RECLAMATION

Managing Water in the West

A Long-Term Assessment of Livestock Impacts on Riparian Vegetation

Elephant Butte Project Lands

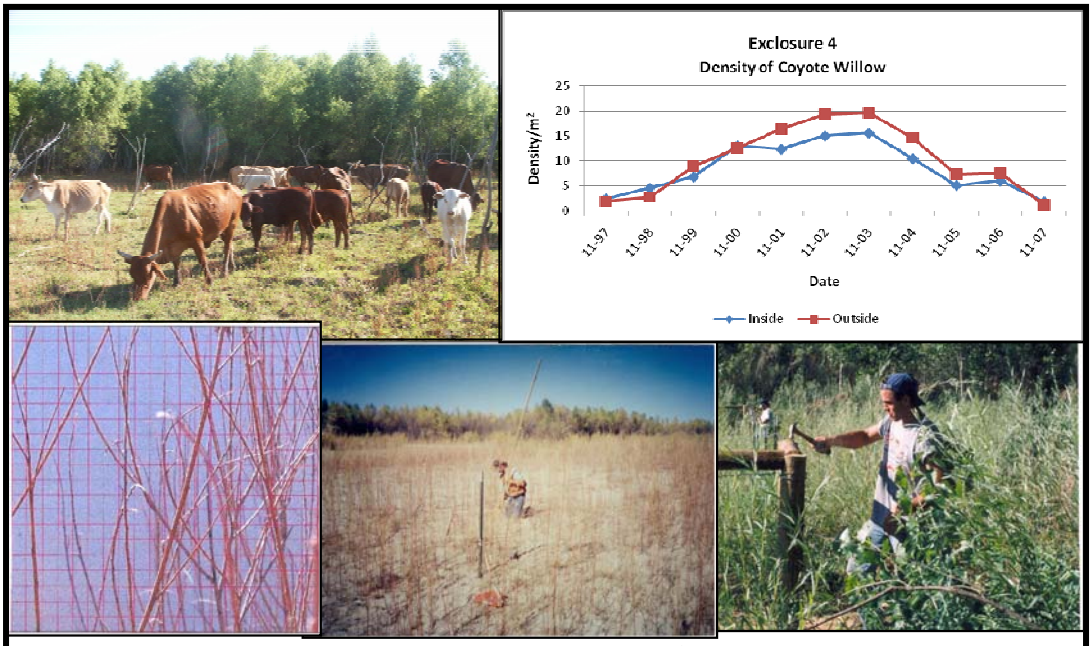

Table 6. Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 4. Alpha = 0.05

	11/97	11/98	11/99	11/00	11/01	11/02	11/03	11/04	11/05	11/06	11/07
Frequency	70%	38%	7%	9%	21%	4%	12%	0%	10%	0%	0%
Height	In>Out[1] P=0.038	In=Out[1] P=0.138	In=Out[2] P=0.140	In=Out[2] P=0.223	In=Out[1] P=0.208	In=Out[1] P=0.126	In=Out[2] P=0.208	In=Out[2] P=0.588	In>Out[1] P=0.035	In=Out[1] P=0.120	In=Out[1] P=0.405
Density	In=Out[1] P=0.681	In=Out[1] P=0.119	In=Out[1] P=0.367	In=Out[1] P=0.867	In=Out[1] P=0.107	In=Out[1] P=0.109	In=Out[1] P=0.158	In=Out[1] P=0.096	In=Out[1] P=0.124	In=Out[2] P=0.515	In=Out[2] P=0.425

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Environmental Services Division
Fisheries and Wildlife Resources Group
Denver, Colorado

March 2009

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

A Long-Term Assessment of Livestock Impacts on Riparian Vegetation

Elephant Butte Project Lands

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SUMMARY

In 1997, the Bureau of Reclamation (Reclamation) initiated a livestock grazing study within the San Marcial reach of the Middle Rio Grande, New Mexico. The study was designed to determine whether livestock browsing was having a significant adverse effect on developing native vegetation which could mature into suitable habitat for the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) (flycatcher).

The study involved the construction of seven livestock exclosures within three grazing allotments surrounding the upper reaches of Elephant Butte Reservoir. Data were collected within and/or outside of the respective exclosures three times annually and additionally when circumstances warranted from November 1997 through April 2008. Concurrent with exclosure data collection, aerial livestock counts were conducted to determine the distribution and abundance of livestock within the study area. Thirty-four photo stations were also established, and photographs were taken annually from 1997 to 2007 to visually document changes in the vegetative community and any livestock impacts. In addition, fecal samples from grazing livestock were collected monthly from November 1999 through February 2001 to determine seasonal use of the available herbaceous and woody forage. In January 2004 an assessment of lateral browsing impacts was also incorporated into the study and carried out through January 2008.

Prior to 1997, livestock grazing within the three allotments was permitted on a year-round basis. In 1997 a seasonal grazing schedule was instituted in an effort to avoid potential impacts to the flycatcher. Livestock grazing was permitted from August 1, 1997, to April 15, 1998, and from August 1, 1998, to April 15, 1999. To prevent a possible "take" to flycatchers, livestock grazing was not reinstated until October 15, 1999, and extended until April 15, 2000. The extended exclusion period also allowed for an initial assessment of the concerns associated with: (1) brown-headed cowbird (*Molothrus ater*) (cowbird) brood parasitism on flycatcher nests. The presence of cattle is believed to be a contributing factor in the abundance of cowbirds, and cowbird parasitism has been identified as one of the primary threats to the flycatcher (Sogge et al. 1997); (2) potential physical destruction or disturbance to the nest tree supporting the flycatcher nest; and (3) potential long-term effects on developing native vegetation which could mature into suitable flycatcher habitat. Seasonal livestock grazing was reinstated in 2000 through a coordinated effort with the Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS), New Mexico Grazing Task Force, Reclamation, and the grazing lessees. Livestock grazing is permitted on a seasonal basis from August 1 to May 6, excluding the primary breeding season of the flycatcher as defined in the 60 FR 10694 and determined by site-specific data (Ahlers, unpublished data, 2000). Conditions of seasonal livestock grazing included the continuation of the ongoing livestock grazing study and an associated cowbird monitoring study.

A livestock browsing frequency threshold was also established in 2000. It was agreed by the entities listed above that livestock grazing could be permitted on a seasonal basis

provided that no more than 35 percent of the native cottonwood and willows were browsed to some degree. The 35 percent frequency of browse threshold allowed livestock to consume a portion of the native vegetation, but not to a degree which significantly reduced the height, density, or vigor of the overall community. Therefore, it was assumed that flycatcher habitat could develop in the presence of livestock grazing as long as the threshold was not exceeded.

Since this threshold of 35 percent was established in 2000, it was exceeded during three of the collection periods (June 2001, April 2003, and April 2004) and included seven incidences at various monitoring sites. The first occasion was in June 2001, which fell during the livestock exclusion period. A gate upstream from Exclosure 2 was left open and approximately 150 trespass cattle entered the allotment. The resulting 39 percent frequency of browse exceeded the threshold. The other two occasions when the threshold was exceeded were during the permitted grazing period of August 1 to May 6. Six incidences occurred during the January to April periods of 2003 and 2004 at Exclosures 4, 5, and 6. During the April 2003 collection period, browsing frequencies of 43 percent, 40 percent, and 41 percent were recorded at Exclosures 4, 5, and 6, respectively. During the April 2004 collection period, browsing frequencies of 70 percent, 79 percent, and 62 percent were recorded at Exclosures 4, 5, and 6, respectively.

In response to the June 2001 trespass event, steel gates were installed and locked to avoid any reoccurrence due to gates being left open. Results indicated that there were long-term effects to vegetation from grazing at this exclosure site. In April 2003 and 2004, thresholds were exceeded at three of the exclosures. Excessive browsing occurred late in the January to April grazing period (i.e., January 2003 browsing frequencies at the three exclosures were 6 percent at Exclosure 4, 10 percent at Exclosure 5, and 6 percent at Exclosure 6; January 2004 browsing frequencies were 17 percent at Exclosure 4, 11 percent at Exclosure 5, and 19 percent at Exclosure 6). It was apparent that the lessees were actively removing livestock from the allotments during both 2003 and 2004: aerial flight in April 2003 recorded 88 head, while in January 2003, 356 head were observed; an April 2004 aerial flight recorded 71 head, while in January 2004, 239 head were observed. No further actions were deemed necessary for the remainder of the respective grazing periods. However, additional data were collected prior to livestock being returned in August of the same year. These data indicated that the vegetation at the three affected exclosures had recovered (determined by statistical analysis comparing vegetation height inside and outside of the exclosures). If the vegetation had failed to recover, livestock management options would have been implemented during the respective August to May grazing season. These options would have been determined through coordination with the USFWS, BLM, Reclamation, and the livestock operators.

Although trespass cattle were observed on several occasions, the total number of animal unit months (AUMs) permitted during the August 1 to May 6 period did not appear to have been exceeded. With only a few possible exceptions, no obvious livestock impacts could be visually detected from the 34 photo stations. The possible exception would be the photo stations within and outside of Exclosure 3. The lack of a noticeable difference between the remaining photo stations is likely due to the minimal effect that livestock

browsing has had on the height and density of the native community over the period of study.

Cattle feces samples were collected from three representative units from November 1999 through October 2001. Twenty to 25 random samples were collected and combined to yield one composite sample per unit area per month. Slides were prepared and examined for composite samples. The botanical composition of the cattle diet was determined from analysis of the fecal samples. Grasses were the most important component of the cattle diet (63 percent relative composition). Forbs were the next most important component (20 percent), followed by trees and shrubs (17 percent).

The lateral browsing study was initiated in 2004 and proved to be a valuable tool in assessing the potential impacts of livestock grazing on riparian vegetation. The study showed that livestock browsing of native woody stemmed vegetation was not having a significant long-term effect on lateral cover density. Results were consistent with findings associated with the livestock exclosure data. Lateral densities were not significantly reduced over time at any of the monitoring sites except Exclosure 2 from 2004 to 2007. Results at Exclosure 2 demonstrate that excessive browsing may result in a reduction of lateral density, especially when hydrologic conditions are less than favorable.

With the exception of the vegetation surrounding Exclosure 2, no obvious long-term adverse livestock impacts were documented during this 10-year study. However, it is important to consider Elephant Butte Reservoir levels over this same period. Reservoir levels began to decline in 1996 and continued to decline throughout the study period. As the reservoir levels declined, herbaceous vegetation and native seedlings became established throughout the conservation pool, providing a large area for livestock to disperse and forage, reducing the intensity of browsing and minimizing adverse impacts outside the reservoir conservation pool where the exclosures were located. If cattle had not been displaced from the study area by the receding reservoir, it is difficult to predict the possible impacts to the developing vegetation in the vicinity of the livestock exclosures.

Results of the study were also influenced by changes in hydrology that occurred in 2005, when the river experienced major degradation due to a high flow event. This event resulted in a drop in the water table that affected riparian vegetation. Stands of cottonwood and willow began dying off within the study area, which was a noticeable impact from the channel degradation and subsequently lowered water table.

INTRODUCTION

Livestock browsing of vegetation in riparian areas is an issue that resource and livestock managers across the West have struggled to address in recent history. Riparian areas include lands that are close to creeks, streams, and rivers where vegetation is strongly influenced by the presence of water (BLM 1991). Riparian areas are among the most productive lands in the Western United States. In Arizona and New Mexico, 80 percent of all vertebrate species depend on riparian areas for at least half their life cycle and more than half are totally dependant on riparian areas (BLM 1991). More than 50 percent of all avian species in the Southwestern United States are completely dependant upon riparian areas (BLM 1991), and several species are currently threatened by extinction.

Riparian areas across the West have been severely impacted by cultivation, road construction, mining, urbanization, logging, and damming of rivers. However, intense livestock browsing has created the greatest geographic impact to riparian areas (BLM 1991). The availability of forage, water, and cooler temperatures attract livestock to riparian areas and wet meadows (Ames 1977, BLM 1993), particularly after upland forage dries out and becomes less palatable. The deterioration of riparian areas began in the late 19th and early 20th centuries when large numbers of cattle were allowed to forage, unmanaged, for extended periods of time within riparian areas. Livestock typically utilize riparian areas as a source of water, particularly in the arid West. Overutilization of riparian areas by livestock has contributed to degradation of water quality by increasing sediment loads, nutrient loading, and raising stream temperatures. Livestock also use the shade provided by trees and shrubs that typically establish in the riparian areas. Overutilization of riparian areas by livestock results in trampling of young vegetation, erosion of streambanks, compaction of soils, and an overall reduction in the vigor of the riparian community. Intensive browsing of young trees and shrubs reduces the potential for plant development. However, light to moderate browsing in some riparian areas can have little adverse effect, and in some cases be beneficial by stimulating the growth of woody plants (Clary and Webster 1989). For example, a 5-year study in Montana found that grazed and ungrazed stream channels were no different, and one grazed site improved, if “improved” is defined as a narrower and deeper channel (Rhodes et al. 1995). Rhodes et al. (1995) also stated that every riparian area possesses unique characteristics and an appropriate grazing regime should consider these characteristics. The intensity and duration of livestock browsing within riparian areas will directly determine the degree of impacts expected on the native riparian community.

Resource Issues

Elephant Butte project lands, which were primarily within a riparian zone, were grazed year-round until 1997 when concerns over potential impacts to the endangered southwestern willow flycatcher (*Empidonax trailii extimus*) (flycatcher) resulted in a review of the current grazing regime. The potential impacts of livestock grazing were categorized into three areas of concern: (1) livestock grazing impeded the development of

younger age classes of native vegetation which could mature into suitable flycatcher habitat; (2) grazing livestock would inadvertently disturb occupied flycatcher territories and physically dislodge the nest from the tree; and (3) the presence of livestock would increase the local abundance of brown-headed cowbirds (*Molothrus ater*), which would increase the potential for brood parasitism and subsequent nest failure.

As a result of these concerns, a seasonal grazing regime was implemented in 1997. Seasonal livestock grazing was permitted from August 1, 1997 to April 15, 1998 and from August 1, 1998 to April 15, 1999. Livestock were excluded during the primary flycatcher breeding season with the exception of 25 head on the Scott Ranch Allotment. Although initial measures had been taken to avoid potential impacts to the flycatcher, rising concerns with livestock grazing resulted in the temporary suspension of all grazing from April 15, 1999 to October 15, 1999. Upon further review of data collected from the early stages of this study, and recommendations from technical experts, seasonal livestock grazing was reinstated in 2000 and extends from August 1 to May 6 annually.

Prior to 1997 livestock grazing was permitted on a year-round basis. During this period, much of the existing native-dominated vegetation community was established. It is apparent that livestock browsing during this period did not prevent the development of suitable breeding habitat for the flycatcher, however it is unknown whether livestock browsing reduced the extent of native habitat development.

In an effort to quantify the impacts of livestock on flycatcher habitat, a series of livestock exclosures and photo stations were established in the fall of 1997. A 2-year livestock fecal analysis study was initiated in October 1999, and quarterly aerial livestock counts began in November 2000. In addition to these study components, an assessment of lateral browsing was also incorporated into the study in January 2004. This report presents methodology used in collecting these data, as well as a current assessment of the study from August 1997 through April 2008.

Study Area

The study area encompassed Elephant Butte project lands from the northern boundary to the headwaters of Elephant Butte Reservoir (Figure 1). Three grazing allotments were within the study area—Bruton River Allotment, Milligan Gulch Allotment, and Scott Ranch Allotment.

Livestock grazing was administered by the Bureau of Land Management (BLM), Socorro Field Office. The Scott Ranch Allotment, which was the most southern of the three allotments, was located in the vicinity of Elephant Butte Reservoir delta. The amount of forage available within this allotment was strongly influenced by reservoir water surface levels (Reclamation 2000). Available forage within the Bruton River and Milligan Gulch Allotments was more consistent but varied based on annual precipitation and the extent of overbank flooding. The three allotments totaled approximately 11,500 acres. As of 2002, approximately 3,700 acres were dominated by native vegetation, 3,300 acres were dominated by saltcedar (*Tamarix* spp.), 1,600 acres were uplands, 300 were a mix of

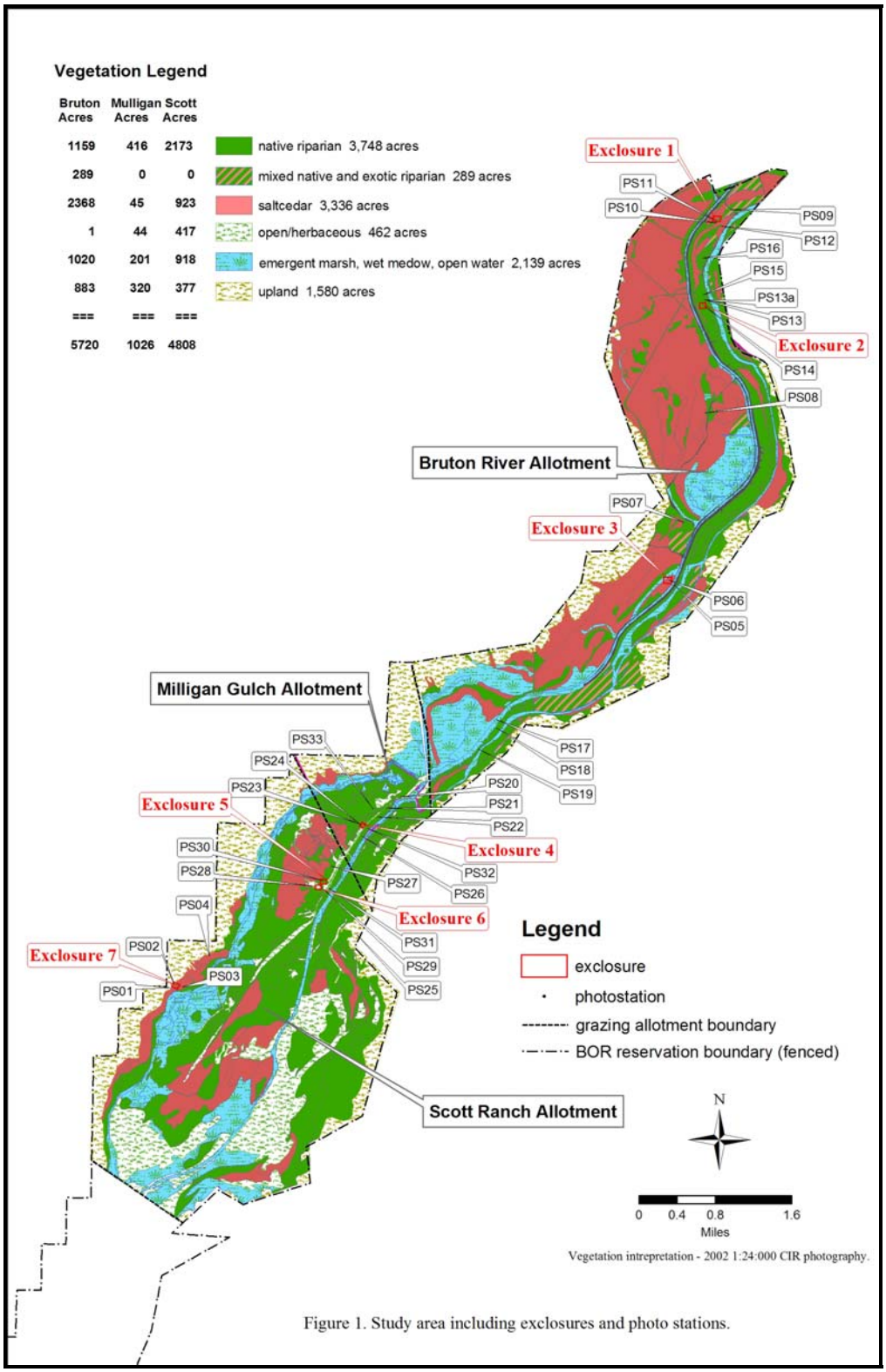

FIGURE 1.—Study area including exclosures and photo stations.

native and exotic vegetation, 500 were open/herbaceous vegetation, and 2,100 acres were marsh and open water (Reclamation unpublished data).

