Bosque Ecosystem Monitoring Program (BEMP): First Report: 1997-2000

Kim D. Eichhorst, Mary C. Stuever, Daniel C. Shaw, and Clifford S. Crawford

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Cover photo by C.S. Crawford

Additional information about BEMP can be accessed at:
http://www.bosqueschool.org/BEMP/bemp.htm

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Table of Contents

List of Figures ii

List of Tables iii

List of Pictures iii

Introduction 1

Outreach and Education 2

Materials and Methods 7

BEMP Collection Data 9

Interpretations 34

Executive Summary 39

Literature Cited 41

Acknowledgements 41

List of Figures

Figure 1. Map of location of BEMP sites along the Rio Grande in New Mexico and a typical site layout 10

Figure 2. Average monthly precipitation for Alameda, Rio Grande Nature Center, Los Lunas, Belen, Santa Ana, Savannah and Lemitar 11

Figure 3. 1997 and 1998 total monthly precipitation collected from rain gauges under dense canopy and in the open 13

Figure 4. 1999 and 2000 total monthly precipitation collected from rain gauges under canopy and in the open 14

Figure 5. Average depth to groundwater from ground surface at Alameda, Rio Grande Nature Center, Los Lunas and Belen for 1997, 1998, and 1999 16

Figure 6. Average depth to groundwater from ground surface for all sites in 2000 16

Figure 7. November 30, 2000 air and ground temperatures at Alameda, Nature Center, Los Lunas, Belen, and Santa Ana 17

Figure 8. June 30, 2000 and November 30, 2000 temperatures at Nature Center 18

Figure 9. 2000 vegetation cover at all sites 19

Figure 10. 2000 dominant tree cover at all sites 19

Figure 11. Plant species diversity at all sites for 2000 20

Figure 12. Mean monthly total leaf fall and mean cottonwood leaf fall per site 25

Figure 13. Average percent of native and exotic leaf fall at each site 28

Figure 14. Total annual litterfall shown as leaf, reproductive, and woody biomass 30

Figure 15. 2001 cottonwood size frequency distribution 31

Figure 16. Frequency of cottonwood sex per site 31

Figure 17. June and October 1998 surface-arthropod activity 32

List of Tables

Table 1. Plant codes for Figure 10 with corresponding scientific and common names, with plant life form 23

Table 2. Maximum and minimum 48-hr air and ground temperatures corresponding to pitfall collection dates from Figure 16 33

List of Pictures

Picture 1. Cover photo by C.S. Crawford; Albuquerque home school group collecting litterfall at Rio Grande Nature Center BEMP site .... cover

Picture 2. Photo by D.C. Shaw; Bosque School students measuring cottonwood diameter at breast height (DBH) at Alameda BEMP site 2

Picture 3. Photo by D.C. Shaw; Bosque School students collecting litterfall from tub at Belen BEMP site 4

Picture 4. Photo by D.C. Shaw; Bosque School students using hand auger to install well at a training session adjacent to Alameda BEMP site 6

Picture 5. Photo by D.C. Shaw; Bosque School students measuring groundwater depth at Savannah BEMP site 6

Introduction

It is generally acknowledged by ecologists that long-term environmental conditions cannot be documented effectively without regular monitoring of selected abiotic and biotic variables. Such monitoring is considered essential for the predictive modeling and management of many ecosystems. In the case of the Middle Rio Grande basin, relatively long-term data sets recorded by federal agencies exist for the river's flows and channel geomorphology. However, except for Bosque del Apache National Wildlife Refuge s wetland operations, the City of Albuquerque s Open Space Division monitoring of the Rio Grande Valley State Park, and University of New Mexico s (UNM) riparian forest (bosque) studies, extensive records of ecosystem change along the Rio Grande are rare. Given the uncertainty of future basin water inputs, the combination of human and native vegetation water needs, and the absence of coordinated implementation of riparian management, increased emphasis on bosque ecosystem monitoring will be important for planning the basin's future (Crawford et al. 1993).

The Bosque Ecosystem Monitoring Program (BEMP) at UNM was begun in 1996 with National Science Foundation (NSF) Informal Science Education Program funding, jointly coordinated by the UNM Department of Biology and Bosque School in Albuquerque. BEMP has two main objectives. One is to involve *citizen volunteers* (mainly K-12 students) and *site representatives* (mainly their teachers) in *monitoring key variables* that reflect bosque ecosystem structure, functioning, and biodiversity at similar sites with different flooding histories. Selection and analysis of BEMP monitored variables are based on many years of UNM bosque research. BEMP volunteers learn to understand and appreciate the ecosystem during monthly field data collection trips supervised by BEMP staff and UNM student interns. Participants are encouraged to make their involvement known to the public. Outreach in the form of inter-school conferences and presentations at local and national meetings is central to BEMP's mission.

BEMP's second -- and closely related -- objective is to *track environmental trends* and make this information available to resource agencies that deal with the Rio Grande bosque. The current seven BEMP sites are located on lands owned and/or controlled by the Middle Rio Grande Conservancy District, Albuquerque Open Space, Belen Schools, Bosque School, the Rio Grande Nature Center, Save Our Bosque Task Force, and the Pueblo of Santa Ana (Figure 1a). Aside from help by many private citizens, BEMP volunteer data collectors have to date come from an Albuquerque home school group, Albuquerque Country Day School, Bosque School, Hubert Humphrey Elementary School, La Cueva High School, and Valley High School in Albuquerque; from Los Lunas High School, Century High School, and the MESA program in Los Lunas; from Rio Grande Elementary School in Belen; from Bernalillo High School in Bernallilo; from Santa Ana Afterschool Program at the Pueblo of Santa Ana; and from Sarracino Middle School in Socorro.

These volunteers synchronously monitor *abiotic* (e.g., shallow groundwater level, precipitation) and *biotic* (e.g., cottonwood productivity, indicator arthropod activity) *change* following a prescribed schedule at similarly organized sites, year around. Other conditions (e.g., air and soil temperatures, vegetation cover) requiring more expertise are monitored by contracted individuals. Two BEMP sites (Los Lunas and Belen) are directly affected by the river's late spring flood pulse. Sites at the Pueblo of Santa Ana, Alameda, Bosque School, the Rio Grande

Nature Center, and Lemitar are not. The Nature Center and Los Lunas sites are also used for shallow groundwater research by the UNM Hydrogeoecology Group s bosque evapotranspiration team. These sites and the Belen site are also part of the group s study of the Rio Grande s flooding regime and its relationship to riparian ecosystem integrity. *Thus BEMP is part of an evolving comprehensive effort to understand and manage the Middle Rio Grande bosque.*

BEMP is currently funded by the Middle Rio Grande Bosque Initiative and the UNM Department of Biology s Sevilleta Long-Term Ecological Research (LTER) Schoolyard Program. Bosque School is an important partner, supporter, and funding source of the program. The combined BEMP budget pays the part time salary of two outreach coordinators and a data manager. It also includes support for a training course taught fall, spring, and summer by BEMP staff for UNM student interns.

In the following pages we discuss in more detail the operation of BEMP s outreach activities. Then we summarize the data amassed at our sites. A brief summary ends this report, which is being sent to agencies and individuals concerned with bosque management. We plan to distribute annual supplements in the future and will be pleased to hear from recipients at any time.

Outreach and Education

The Bosque Ecosystem Monitoring Program (BEMP) is as much about education as science. At its core, BEMP is about science education. From there it branches out and builds connections with other academic disciplines while simultaneously enhancing participants sense of place. BEMP puts students into their local riverside forest while they participate in a science research project consistent with national and state science education standards and reform efforts. In short, students learn about science by practicing it.

Students take the measurement of diameter at breast height of a cottonwood.

How students participate

There is no one model for how a school or sponsoring entity adopts the program. The actual scientific protocols must be followed, but beyond that, participants and schools are free to create systems that work for them. Each site has unique characteristics that require different strategies for accessing and monitoring. This might mean that one site can be walked to in 10 minutes from a classroom while another requires a 20-minute drive. Older students may need more sophisticated challenges to parallel their basic monitoring work while younger students might need one-on-one adult supervision to properly ensure that all procedures are being followed.

At Rio Grande Elementary School in Belen students in second and fifth grade classes rotate site monitoring responsibilities. Older fifth grade students can act as mentors for the younger students while their teachers and UNM interns provide oversight and quality control. Under the Rio Grande Elementary system each student may end up doing the actual monitoring work only a few times within an academic year. However, all second and fifth graders are in the field each month, performing activities that, although not directly connected to collecting BEMP data, supplement BEMP s educational component. In contrast, a group of home schooling families in Albuquerque uses every student on every monitoring day to gather data at the Rio Grande Nature Center site.

There is also wide variation in the ages and types of students who participate in BEMP. At the Santa Ana site, a Native American club from Bernalillo High School carries out much of the monitoring work. At the Savannah and Alameda sites, most of the work is done by sixth grade Bosque School students with augmented support from Albuquerque Public School students, most notably fifth graders from Hubert Humphrey Elementary School. Century High School, an alternative public school in Los Lunas, incorporates BEMP into its multidisciplinary curriculum. When course time is not available for Century High students, they can earn community service credits by gathering data outside of regular school hours. BEMP s newest site, at the Socorro Natural Area in Lemitar, was used in its first year by students from Sarracino Middle School.

During the summer, sites are monitored by a variety of groups, including students from the Rio Grande Nature Center s summer camp program (the Rio Grande Ecology Institute) and teachers and students from various schools who volunteer during the summer (and sometimes earn credit in the process), and UNM BEMP interns.

For some students, participation in BEMP monitoring is a year long activity richly infused into their basic curriculum. For others, it is a one-time site visit and lab experience meant to serve as an enrichment activity. In the 2000-01 school year, between 250 to 300 students were directly involved with BEMP monitoring. Not counting the summer, that amounts to over 1,700 student visits to the bosque and over 5,000 hours of volunteer field monitoring in one year. This does not include lab time or advanced and associated research projects conducted by older students such as Nathan Tooker of Los Lunas High School, who was awarded first place at the state level in the 2001 New Mexico Science Fair with his project on bosque arthropod activity.

Outreach

Dissemination of findings is a critical part of research and BEMP provides a number of opportunities for the sharing of information. On a technical level the program director, coordinators, and data manager prepare traditional scientific reports and presentations, such as this document. Where possible, participating BEMP students are encouraged and supported to enter and be a part of the same level of scientific presentation. However, BEMP also supports a number of less formal outreach efforts.

One key activity is the annual *Spring BEMP Student Congress*, where representatives from each of the sites gather for a day to share data, findings, and related projects. Over the last several years between 50 and 100 students and their teachers have presented posters, research, and even songs about their involvement in BEMP and the Bosque. The event is meant to be as much a celebration of a year of student monitoring as it is a forum for information sharing.

Another annual event, the day long *Fall Workshop*, is offered primarily for the teachers, who are encouraged to bring a handful of students to serve as peer educators. In this workshop discussions include protocols for data collection, idea sharing for curriculum development, and content information to provide background for BEMP activities. Approximately 10 to 20 people attend this event each year.

BEMP students and others have made a number of public presentations about BEMP. These include posters and talks, staffing booths, and providing information at various water and natural resource fairs, conferences, and events. Venues have occurred for several years at Albuquerque s Dia Del Rio river fair, and during the 1998 New Mexico Riparian Conference at UNM, the 2001 New Mexico Riparian Conference at Santa Ana, the 1999 River Day at the New Mexico State Legislature, the 1999 Santa Ana Pueblo Environmental Fair, the 2000 Water Fair at Santa Ana Pueblo, the 2000 Career Fair at Bernalillo High School, and the 1999 and 2000 Teacher Resource Fair hosted by the New Mexico Museum of Natural History and Science. All told, in this way alone, BEMP reaches between 500 to 1,000 people each year.

Where possible, outreach events involve members of the public in BEMP site monitoring, or analysis of previously collected leaf and arthropod samples. One example of this took place in the summer of 2000 when participants in the National State Teachers of The Year conference sorted leaf litter. The session served both to teach about BEMP and to explain how the program can be used as a model of service learning.

A permanent BEMP display is now part of a museum-style educational feature at the Albert J. and Mary Jane Black Institute at Bosque School. A display at the Rio Grande Nature Center also features BEMP. BEMP also has a mobile display that was constructed by UNM interns. Program brochures as well as the Bosque School web page (www.bosqueschool.org) provide additional information about the program.

Students collect litterfall from a tub.

One of the most successful BEMP outreach efforts is an annual series of *Bosque Education Days*, held in cooperation with Albuquerque Public Schools (APS) and the City of Albuquerque s Open Space Division. At each of the Bosque Education Days, BEMP students present 30-minute-long, hands-on sessions throughout the day for the APS students on environmental monitoring of the Bosque and the Rio Grande. Annually this event reaches about 300 students.

Partnerships and support

BEMP is itself a partnership. It is coordinated jointly by UNM s Biology Department and Albuquerque s Bosque School. Its research activities take place on a wide array of public, private, and tribal lands. The monitoring work is done with representatives from over a dozen different schools, school districts, agencies, and organizations. It is also further supported by a variety of private individuals as well as local, state, tribal, and federal governmental agencies. The keystone to BEMP s success is cooperation and partnership.

BEMP s major source of funding since 1998 has been the Bosque Initiative, administered through the U.S. Fish and Wildlife Service s New Mexico Middle Rio Grande Coordinator. This support is consistent with monitoring recommendations discussed in the *Middle Rio Grande Ecosystem: Bosque Biological Management Plan* (Crawford et al. 1993).

BEMP also participates in and is partly funded by the National Science Foundation s (NSF) Schoolyard Program at UNM s Sevilleta Long-Term Ecological Research (LTER) site on the Sevilleta National Wildlife Refuge. This makes BEMP part of a national network of student environmental monitoring and gives participants access to a wide array of educational and ecological resources. The Schoolyard LTER connection is a continuation of BEMP s relationship with the NSF, which originated in 1996 with a supplemental award from the NSF s Informal Science Education program to an existing research grant at UNM.

BEMP has a partnership with the *Bosque Education Guide*, a program enabling teachers and other youth leaders to learn to use the bosque as an educational resource. Within the context of Bosque Education Guide teacher training workshops, BEMP is presented as an opportunity for advanced study of the bosque and a way for concerned students and teachers to involve themselves in bosque conservation.

BEMP has a direct working relationship with the New Mexico Department of Game and Fish s New Mexico Watershed Watch (NM-WW) program. Whereas BEMP primarily studies the riverside forest, NM-WW is a student monitoring program that looks at the relationship between watershed and stream health. The overlapping interests of BEMP and NM-WW concerning student environmental monitoring have led to several joint presentations and research efforts.

Publications

A series of articles about BEMP have appeared in both general circulation publications and member newsletters. The former include Albuquerque Journal articles from 12 March 1997, 3 April 1998, 21 March 2001, and a 28 March 2001 editorial. BEMP has also been prominently featured in the official newsletters of the Rio Grande Nature Center, the LTER Schoolyard Network, and the Environmental Education Association of New Mexico.

Quality control

A major concern of any research effort is quality control. This is especially true in a situation involving a large number of K-12 students. To address quality control several steps have been taken. First, all research procedures have been kept simple. Useful baseline monitoring procedures and data do not have to be complex. On the contrary, sophisticated statistical analysis can emerge from consistently gathered, uncomplicated procedures. Second, all BEMP protocols are outlined in both a hard copy and electronic version field and procedure manual. Third, although many people may help to monitor each site, each site representative directly oversees that location s monitoring efforts.

BEMP staff members provide initial and intensive support and training to site representatives. As needed, additional site visits and support are also provided. Each semester over the last three years, BEMP has offered a 3-hour credit upper level undergraduate and graduate course, *Bosque Internship*, at the University of New Mexico. The course makes available internship opportunities for college students to assist with the program and at the same time to learn much about the bosque. Student interns strengthen the link between BEMP sites and UNM researchers. As part of their class assignment, interns work directly with BEMP site volunteers to provide quality control and supervision. Interns also transport field data and samples to the BEMP data manager.

Here, students are using a hand auger to dig the hole for installing a well.

Later, students use a beeper or water level meter to measure groundwater depth.

Participating teachers perceptions and use of BEMP

In the spring of 2000, as part of a larger study of teachers and their use of environmental monitoring programs, all 15 of the currently participating BEMP teachers were surveyed about their perceptions and use of BEMP. Although a more formal paper is in production, a few preliminary observations are worth noting. Demographically, about three quarters of the BEMP teachers are from public schools, two thirds of BEMP teachers have six or more years teaching experience, and nearly two thirds of BEMP teachers are in either their first or second year in the program.

When asked how much they agreed with various statements about BEMP, participating BEMP teachers were fairly consistent in their responses. In brief, those teachers generally believed that the level of science within BEMP was appropriate and well suited for their students, that because of BEMP their students spent more time in the field than they otherwise would if engaged in a traditional curriculum, and that their students understood that the bosque ecosystem is undergoing tremendous change. There was very strong agreement that teachers did not feel pressured to include certain biological or political perspectives in their curriculum as a function of participating in the program, that their students understood that their research effort had implications beyond their own classroom, and that these teachers felt that their school s administration solidly supported their participation in BEMP.

Although not a problem for all participating schools, several teachers indicated that transportation issues were a significant stumbling block to their continued program participation. Generally though, teacher comments were incredibly supportive of the program s administration and the opportunity BEMP provides their students. In particular a third or more of participating teachers appreciated how BEMP provided a mechanism for their students to participate in real science, was hands-on learning in a field setting, and taught about current environmental issues. Other comments related to: how BEMP aligns with local, state, and national science education standards and reform efforts; provides students with a sense of place related to their home ecosystem; and provides access and a working relationship with university personnel.

Materials and Methods

Study site organization (Figure 1b)

BEMP *study sites* are selected to represent the bosque immediately around them. They have rectangular boundaries (100 meter x 200 meter) with roughly north-south lengths paralleling the nearby Rio Grande. All sites are located between levees and the river except for Lemitar, which is outside a levee, and Santa Ana where there is no levee. All sites except for Alameda and Rio Grande Nature Center are on the west side of the river. Each site is divided into ten 20 m x 100 m equally spaced units, listed as A through J . Within each unit is a 30 m x 5 m *vegetation plot* positioned by use of random numbers and marked on the corners by blue rebar. The southern boundary of each vegetation plot is used for annual vegetation transect measurements. A *litterfall tub* is stationed halfway between each vegetation plot s southern boundary and the line (often a trail). Four *pitfall traps* are inserted along every other line, starting with the B line and located at 10 m intervals centered to reflect the east-west length of the vegetation plot to the north. Orange rebar mark the location of each trap.

