River Bar Biodiversity Studies:
Aerial Insects, Vegetation Structure and Bird Habitat

Final Report

Middle Rio Grande Bosque Initiative

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River Bar Biodiversity Studies: Aerial Insects, Vegetation Structure, and Bird Habitat

Final Report[1]

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Introduction

Vegetated river bars are a significant element of the Middle Rio Grande ecosystem, comprising upwards of 18% of vegetation throughout the Albuquerque Reach (Milford et al. 2003). Yet, while considerable attention has been devoted to the ecology and biodiversity of the neighboring riparian bosque (Hink and Ohmart 1984; Crawford et al. 1993), little is known about the bars. The bars occur along the margins of the active channel (alternate bars or point bars) or in the channel itself (island bars) where they are subject to varying stream flows and ground water fluctuations along with flooding and shifting sediment loads. Typically, they initially support young wetland and riparian vegetation and, of particular note, are the sites where most natural regeneration of cottonwoods takes place. Hence, in these highly dynamic environments, the expectation is that bars may be the most diverse and biologically active component of the bosque ecosystem. In previous studies, we have found that both native- and exotic-dominated river bars support significantly different plant and ground-dwelling arthropod communities than the surrounding mature bosque (Milford and Muldavin 2004). In this study, we examine how and if these differences in vegetation translate up the food chain to aerial insects with respect to abundance and diversity, and ultimately, to their effects on avian habitat use. We report here on a multi-year study (fall 2003 to summer 2006) looking at the vegetation and aerial insects of a variety of different types of river bar habitats. In 2006 we followed the baseline work with a case study of bird use of the bar habitats to explore the relationship between the vegetation diversity, aerial insect abundance, and structure of avian communities in the Middle Rio Grande.

Methods

Study Area

The project area included 13 study sites located within the greater Albuquerque reach of the Rio Grande between Corrales, NM and the Rio Bravo Street bridge over the Rio Grande (Fig. 1). Climatically, the Middle Rio Grande through Albuquerque is located in a semi-arid zone where precipitation ranges from 138 to 477 mm (5.42 to 18.8 in) around a mean of 252 mm (9.92 in)

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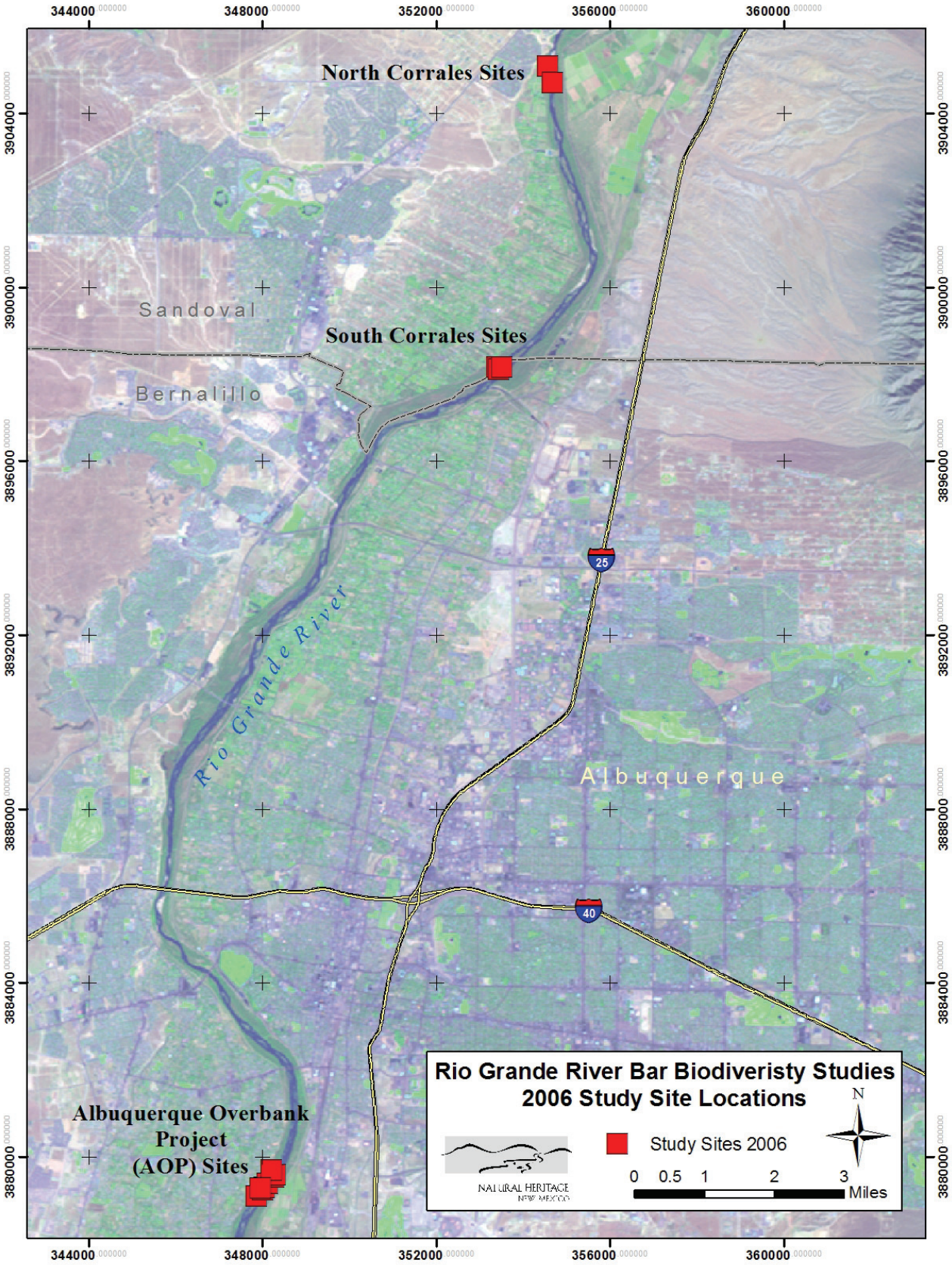


Figure 1. Overview of study site locations.

as reported at Los Lunas, NM, 15 miles to the south along the river corridor. About 50% of the precipitation arrives during the four-month summer "monsoon" season (June-September). Precipitation was also highly variable from month to month, an important factor when comparing arthropod values among sampling periods.

Flooding is historically a significant factor in vegetation dynamics along the Middle Rio Grande, but has been significantly reduced since completion of the Cochiti Dam in the 1970s. However, for river bars, especially lower bars, flooding can still be a significant hydrological factor. This was especially true in the spring of 2005, when the water releases from Cochiti Dam to the Middle Rio Grande were exceptionally high and of long duration compared to most years since flow regulation began in 1972. Water flows exceeded 4,000 cfs at Albuquerque for 66 days between April 19 and June 23, 2005 (Fig. 2). While releases and durations such as this were relatively common in the 1970's and early 1980's (four events), since 1985 the flows of 2005 were exceeded once (84 days in 1995 above 4,000 cfs). In contrast, the five years leading up to 2005 were marked by severe droughts with little or weak spring discharges of relatively short duration. In 2005 the majority of the study sites were either under active flowing water or had ground water levels rise to the point of surface saturation (Milford et al. 2007). However, 2006 spring peak flows were well below average, at less than 1000 cfs from March through July (Fig. 2). A few peak flows topped 1000 cfs later in the summer due to monsoon rains, but that was after the 2006 bird and insect sampling had been completed.

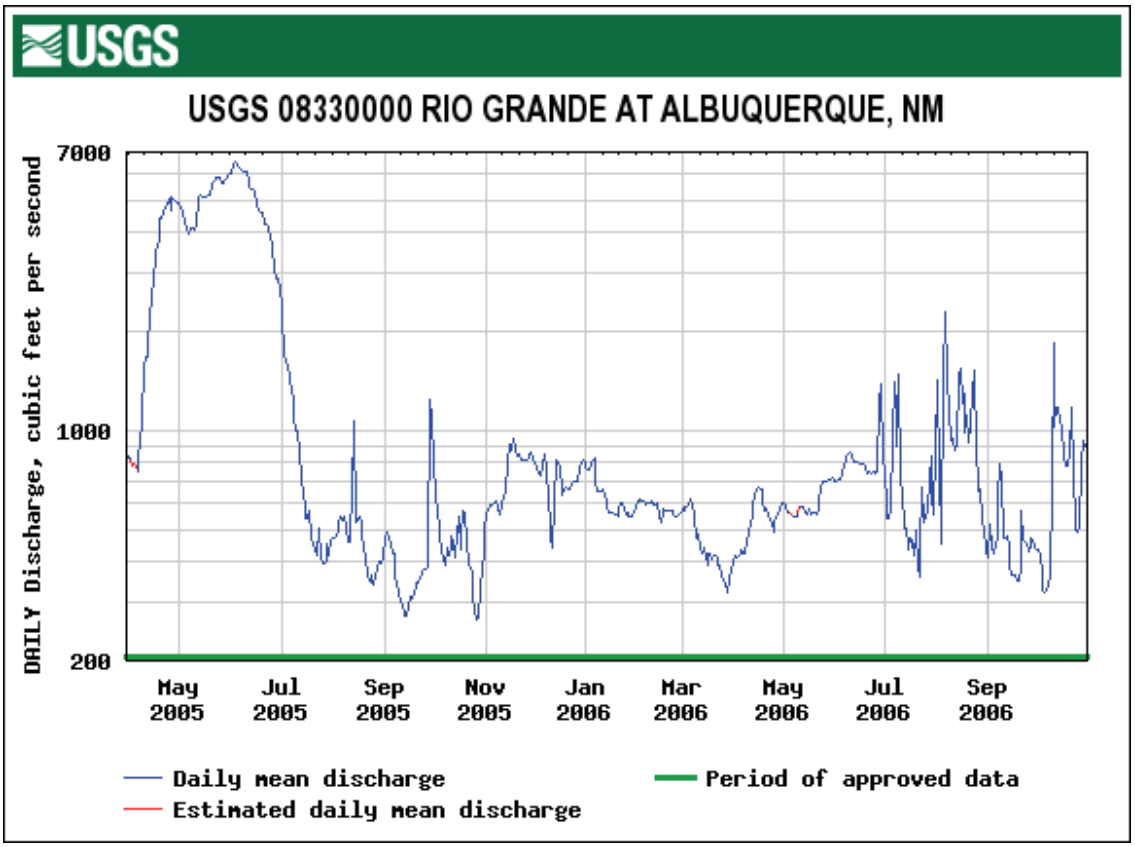


Figure 2. Daily mean discharge in cubic feet per second for the Rio Grande at the Albuquerque gage from April 2005 to October 2006. Data from the U.S. Geological Survey website.

Study Sites

Our objectives were to broaden our comparative biodiversity studies of river bars and bosque in the Middle Rio Grande to include measurements of aerial insects and vertical vegetation structure as a measure of bird habitat, and to include in biodiversity studies of transient wetland island bars (ephemeral bars) a variety of vegetation zones within a bar restoration area (Albuquerque Overbank Project - AOP) (Fig. 3). The AOP site was an experimental restoration project begun in 1998. All Russian olive was removed from a Russian olive-dominated sidebar, which was then bulldozed to a height that would flood at typical modern spring runoff high flows, thus allowing the river to do the restoration naturally. The two-acre site is now dominated by a diverse patchwork of native vegetation including stands of young willows, cottonwoods, and herbaceous vegetation (Muldavin et al. 2004).

Accordingly, we chose a mixture of study sites, some of which had been included in our previous river bar biodiversity studies and some of which were new sites in a young wetland and on a restored bar (AOP). In 2003 twelve sites were chosen for the study (Milford et al. 2007). In 2006, three of the original study sites were abandoned because they had been significantly altered by fire or restoration activities. Four new sites were added to replace the lost sites. Three of these new sites were on a young sidebar in southern Corrales (Fig. 4), and one was added in the cleared mature forest adjacent to the AOP (Fig. 3). The study sites used in 2006 were distributed across three general locations. These locations were the restored bar and surrounding area at the Albuquerque Overbank Project (Fig. 3), the south Corrales sites (Fig. 4), and the north Corrales sites (Fig. 5). The 13 study sites used in 2006 included three willow-dominated sites, two Russian olive-dominated sites, three mature bosque sites, two young cottonwood stands, two young willow stands that had formerly been herbaceous wetlands, and a drier upper-bar herbaceous site. These sites represented the wide range of variation in both vegetation and moisture regime common on bars throughout the Albuquerque reach of the Middle Rio Grande bosque. Table 1 lists the site names, general locations, and center point UTM points for each site. Site photos are provided in figures 7, 8, and 9.

Sampling

Within each site, we selected stands that were homogenous with respect to tree/shrub dominance, on a uniform geomorphic surface, and that were away from obvious public access routes and impacts. A sampling grid of 35 points was established on five-meter centers in a five-by-seven configuration (Fig. 6). Each grid point was monumented with a four-foot rebar stake. The corner rebar stakes were jacketed with white PVC pipe, labeled with aluminum tags, and had a GPS position taken.

Vegetation sampling

One of the most important components of bird habitat is vertical vegetation structure. In 2003 we sampled vertical vegetation structure on the original study sites. We sampled vertical vegetation structure on the four new sites in 2006. Vertical vegetation was measured at 10 points within each site, at rebars two through six along the second (B) and fourth (D) lines - with the site consisting of five lines (A-E) of seven (1-7) rebars each. Vertical vegetation was measured

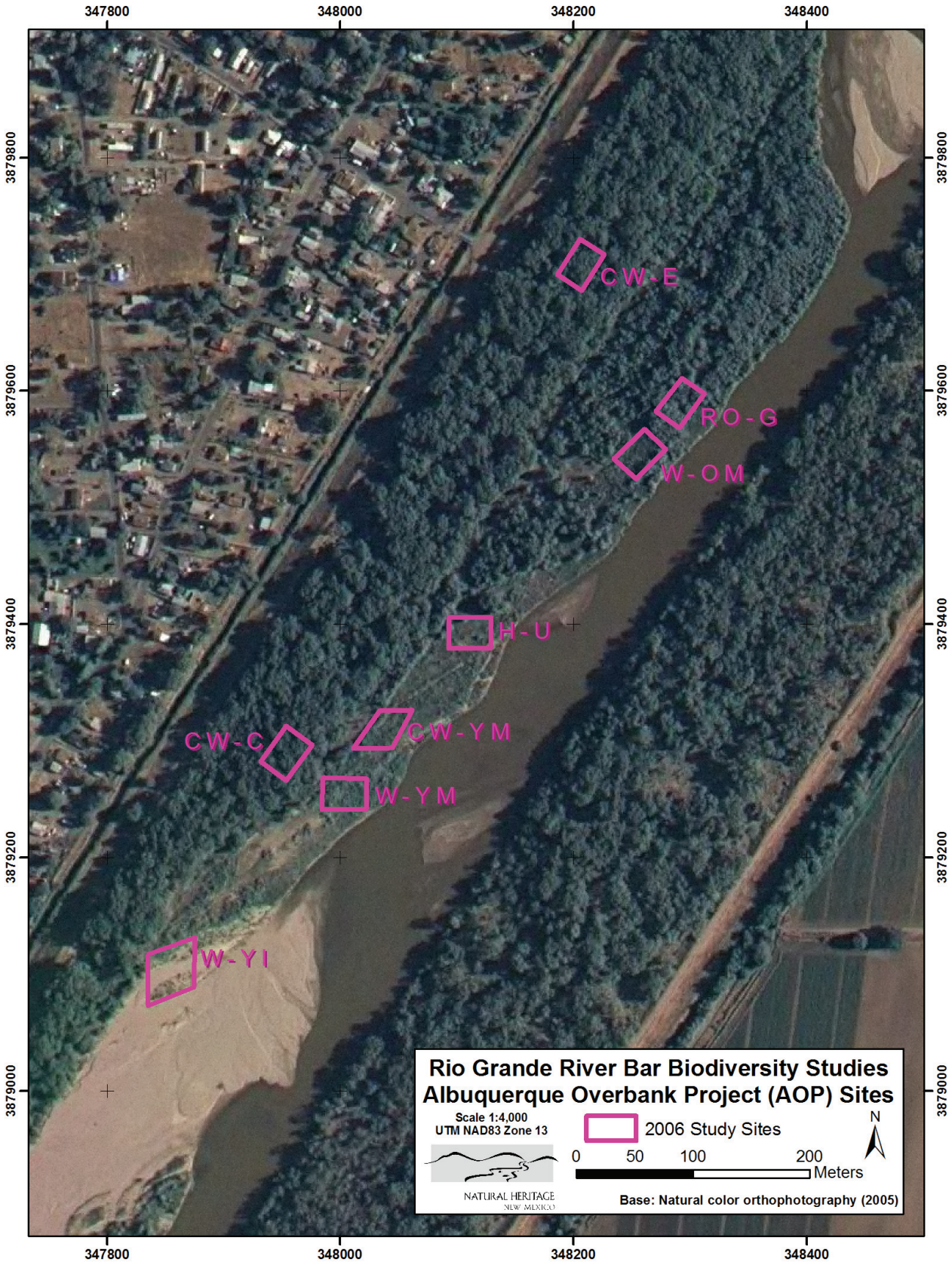


Figure 3. Map of study sites on and around the Albuquerque Overbank Project (AOP) restored bar.

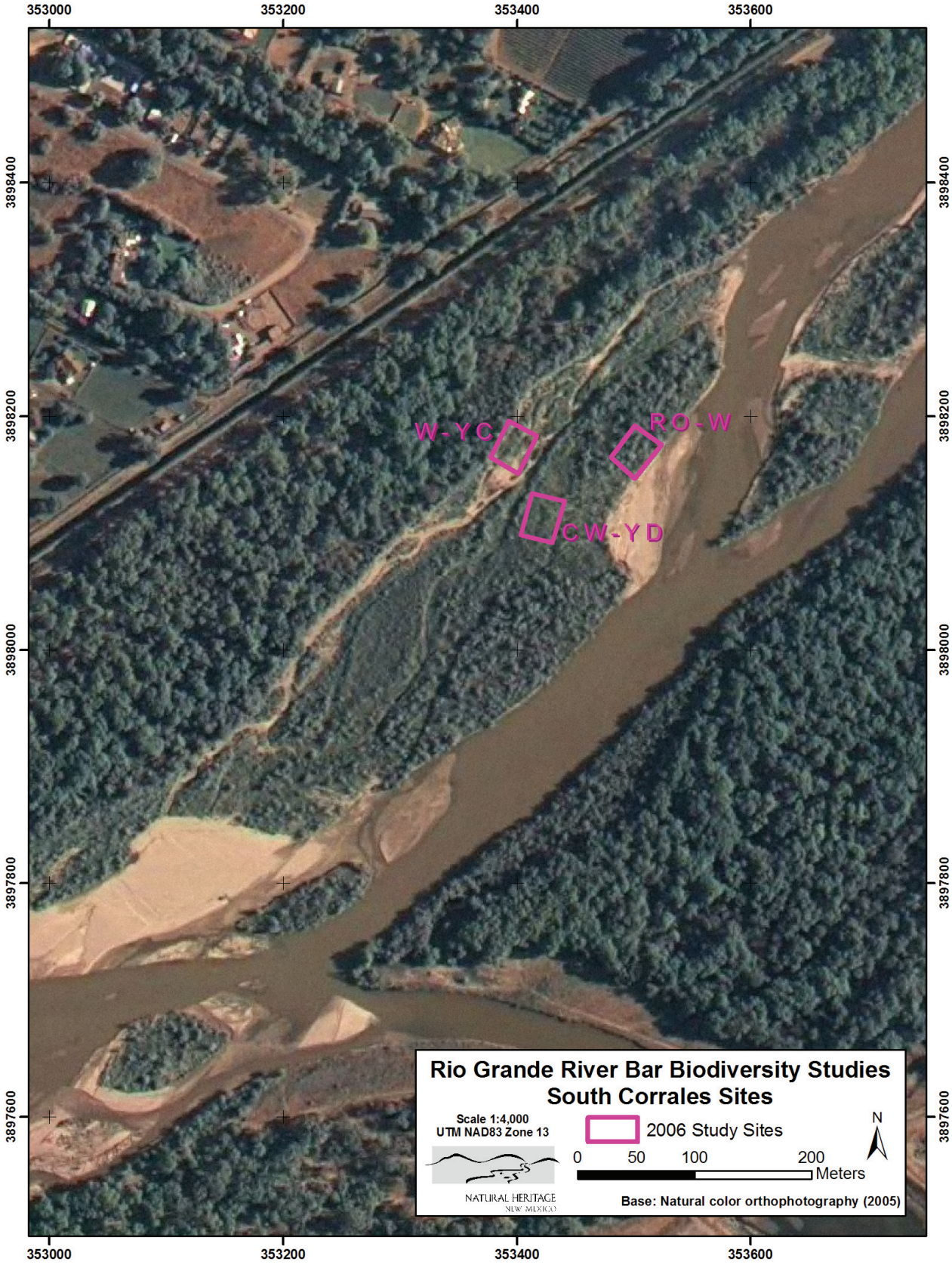


Figure 4. Map of study sites in south Corrales.