The riparian area between the low flow conveyance channel (LFCC) and the Rio Grande was dominated by native cottonwood (*Populus deltoids* var. *wislizenii*) and willow (*Salix* spp.). The flood plain to the west of the LFCC was dominated by exotic saltcedar, with isolated stands of native cottonwood and Goodding's willow (*Salix gooddingii*). The endangered flycatcher occupied breeding territories within the dense riparian community in close proximity to areas which were flooded, exhibited saturated soil conditions, or were near open water. There were stands of suitable flycatcher breeding habitat within the study area that were unoccupied. Most of the dense native riparian community within the area developed over the past 5 to 15 years. Since this study was initiated in 1997, a significant increase in the extent of suitable flycatcher habitat developed within the conservation pool of Elephant Butte Reservoir south of the study area due to decreasing reservoir levels.

METHODS

This study involved monitoring at permanent livestock exclosures located throughout the headwaters area of Elephant Butte project lands to determine if grazing was having an impact on riparian vegetation. In addition to data collected in association with the livestock exclosures, 34 photo stations were established to monitor the impacts of livestock on mature and immature stands of native vegetation. Fecal samples from grazing livestock were also collected and analyzed to determine the seasonal utilization of grasses, herbs, and woody stems. Aerial livestock counts were conducted concurrent with exclosure data collection to determine the distribution and abundance of livestock. In an effort to determine whether livestock browsing was reducing lateral branch development and subsequently reducing the overall structural diversity of the community, a lateral density study was also implemented.

Livestock Exclosures

Livestock exclosures were constructed at seven locations within Elephant Butte project lands (Figure 1). Each exclosure measured 30 by 30 meters (m) and was constructed using four strands of barbed wire attached to t-posts and wooden corner posts (Figure 2). The exclosures were constructed to exclude only livestock; native wildlife (deer, rabbits, etc.) that feed on the vegetation were not excluded. Based on personal observations, the relative abundance of native wildlife species that fed on woody vegetation was limited within the study area. It was also assumed that native species would utilize the woody vegetation within and outside the livestock exclosures in equal proportions and that browsing of woody vegetation by native species would be an insignificant variable. Exclosures were constructed at sites that supported young cottonwoods and willows generally <1 m in height or in areas where cottonwoods and willows could potentially become established. Young, developing stands of cottonwoods and willows are more palatable to livestock and are utilized to a greater extent than more mature individuals.

Construction of Exclosure 2

Construction of Exclosure 7

FIGURE 2.—Construction of livestock exclosures (July 1997).

Also, intensive livestock browsing of young, developing individual cottonwood/willow can be more detrimental than browsing of mature cottonwood/willow since young individuals do not have as large an energy reserve stored in their root systems. Seedling and sapling cottonwoods and willows are also more susceptible to being entirely consumed or having their apical and primary terminal buds removed by browsing. Browsing of the seedlings often results in the entire plant being killed since they can easily be pulled from the ground or trampled (USFWS 2001).

Data from the respective exclosures were collected on a biannual basis (November and April) from November 1997 to April 2000 and three times annually (November, January, and April) from November 2000 to April 2008. These dates were established to encompass the primary growing season of cottonwood/willow in central New Mexico, based on Hink and Ohmart (1984), and also to reflect the late fall, winter, and early spring use of cottonwood and willow by foraging livestock. Data were collected to document any changes in species composition, density, height, and percent of individuals browsed. Additional exclosure data were collected when excessive grazing warranted the need to more closely monitor impacts from these events and determine whether the vegetation had recovered prior to the beginning of the next grazing period.

Ten to 20 permanent vegetation monitoring micro-plots measuring 1 by 3 m were established within and outside each of the respective exclosures to best represent the vegetative and hydrological conditions of the site. Inside and outside micro-plots were positioned from established t-posts, and pins were driven into the ground at the corners of each plot to ensure correct and repeatable placement during each data collection effort. Outside the exclosure, permanent vegetation monitoring micro-plots were established along permanent transects marked by t-posts. The 1- by 3-m grid was placed along this transect at 3- to 4-m intervals. Micro-plots within and outside the exclosures were located in areas that supported similar vegetation composition, height, and density, and similar hydrologic conditions. All cottonwood, Goodding's willow, coyote willow (*Salix exigua*), seep willow (*Baccharis glutinosa*), and saltcedar were counted and measured on a biannual basis from November 1997 to April 2008. Plot layouts for each of the exclosures are shown in Appendix A.

After the 1- by 3-m grid was placed over the established pins, vegetation data were collected (Figure 3). The height of each cottonwood, willow, saltcedar, and seep willow was measured and a determination of whether it was browsed was recorded. Dead vegetation was neither removed nor recorded at the respective vegetation monitoring micro-plots. Figure 4 illustrates the methodology used to determine if the stem was counted when several main stems originated from the same root crown or branch. Stems <25 centimeter (cm) in height were not recorded since the objective of the current study was to determine the long-term effects of livestock browsing on the native cottonwood/willow community. Also, it was not feasible to tally the high number of seedlings that could potentially become established during a growing season. Many of these individuals would fail to develop when the soils became too dry to support them. It was assumed that the effects of livestock browsing of young seedlings <25 cm would be detected if the density of cottonwood/willow seedlings within the exclosure increased and

FIGURE 3.—Collection of vegetation measurements using grid and measuring rod.

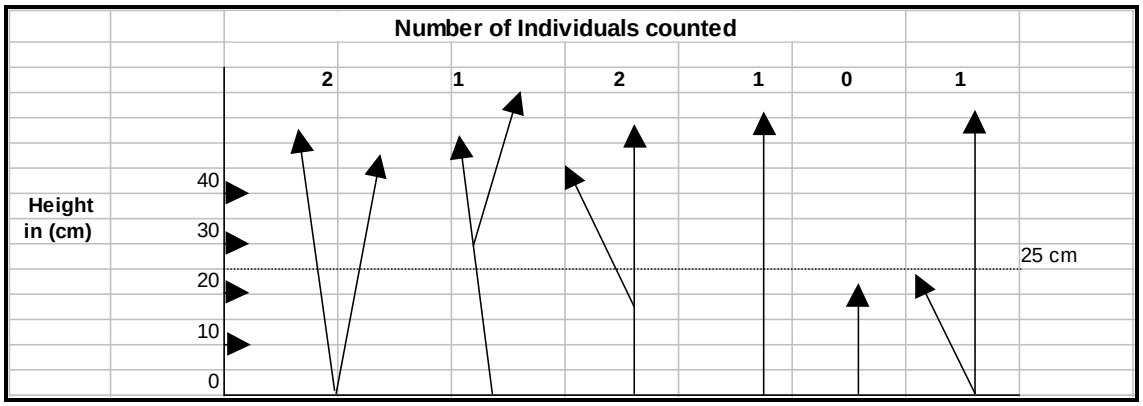

FIGURE 4.—Diagram illustrating the determination of number of stems counted >25 cm in height.

density outside the exclosure did not. Branches that originated from the main stem below 25 cm were included in the stem count if they were believed to have the potential for development into a primary limb.

The percentage of stems browsed between the fall (November), winter (January), and spring (April) data collection periods was cumulative, since the individual plants were dormant and did not establish new growth during this period. The percentage of individual stems browsed between the spring (April) and the fall (November) was not

cumulative from the previous year since individual plants would have established new growth during the April to August period, prior to the subsequent grazing season. Therefore, the November data collection period reflected the number of individual stems browsed from the beginning of the grazing season (August 1) to November, and the April data collection period reflected the total number of individual stems browsed from August 1 to April.

Vegetation data were analyzed for impacts from grazing. Statistical analysis was conducted to compare the height and density of willow between the inside and outside of five of the seven exclosures during the November collection periods. The Student's t-test of means was used for normally distributed data, and the non-parametric Mann-Whitney test of the medians was used for data that were not normally distributed. The vegetation at Exclosures 1 and 3 was sparse, and analysis of stem count data did not provide statistically valid results; however, these data were collected to document vegetation trends. For statistical analysis, the mean height and density of the inside and outside of Exclosures 2, 4, 5, 6, and 7 were compared. The number of micro-plots inside and outside of these exclosures was increased in 2000 to provide a larger sample size for statistical analysis. From November 1997 to November 1999, data were collected from 10 micro-plots (n=10), and from November 2000 to April 2008 data were collected from 20 micro-plots (n=20). The summary tables and graphs provided for each exclosure reflect trends in height and density and show the frequency of browse during each collection period.

Exclosure 1

Exclosure 1 was constructed between the LFCC and the Rio Grande approximately 0.5 kilometer (km) south of the access road leading to the railroad bridge. The exclosure and surrounding area appeared to have been an historic channel of the Rio Grande prior to construction of the San Marcial/Fort Craig berm. The site was relatively dry and sandy and had not been recently flooded. Vegetation was sparse, dominated by coyote willow and a few cottonwoods. Statistical analysis was not conducted for this exclosure because it was not practical to obtain a statistically valid sample based on a sample size determination. Greater than 100 micro-plots would have been required due to the limited abundance of native woody vegetation. However, 10 micro-plots within the exclosure and 15 outside the exclosure were measured to determine trends in height, density, and species composition. Data were collected only in November on an annual basis.

Exclosure 2

Exclosure 2 was constructed approximately 2 km south of the access road leading to the railroad bridge. Like Exclosure 1, it was positioned between the LFCC and the Rio Grande. The exclosure was situated within a borrow site that was used to upgrade the San Marcial/Fort Craig berm in the early 1990s. The area was subject to saturated soil when periodic high flows within the Rio Grande were conveyed to the site via a low water crossing on the San Marcial/Fort Craig berm. Vegetation surrounding this site was relatively dense, dominated by coyote willows with scattered cottonwoods. Saltcedar was nearly absent from the exclosure and immediate area. Data from 20 micro-plots within and 20 micro-plots outside the exclosure were used for statistical comparison of

height, density, and species composition. Data were collected annually inside and outside the exclosure in November for statistical analysis and determination of frequency of browse. In January, only the frequency of browse was determined from outside micro-plots. Height and density were not measured as they would not have changed significantly during the dormant season since November. During the April collection period, the height and density measurements of all outside micro-plots were collected to more accurately reflect the frequency of browse due to the natural die-off of individual plants during the winter months.

Exclosure 3

Exclosure 3 was the only exclosure constructed within a wet meadow dominated by grasses and sedges. The site was not highly suitable for the establishment of native woody vegetation, but was selected to monitor the long-term effects of livestock browsing on the successional development of the wet meadow habitat. The site was located to the west of the LFCC, about 0.5 km south of the Fort Craig bridge that crosses the LFCC. The site remained relatively moist during much of the growing season. Screwbean mesquite (*Prosopis pubescens*) was found in the drier areas of the exclosure and surrounding area. A few cottonwoods and coyote willows were present, in addition to a few scattered clumps of saltcedar. Based on observations, the mature cottonwood stands near Exclosure 3 were well established cattle loafing areas. The surrounding area was heavily utilized by cattle during the grazing season. Statistical analysis was not conducted for this exclosure because it was not practical to obtain a statistically valid sample based on a sample size determination. Greater than 100 micro-plots would have been required due to the limited abundance of native woody vegetation. However, 10 micro-plots within the exclosure and 15 outside the exclosure were measured to determine trends in height, density, and species composition. Data were collected only in November on an annual basis.

Exclosure 4

Exclosure 4 was located immediately to the west of the LFCC levee, approximately 1 km south of the LFCC outfall. The immediate area had been cleared in the early-to-mid 1990s to obtain borrow material for the LFCC levee. When the exclosure was constructed, the site was dominated by saltcedar with scattered stands of relatively young cottonwood and coyote willow. The topsoil was sandy and dry during most of the year. Data from 20 micro-plots within and 20 micro-plots outside the exclosure were used for statistical comparison of height, density, and species composition. Data were collected annually inside and outside the exclosure in November for statistical analysis and determination of frequency of browse. In January, only the frequency of browse was determined from outside micro-plots. Height and density were not measured as they would not have changed significantly during the dormant season since November. During the April collection period, the height and density data of all outside micro-plots were collected to more accurately reflect the frequency of browse due to the natural die-off of individual plants during the winter months. Additional data were collected when conditions warranted.

Exclosure 5

Exclosure 5 was located immediately to the west of the LFCC levee, approximately 1.5 km downstream of Exclosure 4. The site was cleared in the spring of 1997, and only a few stems of coyote willow were present when the exclosure was established. This site was selected to represent potential livestock impacts on the earliest stages of vegetation development (i.e., seedling establishment and development). The site was occasionally flooded, or had saturated soil conditions during the early portion of the growing season due to a culvert placed through the LFCC levee immediately upstream of the site. When Rio Grande flows were high, overflow through the culvert would irrigate the site. The soils were a combination of silts, clays, and sand. Data from 20 micro-plots within and 20 micro-plots outside the exclosure were used for statistical comparison of height, density, and species composition. Data were collected annually inside and outside the exclosure in November for statistical analysis and determination of frequency of browse. In January, only the frequency of browse was determined from outside micro-plots. Height and density were not measured as they would not have changed significantly during the dormant season since November. During the April collection period, the height and density of all outside micro-plots were collected to more accurately reflect the frequency of browse due to the natural die-off of individual plants during the winter months. Additional data were collected when conditions warranted.

Exclosure 6

Exclosure 6 was located immediately southwest of Exclosure 5 near the northern extent of Elephant Butte Reservoir's conservation pool. This site was undisturbed, however the existing vegetation established as the reservoir levels declined and soils were exposed. The topsoil was sandy and generally dry. The ground water table was relatively shallow. The site was originally dominated by saltcedar. Data from 20 micro-plots within and 20 micro-plots outside the exclosure were used for statistical comparison of height, density, and species composition. Data were collected annually inside and outside the exclosure in November for statistical analysis and determination of frequency of browse. In January, only the frequency of browse was determined from outside micro-plots. Height and density were not measured as they would not have changed significantly during the dormant season since November. During the April collection period, the height and density of all outside micro-plots were collected to more accurately reflect the frequency of browse due to the natural die-off of individual plants during the winter months. Additional data were collected when conditions warranted.

Exclosure 7

Exclosure 7 was located on the western bank of Elephant Butte Reservoir, approximately 1 km downstream of Dryland Road. The site was subject to flooding when reservoir levels were high. When the site was not flooded, ground water levels were contingent on reservoir levels and outflows from the LFCC. The soils were predominately silt. Goodding's willow originally dominated the area while cottonwoods were scattered throughout. Data from 20 micro-plots within and 20 micro-plots outside the exclosure were used for statistical comparison of height, density, and species composition. Data were collected annually inside and outside the exclosure in November for statistical analysis and determination of frequency of browse. In January, only the frequency of

browse was determined from outside micro-plots. Height and density were not measured as they would not have changed significantly during the dormant season since November. During the April collection period, the height and density of all outside micro-plots were collected to more accurately reflect the frequency of browse due to the natural die-off of individual plants during the winter months.

Photo Stations

In August 1997, 34 photo stations were established throughout the San Marcial area and headwaters of Elephant Butte project lands within all three grazing allotments (Figure 1). Photo stations were established to: (1) provide a visual comparison to monitor the long-term effects of livestock browsing on the growth and development of native vegetation within and outside the respective exclosures, and (2) to document possible physical disturbance caused by grazing livestock in areas of dense native vegetation that potentially could support breeding flycatchers. All photo stations were established by driving a t-post into the ground at selected locations. Photographs were taken annually through 2007, generally concurrent with the November data collection period.

Aerial Livestock Counts

The grazing period for the three allotments within the study area extended from August 1 through May 6. Livestock were excluded from the study area during the primary flycatcher breeding season.

Beginning in November 2000, aerial livestock counts of the three grazing allotments within the study area were conducted concurrently with exclosure data collection (November, January, and April) and when additional surveys warranted. These aerial counts were conducted to determine the distribution and abundance of livestock throughout the study area and to provide insight into the effects of livestock browsing on riparian vegetation based on stocking rates and season of use.

Livestock counts were conducted during the morning hours from 1 to 3 hours after sunrise. Livestock were typically active during this period and more visible from the fixed-winged aircraft. East/west aerial transects, approximately 400 m apart, were flown from the northern boundary of the Bruton River Allotment to the southern boundary of the Scott Ranch Allotment. An onboard GPS unit was utilized at all times to maintain a consistent transect pattern throughout the study area. All cattle were counted unless the individual was clearly identified as a calf <12 months of age. Since it was not possible to clearly identify the age class (i.e., calf vs cow) of all cattle observed, the number recorded represents the maximum possible animal unit months (AUMs) present during the respective collection period. When cattle were observed, the number and location were recorded. Extreme care was taken to avoid count duplication.

Fecal Analysis

Three representative sampling units (East, West, and Delta) were selected within the larger study area that included the Bruton River, Milligan Gulch, and Scott Ranch Allotments. Cattle movement between the East and West sampling units was somewhat limited by the LFCC, however, there were no fences at the time separating any of the grazing allotments in the flood plain other than those on the upland boundary at the Reclamation property line (Figure 1). Fresh samples of cattle feces were collected monthly from November 1999 through October 2001. In order to obtain a representative sample of the local cattle populations' diet within the study area, 20 to 25 random samples (1 tablespoon/sample) were collected and combined on each sampling unit, yielding three composite samples per month. Each sample was packaged, labeled, preserved by freezing and transferred to Composition Analysis Laboratory in Fort Collins, Colorado. Each composite sample was then air dried and ground in a Wiley Mill through a 20-mesh [1-millimeter (mm) opening] screen. Five slides were prepared for each sample and 20 fields were examined per slide. The baseline results for each composite sample were presented as a mean of the 100 fields. The methodology used for the microhistological analysis of the samples is similar to that discussed in Johnson et al. (1983). For our analysis purposes the monthly data from the East, West, and Delta sampling units were combined and expressed as percent relative density by plant species.