Five 2-in pvc *groundwater monitoring wells* are installed at each site, except Santa Ana. They consist of a center well, an east well, and a west well on the line separating the E and F units, a north well on the line separating the C and D units; and a south well separating the line separating the G and H units. The center well is 40 m from each of the other wells. Each well is designed to equilibrate with groundwater through lateral slots that extend for 1 m upward from the capped well bottom. Wells are inserted to depths up to 1m below groundwater levels when these are seasonally low.

Each site has a weather station consisting of two rain gauges and three *temperature data loggers*. The rain gauges, mounted approximately 1.5 m aboveground on vertical wooden posts, are situated so that one captures precipitation from open sky while the other catches moisture from beneath a cottonwood canopy. One of the data loggers is mounted 2 m above the ground on the north side of a densely canopied cottonwood, close to the canopy rain gauge. The other two are buried approximately 2 cm below the soil surface; one is directly below the tree data logger, while the other is within 1 m of the open rain gauge.

Monitoring schedules

In order to compare ecologically relevant information among sites, data are collected the same way and at the same time, as follows:

- Third Tuesday of every month: record groundwater depths, collect litterfall, record precipitation.
- Every other month: download temperature data loggers.
- First Tuesdays of May and October and fourth Tuesdays of June and August: set pitfall traps, collect specimens 48 hr later.
- First week in April to early May: inventory and sex vegetation plot cottonwoods.
- Late August to late September: measure plant cover along vegetation transects.

Monitoring procedures

Measurements of physical parameters

Groundwater depth: Solinst water level meters are used to measure depth in centimeters to water table. Supervised volunteers (mainly K-12 students) do most of the work. Data are recorded in the field on designated forms and submitted to the BEMP data manager, who subtracts aboveground casing heights from each well to record actual surface to groundwater depths.

Precipitation: Amounts of water accumulated in rain gauges over a month s time are read and recorded in millimeters, usually by volunteers, on the same forms used for reporting groundwater depths and litterfall collections. The water is then poured out of each gauge and about 10 mm (also recorded) of cooking oil is added to prevent evaporation until the next recording is made.

Temperature: Hobo dataloggers are downloaded by a person familiar with their location, operation, and maintenance requirements. Diskettes are then submitted to the data manager.

Measurements of biological parameters

Litterfall: Circular Fortex tubs (40 cm in diameter and 10 cm in depth) are used to trap falling tree and shrub litter consisting of leaves, wood, and reproductive parts. Collected mainly by volunteers, the items are placed in bags marked with site, site unit, and date. Subsequent processing occurs either in schools under trained supervision or at UNM by BEMP staff and interns. Processing to obtain *dry weight biomass* involves oven drying at 60 °C for 48 hr followed by sorting into a number of categories. These are weighed to 0.1 g. Completed data sheets are submitted to the data manager.

Pitfall trapping: Pitfall traps consist of two 16 oz plastic Solo cups, one inserted inside the other, with a small drain hole in the outside cup. The cups are placed in an excavated pit so that their openings are even with the soil surface. When not in use, the openings are closed with plastic wrap beneath tightly fitting plywood lids 15 cm on a side. Four 7-cm screws at each corner ensure lid immobility. Lids are raised 3-4 cm during trapping periods, after which their contents are shaken into plastic Ziplock bags marked with date, site name, and trap number. Animals other than arthropods are noted and released. The remaining bag contents are frozen until identified to taxonomic levels appropriate to BEMP s goals. Voucher specimens are preserved and used for identification by trained personnel. Most trapping is done by volunteers.

Cottonwoods: Cottonwood trees are all counted in site vegetation plots. Trees shorter or taller than 1.5 m in height are recorded, and metal tags with plot letters and tree numbers are attached by aluminum nails to the taller trees. Trunk circumferences of those trees are measured at 1.5 m aboveground and converted to diameter as indicators of *live tree biomass*. Cottonwood sex is determined visually at flowering and recorded for intersite comparison. Binoculars are often essential for this exercise.

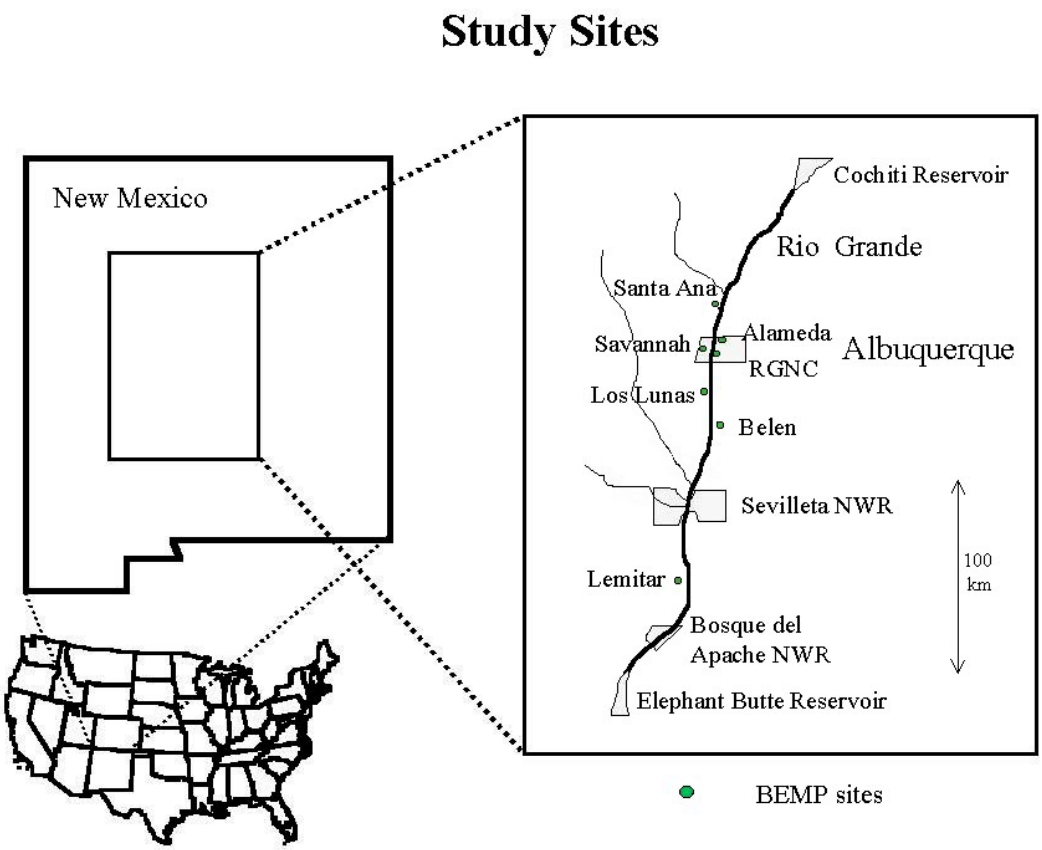
Plant cover: The southern 30-m lengths of each site vegetation plot serve as transects for measurements of plant cover by qualified individuals. Species names are codified for eventual analysis.

Specific monitoring procedures and data sheets can be accessed on the web at http://www.bosqueschool.org/BEMP/bemp.htm.

BEMP Collection Data

The following figures and tables provide data from long-term collections made at each BEMP site, starting with Alameda, Rio Grande Nature Center, and Los Lunas in 1997. Subsequently the following sites came on-line: Belen (1998), Santa Ana (1999), Savannah (2000), and Lemitar (2000). Data are presented largely in the form of bar graphs. Not all collected data are presented here. In particular, woody stem density data have been collected at four sites in various years, but are omitted due to the inherent error in the data. Woody stem densities will no longer be a part of BEMP protocol due to the time-consuming and subjective aspects of the methods involved.

a.



b.

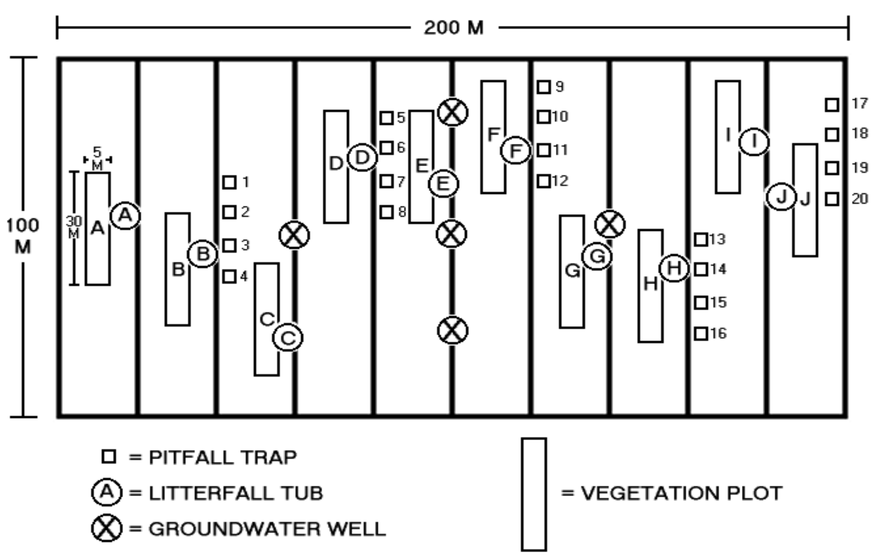


Figure 1. a. Map of BEMP sites along the Rio Grande. b. Typical layout of a BEMP site.

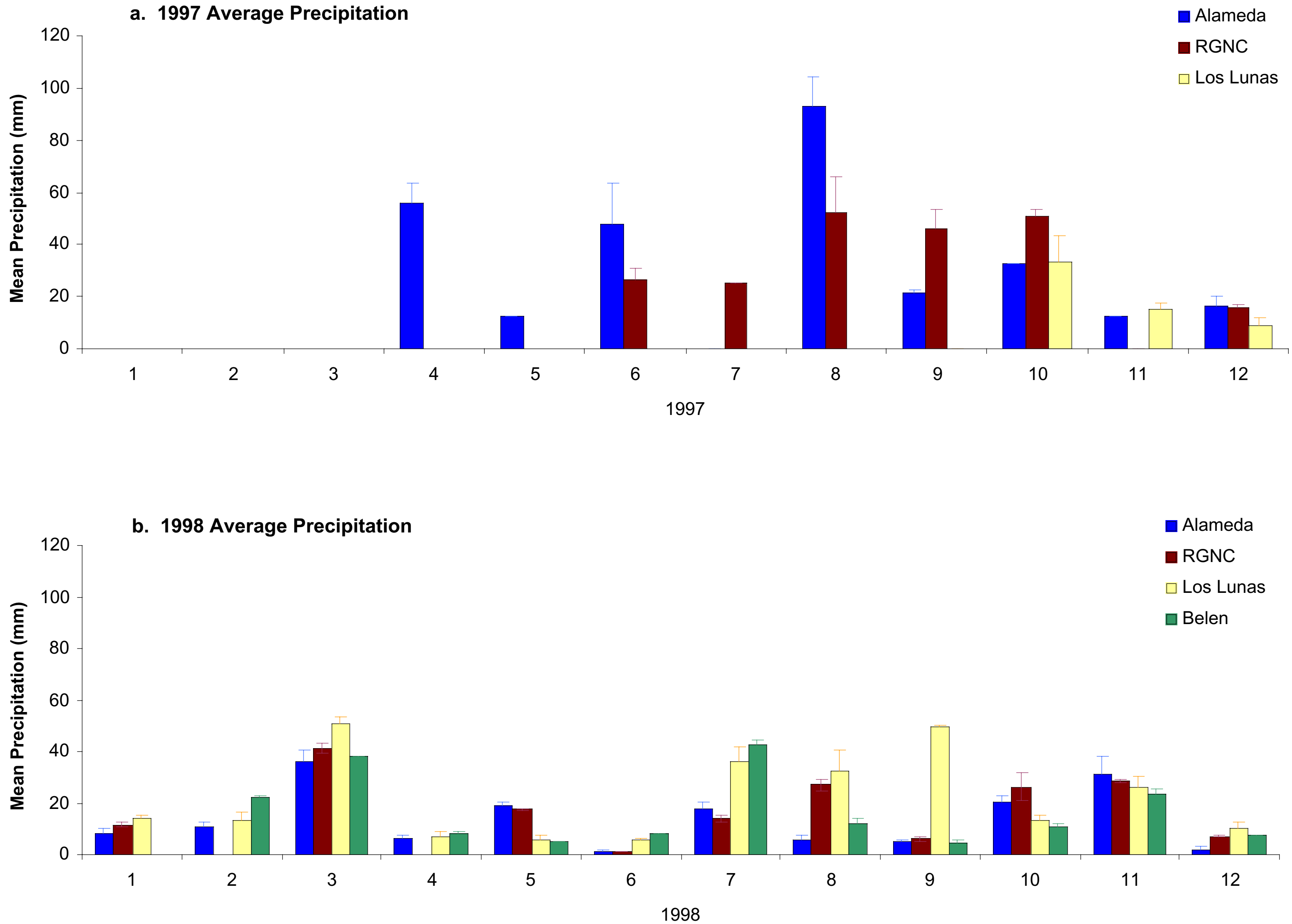
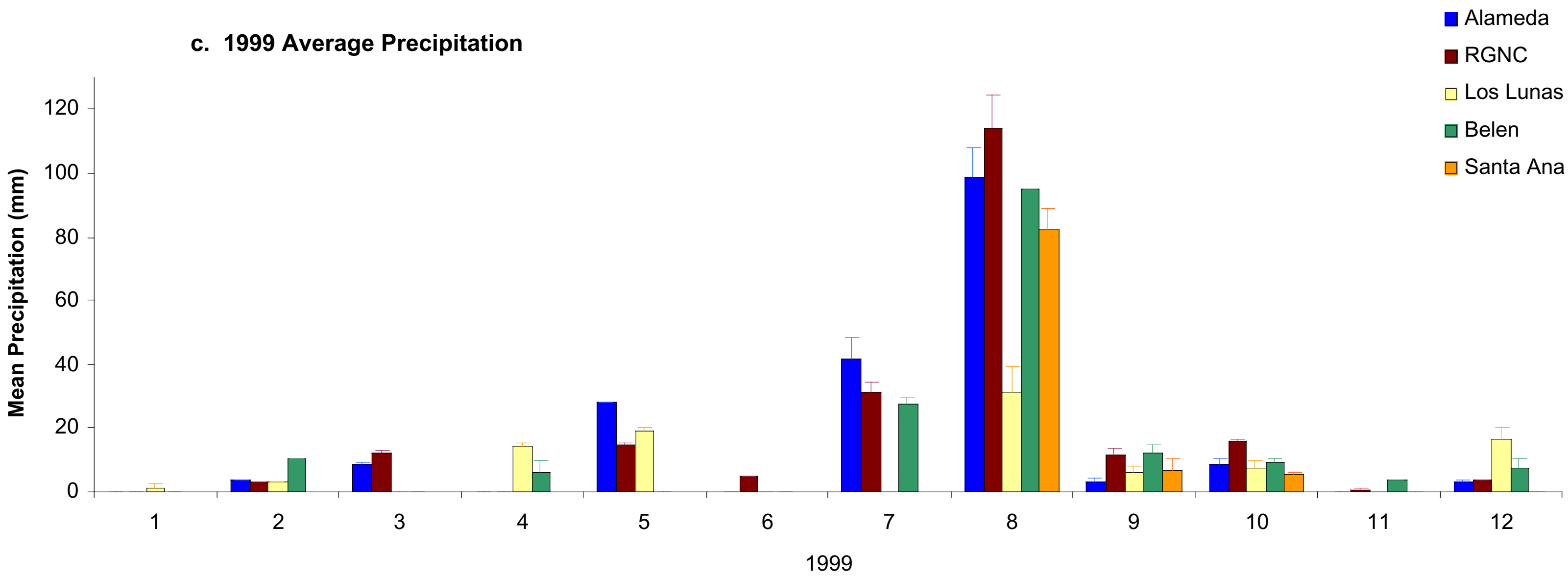


Figure 2. Average monthly precipitation (mean of canopy and open rain gauges) with vertical standard error bars for sites. X-axis is month (Jan-Dec). Y-axis shows precipitation, from 0 to 120 mm. a. 1997 average monthly precipitation b. 1998 average monthly precipitation



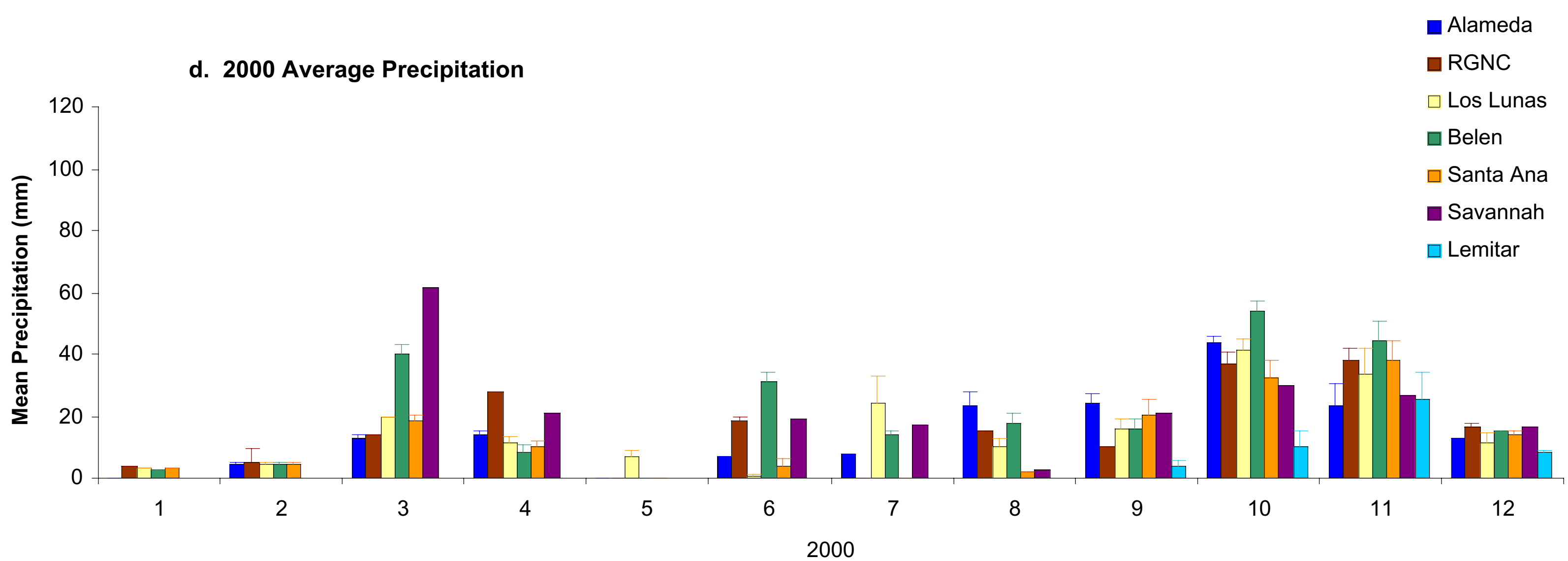


Figure 2 (continued). c. 1999 average monthly precipitation (y-axis scale from 0 to 130 mm) d. 2000 average monthly precipitation