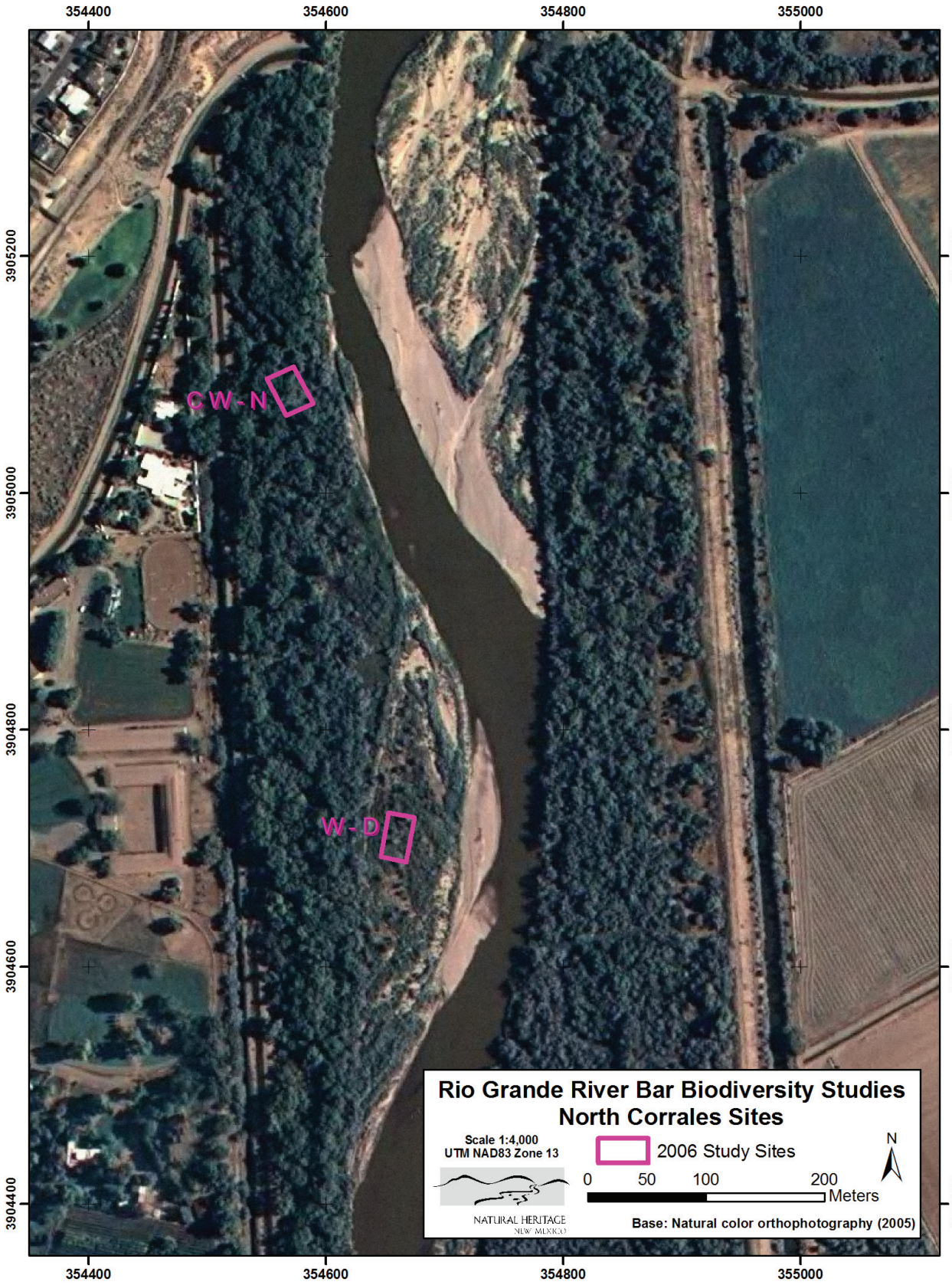


Figure 5. Map of study sites in north Corrales.

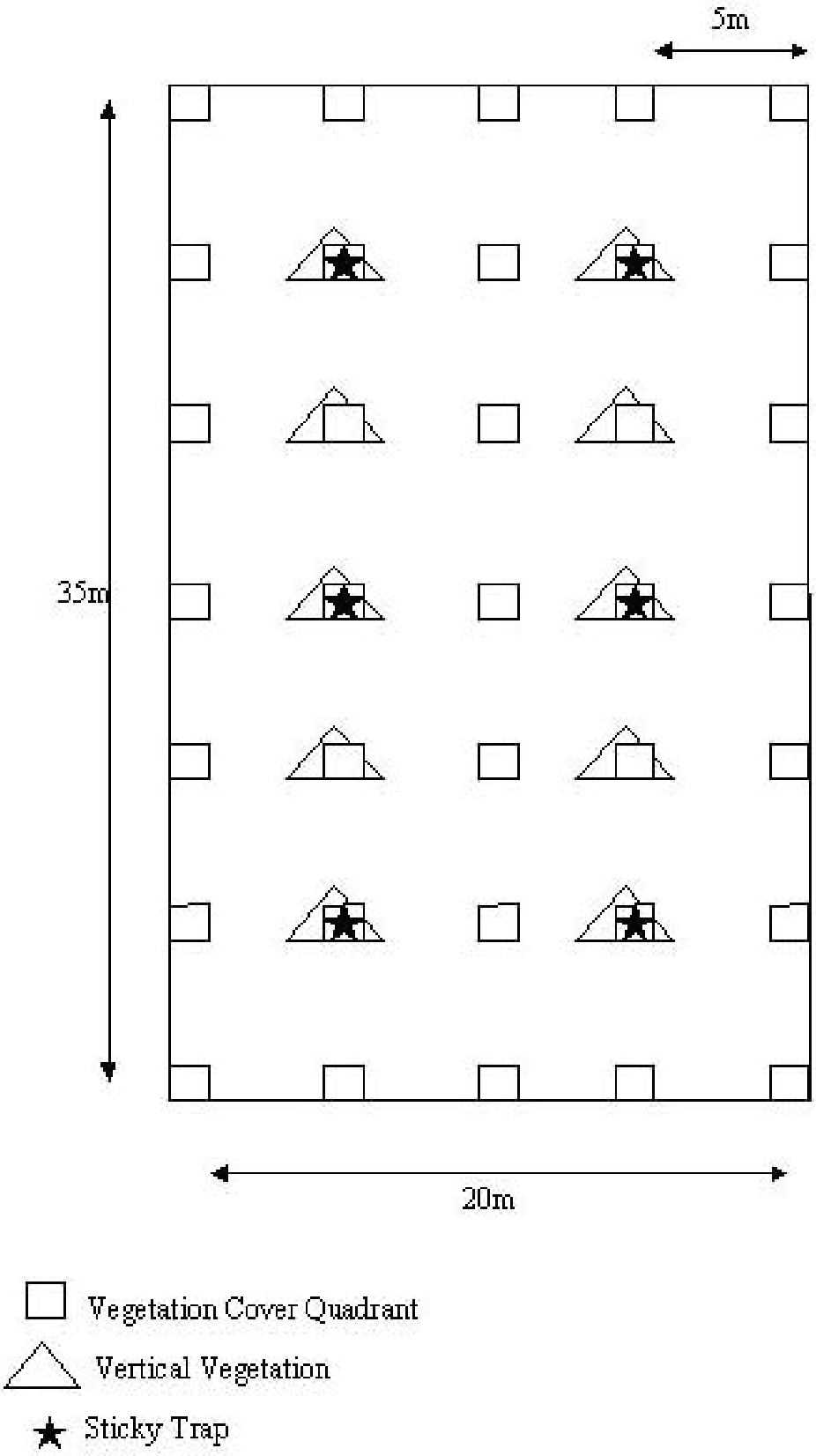


Figure 6. Diagram of site design.

Table 1. List of 2006 study sites ordered by vegetation type, with name, site code, general location, and UTM coordinates.

Site Name	Site Code	PlotID	General Location	Easting*	Northing
Herbaceous Upper-bar	H-U	03AP004	Albuquerque Overbank Project (AOP)	348111	3879392
Young Willow Island Formerly Herbaceous Wetland (H-W)	W-YI	03AP001	Albuquerque Overbank Project (AOP)	347855	3879102
Young Willow Channel Formerly Herbaceous Wetland	W-YC	06RB019	South Corrales	353397	3898174
Willow Young Mesic	W-YM	03AP002	Albuquerque Overbank Project (AOP)	348003	3879254
Willow Old Mesic	W-OM	98RB009	Albuquerque Overbank Project (AOP)	348257	3879546
Willow Dry	W-D	98RB002	North Corrales	354660	3904709
Young Cottonwood Mesic	CW-YM	03AP003	Albuquerque Overbank Project (AOP)	348037	3879309
Young Cottonwood Dry	CW-YD	06RB020	South Corrales	353422	3898113
Russian Olive Willow	RO-W	06RB021	South Corrales	353502	3898170
Russian Olive Grassy	RO-G	98RB008	Albuquerque Overbank Project (AOP)	348292	3879590
Mature Cottonwood Native	CW-N	99RB013	North Corrales	354569	3905086
Mature Cottonwood Exotic	CW-E	99RB017	Albuquerque Overbank Project (AOP)	348206	3879708
Mature Cottonwood Cleared	CW-C	06RB022	Albuquerque Overbank Project (AOP)	347954	3879289

UTM NAD83, Zone 13N

every decimeter using a range pole 7.6 m tall. All species within one decimeter of the range pole were recorded for each decimeter segment, giving a species count per liter. In the mature bosque forest sites where vegetation extended beyond the height of the range pole, the height of intersecting vegetation was estimated up to 18 meters.

In addition to vertical vegetation, in 2004 and 2005 we collected vegetation cover, density, and diversity measurements at the original study sites to provide a comprehensive picture of these sites for analyzing bird habitat preferences. We also collected vegetation cover in 2006, but only at the four new study sites. For vegetation cover measurements, one-meter-square quadrats made of rigid PVC were extended off the northeast corner of all 35 site rebars. The opposite corner of the quadrat was marked with a surveyor pin flag to aid spatial replication. The orientation of the quadrats was noted on the data sheets. Percent canopy cover was recorded for all species within and over hanging the quadrat along with litter, soil, rock, and total herbaceous cover. Voucher specimens were collected and later identified and deposited at the University of New Mexico Herbarium. A complete plant species list is provided in Appendix A, while Appendix B provides cover averages by species, site and year. Besides cover, tree and shrub stems were counted in two-inch-diameter classes along with an estimate of modal height within each one-meter quadrat. Vegetation cover sampling was conducted in the fall of 2004 and 2005, and the summer of 2006.

A) Young Willow Island (W-YI) (formerly H-W)

B) Young Willow Channel (W-YC)

C) Herbaceous Upper-bar (H-U)

D) Willow Young Mesic (W-YM)

E) Willow Old Mesic (W-OM)

F) Willow Dry (W-D)

Figure 7. Site photos for herbaceous- and willow-dominated sites. Photos are labeled with site name and code, see Table 1 for site PlotID and location.

A) Young Cottonwood Mesic (CW-YM)

B) Young Cottonwood Dry (CW-YD)

C) Russian Olive Grassy (RO-G)

D) Russian Olive Willow (RO-W)

Figure 8. Site photos for young cottonwood and Russian olive sites. Photos are labeled with site name and code; see Table 1 for site PlotID and location.

Aerial insect sampling

To examine the potential prey base available for birds we collected aerial insects at the original study sites three times each year during the growing season from the fall of 2003 to the fall of 2005. These collections occurred in October 2003, June, August, and October 2004, and July, August, and October 2005 (Milford et al. 2007). In 2006 we collected aerial insects three times during the early summer bird survey period; once at the beginning on May 19, again in the middle on June 8, and finally at the end of the surveys on June 28. Aerial arthropods were collected using 3x5-inch yellow sticky strip traps hung in shrubs or trees according to the dominant vegetation of the site. At the three herbaceous river bar sites where woody vegetation was limited, traps were hung from three-foot-tall aluminum poles set over the rebar. The traps were hung using twist ties. Six traps were hung at all bar sites, and nine traps were hung in the mature forest sites. At the bar sites traps were hung in the site's dominant shrub species – i.e.

A) Mature Cottonwood Native (CW-N)

B) Mature Cottonwood Exotic (CW-E)

C) Mature Cottonwood Cleared (CW-C)

Figure 9. Site photos for mature cottonwood sites. Photos are labeled with site name and code; see Table 1 for site PlotID and location.

coyote willow at the willow-dominated sites; Russian olive at the Russian olive-dominated sites, etc. Within the bosque sites three traps were hung from mature cottonwoods, and six traps were hung from understory trees and shrubs. At each site, the traps were placed in the shrub or tree of the appropriate species nearest to the B2, B4, B6, D2, D4, and D6 rebar. Most traps were hung approximately 1.5-2 m off the ground, with the exception of those on the poles in the herbaceous sites and those placed in the mature cottonwoods at the bosque sites. Traps were tied only onto living branches near leaves. Flagging was used so that trap locations could be repeated sample to sample, and the locations were only moved in cases where the branch died between sample periods. The sticky traps were left out for 48 hours during all sample periods except for October 2003, when they were left out for 120 hours. Collections of traps occurred in the same order as the traps were set. Clear plastic coverings were placed on both sides of the traps after they were removed from the vegetation. Each trap was labeled with site, date, and vegetation type where the trap was hung. All traps were frozen immediately after collection.

Identification of the arthropods was completed using a Nikon sterio-zoom microscope with 20x/12.5 eyepieces and accompanying lens micometer. The arthropods were left in place on the sticky cards for identification. The number of specimens on the card, the visibility of the crucial body parts such as the wings, legs, and antennae, and the condition of the specimen determined the classification of each arthropod. Specimens were identified to family if possible. All individuals that were at least 50% intact were measured, counted, and marked. The length was measured to the nearest millimeter from the tip of the head to the tip of the abdomen, not including antenna, ovipositors, or wings. The length of incomplete specimens was estimated by the length of the present body parts and the average size of other individuals of the same taxa. A color-coded ink dot was placed beside each measured individual to prevent duplicates. Blue indicated a classification at least to class, red indicated that only the phylum of the individual could be determined and was recorded as "unknown."

Arthropod biomass was calculated using the following equation from Sample et al. (1993):

$y = e^{b(x)^a}$.

Where y = mg biomass per individual; e = a constant of 2.71828183; b and a are taxonomic group-specific constants as determined by Sample et al. (1993), and x = the length times the width of an individual insect. Individuals were grouped into half- or full-millimeter length categories, for which an average length and width were calculated. For each taxonomic group the average biomass was then calculated by size category. This was only done for taxonomic groups for which there were constants available in the literature. These Orders included the Coleoptera, Diptera, Hemiptera, Homoptera, Hymenoptera, Lepidoptera, Neuroptera, and Thysanoptera. Where constants were available, calculations were made for sub-order groupings. There were five of these sub-order groupings used, three in the Diptera (Sub-orders Nematocera and Brachycera, and Infraorder Muscomorpha), one in the Homoptera (family Cicadellidae) and one in the Hymenoptera (family Chalcidoidea).

Number of insects did not correlate well to total biomass due to the large size differences among taxa. A site may have had a very high number of thrips or chalcid wasps, but still have had a very small total biomass of insects. Analysis of the insect results focused on biomass, as in this study we are primarily concerned with insects only in their relation to potential bird habitat.

Bird sampling

Bird surveys were conducted at each site twice weekly (every third or fourth day) for a total of six weeks beginning May 9, 2006 and ending June 28, 2006. This sampling window was chosen to cover the breeding period, as we were most concerned with the breeding population. By starting the surveys in early May, we were also able to catch the end of the spring migration period. During a sampling day, each site was monitored three times, beginning around 6:00 am and ending around10:30 am, for 15 minutes each sampling period. The starting site and starting time varied to distribute observation times across the morning. The observer would vary the route to get to the site and remain still for at least two minutes before beginning the sample. However, once sampling started, the observer was free to move around and through the site as

necessary to determine the species, sex, and activity. Activities were recorded as perched, perched and vocalizing, breeding, nesting, foraging, flight display, and fly-over (fly-through). Birds flying through a site that were not foraging or engaged in displays, were classified as "fly-over" birds. Although we recorded activities, these data were summed into presence/absence values for analysis. Fly-over birds were not included in our analysis.

We compiled two summary data sets: one comprised of the total number of birds by species found on each site, the other of the total number of sampling periods (maximum of 36) a species was found on each site. The first set emphasizes intensity of use while the total samples set emphasizes consistency of use. We use "intensity" and "consistency" to refer to these two data sets. As the intensity values rise relative to the consistency values, more birds of a species are visiting a site during the sampling periods. Since the number of swallows (Fringillidae) foraging on a site could be very large, we determined intensity and consistency of use on sites for swallows as a group separately from non-swallows. As a reference, a group consistency value of 72 results when two species visited a specific site every sampling period (2 x 36) or any other combination of species and sampling periods with a product of 72. Thus, consistency values for groups of bird species are best thought of as an index. In addition, because swallow intensity was low in mature cottonwood sites (CW-C, CW-E, and CW-N), with only eight total visits, these sites were dropped from the analysis when determining percentage of site use by swallows.

While we have sites with habitat similarities, resources limited our capacity to sample a suite of consistent replicate sites. Hence, we have treated this is an exploratory study to evaluate the similarities and differences with respect to species groups and individual bird species among individual or *ad hoc* groups of sites (instead of a strict analysis of variance among of site groups representing specific replicate habitat conditions).

Database

The vegetation, arthropod, and bird data were entered into the NHNM Ecology Group relational database (Microsoft Access platform), and quality controlled through error-checking routines and manual read-backs. The database is provided as a stand alone data set on the accompanying CD and is also available on our website (http://nhnm.unm.edu/).

Results

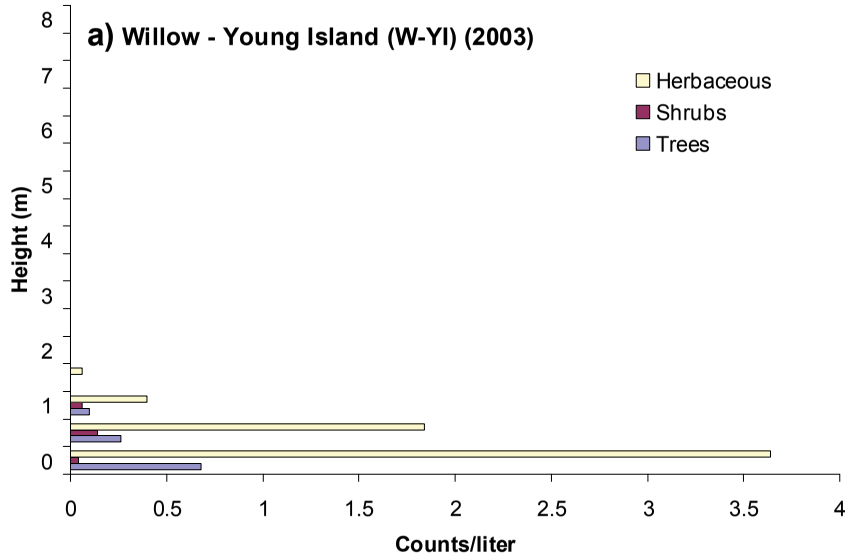
Site Descriptions

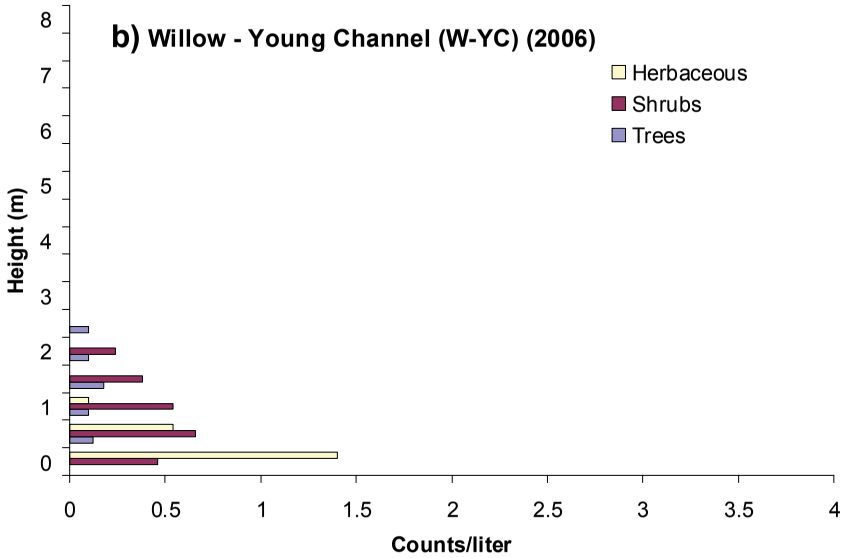
The sites fall into four main categories: willow-, Russian olive-, cottonwood- and herbaceous-dominated. The willow sites included a mesic seven-year-old stand on a restored bar (W-YM), a wetter stand in a sidebar swale (W-OM), and an established willow stand on a dry, sandy sidebar (W-D) (Fig. 7d, e & f). There were also two very young willow- and native tree-dominated sites, that were originally herbaceous wetlands when the study started in 2003, but which had become young shrublands by 2006. These were an island site off the south end of the restored bar (W-YI) and a site within a backchannel between the south Corrales bar and the terrace forest (W-YC) (Fig. 7a & b). The Russian olive stands were older, established stands. One was a moderately mesic dense stand of Russian olive with a grassy understory (RO-G), the other was very mesic, dense mixed stand of mature Russian olive and coyote willow with a few young cottonwoods on the edge of the south Corrales sidebar (RO-W) (Fig. 8c & d). All three of the mature bosque sites were dominated by a mature cottonwood overstory, but had varying understories. One had an understory composed of native shrubs and herbaceous species (CW-N), one an understory composed almost exclusively of exotic shrubs (CW-E), and the third had no understory at all, having been cleared by the City of Albuquerque in 2005 (CW-C) (Fig. 9). There were two young cottonwood stands, one a four-year-old stand on the restored bar site (CW-YM), the other a stand of mixed young cottonwood and coyote willow on the south Corrales sidebar (CW-YD) (Fig. 8a & b). There was one upper-bar herbaceous site (H-U) located on the restored bar site (AOP) (Fig. 7c).

The young willow shrubland (W-YC), former herbaceous wetland, in the backchannel, the Russian olive-coyote willow site (RO-W), and the dryer young cottonwood-coyote willow site (CW-YD) on the south Corrales sidebar, along with the mature bosque cleared site (CW-C) were the four new sites added in 2006. They replaced two Russian olive sites and a dry willow site which had burned or experienced other significant changes of habitat type since originally being included in the study in 2003. For further information on the original study sites see Milford et al. 2007.

Vegetation Composition and Structure

The vegetation structure and composition differed among sites, with apparent trends related to the dominant species' life form and native versus exotic origin. The herbaceous upper-bar site (H-U) was dominated predominantly by native grasses (Figs. 10 & 14). The two former wetland herbaceous sites turned young willow shrublands (W-YI & W-YC) were dominated by a mix of young trees, shrubs, grasses and forbs, the majority of which were native (Fig. 14). When this study was begun in 2003 graminoid cover was very high at the W-YI site, but it declined by over 81% as the active river channel moved away from the site, and it developed from an herbaceous-dominated wetland into a young native shrubland dominated by willows (Appendix B).