Lateral Browsing

In January of 2004, an annual assessment of lateral browsing was initiated to determine whether livestock browsing was having an adverse effect on lateral branch development of native, woody-stemmed species which could subsequently reduce the overall structure of the vegetation. The existing exclosure data were used to determine whether livestock browsing was having an effect on height and density of the native community, but did not assess possible effects of browsing on lateral cover density. The lateral browsing study involved the collection of digital images at each of the respective micro-plots at the five primary exclosures (Exclosures 2, 4, 5, 6, and 7). Data were collected in January when most foliage was absent in order to compare lateral stem density between micro-plots. This assessment was similar to that discussed by Thompson (1975).

Digital images were recorded at each of the 20 micro-plots, inside and outside the livestock exclosures (40 images per exclosure). The images were obtained by placing a white 1- by 1-m background screen at one end of the 1- by 3-m micro-plot (0.5 m above the ground) and capturing the digital image from the opposite end of the plot, 3-m distance from the screen. All photos were taken with illumination from the back or sides of the background screen so that shadows from the woody stems would not be projected on the screen. The images were then downloaded into Microsoft PhotoEditor, cropped to only include the 1- by 1-m background screen, transferred to Microsoft Powerpoint and overlaid with a 20 x 20 grid creating 400 equal cells/image. An example of a digital image and corresponding grid is shown in Figure 5. The images were then printed and the number of cells containing woody vegetation were counted and recorded by micro-plot. The numbers for each micro-plot were then added and expressed as a percentage

FIGURE 5.—Digital image used for lateral density measurements with grid overlayed.

of lateral cover density for outside and inside micro-plots for each of the respective exclosures. Inside and outside data were then statistically compared as described in the Livestock Exclosure section above.

RESULTS AND DISCUSSION

Livestock Exclosures

Data presented in this report were collected between November 1997 and April 2008. The only species of woody vegetation utilized to any extent by livestock within the study area were coyote willow, cottonwood, and Goodding's willow. Although cattle were observed occasionally browsing on young saltcedar adjacent to the LFCC, actual utilization of saltcedar was less than 1 percent. Seep willow was also occasionally utilized, but like saltcedar, only to a very minor extent.

The following section discusses the study results, and provides tabular and graphic illustrations of data for each exclosure, with an emphasis on the effects of livestock browsing on native cottonwood, coyote willow, and Goodding's willow. Although it was important to monitor the seasonal variability of livestock browsing (frequency) on native cottonwood and willow, the long-term impacts of livestock browsing on the height and density of the community needed to be evaluated only on an annual basis. Therefore, graphical illustrations and statistical analysis were consistently conducted for only the November collection periods. However, additional data collection and analysis were also conducted when conditions warranted (i.e., established thresholds were exceeded).

Exclosure 1

The density of coyote willow within the exclosure almost doubled from November 1997 ($2.27/m^2$) to November 2007 ($4.23/m^2$) (Table 1, Figure 6). Outside the exclosure, the density increased from $1.33/m^2$ in November 1997 to $2.36/m^2$ in November 2007. The average height of coyote willow within and outside the exclosure also increased over the 10-year study. The average height of coyote willow increased by 86 cm within the exclosure, from 103 to 189 cm, and increased by 74 cm, from 81 to 155 cm, outside the exclosure. The increases in height and density can be observed in the photos in Figures 7 and 8.

No cottonwoods were detected within the exclosure until 2007, when two were counted. Cottonwoods were always sparse outside the exclosure, but have gradually decreased in numbers, from 10 individuals in 1998 and 1999 to just 3 in 2007. Data regarding the cottonwood height and density are shown in Table 1 and Figure 6. The decline in the number of cottonwood outside the exclosure over time was probably not related to grazing since the percentage of browse has also declined at this site over time.

The frequency of browse on coyote willow outside the exclosure ranged from 71 percent in April 1999 to 0 percent in November 2003 and 2004 (Table 1). Although relatively few individuals were included in our samples, as high as 100 percent of the cottonwoods were browsed in April 1999. No browse of cottonwood has been documented since November 2001.

As of November 2007, the density of coyote willow was greater inside the exclosure, at $4.23/ m^2$, than outside, at $2.36/ m^2$. From 1998 to 2004, however, density was greater outside of the exclosure. The average height of coyote willow was also greater inside the exclosure than outside in 2007, which was the first year since 2001 that willow were taller inside.

As of 2005, heights and densities were greater inside than outside this exclosure (though statistical significance was not tested), however this difference did not appear to be correlated with the frequency of browse. Browsing has not been excessive in recent years as the number of livestock within the allotments has decreased, and no significant adverse impacts to the cottonwood/willow community at Exclosure 1 were observed at this time.

TABLE 1.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 1 (n=10 in; n=15 out).

	11/97		4/98		11/98		4/99		11/99		4/00		11/00		11/01		11/02	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																		
Total number	68	60	59	68	56	90	53	87	80	138	59	128	93	167	110	178	72	234
Density (m^2)	2.27	1.33	1.97	1.51	1.87	2.00	1.77	1.93	2.67	3.07	1.97	2.84	3.10	3.71	3.67	3.96	2.40	5.20
Browsed ht. (cm)	n/a	58	n/a	57	n/a	52	n/a	66	n/a	n/a	n/a	29	n/a	67	n/a	50	n/a	64
Unbrowsed ht. (cm)	103	91	101	80	119	107	120	123	125	95	129	97	126	116	105	94	106	109
Avg. ht. (cm)	103	81	101	73	119	84	120	82	125	95	129	95	126	109	105	88	105	106
Percent browsed	0%	32%	0%	31%	0%	41%	0%	71%	0%	0%	0%	2%	0%	15%	0%	14%	0%	6%
Cottonwood																		
Total number	n/a	9	n/a	10	n/a	10	n/a	10	n/a	10	n/a	9	n/a	6	n/a	7	n/a	7
Density (m^2)	n/a	0.20	n/a	0.22	n/a	0.22	n/a	0.22	n/a	0.22	n/a	0.20	n/a	0.13	n/a	0.16	n/a	0.16
Browsed ht. (cm)	n/a	50	n/a	41	n/a	56	n/a	59	n/a	n/a	n/a	n/a	n/a	135	n/a	89	n/a	n/a
Unbrowsed ht. (cm)	n/a	47	n/a	48	n/a	64	n/a	n/a	n/a	85	n/a	91	n/a	131	n/a	141	n/a	119
Avg. ht. (cm)	n/a	50	n/a	42	n/a	59	n/a	59	n/a	85	n/a	91	n/a	131	n/a	126	n/a	119
Percent browsed	n/a	89%	n/a	90%	n/a	60%	n/a	100%	n/a	0%	n/a	0%	n/a	17%	n/a	29%	n/a	0%

TABLE 1.—Exclosure 1, cont.

	11/03		11/04		11/05		11/06		11/07	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow										
Total number	99	210	145	206	116	118	150	122	127	106
Density (m^2)	3.30	4.67	4.83	4.58	3.87	2.62	5.00	2.71	4.23	2.36
Browsed ht. (cm)	n/a	n/a	n/a	113	n/a	150	n/a	144	n/a	102
Unbrowsed ht. (cm)	110	128	113	150	150	189	149	174	189	156
Avg. ht. (cm)	110	128	113	150	150	185	149	168	189	155
Percent browsed	0%	0%	0%	0%	0%	10%	0%	20%	0%	2%
Cottonwood										
Total number	n/a	4	n/a	3	n/a	3	n/a	2	2	3
Density (m^2)	n/a	0.09	n/a	0.07	n/a	0.07	n/a	0.04	0.07	0.07
Browsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	n/a	192	n/a	205	n/a	201	n/a	228	154	234
Avg. ht. (cm)	n/a	192	n/a	205	n/a	201	n/a	228	154	234
Percent browsed	n/a	0%	n/a	0%	n/a	0%	n/a	0%	0%	0%

n/a = not present

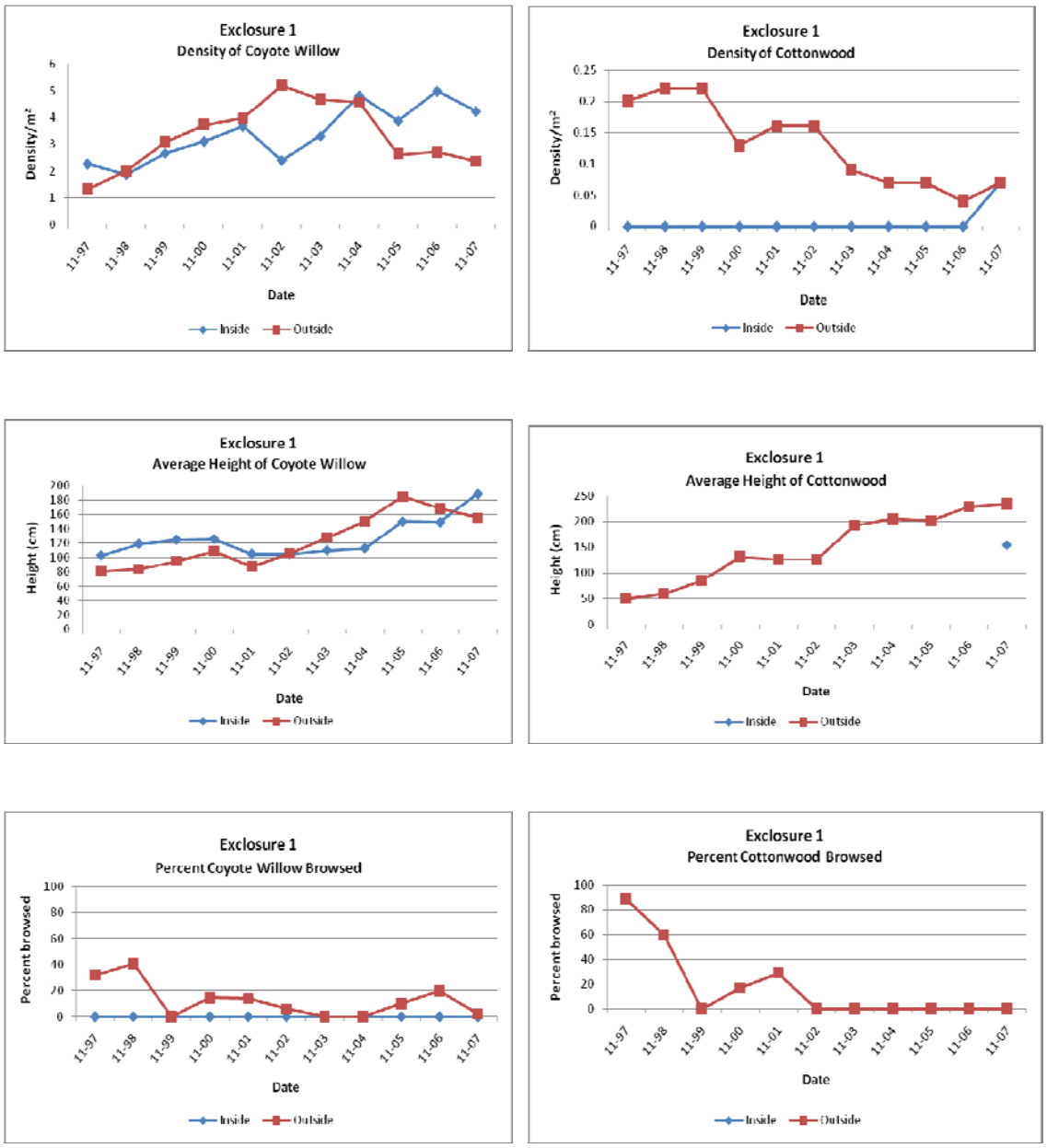

FIGURE 6.—Average height, density, and percent of browse for coyote willow and cottonwood inside and outside of Exclosure 1.

August 1997

November 2007

FIGURE 7.—Photo stations inside Exclosure 1 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 8.—Photo stations outside Exclosure 1 comparing 1997 to 2007.

Exclosure 2

The density of coyote willow within and outside the exclosure decreased from November 1997 to November 2007. The density of coyote willow within the exclosure decreased over 50 percent from 12.00/m^2 in 1997 to 5.27/m^2 in 2007. The density of coyote willow outside the exclosure also decreased by about 50 percent from 12.08/ m^2 in November 1997 to 6.70/ m^2 in November 2007 (Table 2, Figure 9). Because the density of willow declined at comparative rates between the inside and outside of the exclosure, it is unlikely that decreasing densities were caused by grazing. Coyote willow stands were relatively dense when monitoring began, and as the willows grew, competition for space and resources probably accounted for some die-off. A reduction in the amount of surface water in conjunction with low flows and degradation of the Rio Grande channel probably had the greatest effect on densities at this site.

The height of coyote willow within and outside the exclosure increased from November 1997 to November 2007. The average height of coyote willow within the exclosure increased approximately 87 percent from 90 cm in 1997 to 168 cm in 2004. However, the average height of coyote willow outside the exclosure increased less than 10 percent over the same period, from 92 cm in 1997 to 104 cm in 2007 (Table 2, Figure 9). The reason for the lack of growth in the coyote willow community outside the exclosure could be a result of excessive livestock browsing in June 2001 (Table 2). A gate immediately upstream of the exclosure was left open and approximately 150 head of cattle fed through the area as they migrated south towards the delta of Elephant Butte Reservoir. The potential for this type of event reoccurring has been minimized with the installation of two locked steel gates in lieu of wire gates (Figure 10). Although this excessive grazing event was likely the primary cause of the decreased height outside the exclosure, a decreasing trend in the height of coyote willow was observed in November 2000, prior to this event in June 2001.

The interaction between coyote willow densities and heights at Exclosure 2 also suggested an impact from grazing. Densities both inside and outside of the exclosure decreased considerably in 2001, which did not indicate that grazing was a factor since the reduction in unbrowsed vegetation was equal to that of browsed. As the densities fell, there was a noticeable increase in the heights of willow within the exclosure, presumably a release in their growth as crowding subsided. However, heights of willows that had been heavily browsed outside of the exclosure decreased. This outcome appears to support a grazing effect. The effects of intensive browsing were also exacerbated by the drier than normal conditions that had persisted in recent years. Due to low flows and degradation of the Rio Grande channel, flows through the low water crossing were limited or absent.

As previously mentioned, this site supported only a few cottonwoods both inside and outside the exclosure. Graphs showing height and density of cottonwood are in Figure 9. Height of cottonwood has increased from 1997 to 2007 both inside, from 56 to 134 cm,

TABLE 2.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 2 (n=10, 1997–1999; n=20, 2000–2008).

	11/97		4/98		11/98		4/99		11/99		4/00		11/00		1/01		4/01		6/01	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	360	725	332	679	326	561	231	468	308	795	307	663	881	1021	NC	1021	NC	696	NC	672
Density (m^2)	12.00	12.08	11.07	11.32	10.90	9.40	7.70	7.80	10.27	13.25	10.23	11.05	14.68	17.02	NC	17.02	NC	11.6	NC	11.20
Browsed ht. (cm)	n/a	96	n/a	81	n/a	91	n/a	119	n/a	86	n/a	102	n/a	66	NC	NC	NC	74	NC	82
Unbrowsed ht. (cm)	90	91	104	95	118	127	128	128	138	136	131	131	132	119	NC	NC	NC	112	NC	118
Avg. ht. (cm)	90	92	104	92	118	119	128	122	138	136	131	131	132	117	NC	NC	NC	110	NC	104
Percent browsed	0%	15%	0%	19%	0%	24%	0%	71%	0%	<1%	0%	0%	0%	4%	NC	6%	NC	4%	NC	39%
Cottonwood																				
Total number	1	5	1	4	1	4	1	4	1	7	1	8	3	7	NC	7	NC	8	NC	8
Density (m^2)	0.03	0.08	0.03	0.07	0.03	0.07	0.03	0.07	0.03	0.12	0.03	0.13	0.05	0.12	NC	0.12	NC	0.13	NC	0.13
Browsed ht. (cm)	n/a	99	n/a	101	n/a	84	n/a	91	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	NC	185
Unbrowsed ht. (cm)	56	58	60	77	96	n/a	95	n/a	120	129	120	118	175	163	NC	NC	NC	117	NC	100
Avg. ht. (cm)	56	74	60	89	96	84	95	91	120	129	120	118	175	163	NC	NC	NC	117	NC	121
Percent browsed	0%	40%	0%	50%	0%	100%	0%	100%	0%	0%	0%	0%	0%	0%	NC	0%	NC	0%	NC	25%

TABLE 2.—Exclosure 2, cont.

	11/01		1/02		4/02		11/02		1/03		4/03		11/03		1/04		4/04		11/04	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	435	529	NC	529	NC	466	366	465	NC	465	NC	452	473	502	NC	502	NC	302	510	537
Density (m^2)	7.25	8.82	NC	8.82	NC	7.77	6.10	7.75	NC	7.75	NC	7.53	7.88	8.37	NC	8.37	NC	5.03	8.50	8.95
Browsed ht. (cm)	n/a	93	NC	NC	NC	82	72	62	NC	NC	NC	67	n/a	94	NC	NC	NC	65	n/a	60
Unbrowsed ht. (cm)	179	138	NC	NC	NC	141	161	107	NC	NC	NC	122	146	111	NC	NC	NC	73	147	101
Avg. ht. (cm)	179	118	NC	NC	NC	125	161	106	NC	NC	NC	115	146	110	NC	NC	NC	73	147	98
Percent browsed	0%	43%	NC	44%	NC	28%	0%	3%	NC	4%	NC	13%	0%	7%	NC	9%	NC	<1%	0%	5%
Cottonwood																				
Total number	3	8	NC	8	NC	5	3	11	NC	11	NC	9	2	6	NC	6	NC	4	3	7
Density (m^2)	0.05	0.13	NC	0.13	NC	0.08	0.05	0.18	NC	0.18	NC	0.15	0.03	0.10	NC	0.10	NC	0.07	0.05	0.12
Browsed ht. (cm)	n/a	128	NC	NC	NC	93	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a
Unbrowsed ht. (cm)	219	130	NC	NC	NC	147	232	126	NC	NC	NC	129	174	155	NC	NC	NC	213	235	170
Avg. ht. (cm)	219	129	NC	NC	NC	125	232	126	NC	NC	NC	129	174	155	NC	NC	NC	213	235	170
Percent browsed	0%	63%	NC	63%	NC	40%	0%	0%	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%	0%	0%

TABLE 2.—Exclosure 2, cont.

