	Ground		Non-Dependent	Native	Tree
Brewer's Blackbird	*Euphagus cyanocephalus*	Resident	Insectivore	Ground		Non-Dependent	Native	Coniferous Tree
Brown-headed Cowbird	*Molothrus ater*	Resident	Insectivore	Ground		Non-Dependent	Native	Tree
Hooded Oriole	*Icterus cucullatus*	Neotropical	Omnivore	Canopy	PIF 2B	Dependent	Native	Tree

Table 1. Cont.

Species	Scientific Name	Migratory Status	Predominant Diet	Foraging Guild	Conservation Status[1]	Riparian Use	Origin	Nest Location
Bullock's Oriole	*Icterus bullockii*	Neotropical	Omnivore	Canopy	PIF 1	Dependent	Native	Tree
Scott's Oriole	*Icterus parisorum*	Neotropical	Omnivore	Canopy		Non-dependent	Native	Tree
Purple Finch	*Carpodacus purpureus*	Resident	Granivore	Canopy		Non-Dependent	Native	Coniferous Tree
House Finch	*Carpodacus mexicanus*	Resident	Granivore	Ground		Non-Dependent	Native	Tree
Pine Siskin	*Carduelis pinus*	Resident	Granivore	Ground		Non-Dependent	Native	Coniferous 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.

Data Handling and Analysis

All field data were entered into Microsoft Excel® spreadsheets and checked for accuracy. Most data handling and analysis were accomplished with Statistical Analysis System software (SAS Institute, Inc. 1999). Differences in mean counts for species groups (Neotropical migrants, Nearctic migrants, short-distance migrants, resident species, and all species) and for selected individual species between first and second visits to sampling points were tested using t-tests. Data from first and second visits were later summed for IBI development, to account for both early and later nesters. Analysis of variance (ANOVA) was used to determine differences in mean counts for species groups and selected individual species, and mean species richness for species groups, among the six 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), 1 Nearctic migrant (White-crowned Sparrow), and six residents (Spotted Towhee, House Finch, Wrentit, Yellow-rumped [Audubon's] Warbler, and Bushtit) each with at least 40 detections recorded (Burnham et al. 1980).

Using the IBI formula developed previously for the San Jacinto River watershed (Wakeley et al. 2003), we first calculated a provisional IBI for each sampled reach in the Santa Margarita watershed. The performance of the provisional IBI was then evaluated by comparing it with the disturbance index (IHD). A strong correlation would have indicated that the provisional IBI formula was also applicable to the Santa Margarita study area. A weak correlation would have indicated that the index needed to be refined for application beyond the San Jacinto watershed.

Refinement of the IBI for the Santa Margarita watershed involved calculating 65 potential bird-community metrics for each riparian reach and evaluating each metric's relationship to the IHD (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 × 100), and (3) percent abundance of individuals (i.e., number of individual birds in that guild / total number of birds counted in the reach × 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 the IHD for each reach. Any bird-community metric that was significantly ($P < 0.05$) correlated with the 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 categorical 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 and examination of the overall correlation between IBI and IHD. In addition, historical or pre-settlement characteristics of bird communities in the watershed were 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 more individuals of some species now rare in southern California (e.g., Bell's Vireo [*Vireo bellii*], Blue-gray Gnatcatcher [*Polioptila caerulea*], and Yellow-billed Cuckoo [*Coccyzus americanus*]). The final IBI was the sum of scores for the selected metrics and reflected the difference between the existing bird community and the presumed complete and unimpaired bird community.

RESULTS

Bird Counts

During the 2003 breeding season, we counted over 15,000 birds of 160 identified species, not counting captive domestic birds. Thirty-one species were Neotropical migrants, 9 species were short-distance migrants, 12 species were Nearctic migrants, and 108 species were year-round residents (Table 2). During the first visit to each sampling point, >7,000 birds of 139 species were detected, with 25 Neotropical migrants, 8 short-distance migrants, 11 Nearctic migrants, and 95 resident species (Table 3). During the second visit to the sampling points, nearly 8,500 birds of 135 species were detected, with 29 Neotropical migrants, 8 short-distance migrants, and 4 Nearctic migrants, and 94 resident species (Table 4).

Mean counts of residents and total species differed significantly between the two visits, with higher mean counts during the second visit (Figure 15). Neotropical migrants and short-distance migrants had higher mean counts during the second round of visits, while Nearctic species had higher mean counts during the first round of visits (Figure 16). Audubon's Warbler and White-crowned Sparrow had higher mean counts during the first visits to the sampling points, and the Ash-throated Flycatcher had higher mean counts during the second round of surveys (Figure 17). One resident species, the House Finch, had higher mean detections during the second round of surveys, while mean detections for one Neotropical species, Bullock's Oriole, did not differ among visits (Figure 17). No significant differences in mean counts were observed between visits for most resident species, including the Wrentit, Bushtit, and Spotted Towhee (Figure 17).

For residents, Nearctic migrants, and all species combined, mean abundance values were higher in the Riverside Lowlands (Figures 18 and 19), while no statistically significant differences in mean abundance of Neotropical and short-distance migrants were observed among the bioregions (Figure 19). Although not significant, higher mean counts of Neotropical migrants were observed in the Desert Transition (Figure 19). Mean species richness values of residents and total species were significantly lower in the San Jacinto Mountains and Desert Transition bioregions (Figure 20), while no differences were observed among the remaining bioregions for these groups. Mean species richness of Neotropical migrants was significantly higher in the Santa Ana and Agua Tibia Mountains, while Nearctic migrants had higher species richness in the Riverside Lowlands and the San Jacinto Mountains (Figure 21). Short-distance migrants had higher mean richness in the Desert Transition bioregion (Figure 21).

Forty-nine PIF Priority species were detected during point-count surveys in the Santa Margarita watershed (Table 5). Highest total counts and numbers of priority species were observed in the San Jacinto Foothills and Santa Ana Mountains bioregions, while the San Jacinto Mountains and the Agua Tibia Mountains had the fewest priority species and the lowest counts (Table 5). The Lowland and Desert Transition bioregions were only slightly lower than the San Jacinto Foothills and Santa Ana Mountains in counts and species richness values (Table 5). Eighteen observed priority species were classified in the Coastal Scrub / Chaparral habitat type, while 12 were classified as important to Riparian Habitats. Ten species were classified as Coniferous Forest users, while 11 species utilize Oak Woodland habitat (Table 5). Several species, including the Ash-throated Flycatcher, Western Scrub Jay, Bewick's Wren, California Thrasher, and Oak Titmouse, were relatively equally distributed among the bioregions; however, the California Quail and California Towhee were more abundant in the San Jacinto Foothills, and the Acorn Woodpecker, Spotted Towhee, and Wrentit were more common in the Santa Ana Mountains. Several species, including the Black-chinned Sparrow, Costa's Hummingbird, and Wilson's Warbler, were generally more abundant in the Desert Transition bioregion, while the Turkey Vulture was more abundant in the Riverside Lowlands. The Common Yellowthroat and Nuttall's Woodpecker had higher counts in the Lowlands and Santa Ana Mountains bioregions, while Mountain Quail were more common in the San Jacinto Mountains and Desert Transition bioregions (Table 5).

Table 2. Total number of detections by species and number of points (n=470) at which each species was detected during spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, March-early June 2003.

Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
House Finch	1,428	237	Canada Goose	10	4
Red-winged Blackbird	758	66	Lincoln's Sparrow	10	9
Spotted Towhee	740	292	Canyon Wren	9	7
Mourning Dove	640	302	**Barn Swallow**	8	4
American Crow	562	183	**Black-throated Gray Warbler**	8	8
Lesser Goldfinch	515	174	*Fox Sparrow*	8	6
Tricolored Blackbird	514	7	Great Blue Heron	8	4
California Towhee	487	237	Townsend's Warbler	8	7
Wrentit	456	218	Yellow-headed Blackbird	8	4
European Starling	428	109	American White Pelican	7	1
Bushtit	424	174	**Cassin's Vireo**	7	7
Song Sparrow	374	161	**Nashville Warbler**	7	6
California Quail	356	157	**Lesser Nighthawk**	6	3
Western Meadowlark	346	106	Ring-billed Gull	6	2
Western Scrub Jay	324	179	Belted Kingfisher	5	4
Common Raven	319	169	**Empidonax spp.**	5	4
Anna's Hummingbird	315	199	Golden Eagle	5	4
Lazuli Bunting	312	162	Hairy Woodpecker	5	2
White-crowned Sparrow	287	98	**Hermit Warbler**	5	5
House Wren	258	114	Ladder-backed Woodpecker	5	4
Northern Mockingbird	256	146	**Allen's Hummingbird**	4	4
Audubon's Warbler	254	118	**Bank Swallow**	4	2
Brown-headed Cowbird	249	112	Cinnamon Teal	4	2
Oak Titmouse	225	118	Northern Harrier	4	4
Cliff Swallow	212	20	**Olive-sided Flycatcher**	4	4
Ash-throated Flycatcher	205	149	Pygmy Nuthatch	4	1
Brewer's Blackbird	201	42	Sage Thrasher	4	3
Northern Rough-winged Swallow	201	47	Tree Swallow	4	2
Bewick's Wren	191	128	White-breasted Nuthatch	4	4
American Goldfinch	157	73	White-throated Swift	4	2
California Thrasher	157	108	Great Horned Owl	3	2
Black-headed Grosbeak	142	88	Greater Roadrunner	3	3
Acorn Woodpecker	131	47	*Red-breasted Sapsucker*	3	2
Bullock's Oriole	124	71	*Snowy Egret*	3	3
House Sparrow	120	37	Sora	3	3
Common Yellowthroat	119	70	Verdin	3	2
Nuttall's Woodpecker	84	68	Western Grebe	3	2
Red-shafted Flicker	84	59	Domestic Goose	2	1
Horned Lark	81	19	Golden-crowned Sparrow	2	2
Phainopepla	79	46	Hermit Thrush	2	2
Lawrence's Goldfinch	78	33	Long-billed Dowitcher	2	1
Rufous-crowned Sparrow	78	45	Marsh Wren	2	1
Western Kingbird	78	42	Pied-billed Grebe	2	1
Red-tailed Hawk	75	61	Domestic Peacock	2	2
Rock Dove	74	21	Red-breasted Nuthatch	2	2
Costa's Hummingbird	72	60	**Swainson's Thrush**	2	2
Lark Sparrow	72	36	Vesper Sparrow	2	2
Black Phoebe	71	43	**Willow Flycatcher**	2	1
Killdeer	70	44	White-tailed Kite	2	2
Orange-crowned Warbler	67	46	Common Barn-Owl	1	1
Wilson's Warbler	66	50	Black-crowned Night Heron	1	1
American Coot	59	3	**Bell's Vireo**	1	1
Ruddy Duck	57	3	Band-tailed Pigeon	1	1
Cedar Waxwing	56	6	Burrowing Owl	1	1

Table 2. Total number of detections by species and number of points (n=470) at which each species was detected during spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, March-early June 2003.

Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
American Robin	55	25	*California Gull*	1	1
American Pipit	52	3	Clark's Grebe	1	1
Black-chinned Sparrow	51	35	Common Ground Dove	1	1
Pacific-slope Flycatcher	51	34	Cooper's Hawk	1	1
Purple Finch	49	19	Eared Grebe	1	1
Mallard	46	26	Golden-crowned Kinglet	1	1
Sage Sparrow	44	27	Great Egret	1	1
Oregon Junco	40	26	**Gray Flycatcher ***	1	1
Mountain Quail	39	28	Osprey	1	1
Turkey Vulture	39	21	Pine Siskin	1	1
Great-tailed Grackle	38	11	Prairie Falcon	1	1
Savannah Sparrow	38	25	Redhead	1	1
Western Wood-pewee	35	30	**Scott's Oriole**	1	1
Chipping Sparrow	31	21	Sharp-shinned Hawk	1	1
Domestic Chicken	31	14	Stellar's Jay	1	1
Western Tanager	30	25			
Rock Wren	29	23			
Ruby-crowned Kinglet	28	25			
Red-shouldered Hawk	27	23	**Total**	15,530	
Yellow Warbler	25	22			
American Kestrel	24	22			
Cassin's Kingbird	23	15			
Western Bluebird	23	11			
Violet-green Swallow	22	7			
Blue Grosbeak	21	14			
Hooded Oriole	20	15			
Yellow-breasted Chat	19	16			
Black-chinned Hummingbird	18	17			
Gadwall	18	5			
Warbling Vireo	18	13			
Double-crested Cormorant	17	4			
Brewer's Sparrow	16	9			
Loggerhead Shrike	16	15			
Downy Woodpecker	15	12			
Grasshopper Sparrow	13	8			
Mountain Chickadee	13	11			
Brown Creeper	12	5			
Hutton's Vireo	12	11			
Say's Phoebe	12	10			
Blue-gray Gnatcatcher	11	10			
Green-tailed Towhee	11	7			

[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 (n=470) at which each species was detected during the first visit of early spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, March - mid-April 2003.

