WALNUT CREEK CENTER FOR EDUCATION AND RESEARCH
(WCCER)
BIOLOGICAL INVENTORY

Preface

The Walnut Creek Center for Education and Research (WCCER) is located within the western portion of the Prescott National Forest, Chino Ranger District. Emplaced 40 miles northwest of Prescott in Yavapai County, this sector of the District includes the Santa Maria and Juniper Mountains, adjacent valleys and foothills, and Chino Valley to the east. No major highways or large population centers occur in the area at this time. Regional topography is commonly extreme and ranges from 4,070 feet at the bottom of Smith Canyon to 7,270 feet at Hyde Mountain.

WCCER is located within the lower floodplain of Walnut Creek that is a major headwater of the Verde River. Both Walnut Creek (Juniper Mountains drainage) and Apache Creek (Santa Maria Mountains drainage) converge on the site. Stream flows are mostly perennial (intermittent during extended droughts) with greatest surface flows usually occurring during the winter-spring months and summer monsoons.

Zones of Riparian Deciduous Forest, Grassland, Interior Chaparral, and Juniper-Pinyon communities occur within the Center. A well developed Cottonwood-Willow gallery forest and Scrub Willow community occurs adjacent to the active channel. Patches of Arizona Walnut with an understory of diverse grasses stretch across the more level floodplain proper. The unique riparian forest appears to be a relict community, particularly the Walnut association, and reflects a contraction of a more widespread distribution during the past. Extensive second growth Junipers and Pinyons cover the northern foothills and mosaics of Interior Chaparral-Juniper-Pinyon occupy the more rugged rocky southern hills.

Due to the diversity of available habitats, food resources, and moisture, the WCCER site promotes a diversity of resident, seasonal, and visiting wildlife species. Many obligate and facultative vertebrate and invertebrate species benefit directly or indirectly on riparian microclimates and macroclimates for food, cover, and reproduction.

The Center is chartered and managed by the Walnut Creek Education and Research Partnership. This unique union of educational and research institutions is comprised of Yavapai College, Prescott College, Northern Arizona University, and Sharlot Hall Museum. The site is leased from the Prescott National Forest, Chino District, under a special use permit. Presently, the infrastructure consists of three main buildings and four outbuildings: a house, a barn, and a pump-house. The house and barn, with attached corral, are listed on the National Historic Register. A water storage tank north of the house provides adequate water. The existing septic system can accommodate 40 people. Six sites with electrical, water, and septic hook-ups are also available for future use.

The Partnership intends to employ WCCER as a natural rural base to offer hands-on educational experiences to a variety of students and the public in areas such as riparian ecology, field biology, geology, and cultural history. The site also offers limitless research opportunities. In addition, the Partnership seeks to develop a working relationship with neighbors and land managers (three ranching families and the Forest Service).

The purpose of this study was to carry out a two-year ecological study of the 280-acre Walnut Creek Center site. The study was designed to collect baseline information and to assist in the establishment and management of the site. Briefly, physical components of stream geomorphology, topography, and soils were investigated, plant collections were accomplished, and ecological studies of vegetation, amphibians, reptiles, birds, and mammals were performed.

Acknowledgements

Special recognition is due to the wealth of individuals who participated in this collaborative effort, many of which, labored long hours in the field and often in adverse weather conditions.

- *Principal investigator:* Ken Abbott (fauna, manuscript, and liaison)
- *Co-principal investigator*: Eric Glomski (flora and geomorphology)
- *Flora and geomorphology :* Paul Sneed, Michael Byrd, Jeff Hogue, Romie Haberle, Marc Baker
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Introduction

In riparian ecosystems hydrological processes, such as runoff, drive geomorphic processes that form surface features in stream corridors. A *lateral view* or cross section of a stream corridor usually reveals three dynamic and interrelated geomorphic elements: stream channel (active and bankful), floodplain (floodprone), and transitional upland fringe (terraces). The *longitudinal view or profile*, on the other hand, describes the stream corridor's gradient and channel pattern (sinuosity). Both stream corridor cross-sections (with associated pebble counts) and profiles (omitting a quantification of sinuosity) were measured at the Walnut Creek Center for Education and Research (WCCER) in order to provide a baseline for the landforms created by the fluvial system. These forms have causal relationships with the composition and distribution of riparian vegetation in the area, and thus are formative in all aspects of the riparian ecosystem (including fauna).

Methods

Within the site, there are approximately 0.65 river miles along Walnut Creek and 0.15 river miles along Apache Creek with at least three distinct geomorphic reaches. One permanent cross section was established in each of these reaches, one of which crosses Walnut Creek, pivots, and then crosses Apache Creek (Fig. 1).

Data collection procedures for measuring cross-section, identifying bankful and floodprone, features and for assessing bed and bank material size followed methods described in "Stream Channel Reference Sites: An Illustrated Guide to Field Technique", General Technical Report RM-245, Harrelson et al. (1994). Measurements in these procedures were taken with a transit and leveling rod. Timing of sampling roughly coordinated with spring and summer flooding (occurring just after these events).

Channel profiles were calculated from the top of each stream to its end within the site. The start points for both Apache and Walnut were their upstream fencelines. Apache's end point was its confluence with Walnut. Walnut's end point was the downstream fenceline. Profiles were measured with hand level, tape, and rod. Individual measurements were taken from top of riffle to top-off riffle, successively downstream.

Cross sections were marked with wooden stakes at measurement start and end points. A GPS coordinate also was taken for these points (Table 1). Geomorphic photo points were shot upstream and downstream for the bankful and floodprone, shooting through the cross section in the middle of the photo (Table 3. and GM#1 – GM# 3). A GPS coordinate was not taken for these photos, as the unit would not lock on in this area.

Pebble counts follow the described methods, with one exception. The pebble size classes (Table 2) were simplified so that there was only one measurement class, each, for the gravels. Cross section, profile, and pebble count data were graphed using Microsoft Excel software.

The Lateral View

Three permanent geomorphic lateral transects were established to describe "coarse resolution" valley-wide (terraces, floodplain, and stream channel) cross sections (Fig. 1 – location and Fig. 2 - data). In addition, within or very near each valley transect, "fine resolution" stream channel (bankful and floodprone) cross sections were measured (Fig. 1 – location and Fig. 3 - data). These two sets of cross sections are described separately.

Valley-Wide Cross Sections

Although the graphs are vertically exaggerated (Fig. 2), all three valley cross sections clearly illustrate relatively wide, inactive floodplain terraces punctuated by deeply incised, active stream channels. Further, while the valley floor terraces are not currently active floodplains, there is evidence, especially on the right (southeastern) side of cross section #2 (Fig. 2), of older, abandoned stream channels located at a much higher elevation (9 to 10 feet) than the current active channel. Interestingly, as seen in cross section #3, Walnut Creek, above its confluence with Apache Creek displays slightly less severe and channelized down-cutting than further downstream. Down-cutting of Walnut and Apache Creeks may have begun in the late 19th century, coincident with a well-documented southwestern down-cutting event. However, there is oral history evidence that deep incision of the creek reaches on WCCER may have occurred following collapse, in the late 1970s, of a weir dam located several miles downstream. More historical and paleoecological research is needed to determine the cause and timing of down-cutting in the Walnut Creek and Apache Creek floodplains.

Bankful and Floodprone Cross Sections

The bankful stage is described, as the water flow required to create and maintain a natural stream channel. Although the geomorphic features created by the bankful stage can be difficult to identify in the field, the existence of natural, low "levees" can be indicators. For example, cross section #1 (Fig. 3) manifests a narrow, relatively flat floodprone "terrace" on the left bank giving way to a relatively steep drop to the stream thalweg, followed by a relatively steep rise to a narrow "levee" of fine sediments which transitions to a relatively wide, flat floodprone "terrace" on the right bank. However, because severe down-cutting has created steep, highly eroded banks in some places, it is sometimes difficult to identify one edge of bankful (e.g., the left bank of Walnut Creek in cross section #2 or the right bank of Apache Creek in cross section # 3, Fig. 3). Floodprone is usually described as the leveled width at twice the depth of bankful stage, but floodprone geomorphic features are usually very difficult to identify in the cross sections or possibly do not coincide with this statistical figure. Nevertheless, in these transects, the right edge of floodprone stage can often be identified as a point where the cross section changes from a relatively flat surface to a relatively steep incline (around 125 feet in cross section #1 and about 100 feet in cross section #2, Fig. 3).

Pebble counts on the four fine resolution cross sections were fairly uniform, which is expected for such a small research area (Fig. 1 – location and Fig. 4 - data). Cross Section #1, on Walnut Creek, primarily consisted of Small Gravel, also with a fair amount

of Sand, Large Gravel and Cobbles. Sand often was deposited amongst the larger materials, particularly in the floodprone zone. Cross Section #2, on Walnut Creek, had almost identical channel materials, with slightly higher organic content (due to a series of debris piles/log jams in the area). Both of these cross sections are located downstream from Apache Creek (which certainly affects the flow rates and the delivery of materials to these reaches). Cross Section #3, on Walnut Creek, had reduced levels of gravel, and much higher levels of Sand and Cobble. There are many variables that are likely affecting this change. Clear-cutting immediately upstream on Walnut may be contributing fine sediments to the system, differences in gradient between these reaches (with Cross Section #3 having the lowest gradient) may be playing a role here, and the road located just above Cross Section #3 also may be contributing additional fine sediments during runoff events. It is suggested that in the future, the exact points of the cross sections be indicated on the profile graph for cross-referencing.

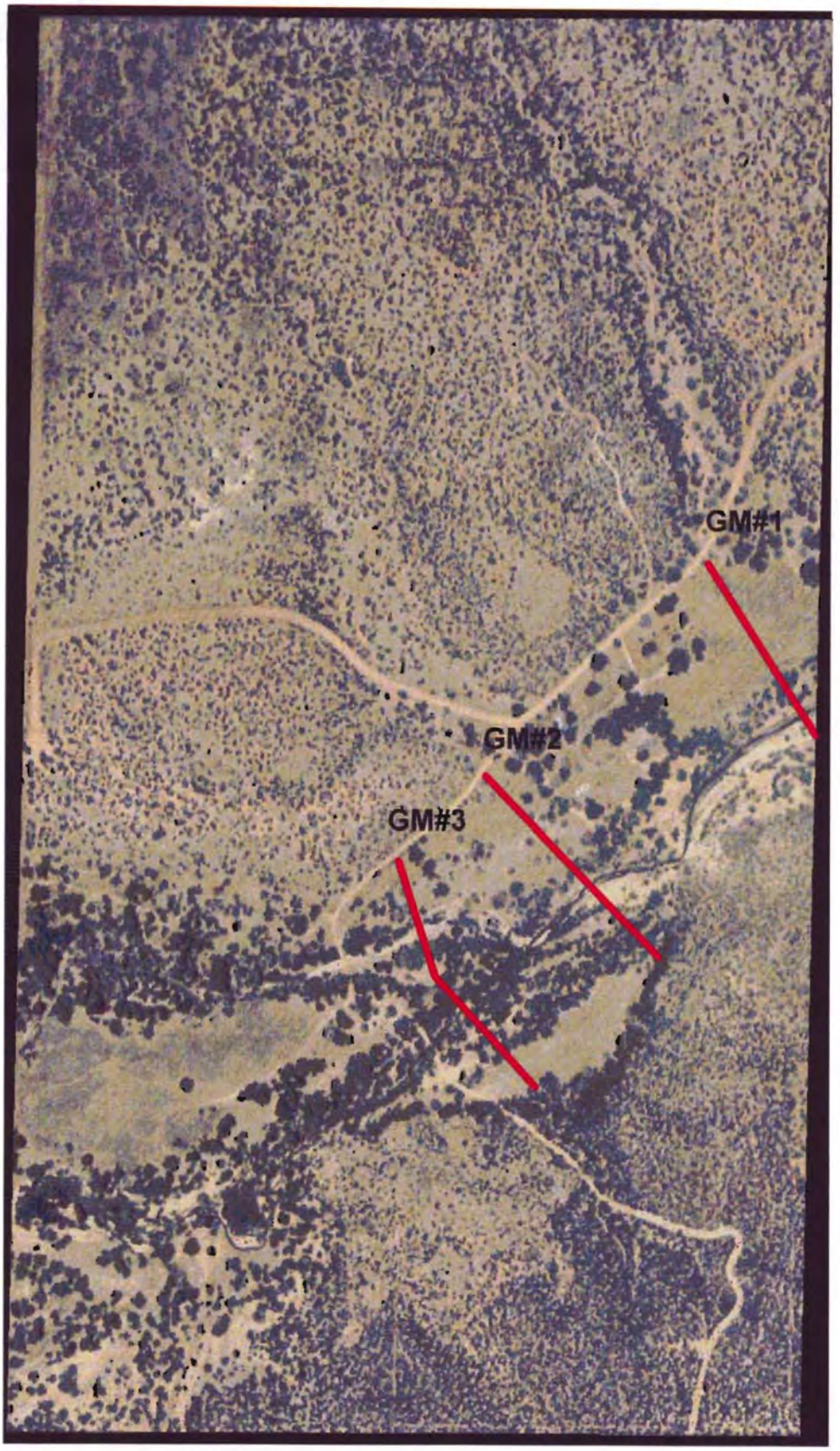
The Longitudinal View

Longitudinal profiles or gradients were surveyed along the reaches of Walnut Creek and Apache Creek located within the boundaries of WCCER (Fig. 5). The gradient along the Walnut Creek reach was relatively low and consistent, ranging between about 0.5% and 2.0% with an average of around 0.8%. The Apache Creek reach was a bit steeper with an average gradient of 1.1% and displayed greater extremes ranging from 0% to around 3.0% (note, these extremes in gradient occur at around 150 feet along the longitudinal transect where a road and weir form a man-made "pool and drop" feature). Just above the upper start point on Apache creek, the gradient appears to increase a great deal as it rapidly moves into the adjoining mountains. Overall, these generally low gradients, exhibited by the longitudinal profiles, are consistent with the stream channel patterns (i.e., moderately meandering active channels located in a relatively flat, wide, older floodplain valley).

Future Research

Both ends of each valley-wide cross section and each bankful-floodprone cross section were staked with permanent markers to facilitate monitoring of future changes in the Walnut Creek-Apache Creek stream corridor. Since it is unlikely that the valley-wide cross sections will change rapidly or radically, they will need to be re-surveyed for monitoring purposes on average of once every 10 to 15 years (or after any *major* flooding events that *totally* reform the valley floor). The bankful and floodprone cross-sections of the active channel, on the other hand, should be re-surveyed no less than every two years. Longitudinal profiles also should be re-measured at the same time. These frequent, "fine resolution" cross sections will help researchers and managers develop an understanding of the changes occurring in the Walnut-Apache Creek watersheds over time and also will help in illuminating the role the physical system plays at WCCER. This information will be essential both for understanding the stream corridor landscape and in restoring it to an ecologically healthier state.

Map of Geomorphic Cross Sections



Map is registered in
NAD27 12S Datum
December 1998

Grid North

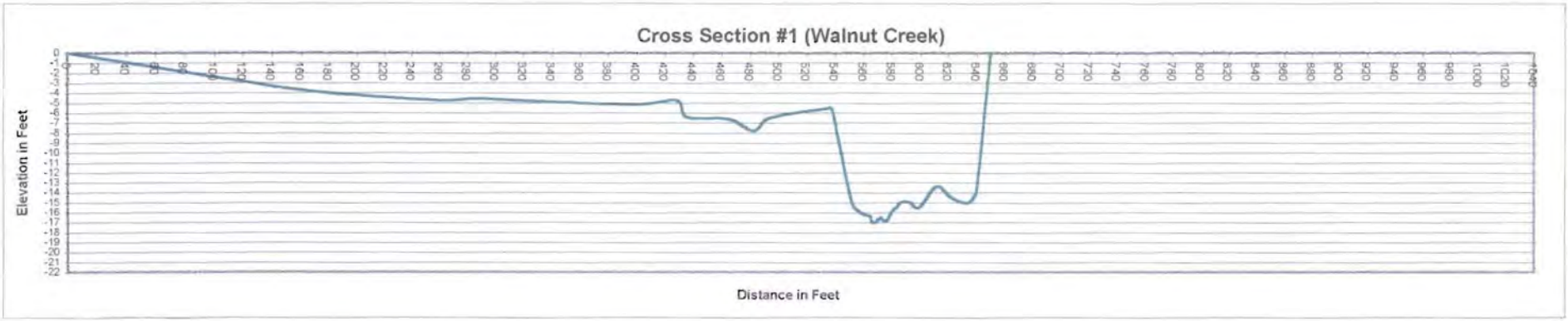
Meters
100.00

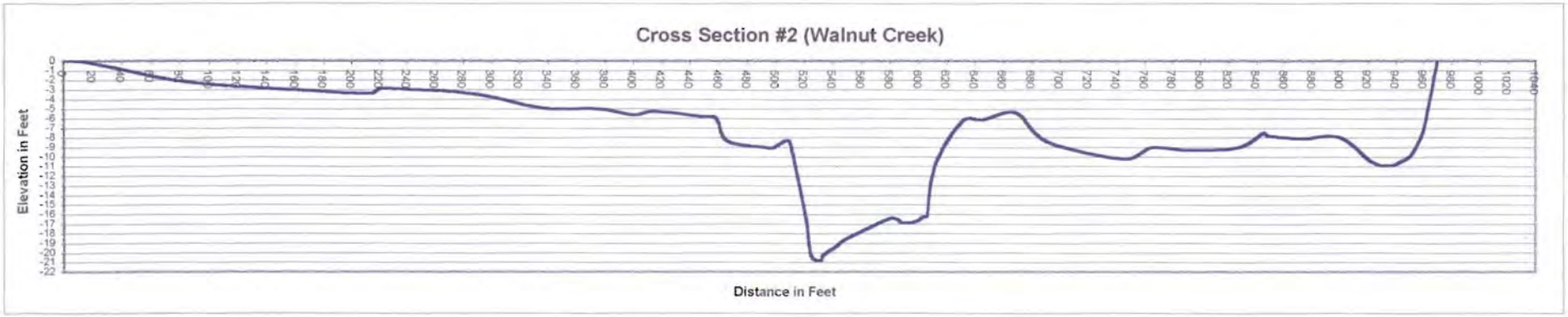
Riparia Inc.

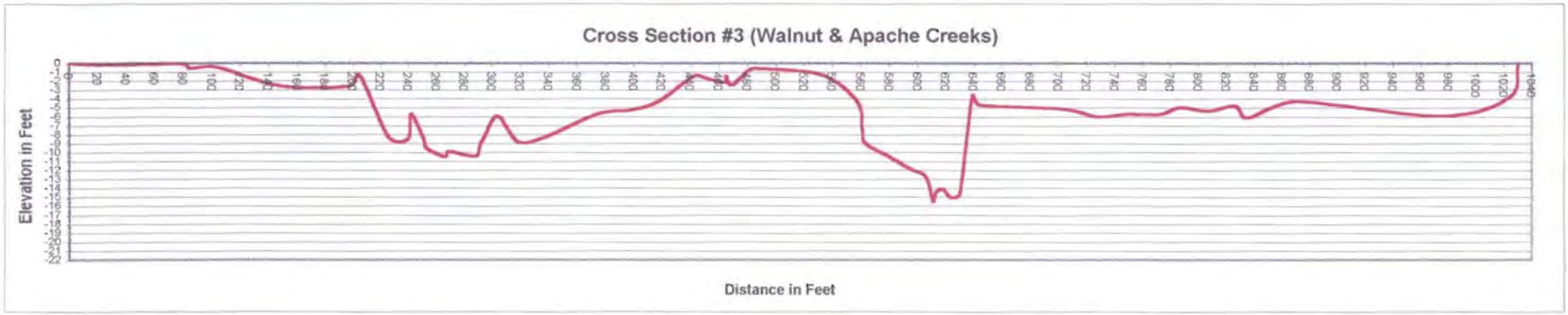
Fig. 1

Fig. 2

Geomorphic Cross Sections - Valley Wide
The Walnut Creek Center For Education and Research



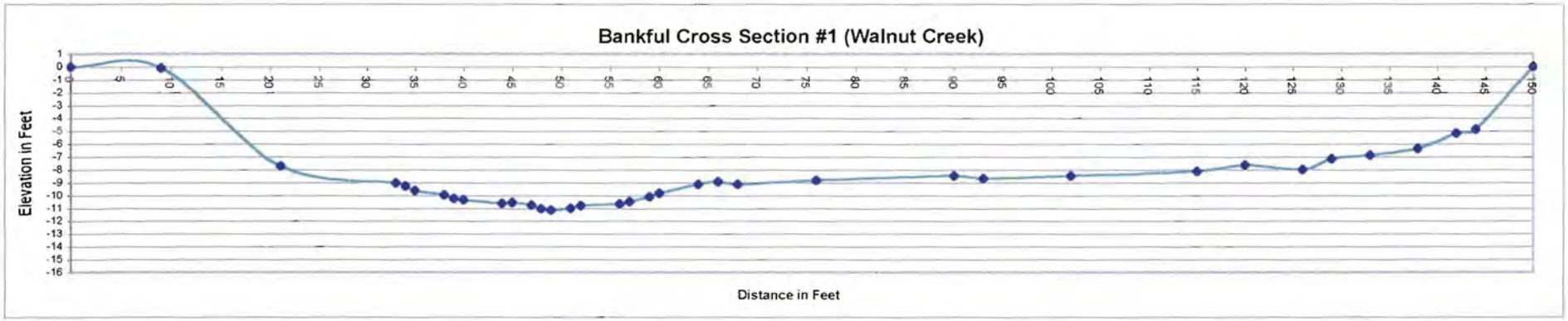


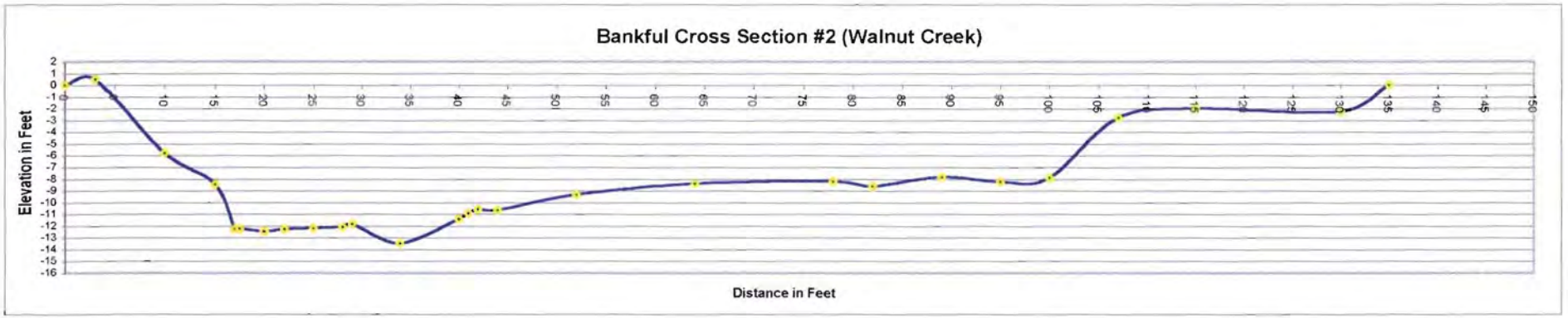


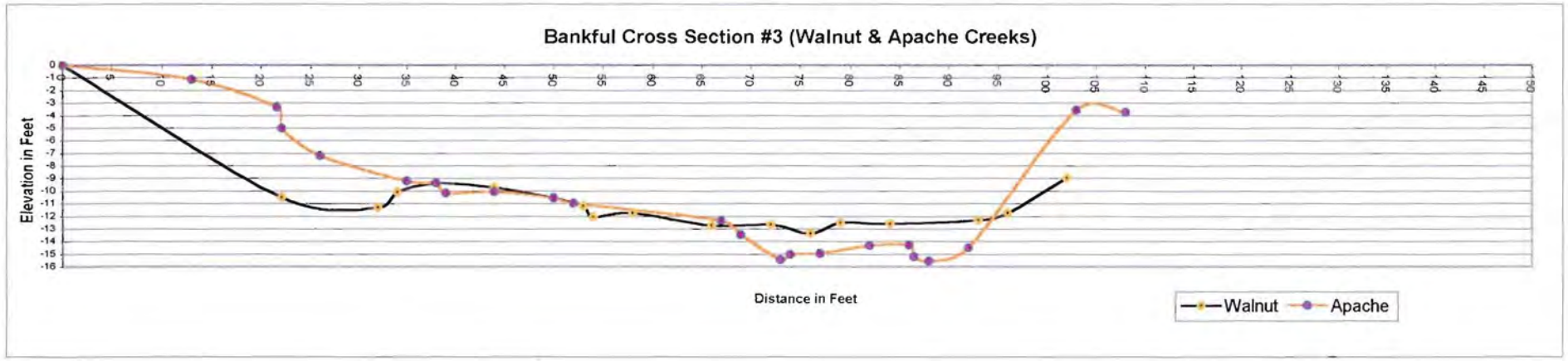
Note: Bank slope and other features are excentuated due to the interval differences of the x and y axes. The nature of the data set and page width limitations have led to this skewing.

Fig. 3

Geomorphic Cross Sections - Bankful & Floodprone
The Walnut Creek Center For Education and Research







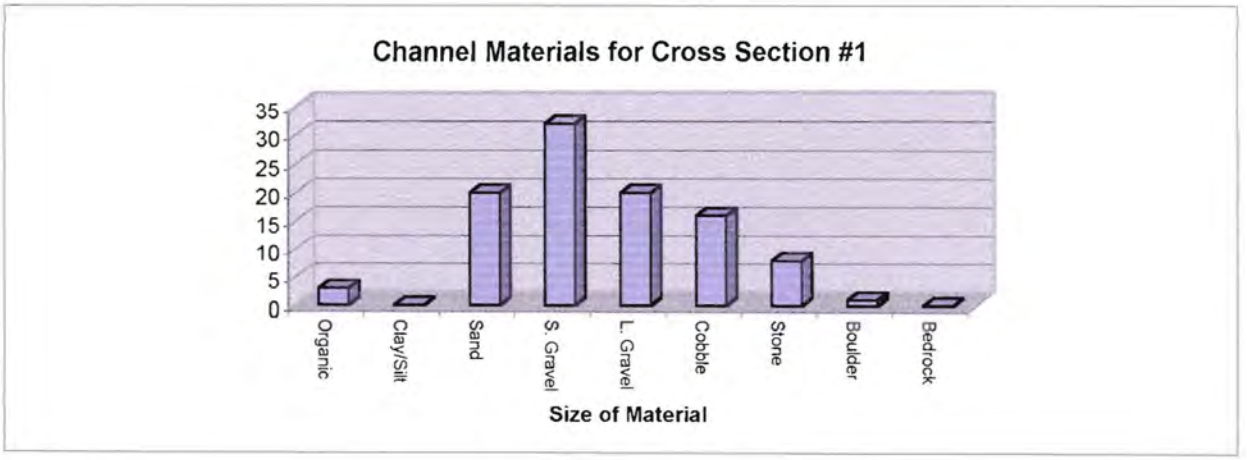
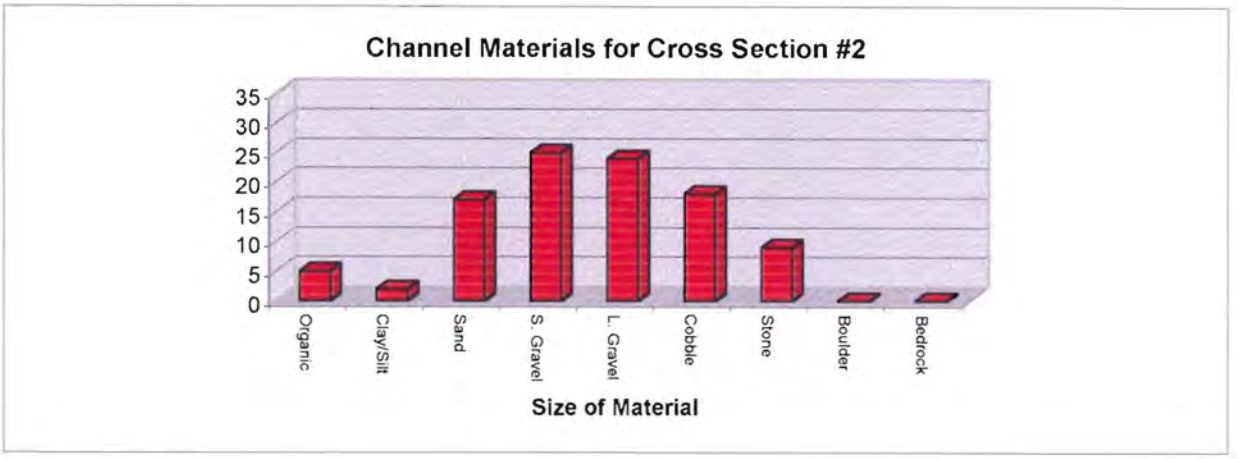
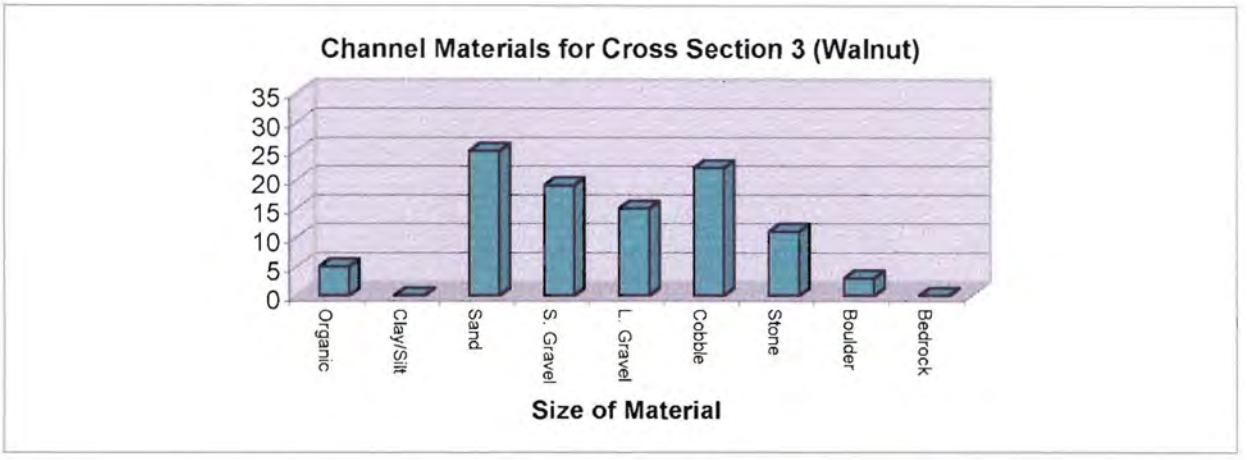

Channel Materials for Cross Section #1
35
30
25
20
15
10
5
0
Organic
Clay/Silt
Sand
S. Gravel
L. Gravel
Cobble
Stone
Boulder
Bedrock
Size of Material

Fig. 4


Channel Materials for Cross Section #2
35
30
25
20
15
10
5
0
Organic
Clay/Silt
Sand
S. Gravel
L. Gravel
Cobble
Stone
Boulder
Bedrock
Size of Material


Channel Materials for Cross Section 3 (Walnut)
35
30
25
20
15
10
5
0
Organic
Clay/Silt
Sand
S. Gravel
L. Gravel
Cobble
Stone
Boulder
Bedrock
Size of Material

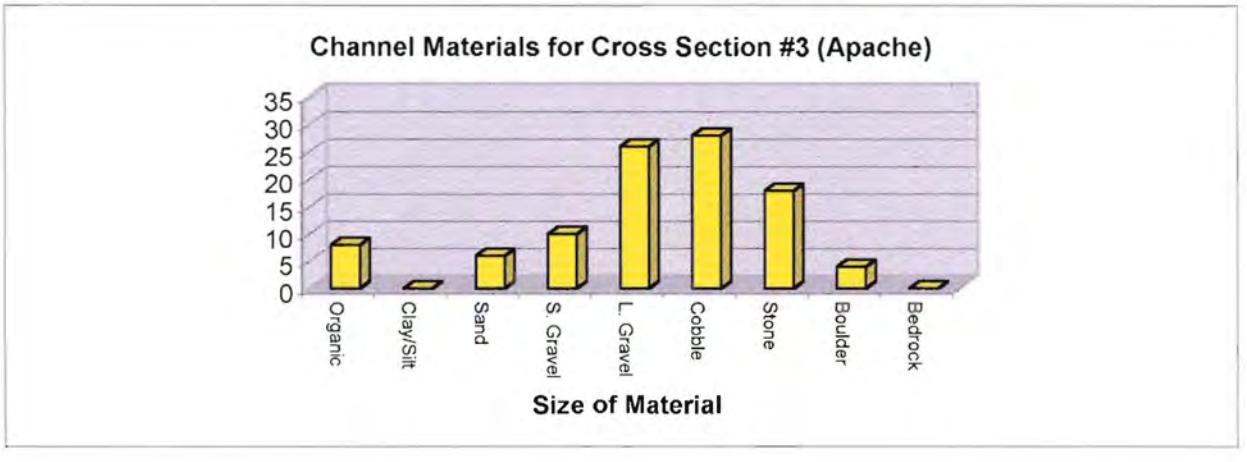
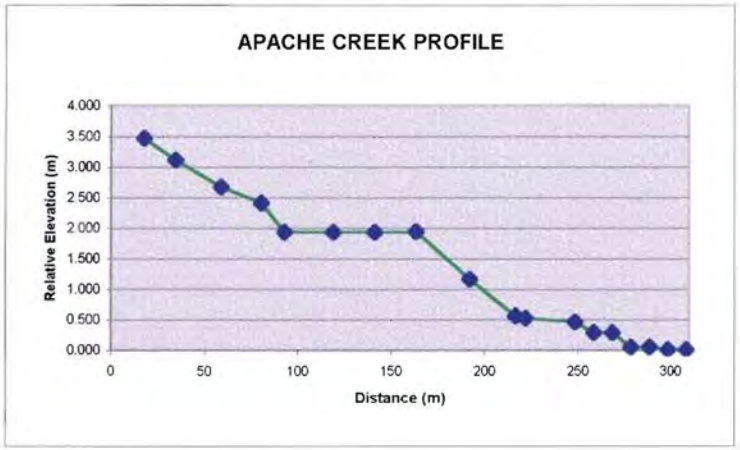
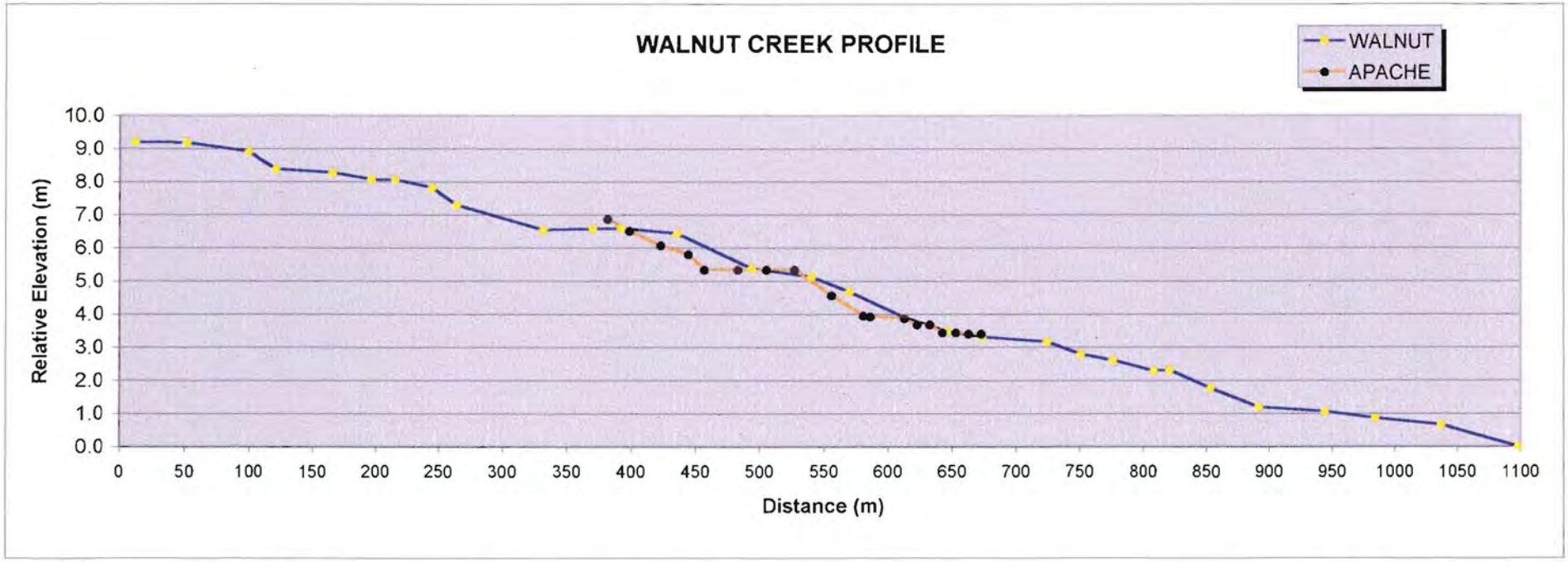

Channel Materials for Cross Section #3 (Apache)
35
30
25
20
15
10
5
0
Organic
Clay/Silt
Sand
S. Gravel
L. Gravel
Cobble
Stone
Boulder
Bedrock
Size of Material

Fig. 5

PROFILE GRAPHS



Average gradient for Walnut Creek is 0.8
Average gradient for Apache Creek is 1.1



NOTE: Apache creek profile was added by plotting Apache data with corrected elevation values from the point of confluence upstream. The corrected relative elevation was derived from equalizing Apache's last elevation figure (which was 0) with the elevation of Walnut at the confluence point. This constant was then added to all Apache elevations.

Table 1. GPS Data for Geomorph Cross Sections-Valley

Location	Point	Garmin GPS
GM#1		
	LB-Start	331004
		3866005
	RB-End	331047
		3865099
GM#2		
	LB-Start	330967
		3665703
	RB-End	33190
		3864876
GM#3		
	LB-Start	330340
		3665221
	Center	330790
		3864209
	RB-End	330977
		3863111

Table 2. Pebble Count Data

Site#	Organic	Clay/Silt	Sand	S. Gravel	L. Gravel	Cobble	Stone	Boulder	Bedrock	TOTAL
1	3	0	20	32	20	16	8	1	0	100
2	5	2	17	25	24	18	9	0	0	100
3a	5	0	25	19	15	22	11	3	0	100
3b	8	0	6	10	26	28	18	4	0	100

Table 3. Geomorphology Photo Log

Transect #	Date	Roll #	Frame #	Location Code	Compass Bearing	Description
GM #1	4/1/99	1	1	WC	320	Benchmark for GM#1, left, upper terrace marked with wooden stake.
			2	WC	50	Bankful, looking downstream. Dense willows made channel shot impossible.
			3	WC	235	Bankful, looking upstream. Dense willows made center of channel shot impossible.
			4	WC	40	Floodprone, looking downstream. Shot on right side of channel-left side is cut bank
GM #2	4/1/99		5	WC	245	Floodprone, looking upstream Shot on right side of channel-left side is cut bank
			6	WC	310	Benchmark for GM#2, left, upper terrace next to road, marked with wooden stake.
			7	WC	105	Bankful, looking downstream. Shot slightly elevated, dense willows precluded in channel shot.
			8	WC	230	Bankful, looking upstream. Dense willows made good shot of channel diffucult.
			9	WC	40	Floodprone, looking downstream. Shot on right side of channel-left side is cut bank
			10	WC	240	Floodprone, looking upstream Shot on right side of channel-left side is cut bank
GM #3	4/1/99		11	WC	340	Benchmark for GM#3, left, upper terrace along road marked with wooden stake.
			12	WC		Bankful, looking downstream.
			13	WC		Bankful, looking upstream.
			14	AC		Bankful and floodprone, looking downstream.

Note: Left bank and right bank are based on looking downstream.

Location Codes: WC= Walnut Creek, AC= Apache Creek

GM#1 – Left Valley Reference Stake (Walnut Creek)

GM#1 – Bankful Looking Downstream (Walnut Creek)

GM#1 – Bankful Looking Upstream (Walnut Creek)

GM#1 – Floodprone Looking Downstream (Walnut Creek)

GM#1 – Floodprone Looking Upstream (Walnut Creek)

GM#2 – Left Valley Reference Stake (Walnut Creek)

GM#2 – Bankful Looking Upstream (Walnut Creek)

GM#2 – Bankful Looking Downstream (Walnut Creek)

GM#2 – Floodprone Looking Downstream (Walnut Creek)

GM#2 – Floodprone Looking Upstream (Walnut Creek)

GM#3 – Left Valley Reference Stake (Walnut Creek)

GM#3 – Bankful Looking Downstream (Walnut Creek)

GM#3 – Bankful and Floodprone Looking Downstream (Apache Creek)

GM#3 – Bankful and Floodprone Looking Upstream (Apache Creek)

CONTENTS - Plant Survey and Collection

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Plant Survey and Collection

Introduction

In 1998 and 1999, a vascular plant survey of WCCER was conducted in tandem with the mapping of plant associations on the site. The plant survey was undertaken in order to create a master taxonomic record for the plants in the area as well as to provide a checklist and a learning tool for students and researchers utilizing the site. All of the species found were subsequently collected and mounted for future use. This collection provides legal deposit for the species collection (specimens were deposited at the Yavapai College Herbarium). It should streamline future plant identification at the site and specimens may serve as excellent interpretive aids for the flora of WCCER. The creation of the plant list and establishment of a collection also furnished crucial information for the creation of site vegetation maps.

Methods

The generated plant list includes all vascular plants found within the project area. Species are grouped alphabetically by genera and family (Tables 1 & 2). The most current nomenclature for species name and common name was provided. A collection number is assigned to each species collected.

Total coverage of the site was accomplished by systematically walking at the center of 50m wide belt transects running consecutively and longitudinally within the project area. Transects were sited with a compass. Parallel bearings were determined by longitudinal (north-south running) fence boundaries. Seven-meter poles with fluorescent pink flagging were placed at the center and edges of each transect start point as well as at other topographically useful points within the transect to reduce sampling overlap and to help field staff stay within determined belts. More thorough searching was conducted in situations where visibility was reduced or where other unique conditions existed, such as the following:

- Along drainages
- On saddles
- On hilltops
- On cliffs
- In rock outcroppings
- In bowls
- In areas of past cultural dwelling

An attempt was made to collect at least two samples for all plant taxa encountered. One specimen was deposited in the Yavapai College herbarium in Prescott, Arizona; the other was stored in a herbarium closet at the site. Taxa that occurred as individuals or ones that were in poor condition were not collected. Samples were pressed on site with a standard 12" x 18" field press, later being rearranged and re-pressed in a standard herbarium press. Presses were placed on an asphalt roof to dry samples.

Field notes included elevation, Universal Transverse Mercator (UTM) grid system coordinates, USGS quadrangle, distances from major landmarks, a GPS bearing, date, collection number, substrate type, community type, frequency and plant associations. Characteristics of the individuals and/or population that might not be apparent after the specimen has been pressed also were recorded. Photographs were taken for all species that would be distinguishable in a photo. Fuji 100 print film was utilized. Whenever possible, species were shot in their respective habitat and close-ups were shot as well. Whenever possible, one print was produced for inclusion in the interpretive pressings. An experienced Ph.D. botanist (Dr. Marc Baker) proofed all species. Recent taxonomic designations were researched and proofed at the ASU, Tempe Library and Herbarium. Collection data was entered into a Word Perfect 5.1 database and merged via a primary file into a text file for printing.

Results

A total of 279 species were recorded, with 256 being collected (Tables 1 & 2). To date, no special status species, threatened or endangered, were found.

Future Research

It is recommended that small scale, site by site, surveys be conducted over the next two to three years, particularly in the pastures within the site. These surveys ideally should be conducted under non-drought conditions. Due to the recent no-grazing status of WCCER, it is very likely that several new species will be found during this recovery period. The zones along the active channels of Apache and Walnut Creeks also should be watched; the removal of grazing pressure should allow aquatic and emergent vegetation to expand in abundance and diversity. Over time, plants that have not been collected and archived that are found during other activities and surveys should be added to the collection and list.

Table 1. Walnut Creek Plant List 1998-1999 (by genera)

Species	Family	Common Name	coll. #
Acalypha neomexicana	EUPHORBIACEAE	New Mexican	13159
Acer negundo	ACERACEAE	box-elder	13133
Achillea millefolium	ASTERACEAE	yarrow	13289
Agave parryi. var. *couesii*	AGAVACEAE	Parry agave	13040
Ageratina herbacea	ASTERACEAE		13280
Agoseris aurantiaca	ASTERACEAE		12927
Agropyron desertorum	POACEAE	crested wheatgrass	13015
Agrostis viridis	POACEAE		13001
Amaranthus blitoides	AMARANTHACEAE	prostrate pigweed	13106
Amaranthus palmeri	AMARANTHACEAE	Palmer pigweed	13166
Ambrosia acanthicarpa	ASTERACEAE		13195
Ambrosia psilostachya	ASTERACEAE		13168
Anoda cristata	MALVACEAE		13123
Apocynum cannibinum	APOCYNACEAE	dogbane	12998
Aquilegia chrysantha	RANUNCULACEAE	yellow columbine	13006
Arabis gracilipes	BRASSICACEAE	rockcress	12874
Arabis perennans	BRASSICACEAE	rockcress	12861
Arctostaphylos pungens	ERICACEAE	point-leaf manzanita	12873
Argemone gracilenta	PAPAVERACEAE	graceful prickly-poppy	12996
Aristida divaricata	POACEAE	poverty three-awn	13183
Aristida orcuttiana	POACEAE	Orcutt three-awn	13199
Aristida purpurea var. *fendleriana*	POACEAE	Fendler three-awn	13146
Artemisia carruthii	ASTERACEAE	Carruth wormwood	
Artemisia dracunculus	ASTERACEAE	wormwood	13190
Artemisia ludoviciana	ASTERACEAE	silver wormwood	13189
Asclepias involucrata	ASCLEPIADACEAE	little leafy milkweed	12947
Asclepias subverticillata	ASCLEPIADACEAE	whorled milkweed	13127
Asparagus officinalis	LILIACEAE	common asparagus	13294
Astragalus humistratus	FABACEAE	prostrate milkvetch	12941
Astragalus tephrodes	FABACEAE	locoweed	12858
Atriplex canescens	CHENOPODIACEAE	four-wing saltbush	13286
Baccharis pteronioides	ASTERACEAE	hierba de pasmo	12984
Bahia dissecta	ASTERACEAE		13193
Berberis fremontii	BERBERIDACEAE	Frémont barberry	12986
Bidens pilosa	ASTERACEAE		13125
Boerhavia coccinea	NYCTAGINACEAE	red spiderling	13165
Boerhavia coulteri	NYCTAGINACEAE	Coulter spiderling	13116
Boerhavia purpurescens	NYCTAGINACEAE	purple spiderling	13201
Bothriochloa barbinodis	POACEAE	cane bluestem	13141
Bouteloua barbata	POACEAE	six-weeks grama	13169
Bouteloua curtipendula	POACEAE	side-oats grama	13147
Bouteloua gracilis	POACEAE	blue grama	13170

Table 1. Continued

Bouteloua hirsuta	POACEAE	hairy grama	13197
Brickellia californica	ASTERACEAE	California brickellia	13301
Brickellia eupatorioides var. *chlorolepis*	ASTERACEAE		13161
Brickellia grandiflora	ASTERACEAE	flowering brickellia	13296
Bromus diandrus	POACEAE	ripgut grass	12887
Bromus marginatus	POACEAE		12891
Bromus rubens	POACEAE	red brome	12876
Bromus tectorum	POACEAE	soft chess	12882
Calibrachoa parviflora	SOLANACEAE		13297
Calliandra humilis	FABACEAE	dwarf fairy-duster	12977
Calochortus nuttallii	LILIACEAE	Nuttall mariposa-lily	12940
Capsella bursi-pastoris	BRASSICACEAE	shepard's-purse	
Carex occidentalis	CYPERACEAE	western sedge	
Castilleja integra	SCROPHULARIACEAE	Indian paintbrush	12923
Ceanothus greggii	RHAMNACEAE	Gregg mountain-lilac	12871
Celtis reticulata	ULMACEAE	net-leaf hackberry	
Cercocarpus montanus	ROSACEAE	Mountain-mohogany	13149
Chaetopappa ericoides	ASTERACEAE	upland daisy	12937
Chamaesyce albomarginata	EUPHORBIACEAE	white-margined spurge	12982
Chamaesyce serpyllifolia	EUPHORBIACEAE	snake-leaf spurge	13162
Chenopodium fremontii	CHENOPODIACEAE	Frémont goosefoot	13288
Chenopodium graveolens	CHENOPODIACEAE	sage goosefoot	13157
Chloris virgata	POACEAE		13174
Chorispora tenella	BRASSICACEAE	blue-mustard	12885
Chrysothamnus nauseosus ssp. *consimilis*	ASTERACEAE		13283
Cichorium intybus	ASTERACEAE	chicory	13155
Cirsium neomexicanum	ASTERACEAE	New Mexican thistle	13021
Cirsium ochrocentrum	ASTERACEAE	large-flowered thistle	13031
Collinsia parviflora	SCROPHULARIACEAE	blue-eyed-Mary	12890
Convolvulus arvensis	CONVOLVULACEAE	field bindweed	
Convolvulus equitans	CONVOLVULACEAE	hoary bindweed	12988
Conyza canadensis	ASTERACEAE	horseweed	13160
Conyza coulteri	ASTERACEAE	Coulter horseweed	13192
Cordylanthus laxiflorus	SCROPHULARIACEAE	yellow bird-beak	13143
Corydalis aurea	PAPAVERACEAE	golden corydalis	12896
Coryphantha vivipara var. *arizonica*	CACTACEAE	pincushion cactus	
Cryptantha cinerea	BORAGINACEAE	silver popcorn-flower	12933
Cryptantha micrantha	BORAGINACEAE	little popcorn-flower	12878
Curcurbita foetidissima	CUCURBITACEAE	buffalo-gourd	13121
Cymopteris multinervata	APIACEAE		12866
Cyperus fendleriana	CYPERACEAE	Fendler flat-sedge	13112
Dalea albiflora	FABACEAE	white-flowered pea-bush	13111
Descurainia pinnata	BRASSICACEAE	tansy-mustard	12865
Descurainia sophia	BRASSICACEAE	tansy-mustard	12884
Dianthus barbatus	CAROPHYLLACEAE	sweet William	

Table 1. Continued

Dichelostemma congestum	LILIACEAE	blue-dicks	12860
Draba cuneifolia	BRASSICACEAE	whitlow-grass	12868
Echinocereus coccineus	CACTACEAE	claret-cup cactus	12934
Echinocereus fendleri	CACTACEAE	Fendler hedgehog	13144
Echinochloa crus-galli	POACEAE		13292
Elymus elymoides	POACEAE	squirrel-tail	12924
Elymus glaucus	POACEAE		12994
Epilobium ciliatum	ONAGRACEAE		13298
Equisetum arvense	EQUISETACEAE	horsetail	
Eragrostis cilianensis	POACEAE	stinking lovegrass	13164
Eragrostis curvula	POACEAE	weeping lovegrass	13023
Eragrostis intermedia	POACEAE	plains lovegrass	13204
Eragrostis pectinacea var. *pectinacea*	POACEAE		13172
Eriastrum diffusum	POLEMONIACEAE		12944
Erigeron divergens	ASTERACEAE	annual fleabane	12928
Erigeron neomexicanus	ASTERACEAE	New Mexican fleabane	13194
Eriogonum pharnaceoides	POLYGONACEAE	false-buckwheat	13119
Eriogonum polycladon	POLYGONACEAE	false-buckwheat	13182
Eriogonum wrightii	POLYGONACEAE	Wright false-buckwheat	13110
Erodium cicutarium	GERANIACEAE	filary	12922
Erysimum repandrum	BRASSICACEAE	weedy wallflower	12945
Euphorbia bilobata	EUPHORBIACEAE	spurge	13126
Euphorbia dentata	EUPHORBIACEAE	spurge	13124
Evolvulus sericeus	CONVOLVULACEAE	silver-spider	12979
Fallugia paradoxa	ROSACEAE	Apache-plume	13039
Forestiera pubescens	OLEACEAE	desert-olive	12872
Fraxinus velutina	OLEACEAE	velvet ash	13137
Gaillardia pinnatifida	ASTERACEAE	blanker-flower	12987
Galium wrightii	RUBIACEAE	Wright bedstraw	13038
Garrya wrightii	GARRYACEAE	Wright silk-tassle	
Gaura coccinea	ONAGRACEAE	red gaura	12969
Gaura hexandra ssp. *gracilis*	ONAGRACEAE	intermediate gaura	13029
Gaura parviflora	ONAGRACEAE	small-flowered gaura	13129
Geranium cespitosum var. *eremophilum*	GERANIACEAE	purple geranium	13134
Gilia sinuata	POLEMONIACEAE	sinuous gilia	12862
Gleditsia triacanthos	FABACEAE		13181
Gnaphalium canescens	ASTERACEAE	perennial cudweed	13281
Gnaphalium luteoalbum	ASTERACEAE	annual cudweed	13299
Gutierrezia sarothrae	ASTERACEAE	snakeweed	13179
Hedeoma oblongifolium	LAMIACEAE	strict false-pennyroyal	13035
Helianthus annuus	ASTERACEAE	common sunflower	13135
Heliomeris longiflora var. *annua*	ASTERACEAE	annual heliomeris	13285
Hesperostipa neomexicana	POACEAE	needle-and-thread	19243
Hilaria mutica	POACEAE	tobosa	
Hordeum murinum ssp. *glaucum*	POACEAE	powdered barley	12881