	1/05		11/05		1/06		4/06		11/06		1/07		4/07		11/07		1/08		4/08	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	NC	537	401	477	NC	477	NC	276	416	370	NC	370	NC	238	316	402	NC	402	NC	216
Density (m^2)	NC	8.95	6.68	7.95	NC	7.95	NC	4.60	6.93	6.17	NC	6.17	NC	3.97	5.27	6.70	NC	6.70	NC	3.60
Browsed ht. (cm)	NC	NC	n/a	84	NC	NC	NC	n/a	n/a	94	NC	NC	NC	n/a	n/a	91	NC	NC	NC	89.1
Unbrowsed ht. (cm)	NC	NC	190	115	NC	NC	NC	120	166	113	NC	NC	NC	112	168	105	NC	NC	NC	113.8
Avg. ht. (cm)	NC	NC	190	105	NC	NC	NC	120	166	111	NC	NC	NC	112	168	104	NC	NC	NC	113.0
Percent browsed	NC	6%	0%	32%	NC	32%	NC	0%	0%	10%	NC	10%	NC	0%	0%	4%	NC	4%	NC	3%
Cottonwood																				
Total number	NC	7	3	4	NC	4	NC	5	1	4	NC	4	NC	4	1	4	NC	4	NC	5
Density (m^2)	NC	0.12	0.05	0.07	NC	0.07	NC	0.08	0.02	0.07	NC	0.07	NC	0.07	0.02	0.07	NC	0.07	NC	0.08
Browsed ht. (cm)	NC	NC	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	0
Unbrowsed ht. (cm)	NC	NC	169	224	NC	NC	NC	211	231	243	NC	NC	NC	236	134	226	NC	NC	NC	205.4
Avg. ht. (cm)	NC	NC	169	224	NC	NC	NC	211	231	243	NC	NC	NC	236	134	226	NC	NC	NC	205.4
Percent browsed	NC	0%	0%	0%	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%

n/a = not present; NC=not collected

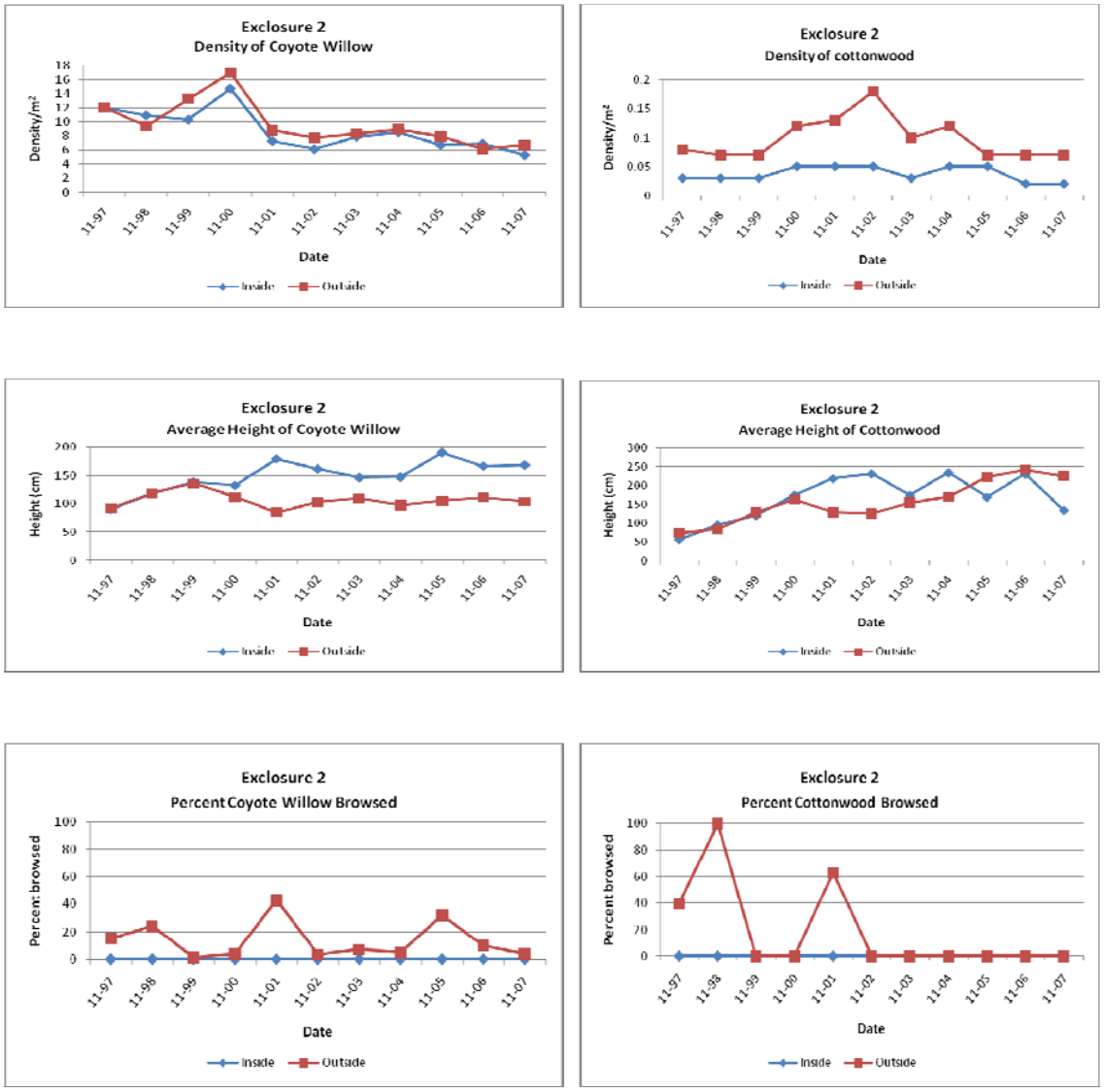

FIGURE 9.—Average height, density, and percent of browse for coyote willow and cottonwood inside and outside of Exclosure 2.

FIGURE 10.—Steel gates installed to reduce potential for excessive grazing events at Exclosure 2.

and outside, from 74 to 226 cm, the exclosure. Density has varied slightly but no obvious pattern has developed. Due to the limited number of individuals established at this site, it was not possible to derive any meaningful conclusions from the data—other than cottonwood were present and were increasing in height.

Browsing frequency of coyote willow has been fairly low over the study period with the exception of 2001 and 2005 (see Figure 9). Excessive grazing in 2001 appeared to have affected the height of willow outside the exclosure, though no effects from a browsing frequency of 32 percent in 2005 were evident. Cottonwoods experienced heavy grazing in 1998 and 2001, with browsing frequencies of 100 percent and 63 percent, respectively. Although percentages were high, the actual number of individual cottonwood sampled was only four and seven for those years. There did not appear to be any impacts to height or density of cottonwoods following these grazing events (Figure 9).

Statistical analysis indicated that willow density remained equal inside and outside the exclosure in 2007 (P=0.306; Table 3). Willow within the exclosure were significantly greater in height than outside (P<0.001), a trend first observed in November 2001 following the excessive browsing event of June 2001. The photos in Figures 11 and 12 do appear to show differences between vegetation inside and outside of the exclosure. The average densities have remained equal since the exclosure was constructed in 1997, and the average height within the exclosure has remained greater than outside the exclosure since November 2001. Therefore it appeared that livestock did have a long-term effect on the height of coyote willow, but did not affect density. If surface and ground water hydrology had not changed at this site and had remained favorable for plant growth, the impacts from excessive grazing may not have been as long term. This site demonstrated the effects that intensive grazing coupled with a decrease in plant-available water can have on riparian vegetation.

TABLE 3.—Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 2. Alpha = 0.05.

	11/97	**11/98**	**11/99**	**11/00**	**11/01**	**11/02**	**11/03**	**11/04**	**11/05**	**11/06**	**11/07**
Frequency	15%	24%	1%	4%	43%	3%	7%	6%	32%	10%	4%
Height	In=Out[2] P=0.391	In=Out[1] P=0.663	In=Out[1] P=0.866	In=Out[2] P=0.137	In>Out[2] P<0.001	In>Out[2] P<0.001	In>Out[2] P=0.002	In>Out[2] P<0.001	In>Out[1] P<0.001	In>Out[2] P<0.001	In>Out[1] P<0.001
Density	In=Out[2] P=0.741	In=Out[1] P=0.572	In=Out[1] P=0.236	In=Out[1] P=0.385	In=Out[1] P=0.263	In=Out[1] P=0.235	In=Out[1] P=0.765	In=Out[1] P=0.794	In=Out[2] P=0.704	In=Out[1] P=0.560	In=Out[1] P=0.306

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

August 1997

November 2007

FIGURE 11.—Photo stations inside Exclosure 2 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 12.—Photo stations outside Exclosure 2 comparing 1997 to 2007.

Exclosure 3

Although Exclosure 3 was located in a wet meadow with a somewhat sparse cover of woody vegetation, coyote willow experienced relatively large increases in both densities and heights inside and outside of the exclosure over the study period. The density of coyote willow within the exclosure increased from 0.03/m^2 in November 1997 to 2.63/m^2 in November 2007, with a noticeable increase in 2005 (Table 4, Figure 13). The density of coyote willow outside the exclosure increased from 0.02/m^2 to 2.60/m^2, with a considerable increase in 2004. The average height of coyote willow within the exclosure also increased from 83 cm in November 1997 to 190 cm in November 2007. Outside the exclosure, coyote willow increased in average height from 40 cm to 146 cm over the same period.

The density of cottonwood within the exclosure remained essentially the same over the period of study, at 0.23/m^2 in 1997 and 0.27/m^2 in 2007 (Table 4, Figure 13), while the density of cottonwood outside the exclosure increased from 0.02/m^2 to 0.31/m^2. The average height of cottonwood within the exclosure increased from 61 cm in November 1997 to 260 cm in November 2007. Outside the exclosure, cottonwood increased slightly in average height from 86 cm to 94 cm over the same period.

As shown in the photos comparing November 1997 to November 2007 (Figures 14 and 15), the cottonwoods within the exclosure, although few in abundance, have grown in height to a greater degree than outside the exclosure. This is likely due to the high grazing utilization of the scattered cottonwoods. This site was in close proximity to livestock loafing areas—cattle frequently moved through this area. Cottonwood and willow outside the exclosure often experienced 100 percent frequency of browse during the grazing season early in the study (Table 4, Figure 13).

Although there was a noticeable difference between the growth rates of cottonwood inside and outside of the exclosure, which suggests an impact from grazing on this species, coyote willows did not show obvious effects in the rate of growth. Heights of coyote willow have been consistently lower outside than inside over the course of the study, though these differences were not statistically compared. These differences could potentially be attributed to grazing since the frequency of browse was relatively high until 2004, around the time that numbers of livestock in the area began to decline and densities outside the exclosure increased noticeably. In any event, impacts to willows have not been severe, as heights and densities have had relatively large increases since the study began.

TABLE 4.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 3 (n=10 in; n=15 out).

	11/97		5/98		11/98		4/99		11/99		4/00		11/00		11/01		11/02	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																		
Total number	1	1	1	1	1	4	3	4	9	8	6	23	11	33	13	37	16	42
Density (m^2)	0.03	0.02	0.03	0.02	0.03	0.09	0.10	0.09	0.30	0.18	0.20	0.51	0.37	0.73	0.43	0.82	0.53	0.93
Browsed ht. (cm)	n/a	40	n/a	52	n/a	n/a	n/a	55	n/a	34	n/a	66	n/a	79.11	n/a	99	n/a	97
Unbrowsed ht. (cm)	83	n/a	83	n/a	143	58	88	n/a	123	71	162	39	80	68	133	57	154	74
Avg. ht. (cm)	83	40	83	52	143	58	88	55	123	66	162	47	80	74	133	84	154	87
Percent browsed	0%	100%	0%	100%	0%	0%	0%	100%	0%	13%	0%	30%	0%	48%	0%	65%	0%	57%
Cottonwood																		
Total number	7	1	9	6	8	8	8	5	10	5	11	7	8	2	8	11	8	6
Density (m^2)	0.23	0.02	0.30	0.13	0.27	0.18	0.27	0.11	0.33	0.11	0.37	0.16	0.27	0.04	0.27	0.24	0.27	0.13
Browsed ht. (cm)	n/a	86	n/a	40	n/a	47	n/a	50	n/a	38	n/a	n/a	n/a	89	n/a	48	n/a	60
Unbrowsed ht. (cm)	61	n/a	59	n/a	116	n/a	109	n/a	127	55	121	46	163	61	204	40	209	n/a
Avg. ht. (cm)	61	86	59	40	116	47	109	50	127	52	121	46	163	75	204	44	209	60
Percent browsed	0%	100%	0%	100%	0%	100%	0%	100%	0%	20%	0%	0%	0%	50%	0%	45%	0%	100%

TABLE 4.—Exclosure 3, cont.

	11/03		11/04		11/05		11/06		11/07	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow										
Total number	24	44	17	98	41	101	89	89	79	117
Density (m^2)	0.80	0.98	0.57	2.18	1.37	2.24	2.97	1.98	2.63	2.60
Browsed ht. (cm)	n/a	76	n/a	155	n/a	130	n/a	34	n/a	121
Unbrowsed ht. (cm)	159	77	188	102	140	130	159	148	190	156
Avg. ht. (cm)	159	76	188	103	140	130	159	147	190	146
Percent browsed	0%	57%	0%	2%	0%	31%	0%	1%	0%	27%
Cottonwood										
Total number	6	6	8	10	8	5	7	24	8	14
Density (m^2)	0.20	0.13	0.27	0.22	0.27	0.11	0.23	0.53	0.27	0.31
Browsed ht. (cm)	n/a	43	n/a	n/a	n/a	63	n/a	40	n/a	83
Unbrowsed ht. (cm)	266	44	228	51	257	88	268	84	260	94
Avg. ht. (cm)	266	44	228	51	257	83	268	82	260	93
Percent browsed	0%	33%	0%	0%	0%	20%	0%	4%	0%	7%

n/a=not present

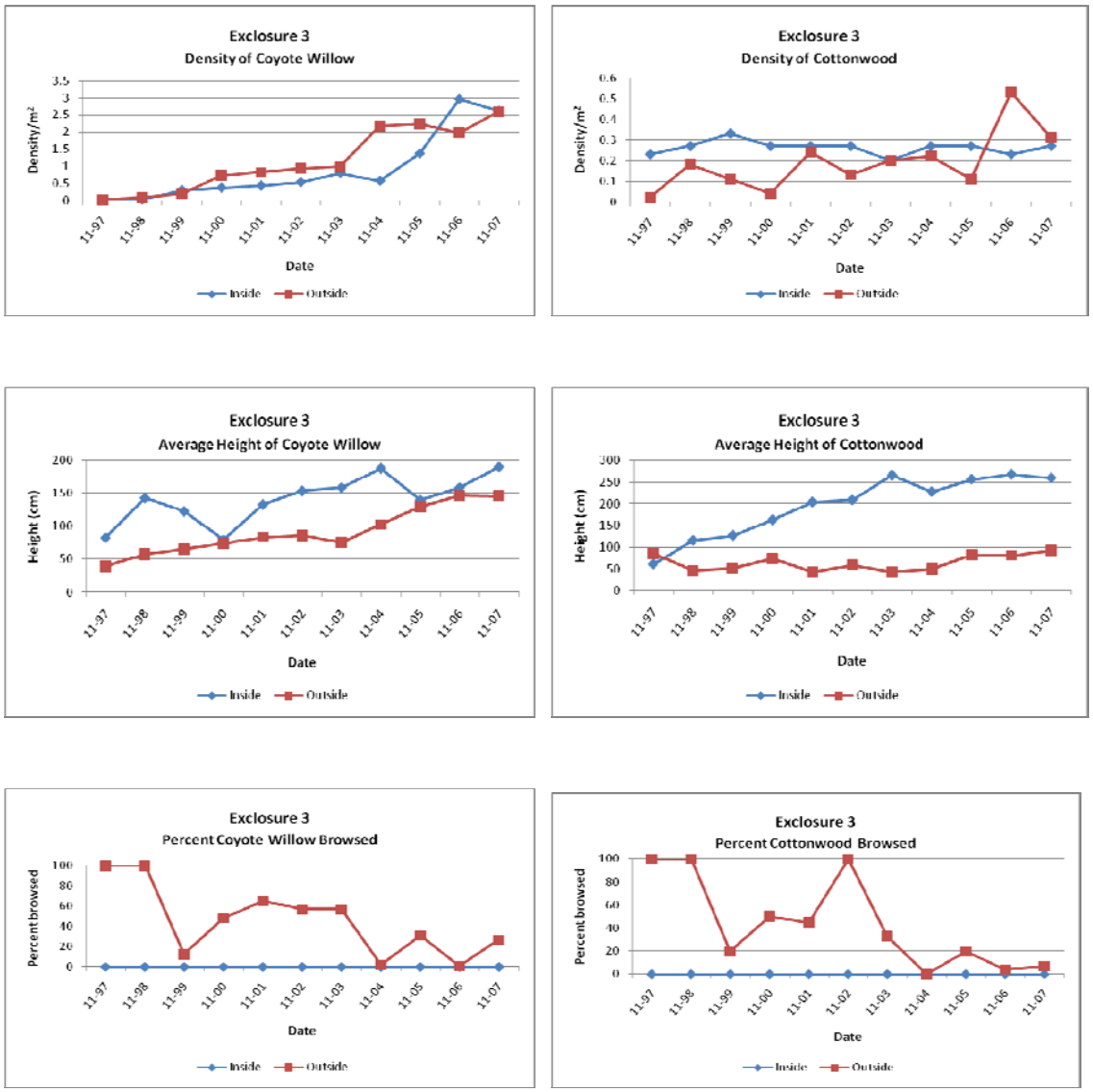

FIGURE 13.—Average height, density, and percent of browse for coyote willow and cottonwood inside and outside of Exclosure 3.

August 1997

November 2007

FIGURE 14.—Photo stations inside Exclosure 3 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 15.—Photo stations outside Exclosure 3 comparing 1997 to 2007.

Exclosure 4

In 1997, when this exclosure was established, the site was dominated by saltcedar. Although coyote willow temporarily outcompeted saltcedar from 2001 to 2005, saltcedar regained dominance following 2005. This shift in the composition of vegetation in recent years, characterized by a reversion to higher saltcedar densities, was likely caused by low flows and a degrading channel in the river that resulted in a lowered water table. Figure 16 illustrates the potential for native vegetation to outcompete saltcedar when soils and hydrology are favorable, as in the years from 2001 to 2004.