Early Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
House Finch	579	177	Hutton's Vireo	8	7
Spotted Towhee	345	223	Mountain Quail	8	6
Red-winged Blackbird	313	51	Western Bluebird	8	5
American Crow	303	139	**Yellow Warbler**	8	7
<u>White-crowned Sparrow</u>	287	98	<u>American White Pelican</u>	7	1
California Towhee	256	171	Blue-gray Gnatcatcher	6	6
Lesser Goldfinch	249	117	**Nashville Warbler**	6	5
Audubon's Warbler	234	108	<u>Ring-billed Gull</u>	6	2
Wrentit	221	146	Yellow-headed Blackbird	6	4
Mourning Dove	209	146	**Barn Swallow**	5	3
Bushtit	205	102	**Black-throated Gray Warbler**	5	5
Song Sparrow	184	114	Canada Goose	5	2
European Starling	168	77	Golden Eagle	5	4
Western Scrub Jay	166	123	*Grasshopper Sparrow*	5	3
Anna's Hummingbird	151	121	Belted Kingfisher	4	3
Western Meadowlark	150	79	Canyon Wren	4	4
Common Raven	144	85	<u>Tree Swallow</u>	4	2
Tricolored Blackbird	142	5	**Western Wood-pewee**	4	4
House Wren	135	85	**Allen's Hummingbird**	3	3
Northern Mockingbird	129	97	**Cassin's Vireo**	3	3
California Quail	125	71	**Empidonax spp.**	3	2
Oak Titmouse	107	76	Greater Roadrunner	3	3
Brown-headed Cowbird	104	45	Hairy Woodpecker	3	1
Northern Rough-winged Swallow	101	21	Northern Harrier	3	3
Bewick's Wren	98	78	*Snowy Egret*	3	3
American Goldfinch	94	51	Sora	3	3
California Thrasher	79	65	*Violet-green Swallow*	3	2
Common Yellowthroat	66	44	**Western Tanager**	3	3
Acorn Woodpecker	61	32	**Blue Grosbeak**	2	2
Brewer's Blackbird	56	20	Cinnamon Teal	2	1
Rock Dove	56	17	Great Blue Heron	2	1
Ruddy Duck	55	2	<u>Golden-crowned Sparrow</u>	2	2
Bullock's Oriole	53	38	*Green-tailed Towhee*	2	1
<u>American Pipit</u>	51	2	Hermit Thrush	2	2
Ash-throated Flycatcher	51	46	**Hermit Warbler**	2	2
Western Kingbird	49	23	Long-billed Dowitcher	2	1
American Robin	48	20	Ladder-backed Woodpecker	2	2
Red-shafted Flicker	48	38	Red-breasted Nuthatch	2	2
Nuttall's Woodpecker	47	40	*Red-bellied Sapsucker*	2	1
Red-tailed Hawk	45	38	Verdin	2	1
Black-headed Grosbeak	41	31	<u>Vesper Sparrow</u>	2	2
<u>Cedar Waxwing</u>	40	4	**Warbling Vireo**	2	1
Killdeer	39	27	**Yellow-breasted Chat**	2	2
Lawrence's Goldfinch	39	20	Common Barn-Owl	1	1
Orange-crowned Warbler	39	34	Black-crowned Night Heron	1	1
Horned Lark	38	12	**Bell's Vireo**	1	1
Lark Sparrow	36	18	Band-tailed Pigeon	1	1
Rufous-crowned Sparrow	33	23	Clark's Grebe	1	1
Oregon Junco	31	20	Domestic Goose	1	1
Great-tailed Grackle	29	7	Eared Grebe	1	1
Mallard	28	18	*Fox Sparrow*	1	1
<u>Ruby-crowned Kinglet</u>	28	25	Golden-crowned Kinglet	1	1
Black-chinned Sparrow	23	16	Osprey	1	1
Lazuli Bunting	22	12	Domestic Peacock	1	1

Table 3. Number of detections by species and number of points (n=470) at which each species was detected during the first visit of early spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, March - mid-April 2003.

Early Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
American Coot	21	2	Prairie Falcon	1	1
Black Phoebe	21	18	Redhead	1	1
Domestic Chicken	19	8	**Scott's Oriole**	1	1
Rock Wren	19	17	Sharp-shinned Hawk	1	1
Chipping Sparrow	18	11	<u>Townsend's Warbler</u>	1	1
Cliff Swallow	18	5	White-breasted Nuthatch	1	1
Red-shouldered Hawk	18	16	White-tailed Kite	1	1
Turkey Vulture	18	11			
Savannah Sparrow	17	9			
Costa's Hummingbird	16	13			
Double-crested Cormorant	16	3	**Total**	7,039	
American Kestrel	14	13			
House Sparrow	14	10			
Sage Sparrow	14	11			
Phainopepla	13	9			
Cassin's Kingbird	12	8			
Gadwall	12	4			
Pacific-slope Flycatcher	12	11			
Purple Finch	11	7			
Wilson's Warbler	11	7			
Black-chinned Hummingbird	10	10			
Brown Creeper	10	4			
<u>Lincoln's Sparrow</u>	10	9			
Loggerhead Shrike	10	9			
Mountain Chickadee	10	8			
Say's Phoebe	10	8			
Hooded Oriole	9	7			
Brewer's Sparrow	8	3			
Downy Woodpecker	8	8			

[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 (n=470) at which each species was detected during the second visit of late spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, mid-April – early June 2003.

Late Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
House Finch	849	192	Red-shouldered Hawk	9	9
Red-winged Blackbird	445	43	**Black-chinned Hummingbird**	8	7
Mourning Dove	431	251	Brewer's Sparrow	8	7
Spotted Towhee	395	231	*Grasshopper Sparrow*	8	7
Tri-colored Blackbird	372	6	American Robin	7	6
Lazuli Bunting	290	155	Downy Woodpecker	7	5
Lesser Goldfinch	266	102	*Fox Sparrow*	7	5
European Starling	260	121	Townsend's Warbler	7	6
American Crow	269	63	Gadwall	6	1
Wrentit	235	161	Great Blue Heron	6	4
California Towhee	231	145	**Lesser Nighthawk**	6	3
California Quail	231	128	Loggerhead Shrike	6	6
Bushtit	219	109	Blue-gray Gnatcatcher	5	4
Western Meadowlark	196	86	Canada Goose	5	2
Cliff Swallow	194	17	Canyon Wren	5	4
Song Sparrow	190	115	**Bank Swallow**	4	2
Common Raven	175	112	**Cassin's Vireo**	4	4
Anna's Hummingbird	164	133	Hutton's Vireo	4	4
Western Scrub Jay	158	110	**Olive-sided Flycatcher**	4	4
Ash-throated Flycatcher	154	124	Pygmy Nuthatch	4	1
Brown-headed Cowbird	145	77	Sage Thrasher	4	3
Brewer's Blackbird	145	25	White-throated Swift	4	2
Northern Mockingbird	127	92	**Barn Swallow**	3	2
House Wren	123	75	**Black-throated Gray Warbler**	3	3
Oak Titmouse	118	66	Great Horned Owl	3	2
House Sparrow	106	31	**Hermit Warbler**	3	3
Black-headed Grosbeak	101	64	Ladder-backed Woodpecker	3	2
Northern Rough-winged Swallow	100	30	Mountain Chickadee	3	3
Bewick's Wren	93	71	White-breasted Nuthatch	3	3
California Thrasher	78	67	Western Grebe	3	2
Bullock's Oriole	71	48	Brown Creeper	3	1
Acorn Woodpecker	70	32	Cinnamon Teal	2	1
Phainopepla	66	40	**Empidonax spp.**	2	2
American Goldfinch	63	34	Hairy Woodpecker	2	1
Costa's Hummingbird	56	50	Marsh Wren	2	1
Wilson's Warbler	55	44	Pied-billed Grebe	2	1
Common Yellowthroat	53	40	Ruddy Duck	2	2
Black Phoebe	50	31	Say's Phoebe	2	2
Rufous-crowned Sparrow	45	27	**Swainson's Thrush**	2	2
Horned Lark	43	15	**Willow Flycatcher**	2	1
Lawrence's Goldfinch	39	18	Yellow-headed Blackbird	2	2
Pacific-slope Flycatcher	39	30	**Allen's Hummingbird**	1	1
American Coot	38	3	American Pipit	1	1
Purple Finch	38	13	Belted Kingfisher	1	1
Nuttall's Woodpecker	37	34	Black-throated Sparrow	1	1
Lark Sparrow	36	21	Burrowing Owl	1	1
Red-shafted Flicker	36	29	*California Gull*	1	1
Killdeer	31	23	Common Ground Dove	1	1
Mountain Quail	31	26	Cooper's Hawk	1	1
Western Wood-pewee	31	27	Crissal Thrasher	1	1
Red-tailed Hawk	30	30	Double-crested Cormorant	1	1
Sage Sparrow	30	19	Domestic Goose	1	1
Western Kingbird	29	22	Great Egret	1	1
Black-chinned Sparrow	28	23	**Gray Flycatcher**	1	1

Table 4. Number of detections by species and number of points (n=470) at which each species was detected during the second visit of late spring point-count surveys in riparian habitats, Santa Margarita River watershed, CA, mid-April – early June 2003.

Late Spring 2003					
Species	# Detected	# Points	Species	# Detected	# Points
Orange-crowned Warbler	28	16	**Nashville Warbler**	1	1
Western Tanager	27	22	Northern Harrier	1	1
Savannah Sparrow	21	17	Domestic Peacock	1	1
Turkey Vulture	21	11	Pine Siskin	1	1
Audubon's Warbler	20	14	*Red-breasted Sapsucker*	1	1
Blue Grosbeak	19	12	Stellar's Jay	1	1
Violet-green Swallow	19	5	Verdin	1	1
Mallard	18	10	White-tailed Kite	1	1
Rock Dove	18	8			
Yellow-breasted Chat	17	14			
Yellow Warbler	17	15			
Cedar Waxwing	16	2	**Total**	8,491	
Warbling Vireo	16	12			
Western Bluebird	15	6			
Chipping Sparrow	13	10			
Domestic Chicken	12	9			
Cassin's Kingbird	11	8			
Hooded Oriole	11	9			
American Kestrel	10	10			
Rock Wren	10	8			
Great-tailed Grackle	9	6			
Green-tailed Towhee	9	6			
Oregon Junco	9	6			

[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.

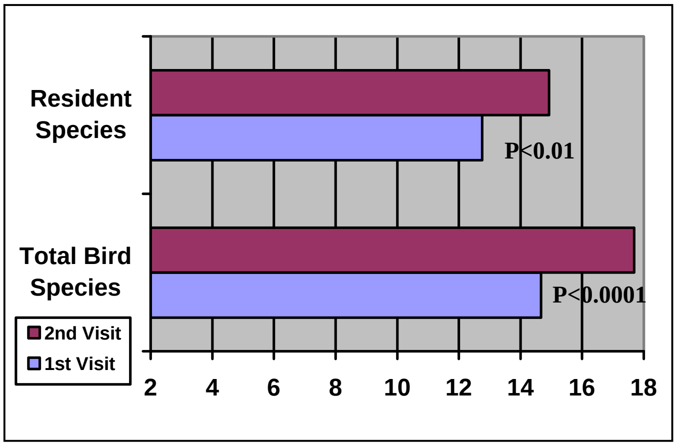


Figure 16. T-test comparisons of mean counts per reach for resident species and all species between the two visits to each sampling station during spring bird surveys in the Santa Margarita watershed 2003**.**

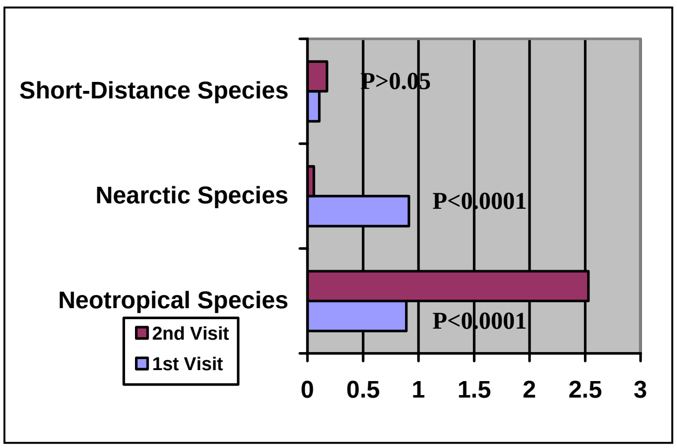


Figure 17. T-test comparisons of mean counts per reach for Neotropical, Nearctic, and short-distance migrants between the two visits to each sampling station during spring bird surveys in the Santa Margarita watershed 2003.