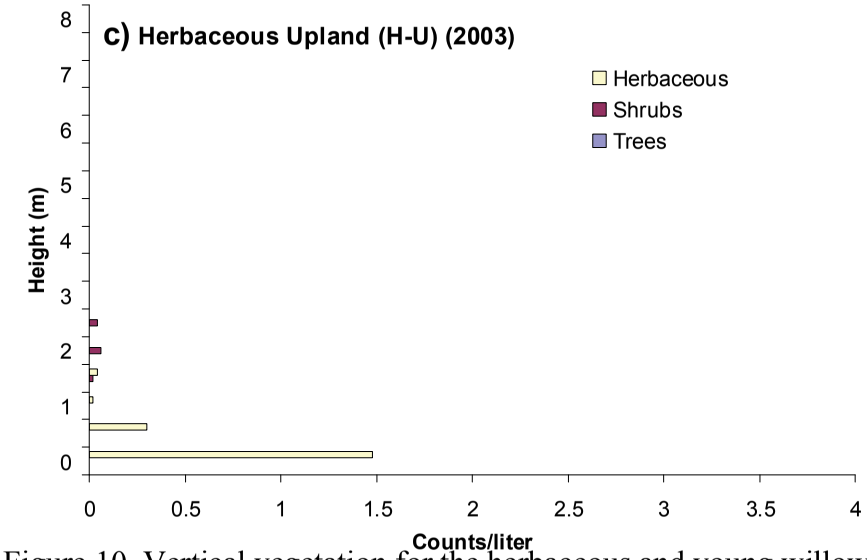


Figure 10. Vertical vegetation for the herbaceous and young willow (former herbaceous-wetland) sites showing average count of species per liter by half-meter and life form. Vertical vegetation was only measured once at each site. The year the vertical vegetation was measured is shown in parentheses after the site name.

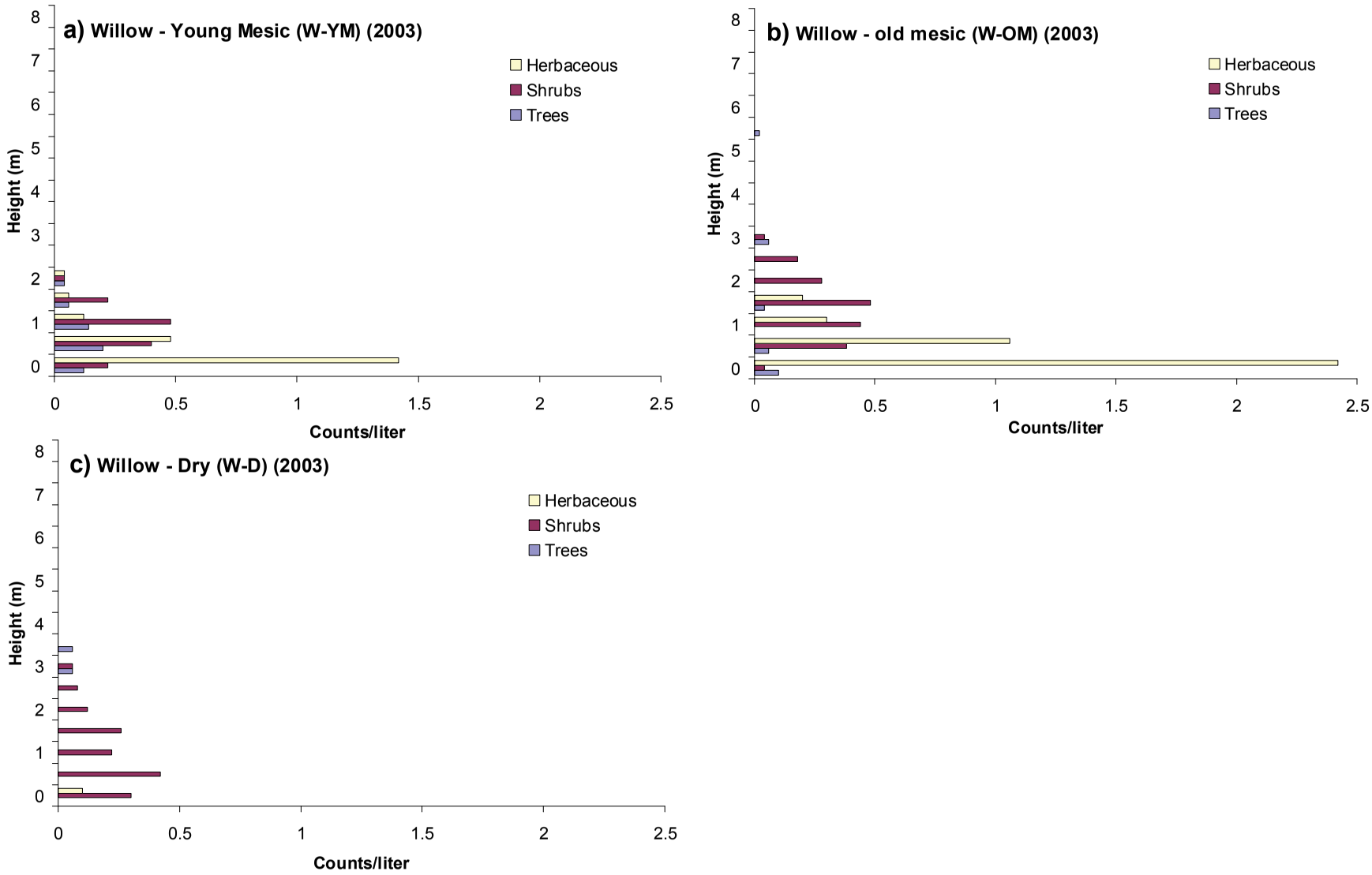


Figure 11. Vertical vegetation for the willow sites showing average count of species per liter by half-meter and life form. Vertical vegetation was only measured once at each site. The year the vertical vegetation was measured is shown in parentheses after the site name.

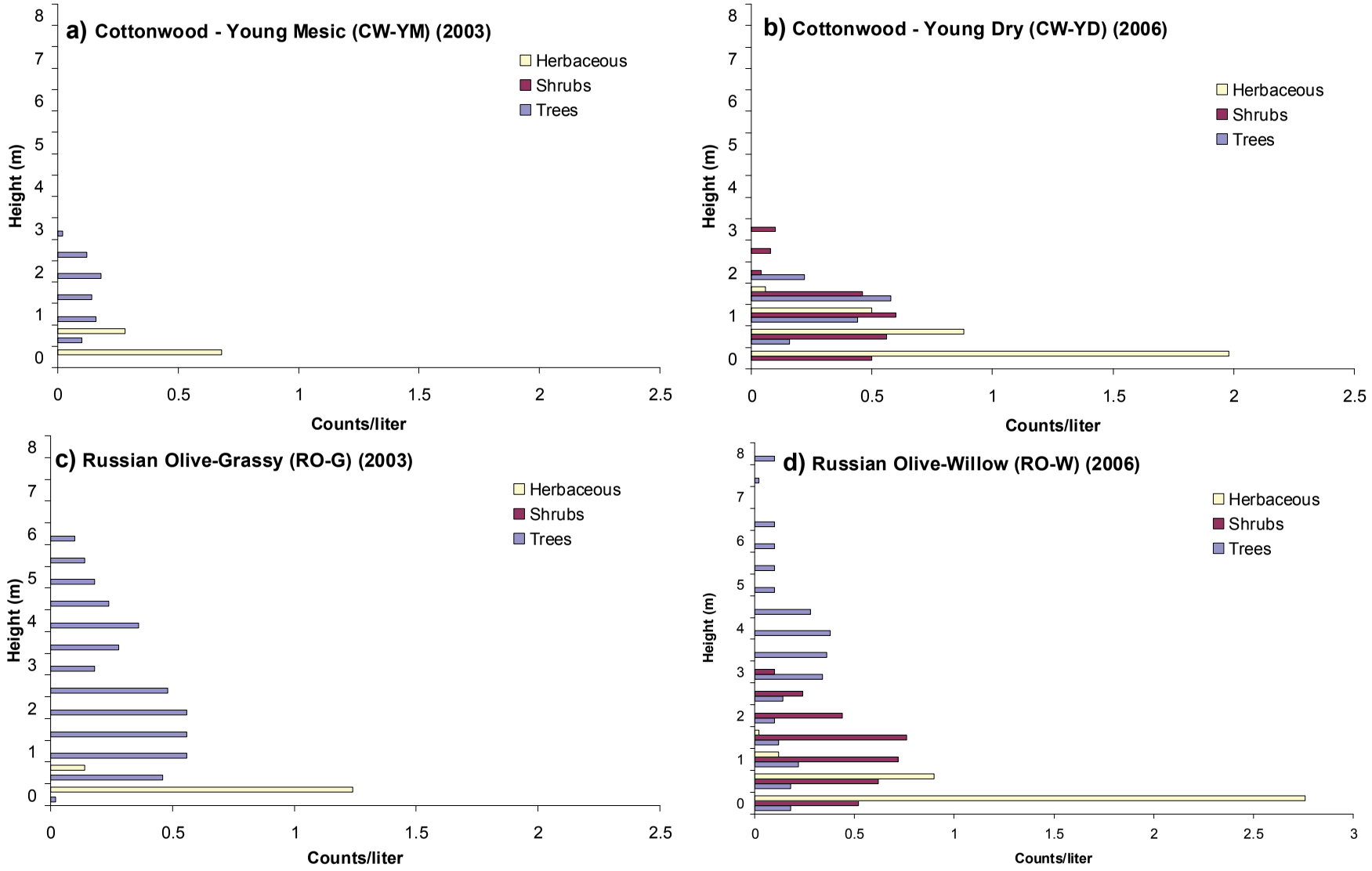


Figure 12. Vertical vegetation for the Russian olive and young cottonwood sites showing average count of species per liter by half-meter and life form. Vertical vegetation was only measured once at each site. The year the vertical vegetation was measured is shown in parentheses after the site name.

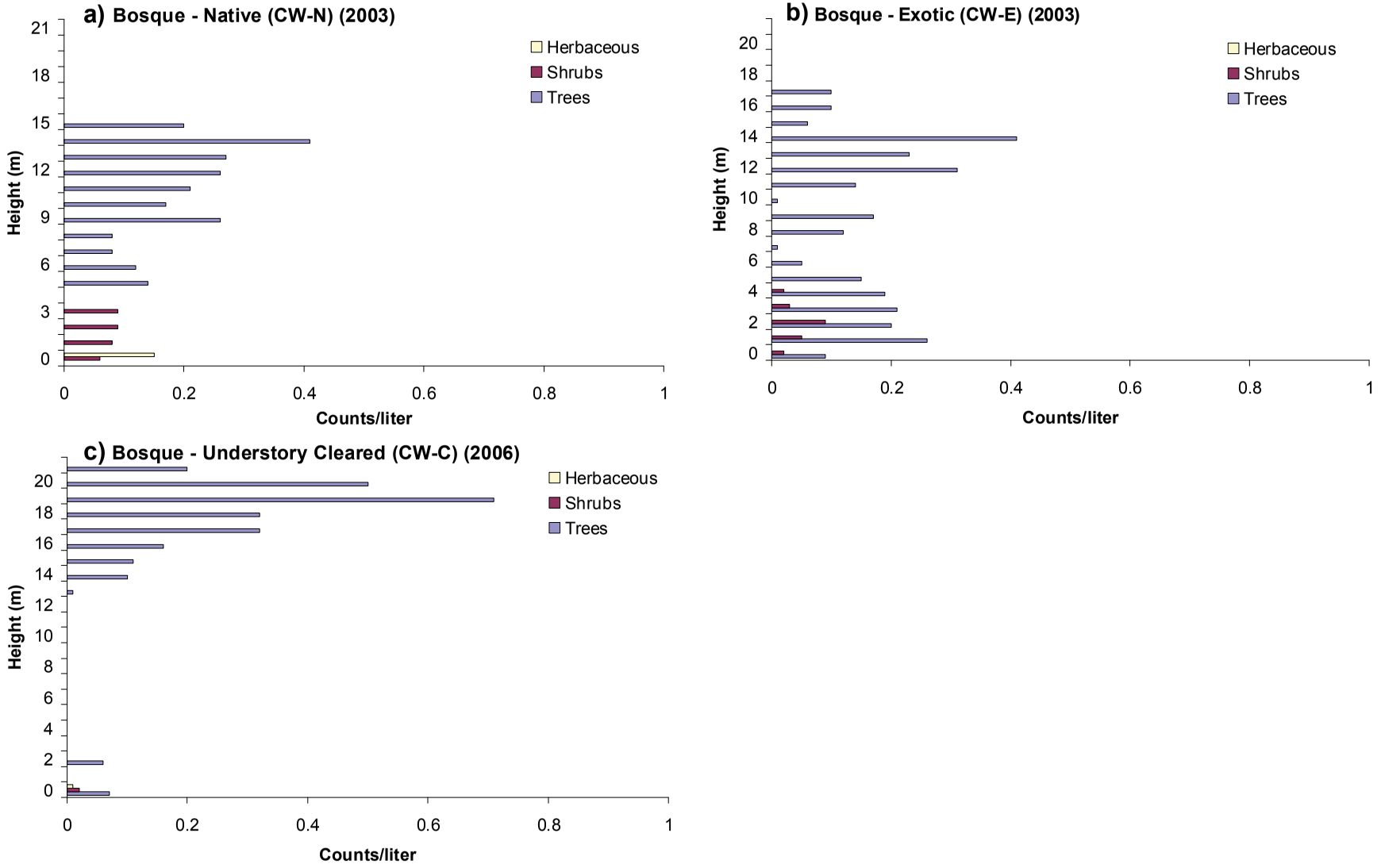


Figure 13. Vertical vegetation for the mature bosque sites showing average count of species per liter by meter and life form. Vertical vegetation was only measured once at each site. The year the vertical vegetation was measured is shown in parentheses after the site name.

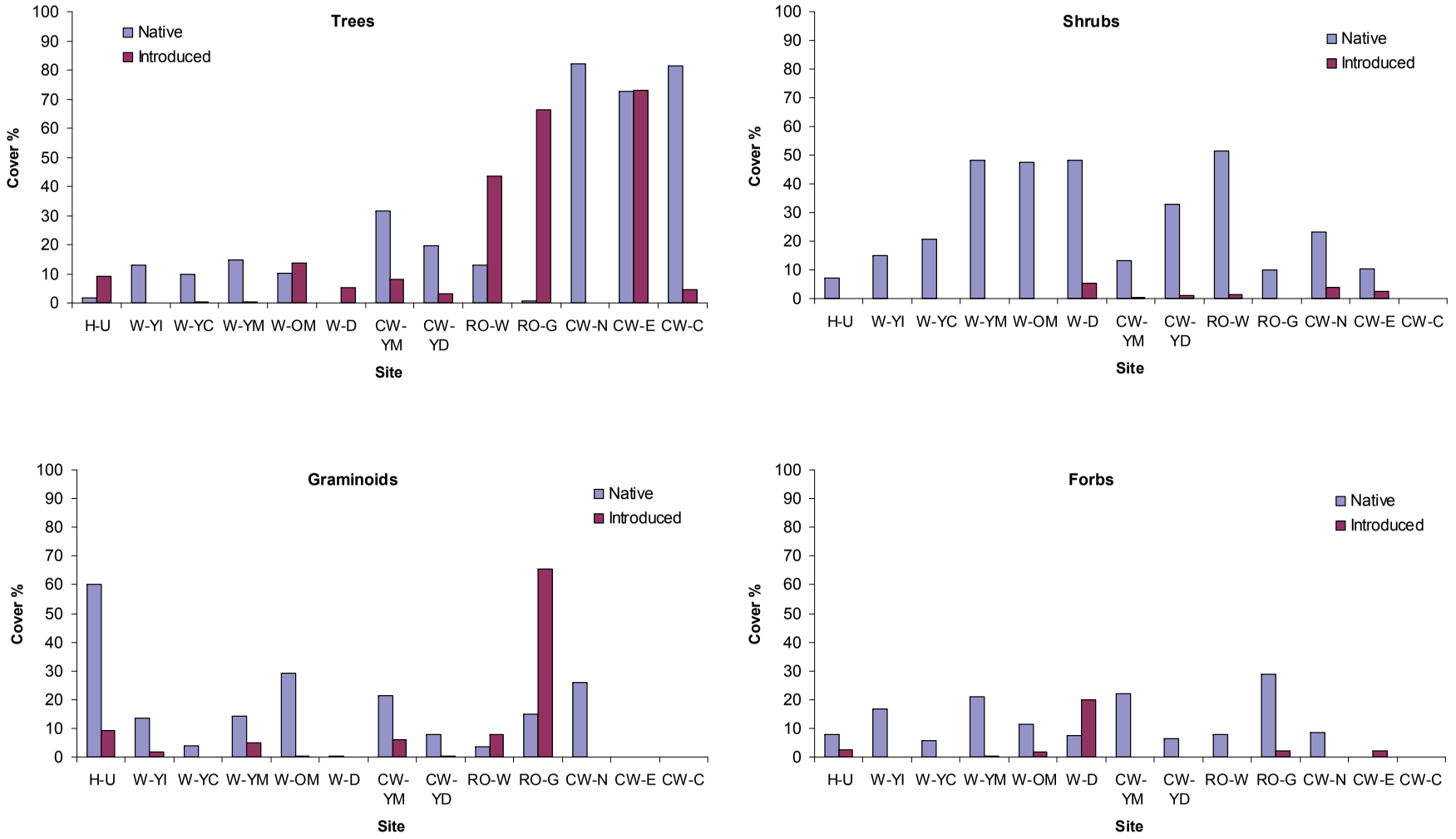


Figure 14. Vegetative cover by life form and origin for all sites from 2005 for original sites and 2006 for the four new sites (W-YC, CW-YD, RO-W, and CW-C). W-YI=Willow-Young Island; W-YC=Willow-Young Channel; H-U=Herbaceous upper-bar; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YD=Cottonwood-Young Dry; CW-YM=Cottonwood-Young Mesic; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

For further discussion on the successional change at the W-YI site see Milford et al. 2007. The vertical vegetation structure of the young willow shrublands demonstrates their transitional state with many young trees and shrubs 2 m and under, while the more established herbaceous upper-bar had few, taller shrubs, and lacked tree reproduction (Fig. 10). Species richness per square meter was relatively high at one of the young willow shrublands (W-YI), and relatively low at the other (W-YC) (Fig. 15), while both sites were average for bar sites in overall species richness (Fig. 16). The herbaceous upper-bar site, although among the lower sites in species richness per square meter (Fig. 15), was among the highest sites in overall species richness (Fig. 16).

The three willow-dominated sites had clear differences in structure related to moisture regime (Fig. 11). The mesic willow stands (W-YM and W-OM) had high density of herbaceous species in height between 0-2 m (Figs. 11a & b). This herbaceous layer at the mesic sites was dominated by native grasses, while at the dry willow site there was little herbaceous structure and herbaceous cover was limited mostly to exotic forbs (Figs. 11 & 14). Shrub cover at all three of the willow sites was similar and dominated by native coyote willow (*Salix exigua*) (Fig. 14). The mesic willow sites (W-YM & W-OM) were more species rich than the mature bosque sites (Fig. 16) and were among the sites highest in species richness per square meter (Fig. 15).

The Russian olive sites (RO-G & RO-W) were similar in vertical tree structure to each other, but the Russian Olive-Willow site included a shrub layer that was lacking in the Russian Olive-Grassy site (Fig. 12c & d). The two sites, although similar in tree cover, differed greatly in shrub and graminoid cover (Fig. 14). While the Russian Olive-Grassy site was predominantly composed of exotic species, the Russian Olive-Willow site was a mix of exotic and native species (Fig. 14), and had one of the highest species richness's of any of the sites (Figs. 15 & 16).

The young cottonwood sites (CW-YM and CW-YD) were quite different from each other in vertical structure (Fig. 12a & b). The site on the south Corrales sidebar (CW-YD) was denser structurally in trees, shrubs, and herbaceous layers (Fig. 12b). However, this structural density, while translating into higher shrub cover due to the coyote willow component of the site, did not translate into a higher herbaceous cover (Fig. 14). The young cottonwood site on the restored bar (CW-YM) had more than twice as much graminoid and forb cover. The site on the restored bar also had approximately 30% greater species richness than the Corrales young cottonwood site, and was across all sites the one with the greatest species richness both per square meter and overall (Figs.. 15 & 16). Both young cottonwood sites were dominated by native species in all life form groups (Fig. 14).

Vegetation at the mature cottonwood bosque sites (CW-N, CW-E and CW-C) was much taller than any of the bar types, extending 16-18 m to the top of the canopy with complex understories when unaltered (Fig. 13). The native site differed from the others in that it had some herbaceous cover in the 0-0.5 m zone, while the other two sites had almost none (Figs. 13 & 14). At the CW-E site, the trees and shrubs created a relatively dense woody understory at 0-6 m dominated by exotic species, while the CW-N site characterized lower density native shrubs, and the cleared bosque (CW-C) site had no structure of any kind between 2-12 m (Fig. 13 and Appendix B). Tree cover was very high at all bosque sites, but differed in composition, with the native and cleared sites comprised almost exclusively of native species, while the exotic site

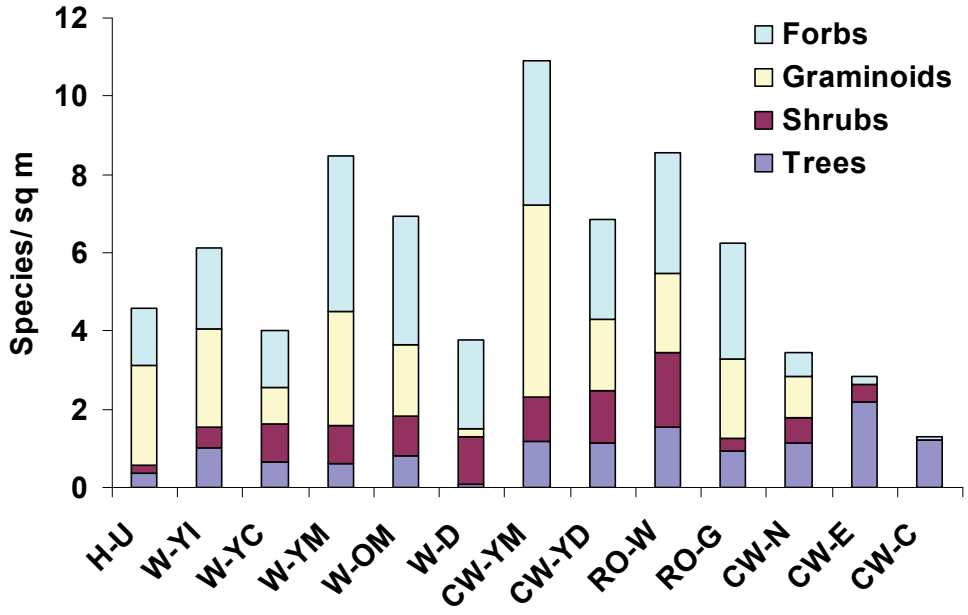


Figure 15. Average number of plant species per square meter by site. W-YI=Willow-Young Island; W-YC=Willow-Young Channel; H-U=Herbaceous upper-bar; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YD=Cottonwood-Young Dry; CW-YM=Cottonwood-Young Mesic; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

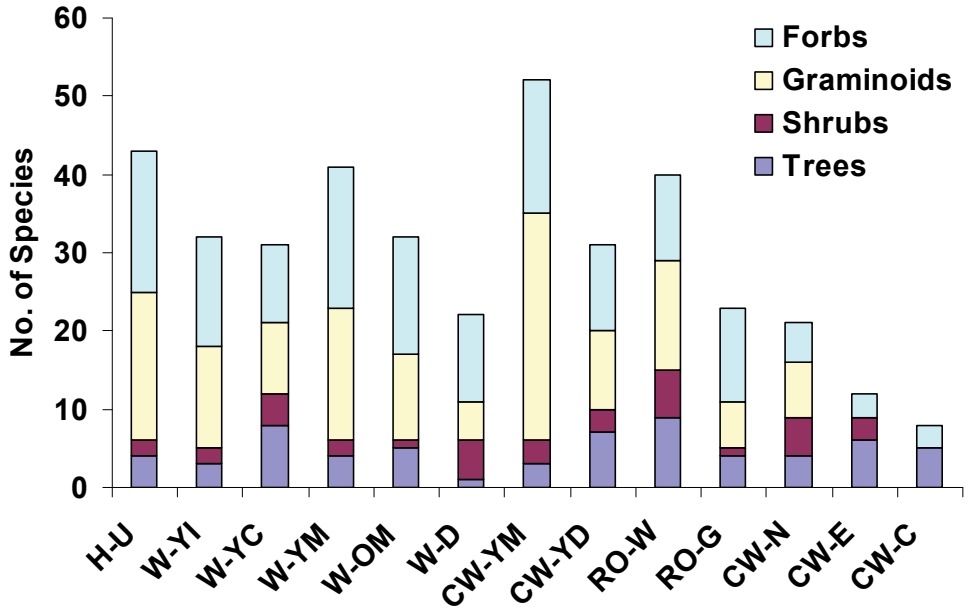


Figure 16. Total number of plant species observed by site in 2005 for original sites and 2006 for the four new sites (W-YC, CW-YD, RO-W, and CW-C). W-YI=Willow-Young Island; W-YC=Willow-Young Channel; H-U=Herbaceous upper-bar; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YD=Cottonwood-Young Dry; CW-YM=Cottonwood-Young Mesic; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

was split between native and exotic species (Fig. 14). At the exotic bosque site, the native cover came from the overstory mature cottonwoods, while the understory trees were almost exclusively exotic species such as tree of heaven (*Ailanthus altissima*), Russian olive, and Siberian elm (*Ulmus pumila*) (Appendix B). Species richness on both the site and per-meter basis was lowest at the mature bosque sites (Figs. 15 & 16). The exotic-dominated and cleared sites were particularly low in overall species richness, with the cleared bosque site lowest on all measures of species richness (Figs. 15 & 16).