The density of coyote willow within the exclosure decreased from 2.47/m^2 in November 1997 to 1.82/m^2 in November 2007 (Table 5, Figure 17), although densities had reached a maximum of 15.65/m^2 in November of 2003 inside of the exclosure. Outside the exclosure, coyote willow densities decreased from 2.00/m^2 in November 1997 to 1.33/m^2 in November 2007. Again, densities had increased substantially to 19.78/m^2 outside the exclosure in November of 2003 before declining. As discussed above and shown in Figure 16, when coyote willow densities were at their minimum, saltcedar dominated the site, a trend that was probably influenced by a lowered water table. The height of coyote willow increased within and outside the exclosure. Inside the exclosure, the height of coyote willow increased from 102 cm to 212 cm over the study period (Table 5, Figure 17). Over the same period, the height of coyote willow outside the exclosure increased from 78 cm to 210 cm. The change in hydrology appeared to affect densities but did not affect the growth of coyote willow over the monitoring period.

No cottonwoods were found in any of the vegetation monitoring micro-plots within or outside of Exclosure 4 from 1997 to 2007 (Table 5) and therefore were not evaluated.

When the study was initiated in November 1997, the height of coyote willow inside Exclosure 4 was significantly greater than the height outside (P=0.038; Table 6). However, by November 1998 the difference in height became insignificant (P=0.138). The initial difference was likely a result of intensive browsing (70 percent frequency of browse in November of 1997), although in subsequent years extensive browsing did not appear to cause a significant reduction in height until April 2004. In April 2003, the frequency of browse was 43 percent (Table 5), which exceeded the 35 percent threshold established in 2000. Statistical analysis was not conducted immediately following this event, however data were collected inside and outside of the exclosure in July 2003, prior to the August 1 grazing period. Both height and density were found to be statistically equal (P= 0.190, P= 0.054, respectively) at that time. Thresholds were again exceeded at Exclosure 4 in April 2004, when frequency of browse reached 70 percent. Data from within and outside the exclosure were collected and analyzed. Browsing appeared to significantly reduce the overall height of coyote willow outside of this exclosure (P=0.041). However, a similar reduction in density was not indicated (P=0.103). Data were collected again in June 2004, prior to the August 1 grazing period, to determine whether the vegetation had recovered. Statistical analysis revealed that by June, the height of coyote willow outside the exclosure had reached heights of willow inside

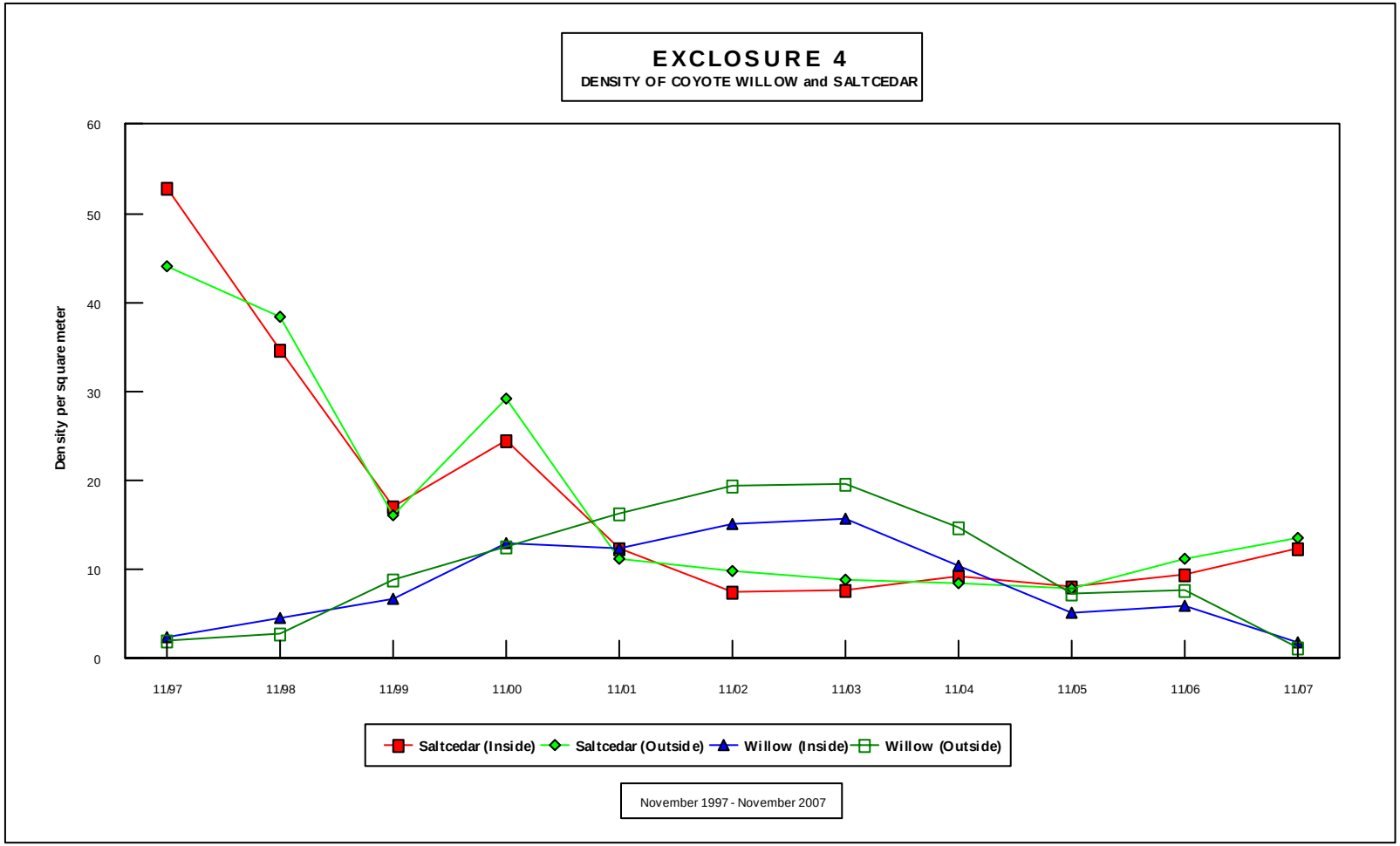

FIGURE 16.—Saltcedar and coyote willow densities inside and outside Exclosure 4, November 1997 to November 2007.

TABLE 5.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 4 (n=10, 1997–1999; n=20, 2000–2008).

	11/97		5/98		11/98		4/99		11/99		4/00		11/00		1/01		4/01		11/01	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	74	60	107	60	137	86	117	110	205	268	222	261	783	757	NC	757	NC	564	745	984
Density (m^2)	2.47	2.00	3.57	2.00	4.57	2.87	3.90	3.67	6.83	8.93	7.40	8.70	13.05	12.62	NC	12.62	NC	9.4	12.42	16.40
Browsed ht. (cm)	n/a	61	n/a	67	n/a	90	n/a	90	n/a	94	n/a	101	72	98	NC	NC	NC	93	n/a	114
Unbrowsed ht. (cm)	102	116	82	98	120	147	118	144	135	120	121	116	123	118	NC	NC	NC	123	157	142
Avg. ht. (cm)	102	78	82	77	120	125	118	116	135	118	121	115	123	116	NC	NC	NC	115	157	136
Percent browsed	0%	70%	0%	68%	0%	38%	0%	52%	0%	7%	0%	5%	0%	9%	NC	13%	NC	25%	0%	21%
Cottonwood																				
Total number	0	0	0	0	0	0	0	0	0	0	0	0	0	0	NC	0	NC	0	0	0
Density (m^2)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a
Browsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a
Unbrowsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a
Avg. ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a
Percent browsed	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a

TABLE 5.—Exclosure 4, cont.

	1/02		4/02		11/02		1/03		4/03		7/03		11/03		1/04		4/04		6/04		11/04	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	984	NC	792	903	1162	NC	1162	NC	1129	904	1210	939	1181	NC	1181	502	701	743	1187	630	885
Density (m^2)	NC	16.40	NC	13.20	15.05	19.37	NC	19.37	NC	18.82	15.07	20.17	15.65	19.68	NC	19.68	8.37	11.68	12.38	19.78	10.50	14.75
Browsed ht. (cm)	NC	NC	NC	110	57	123	NC	NC	NC	126	n/a	n/a	n/a	129	NC	NC	n/a	165	n/a	n/a	60	n/a
Unbrowsed ht. (cm)	NC	NC	NC	155	175	162	NC	NC	NC	161	178	164	183	175	NC	NC	202	181	171	152	189	177
Avg. ht. (cm)	NC	NC	NC	145	174	160	NC	NC	NC	146	178	164	183	169	NC	NC	202	170	171	152	188	177
Percent browsed	NC	22%	NC	22%	0%	4%	NC	6%	NC	43%	0%	0%	0%	12%	NC	17%	0%	70%	0%	0%	<1%	0%
Cottonwood																						
Total number	NC	0	NC	0	0	0	NC	0	NC	0	0	0	0	0	NC	0	0	0	0	0	0	0
Density (m^2)	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	n/a	n/a	NC	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	n/a	n/a	NC	NC	n/a	n/a	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	n/a	n/a	NC	NC	n/a	n/a	n/a	n/a	n/a	n/a
Avg. ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	n/a	n/a	NC	NC	n/a	n/a	n/a	n/a	n/a	n/a
Percent browsed	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	n/a	n/a	NC	n/a	n/a	n/a	n/a	n/a	n/a	n/a

TABLE 5.—Exclosure 4, cont.

	1/05		4/05		11/05		1/06		4/06		11/06		1/07		4/07		11/07		1/08		4/08	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	885	NC	545	308	442	NC	442	NC	270	362	459	NC	459	NC	192	109	80	NC	80	NC	60
Density (m^2)	NC	14.75	NC	9.08	5.13	7.37	NC	7.37	NC	4.50	6.03	7.65	NC	7.65	NC	3.2	1.82	1.33	NC	1.33	NC	1.00
Browsed ht. (cm)	NC	NC	NC	161	n/a	135	NC	NC	NC	n/a	n/a	101	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	85.0
Unbrowsed ht. (cm)	NC	NC	NC	201	229	216	NC	NC	NC	158	148	152	NC	NC	NC	175	212	210	NC	NC	NC	245.3
Avg. ht. (cm)	NC	NC	NC	201	229	208	NC	NC	NC	158	148	151	NC	NC	NC	175	212	210	NC	NC	NC	242.7
Percent browsed	NC	0%	NC	<1%	0%	10%	NC	10%	NC	0%	0%	1%	NC	1%	NC	0%	0%	0%	NC	0%	NC	2%
Cottonwood																						
Total number	NC	0	NC	0	0	0	NC	0	NC	0	0	0	NC	0	NC	0	0	0	NC	0	NC	0
Density (m^2)	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a
Browsed ht. (cm)	NC	n/a	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a
Unbrowsed ht. (cm)	NC	n/a	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a
Avg. ht. (cm)	NC	n/a	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a
Percent browsed	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a	n/a	n/a	NC	n/a	NC	n/a

n/a = not present; NC=not collected

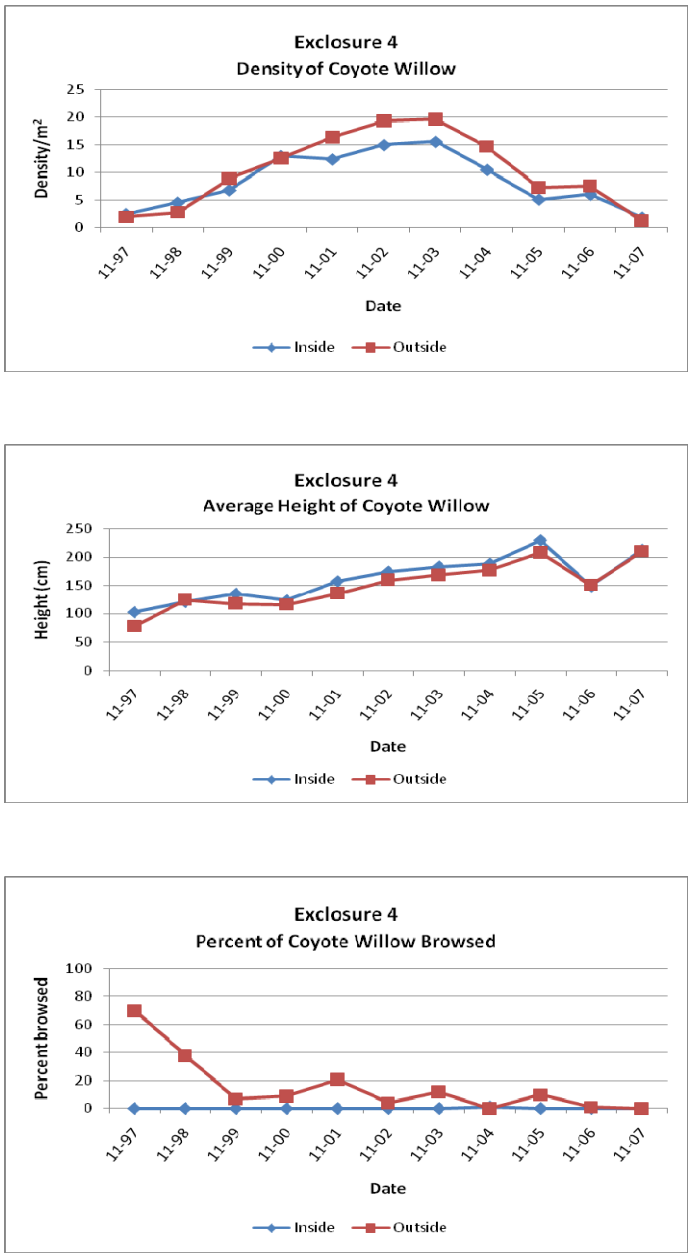

FIGURE 17.—Average height, density, and percent of browse for coyote willow inside and outside of Exclosure 4.

Note: Cottonwoods were absent inside and outside the exclosure.

TABLE 6.—Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 4. Alpha = 0.05.

	11/97	11/98	11/99	11/00	11/01	11/02	11/03	11/04	11/05	11/06	11/07
Frequency	70%	38%	7%	9%	21%	4%	12%	0%	10%	0%	0%
Height	In>Out[1] P=0.038	In=Out[1] P=0.138	In=Out[2] P=0.140	In=Out[2] P=0.223	In=Out[1] P=0.208	In=Out[1] P=0.126	In=Out[2] P=0.208	In=Out[2] P=0.588	In>Out[1] P=0.035	In=Out[1] P=0.120	In=Out[1] P=0.405
Density	In=Out[1] P=0.681	In=Out[1] P=0.119	In=Out[1] P=0.367	In=Out[1] P=0.867	In=Out[1] P=0.107	In=Out[1] P=0.109	In=Out[1] P=0.158	In=Out[1] P=0.096	In=Out[1] P=0.124	In=Out[2] P=0.515	In=Out[2] P=0.425

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

(P=0.133). However, average densities outside the exclosure significantly increased (P=0.012) during the April–June 2004 period, which may have been a response to browsing. By November 2004, both height and density were statistically equal (P=0.588 and P=0.096, respectively). Heights were again greater inside than outside in November of 2005 (P=0.035; Table 6), but this does not appear to be an effect from grazing since the frequency of browse was low during and prior to the collection of this data set.

The photos shown in Figure 18 and Figure 19 also illustrate the dramatic changes in species composition, density, and height observed at this exclosure. No obvious livestock impacts can be seen in the photos from within and outside the exclosure.

The effects of intense livestock browsing in 1997 and 2004 had only a limited short-term effect on the height of coyote willow in the immediate area. The density of coyote willow did not show negative effects from the most intense browsing experienced at this site. Based on this observation, it appeared that livestock browsing did not result in any adverse impacts to the native vegetative community. The density of willows at this site, however, did decrease considerably from the maximum reached in 2003. This decrease was most likely caused by changes in hydrology and competition from encroaching saltcedar, which thrived under an altered hydrologic regime. The river experienced major degradation in 2005, resulting in a drop in the water table. Since then, stands of cottonwood and willow began dying off within the study area, especially within the vicinity of this exclosure, which was a noticeable impact from the lowered water table.

August 1997

November 2007

FIGURE 18.—Photo stations inside Exclosure 4 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 19.—Photo stations outside Exclosure 4 comparing 1997 to 2007.

Exclosure 5

As mentioned, this site had been cleared prior to construction of Exclosure 5 and a high water table and occasional flooding during the early spring of 1997 to 1999 were conducive to the establishment and growth of native vegetation. However, this site was not subject to overbank flooding after 1999, although the water table was likely higher than much of the surrounding area since borrow material was removed to upgrade the adjacent levee.

The density of coyote willow within and outside the exclosure dramatically increased over the past 10 years. From November 1997 to November 2007, the density of coyote willow within the exclosure increased from 1.80/m^2 to 13.35/m^2, reaching a maximum density of 23.25/m^2 in November 2002 (Table 7, Figure 20). Outside the exclosure, the density of coyote willow increased from 0.23/m^2 to 10.68/m^2 over the same period, and reached a maximum density of 17.72/m^2 in November 2003. From November 1997 to November 2007, the height of coyote willow within the exclosure increased from 57 cm to 155 cm. Over the same period, the height of coyote willow outside the exclosure increased from 58 cm to 149 cm. Coyote willow actually reached maximum heights in November 2005, when the average height inside the exclosure was 219 cm and outside the exclosure was 204 cm. Although Exclosure 5 exhibited the greatest increase in height and density of coyote willow in comparison to all other exclosures, there was still a decreasing trend occurring as the monitoring period ended. This trend was probably attributed to the aforementioned changes in hydrology that resulted in a decreasing water table.

Cottonwoods were not present within the exclosure until the 1998 growing season, when two individuals were found for an overall density of 0.07/ m^2. In November 1997, the density of cottonwood outside the exclosure was 0.07/m^2. Since then, the density of cottonwood within the exclosure has essentially remained the same at 0.08/m^2, while the density of cottonwood outside the exclosure has increased to 0.48/m^2 (Table 7, Figure 20). From November 1998 to November 2007, the height of cottonwood inside the exclosure increased from 64 cm to 183 cm. Outside the exclosure, the height of cottonwood increased from 34 cm to 213 cm. Statistical analyses of the cottonwood data were not conducted. The overall height and density of cottonwood was greater outside the exclosure throughout the study period, which does not indicate an effect from livestock grazing on this species.

The average height of coyote willow remained statistically equal between the inside and outside of Exclosure 5 throughout the course of the study (Table 8). The average density of coyote willow within and outside the exclosure has varied significantly over the past 10 years (Table 7), with densities inside the exclosure significantly greater than those outside in November of 1997, 1999, 2000, 2001, and 2005 (Table 8). It is unclear whether livestock browsing can be held directly responsible for this variation. Although livestock browsing could be considered severe in November 1997, when 100 percent of the individuals were browsed, it is important to note that only seven individuals existed at that time. From 1999 through 2001, density of coyote willow inside Exclosure 5 was

TABLE 7.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 5 (n=10, 1997–1999; n=20, 2000–2008).