Table 1. Continued

Hymenopappus filifolius var. *lugens*	ASTERACEAE		13010
Hymenothrix loomisii	ASTERACEAE	lace-daisy	13173
Ipomoea coccinea	CONVOLVULACEAE	red morning-glory	13184
Ipomoea costellata	CONVOLVULACEAE	ribbed morning-glory	13175
Ipomoea purpurea	CONVOLVULACEAE	blue-heaven morning-glory	
Ipomopsis aggregata	POLEMONIACEAE	sky-rocket	13033
Ipomopsis multiflora	POLEMONIACEAE		13138
Iris	IRIDACEAE	garden iris	
Juglans major	JUGLANDACEAE	Arizona walnut	13113
Juncus balticus	JUNCACEAE	wire rush	13007
Juncus nevadense var. *badius*	JUNCACEAE	nevada rush	13009
Juncus xiphioides	JUNCACEAE	iris-leaved rush	13000
Juniperus deppeana	CUPRESSACEAE	alligator juniper	12892
Juniperus osteosperma	CUPRESSACEAE	Utah juniper	12893
Kochia scoparia	CHENOPODIACEAE	summer-cypress	13132
Koeleria macrantha	POACEAE	junegrass	12983
Lactuca serriola	ASTERACEAE	lettuce	13142
Lappula occidentalis	BORAGINACEAE	stickseed	12867
Layia glandulosa	ASTERACEAE	tidy-tips	12920
Lepidium densiflorum	BRASSICACEAE	pepper-grass	12975
Lepidium thurberi	BRASSICACEAE	Thurber peppergrass	13026
Leptochloa dubia	POACEAE	green sprangletop	13187
Linanthus aureus	POLEMONIACEAE		12877
Linum lewisii	LINACEAE	Lewis flax	12989
Linum puberlum	LINACEAE	blue flax	12938
Lithospermum incisum	BORAGINACEAE	gromwell	12942
Lomatium nevadense	APIACEAE	wild-parsley	12879
Lotus wrightii	FABACEAE	Wright deervetch	12973
Lupinus brevicaulis	FABACEAE	short-stemmed lupine	12926
Lupinus latifolius ssp. *leucanthus*	FABACEAE	Prescott lupine	13019
Lycium pallidum	SOLANACEAE	pale wolfberry	12925
Lycurus setosus	POACEAE	wolf-tail	13148
Machaeranthera canescens	ASTERACEAE		13177
Machaeranthera gracilis	ASTERACEAE	little yellow-aster	12980
Machaeranthera tanacetifolia	ASTERACEAE	tansy-leaf-aster	13118
Malus sylvestris	ROSACEAE	apple	
Malva parviflora	MALVACEAE		13154
Marrubium vulgare	LAMIACEAE	horehound	13024
Matelea producta	ASCLEPIADACEAE	trailing-hearts	13025
Medicago sativa	FABACEAE	alfalfa	13176
Melilotus officinalis	FABACEAE	yellow sweetclover	12970
Menodora scabra	OLEACEAE	rough twinberry	12972
Mentzelia	LOASACEAE	annual blazingstar	12895
Mimosa biuncifera	FABACEAE	wait-a-minute	13042
Mimulus guttatus	SCROPHULARIACEAE	yellow monkey-flower	13005

Table 1. Continued

Mirabilis coccineus	NYCTAGINACEAE	red four-o'clock	13028
Mirabilis longiflora	NYCTAGINACEAE	long-flowered four-o'clock	13115
Mirabilis multiflora	NYCTAGINACEAE	Colorado four-o'clock	
Mirabilis oxybaphoides	NYCTAGINACEAE	four-o'clock	13167
Morus microphylla	MORACEAE	Texas mulberry	13030
Muhlenbergia emersleyi	POACEAE	bulgrass	13278
Muhlenbergia fragilis	POACEAE	fragile muhly	13202
Muhlenbergia repens	POACEAE	creeping muhly	
Muhlenbergia torreyi	POACEAE	ring muhly	13287
Munroa squarrosa	POACEAE	false-buffalograss	13108
Nolina microcarpa	NOLINACEAE	beargrass	13011
Oenothera albicaulis	ONAGRACEAE	white-stemmed evening-rose	12946
Oenothera elata ssp. *hirsutissima*	ONAGRACEAE	tall evening-primrose	13300
Opuntia engelmannii var. *engelmannii*	CACTACEAE	Engelmann prickly-pear	13041
Opuntia macrorhiza	CACTACEAE	plains pricklypear	13012
Opuntia phaeacantha	CACTACEAE	brown-spined pricklypear	13013
Opuntia whipplei	CACTACEAE	Whipple cholla	13020
Panicum obtusum	POACEAE	vine-mesquite	13151
Parthenocissus quinquefolia	VITACEAE	Virginia-creeper	13136
Pascopyrum smithii	POACEAE	western wheatgrass	12991
Penstemon barbatus	SCROPHULARIACEAE	bearded penstemon	13027
Penstemon linarioides	SCROPHULARIACEAE	line-leaf penstemon	12971
Phaseolus angustissimus	FABACEAE		13034
Phlox gracilis ssp. humilis	POLEMONIACEAE		12864
Phlox speciosa ssp. woodhausei	POLEMONIACEAE	Woodhause phlox	12870
Physalis hederifolia var. *palmeri*	SOLANACEAE	Palmer tomatillo	13117
Pinus edulis	PINACEAE	pinyon pine	13282
Pinus ponderosa	PINACEAE	ponderosa pine	
Piptotherum micranthum	POACEAE	little Indian ricegrass	12993
Plagiobothrys arizonicus	BORAGINACEAE		12931
Plantago patagonica	PLANTAGINACEAE	silky plaintain	12981
Poa compressa	POACEAE	Canadian bluegrass	12883
Poa fendleriana	POACEAE	muttongrass	12857
Poa pratense	POACEAE	Kentucky bluegrass	12992
Polygonum aviculare	POLYGONACEAE	prostrate knotweed	13163
Polygonum persicaria	POLYGONACEAE	knotweed	13291
Polypogon monspeliensis	POACEAE	rabbit'sfoot grass	13003
Populus fremontii	SALICACEAE	Frémont cottonwood	12999
Populus xhinckleyana	SALICACEAE	Hinckley cottonwood	13293
Portulaca halimoides	PORTULACACEAE	hairy purslane	
Prunus serotina var. *virens*	ROSACEAE	wild cherry	13128
Psoralidium tenuiflorum	FABACEAE	scurvy-pea	12976
Purshia stansburiana	ROSACEAE	common cliffrose	13036
Pyrus communis	ROSACEAE	pear	
Quercus emoryi	FAGACEAE	Emory oak	13043

Table 1. Continued

Quercus gambelii	FAGACEAE	Gambel oak	13295
Quercus grisea	FAGACEAE	gray oak, Arizona oak	13279
Quercus turbinella	FAGACEAE	scrub oak	13044
Ranunculus testiculatus	RANUNCULACEAE	bur buttercup	12880
Rhamnus californica	RHAMNACEAE	coffee-berry	13037
Rhus trilobata	ANACARDIACEAE	lemonade-berry	12875
Rhynchosia senna var. *texana*	FABACEAE		13140
Ribes aureum	GROSSULARIACEAE	golden currant	12889
Ribes cereum	GROSSULARIACEAE	wax currant	12886
Robinia neomexicana	FABACEAE	New Mexican locust	13016
Rorippa nasturtium-aquaticum	BRASSICACEAE	watercress	13004
Rosa woodsii var. ultramontana	ROSACEAE	wild rose	13131
Rumex crispus	POLYGONACEAE	wavy-leaf dock	13017
Salix laevigata	SALICACEAE	red willow	12894
Salix lasiolepis	SALICACEAE	arroyo willow	12888
Salsola kali ssp. *tragus*	CHENOPODIACEAE	Russian-thistle, tumbleweed	13109
Salvia reflexa	LAMIACEAE	annual sage	13185
Sanguisorba minor ssp. *muricata*	ROSACEAE	burnet	13014
Sanvitalia abertii	ASTERACEAE	Abert sanvitalia	
Scirpus pungens	CYPERACEAE	sharp three-square	13008
Senecio flaccidus var. *douglasii*	ASTERACEAE		13191
Senecio multilobatus	ASTERACEAE	threadleaf groundsel	12939
Setaria glauca	POACEAE	golden bristly-grass	13290
Setaria grisebachii	POACEAE	Grisebach bristlegrass	13186
Sisybrium altissimum	BRASSICACEAE	tumble-mustard	12929
Solanum eleagnifolium	SOLANACEAE	silver nightshade	12997
Solidago velutina	ASTERACEAE	velvet goldenrod	13277
Sorghum halapense	POACEAE	Johnsongrass	13130
Sphaeralcea fendleri	MALVACEAE	Fendler globemallow	13158
Sphaeralcea hastulata	MALVACEAE	prairie globmallow	12974
Sporobolus airoides	POACEAE	alkali sakaton	13120
Sporobolus contractus	POACEAE	spike dropseed	13188
Sporobolus cryptandrus	POACEAE	sand dropseed	13122
Stephanomeria thurberi	ASTERACEAE	Thurber wirelettuce	12968
Talinum parviflorum	PORTULACACEAE	small-flowered flameflower	13150
Taraxacum laevigatum	ASTERACEAE	dandelion	12897
Townsendia exscapa	ASTERACEAE	stemless townsendia	12869
Tragia ramosa	EUPHORBIACEAE	desert-nettle	13145
Tragopogon dubius	ASTERACEAE	yellow goats-beard	
Tribilus terrestris	ZYGOPHYLLACEAE	goatheads, puncture-vine	13105
Trifolim wormskioldii	FABACEAE	Wormskiold clover	13018
Triticum aestivum	POACEAE	wheat	12978
Ulmus	ULMACEAE	elm	13180
Ulmus pumila	ULMACEAE	Siberian elm	
Uropappus lindleyi	ASTERACEAE	silver-puffs	12921

Table 1. Continued

Verbascum thapsus	SCROPHULARIACEAE	mullein	13114
Verbena bipinnatifida	VERBENACEAE	verbena	12932
Verbena gooddingii	VERBENACEAE	Goodding verbena	12859
Veronica anagallis-aquatica	SCROPHULARIACEAE	speedwell	13002
Vitis arizonica	VITACEAE	Arizona grape	12990
Vulpia octoflora	POACEAE	six-weeks fescue	12930
Yucca angustissima var. *angustissima*	AGAVACEAE	narrow-leaf yucca	
Zinnia grandiflora	ASTERACEAE	large-flowered zinnia	13302

Table 2. Walnut Creek Plant List 1998-1999 (by family)

Family	Species	Common Name	coll. #
ACERACEAE	*Acer negundo*	box-elder	13133
AGAVACEAE	*Agave parryi.* var. *couesii*	Parry agave	13040
AGAVACEAE	*Yucca angustissima* var. *angustissima*	narrow-leaf yucca	
AMARANTHACEAE	*Amaranthus blitoides*	prostrate pigweed	13106
AMARANTHACEAE	*Amaranthus palmeri*	Palmer pigweed	13166
ANACARDIACEAE	*Rhus trilobata*	lemonade-berry	12875
APIACEAE	*Cymopteris multinervata*		12866
APIACEAE	*Lomatium nevadense*	wild-parsley	12879
APOCYNACEAE	*Apocynum cannibinum*	dogbane	12998
ASCLEPIADACEAE	*Asclepias involucrata*	little leafy milkweed	12947
ASCLEPIADACEAE	*Asclepias subverticillata*	whorled milkweed	13127
ASCLEPIADACEAE	*Matelea producta*	trailing-hearts	13025
ASTERACEAE	*Achillea millefolium*	yarrow	13289
ASTERACEAE	*Ageratina herbacea*		13280
ASTERACEAE	*Agoseris aurantiaca*		12927
ASTERACEAE	*Ambrosia acanthicarpa*		13195
ASTERACEAE	*Ambrosia psilostachya*		13168
ASTERACEAE	*Artemisia carruthii*	Carruth wormwood	
ASTERACEAE	*Artemisia dracunculus*	wormwood	13190
ASTERACEAE	*Artemisia ludoviciana*	silver wormwood	13189
ASTERACEAE	*Baccharis pteronioides*	hierba de pasmo	12984
ASTERACEAE	*Bahia dissecta*		13193
ASTERACEAE	*Bidens pilosa*		13125
ASTERACEAE	*Brickellia californica*	California brickellia	13301
ASTERACEAE	*Brickellia eupatorioides* var. *chlorolepis*		13161
ASTERACEAE	*Brickellia grandiflora*	flowering brickellia	13296
ASTERACEAE	*Chaetopappa ericoides*	upland daisy	12937
ASTERACEAE	*Chrysothamnus nauseosus* ssp. *consimilis*		13283
ASTERACEAE	*Cichorium intybus*	chicory	13155
ASTERACEAE	*Cirsium neomexicanum*	New Mexican thistle	13021
ASTERACEAE	*Cirsium ochrocentrum*	large-flowered thistle	13031
ASTERACEAE	*Conyza canadensis*	horseweed	13160
ASTERACEAE	*Conyza coulteri*	Coulter horseweed	13192
ASTERACEAE	*Erigeron divergens*	annual fleabane	12928
ASTERACEAE	*Erigeron neomexicanus*	New Mexican fleabane	13194
ASTERACEAE	*Gaillardia pinnatifida*	blanker-flower	12987
ASTERACEAE	*Gnaphalium canescens*	perennial cudweed	13281
ASTERACEAE	*Gnaphalium luteoalbum*	annual cudweed	13299
ASTERACEAE	*Gutierrezia sarothrae*	snakeweed	13179
ASTERACEAE	*Helianthus annuus*	common sunflower	13135
ASTERACEAE	*Heliomeris longiflora* var. *annua*	annual heliomeris	13285
ASTERACEAE	*Hymenopappus filifolius* var. *lugens*		13010

Table 2. Continued

ASTERACEAE	*Hymenothrix loomisii*	lace-daisy	13173
ASTERACEAE	*Lactuca serriola*	lettuce	13142
ASTERACEAE	*Layia glandulosa*	tidy-tips	12920
ASTERACEAE	*Machaeranthera canescens*		13177
ASTERACEAE	*Machaeranthera gracilis*	little yellow-aster	12980
ASTERACEAE	*Machaeranthera tanacetifolia*	tansy-leaf-aster	13118
ASTERACEAE	*Sanvitalia abertii*	Abert sanvitalia	
ASTERACEAE	*Senecio flaccidus* var. *douglasii*		13191
ASTERACEAE	*Senecio multilobatus*	threadleaf groundsel	12939
ASTERACEAE	*Solidago velutina*	velvet goldenrod	13277
ASTERACEAE	*Stephanomeria thurberi*	Thurber wirelettuce	12968
ASTERACEAE	*Taraxacum laevigatum*	dandelion	12897
ASTERACEAE	*Townsendia exscapa*	stemless townsendia	12869
ASTERACEAE	*Tragopogon dubius*	yellow goats-beard	
ASTERACEAE	*Uropappus lindleyi*	silver-puffs	12921
ASTERACEAE	*Zinnia grandiflora*	large-flowered zinnia	13302
BERBERIDACEAE	*Berberis fremontii*	Frémont barberry	12986
BORAGINACEAE	*Lithospermum incisum*	gromwell	12942
BORAGINACEAE	*Cryptantha cinerea*	silver popcorn-flower	12933
BORAGINACEAE	*Cryptantha micrantha*	little popcorn-flower	12878
BORAGINACEAE	*Lappula occidentalis*	stickseed	12867
BORAGINACEAE	*Plagiobothrys arizonicus*		12931
BRASSICACEAE	*Arabis gracilipes*	rockcress	12874
BRASSICACEAE	*Arabis perennans*	rockcress	12861
BRASSICACEAE	*Capsella bursi-pastoris*	shepard's-purse	
BRASSICACEAE	*Chorispora tenella*	blue-mustard	12885
BRASSICACEAE	*Descurainia pinnata*	tansy-mustard	12865
BRASSICACEAE	*Descurainia sophia*	tansy-mustard	12864
BRASSICACEAE	*Draba cuneifolia*	whitlow-grass	12868
BRASSICACEAE	*Erysimum repandrum*	weedy wallflower	12945
BRASSICACEAE	*Lepidium densiflorum*	pepper-grass	12975
BRASSICACEAE	*Lepidium thurberi*	Thurber peppergrass	13026
BRASSICACEAE	*Rorippa nasturtium-aquaticum*	watercress	13004
BRASSICACEAE	*Sisybrium altissimum*	tumble-mustard	12929
CACTACEAE	*Coryphantha vivipara* var. *arizonica*	pincushion cactus	
CACTACEAE	*Echinocereus coccineus*	claret-cup cactus	12934
CACTACEAE	*Echinocereus fendleri*	Fendler hedgehog	13144
CACTACEAE	*Opuntia engelmannii* var. *engelmannii*	Engelmann prickly-pear	13041
CACTACEAE	*Opuntia macrorhiza*	plains pricklypear	13012
CACTACEAE	*Opuntia phaeacantha*	brown-spined pricklypear	13013
CACTACEAE	*Opuntia whipplei*	Whipple cholla	13020
CAROPHYLLACEAE	*Dianthus barbatus*	sweet William	
CHENOPODIACEAE	*Atriplex canescens*	four-wing saltbush	13286
CHENOPODIACEAE	*Chenopodium fremontii*	Frémont goosefoot	13286
CHENOPODIACEAE	*Chenopodium graveolens*	sage goosefoot	13157

Table 2. Continued

CHENOPODIACEAE	*Kochia scoparia*	summer-cypress	13132
CHENOPODIACEAE	*Salsola kali* ssp. *tragus*	Russian-thistle, tumbleweed	13109
CONVOLVULACEAE	*Convolvulus arvensis*	field bindweed	
CONVOLVULACEAE	*Convolvulus equitans*	hoary bindweed	12988
CONVOLVULACEAE	*Evolvulus sericeus*	silver-spider	12979
CONVOLVULACEAE	*Ipomoea coccinea*	red morning-glory	13184
CONVOLVULACEAE	*Ipomoea costellata*	ribbed morning-glory	13175
CONVOLVULACEAE	*Ipomoea purpurea*	blue-heaven morning-glory	
CUCURBITACEAE	*Curcurbita foetidissima*	buffalo-gourd	13121
CUPRESSACEAE	*Juniperus deppeana*	alligator juniper	12892
CUPRESSACEAE	*Juniperus osteosperma*	Utah juniper	12893
CYPERACEAE	*Carex occidentalis*	western sedge	
CYPERACEAE	*Cyperus fendleriana*	Fendler flat-sedge	13112
CYPERACEAE	*Scirpus pungens*	sharp three-square	13008
EQUISETACEAE	*Equisetum arvense*	horsetail	
ERICACEAE	*Arctostaphylos pungens*	point-leaf manzanita	12873
EUPHORBIACEAE	*Acalypha neomexicana*	New Mexican	13159
EUPHORBIACEAE	*Chamaesyce albomarginata*	white-margined spurge	12982
EUPHORBIACEAE	*Chamaesyce serpyllifolia*	snake-leaf spurge	13162
EUPHORBIACEAE	*Euphorbia bilobata*	spurge	13126
EUPHORBIACEAE	*Euphorbia dentata*	spurge	13124
EUPHORBIACEAE	*Tragia ramosa*	desert-nettle	13145
FABACEAE	*Astragalus humistratus*	prostrate milkvetch	12941
FABACEAE	*Astragalus tephrodes*	locoweed	12858
FABACEAE	*Calliandra humilis*	dwarf fairy-duster	12977
FABACEAE	*Dalea albiflora*	white-flowered pea-bush	13111
FABACEAE	*Gleditsia triacanthos*		13181
FABACEAE	*Lotus wrightii*	Wright deervetch	12973
FABACEAE	*Lupinus brevicaulis*	short-stemmed lupine	12926
FABACEAE	*Lupinus latifolius* ssp. *leucanthus*	Prescott lupine	13019
FABACEAE	*Medicago sativa*	alfalfa	13176
FABACEAE	*Melilotus officinalis*	yellow sweetclover	12970
FABACEAE	*Mimosa biuncifera*	wait-a-minute	13042
FABACEAE	*Phaseolus angustissimus*		13034
FABACEAE	*Psoralidium tenuiflorum*	scurvy-pea	12976
FABACEAE	*Rhynchosia senna* var. *texana*		13140
FABACEAE	*Robinia neomexicana*	New Mexican locust	13016
FABACEAE	*Trifolim wormskioldii*	Wormskiold clover	13018
FAGACEAE	*Quercus emoryi*	Emory oak	13043
FAGACEAE	*Quercus gambelii*	Gambel oak	13295
FAGACEAE	*Quercus grisea*	gray oak, Arizona oak	13279
FAGACEAE	*Quercus turbinella*	scrub oak	13044
GARRYACEAE	*Garrya wrightii*	Wright silk-tassle	
GERANIACEAE	*Erodium cicutarium*	filary	12922
GERANIACEAE	*Geranium cespitosum* var. *eremophilum*	purple geranium	13134

Table 2. Continued

GROSSULARIACEAE	*Ribes aureum*	golden currant	12889
GROSSULARIACEAE	*Ribes cereum*	wax currant	12886
IRIDACEAE	*Iris*	garden iris	
JUGLANDACEAE	*Juglans major*	Arizona walnut	13113
JUNCACEAE	*Juncus balticus*	wire rush	13007
JUNCACEAE	*Juncus nevadense* var. *badius*	nevada rush	13009
JUNCACEAE	*Juncus xiphioides*	iris-leaved rush	13000
LAMIACEAE	*Hedeoma oblongifolium*	strict false-pennyroyal	13035
LAMIACEAE	*Marrubium vulgare*	horehound	13024
LAMIACEAE	*Salvia reflexa*	annual sage	13185
LILIACEAE	*Asparagus officinalis*	common asparagus	13294
LILIACEAE	*Calochortus nuttallii*	Nuttall mariposa-lily	12940
LILIACEAE	*Dichelostemma congestum*	blue-dicks	12860
LINACEAE	*Linum lewisii*	Lewis flax	12989
LINACEAE	*Linum puberlum*	blue flax	12938
LOASACEAE	*Mentzelia*	annual blazingstar	12895
MALVACEAE	*Anoda cristata*		13123
MALVACEAE	*Malva parviflora*		13154
MALVACEAE	*Sphaeralcea fendleri*	Fendler globemallow	13158
MALVACEAE	*Sphaeralcea hastulata*	prairie globmallow	12974
MORACEAE	*Morus microphylla*	Texas mulberry	13030
NOLINACEAE	*Nolina microcarpa*	beargrass	13011
NYCTAGINACEAE	*Boerhavia coccinea*	red spiderling	13165
NYCTAGINACEAE	*Boerhavia coulteri*	Coulter spiderling	13116
NYCTAGINACEAE	*Boerhavia purpurescens*	purple spiderling	13201
NYCTAGINACEAE	*Mirabilis coccineus*	red four-o'clock	13028
NYCTAGINACEAE	*Mirabilis longiflora*	long-flowered four-o'clock	13115
NYCTAGINACEAE	*Mirabilis multiflora*	Colorado four-o'clock	
NYCTAGINACEAE	*Mirabilis oxybaphoides*	four-o'clock	13167
OLEACEAE	*Forestiera pubescens*	desert-olive	12872
OLEACEAE	*Fraxinus velutina*	velvet ash	13137
OLEACEAE	*Menodora scabra*	rough twinberry	12972
ONAGRACEAE	*Epilobium ciliatum*		13298
ONAGRACEAE	*Gaura coccinea*	red gaura	12969
ONAGRACEAE	*Gaura hexandra* ssp. *gracilis*	intermediate gaura	13029
ONAGRACEAE	*Gaura parviflora*	small-flowered gaura	13129
ONAGRACEAE	*Oenothera albicaulis*	white-stemmed evening-rose	12948
ONAGRACEAE	*Oenothera elata* ssp. *hirsutissima*	tall evening-primrose	13300
PAPAVERACEAE	*Argemone gracilenta*	graceful prickly-poppy	12996
PAPAVERACEAE	*Corydalis aurea*	golden corydalis	12896
PINACEAE	*Pinus edulis*	pinyon pine	13282
PINACEAE	*Pinus ponderosa*	ponderosa pine	
PLANTAGINACEAE	*Plantago patagonica*	silky plaintain	12981
POACEAE	*Agropyron desertorum*	crested wheatgrass	13015
POACEAE	*Agrostis viridis*		13001

Table 2. Continued

POACEAE	*Aristida divaricata*	poverty three-awn	13183
POACEAE	*Aristida orcuttiana*	Orcutt three-awn	13199
POACEAE	*Aristida purpurea* var. *fendleriana*	Fendler three-awn	13146
POACEAE	*Bothriochloa barbinodis*	cane bluestem	13141
POACEAE	*Bouteloua barbata*	six-weeks grama	13189
POACEAE	*Bouteloua curtipendula*	side-oats grama	13147
POACEAE	*Bouteloua gracilis*	blue grama	13170
POACEAE	*Bouteloua hirsuta*	hairy grama	13197
POACEAE	*Bromus diandrus*	ripgut grass	12887
POACEAE	*Bromus marginatus*		12891
POACEAE	*Bromus rubens*	red brome	12876
POACEAE	*Bromus tectorum*	soft chess	12882
POACEAE	*Chloris virgata*		13174
POACEAE	*Echinochloa crus-galli*		13292
POACEAE	*Elymus elymoides*	squirrel-tail	12924
POACEAE	*Elymus glaucus*		12994
POACEAE	*Eragrostis cilianensis*	stinking lovegrass	13164
POACEAE	*Eragrostis curvula*	weeping lovegrass	13023
POACEAE	*Eragrostis intermedia*	plains lovegrass	13204
POACEAE	*Eragrostis pectinacea* var. *pectinacea*		13172
POACEAE	*Hesperostipa neomexicana*	needle-and-thread	19243
POACEAE	*Hilaria mutica*	tobosa	
POACEAE	*Hordeum murinum* ssp. *glaucum*	powdered barley	12881
POACEAE	*Koeleria macrantha*	junegrass	12983
POACEAE	*Leptochloa dubia*	green sprangletop	13187
POACEAE	*Lycurus setosus*	wolf-tail	13146
POACEAE	*Muhlenbergia emersleyi*	bulgrass	13278
POACEAE	*Muhlenbergia fragilis*	fragile muhly	13202
POACEAE	*Muhlenbergia repens*	creeping muhly	
POACEAE	*Muhlenbergia torreyi*	ring muhly	13287
POACEAE	*Munroa squarrosa*	false-buffalograss	13108
POACEAE	*Panicum obtusum*	vine-mesquite	13151
POACEAE	*Pascopyrum smithii*	western wheatgrass	12991
POACEAE	*Piptotherum micranthum*	little Indian ricegrass	12993
POACEAE	*Poa compressa*	Canadian bluegrass	12883
POACEAE	*Poa fendleriana*	muttongrass	12857
POACEAE	*Poa pratense*	Kentucky bluegrass	12992
POACEAE	*Polypogon monspeliensis*	rabbit'sfoot grass	13003
POACEAE	*Setaria glauca*	golden bristly-grass	13290
POACEAE	*Setaria grisebachii*	Grisebach bristlegrass	13186
POACEAE	*Sorghum halapense*	Johnsongrass	13130
POACEAE	*Sporobolus airoides*	alkali sakaton	13120
POACEAE	*Sporobolus contractus*	spike dropseed	13188
POACEAE	*Sporobolus cryptandrus*	sand dropseed	13122
POACEAE	*Triticum aestivum*	wheat	12978

Table 2. Continued

POACEAE	*Vulpia octoflora*	six-weeks fescue	12930
POLEMONIACEAE	*Eriastrum diffusum*		12944
POLEMONIACEAE	*Gilia sinuata*	sinuous gilia	12862
POLEMONIACEAE	*Ipomopsis aggregata*	sky-rocket	13033
POLEMONIACEAE	*Ipomopsis multiflora*		13138
POLEMONIACEAE	*Linanthus aureus*		12877
POLEMONIACEAE	*Phlox gracilis ssp. humilis*		12864
POLEMONIACEAE	*Phlox speciosa ssp. woodhausei*	Woodhause phlox	12670
POLYGONACEAE	*Eriogonum pharnaceoides*	false-buckwheat	13119
POLYGONACEAE	*Eriogonum polycladon*	false-buckwheat	13182
POLYGONACEAE	*Eriogonum wrightii*	Wright false-buckwheat	13110
POLYGONACEAE	*Polygonum aviculare*	prostrate knotweed	13163
POLYGONACEAE	*Polygonum persicaria*	knotweed	13291
POLYGONACEAE	*Rumex crispus*	wavy-leaf dock	13017
PORTULACACEAE	*Portulaca halimoides*	hairy purslane	
PORTULACACEAE	*Talinum parviflorum*	small-flowered flameflower	13150
RANUNCULACEAE	*Aquilegia chrysantha*	yellow columbine	13006
RANUNCULACEAE	*Ranunculus testiculatus*	bur buttercup	12880
RHAMNACEAE	*Ceanothus greggii*	Gregg mountain-lilac	12871
RHAMNACEAE	*Rhamnus californica*	coffee-berry	13037
ROSACEAE	*Sanguisorba minor* ssp. *muricata*	burnet	13014
ROSACEAE	*Cercocarpus montanus*	Mountain-mohogany	13149
ROSACEAE	*Fallugia paradoxa*	Apache-plume	13039
ROSACEAE	*Malus sylvestris*	apple	
ROSACEAE	*Prunus serotina* var. *virens*	wild cherry	13128
ROSACEAE	*Purshia stansburiana*	common cliffrose	13036
ROSACEAE	*Pyrus communis*	pear	
ROSACEAE	*Rosa woodsii var. ultramontana*	wild rose	13131
RUBIACEAE	*Galium wrightii*	Wright bedstraw	13038
SALICACEAE	*Populus fremontii*	Frémont cottonwood	12999
SALICACEAE	*Populus xhinckleyana*	Hinckley cottonwood	13293
SALICACEAE	*Salix laevigata*	red willow	12694
SALICACEAE	*Salix lasiolepis*	arroyo willow	12888
SCROPHULARIACEAE	*Penstemon linarioides*	line-leaf penstemon	12971
SCROPHULARIACEAE	*Castilleja integra*	Indian paintbrush	12923
SCROPHULARIACEAE	*Collinsia parviflora*	blue-eyed-Mary	12890
SCROPHULARIACEAE	*Cordylanthus laxiflorus*	yellow bird-beak	13143
SCROPHULARIACEAE	*Mimulus guttatus*	yellow monkey-flower	13005
SCROPHULARIACEAE	*Penstemon barbatus*	bearded penstemon	13027
SCROPHULARIACEAE	*Verbascum thapsus*	mullein	13114
SCROPHULARIACEAE	*Veronica anagallis-aquatica*	speedwell	13002
SOLANACEAE	*Calibrachoa parviflora*		13297
SOLANACEAE	*Lycium pallidum*	pale wolfberry	12925
SOLANACEAE	*Physalis hederifolia* var. *palmeri*	Palmer tomatillo	13117
SOLANACEAE	*Solanum eleagnifolium*	silver nightshade	12997

Table 2. Continued

ULMACEAE	*Celtis reticulata*	net-leaf hackberry	
ULMACEAE	*Ulmus*	elm	13180
ULMACEAE	*Ulmus pumila*	Siberian elm	
VERBENACEAE	*Verbena bipinnatifida*	verbena	12932
VERBENACEAE	*Verbena gooddingii*	Goodding verbena	12859
VITACEAE	*Parthenocissus quinquefolia*	Virginia-creeper	13136
VITACEAE	*Vitis arizonica*	Arizona grape	12990
ZYGOPHYLLACEAE	*Tribilus terrestris*	goatheads, puncture-vine	13105

CONTENTS - Vegetation Mapping

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Vegetation Mapping

Introduction

In 1998 and 1999 two vegetation maps were created, one depicting the upland vegetation associations (Fig. 1) and another detailing the bottomlands within the site (Fig. 2). The maps are intended to visually depict the distribution of dominant plants within the site. The maps are to be used for a variety of purposes including aiding efforts to correlate animal distribution, diversity and abundance with habitat, in creating a baseline around which vegetation at the site may be managed and restored over time, and in identifying areas of major human disturbance.

Methods

Upland vegetation was mapped between May and September 1998 using the relative occurrence of the dominant plant species (see Munz & Keck 1949-1950, Whittaker 1962). This method was chosen because it follows traditional approaches to vegetation mapping in Arizona (Brown et al. 1979, Warren et al. 1982). The procedure generally follows that of Kulcher's comprehensive method (Kulcher 1967) and Braun-Blanquet's table method (see Ellenberg 1956). In contrast with the aforementioned mapping tenets, after community designations were made in the office (see below), upland vegetation was mapped at the more detailed, association level, in the field. The bottomland (generally riparian) vegetation was mapped at an even more detailed level. Whenever possible, individual trees were mapped. When individuals were not distinct, stands (groups) of trees were mapped as individual polygons (areas).

An aerial photograph was shot after it had been determined that all winter deciduous vegetation had leafed out. The site is 280 acres; photography scale was chosen so that the whole area would fit into one photograph. The scale was approximately 1:12,000. This photograph was used to remotely determine the major upland vegetation communities present at the site. Mylar was placed over the photograph and polygons were drawn around estimated community boundaries. These designations were then proofed in the field (using the methods described above), with revisions being made on a field copy of the base-photo/mylar. At this time, more distinct associations also were sub-divided. The same process was undertaken for the bottomlands mapping with the exception that this zone of the aerial photograph was enlarged with the use of a digital scanner which facilitated more detailed (yet time consuming) mapping.

Once all field proofing was completed, mylar boundaries were digitized in the office in IDRISI GIS. Mapping resolution was ca. 5m for the uplands and ca. 1m for the bottomlands map.

Using this software, a scaled uplands map was produced showing the following:

- Site boundaries
- Scale and North bearing
- Roads (major and minor) and structures
- All vegetation associations (each with a unique color code)
- Apache and Walnut Creeks

A bottomlands map was produced depicting the following:

- General bottomland zone boundaries
- Scale and North bearing
- Major roads (to help in assessing relative locations on the map)
- Structures
- All individuals and stands of riparian trees (each with unique color codes)
- Apache and Walnut Creeks

In addition, two other map products were produced using these base layers, one illustrating the location of geomorphic cross sections, the other showing the location of Foliar Height Density transects.

Uplands

Please refer to Fig.1, WCCER Vegetation Associations, for map reference. A total of 18 vegetation associations were mapped within the boundaries of WCCER.

The gently sloping, generally south facing slopes north of Forest Service Road 95 primarily consist of inter-gradations of Utah juniper (*Juniperus osteosperma*) and mixed graminoids (including *Bouteloua curtipendula, B. hirsuita, B. Gracilis, Aristida pupurea, Bromus rubens, Elymus elemoides* and several sub-dominant forbs). In a few areas, oak (primarily *Quercus turbinella*), and Colorado pinyon (*Pinus edulis*) also become dominant or share co-dominance. The distribution of oak here, in particular, appears to be linked to micro-climatological (cold air drainage, increased plant available-soil moisture, increased ephemeral runoff) and micro-edaphic (soil texture, depth, nutrient richness) conditions associated with ephemeral drainage patterns in this area. This is clearly demonstrated with the Utah Juniper/Scrub Oak association. Also present in this area is a small population of Wait-a Minute Bush (*Mimosa biuncifera*), growing amongst mid-sized junipers in the site's northeast corner. There also is a small patch of mixed graminoids in the northwestern corner of the site. This grassland appears to be an area that was either recently burned, pushed (with a tractor), or both.

The portion of the site south of Forest Service Road 95 consists of the Bottomlands, which is treated below, and a diverse mixture of woodland and scrubland associations. Topographically, the area encompassing the woodlands and scrublands is much more complex than the gentle slopes to the north (at the base of Juniper Mesa). This bisected environment has a number of steep, north facing slopes, several rugged rock outcrops, and a number of high gradient ephemeral washes. The gentlest terrain is found in the south and it is dominated by Manzanita (*Arctostaphylos pungens*) and some Scrub Oak (*Quercus turbinella*). Soils here are well-drained granitics, with a poorly developed or nonexistent organic horizon. Herbaceous vegetation is very scant

As one moves north, the terrain gives way to a mosaic of plant associations, Emory Oak (*Quercus emoryii*) and Scrub Oak are found together in the central drainage (and along FS Road 95) as well as Gambel's *Oak (Quercus gambelli*) and Juniper (*Juniperus spp.*) on the north facing slopes near and at base of the drainage. Soils along these north faces also are more diverse with basalt, limestone and quartzite being present. Mountain Mahogany (*Cercocarpus montanus)* also is found on the steepest slopes, facing west and northwest, just above the bottomlands.

Bottomlands

Please refer to Fig. 2, Detail for Mixed Deciduous Broadleaf Association, for map reference. The bottomlands within the site are generally dominated by mixed-deciduous broadleaf species (*Populus, Acer, Fraxinus, and Salix*) as well as a wide variety of grasses (*Pascopyrum smithii, Aristida purpurea, Bouteloua curtipendula, B. Gracilis, Bromus rubens, B. tectorum, Elymus glaucus* and others) and forbs (*Eriogonum wrightii, Erodium circutarium, Erigeron divergens, Marrubium vulgare* and others). The soils in this area are deep and primarily consist of silty-loams with some sand (in areas). Relief is minimal (+- 3m) on the valley bottom terraces, with a steep drop-off occurring near the active channels of Walnut and Apache Creeks.

Of particular interest are the asexually reproducing stands of Hinckley's cottonwood (*Populus x hinckleyana*) that are found throughout the area in close proximity to the active channel of Walnut Creek. It appears that there are at least six distinct stands (individuals) of this hybrid between Fremont cottonwood (*Populus fremontii*) and Narrowleaf cottonwood (*Populus angustifolia*). In addition to the fact that no known populations of *P. angustifolia* exist upstream from the site (suggesting that these are Pleistocene relicts), many of these individuals also are sprouting rigorously from the cutbanks along Walnut Creek. This has many implications. First, it appears that exposure to air (no longer being below ground) stimulates rapid root sprouting. In this case, these roots have been exposed along a cutbank. Where Hinckley's cottonwood is not present, the cutbank is eroding quite rapidly. Where this species is present, the bank is being stabilized quite well, and is maintaining a steep grade. This sprouting is also likely armoring the bank from flooding. It also should be noted that there are a few cases of root sprouting occurring up on the terraces as well. Although much less frequent, it is difficult to tell if these were initiated by exposure of lateral roots. It is possible that the local population of Botta's pocket gopher (*Thomomys bottae*) may be exposing these roots within their tunnels, thus initiating sprouting on the terraces.

Another interesting pattern that has been revealed by mapping the bottomlands is the presence of middle to large sized junipers on the terraces north of Walnut Creek (with the exception of the northeast corner). These junipers (and a few other upland species) are inter-grading with relict phreatophytes - creating a terrace ecotone between uplands and bottomlands. Throughout the area north of Walnut Creek, Arizona walnut (*Juglans major*) is the most common co-dominant with juniper, but there also are stands of Boxelder (*Acer negundo*), Texas mulberry (*Morus microphylla*), New-mexican locust (*Robinia neomexicana*), Southwest chokecherry (*Prunus serotina*) and other facultative riparian species here. These woody species, along with a very diverse and abundant grass/forb groundcover show this to be a very structurally diverse area with high plant species richness. It is likely that this mixing has occurred in the past 100 years as the terrace has remained stable. Phreatophytes that need flood related disturbance (species that also tend to be shade intolerant) are no longer recruiting here; a few dead and dying individuals of Fremont cottonwood and Red willow can be found, but no juveniles were observed. As the juniper move into this rich alluvial zone, they grow with vigor to heights exceeding individuals in nearby uplands. Shade tolerant phreatophytes such as Arizona walnut and Boxelder are still recruiting here. These species have seed ecologies that are better suited for establishment in stable, occupied habitats due to larger cotyledons/greater carbohydrate

stores (in comparison to early sucessional species such as Salix and Populus which have extremely small seeds that are adapted to open habitats such as sand bars). It also is very likely that the area around the existing buildings also would have been occupied by junipers (and possibly oak) had this area not been mechanically cleared and maintained over time.

As expected, classic, early successional phreatophytes (*Salix lasiolepis*, *S. laevigata*, *S. exigua* and *Populus fremontii*) are almost exclusively recruiting within the floodprone zone along the active channel. These species are clearly regenerating in a zone characterized by the presence of water within one foot of the surface, high levels of direct sunlight, frequent flood disturbance, and minimal coverage by herbaceous perennials and annuals. While these species have distributions outside of the floodprone zone, these individuals are usually mature to old (and dying[1]).

Mixed age stands of Boxelder and to a lesser degree, Velvet ash (Fraxinus velutina) are present throughout the area, but primarily are present on the south side of Walnut Creek. It is unclear why Boxelder has greater abundance in this area; it may have to do with long term human habitation on the north side of the creek. From a soils and micro-climate perspective, both sides of the creek represent ideal habitat for the Boxelder. It is possible that the south side has seen more overflow flooding in the past several decades.

Future Research

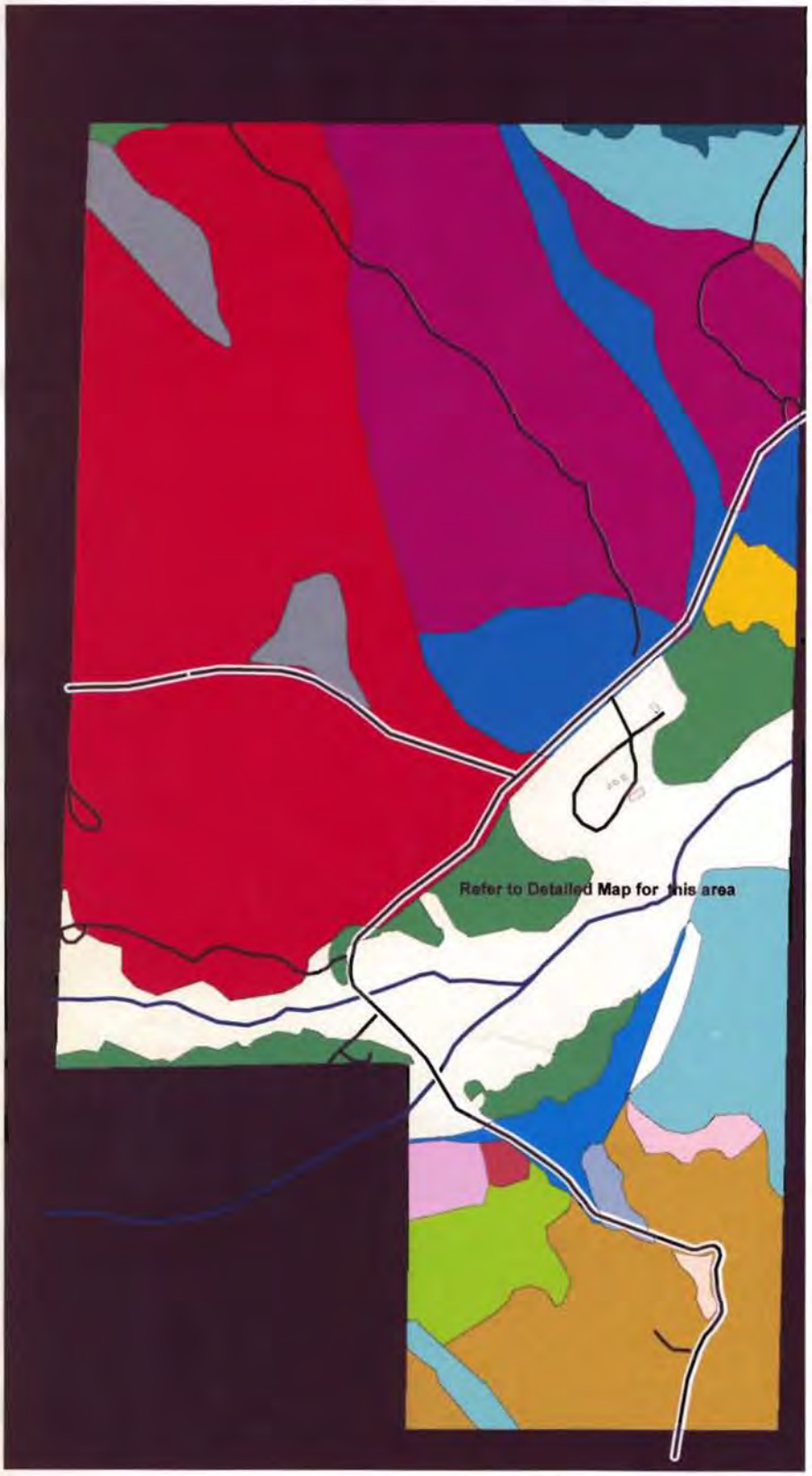
The opportunity for future research to build upon these initial studies is limitless. From a management and restoration perspective, the most fruitful paths will be ones that illuminate ecological processes and relationships as they pertain to human use and maintenance of the area. In the uplands, long term remapping (every 25-50 years) would likely provide enough insight to monitor vegetation change over time. This would not be the case if any disturbance (such as fire), long term drought, or several years of excessive rainfall occurred. In these cases, remapping should occur sooner (or just after the perceived perturbation).

Remapping of the bottomlands on a set schedule (possibly every ten-years) would provide a good "snap-shot" of succession throughout this area over time. Remapping would have to be more frequent here due to the cyclically disturbed nature of the riparian system

Bottomlands data also will be particularly valuable when analyzed in conjunction with Foliar Height Density data and Geomorphic data. Should any major realignments occur in either Apache or Walnut Creeks, subsequent mapping would prove very valuable. This not only would illuminate succession in areas that the active channel has abandoned, but it would also document early succession along the new active channel alignment. These trends could be documented simply by remapping the area where the channel was (at the time of this mapping) and then mapping the area associated with the new channel alignment.

[1] Dying is defined as having more dead biomass (above ground) than evident, live structure.

WCCER VEGETATION ASSOCIATIONS



Map is registered in NAD27 12S Datum
December 1998

- Outside of Project Boundaries
- Utah Juniper/Colorado Pinyon
- Utah Juniper/Scrub Oak
- Arizona Walnut/Utah Juniper
- Mixed Grassland/Utah Juniper
- Utah Juniper/Mixed Grassland
- Mixed Grassland
- Mixed Deciduous Broadleaf
- Utah Juniper/Wait-a-minute Bush
- Gam Oak/Ut Juniper/Alig Juniper
- Emory Oak/Scrub Oak
- Scrub Oak
- Manzanita/Scrub Oak
- Col Pinyon/Ut Jun/Mixed Grass
- Mountain Mahogany/Scrub Oak
- Manzanita/Colorado Pinyon
- Mixed Grass/Col Pinyon/Mt Mahog
- Scrub Oak/Colorado Pinyon
- Scrub Oak/Mixed Grassland

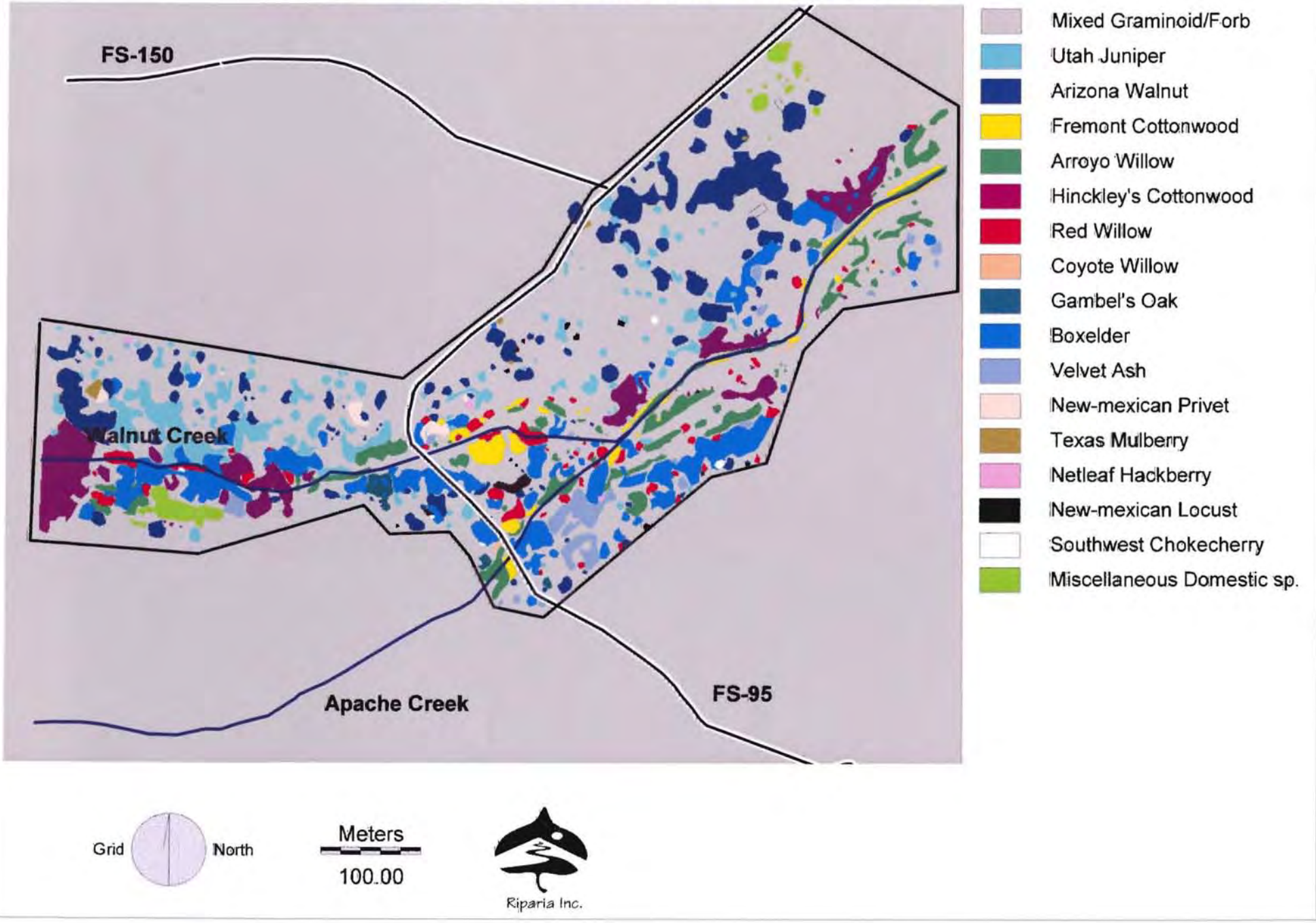
Grid North

Meters
100.00

Riparia Inc.

Fig. 2

Detail For Mixed Deciduous Broadleaf Association



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Volumetric (Structural) Vegetation Survey

Introduction

In 1998 a volumetric (structural) vegetation (a.k.a. foliar height distribution) survey was undertaken at the WCCER site. The foliar height distribution survey was conducted to estimate community vegetation structure and gather tabular and graphic data representing how the woody and herbaceous vegetation in the bottomlands at Walnut Creek appears. In essence, the graphs presented herein can be viewed as "snapshots" of the forest from the side. One can "see" the relationship between the canopy, mid, and understory in each transect when viewing the graphs. Such baseline data will provide researchers (professional, academic, or student) an excellent tool with which to compare future data or qualitative changes in the vegetation structure at the Walnut Creek Center for Education and Research. Additionally, foliar height distribution for plant associations correlates closely with breeding bird densities (Mills et al. 1991). Since the research program at WCCER includes birds and mammals, in addition to vegetation, the value of this information is significantly increased.

Methods

FHD Transects

Foliar Height Distribution transects were installed at ten locations in the existing and historic floodplains (bottomlands) at Walnut Creek. General locations were chosen in the office and marked on maps to include a variety of vegetation associations identified during the vegetation-mapping phase of the project. Field technicians then randomly located the actual starting points for each transect. A map (Fig. 1) is included with the starting point (SP) of each transect marked.

Reference points (RP) for each transect were selected throughout the site such that they were as evenly distributed as possible and easily relocatable. Each reference point was marked with a fluorescent orange-painted 18 inch long rebar rod (with at least 6 inches showing above ground). The point was then photographed along with a reference placard. A GPS coordinate was then taken (Tables 1 & 2).

Transects were established along randomly determined headings (n degrees of magnetic north) from starting points at a randomly determined distance from the reference points. To avoid boundary effects, starting points were established at least 40 meters from the site boundaries. The transects were delineated along the determined heading for 20m then, pivoted to the right such that the remaining 20m was perpendicular to the first 20m. The turn in the transects was made to minimize the effects of linear influences, such as those caused by old canal banks and drainages. Each starting (SP), pivot (PP), and ending point was marked with rebar and each starting point and pivot point was photographed using a reference placard listing the date, transect number, and "SP" or "RP". Rebar was not placed in water-saturated soil.

Vegetation volume measurements and Diameter at Breast Height (DBH) were taken for each tall-growing woody species every two meters along the transect, beginning with meter two. A nine meter telescoping fiberglass pole was set vertically, and live vegetation

within 1dm (horizontally) of the pole was recorded as "hits" within height increments of 1m. This was done by recording the acronym of the plant species that fell within a particular meter mark on the pole. Thus, for each 20m transect, vegetation volume, according to species, was sampled within ten vertical cylinders with a radius of 1dm. Since raising poles above nine meters was impractical, if not impossible, rough estimates of vegetation volume above nine meters were made.

At each 2m point along each transect a 20cm by 50cm Daubenmire Grid was laid on top of the herbaceous layer and the percent cover of herbs estimated by counting the number of squares occupied and dividing by 10. Cover was recorded as cover classes one through seven (1=<1%, 2=1-5%, 3=5-25%, 4=25-50%, 6=75-95%, 7=95-100%).

Streamside Transects

Four transects were located near, or crossing, the streams at WCCER. Two transects cross Walnut Creek. Meters 0-20 of these transects cross perpendicular to the channel before pivoting 90 degrees and generally paralleling the channel. Two transects had a starting point near the bankful mark. From the starting point at bankful, transects ran up to the terrace and then pivoted 90 degrees to generally parallel the channel.

Calculations

Calculations of total foliar height densities, frequencies, relative densities, and size class diversity for the major woody riparian species were not calculated due to a general lack of data. Once data collection was complete it became apparent that not enough individuals fell within one meter of the transect for such calculations to be made. For instance, DBH data was collected in the first 5 transects, but only two trunks actually fell within the sample. Since calculations were not made, and due to the fact that this is a *baseline* study, we have included below short narratives for all transects.

Foliar Height Distribution Transects

Ten transects were surveyed with an observance of more than 80 plant species. Refer to transect photo-logs and associated data graphs (pp. 51-80).

Transect 1: Is located in a remnant walnut grove near the barn and main entrance to the facility. Woody vegetation solely consists of Arizona Walnut (*Juglans major*). The herbaceous cover below the walnuts includes Horehound (*Marrubium vulgare),* Bromes (*Bromus spp.*), and Dandelion (*Taraxacum laevigatum).* Despite the presence of one native grass, the aforementioned species indicate significant disturbance (most likely by human trampling, stock grazing, and mowing) to the area.

Transect 2: Is located on a historic floodplain terrace of Walnut Creek near the western border of the property. The transect contains Utah Juniper (*Juniperus osteosperma),* Colorado Pinyon (*Pinus edulis*), and Arizona Walnut with dense and open canopy

alternating in ca. 6 meter intervals. The herbaceous layer is characteristically sparse under the dense juniper canopy. This area shows less disturbance than T1.

Transect 3: Is located in the floodprone zone of Walnut Creek near the eastern border of the property. Meter 0 is located farthest from the active channel, while meters 20—40 parallels more closely the channel. The vegetation reflects this relationship. There is low herbaceous cover (most likely due to scouring and gravelly substrates) with sand dropseed (*Sporobolus cryptandra*) present.

Transect 4: Is found in a large Hinkley's cottonwood (*Populus x. hinckleyana*) grove on a high terrace just above Walnut Creek. Note the high canopy of the early successional obligate species with later recruitment of shade-tolerant species below. The herbaceous cover consists mainly of litter from the cottonwood, boxelder (*Acer negundo*) and New-mexican privet (*Forestiera neomexicana*). Some wheat grass is present.