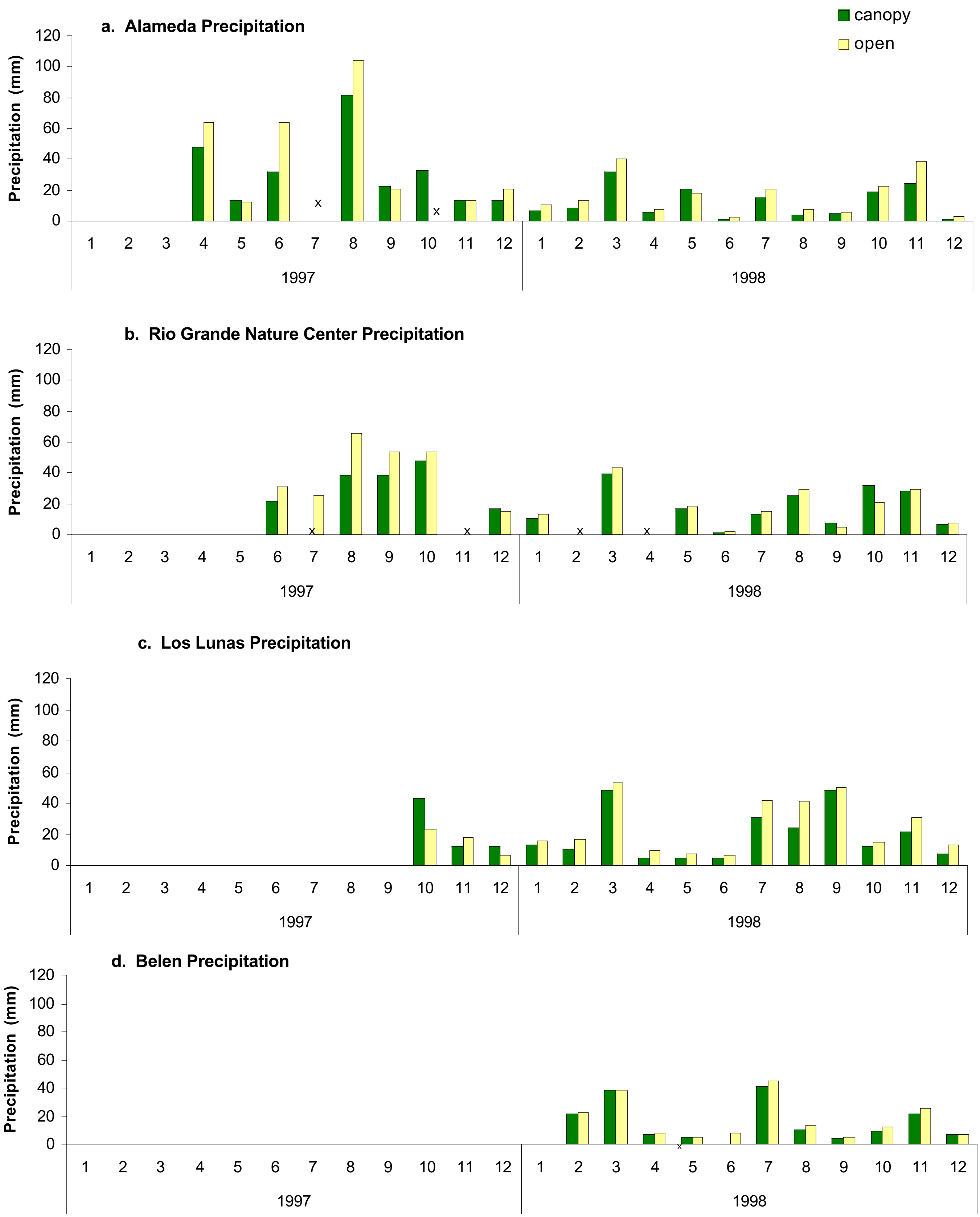


Figure 3. 1997 and 1998 total monthly precipitation (mm) collected from rain gauges under dense canopy and in the open. All graphs are on a 0 to 120 mm scale; x denotes missing data, not a value of 0 .
a. Alameda (collections begun 4/1997) b. Nature Center (collections begun 6/1997) c. Los Lunas (collections begun 10/1997). d. Belen (collections begun 2/1998)

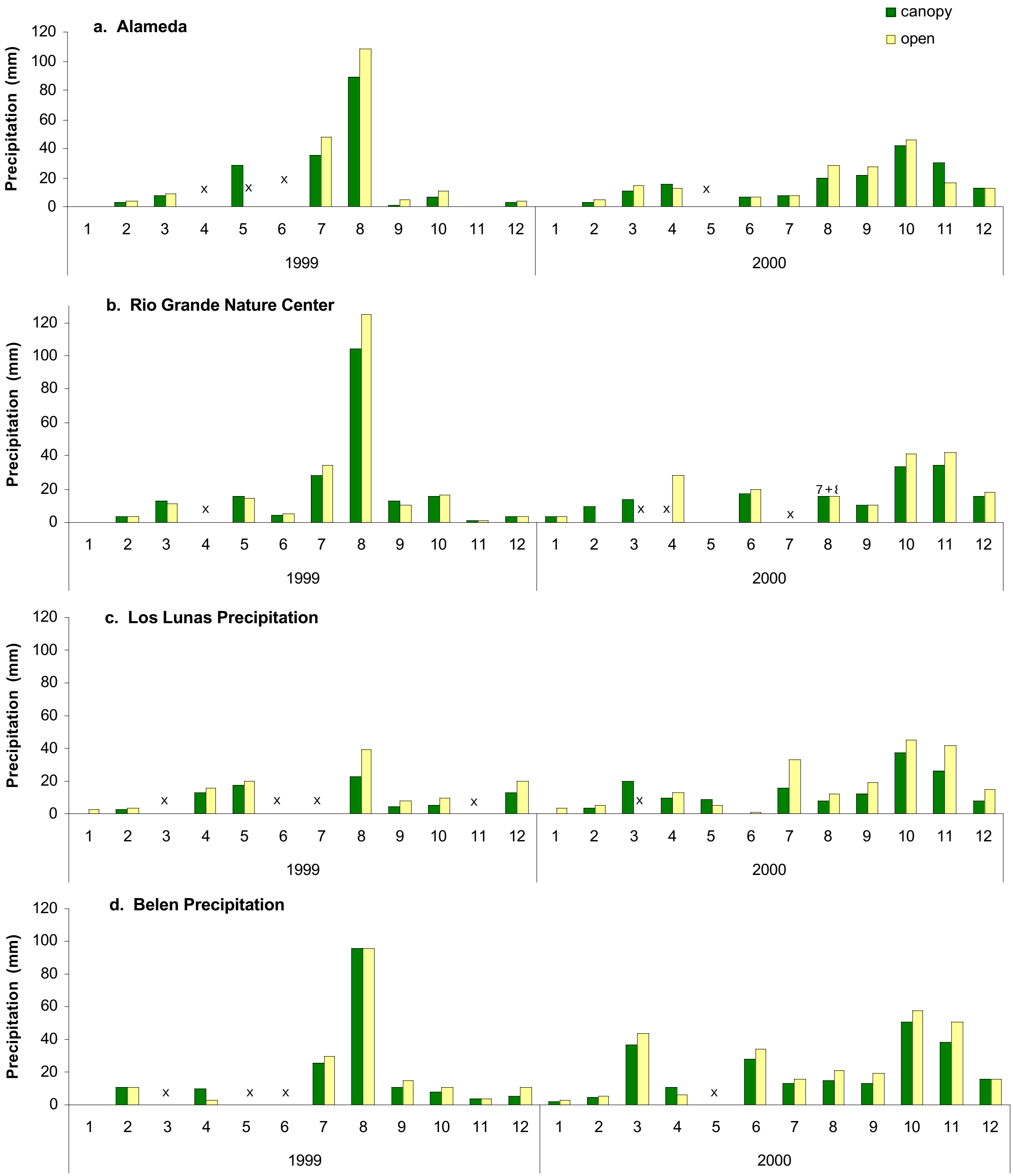


Figure 4. 1999 and 2000 total monthly precipitation (mm) collected from rain gauges under dense canopy and in the open. All graphs are on a 0 to 120 mm scale, except for the Nature Center, which extends to 130 mm; x denotes missing data, not a value of 0 . August 2000 Nature Center data are a combination of July and August data, represented by 7+8 a. Alameda b. Nature Center c. Los Lunas d. Belen

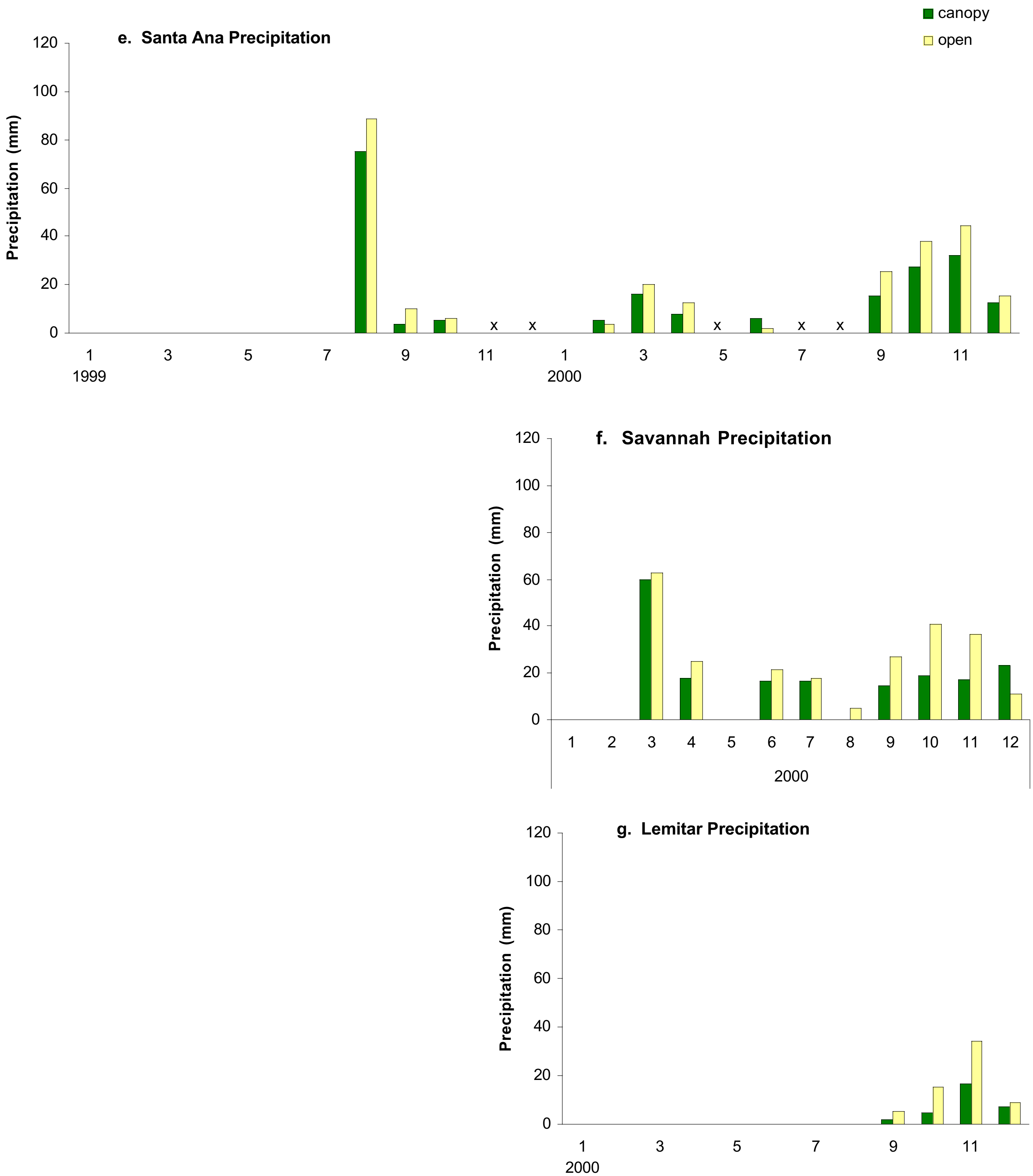


Figure 4 (continued). e. Santa Ana (collections begun 8/1999) f. Savannah (collections begun 3/2000) g. Lemitar (collections begun 9/2000).

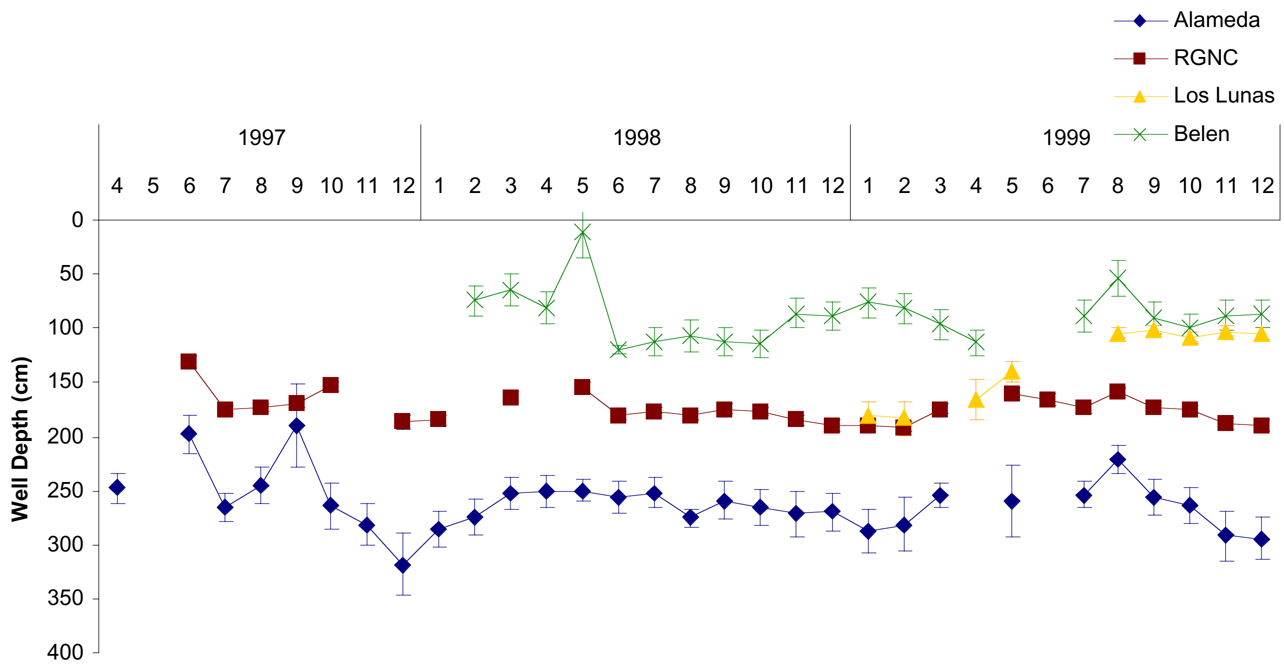


Figure 5. Average depth to groundwater from ground surface in cm at Alameda, Rio Grande Nature Center (RGNC), Los Lunas, and Belen for 1997, 1998, and 1999. Values represent the mean of five wells at each site; readings taken on the third Tuesday of the month (Jan-Dec). Vertical bars are standard errors. Gaps in mid-line indicate missing data.

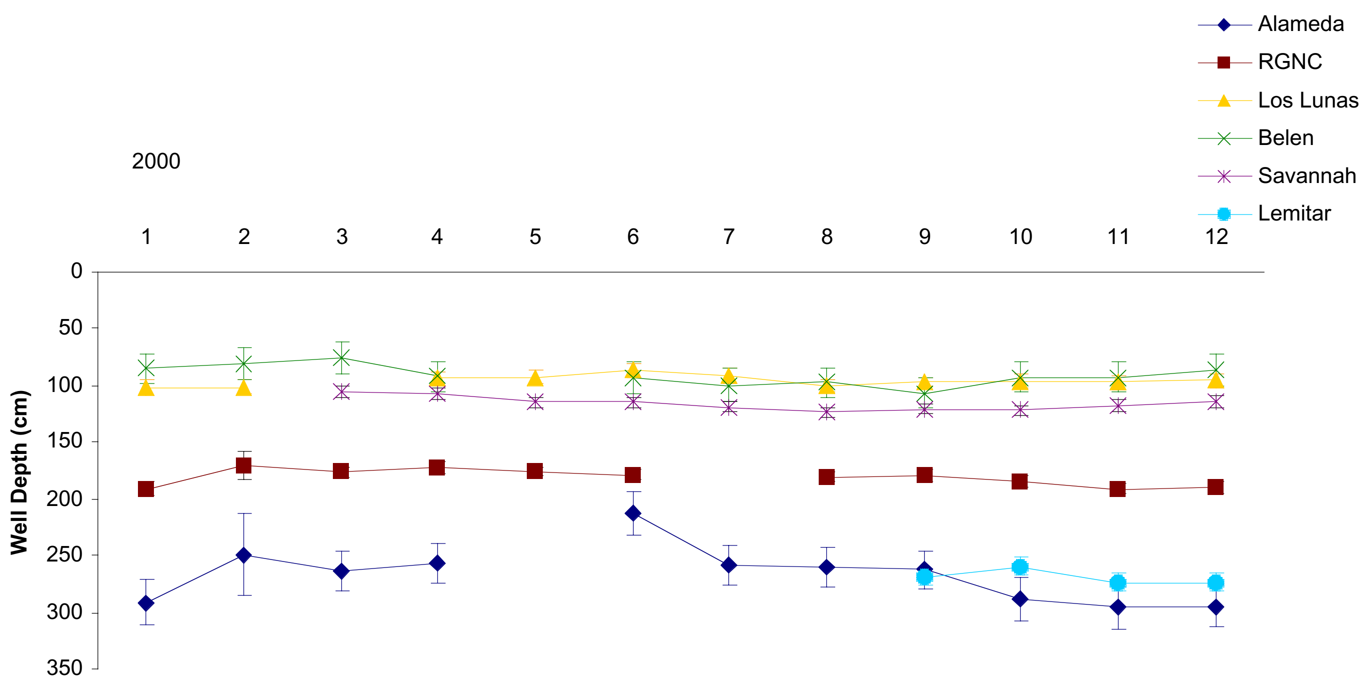


Figure 6. Average depth to groundwater from ground surface at Alameda, Rio Grande Nature Center, Los Lunas, Belen, Savannah, and Lemitar for 2000. Values represent the mean readings of five wells at each site taken the third Tuesday of the month (Jan-Dec). Vertical bars are standard errors. Gaps indicate missing data.