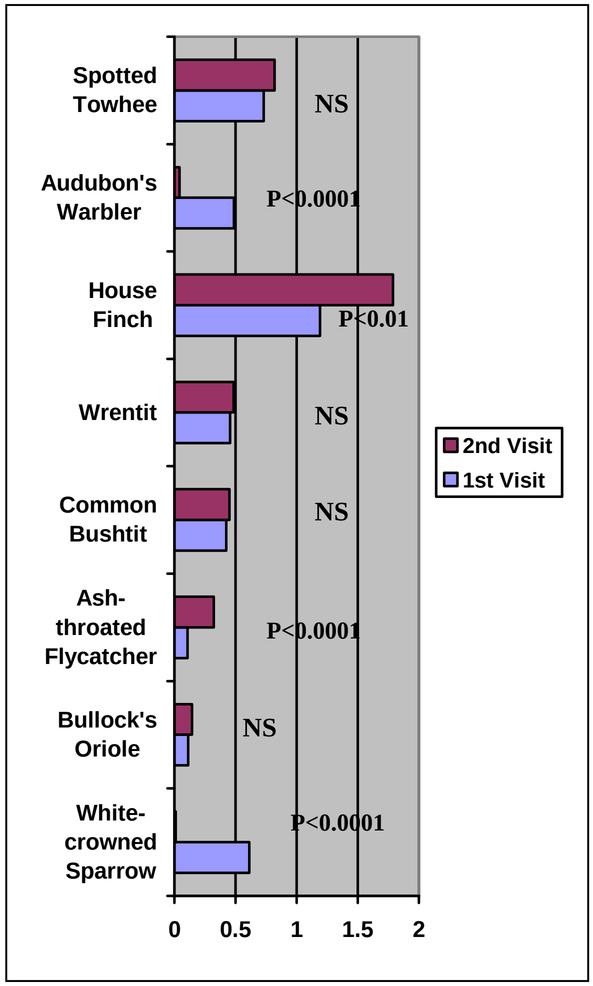


Figure 18. T-test comparisons of mean counts per reach for selected species between the two visits to each sampling station during spring bird surveys in the Santa Margarita watershed 2003**.**

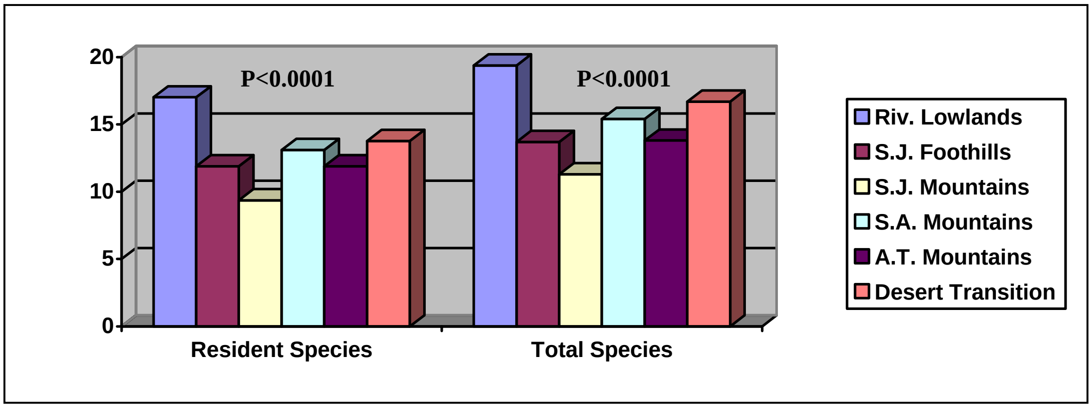


Figure 19. ANOVA results of mean counts per reach for residents and all species among the six bioregions during spring bird surveys in the Santa Margarita watershed 2003.

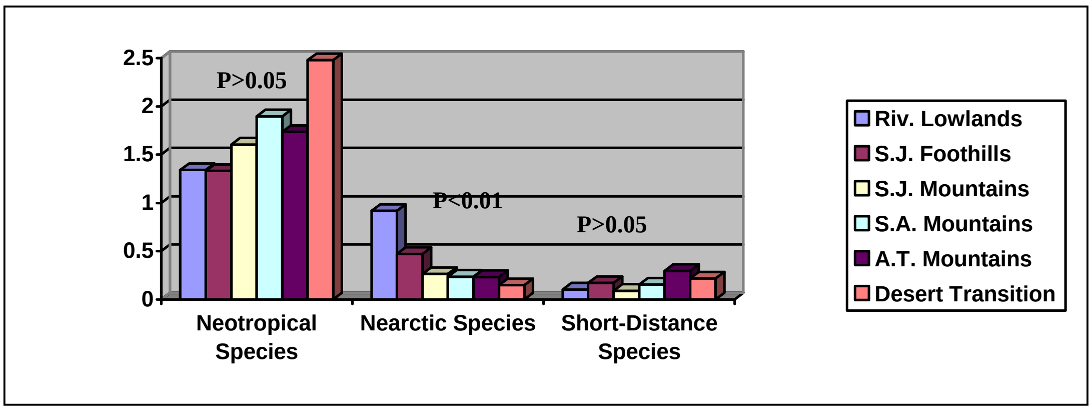


Figure 20. ANOVA results of mean counts per reach for Neotropical, Nearctic, and short-distance migrants among the six bioregions during spring bird surveys in the Santa Margarita watershed 2003.

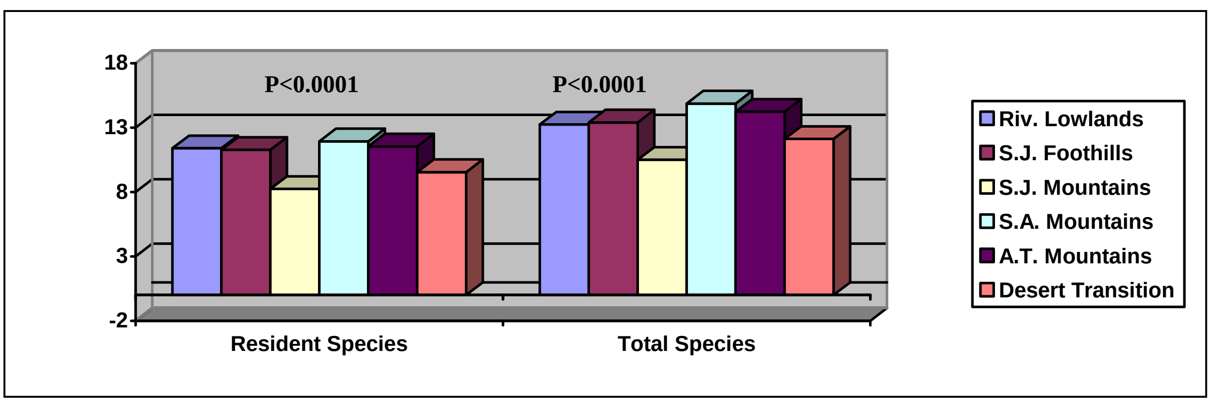


Figure 21. ANOVA results of mean species richness per reach for Neotropical, Nearctic, and short-distance migrants among the six bioregions during spring bird surveys in the Santa Margarita watershed 2003**.**

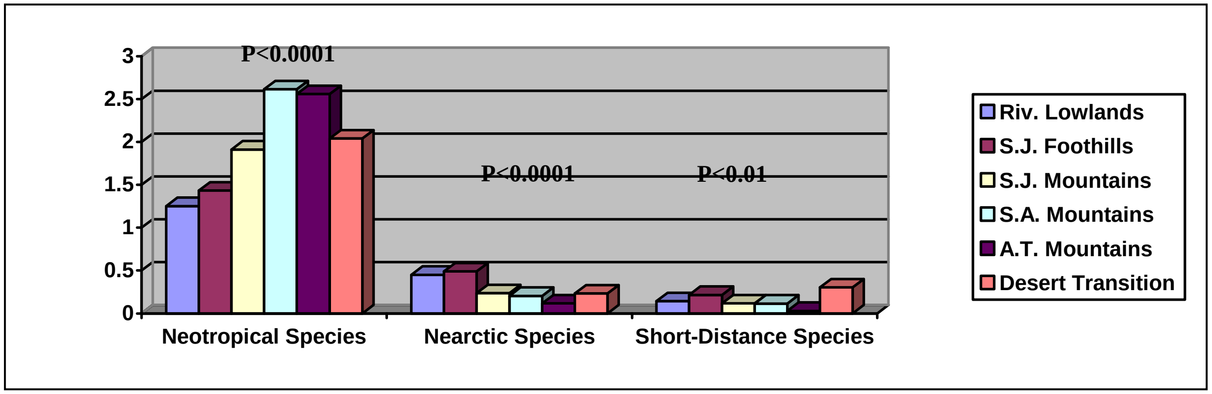


Figure 22. ANOVA results of mean species richness per reach for residents and all species among the six bioregions during spring bird surveys in the Santa Margarita watershed 2003**.**

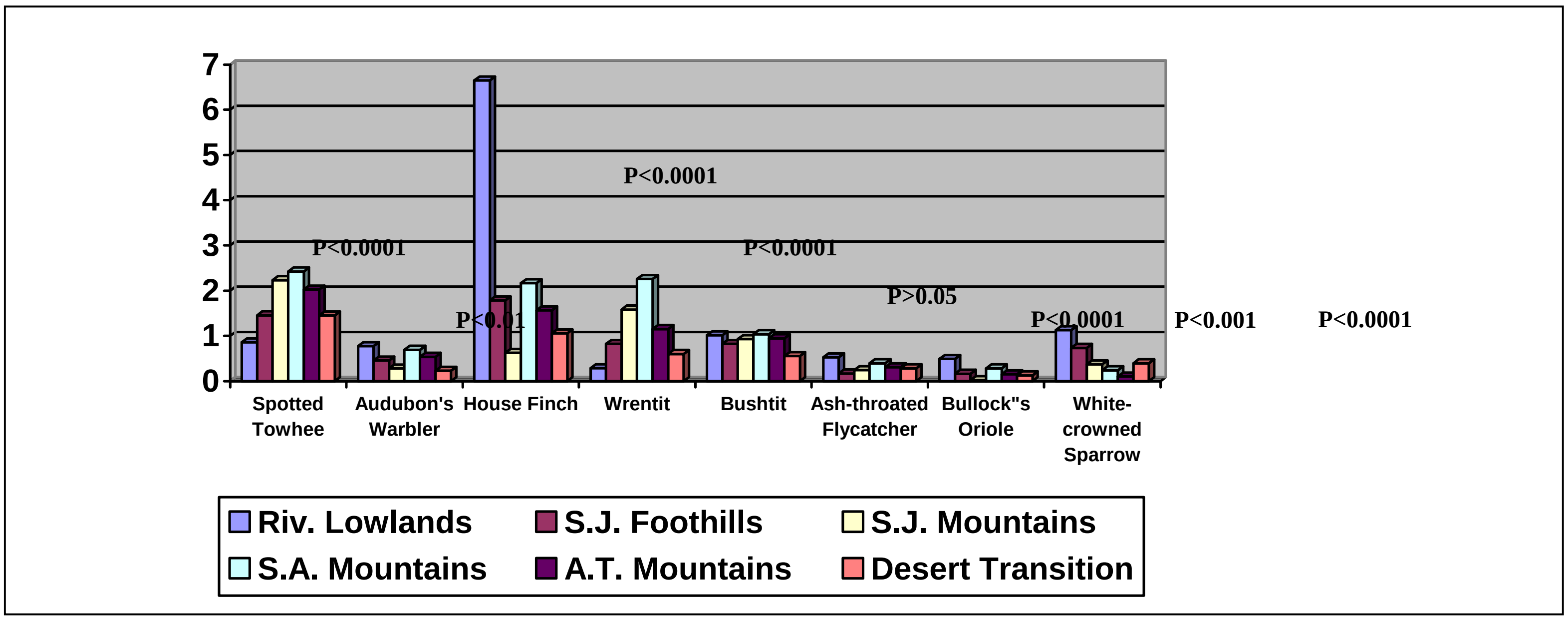


Figure 23. ANOVA results of mean counts per reach for selected species among the six bioregions during spring bird surveys in the Santa Margarita watershed 2003**.**

Table 5. Partners in Flight Priority bird species, listed in habitat conservation plans, detected in each bioregion during spring surveys in the Santa Margarita watershed, California, 2003.

PIF Priority Species	PIF California Habitat Type[1]	Riverside Lowlands	San Jacinto Foothills	San Jacinto Mountains	Santa Ana Mountains	Agua Tibia Mountains	Desert Transition	Total Counts
Acorn Woodpecker	OWH	14	3	2	81	30	0	131
Allen's Hummingbird	CSCH	1	1	0	1	0	1	4
Ash-throated Flycatcher	OWH	15	29	20	62	24	55	205
Band-tailed Pigeon	OWH	1	0	0	0	0	0	1
Bank Swallow	RH	1	0	0	0	0	3	4
Bell's Vireo	RH	0	1	0	0	0	0	1
Bewick's Wren	CSCH, OWH	50	40	26	26	14	35	191
Black-chinned Sparrow	CSCH	1	4	3	2	0	41	51
Black-headed Grosbeak	RH	17	17	32	17	17	42	142
Black-throated Gray Warbler	CFH	0	2	1	3	0	2	8
Blue-gray Gnatcatcher	CSCH, OWH	1	3	1	3	1	2	11
Blue Grosbeak	RH	4	14	0	1	0	2	21
Brown Creeper	CFH	0	2	10	0	0	0	12
California Quail	OWH	63	158	12	29	24	70	356
California Thrasher	CSCH, OWH	26	50	10	18	19	34	157
California Towhee	CSCH, OWH	113	160	20	61	53	80	487
Chipping Sparrow	CFH	4	9	1	10	2	5	31
Common Yellowthroat	CSCH, RH	40	10	0	52	4	13	119
Costa's Hummingbird	CSCH	3	20	1	6	8	34	72
Fox Sparrow	CFH	1	5	1	0	0	1	8
Golden-crowned Kinglet	CFH	0	0	0	1	0	0	1
Greater Roadrunner	CSCH	2	0	0	0	0	1	3
Hutton's Vireo	OWH	1	0	1	1	3	6	12
Lark Sparrow	OWH	18	16	6	5	0	27	72
Lesser Nighthawk	CSCH	0	0	5	0	0	1	6
Mountain Quail	CSCH	0	2	19	1	4	13	39
Nuttall's Woodpecker	OWH	24	14	5	22	13	6	84
Oak Titmouse	OWH	22	30	35	58	46	34	225
Olive-sided Flycatcher	CFH	0	1	0	0	0	3	4
Oregon Junco	CFH	4	11	1	15	2	7	40
Purple Finch	CFH	6	3	2	24	0	14	49
Red-breasted Nuthatch	CFH	0	0	1	0	1	0	2
Red-shouldered Hawk	OWH	13	0	0	11	3	0	27
Rufous-crowned Sparrow	CSCH	10	45	0	7	1	15	78
Sage Sparrow	CSCH	3	19	0	3	0	19	44
Song Sparrow	CSCH, RH	200	42	3	88	10	31	374

Table 5. Cont.