Transect 5: Begins on the active channel of Apache Creek (ca. 50 meters upstream from the confluence with Walnut Creek). Meters 0—20 span the floodprone area to the upper terrace at river-left. Meters 20—40 on the terrace generally parallel the channel. There is a nearly vertical (ca. 3.5m) cutbank on river-right of the channel where this transect is located. Note riparian obligate species on terrace and facultative species on the bank of the creek. Annual grasses are found below facultative trees on the bank while litter dominates terrace cover.

Transect 6: Is located on right side of Walnut Creek ca. 150 meters upstream from its confluence with Apache Creek. All the Fremont cottonwood (*Populus fremontii)* in this transect is one large individual. All other woody species are found in several dense clusters below the cottonwood. The ground cover is dominated by litter from the cottonwood and some other woody species.

Transect 7: Is located in a historic pasture located near the entrance to the facility. The transect is located near the eastern border of the property. No woody species are present on this transect. It is likely that they were cleared by humans and maintained by constant stock grazing. Many years of accumulated litter dominate the ground cover. Philaree (*Erodium circutarium*) and bindweed (*Convolvulus spp.)* are present. Although the data does not show it, it is noteworthy to mention that several large stands of Alkali sacaton (*Sporobolus airoides*) are present very close to this transect.

Transect 8: Is found on the left side of Walnut Creek and continues onto the terrace. Large Hinkley's cottonwoods dominate the transect with additional recruitment of other riparian tree and shrub species occurring. Many root sprouts from the large Hinkley's cottonwoods appear in the transect as well. Litter dominates the ground cover below the hybrid cottonwood canopy. Ragweed (*Ambrosia psilostachya*) and mixed grasses also are present.

Transect 9: Crosses the active channel near the western border where Walnut Creek enters the property. Riparian vegetation has been clear-cut on the neighboring, upstream, property. This transect is located in an old Hinkley's cottonwood grove. Unlike many

other areas with this cottonwood, little to no root sprouting is occurring. Litter and bare ground dominate the cover below the hybrids. Significant amounts of Ragweed and Horehound suggest past disturbance.

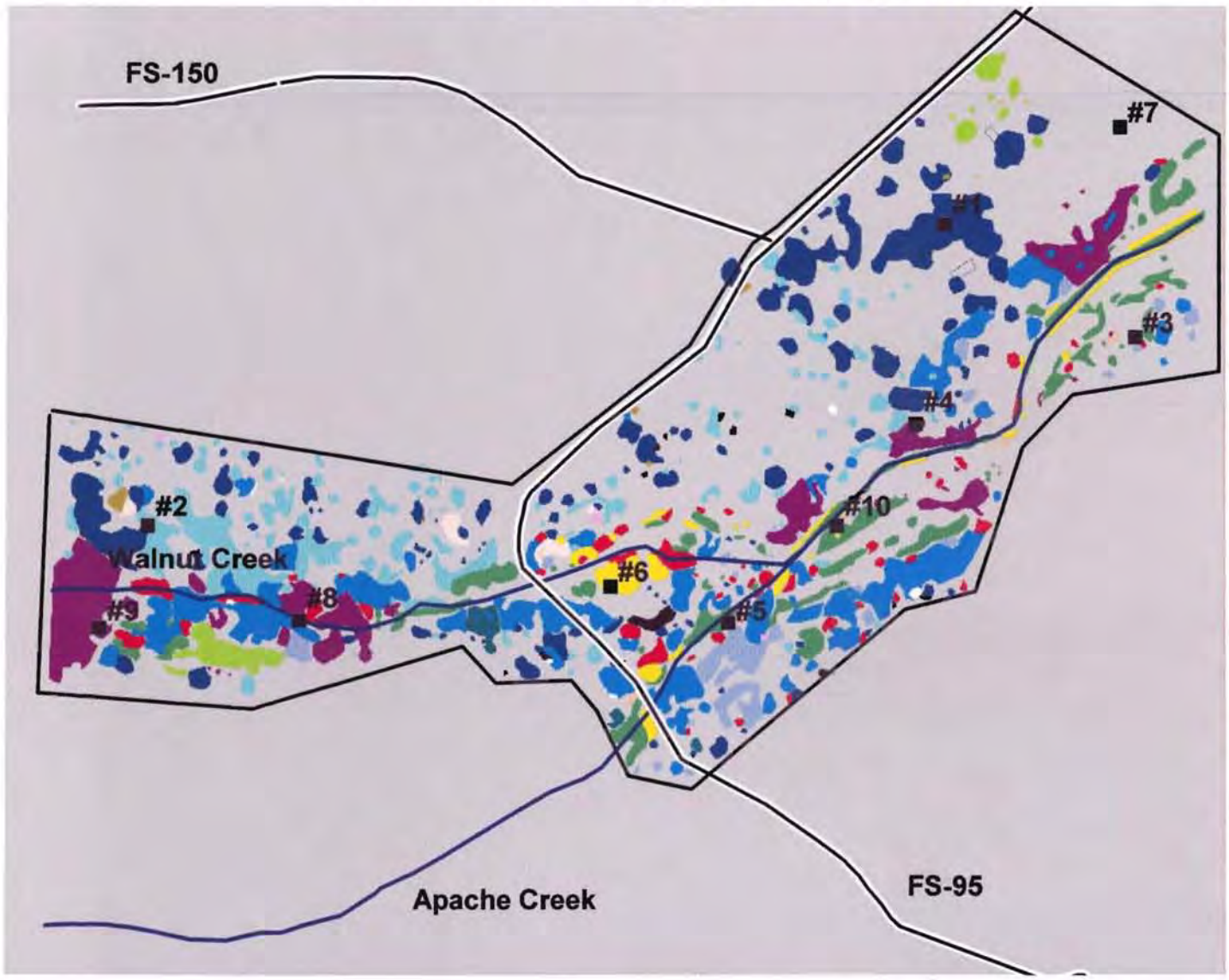
Transect 10: Crosses Walnut Creek ca. 75 meters downstream from its confluence with Apache Creek. Meters 0—20 cross the channel, while meters 20—40 parallel the channel in the floodprone zone just below the terrace. Coyote willow (*Salix exigua*) dominates with three tree species lightly interspersed. Bare ground and litter dominate the cover. Yellow columbine (*Aquilegia chysantha*) is locally common. Bent grass (*Agrostis semiverticillata*) and ragweed are present.

Future Research

With a change in management (from Forest Service to the Walnut Creek Partnership) it is likely that the riparian vegetation community will change. Therefore, it is recommended that the Foliar Height Distribution transects be re-surveyed on a regular basis. Re-sampling every five years should provide good data for monitoring structural changes that are related to successional processes. With the removal of stock grazing, aquatic and emergent vegetation also may expand in abundance and diversity in and around the streamside transects. It is also possible that perennial native grasses may recover and begin out-competing invasive exotics such as Horehound and Brome with the removal of anthropogenic disturbance. These potential changes can be easily documented by repeating this methodology. Additional transects should be established in zones where controlled burns and other such human induced management/restoration strategies are applied. Should any major, natural disturbances take place in the lowlands, these baseline transects should prove invaluable for quantifying the true short and long term changes associated with such perturbations.

Fig. 1

Foliar Height Density Transect Locations



- Mixed Graminoid/Forb
- Utah Juniper
- Arizona Walnut
- Fremont Cottonwood
- Arroyo Willow
- Hinckley's Cottonwood
- Red Willow
- Coyote Willow
- Gambel's Oak
- Boxelder
- Velvet Ash
- New-mexican Privet
- Texas Mulberry
- Netleaf Hackberry
- New-mexican Locust
- Southwest Chokecherry
- Miscellaneous Domestic sp.

Black squares and associated numbers are the start points for the Foliar Height Density Transects.

Grid North

Meters
100.00

Riparia Inc.

Table 1. GPS Data for FHD Transects (Walnut Creek).

Transect	Garmin GPS
T1RP	331589
	3866053
T1SP	331573
	3866057
T2RP	330967
	3865806
T2SP	330936
	3865786
T3RP	331747
	3865929
T3SP	331745
	3865958
T4RP	331604
	3865918
T4SP	331566
	3865902
T5RP	331394
	3865767
T5SP	331410
	3865734
T6RP	331318
	3865745
T6SP	331307
	3865743
T7RP	331647
	3866090
T7SP	331333
	3866146
T8RP	331084
	3865769
T8SP	331102
	3865746
T9RP	330896
	3865767
T9SP	330892
	3865732
T10RP	331490
	3865872
T10SP	331526
	3865834

Table 2. Foliar Height Distribution--Photo Log

Location Codes: RP = Reference Point, SP = Start Point, PP = Pivot Point

Transect	Date	Roll #	Frame #	Location Code	Compass Bearing	Description
T1	10/6/98	1	7	RP	260	Red and White spigot east of road to barn
	"	"	8	SP	138	From above rebar
	"	"	9	PP	228	"
T2	10/15/98	2	12	RP	79	Located below ACNE/JUMA& snag clump ~71m from west boundary. Clump just off old road. Foto from ~12 from rebar.
	"	"	13	SP	310	Begins below large JUOS with broken limb. Foto from 5m away from rebar.
	"	"	14	PP	40	Foto from above rebar.
T3	10/7/98	1	13	RP	248	Foto ~5m from rebar at eastern fence.
	"	"	14	SP	335	Foto ~5m from rebar.
	"	"	15	PP	328	"
T4	10/7/98	1	16	RP	46	Located below JUMA behind barn (between corral and quartzite dike). Foto ~5m from rebar.
	"	"	17	SP	238	SW of lg. POFR snag on river left.
	"	"	18	PP	328	Foto ~5m from rebar.
T5	10/29/98	3	4	RP	180	Located on river right of Apache Creek. Rebar at base of ACNE ~6m from cut bank where large cable exits bank. Foto from edge of bank.
	"	"	5	SP	318	Looking up north bank of Apache Creek. Fot from above rebar.
	"	"	6	PP	48	Pin located in front of lg. Wooden box with lg. ACNE fallen on top of it. Foto from above rebar.
T6	10/14/98	2	2	RP	284	Located at base of lg. POFR between Walnut & Apache Creeks. NE of poperty boundary "notch."
	"	"	3	SP	320	Foto from above rebar.
	"	"	4	PP	50	"
T7	10/7/98	1	10	RP	226	Located at fence corner behind ranch house. Foto ~5m from rebar.
	"	"	11	SP	46	Foto ~5m from rebar.
	"	"	12	PP	136	"
T8	10/29/98	3	7	RP	113	Located on river left of Walnut Creek above road crossing. Looking towards creek, note rocky hill in background. Foto ~8m from rebar.
	"	"	8	SP	338	Looking up north bank of Walnut Creek from below lg. JUMA.
	"	"	9	PP	68	Foto from above rebar.
T9	10/15/98	2	15	RP	321	Located near Walnut Creek and property boundary intersection. RP located below large POHI. Foto ~7m from rebar.
	"	"	16	SP	253	Foto shot from ~1m north of rebar due to obstructions. Located on east side of Walnut Creek.
	"	"	17	PP	343	Foto ~5m from rebar.
T10	10/29/98	3	1	RP	290	Located on river left ~100m downstream from Apache and Walnut Creek junction. Rebar at base of lg. ACNE
	"	"	2	SP	138	Foto from above rebar.
	"	"	3	PP	228	"

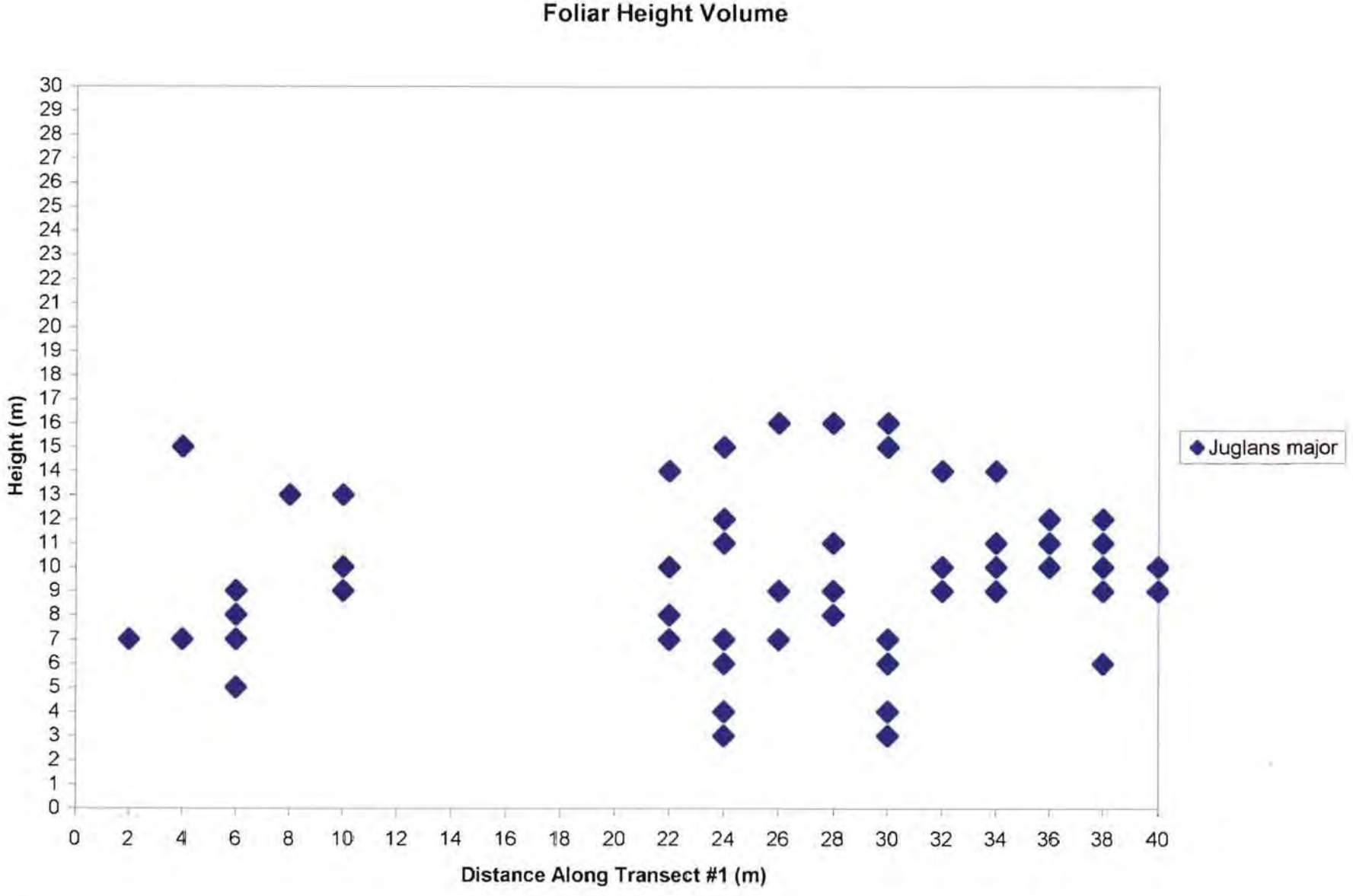
Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 1

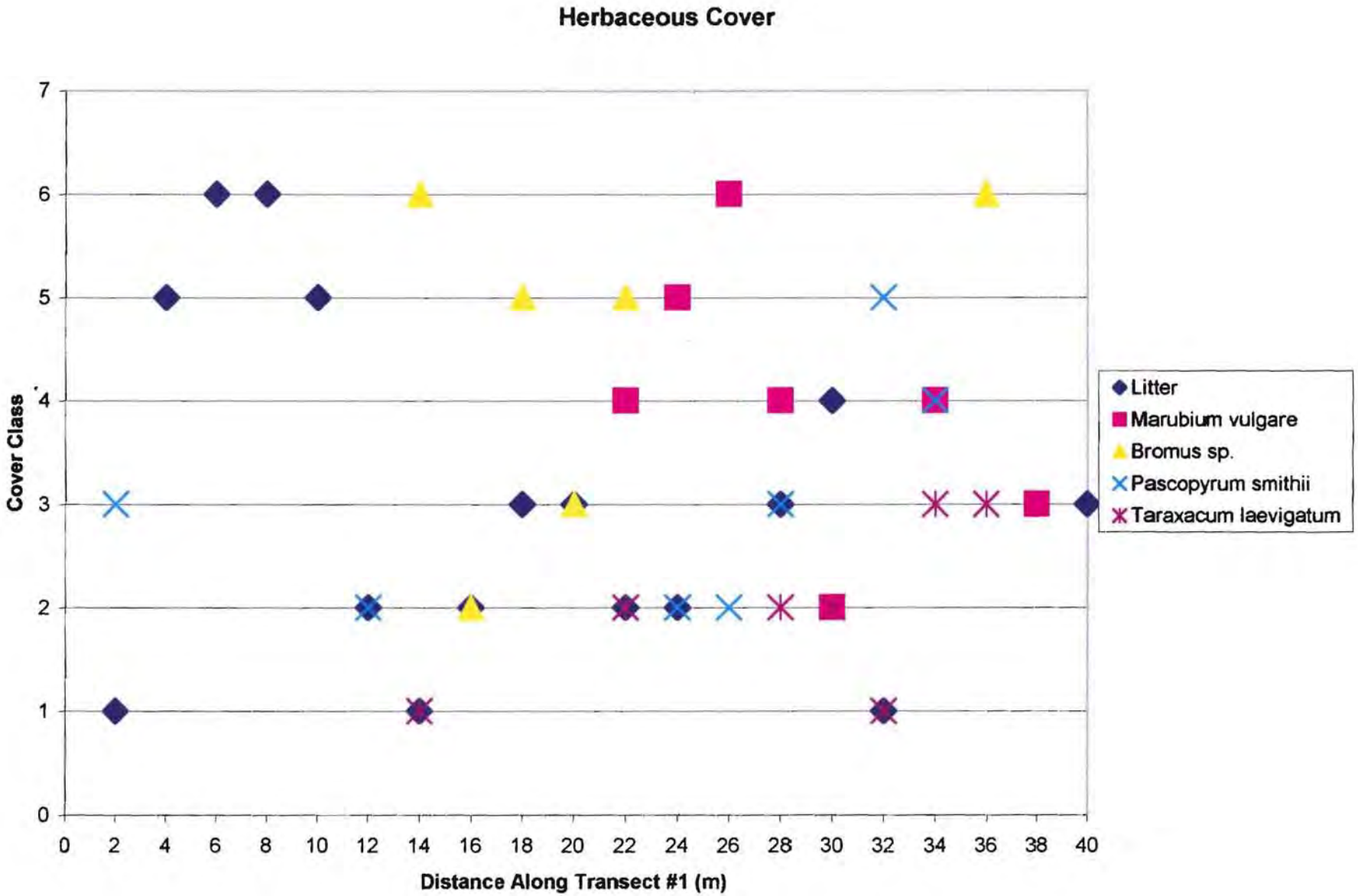
RP

SP

PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T1	10/6/98	RP	260	Red and White spigot east of road to barn
	"	SP	138	From above rebar
	"	PP	228	"

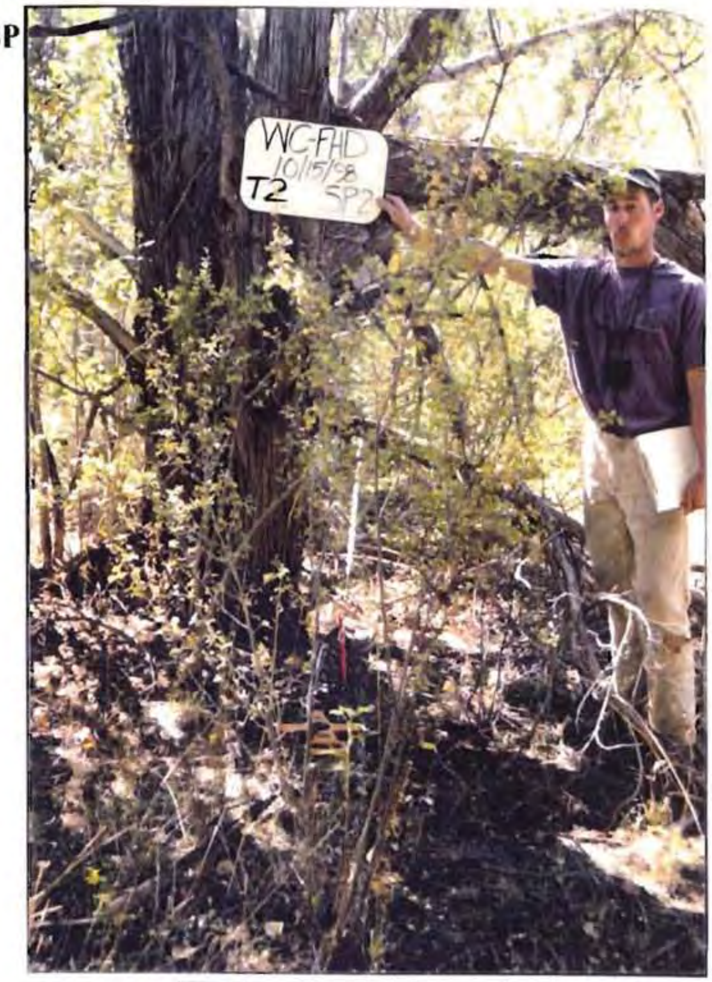

Foliar Height Volume
Height (m)
Distance Along Transect #1 (m)
Juglans major
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40


Herbaceous Cover
Cover Class
Distance Along Transect #1 (m)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Litter
Marubium vulgare
Bromus sp.
Pascopyrum smithii
Taraxacum laevigatum

Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 2

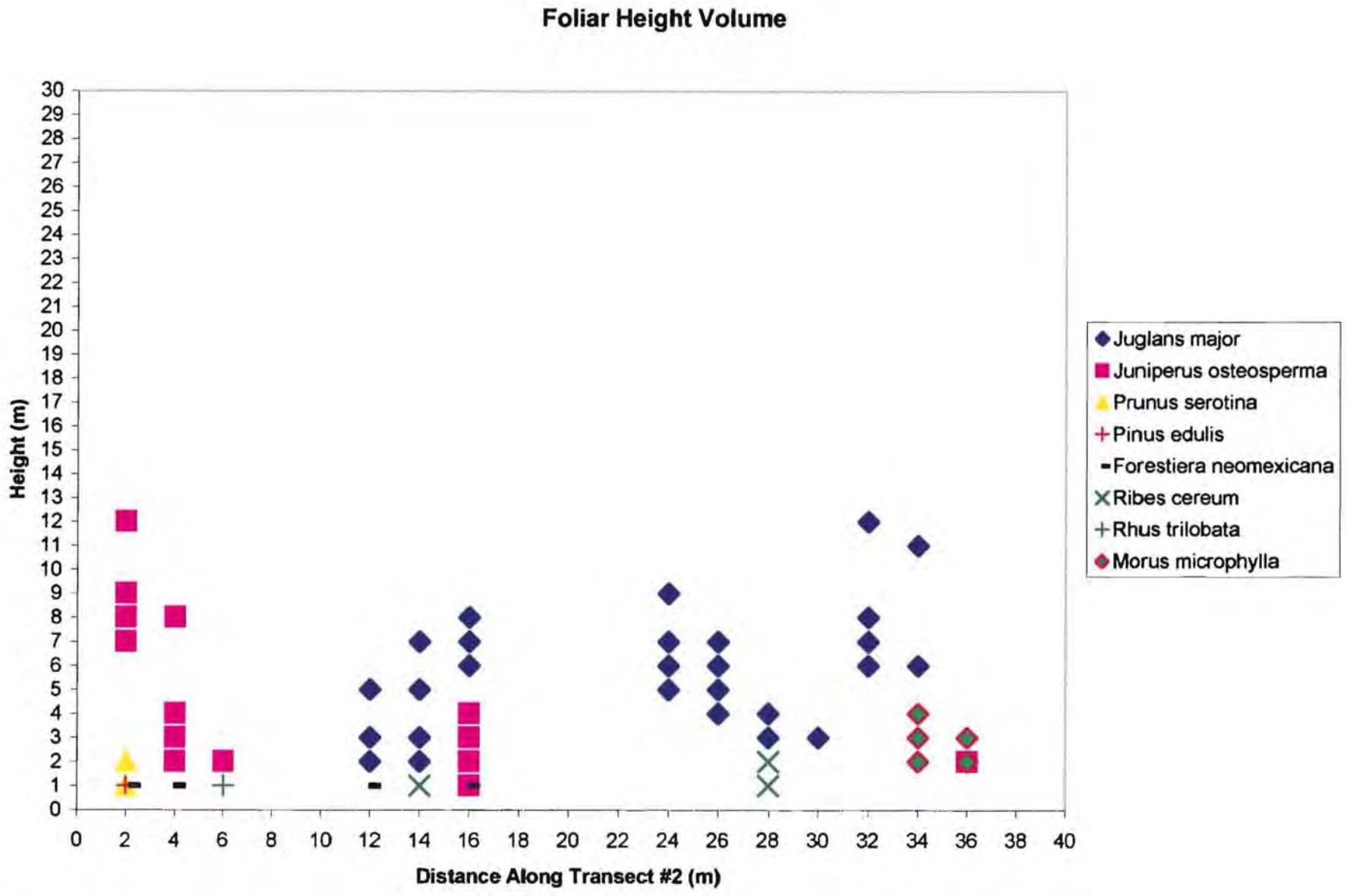
RP

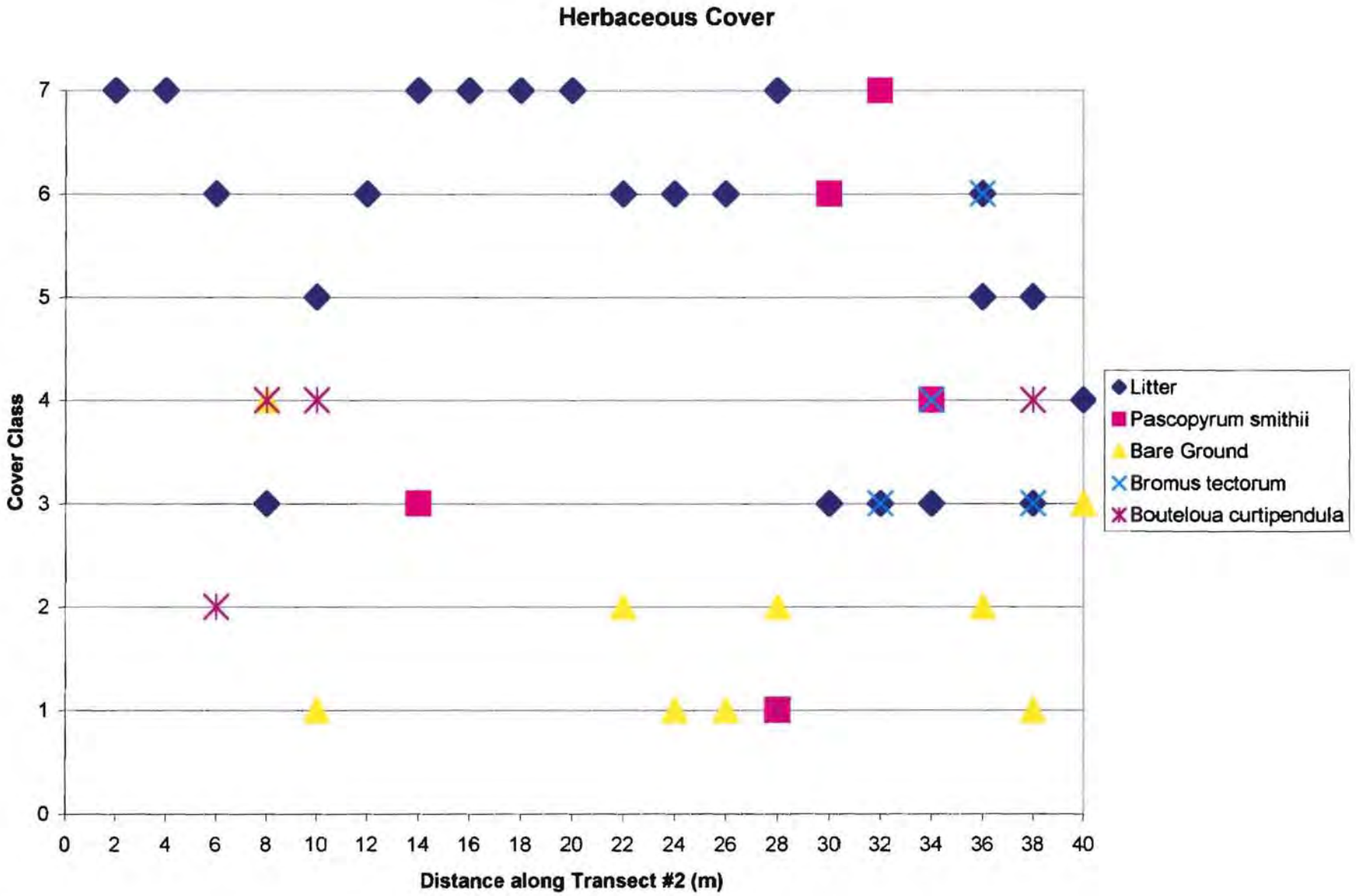
SP



PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T2	10/15/98	RP	79	Located below ACNE/JUMA& snag clump ~71m from west boundary. Clump just off old road. Foto from ~12 from rebar.
	"	SP	310	Begins below large JUOS with broken limb. Foto from 5m away from rebar.
	"	PP	40	Foto from above rebar.

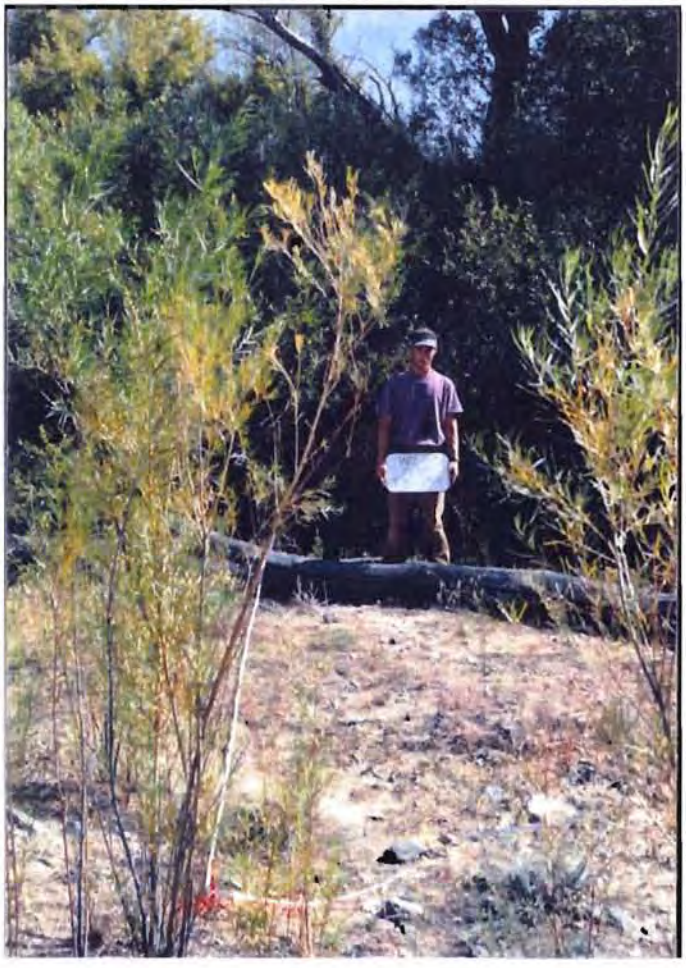

Foliar Height Volume
Height (m)
Distance Along Transect #2 (m)
Juglans major
Juniperus osteosperma
Prunus serotina
Pinus edulis
Forestiera neomexicana
Ribes cereum
Rhus trilobata
Morus microphylla


Herbaceous Cover
Cover Class
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Distance along Transect #2 (m)
Litter
Pascopyrum smithii
Bare Ground
Bromus tectorum
Bouteloua curtipendula

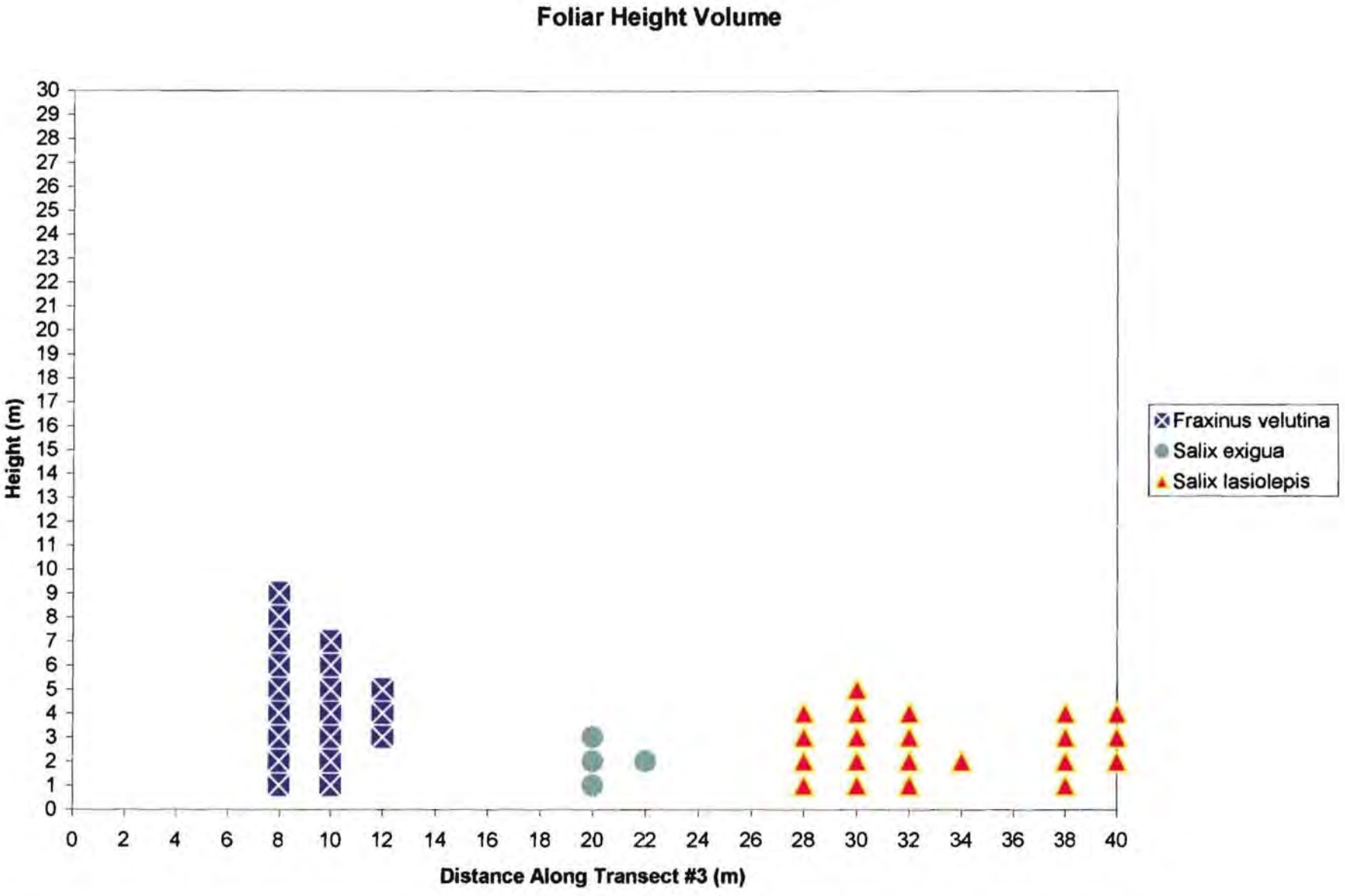
RP

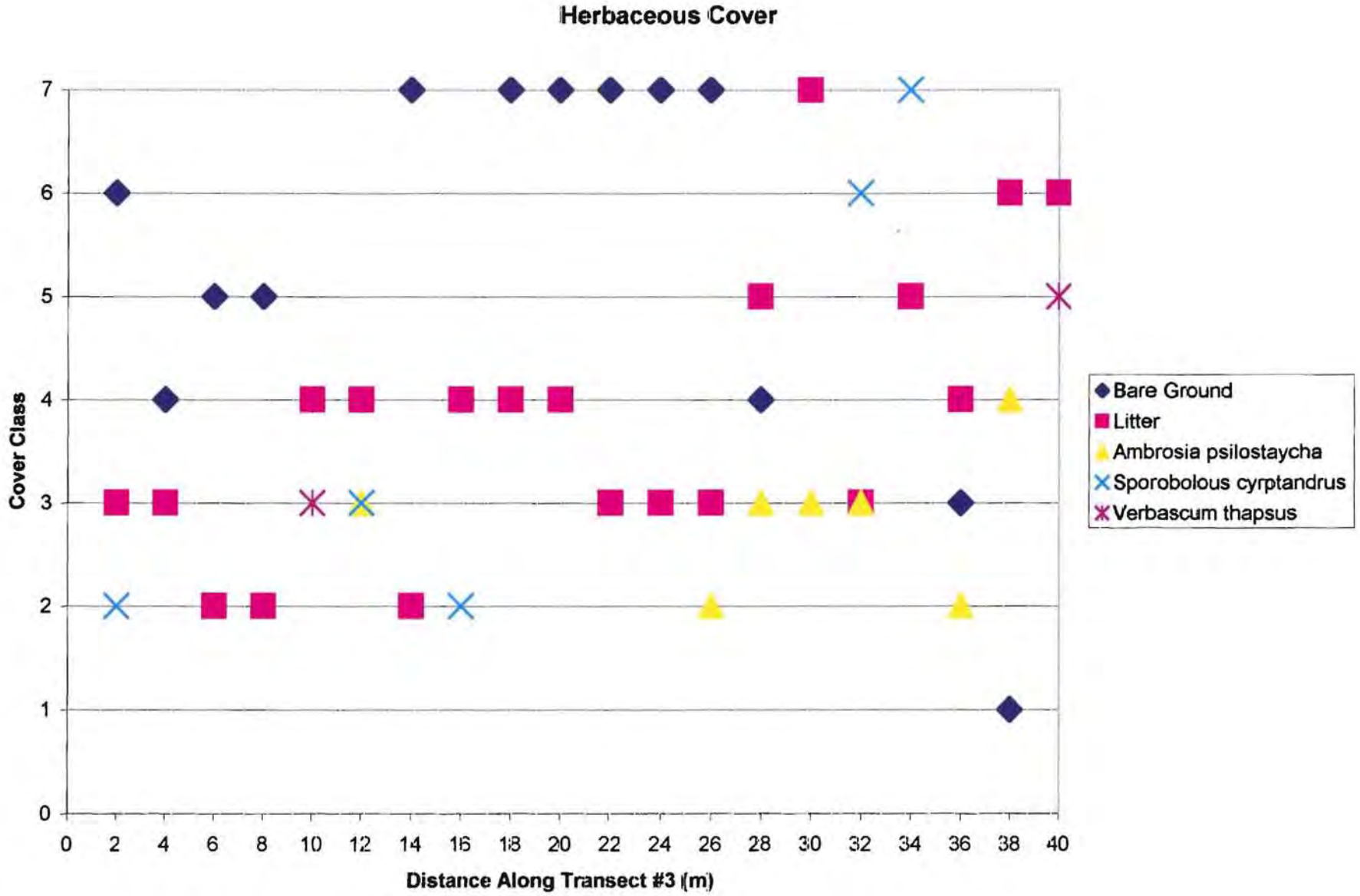
SP

PP



Transect #	Date	Location Code	Compass Bearing in degrees	Description
T3	10/7/98	RP	248	Foto ~5m from rebar at eastern fence.
	"	SP	335	Foto ~5m from rebar.
	"	PP	328	"


Foliar Height Volume
Height (m)
Distance Along Transect #3 (m)
Fraxinus velutina
Salix exigua
Salix lasiolepis

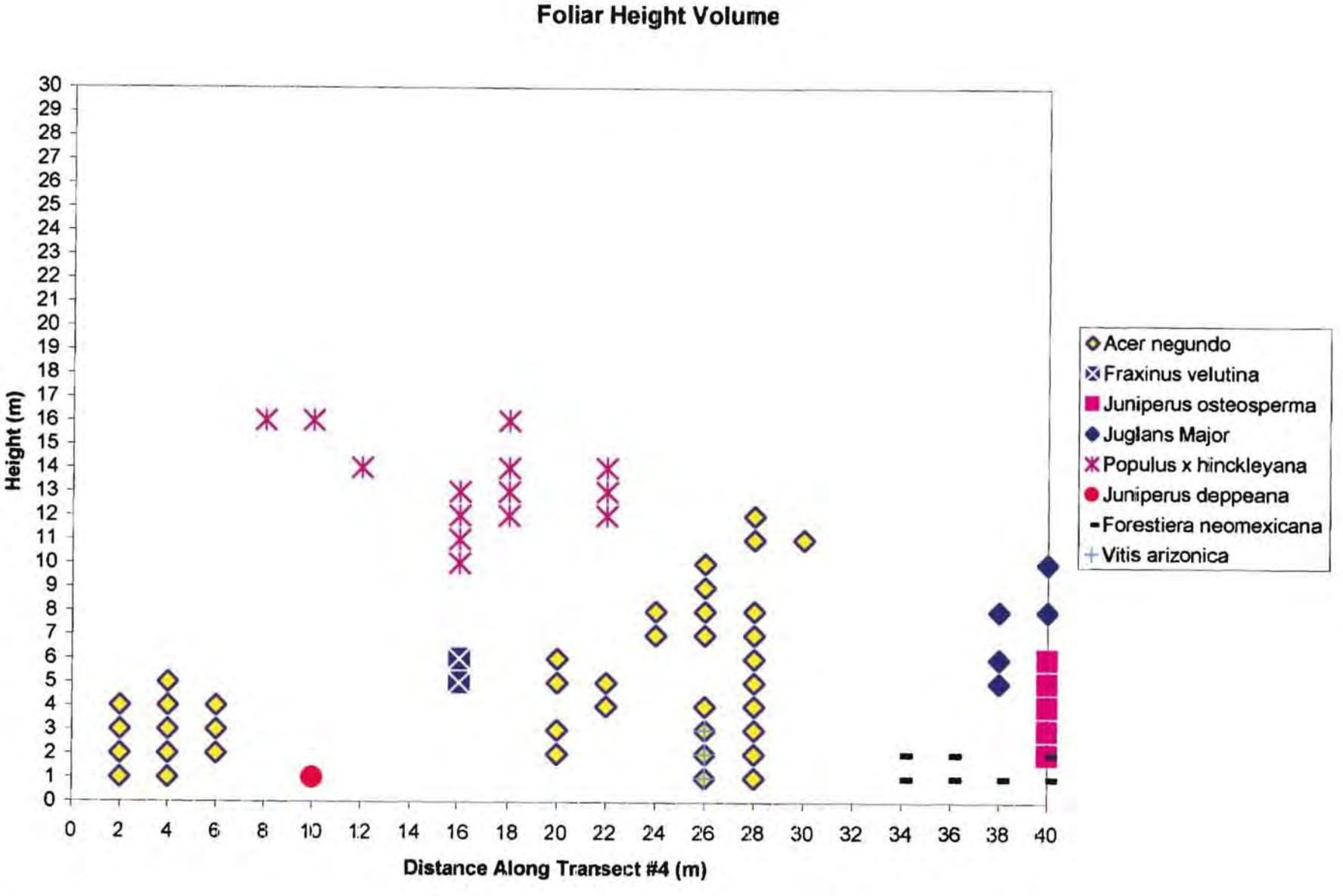

Herbaceous Cover
Cover Class
Distance Along Transect #3 (m)
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Bare Ground
Litter
Ambrosia psilostaycha
Sporobolous cyrptandrus
Verbascum thapsus

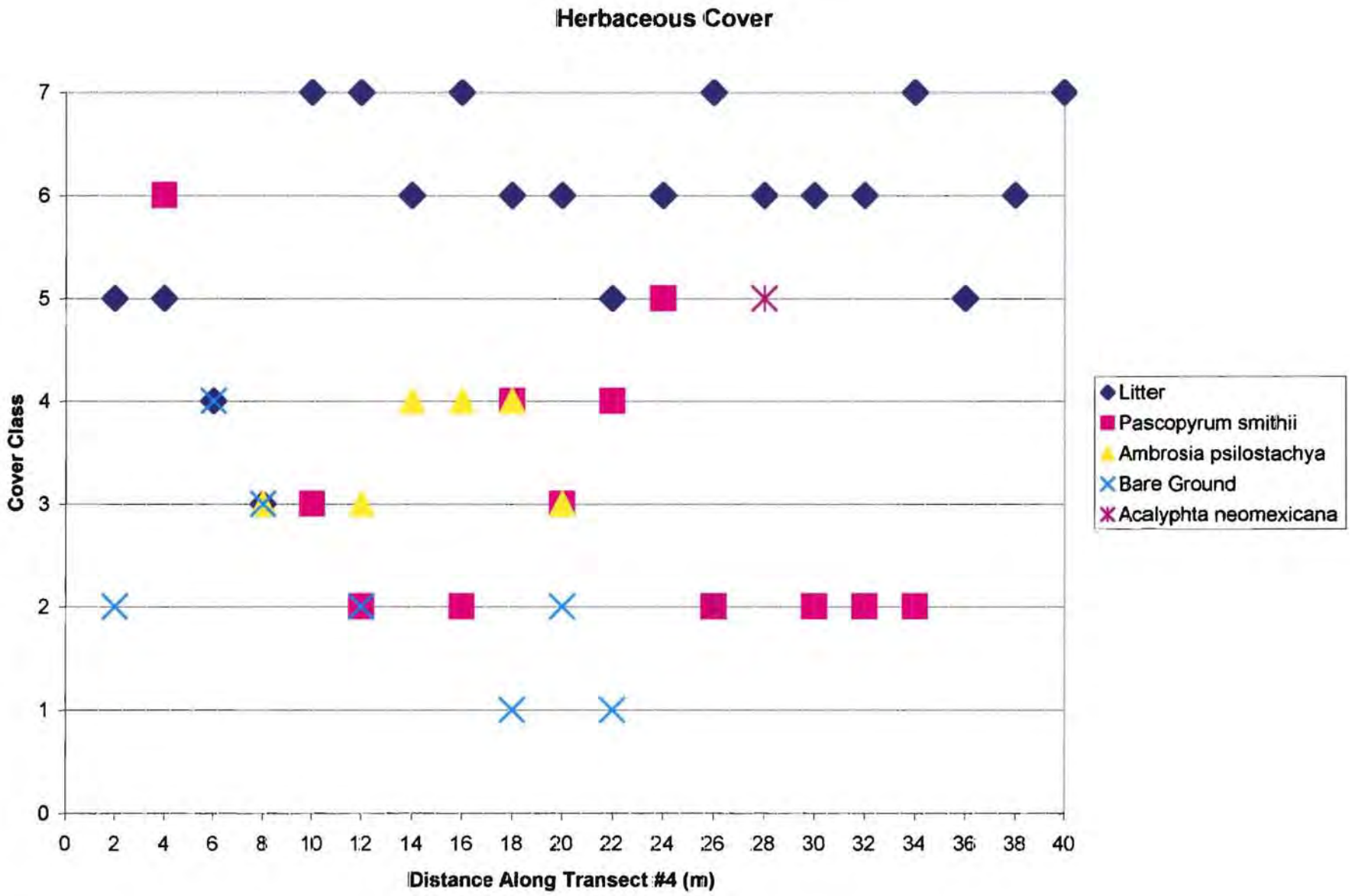
RP

SP

PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T4	10/7/98	RP	46	Located below JUMA behind barn (between corral and quartzite dike). Foto ~5m from rebar.
	"	SP	238	SW of lg. POFR snag on river left
	"	PP	328	Foto ~5m from rebar.

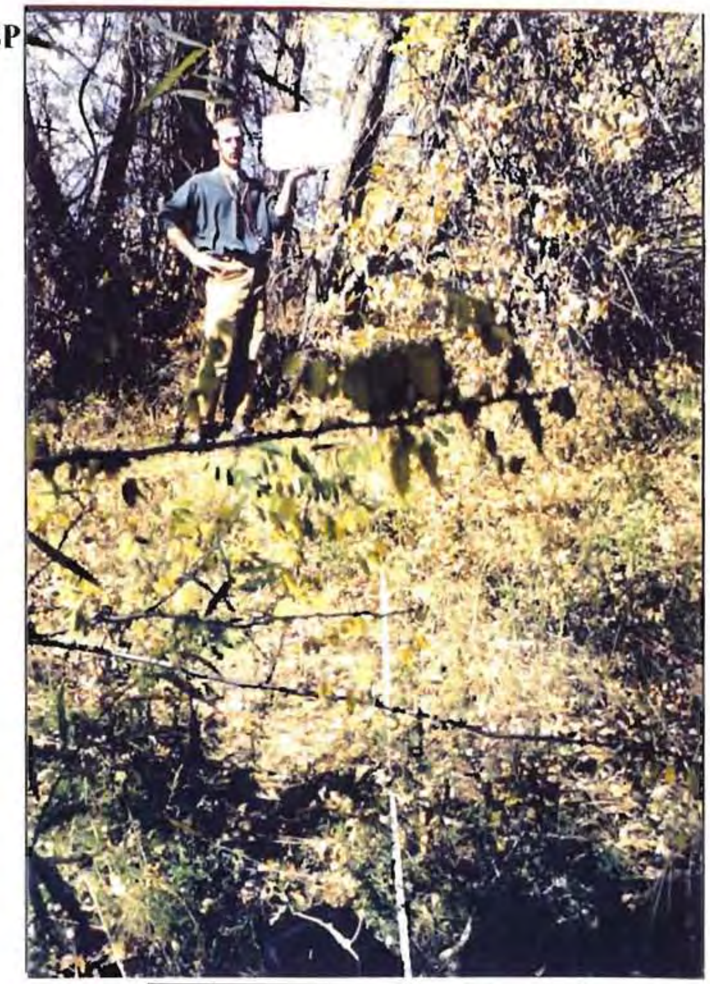

Foliar Height Volume
Height (m)
Distance Along Transect #4 (m)
Acer negundo
Fraxinus velutina
Juniperus osteosperma
Juglans Major
Populus x hinckleyana
Juniperus deppeana
Forestiera neomexicana
Vitis arizonica


Herbaceous Cover
Cover Class
Distance Along Transect #4 (m)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Litter
Pascopyrum smithii
Ambrosia psilostachya
Bare Ground
Acalyphta neomexicana

Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 5

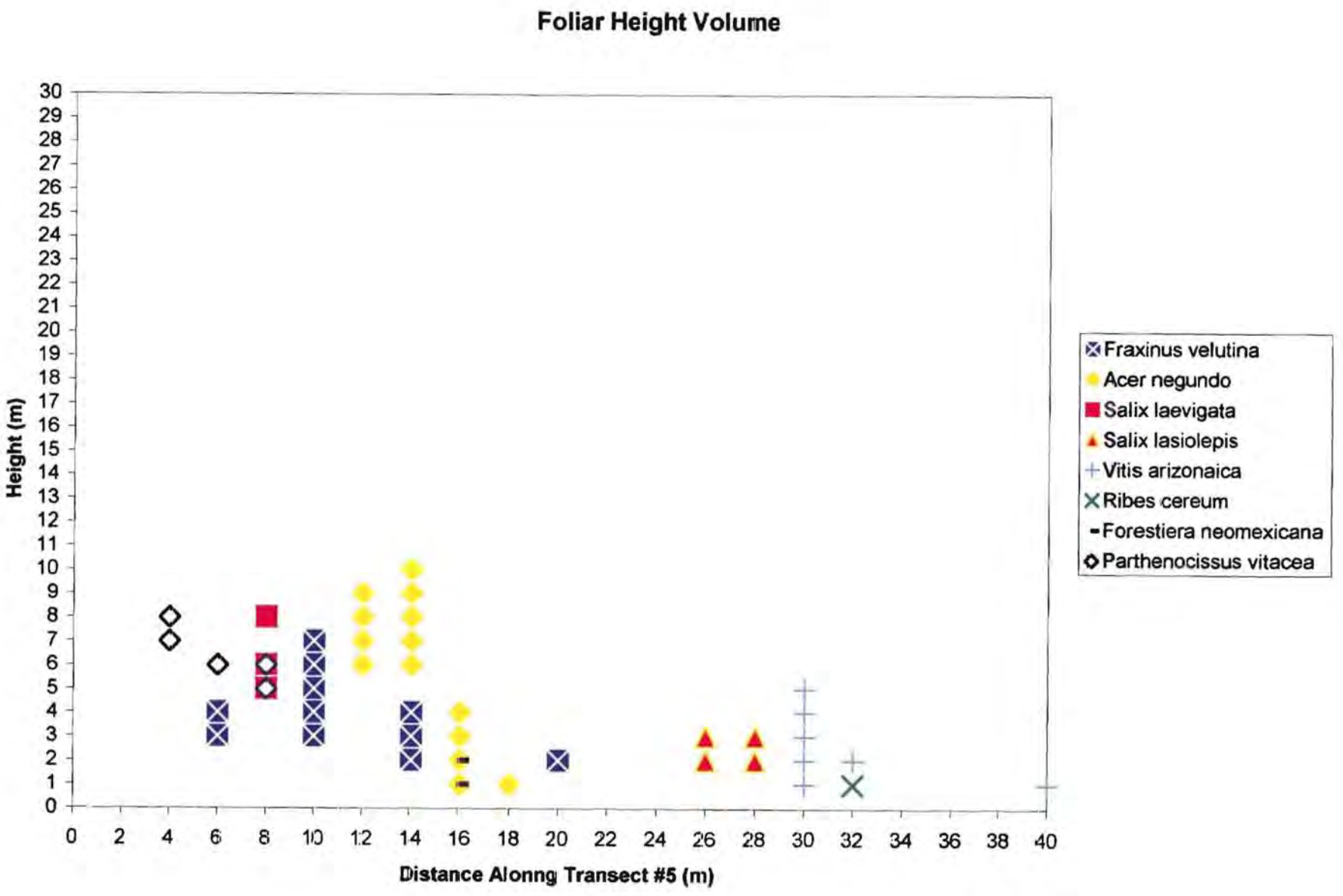
RP

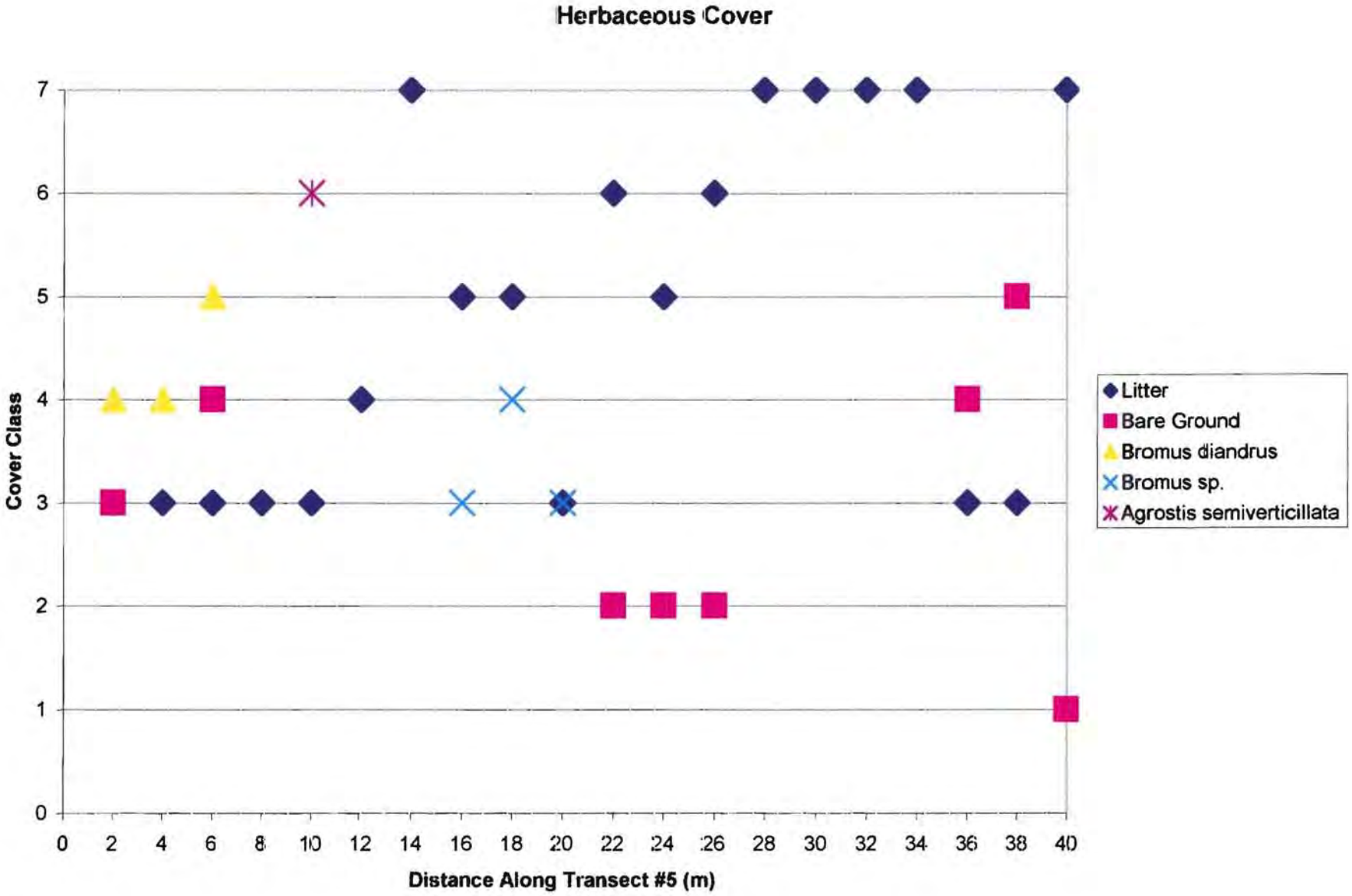
SP



PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T5	10/29/98	RP	180	Located on river right of Apache Creek. Rebar at base of ACNE ~6m from cut bank where large cable exits bank. Foto from edge of bank.
	"	SP	318	Looking up north bank of Apache Creek. Fot from above rebar.
	"	PP	48	Pin located in front of lg. Wooden box with lg. ACNE fallen on top of it. Foto from above rebar.