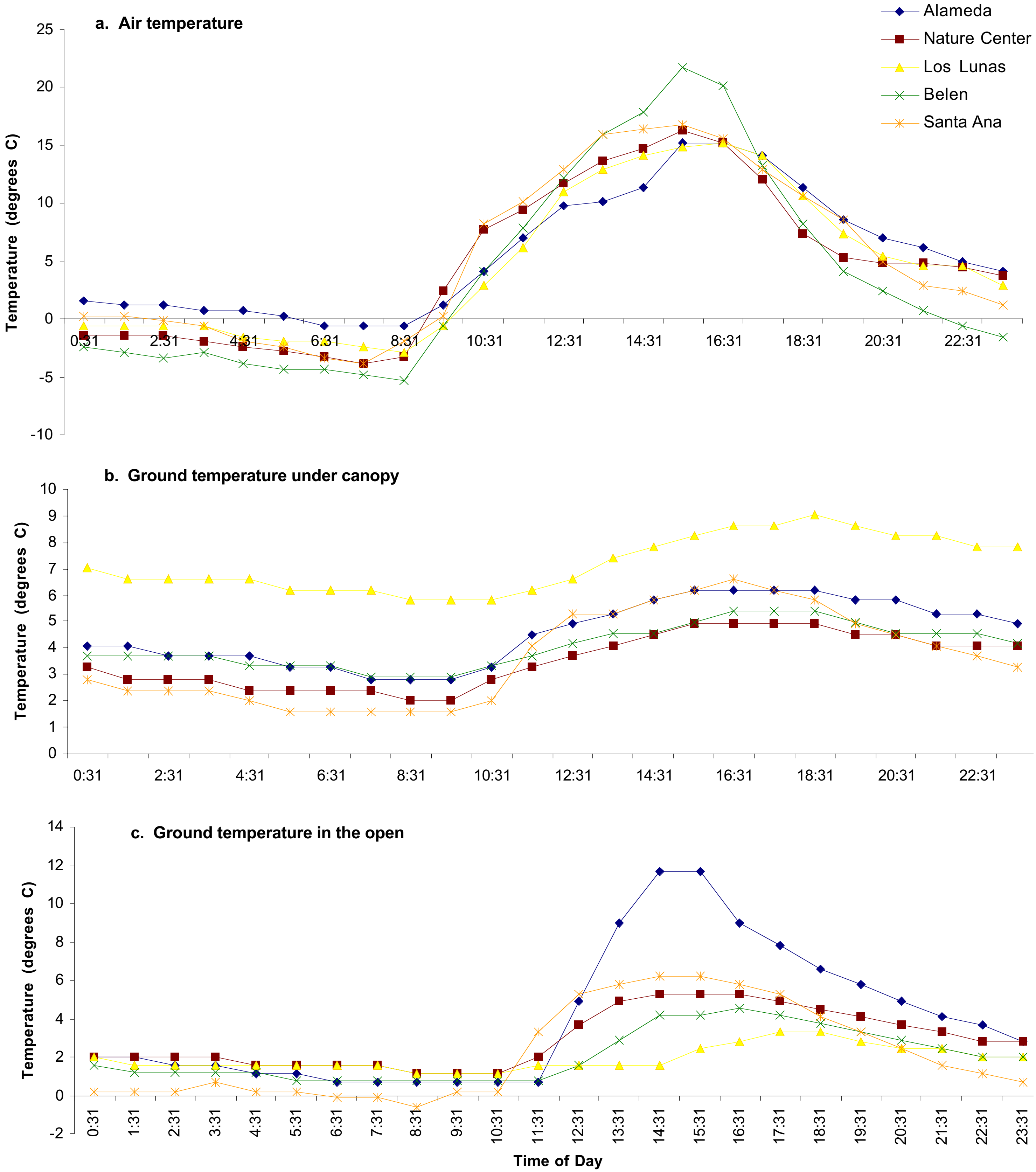


Figure 7. November 30, 2000 temperatures at 2 m above ground, 2 cm below ground under the canopy and 2 cm below ground within 1 m of the open rain gauge at Alameda, Nature Center, Los Lunas, Belen and Santa Ana. (Note different x-axis scales.)

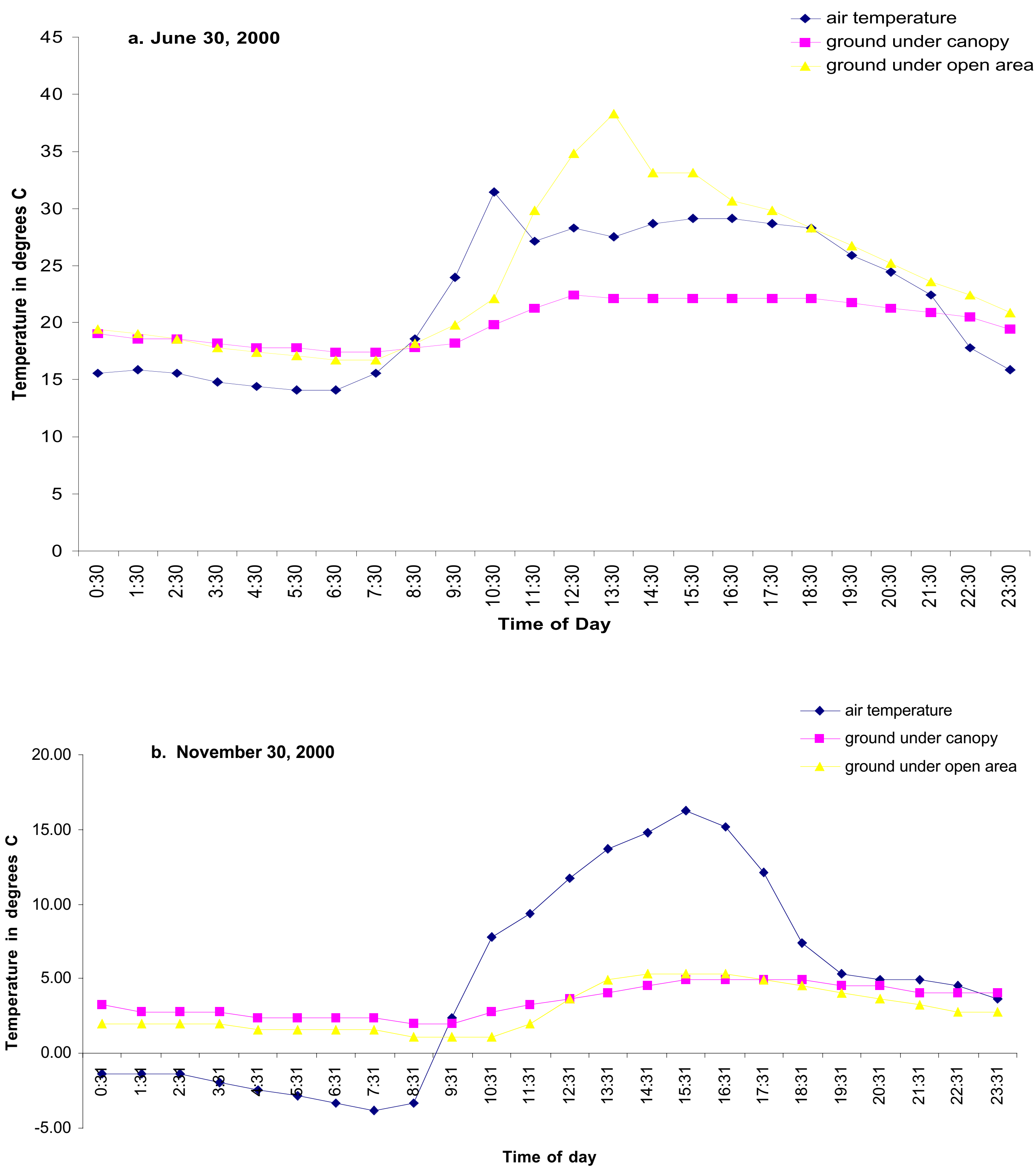


Figure 8. a. June 30, 2000 and b. November 30, 2000 air and ground temperatures at the Rio Grande Nature Center. Note different x-axis scales.

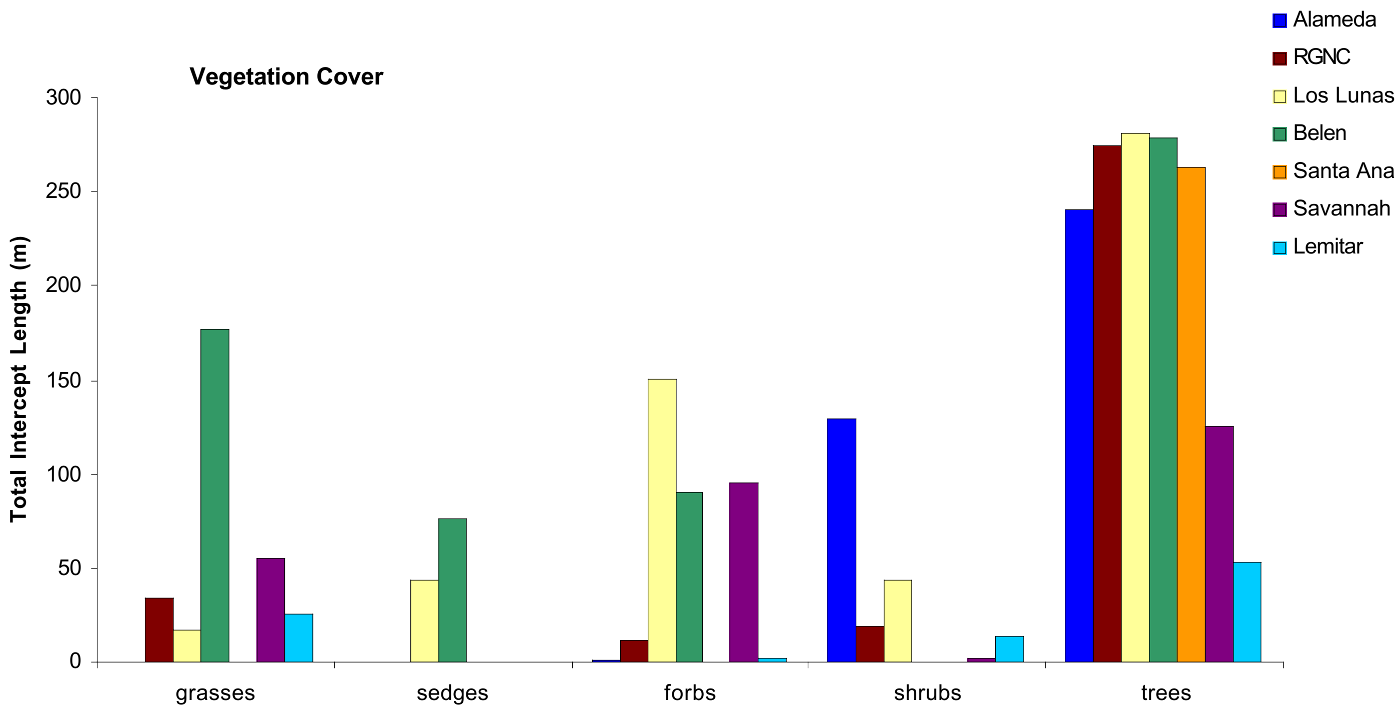


Figure 9. 2000 vegetation cover at Alameda, Nature Center, Los Lunas, Belen, Santa Ana, Savannah and Lemitar. X-axis is vegetation type. Y-axis is total intercept length summed across all ten 30-m transects, indicating patch size of each vegetation type.

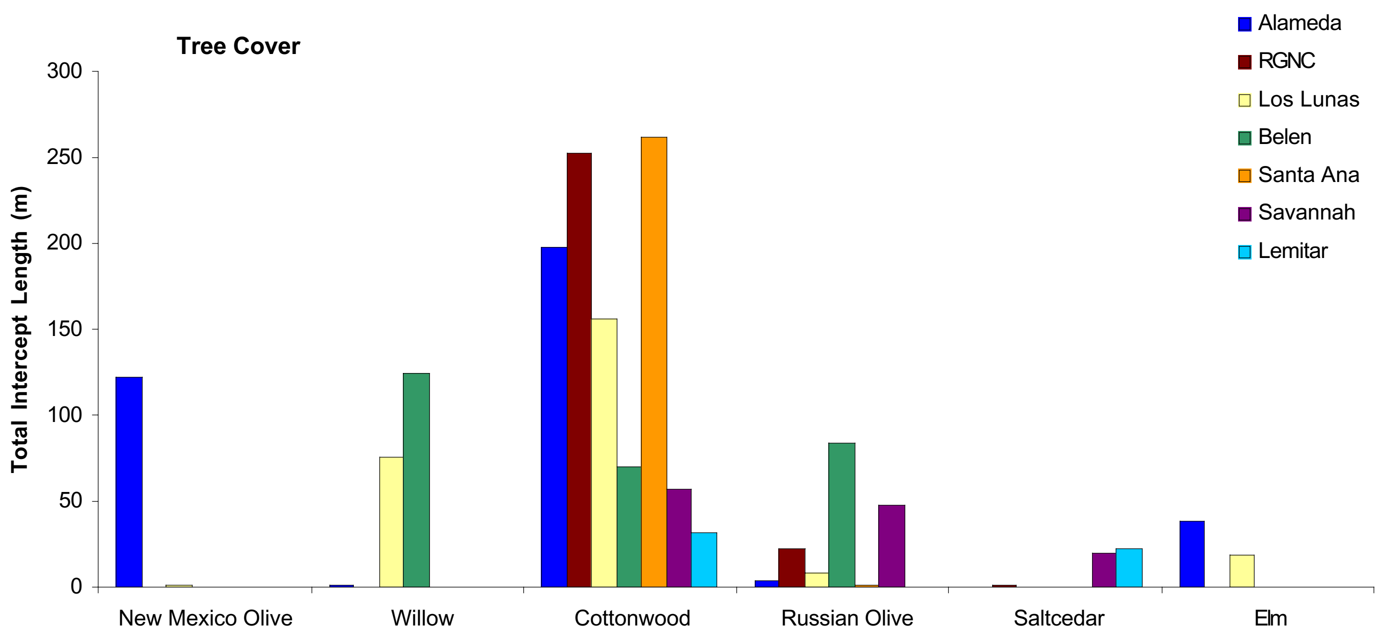


Figure 10. 2000 tree cover. X-axis shows most dominant trees. Four native trees: *Forestiera pubescens* var. *pubescens* (New Mexico olive), *Salix exigua* and *Salix gooddingii* (willows) and *Populus deltoides* ssp. *wislizenii* (cottonwood). Three exotic/introduced trees: *Elaeagnus angustifolia* (Russian olive), *Tamarix ramosissima* (saltcedar) and *Ulmus pumila* (Siberian elm). Y-axis is total intercept length summed across all ten 30-m transects.

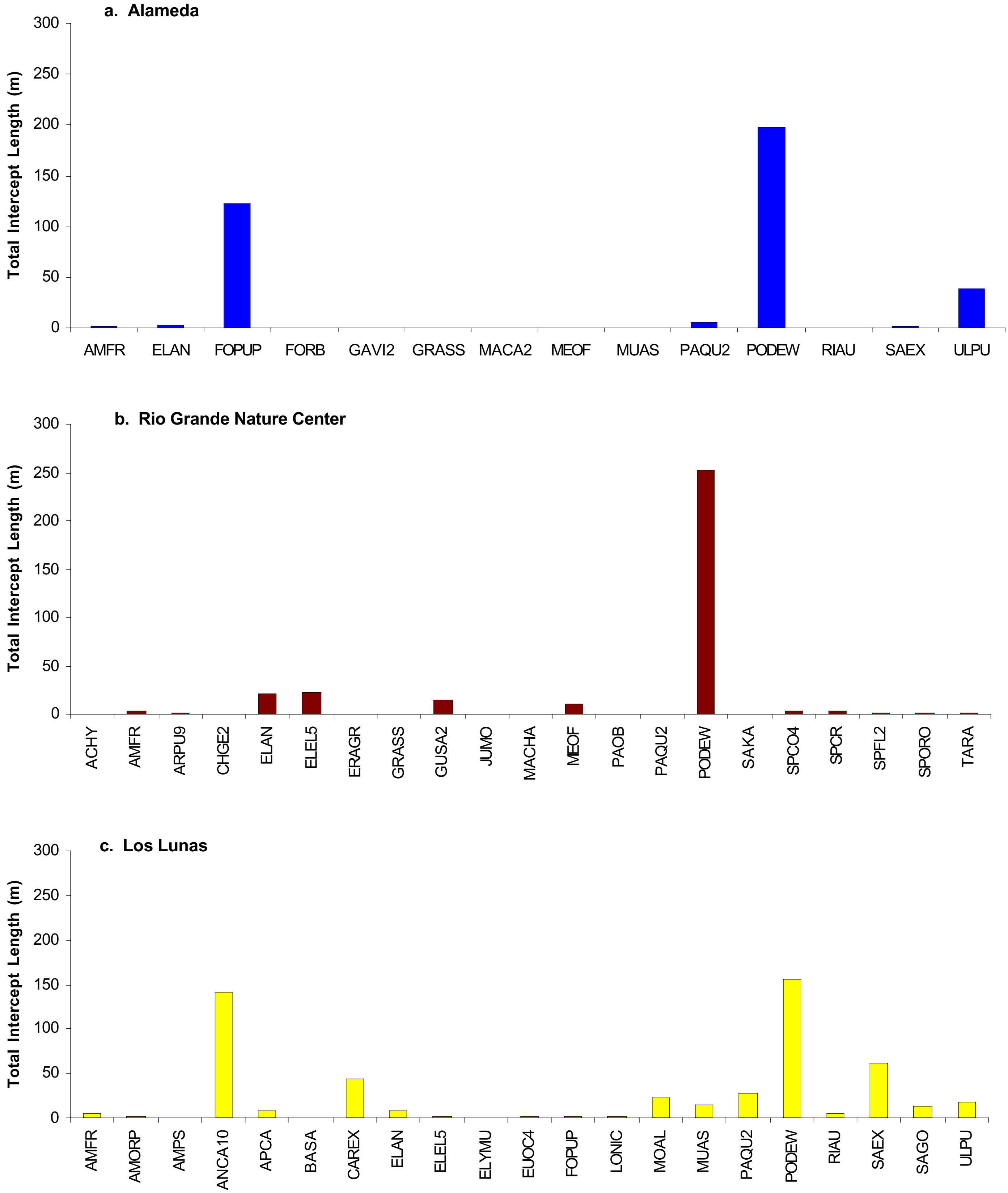


Figure 11. Plant species diversity. X-axis lists plant species codes for species found at each individual site (see Table 1 for scientific and common plant names). Y-axis is total intercept length summed over ten 30-m transect lines. a. Alameda b. Nature Center c. Los Lunas