Arthropod Abundance and Biomass

Overall, there was a high diversity of arthropods captured in our sampling. Over the study period of 2003-2006, 87,227 individual arthropods were collected on sticky cards representing 18 different insect orders plus arachnids (spiders) and diplopoda (millipedes) (see Appendix C). Among the insects, 70 families and 10 additional below-order level taxonomic groups were identified. The overwhelming majority of the individuals (94%) came from five orders: the Diptera (flies), Hymenoptera (bees and wasps), Thysanoptera (thrips), Homoptera (leaf hoppers), and Coleoptera (beetles) orders. Only these orders occurred in high enough densities to be used in the subsequent analyses.

The year 2006 had the highest density of individual arthropods (37,712) collected, however insect biomass was higher in years prior to 2006 (Figs. 17-20). While there were large variations in biomass of insects collected across sites and between sample periods, some general patterns emerged. Across most sites for which there are data prior to 2006, total insect biomass shows a decline from 2004 through 2006 (Figs. 17-19). This pattern is particularly evident when average summer biomass is examined by year (Fig. 20). Only two sites experienced a peak in biomass in 2005, the dry willow site (W-D) and the grassy Russian olive site (RO-G) (Figs. 17f & 18d). These sites, while not directly flooded by the river, experienced some standing water on site from ground water seepage in 2005. Thus, they were much wetter during the early summer of 2005 than they were during other years. The other site which is an exception to the peak biomass in 2004 is the old mesic willow site (W-OM) which experienced peak biomass values in October 2003 due to a huge number of leaf hoppers (Cicadellidae) (Fig. 17e).

Generally, all sites followed a pattern of peak insect biomass in the early summer with a decline throughout the growing season (Figs. 17-19). Exceptions to this pattern were generally small, and involved a peak at the second summer sample period instead of the first. The young willow island site (W-YI), which had been a herbaceous wetland at the start of the study in 2003, had a major peak at the second summer sample of 2004 (Fig. 17a). This was due to the prominence of large brachycerid flies and wasps at the site while it was still a herbaceous wetland. One possible exception to the general annual pattern of peak summer biomass is October 2003, when four sites had very high overall biomass (W-YI, W-OM, CW-YM and RO-G) (Figs. 17 & 18). However, without other insect samples from 2003 there is no way to know if all of 2003 was high in biomass at those sites or if the annual pattern in biomass was different in 2003 than for following years at those sites. In 2006 all of the insect samples occurred in the early summer, and do not exhibit a clear pattern of biomass peaks between the three sample periods (Figs. 17-19).

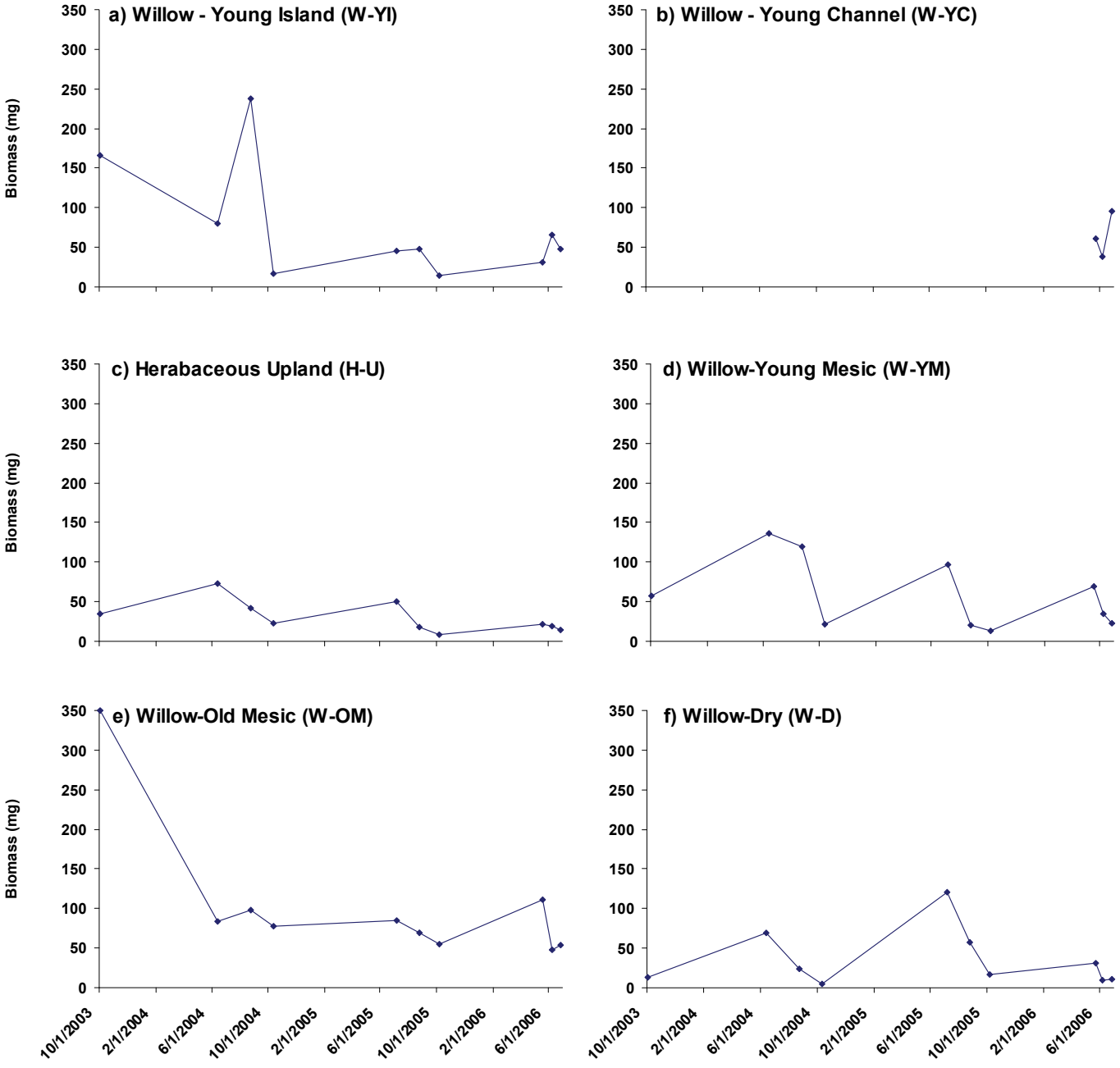


Figure 17. Average total biomass of insects per sticky card by month and year for herbaceous and willow sites.

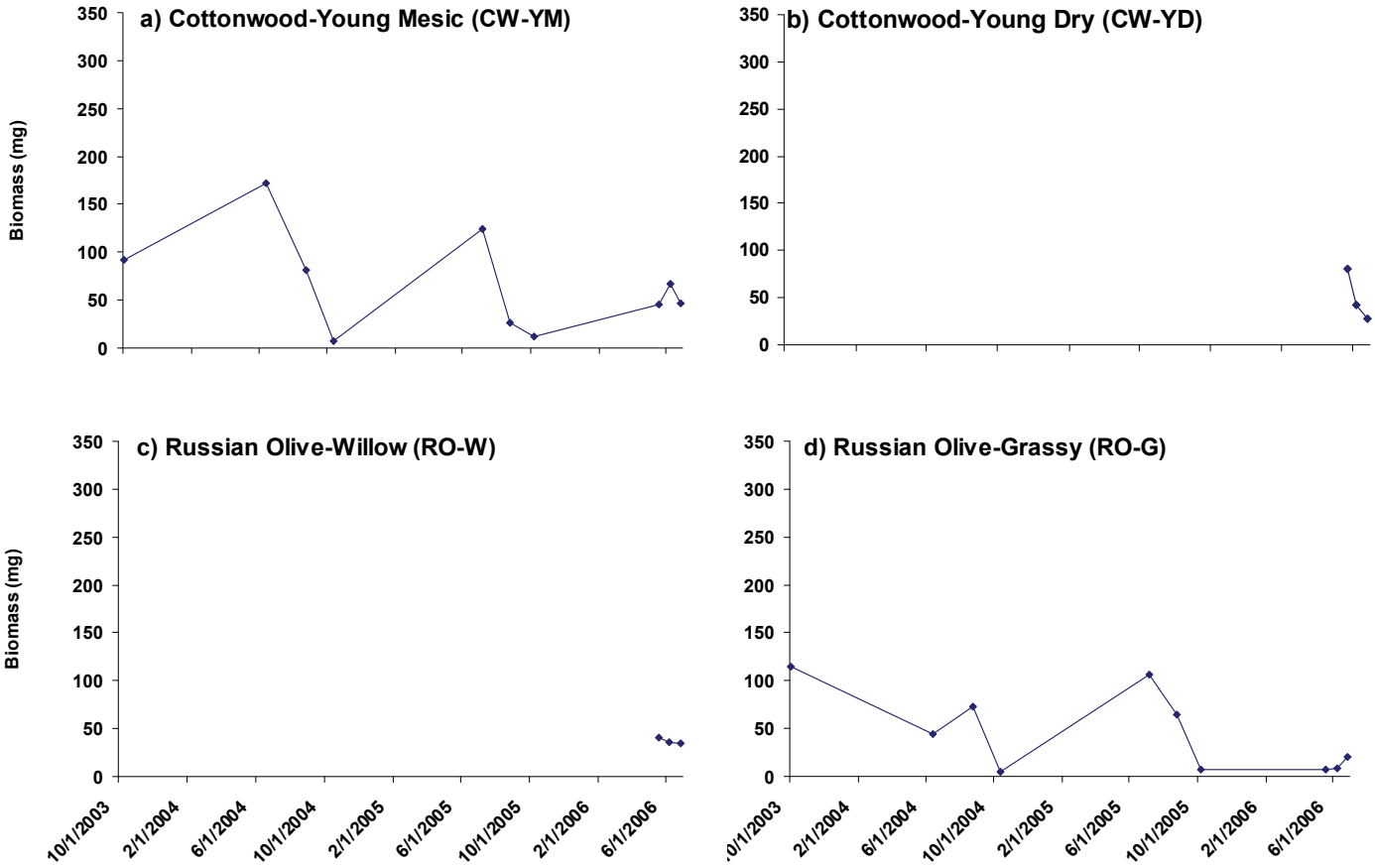


Figure 18. Average total biomass of insects per sticky card by month and year for Russian olive and young cottonwood sites.

Overall, insect biomass was higher at the willow and young cottonwood sites in 2006 than at most other site types (Fig. 20). Leaf hoppers (Cicadellidae) were a major component of the insect biomass at sites where willows or young cottonwoods were prevalent (W-YI, W-YC, CW-YD, & RO-W) and were highest at the older mesic willow site (W-OM) (Fig. 21a). High numbers of leaf hoppers, which are large members of the aerial fauna, drove the very high biomass at the old mesic willow site in October 2003 (Fig. 17e). Although the W-OM site continued to have the highest biomass of leaf hoppers across all sample years, the average biomass dropped every year, and was less than one sixth the 2003 average in 2006 (Fig. 21a).

While there was important temporal variation, within insect taxa there were few clear patterns of biomass related to vegetation type and habitat conditions. Leaf-hoppers were almost absent from all mature cottonwood sites (CW-N, CW-E and CW-C) in 2006 (Fig 21a), and had been very sparse at mature cottonwood sites in previous years (Milford et al. 2007). Although it was not as dramatic, non-chalcid wasps were also scarce among the mature bosque sites, as well as the herbaceous upper-bar (H-U), dry willow (W-D) and Russian olive grassy (RO-G) sites in 2006 (Fig. 21c). Brachyceran flies were scarce at both Russian olive-dominated sites (RO-G & RO-W) and the dry willow site (W-D) (Fig. 21b).

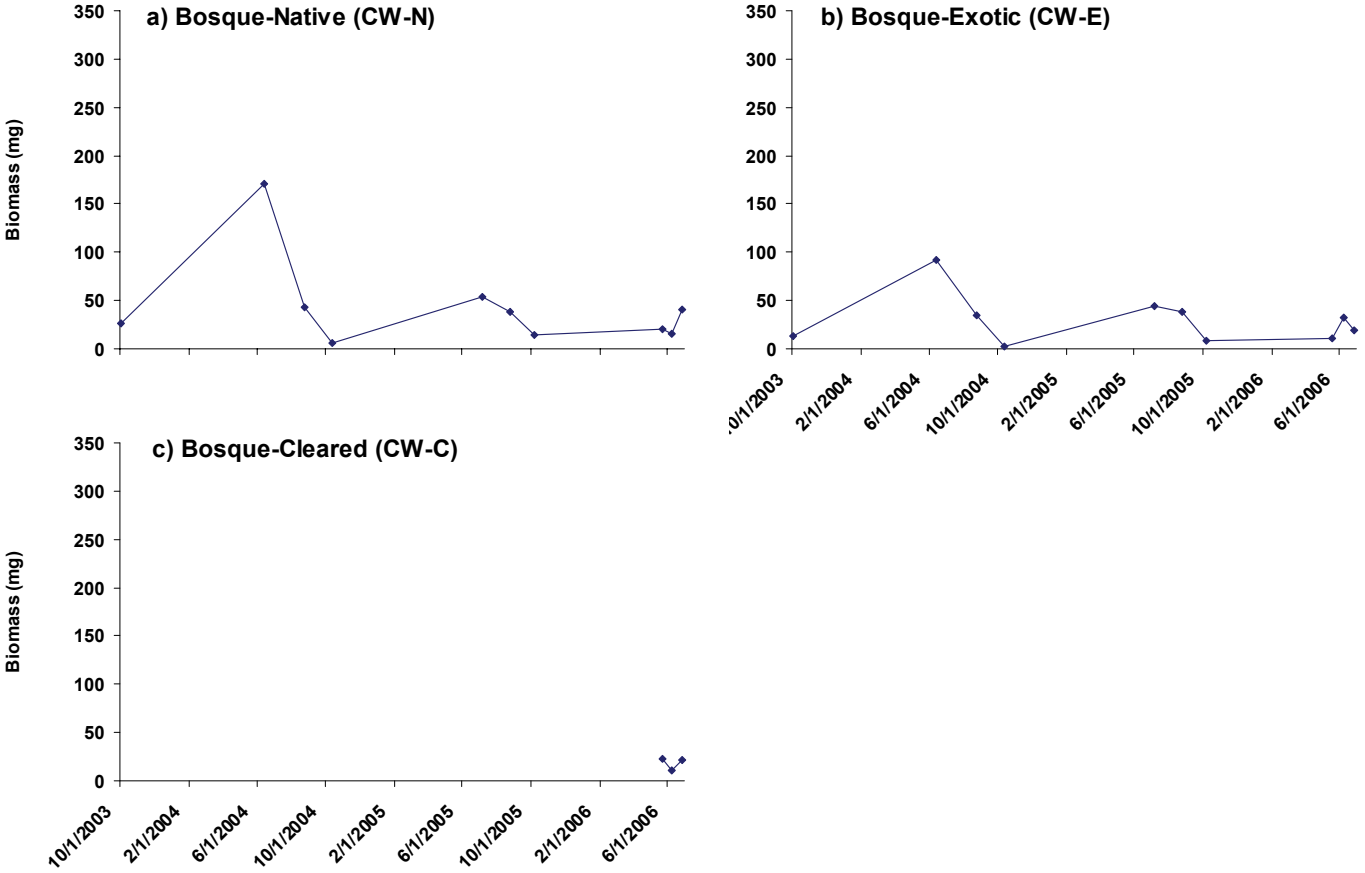


Figure 19. Average total biomass of insects per sticky card by month and year for mature cottonwood sites.

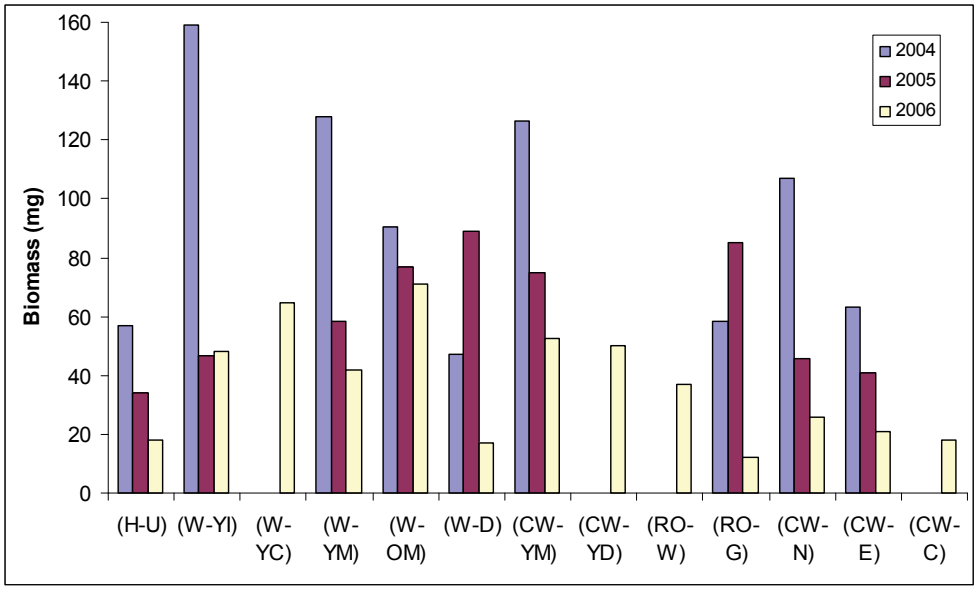


Figure 20. Average summer total insect biomass by site. Average was created using May-August samples only.

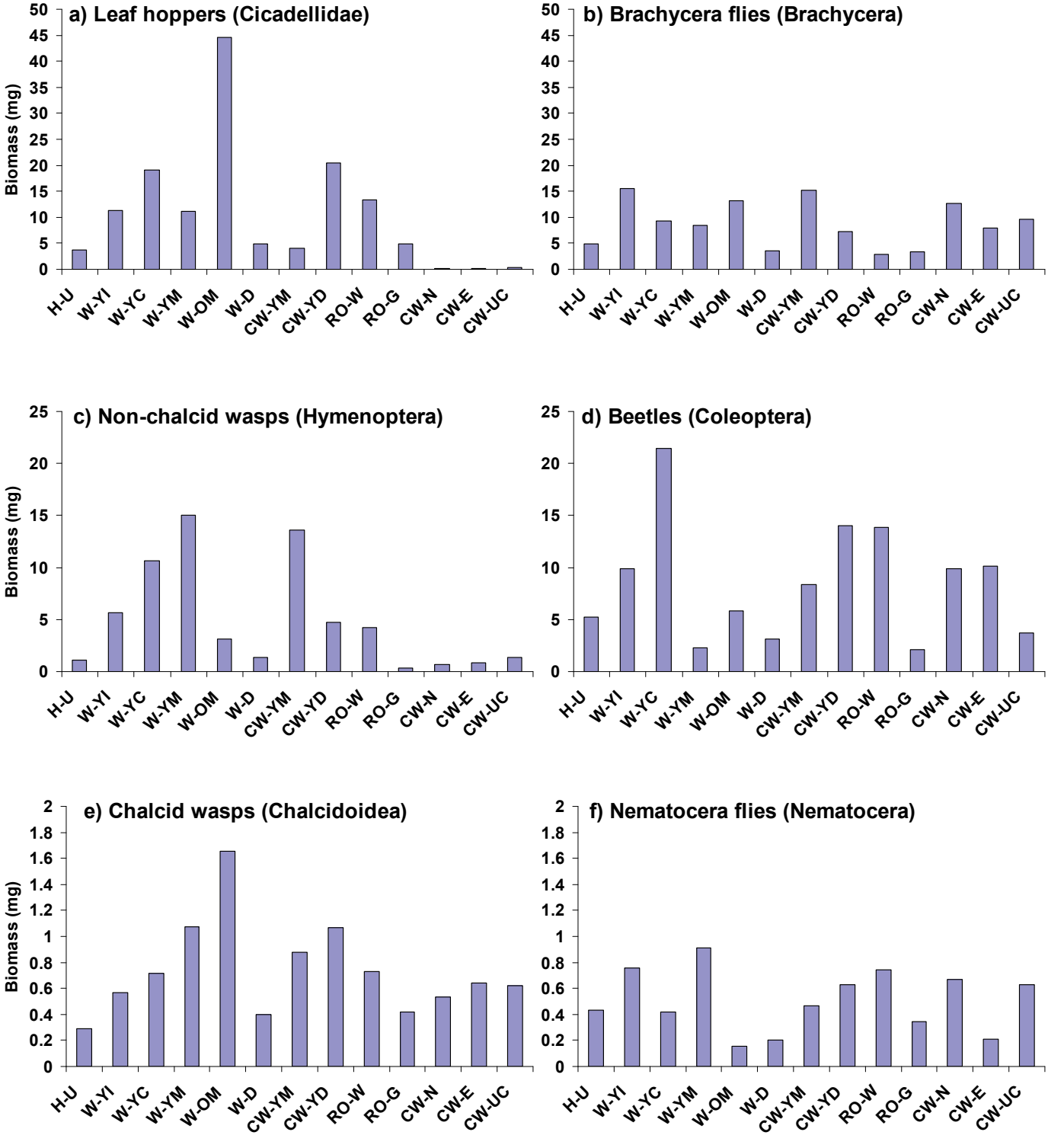


Figure 21. Average biomass per card for six most common insects groups by site for 2006.