	11/97		5/98		11/98		4/99		11/99		4/00		11/00		1/01		4/01		11/01	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	54	7	63	Error	128	59	107	52	341	127	273	86	1187	627	NC	627	NC	380	1037	666
Density (m^2)	1.80	0.23	2.10	Error	4.27	1.97	3.57	1.73	11.37	4.23	9.10	2.87	19.78	10.45	NC	10.45	NC	6.33	17.28	11.10
Browsed ht. (cm)	n/a	58	28	Error	n/a	101	n/a	105	n/a	87	n/a	n/a	n/a	49	NC	NC	NC	83	n/a	73
Unbrowsed ht. (cm)	57	n/a	54	Error	82	70	89	75	98	82	n/a	n/a	84	85	NC	NC	NC	83	83	91
Avg. ht. (cm)	57	58	54	Error	82	77	89	81	98	82	101	86	84	85	NC	NC	NC	83	83	88
Percent browsed	0%	100%	2%	Error	0%	22%	0%	19%	0%	8%	0%	0%	0%	1%	NC	2%	NC	5%	0%	17%
Cottonwood																				
Total number	0	2	0	Error	2	10	2	12	2	17	1	12	6	36	NC	36	NC	34	10	33
Density (m^2)	n/a	0.07	n/a	Error	0.07	0.33	0.07	0.40	0.07	0.57	0.03	0.40	0.10	0.60	NC	0.60	NC	0.57	0.17	0.55
Browsed ht. (cm)	n/a	33	n/a	Error	n/a	67	n/a	55	n/a	82	n/a	110	n/a	69	NC	NC	NC	93	n/a	94
Unbrowsed ht. (cm)	n/a	34	n/a	Error	64	52	65	50	93	93	84	113	88	97	NC	NC	NC	100	91	112
Avg. ht. (cm)	n/a	34	n/a	Error	64	57	65	55	93	91	84	113	88	94	NC	NC	NC	98	91	107
Percent browsed	n/a	50%	n/a	Error	0%	30%	0%	92%	0%	18%	0%	8%	0%	11%	NC	17%	NC	21%	0%	30%

TABLE 7.—Exclosure 5, cont.

	1/02		4/02		11/02		1/03		4/03		7/03		11/03		1/04		4/04		6/04		11/04	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	666	NC	583	1395	1054	NC	1054	1240	872	1527	1277	1376	1063	NC	1063	1018	674	1415	1224	1160	887
Density (m^2)	NC	11.10	NC	9.72	23.25	17.57	NC	17.57	20.67	14.53	25.45	21.28	22.93	17.72	NC	17.72	16.97	11.23	23.58	20.40	19.33	14.78
Browsed ht. (cm)	NC	NC	NC	70	90	90	NC	NC	n/a	105	n/a	n/a	n/a	109	NC	NC	52	121	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	NC	NC	NC	94	111	105	NC	NC	117	93	120	113	128	126	NC	NC	147	102	147	119	172	149
Avg. ht. (cm)	NC	NC	NC	89	111	104	NC	NC	117	98	120	113	128	125	NC	NC	147	117	147	119	172	149
Percent browsed	NC	17%	NC	23%	0%	5%	NC	10%	0%	40%	0%	0%	0%	7%	NC	11%	<1%	79%	0%	0%	0%	0%
Cottonwood																						
Total number	NC	33	NC	36	7	49	NC	49	7	41	9	51	9	52	NC	52	6	38	24	81	20	50
Density (m^2)	NC	0.55	NC	0.60	0.12	0.82	NC	0.82	0.12	0.68	0.15	0.85	0.15	0.87	NC	0.87	0.10	0.63	0.40	1.35	0.33	0.83
Browsed ht. (cm)	NC	NC	NC	77	n/a	63	NC	NC	n/a	116	n/a	n/a	n/a	186	NC	NC	n/a	130	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	NC	NC	NC	96	125	97	NC	NC	132	110	143	113	119	109	NC	NC	148	107	102	100	130	145
Avg. ht. (cm)	NC	NC	NC	91	125	97	NC	NC	132	110	143	113	119	110	NC	NC	148	115	102	100	130	145
Percent browsed	NC	30%	NC	28%	0%	2%	NC	2%	0%	5%	0%	0%	0%	2%	NC	2%	0%	34%	0%	0%	0%	0%

TABLE 7.—Exclosure 5, cont.

	1/05		4/05		11/05		1/06		4/06		11/06		1/07		4/07		11/07		1/08		4/08	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	887	NC	729	782	587	NC	587	NC	505	975	838	NC	838	NC	452	801	641	NC	641	NC	189
Density (m^2)	NC	14.78	NC	12.15	13.03	9.78	NC	9.78	NC	8.42	16.25	13.97	NC	13.97	NC	7.53	13.35	10.68	NC	10.68	NC	3.15
Browsed ht. (cm)	NC	NC	NC	132	n/a	77	NC	NC	NC	78	n/a	80	NC	NC	NC	80	n/a	58	NC	NC	NC	77.0
Unbrowsed ht. (cm)	NC	NC	NC	173	219	205	NC	NC	NC	208	122	131	NC	NC	NC	157	155	150	NC	NC	NC	178.3
Avg. ht. (cm)	NC	NC	NC	173	219	204	NC	NC	NC	207	122	125	NC	NC	NC	151	155	149	NC	NC	NC	175.6
Percent browsed	NC	0%	NC	<1%	0%	<1%	NC	<1%	NC	<1%	0%	12%	NC	12%	NC	8%	0%	1%	NC	1%	NC	3%
Cottonwood																						
Total number	NC	50	NC	26	7	26	NC	26	NC	35	12	46	NC	46	NC	47	5	29	NC	29	NC	24
Density (m^2)	NC	0.83	NC	0.43	0.12	0.43	NC	0.43	NC	0.58	0.20	0.77	NC	0.77	NC	0.78	0.08	0.48	NC	0.48	NC	0.40
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	140	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a
Unbrowsed ht. (cm)	NC	NC	NC	154	206	194	NC	NC	NC	198	120	143	NC	NC	NC	164	183	213	NC	NC	NC	221.6
Avg. ht. (cm)	NC	NC	NC	154	206	194	NC	NC	NC	198	120	143	NC	NC	NC	164	183	213	NC	NC	NC	221.6
Percent browsed	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%	0%	2%	NC	2%	NC	0%	0%	0%	NC	0%	NC	0%

n/a = not present; NC=not collected

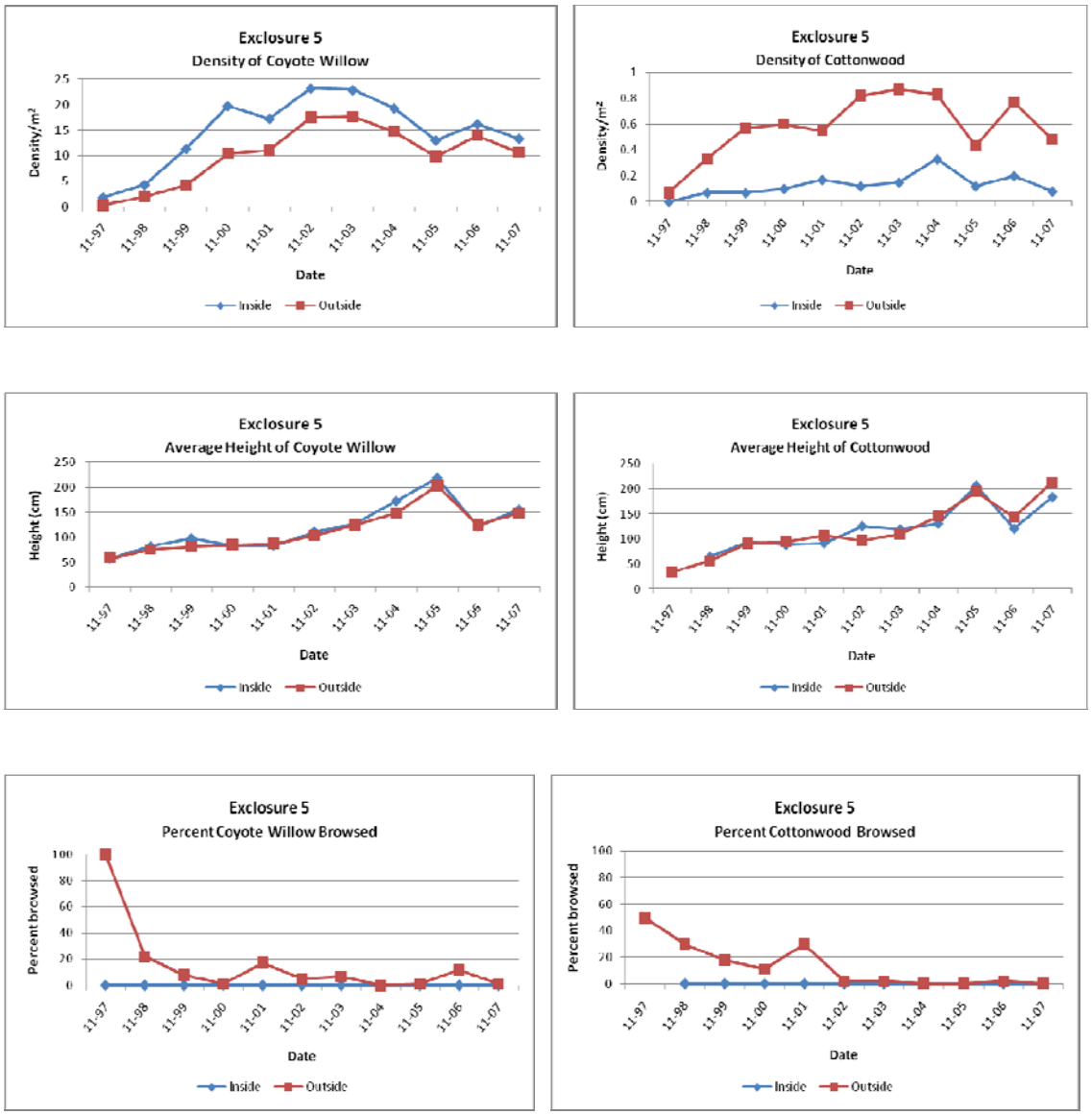

FIGURE 20.—Average height, density, and percent of browse for coyote willow and cottonwood inside and outside of Exclosure 5.

TABLE 8.—Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 5. Alpha = 0.05.

	11/97	11/98	11/99	11/00	11/01	11/02	11/03	11/04	11/05	11/06	11/07
Frequency	100%	22%	8%	1%	17%	5%	7%	0%	1%	12%	1%
Height	In=Out[2] P=0.052	In=Out[1] P=0.943	In=Out[2] P=0.273	In=Out[1] P=0.413	In=Out[1] P=0.712	In=Out[1] P=0.220	In=Out[1] P=0.208	In=Out[1] P=0.070	In=Out[1] P=0.357	In=Out[1] P=0.271	In=Out[2] P=0.636
Density	In>Out[2] P=0.020	In=Out[2] P=0.053	In>Out[1] P=0.004	In>Out[1] P=0.002	In>Out[1] P=0.012	In=Out[1] P=0.096	In=Out[1] P=0.101	In=Out[1] P=0.064	In>Out[1] P=0.028	In=Out[1] P=0.298	In=Out[1] P=0.161

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

significantly greater than density outside, even when browsing frequencies ranged from only 1 to 17 percent.

Certain intensive browsing events, such as those experienced in April 2003 and April 2004, were clearly linked to very short-term livestock impacts. During the April 2003 data collection period, the browse thresholds were exceeded (40 percent), and the densities were significantly greater inside than outside the exclosure (P=0.029). The height of vegetation outside the exclosure was also significantly reduced (P=0.008). A follow-up data collection effort in July 2003, prior to the August 1 grazing period, indicated that the height and density of vegetation surrounding Exclosure 5 had recovered and was statistically equal to that within the exclosure (P=0.766 and P=0.242, respectively). The threshold was again exceeded in April 2004. Data analysis indicated that the 79 percent frequency of browse that had occurred over the grazing period (August 2003 to April 2004) had significantly reduced both height and density outside the exclosure (P=0.002 and P=0.003, respectively). Another follow-up collection effort in June 2004 showed that both height and density outside the exclosure had recovered and were statistically equal to inside the exclosure (P=0.093 and P=0.361, respectively).

The photos in Figures 21 and 22 may suggest a lower density of vegetation outside the exclosure when compared to that within the exclosure, although differences in the overall height of the vegetation are less apparent.

Analyses of data collected from Exclosure 5 indicated that excessive livestock browsing (>35 percent frequency) may result in a significant reduction in height and density in the short term. However, if adequate hydrologic conditions exist, as they did prior to 2005, and further stress on the vegetation is eliminated, the vegetation can quickly recover. Results in November 2005, when significant differences between inside and outside of the exclosure were found, did not appear to be caused by livestock browsing, which occurred at a frequency of only 1 percent that year. Nor did they appear to be linked to the degradation of the river channel that occurred that year since decreases in the density of willows at the site were not experienced at the same rate. Also, there was an increase in the actual densities both inside and outside of the exclosure the following year, which did not appear to indicate an effect from lack of hydrology. Unexplainably, the average

August 1997

November 2007

FIGURE 21.—Photo stations inside Exclosure 5 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 22.—Photo stations outside Exclosure 5 comparing 1997 to 2007.

density of coyote willow outside of the exclosure returned to that inside the exclosure for the remainder of the study. Regardless of the reasons for this phenomenon, there were no significant long-term effects from grazing based on results at the conclusion of monitoring.

Exclosure 6

Although saltcedar was originally the dominant species at this site, native vegetation dominated when monitoring ended. Figure 23 illustrates the potential for native vegetation to outcompete saltcedar when soils and hydrology are favorable, conditions that have apparently prevailed since 2001. There was generally a decreasing trend in willow densities since 2003, although this trend was not in conjunction with increasing saltcedar densities, which remained low.

The density of coyote willow within and outside the exclosure increased over the 10-year study period. From November 1997 to November 2007, the density of coyote willow within the exclosure increased from 1.93/m^2 to 8.75/m^2, with a maximum average density of 11.65/m^2 in November 2006 (Table 9, Figure 24). Outside the exclosure, the density of coyote willow increased from 2.60/m^2 to 7.15/m^2 over the same period, reaching a maximum average density of 15.95/m^2 in November 2003. From November 1997 to November 2007, the height of coyote willow within the exclosure increased from 64 cm to 133 cm. Over the same period, the height of coyote willow outside the exclosure increased from 80 cm to 114 cm. Willows actually reached maximum heights both inside and outside the exclosure, at 158 cm and 166 cm, respectively, in November 2005.

In November 1997, the density of cottonwood inside the exclosure was 0.10/m^2 (Table 9, Figure 24). Since then, the density of cottonwood within the exclosure decreased to 0.03/m^2. Cottonwoods were not present outside the exclosure until November 2000, when 14 individuals were detected for an overall density of 0.23/m^2. The density of cottonwood outside the exclosure remained the same at 0.22/m^2. From November 2000 to November 2007, the height of cottonwood inside the exclosure increased from 41 cm to 206 cm. Outside the exclosure, the height of cottonwood increased from 106 cm to 165 cm from 1997 to 2007. A statistical comparison of cottonwood data was not conducted. There was no observable correlation between average heights and densities and browsing frequencies over the years.

The photos in Figures 25 and 26 suggest no visible differences in vegetative height or density between the inside and outside of the exclosure. However, overall increases in both height and density from 1997 to 2007 are apparent in the photos.

This particular site consistently experienced relatively low frequency of browse on coyote willow, ranging from 0 percent to 13 percent as measured during the November collection periods (Table 10). No significant impacts to either height or density of the coyote willow community were shown at this site when browsing fell within this range ($P>0.05$; Table 10). In November 2002, both the average height and density of coyote willow outside the exclosure were greater than within the exclosure ($P=0.018$ and $P=0.031$, respectively). The cause for a greater height and density among browsed

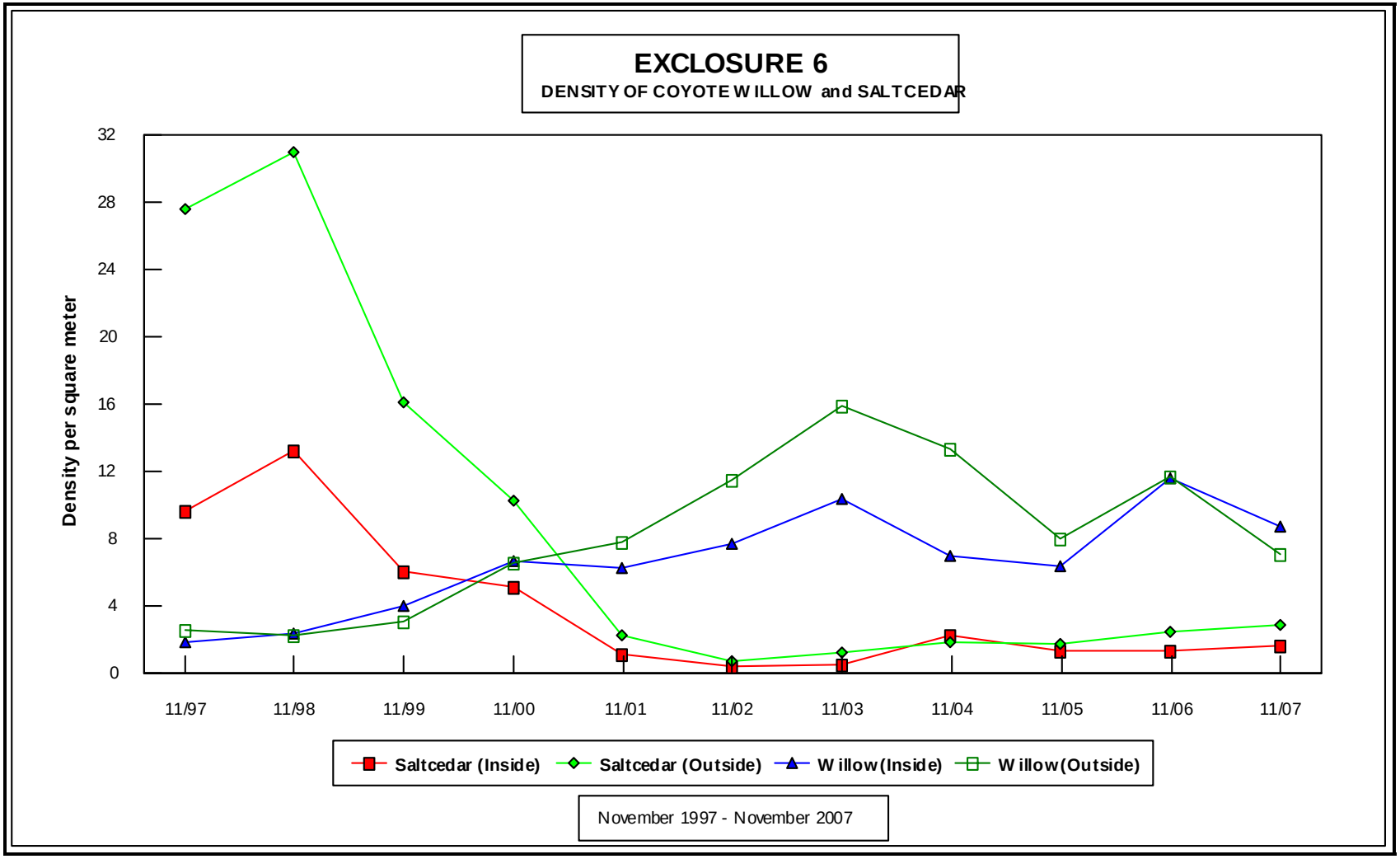

FIGURE 23.—Saltcedar and coyote willow densities inside and outside Exclosure 6, November 1997 to November 2007.