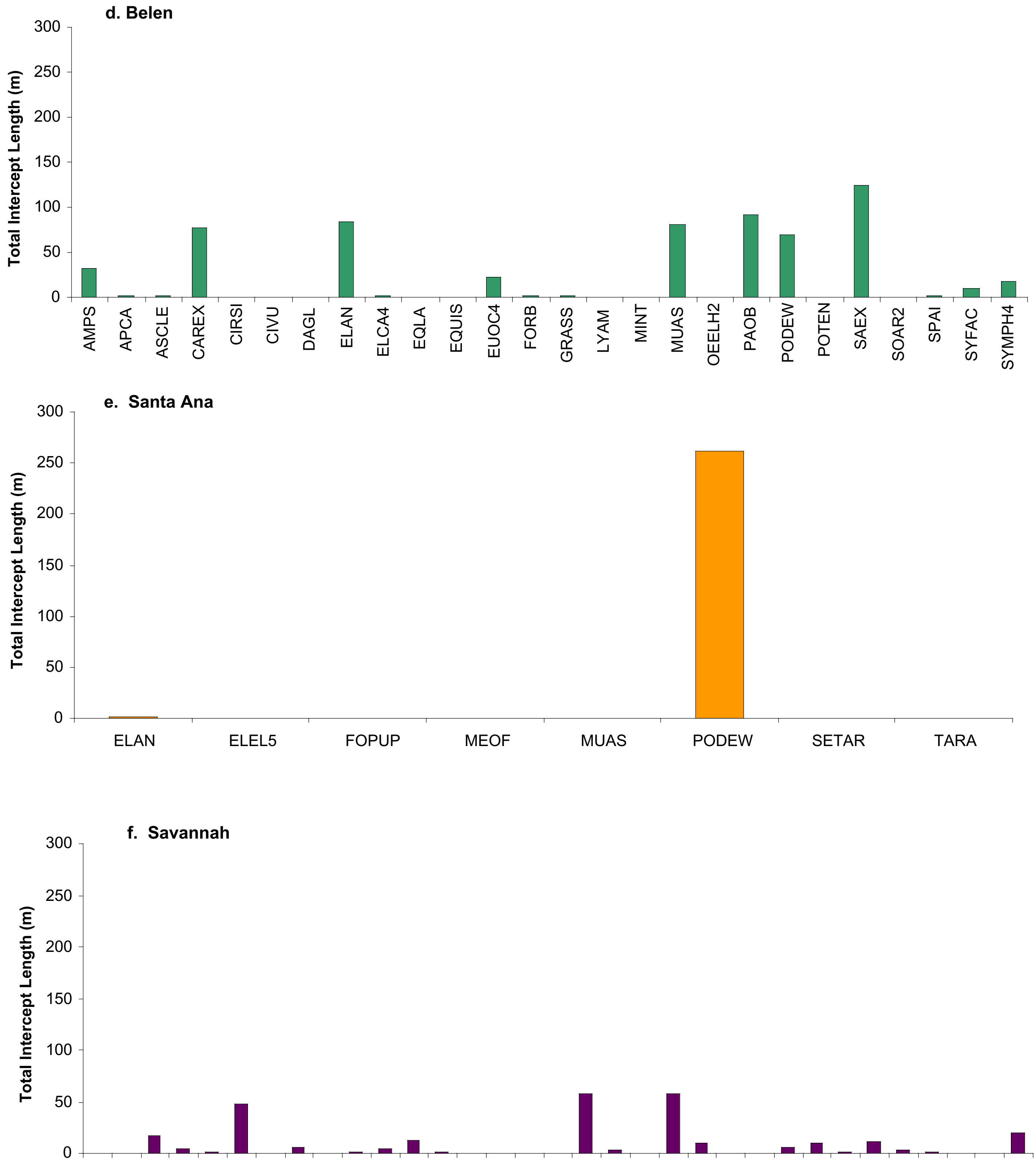


Figure 11 (continued). d. Belen e. Santa Ana f. Savannah

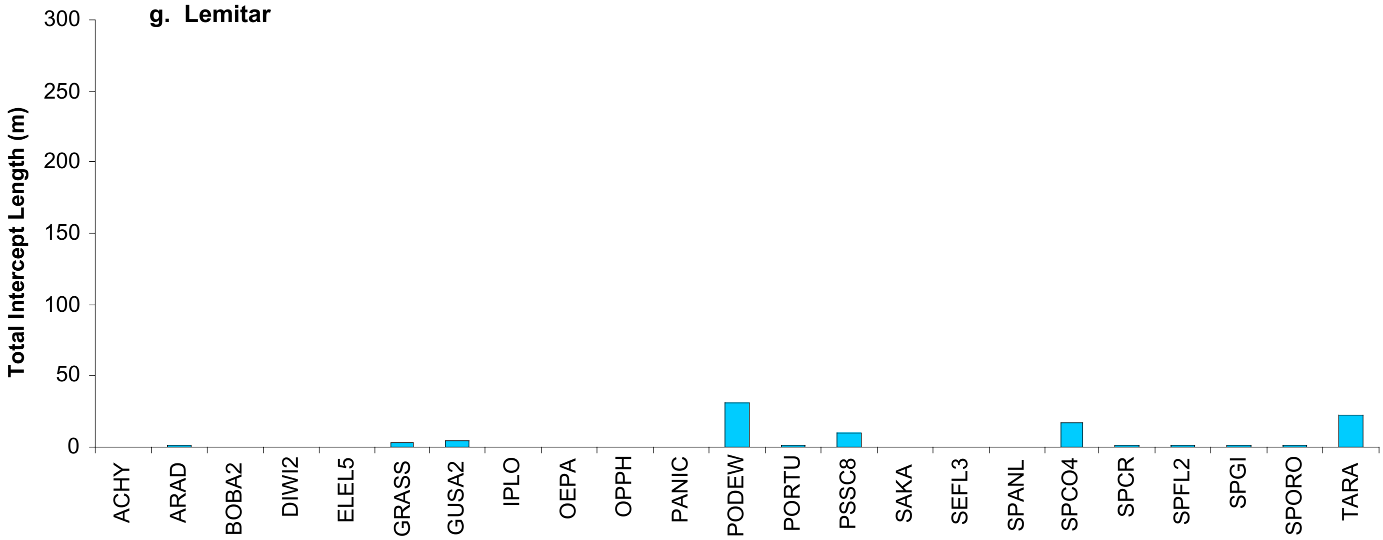


Figure 11 (continued). g. Lemitar

Table 1. Plant codes for Figure 10 with corresponding scientific and common names and plant life forms. Life form codes: G = grass and sedge, F = forb (flowering, non-woody plants), S = shrub, T = tree.

Plant code	Scientific Name	Common Name	Life Form
ACHY	*Achnatherum hymenoides*	Indian rice grass	G
AMFR	*Amorpha fruticosa*	desert false indigo	S
AMORP	*Amorpha*	false indigo	S
AMPS	*Ambrosia psilostachya*	Cuman ragweed	F
ANCA10	*Anemopsis californica*	yerba mansa	F
APCA	*Apocynum cannabinum*	Indianhemp	F
ARAD	*Aristida adscensionis*	sixweeks threeawn	G
ARPU9	*Aristida purpurea*	purple threeawn	G
ASCLE	*Asclepias*	milkweed	F
BASA	*Baccharis salicina*	Great Plains false willow	S
BOBA2	*Bouteloua barbata*	sixweeks grama	G
BRINI	*Bromus inermis* ssp. *inermis*	smooth brome	G
CAREX	*Carex* sp.	sedge	G
CHGE2	*Chamaesyce geyeri*	Geyer's sandmat	F
CIRSI	*Cirsium* sp.	thistle	F
CIVU	*Cirsium vulgare*	bull thistle	F
COAR4	*Convolvulus arvensis*	field bindweed	F
DAGL	*Dactylis glomerata*	orchardgrass	G
DIWI2	*Dimorphocarpa wislizeni*	spectaclepod	F
ELAN	*Elaeagnus angustifolia*	Russian olive	T
ELCA4	*Elymus canadensis*	Canada wildrye	G
ELEL5	*Elymus elymoides*	squirreltail	G
ELYMU	*Elymus* sp.	wildrye	G
EQLA	*Equisetum laevigatum*	smooth horsetail	F
EQUIS	*Equisetum* sp.	horsetail	F
ERAGR	*Eragrostis* sp.	lovegrass	G
EUOC4	*Euthamia occidentalis*	western goldentop	F
FOPUP	*Forestiera pubescens* var. *pubescens*	New Mexico olive	S
FORB		unidentified forb	F
GAVI2	*Gaura villosa*	woolly beeblossom	F
GLLE3	*Glycyrrhiza lepidota*	American licorice	F
GRASS		unidentified grass	G
GUSA2	*Gutierrezia sarothrae*	broom snakeweed	S
HEAN3	*Helianthus annuus*	common sunflower	F
HECI	*Helianthus ciliaris*	Texas blueweed	F
IPLO	*Ipomoea longifolia*	pinkthroat morning-glory	F
JUMO	*Juniperus monosperma*	oneseed juniper	T
KOSC	*Kochia scoparia*	summer cypress	F
LONIC	*Lonicera* sp.	honeysuckle	S
LYAM	*Lycopus americanus*	American water horehound	F

MACA2	*Machaeranthera canescens*	hoary tansyaster	F
MACHA	*Machaeranthera*	tansyaster	F
MEOF	*Melilotus officinalis*	white sweet clover	F
MINT		unidentified mint	F
MOAL	*Morus alba*	white mulberry	T
MUAS	*Muhlenbergia asperifolia*	scratchgrass	G
OEELH2	*Oenothera elata* ssp. *Hookeri*	primrose	F
OEPA	*Oenothera pallida*	pale evening-primrose	F
OPPH	*Opuntia phaeacantha*	tulip pricklypear	S
PANIC	*Panicum* sp.	panicgrass	G
PAOB	*Panicum obtusum*	vine mesquite	G
PAQU2	*Parthenocissus quinquefolia*	Virginia creeper	F
PASM	*Pascopyrum smithii*	western wheatgrass	G
PHYSA	*Physalis* sp.	groundcherry	F
PODEW	*Populus deltoides* ssp. *wislizenii*	Rio Grande cottonwood	T
PORTU	*Portulaca* sp.	purslane	F
POTEN	*Potentilla* sp.	cinquefoil	F
PSSC8	*Pediomelum hypogaeum* var. *scaposum*	subterranean Indian breadroot	S
RIAU	*Ribes aureum*	golden currant	S
SAEX	*Salix exigua*	narrowleaf willow	S
SAGO	*Salix gooddingii*	Goodding's willow	T
SAKA	*Salsola kali*	Russian thistle	F
SEFL3	*Senecio flaccidus*	threadleaf ragwort	F
SELE6	*Setaria leucopila*	streambed bristlegrass	G
SETAR	*Setaria* sp.	bristlegrass	G
SEVI4	*Setaria viridis*	green bristlegrass	G
SOAR2	*Sonchus arvensis*	field sowthistle	F
SOEL	*Solanum elaeagnifolium*	silverleaf nightshade	F
SPAI	*Sporobolus airoides*	alkali sacaton	G
SPANL	*Sphaeralcea angustifolia*	copper globemallow	F
SPCO4	*Sporobolus contractus*	spike dropseed	G
SPCR	*Sporobolus cryptandrus*	sand dropseed	G
SPFL2	*Sporobolus flexuosus*	mesa dropseed	G
SPGI	*Sporobolus giganteus*	giant dropseed	G
SPHAE	*Sphaeralcea* sp.	globemallow	F
SPORO	*Sporobolus* sp.	dropseed	G
SYFAC	*Symphyotrichum falcatum* var. *commutatum*	white prairie aster	F
SYMPH4	*Symphoricarpos* sp.	snowberry	S
TARA	*Tamarix ramosissima*	saltcedar	T
ULPU	*Ulmus pumila*	Siberian elm	T

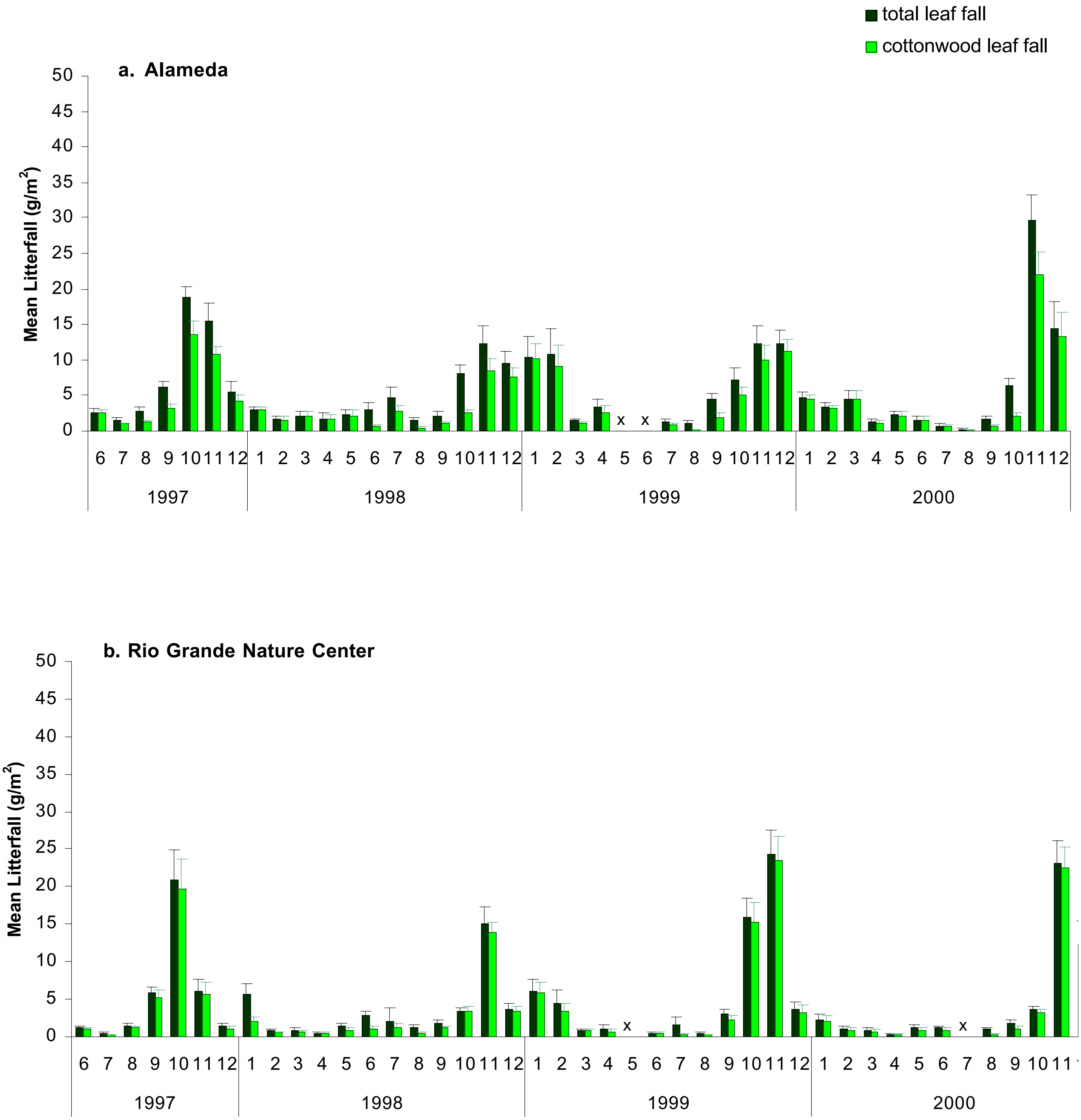


Figure 12. Mean monthly total leaf fall and mean cottonwood leaf fall per site. Values are the means for 10 litter tubs at each site with standard error bars; x denotes missing data.
a. Alameda (6/1997 — 12/2000) b. Rio Grande Nature Center (6/1997 — 12/2000)