Spotted Towhee	CSCH	125	140	74	189	70	142	740
Swainson's Thrush	RH	1	0	0	1	0	0	2
Turkey Vulture	CSCH	23	1	0	9	2	4	39
Warbling Vireo	RH	2	4	0	7	1	4	18
Western Bluebird	OWH	10	2	0	9	2	0	23
Western Scrub Jay	CSCH, OWH	58	69	53	61	44	39	324
Western Tanager	CFH	15	1	1	6	0	7	30
White-breasted Nuthatch	OWH	0	1	0	1	2	0	4
Willow Flycatcher	RH	0	2	0	0	0	0	2
Wrentit	CSCH	48	76	58	176	39	59	456
Wilson's Warbler	RH	12	10	9	13	5	17	66
Yellow-breasted Chat	RH	4	1	0	11	2	1	19
Yellow Warbler	RH	3	1	0	5	6	10	25
Total counts		959	1019	413	1097	452	880	4,820
Total number of species		39	40	29	39	30	38	47

[1] California Conservation Plans written for specific habitat types, including CSCH=Coastal Shrub and Chaparral Habitat; CFH=Coniferous Forest Habitat; OWH=Oak Woodland Habitat; and RH=Riparian Habitat.

Testing and Refining the IBI

A provisional IBI value was calculated for each of the sampled reaches in the Santa Margarita watershed using the formula developed previously for the San Jacinto watershed. The San Jacinto IBI formula consisted of seven metrics (Table 6) so that IBI values potentially ranged from 7 to 35. Actual values in the San Jacinto watershed ranged from 7 to 33 and the watershed-wide correlation between IBI scores and an index of human disturbance to riparian reaches was $r = -0.74$ ($r = -0.79$ when one outlier was eliminated) (Wakeley et al. 2003).

Table 6. Scoring criteria for metrics included in the IBI for riparian reaches in the San Jacinto River watershed (Wakeley et al. 2003).

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

In the Santa Margarita watershed, application of the San Jacinto IBI formula resulted in values ranging from 11 to 35. The overall correlation of IBI scores with IHD was $r = -0.63$. Correlation coefficients for individual bioregions are shown in Table 7.

Table 7. Means and ranges of provisional IBI scores (based on the San Jacinto IBI formula), and correlations with an index of human disturbance, for riparian reaches in the Santa Margarita watershed.

Bioregion (n)	Provisional IBI Scores		Correlation with Human Disturbance Index	
	Mean	**Range**	**Old Index[1]**	**IHD**
Riverside Lowlands (28)	22.1	11-31	-0.32 ($P > 0.05$)	-0.46 ($P = 0.013$)
San Jacinto Foothills (18)	25.4	19-33	-0.24 ($P > 0.05$)	-0.12 ($P > 0.05$)
San Jacinto Mountains (7)	28.4	17-33	-0.85 ($P = 0.016$)	-0.87 ($P = 0.010$)
Santa Ana Mountains (16)	29.8	25-33	-0.52 ($P = 0.041$)	-0.50 ($P = 0.048$)
Agua Tibia Mountains (7)	31.3	29-35	-0.55 ($P > 0.05$)	-0.60 ($P > 0.05$)
Desert Transition (20)	24.7	11-31	-0.80 ($P < 0.0001$)	-0.72 ($P = 0.0003$)
Total watershed (96)	25.7	11-35	-0.57 ($P < 0.0001$)	-0.63 ($P < 0.0001$)

[1]Old index = Mean of the total coverage of agricultural and urban/industrial/developed land uses in the local drainage and within 100 m of bird sampling points. This version of a human disturbance index was used in the San Jacinto analysis (Wakeley et al. 2003).

Although the overall correlation between the provisional IBI and IHD in the Santa Margarita watershed was highly significant, it was not as high as that calculated for the San Jacinto watershed. In addition, the San Jacinto IBI formula seemed to over-rate some reaches, giving no reach a score less than 11 and giving the maximum theoretical score to one reach (Rattle 1). A closer look at correlations between the seven individual metrics in the provisional IBI and the human disturbance index revealed that two metrics that had been significantly correlated with human disturbance in the San Jacinto watershed showed no relationship with IHD in the Santa Margarita watershed (i.e., native species richness, $r = -0.14$, $P = 0.17$; and percent abundance of tree and shrub nesters, $r = -0.10$, $P = 0.36$). Therefore, we concluded that the provisional IBI formula needed to be modified to improve its applicability and performance in both watersheds.

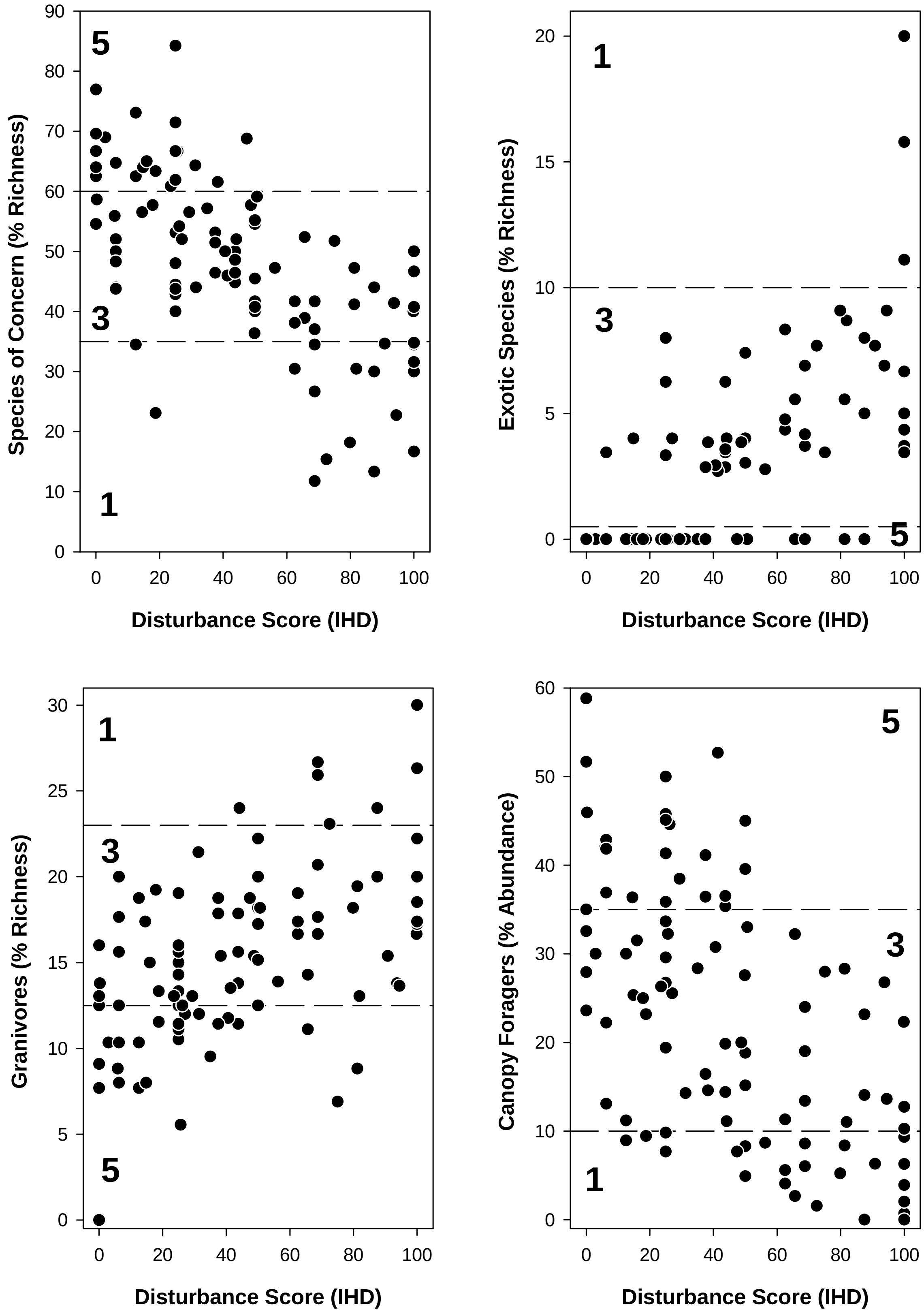
Correlations between the 65 potential bird-community metrics and IHD in the Santa Margarita watershed revealed 31 significant results ($P < 0.05$) (Table 8). Four metrics that had been used in the provisional IBI for the San Jacinto watershed were also strongly correlated with IHD in the Santa Margarita watershed (i.e., percent richness of exotic species, percent richness of species of conservation concern, percent abundance of tree and shrub canopy foragers, and percent richness of native cavity nesters). We retained these metrics in the final IBI. Two additional metrics (percent richness of granivores, and percent abundance of granivores and omnivores combined) (Table 8) were also correlated with human disturbance of reaches in the San Jacinto watershed ($r = 0.44$, $P < 0.0001$, and $r = 0.37$, $P = 0.0002$, respectively [n = 95]) but had not been included in the provisional IBI. These two metrics appeared to be applicable to both watersheds and, therefore, were added to the final IBI. Native species richness and percent abundance of tree and shrub nesters were dropped from the provisional IBI formula due to the lack of significant correlations with IHD in the Santa Margarita watershed. Another metric included in the provisional IBI for the San Jacinto watershed, percent richness of ground foragers, was also individually correlated with IHD in the Santa Margarita watershed (Table 8), but was dropped because its presence in the final IBI did not improve the overall correlation between IBI and IHD. None of these metrics were highly correlated with one another ($|r| < 0.80$). Therefore, six metrics were selected as components of the final IBI (Table 8). We considered that an IBI composed of these six metrics would be applicable to both the Santa Margarita and San Jacinto watersheds because all were significantly correlated with the level of human disturbance of riparian reaches in both watersheds.

Plots of bird-community metrics versus IHD for the Santa Margarita watershed (Figure 24) were used to identify thresholds for dividing each metric into three categories and assigning a numeric score of 1, 3, or 5 to each category (Chu and Karr 1999). Similar plots for the San Jacinto watershed were also examined to help in selecting final thresholds that were appropriate to both watersheds. Scoring thresholds for the final IBI are given in Table 9, and metric scores and IBI values for each sampled reach are shown in Table 10. IBI was calculated by summing the scores for each metric. With six component metrics, IBI potentially ranged from 6 (minimum integrity) to 30 (maximum integrity). Actual IBI values for sampled reaches in the Santa Margarita watershed ranged from 6 to 28.

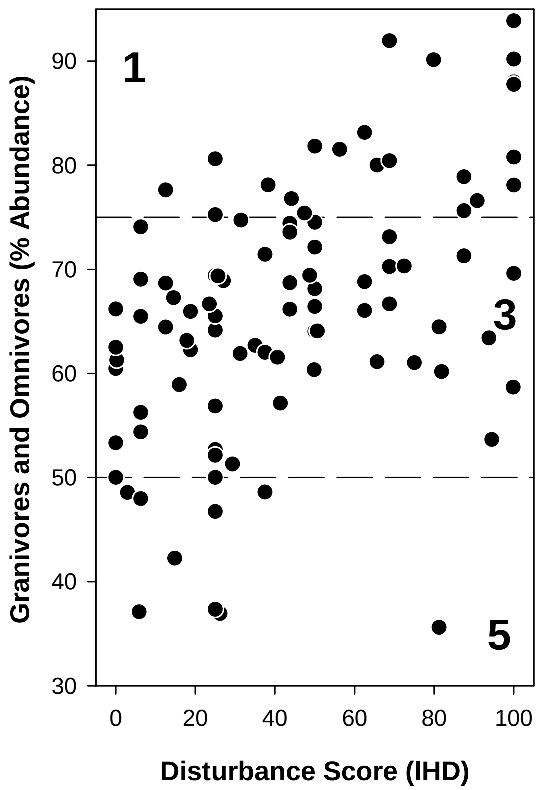
Table 8. Correlation coefficients, listed in decreasing order of absolute value, between bird-community metrics and the Index of Human Disturbance (IHD) for all sampled reaches in the Santa Margarita watershed (n = 96).