Foliar Height Volume
Height (m)
Distance Alonng Transect #5 (m)
Fraxinus velutina
Acer negundo
Salix laevigata
Salix lasiolepis
Vitis arizonaica
Ribes cereum
Forestiera neomexicana
Parthenocissus vitacea


Herbaceous Cover
Cover Class
Distance Along Transect #5 (m)
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Litter
Bare Ground
Bromus diandrus
Bromus sp.
Agrostis semiverticillata

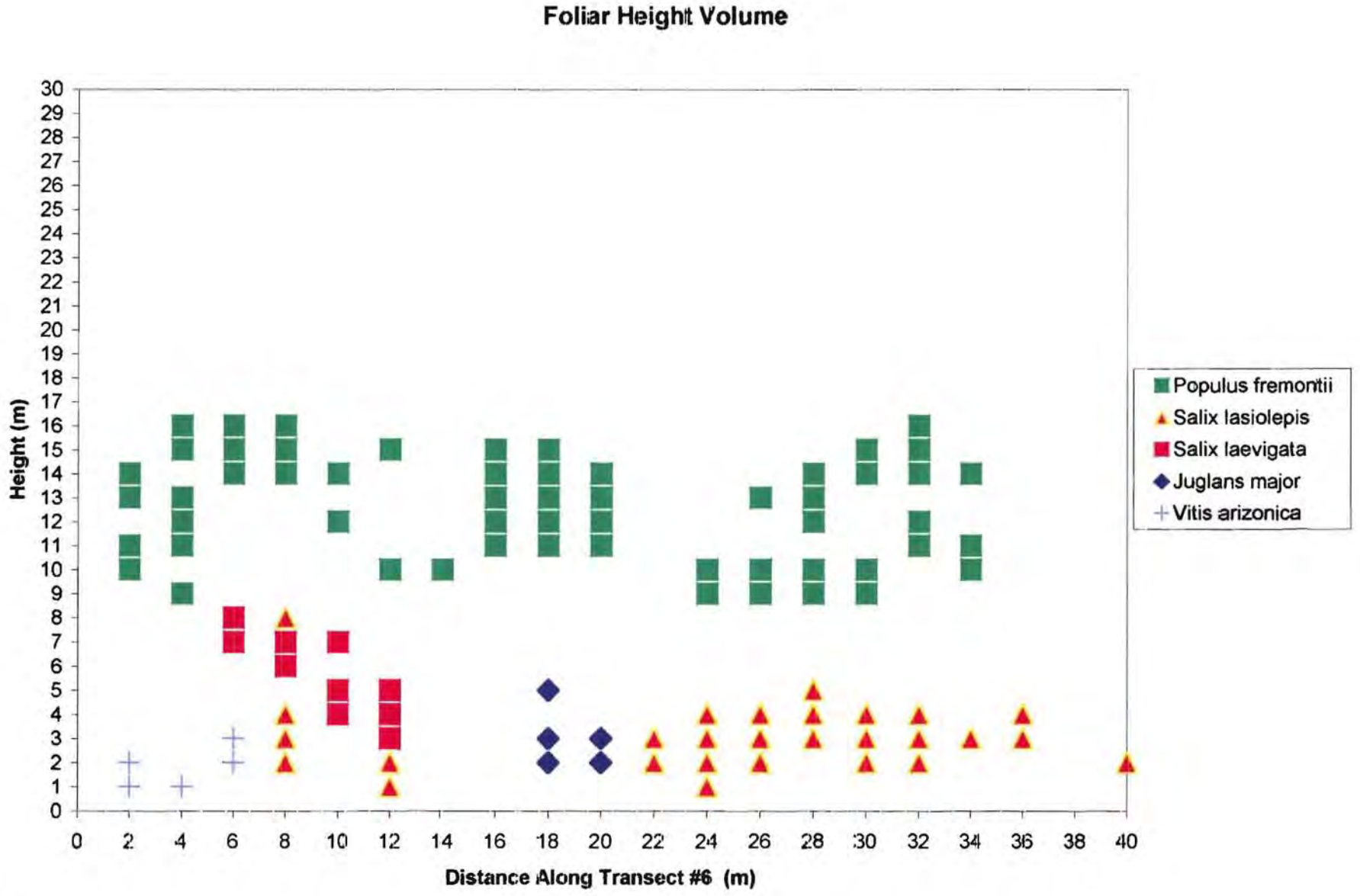
Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 6

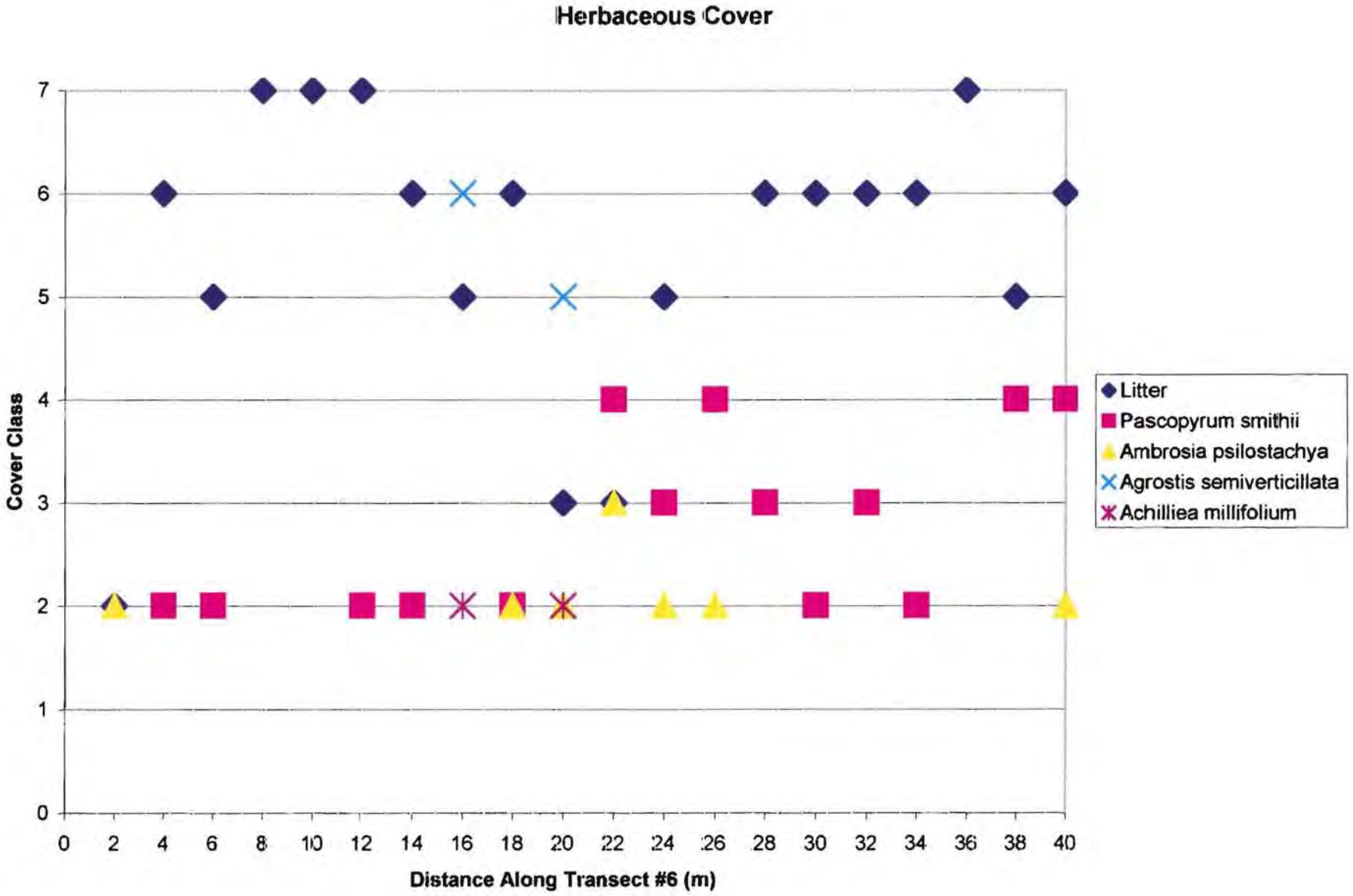
RP

SP

PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T6	10/14/98	RP	284	Located at base of lg. POFR between Walnut & Apache Creeks. NE of poperty boundary "notch."
	"	SP	320	Foto from above rebar.
	"	PP	50	"


Foliar Height Volume
Height (m)
Distance Along Transect #6 (m)
Populus fremontii
Salix lasiolepis
Salix laevigata
Juglans major
Vitis arizonica


Herbaceous Cover
Cover Class
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Distance Along Transect #6 (m)
Litter
Pascopyrum smithii
Ambrosia psilostachya
Agrostis semiverticillata
Achilliea millifolium

Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 7

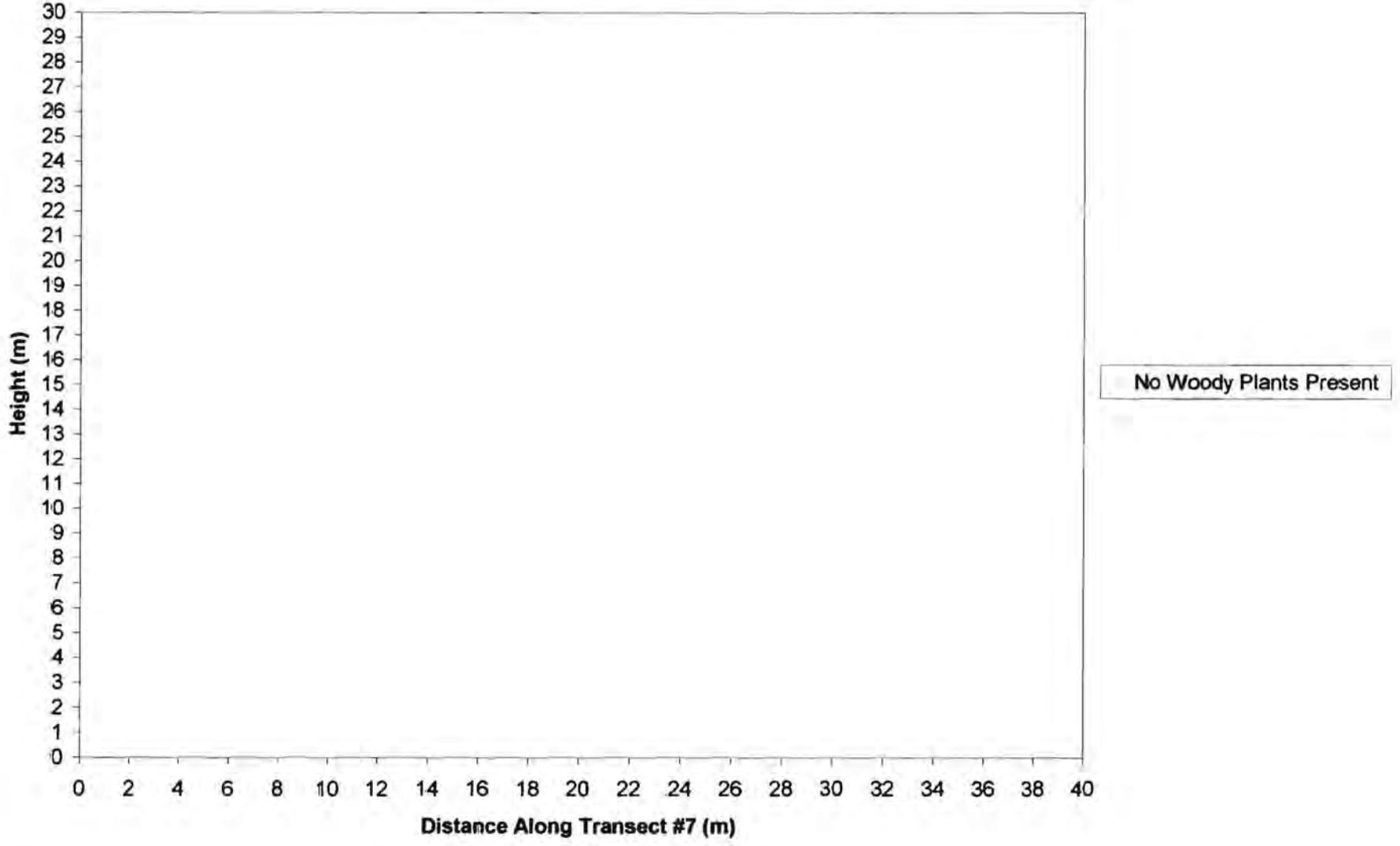
RP

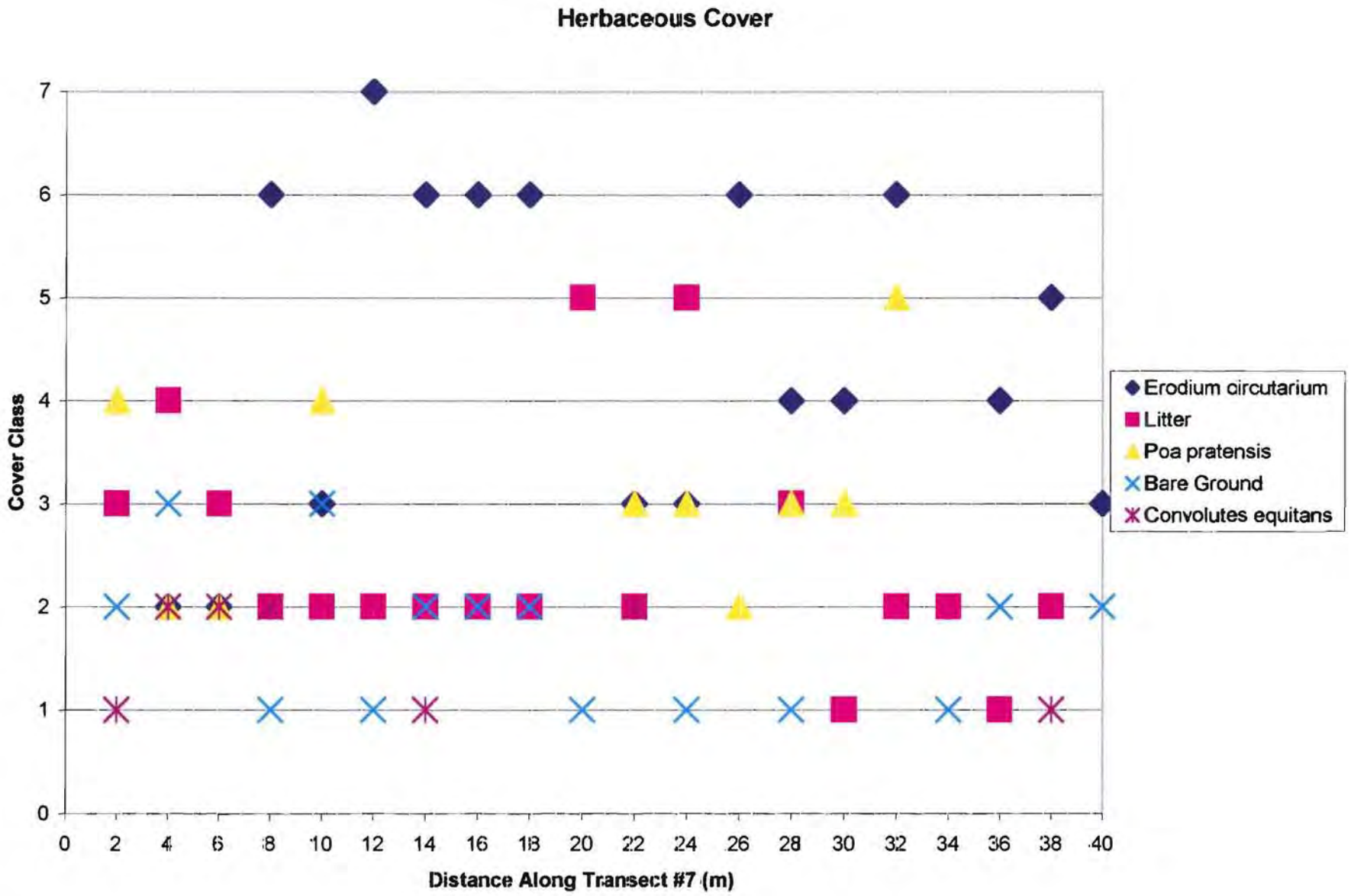
SP

PP

Transect #	Date	Location Code	Compass Bearing in degrees	Description
T7	10/7/98	RP	226	Located at fence corner behind ranch house. Foto ~5m from rebar.
	"	SP	46	Foto ~5m from rebar.
	"	PP	136	"

Foliar Height Volume



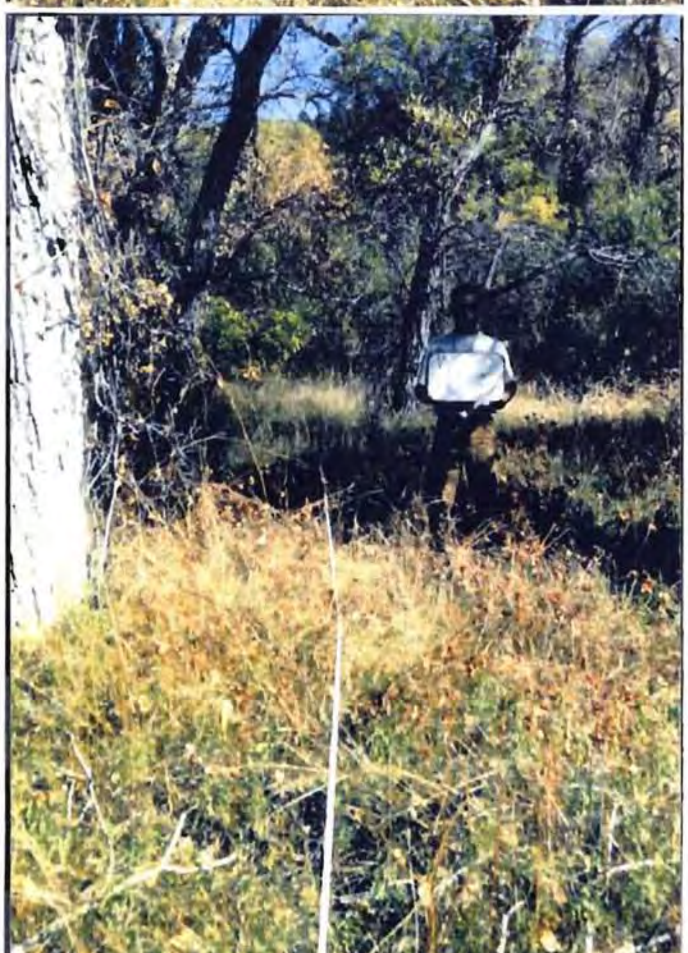

Herbaceous Cover
Cover Class
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Distance Along Transect #7 (m)
Erodium circutarium
Litter
Poa pratensis
Bare Ground
Convolutes equitans

Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 8

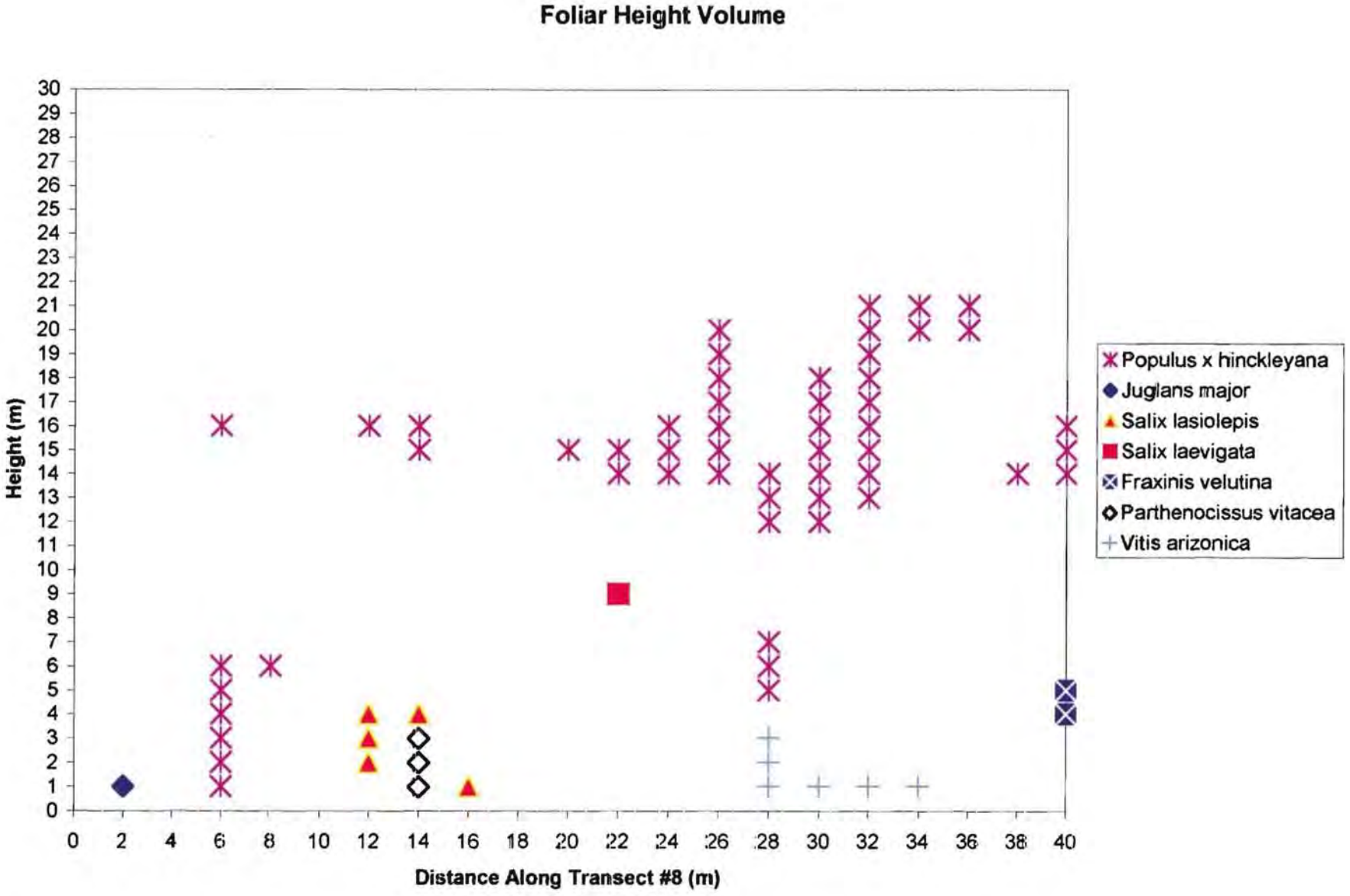
RP

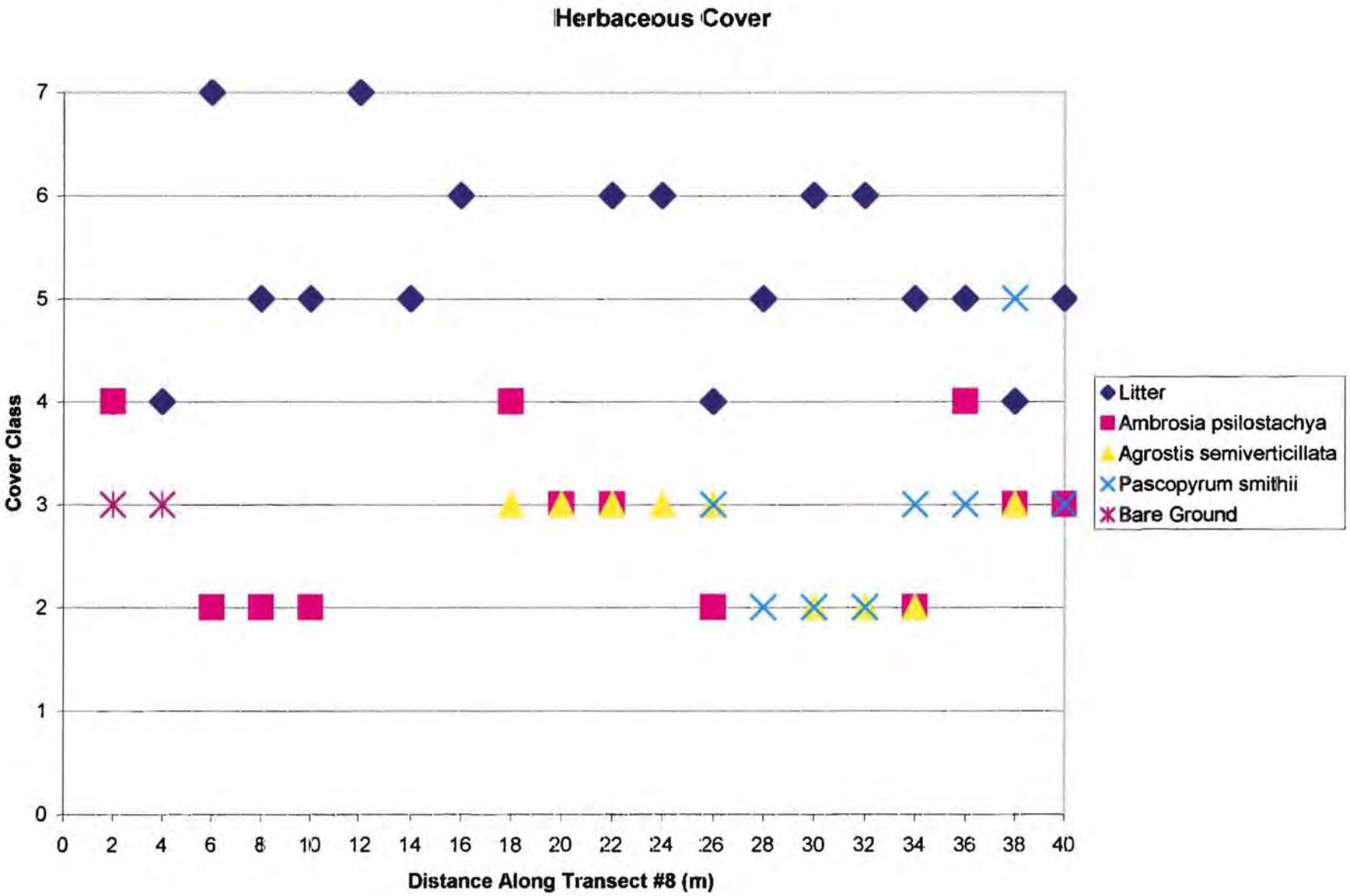
SP

PP



Transect #	Date	Location Code	Compass Bearing in degrees	Description
T8	10/29/98	RP	113	Located on river left of Walnut Creek above road crossing. Looking towards creek, note rocky hill in background. Foto ~8m from rebar.
	"	SP	338	Looking up north bank of Walnut Creek from below lg. JUMA.
	"	PP	68	Foto from above rebar.

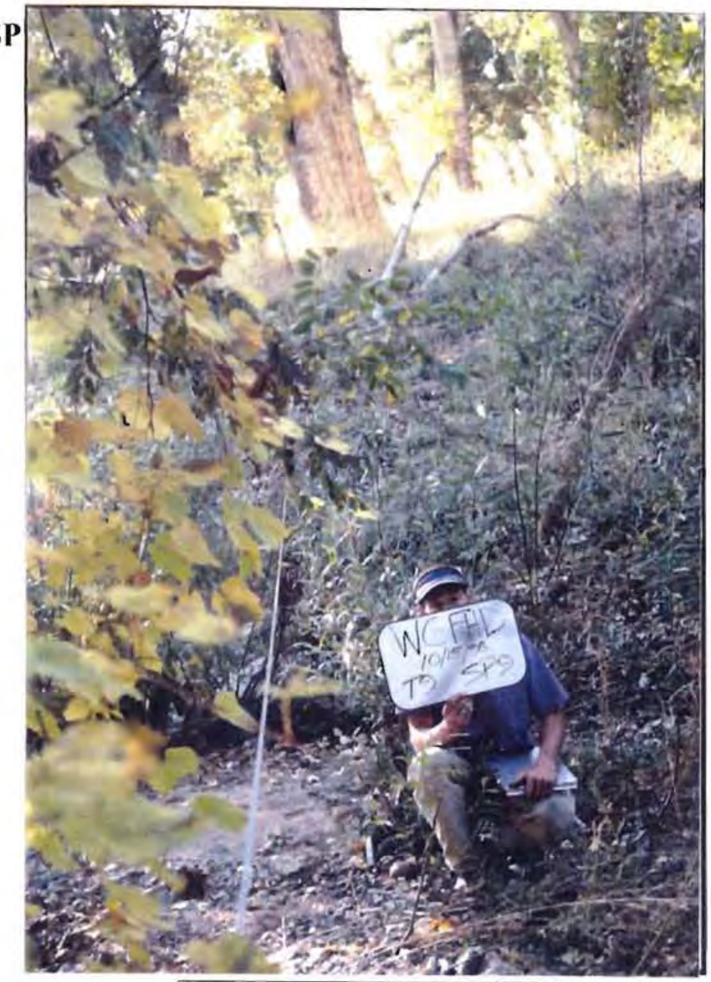

Foliar Height Volume
Height (m)
Distance Along Transect #8 (m)
Populus x hinckleyana
Juglans major
Salix lasiolepis
Salix laevigata
Fraxinis velutina
Parthenocissus vitacea
Vitis arizonica


Herbaceous Cover
Cover Class
Distance Along Transect #8 (m)
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Litter
Ambrosia psilostachya
Agrostis semiverticillata
Pascopyrum smithii
Bare Ground

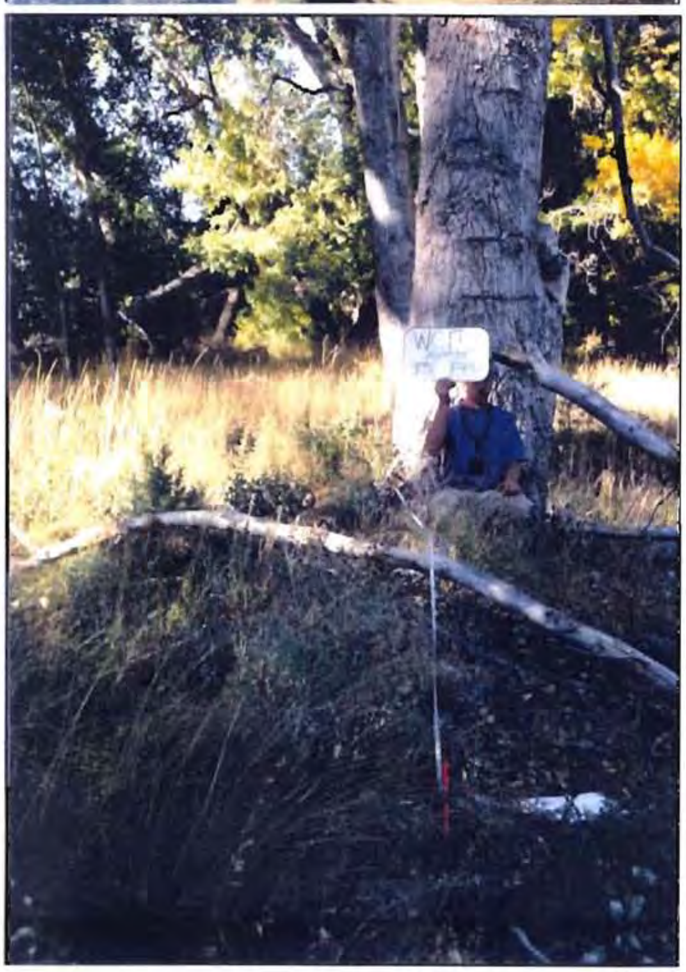
Walnut Creek Center for Education and Research—Foliar Hieght Distribution—Transect # 9

RP

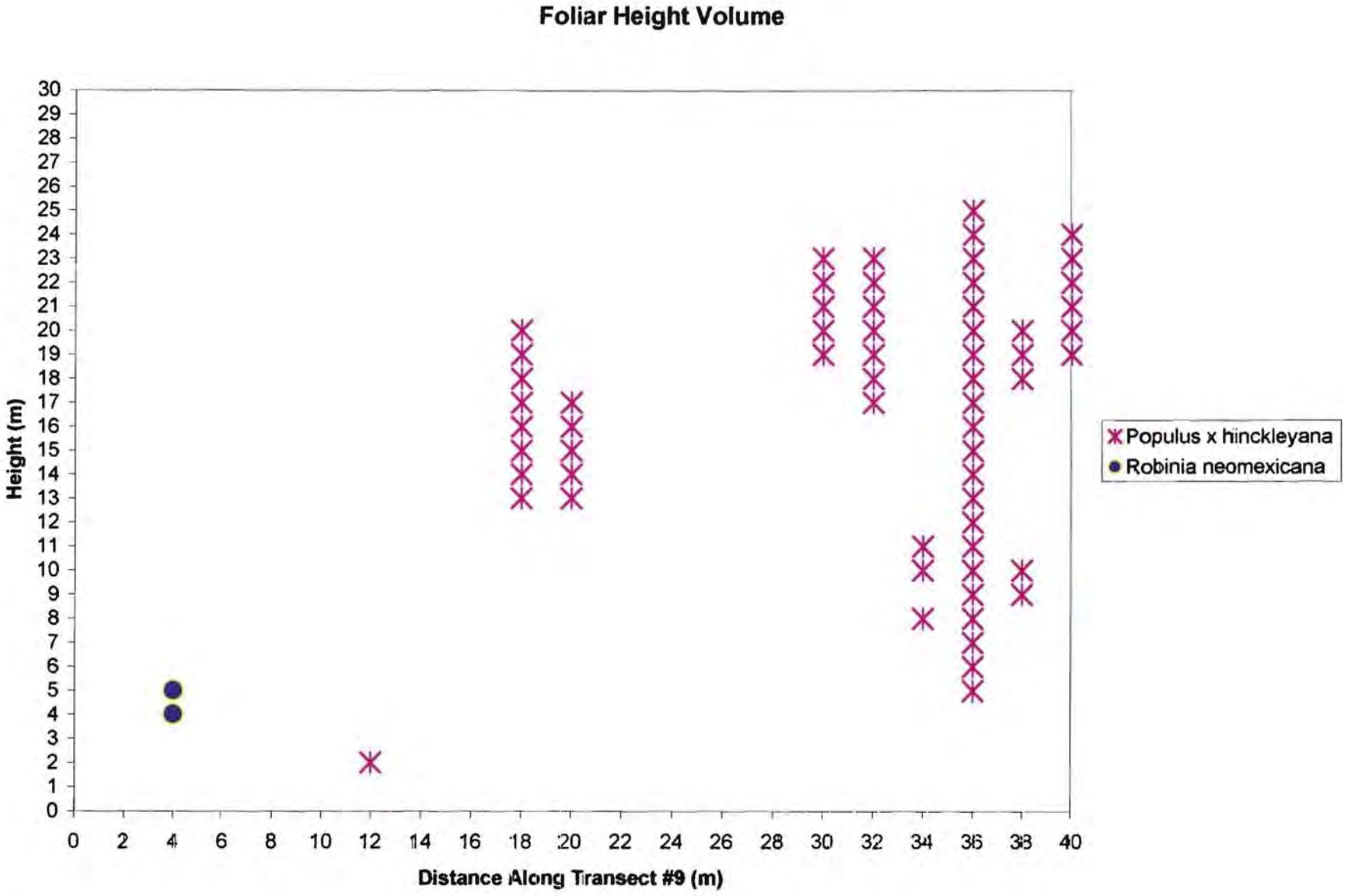
SP

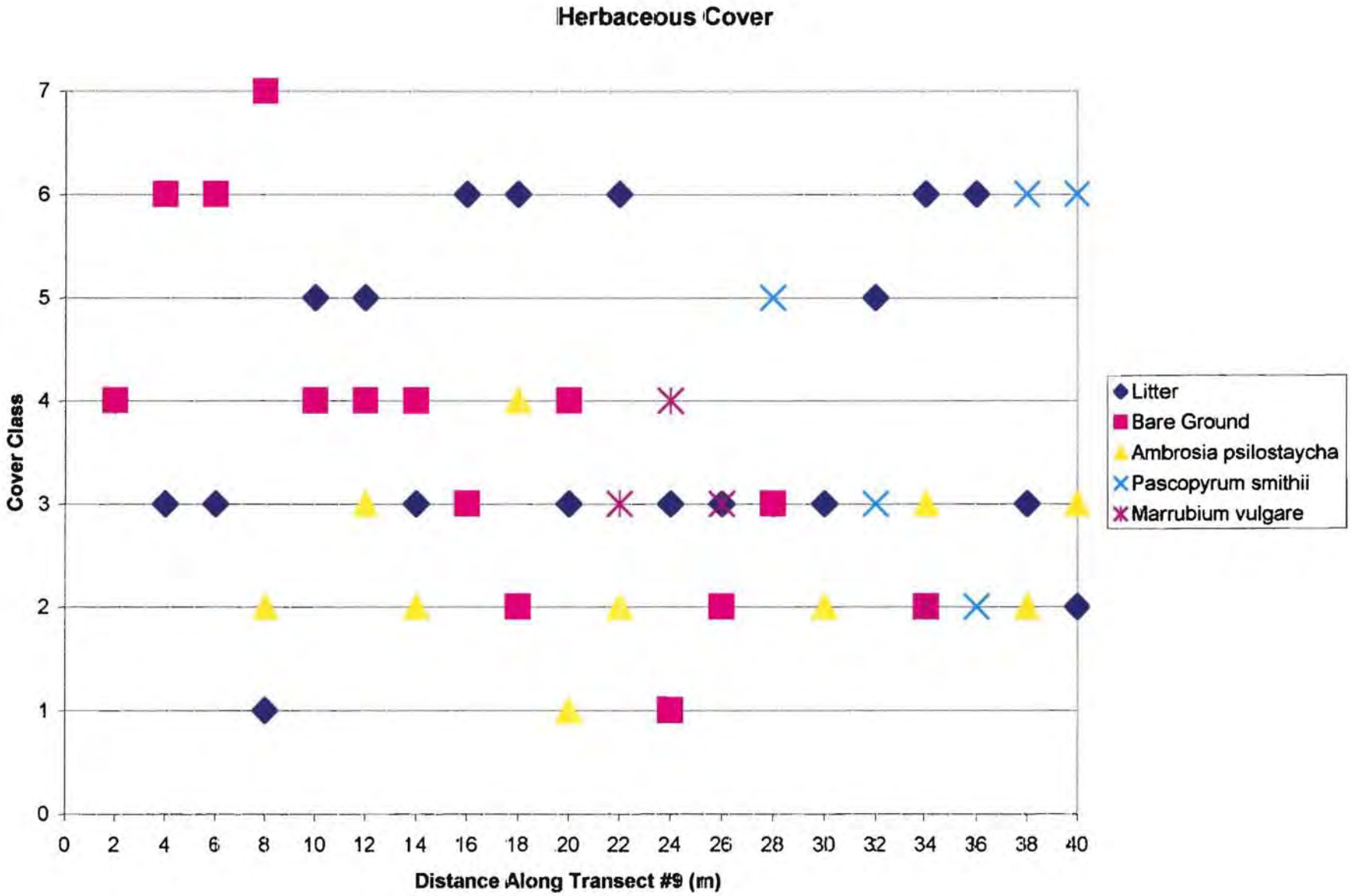


PP



Transect #	Date	Location Code	Compass Bearing in degrees	Description
T9	10/15/98	RP	321	Located near Walnut Creek and property boundary intersection. RP located below large POHI. Foto ~7m from rebar.
	"	SP	253	Foto shot from ~1m north of rebar due to obstructions. Located on east side of Walnut Creek.
	"	PP	343	Foto ~5m from rebar.

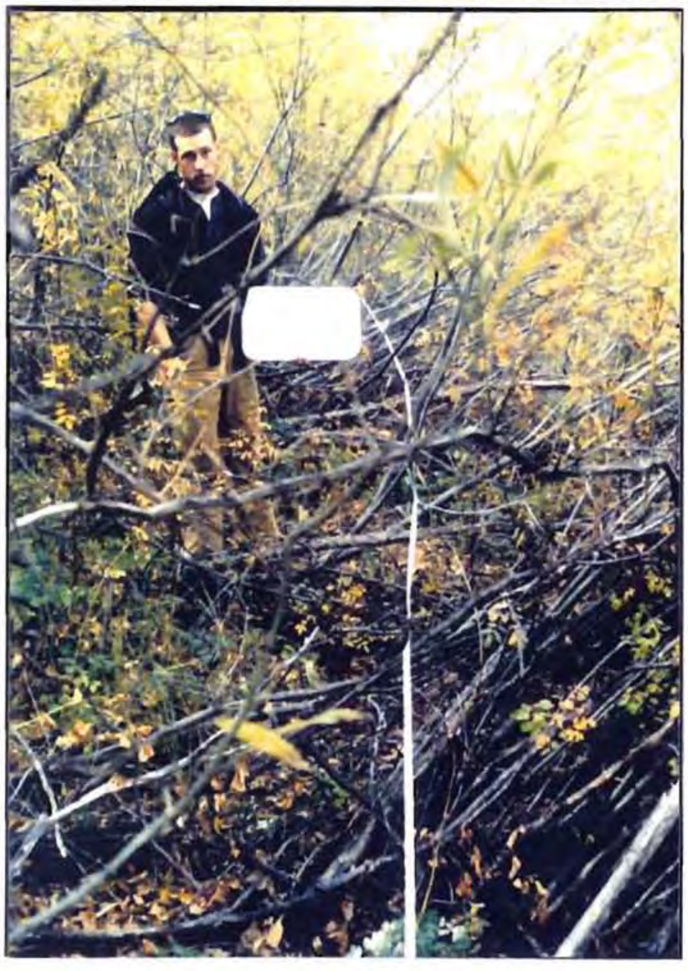

Foliar Height Volume
Height (m)
Distance Along Transect #9 (m)
Populus x hinckleyana
Robinia neomexicana


Herbaceous Cover
Cover Class
Distance Along Transect #9 (m)
0
1
2
3
4
5
6
7
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Litter
Bare Ground
Ambrosia psilostaycha
Pascopyrum smithii
Marrubium vulgare

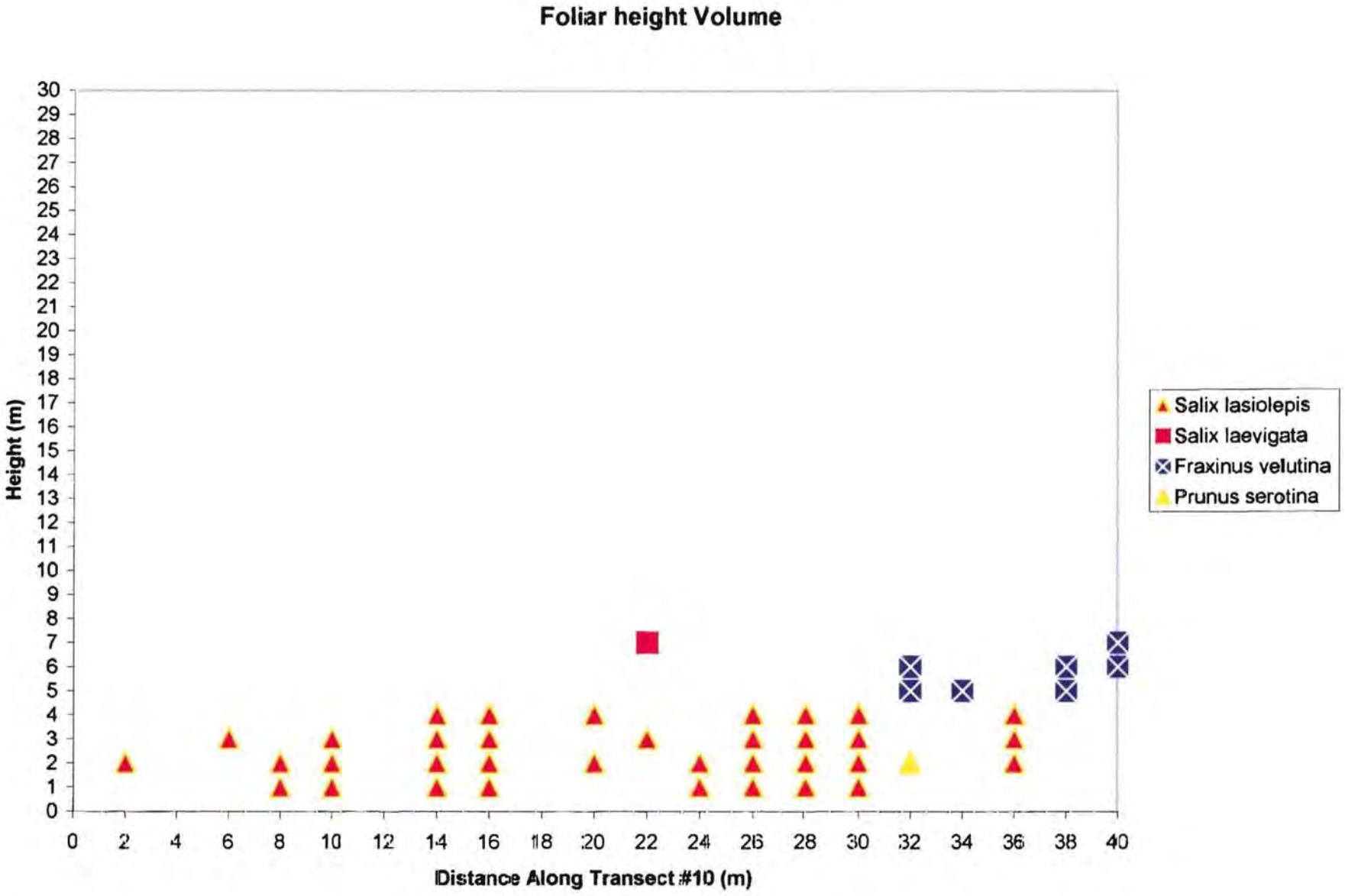
RP

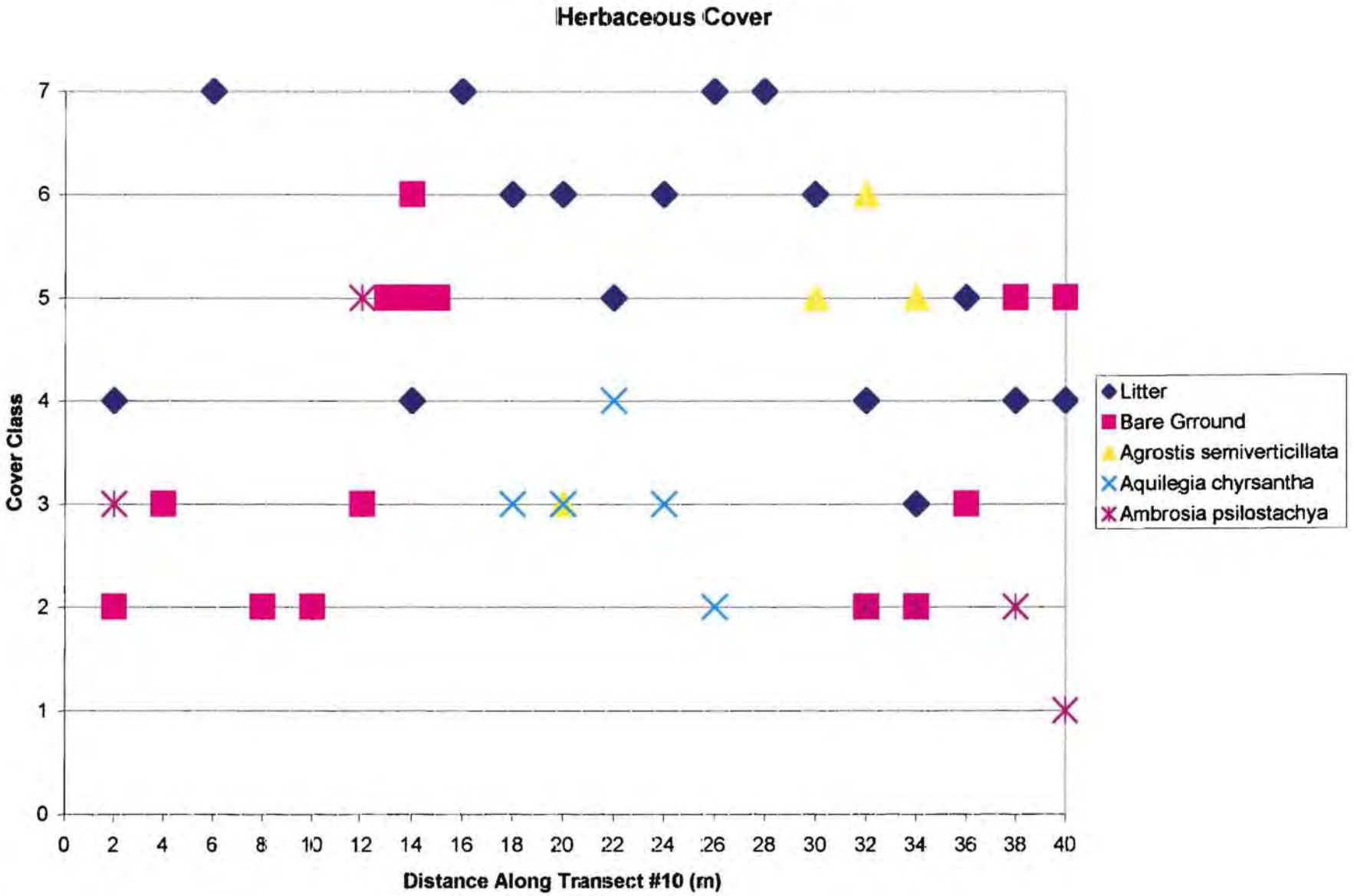
SP

PP



Transect #	Date	Location Code	Compass Bearing in degrees	Description
T10	10/29/98	RP	290	Located on river left ~100m downstream from Apache and Walnut Creek junction. Rebar at base of lg. ACNE.
	"	SP	138	Foto from above rebar.
	"	PP	228	"


Foliar height Volume
Height (m)
Distance Along Transect #10 (m)
Salix lasiolepis
Salix laevigata
Fraxinus velutina
Prunus serotina


Herbaceous Cover
Cover Class
Distance Along Transect #10 (m)
0
1
2
3
4
5
6
7
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
Litter
Bare Grround
Agrostis semiverticillata
Aquilegia chyrsantha
Ambrosia psilostachya

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Reptile and Amphibian Survey

Introduction

We researched reptile and amphibian populations through the spring and summer seasons of 1998 and 1999 (May through September). The emergence, abundance, and distribution of these animals were spatially and temporally variable and appeared to be related to seasonal precipitation, changing aquatic and structural conditions of Walnut and Apache Creeks, and variable insect and rodent food resources.

Few herpetofaunal studies have been associated with central and northern Arizona riparian ecosystems and in particular, Interior Riparian Deciduous Forest bordering mixed Chaparral and Pinyon-Juniper communities. Through the activities of this survey, we were able to investigate species composition, relative densities, identify riparian obligate and facultative species, monitor changing habitat conditions, observe foraging styles, and monitor seasonal occurrence and dispersal patterns. To date, we have found no threatened and or endangered reptile or amphibian species within the Walnut Creek site.