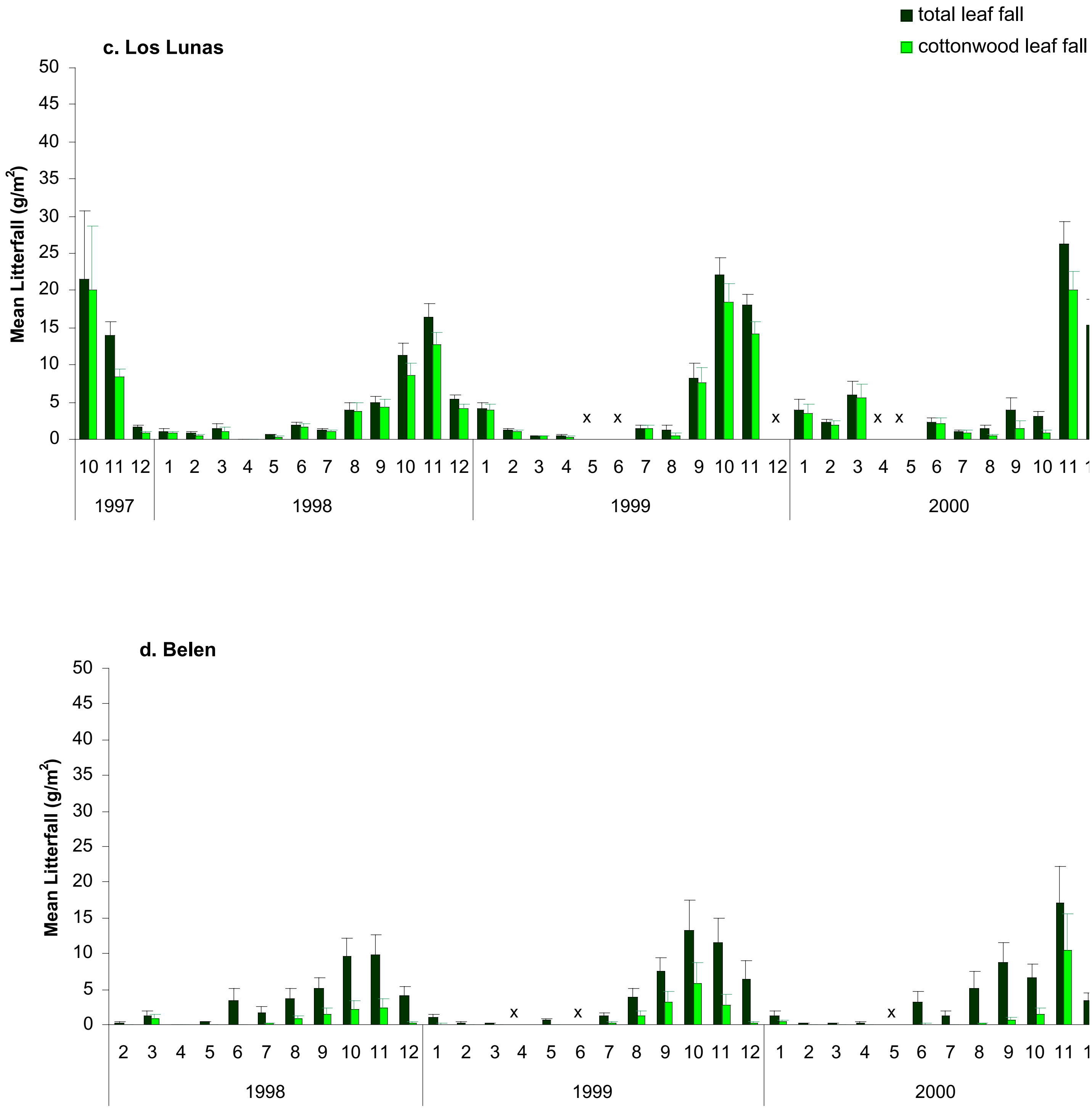
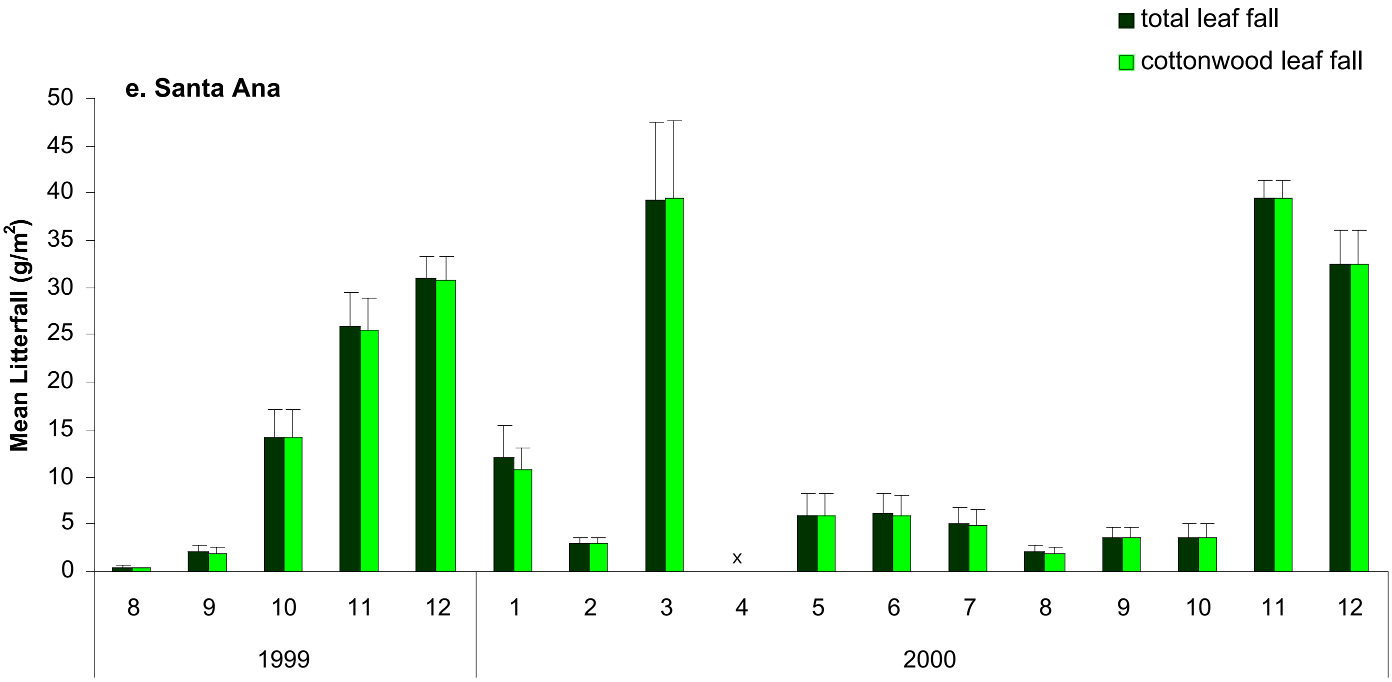


Figure12 (continued). c. Los Lunas (10/1997 — 12/2000) d. Belen (2/1998 — 12/2000)



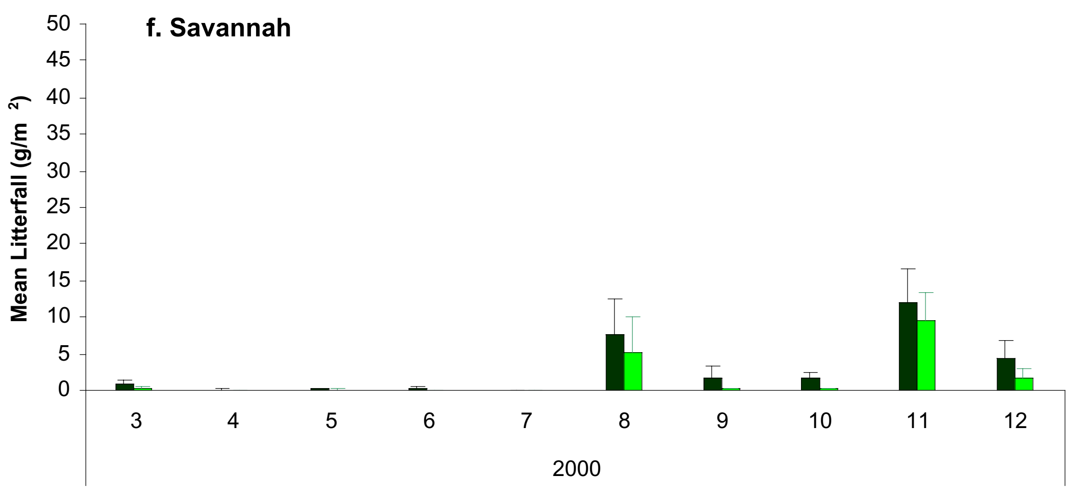


Figure 12 (continued). e. Santa Ana (8/1999 — 12/2000) f. Savannah (3/2000 — 12/2000)

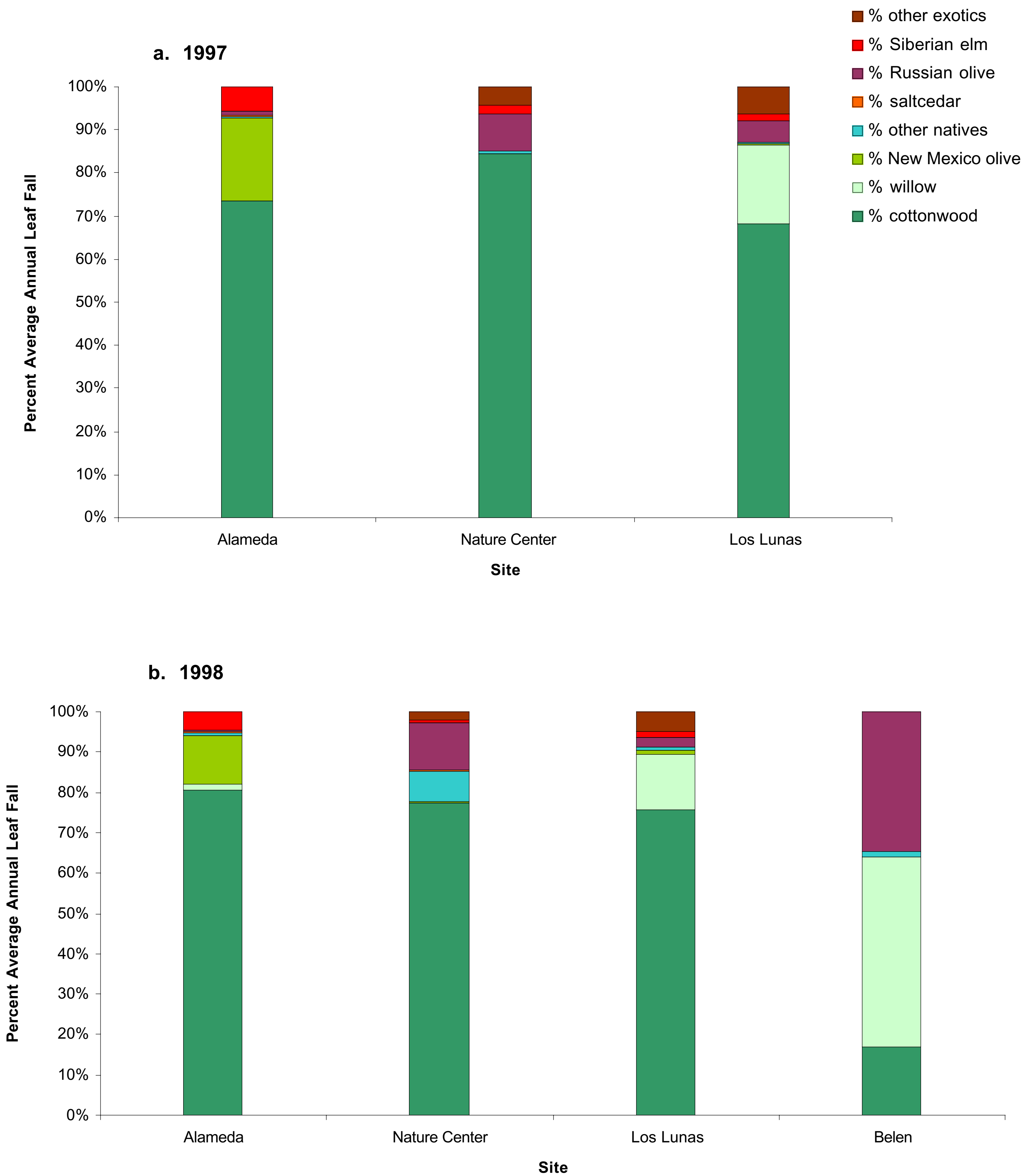
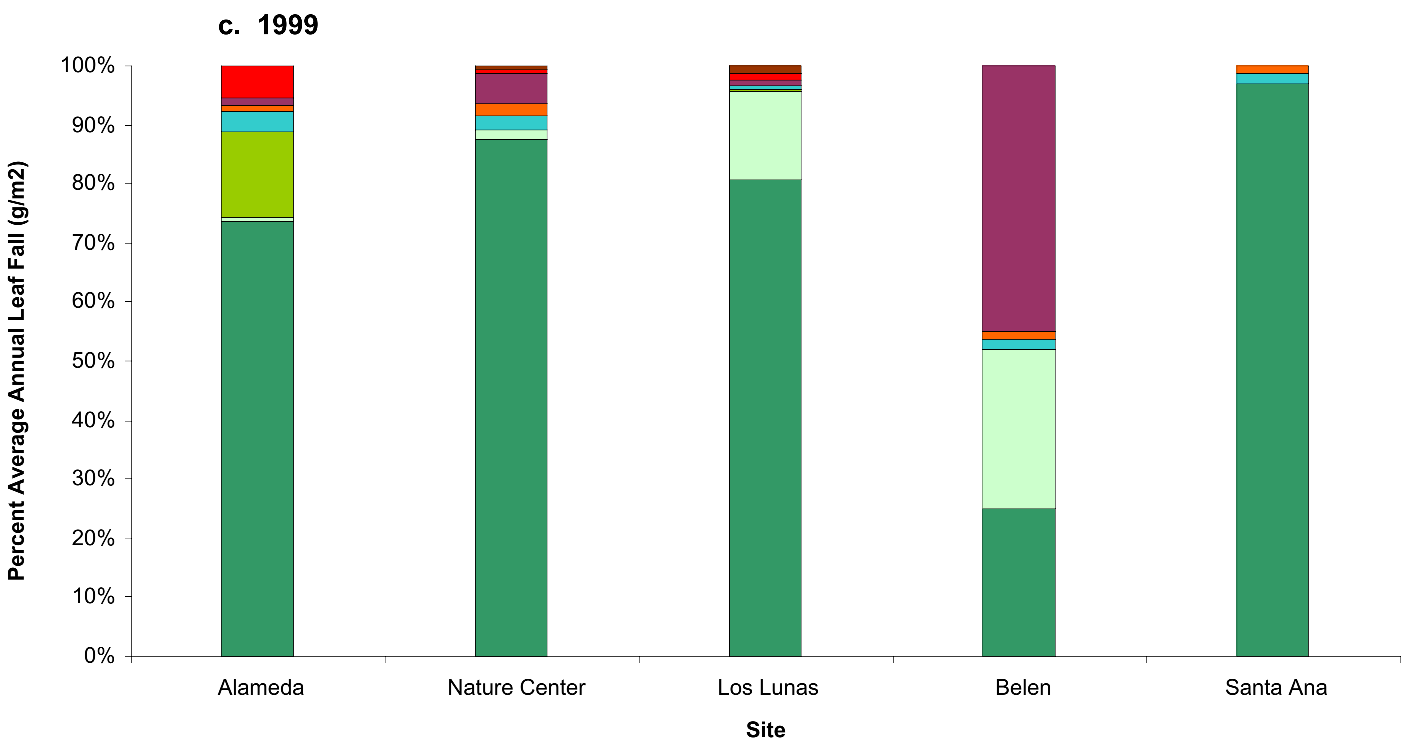


Figure 13. Average percent of native and exotic leaf fall at each site. Native species shown are cottonwood, willows, New Mexico olive and all other native plants. Exotic species shown are saltcedar, Russian olive, Siberian elm and all other exotic plants. a. 1997 b. 1998