Bird Metric	Correlation (*r*)	*P*
Species of concern (% abundance)	-0.76	<0.0001
Exotic species (% richness) [1]	0.66	<0.0001
Exotic species richness	0.65	<0.0001
Species of conservation concern (% richness)	-0.65	<0.0001
Canopy foragers in trees and shrubs (% abundance)	-0.59	<0.0001
Canopy foragers (% richness)	-0.59	<0.0001
Granivores (% richness)	0.52	<0.0001
Native cavity nesters (% abundance)	-0.50	<0.0001
Native cavity nesters (% richness)	-0.49	<0.0001
Granivores and omnivores combined (% abundance)	0.49	<0.0001
Species of concern richness	-0.49	<0.0001
Resident species (% richness)	0.47	<0.0001
Ground foragers (% abundance)	0.46	<0.0001
Native canopy forager richness	-0.44	<0.0001
Exotic species (% abundance)	0.44	<0.0001
Neotropical migrants (% richness)	-0.43	<0.0001
Insectivores (% abundance)	-0.42	<0.0001
Granivores (% abundance)	0.41	<0.0001
Resident species (% abundance)	0.41	<0.0001
Granivore richness	0.37	0.0002
Ground foragers (% richness)	0.37	0.0002
Native cavity nester richness	-0.37	0.0003
Migrant species richness	-0.36	0.0003
Neotropical migrants (% abundance)	-0.36	0.0003
Insectivores (% richness)	-0.34	0.0008
Riparian obligates and dependents (% abundance)	-0.32	0.0016
Neotropical migrant richness	-0.32	0.0017
Granivores and omnivores combined (% richness)	0.31	0.0022
Riparian obligates and dependents (% richness)	-0.28	0.0063
Ground nesters (% abundance)	-0.24	0.0197
Insectivore richness	-0.21	0.0397

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



Species of Concern (% Richness)
Disturbance Score (IHD)
5
3
1
Exotic Species (% Richness)
Disturbance Score (IHD)
1
3
5
Granivores (% Richness)
Disturbance Score (IHD)
1
3
5
Canopy Foragers (% Abundance)
Disturbance Score (IHD)
5
3
1



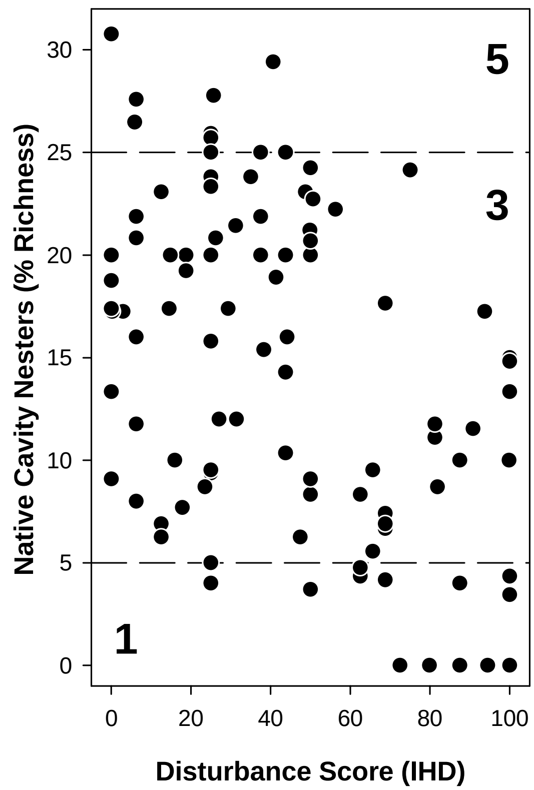


Figure 24 (This and the previous page). Plots of selected bird metrics versus the Index of Human Disturbance (IHD) for all sampled reaches in the Santa Margarita River watershed (n = 96). Zones labeled 1, 3, and 5 indicate the scores for each metric that were summed to calculate IBI.

Table 9. Scoring criteria for bird-community metrics selected as components of the final IBI.			
Metric	**Assigned Score**		
	1	**3**	**5**
Exotic species (% richness)	>10%	Intermediate	= 0%
Species of concern (% richness)	≤35%	Intermediate	>60%
Canopy foragers (% abundance)	≤10%	Intermediate	≥35%
Granivores (% richness)	>23%	Intermediate	≤12.5%
Native cavity nesters (% richness)	≤5%	Intermediate	>25%
Granivores and omnivores (% abundance)	>75%	Intermediate	≤50%

Figure 25 is a plot of final IBI scores versus the disturbance index for all sampled reaches in the Santa Margarita watershed. Although the amount of variability was considerable, there was a clear trend ($r = -0.78$, $P < 0.0001$) and good separation between those reaches with high biological integrity (e.g., IBI ≥ 24, IHD ≤ 40) and those with low integrity (e.g., IBI ≤ 12, IHD ≥ 60). Approximately 60% (r^2) of the variance in IBI was attributable to variations in human disturbance of reaches and their local drainages. However, it is also clear that some reaches with high levels of disturbance as indicated by IHD still had moderate bird-community integrity, equaling that of some reaches with little disturbance. Much of the unaccounted-for variance in bird-community integrity probably was due to differences among reaches in habitat characteristics within the riparian zone (e.g., shrub and tree density, vertical structure of vegetation, riparian zone width) independent of the level of human activity. However, detailed analysis of bird/habitat relationships was beyond the scope of this study.

Another possible source of variability in the IBI/IHD plot was fundamental differences in the relationship between IBI and the level of human disturbance in different bioregions. These might occur because of spatial variations in avian community composition and ecology due to variations in elevation, climate, or other environmental factors across the watershed. We used analysis of variance with an interaction term (PROC GLM, SAS Institute, Inc. 1999) to test for differences in the IBI/IHD relationship across bioregions. IBI was significantly influenced by both IHD and bioregions as individual effects ($P < 0.0001$ for both effects), but there was no significant interaction between IHD and bioregions ($P = 0.61$). Therefore, there was no evidence of any fundamental differences in the relationship between IBI and the level of human disturbance among bioregions.

Plots of IBI versus the disturbance index for each bioregion (Figure 26) showed that bioregions tended to have different average levels of human disturbance to riparian reaches and, consequently, different average values of biological integrity. However, when plotted together, the data for all six bioregions form a single cohesive relationship (Figure 25). Therefore, we concluded that a single IBI formulation was appropriate for the entire Santa Margarita watershed and there was no need to develop separate IBI formulas for different bioregions. This confirms a similar conclusion reached previously for the San Jacinto watershed.

Table 10. Measured bird-community metrics, metric scores, reach disturbance scores, and calculated IBI values for sampled riparian reaches in the Santa Margarita River watershed.

Reach Identifier	Bioregion	Disturbance Score (IHD)	Exotic Species (% Richness)		Species of Concern (% Richness)		Canopy Foragers (% Abundance)		Granivores (% Richness)		Native Cavity Nesters (% Richness)		Granivores & Omnivores (% Abundance)		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
COLE T1-1	S. A. Mountains	25.0	0.0	5	44.4	3	45.8	5	11.1	5	25.9	5	50.0	5	28
DIEGO T2-2	S. J. Mountains	0.0	0.0	5	62.5	5	58.8	5	12.5	5	18.8	3	50.0	5	28
SMARG 5	S. A. Mountains	5.9	0.0	5	55.9	3	41.9	5	8.8	5	26.5	5	37.1	5	28
COOPER T1-1	Desert Trans.	0.0	0.0	5	76.9	5	32.6	3	7.7	5	30.8	5	60.5	3	26
COOPER T1-2	Desert Trans.	0.0	0.0	5	66.7	5	51.7	5	0.0	5	13.3	3	53.3	3	26
DRAKE 3	S. A. Mountains	3.0	0.0	5	69.0	5	30.0	3	10.3	5	17.2	3	48.6	5	26
HAMILTON 5	S. J. Mountains	26.2	0.0	5	54.2	3	44.6	5	12.5	5	20.8	3	36.9	5	26
HAMILTON T4-2	S. J. Mountains	25.7	0.0	5	66.7	5	32.3	3	5.6	5	27.8	5	69.4	3	26
SMARG 2	S. A. Mountains	25.0	0.0	5	42.9	3	35.9	5	11.4	5	25.7	5	64.1	3	26
SANDIA T2-1	S. A. Mountains	25.0	0.0	5	71.4	5	41.3	5	14.3	3	23.8	3	37.3	5	26
CALOAKS T1-6	Lowlands	6.3	0.0	5	52.0	3	36.9	5	8.0	5	16.0	3	54.4	3	24
COLE 3	S. A. Mountains	6.3	3.4	3	48.3	3	42.9	5	10.3	5	27.6	5	56.3	3	24
DIEGO 3	S. J. Mountains	6.3	0.0	5	50.0	3	42.9	5	12.5	5	20.8	3	65.5	3	24
KOHLER 1	A. T. Mountains	0.0	0.0	5	64.0	5	35.0	5	16.0	3	20.0	3	66.3	3	24
RAINBOW 4	Lowlands	37.5	0.0	5	46.4	3	41.1	5	17.9	3	25.0	3	48.6	5	24
RATTLE 1	A. T. Mountains	12.5	0.0	5	73.1	5	30.0	3	7.7	5	23.1	3	64.4	3	24
SMARG T1-2	S. A. Mountains	6.3	0.0	5	43.8	3	41.8	5	15.6	3	21.9	3	48.0	5	24
TEMECULACK 14	Desert Trans.	14.8	4.0	3	64.0	5	25.4	3	8.0	5	20.0	3	42.3	5	24
ARROYO T2-2	A. T. Mountains	37.5	0.0	5	53.1	3	36.4	5	18.8	3	21.9	3	62.0	3	22
CAHUILLA T1-1	S. J. Foothills	25.0	0.0	5	53.1	3	29.6	3	12.5	5	9.4	3	69.4	3	22
CHIHUAHUA 1	Desert Trans.	81.3	0.0	5	41.2	3	8.4	1	8.8	5	11.8	3	35.6	5	22
CHIHUAHUA 5	Desert Trans.	0.3	0.0	5	58.6	3	45.9	5	13.8	3	17.2	3	61.3	3	22
CHIHUAHUA T1-2	Desert Trans.	0.0	0.0	5	69.6	5	23.6	3	13.0	3	17.4	3	62.5	3	22
COOPER 2	Desert Trans.	0.0	0.0	5	54.5	3	27.9	3	9.1	5	9.1	3	66.2	3	22
COOPER 5	Desert Trans.	6.3	0.0	5	64.7	5	22.2	3	17.6	3	11.8	3	74.1	3	22
COTTON 1	A. T. Mountains	40.6	2.9	3	50.0	3	30.8	3	11.8	5	29.4	5	61.5	3	22
DELUZ 5	S. A. Mountains	43.8	2.9	3	48.6	3	35.4	5	11.4	5	20.0	3	66.2	3	22

Table 10. Cont.

Reach Identifier	Bioregion	Disturbance Score (IHD)	Exotic Species (% Richness)		Species of Concern (% Richness)		Canopy Foragers (% Abundance)		Granivores (% Richness)		Native Cavity Nesters (% Richness)		Granivores & Omnivores (% Abundance)		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
DELUZSCH 2	S. A. Mountains	29.4	0.0	5	56.5	3	38.5	5	13.0	3	17.4	3	51.3	3	22
DIEGO 4	S. J. Mountains	25.0	0.0	5	84.2	5	33.7	3	10.5	5	15.8	3	75.2	1	22
OLDMINE 4	Desert Trans.	23.5	0.0	5	60.9	5	26.3	3	13.0	3	8.7	3	66.7	3	22
ROSS 1	S. A. Mountains	25.0	0.0	5	40.0	3	45.1	5	13.3	3	20.0	3	56.9	3	22
SKINNER 1	S. J. Foothills	18.8	0.0	5	63.3	5	23.2	3	13.3	3	20.0	3	65.9	3	22
SMARG T1-1	S. A. Mountains	25.0	6.3	3	43.8	3	50.0	5	15.6	3	25.0	3	46.7	5	22
SMARG T4-3	S. A. Mountains	50.0	0.0	5	55.2	3	39.6	5	17.2	3	20.7	3	64.0	3	22
SANIG T1-1	S. J. Foothills	31.5	0.0	5	44.0	3	14.3	3	12.0	5	12.0	3	74.7	3	22
TEMECULACK 12	S. J. Foothills	31.3	0.0	5	64.3	5	14.3	3	21.4	3	21.4	3	61.9	3	22
TULE 5	Desert Trans.	16.0	0.0	5	65.0	5	31.5	3	15.0	3	10.0	3	58.9	3	22
WILSON T02-2	S. J. Foothills	14.5	0.0	5	56.5	3	36.4	5	17.4	3	17.4	3	67.3	3	22
WILSON T08-2	S. J. Mountains	35.0	0.0	5	57.1	3	28.4	3	9.5	5	23.8	3	62.7	3	22
ARROYO T2-4	A. T. Mountains	65.6	0.0	5	52.4	3	32.2	3	14.3	3	9.5	3	61.1	3	20
COTTON 2	A. T. Mountains	25.0	3.3	3	66.7	5	26.7	3	13.3	3	23.3	3	65.5	3	20
DRAKE 1	S. A. Mountains	41.4	2.7	3	45.9	3	52.7	5	13.5	3	18.9	3	57.1	3	20
FRENCH 5	S. J. Foothills	12.5	0.0	5	34.5	1	11.2	3	10.3	5	6.9	3	68.7	3	20
FRENCH T3-1	S. J. Foothills	6.3	0.0	5	44.0	3	13.1	3	20.0	3	8.0	3	69.0	3	20
IRONSPRG T1-2	Desert Trans.	25.0	0.0	5	61.9	5	19.4	3	19.0	3	9.5	3	80.6	1	20
ROSS 2	S. A. Mountains	43.8	3.6	3	46.4	3	36.5	5	17.9	3	14.3	3	68.7	3	20
SH T1-2	S. A. Mountains	50.7	0.0	5	59.1	3	33.0	3	18.2	3	22.7	3	64.1	3	20
TEMECULACK 01	Lowlands	75.0	3.4	3	51.7	3	28.0	3	6.9	5	24.1	3	61.0	3	20
TEMECULACK 17	A. T. Mountains	50.0	3.0	3	45.5	3	45.0	5	15.2	3	24.2	3	66.4	3	20
TUCALOTA 08	S. J. Foothills	50.0	0.0	5	41.7	3	15.2	3	12.5	5	8.3	3	81.8	1	20
TUCALOTA T2-1	S. J. Foothills	50.0	0.0	5	54.5	3	18.8	3	18.2	3	9.1	3	68.1	3	20
TULE 3	Desert Trans.	17.9	0.0	5	57.7	3	25.0	3	19.2	3	7.7	3	63.2	3	20
WILSON 08	S. J. Foothills	27.1	4.0	3	52.0	3	25.6	3	12.0	5	12.0	3	68.9	3	20
WILLIAMS 2	Desert Trans.	37.5	2.9	3	51.4	3	16.4	3	11.4	5	20.0	3	71.4	3	20
CAHUILLA T1-2	Desert Trans.	47.4	0.0	5	68.8	5	7.7	1	18.8	3	6.3	3	75.4	1	18

Table 10. Cont.