Methods

Site Descriptions

During June of 1998 five pit-fall arrays were established at locations deemed conducive to reptile and amphibian activity and represented different habitats (Fig. 1). No pit-fall arrays were established on avian Grid B because of the extensive graminoid and shrub cover. The pitfall arrays consisted of five 5-gallon buckets and four 1ft.x 8ft. corrugated plastic sheets. Each bucket was buried to a depth that allowed the upper open orifice to remain flush with the ground surface. From the central buried pit-bucket, the four 8ft. corrugated sheets extended out at the four cardinal angles. At the outer ends of each 8ft. sheet, a pit-fall bucket was positioned and buried. Hence, animals encountering the corrugated drift fence were forced to follow the obstructive drift fence and most often drop into one of the pit-fall buckets. Lids were secured over the buckets during the hot and often wet afternoon hours and removed during early evening hours.

During the summer season of 1999 we placed several large flat boards at promising reptilian areas throughout both grids (Figs. 1 & 2). Most of the board arrays were positioned at locations where progressive rodent data reflected substantial numbers.

Capture-Release Methods

Small reptiles and amphibians were collected utilizing pit-fall traps with drift fences, boards, hand snares, and pole nooses during the summer months. Snakes were captured by hand, snake pole, and night driving. Many amphibians were identified and located by crepuscular and nocturnal calls during the breeding season. Mid morning and afternoon time constraint searches, (searches within a visual set area over a certain period of time) were carried out during fair weather. Observations and/or capture locations, date/time, gender, body measurements of snakes, and habitats were recorded for most

species. Captured individuals were identified and subsequently returned and released at points of capture.

Fig. 1 Locations of pit-fall arrays and reptile boards, Avian A-Grid: Walnut Creek.

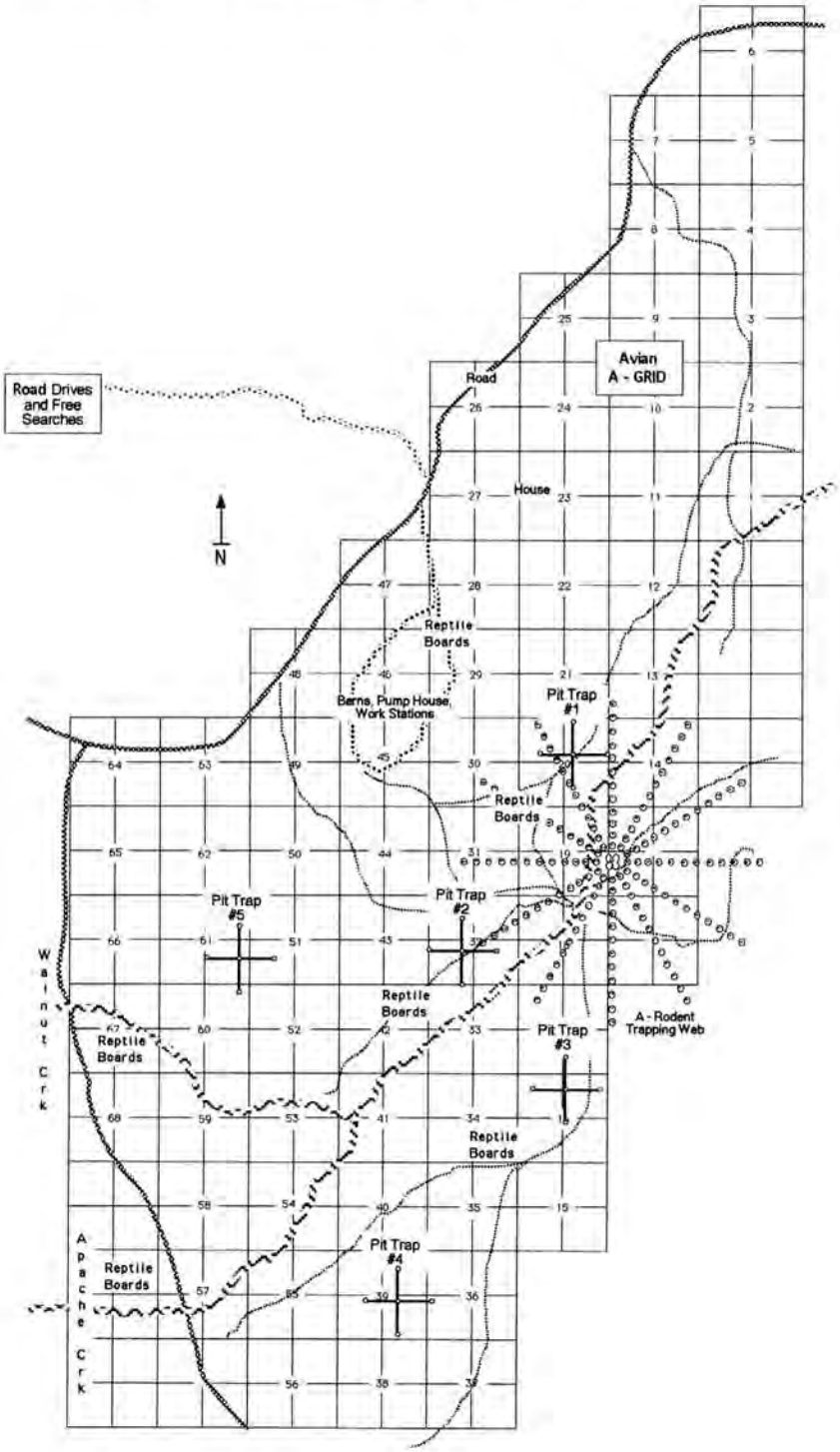


Fig. 2 Locations of pit-fall arrays and reptile boards, Avian B-Grid: Walnut Creek.

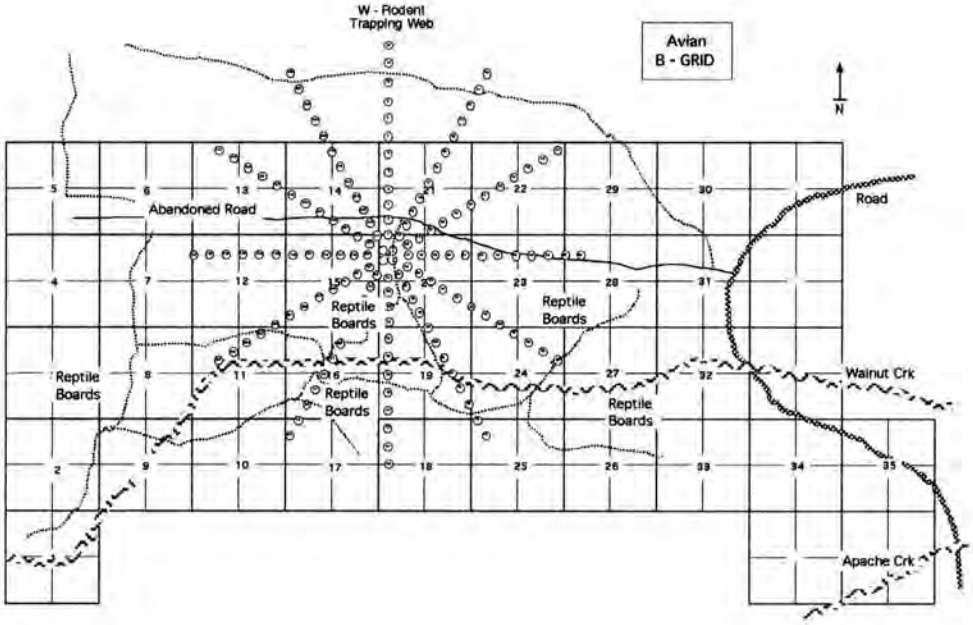


Table 1. Reptile & amphibian species list and relative abundance for Walnut Creek Education and Research Station.

		Relative Abundance		1998		1999	
		1998	1999	Captures	Observed	Captures	Observed
Lowland Leopard Frog	*Rana yavapaiensis*	Abundant	Occasional	12	> 100	12	< 20
Arizona Toad	*Bufo microscaphus*	Abundant	Occasional	14	> 100	4	< 20
Canyon Tree Frog	*Hyla arenicolor*	Occasional	Occasional	2	6	2	> 10
Woodhouse's Toad	*Bufo woodhousei*	Rare	O	3	8	0	0
Plateau Striped Whiptail	*Cnemidophorus velox*	Abundant	Common	25	> 200	17	> 100
Eastern Fence Lizard	*Sceloporus undulatus*	Abundant	Abundant	11	> 100	9	> 100
Tree Lizard	*Urosaurus oranatus*	Abundant	Abundant	9	> 100	5	> 100
Short-horned Lizard	*Phrynosoma douglassii*	Occasional	Occasional	2	4	4	6
Collard Lizard	*Crotophytus collaris*	O	Occasional	0	0	4	8
Greater Earless Lizard	*Cophosaurus texanus*	Occasional	Occasional	1	3	2	3
Gila Spotted Whiptail	*Cnemidophorus flagellicaudus*	Rare	O	2	4	0	0
Clark Spiny Lizard	*Sceloporus clarki*	Off site	Off site	0	3	1	6
Black-necked Garter Snake	*Thamnophis cyrtopsis*	Abundant	Occasional	9	> 30	9	< 20
Wandering Garter Snake	*Thamnophis elegans*	Occasional	Common	2	< 20	3	> 20
Western Patch-nosed Snake	*Salvadora hexalepis*	Occasional	Occasional	1	2	1	3
Gopher Snake	*Pituophus melanoleucus*	Common	Common	6	2	6	2
Striped Whipsnake	*Masticophis taeniatus*	Occasional	Common	1	2	2	2
Night Snake	*Hypsiglena torquata*	Occasional	Occasional	1	0	1	0
Black-tailed Rattlesnake	*Crotalus molossus*	Occasional	Common	3	2	6	2
Arizona Black Rattlesnake	*Crotalus viridis*	Occasional	Occasional	2	1	2	1
Mojave Rattlesnake	*Crotalus scutulatus*	Off site	Off site	1	0	2	0

Survey Trends and Species Composition

We collected 17 reptile and four amphibian species during this survey (Table 1). Based on distribution patterns, seasonal occurrence, and behavior, four proved to be obligate riparian species: Lowland leopard, Canyon tree frog, Black-necked garter snake, and Wandering garter snake. The remaining species may be considered facultative riparian at Walnut Creek since most were regularly found in both riparian and floodplain areas. Two species were found off the study site but near the borders of the Walnut Creek research site. At the base of the northern foothills, Clark spiny lizards occupy rocky areas and large boulder fields, and Mojave rattlesnakes were found among the grasslands southeast of the K-4 Ranch.

Large populations of Lowland leopard frogs and Arizona toads occurred at Walnut Creek during the summer of 1998. However, over the summer of 1999 these species were rare (Table 1). The Arizona Game and Fish Department consider both of these amphibian species sensitive species.

The differences in breeding success and abundance appeared to be related to the condition of the creek channel. In 1998, water flow was relatively slow, the stream was shallow, and emergent vegetation was scarce due to extensive cattle grazing. Consequently, numerous tadpoles congregated at various locations within most stream channel reaches (Fig. 3). Tadpole concentrations could frequently be seen migrating to warm shallow sections of the stream during the day where they typically feed on clumps of floating algae. We observed the full life cycle of both species, from tadpoles to adults through the summer months. In contrast, no tadpoles were observed in 1999. This absence of breeding by lowland leopard frogs may have been due to the extensive emergent vegetation that covered most all shallow regions of the stream. After the August monsoons and channel scouring a few frogs were observed in isolated pockets (Fig. 3). We assume that they were carried down from higher elevations.

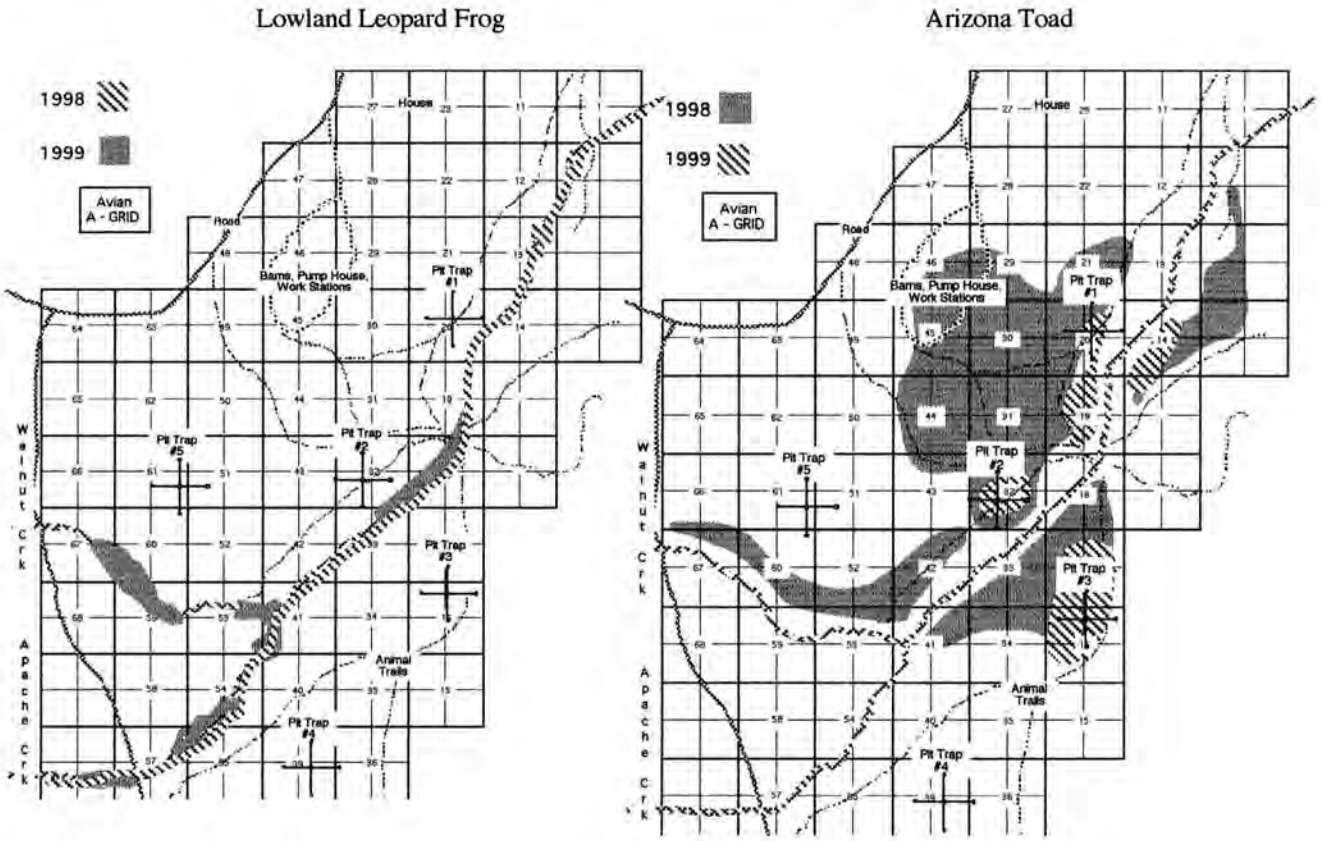
Arizona toads exhibited similar population trends, numerous individuals through the summer of 1998 and few toads during 1999. Throughout the floodplain riparian areas in 1998, toads were abundant, so much so that they were frequently seen in and around the barn bays, and field workers had to be careful not to step on them (Fig. 3). Few roaming toads were observed over the summer of 1999 while fewer than 12 were collected in pit-fall arrays. The noticeable reduction of Arizona toads in 1999 is intriguing but may have been related to the widespread emergence and cover of graminoid species.

Tadpoles of the Lowland leopard frog appeared to be the favored food of the black-necked garter snake. In 1998 the most common and abundant snake was the Black-necked garter snake which was most abundant in and around the stream channel where tadpoles congregated. On one occasion, we observed an aggressive garter snake move across the stream and take seven tadpoles during a single feeding foray. The rarity of Black-necked garter snakes throughout the summer of 1999 appeared to be related to the lack of frog tadpoles (Table 1).

On the other hand, Wandering garter snakes were more abundant during the summer of 1999 (Table 1). These snakes appeared to be less aquatic than the Black-necked garter snake. We often captured them well away from the creek channel but within the floodplain. The swings in population densities may reflect resource competition between these species

or simply that Black-necked garter snakes are more dependent on aquatic prey and changing densities reflect differences in prey selection.

Fig. 3 Distributions of the lowland leopard frog and Arizona toad, Walnut Creek: 1998-1999.



Eastern fence and Tree lizards are common regional species and are essentially ubiquitous and in some areas abundant at Walnut Creek (Table 1). Plateau striped whiptails and Short-horned lizards are also relatively common regional species but distributions are more restrictive due to specific habitat preferences.

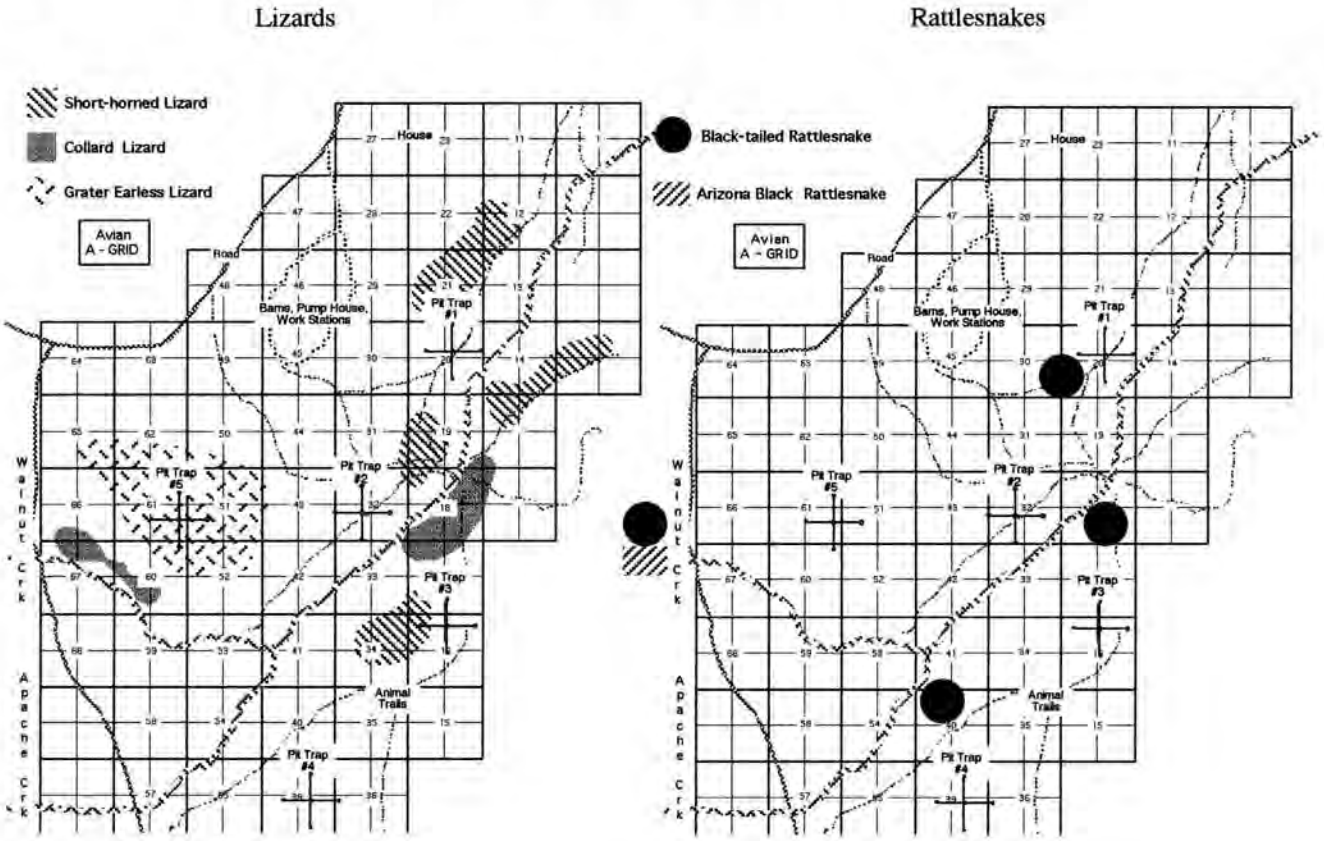
Plateau striped whiptails were numerous throughout Walnut Creek during the summer of 1998. However, densities decreased considerably in 1999. This trend may be related to changes in graminoid density and associated habitat structure between the summers of 1998 and 1999. At Walnut Creek Plateau striped whiptails favor open areas, especially sandy open areas near ant mounds amongst grasslands and willows. Presumably, the open areas enable them to capture ants and other small insects.

Due to past domestic grazing practices, ground cover was minimal and weedy species were common during the summer of 1998. By the summer of 1999, after and during which no grazing took place, native graminoid species flourished and in most areas

vegetative cover and biomass were extensive. This increase in vegetative cover and biomass may have reduced insect prey and restricted Plateau striped whiptails since they favor open areas for feeding zones and basking.

Short-horned, Collard, and Greater earless lizards were less frequent and their distribution patterns reflect their habitat preferences (Fig. 4). We found Short-horned lizards both summers but Earless and Collard lizards during the 1998 and 1999 summer seasons respectively.

Fig. 4 Distributions of selected lizards and rattlesnakes, Walnut Creek: 1998-1999.



The eight snake species sampled at Walnut Creek are common regional species except for the night and Western patch-nosed snakes. Gopher snakes and Striped whipsnakes were regularly encountered throughout most of the floodplain. In general, snake densities increased in 1999 and appeared to be related to associated high rodent densities.

The increase in snake densities was most apparent for rattlesnakes during 1999, particularly Black-tailed rattlesnakes. On numerous occasions avian researchers related their brief encounters with rattlesnakes but since they were characteristically rattlesnake shy

they related only general locations of snakes. Four Black-tails appeared to be quite territorial and the same marked individuals were repeatedly captured around the vicinity where they were initially captured. To avoid potential problems during the August rodent trapping period, we moved the Black-tail near pit-fall #1 because it was positioned near several rodent traps. It was relocated near Apache Creek. Over the next two days, during time constant surveys, this individual was captured at locations progressively closer to pit-fall #1, indicating that this fellow knew his way back to his territory. Arizona black rattlesnakes were located only on avian B grid, which may demonstrate another example of species resource competition since habitats on both avian grids are in general similar.

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Bird Survey

Introduction

We monitored avian populations on two permanent survey grids at Walnut Creek for 18 months, May 1998 through October 1999. During this period we observed 131 species within the Walnut Creek floodplain (Table 1). Twenty percent of these species were recurrent residents, 43 percent were regular seasonal visitors (winter and summer), and 37 percent were irregular or transient visitors. Results from this study reflect the diversity of habitats, moisture, and food resources available at Walnut Creek for local, regional, and migratory birds.

Few longitudinal bird studies have been conducted in central and northern Arizona riparian ecosystems and in particular Interior Riparian Deciduous Forests contiguous with Chaparral, Pinyon-Juniper, and grassland communities. Through the activities of this survey, we have been able to investigate resident and seasonal species composition, relative densities of seasonal and resident species, relative densities within riparian areas, delineate riparian obligate and facultative species, riparian shelterbelt preferences, and floodplain habitat utilization.

We also archived a large amount of data and are able to define seasonal and resident populations and tease out information concerning critical habitats and other unique areas for future management operations and educational purposes.

Methods

Site Descriptions

Two large censuring grids were established during the spring of 1998. Grid points were established at 50m intervals along marked grids and were identified with an 18" stake that was flagged and numbered for reference. The shapes and sizes of the sampling grids varied since the grids were fitted to existing terrain and confined by differences in existing physiognomy.

-Avian A-Grid

This grid extends over 17 hectare (42 acres) and consists of 68 point count stations (Fig. 2). It stretches across the floodplain, active channels of Walnut and Apache Creeks, and abuts rocky foothills at the southern edge. Consequently, this sampling grid comprises a variety of avian habitats and ecotones including large open grasslands of the floodplain, grasslands with Walnut stands, cottonwood and willow stands along the riparian channel, and juniper-pinyon-chaparral occupying the southern foothills.

-Avian B-Grid

This smaller grid lies upstream and west of the previously described A-Grid. B-Grid covers 8.8 hectare (21.6 acres) and consists of 35 point count stations (Fig. 1). The deeply incised active channel of Walnut Creek cuts through the riparian floodplain and approximate center of the avian grid. A variety of grasses provide thick undergrowth in

many areas while the riparian forest consists of tall old growth cottonwoods and stands of thick willow. A relict alligator juniper forest and mixed chaparral occur north of the riparian zone and give way to Utah juniper stands on the northern hillsides.

During the winter months of the first year, January to April 1998, extreme and recurring wet conditions of an El Nino period hindered fieldwork; wet conditions were so severe during March that we were unable to visit the site. During this time, we had not established point count stations due to permit and contract negotiations (Ruth Valencia 7/98 and 9/98, Pete James, USFS Chino District, 3/98). Alternatively we walked preplanned transects that were precursors to the point count stations subsequently established in May 1998. These data, however, proved to offer insight into winter populations even during an unusual wet season.

Point Counts and Censuring Methods

The point count method was used for surveying bird populations. Because counts were made from a stationary location, an observer was able to concentrate fully on visual and aural detections of birds within a fixed or unlimited distance. Three-minute counts are used in the Breeding Bird Survey, which has been used in North America since the late 1960's. Consequently, three-minute counts were performed during this study in order to detect resident, winter and spring migrants, and in particular neotropical migrants.

Avian censuring was carried out monthly, 2.5 consecutive days during the winter months (October through March). Through the spring and summer months surveying was performed bimonthly (April through September). Two professional observers surveyed during each sampling session.

Point counts were normally begun prior to sunrise and generally ended five to six hours later. On each visit counts were made of all birds during a three-minute period at each point. For each species, data concerning singing males, singing females, juveniles, birds flying over, nesting, foraging, resting, and other behaviors were recorded. Our plan of monitoring each nest, however, was abandoned due to budget constraints since adequate nest searches are too labor and time intensive for our limited budget. Other reasons included; activities required by point counts, field time, vegetation density did not allow close scrutiny of nests due to the possibility of disturbing the nest or bird behavior, nest height, and new Arizona Game and Fish Department regulations.

During the winter months of October 1998 to March 1999 we noticed an increase in species detection from the previous winter season. This increase in species recognition was undoubtedly due to the establishment of point count stations, acquired knowledge by field observers, longer period of observation, and a mild winter. After a few months, then, observers became more routinely familiar with the grids and were able to locate more easily and accurately individual birds. This is typical of most field studies where learning and efficiency curves increase over time.

We used visual identifications (observed) to gain insight into riparian habitat utilization and preference by birds on both established grids. During this survey many birds were recognized by characteristic calls and songs; about 37% of identifications were audible. Visual sightings are used herein for comparative relationships since visual sightings comprised 57% of identifications and tended to be more reliable for station analysis than audible recognition.

On Grid-A, 30 point count stations were designated as riparian stations. Twenty riparian stations were specified on Grid-B. Stations were defined as riparian if they were located within or overlapped stream channel or deciduous riparian woodland vegetation: willows, cottonwoods, Box elder, Velvet ash (Figs. 1 & 2). However, some of the marginal riparian stations formed linear ecotones with adjacent grasslands, juniper-chaparral hillsides, and walnut floodplain.

Fig. 1 B-Grid: general locations of Walnut and Apache Creeks, riparian and floodplain stations, and approximate locations of major vegetation associations.

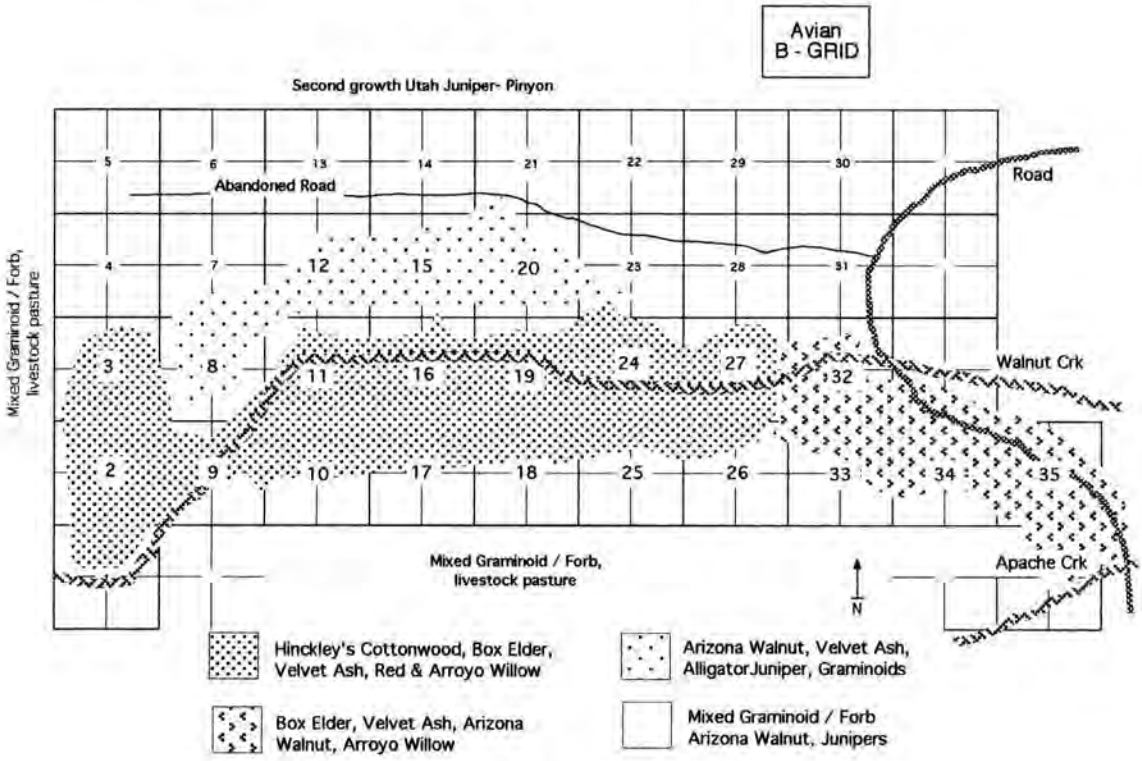
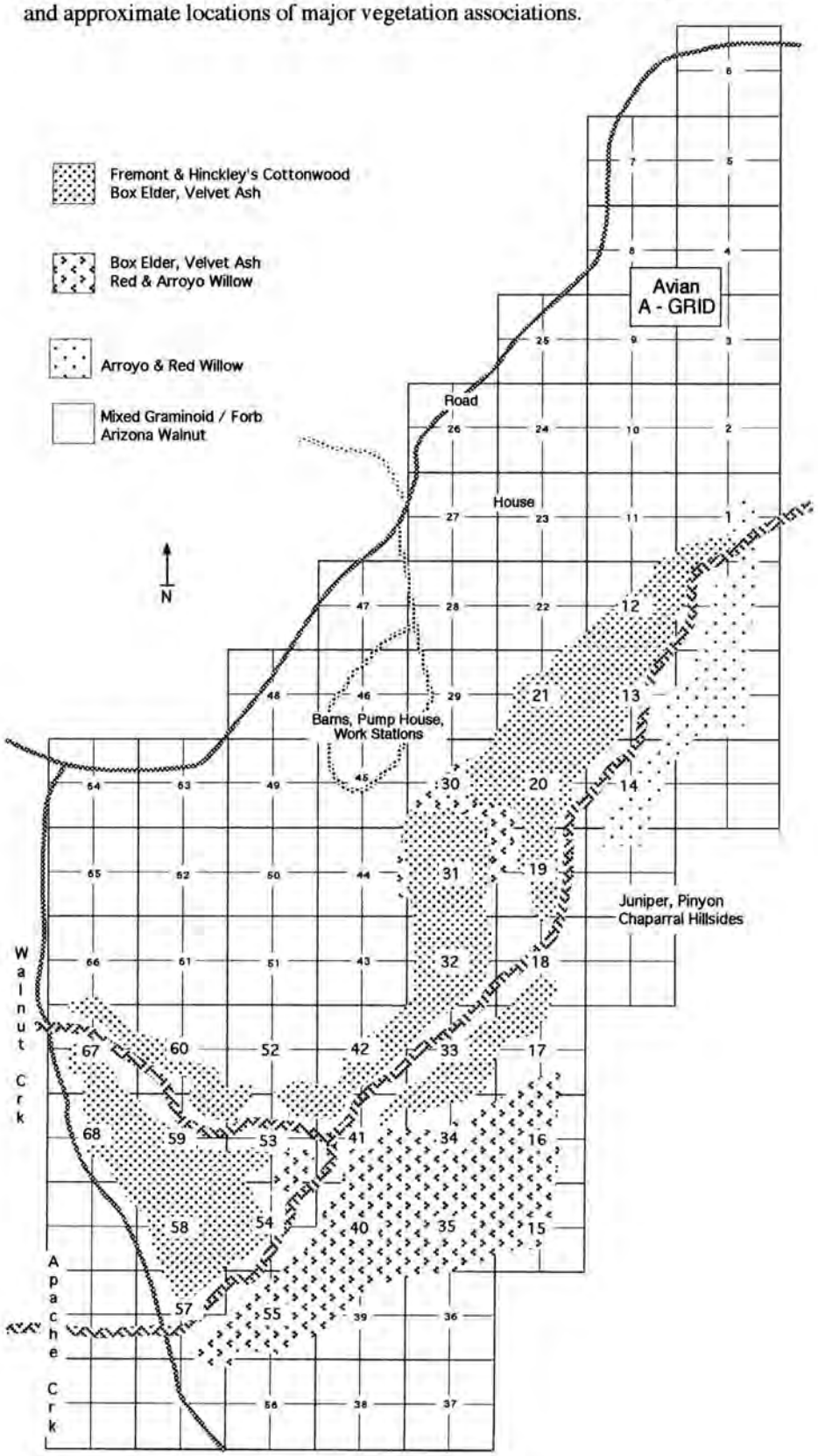


Fig. 2 A-Grid: general locations of Walnut and Apache Creeks, riparian and floodplain stations, and approximate locations of major vegetation associations.



Species Composition

Species comprising the avian community at Walnut Creek represent an array of birds reflective of neotropical migrants, regional migrants, and local residents (Table 1). No threatened or endangered bird species were encountered during this study.

Of the 153 species listed in Table 1, 22 (14%) were not detected during this survey but were observed previously by Forestry Service personnel. The majority of which were seasonal transients. The remaining 131 (86%) species were observed during this survey and illustrate the importance of longitudinal studies in obtaining significant ecological data for scientific, management, and educational purposes. The diverse avian community also mirrors the complex biological communities of plants and other animal groups at Walnut Creek - most importantly, plant diversity, habitat patches and richness, and vegetative physiognomy (vertical and horizontal).

Southwestern riparian habitats such as those found at Walnut Creek often include a diverse mixture of trees, shrubs, and grasses. In higher elevations of Arizona, southwestern riparian deciduous forest and woodlands are often made up of two vegetative associations (series): cottonwood-willow and mixed broadleaf (cottonwood-ash-box elder-walnut). At Walnut Creek the cottonwood-willow-aquatic habitats are linear and lie along Apache and Walnut Creeks. Linear wetland zones blend with adjacent floodplain riparian woodlands, which are, in some areas, fragmented with grassland, chaparral, and pinyon-juniper species. Well-defined vegetative belts are not common, and, as a result of vegetative edges and several ecotones, the existing mosaic landscape provides optimal diverse habitats for a wide variety of birds.

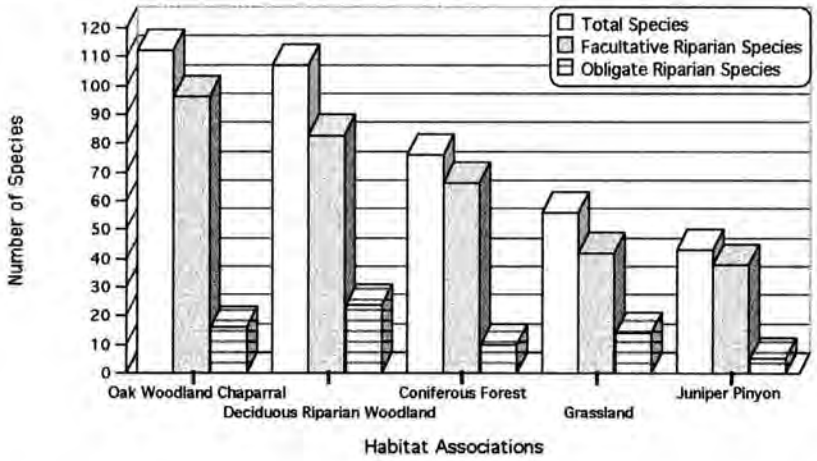
Herein we use 'riparian' in the limited sense, pertaining to the watercourses and adjacent banks of cottonwood-willow-aquatic habitats. The deciduous riparian woodland blends with riparian habitats but herein refers to the common vegetation of the floodplain. We are also aware that the term 'obligate' infers a restrictive status, which is used loosely by several researchers. We use the term 'obligate' to indicate those bird species that depend on water-related habitats for reproduction, food, and shelter. They therefore carry on most of their activities within the riparian belt but occasionally leave for a short time. Consequently, obligate riparian is used here to segregate species that commonly occur in riparian habitats but may utilize adjacent areas. The term 'facultative riparian' is used for those species that are often associated with other habitats but commonly, or on occasion, use riparian belts and woodlands.

We grouped bird species into two habitat foraging guilds based on results from this study and literature reviews. These include 25 (19%) obligate riparian species and 106 (81%) facultative riparian species (Table 2, Figs. 3 & 4). We analyzed distribution patterns for a few individual species. Common and abundant riparian obligates include; Yellow-breasted chats, Lesser goldfinches, Winter wrens, Black phoebes, Say's phoebes, and Song sparrows. Several of the listed facultative species are probably obligates but the majority of the facultative species are most often associated with the floodplain deciduous and oak woodlands at Walnut Creek, e.g., warblers, vireos, and flycatchers.

All 25 obligate riparian species, of course, favor Deciduous Riparian Woodlands while the least preferred habitat of this guild is Pinyon-Juniper areas, which are very common in central and northern Arizona (Table 2, Fig. 3). In contrast, the majority of

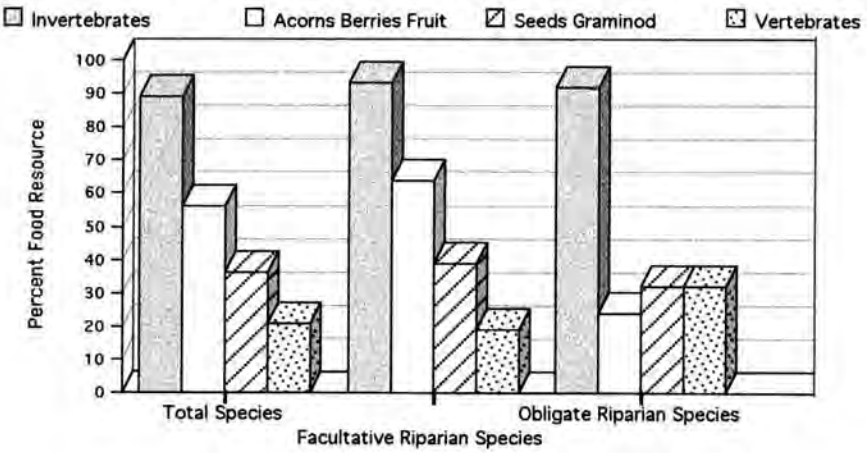
listed facultative species favor Oak-Chaparral Woodlands and Coniferous Forests that are common regional habitats and adjacent to Walnut Creek.

Fig. 3 Number of species associated with major habitats-Walnut Creek .



The favored food resource of the Walnut Creek bird community appears to consist of insects and other invertebrates (Table 2, Fig. 4). Ninety percent of the species take invertebrates, 44% feed on berries-mast-fruit, 35% graminoid seeds, and 28% take small and medium sized vertebrates. The majority of birds are omnivorous, feeding on invertebrates and mast, or invertebrates and small vertebrates. A few are strict insectivores and fewer yet are granivores. Differences in food resources other than invertebrates do appear between obligate and facultative riparian species (Fig. 4). Other than insects, facultative riparian species favor mast-berries-fruit and graminoid seeds of the floodplain woodlands while obligate riparian species favor equally graminod seeds and small vertebrates. In general, then, the consistent abundant and diverse plant and animal food resources support the diverse and abundant bird community at Walnut Creek.

Fig. 4 Species habitat types and percent food preferences-Walnut Creek .



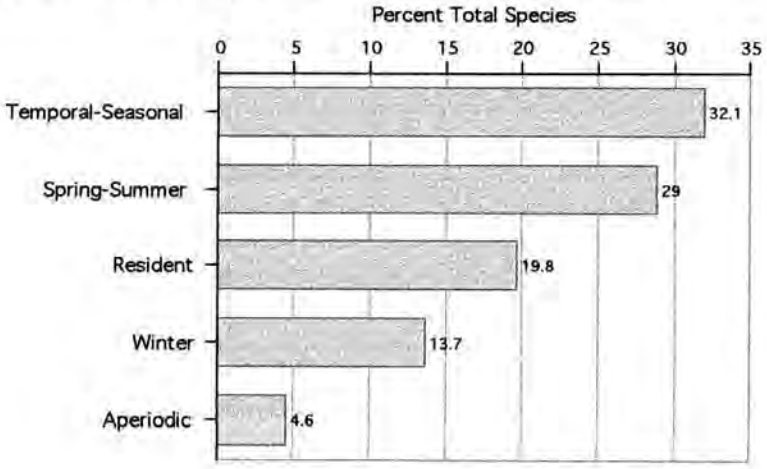
Unanimity in the literature concerning what constitutes a neotropical species appears wanting. Some regard migratory landbirds that breed primarily in the Neartic and winter generally south of the United States-Mexico border as neotropical. Others regard neotropical species as only those North American migrants that overwinter in mature tropical forests. Based on various literature lists and using the most extensive, we have listed 61 visiting neotropical species at Walnut Creek (Table 3). Shorter lists by various researchers exist and future developments may help solve the running controversies over what constitutes a neotropical migrant.

To date, our data suggest that 5 (8%) of the listed neotropicals appeared as residents and 7 (12%) visited during the winter months. This trend may have been due to the mild winter the region experienced during 1998-1999, or more simply, these resident species may not be neotropical species in the strict sense. Of the remaining 51 listed neotropical species, all appear to be spring-summer visitors or transients, and most have been, basically, regional migrants, migrating to the southern United States. Overall, May and September were the months of greatest turnover of migrants, but the majority of neotropical species visited Walnut creek throughout the five spring-summer months of May to September (Table 3).

Population Trends, Temporal

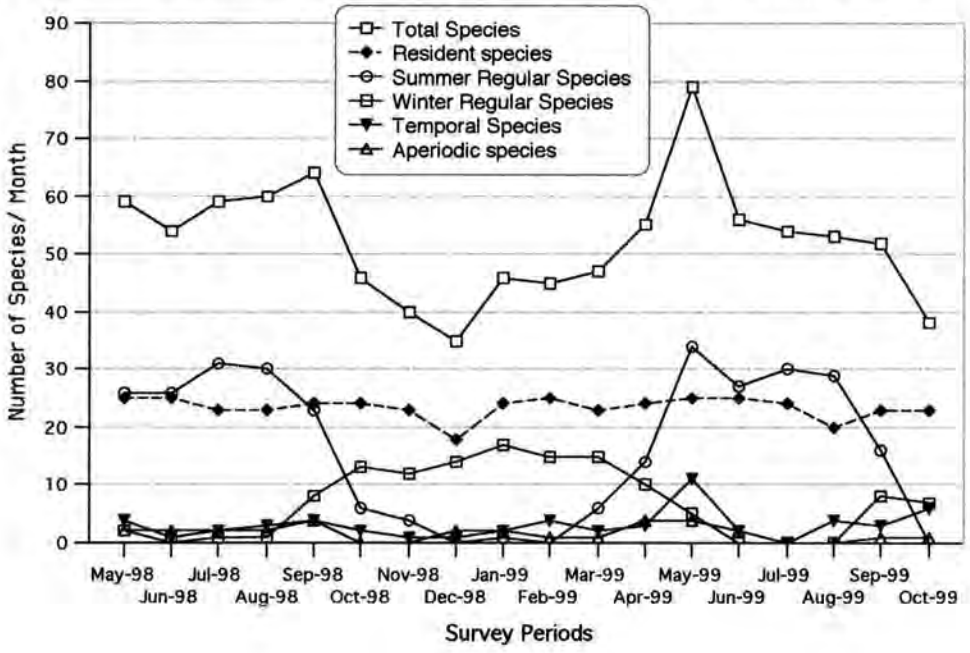
Of the 123 species observed on the two sampling grids at Walnut Creek (25.8 hectare, 63 acres), 19.8% were year-around resident species, 29% were spring-summer visitors, 13.7% winter visitors, 32.1% temporal seasonal, and 4.6% aperiodic species (Tables 4 & 5, Figs. 5 & 6). Individual species were considered residents if they were consistently observed month after month, albeit not observed on occasion. Nineteen of the 26 residents were observed every month while, as commonly experienced, predatory birds, hawks and owls, were not consistently observed. Except for December 1998, the number of resident species remained relatively constant month after month, which suggests that food and shelter resources have been temporally and spatially adequate to maintain resident populations (Table 4, Fig. 6).

Fig. 5 Avian occupancy trends - Walnut Creek (131 species).



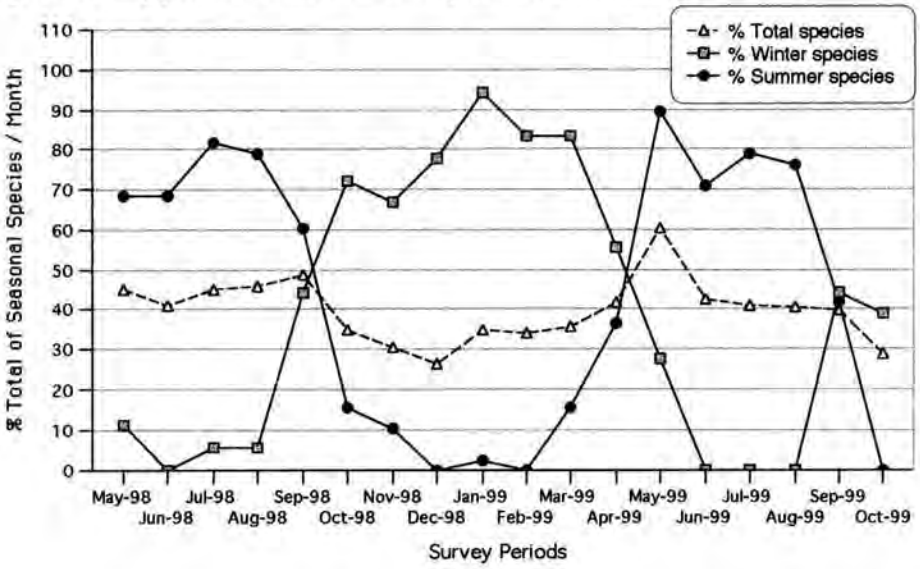
We grouped those species that appeared regularly during the months of September through March as winter visitors and species occurring regularly through May to August were considered summer visitors (Tables 4 & 6, Figs. 5 & 6). Winter and summer visitors were considered regulars if they were observed for at least three months. Transitory species that visited Walnut Creek for only one or two months were grouped as temporal-seasonals. At least one transitory species was recorded during every survey month (min. 1/month, max. 11/month). Aperiodic species were those individuals that were observed at irregular months and could not be placed in a seasonal category.

Fig. 6 Number of avian species and seasonal occurrence- Walnut Creek (18 months)



The autumn transition period (species turnover) included the two months of September and October when summer species left and winter visitors migrated into the area. The spring transition period also consisted of two months, April and May, when winter visitors left and summer regulars appeared (Fig. 7). Species turnover of regular summer and winter species was inversely related, R-squared = 0.929 (Y=29.845 – 1.79758X) and illustrates the familiar bimodal seasonal change in species composition at Walnut Creek.

Fig. 7 Monthly percent totals of seasonal species- Walnut Creek (18 months)

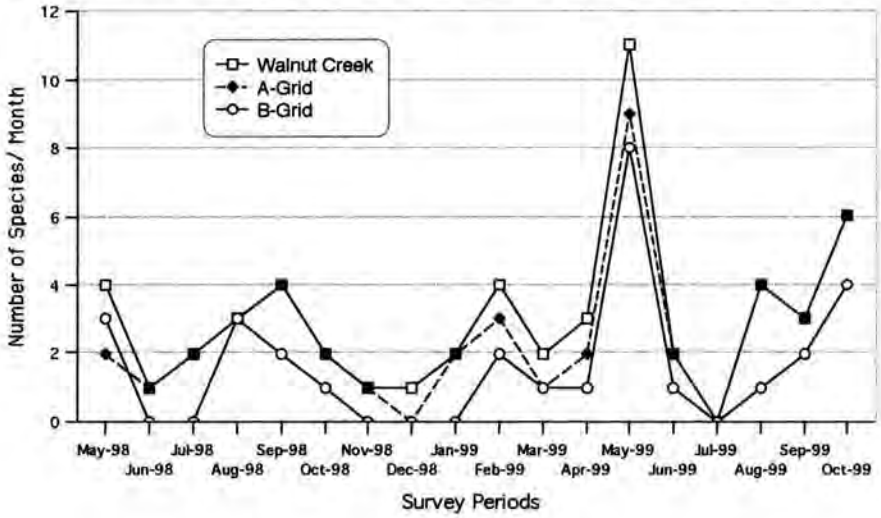


For the 18-month survey period, the number of resident and non-resident species / month was not significantly different (Table 6). However, the number of total summer species (mean 59 per month) was significantly greater than the total winter species (mean 43 per month) (t = 5.0, df = 13, $p < 0.001$). This was due primarily to the significantly greater number of summer visitors (mean 35 per month) and fewer winter visitors (mean 20 per month) (t = 5.6, df = 12, $p < 0.001$). Numbers of resident and winter visitors were similar. During both summer seasons, resident densities were maintained at significantly lower levels (mean 24 per month) than summer densities (mean 35 per month) (t = 4.7, df = 9, $p = 0.002$). These data suggest, then, that available food, shelter, and nesting sites at Walnut Creek support seasonally diverse bird communities year after year.

Population Trends, Spatial

Long-term and seasonal population trends for both grids were quite similar. There were no significant differences between the two sampling grids for resident, winter, and summer species, which suggests that most birds utilized the available shelter and food resources equally (Table 6). However, there were differences in transitory migrants visiting the two grids: Grid-A, 2.6 species /month, Grid-B, 1.6 species /month (Fig. 8).

Fig. 8 Number of temporal-seasonal species / month, Walnut Creek.



Seventy-six percent (99 species) of the listed bird species occurred on both survey grids. The remaining twenty-four percent (32 species) were observed exclusively on Grid-A or on Grid-B: 24 species on Grid-A and 8 species on Grid-B (Table 7). Those species sighted on Grid-B tended to be spring-summer visitors, while most of the listed birds of Grid-A were both summer and winter migrants.

Some of these spatial differences may be due to the different habitat physiognomies of the grids, individual species behavior, and habitat preferences. For example, Common snipe favored the more open riparian areas afforded by Grid-A, and Hepatic tanagers appear to favor more open areas of the walnut-grassland floodplain. Other factors that may have promoted species differences between the two grids include; Grid-A is much larger, comparatively open landscape of Grid-A increased visual probabilities by observers, dense tree canopies and dense brush of Grid-B hindered line-of-sight probabilities, and observers were often limited to proximate and close in sightings.

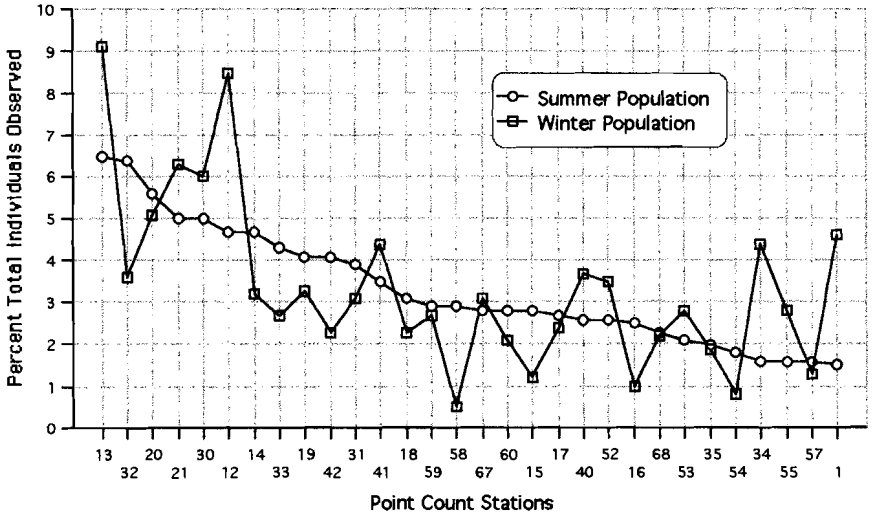
Population Trends, Riparian Habitats

Grid-A

Approximately 2,261 visual identifications were recorded within the 30 riparian point count stations during the 18 month-survey period (Table 8). The most favored (preferred) riparian area, stations where bird densities were greater than five percent of total observations, appeared to be the deciduous woodland-grassland adjacent to the relatively wide stream channel of Walnut Creek (Figs. 9 & 10). This area is comparatively more diverse and consists of a multitude of vegetative edges and ecotones. Indeed, this area was also popular for various predatory animals. The seven observations of American kestrels were within the large cottonwoods, small mammal researchers during nocturnal forays often heard calls of great horned owls, and the ever-persistent black feral cat most often searched this area for ground birds.

A few stations were favored equally by summer and winter bird populations, but seasonal utilization was quite different for most stations and appeared to be related to different foraging behaviors of summer and winter species (Figs. 9 & 10). Predominately grainivorous winter populations, White crowned-sparrows, Juncos, other sparrows, tended to prefer stations that merged with grasslands. Predominately insectivorous summer populations, Yellow-breasted chat, Black phoebe, other flycatchers, on the other hand, favored stations adjacent to Apache and Walnut stream channels where insects within dense vegetation were abundant.

Fig. 9 Grid-A riparian stations and number of birds observed (% total), 18 months.



A few obligate riparian species exhibited characteristic habitat preferences (Fig. 11). Yellow-breasted chats were commonly observed within relatively dense vegetation near stream channels. Black phoebes favored more open streamside areas for aerial insect foraging. Lesser goldfinches were observed most often in woodland-grassland ecotones. Wilson's warblers, Song sparrows, and Lincoln's sparrows were common throughout most of the riparian zone and formed no consistent distribution patterns.

Fig. 10 A-Grid: riparian and floodplain stations, approximate locations of major vegetation associations, and preferred winter and summer riparian stations.