Bird Abundance

More than 13,000 individual bird visits, representing 52 species, were observed across all study sites during 2006 (Table 2). Swallows (Fringillidae) as a group were highest in intensity and consistency. Four sites had more than 1600 swallow visits each, nearly twice as many as the next highest site and they were the most consistently visited with consistency values of 40 or more (Fig. 22). Overall, the six AOP bar sites were the most used. Conversely, of the 11,234 intensity visits made by swallows, only eight were to mature cottonwood sites. For non-swallows, the four sites with the greatest intensity and consistency were two mature cottonwood sites (CW-N, CW-E) and the Russian olive dominated sites (RO-G, RO-W) (Fig. 23). These four sites also contain the greatest structural complexity among all sites in the study (Figs. 12 & 13).

In general, individual species concentrated use in the mature cottonwood/Russian olive sites, avoided mature cottonwood sites, or used a mosaic of sites (Table 2). Species detected often and predominantly in the mature cottonwood and Russian olive sites include black-headed grosbeak, brown-headed cowbird, yellow-breasted chat, and white-breasted nuthatch. The black-headed grosbeak had higher intensity and consistency in sites with a significant Russian olive component (CW-E, RO-W, RO-G). Similarly, the brown-headed cowbird and yellow-breasted chat also had their highest intensities and were most consistent in the Russian olive sites (RO-W, RO-G). In contrast, the white-breasted nuthatch was found exclusively in mature cottonwood sites. Other species that were also found predominantly in mature cottonwood/Russian olive but not as often included Cooper's hawk (exclusively native mature cottonwood), lesser goldfinch (predominantly native mature cottonwood), black-capped chickadee, summer tanager (predominantly mature cottonwood), downy woodpecker, and northern flicker (Table 2).

Birds generally avoiding mature cottonwood habitat include swallows (Fringillidae), blue grosbeak, ash-throated flycatcher and willow flycatcher (Table 2). Blue grosbeak, ash-throated flycatcher and willow flycatcher were all detected in the Russian olive-dominated sites together with a few additional bar sites. While not found in high numbers, killdeer were found consistently at W-YI. Six species of warbler were recorded during the surveys, most of which were likely spring migrants (Table 2). All but two of the warbler observations occurred in the bar habitats, often on willow-dominated bar sites.

Swallow species used AOP and Corrales bars differently. Cliff, barn and northern rough-winged swallows used AOP bar sites more intensely and consistently than Corrales bar sites (Fig. 24). They not only used AOP bar sites more, they also visited sites in similar proportions (Fig. 24). All three of these species used all Corrales bar sites less than expected, barn swallows most of all. In contrast, bank, tree and violet-green swallows used Corrales bar sites more intensely, but only violet-green swallows used Corrales bar sites with more consistency (Fig. 25). Bank and tree swallows had the lowest intensity and consistency values of any swallow species, and visited sites in similar proportions (Table 2 & Fig. 25). Violet-green swallows, however, differ from bank and tree swallows in that they use sites in different intensity proportions and used five sites more than expected (Fig. 25). Violet-green swallows appear to use some sites very intensely and strongly avoid others (Fig. 25). However, using consistency, there are only two sites (W-OM & R-G) that violet-green swallows appear to use less than expected (Fig. 25).

Table 2. Intensity and consistency visits for all birds by site, listed by common name in taxonomic order. Intensity values are first in cells, with consistency values following in parentheses. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

Common Name	H-U	W-YI	W-YC	W-YM	W-OM	W-D	CW-YM	CW-YD	RO-W	RO-G	CW-N	CW-E	CW-C
mallard				1 (1)	1 (1)								
ring-necked pheasant	1 (1)	4 (4)					1 (1)			1 (1)			
turkey vulture									1 (1)				
sharp-shinned hawk	1 (1)												
cooper's hawk											7 (5)		
killdeer		3 (3)											
mourning dove	2 (1)	8 (5)			1 (1)			2 (1)	5 (3)	1 (1)		4 (4)	2 (2)
black-chinned hummingbird	43 (20)	78 (19)	59 (20)	43 (17)	106 (25)	37 (17)	47 (15)	90 (30)	110 (34)	75 (27)	113 (29)	81 (27)	23 (14)
unidentified hummingbird	3 (2)	4 (4)	8 (3)				2 (1)						
downy woodpecker									2 (2)	2 (2)	1 (1)	4 (2)	15 (9)
hairy woodpecker													2 (2)
northern flicker				1 (1)	1 (1)				3 (2)		1 (1)		2 (2)
western wood-pewee	1 (1)	2 (2)	1 (1)		2 (2)		5 (4)		4 (4)	2 (2)	2 (2)	2 (2)	11 (8)
willow flycatcher			1 (1)		1 (1)	1 (1)			4 (3)	2 (2)			
dusky flycatcher					1 (1)					2 (2)			
ash-throated flycatcher	9 (4)	9 (5)		2 (1)	6 (4)		2 (1)		6 (5)	7 (2)			
western kingbird				1 (1)									
unidentified flycatcher		1 (1)							1 (1)	1 (1)		1 (1)	1 (1)
plumbeous vireo													1 (1)
warbling vireo		1 (1)				1 (1)				1 (1)			2 (2)
american crow													3 (2)
tree swallow	9 (1)		6 (1)	6 (2)	29 (3)		11 (3)	38 (1)	40 (2)	1 (1)	1 (1)		
violet-green swallow	10 (4)	46 (3)	88 (4)	131 (5)	3 (1)	170 (7)	103 (5)	106 (7)	41 (5)	2 (1)	5 (2)		1 (1)
northern rough-winged swallow	212 (6)		5 (2)	14 (2)	229 (8)		44 (6)	20 (2)	2 (1)	160 (3)			
bank swallow	11 (5)		7 (1)	2 (2)	31 (2)	6 (2)	12 (1)	11 (2)	62 (2)	1 (1)			
cliff swallow	528 (11)	74 (5)	105 (4)	308 (12)	717 (9)	2 (1)	253 (9)	110 (6)	159 (4)	368 (4)			
barn swallow	1748 (19)	299 (11)		1236 (13)	1945 (14)	2 (1)	1254 (18)	7 (2)	4 (3)	292 (9)			1 (1)
unidentified swallow	12 (6)	9 (5)	3 (2)	19 (7)	25 (3)	10 (3)	18 (8)	26 (4)	12 (3)	4 (1)	7 (4)		1 (1)
black-capped chickadee	3 (2)						1 (1)		2 (1)	6 (2)	4 (2)		5 (3)
bushtit			4 (1)	4 (2)	3 (1)	36 (4)	23 (4)	3 (1)		12 (3)	30 (3)	11 (2)	
white-breasted nuthatch											13 (10)	9 (7)	10 (6)
bewick's wren	6 (3)			1 (1)					1 (1)		4 (4)	7 (7)	3 (2)

Table 2 cont. Intensity and consistency visits for all birds by site, listed by common name in taxonomic order. Intensity values are first in cells, with consistency values following in parentheses. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

Common Name	H-U	W-YI	W-YC	W-YM	W-OM	W-D	CW-YM	CW-YD	RO-W	RO-G	CW-N	CW-E	CW-C
ruby-crowned kinglet						2 (1)							
blue-gray gnatcatcher						1 (1)							
hermit thrush												1 (1)	
american robin													1 (1)
northern mockingbird									1 (1)				
orange-crowned warbler		1 (1)					6 (2)						
virginia's warbler		1 (1)	1 (1)	2 (2)	1 (1)	1 (1)			1 (1)				
yellow warbler										1 (1)		1 (1)	
yellow-rumped warbler		3 (1)		1 (1)									1 (1)
macgillivray's warbler				1 (1)			1 (1)			2 (1)			
common yellowthroat		8 (4)					5 (3)		9 (9)				
wilson's warbler			3 (1)	3 (3)	3 (2)		2 (1)						
yellow-breasted chat			9 (5)		4 (4)	4 (4)	3 (3)	8 (7)	18 (10)	11 (10)	4 (4)		
unidentified wood-warbler	1 (1)	2 (2)	2 (1)	1 (1)					1 (1)	2 (1)			
summer tanager					1 (1)						1 (1)	6 (6)	4 (3)
western tanager													1 (1)
green-tailed towhee								1 (1)					
spotted towhee	1 (1)	4 (3)	1 (1)	3 (2)	6 (5)	12 (10)	6 (3)	4 (3)	8 (7)	6 (6)	16 (15)	20 (15)	
white-crowned sparrow				1 (1)		1 (1)	3 (2)	1 (1)					
black-headed grosbeak		8 (4)	2 (2)	2 (2)	2 (2)	3 (3)	3 (3)	12 (10)	22 (13)	26 (16)	7 (3)	26 (16)	11 (8)
blue grosbeak	2 (2)	16 (9)	1 (1)	2 (2)	4 (3)	1 (1)	8 (4)	2 (2)	10 (7)	7 (5)		1 (1)	1 (1)
brown-headed cowbird							3 (3)		9 (7)	19 (9)	5 (3)		4 (2)
house finch	3 (2)	2 (1)		2 (1)				1 (1)	3 (2)		3 (1)	2 (2)	1 (1)
lesser goldfinch									1 (1)	1 (1)	5 (4)	1 (1)	
unidentified bird	2 (2)			4 (3)	3 (3)	2 (2)	3 (2)	1 (1)	4 (3)	5 (4)	2 (2)	10 (8)	3 (3)

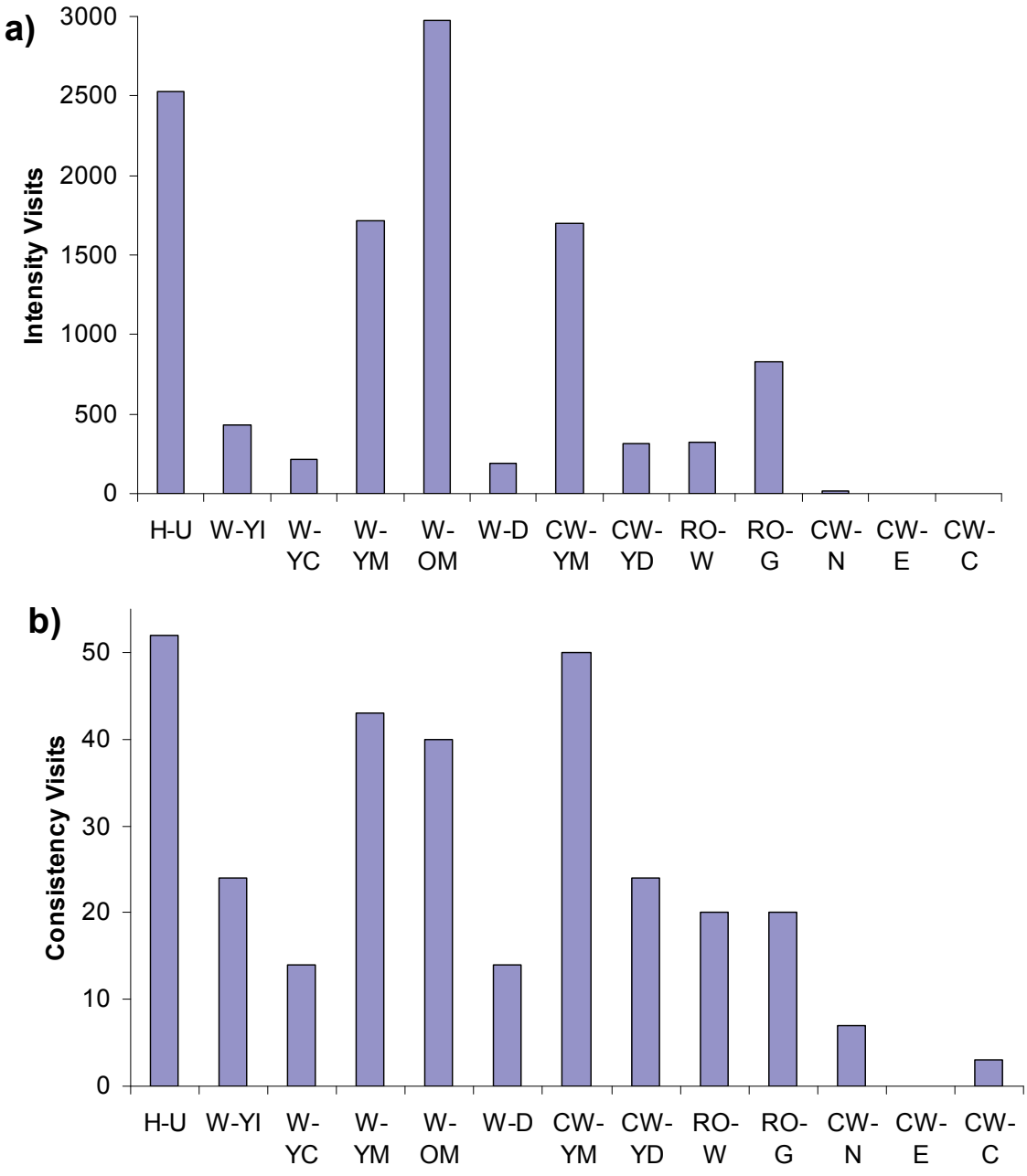


Figure 22. Swallow (Fringillidae) (a) intensity and (b) consistency visits per site. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

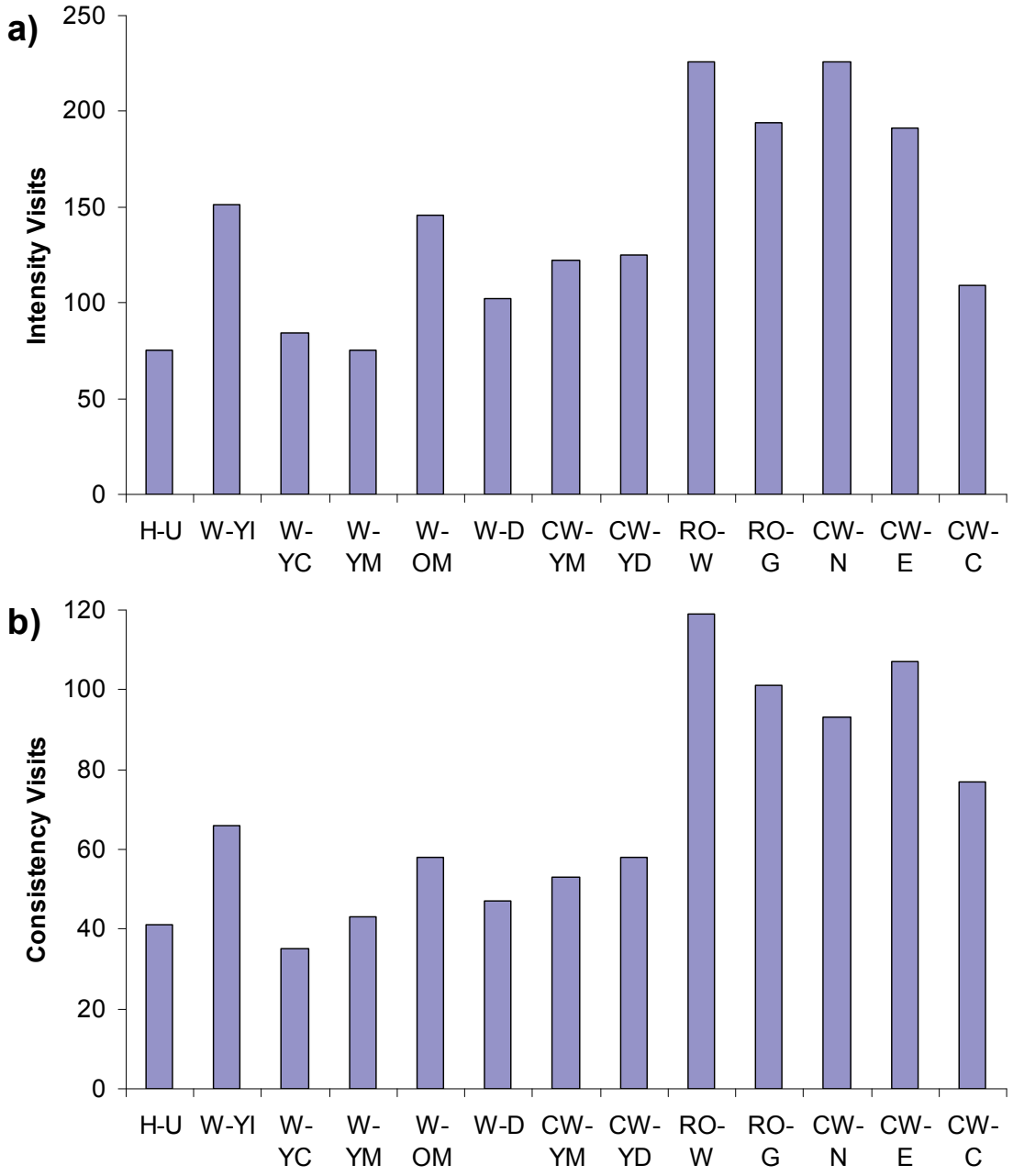


Figure 23. Non-swallow (a) intensity and (b) consistency visits per site. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

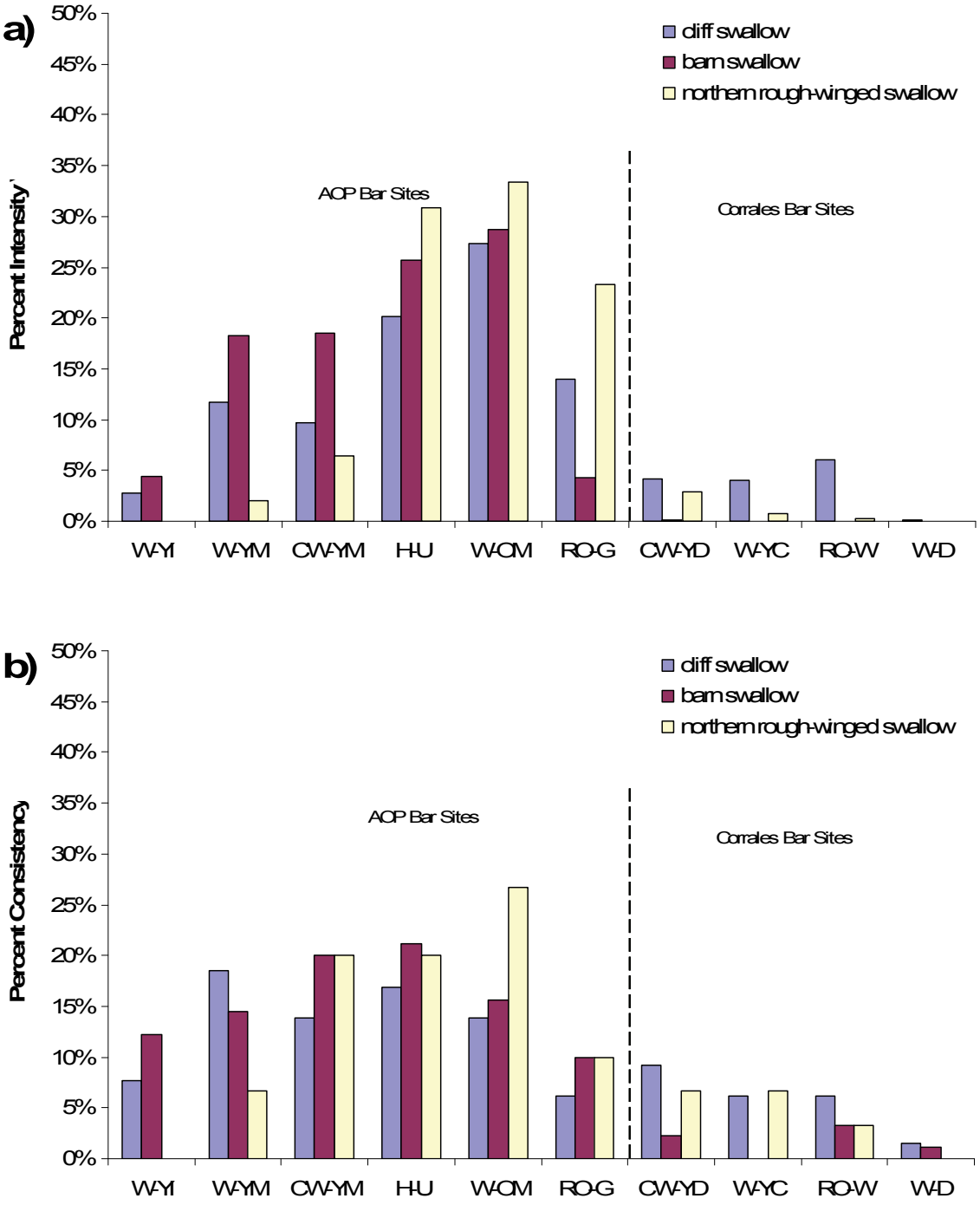


Figure 24. Cliff, barn and northern rough-winged swallow (a) intensity percent use and (b) consistency percent use per site. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