Reach Identifier	Bioregion	Disturbance Score (IHD)	Exotic Species (% Richness)		Species of Concern (% Richness)		Canopy Foragers (% Abundance)		Granivores (% Richness)		Native Cavity Nesters (% Richness)		Granivores & Omnivores (% Abundance)		IBI
			Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	Metric	Score	
JOJOBA 2	S. J. Foothills	12.5	0.0	5	62.5	5	9.0	1	18.8	3	6.3	3	77.6	1	18
LEWIS 3	S. J. Foothills	43.8	3.4	3	44.8	3	19.8	3	13.8	3	10.3	3	73.6	3	18
LONG 6	S. J. Foothills	49.9	3.0	3	36.4	3	27.6	3	15.2	3	21.2	3	60.3	3	18
LONGV 1	Lowlands	100.0	5.0	3	50.0	3	12.7	3	20.0	3	15.0	3	69.6	3	18
MURRIETA 12	Lowlands	43.8	6.3	3	50.0	3	14.4	3	15.6	3	25.0	3	74.4	3	18
MURRIETA T2-2	Lowlands	38.3	3.8	3	61.5	5	14.6	3	15.4	3	15.4	3	78.1	1	18
PECHANGA 1	Lowlands	81.3	5.6	3	47.2	3	28.3	3	19.4	3	11.1	3	64.5	3	18
RAINBOW 3	Lowlands	93.8	6.9	3	41.4	3	26.8	3	13.8	3	17.2	3	63.4	3	18
RAWSON T2-2	S. J. Foothills	18.8	0.0	5	23.1	1	9.4	1	11.5	5	19.2	3	62.3	3	18
SANIG T1-2	S. J. Foothills	48.8	3.8	3	57.7	3	20.0	3	15.4	3	23.1	3	69.4	3	18
TEMECULACK 02	Lowlands	99.9	6.7	3	40.0	3	22.3	3	16.7	3	10.0	3	58.7	3	18
CAHUILLA 04	Desert Trans.	68.8	6.9	3	34.5	1	19.0	3	20.7	3	6.9	3	70.2	3	16
CALOAKS 2	Lowlands	81.9	8.7	3	30.4	1	11.0	3	13.0	3	8.7	3	60.2	3	16
FRENCH 2	Lowlands	68.8	0.0	5	26.7	1	24.0	3	26.7	1	6.7	3	66.7	3	16
FRENCH T1-1	Lowlands	65.6	5.6	3	38.9	3	2.7	1	11.1	5	5.6	3	80.0	1	16
GERT 3	Lowlands	50.0	4.0	3	40.0	3	8.3	1	20.0	3	20.0	3	74.5	3	16
LAKER 1	Desert Trans.	68.8	0.0	5	11.8	1	8.6	1	17.6	3	17.6	3	73.1	3	16
RAWSON 4	S. J. Foothills	25.0	0.0	5	40.0	3	9.8	1	15.0	3	5.0	1	52.7	3	16
TEMECULACK 05	Lowlands	62.5	8.3	3	41.7	3	5.6	1	16.7	3	8.3	3	68.8	3	16
ALAMO T1-3	Lowlands	87.5	5.0	3	30.0	1	23.2	3	20.0	3	10.0	3	75.6	1	14
CAHUILLA 05	Desert Trans.	50.0	7.4	3	40.7	3	4.9	1	22.2	3	3.7	1	72.1	3	14
CALOAKS 1	Lowlands	100.0	3.7	3	40.7	3	6.3	1	18.5	3	14.8	3	88.0	1	14
DURASNO 2	Desert Trans.	25.0	8.0	3	48.0	3	7.7	1	16.0	3	4.0	1	52.1	3	14
HAMILTON 4	S. J. Mountains	87.5	0.0	5	13.3	1	0.0	1	20.0	3	0.0	1	71.3	3	14
LEWIS T1-1	S. J. Foothills	68.8	4.2	3	41.7	3	13.4	3	16.7	3	4.2	1	80.4	1	14
LONG 1	Lowlands	62.5	4.3	3	30.4	1	11.3	3	17.4	3	4.3	1	66.0	3	14
SH T1-5	S. A. Mountains	56.3	2.8	3	47.2	3	8.7	1	13.9	3	22.2	3	81.5	1	14
SANTIAGO 1	Lowlands	100.0	6.7	3	46.7	3	9.3	1	20.0	3	13.3	3	80.8	1	14

Table 10. Cont.

Reach Identifier	Bioregion	Disturbance Score (IHD)	Exotic Species (% Richness)		Species of Concern (% Richness)		Canopy Foragers (% Abundance)		Granivores (% Richness)		Native Cavity Nesters (% Richness)		Granivores & Omnivores (% Abundance)		IBI
			Metric	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	**Metric**	**Score**	
SPRING 1	Lowlands	94.5	9.1	3	22.7	1	13.6	3	13.6	3	0.0	1	53.6	3	14
WILSON T03-2	S. J. Foothills	44.2	4.0	3	52.0	3	11.1	3	24.0	1	16.0	3	76.8	1	14
LONG 2	Lowlands	68.8	3.7	3	37.0	3	6.0	1	25.9	1	7.4	3	91.9	1	12
LONG 5	Lowlands	62.5	4.8	3	38.1	3	4.1	1	19.0	3	4.8	1	83.1	1	12
MEADOW 2	Lowlands	90.8	7.7	3	34.6	1	6.3	1	15.4	3	11.5	3	76.6	1	12
MURRIETA 11	Lowlands	87.5	8.0	3	44.0	3	14.1	3	24.0	1	4.0	1	78.9	1	12
TEMECULACK 03	Lowlands	100.0	3.4	3	34.5	1	10.3	3	17.2	3	3.4	1	78.1	1	12
ALAMO 1	Lowlands	79.9	9.1	3	18.2	1	5.2	1	18.2	3	0.0	1	90.1	1	10
PEACEFIELD 1	Lowlands	100.0	4.3	3	34.8	1	0.7	1	17.4	3	4.3	1	90.3	1	10
WILLIAMS 1	Desert Trans.	72.5	7.7	3	15.4	1	1.6	1	23.1	1	0.0	1	70.3	3	10
HAMILTON 2	Desert Trans.	100.0	11.1	1	16.7	1	0.0	1	22.2	3	0.0	1	93.9	1	8
GERT T1-1	Lowlands	100.0	20.0	1	30.0	1	2.0	1	30.0	1	0.0	1	87.8	1	6
WOLF 1	Lowlands	100.0	15.8	1	31.6	1	3.9	1	26.3	1	0.0	1	90.2	1	6

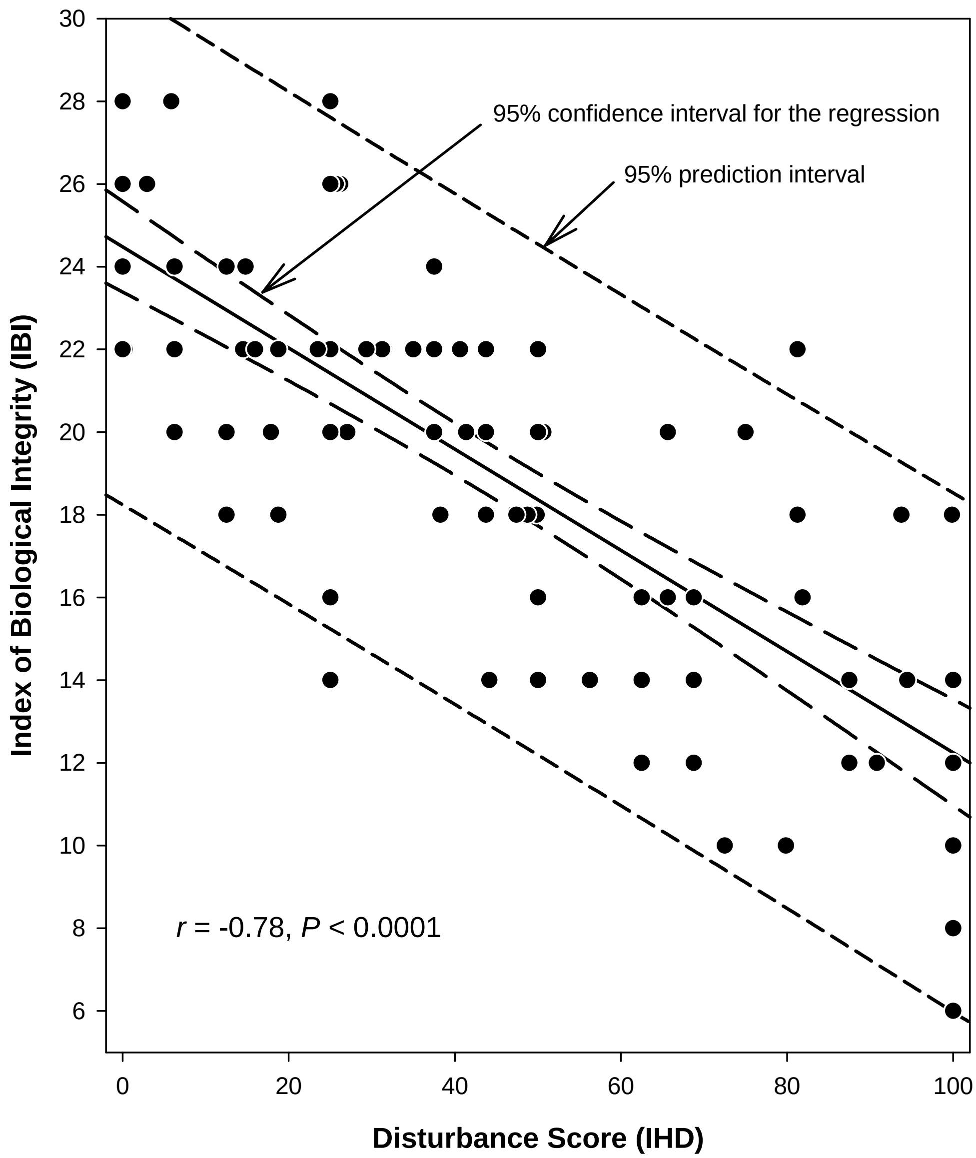
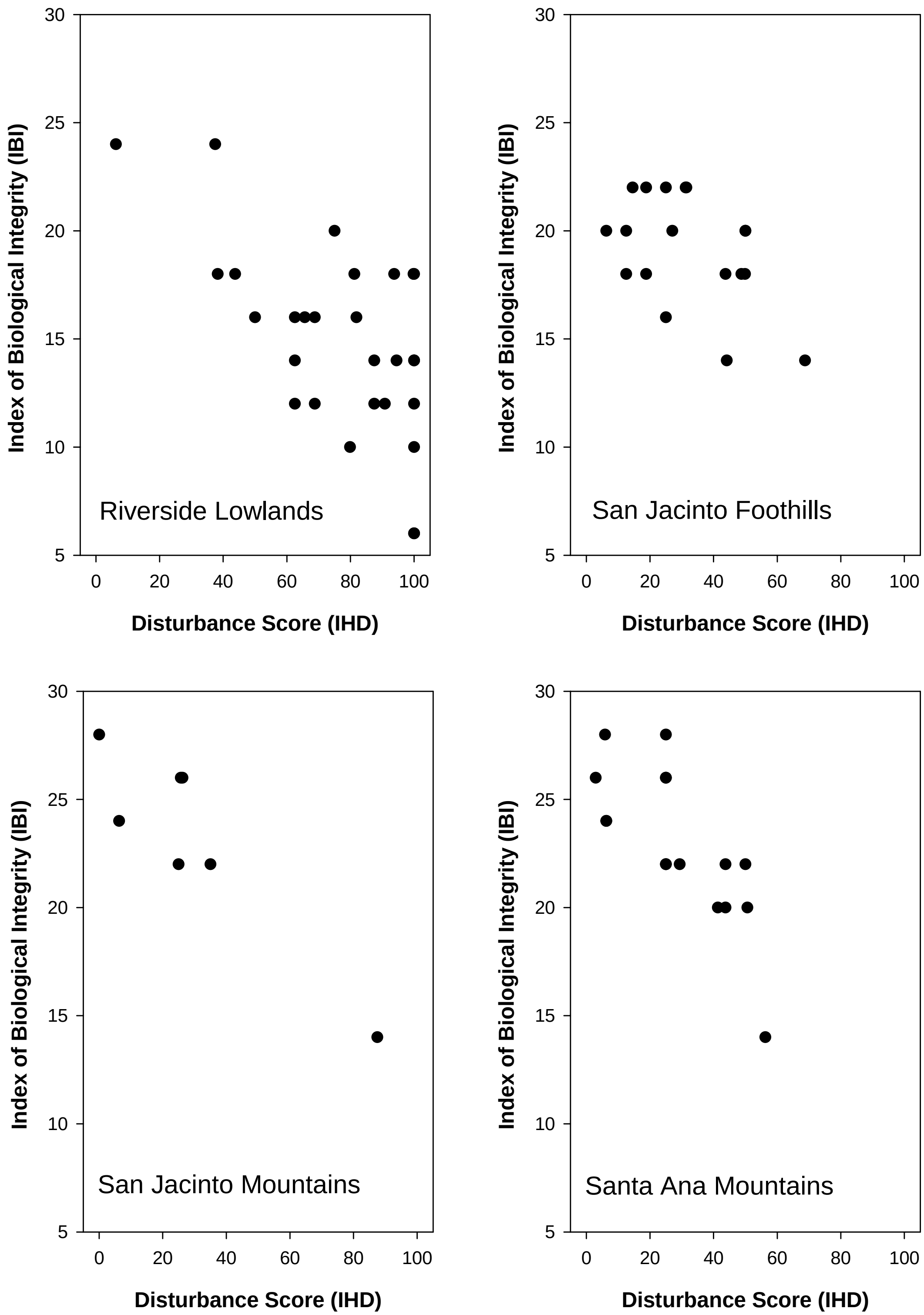


Figure 25. Plot of IBI versus IHD for all sampled reaches in the Santa Margarita watershed (n = 96).