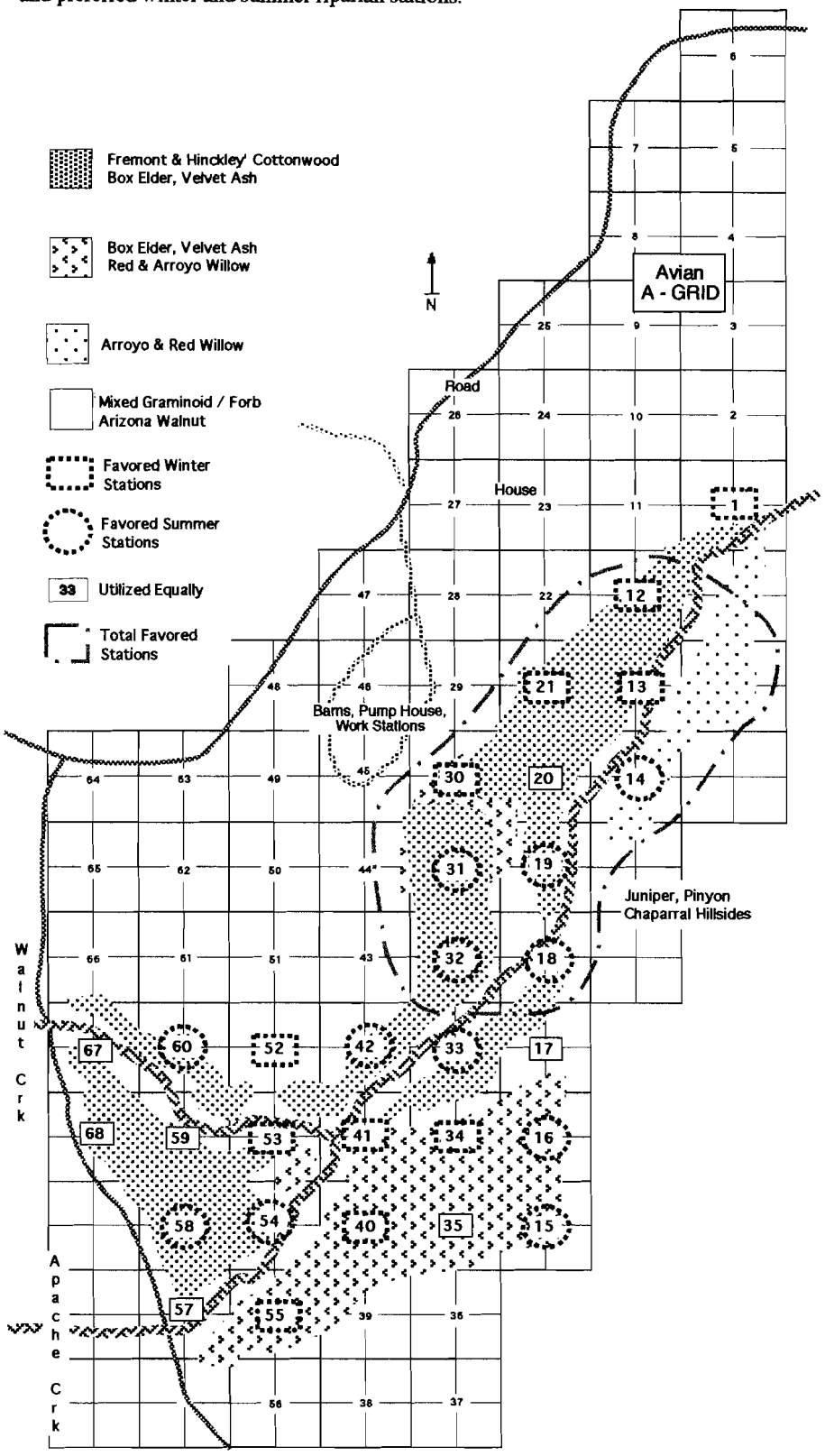
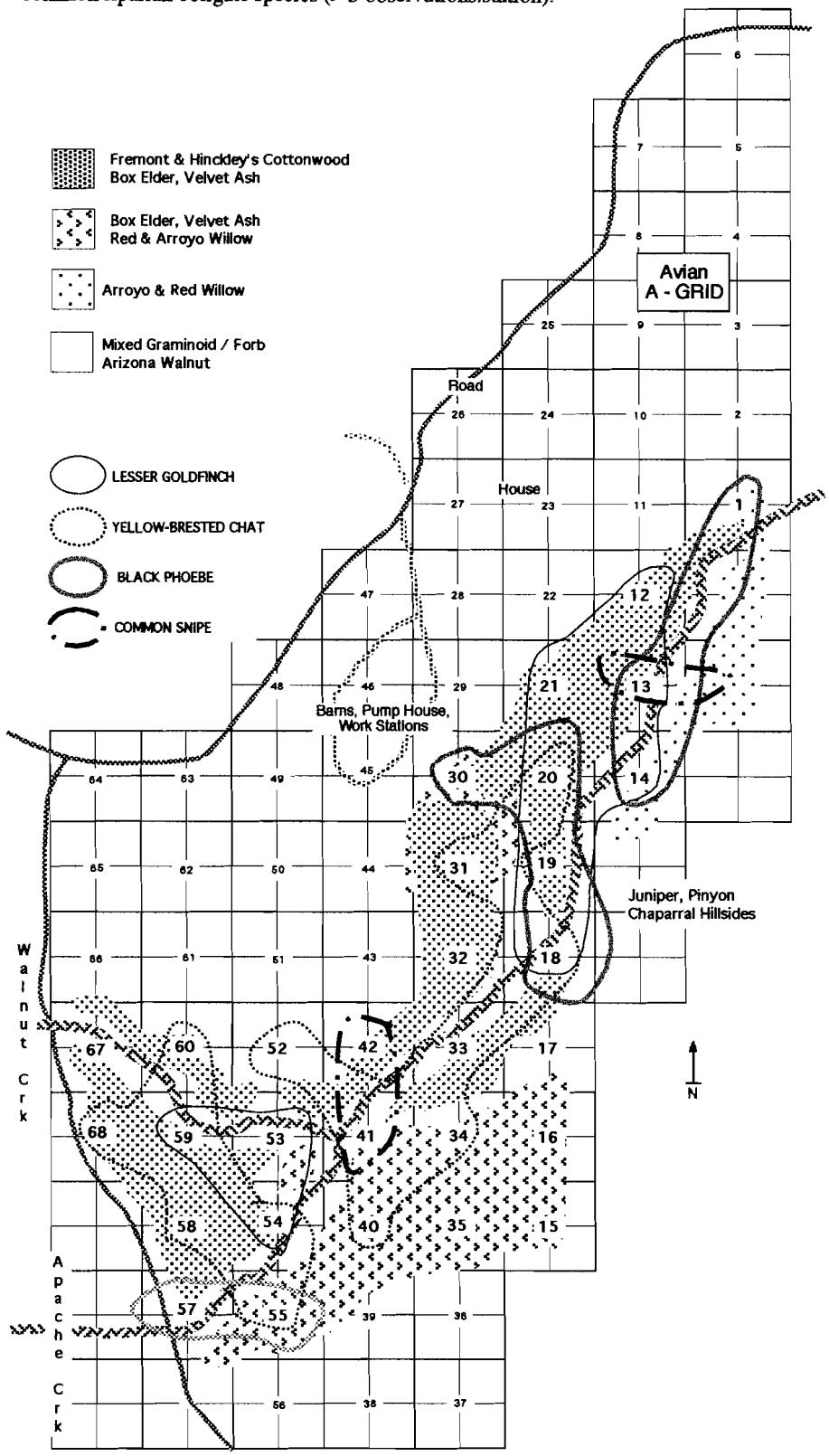


Fig. 11 A-Grid: riparian and floodplain stations, vegetation associations, and preferred stations of common riparian obligate species (> 3 observations.station).

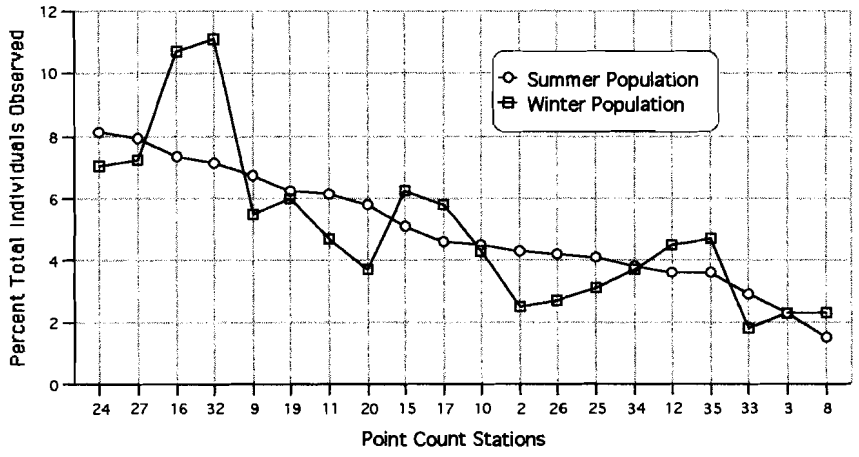


Grid-B

Approximately 1,674 visual identifications were recorded within the 20 riparian point count stations during the 18 month-survey period. The most favored (preferred) riparian area, stations where bird densities were greater than five percent of total observations (Fig. 12), appeared to be the deciduous cottonwood-willow stands adjacent to the deeply incised stream channel of Walnut Creek and patch of tall relict alligator juniper. This area is vegetatively dense and consists of diverse vegetative edges and patches (Fig. 13). This grid was also popular for various predatory animals. Twelve observations of American kestrels were within the large cottonwoods, small mammal researchers during nocturnal forays often heard calls and observed perched Great horned owls during the day. Bald eagles were sighted here. At the center of the area is a seasonally active Cooper's hawk nest where young were raised during each summer of this survey and where adults were often seen hunting through the large cottonwood woodland.

A few stations were favored equally by summer and winter bird populations, but seasonal utilization was different for seven stations and, similar to Grid-A, appeared to be related to different foraging behaviors of summer and winter species (Figs. 12 & 13). Predominately grainivorous winter populations, White crowned-sparrows, Juncos, other sparrows, tended to prefer more open stations that merged with grasslands. Chiefly insectivorous summer populations, Yellow-breasted chat, Phainopeplas, Wilson's warblers, on the other hand, favored stations adjacent to the Walnut Creek stream channel where insects within dense vegetation were abundant.

Fig. 12 Grid-B riparian stations and number of birds observed (% total), 18 months.



A few obligate riparian species exhibited characteristic habitat preferences (Fig. 14). Yellow-breasted chats were commonly observed within relatively dense vegetation near stream channels, but interesting enough, avoided the area near the Cooper's hawk nest. Black phoebes were less common on Grid-B, which may have been related to the density of vegetation. Lesser goldfinches were common throughout the riparian zone. Wilson's warblers preferred willow belts adjacent to the stream channel, and song sparrows characteristically favored cottonwood-grassland edges. Familiar Great horned owls favored perches above patchy grassy areas that maintained comparatively high rodent densities.

Fig. 13 B-Grid: riparian and floodplain stations, approximate locations of major vegetation associations, and preferred winter and summer riparian stations.

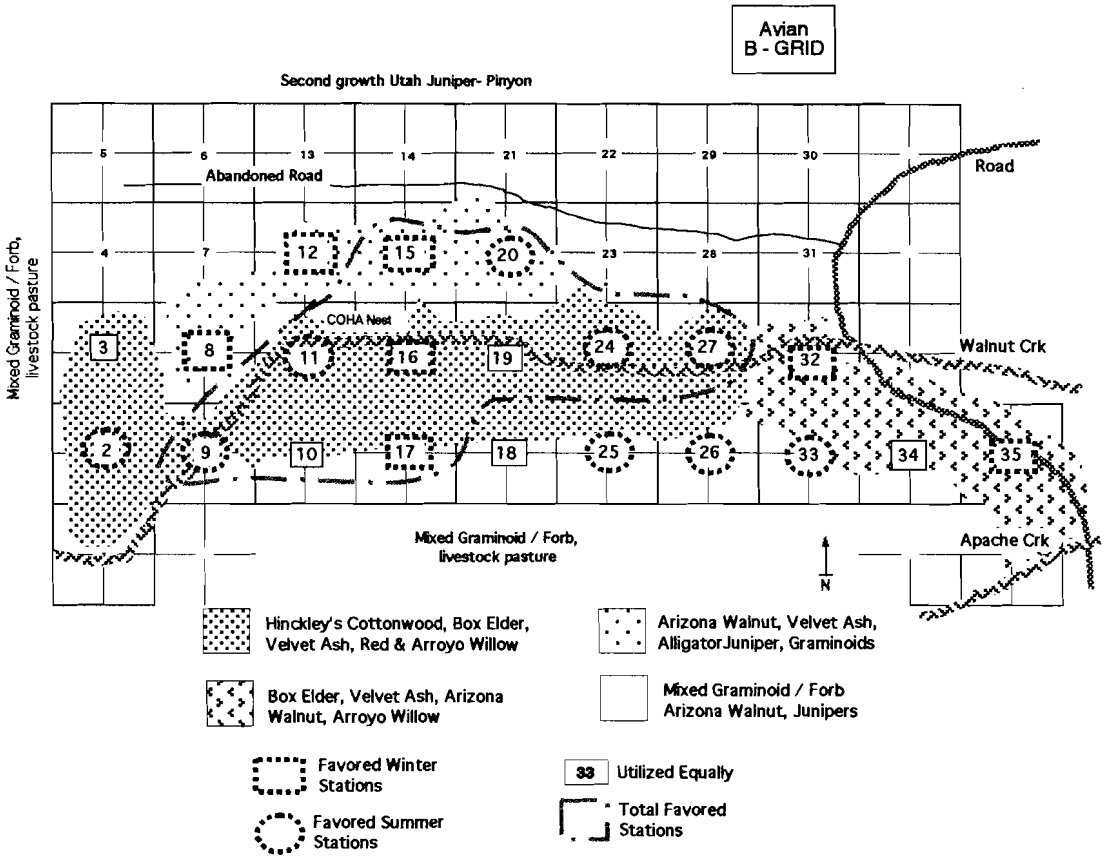
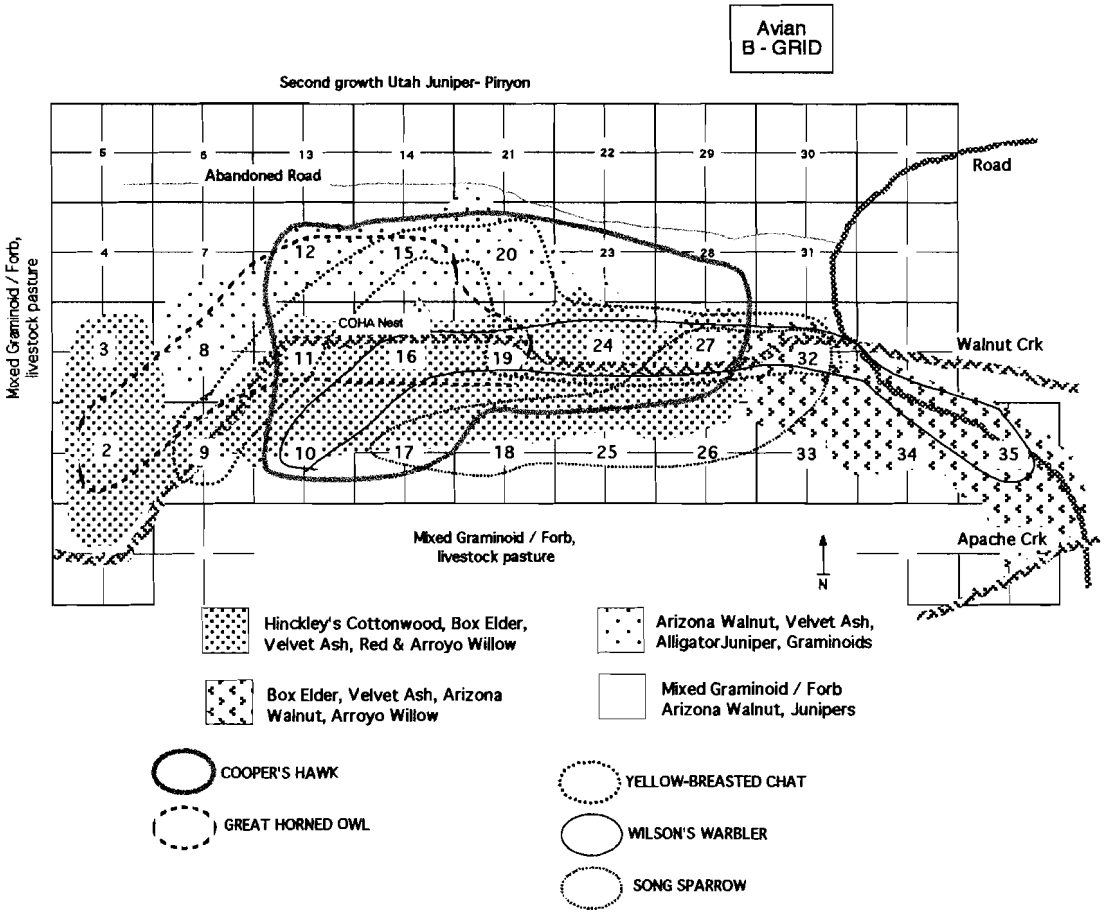


Fig. 14 B-Grid: riparian and floodplain stations, vegetation associations, and preferred stations of common riparian obligate species (> 3 observations.station).

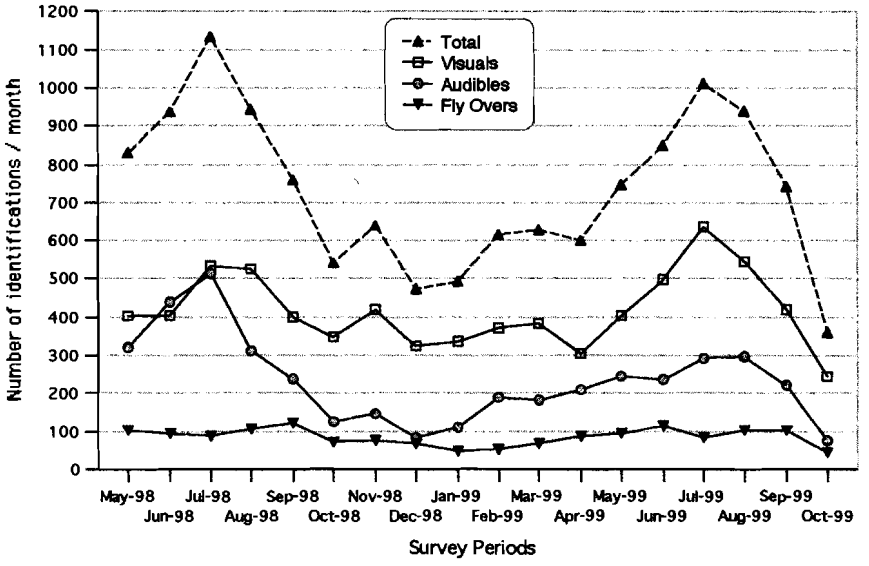


Detection Trends, Temporal

We attempted to characterize numbers and distributions of birds through time and space by detecting and recording birds at 103 point count stations. The analysis, by the nature of bird behavior, is an estimate since it has been noted that most point counts may miss about 50 percent of individual birds. But because of field design, length of study, and observer quality and persistence, the data herein characterizes well the bird community at Walnut Creek and satisfies the initial survey goals.

During point count census, individual birds were detected, identified, and recorded as fly-overs, audibles (calls, songs, etc), and visuals (Table 8). A total of 13,232 birds were identified (mean 735 per month) by these methods during the 18 month survey period. Most identifications were accomplished by visual detection, 57%, audible, 32%, and fly-over, 12%. The mean number of visual identifications was significantly greater than audibles (416 and 235 per month, respectively; $t = 5.06$, df = 33, $p < 0.001$)

Fig. 15 Number of identifications of fly-overs, audibles, and visuals- Walnut Creek.

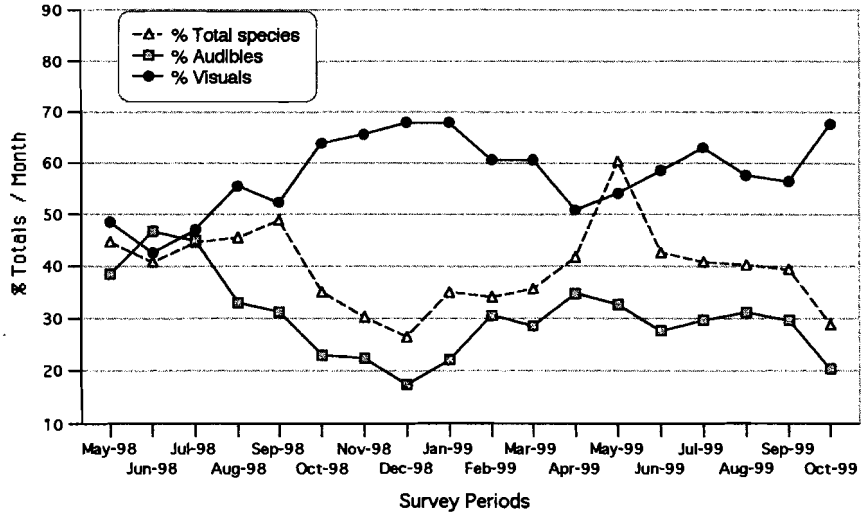


During both years, 1998 and 1999, peak detection months were June, July, and August (Fig. 15). These detection peaks (mean 968 / month) correlate well with densities of summer visitors but do not correlate with the total number of bird species/ month (Figs. 6 & 15). As a result, higher summer detection was apparently influenced by the species composition of mostly breeding birds and noticeable calls, songs, and breeding behaviors. As expected, mean winter detection (574 / month) was less ($p < 0.001$) and was due to species composition of the winter bird community.

Three observers surveyed birds during this study: one for 18 months and the other two for 9 months each. One surveyed from May 98 to January 99, the other from February 99 to October 99. A noticeable difference in detection methods by the two 9 month observers is depicted in Fig. 15. Visual and audible detection was similar during the initial summer months for the 98 observer, but the 99 observer relied consistently on visuals. Overall, however, visual and audible mean detection / month by the two 9 month observers were similar (98 observer, 57 & 31, 99 observer, 58 & 30).

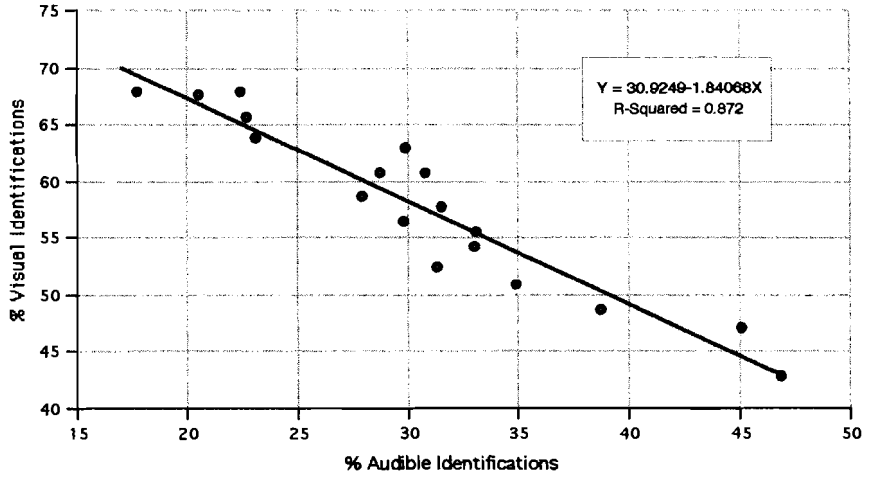
Seasonal differences in visual and audible detection rates were evident and resulted in intriguing relationships (Figs. 16 & 17). As expected, mean summer audible detection was greater than winter audibles (36% and 25% per month, respectively; $t = 2.98$, df = 12, p = 0.01). Unexpectedly, mean winter visual detection was greater than summer visuals (63% and 53% per month, respectively; t = 2.76, df = 12, p = 0.01). Higher winter detection may have been influenced by species behavior, community composition, and the comparatively openness of winter vegetation.

Fig. 16 Monthly trends of visual and audible identifications- Walnut Creek (18 months)



For the 18-month bird survey, when visual detection, as % / month, was high audible detection was usually lower (Fig. 17). This relationship illustrates seasonal species turnover and associated changes in bird community behaviors at Walnut Creek. It also demonstrates the consistency and efficiency of the three field observers and points out the value of longitudinal bird studies.

Fig. 17 Relationship between visual and audible identifications- Walnut Creek.



Detection Trends, Spatial

Of the 103 stations visited monthly during this survey, 50 were situated in riparian habitats, and 53 in floodplain areas. Grid-A was more open and twice the size of Grid-B (Figs. 1 & 2, Table 9).

Table 9 Riparian, floodplain, and grid analysis summary, Walnut Creek, 18 months.

	Number of Species / Month				Number of Visual Identifications / Month				Number of fly-over, audible, visual Identifications / Month			
	Mean	Min.	Max.	95% C.I.	Mean	Min.	Max.	95% C.I.	Mean	Min.	Max.	95% C.I.
Riparian	68	39	91	60-77	230	147	347	198-261	391	206	583	334-449
Floodplain	62	29	98	53-72	207	97	440	170-245	343	155	551	295-392
Grid-A Riparian	36	19	50	32-41	134	84	218	112-155	225	103	323	191-259
Grid-A Floodplain	36	18	54	31-40	151	74	310	123-180	245	104	351	213-277
Grid-B Riparian	32	20	49	28-36	96	57	154	82-110	166	82	266	140-193
Grid-B Floodplain	27	11	48	22-32	56	23	130	45-67	99	51	200	79-118

	No. Stations	Major vegetation associations
Riparian	50	Fremont & Hinkley's Cottonwood, Box Elder, Velvet Ash, Arroyo & Red Willow, mixed graminoids & forbs
Floodplain	53	Arizona Walnut, Alligator & Utah Juniper, Chaparral species, mixed graminoids & forbs
Grid-A Riparian	30	
Grid-A Floodplain	38	Arizona Walnut, mixed graminoids & forbs, Chaparral species
Grid-B Riparian	20	
Grid-B Floodplain	15	Alligator & Utah Juniper, Chaparral species, mixed graminoids & forbs, Arizona Walnut

For the 103 Walnut Creek point count stations the number of species observed in riparian and floodplain areas was similar (mean 68 and 62 per month, respectively). The survey area of Grid-B was much smaller than other grids. Consequently, monthly species detection and identifications were consistently and significantly fewer than other grids ($p < 0.001$).

Though more detection took place within the comparatively larger Grid-A floodplain than within the riparian grid, numbers of species observed / month and detection rates were not significantly different ($p > 0.05$). The lack of sharp delineation between these two habitats, and thus resulting analysis, was apparently due to the gradual and overlapping ecotones or edges of the riparian and floodplain areas which may have enabled birds to frequent both habitats with ease and allow increased detection by field observers.

Differences in riparian and floodplain habitats were more pronounced within Grid-B which apparently contributed to significant differences in species composition, species observed / month, and detection rates ($p < 0.05$). Factors that may have contributed to these differences include; reduced habitat diversity, lack of available niches, and comparative smaller survey area within Grid-B.

Overall species composition and species / month were similar on the two riparian grids. Detection rates, however, were greater on Grid-A ($t = 2.77$, $df = 30$, $p = 0.01$). This may be expected since vegetative structure and stream channels are more open within Grid-A, both Walnut and Apache Creeks pass through the grid, and Grid-A was larger then Grid-B. On the other hand, species composition on the two grids were consistently similar, suggesting that most species utilized the riparian belt equally, though some species favored Grid-A while others favored Grid-B.

Table 1. Avian species list for Walnut Creek (22 months), 01/98 - 10/99.

HERONS, EGRETS, etc.: Ardeidae
- GREAT BLUE HERON, *Ardea herodias*

IBISES AND SPOONBILLS : Threskiornithidae
- WHITE-FACED IBIS, *Plegadis chihi*

WATERFOWL: Anatidae
- MALLARD, *Anas platyrhynchos*

AMERICAN VULTURES: Cathartidae
- TURKEY VULTURE, *Cathartes aura*

HAWKS, etc.: Accipitridae
- BALD EAGLE, *Haliaeetus leucocephalus*
- NORTHERN HARRIER, *Circus cyaneus*
- SHARP-SHINNED HAWK, *Accipiter striatus*
- COOPER'S HAWK, *Accipiter cooperii*
- RED-TAILED HAWK, *Buteo jamaicensis*
- COMMON BLACK HAWK, *Buteogallus anthracinus*
- ZONE-TAILED HAWK, *Buteo albonotatus*
- FERRUGINOUS HAWK, *Buteo regalis*
- GOLDEN EAGLE, *Aquila chrysaetos*

FALCONS: Falconidae
- AMERICAN KESTREL, *Falco sparverius*
- MERLIN, *Falco columbarius*

FOWL-LIKE BIRDS: Phasianidae
- WILD TURKEY, *Meleagris gallopavo*
- GAMBEL'S QUAIL, *Callipepla gambelii*

PLOVERS: Charadriidae
- KILLDEER, *Charadrius vociferus*

SANDPIPERS, etc.: Scolopacidae
- SPOTTED SANDPIPER, *Actitis macularia*
- COMMON SNIPE, *Gallinago gallinago*

PIGEONS, DOVES: Columbidae
- PLAIN PIGEON (ROCK DOVE), *Columba livia*
- BAND-TAILED PIGEON, *Columba fasciata*
- MOURNING DOVE, Zenaidura macroura

CUCKOOS: Cuculidae
- GREATER ROADRUNNER, *Geococcyx californianus*

TYPICAL OWLS: Strigidae
- WESTERN SCREECH-OWL, *Otus kennicotti*
- GREAT HORNED OWL, *Bubo virginianus*

GOATSUCKERS: Caprimulgidae
- COMMON NIGHTHAWK, *Chordeiles minor*
- COMMON POOR-WILL, *Phalaenoptilus nuttallii*

SWIFTS: Apodidae
- WHITE-THROATED SWIFT, *Aeronautes saxatilis*

HUMMINGBIRDS: Trochilidae
- BLACK-CHINNED HUMMINGBIRD, *Archilochus alexandri*
- ANNA'S HUMMINGBIRD, *Calypte anna*
- BROAD-TAILED HUMMINGBIRD, *Selasphorus platycercus*
- RUFOUS HUMMINGBIRD, *Selasphorus rufus*

KINGFISHERS: Alcedinidae
- BELTED KINGFISHER, *Ceryle alcyon*

WOODPECKERS: Picidae
- LEWIS'S WOODPECKER, *Melanerpes lewis*
- ACORN WOODPECKER, *Melanerpes formicivorus*
- GILA WOODPECKER, *Melanerpes uropygialis*
- LADDER-BACKED WOODPECKER, *Picoides scalaris*
- HAIRY WOODPECKER, *Picoides villosus*
- NORTHERN FLICKER, *Colaptes auratus*

FLYCATCHERS: Tyrannidae
- OLIVE-SIDED FLYCATCHER, *Centopus borealis*
- WESTERN WOOD PEWEE, *Contonpus sordidulus*
- HAMMOND'S FLYCATCHER, *Empidonax hammondii*
- DUSKY FLYCATCHER, *Empidonax oberholseri*
- GRAY FLYCATCHER, *Empidonax wrightii*
- CORDILLERAN FLYCATCHER, *Empidonax occidentalis*
- BLACK PHEOBE, *Sayornis nigricans*
- SAY'S PHOEBE, *Sayornis saya*
- DUSKY-CAPPED FLYCATCHER, *Myiarchus tuberculifer*
- ASH-THROATED FLYCATCHER, *Myiarchus cinerascens*
- GREAT CRESTED FLYCATCHER, *Mylarchus crinitus*
- BROWN CRESTED FLYCATCHER, *Myiarchus tyrannulus*
- CASSIN'S KINGBIRD, *Tyrannus vociferans*
- WESTERN KINGBIRD, *Tyrannus verticalis*

SWALLOWS: Hirundinidae
- TREE SWALLOW, *Tachycineta bicolor*
- VIOLET-GREEN SWALLOW, *Tachycineta thalassina*
- NO. ROUGH-WINGED SWALLOW, *Stelgidopteryx serripennis*
- BANK SWALLOW, *Riparia riparia*
- CLIFF SWALLOW, *Hirundo pyrrhonota*
- BARN SWALLOW, *Hirundo rustica*

JAYS, CROWS, etc: Corvidae
- STELLER'S JAY, *Cyanocitta stelleri*
- WESTERN SCRUB JAY, *Aphelocoma coerulescens*
- PINYON JAY, *Gymnorhinus cyanocephalus*
- CLARK'S NUTCRACKER, *Nucifraga columbiana*
- AMERICAN CROW, *Corvus brachyrhynchos*
- COMMON RAVEN, *Corvus corax*

TITIMICE, CHICKADEES: Paridae
- BRIDLED TITMOUSE, *Parus wollweberi*
- PLAIN (JUNIPER) TITMOUSE, *Parus inornatus*

BUSHTIT: Aegithalidae
- BUSHTIT, *Psaltriparus minimus*

NUTHATCHES: Sittidae
- WHITE-BREASTED NUTHATCH, *Sitta carolinensis*

WRENS: Troglodytidae
- CANYON WREN, *Catherpes mexicanus*
- BEWICK'S WREN, *Thryomanes bewickii*
- HOUSE WREN, *Troglodytes aedon*
- WINTER WREN, *Troglodytes troglodytes*

Table 1. Continued

THRUSHES, etc.: Muscicapidae
- GOLDEN-CROWNED KINGLET, *Regulus satrapa*
- RUBY-CROWNED KINGLET, *Regulus calendula*
- BLACK-TAILED GNATCATCHER, *Polioptila melanura*
- WESTERN BLUEBIRD, *Sialia mexicana*
- TOWNSEND'S SOLITAIRE, *Myadestes townsendi*
- HERMIT THRUSH, *Catharus guttatus*
- AMERICAN ROBIN, *Turdus migratorius*

MIMIC THRUSHES: Mimidae
- NORTHERN MOCKINGBIRD, *Mimus polyglottos*

WAXWINGS: Bombycillidae
- CEDAR WAXWING, *Bombycilla cedrorum*

SILKY FLYCATCHERS: Ptilogonatidae
- PHAINOPEPLA, *Phainopepla nitens*

STARLINGS: Sturnidae
- EUOPEAN STARLING, *Sturnus vulgaris*

VIREOS: Vireonidae
- SOLITARY VIREO, *Vireo solitarius*
- HUTTON'S VIREO, *Vireo huttoni*
- WARBLING VIREO, *Vireo gilvus*

WOOD WARBLERS: Parulinae
- ORANGE-CROWNED WARBLER, *Vermivora celata*
- NASHVILLE WARBLER, *Vermivora ruficapilla*
- VIRGINIA'S WARBLER, *Vermivora virginiae*
- LUCY'S WARBLER, *Vermivora luciae*
- YELLOW WARBLER, *Dendroica petechia*
- BLACK-THROATED BLUE WARBLER, *Dendroica caerulescens*
- YELLOW-RUMPED WARBLER, *Dendroica coronata*
- TOWNSEND'S WARBLER, *Dendroica townsendi*
- GRACE'S WARBLER, *Dendroica graciae*
- NORTHERN WATERTHRUSH, *Seiurus noveboracensis*
- MACGILLIVRAY'S WARBLER, *Oporornis tolmiei*
- COMMON YELLOWTHROAT, *Geothlypis trichas*
- WILSON'S WARBLER, *Wilsonia pusilla*
- YELLOW-BREASTED CHAT, *Icteria virens*

TANAGERS: Thraupinae
- HEPATIC TANAGER, *Piranga flava*
- SUMMER TANAGER, *Piranga rubra*
- WESTERN TANAGER, *Piranga ludoviciana*

GROSBEAKS, etc.: Cardinalinae
- BLACK-HEADED GROSBEAK, *Pheucticus melanocephalus*
- BLUE GROSBEAK, *Guiraca caerulea*
- LAZULI BUNTING, *Passerina amoena*
- INDIGO BUNTING, *Passerina cyanea*

TOWHEES, SPARROWS, etc.: Emberizinae
- GREEN-TAILED TOWHEE, *Pipilo chlorurus*
- SPOTTED (RUFOUS-SIDED) TOWHEE, *Pipilo erythrophthalmus*
- CANYON (BROWN) TOWHEE, *Pipilo fuscus*
- CASSIN'S SPARROW, *Aimophila cassinii*
- RUFOUS-WINGED SPARROW, *Aimophila carpalis*
- CHIPPING SPARROW, *Spizella passerina*
- BREWER'S SPARROW, *Spizella breweri*
- BLACK-CHINNED SPARROW, *Spizella atrogularis*
- VESPER SPARROW, *Pooecetes gramineus*
- LARK SPARROW, *Chondestes grammacus*
- SONG SPARROW, *Melospiza melodia*
- LINCOLN'S SPARROW, *Melospiza lincolnii*
- WHITE-CROWNED SPARROW, *Zonotrichia leucophrys*
- DARK EYED JUNCO, *Junco hyemalis*

BLACKBIRDS, ORIOLES, etc.: Icterinae
- REDWINGED BLACKBIRD, *Agelaius phoeniceus*
- WESTERN MEADOWLARK, *Sturnella neglecata*
- BROWN-HEADED COWBIRD, *Molothrus ater*
- HOODED ORIOLE, *Icterus cucullatus*
- NORTHERN ORIOLE, *Icterus galbula*

FINCHES: Fringillidae
- HOUSE FINCH, *Carpodacus mexicanus*
- PINE SISKIN, *Carduelis pinus*
- LESSER GOLDFINCH, *Carduelis psaltria*
- AMERICAN GOLDFINCH, *Carduelis tristis*

WEAVER FINCHES: Passeridae
- HOUSE SPARROW, *Passer domesticus*

Additional species observed previously by Forestry Service residents at Walnut Creek Ranger Station (unpublished records, Cara Staab, Chino RS).

- GREAT EGRET, *Casmerodius albus*
- GREEN BACKED HERON, *Butorides striatus*
- BLUE-WINGED TEAL, *Anas discors*
- NORHTERN GOSHAWK, *Accipiter gentilis*
- HARRIS' HAWK, *Parabuteo unicinctus*
- AMERICAN COOT, *Fulica americana*
- SOLITARY SANDPIPER, *Tringa solitaria*
- RED-NAPED SAPSUCKER, *Sphyrapicus nuchalis*
- DOWNY WOODPICKER, *Picoides pubescens*
- VERMILION FLYCATCHER, *Pyrocephalus rubinus*
- PURPLE MARTIN, *Progne subis*
- BLACK-CAPPED CHICKADEE, *Parus atricapillus*
- GRAY CATBIRD, *Dumetella carolinensis*
- SAGE THRASHER, *Oreoscoptes montanus*
- LOGGERHEAD SHRIKE, *Lanius ludovicianus*
- GRAY VIREO, *Vireo vicinior*
- CHESTNUT-SIDED WARBLER, *Dendroica pensylvanica*
- PAINTED REDSTART, *Mioborus picta*
- YELLOW-HEADED BLACKBIRD, *Xanthocephalus xanthocephalus*
- GREAT-TAILED GRACKLE, *Quiscalus mexicanus*
- SCOTT'S ORIOLE, *Icterus parisorum*
- EVENING GROSBEAK, *Coccothraustes vespertina*

Table. 2 Habitat, food, and seasonal preferances of obligate riparian and facultative avian species, Walnut Creek.

OBLIGATE RIPARIAN

	Riparian	Deciduous Riparian Woodland	Grassland	Oak Woodland Chaparral	Juniper Pinyon	Coniferous Forest	Seeds Graminod	Insects Invertebrate	Vertebrate	Acorns Berries Fruit-Nectar	Res	WV	SSV	TS
LESSER GOLDFINCH	O	1		1	1		1	1			1			
SAY'S PHOEBE	O	1	1	1			1	1			1			
BALD EAGLE	O	1		1	1	1			1			1		
COMMON SNIPE	O	1	1					1				1		
LINCOLN'S SPARROW	O	1				1	1	1				1		
SONG SPARROW	O	1		1		1	1	1		1		1		
WINTER WREN	O	1				1		1				1		
BARN SWALLOW	O	1	1	1			1	1		1			1	
BELTED KINGFISHER	O	1		1	1	1			1				1	
BLACK PHOEBE	O	1	1	1				1	1				1	
COMMON YELLOWTHROAT	O	1	1				1	1					1	
GREAT BLUE HERON	O	1	1	1	1	1		1	1				1	
MacGILLIVRAY'S WARBLER	O	1		1		1		1					1	
N. ROUGH-WINGED SWALLOW	O	1	1	1				1					1	
WILSON'S WARBLER	O	1						1		1			1	
YELLOW-BREASTED CHAT	O	1		1				1		1			1	
CLIFF SWALLOW	O		1	1				1		1				1
CORDILLERAN FLYCATCHER	O	1		1	1	1		1		1				1
KILLDEER	O	1	1					1						1
MALLARD	O	1	1	1			1	1						1
NORTHERN WATERTHRUSH	O	1		1		1		1	1					1
RED-WINGED BLACKBIRD	O	1	1				1	1						1
SPOTTED SANDPIPER	O	1	1			1		1	1					1
WHITE-FACED IBIS	O	1	1					1	1					1
ZONE-TAILED HAWK	O	1	1	1				1	1					1
25 Species		24 96.0%	14 56.0%	16 64.0%	5 20.0%	10 40.0%	8 32.0%	23 92.0%	8 32.0%	6 24.0%	2 8.0%	5 20.0%	9 36.0%	9 36.0%

FACULTATIVE RIPARIAN

	Riparian	Deciduous Riparian Woodland	Grassland	Oak Woodland Chaparral	Juniper Pinyon	Coniferous Forest	Seeds Graminod	Insects Invertebrate	Vertebrate	Acorns Berries Fruit-Nectar	Res	WV	SSV	TS
ACORN WOODPECKER	F	1		1	1	1		1		1	1			
AMERICAN KESTREL	F	1	1	1	1	1		1	1		1			
AMERICAN ROBIN	F	1	1	1	1	1	1	1		1	1			
BEWICK'S WREN	F	1	1	1	1			1			1			
BRIDLED TITMOUSE	F	1		1		1		1		1	1			
BUSHTIT	F	1		1			1	1		1	1			
CHIPPING SPARROW	F	1	1	1		1	1	1			1			
COMMON RAVEN	F	1	1	1	1	1	1	1	1	1	1			
COOPER'S HAWK	F	1							1		1			
EUROPEAN STARLING	F	1	1	1			1	1		1	1			
GAMBEL'S QUAIL	F	1	1	1	1	1				1	1			
GREAT HORNED OWL	F	1		1		1			1		1			
GREATER ROADRUNNER	F	1	1	1	1	1	1	1	1	1	1			
HAIRY WOODPECKER	F	1		1	1	1		1		1	1			
HOUSE FINCH	F	1	1	1	1	1	1				1			
JUNIPER TITMOUSE (PLAIN)	F			1	1		1	1		1	1			
MOURNING DOVE	F	1	1	1	1	1	1			1	1			
NORTHERN FLICKER	F	1	1	1	1	1	1	1		1	1			
PINYON JAY	F	1		1	1	1	1	1		1	1			
RED-TAILED HAWK	F	1	1	1	1	1			1		1			
SPOTTED TOWHEE	F	1	1	1	1	1	1	1		1	1			
WESTERN BLUEBIRD	F	1	1	1				1		1	1			
WESTERN SCRUB JAY	F	1		1	1	1	1	1	1	1	1			
WHITE-BREASTED NUTHATCH	F	1		1		1		1		1	1			
AMERICAN CROW	F	1	1				1	1	1	1		1		
CANYON WREN	F			1	1	1		1				1		
DARK-EYED JUNCO	F	1	1	1	1	1	1	1		1		1		
HERMIT THRUSH	F	1		1		1		1		1		1		
HOUSE WREN	F	1	1	1				1				1		
LADDER-BACKED WOODPECKER	F	1		1	1	1		1		1		1		
PINE SISKIN	F	1		1	1	1	1	1		1		1		
RED-NAPED SAPSUCKER	F	1				1		1		1		1		
RUBY-CROWNED KINGLET	F	1				1	1	1		1		1		
SHARP-SHINNED HAWK	F	1		1		1			1			1		
TOWNSEND'S SOLITAIRE	F			1		1		1		1		1		
WHITE-CROWNED SPARROW	F	1	1	1	1		1	1		1		1		
YELLOW-RUMPED WARBLER	F	1		1		1		1		1		1		

Table. 2 continued

FACULTATIVE RIPARIAN

	Riparian	Deciduous Riparian Woodland	Grassland	Oak Woodland Chaparral	Juniper Pinyon	Coniferous Forest	Seeds Graminod	Insects Invertebrate	Vertebrate	Acorns Berries Fruit-Nectar	Res	WV	SSV	TS
ANNA'S HUMMINGBIRD	F	1		1		1		1		1			1	
ASH-THROATED FLYCATCHER	F	1		1	1			1		1			1	
BAND-TAILED PIGEON	F	1		1		1				1			1	
BLACK-CHINNED HUMMINGBIRD	F	1		1				1		1			1	
BLACK-HEADED GROSBEAK	F	1		1		1	1	1		1			1	
BLUE GROSBEAK	F	1	1	1			1	1		1			1	
BROAD-TAILED HUMMINGBIRD	F			1				1		1			1	
BROWN-CRESTED FLYCATCHER	F	1		1				1		1			1	
BROWN-HEADED COWBIRD	F	1	1	1			1	1					1	
BULLOCK'S ORIOLE (NORTHERN)	F	1		1				1		1			1	
CASSIN'S KINGBIRD	F	1		1	1	1		1		1			1	
CASSIN'S SPARROW	F		1	1			1	1					1	
COMMON NIGHTHAWK	F	1	1	1	1	1		1					1	
HEPATIC TANAGER	F	1		1		1		1		1			1	
INDIGO BUNTING	F	1	1	1			1	1		1			1	
LARK SPARROW	F	1	1	1			1	1					1	
LAZULI BUNTING	F	1		1			1	1					1	
LUCY'S WARBLER	F	1		1				1					1	
ORANGE-CROWNED WARBLER	F	1		1		1		1		1			1	
PHAINOPEPLA	F	1		1	1			1		1			1	
RUFOUS HUMMINGBIRD	F			1		1		1		1			1	
SOLITARY VIREO	F	1		1		1		1		1			1	
SUMMER TANAGER	F	1		1	1	1		1		1			1	
TURKEY VULTURE	F	1	1	1	1	1			1				1	
VIOLET-GREEN SWALLOW	F	1		1		1		1					1	
VIRGINIA'S WARBLER	F			1	1	1		1					1	
WARBLING VIREO	F	1		1		1		1		1			1	
WESTERN KINGBIRD	F	1	1	1				1		1			1	
WESTERN WOOD-PEWEE	F	1		1		1		1		1			1	
WILD TURKEY	F	1		1		1	1	1		1			1	
YELLOW WARBLER	F	1		1		1		1		1			1	
DUSKY FLYCATCHER	F	1		1		1		1						1
FERRUGINOUS HAWK	F		1	1	1	1			1					1
GOLDEN-CROWNED KINGLET	F			1		1	1	1		1				1
MERLIN	F		1	1				1	1					1
WESTERN MEADOWLARK	F		1	1			1	1						1
WESTERN SCREECH OWL	F	1		1		1		1	1					1
BREWER'S SPARROW	F			1			1	1						1
CLARK'S NUTCRACKER	F					1	1	1	1	1				1
AMERICAN GOLDFINCH	F	1	1	1			1	1		1				1
BLACK-CHINNED SPARROW	F			1	1		1	1						1
BLACK-TAILED GNATCATCHER	F			1			1	1						1
BLACK-THROATED GRAY WARBLER	F			1	1	1		1						1
CANYON TOWHEE (BROWN)	F	1	1	1	1	1		1		1				1
CEDAR WAXWING	F	1	1					1		1				1
COMMON POORWILL	F	1		1	1	1		1						1
DUSKY-CAPPED FLYCATCHER	F	1		1				1		1				1
GOLDEN EAGLE	F		1	1	1	1			1					1
GRAY FLYCATCHER	F	1		1				1	1	1				1
GREEN-TAILED TOWHEE	F	1		1	1	1	1	1		1				1
HAMMOND'S FLYCATCHER	F					1		1						1
HOODED ORIOLE	F	1		1				1		1				1
HOUSE SPARROW	F	1	1	1	1		1	1		1				1
HUTTON'S VIREO	F	1		1		1		1		1				1
PLAIN PIGEON(ROCK DOVE)	F	1	1	1			1	1		1				1
RUFOUS-WINGED SPARROW	F	1	1	1			1	1						1
TOWNSEND'S WARBLER	F	1	1	1		1		1		1				1
TREE SWALLOW	F	1	1	1				1		1				1
WHITE-THROATED SWIFT	F	1	1	1	1	1		1						1
NASHVILLE WARBLER	F	1		1		1		1						1
NORTHERN HARRIER	F	1	1	1					1					1
NORTHERN MOCKINGBIRD	F	1	1	1	1	1	1	1	1	1				1
GRACE'S WARBLER	F			1		1		1						1
LEWIS' WOODPECKER	F	1		1		1		1		1				1
OLIVE-SIDED FLYCATCHER	F					1		1						1
STELLER'S JAY	F			1		1		1	1	1				1
VESPER SPARROW	F		1	1			1	1						1
WESTERN TANAGER	F	1				1		1		1				1
106 Species		83 79.0%	42 40.0%	96 91.4%	38 36.2%	66 62.9%	39 37.1%	93 88.6%	19 18.1%	67 63.8%	24 22.9%	13 12.4%	31 29.5%	37 35.2%

Table. 3 Avian neotropical migrant species and monthly occurrence, Walnut Creek, 05/98-10/99

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	# obs
AMERICAN KESTREL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
AMERICAN ROBIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
CHIPPING SPARROW	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
SAY'S PHOEBE	1	1	1	1		1	1	1	1	1	1	1	1	1	1			1	15
COOPER'S HAWK	1	1	1	1	1	1	1		1			1	1	1	1		1	1	14
LINCOLN'S SPARROW					1	1	1	1	1	1	1	1	1				1	1	11
RUBY-CROWNED KINGLET					1	1	1	1	1	1	1	1					1	1	10
RED-NAPED SAPSUCKER					1	1	1	1	1	1	1						1	1	9
HOUSE WREN					1	1	1	1	1			1	1				1		8
SHARP-SHINNED HAWK					1	1	1	1			1	1					1	1	8
HERMIT THRUSH						1	1		1	1									4
NORTHERN WATERTHRUSH									1	1									2
MERLIN							1												1
YELLOW WARBLER	1	1	1	1	1	1	1					1	1	1	1	1	1		13
TURKEY VULTURE	1	1	1	1	1						1	1	1	1	1	1	1		12
WESTERN KINGBIRD	1	1	1	1	1	1	1						1	1	1	1			11
BLUE GROSBEAK	1	1	1	1	1	1							1	1	1	1	1		11
LUCY'S WARBLER	1	1	1	1							1	1	1	1	1	1	1		11
WESTERN TANAGER			1	1	1	1	1		1				1	1	1	1			10
LAZULI BUNTING	1	1	1	1	1	1							1		1	1	1		10
BLACK-HEADED GROSBEAK	1	1	1	1	1								1	1	1	1	1		10
BROWN-HEADED COWBIRD	1	1	1	1	1							1	1	1	1	1			10
SOLITARY VIREO	1	1	1	1	1								1	1	1	1	1		10
SUMMER TANAGER	1	1	1	1	1								1	1	1	1	1		10
VIOLET-GREEN SWALLOW	1	1	1	1	1							1	1	1	1	1			10
WESTERN WOOD-PEWEE	1	1	1	1	1								1	1	1	1	1		10
YELLOW-BREASTED CHAT	1	1	1	1	1								1	1	1	1	1		10
ASH-THROATED FLYCATCHER	1	1	1	1								1	1	1	1				8
WARBLING VIREO	1	1	1	1	1								1	1	1				8
WILSON'S WARBLER	1	1		1	1							1	1			1	1		8
ORANGE-CROWNED WARBLER	1				1	1						1	1			1	1		7
BROAD-TAILED HUMMINGBIRD	1	1	1	1	1								1			1			7
BULLOCK'S ORIOLE (NORTHERN)	1	1	1	1									1	1	1				7
BAND-TAILED PIGEON			1	1	1								1		1	1			6
BELTED KINGFISHER				1	1	1											1	1	5
COMMON YELLOWTHROAT												1	1	1	1	1			5
INDIGO BUNTING			1	1										1	1	1			5
N. ROUGH-WINGED SWALLOW											1	1	1	1		1			5
RUFOUS HUMMINGBIRD				1	1										1	1	1		5
VIRGINIA'S WARBLER	1				1							1	1		1				5
BLACK-CHINNED HUMMINGBIRD			1	1									1	1					4
CASSIN'S KINGBIRD	1		1	1									1						4
COMMON NIGHTHAWK		1	1												1	1			4
DUSKY FLYCATCHER		1		1					1			1							4
MacGILLIVRAY'S WARBLER	1			1	1								1						4
GREEN-TAILED TOWHEE					1							1	1						3
NASHVILLE WARBLER					1							1							2
CLIFF SWALLOW													1	1					2
CORDILLERAN FLYCATCHER													1					1	2
RED-WINGED BLACKBIRD													1					1	2
TOWNSEND'S WARBLER	1												1						2
BARN SWALLOW													1						1
CEDAR WAXWING													1						1
GRAY FLYCATCHER													1						1
HAMMOND'S FLYCATCHER													1						1
TREE SWALLOW													1						1
WHITE-FACED IBIS																1			1
VESPER SPARROW																		1	1
BLACK-CHINNED SPARROW				1															1
BLACK-THROATED GRAY WARBLER	1																		1
WHITE-THROATED SWIFT	1																		1
81 Species	30	25	28	33	33	18	15	9	13	9	11	23	44	26	28	27	23	13	408
	62.5%	41.0%	45.9%	54.1%	54.1%	29.5%	24.6%	14.8%	21.3%	14.8%	18.0%	37.7%	72.1%	42.6%	45.9%	44.3%	37.7%	21.3%	

Table. 4 Avian species seasonal and monthly occurrence, 18 months, Walnut Creek, 05/98-10/99.