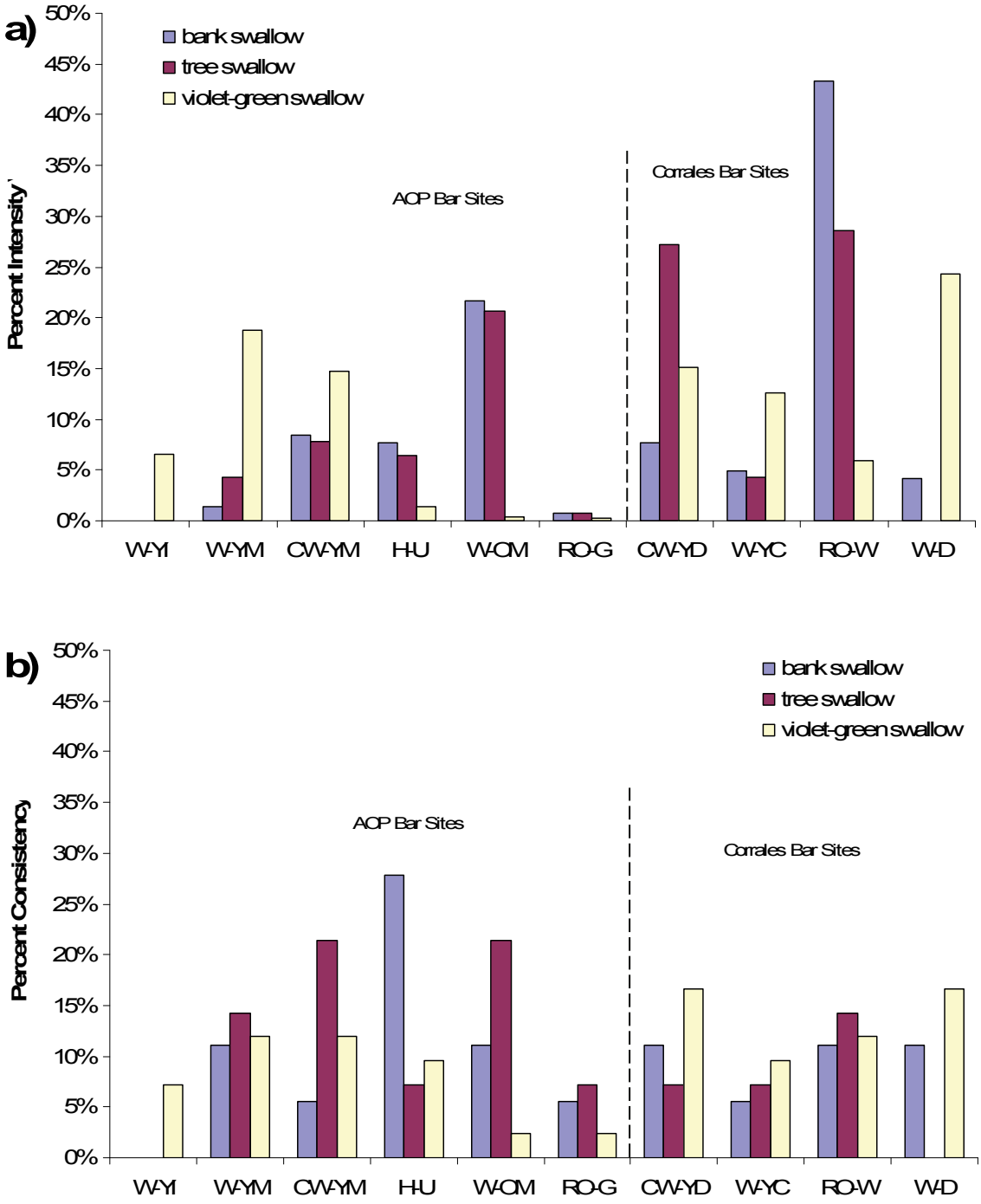


Figure 25. Bank, tree and violet-green swallow (a) intensity percent use and (b) consistency percent use per site. H-U=Herbaceous upper-bar; W-YI=Willow-Young Island; W-YC=Willow-Young Channel; W-YM=Willow-Young Mesic; W-OM=Willow-Old Mesic; W-D=Willow-dry; CW-YM=Cottonwood-Young Mesic; CW-YD=Cottonwood-Young Dry; RO-W=Russian Olive-Willow; RO-G=Russian Olive-Grassy; CW-N=Bosque-Native; CW-E=Bosque-Exotic; CW-C=Bosque-Understory Cleared.

Many species used a mosaic of sites and for those species detected often, the "high structure" sites usually received more visits and "low structure" sites, such as the cleared cottonwood (CW-C), fewer visits (Table 2). Black-chinned hummingbird used all sites but those above the mean number of intensity visits include the mature cottonwood and Russian olive sites (CW-N, CW-E, RO-G, RO-W) together with CW-YD, W-OM, and W-YI. Hummingbird consistency visits mimic the intensity results except for site W-YI, where the number of visits was below the mean and indicates many visits per sampling period. The cleared mature cottonwood site (CW-C) had the lowest intensity and consistency values for black-chinned hummingbirds. Spotted towhee was detected at every site except for CW-C. It was found above the intensity and consistency means at only four sites, CW-N, CW-E, RO-W, and W-D. Bushtit is similar; it was detected at nine of the 13 sites, not found at CW-C, and found above the intensity and consistency means at five sites, CW-N, CW-E, RO-G, CW-YM and W-D. Western wood-pewee is an exception to the pattern displayed above. Detected at 10 of the 13 sites, it was found most at CW-C. Other birds using a mosaic of sites include mourning dove, house finch, common yellowthroat and bewick's wren (Table 2).

Of the 22 species found infrequently in our survey (Table 2), only the mallard, sharp-shinned hawk, American crow, northern mockingbird, yellow warbler, American robin, and western kingbird are likely to nest locally. However, many others are common spring species in the river corridor including turkey vulture, green-tailed towhee, white-crowned sparrow, Wilson's warbler, yellow-rumped warbler (Audubon's), ruby-crowned kinglet, and dusky flycatcher.

Discussion

Insect collection methods

While collecting aerial insects on sticky traps is not considered ideal for examining potential prey base for birds (Durst 2004), we believe they have proved useful for preliminary examination of the insect fauna, particularly when more expensive and time-consuming methods such as malaise traps are not feasible. They were effective for collecting leaf hoppers, and other homopterans along with many flies, but were not consistent across all insect groups. For example, they did not significantly attract mosquitoes (Culicidae) nor do they capture large, strong insects. In addition, birds also came to view the sticky traps as an easy meal, and removed some unknown number of insects. We discovered many sets of insect legs and wings, minus heads, thoraxes and abdomens, with the occasional feather stuck to traps. However, the sticky trap method of monitoring aerial insects was sensitive enough to pick up the effect of the 2005 flood on two of our driest sites (W-D and RO-G), which indicates that it is a useful, if limited, index.

General patterns of vegetation, insect and bird distributions

Our purpose was to initially explore the broad patterns of aerial insect and bird distribution in the context of vegetation structure and composition in the middle Rio Grande. Accordingly, our approach was to sample a wide range of river bar and mature bosque communities without

formal replication and to use relatively simple, cost-effective surveying techniques. While this set limits on the depth of data and its statistical power, our results indicate that there were not only major differences in structure among Middle Rio Grande vegetation communities, but also that aerial insect fauna and bird use varied among habitats, particularly between early successional river bars communities and the mature bosque.

As we have found in previous bar studies (Milford and Muldavin 2004), bar sites support higher plant species richness and species density than the mature bosque (Figs. 15 &16). This is true of both native- and exotic-dominated bars. This is due in part to the generally higher graminoid and forb cover on bars (Fig. 14). However, not all bar sites, nor all mature bosque sites are equal, as the wide variation between our study sites shows. Older, drier bar sites tend to be lower in diversity than younger sites experiencing active succession. Also, native-dominated mature bosque sites appear, from our limited sample, to support greater plant species richness.

In this study we included among our original sites in 2003 a naturally occurring herbaceous wetland (Site W-YI). When we first sampled this site in 2003 it was dominated by wetland herbaceous species, and had high herbaceous cover (Appendix B and Milford et al. 2007). However, over the three years of the study the site rapidly evolved from an herbaceous-dominated wetland to a young native-dominated shrubland (Appendix B). When we attempted to chose a replicate herbaceous wetland site in 2006 we had a similar problem, as a site (W-YC) that had been dominated by herbaceous species in 2005 was dominated by young shrubs in 2006. This seems to indicate that natural herbaceous wetlands within the Rio Grande are highly ephemeral. Thus, to keep natural herbaceous wetlands in the system, conditions conducive to the formation of new wetlands need to be included in restoration and maintenance planning.

A variety of aerial insects are likely to contribute significantly to bird diet. The majority of the insect biomass at most sites came from leaf hoppers, brachycerid flies, non-chalcid wasps, and beetles, which are among the largest of the aerial insects collected. They are also all taxa that are known to be food sources for birds. Members of all four groups have also been shown to be significant components in the diet of Southwestern Willow Flycatchers (Durst 2004). Warblers are insectivores known to take advantage of leafhoppers when available (Yard et al. 2004), which may have contributed to their greater occurrence on native-dominated bar sites where leafhoppers were abundant. Durst (2004) also suggests that smaller taxa may be a resource too small to be exploited by birds, and for this reason did not include thrips (Thysanoptera) in analysis of bird habitat. Similarly, in our case, thrips were present in large numbers at many of our sites, but their contribution to overall biomass was small and they may not be important energetically. Although chalcid wasps and nematocerid files are also small in size, they did occur in large enough numbers at some sites to possibly be a viable food resource for small bird species like hummingbirds.

All swallows require fresh water and productive open areas for foraging. Generally bar sites, particularly the early successional sites with mesic vegetation dominated by willows or young cottonwood, were those that had the highest plant species diversity and the highest insect biomass. Native-dominated bar sites also had a much higher overall number of swallows. Swallows are aerial foragers, gleaning insects produced in the vegetation of the bars and adjacent aquatic habitats. The swallow species found along the middle Rio Grande avoid interior mature

cottonwood and use much of the open bar areas at both AOP and Corrales. The most intense and consistent use occurred at AOP where cliff and barn swallows dominated the foraging flocks. While bank, tree and violet-green swallows used Corrales bar sites more intensely than expected, all swallows except violet green swallows had consistency values highest at AOP bars, although with far less intensity than the dominant swallows at AOP. And while there appear to be species differences in sites used, these differences are likely due to a combination of nesting biology, bar availability, and chance.

Swallows nest in areas separate from foraging areas. Cliff and barn swallows build mud nests using a vertical surface with an overhang, such as that afforded by rock walls. They have adapted well to human structures, particularly buildings and bridges. Northern rough-winged and bank swallows use burrows dug in vertical substrates, such as along streams and arroyos. Violet-green and tree swallows are woodland edge species, typically nesting in tree cavities. Northern rough-winged, violet-green and tree swallows nest as individual pairs or in small colonies. Cliff, barn, and bank swallows nest in colonies.

The nesting biology of each swallow species, the amount of bar habitat near nesting habitat, and chance variation in feeding flock formation are all factors influencing site use by swallows. While bridges and buildings are close to both AOP and Corrales bars, the Rio Grande north of Alameda bridge provides extensive bar habitat whereas between Barelas bridge and Rio Bravo bridge, AOP provides the only significant bar habitat (Milford et al. 2003, Milford et al. 2005). It is not surprising that the AOP bar sites were used with such high intensity and consistency, as it is the sole patch of productive habitat for foraging swallows in that portion of the Rio Grande. The Corrales bar sites are but a small patch among extensive bar habitat. As the feeding flocks dominated by cliff and barn swallows form and move along the river, they would be joined by other species. For AOP bar sites this appears to be northern rough-winged swallows, which are likely nesting nearby.

Given their different nesting biology, it is noteworthy that bank and tree swallows exhibit similar bar use profiles and use AOP and Corrales bar sites in expected proportions. This could be due to chance as both species were found in such low numbers. However, if their nesting areas are distributed evenly along the river and thus, somewhat close to each other, they could form foraging flocks together.

As Corrales bar sites are adjacent to a senescent cottonwood bosque we would have expected both tree and violet-green swallow numbers to be higher at Corrales. However, only violet-green swallows had higher numbers at Corrales bar sites. Habitat requirements are very similar for tree and violet-green swallows and, as a predominantly eastern and northern species, tree swallows are at the edge of their range in New Mexico. Thus, violet-green swallows may have an advantage over tree swallows in the middle Rio Grande and displace them in preferred habitat. Additionally, as both are tree-cavity nesters, they could be negatively impacted by management practices to reduce fuels in the AOP area bosque and by replacement of cottonwood bosque with Russian olive bosque at Corrales.

For non-swallows, Russian olive bar sites and mature bosque sites had higher numbers of birds. This may reflect the greater vertical vegetation structure of those sites, a common driver

of bird abundance (Mosconi and Hutto 1982, Taylor 1986) and species richness (Page et al. 1978, Taylor 1986). Shrub layers may be particularly important, especially to willow flycatchers (Taylor 1986, Sanders and Edge 1998,). However, each species has habitat preferences and birds were found in habitat typical of their species. Some used mostly "high structure" habitat (e.g., black-headed grosbeak) while others used "high structure" habitat together with other habitat (e.g., black-chinned hummingbird, spotted towhee and bushtit). Some used narrower habitat such as mature bosque (e.g., white-breasted nuthatch) or Russian olive-dominated habitat (e.g., brown-headed cowbird and yellow-breasted chat). The only site surrounded by periodically inundated sand flats, W-YI, was used by killdeer. This suggests that greater patch diversity across the entire bosque ecosystem may lead to richer bird biodiversity (Sisk et al. 1997).

Clearing mature cottonwood habitat of a shrub layer did not appear to improve bird habitat. In fact, long-term bosque bird monitoring by Hawks Aloft Inc. has shown mature bosque areas subjected to mechanical removal of all non-native vegetation to support the lowest avian densities and richness (Hawks Aloft Inc. 2009). For non-swallows, cleared mature cottonwood clustered with the sites with the lowest average for both intensity and consistency. Cleared mature cottonwood had low bird use by several species including black-chinned hummingbird and bushtit. In particular. as a ground forager, spotted towhee used all sites except cleared cottonwood. The shrub layer, particularly streamside mesic shrubs, is an important variable for bird abundance in riparian zones (Sanders and Edge 1998). Given their foraging practices, western wood-pewee and white-breasted nuthatch are expected exceptions.

The role of invasive and exotic Russian olive in these riparian ecosystems remains equivocal. Russian olive sites may be significantly heterogeneous with respect to vegetation composition and insect biomass and this may be a factor in enhancing bird diversity. Our Russian olive-dominated sites (either in the overstory or understory) were among those most used by many bird species, including swallows. Willow flycatcher seems to be a habitat specialist within willow-dominated riparian zones (Knopf et al. 1988) and makes use of Russian olive sites with and without willow understory. It does best in native willow habitat where it is more abundant and has greater fat stores than when found in Russian olive habitat (Yong and Finch 1997). It also appears intolerant of changes in vegetation structure (Knopf et al. 1988). Additionally it can experience greater parasitism by brown-headed cowbird in Russian olive habitat than when found in native habitat (Stoleson and Finch 2001), and brown-headed cowbirds were observed with greatest intensity and consistency at both Russian olive sites. The RO-W site in south Corrales stands out as a site with high non-swallow diversity and is one of the Russian olive sites with willow flycatcher, but it also includes, along with the Russian olive overstory, young cottonwoods and abundant coyote willow in the understory, and was a site that, overall, was rich in plant species and in the upper half of arthropod biomass. This suggests two scenarios among others for the role Russian olive-dominated bars within the larger bosque ecosystem: 1) Russian olive is simply replacing other small trees such as Goodding's willow (*Salix gooddingii*) on already historically highly structured and diverse bar habitat types, or 2) Russian olive-invaded sites represent a novel habitat type that presents new opportunities in forging and nesting for bosque birds. This issue needs to be addressed further as restoration activities throughout the Rio Grande Bosque are removing stands of Russian olive that are currently providing bird habitat (Hawks Aloft Inc. 2009).

Restoration can also have a clearly positive impact on insect and bird diversity. For example, the Albuquerque Overbank Project (AOP) restoration site stands out for swallow usage insect biomass, and plant species diversity. The AOP restoration was designed to generate a mosaic of different habitat types that include a young cottonwood stand (CW-YM), young willow stand (W-YM), herbaceous upper-bar (H-U), and young willow island that was formerly an herbaceous wetland (W-YI) all within close proximity of each other and the mature cottonwood bosque. These sites were high in plant diversity, and frequently among the highest in arthropod biomass and bird numbers. This type of patch mosaic can also occur naturally in the reach, e.g., the south Corrales bar sites, which are a mixture of a young cottonwood stand (CW-YD), a young willow stand (W-YC) and a mesic and diverse Russian olive stand (RO-W), all in close proximity. This suggests that small-patch mosaics were likely something that was common within the Rio Grande Bosque of the past and something that can be achieved by modern restoration activities to generate highly desirable bird habitat as well as diverse plant and insect communities (see Muldavin et al. 2004).

Temporal constraints and future work

This study was conducted over a very limited time frame and, hence, the detection of trends was limited. While insect number and biomass were variable across years, there appeared to be a seasonal pattern of peak biomass in the spring/early summer, followed by decreasing biomass into the fall that was consistent across most sites. This pattern correlates with expected bird breeding periods and possibly with spring migration. In addition to the annual pattern of insect abundance, there was also a general decline across the sample years. Whether this decline was specific to these sites, or is indicative of ongoing bosque-wide change in condition needs further study.

While we had only one year of bird data, our initial results suggest that bird populations within the bosque partition the habitat to some degree by dominant vegetation, and definitely make significant use of the bars, both native- and exotic-dominated. Accordingly, additional and more comprehensive surveys of bird populations with replication on river bars and adjacent forests will likely provide additional insight on how these different habitats are being used by the avifauna and further test the significance of small-patch habitat heterogeneity in maintaining the biodiversity of the Rio Grande Bosque.

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Appendix A – Plant Species List

Species Name	Common Name	NHNM Acronym	Origin
Trees			
Ailanthus altissima	tree of heaven	AILALT	Introduced
Elaeagnus angustifolia	Russian olive	ELAANG	Introduced
Fraxinus velutina	velvet ash	FRAVEL	Native
Morus alba	white mulberry	MORALB	Introduced
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	POPDELW	Native
Salix amygdaloides	peachleaf willow	SALAMY	Native
Salix gooddingii	Goodding's willow	SALGOO	Native
Ulmus pumila	Siberian elm	ULMPUM	Introduced
Shrubs			
Amorpha fruticosa	desert false indigo	AMOFRU	Native
Baccharis salicifolia	seepwillow	BACSAL	Native
Clematis ligusticifolia	western white clematis	CLELIG	Native
Forestiera pubescens var. pubescens	New Mexico olive	FORPUBP	Native
Opuntia imbricata	tree cholla	OPUIMB	Native
Parthenocissus vitacea	woodbine	PARVIT	Native
Ribes aureum	golden currant	RIBAUR	Native
Salix exigua	coyote willow	SALEXI	Native
Tamarix ramosissima	saltcedar	TAMRAM	Introduced
Sub-Shrubs			
Desmanthus illinoensis	prairie bundleflower	DESILL	Native
Gutierrezia sarothrae	broom snakeweed	GUTSAR	Native
Opuntia phaeacantha	tulip pricklypear	OPUPHA	Native
Graminoids			
Agrostis gigantea	redtop	AGRGIG	Introduced
Agrostis spp.	bentgrass	AGROST	
Bolboschoenus maritimus ssp. paludosus	saltmarsh bulrush	BOLMARP	Native
Bothriochloa laguroides ssp. torreyana	silver beardgrass	BOTLAGT	Native
Bouteloua barbata	sixweeks grama	BOUBAR	Native
Bouteloua curtipendula	sideoats grama	BOUCUR	Native
Bromus carinatus	California brome	BROCAR	Native
Bromus catharticus	rescuegrass	BROCAT	Introduced
Bromus japonicus	Japanese brome	BROJAP	Introduced
Bromus spp.	brome	BROMUS	
Bromus tectorum	cheatgrass	BROTEC	Introduced
Carex emoryi	Emory's sedge	CAREMO	Native
Carex praegracilis	clustered field sedge	CARPRA	Native
Carex spp.	sedge	CAREX	
Cenchrus spinifex	sandbur	CENSPI	Native
Chloris verticillata	tumble windmill grass	CHLVER	Native
Cynodon dactylon	bermudagrass	CYNDAC	Introduced

Species Name	Common Name	NHNM Acronym	Origin
Graminoids Cont.			
Cyperus niger	black flatsedge	CYPNIG	Native
Cyperus odoratus	fragrant flatsedge	CYPODO	Native
Cyperus spp.	flatsedge	CYPERU	
Cyperus squarrosus	bearded flatsedge	CYPSQU	Native
Digitaria sanguinalis	hairy crabgrass	DIGSAN	Native
Distichlis spicata	inland saltgrass	DISSPI	Native
Echinochloa crus-galli	barnyardgrass	ECHCRU	Introduced
Eleocharis palustris	common spikerush	ELEPAL	Native
Elymus canadensis	Canada wildrye	ELYCAN	Native
Elymus elymoides	bottlebrush squirreltail	ELYELY	Native
Elymus x pseudorepens	false quackgrass	ELYPSE	Native
Eragrostis pectinacea	tufted lovegrass	ERAPEC	Native
Festuca arundinacea	tall fescue	FESARU	Introduced
Hordeum jubatum	foxtail barley	HORJUB	Native
Hordeum murinum ssp. glaucum	smooth barley	HORMURG	Introduced
Hordeum spp.	barley	HORDEU	
Juncus arcticus var. balticus	Baltic rush	JUNARCB	Native
Juncus torreyi	Torrey's rush	JUNTOR	Native
Leersia oryzoides	rice cutgrass	LEEORY	Native
Leptochloa fusca ssp. fascicularis	bearded sprangletop	LEPFUSF	Native
Muhlenbergia asperifolia	alkali muhly	MUHASP	Native
Panicum capillare	witchgrass	PANCAP	Native
Panicum obtusum	vine mesquite	PANOBT	Native
Panicum spp.	panicgrass	PANICU	
Pascopyrum smithii	western wheatgrass	PASSMI	Native
Paspalum distichum	knotgrass	PASDIS	Native
Poa pratensis	Kentucky bluegrass	POAPRA	Native
Poa spp.	bluegrass	POA	
Polypogon monspeliensis	annual rabbitsfoot grass	POLMON	Introduced
Saccharum ravennae	ravennagrass	SACRAV	Introduced
Schoenoplectus pungens	common threesquare	SCHPUN	Native
Schoenoplectus tabernaemontani	softstem bulrush	SCHTAB	Native
Setaria pumila	yellow bristlegrass	SETPUM	Introduced
Sorghastrum nutans	Indiangrass	SORNUT	Native
Sorghum halepense	johnsongrass	SORHAL	Introduced
Sphenopholis obtusata	prairie wedgescale	SPHOBT	Native
Sporobolus airoides	alkali sacaton	SPOAIR	Native
Sporobolus compositus var. compositus	tall dropseed	SPOCOMC	Native
Sporobolus contractus	spike dropseed	SPOCON	Native
Sporobolus cryptandrus	sand dropseed	SPOCRY	Native
Forbs			
Ambrosia acanthicarpa	flatspine burr ragweed	AMBACA	Native
Ambrosia psilostachya	Cuman ragweed	AMBPSI	Native
Aphanostephus ramosissimus	plains dozedaisy	APHRAM	Native
Apocynum cannabinum	Indianhemp	APOCAN	Native
Asclepias speciosa	showy milkweed	ASCSPE	Native