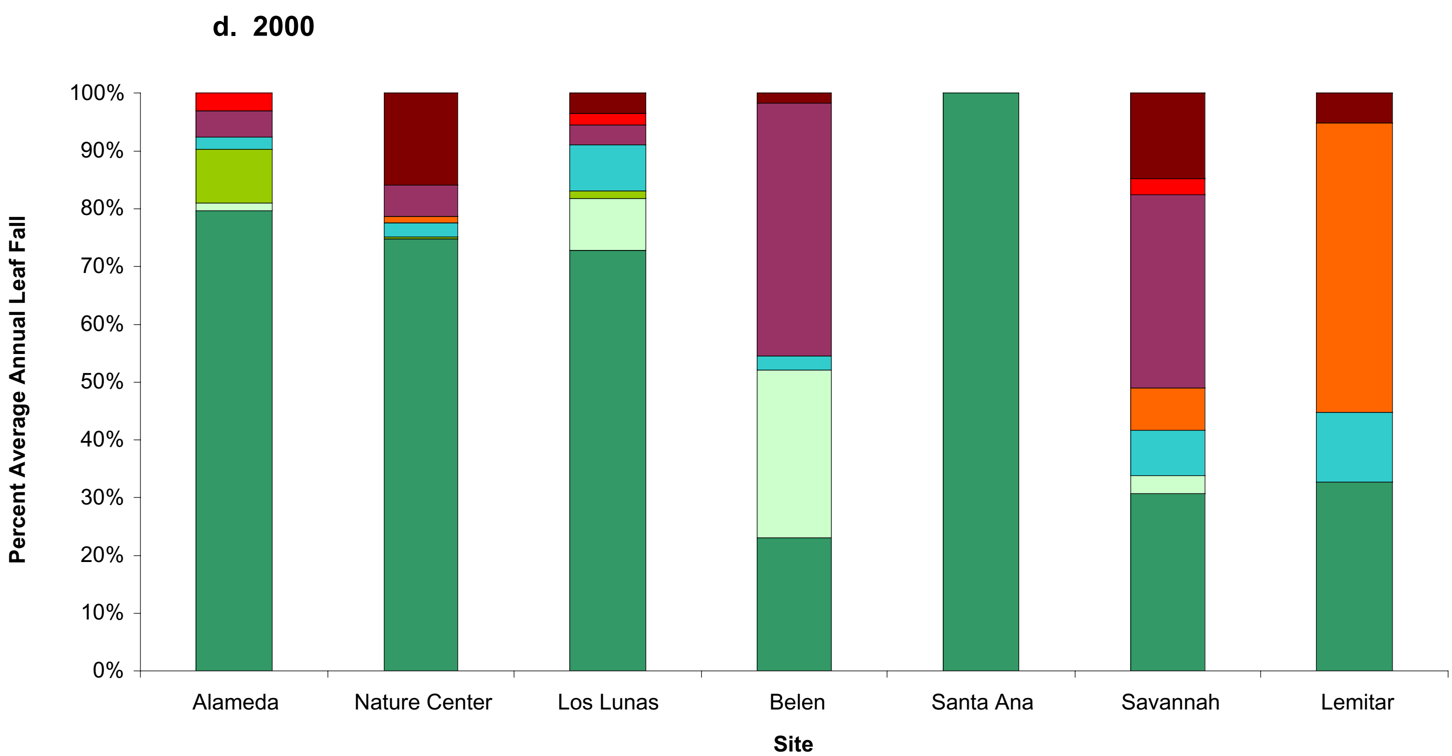


Figure 13 (continued). (Legend on 12 a.) c. 1999 d. 2000

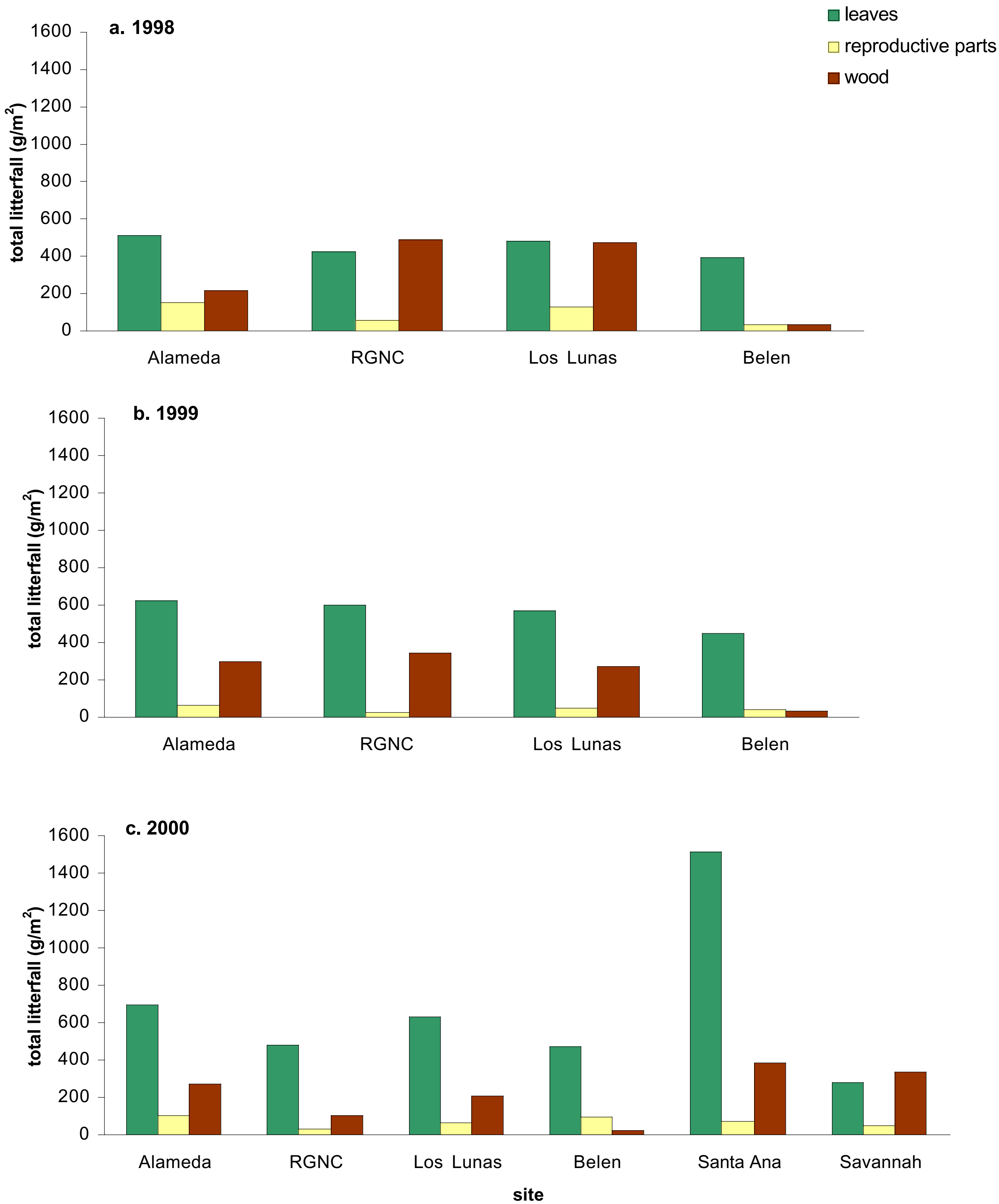


Figure 14. Total annual litterfall (g/m^2) divided into leaf biomass, reproductive biomass, and woody biomass for each site. Sites with more than 3 months missing data in a given year are not included in that year. a. 1998 b. 1999 c. 2000

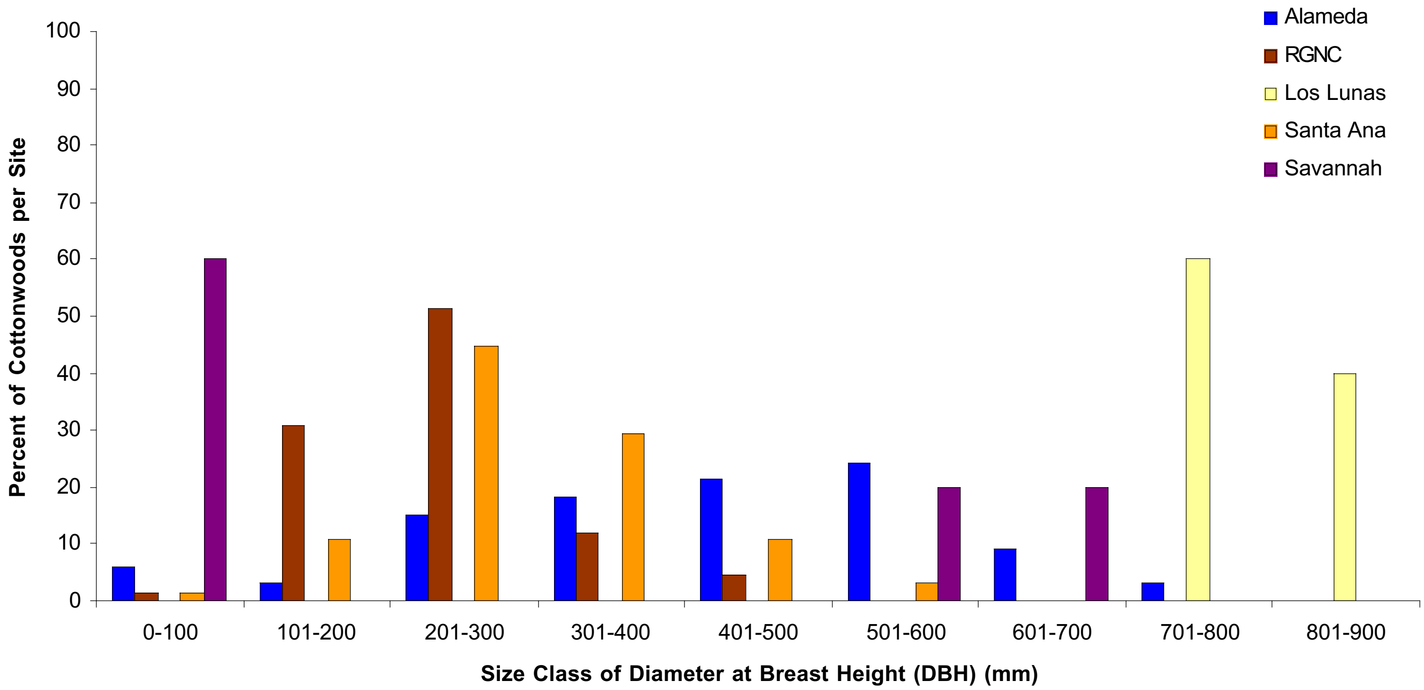


Figure 15. 2001 cottonwood size frequency distribution at Alameda, Nature Center, Los Lunas, Santa Ana, and Savannah. X-axis represents the percentage of cottonwoods at each site that fall into each size class of trees shown on the y-axis.

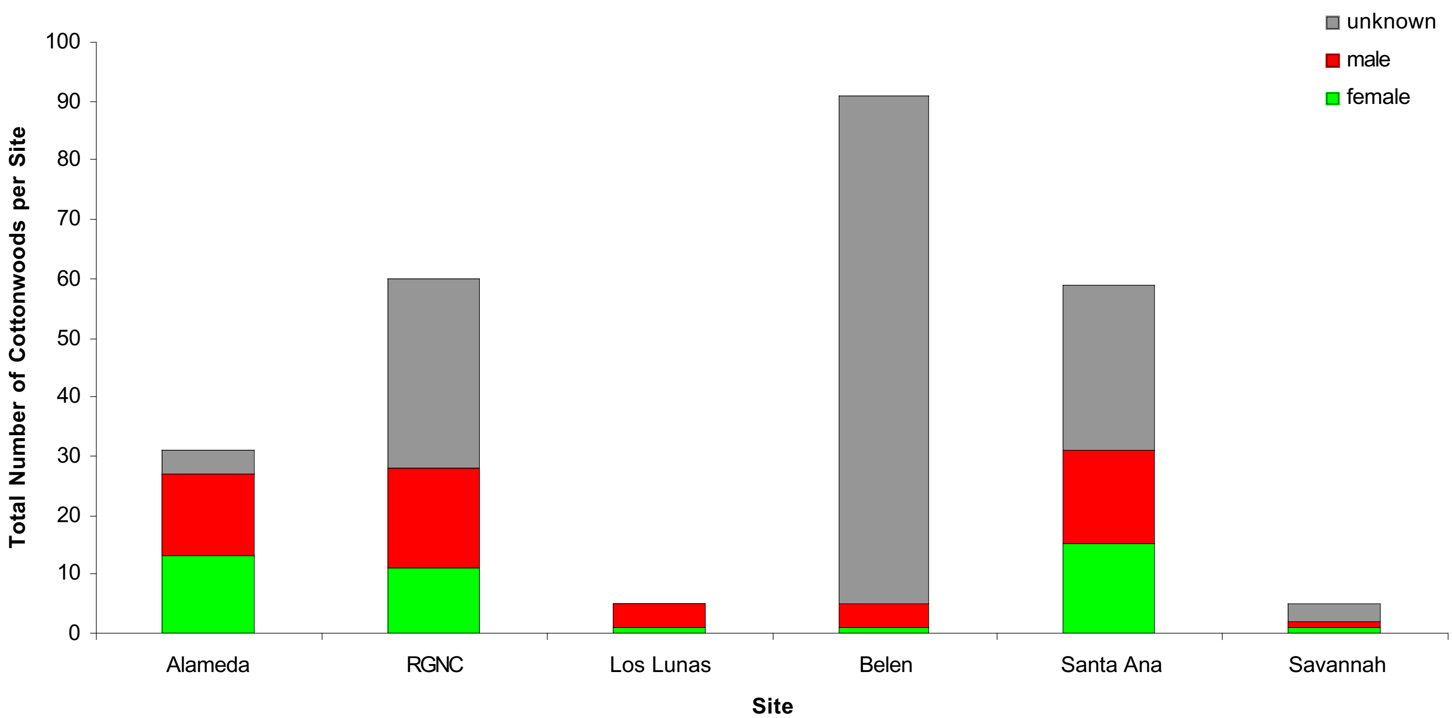


Figure 16. Frequency of cottonwood sex at Alameda, Nature Center, Los Lunas, Belen, Santa Ana, and Savannah. Cottonwoods of undetermined sex (grey) represent possibly male, female, or immature trees. X-axis represents total number of cottonwoods per site.

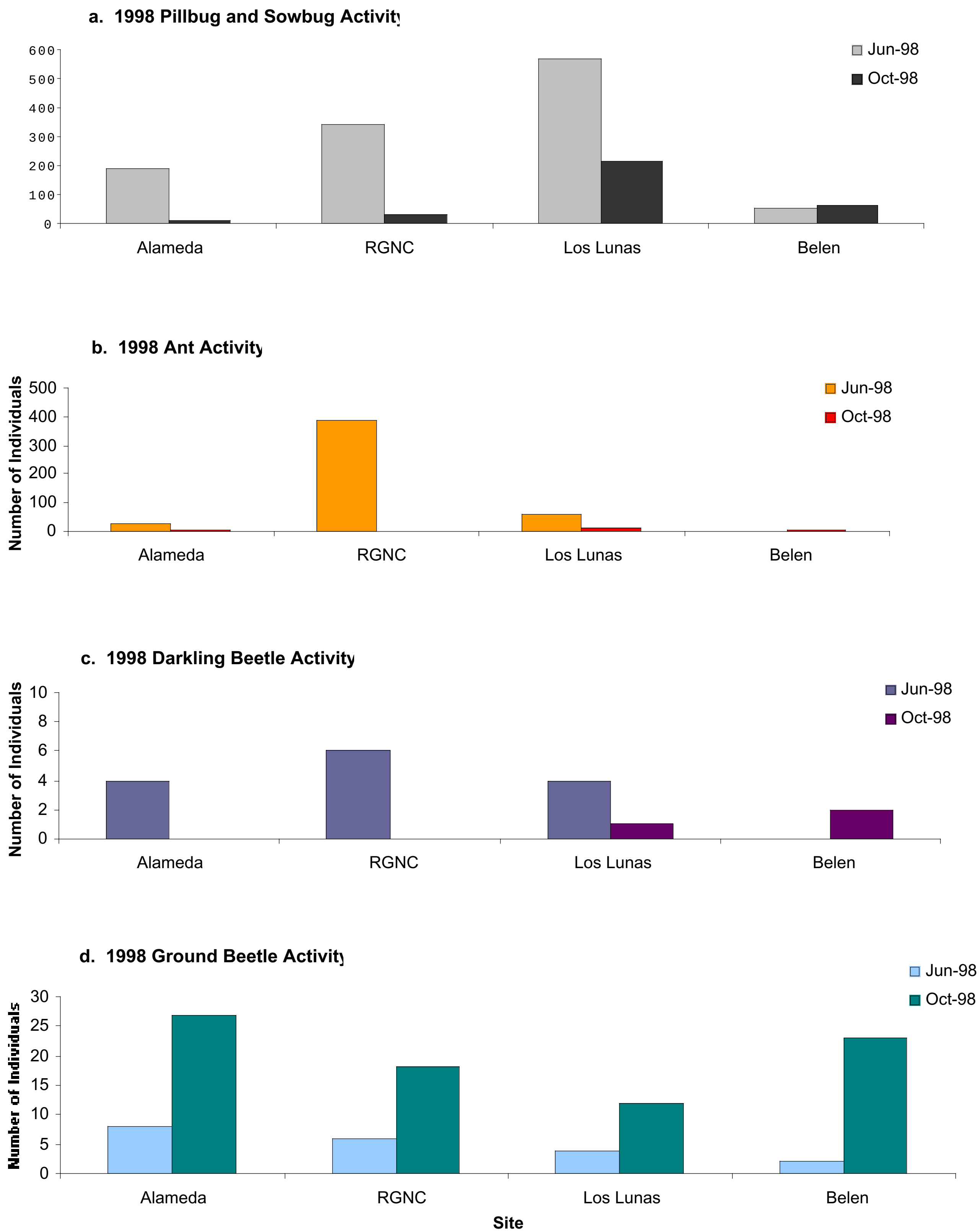


Figure 17. 1998 June and October surface-arthropod activity as determined by pitfall sampling at Alameda, Nature Center, Los Lunas, and Belen. X-axis is total number of individuals per site, with different scales on each graph. a. Isopoda (pillbug & sowbug) activity b. Formicidae (ant) activity c. Tenebrionidae (darkling beetle) activity d. Carabidae (ground beetle) activity

Table 2. Maximum and minimum 48-hr air (at 2 m) and soil (at —2 cm) temperatures corresponding to June and October 1998 pitfall collection dates. * denotes temperature data from a 32-hr period.

Site	Dates	Data logger position	Maximum temperature (°C)	Minimum temperature (°C)
Alameda	6/23/98 — 6/25/98	Air	35.2	12.9
		Surface under canopy	20.8	17.1
		Surface under open	44.8	17.8
	10/6/98 — 10/8/98	Air	22.8	3.3
		Surface under canopy	17.1	12.9
		Surface under open	28.7	7.0
Nature Center	6/23/98 — 6/25/98	Air	35.2	10.9
		Surface under canopy *	27.1	17.8
		Surface under open	41.0	19.8
	10/6/98 — 10/8/98	Air	23.2	0.2
		Surface under canopy	—	—
		Surface under open	15.6	4.5
Los Lunas	6/22/98 — 6/24/98	Air	—	—
		Surface under canopy	—	—
		Surface under open	40.6	16.3
	10/6/98 — 10/8/98	Air	22.4	0.2
		Surface under canopy	15.6	9.4
		Surface under open	20.5	6.6
Belen	6/23/98 — 6/25/98	Air	35.7	8.2
		Surface under canopy	35.7	11.7
		Surface under open *	33.6	20.9
	10/5/98 — 10/7/98	Air	24.8	-1.9
		Surface under canopy	—	—
		Surface under open	—	—

Interpretations

A large amount of information has been collected on the BEMP sites since 1997, though not all of it has been included in this report. In some cases, additional information does not change or add to our view of site differences or similarities. In other instances, the data are inaccurate or questionable, and so have not yet been analyzed (e.g., the temperature data loggers have had calibration and calendar problems). Data are representative of each site s general area and do not reflect any set boundary around the site. We hope to capture variation between and within sites for a useful conception of different bosque areas. *The following pages provide our early interpretations of site differences based on the data.*

Abiotic Factors

Average (Figure 2) and total (Figures 3 & 4) monthly precipitation

Variation and abundance of available water affect the abundance, survival, and levels of activity of all organisms occurring in a given area. Timing and level of precipitation are particularly important in this regard. Monitoring precipitation in the open and under the canopy at each BEMP site gives an *overall view* of surface-accessible water and its variation over time and location. Different types of soil with varying permeability and conductivity properties influence water infiltration and conductivity, while recent history of precipitation can also influence water conductivity in the soil. These potential habitat and site differences should be recognized even though they are not included in the BEMP monitoring protocol.

At the BEMP sites in 1997 and 1999, the highest amount of rainfall occurred in August, with August 1999 s rainfall being significantly higher than other months of that year. Precipitation in 1998 and 2000 was more evenly distributed throughout the months of the year, though overall levels were lower (less than 60 mm in any one month), with slight peaks in March, October, and November of 2000. The variation between years in the timing and amount of rainfall (e.g., the valleys and peaks in 1999 versus low but constant amounts of precipitation in 2000) should affect the abundance and diversity of vegetation that occurs each year. Mesic plants grow and survive best with a relatively continuous source of water. Many xeric plants are adapted to conditions of little to no rainfall with occasional high water input to the system. This should be especially important in sites with low water tables. Shifts in annual vegetation may eventually show some correlation with this aspect of the precipitation data.

Figures 3 and 4 clearly show that more precipitation reaches the ground in open areas as opposed to areas under the canopy, though the Savannah site, largely open grassland, does not always have higher levels of precipitation when compared to other sites.