RESIDENT SPECIES (26)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Number of Months Observed
ACORN WOODPECKER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
AMERICAN KESTREL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
AMERICAN ROBIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
BEWICK'S WREN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
CHIPPING SPARROW	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
COMMON RAVEN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
HAIRY WOODPECKER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
HOUSE FINCH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
JUNIPER TITMOUSE (PLAIN)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
NORTHERN (RED-SHAFTED) FLICKER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
SPOTTED TOWHEE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
WHITE-BREASTED NUTHATCH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
WESTERN SCRUB JAY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
BRIDLED TITMOUSE	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	17
MOURNING DOVE	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	17
WESTERN BLUEBIRD	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	17
EUROPEAN STARLING	1	1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	16
GAMBEL'S QUAIL	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		16
LESSER GOLDFINCH	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		16
BUSHTIT	1	1	1	1	1	1				1	1	1	1	1	1	1	1	1	15
SAY'S PHOEBE	1	1	1	1		1	1	1	1	1	1	1	1	1	1			1	15
COOPER'S HAWK	1	1	1	1	1	1	1		1			1	1	1	1		1	1	14
PINYON JAY	1	1	1	1	1	1	1	1	1	1	1	1	1					1	14
RED-TAILED HAWK	1	1			1	1	1		1	1	1	1	1	1	1		1	1	14
GREAT HORNED OWL	1	1		1	1	1		1	1	1				1			1	1	11
GREATER ROADRUNNER				1		1				1			1	1	1				6

WINTER (FALL) SPECIES (18)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Number of Months Observed
LINCOLN'S SPARROW					1	1	1	1	1	1	1	1	1				1	1	11
RUBY-CROWNED KINGLET					1	1	1	1	1	1	1	1					1	1	10
SONG SPARROW	1				1	1	1	1	1	1	1	1	1						10
WHITE-CROWNED SPARROW					1	1	1	1	1	1	1	1					1	1	10
RED-NAPED SAPSUCKER					1	1	1	1	1	1	1						1	1	9
DARK-EYED JUNCO						1	1	1	1	1	1	1						1	8
HOUSE WREN					1	1	1	1	1			1	1				1		8
SHARP-SHINNED HAWK					1	1	1	1			1	1					1	1	8
TOWNSEND'S SOLITAIRE						1	1	1	1	1	1	1							7
CANYON WREN				1			1	1	1	1	1								6
LADDER-BACKED WOODPECKER			1		1				1	1	1						1		6
PINE SISKIN	1					1			1		1	1	1						6
WINTER WREN							1	1	1	1	1						1		6
YELLOW-RUMPED WARBLER									1	1	1	1	1					1	6
AMERICAN CROW						1		1	1	1	1								5
COMMON SNIPE						1		1	1	1	1								5
HERMIT THRUSH						1	1		1	1									4
BALD EAGLE								1	1	1									3

Table. 4 continued

SPRING-SUMMER SPECIES (38)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Number of Months Observed
BLACK PHOEBE	1	1	1	1	1		1				1	1	1	1	1	1	1		13
YELLOW WARBLER	1	1	1	1	1	1	1					1	1	1	1	1	1		13
TURKEY VULTURE	1	1	1	1	1						1	1	1	1	1	1	1		12
BLUE GROSBEAK	1	1	1	1	1	1							1	1	1	1	1		11
LUCY'S WARBLER	1	1	1	1							1	1	1	1	1	1	1		11
WESTERN KINGBIRD	1	1	1	1	1	1	1						1	1	1	1			11
BROWN-HEADED COWBIRD	1	1	1	1	1							1	1	1	1	1			10
BLACK-HEADED GROSBEAK	1	1	1	1	1								1	1	1	1	1		10
GREAT BLUE HERON		1		1	1						1	1	1	1	1	1	1		10
LAZULI BUNTING	1	1	1	1	1	1							1		1	1	1		10
SOLITARY VIREO	1	1	1	1	1								1	1	1	1	1		10
SUMMER TANAGER	1	1	1	1	1								1	1	1	1	1		10
VIOLET-GREEN SWALLOW	1	1	1	1	1							1	1	1	1	1			10
WESTERN TANAGER			1	1	1	1	1		1				1	1	1	1			10
WESTERN WOOD-PEWEE	1	1	1	1	1								1	1	1	1	1		10
YELLOW-BREASTED CHAT	1	1	1	1	1								1	1	1	1	1		10
ANNA'S HUMMINGBIRD	1	1	1	1							1		1	1	1	1			9
ASH-THROATED FLYCATCHER	1	1	1	1								1	1	1	1				8
PHAINOPEPLA		1	1	1									1	1	1	1	1		8
WARBLING VIREO	1	1	1	1	1								1	1	1				8
WILSON'S WARBLER	1	1		1	1							1	1			1	1		8
BROAD-TAILED HUMMINGBIRD	1	1	1	1	1								1			1			7
BULLOCK'S ORIOLE (NORTHERN)	1	1	1	1									1	1	1				7
HEPATIC TANAGER	1	1	1	1	1								1		1				7
LARK SPARROW	1	1	1	1								1	1			1			7
ORANGE-CROWNED WARBLER	1				1	1						1	1			1	1		7
BAND-TAILED PIGEON			1	1	1								1		1	1			6
CASSIN'S SPARROW	1	1	1											1	1	1			6
COMMON YELLOWTHROAT												1	1	1	1	1			5
INDIGO BUNTING			1	1										1	1	1			5
N. ROUGH-WINGED SWALLOW											1	1	1	1		1			5
RUFOUS HUMMINGBIRD				1	1										1	1	1		5
VIRGINIA'S WARBLER	1				1							1	1		1				5
BROWN-CRESTED FLYCATCHER			1										1	1	1				4
BLACK-CHINNED HUMMINGBIRD			1	1									1	1					4
CASSIN'S KINGBIRD	1		1	1									1						4
COMMON NIGHTHAWK		1	1												1	1			4
WILD TURKEY			1										1	1					3

APERIODIC SPECIES (6)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Number of Months Observed
MALLARD			1					1	1		1	1	1	1				1	8
NORTHERN MOCKINGBIRD	1		1		1			1					1	1					6
BELTED KINGFISHER				1	1	1											1	1	5
KILLDEER		1			1					1		1					1		5
MacGILLIVRAY'S WARBLER	1			1	1								1						4
DUSKY FLYCATCHER		1		1					1			1							4
GREEN-TAILED TOWHEE					1							1	1						3

Table. 4 continued

TEMPORAL-SEASONAL SPECIES (42)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Number of Months Observed
BLACK-THROATED GRAY WARBLER	1																		1
RUFOUS-WINGED SPARROW	1																		1
WHITE-THROATED SWIFT	1																		1
HOUSE SPARROW		1																	1
COMMON POORWILL			1																1
BLACK-TAILED GNATCATCHER				1	1														2
BLACK-CHINNED SPARROW				1															1
BREWER'S SPARROW					1														1
NORTHERN HARRIER					1	1													2
CLARK'S NUTCRACKER						1													1
MERLIN							1												1
SPOTTED SANDPIPER								1											1
NORTHERN WATERTHRUSH									1	1									2
FERRUGINOUS HAWK									1										1
GOLDEN-CROWNED KINGLET										1									1
WESTERN MEADOWLARK										1									1
WESTERN SCREECH OWL										1									1
AMERICAN GOLDFINCH											1								1
HUTTON'S VIREO											1		1						2
GOLDEN EAGLE												1							1
NASHVILLE WARBLER					1							1							2
PLAIN PIGEON(ROCK DOVE)												1							1
BARN SWALLOW													1						1
CLIFF SWALLOW													1	1					2
CEDAR WAXWING													1						1
CORDILLERAN FLYCATCHER													1					1	2
DUSKY-CAPPED FLYCATCHER													1						1
GRAY FLYCATCHER													1						1
HAMMOND'S FLYCATCHER													1						1
RED-WINGED BLACKBIRD													1					1	2
TOWNSEND'S WARBLER	1												1						2
TREE SWALLOW													1						1
HOODED ORIOLE			1											1					2
CANYON TOWHEE				1												1			2
COMMON BLACK-HAWK																1			1
WHITE-FACED IBIS																1			1
ZONE-TAILED HAWK																1			1
GRACE'S WARBLER																	1	1	2
LEWIS' WOODPECKER																	1	1	2
OLIVE-SIDED FLYCATCHER																	1		1
STELLER'S JAY																		1	1
VESPER SPARROW																		1	1

Table. 5 Number of total and seasonal avian species observed during survey periods and percent total/month for Walnut Creek, 05/98-10/99.

Total Species Observed -Walnut Creek

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	59	54	59	60	64	46	40	35	46	45	47	55	79	56	54	53	52	38
															No. of Species-Total			131
% Species/Month	45.0%	41.2%	45.0%	45.8%	48.9%	35.1%	30.5%	26.7%	35.1%	34.4%	35.9%	42.0%	60.3%	42.7%	41.2%	40.5%	39.7%	29.0%

Residents

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	25	25	23	23	24	24	23	18	24	25	23	24	25	25	24	20	23	23
															No. of Resident Species		26	% Total 19.8%
% Resident Species/Month	96.2%	96.2%	88.5%	88.5%	92.3%	92.3%	88.5%	69.2%	92.3%	96.2%	88.5%	92.3%	96.2%	96.2%	92.3%	76.9%	88.5%	88.5%

Aperiodic

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	2	2	2	2	4	0	0	2	2	1	1	4	4	2	0	0	1	1
															No. of Aperiodic Species		6	% Total 4.6%
% Aperiodic Species/Month	33.3%	33.3%	33.3%	33.3%	66.7%	0.0%	0.0%	33.3%	33.3%	16.7%	16.7%	66.7%	66.7%	33.3%	0.0%	0.0%	16.7%	16.7%

Winter

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	2	0	1	1	8	13	12	14	17	15	15	10	5	0	0	0	8	7
															No. of Winter Species		18	% Total 13.7%
% Winter Species/Month	11.1%	0.0%	5.6%	5.6%	44.4%	72.2%	66.7%	77.8%	94.4%	83.3%	83.3%	55.6%	27.8%	0.0%	0.0%	0.0%	44.4%	38.9%

Summer

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	26	26	31	30	23	6	4	0	1	0	6	14	34	27	30	29	16	0
															No. of Summer Species		38	% Total 29.0%
% Summer Species/Month	68.4%	68.4%	81.6%	78.9%	60.5%	15.8%	10.5%	0.0%	2.6%	0.0%	15.8%	36.8%	89.5%	71.1%	78.9%	76.3%	42.1%	0.0%

Temporal

Survey Month	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99
Number of Species/Month	4	1	2	3	4	2	1	1	2	4	2	3	11	2	0	4	3	6
															No. of Temporal Species		42	% Total 32.1%
% Temporal Species/Month	9.5%	2.4%	4.8%	7.1%	9.5%	4.8%	2.4%	2.4%	4.8%	9.5%	4.8%	7.1%	26.2%	4.8%	0.0%	9.5%	7.1%	14.3%

Table. 6 Seasonal and spatial data, Walnut Creek, 05/98-10/99.

Condition	No. Months	Mean	Min.	Max.	StDev	SEMean
Number of Species/ Month						
Total WC	18	52.3	35	79	10.41	2.45
Total A	18	51.3	35	77	9.89	2.33
Total B	18	50.3	33	75	10.03	2.36
Residents WC	18	23.4	18	25	1.82	0.43
Residents A	18	23.4	18	25	1.82	0.43
Residents B	18	23.4	18	25	1.82	0.43
Temporal WC	18	3.1	0	11	2.46	0.58
Temporal A	18	2.6	0	9	2.17	0.051
Temporal B	18	1.6	0	8	2	0.47
Regulars						
Winter WC	18	7.1	0	17	6.16	1.45
Winter A	18	7.1	0	17	6.16	1.45
Winter B	18	6.9	0	16	5.79	1.36
Regulars						
Summer WC	18	16.8	0	34	12.85	3.03
Summer A	18	16.2	0	34	12.27	2.89
Summer B	18	16	0	32	12.2	2.88

Condition	No. Months	Mean	Min.	Max.	StDev	SEMean
Number of Species/ Month						
Totals, Resident, Non-Residents						
Resident	18	23.4	18	25	1.82	0.43
Non-Resident	18	28.7	14	54	9.71	2.29
Total Summer	10	59	52	79	7.96	2.52
Resident Sum	10	23.7	20	25	1.56	0.5
Non-Res Sum	10	35	28	54	7.53	2.38
Total Winter	6	43.2	35	47	4.71	1.92
Resident Win	6	22.8	18	25	2.48	1.01
Non-Res Win	6	20.2	17	24	2.79	1.14
Summer Resident, Non-Residents						
Total Summer (98)	5	59.2	54	64	3.56	1.59
Resident Sum (98)	5	24	23	25	1	0.45
Non-Res Sum (98)	5	34.8	29	39	3.7	1.66
Total Summer (99)	5	58.8	52	79	11.39	5.09
Resident Sum (99)	5	23.4	20	25	2.07	0.93
Non-Res Sum (99)	5	35.2	28	54	10.66	4.77

Summer Population (May-Sept)

No. Species/ Month						
Total WC	10	59	52	79	7.96	2.52
Total A	10	57.5	51	77	7.91	2.5
Total B	10	56	50	75	7.26	2.3
Regulars: observed > 3 months						
Summer WC	10	27.2	16	34	5.01	1.58
Summer A	10	26.1	16	34	4.7	1.49
Summer B	10	25.8	15	32	4.98	1.58
Summer Visitors (May-Sept)						
Summer WC	10	32.5	20	49	7.18	2.27
Summer A	10	30.9	20	46	6.54	2.07
Summer B	10	29.7	19	43	6.06	1.92

Winter Population (Oct - March)

No. Species/ Month						
Total WC	6	43.2	35	47	4.71	1.92
Total A	8	42.8	35	46	4.49	1.83
Total B	6	41.3	33	45	4.59	1.87
Regulars: observed > 3 months						
Winter WC	6	14.3	12	17	1.75	0.72
Winter A	6	14.3	12	17	1.75	0.72
Winter B	6	13.5	12	16	1.52	0.62
Winter Visitors (Oct - March)						
Winter WC	6	17.3	13	21	3.01	1.23
Winter A	6	16.3	15	19	1.75	0.72
Winter B	6	14.8	12	18	2.12	0.95

Summer Population (May-Sept)

No. Species/ Month (98)						
Total WC	5	59.2	54	64	3.56	1.59
Total A	5	57.8	53	64	4.09	1.83
Total B	5	57	52	61	3.39	1.52
Regulars: observed > 3 months (98)						
Summer WC	5	27.2	23	31	3.27	1.46
Summer A	5	26.2	23	29	2.68	1.2
Summer B	5	25.4	21	30	3.58	1.6
Summer Visitors (May-Sept) (98)						
Summer WC	5	32.4	29	35	2.61	1.17
Summer A	5	31	28	34	2.55	1.14
Summer B	5	29.6	26	34	3.05	1.36

No. Species/ Month (99)						
5	58.8	52	79	11.39	5.09	
5	57.2	51	77	11.12	4.97	
5	56.8	50	75	10.35	4.63	
Regulars: observed > 3 months (99)						
5	27.2	16	34	6.76	3.02	
5	26	16	34	6.52	2.92	
5	26.2	15	32	6.53	2.92	
Summer Visitors (May-Sept) (99)						
5	32.6	20	49	10.45	4.68	
5	30.8	20	46	9.47	4.24	
5	29.8	19	43	8.56	3.83	

Table. 7 Avian species observed exclusively on Grid A or Grid B, Walnut Creek, 05/98-10/99.

OBSERVED ON GRID A (24)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Grid
HEPATIC TANAGER	1	1	1	1	1								1		1				A
COMMON SNIPE						1		1	1	1	1								A
BLACK-THROATED GRAY WARBLER	1																		A
HOUSE SPARROW		1																	A
COMMON POORWILL			1																A
HOODED ORIOLE			1											1					A
BREWER'S SPARROW					1														A
NASHVILLE WARBLER					1							1							A
CLARK'S NUTCRACKER						1													A
MERLIN							1												A
SPOTTED SANDPIPER								1											A
FERRUGINOUS HAWK									1										A
GOLDEN-CROWNED KINGLET										1									A
AMERICAN GOLDFINCH											1								A
GOLDEN EAGLE												1							A
BARN SWALLOW													1						A
GRAY FLYCATCHER													1						A
TREE SWALLOW													1						A
COMMON BLACK-HAWK																1			A
WHITE-FACED IBIS																1			A
ZONE-TAILED HAWK																1			A
OLIVE-SIDED FLYCATCHER																	1		A
STELLER'S JAY																		1	A
VESPER SPARROW																		1	A

OBSERVED ON GRID B (8)

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Grid
CASSIN'S SPARROW	1	1	1											1	1	1			B
INDIGO BUNTING			1	1										1	1	1			B
RUFOUS-WINGED SPARROW	1																		B
WHITE-THROATED SWIFT	1																		B
WESTERN SCREECH OWL										1									B
HUTTON'S VIREO											1		1						B
PLAIN PIGEON(ROCK DOVE)												1							B
CEDAR WAXWING													1						B

Table. 8 Total number of birds identified as fly-overs, audibles, and visuals, Walnut Creek.

RIPARIAN STATIONS

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99	Totals 18 months	Percent Totals
A-Grid																				
Fly-over I.D.	13	26	21	29	27	28	22	10	9	10	16	18	20	26	16	31	24	8	354	8.7%
Audible I.D.	86	133	151	101	97	50	43	9	31	40	60	67	88	108	99	119	128	26	1436	35.4%
Visual I.D.	117	110	145	144	127	118	142	84	84	131	109	90	128	170	208	137	127	90	2261	55.8%
Total/Month	216	269	317	274	251	196	207	103	124	181	185	175	236	304	323	287	279	124	4051	57.5%
B-Grid																				
Fly-over I.D.	32	22	18	31	30	18	12	14	7	10	11	23	19	22	15	21	27	4	336	11.2%
Audible I.D.	79	108	119	95	61	14	33	23	34	47	46	50	51	48	68	61	28	21	986	32.9%
Visual I.D.	101	106	129	115	102	79	90	71	70	61	82	68	82	89	128	132	112	57	1674	55.9%
Total/Month	212	236	266	241	193	111	135	108	111	118	139	141	152	159	211	214	167	82	2996	42.5%
Riparian Totals																				
Fly-over I.D.	45	48	39	60	57	46	34	24	16	20	27	41	39	48	31	52	51	12	690	9.8%
Audible I.D.	165	241	270	196	158	64	76	32	65	87	106	117	139	156	167	180	156	47	2422	34.4%
Visual I.D.	218	216	274	259	229	197	232	155	154	192	191	158	210	259	336	269	239	147	3935	55.8%
Total/Month	428	505	583	515	444	307	342	211	235	299	324	316	388	463	534	501	446	206	7047	53.3%

FLOODPLAIN STATIONS

	5\98	6\98	7\98	8\98	9\98	10\98	11\98	12\98	1\99	2\99	3\99	4\99	5\99	6\99	7\99	8\99	9\99	10\99		
A-Grid																				
Fly-over I.D.	29	29	34	30	42	19	32	35	23	21	25	32	36	44	35	35	34	19	554	12.6%
Audible I.D.	105	143	144	77	57	47	53	40	36	78	55	80	79	57	80	82	41	11	1265	28.7%
Visual I.D.	114	117	173	207	115	102	148	129	124	130	150	109	145	182	234	203	131	74	2587	58.7%
Total/Month	248	289	351	314	214	168	233	204	183	229	230	221	260	283	349	320	206	104	4406	71.2%
B-Grid																				
Fly-over I.D.	30	18	15	16	25	6	8	9	9	11	14	12	20	22	15	14	17	12	273	15.3%
Audible I.D.	51	55	98	39	22	14	16	12	9	24	19	12	28	23	45	34	24	16	541	30.4%
Visual I.D.	72	69	87	58	53	47	40	38	56	51	41	38	49	56	66	72	49	23	965	54.2%
Total/Month	153	142	200	113	100	67	64	59	74	86	74	62	97	101	126	120	90	51	1779	28.8%
Floodplain Totals																				
Fly-over I.D.	59	47	49	46	67	25	40	44	32	32	39	44	56	66	50	49	51	31	827	13.4%
Audible I.D.	156	198	242	116	79	61	69	52	45	102	74	92	107	80	125	116	65	27	1806	29.2%
Visual I.D.	186	186	260	265	168	149	188	167	180	181	191	147	194	238	300	275	180	97	3552	57.4%
Total/Month	401	431	551	427	314	235	297	263	257	315	304	283	357	384	475	440	296	155	6185	46.7%

WALNUT CREEK STATIONS

Fly-over I.D.	104	95	88	106	124	71	74	68	48	52	66	85	95	114	81	101	102	43	1517	11.5%
Audible I.D.	321	439	512	312	237	125	145	84	110	189	180	209	246	236	292	296	221	74	4228	32.0%
Visual I.D.	404	402	534	524	397	346	420	322	334	373	382	305	404	497	636	544	419	244	7487	56.6%
Total/Month	829	936	1134	942	758	542	639	474	492	614	628	599	745	847	1009	941	742	361	13232	

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Bat Survey

Introduction

We enmeshed bats through the summer seasons of 1998 and 1999 (June through August). Sampling efforts during September and October were abandoned because of persistent evening threats of monsoon rains. The arrival of bats at the Walnut Creek site proved to be seasonally late during both summers, beginning in June and peaking in July and August. This trend appeared common throughout Arizona as confirmed with personnel from the Arizona Game and Fish Department and others who were involved with bat research. Fifty individual bats representing nine bat species were successfully netted and identified (Table 1). Most of the nine species appear to be relatively common species throughout the central northwest region of Arizona.

Methods

Site Descriptions

During the 1998 summer season, mistnetting locations were established over Walnut and Apache Creeks at sites that were deemed most conducive to bat captures (Fig. 1). Qualified bat consultants included Dan Taylor, Mike Robbie (Arizona Game and Fish Department), and Cara Staab (Chino Ranger District).

- *Walnut site*

This relatively wide, ca. 15m, channel was relatively open at the netting station but heavily forested (cottonwoods and willows) well upstream and downstream. We sampled this site for three months; the netting sessions here proved to be the least productive.

- *Apache site*

Apache Creek is narrow, ca. 8m, with an enclosed narrow tunnel of large willow stands on both sides of the channel. Stream flow is constant with occasional deep pools, .3 to .6m, near the netting station. We sampled this site for three months, and the netting sessions here proved to be moderately productive.

- *Admin site*

This site proved to be the most productive and was used as the primary bat sampling station during the 1999 summer season. During the 1998 season, two nets were established across the relatively wide and open channel just southeast of the existing administrative barn. One net was across a large deep pool, ca. .8m and another downstream across relatively wide algal riffles. This area typically provides more insect diversity and activity than the other two sampling sites.

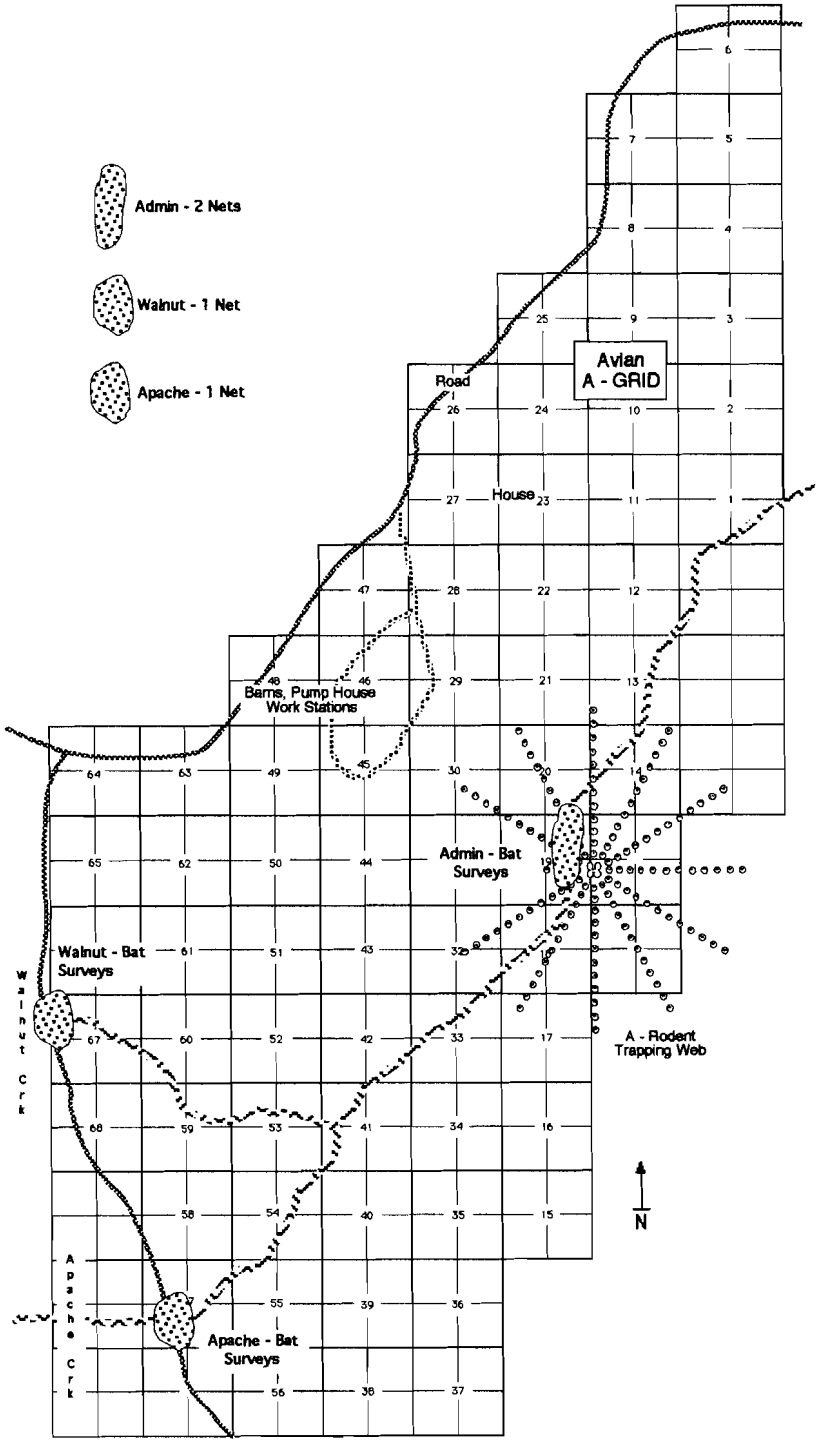
From the collecting results of 1998, we established nets only at the Admin site during the 1999 summer season. We concentrated efforts at this site since nocturnal sampling is time and labor intensive and the Admin site proved to be the most productive the previous year.

Capture-Release Methods

With the advisement and collaboration of Mike Robbie and Tim Snow (Arizona Game and Fish Department) the processing methodologies of bats as proposed in the initial protocol was altered due to regulatory and health concerns. Since we were not involved

with a taxonomic research project, Arizona Game and Fish officials suggested (and was noted in our 1999 scientific collecting permit) that the handling of bats during capture be reduced to just identification, i.e., times of net capture, handling, and release should be minimized. Besides measurements for identification, prolonged handling was minimized to reduce potential harmful effects. Health concerns during the 1999 summer session also emerged due to the increased incidence of bat-induced rabies cases in the southwest.

Fig. 1 Locations of Walnut and Apache Creeks, netting stations for bats.



Survey Trends and Species Composition

Results from this survey suggest that the Walnut Creek site provides a variety of resources for regional bat species (Tables 1 & 2). Nine species representing wide-ranging and more narrow-ranging species were captured and identified during this survey.

Table 1. Bat species list and monthly occurrence for Walnut Creek, 06-08/1998 and 1999.

		June		July		August		Totals		
		1998	1999	1998	1999	1998	1999	1998	1999	
Small--Footed Myotis	*Myotis ciliolabrum (leibii)*	0	1	5	3	3	2	8	6	14
Big Brown Bat	*Eptesicus fuscus*	2	2	2	3	2	1	6	6	12
Hoary Bat	*Lasiurus cinereus*	0	0	2	2	1	0	3	2	5
Pallid Bat	*Antrozous pallidus*	0	1	1	0	2	1	3	2	5
Arizona Myotis	*Myotis lucifugus (occultus)*	1	0	2	0	1	0	4	0	4
American Free-Tailed Bat	*Tadarida brasiliensis*	1	0	1	0	2	0	4	0	4
Western Pipistrelle	*Pipostrellus hesperus*	0	0	0	0	3	0	3	0	3
California Myotis	*Myotis californicus*	2	0	0	0	0	0	2	0	2
Long-Eared Myotis	*Myotis evoltis*	0	0	0	1	0	0	0	1	1
	Total Individuals/Month	6	4	13	9	14	4	33	17	50

Table 2. Ecological traits of bat species observed at Walnut Creek, 06-08/1998 and 1999 (Hoffmeister,1986, AZGFD, 1995).

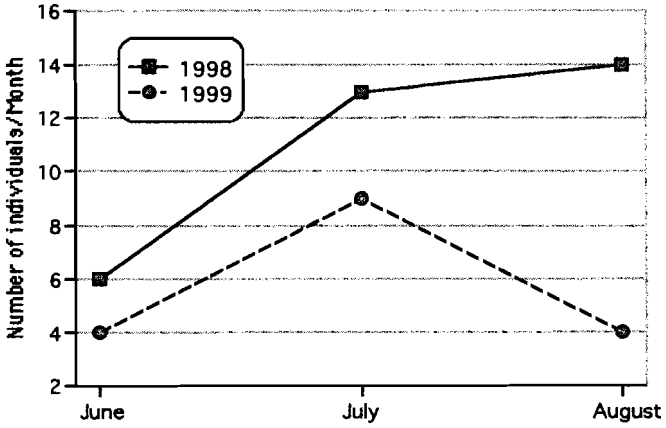
	Arizona Distribution	Habitat Distribution	Primary Roosting Sites
Small--Footed Myotis *Myotis ciliolabrum (leibii)*	Widespread except for Sonoran desertscrub	Grasslands to Pine Forests	rock crevices caves / mines
Big Brown Bat *Eptesicus fuscus*	Widespread - more common in wooded areas	Desertscrub to Mixed Conifer Forests	buildings caves / mines
Hoary Bat *Lasiurus cinereus*	Widespread-more common in mountain forests	Desertscrub to Mixed Conifer Forests	trees foliage
Pallid Bat *Antrozous pallidus*	Widespread-more common in desertscrub areas	Deserts to Pine Forests	buildings caves / mines
Arizona Myotis *Myotis lucifugus (occultus)*	Oak-Pine woodlands of Mogollon rim	Juniper-Pinyon to Pine Forests	tree cavities caves / mines
American Free-Tailed Bat *Tadarida brasiliensis*	Widespread-more common in desert areas as large colonies	Deserts to Pine Forests	buildings caves / mines
Western Pipistrelle *Pipostrellus hesperus*	Widespread-more common rocky canyons, cliffs	Deserts to Pine Forests	rock crevices caves / mines
California Myotis *Myotis californicus*	Widespread- less common in high mountains	Deserts to Pine Forests	rock crevices caves / mines
Long-Eared Myotis *Myotis evoltis*	Pine-Coniferous Forests of Mogollon Plateau	Juniper-Pinyon to Mixed Conifer Forests	tree cavities caves / mines

The variety of species that visited Walnut Creek typically range from deserts to coniferous forests (Table 2). The feature that such a variety of species was identified demonstrates the unique location and biotic diversity of the Walnut Creek site. For example, diverse and abundant insects associated with the watershed and associated riparian zones supply an invaluable food base for seasonal bats. The floodplain consists, also, of a patchwork of grassland and wooded habitats that serve as potential roosts. The site is contiguous with pine-oak and juniper-pinyon forests, and is adjacent to massive rocky cliffs of the Colorado Plateau southern border. Consequently, the array of available habitats and micro-habitats within and adjacent to the Walnut and Apache Creek drainage offer suitable resources for those species requiring rock crevices, tree cavities, or dense foliage.

The only roosting site located during the 1998 season was in the west-end of the existing barn, the second level hayloft. A large contingent (estimated number was 15-25) of Small-footed myotis occupied the loft and crevices under the external siding and remained there throughout the 1998 season. Unfortunately, the hay was removed (due to biohazard potential from numerous rodents), doors closed, the loft sanitized, and siding will be renovated in the near future. Consequently, this roost has been eliminated, but we occasionally observed a few myotis flying in and out of the lower horse stalls during the 1999 season. Bat boxes established by the Forest Service in 1992 still remain near Apache and Walnut Creeks. We have observed a few bird nests and a rodent nest but no evidence of bat occupation has been noted in these artificial shelters.

Peak visitations appeared to be during July and August, the same peaks of insect abundance and seasonal monsoons (Fig. 2). During the 1998 season, emerging aquatic insects were relatively abundant through July and August, but during the 1999 season monsoon flooding scoured Walnut Creek and altered aquatic habitats considerably. This may have reduced the food source for bats and may have contributed to lower levels of species diversity and abundance during August 1999.

Fig. 2 Number of bats captured by net / month - Walnut Creek



Bat activity was also associated with crepuscular and nocturnal insect activity as demonstrated by the use of Anabat methods utilized in July 1998 by Mike Robbie (AZGFD). Along with net captures we used the Anabat from sunset, 19:30 hrs, to around 22:30 hrs to identify bats flying over. We were able to follow activity peaks for the various species which appeared to be between 19:45 hrs to 20:30 hrs which was associated with peak airborne insect activity.

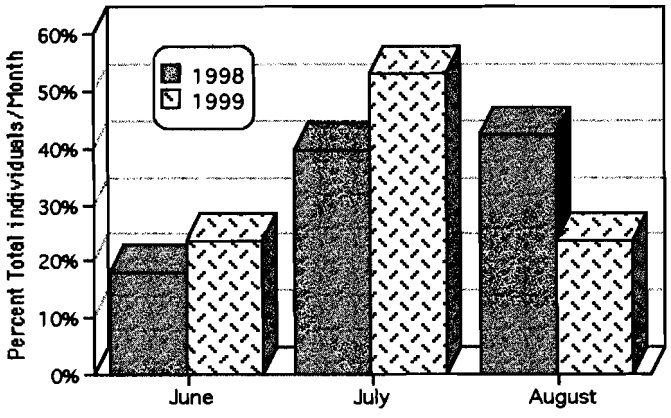
During the two summer seasons of this survey, bat activity appeared to be spatially and temporally influenced by the condition of streamside vegetation and associated insect abundance. Bat activity and abundance was noticeably reduced during the 1999 summer season.

Only five species were identified, Big brown bat, Hoary bat, Small-footed myotis, and Pallid bat, and one Long-eared myotis. The reduction in bat densities may have been related to the reduction of open water and heavy plant growth in the stream channel.

As mentioned elsewhere, cattle were eliminated from the site during the fall of 1998 and as a result young cottonwoods and willow stands flourished along the stream channel during the spring of 1999. Concomitantly, emergent aquatic plants inundated the stream leaving little open water and presumably altering the composition of insects. Consequently, open water surfaces for foraging were restricted during the prime month of July. Indeed, discussions with Mike Robbie indicated that most bats prefer open areas and open water surfaces (e.g., cow tanks, ponds, open streams) for nocturnal forays and to increase bat diversity at Walnut Creek ponds could be established in the open gaminoid fields.

The stream channel aquatic vegetation was eliminated and young cottonwoods and willows striped of leaves by the scouring action of monsoon floods during August 1999. This extreme alteration of stream channel conditions may have also contributed to the reduction of flying insects and thus the minimal number of bats identified in August (Fig. 3).

Fig. 3 Number (%) of bats captured by net / month - Walnut Creek



CONTENTS - Large Mammals

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Large Mammal Survey

Introduction

Results from this large mammal survey demonstrate that the relatively undisturbed floodplain and riparian habitats at Walnut Creek provide a variety of essential resources for several regional mammals (Table 1). Some of the more significant and obvious resources include: reliable water sources, sanctuary for several large wildlife from hunting pressures, buffer from adjacent manipulated landscapes, reliable food resources without the interference and competition from domestic livestock, seasonal reproductive refuges, den sites for larger mammals, major crossing points for migrant upland wildlife.

Methods

During the summer of 1998 we identified well-established and heavily used animal trails. Nearly all of the major trails are well worn, one to two inch surface depressions and most often devoid of vegetation (Figs. 1 & 2). Smaller animal routes were designated as minor trails if they were narrow and regularly encroached upon by seasonal grasses or non-native forbs.

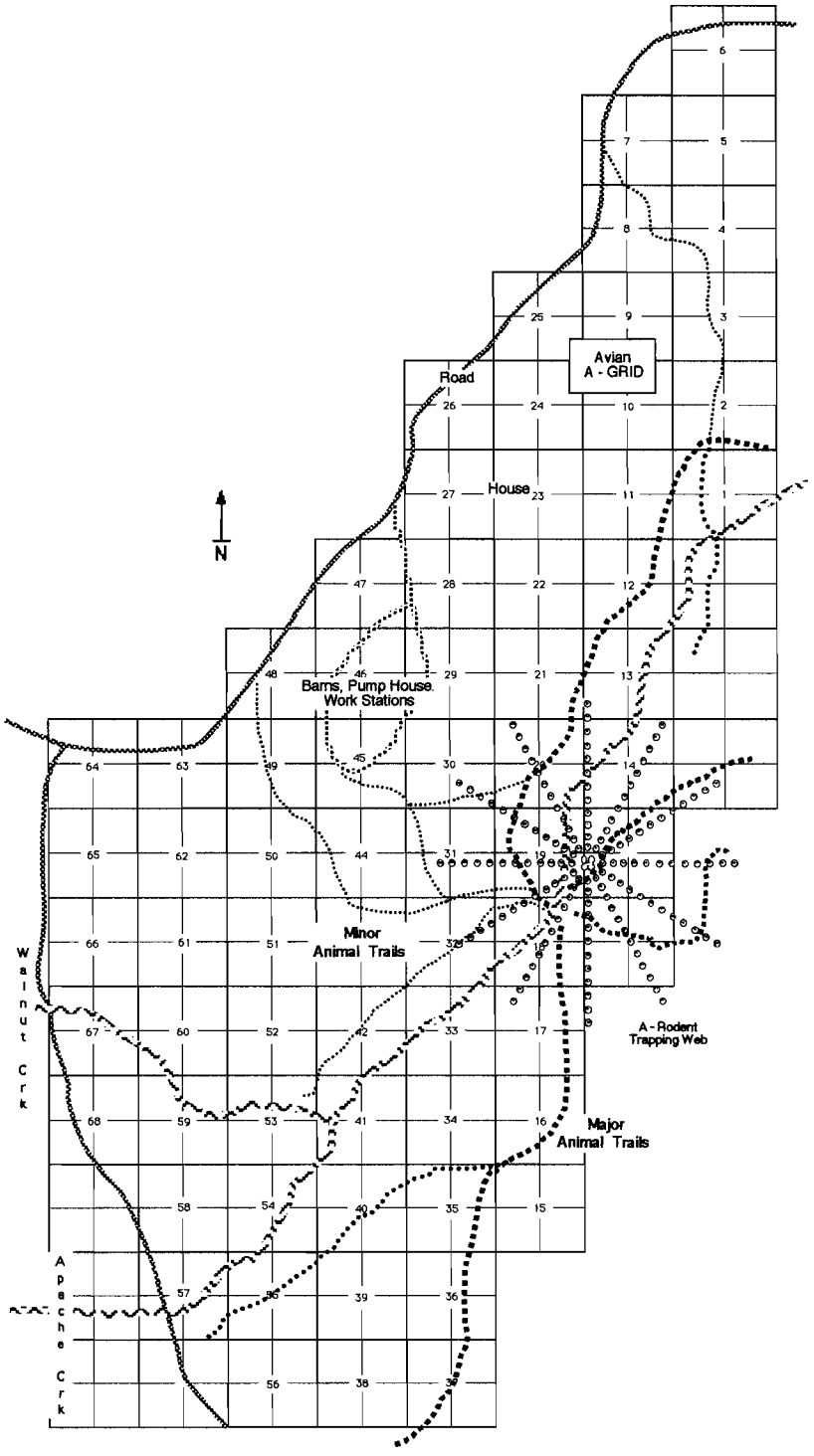
Direct methods included walking the designated animal trails during the monthly field sessions and recording tracks, scats, markings, and forage sites. Field workers also recorded occasional, ad-lib, spur-of-the-moment large mammal sightings and/or recognition of signs. During the fall of 1998 we attempted to use Havahart wire traps for medium sized mammals. After several attempts, we found that Havaharts proved to be too small for skunks, Ring-tail cats, or Foxes. Most often the traps were turned over, moved, or shut by animals attempting to obtain the bait. It is interesting to note that most all Havaharts were manipulated during nocturnal trapping attempts, suggesting that larger animals were interested but unable to enter traps.

Survey Trends and Species Composition

Observations or signs of 28 mammal species were recorded during this survey: 11 small and 17 larger mammals. Excluding the four domestic animals (dog, horse, cow, human), 24 wildlife species were recorded. We considered the House cats as a wildlife species since they were feral and were the most consistent and influential predator of small mammals and birds. Three species are considered historical since they at one time occurred within the Walnut Creek site: Mexican vole, Horse, and cattle. On occasion, however, a recreational Horse and rider or a few cattle from adjacent ranches wander through the site.

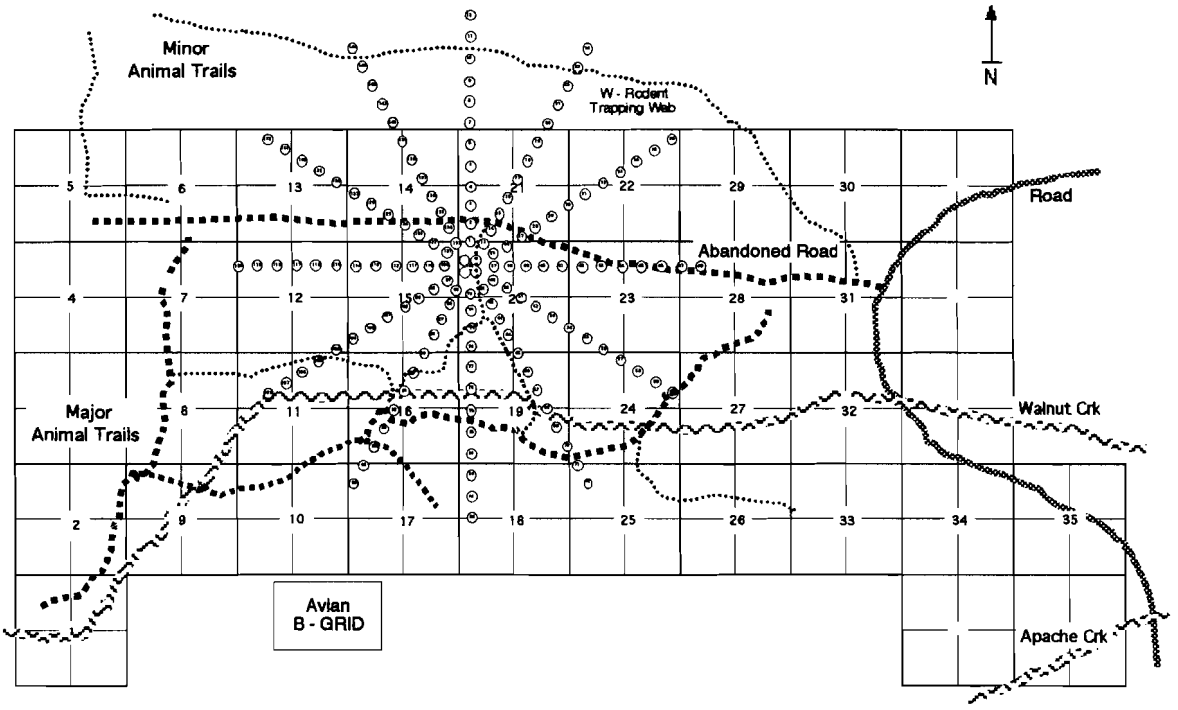
Previous to the summer of 1998 cattle from the K-4 ranch grazed heavily the northern section of the stream channel at A-Grid. As a result and to inhibit cattle entry, we constructed a fence across the area and repaired perimeter fence surrounding the 280-acre Walnut Creek site.

Fig. 1 Large mammal trails, Avian A-Grid : Walnut Creek



Within Avian Grid-A major animal trails tend to follow or parallel the stream channel. The most prominent and well-used routes are on the northern terrace bank, along the southern edge of the over-bank channel, and at the base of the southern foothills (Fig. 1). An important dispersal hub lies at the stream crossing at the base of the large quartz outcrop. Here, four major trails meet. Fresh sign and tracks from a variety of large mammals were observed monthly and most often daily when field crews were working. This major trail hub is used countless times by Mule deer venturing down from adjacent hillsides presumably seeking water in Walnut Creek. Predators also use these major trails, on occasion by Bobcats, Mountain lions, Foxes, and regularly by Feral cats and Coyotes.

Fig. 2 Large mammal trails, Avian B-Grid : Walnut Creek.



At Avian Grid-B trails are less defined due to extensive tall grass, but nevertheless four existing and well-worn major animal trails are prominent (Fig. 2). The abandoned road appears to be one of the major routes through this grid, and tracks and scats of a variety of larger species were continuously encountered. The most common signs within the abandoned road regularly consisted of deer, Ring-tail cat, Feral cat, and skunk. Elk droppings were observed on two occasions during the fall seasons of 1998 and 1999.

Also within Avian Grid-B, well-worn deep trails (1-2 feet) cross the steep banks of the stream channel at three locations but most often disappear into the grasses. The trails

along and within Walnut Creek are used extensively by Peccaries, most often on a nightly basis. Near avian-station 19 and on the edge of the creek channel, Peccaries maintain two mud-wallows that are visited regularly during the summer months.

A relatively large herd of Peccaries, 20 to 30 individuals with young, occupied B-Grid during 1998 but numbers decreased considerably during 1999. They favor the tall grass, shallow waters of Walnut Creek, root after decaying material under downed logs, and forage for mushrooms and other temporal fungus species. Peccaries foraged heavily throughout Avian B- Grid on the numerous reproductive-masses of the white slime mold that typically emerged during the late monsoon seasons. Another favorite food source of the Peccary herd, as well as deer, skunks, and birds, are the four apple trees near avian-station 10. When the apples ripened, usually in October, Peccaries foraged on apples that dropped to the ground, while deer and birds foraged on apples attached to tree branches - a rather popular apple market during October.

The most consistent and relatively abundant large mammals include Ringtails, Coyotes, Peccaries, and Mule deer. Deer populations decreased regionally during 1996 and 1997 due to prolonged drought but increased at the Walnut site during the summer of 1999. The increase in deer browse and tracks may have been related to one or all of the following influences; abundant spring and summer graminoid crops and available water in Walnut and Apache Creeks, mast failures (acorn crops of all oak species) in upland regions during 1999 fall season, reduced human hunting pressures within the Walnut Creek preserve.

Table 1. Mammal species list and relative abundance for Walnut Creek Education and Research Station.

Small Mammals		Relative Abundance
Botta's Pocket Gopher	*Thomomys bottae*	Abundant
Brush Mouse	*Peromyscus boylii*	Abundant
Pinyon Mouse	*Peromyscus truei*	Abundant
Deer Mouse	*Peromyscus maniculatus*	Occasional
White-footed Mouse	*Peromyscus leucopus*	Common
Western Harvest Mouse	*Reithrodotomys megalotis*	Common
Silky Pocket Mouse	*Perognathus flavus*	Occasional
Mexican Vole	*Microtus mexicanus*	Rare (historical)
White-throated Wood Rat	*Neotoma albigula*	Common
Cliff Chipmunk	*Tamias dorsalis*	Common
Rock Squirrel	*Spermophilus variegatus*	Common
Eastern Cottontail	*Sylvilagus floridanus*	Common
Black-tailed Hare	*Lepus californicus*	Occasional

Large Mammals		Relative Abundance
Ringtail	*Bassaricus astutus*	Abundant
Hooded Skunk	*Mephitis macroura*	Common
Coyote	*Canis latrans*	Common
Domestic Dog	*Canis familaris*	Occasional
Gray Fox	*Urocyon cinereoargenteus*	Occasional
Black Bear	*Ursus americanus*	Rare
Mountain Lion	*Felis concolor*	Occasional
Bobcat	*Felis rufus*	Occasional
Domestic Cat	*Felis catus*	Common
Collard Peccary	*Tayassu tajacu*	Common
Elk	*Cervus elaphus*	Rare
Mule Deer	*Odocoileus hemionus*	Common
Horse	*Equus caballus*	Rare (historical)
Cattle	*Bos taurus*	Rare (historical)
Humans	*Homo sapiens*	Common

Prior to the suspension of the site to random camping, the landscape near Walnut Creek and Apache Creeks was a favored and well-used seasonal camping site for large groups of seasonal hunters. Needless to say, the area, particularly along the access road on Avian Grid-B, was severely denuded from extensive camping activities. Since the closure of the access road, mixed graminoids and forbs have retaken the once barren ground and few signs of disturbance are presently evident. At this juncture, the refuge is visited regularly by deer and other wildlife species without encroachment by hunters.

A family of Gray fox also occurred on Avian Grid-B near a clump of downed cottonwood logs at the edge of a steep steam-bank near avian-station 27. These attractive and inquisitive animals were often observed during the day. Several foxes were observed routinely on Grid-B and near the barn during the 1998 surveys but for some unknown reason, few were seen during the 1999 season.

To date Bear have not ventured onto our study grid but field crews have observed them in and around Apache Creek. Coyotes are abundant and omnipresent throughout the valley and on occasion the entire valley is aware of several calling packs. The most persistent predator, however, is the feral black cat that was been on board since our arrival. It is observed frquently stalking birds and gophers and, for the first year, favored our excess camping food at night. Another gray feral cat joined the black cat during the spring of 1999, but it disappeared during the subsequent summer. The disappearance of the gray cat and the migration of the black cat to Grid-B may have been related to the arrival of a Bobcat that took up summer residence among the granite outcrop near Walnut Creek and across from the barn. The Bobcat was often heard nightly during field sessions. Judging by numerous characteristic scats and territorial markings the Bobcat hunted regularly throughout Grids A and B during the late summer of 1999.

The most omnipresent large mammal, however, are secretive Ringtails. They leave their characteristic scat sign almost everywhere, including tents, camp gear, tables, and footprints. The most personally encountered large mammal was the Hooded skunk, which was always treated with cautious respect. During the summer of 1999, field workers at W rodent web regularly experienced large black and white bushy tails of skunks within the tall grasses. Prudent field workers seldom intimidated these self-assured animals and most often they merely glanced confidently at the field workers and continued their activities without hesitation or concern.

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Small Mammal Survey

Introduction

We have monitored small mammal populations and hantavirus prevalence on two trapping webs for 18 months, June 1998 through November 1999. During this period we captured nine small mammal species at Walnut Creek. We also monitored small mammal populations on three trapping webs at Limestone Canyon; about 40 miles west of Walnut Creek (a site associated with the Centers for Disease Control southwestern longitudinal hantavirus studies). Over a period of 64 months, 11 rodent species have been captured at Limestone Canyon.

Riparian and floodplain areas play a significant role in the spatial and temporal distribution of small mammals. These relatively mesic enclaves are most often gradients of diverse patch types and provide refuges within comparatively drier macrohabitats such as Chaparral, Pinyon Pine, Juniper, and Ponderosa Pine, and grassland areas. Relatively little is known about the use of riparian, floodplain, and arroyo habitats in central and northern Arizona by small mammals. A few studies have been carried out in desert riparian environments. Through the activities and results of these studies we have been able to investigate the population and community ecology of small rodents in four major habitats in central Arizona.

Hantaviruses are rodent-borne zoonotic agents that cause hantavirus pulmonary syndrome (HPS) in North and South America. The epidemiology of human diseases caused by these viruses is tied to the ecology of rodent hosts while effective control and prevention relies on understanding host ecology. Of the nine small mammals captured at Walnut Creek, hantavirus antibody-positive individuals have been found in five rodent species presumably representing four types of hantavirus. Captured hantavirus antibody-positive species include *Peromyscus boylii* (Brush Mouse), *Peromyscus maniculatus* (Deer Mouse), *Peromyscus leucopus* (White-footed Mouse), *Reithrodontomys megalotis* (Harvest Mouse), and *Neotoma albigula* (White-throated Wood Rat). *P. boylii* has been the primary hantavirus host.

The riparian floodplain at Walnut Creek provides enhanced rodent habitats due to greater amounts of seasonal mast, graminoid biomass, invertebrates, and moisture. Consequently, rodent populations at Walnut Creek are appreciably greater and more stable then fluctuating populations at Limestone Canyon (Pinyon-Juniper-Chaparral). By using established and emerging ecological and serological information we are gaining insights into spatial and temporal changes in hantavirus infection and rodent populations that occupy different habitats characteristic of the region.

Data from both of our study sites enabled us to advise and deal with the vast amount of community concerns and questions dealing with the overwhelming increase in rodent populations in central and northern Arizona during the summer of 1999. The 1999 season represented an episodic event where the abundance, biomass, and diversity of graminiods, annuals, and insects were abnormally high. At the same time, most of the four major oak species characteristic of the region experienced a mast collapse and did not produce acorns. The summer monsoon season was also the longest in recorded history and may have contributed to the unexpected plant and rodent events.

In this region of Arizona, rodent populations started to increase in May and by June and July an overabundance of *Peromyscus* species and *Neotoma albigula* invaded commercial buildings, residences, outbuildings, and automobiles. A multitude of anecdotes from various individuals indicated that *P. leucopus* and *N. albigula* regularly invaded automobiles (motors and interior-even glove compartments), often established nests in air filters, and sometimes demolished brightly colored wires. *P. leucopus* and *P. maniculatus* were common in commercial buildings and out-buildings while *P. boylii* and *P. leucopus* readily invaded residences, trailers, and barns. Several dispersing rodents, primarily *P. boylii* and *N. albigula*, were also captured in offices, classrooms, laboratories, and dormitories on the Yavapai College campus.

Methods

Site Descriptions

Three small mammal-sampling webs were established within the boundaries of the Walnut Creek Center for Education and Research. Web site design and methodologies are identical to those practiced by the Center for Disease Control southwest longitudinal studies (1995 – 2001). The three sampling webs were established at distinctly different habitats. In an attempt to gain a better understanding of population structure and dispersal adjacent to the floodplain, we established a third trapping web, Web J, about one-half mile above the floodplain and within drainage towards Walnut Creek.

Trapping webs A and W were sampled monthly except for December 1998 and April 999 when inclement weather conditions prohibited fieldwork. Sampling at J web, however, was inconsistent and activities were terminated completely in September 1999. The trapping sessions during the summer of 1998 resulted in few animals; we captured two individuals in September and none in October 1998. By the spring of 1999 population densities increased but not significantly to warrant the continuation of trapping efforts due to field-time and budget constraints.

- *Web A* is quite variable. The southern half of the web occupies a north-facing rocky pinyon-juniper-chaparral hillside. The rest of the web is located within the active channel and up on the cottonwood-willow terraces (Fig. 1). The channel and terraces were heavily grazed in the past but since the spring of 1998 cattle have been fenced out.

- *Web W* is positioned across a relatively broad and flat floodplain (Fig. 2). The deeply incised, 3-12 feet, active channel of Walnut Creek cuts through the center of the trapping web. The riparian forest is a relict community composed of tall old cottonwoods, willows, alligator and Utah junipers, and thickets of wild grape. Grasses are abundant and dense in open areas.