Riverside Lowlands
San Jacinto Foothills
San Jacinto Mountains
Santa Ana Mountains
Index of Biological Integrity (IBI)
Disturbance Score (IHD)
30
25
20
15
10
5
0
20
40
60
80
100

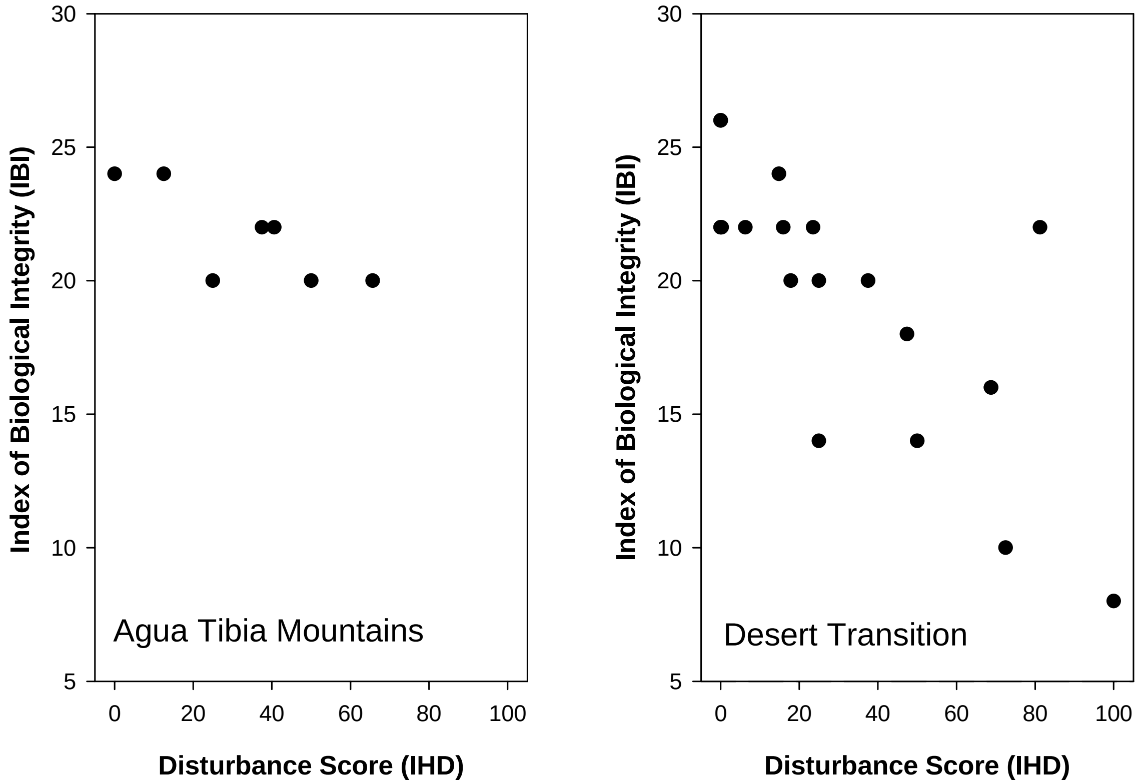


Figure 26 (This and the previous page). Plots of IBI versus the Index of Human Disturbance for each bioregion in the Santa Margarita watershed.

DISCUSSION

Testing of the San Jacinto IBI formulation in the Santa Margarita watershed confirmed that several of the individual bird-community metrics identified in the San Jacinto watershed were also relevant to the assessment of riparian integrity in the Santa Margarita watershed. Four metrics – percent richness of bird species of conservation concern, percent richness of exotic species, percent abundance of canopy foragers, and percent richness of native cavity nesters – were important predictors of the level of human disturbance of riparian reaches in both watersheds. Therefore, these four metrics were retained in the IBI, although scoring thresholds were modified to fit both watersheds. Two other metrics identified in the San Jacinto watershed – percent abundance of tree and shrub nesters, and native species richness – were dropped when it was found that they showed no significant relationship to human disturbance in the Santa Margarita watershed. They were replaced by two other metrics – percent richness of granivores and percent abundance of granivores and omnivores combined – that were significantly correlated with the disturbance index in both watersheds. A final variable – percent richness of ground foragers – was significant in both watersheds but contributed little to the overall correlation between IBI and the disturbance index, and was dropped to simplify the IBI formula. The goal of model testing is to evaluate model reliability when applied to new data, and to provide the information needed to refine the model to improve its performance (Overton 1977, O'Neil et al. 1988). Thus, the San Jacinto IBI formula required some modification to improve its reliability and ensure its applicability to both watersheds. The final IBI formulation presented here is also more likely be to useful in assessing riparian integrity in other similar southern California watersheds, but still should be verified again before applying it outside of the area where it was developed.

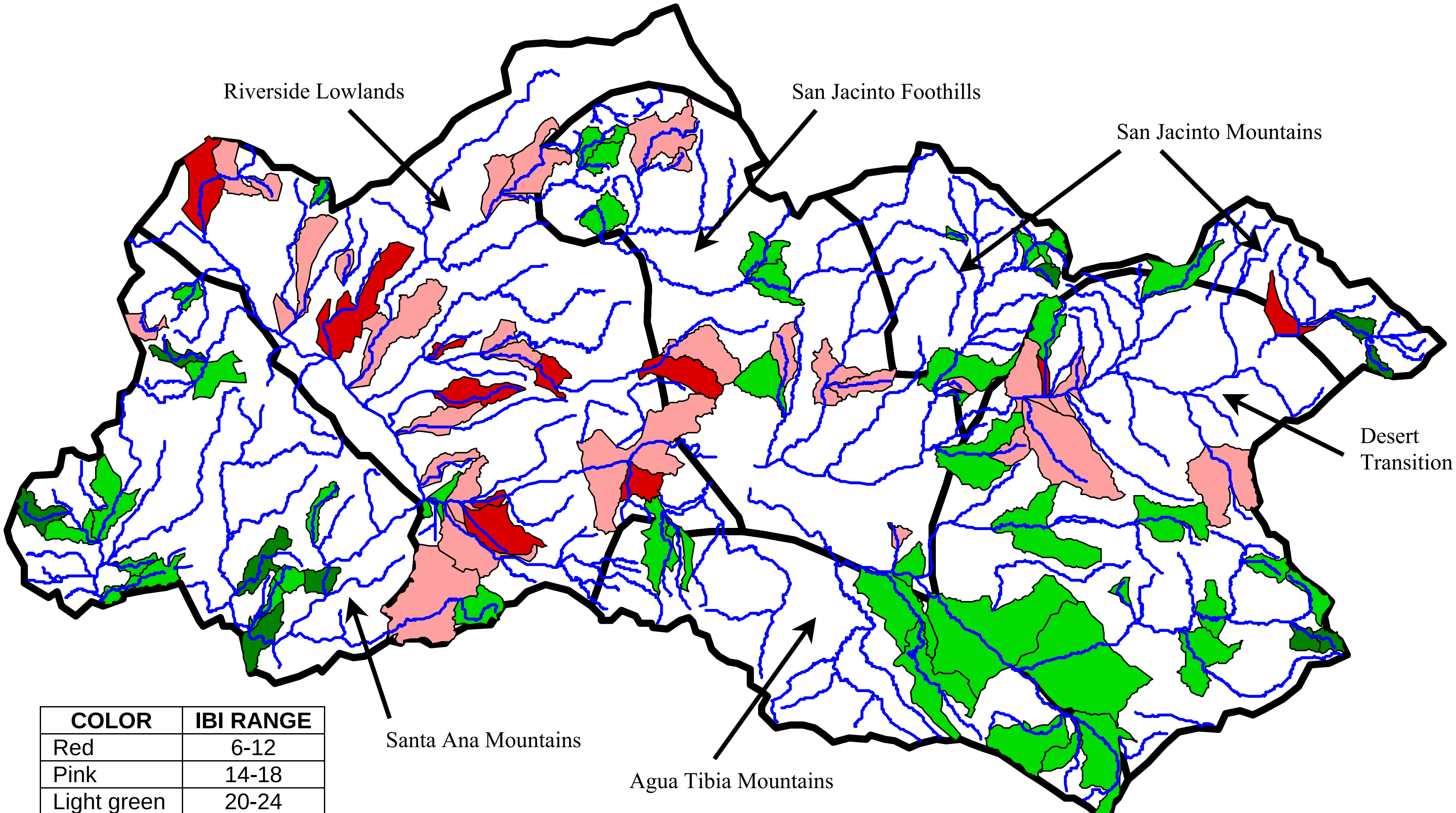
A further test of the refined IBI formula is to apply it to the San Jacinto data and see whether its ability to predict the level of human disturbance of riparian reaches is as strong as the provisional IBI formula had been. Based on all 95 sampled reaches, the correlation coefficient between IBI and the San Jacinto reach disturbance index was $r = -0.73$ (53% of variance explained). Under the provisional IBI formula, the correlation had been $r = -0.74$ (Wakeley et al. 2003). Both of these correlations might have been higher if the San Jacinto index of human disturbance had taken into account other human activities within the riparian zone (e.g., ATV riding, etc.) that were not reflected in land-use coverages.

In the Santa Margarita watershed, the conversion of natural habitats associated with riparian ecosystems to agriculture and developed land uses had predictable impacts on riparian landbird communities. Higher levels of human use were associated with (1) increases in the proportion of introduced, invasive bird species (House Sparrows, European Starlings, and Rock Doves); (2) decreases in the proportion of bird species previously identified as vulnerable in the region based on small population sizes, limited distribution, or long-term population declines; (3) decreases in the proportion of species that forage in the canopies of shrubs and trees; (4) decreases in native cavity-nesting bird species; (5) increases in the proportion of species that are granivores; and (6) increases in the relative abundance of granivores and omnivores at the expense of insectivorous species. Degradation of riparian bird communities probably occurs due to such factors as the increased availability of grass and weed seeds, cultivated grain and other crops, and human garbage in human-dominated landscapes; fragmentation and loss of woody vegetation that can result in the loss of insectivores, other foliage gleaners, and area-sensitive bird species; simplification of habitat structure in and near the riparian zone due to clearing, mowing, grazing, and off-road vehicle use; loss of cavity trees and the increased competition for available cavities from introduced cavity-nesting species; and noise and other immediate disturbance due to vehicular and pedestrian traffic. Others have described similar trends in bird communities with increasing levels of agricultural and urban development (McKinney 2002). Previous attempts to develop IBI-like indices based on bird communities (O'Connell et al. 2000, Bryce et al. 2002) also identified functional and taxonomic guilds that varied with human land-use changes.

This study focused on human alteration of the land and could not account for all of the factors that might affect the species composition and abundance of riparian bird communities. In particular, natural variations in riparian zone width, structure and density of woody vegetation, and other habitat factors were not addressed directly, nor were the effects of habitat succession following periodic fires and flood events in these fire- and flood-prone systems. Despite these other sources of variability, however, we found a strong relationship between IBI and the level of human disturbance in these watersheds.

In the Santa Margarita watershed, we found that the riparian bird communities with the highest integrity scores (i.e., those most similar to the presumed unimpacted, pre-settlement condition) were in the less-developed portions of the foothill and mountain areas (Figure 27). Those with the lowest integrity scores tended to be in the highly urbanized and agricultural portions of the Riverside Lowlands and in scattered reaches elsewhere where agricultural and low-density urban land uses predominated. These qualitative results were not surprising. However, in IBI we now have a tool to quantify human impacts to riparian ecosystems that can be used for a variety of purposes.

The sampling protocol and IBI formula refined in this study can be used to assess the current biological integrity of other reaches in the two watersheds, for example to identify candidate parks or conservation areas, or they can be incorporated into a continuing effort to monitor changes in riparian ecosystems over time. Both watersheds are experiencing rapid human population growth. Thus there is a critical need for tools to assess the effects of land-use changes on important ecosystem characteristics and services, and to help guide planning and conservation efforts and evaluate their success or failure. IBI can fill that need directly, or it can be used as a standard of comparison to validate more rapid indicator-based assessment methods (e.g., Smith 2003) that can be applied efficiently over large areas.



COLOR	IBI RANGE
Red	6-12
Pink	14-18
Light green	20-24
Dark green	26-30

Figure 27. Spatial distribution of IBI scores across the Santa Margarita River watershed. For display purposes, the entire local drainage of each sampled reach is highlighted (n = 96). Color categories are arbitrary and are only intended to show where relatively high and low values of the Index of Biological Integrity were measured. Blue lines are mainstem streams; bold black lines are bioregion boundaries. See Table 10 for a complete data listing.

ACKNOWLEDGMENTS

We thank Karen Wiens for helping to organize field crews, obtaining permission from private landowners, and sampling habitat in riparian reaches; and we are grateful to bird counters Melissa Clemons, Anne Condon, Doug Cooper, David Kisner, Brynne Langan, and Brennan Mulrooney. The work was supported by the U.S. Environmental Protection Agency, Region 9.

LITERATURE CITED

Ballard, G., L. Comrack, G. Elliott, T. Gardali, G. Geupel, D. Humple, M. Lynes, and M. Pitkin. 2000. The Riparian Bird Conservation Plan: A strategy for reversing the decline of riparian associated birds in California. California Partners in Flight, Riparian Habitat Joint Venture. http://www.prbo.org/calpif/plans.html

Brinson, M. M., B. L. Swift, R. C. Plantico, and J. S. Barclay. 1981. Riparian ecosystems: Their ecology and status. FWS/OBS-81/17, U.S. Fish and Wildlife Service, Washington, DC.