Species Name	Common Name	NHNM Acronym	Origin
Forbs Cont.			
Asclepias subverticillata	whorled milkweed	ASCSUB	Native
Asparagus officinalis	garden asparagus	ASPOFF	Introduced
Bahia spp.	bahia	BAHIA	
Bidens cernua	nodding beggarstick	BIDCER	Introduced
Bidens frondosa	devil's beggartick	BIDFRO	Native
Chamaesyce serpyllifolia	thymeleaf sandmat	CHASER2	Native
Chamaesyce serrula	sawtooth sandmat	CHASER3	Native
Chamaesyce spp.	sandmat	CHAMAE2	
Chenopodium incanum	mealy goosefoot	CHEINC	Native
Chenopodium leptophyllum	narrowleaf goosefoot	CHELEP	Native
Chenopodium spp.	goosefoot	CHENOP	
Convolvulus arvensis	field bindweed	CONARV	Introduced
Conyza canadensis	Canadian horseweed	CONCAN	Native
Dalea leporina	foxtail prairieclover	DALLEP	Native
Descurainia spp.	tansymustard	DESCUR	
Dimorphocarpa wislizeni	spectacle pod	DIMWIS	Native
Epilobium spp.	willowherb	EPILOB	
Equisetum laevigatum	smooth horsetail	EQULAE	Native
Erigeron divergens	spreading fleabane	ERIDIV	Native
Erigeron flagellaris	trailing fleabane	ERIFLA	Native
Erigeron spp.	fleabane	ERIGER	
Erodium cicutarium	redstem stork's bill	EROCIC	Introduced
Euthamia occidentalis	western goldenrod	EUTOCC	Native
Gaura parviflora	velvetweed	GAUPAR	Native
Glycyrrhiza lepidota	American licorice	GLYLEP	Native
Grindelia nuda var. nuda	curlytop gumweed	GRINUDN	Native
Helianthus annuus	common sunflower	HELANN	Native
Helianthus petiolaris	prairie sunflower	HELPET	Native
Heterotheca villosa	hairy goldenaster	HETVIL	Native
Kallstroemia parviflora	warty caltrop	KALPAR	Native
Kochia scoparia	common kochia	KOCSCO	Introduced
Lactuca serriola	prickly lettuce	LACSER	Introduced
Lactuca tatarica var. pulchella	blue lettuce	LACTATP	Native
Lycopus americanus	American bugleweed	LYCAME	Native
Machaeranthera canescens ssp. glabra	hoary tansyaster	MACCANG	Native
Machaeranthera pinnatifida	lacy tansyaster	MACPIN	Native
Medicago sativa	alfalfa	MEDSAT	Introduced
Melilotus officinalis	yellow sweetclover	MELOFF	Introduced
Mentha arvensis	wild mint	MENARV	Native
Oenothera elata ssp. hirsutissima	Hooker's eveningprimrose	OENELAH	Native
Oxalis spp.	woodsorrel	OXALIS	
Physalis spp.	groundcherry	PHYSAL	
Plantago major	common plantain	PLAMAJ	Introduced
Polygonum lapathifolium	curlytop knotweed	POLLAP	Native
Polygonum persicaria	Lady's thumb	POLPER	Introduced
Polygonum ramosissimum	knotweed	POLRAM	Native

Species Name	Common Name	NHNM Acronym	Origin
Forbs Cont.			
Polygonum spp.	knotweed	POLYGO	
Portulaca oleracea	common purslane	POROLE	Native
Portulaca spp.	hogweed	PORTUL	
Pseudognaphalium stramineum	cottonbatting cudweed	PSESTR	Native
Ranunculus cymbalaria	alkali buttercup	RANCYM	Native
Ratibida tagetes	green prairie coneflower	RATTAG	Native
Rumex crispus	curly dock	RUMCRI	Introduced
Rumex pulcher	fiddle dock	RUMPUL	Introduced
Rumex spp.	dock	RUMEX	
Salsola tragus	prickly Russian thistle	SALTRA	Introduced
Senecio flaccidus var. flaccidus	threadleaf ragwort	SENFLAF	Native
Senecio riddellii	Riddell's ragwort	SENRID	Native
Sisymbrium altissimum	tall tumblemustard	SISALT	Introduced
Solanum elaeagnifolium	silverleaf nightshade	SOLELA	Native
Solanum spp.	nightshade	SOLANU	
Solidago canadensis	Canada goldenrod	SOLCAN	Native
Sonchus asper	spiny sowthistle	SONASP	Introduced
Sphaeralcea incana	gray globemallow	SPHINC	Native
Symphyotrichum ericoides	heath aster	SYMERI	Native
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	SYMLANH	Native
Taraxacum officinale	common dandelion	TAROFF	Introduced
Teucrium canadense var. occidentale	western germander	TEUCANO	Native
Thelesperma megapotamicum	Hopi tea greenthread	THEMEG	Native
Typha angustifolia	narrowleaf cattail	TYPANG	Native
Typha domingensis	southern cattail	TYPDOM	Native
Typha latifolia	broadleaf cattail	TYPLAT	Native
Verbascum thapsus	common mullein	VERTHA	Introduced
Verbena bracteata	bigbract verbena	VERBRA	Native
Veronica anagallis-aquatica	water speedwell	VERANA	Native
Xanthium strumarium	rough cocklebur	XANSTR	Native

Appendix B

Individual site floristic summary tables, ordered by vegetation type as presented in the figures within the report.

Herbaceous Upper-bar (H-U) PlotID 03AP004

Scientific Name	Common Name	Origin	2004	2005
Trees				
Elaeagnus angustifolia	Russian olive	I	5.14	6.71
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	0.03	1.63
Salix gooddingii	Goodding's willow	N		0.14
Ulmus pumila	Siberian elm	I	2.80	2.43
Shrubs				
Baccharis salicifolia	seepwillow	N		0.03
Salix exigua	coyote willow	N	7.00	7.09
Graminoids				
Agrostis gigantea	redtop	I	0.29	
Bromus japonicus	Japanese brome	I	0.03	0.06
Bromus tectorum	cheatgrass	I		0.06
Carex emoryi	Emory's sedge	N	0.60	0.20
Cynodon dactylon	bermudagrass	I	3.66	4.86
Cyperus odoratus	fragrant flatsedge	N		0.43
Distichlis spicata	inland saltgrass	N	17.23	25.74
Echinochloa crus-galli	barnyardgrass	I		0.20
Elymus canadensis	Canada wildrye	N	0.49	0.43
Elymus x pseudorepens	false quackgrass	N	0.51	0.09
Eragrostis pectinacea	tufted lovegrass	N		0.11
Muhlenbergia asperifolia	alkali muhly	N	15.77	23.97
Panicum capillare	witchgrass	N		0.06
Panicum obtusum	vine mesquite	N	5.09	7.43
Pascopyrum smithii	western wheatgrass	N		1.17
Paspalum distichum	knotgrass	N		0.04
Schoenoplectus pungens	common threesquare	N	0.17	0.27
Sorghastrum nutans	Indiangrass	N	1.00	
Sorghum halepense	johnsongrass	I	9.03	4.00
Sporobolus airoides	alkali sacaton	N	0.29	
Sporobolus compositus var. compositus	tall dropseed	N	2.31	0.01
Sporobolus cryptandrus	sand dropseed	N	0.69	0.09
unidentified graminoid	unidentified graminoid		0.14	

Herbaceous Upper-bar (H-U) PlotID 03AP004 cont.

Scientific Name	Common Name	Origin	2004	2005
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	2.74	0.57
Asclepias speciosa	showy milkweed	N	0.10	
Asclepias subverticillata	whorled milkweed	N		0.00
Bidens frondosa	devil's beggartick	N		0.29
Convolvulus arvensis	field bindweed	I	4.77	0.21
Conyza canadensis	Canadian horseweed	N	0.00	0.16
Equisetum laevigatum	smooth horsetail	N	0.03	0.05
Euthamia occidentalis	western goldenrod	N	0.80	0.97
Gaura parviflora	velvetweed	N	0.03	0.53
Glycyrrhiza lepidota	American licorice	N	1.14	2.57
Helianthus annuus	common sunflower	N	6.89	2.29
Helianthus petiolaris	prairie sunflower	N	0.05	
Kochia scoparia	common kochia	I	8.01	1.74
Lactuca serriola	prickly lettuce	I		0.03
Lactuca tatarica var. pulchella	blue lettuce	N	0.06	
Machaeranthera canescens ssp. glabra	hoary tansyaster	N	1.14	0.29
Melilotus officinalis	yellow sweetclover	I	1.63	
Polygonum persicaria	Lady's thumb	I		0.14
Ratibida tagetes	green prairie coneflower	N	0.09	0.01
Salsola tragus	prickly Russian thistle	I	17.60	0.20
Symphyotrichum ericoides	heath aster	N	1.83	
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	0.14	0.23
Teucrium canadense var. occidentale	western germander	N	0.06	0.03

Young Willow Island (W-YI) (Formerly Herbaceous Wetland) PlotID 03AP001

Scientific Name	Common Name	Origin	2003	2004	2005
Trees					
Ailanthus altissima	tree of heaven	I		0.01	
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	7.90	3.64	7.25
Salix amygdaloides	peachleaf willow	N			2.97
Salix gooddingii	Goodding's willow	N	2.30	0.83	3.05
Ulmus pumila	Siberian elm	I	0.05		
Shrubs					
Salix exigua	coyote willow	N	0.40	1.98	15.09
Salix spp.	willow			1.08	
Tamarix ramosissima	saltcedar	I	0.01	0.38	0.05
Graminoids					
Agrostis gigantea	redtop	I	9.30	0.38	
Agrostis spp.	bentgrass			0.01	
Bolboschoenus maritimus ssp. paludosus	saltmarsh bulrush	N			0.71
Carex emoryi	Emory's sedge	N	0.10		0.91
Carex spp.	sedge			0.68	
Cynodon dactylon	bermudagrass	I			0.09
Cyperaceae family	sedge family		0.30	0.15	
Cyperus niger	black flatsedge	N		0.00	
Cyperus odoratus	fragrant flatsedge	N		3.38	0.03
Cyperus spp.	flatsedge			0.32	
Cyperus squarrosus	bearded flatsedge	N		0.05	
Echinochloa crus-galli	barnyardgrass	I	1.20	17.88	1.65
Eleocharis palustris	common spikerush	N	39.00	4.28	
Eragrostis pectinacea	tufted lovegrass	N		6.56	4.81
Hordeum jubatum	foxtail barley	N	0.05		
Hordeum murinum ssp. glaucum	smooth barley	I	0.60	0.00	
Juncus torreyi	Torrey's rush	N	1.32	0.00	
Leersia oryzoides	rice cutgrass	N	38.30	37.21	4.86
Leptochloa fusca ssp. fascicularis	bearded sprangletop	N		1.83	0.06
Muhlenbergia asperifolia	alkali muhly	N	0.90	0.03	
Panicum capillare	witchgrass	N		4.03	0.93
Panicum obtusum	vine mesquite	N		0.01	0.03
Panicum spp.	panicgrass			0.41	
Paspalum distichum	knotgrass	N	1.80	2.74	1.06
Polypogon monspeliensis	annual rabbitsfoot grass	I	4.65		
Schoenoplectus pungens	common threesquare	N	1.15	2.59	0.59
Schoenoplectus tabernaemontani	softstem bulrush	N	0.60	0.44	
Sporobolus cryptandrus	sand dropseed	N		0.04	0.06
Forbs					
Ambrosia psilostachya	Cuman ragweed	N		0.03	
Bidens cernua	nodding beggarstick	I	1.30	0.06	0.10
Bidens frondosa	devil's beggartick	N	42.70	2.31	0.52
Chamaesyce serpyllifolia	thymeleaf sandmat	N		0.62	0.25
Chenopodiaceae family	goosefoot family			0.01	
Convolvulus arvensis	field bindweed	I		0.03	
Conyza canadensis	Canadian horseweed	N	0.40	0.01	
Epilobium spp.	willowherb		0.01		
Euthamia occidentalis	western goldenrod	N	8.10	10.71	1.08
Kochia scoparia	common kochia	I			0.00

Young Willow Island (W-YI) (Formerly Herbaceous Wetland) PlotID 03AP001 cont.

Scientific Name	Common Name	Origin	2003	2004	2005
Forbs cont.					
Lactuca tatarica var. pulchella	blue lettuce	N	0.05		
Lycopus americanus	American bugleweed	N	0.01	0.02	
Medicago sativa	alfalfa	I		0.06	
Melilotus officinalis	yellow sweetclover	I	5.55	0.06	
Mentha arvensis	wild mint	N			0.02
Plantago major	common plantain	I		0.04	
Polygonum persicaria	Lady's thumb	I		0.43	0.06
Polygonum spp.	knotweed		0.40		
Pseudognaphalium stramineum	cottonbatting cudweed	N		0.01	0.08
Ranunculus cymbalaria	alkali buttercup	N	0.40		
Rumex pulcher	fiddle dock	I	0.30		
Rumex spp.	dock			0.03	
Sonchus asper	spiny sowthistle	I			0.02
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N		0.38	0.03
Typha angustifolia	narrowleaf cattail	N			3.62
Typha domingensis	southern cattail	N	4.10	4.06	
Typha latifolia	broadleaf cattail	N			0.30
unidentified forb	unidentified forb		0.28	0.02	0.06
Veronica anagallis-aquatica	water speedwell	N	3.10		
Xanthium strumarium	rough cocklebur	N	2.20	4.85	11.36

Young Willow Channel (W-YC) (Formerly Herbaceous Wetland) PlotID 06RB019

Scientific Name	Common Name	Origin	2006
Trees			
Elaeagnus angustifolia - mature	Russian olive	I	0.09
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	7.69
Salix amygdaloides	peachleaf willow	N	0.15
Salix gooddingii	Goodding's willow	N	1.83
Ulmus pumila - adv regen	Siberian elm	I	0.17
Shrubs			
Baccharis salicifolia	seepwillow	N	0.09
Salix exigua	coyote willow	N	20.59
Tamarix ramosissima	saltcedar	I	0.06
Sub-Shrubs			
Gutierrezia sarothrae	broom snakeweed	N	0.04
Graminoids			
Bromus catharticus	rescuegrass	I	0.00
Bromus tectorum	cheatgrass	I	0.00
Elymus elymoides	bottlebrush squirreltail	N	0.03
Elymus x pseudorepens	false quackgrass	N	0.01
Paspalum distichum	knotgrass	N	3.53
Schoenoplectus pungens	common threesquare	N	0.04
Sphenopholis obtusata	prairie wedgescale	N	0.06
Sporobolus cryptandrus	sand dropseed	N	0.30
unidentified graminoid	unidentified graminoid		0.00
Forbs			
Aphanostephus ramosissimus	plains dozedaisy	N	0.01
Chamaesyce spp.	sandmat		0.00
Conyza canadensis	Canadian horseweed	N	0.36
Equisetum laevigatum	smooth horsetail	N	0.09
Euthamia occidentalis	western goldenrod	N	4.44
Grindelia nuda var. nuda	curlytop gumweed	N	0.06
Machaeranthera pinnatifida	lacy tansyaster	N	0.00
Typha latifolia	broadleaf cattail	N	0.63
unidentified forb	unidentified forb		0.00
Xanthium strumarium	rough cocklebur	N	0.15

Willow Young Mesic (W-YM) PlotID 03AP002

Scientific Name	Common Name	Origin	2004	2005
Trees				
Morus alba	white mulberry	I	0.06	0.09
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	9.60	14.69
Salix gooddingii	Goodding's willow	N	0.29	0.14
Ulmus pumila	Siberian elm	I	0.43	0.23
Shrubs				
Salix exigua	coyote willow	N	24.86	48.09
Tamarix ramosissima	saltcedar	I	0.31	0.13
Graminoids				
Bolboschoenus maritimus ssp. paludosus	saltmarsh bulrush	N		0.12
Bromus carinatus	California brome	N	0.23	
Carex emoryi	Emory's sedge	N	3.00	4.97
Cynodon dactylon	bermudagrass	I	4.46	2.20
Cyperus odoratus	fragrant flatsedge	N		0.12
Distichlis spicata	inland saltgrass	N	6.17	4.46
Echinochloa crus-galli	barnyardgrass	I	0.20	2.01
Eleocharis palustris	common spikerush	N		0.03
Elymus canadensis	Canada wildrye	N	0.51	0.57
Elymus elymoides	bottlebrush squirreltail	N	0.77	
Festuca arundinacea	tall fescue	I		0.17
Hordeum murinum ssp. glaucum	smooth barley	I	1.43	0.06
Leptochloa fusca ssp. fascicularis	bearded sprangletop	N		1.29
Muhlenbergia asperifolia	alkali muhly	N	0.69	
Panicum capillare	witchgrass	N	0.09	0.50
Panicum obtusum	vine mesquite	N	2.09	0.37
Paspalum distichum	knotgrass	N	0.03	1.63
Schoenoplectus pungens	common threesquare	N	0.03	0.06
Sorghastrum nutans	Indiangrass	N	0.51	
Sorghum halepense	johnsongrass	I	1.14	0.67
Sporobolus compositus var. compositus	tall dropseed	N	0.79	
Sporobolus cryptandrus	sand dropseed	N		0.00
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	3.74	0.02
Apocynum cannabinum	Indianhemp	N	2.80	7.06
Bidens frondosa	devil's beggartick	N		0.21
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.05	0.21
Convolvulus arvensis	field bindweed	I	0.01	0.01
Conyza canadensis	Canadian horseweed	N	4.37	0.39
Equisetum laevigatum	smooth horsetail	N	0.12	0.28
Euthamia occidentalis	western goldenrod	N	2.29	5.97
Gaura parviflora	velvetweed	N		0.06
Grindelia nuda var. nuda	curlytop gumweed	N	0.86	
Helianthus annuus	common sunflower	N	7.46	0.01
Helianthus petiolaris	prairie sunflower	N	1.72	0.00
Lactuca serriola	prickly lettuce	I	2.41	
Melilotus officinalis	yellow sweetclover	I	23.14	0.30
Polygonum persicaria	Lady's thumb	I		0.03
Salsola tragus	prickly Russian thistle	I	3.90	0.06
Solanum elaeagnifolium	silverleaf nightshade	N	0.89	0.02
Symphyotrichum ericoides	heath aster	N	0.29	
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	0.31	0.23
Teucrium canadense var. occidentale	western germander	N		2.16
unidentified forb	unidentified forb		1.94	
Xanthium strumarium	rough cocklebur	N	1.29	4.49

Willow Old Mesic (W-OM) PlotID 98RB009

Scientific Name	Common Name	Origin	2004	2005
Trees				
Elaeagnus angustifolia	Russian olive	I	9.29	10.43
Morus alba	white mulberry	I	0.40	1.60
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	6.37	9.61
Salix gooddingii	Goodding's willow	N	0.44	0.40
Ulmus pumila	Siberian elm	I	1.43	1.57
Shrubs				
Salix exigua	coyote willow	N	32.31	47.61
Graminoids				
Agrostis gigantea	redtop	I	0.67	0.29
Agrostis spp.	bentgrass		0.04	
Carex emoryi	Emory's sedge	N	5.81	25.66
Carex praegracilis	clustered field sedge	N	3.26	
Cynodon dactylon	bermudagrass	I		0.16
Distichlis spicata	inland saltgrass	N		0.01
Elymus canadensis	Canada wildrye	N	2.09	0.09
Elymus elymoides	bottlebrush squirreltail	N	0.29	
Elymus x pseudorepens	false quackgrass	N	0.20	
Hordeum spp.	barley		0.03	
Juncus arcticus var. balticus	Baltic rush	N	0.13	0.14
Leptochloa fusca ssp. fascicularis	bearded sprangletop	N		0.91
Muhlenbergia asperifolia	alkali muhly	N	1.14	0.06
Panicum capillare	witchgrass	N		0.03
Schoenoplectus pungens	common threesquare	N		0.00
Sorghastrum nutans	Indiangrass	N	44.71	2.17
unidentified graminoid	unidentified graminoid		3.09	
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	7.50	0.46
Apocynum cannabinum	Indianhemp	N	1.81	3.59
Asclepias speciosa	showy milkweed	N	0.79	2.53
Asclepias subverticillata	whorled milkweed	N	0.09	0.11
Convolvulus arvensis	field bindweed	I	0.90	1.56
Dalea leporina	foxtail prairieclover	N		0.04
Equisetum laevigatum	smooth horsetail	N	0.12	0.57
Euthamia occidentalis	western goldenrod	N	1.93	1.37
Gaura parviflora	velvetweed	N		0.06
Helianthus annuus	common sunflower	N		0.07
Helianthus petiolaris	prairie sunflower	N	0.20	
Lactuca tatarica var. pulchella	blue lettuce	N	0.39	0.09
Lycopus americanus	American bugleweed	N	0.07	0.03
Melilotus officinalis	yellow sweetclover	I	2.69	
Mentha arvensis	wild mint	N	0.00	
Rumex crispus	curly dock	I		0.04
Senecio riddellii	Riddell's ragwort	N	0.09	
Symphyotrichum ericoides	heath aster	N	0.92	
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	5.51	2.36
Taraxacum officinale	common dandelion	I	0.21	
unidentified forb	unidentified forb		0.14	
Xanthium strumarium	rough cocklebur	N		0.11