- *Web J* is situated in the adjacent foothills north of the floodplain. Vegetatively this web is similar to our Limestone Canyon (CDC) site consisting of a mix of Utah juniper, pinyon pine, and chaparral elements. This area was also heavily grazed in the past.

Capture-Recapture Methods

Three web sites (3.14 hectare/site) were established in the spring of 1998. All web site trap stations were marked with wooden stakes and flagging. The project site was visited monthly where capture-mark-release-sampling activities were performed for 2.5 days/2 nights consecutively on or close to the new moon. Field crews of a minimum of 3, typically 4, transported supplies and equipment, usually on Friday, and set up webs and the processing site. Sherman live traps were set at existing trap stations and baited with a mixture of mixed birdseed-oats and lightly sprayed with an anise-vanilla extract solution. During cold weather, various amounts of polyfill were placed at the rear of traps to provide nesting material and reduce mortality. Traps were checked early the following morning (after sunrise during cold months, sunrise during hot months). Protective clothing and rubber gloves were worn during trap searches (snake gaiters during warm months). Traps occupied with rodents were marked with web and trap stations numbers and each trap capture placed in a 10" x 16" restaurant polyethylene bag to protect against possible contamination. After crews employed protective gear and Hepa/Racal masks, the captured animals were removed secured in a well-ventilated section of the barn. After processing, each animal was placed in a Mason jar with apple slices, the jars marked with web and trap stations ID, and returned to respective webs. Mason jars are covered with duct tape and the cap fitted with galvanized wire grid. When crews returned the processed animals to their respective capture stations a clean baited trap was placed at that station. All web traps were examined and rebaited if necessary. Animals found during the afternoon check were transported to the processing station and if possible, processed that day. Traps remained open during cold and temperate months. During hot months, however, traps were tripped during the early morning survey and reopened in the afternoon. All contaminated traps were submerged in a 10% Lysol bath, soaked for at least 15 minutes, scrubbed with a brush, and double rinsed.

Processing

The processing station was located in an area out-of-the-way of human interference and livestock. Three tables were set up with necessary supplies and materials. Protective clothing including surgeons' gowns, latex gloves, and HEPA respirators/Racal masks were worn. Processing commenced by shaking a captured animal into a protective plastic bag. Animals were anesthetized by securing the dorsal skin behind the head; a nose cone with cotton wetted with isoflorane slipped over the animal's nose. When it was apparent that the animal was anesthetized, it was placed on the table for measurements. Anesthetized animals were examined and the following data recorded; ID number, date, trap station, tag number, fate, species, sex, age, weight, body measurements, reproductive condition, wounds, and other observable conditions. Ectoparasites were removed from anesthetized animals, placed in labeled cyovials, and temporarily stored on ice. If the animal was a new capture a small numbered ear tag was implanted, either in the left or right ear depending on the animals web origin. Blood samples were collected from the animals' retro-orbital sinus. Blood samples were then secured in nylon hose and stored in a liquid nitrogen tank until shipment to the Centers for Disease Control and Prevention (CDC, Atlanta, Ga). The processing station was disinfected daily at the conclusion of processing activities by

cleaning all tools, surfaces, and other materials in 10% Lysol and placing all items in direct sunlight.

Serologic testing was conducted at the CDC, Atlanta, GA. Samples of whole blood were tested for antibody reactive with SNV recombinant nucleocapsid protein antigen by enzyme-linked immunosorbent assay according to a standardized protocol. Descriptions of laboratory analyses are described elsewhere.

Data Analysis

Mark-recapture data is used to estimate survival of trappable populations by examining the frequency of intervals from first to last capture. While not a measure of actual life span, average survival provides some insight into population turnover and longevity. The minimum number alive (MNA) is used to estimate population sizes. The MNA is calculated for each month by adding the number of individual rodents captured in a month to rodents that were captured on at least one prior and one subsequent occasion. The minimum number infected (MNI) is calculated for antibody-positive rodents using the same technique for MNA. Estimated standing prevalence (ESP) is calculated by dividing the monthly MNI by the MNA. These methods provide an estimate of the number of rodents alive and population sizes for a period of time, estimates of the number of infected rodents, and comparisons of antibody-prevalence between web locations.

Field data was transferred to a computer database using Excel (Microsoft Corp., Redmond, WA) and Lotus 1-2-3 for Macintosh (Lotus Development Corporation, Cambridge, MA). Statistical analyses were performed using MINITAB (Minitab Inc, State College, PA) statistical software: the Mann-Whitney and two-sample t tests, one-way analysis of variance, and linear trend model.

Trapping Results

During the 18 months of trapping (6/98-11/99) at the two grids 752 rodents were captured 2,772 times (Table 1). Within this period, two scheduled trapping sessions were canceled due to inclement weather conditions. From these rodents, 1,787 blood samples were collected (as a result of subsequent captures of the same rodents during progressive trapping sessions) and tested for hantavirus at the Centers for Disease Control, Atlanta, GA.

Total trapping effort consisted of 10,730 trap-nights. For the 16 months of trapping, the mean number of individuals captured per night was 52 animals per night, range 18 to 112. The mean number of captures per night (catch/night) was 79 captures per night, range 26 to 180. The mean number of captures per night during the initial eight months of the study, 6/98-2/99, was significantly lower than the following eight months, 3/99-11/99, (34 and 124 respectively; $t = 7.20$, $df = 7$, $p < 0.001$).

Table 1 WALNUT CREEK: Number of Samples, Individuals, Virus Prevalence, and Captures : 18 (16) Months* (6/98-11/99). * (12/98,4/99 canceled-wx)

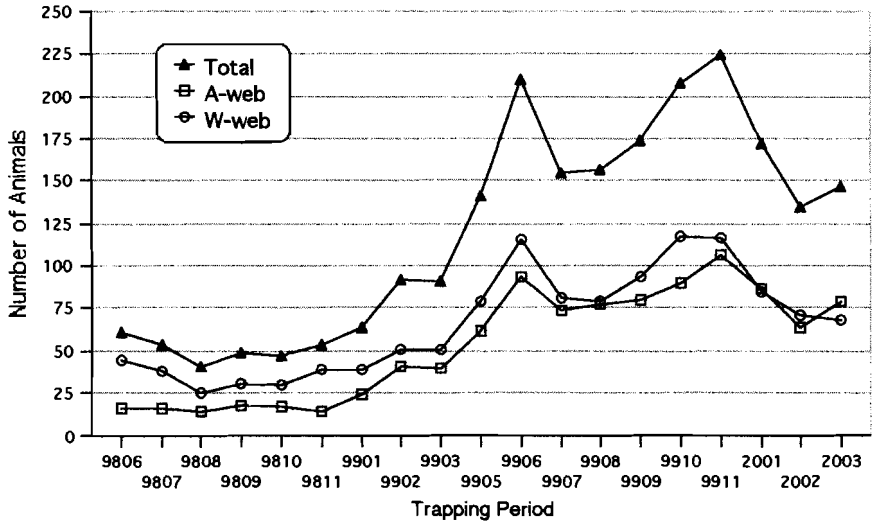
Species	Web A				Web W				Totals			
	Positive Samples	Samples Tested	Sample Prevalence	Total Captures	Positive Samples	Samples Tested	Sample Prevalence	Total Captures	Positive Samples	Samples Tested	Sample Prevalence	Total Captures
Peromyscus boylii	99	646	15.3%	1057	32	578	5.5%	986	131	1224	10.7%	2043
(Brush Mouse)	Positive Individuals	Individuals Tested	Prevalence	Total Individuals	Positive Individuals	Individuals Tested	Prevalence	Total Individuals	Positive Individuals	Individuals Tested	Prevalence	Total Individuals
	39	258	15.1%	258	14	210	6.7%	212	53	468	11.3%	470
Peromyscus truei	0	2	0.0%	2	0	19	0.0%	27	0	21	0.0%	29
(Pinyon Mouse)	0	2	0.0%	2	0	11	0.0%	12	0	13	0.0%	14
Peromyscus maniculatus	0	12	0.0%	19	1	36	2.8%	9	1	48	2.1%	28
(Deer Mouse)	0	5	0.0%	5	1	19	5.3%	19	1	24	4.2%	24
Peromyscus leucopus	2	15	13.3%	21	2	39	5.1%	51	4	54	7.4%	72
(White-footed Mouse)	2	11	18.2%	11	1	24	4.2%	23	3	35	8.6%	34
Neotoma albigula	1	60	1.7%	78	0	189	0.0%	293	1	249	0.4%	371
(White-throated Wood Rat)	1	28	3.6%	28	0	72	0.0%	72	1	100	1.0%	100
Tamias dorsalis	0	10	0.0%	8	0	37	0.0%	39	0	47	0.0%	47
(Cliff Chipmunk)	0	8	0.0%	8	0	26	0.0%	27	0	34	0.0%	35
Reithrodotomys megalotis	2	24	8.3%	30	5	116	4.3%	148	7	140	5.0%	178
(Western Harvest Mouse)	2	18	11.1%	18	3	56	5.4%	56	5	74	6.8%	74
Spermophilus variegatus	0	2	0.0%	2	0	0	0.0%	0	0	2	0.0%	2
(Rock Squirrel)	0	2	0.0%	2	0	0	0.0%	0	0	2	0.0%	2
Sylvilagus floridanus	0	1	0.0%	1	0	1	0.0%	1	0	2	0.0%	2
(Eastern Cottontail)	0	1	0.0%	1	0	1	0.0%	1	0	2	0.0%	2
	Web A				Web W				Totals			
All species	104	772	13.5%	1218	40	1015	3.9%	1554	144	1787	8.1%	2772
	44	333	13.2%	333	19	419	4.5%	422	63	752	8.4%	755

Population Trends

Population densities were relatively stable through the mild summer and winter of 1998/1999 but escalated dramatically at both trapping sites during the spring and fall of 1999 (Fig. 3). For the 21-month trapping period, 6/98-3/2000, the mean number of individuals captured per trapping session was 120 animals per session. Significantly fewer animals, however, were captured during the initial nine month period; $t = 9$, df = 12, $p < 0.001$. For the initial nine month trapping period, 6/98-3/99, the mean number of individuals captured per trapping period was 61 animals per session, range 41 to 92. The mean number of animals for the subsequent nine months, 6/99 to 3/2000, was 172 animals per tapping session, range 135 to 224.

Several sequential environmental factors may have contributed to the overall increase in rodent densities at Walnut Creek. A few of these factors include; exclusion of cattle by fencing in July 1998, increase in graminoid diversity and biomass, abundant invertebrates, and above normal summer precipitation. Peak densities occurred during the spring and fall months, which, we are also finding at other trapping sites, appears typical of the region. These spring and fall peaks reflect female reproductive efforts that appear to mirror bimodal mast and graminoid biomass production and reflective of regional vegetative patterns.

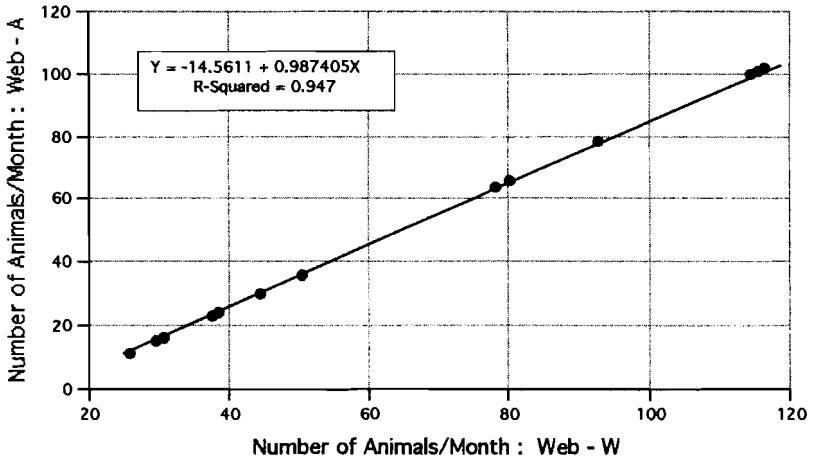
Fig. 3 Population trends - number of individuals / month : Walnut Creek



After the dramatic June 1999 peak, densities decreased slightly in July and August but then increased to peak levels in October and November, above the June levels (Fig. 3). This mid-summer decrease may have been due to warm summer temperatures in combination of predation from several predatory animals; raptors (owls and hawks), snakes (particularly rattlesnakes), bobcats on A web and foxes on W web. Recruitment was minimal during the winter months (January – March) due to reduced reproduction and minimal immigration.

Over the entire tapping period, monthly rodent densities remained similar on the two trapping webs (Fig. 4). This trend is an intriguing phenomenon since the two webs vary in species diversity, topography, and vegetative composition. This trend may reflect the overall influence of macrohabitat factors rather than microhabitat differences.

Fig. 4 Association of number of individuals captured / month on webs A&W



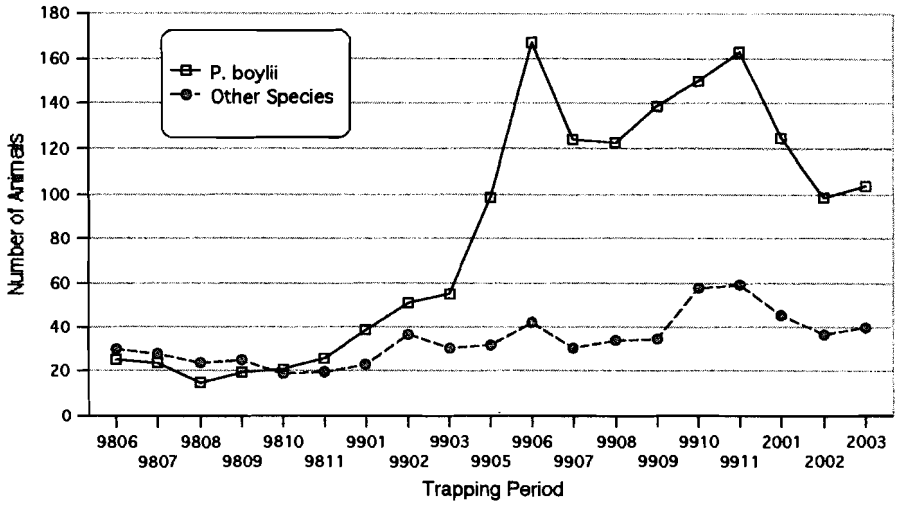
Species Composition

On the two trapping webs at Walnut Creek, *P. boylii* was repeatedly the domiant species, 62.1% (Table 5). The other more common species included *N. albigula*, 26.6%, and *R. megalotis*, 9.0% (Table 2 and Fig. 6). Species composition was not static and, other than *P. boylii*, on both webs fluctuated considerably during the two year trapping period (Table 2).

Table 2. Species composition as percent total / month for the total trapping period (6/9803/2000), low density period (6/98-3/99), and high density period (6/99-3/200).

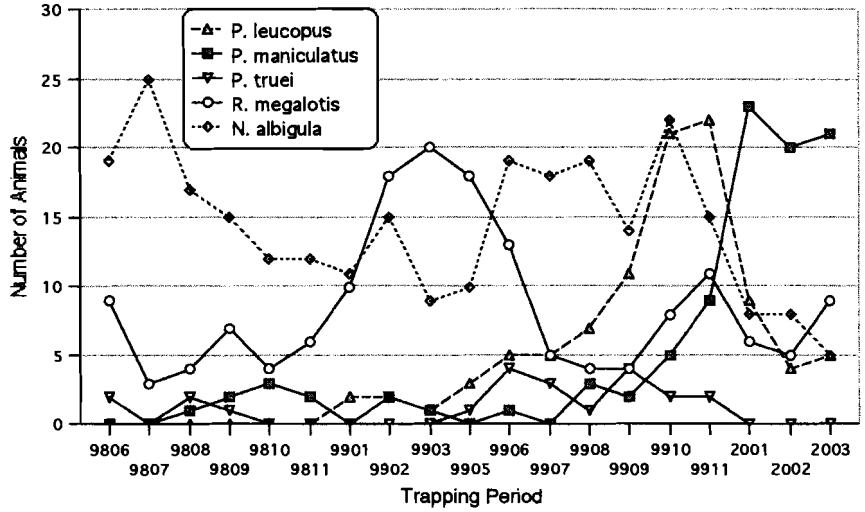
Web sites	*P. boylii*	*N. albigula*	*R. megalotis*	*T. dorsalis*	*P. maniculatus*	*P. leucopus*	*P. truei*
A & W							
6/98-3/200	62.1	16.9	9.0	4.0	4.0	2.9	1.0
6/98-3/99	47.8	26.6	13.4	7.2	2.2	0.7	1.1
6/99-3/200	75.8	8.0	4.0	3.7	6.0	5.2	1.0
A							
6/98-3/200	77.8	9.6	2.9	2.5	4.8	1.3	0.1
6/98-3/99	67.4	15.7	3.8	5.0	6.2	0.0	0.0
6/99-3/200	87.2	4.1	1.8	0.0	3.9	2.7	0.3
W							
6/98-3/200	51.2	21.4	13.0	4.7	3.7	4.3	1.6
6/98-3/99	37.0	32.5	19.3	8.0	0.0	1.2	1.7
6/99-3/200	64.7	11.6	6.1	0.7	7.8	7.4	1.6

Fig. 5 Population trends, P. boylii & minor species(total) - number of animals / month



P. boylii populations increased significantly (t = 9, df = 10, $p < 0.001$) during the high density second year period while *N. albigula* and *R. megalotis* decreased significantly (t = 4.5, df = 9, p = 0.002), t = 5.1, df = 9, $p < 0.001$, respectively). These trends were more evident on W web where numerous woodrat dens, initially occupied by several woodrats, were overrun by *P. boylii* and *P. maniculatus* during high density periods.

Fig. 6 Population trends, minor species - number of animals / month



Initially *P. leucopus* and *P. maniculatus* occurred in marginal areas at low numbers, but during the second year densities increased and decreased asynchronously (Fig. 6). *P. leucopus* immigrated in from the lower elevation grasslands and *P. maniculatus* from higher Ponderosa pine forests. The extreme asynchronous fluctuations in *N. albigula*, *R. megalotis*, *P. leucopus*, and *P. maniculatus* may demonstrate examples of resource competition since the densities of the former two species decreased and densities of the latter two species increased in quite different spatial and temporal oscillations.

Patterns of Hantavirus Infection

Similar to the longitudinal hantavirus study at Limestone Canyon (1995 to present), *P. boylii* has been the primary hantavirus host at Walnut Creek (Table 1). Seroprevalence was occasional and inconsistent in other species even though different species were regularly captured at common trap stations. During high population densities of the second year, antibody was detected in *P. leucopus*, *P. maniculatus*, *R. megalotis*, and *N. albigula*. The occasional seroprevalence in these species may represent incidences of viral spillover or different hantavirus types characteristic of each species.

P. boylii - Population Dynamics and Infection

The number of captures per month and the number of samples per month were often not the same. Some animals were not sampled because of weakened physical condition, hypothermia, pregnant conditions, or escape. The number of animals tested for antibody to hantavirus, however, mirrored population trends.

During the 18-month trapping period, *P. boylii* populations and the incidence of infection increased dramatically (Fig.7, Table 3). Precipitous increases in rodent densities are sometimes characteristic in strongly seasonal regions, but at Walnut Creek increased densities appear to be related to the recovery and consistent abundant graminoid, mast, and insect resources. To date, minimum numbers infected have been directly related to minimum numbers alive, R-squared = 0.89 (Y=19.6551+0.852737X). For Walnut Creek, then, this relationship appears consistent with the mass action principle of disease transmission, which assumes that transmission is a function of density.

Fig. 7 Association of number of animals captured / month and infection index.

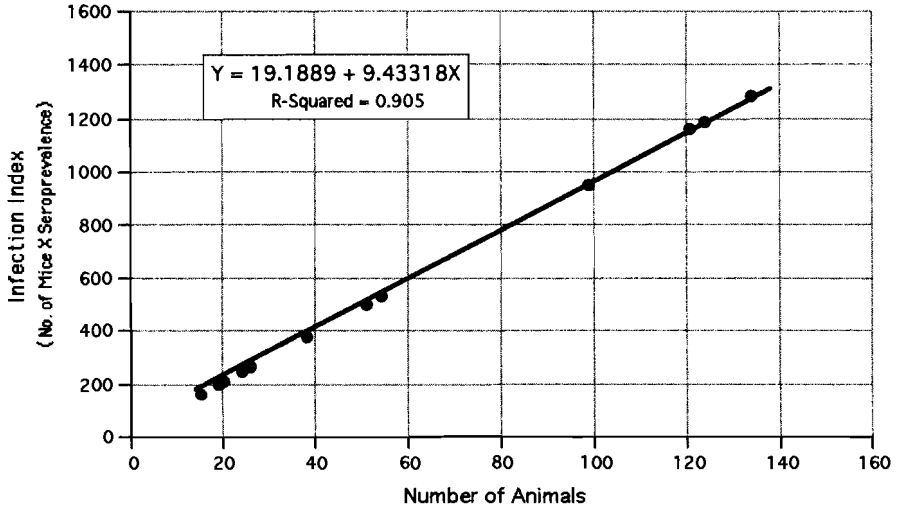


Table 3. Population densities, infection, and antibody prevalence to hantavirus in *Peromyscus boylii* at two mark-recapture webs, by period.

Web Sites	June 1998-November 1999			Low Density[a]			High Density[b]		
	Mean MNA / month[c]	Mean MNI / month[d]	Mean ESP / month[e]	Mean MNA / month	Mean MNI / month	Mean ESP / month	Mean MNA / month	Mean MNI / month	Mean ESP / month
A & W	80.8 (18-172)	9.5 (1-22)	12.9 (4-19)	30.1 (18-54)	4.4 (1-8)	14.3 (4-19)	131.4 (58-172)	14.6 (10-22)	11.4 (9-16)
A	44.5 (9-98)	7.4 (1-17)	20.8 (9-40)	16.5 (9-34)	4.0 (1-8)	26.5 (10-40)	72.5 (36-98)	10.5 (7-17)	15.1 (9-22)
W	38.6 (9-84)	2.0 (0-7)	3.1 (0-8)	14.5 (9-23)	0.0 ()	0.0 ()	62.6 (26-84)	4.0 (1-7)	6.1 (4-8)

[a]June 1998 to February 1999.
[b]March 1999 to November 1999.
[c]Population density (number of individuals per 6.2 hectares) as determined by minimum number alive. Values in parenthesis are ranges.
[d]The number of animals tested positive for hantavirus antibodies.
[e]Antibody prevalence to hantavirus (%) as determined by estimated standing prevalence.

For the 18-month sampling period, the mean number of anti-positive *P. boylii* was 9.5 animals per 6.2 ha per month, range 1 to 22 (Table 3, Fig.8). The number of anti-positive *P. boylii* was higher during high population densities than during low densities (14.6 and 4.4 animals per 6.2 ha per month, respectively; $t = 6.19$, df = 11, $p < 0.001$).

The mean antibody prevalence for the sampling period was 12.9%, range 4% to 19%, and was slightly higher during low densities (Fig. 9) than during high densities (14.3% and 11.4% respectively; $t = 1.38$, df = 9, $p = 0.20$). It may be assumed, then, risk of human contact with infected rodents would have been greatest during the spring and fall of 1999 when rodent density was highest within the floodplain of Walnut Creek. It follows that absolute numbers of infected rodents associated with high densities may be a reliable measure of human risk rather than antibody prevalence.

Fig. 8 Peromyscus boylii: estimated standing prevalence/month and minimum number infected/month (A & W webs).

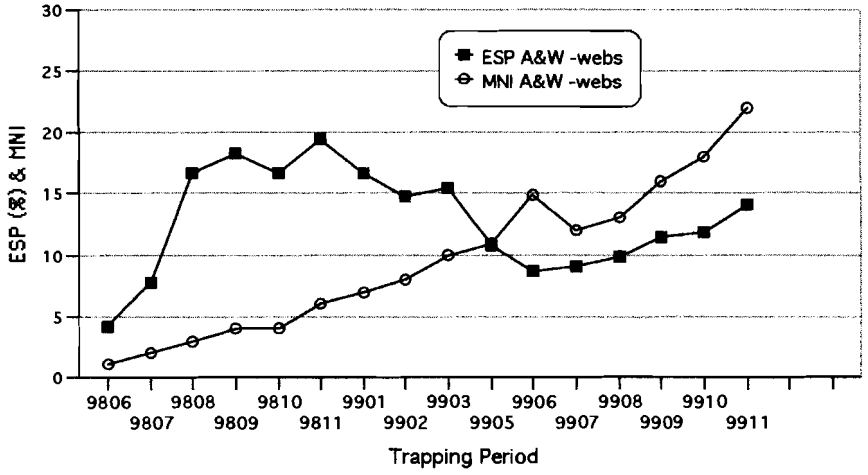
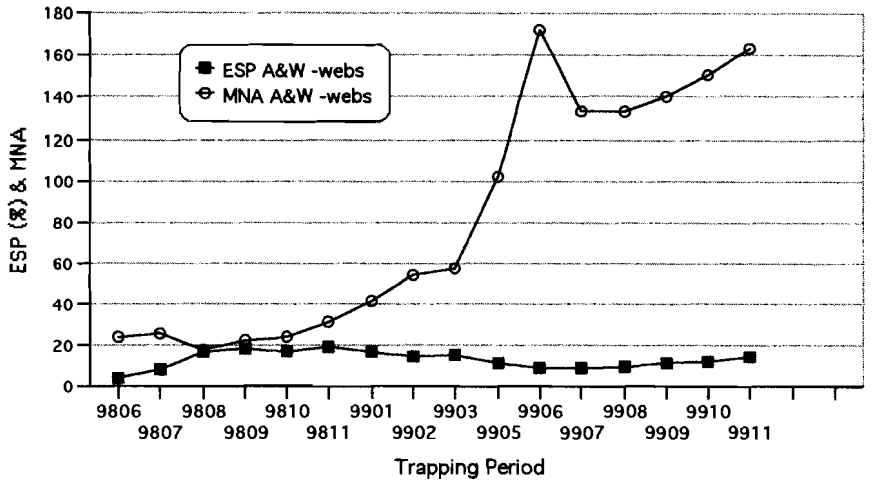


Fig. 9 Peromyscus boylii: estimated standing prevalence/month and minimum number alive/month (Walnut Creek-A & W webs).



P. boylii - Temporal and Spatial Patterns of Infection

Population levels and trends were similar at both trapping sites, densities were relatively stable and low during the initial 10 months and high during the subsequent eight month spring, summer, and fall trapping period (Table 3, Figs. 10 & 11). However, proportions of hantavirus antibody-positive (prevalence) and numbers of infected *P. boylii* varied considerably by trapping web and population density.

Hantavirus-infected *P. boylii* were captured at trapping web A month to month (mean 7.4 animals per 3.1 ha per month, range 1 to 17) and increased with population densities: 1 animal per month in 6/1998 to 17 animals in 11/1999 (Table 3, Fig. 10). Infection was absent from trapping web W until March 1999 when a large 28g male seroconverted after four previous seronegative captures (Fig. 11). Subsequently, the mean number of hantavirus-infected mice persisted at 4.0 animals per 3.1 ha per month, range 1 to 7.

The differences in site to site hantavirus infection appear to be related to behavioral attributes of *P. boylii* and the mechanisms of horizontal transmission within reservoir populations. It has been assumed that opportunities for virus transmission may increase over time with increased rodent to rodent contact during increasing population densities. For the time of this trapping period, overall cumulative infection occurred at both sites but was asynchronous and apparently related to habitat quality and *P. boylii* behaviors.

The rocky pinyon-juniper-chaparral hillsides at A web provide *P. boylii* optimal and stable resources to maintain reservoir populations (Fig. 12). With increased graminoids, mast, and invertebrates during the spring, summer, and fall of 1999, populations increased and expanded into the adjacent grassland-gallery forests areas of the floodplain. As a result of the population expansion, infection increased from 4.0 animals per month to 10.5 animals per month. To date, no captures have taken place at 25 trap stations; most of these are located in open areas within the stream channel. Of the remaining 120 trap stations where rodents have been captured, 60 stations (50%) have been visited by antibody-positive *P. boylii* (Fig. 12).

Fig. 10 Peromyscus boylii: number alive, antibody prevalence (%), and number infected / month (A web).

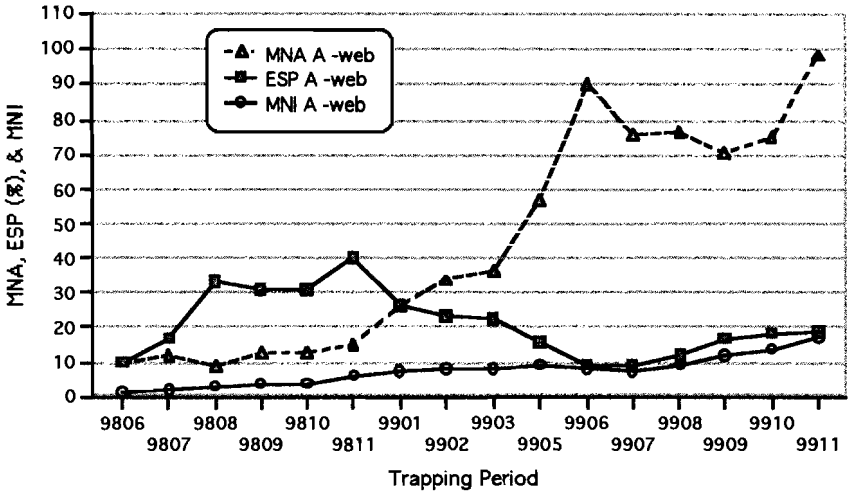
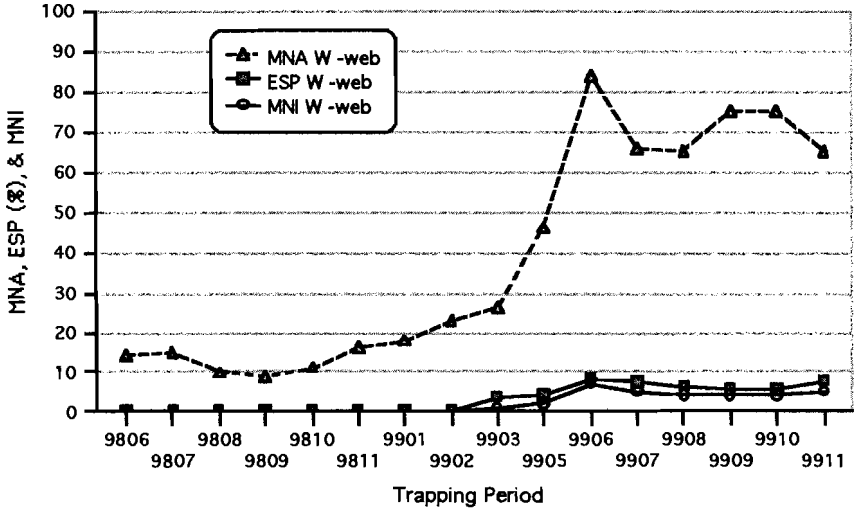


Fig. 11 Peromyscus boylii: number alive, antibody prevalence (%), and number infected / month (W web).



During initial low population densities at W web, *P. boylii* occupied the southern section of the web and were consistently captured near large downed cottonwoods and channel banks (Fig. 13). Infection was completely absent until the spring 1999 population increase. Subsequently, infection persisted at 4.0 animals per month and expanded across Walnut Creek but was restricted to old slash-piles and chaparral clumps. The more restricted distribution of *P. boylii* at W web may be due to numerous *R. megalotis*, *P. maniculatus*, *P. leucopus*, and *N. albigula* that coexist here. To date, no captures have taken place at 26 trap stations; most of these are located in open-barren grassland areas. Of the remaining 119 trap stations where rodents have been captured, 17 stations (14.3%) have been visited by antibody-positive *P. boylii* (Fig. 13).

Fig. 12 Web A, trap stations occupied by antibody-negative and antibody-positve mice.

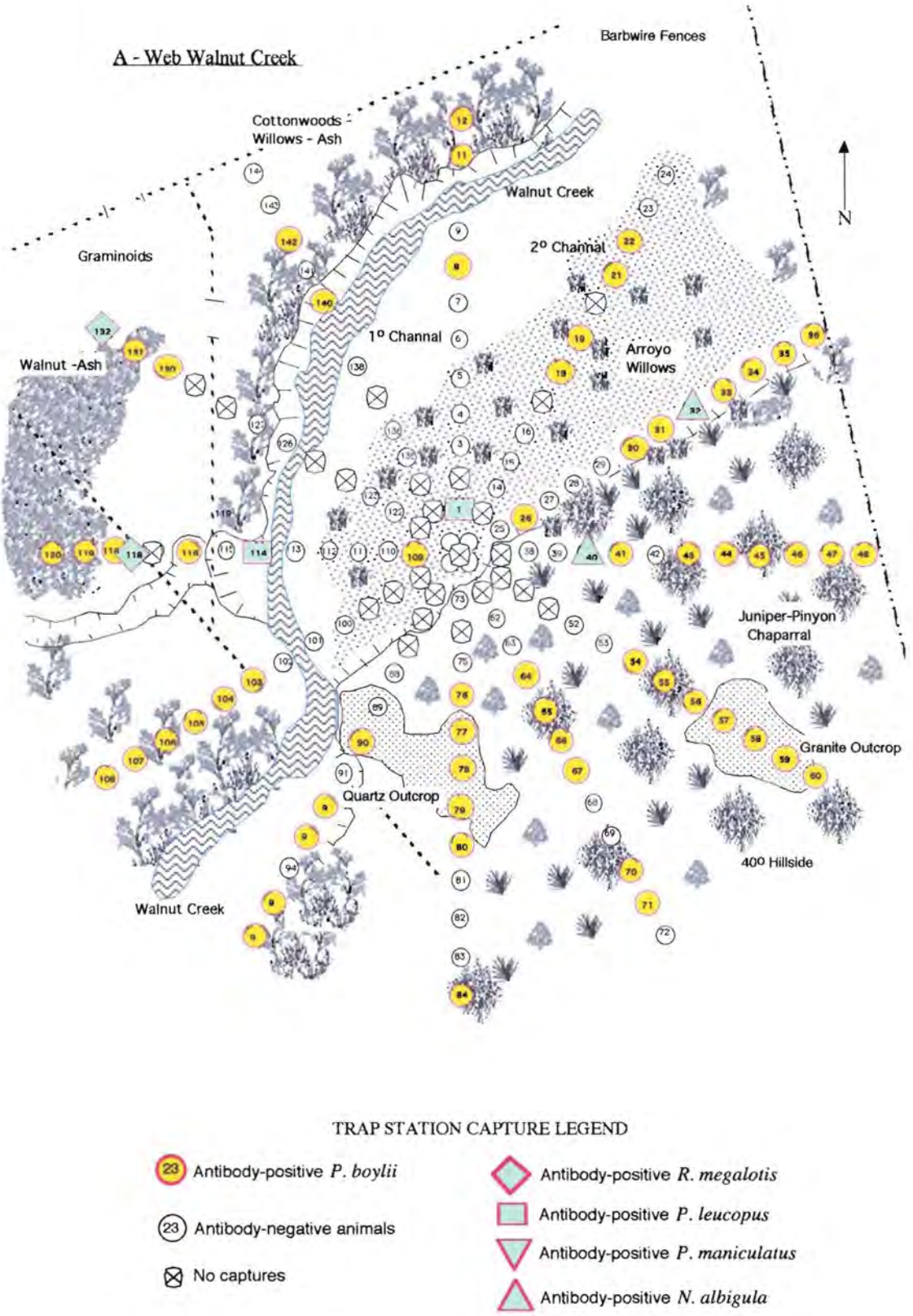
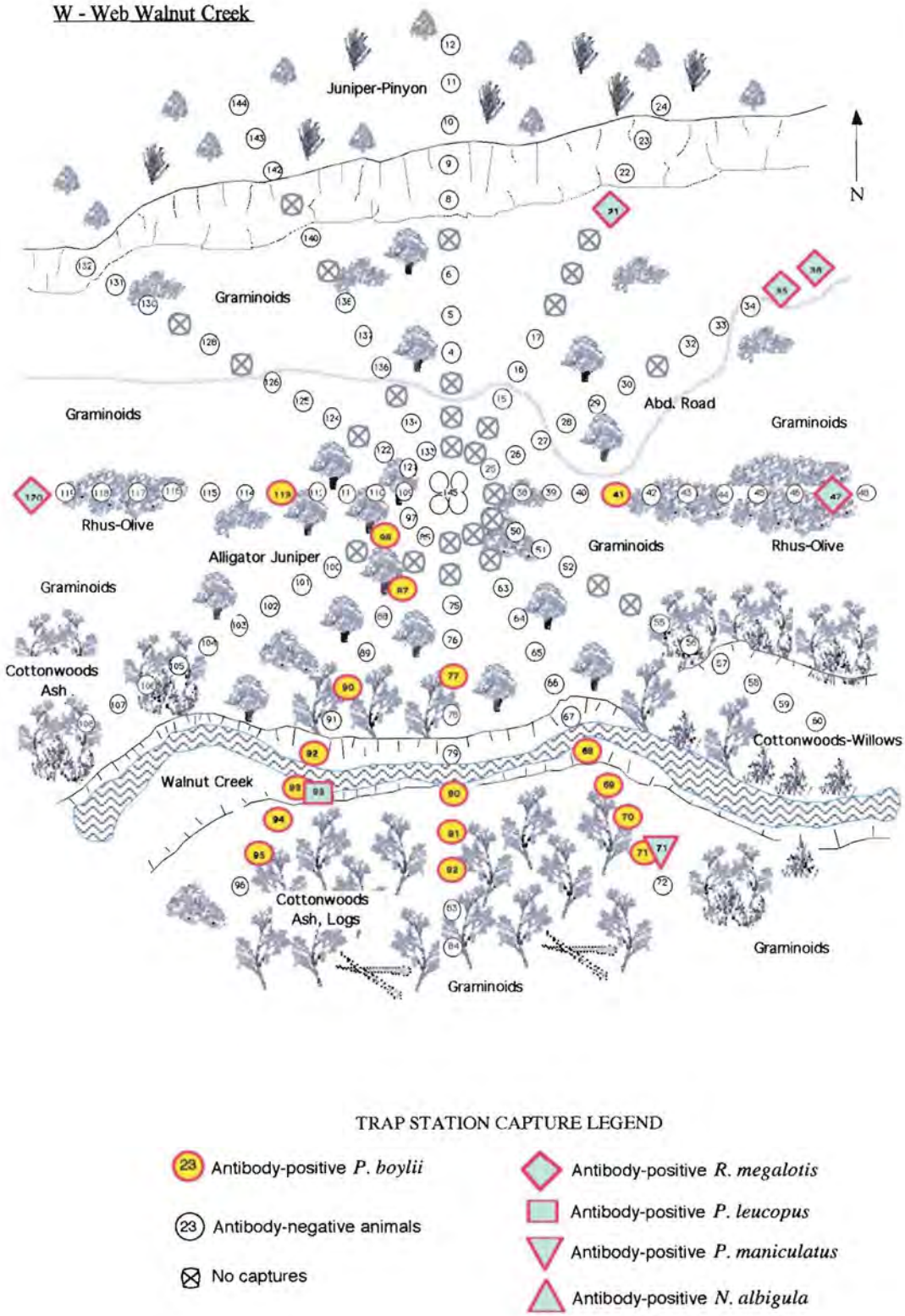


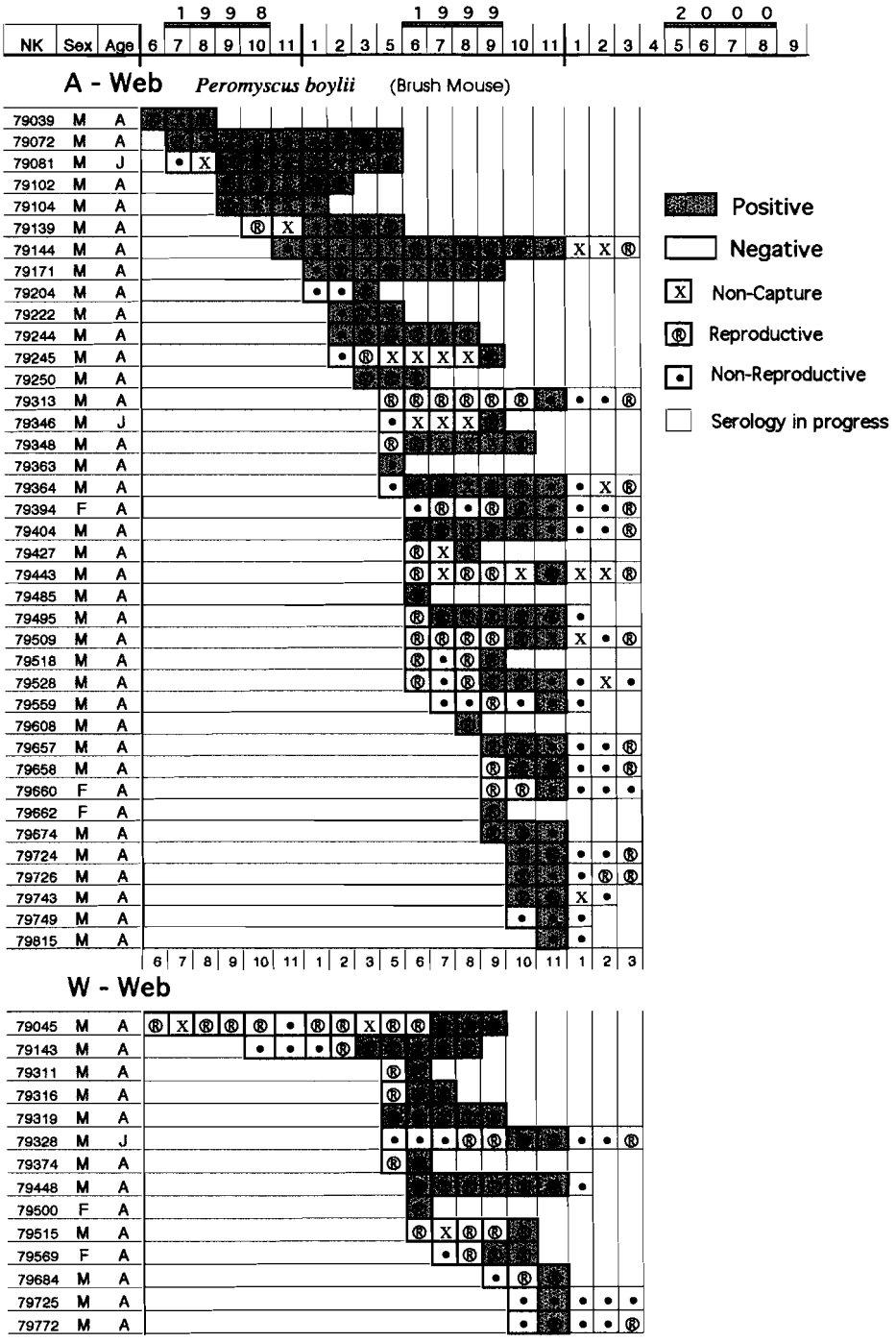
Fig. 13 Web W, trap stations occupied by antibody-negative and antibody-positve mice.



Seroconversion of Infected P. boylii

To date, 53 *P. boylii* have tested positive for hantavirus antibody, 48 (91%) males and 5 (9%) females. Twenty-three (43%) of the antibody-positive mice have been positive at first capture and 30 (57%) acquired antibody, seroconverted, subsequent to first capture (Table 4). The majority of seroconversions occurred during peak reproductive periods, 20% during spring (June-July) and 80% during the fall (September-November).

Table 4. Antibody persistence and seroconversions in *P. boylii*, 6.2ha.



P. boylii - Appendices for Population and Serological Data-Walnut Creek

Included herein are data representing field results and calculated MNA, MNI, ESP, and Infection Indices for total animals per hectare.

Table 5 WALNUT CREEK: Monthly serological data and infection indices (Calisher) 13 Months* (6/98-9/99) WEBS A&W (12/98,4/99 canceled-wx)

Trapping Periods	A MNA	A MNI	A ESP	Field-Session Prevalence	A Totals / Hectare MNA	A Totals / Hectare MNI	A Totals / Hectare ESP	Infection Index No. Cap X Field Prevalence	Infection Index MNA X ESP
6\98	10	1	10.0%	10.0%	3	0.3	10.0%	100	100
7\98	12	2	16.7%	10.0%	4	0.6	16.7%	100	200
8\98	9	3	33.3%	16.7%	3	1.0	33.3%	100	300
9\98	13	4	30.8%	20.0%	4	1.3	30.8%	200	400
10\98	13	4	30.8%	22.2%	4	1.3	30.8%	200	400
11\98	15	6	40.0%	20.0%	5	1.9	40.0%	200	600
1\99	26	7	26.9%	22.7%	8	2.3	26.9%	500	700
2\99	34	8	23.5%	25.8%	11	2.6	23.5%	800	800
3\99	36	8	22.2%	15.6%	12	2.6	22.2%	500	800
5\99	57	9	15.8%	14.8%	18	2.9	15.8%	800	900
6\99	90	8	8.9%	8.3%	29	2.6	8.9%	700	800
7\99	76	7	9.2%	7.8%	25	2.3	9.2%	500	700
8\99	77	9	11.7%	10.3%	25	2.9	11.7%	700	900
9\99	71	12	16.9%	18.5%	23	3.9	16.9%	1200	1200
	38.5	6.3	21.2%	15.9%	12.4	2.0	21.2%	540	818

Trapping Periods	W MNA	W MNI	W ESP	Field-Session Prevalence	W Totals / Hectare MNA	W Totals / Hectare MNI	W Totals / Hectare ESP	Infection Index No. Cap X Field Prevalence	Infection Index MNA X ESP
6\98	14	0	0.0%	0.0%	5	0.0	0.0%	0	0
7\98	15	0	0.0%	0.0%	5	0.0	0.0%	0	0
8\98	10	0	0.0%	0.0%	3	0.0	0.0%	0	0
9\98	9	0	0.0%	0.0%	3	0.0	0.0%	0	0
10\98	11	0	0.0%	0.0%	4	0.0	0.0%	0	0
11\98	16	0	0.0%	0.0%	5	0.0	0.0%	0	0
1\99	18	0	0.0%	0.0%	6	0.0	0.0%	0	0
2\99	23	0	0.0%	0.0%	7	0.0	0.0%	0	0
3\99	26	1	3.8%	4.5%	8	0.3	3.8%	100	100
5\99	46	2	4.3%	4.4%	15	0.6	4.3%	200	200
6\99	84	7	8.3%	8.5%	27	2.3	8.3%	700	700
7\99	66	5	7.6%	8.8%	21	1.6	7.6%	500	500
8\99	65	4	6.2%	7.1%	21	1.3	6.2%	400	400
9\99	75	4	5.3%	5.8%	24	1.3	5.3%	400	400
	34.1	1.6	2.5%	2.8%	11.0	0.5	2.5%	88	87

Trapping Periods	A&W MNA	A&W MNI	A&W ESP	Field-Session Prevalence	A&W Totals / Hectare MNA	A&W Totals / Hectare MNI	A&W Totals / Hectare ESP	Infection Index No. Cap X Field Prevalence	Infection Index MNA X ESP
6\98	24	1	4.2%	4.2%	4	0.2	4.2%	100	100
7\98	26	2	7.7%	4.2%	4	0.3	7.7%	100	200
8\98	18	3	16.7%	6.7%	3	0.5	16.7%	100	300
9\98	22	4	18.2%	10.5%	4	0.6	18.2%	200	400
10\98	24	4	16.7%	10.0%	4	0.6	16.7%	200	400
11\98	31	6	19.4%	7.7%	5	1.0	19.4%	200	600
1\99	42	7	16.7%	13.2%	7	1.1	16.7%	500	700
2\99	54	8	14.8%	15.7%	9	1.3	14.8%	800	800
3\99	58	9	15.5%	11.1%	9	1.5	15.5%	600	900
5\99	102	11	10.8%	10.1%	16	1.8	10.8%	1000	1100
6\99	172	15	8.7%	8.4%	28	2.4	8.7%	1400	1500
7\99	133	12	9.0%	8.3%	21	1.9	9.0%	1000	1200
8\99	133	13	9.8%	8.9%	21	2.1	9.8%	1100	1300
9\99	140	16	11.4%	11.9%	23	2.6	11.4%	1600	1600
	69.9	7.9	12.6%	9.3%	11.3	1.3	12.8%	611	896

Factors Affecting Density and Hantavirus Infection-Prevalence

Prevalence of infection may not necessarily be directly related to population density but may be associated with a variety of factors including temporal population composition, habitat structure, and seasonal habitat quality, and species-specific behaviors. The number of mice infected (MNI), more often, may be associated with population densities which reflect overall population responses to temporal precipitation and habitat conditions.

These trends appear to be emerging from data collected at Limestone Canyon and Walnut Creek. Population densities and cycles reflect habitat diversity and seasonal habitat quality. Shorter seasonal density cycles at Limestone appear associated with the reliance on seasonal chaparral mast, whereas the greater densities at Walnut Creek appear associated with abundant and diverse food resources.

- Higher Prevalence
  - Drought or seasonal periods associated with minimal food resources (mast, graminoids, invertebrates).
    1. Relatively lower population densities
    2. Population composition: male dominated, adult dominated, recaptures (low turnover rate), minimal reproduction (females not receptive), minimal juveniles, if any.
    3. Number of infected mice (MNI) may be relatively low
- Lower Prevalence
  - Mild year following a wet year (El Nino possibly) and subsequent successive wet years with abundant food resources (maximal plant and invertebrate food resources).
    1. Relatively higher population densities with population surges
    2. Population composition: equal numbers of males and females, variety of age classes, mix of new and recaptured mice (greater turnover rate), female dominance during reproductive periods, increased reproduction (females receptive), increase in juveniles.
    3. Number of infected mice (MNI) may be relatively high

- Riparian Habitats
  - Riparian and arroyo habitats appear to serve as refuges and corridors for several rodent species. As a result, these optimal habitats may also serve as a refuge and corridor for various hantaviruses associated with rodents.
  - Within reservoir populations, virus "overwinters" (mainly in older adult males), and transmission may increase during peak spring and fall reproductive periods. Human risk may also increase simultaneously during these periods.

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CONTENTS - Photos

Amphibians

Rana yavapaiensis (Lowland Leopard Frog)

Bufo woohousei (Woodhouse's Toad)

Rana yavapaiensis (Lowland Leopard Frog)

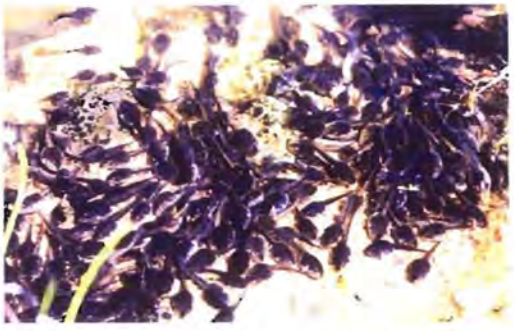
Bufo microscaphus (Arizona Toad)

Tadpole
Rana yavapaiensis (Lowland Leopard Frog)

Amphibians

Rana yavapaiensis – Breeding Habitat
Walnut Creek – Summer (1998)

Rana yavapaiensis – 100's of Tadpoles
Walnut Creek – Summer (1998)



Rana yavapaiensis – Tadpoles feeding on
Algae, Walnut Creek – Summer (1998)

Rana yavapaiensis – Tadpole mass in shallow
edge of slow moving stream, Walnut Creek –
Summer (1998)

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Cnemidophorus velox (Plateau Striped Lizard)

Phrynosoma douglassii (Short-horned Lizard)

Lizards

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Pit Trap and Drift Fences

Snakes

Masticophus taeniatus
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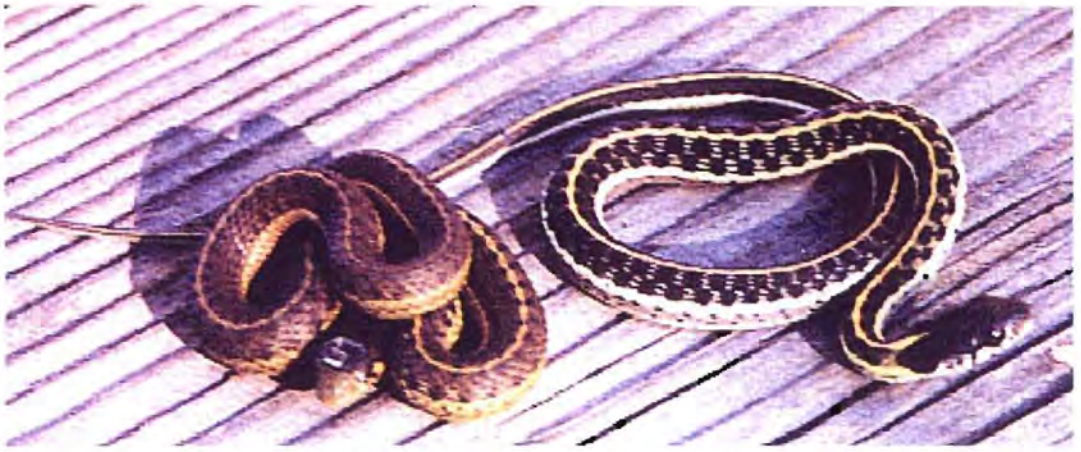
Pituophus melanoleucous
(Gopher Snake)

Snakes



Thamnophis elegans
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Hypsiglena torquata (Night Snake)

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Snakes

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Snakes

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Peromyscus maniculatus (Deer Mouse)

Peromyscus leucopus (White-footed Mouse)

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Tamias dorsalis (Cliff Chipmunk)

Neotoma albigula (White-throated Woodrat)

Mammals

Canis latrans (Coyote)

Scats
Ringtail with juniper berries
Coyote with bleached Rock
squirrel bones

Small Mammal Trapping Web - A

Northern Section
Walnut Creek - Riparian Willows, Cottonwoods, Grassland

Eastern Section
Floodprone channel, Riparian Willows, Cottonwoods

Southeastern Section
Floodprone channel, Riparian Willows, Juniper-Pinyon-Chaparral foothills

Small Mammal Trapping Web - W

Northern Section
Grassland, Walnut, Juniper

Central Section
Walnut Creek, Cottonwoods,
Willows, understory grasses

Southern Section
Old growth Cottonwoods,
understory grasses & shrubs

Hantavirus-Small Mammal Processing

INITIAL I.D.

ANESTHESIA

EAR TAG

RETRO-ORBITAL BLEED

CRYOVIAL to LIQUID NITROGEN

TRANSFER JAR with APPLE

DATA & SAMPLE STORAGE

TRAPS & TRANSFER JARS

Hantavirus-Small Mammal Processing

PROCESSING STATIONS

TRAP DISINFECTION

TRAPPING STATIONS

fini