TABLE 9.—Measurements for coyote willow and cottonwood inside and outside of Exclosure 6 (n=10, 1997–1999; n=20, 2000–2008).

	11/97		5/98		11/98		4/99		11/99		4/00		11/00		1/01		4/01		11/01	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																				
Total number	58	78	67	64	71	70	83	60	120	94	144	116	400	399	NC	399	NC	311	381	468
Density (m^2)	1.93	2.60	2.23	2.13	2.37	2.33	2.77	2.00	4.00	3.13	4.80	3.87	6.67	6.65	NC	6.65	NC	5.18	6.35	7.80
Browsed ht. (cm)	n/a	87	n/a	89	n/a	178	n/a	164	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	70	n/a	78
Unbrowsed ht. (cm)	64	79	74	87	135	141	115	135	124	140	117	131	103	115	NC	NC	NC	119	104	122
Avg. ht. (cm)	64	80	74	87	135	142	115	137	124	140	117	131	103	115	NC	NC	NC	117	104	116
Percent browsed	0%	6%	0%	8%	0%	3%	0%	8%	0%	0%	0%	0%	0%	0%	NC	2%	NC	4%	0%	12%
Cottonwood																				
Total number	3	0	3	0	3	0	3	0	3	0	3	0	17	14	NC	14	NC	14	8	11
Density (m^2)	0.10	n/a	0.10	n/a	0.10	n/a	.10	n/a	0.10	n/a	0.10	n/a	0.28	0.23	NC	0.23	NC	0.23	0.13	0.18
Browsed ht. (cm)	n/a	n/a	34	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	n/a
Unbrowsed ht. (cm)	41	n/a	42	n/a	70	n/a	67	n/a	82	n/a	82	n/a	77	106	NC	NC	NC	111	96	132
Avg. ht. (cm)	41	n/a	42	n/a	70	n/a	67	n/a	82	n/a	82	n/a	77	106	NC	NC	NC	111	96	132
Percent browsed	0%	n/a	33%	n/a	0%	n/a	0%	n/a	0%	n/a	0%	n/a	0%	0%	NC	0%	NC	0%	0%	0%

TABLE 9.—Exclosure 6, cont.

	1/02		4/02		11/02		1/03		4/03		7/03		11/03		1/04		4/04		6/04		11/04	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	468	NC	407	466	691	NC	691	453	756	614	969	622	957	NC	957	360	650	475	858	424	802
Density (m^2)	NC	7.80	NC	6.78	7.77	11.52	NC	11.52	7.55	12.60	10.23	16.15	10.37	15.95	NC	15.95	6.00	10.83	7.92	14.3	7.07	13.37
Browsed ht. (cm)	NC	NC	NC	99	n/a	93	NC	NC	n/a	115	n/a	n/a	n/a	100	NC	NC	31	114	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	NC	NC	NC	122	102	125	NC	NC	103	118	103	115	104	118	NC	NC	120	109	109	119	130	127
Avg. ht. (cm)	NC	NC	NC	119	102	124	NC	NC	103	116	103	115	104	116	NC	NC	119	112	109	119	130	127
Percent browsed	NC	12%	NC	14%	0%	2%	NC	6%	0%	41%	0%	0%	0%	13%	NC	19%	1%	62%	0%	0%	0%	0%
Cottonwood																						
Total number	NC	11	NC	10	11	6	NC	6	7	8	8	9	10	9	NC	9	4	3	6	13	1	14
Density (m^2)	NC	0.18	NC	0.17	0.18	0.10	NC	0.10	0.12	0.13	0.13	0.15	0.17	0.15	NC	0.15	0.07	0.05	0.10	0.22	0.02	0.23
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	n/a	n/a	n/a	n/a	n/a	110	NC	NC	n/a	145	n/a	n/a	n/a	n/a
Unbrowsed ht. (cm)	NC	NC	NC	138	71	168	NC	NC	87	155	74	159	90	164	NC	NC	95	n/a	80	96.5	147	123
Avg. ht. (cm)	NC	NC	NC	138	71	168	NC	NC	87	155	74	159	90	158	NC	NC	95	145	80	96.5	147	123
Percent browsed	NC	0%	NC	0%	0%	0%	NC	0%	0%	0%	0%	0%	0%	11%	NC	11%	0%	100%	0%	0%	0%	0%

TABLE 9.—Exclosure 6, cont.

	1/05		4/05		11/05		1/06		4/06		11/06		1/07		4/07		11/07		1/08		4/08	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Coyote willow																						
Total number	NC	802	NC	619	382	485	NC	485	NC	486	699	706	NC	706	NC	402	525	429	NC	429	NC	150
Density (m^2)	NC	1337	NC	10.32	6.37	8.08	NC	8.08	NC	8.10	11.65	11.77	NC	11.77	NC	6.70	8.75	7.15	NC	7.15	NC	2.50
Browsed ht. (cm)	NC	NC	NC	88	n/a	n/a	NC	NC	NC	162	n/a	70	NC	NC	NC	68	48	67	NC	NC	NC	65.9
Unbrowsed ht. (cm)	NC	NC	NC	139	158	166	NC	NC	NC	169	115	106	NC	NC	NC	120	134	115	NC	NC	NC	134.6
Avg. ht. (cm)	NC	NC	NC	138	158	166	NC	NC	NC	169	115	104	NC	NC	NC	116	133	114	NC	NC	NC	129.5
Percent browsed	NC	0%	NC	1%	0%	0%	NC	0%	NC	<1%	0%	6%	NC	6%	NC	7%	2%	1%	NC	1%	NC	7%
Cottonwood																						
Total number	NC	14	NC	9	1	5	NC	5	NC	5	1	8	NC	8	NC	8	2	13	NC	13	NC	11
Density (m^2)	NC	0.23	NC	0.15	0.02	0.08	NC	0.08	NC	0.08	0.02	0.13	NC	0.13	NC	0.13	0.03	0.22	NC	0.22	NC	0.18
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	102	NC	NC	NC	104	n/a	n/a	NC	NC	NC	n/a
Unbrowsed ht. (cm)	NC	NC	NC	127	153	199	NC	NC	NC	203	154	168	NC	NC	NC	170	206	165	NC	NC	NC	145.2
Avg. ht. (cm)	NC	NC	NC	127	153	199	NC	NC	NC	203	154	143	NC	NC	NC	145	206	165	NC	NC	NC	145.2
Percent browsed	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%	0%	38%	NC	38%	NC	0%	0%	0%	NC	0%	NC	0%

n/a = not present; NC=not collected

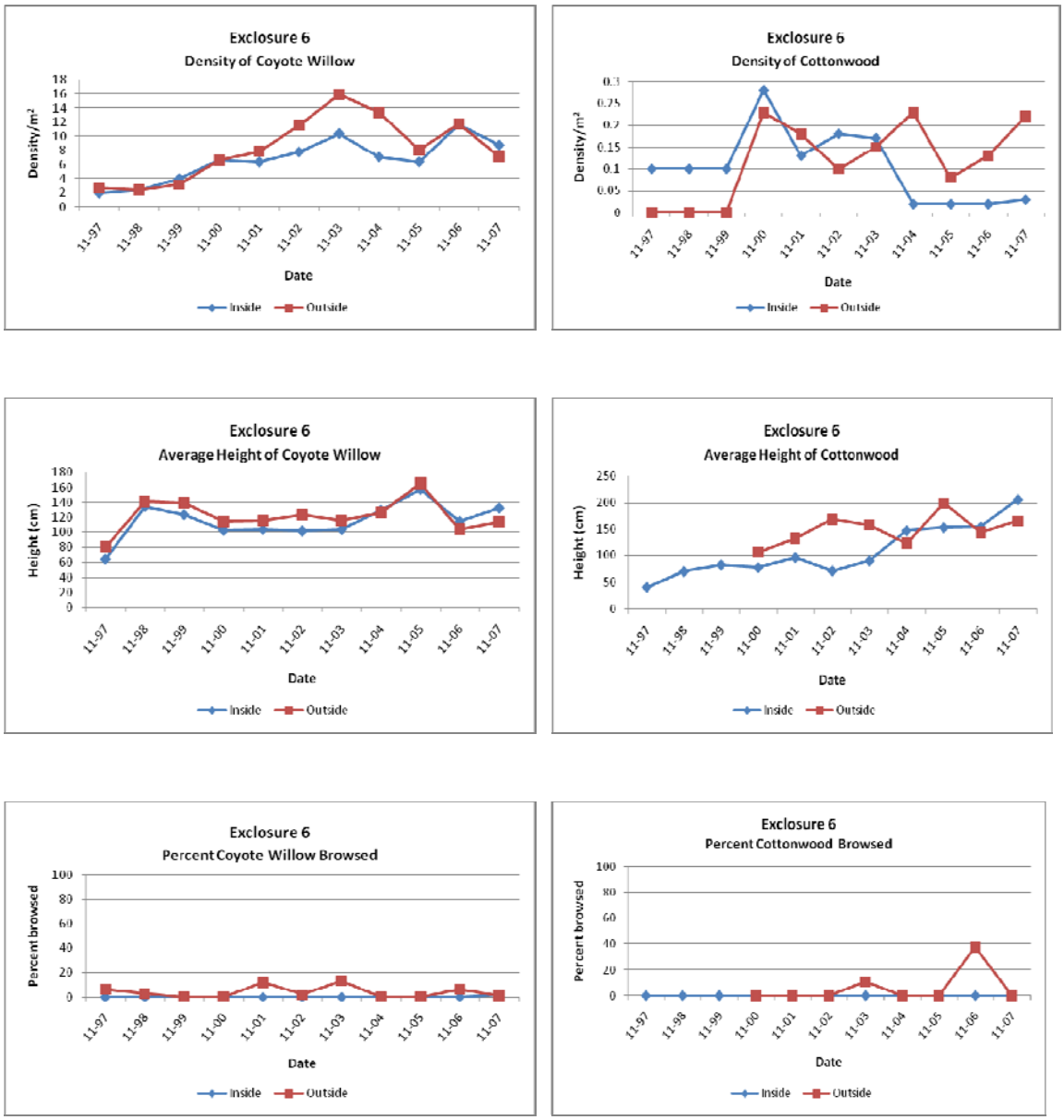

FIGURE 24.—Average height, density, and percent of browse for coyote willow and cottonwood inside and outside of Exclosure 6.

August 1997

November 2007

FIGURE 25.—Photo stations inside Exclosure 6 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 26.—Photo stations outside Exclosure 6 comparing 1997 to 2007.

TABLE 10.—Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 6. Alpha = 0.05.

	11/97	11/98	11/99	11/00	11/01	11/02	11/03	11/04	11/05	11/06	11/07
Frequency	6%	3%	0%	0%	12%	2%	13%	0%	0%	6%	1%
Height	In=Out[1] P=0.704	In=Out[1] P=0.289	In=Out[1] P=0.788	In=Out[1] P=0.262	In=Out[1] P=0.474	In<Out[1] P=0.018	In=Out[1] P=0.155	In=Out[1] P=0.471	In=Out[1] P=0.265	In=Out[1] P=0.943	In=Out[2] P=0.076
Density	In=Out[2] P=0.784	In=Out[1] P=0.978	In=Out[2] P=0.304	In=Out[1] P=0.992	In=Out[2] P=0.140	In<Out[2] P=0.031	In=Out[2] P=0.053	In<Out[2] P=0.007	In=Out[2] P=0.116	In=Out[2] P=0.745	In=Out[2] P=0.323

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

vegetation was not clearly evident. During the April 2002 data collection period, 14 percent of the individual coyote willow was browsed, reflecting the cumulative frequency of browse beginning in August 2001 when the 9-month livestock grazing season began. Since the greatest frequency of browse (14 percent) that was not in excess of the threshold corresponds to the following year's (November 2002) difference in height and growth, these data suggested that limited browsing may have been a factor in the increases. Limited browsing can stimulate growth.

The frequency of browse at Exclosure 6 was 41 percent in April 2003, which exceeded the 35 percent threshold. This level of browsing reduced the overall height of coyote willow outside the exclosure, so that it was statistically equal to inside the exclosure (P= 0.209). The density of willow outside the exclosure remained greater than within the exclosure (P=0.038), which did not signify a change from the November 2002 data collection period. Although the height of coyote willow was statistically equal inside and outside the exclosure in April 2003, the change from statistical results in November 2002 appeared to support intensive browsing as a factor in the overall reduction in height. A follow-up collection effort in July 2003 indicated similar results to those found in April.

In April 2004, the threshold of 35 percent was again exceeded and the overall height of coyote willows was reduced, however not to a significant degree. Densities were significantly greater outside the exclosure. A follow-up collection effort in June 2004 revealed the same statistical results as found during the April 2004 period and these results carried over into the November 2004 collection period.

There was no evidence to suggest that livestock browsing resulted in any adverse long-term impacts to the developing native vegetation community. Actually, livestock browsing that did occur appeared to have favorable effects by temporarily increasing heights and/or densities of willows that were browsed.

Exclosure 7

During the May 1998 data collection period, much of the site was inundated by high reservoir levels, and only 6 of 10 inside vegetation monitoring micro-plots and 3 of 12 outside vegetation monitoring micro-plots were measured and recorded. Although

Goodding's willow was dominant and coyote willow was absent from the vicinity of Exclosure 7 in 1997, coyote willow became established in 1999 and was the dominant species in November 2007 (Table 11).

The density of Goodding's willow within and outside the exclosure steadily increased from November 1997 to November 1998 (Table 11, Figure 27). Since November 1998, the density steadily decreased as Goodding's willow died and coyote willow became more prevalent. The reduction in Goodding's willow densities was probably attributed to changes in hydrology due to the receding reservoir levels brought on by recent drought conditions. Goodding's willow appears to be an obligate phreatophyte that requires permanently available shallow ground water (Busch et al. 1992; Horton et al. 2001). The density of Goodding's willow within the exclosure decreased considerably from 17.60/m^2 in November 1997 to 0.05/m^2 in November 2007, with a maximum density of 27.13/m^2 in November 1998. During the same period, the density of Goodding's willow outside the exclosure decreased from 18.14/m^2 to 0.18/m^2 after reaching a maximum of 31.36/m^2 in 1998. While the densities decreased, the height of Goodding's willow within and outside the exclosure increased. The height of Goodding's willow within the exclosure increased from 47 cm in November 1997 to 127 cm in November 2007. Over the same period, the height of Goodding's willow outside the exclosure increased from 48 cm to 71 cm (Table 11, Figure 27).

As previously mentioned, coyote willow was absent from the site until April 1999. From April 1999 to November 2007, the density of coyote willow within the exclosure increased from 0.13/m^2 to 1.62 /m^2. Outside the exclosure, during the same period, coyote willow increased from 0.06/m^2 to 0.97/m^2 (Table 11, Figure 27). The average height of coyote willow within the exclosure increased from 126 cm to 151 cm from April 1999 to November 2007. Outside the exclosure, the height of coyote willow increased from 26 cm to 68 cm over the same period.

Cottonwoods increased slightly in density and more dramatically in height from November 1997 to November 2007 (Table 11, Figure 27). Within the exclosure, cottonwood density increased from 0.43 /m^2 to 0.87/m^2, while outside the exclosure the density of cottonwood remained the same at 0.47/m^2. The height of cottonwood within the exclosure increased from 48 cm in November 1997 to 220 cm in November 2007. Outside the exclosure the height of cottonwood increased from 49 cm to 258 cm over the same period.

The photos shown in Figure 28 and Figure 29 also reveal the increases in height and the "overstory" dominance of cottonwood both within and outside the exclosure. No obvious livestock browsing impacts can be seen in the photographs.

Exclosure 7 experienced only limited livestock browsing until November 2004. As shown in Table 11, the frequency of browse on Goodding's willow outside the exclosure ranged from 0 percent in November 1997 to as high as 27 percent in April 1999.

TABLE 11.—Measurements for Goodding's willow, coyote willow, and cottonwood inside and outside of Exclosure 7 (n=10, 1997–1999; n=20, 2000–2008).

	11/97		5/98		11/98		4/99		11/99		4/00		11/00		1/01		4/01		6/01	
	In	Out	In	Out	In	Out	In	Out	In	In	Out	Out	In	Out	In	Out	In	Out	In	Out
Goodding's willow																				
Total number	528	653	443[1]	178[2]	814	1129	575	753	640	903	421	600	1366	1278	NC	1278	NC	678	NC	770
Density (m^2)	17.60	18.14	24.61	19.78	27.13	31.36	19.17	20.92	21.33	25.08	14.03	16.67	22.77	21.30	NC	21.30	NC	11.30	NC	12.83
Browsed ht. (cm)	n/a	36	n/a	29	n/a	67	n/a	60	n/a	n/a	n/a	28	64	72	NC	NC	NC	61	NC	73
Unbrowsed ht. (cm)	47	48	41	37	89	82	98	101	98	89	109	97	87	91	NC	NC	NC	98	NC	84
Avg. ht. (cm)	47	48	41	37	89	81	98	90	98	89	109	97	87	91	NC	NC	NC	97	NC	84
Percent browsed	0%	0%	0%	4%	0%	8%	0%	27%	0%	0%	0%	0%	0%	2%	NC	3%	NC	2%	NC	0%
Coyote willow																				
Total number	0	0	0	0	0	0	4	2	19	61	19	34	130	131	NC	131	NC	118	NC	135
Density (m^2)	0	0	0	0	0	0	0.13	0.06	0.63	1.69	0.63	0.94	2.17	2.18	NC	2.18	NC	1.97	NC	2.25
Browsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	75	n/a	37	n/a	49	NC	NC	NC	70	NC	n/a
Unbrowsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	126	26	108	88	115	92	106	92	NC	NC	NC	102	NC	96
Avg. ht. (cm)	n/a	n/a	n/a	n/a	n/a	n/a	126	26	108	88	115	90	106	91	NC	NC	NC	98	NC	96
Percent browsed	n/a	n/a	n/a	n/a	n/a	n/a	0%	0%	0%	2%	0%	3%	0%	2%	NC	15%	NC	14%	NC	0%
Cottonwood																				
Total number	13	17	6[1]	0[2]	22	19	19	20	25	22	21	22	68	59	NC	59	NC	36	NC	39
Density (m^2)	0.43	0.47	0.33	n/a	0.73	0.53	0.63	0.56	0.83	0.61	0.70	0.61	1.13	0.98	NC	0.98	NC	0.60	NC	0.65
Browsed ht. (cm)	n/a	n/a	n/a	n/a	n/a	93	n/a	67	n/a	n/a	n/a	n/a	n/a	n/a	NC	NC	NC	n/a	NC	0
Unbrowsed ht. (cm)	48	49	38	n/a	71	79	76	77	117	123	112	103	108	121	NC	NC	NC	154	NC	173
Avg. ht. (cm)	48	49	38	n/a	71	80	76	76	117	123	112	103	108	121	NC	NC	NC	154	NC	173
Percent browsed	0%	0%	0%	0%	0%	5%	0%	10%	0%	0%	0%	0%	0%	0%	NC	3%	NC	0%	NC	0%

[1] - 4 out of 10 vegetation monitoring plots were flooded and were not recorded
[2] - 9 out of 12 vegetation monitoring plots were flooded and were not recorded
(Note: On 5/98 only 6 inside and 3 outside vegetation monitoring plots were measured due to high reservoir elevations)

TABLE 11.—Exclosure 7, cont.