Willow Dry (W-D) PlotID 98RB002

Scientific Name	Common Name	Origin	2004	2005
Trees				
Ulmus pumila	Siberian elm	I	3.72	5.17
Shrubs				
Opuntia imbricata	tree cholla	N	0.03	0.03
Salix exigua	coyote willow	N	44.03	48.31
Tamarix ramosissima	saltcedar	I	6.23	5.30
Sub-Shrubs				
Gutierrezia sarothrae	broom snakeweed	N	0.01	0.03
Opuntia phaeacantha	tulip pricklypear	N		0.00
Graminoids				
Bromus japonicus	Japanese brome	I		0.00
Elymus canadensis	Canada wildrye	N	0.03	0.01
Elymus x pseudorepens	false quackgrass	N	0.00	
Muhlenbergia asperifolia	alkali muhly	N	0.00	
Panicum obtusum	vine mesquite	N	0.27	0.07
Sporobolus airoides	alkali sacaton	N	0.30	0.11
Sporobolus cryptandrus	sand dropseed	N	0.07	0.06
unidentified graminoid	unidentified graminoid		0.00	
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	0.49	0.29
Chamaesyce serpyllifolia	thymeleaf sandmat	N	1.57	0.02
Chenopodium incanum	mealy goosefoot	N		0.00
Chenopodium leptophyllum	narrowleaf goosefoot	N		0.00
Conyza canadensis	Canadian horseweed	N	0.64	6.46
Dimorphocarpa wislizeni	spectacle pod	N	0.03	
Erigeron divergens	spreading fleabane	N		0.67
Erigeron spp.	fleabane		0.01	
Euthamia occidentalis	western goldenrod	N	0.09	
Lactuca serriola	prickly lettuce	I		0.03
Machaeranthera canescens ssp. glabra	hoary tansyaster	N		0.01
Melilotus officinalis	yellow sweetclover	I	7.22	20.06
Portulaca spp.	hogweed		0.00	
Senecio flaccidus var. flaccidus	threadleaf ragwort	N		0.03
Senecio riddellii	Riddell's ragwort	N	0.14	
Solanum spp.	nightshade		0.06	
Thelesperma megapotamicum	Hopi tea greenthread	N	0.03	
unidentified forb	unidentified forb		0.02	0.03
Xanthium strumarium	rough cocklebur	N	0.11	

Young Cottonwood Mesic (CW-YM) PlotID 03AP003

Scientific Name	Common Name	Origin	2004	2005
Trees				
Elaeagnus angustifolia	Russian olive	I	2.29	5.00
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	21.83	30.57
Salix gooddingii	Goodding's willow	N	0.14	
Ulmus pumila	Siberian elm	I	0.01	0.31
Shrubs				
Baccharis salicifolia	seepwillow	N	6.75	8.20
Salix exigua	coyote willow	N	2.05	4.53
Tamarix ramosissima	saltcedar	I	0.43	0.43
Tamarix ramosissima - seedling	saltcedar	I	0.03	
Sub-Shrubs				
Gutierrezia sarothrae	broom snakeweed	N	0.20	
Graminoids				
Agrostis gigantea	redtop	I	0.14	0.49
Bolboschoenus maritimus ssp. paludosus	saltmarsh bulrush	N		1.95
Bouteloua curtipendula	sideoats grama	N	0.03	
Bromus japonicus	Japanese brome	I	4.37	
Bromus spp.	brome		0.01	
Carex emoryi	Emory's sedge	N	0.21	0.64
Cenchrus spinifex	sandbur	N		0.03
Cynodon dactylon	bermudagrass	I	0.09	0.47
Cyperus odoratus	fragrant flatsedge	N	0.01	1.19
Cyperus squarrosus	bearded flatsedge	N		1.89
Digitaria sanguinalis	hairy crabgrass	N	0.07	0.00
Distichlis spicata	inland saltgrass	N	0.59	1.54
Echinochloa crus-galli	barnyardgrass	I	0.06	0.65
Elymus canadensis	Canada wildrye	N	2.86	0.50
Elymus elymoides	bottlebrush squirreltail	N	0.04	
Elymus x pseudorepens	false quackgrass	N	0.07	0.06
Eragrostis pectinacea	tufted lovegrass	N		0.36
Festuca arundinacea	tall fescue	I	1.83	1.46
Hordeum jubatum	foxtail barley	N		0.09
Hordeum murinum ssp. glaucum	smooth barley	I	0.46	
Hordeum spp.	barley			0.03
Juncus torreyi	Torrey's rush	N		0.00
Leptochloa fusca ssp. fascicularis	bearded sprangletop	N	0.11	
Muhlenbergia asperifolia	alkali muhly	N	17.89	5.19
Panicum capillare	witchgrass	N	0.10	1.55
Panicum obtusum	vine mesquite	N	0.13	0.54
Paspalum distichum	knotgrass	N		0.31
Poa pratensis	Kentucky bluegrass	N		0.01
Poa spp.	bluegrass		0.26	
Saccharum ravennae	ravennagrass	I	0.03	0.11
Schoenoplectus pungens	common threesquare	N	0.03	0.49
Sorghastrum nutans	Indiangrass	N	1.97	0.35
Sorghum halepense	johnsongrass	I	0.57	1.69
Sporobolus airoides	alkali sacaton	N	0.57	0.51
Sporobolus compositus var. compositus	tall dropseed	N	3.11	0.29
Sporobolus cryptandrus	sand dropseed	N	3.23	0.26
unidentified graminoid	unidentified graminoid		0.04	

Young Cottonwood Mesic (CW-YM) PlotID 03AP003 cont.

Scientific Name	Common Name	Origin	2004	2005
Forbs				
Ambrosia acanthicarpa	flatspine burr ragweed	N	0.01	
Ambrosia psilostachya	Cuman ragweed	N	2.64	0.11
Apocynum cannabinum	Indianhemp	N	0.06	0.19
Asclepias speciosa	showy milkweed	N	0.11	0.40
Asparagus officinalis	garden asparagus	I	0.03	0.06
Bidens frondosa	devil's beggartick	N		0.03
Chamaesyce serpyllifolia	thymeleaf sandmat	N	0.69	1.24
Convolvulus arvensis	field bindweed	I	0.06	
Conyza canadensis	Canadian horseweed	N	0.99	0.05
Equisetum laevigatum	smooth horsetail	N	0.93	2.96
Erigeron flagellaris	trailing fleabane	N	0.07	
Euthamia occidentalis	western goldenrod	N	5.36	9.92
Gaura parviflora	velvetweed	N		0.12
Grindelia nuda var. nuda	curlytop gumweed	N	0.43	
Helianthus annuus	common sunflower	N	0.71	0.14
Helianthus petiolaris	prairie sunflower	N	0.02	
Heterotheca villosa	hairy goldenaster	N	0.03	
Lactuca serriola	prickly lettuce	I	0.04	
Lactuca tatarica var. pulchella	blue lettuce	N	0.00	
Machaeranthera canescens ssp. glabra	hoary tansyaster	N	0.14	
Melilotus officinalis	yellow sweetclover	I	4.17	0.11
Oenothera elata ssp. hirsutissima	Hooker's eveningprimrose	N	0.19	
Polygonum lapathifolium	curlytop knotweed	N		0.00
Polygonum spp.	knotweed		0.09	
Salsola tragus	prickly Russian thistle	I	0.00	
Solidago canadensis	Canada goldenrod	N	2.26	0.03
Symphyotrichum ericoides	heath aster	N	0.51	
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	0.09	0.23
Thelesperma megapotamicum	Hopi tea greenthread	N	0.06	
Verbascum thapsus	common mullein	I	0.00	
Verbena bracteata	bigbract verbena	N		0.01
Xanthium strumarium	rough cocklebur	N	2.36	3.00

Young Cottonwood Dry (CW-YD) PlotID 06RB020

Scientific Name	Common Name	Origin	2006
Trees			
Elaeagnus angustifolia	Russian olive	I	2.86
Elaeagnus angustifolia - adv regen	Russian olive	I	0.14
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	19.03
Salix gooddingii	Goodding's willow	N	0.69
Ulmus pumila	Siberian elm	I	0.01
Shrubs			
Baccharis salicifolia	seepwillow	N	0.40
Salix exigua	coyote willow	N	32.60
Tamarix ramosissima	saltcedar	I	0.96
Graminoids			
Agrostis gigantea	redtop	I	0.06
Bromus japonicus	Japanese brome	I	0.01
Elymus canadensis	Canada wildrye	N	0.01
Elymus x pseudorepens	false quackgrass	N	0.00
Juncus arcticus var. balticus	Baltic rush	N	0.01
Muhlenbergia asperifolia	alkali muhly	N	6.16
Panicum obtusum	vine mesquite	N	0.00
Saccharum ravennae	ravennagrass	I	0.20
Sporobolus airoides	alkali sacaton	N	1.49
Sporobolus cryptandrus	sand dropseed	N	0.17
Forbs			
Ambrosia psilostachya	Cuman ragweed	N	0.00
Conyza canadensis	Canadian horseweed	N	0.21
Equisetum laevigatum	smooth horsetail	N	3.35
Euthamia occidentalis	western goldenrod	N	1.45
Grindelia nuda var. nuda	curlytop gumweed	N	0.01
Oenothera elata ssp. hirsutissima	Hooker's eveningprimrose	N	0.09
Pseudognaphalium stramineum	cottonbatting cudweed	N	0.00
Solidago canadensis	Canada goldenrod	N	0.83
Symphyotrichum ericoides	heath aster	N	0.39
unidentified forb	unidentified forb		0.01
Xanthium strumarium	rough cocklebur	N	0.00

Russian Olive Willow (RO-W) PlotID 06RB021

Scientific Name	Common Name	Origin	2006
Trees			
Elaeagnus angustifolia	Russian olive	I	35.77
Fraxinus velutina	velvet ash	N	1.43
Morus alba - young regen	white mulberry	I	0.09
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	10.00
Salix gooddingii	Goodding's willow	N	1.49
Ulmus pumila	Siberian elm	I	0.17
Shrubs			
Amorpha fruticosa	desert indigobush	N	0.06
Baccharis salicifolia	seepwillow	N	3.77
Forestiera pubescens var. pubescens	New Mexico olive	N	0.00
Salix exigua	coyote willow	N	42.63
Tamarix ramosissima	saltcedar	I	1.06
Graminoids			
Agrostis gigantea	redtop	I	6.03
Bromus japonicus	Japanese brome	I	0.01
Echinochloa crus-galli	barnyardgrass	I	0.03
Elymus canadensis	Canada wildrye	N	0.36
Festuca arundinacea	tall fescue	I	1.41
Juncus arcticus var. balticus	Baltic rush	N	0.17
Muhlenbergia asperifolia	alkali muhly	N	1.77
Panicum obtusum	vine mesquite	N	0.34
Paspalum distichum	knotgrass	N	0.03
Poa pratensis	Kentucky bluegrass	N	0.63
Saccharum ravennae	ravennagrass	I	0.06
Schoenoplectus pungens	common threesquare	N	0.14
Sporobolus airoides	alkali sacaton	N	0.06
unidentified graminoid	unidentified graminoid		0.00
Forbs			
Ambrosia psilostachya	Cuman ragweed	N	0.01
Apocynum cannabinum	Indianhemp	N	0.00
Asclepias subverticillata	whorled milkweed	N	0.03
Conyza canadensis	Canadian horseweed	N	0.00
Equisetum laevigatum	smooth horsetail	N	2.73
Euthamia occidentalis	western goldenrod	N	3.33
Oenothera elata ssp. hirsutissima	Hooker's eveningprimrose	N	0.00
Oxalis spp.	woodsorrel		0.00
Solidago canadensis	Canada goldenrod	N	0.67
Symphyotrichum ericoides	heath aster	N	0.37
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	0.33

Russian Olive Grassy (RO-G) PlotID 98RB008

Scientific Name	Common Name	Origin	2004	2005
Trees				
Elaeagnus angustifolia	Russian olive	I	59.97	57.57
Morus alba	white mulberry	I	4.57	2.86
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N		0.57
Ulmus pumila	Siberian elm	I	1.57	6.00
Shrubs				
Salix exigua	coyote willow	N	8.17	9.89
Graminoids				
Cynodon dactylon	bermudagrass	I	46.91	65.54
Distichlis spicata	inland saltgrass	N	1.57	
Elymus canadensis	Canada wildrye	N	2.20	6.50
Leptochloa fusca ssp. fascicularis	bearded sprangletop	N		0.01
Muhlenbergia asperifolia	alkali muhly	N	11.40	5.34
Sporobolus airoides	alkali sacaton	N	1.59	0.57
Sporobolus compositus var. compositus	tall dropseed	N	5.14	2.37
unidentified graminoid	unidentified graminoid		0.09	
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	8.91	5.77
Apocynum cannabinum	Indianhemp	N	0.37	0.09
Convolvulus arvensis	field bindweed	I	0.17	0.06
Conyza canadensis	Canadian horseweed	N	0.06	0.42
Equisetum laevigatum	smooth horsetail	N	0.24	0.12
Helianthus annuus	common sunflower	N	0.77	3.30
Helianthus petiolaris	prairie sunflower	N	0.01	
Lactuca serriola	prickly lettuce	I	0.03	0.91
Lactuca tatarica var. pulchella	blue lettuce	N	0.26	1.79
Machaeranthera canescens ssp. glabra	hoary tansyaster	N		0.14
Melilotus officinalis	yellow sweetclover	I	0.15	1.02
Salsola tragus	prickly Russian thistle	I	0.24	0.14
Symphyotrichum ericoides	heath aster	N	8.17	17.23
Symphyotrichum lanceolatum ssp. hesperium	white panicle aster	N	0.03	

Mature Cottonwood Native (CW-N) PlotID 99RB013

Scientific Name	Common Name	Origin	2004	2005
Trees				
Elaeagnus angustifolia	Russian olive	I	0.15	0.15
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	72.69	73.14
Salix gooddingii	Goodding's willow	N	8.77	8.86
Ulmus pumila	Siberian elm	I	0.02	0.01
Ulmus pumila - seedling	Siberian elm	I	0.01	
Shrubs				
Amorpha fruticosa	desert indigobush	N	0.29	0.43
Baccharis salicifolia	seepwillow	N	0.06	
Clematis ligusticifolia	western white clematis	N	3.69	4.34
Forestiera pubescens	New Mexico olive	N		1.14
Forestiera pubescens var. pubescens	New Mexico olive	N	17.16	17.14
Tamarix ramosissima	saltcedar	I	4.00	3.87
Graminoids				
Distichlis spicata	inland saltgrass	N	3.97	1.52
Elymus canadensis	Canada wildrye	N	0.29	1.03
Elymus x pseudorepens	false quackgrass	N	0.00	0.04
Hordeum jubatum	foxtail barley	N		0.03
Muhlenbergia asperifolia	alkali muhly	N	16.99	21.49
Sporobolus airoides	alkali sacaton	N	1.20	1.71
Sporobolus cryptandrus	sand dropseed	N		0.03
Forbs				
Ambrosia psilostachya	Cuman ragweed	N	1.14	4.02
Conyza canadensis	Canadian horseweed	N	0.03	1.00
Helianthus annuus	common sunflower	N		0.03
Lactuca serriola	prickly lettuce	I		0.03
Machaeranthera canescens ssp. glabra	hoary tansyaster	N	0.80	3.37
Melilotus officinalis	yellow sweetclover	I	0.00	
Salsola tragus	prickly Russian thistle	I	0.15	
Symphyotrichum ericoides	heath aster	N	0.03	

Mature Cottonwood Exotic (CW-E) PlotID 99RB017

Scientific Name	Common Name	Origin	2004	2005
Trees				
Ailanthus altissima	tree of heaven	I	10.29	15.20
Elaeagnus angustifolia	Russian olive	I	32.71	35.54
Morus alba	white mulberry	I		3.43
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	64.00	70.29
Salix amygdaloides	peachleaf willow	N		2.29
Ulmus pumila	Siberian elm	I	15.77	18.97
Ulmus pumila - seedling	Siberian elm	I	0.00	
Shrubs				
Amorpha fruticosa	desert indigobush	N	0.71	0.09
Parthenocissus vitacea	thicket creeper	N	6.09	10.43
Tamarix ramosissima	saltcedar	I	2.37	2.37
Forbs				
Convolvulus arvensis	field bindweed	I	1.44	1.36
Conyza canadensis	Canadian horseweed	N	0.01	
Machaeranthera canescens ssp. glabra	hoary tansyaster	N		0.03
Melilotus officinalis	yellow sweetclover	I	0.34	0.80

Mature Cottonwood Cleared (CW-C) PlotID 06RB022

Scientific Name	Common Name	Origin	2006
Trees			
Elaeagnus angustifolia - yng regen	Russian olive	I	1.88
Morus alba	white mulberry	I	2.50
Populus deltoides ssp. wislizeni	Rio Grande cottonwood	N	81.25
Ulmus pumila - seedling	Siberian elm	I	0.02
Forbs			
Machaeranthera canescens ssp. glabra	hoary tansyaster	N	0.03
Salsola tragus	prickly Russian thistle	I	0.00
unidentified forb	unidentified forb		0.00

Appendix C

List of all arthropod taxa identified with total number of individuals counted by taxa. Listed by Order and Family, with Sub-Order, Infraorder, Section, and Superfamily included, where relevant.

			2003	2004	2005	2006
Arachnida						
Acari			**24**	**26**	**2**	**1**
Araneae			**48**	**68**	**143**	**85**
Pseudoscorpiones			**2**			**1**
Diplopoda						**2**
Insecta						
Coleoptera			**47**	**1061**	**964**	**1672**
		Anthicidae			3	5
		Carabidae		4	3	
		Chrysomelidae	19	11	24	24
		Cleridae		234	415	496
		Coccinellidae	6	37	27	15
		Cryptophagidae		5		3
		Curculionidae	2	17	7	3
		Elateridae		1	4	3
		Staphylinidae	2	69	30	9
		Tenebrionidae	4			
	Tenebrionoidea					
		Melandryidae	1	271	261	718
Polyphaga						
		Chrysomelidae		2		9
	Cantharoidea					
		Lampyridae		3		
	Hydrophiloidea					
		Scirtidae		1		
	Tenebrionoidea					
		Mordellidae		222	73	83
Unidentified Coleoptera			13	184	117	304
Collembola			**7**	**741**	**170**	**5**

Family	2003	2004	2005	2006
Insecta cont.				
Diptera	**2684**	**6925**	**5453**	**5758**
Brachycera	15	1908	1804	2440
Asilomorpha				
Asiloidea				
Asilidae			5	2
Therevidae		6		
Bombylioidea				
Acroceridae		4		2
Empidoidea				
Dolichopodidae		10	3	138
Empididae		32	25	
Muscomorpha		13		
Acalyptratae		41		
Conopoidea				
Conopidae		13	62	65
Ephydroidea				
Chloropidae		15	50	389
Lauxanioidea				
Chamaemyiidae			5	
Lauxaniidae		2995	904	927
Neriodea				
Micropezidae			2	1
Sciomyzoidea				
Sepsidae			1	
Tephritoidea				
Otitidae	2	16	6	
Tephritidae		64	80	6
Aschiza				
Platypezoidea				
Phoridae		194	398	313
Syrphoidea				
Pipunculidae		8	13	24
Syrphidae			28	2
Calyptratae		54	1	
Oestroidea				
Calliphoridae		5	8	68
Sarcophagidae			305	41
Tachinidae	479	389	436	66
Tabanomorpha				
Stratiomyoidea				
Xylomyidae		4		
Tabanoidea				
Tabanidae		3	10	13

Family	2003	2004	2005	2006
Insecta cont.				
Diptera cont.				
Nematocera	1924	975	582	1199
Bibionomorpha				
Bibionoidea				
Bibionidae			57	2
Sciaroidea				
Cecidomyiidae		3	10	8
Mycetophilidae		5		4
Sciaridae		118	425	47
Culicomorpha				
Chirnomoidea				
Chirnomidae			4	
Culicomorpha				
Culicidae			2	
Psychodomorpha				
Psychodomorpha				
Psychodidae			222	
Scatopsoidea				
Scatopsidae		16		
Tipulomorpha				
Tipuloidea				
Tipulidae	1			1
Unidentified Diptera	263	34	5	
Ephemeroptera	**1**	**1**	**11**	**11**
Hemiptera	**107**	**191**	**339**	**645**
Cimicomorpha				
Reduviidae		1		
Tingidae		2		
Pentatomomorpha				
Lygaeidae		1	60	
Pentatomidae			1	
Unidentified Hemiptera	107	187	278	645
Homoptera	**3851**	**2538**	**2418**	**5423**
Auchenorrhyncha				
Cicadoidea				
Cicadellidae	3417	1893	1767	3669
Fulgoroidea		7		
Cixiidae				1

Family	2003	2004	2005	2006
Insecta cont.				
Homoptera cont.				
Sternorrhyncha				
Aleyrodoidea				
Aleyrodidae		72	409	30
Aphidoidea				
Aphididae	434	490	168	828
Psylloidea				
Psyllidae		69	73	881
Unidentified Homoptera		7	1	14
Hymenoptera	**3566**	**4447**	**2883**	**7315**
Apocrita				
Formicidae	53	105	37	138
Chalcidoidea	3266	3732	2492	5218
Cynipoidea	1			
Figitidae		100	4	
Evanioidea				
Gasteruptiidae				1
Ichneumonoidea	30	36	11	1
Braconidae		2		
Pompiloidea				
Pompilidae		1		
Sphecoidea	43	8	8	
Sphecidae	2	30	1	
Tiphioidea		46		
Tiphiidae				
Vespoidea	4	10		
Unidentified Hymenoptera	167	377	330	1957
Isoptera	**0**	**0**	**1**	**0**
Lepidoptera	**37**	**12**	**17**	**8**
Ditrysia				
Noctuoidea				
Noctuidae	31		1	
Papilionoidea				
Nymphalidae		1		
Pieridae	1	3	3	1
Unidentified Lepidoptera	5	8	13	7

	Family	2003	2004	2005	2006
Insecta cont.					
Neuroptera		**2**	**6**	**25**	**15**
Planipennia					
	Hemerobioidea				
	Chrysopidae			23	
Unidentified Neuroptera		2	6	2	15
Orthoptera		**0**	**3**	**3**	**5**
	Gryllidae				1
Caelifera					
	Acrididae				2
Unidentified Orthoptera			3	3	2
Plecoptera		**1**	**0**	**0**	**0**
Polyxenida		**0**	**0**	**1**	**0**
	Polyxenidae			1	
Psocoptera		**1**	**15**	**0**	**4**
Psocomorpha					
	Psocidae		1		
Unidentified Psocoptera		1	14		4
Thysanoptera		**1000**	**5915**	**2674**	**16671**
Trichoptera		**0**	**61**	**76**	**85**
Annulipalpia					
	Hydroptilidae			65	
Unidentified Trichoptera			61	11	85
Unidentified Insecta		**708**	**95**	**144**	**6**