Bryce, S. A., R. M. Hughes, and P. R. Kaufmann. 2002. Development of a bird integrity index: Using bird assemblages as indicators of riparian condition. Environmental Management 30: 294-310.

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildl. Monogr. 72:1-202.

Cairns, J. 1977. Quantification of biological integrity. Pages 171-187 in R. K. Ballentine and L. J. Guarraia, editors. The integrity of water. U. S. Environmental Protection Agency, Office of Water and Hazardous Materials, Washington, DC, USA.

Carter, M. F., W. C. Hunter, D. N. Pashley, and K. V Rosenberg. 2000. Setting conservation priorities for landbirds in the United States: The Partners In Flight Approach. Auk 117:541-548.

Croonquist, M. J., and R. P. Brooks. 1991. Use of avian and mammalian guilds as indicators of cumulative impacts in riparian-wetland areas. Environmental Management 15: 701-714.

De Leo, G. A., and S. Levin. 1997. The multifaceted aspects of ecosystem integrity. Conservation Ecology [online] 1(1): 3. Available on the Internet. URL: http://www.consecol.org/vol1/iss1/art3.

DeGraaf, R. M. and J. H. Rappole. 1995. Neotropical migratory birds: Natural history, distribution, and population change. Comstock Publishing, Ithaca, NY.

DeGraaf, R. M., N. G. Tilghman, and S. H. Anderson. 1985. Foraging guilds of North American birds. Environmental Management 9: 493-536.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. The birder’s handbook: A field guide to the natural history of North American birds. Simon and Schuster, New York.

Guilfoyle, M. P. 2001. Sensitive western riparian songbirds potentially impacted by USACE reservoir operation. EMRRP Technical Notes Collection (TN EMRRP-SI-19), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes,army.mil/el/emrrp.

Hamel, P. B., W. P. Smith, D. J. Twedt, J. R. Woehr, E. Morris, R. B. Hamilton, and R. J. Cooper. 1996. A land manager's guide to point counts of birds in the Southeast. General Technical Report SO-120. New Orleans: U.S. Department of Agriculture, Forest Service, Southern Research Station, Stoneville, MS.

Hubbard, J. P. 1977. Importance of riparian ecosystems: Biotic considerations. *Importance, preservation and management of riparian habitat*. R. R. Johnson and D. A. Jones, ed., General Technical Report RM-43, Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture Forest Service, Fort Collins, CO, 14-18.

Johnson, R. R., L. T. Haight, and J. M. Simpson. 1977. Endangered species vs. endangered habitats: A concept. *Importance, preservation and management of riparian habitat*. R. R. Johnson and D. A. Jones, ed., General Technical Report RM-43, Rocky Mountain Forest and Range Experiment Station, U.S. Department of Agriculture Forest Service, Fort Collins, CO, 68-79.

Karr, J. R. 1987. Biological monitoring and environmental assessment: a conceptual framework. Environmental Management 11: 249-256.

Karr, J. R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1: 66-84.

Karr, J. R. and E. W. Chu. 1999. Restoring life in running waters: Better biological monitoring. Island Press, Washington, DC.

Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5: 55-68.

Kimberling, D. N., J. R. Karr, and L. S. Fore. 2001. Measuring human disturbance using terrestrial invertebrates in the shrub-steppe of eastern Washington (USA). Ecological Indicators 1: 63-81.

Kozma, J. M., and N. E. Mathews. 1997. Breeding bird communities and nest plant selection in Chihuahuan desert habitats in south-central New Mexico. Wilson Bulletin 109: 424-436.

Lichvar, R, G. Gustina, and M. Ericsson. 2003. Planning level wetland delineation and geospatial characterization of San Jacinto and portions of Santa Margarita watersheds, Riverside County, CA. U.S. Army Corps of Engineers Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, NH. 48 pp.

Los Angeles District Corps of Engineers. 2000. Draft scope of work: Special area management plan, Santa Margarita and San Jacinto Watershed, Riverside County California.

Lovio, J. C., G. Ballard, M. Chase, T. Gardali, G. Geupel, A. Holmes, D. Humple, M. Lynes, S. Scoggin, and D. Stralberg. 2002. The draft Coastal Scrub and Chaparral Bird Conservation Plan: A strategy for protecting and managing coastal scrub and chaparral habitats and associated birds in California. California Partners In Flight, Point Reyes Bird Observatory, Stinson Beach, CA. www.prbo.org/calpif/plans.html.

McKinney, M. L. 2002. Urbanization, biodiversity, and conservation. BioScience 52: 883-890.

Morrison, M. L. 1986. Bird populations as indicators of environmental change. Current Ornithology 3: 429-451.

National Research Council. 2002. Riparian areas: Functions and strategies for management. National Academy Press, Washington, DC.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. Ecological Applications 10: 1706-1721.

O'Neil, L. J., T. H. Roberts, J. S. Wakeley, and J. W. Teaford. 1988. A procedure to modify habitat suitability index models. Wildlife Society Bulletin 16: 33-36.

Overton, W. S. 1977. A strategy of model construction. Pages 49-73 in C. A. S. Hall and J. W. Day, Jr. (eds.), Ecosystem Modeling in Theory and Practice. John Wiley and Sons, New York.

Panjabi, A. 2001. The Partners in Flight Handbook on Species Assessment and Prioritization, Version 1.1. Partners in Flight and the Rocky Mountain Bird Observatory. Available at http://www.rmbo.org/pubs/downloads/Handbook.pdf.

Partners in Flight. (2002). Partners in Flight: Physiographic area plans. http://www.blm.gov/wildlife/pifplans.htm. (10 Sept. 2002).

Poole, A. and F. Gill, eds. 2002. The birds of North America. Birds of North America, Inc., Philadelphia, PA.

Ralph, C. J., J. R. Sauer, and S. Droege, eds. 1995. Monitoring Bird Populations by Point Counts. General Technical Report PSW-GTR-149. U. S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA.

Rich, T. D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin 30: 1128-1139.

Riverside County. 2002. Western Riverside County Multiple Species Habitat Conservation Plan. Public Review Draft posted on the web site of the Riverside County Integrated Project (http://www.rcip.org/draft_mshcp_2_toc.htm).

Robinson, J. C., J. Alexander, S. Abbott, G, Ballard, D. Barton, G. Elliott, S. Heath, D. Humple, M. Pitkin, S. Scoggin, and D. Stralberg. 2002. The draft Coniferous Forest Bird Conservation Plan: A strategy for protecting and managing coniferous forest habitats and associated birds in California. California Partners In Flight, Point Reyes Bird Observatory, Stinson Beach, CA. www.prbo.org/calpif/plans.html.

SAS Institute, Inc. 1999. SAS Language Reference: Concepts. Cary, NC.

Smith, R. D. 2003. Assessment of Riparian Ecosystem Integrity: San Jacinto and Upper Santa Margarita River Watersheds, Riverside County, California. U.S. Army Engineer Research and Development Center, Waterways Experiment Station, Vicksburg, MS. Final Report to the U.S. Army Corps of Engineers, Los Angeles District.

Wakeley, J. S., R. A. Fischer, M. P. Guilfoyle, D. D. Dickerson, and C. T. Theriot. 2003. Development of an index of biological integrity for riparian ecosystems in the San Jacinto River watershed, Riverside County, California. Final report to the U. S. Army Engineer District, Los Angeles, CA.

Williams, G. P. 1978. Bankfull discharge of rivers. Water Resources Research 14: 1141-1154.

Yong, W., D. M. Finch, F. R. Moore, and J. F. Kelly. 1998. Stopover ecology and habitat use of migratory Wilson's warblers. Auk 115: 829-842.

Zack, S., G. Ballard, M. Chase, G. Elliott, T. Gardali, G. R. Geupel, S. Heath, D. Humple, M. Lynes, M. Pitkin, S. Scoggin, and D. Stralberg. 2002. The draft Oak Woodland Bird Conservation Plan: A strategy for protecting and managing oak woodland habitats and associated birds in California. California Partners In Flight, Point Reyes Bird Observatory, Stinson Beach, CA. www.prbo.org/calpif/plans.html.

APPENDIX A

Bird Sampling Protocol

Santa Margarita Watershed 2003

Bird Sampling Protocol – Santa Margarita River Watershed

Spring 2003

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 approximately 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 (UTM), and downstream compass bearing for each station. The six bioregions can be denoted using '1' for Riverside Lowlands, '2' for San Jacinto Foothills, '3' for San Jacinto Mountains, '5' for Santa Ana Mountains, '6' for Agua Tibia Mountains, and '7' for Desert Transition.
4. Other pertinent info to record: month, day, year, time and visit no. Be sure to note the observer, the temperature if known, and describe the wind and sky conditions using the following codes:

   Wind:
   1) 0 - ≤ 2 mph.
   2) 1 - 2-5 mph.
   3) 2 - 5-10 mph
   4) 3 - 10-20 mph.
   5) 4 - ≥ 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 early June), 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-June.
9. Perform point counts during the first 4 hours after sunrise.

APPENDIX B

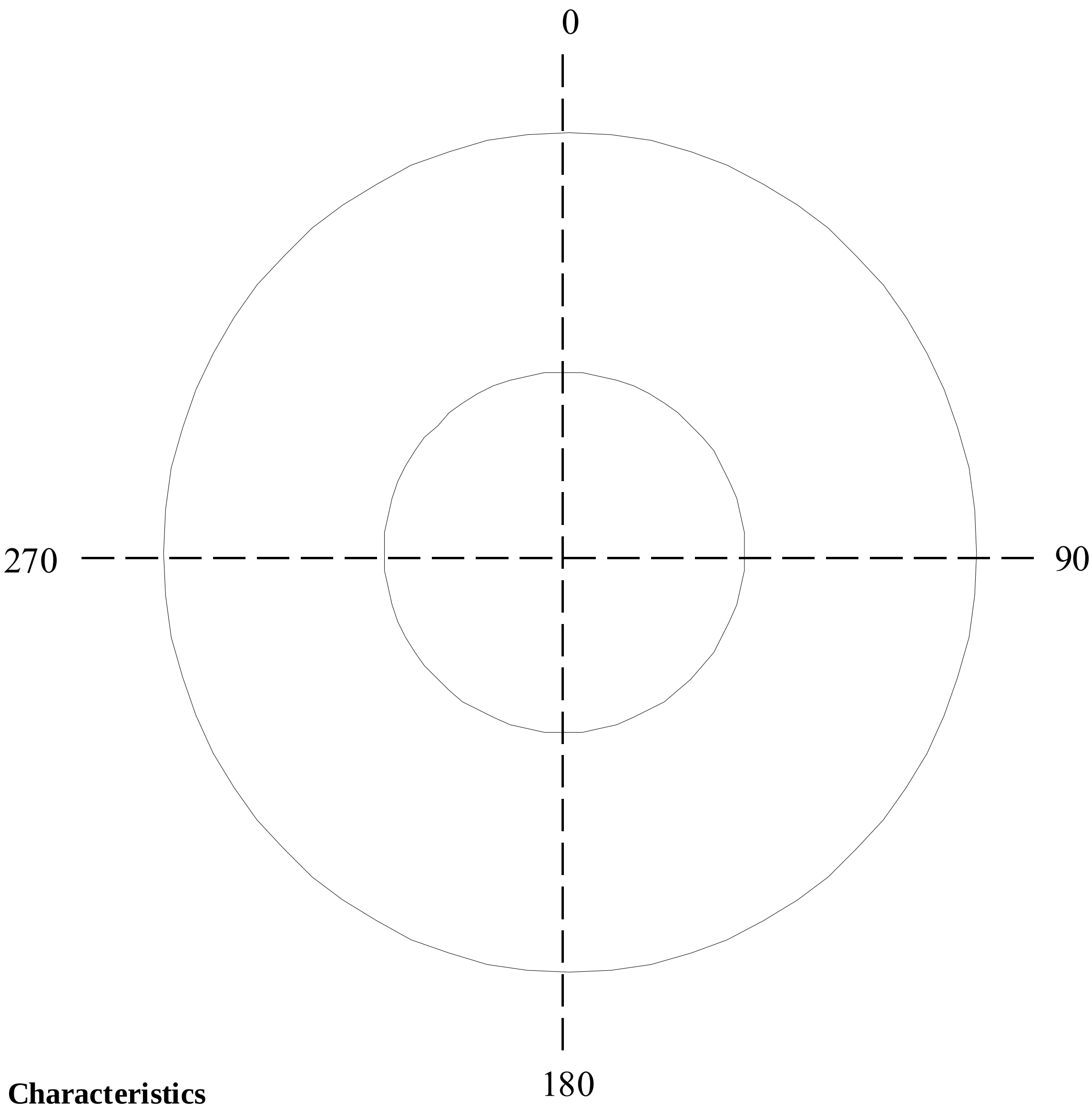
Sample Point-count Data Form

SANTA MARGARITA WATERSHED
POINT COUNT SURVEYS
SPRING 2003

Observer

Bioregion	Reach	Month	Day	Year	Time	Point	Visit
							2

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

Vegetation Characterization Sampling Protocol

Vegetation Sampling Protocol for Santa Margarita Watershed, Summer 2003

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).

The following are 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 on 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 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)

Other human disturbance within or immediately adjacent to the riparian zone. Give subjective rating and check the type of disturbance:

1 = None
2 = Light
3 = Moderate
4 = Heavy
5 = Severe

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%