Depth to ground water (Figures 5 & 6)

Monitoring groundwater levels has given us a picture of how hydrologically *connected* or *disconnected* each site is to the river, in other words, how responsive the water table is to river flow. At each site, five wells are positioned with one well relatively close to the river, three centralized parallel to the river, and one further away from the river. Monthly groundwater variation between the five wells thus reflects the extent of their underground connection, or responsiveness to river flow. Variation of groundwater depth between months also reflects connection to the river. Groundwater depth has a potentially strong effect on the vegetation at each site, depending on root depth. Low groundwater levels with little fluctuation should support established trees, but plants with shallow root systems must rely on precipitation. Sites with high water tables should support plants with deep and/or shallow roots. Relatively disconnected sites and sites with low water tables should inhibit cottonwood regeneration and possibly reestablishment techniques that do not place the roots in the water table. *High groundwater levels that respond to changes in river flow should indicate areas where cottonwood regeneration and establishment will be successful.*

Alameda, which has the lowest water table, has the highest variability between wells. Its monthly variation shows water levels ranging from 150 cm to 350 cm below ground level. This suggests that Alameda is a site still connected to the river, in that the water table responds to the changing river flows. However, the overall depth of the water table indicates that this is a perched site, well above the river and unlikely to flood except in years of extremely high discharge. Thus, Alameda is unlikely to support natural germination and establishment of cottonwoods.

Belen is similar to Alameda in its responsiveness to river flow, as indicated by the high variation between wells and months. Belen has been known to flood in years of high flow, and the high water table (highest of all our sites) indicates a site still well connected to the river. Belen may easily flood in years of large river flows and appears to be the site most suited to cottonwood restoration.

Rio Grande Nature Center, Savannah, and Lemitar all appear to be sites that are relatively disconnected or less responsive to river flow. The relatively small variation between the five wells at each of these sites, represented by the error bars, suggests a uniform water table depth within the three sites. Little to no monthly variation also suggests that the water table at these sites does not reflect or respond to the high and low river flows.

Los Lunas has more variation between wells and months than the comparatively disconnected sites, but does not appear as responsive to river flow as Alameda and Belen. Some of this may be due to differences in soil texture and conductivity. Its water table is relatively high, making this site accessible to many different types of vegetation. In years of high flow, the site is known to flood, but that has not yet been reflected in our data. Although wells have been monitored in Los Lunas since 1997, well casing heights were unfortunately not recorded before 1999.

Temperature (Figures 7 & 8)

Variations in temperature affect biological activity, and are an important consideration when analyzing surface arthropod activity levels (or captures). We monitor temperatures 2 m above ground under the canopy and 2 cm below ground under the canopy and in the open. Readings are taken every hour daily. This helps us to understand the difference between air temperature, which people readily recognize, and ground temperature, which has more impact on low growing plants and ground-active animals. Single dates in late spring and late fall were arbitrarily chosen to represent typical temperature patterns for those seasons.

Figure 7 compares the air and soil temperature variations between five sites on a winter day. Figure 8 demonstrates the relative variation of air and soil temperatures on a summer and a winter day at the Rio Grande Nature Center. While the air temperature has much larger fluctuations, it is the ground temperature (both in the open and underneath the canopy) that most directly influences animal activity on the surface (e.g., pitfall captures). Both figures show that ground temperatures under the canopy are the most consistent of the three recorded temperatures, evidence that tree canopies provide a buffer against temperature extremes. Ground temperatures in the open follow air temperatures more closely, and should be more affected by cloud cover than temperatures under the canopy. Summer ground temperatures in the open can be much more extreme than air temperatures. This suggests that organisms in the open must be more adapted to temperature extremes, and sites with large percentages of canopy may be preferable to ground organisms, though plants that are not shade-tolerant prefer open areas.

Biotic Factors

Plant diversity (Figures 9, 10 & 11; Table 1)

Plant cover at each site is divided into different classes of vegetation: grasses, sedges, forbs, shrubs and trees. Grasses (Poaceae) are a large family of herbaceous plants that grow in a wide variety of environments. Sedges, related to grasses but in their own family (Cyperaceae), grow in moist, wetland-type areas. Forbs are non-woody flowering plants of many different families (e.g., asters, clover, tumbleweed). Shrubs are often classified as multi-stemmed, woody plants shorter than 4 meters aboveground. Trees usually have one or two main trunks and grow higher than 4 meters. Some woody plants are difficult to classify; Table 1 lists the life forms we have used in our report. Of all the trees, cottonwoods are the most difficult and least accurate to quantify using a line intercept method. They are included here despite the large inherent error to provide some measure of comparison with other types of vegetation.

In this southwestern riparian system, native trees and shrubs include cottonwood, willow, and New Mexico olive. Many of native plants, including some grasses, forbs, and sedges, are dependent on annual flooding for regeneration and survival. Exotic species, such as saltcedar, Russian olive, Siberian elm, and Russian thistle (tumbleweed) are able to invade and out-compete native vegetation in areas that are altered or disturbed and no longer experience the annual flood-pulse.

Most sites are dominated by trees, though Lemitar has very little tree cover when compared to the other sites, and Savannah has approximately half the tree cover of most sites. Savannah s main vegetation consists of both trees and forbs: two large cottonwoods (*Populus deltoides* ssp. *wislizenii*), some Russian olives (*Elaeagnus angustifolia*), and tumbleweed (*Salsola kali*) are the main plant species. Savannah is a maintained grassland, and while it has the largest number of species present at a site (33+), exotics such as tumbleweed and summer cypress (*Kochia scoparia*) easily dominate in its disturbed soils. Alameda is dominated by trees and shrubs, with few to no forbs and grasses. This site has a very low water table (Figure 5), which means that understory plants that are unable to reach the groundwater as easily as the established woody plants are relatively more dependent on precipitation. Los Lunas and Belen, both dominated by trees, also have large amounts of sedges and forbs, and Belen has a significant amount of grass cover. This is likely indicative of the high water table (readily available water source) and the tendency of these two sites to flood in years of high river flow. The sedges in particular indicate moisture-rich sites. The Los Lunas forb cover is mainly yerba mansa (*Anemopsis californica*), which is often indicative of high water table or seeps in the ground that contributes to soil moisture (Figure 11). Santa Ana, which has been cleared of exotic species, is dominated by cottonwoods, with very little other vegetation present.

All sites have cottonwoods, and all but Lemitar have Russian olives. Cottonwoods, New Mexico olives (*Forestiera pubescens* var. *pubescens*, previously *F. neomexicana*) and Siberian elms (*Ulmus pumila*) provide most of the cover at Alameda. The Nature Center is dominated by cottonwoods, Russian olives, squirrel tail grass (*Elymus elymoides*), snakeweed (*Gutierrezia sarothrae*), and white sweet clover (*Melilotus officinalis*). Los Lunas and Belen, in addition to cottonwoods and sedges (yerba mansa in Los Lunas and grasses in Belen), have a considerable amount of cover provided by willows (*Salix* spp.). Belen also has several groves of Russian olive.

Litterfall (Figures 12, 13, & 14)

Litterfall represents all leaves, reproductive parts and wood that fall to the ground. Although some herbaceous plants may be represented in these data, the majority of litterfall is from trees and shrubs ($\geq$ 85%). Leaf litter and reproductive parts (flowers and seeds) provide an overall indication of net primary production and reproductive effort, respectively, of the trees. Woody debris falling to the forest floor often indicates plant die-back or loss of twigs and branches due to storms.

Figure 12 gives us an idea of when the predominant leaf fall occurs, in autumn, and when leaf fall levels are low, in spring and summer. Winter represents the time of year when remaining leaves drop or are taken off by winds and storms. Years with relatively more leaf fall in the spring and summer months have lower leaf fall peaks in the fall. Years with low levels of leaf fall in the spring and summer have higher levels of leaf fall during autumn months. Figure 12 also demonstrates how much of the total leaf fall at each site is comprised of cottonwood leaves. Lemitar had insufficient data for inclusion.

As seen in the vegetation cover and tree cover data (see Figures 9 & 10), Alameda, Nature Center, Los Lunas, and Santa Ana are dominated by cottonwoods, determined here by the percentage of cottonwood leaves in the total annual leaf fall (Figure 12). New Mexico olive represents 10 % of the leaf fall in Alameda and willow represents 9 % in Los Lunas. Belen has more willow leaf fall, 29% (and more willow cover, Figure 10) than cottonwood; Russian olive contributes the largest percentage to Belen leaf fall, at 44%. Savannah and Lemitar both have higher percentages of exotic leaf fall than native leaf fall (also supported by Figure 10). Much of Savannah s 15% other exotics may be herbaceous plants, but 33% of the leaf fall is from Russian olive and 7% is from salt cedar. Fifty percent of the leaf fall in Lemitar is salt cedar leaves.

Alameda, Nature Center, and Los Lunas have similar levels of all types of litterfall (Figure 14b, 14c). This seems to indicate similar stages of bosque development among these sites. Belen has far more leaf production than woody debris levels, and low levels of reproductive effort that start increasing in the year 2000. This describes a young site with rapid growth until trees are established enough to reproduce, and with little die-back (indicated by loss of branches).

The Nature Center is one of two sites that have higher levels of woody biomass falling than leaf biomass for at least one year (Figure 14a). Levels of wood and leaf fall in Los Lunas 1998 are very similar. High levels of woody litterfall with reduced leaf production levels may indicate sections of forest in decline. Wood is not separated into different species in this study, but as cottonwoods are prone to drop branches and bark, we speculate that much of the woody debris is from cottonwoods. By 1999, both the Nature Center and Los Lunas had higher levels of leaf production than loss of woody material. Data from cottonwood monitoring will eventually indicate whether or not the large amounts of woody litterfall indicate an actual decline of cottonwoods.

Santa Ana has significantly more leaf fall than all other sites (Figure 14c), yet its woody litterfall is actually similar to other sites. In this case, the high levels of leaf fall are 99.8% cottonwood leaves (see Figure 13). It may be that after the recent manual clearing at this site, the lack of an understory (see Figure 9) allows more leaves to be caught by the litter tubs. Perhaps this is an artifact of the recent management efforts and leaf production levels are not twice as high at Santa Ana.

Savannah in 2000, like the Nature Center in 1998, had higher levels of woody litterfall than leaf fall (Figure 14c). Like Santa Ana, Savannah is a managed site, though in this case there are fewer trees to contribute to litterfall. The low levels of leaf fall are indicative of grassland, and the high levels of woody debris may be from the few surrounding cottonwoods or from nearby Russian olive stands. In this case, a lack of a shrub understory may lead to higher amounts of woody debris falling in the litter tubs.

Cottonwood monitoring (Figures 15 & 16)

Although the correlation between cottonwood tree diameter and cottonwood tree age varies with species and area, it is strong enough for us to use DBH (diameter at breast height) as an indicator of age and growth (Stromberg and Patten 1992, Poff et al. 1997). Cottonwood sex ratios may indicate past or present levels of environmental stress, as female trees are often associated with higher physiological costs than males, and areas of the ecosystem with reduced stress (Rowland 1998). Cottonwoods that do not produce flowers and are not sexually immature may indicate present environmental stress (Rowland 1998).

The Nature Center and Santa Ana have similar, normal curves for cottonwood size distribution, with a greater number of larger trees at Santa Ana and thinner trees at the Nature Center. Alameda has an almost equal distribution of size classes, though most of its cottonwoods are large trees and few trees are thin. Savannah has a few small, young trees and a couple of large, mature trees. This seems to indicate that Alameda is an old, established site and Savannah could be considered a newer section of cottonwood-dominated bosque. Note that Figure 15 is expressed as percentages; look at Figure 16 for actual numbers of cottonwoods on the vegetation plots within a site.

Most sites have more male than female cottonwood trees, though cottonwoods of undetermined sex may shift the true ratios in either direction. Although Los Lunas and Belen are similar in vegetation, the two sites are very different in age. At Belen, the 86 unsexed cottonwoods are young trees that have not yet matured. Four of the five reproductive cottonwoods on the Los Lunas site are old, mature males, the fifth is a female. The large number of unknowns at the Nature Center and Santa Ana may be trees that flowered before or after monitoring , and so were missed, or they could be trees that are under some environmental stress and have not flowered for one to several years.

Surface-active arthropod activity in 1998 (Figure 17; Table 2)

Surface-arthropod activity provides information on habitat conditions and changes. Due to currently incomplete processing of pitfall captures, few comparisons can presently be made between sites. There were no correlations with temperature (over the 48-hour period traps are open; Table 2) or precipitation (during that month). Precipitation over the 48-hour period is now being recorded for future analyses.

Pillbug and sowbug (Isopoda) activity was highest in June at all sites, when reproduction is high. Ants (Formicidae) can indicate dry environments or moist, canopied environments, depending on the species present. The large number of ants caught in the Nature Center were mostly *Monomorium* and *Pogonomyrmex* species that are fairly indicative of dry environments. Darkling beetles (Tenebrionidae) typically indicate drier environments, though our capture numbers are too low to indicate much at this point. Ground beetle (Carabidae) activity is a good indicator of moist environments. The highest activity levels for ground beetles were in the fall at each site, though whether this is due to capture date weather conditions or not will be determined in future analyses.

Executive Summary

The Bosque Ecosystem Monitoring Program (BEMP) is long-term ecological research that utilizes volunteers (mainly teachers and their students) to monitor key indicators of structural and functional change in the Middle Rio Grande riparian forest, or bosque , over time. Involving students in the collection of data and lab processing helps to increase their understanding and concern about the riparian ecosystem. At the same time, the abiotic (e.g., groundwater level, precipitation, air and soil temperatures) and biotic (e.g., cottonwood productivity, surface-active arthropod activity, vegetation cover) data gives us insight into the status or health of various sites. Site representatives, UNM interns, and contracted experts provide quality control on the data. Any questionable data were not included in this report. Our high level of confidence in the presented data allows us to make certain statements about BEMP sites. Land and resource managers or researchers attempting to restore or manage cottonwood-dominated sites along the Rio Grande should use this information to locate suitable areas and determine strategies to further increase their chances of success. Scientific and student presentations, displays, and reports make this information available to the public and increase public awareness of the ecological state of one of New Mexico s richest ecosystems.

Funding from various sources, including U.S. Fish and Wildlife Service, National Science Foundation, Bosque School, and Sevilleta Long-Term Ecological Research Schoolyard Education Program, is jointly coordinated by University of New Mexico s Biology Department and Bosque School to allow development of new sites and continue year-round monitoring of established sites. Our current seven sites (north to south: Santa Ana Pueblo, Alameda, Bosque School/Savannah, Rio Grande Nature Center, Los Lunas, Belen, and Lemitar) span approximately 130 km of the Rio Grande and cover public, private, and tribal lands. Sites are monitored by public, private, and home school students ranging from kindergarten through high school. Summertime monitoring provides an opportunity for other groups to monitor, including summer camp groups.

BEMP vegetation and litterfall data show that Alameda, the Nature Center, and Los Lunas are all senescing cottonwood-dominated sites. Restoring cottonwoods once canopy openings are available will be easiest at Los Lunas where the potential for overbank flooding and connection to the river will naturally promote cottonwood seedling germination and establishment. Although Alameda is dominated by native cottonwoods and New Mexico olive, and its water table is well connected to river flow, the site is perched, and low water table depths are not likely to support cottonwood seedling establishment. The Nature Center, like Lemitar and Savannah, is hydrologically disconnected from the Rio Grande. Water table depths differ at these three sites, but the lack of spatial and temporal variation in the water table indicates efforts to establish new cottonwoods by seed or pole planting will likely fail without periodic overbank flooding or artificial watering. Savannah and Lemitar, our newest sites, are both dominated by exotic plant species.

Data from Santa Ana suggest that this, too, is a senescing cottonwood-dominated site. However, active efforts at restoring native vegetation and eliminating exotics have been undertaken. Continued monitoring of this site will give managers insight into the effectiveness of different techniques.

Long-term monitoring is especially important for sites like Belen, where the dominant vegetation is undergoing rapid change. Vegetation and litterfall data suggest that Belen is a young, growing cottonwood site, still dominated by willows and Russian olive. Data show strong response to fluvial change and there are large variations in water table depth within the site. This site also floods in years of high river flow, and is an excellent area for aiding naturally occurring cottonwood restoration.

BEMP data provides information about the overall age and health of cottonwood-dominated sites, change in the amount of exotic or native vegetation, accessibility of groundwater, ground moisture levels, and the potential for restoration of native cottonwoods and willows, which are under threat by exotics species and fire. Long-term data can indicate where restoration efforts are most likely to be successful, what efforts are needed to make restoration successful, and where naturally occurring restoration can be aided. Where restoration or management efforts are in place, monitoring will help us evaluate their success and effectiveness.

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Other BEMP sites are on land belonging to and/or controlled by the Middle Rio Grande Conservancy District (MRGCD), the State of New Mexico, the City of Albuquerque, Pueblo of Santa Ana, and the U.S. Bureau of Land Management (BLM). We thank them all for permitting us to use their properties. In particular we appreciate the Board of Directors, Subhas K. Shah, Richard Jaramillo, Sterling Grogan, and the staff of the MRGCD for their cooperative approach to BEMP s use of their bosque lands. Special thanks also go to Ondrea Linderoth-Hummel of Albuquerque Open Space for being so helpful in approving the locations of BEMP sites in the Rio Grande Nature Center State Park (RGNCSP).

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The location of the Los Lunas BEMP site in 1997 was facilitated by Richard Jaramillo (MRGCD) and Los Lunas Schools. Debbie Loftin, then a Los Lunas High School teacher, assisted in setting up the site, as did Troy Maddox, then a botanist with the Sevilleta LTER.

The Belen BEMP site, begun in 1997, is now part of the Willie Chavez Education Center (formerly a New Mexico state park). The site owes its existence to the MRGCD (through Richard Jaramillo) and the Belen Schools Administration (through Marie Garcia-Schaffner, Christina Wright, and Michael Grossman), and to Rio Grande Elementary School teacher Molly Madden and park caretaker Ron Goodwin.

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BEMP site representatives, their schools or agencies, and their BEMP sites during periods between 1997 and 2001 are listed alphabetically as follows:

Kim Atchison	Albuquerque Home Schools, Nature Center site
Cathy Bailey	Bosque School, Alameda and Savannah sites
Lisa Durkin	Los Lunas High School, Los Lunas site
Pauline Clements	Albuquerque Home Schools, Nature Center site
Lee Crowder	Albuquerque Home Schools, Nature Center site
Brian Crawford	Sarracino Middle School, Lemitar site
Kim Lester	Albuquerque Country Day School, Nature Center site
Debbie Loftin	Los Lunas High School, Los Lunas site
Molly Madden	Rio Grande Elementary School, Belen site
Laura Pe a	Santa Ana Pueblo, Santa Ana site
Roger Reese	Century High School, Los Lunas site
Janet Tabet	Special Assistant, Belen site
Janet Tooker	Special Assistant, Los Lunas site
Rob Yaksich	Special Assistant, Nature Center site