	11/01		1/02		4/02		11/02		1/03		4/03		11/03		1/04		4/04		11/04	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Goodding's willow																				
Total number	631	730	NC	730	NC	411	171	325	NC	325	NC	246	125	163	NC	163	NC	65	46	125
Density (m^2)	10.52	12.17	NC	12.17	NC	6.85	2.85	5.42	NC	5.42	NC	4.10	2.08	2.72	NC	2.72	NC	1.08	0.77	2.08
Browsed ht. (cm)	0	75	NC	NC	NC	26	n/a	47	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	38	n/a	59
Unbrowsed ht. (cm)	88	96	NC	NC	NC	97	81	70	NC	NC	NC	83	104	97	NC	NC	NC	69	90	72
Avg. ht. (cm)	88	96	NC	NC	NC	97	81	70	NC	NC	NC	83	104	97	NC	NC	NC	68	90	72
Percent browsed	0%	4%	NC	4%	NC	0%	0%	0%	NC	2%	NC	0%	0%	0%	NC	0%	NC	3%	0%	5%
Coyote willow																				
Total number	90	165	NC	165	NC	162	161	259	NC	259	NC	177	145	334	NC	334	NC	121	134	169
Density (m^2)	1.50	2.75	NC	2.75	NC	2.70	2.68	4.32	NC	4.32	NC	2.95	2.42	5.57	NC	5.57	NC	2.02	2.23	2.82
Browsed ht. (cm)	n/a	88	NC	NC	NC	79	n/a	55	NC	NC	NC	78	n/a	50	NC	NC	NC	66	35	62
Unbrowsed ht. (cm)	131	92	NC	NC	NC	99	118	78	NC	NC	NC	86	129	82	NC	NC	NC	82	135	85
Avg. ht. (cm)	131	91	NC	NC	NC	93	118	77	NC	NC	NC	85	129	82	NC	NC	NC	82	134	74
Percent browsed	0%	21%	NC	22%	NC	30%	0%	5%	NC	14%	NC	10%	0%	1%	NC	6%	NC	2%	<1%	49%
Cottonwood																				
Total number	79	43	NC	43	NC	44	67	45	NC	45	NC	44	77	47	NC	47	NC	44	72	41
Density (m^2)	1.32	0.72	NC	0.72	NC	0.73	1.12	0.75	NC	0.75	NC	0.73	1.28	0.78	NC	0.78	NC	0.73	1.20	0.68
Browsed ht. (cm)	n/a	n/a	NC	NC	NC	140	n/a	n/a	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a	n/a	68
Unbrowsed ht. (cm)	130	184	NC	NC	NC	185	161	185	NC	NC	NC	192	161	206	NC	NC	NC	209	172	230
Avg. ht. (cm)	130	184	NC	NC	NC	181	161	185	NC	NC	NC	192	161	206	NC	NC	NC	209	172	210
Percent browsed	0%	0%	NC	0%	NC	9%	0%	0%	NC	0%	NC	0%	0%	0%	NC	0%	NC	0%	0%	12%

TABLE 11.—Exclosure 7, cont.

	1/05		4/05		11/05		1/06		4/06		11/06		1/07		4/07		11/07		1/08		4/08	
	In	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**	**In**	**Out**
Goodding's willow																						
Total number	NC	125	NC	59	19	53	NC	53	NC	27	7	31	NC	31	NC	27	3	11	NC	11	NC	10
Density (m^2)	NC	2.08	NC	0.98	0.32	0.88	NC	0.88	NC	0.45	0.12	0.52	NC	0.52	NC	0.45	0.05	0.18	NC	0.18	NC	0.17
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	51	NC	NC	NC	55	n/a	64	NC	NC	NC	79	n/a	n/a	NC	NC	NC	30.0
Unbrowsed ht. (cm)	NC	NC	NC	83	88	78	NC	NC	NC	72	97	48	NC	NC	NC	54	127	71	NC	NC	NC	75.8
Avg. ht. (cm)	NC	NC	NC	83	88	76	NC	NC	NC	69	97	50	NC	NC	NC	56	127	71	NC	NC	NC	71.2
Percent browsed	NC	5%	NC	0%	0%	6%	NC	6%	NC	15%	0%	13%	NC	13%	NC	7%	0%	0%	NC	0%	NC	10%
Coyote willow																						
Total number	NC	169	NC	103	99	141	NC	141	NC	77	96	106	NC	106	NC	73	97	58	NC	58	NC	60
Density (m^2)	NC	2.82	NC	1.72	1.65	2.35	NC	2.35	NC	1.28	1.60	1.77	NC	1.77	NC	1.22	1.62	0.97	NC	0.97	NC	1.00
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	59	NC	NC	NC	64	n/a	46	NC	NC	NC	55	n/a	51	NC	NC	NC	55.4
Unbrowsed ht. (cm)	NC	NC	NC	86	159	69	NC	NC	NC	68	145	59	NC	NC	NC	51	151	92	NC	NC	NC	69.8
Avg. ht. (cm)	NC	NC	NC	86	159	66	NC	NC	NC	66	145	53	NC	NC	NC	53	151	68	NC	NC	NC	65.7
Percent browsed	NC	49%	NC	0%	0%	32%	NC	32%	NC	48%	0%	53%	NC	53%	NC	40%	0%	57%	NC	57%	NC	28%
Cottonwood																						
Total number	NC	41	NC	36	76	47	NC	47	NC	48	66	47	NC	47	NC	34	52	28	NC	28	NC	33
Density (m^2)	NC	0.68	NC	0.60	1.27	0.78	NC	0.78	NC	0.80	1.10	0.78	NC	0.78	NC	0.57	0.87	0.47	NC	0.47	NC	0.55
Browsed ht. (cm)	NC	NC	NC	n/a	n/a	116	NC	NC	NC	n/a	n/a	52	NC	NC	NC	n/a	n/a	n/a	NC	NC	NC	n/a
Unbrowsed ht. (cm)	NC	NC	NC	236	169	210	NC	NC	NC	193	188	194	NC	NC	NC	235	220	258	NC	NC	NC	263.9
Avg. ht. (cm)	NC	NC	NC	236	169	208	NC	NC	NC	193	188	188	NC	NC	NC	235	220	258	NC	NC	NC	263.9
Percent browsed	NC	12%	NC	0%	0%	2%	NC	2%	NC	0%	0%	4%	NC	4%	NC	0%	0%	0%	NC	0%	NC	0%

n/a = not present; NC=not collected

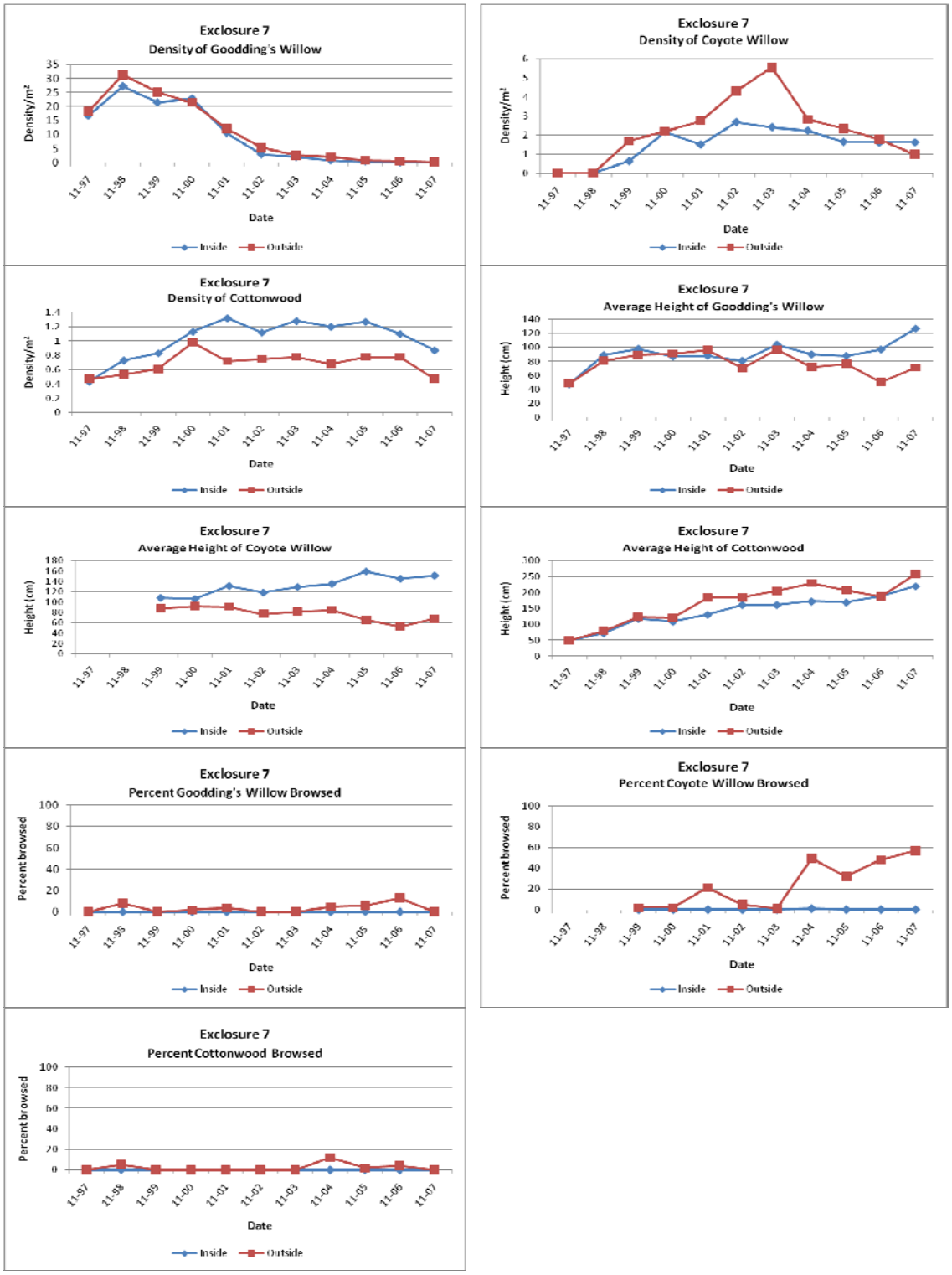

FIGURE 27.—Average height, density, and percent of browse for Goodding's willow, coyote willow, and cottonwood inside and outside of Exclosure 7.

August 1997

November 2007

FIGURE 28.—Photo stations inside Exclosure 7 comparing 1997 to 2007.

August 1997

November 2007

FIGURE 29.—Photo stations outside Exclosure 7 comparing 1997 to 2007.

Typically, the frequency of browse was less than 10 percent. After coyote willow became established in 1999, this species experienced browsing frequencies ranging from 0 percent in 1999 to as high as 57 percent in November 2007. The height of coyote willow was significantly less outside the exclosure than within since November 2002 (Table 12). The frequency of browse on this species was relatively high since November 2004, which may have had some effect on heights. However, the density of coyote willow remained statistically equal or was significantly greater outside the exclosure than inside. The height of Goodding's willow within and outside the exclosure remained statistically equal throughout the study period. Density of Goodding's willow was either significantly greater outside of the exclosure or equal between inside and outside (Table 12). Total willow (*Salix* spp.) densities were greater outside the exclosure from November 2002 to 2004 but were statistically equal in other years.

Based on the available data, there did not appear to be any significant adverse livestock browsing impacts associated with this exclosure. The higher densities of willows outside the exclosure in some years may have been attributed to limited browsing. It is difficult to determine if the shorter heights of coyote willow outside of the exclosure were correlated to heavy browsing since these differences were first documented prior to when grazing thresholds were exceeded. The overall numbers of willow and cottonwood decreased from their maximum densities over the study period. The general loss in health and vigor of the vegetation at this site was probably attributed to hydrologic changes as the reservoir receded and the river degraded, causing a lowering of the water table.

TABLE 12.—Frequency of browse (outside plots) and statistical comparison of heights and densities for *Salix* inside and outside of Exclosure 7. Alpha = 0.05.

	11/97	11/98	11/99	11/00	11/01	11/02	11/03	11/04	11/05	11/06	11/07
Goodding Frequency	1%	8%	0%	2%	4%	0.3%	0%	5%	6%	13%	0%
Coyote Frequency	n/a	n/a	2%	2%	21%	5%	1%	50%	32%	48%	57%
Goodding Height	In=Out[1] P=0.770	In=Out[1] P=0.393	In=Out[1] P=0.147	In=Out[2] P=0.114	In=Out[1] P=0.292	In=Out[2] P=0.441	In=Out[1] P=0.399	In=Out[1] P=0.778	In=Out[2] P=0.303	In=Out[2] P=0.076	In=Out[2] P=0.759
Coyote Height	n/a	n/a	In=Out[1] P=0.496	In=Out[1] P=0.921	In=Out[1] P=0.710	In>Out[2] P=0.002	In>Out[1] P=0.002	In>Out[1] P=0.027	In>Out[2] P<0.001	In>Out[1] P=0.007	In>Out[2] P=0.005
Goodding Density	In=Out[2] P=0.531	In=Out[1] P=0.529	In=Out[1] P=0.355	In=Out[1] P=0.585	In=Out[1] P=0.342	In<Out[2] P=0.009	In=Out[2] P=0.414	In<Out[2] P=0.015	In<Out[2] P=0.041	In<Out[2] P=0.016	In=Out[2] P=0.668
Coyote Density	n/a	n/a	In<Out[2] P=0.042	In=Out[2] P=0.596	In<Out[2] P=0.006	In<Out[2] P=0.033	In<Out[2] P=0.001	In=Out[2] P=0.216	In=Out[2] P=0.302	In=Out[2] P=0.712	In=Out[2] P=0.671
Total willow density	n/a	n/a	In=Out[1] P=0.238	In=Out[1] P=0.626	In=Out[1] P=0.169	In<Out[2] P=0.001	In<Out[2] P=0.001	In<Out[2] P=0.011	In=Out[2] P=0.122	In=Out[2] P=0.348	In=Out[2] P=0.956

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

Photo Stations

All photographs can be found in Appendix B. Figure 30 provides examples of photo stations that were established to document possible physical disturbance caused by grazing livestock. The photographs shown in Appendix B illustrate the vegetative changes over 10 growing seasons and 10 grazing seasons (livestock grazing was temporarily suspended from April 15, 1999 to August 1, 2000).

Several of the photo stations illustrated the potential for young vegetation to significantly increase in height and density over several growing seasons (e.g., Appendix B—Photo stations 3, 13, 19, 23, and 26).

It is difficult to visually detect any significant changes in the vegetation between photos taken inside and outside the exclosures. The lack of a noticeable difference between the photo stations established within and outside the exclosures appears to show that livestock browsing had a minimal effect on the height and density of the native vegetation over the 10-year period of study. None of the photo stations established within dense native riparian vegetation indicated any significant physical disturbance as a result of cattle trampling or browsing.

Aerial Livestock Counts

Aerial livestock counts were conducted concurrent with exclosure data collection beginning in November 2000. Additional aerial counts were conducted during the exclusion period (June 2001, July 2002, May2003, June 2004, June 2006, and July 2007) to oversee compliance with the current grazing schedule. Trespass cattle were observed and reported to the BLM.

The results of the aerial livestock counts are shown in Table 13. The total numbers shown in Table 13 reflect the number of cattle observed that were not clearly identifiable as calves. Therefore, it is likely that these values are a slight over-estimate of the actual AUMs present during the flight. The stocking rates (AUMs) for the three respective allotments are shown in Table 14. Due to the absence of physical boundaries between the three allotments through 2002, livestock moved freely from one allotment to another. In 2003, a fence between the Milligan Gulch and Scott Ranch Allotment was constructed to more effectively manage the distribution of livestock and utilization of available AUMs. Within a year of the fence being constructed, livestock numbers declined considerably within all three allotments. It appeared that the total AUMs designated for the three allotments was not exceeded. However, a disproportionate number of livestock were observed within the Scott Ranch Allotment. Livestock likely congregated in the Scott Ranch Allotment to forage due to the decreasing reservoir levels which exposed sediments suitable for the establishment of young herbaceous vegetation, as well as developing stands of native and exotic woody vegetation.

FIGURE 30.—Examples of photo stations established to document disturbance to mature vegetation.

TABLE 13.—Aerial livestock counts from November 2000 to November 2007.

Date	Bruton River Allotment	Milligan Gulch Allotment	Scott Ranch Allotment	Total
November 2000	59	25	108	192
January 2001	80	24	161	265
June 2001*	11	0	168	179
September 2001	170	21	66	257
November 2001	74	15	172	261
February 2002	98	6	362	466
April 2002	57	5	250	312
July 2002*	10	0	179	189
November 2002	88	22	168	278
January 2003	102	41	213	356
April 2003	29	5	54	88
May 2003*	13	2	154	169
November 2003	27	5	85	117
January 2004	48	17	174	239
April 2004	7	9	55	71
June 2004*	15	0	23	37
November 2004	3	1	19	23
January 2005	15	2	11	28
April 2005	7	4	36	47
December 2005	28	0	48	76
April 2006	5	0	50	55
June 2006*	0	0	49	49
December 2006	3	2	43	48
January 2007	0	0	43	43
April 2007	0	0	23	23
July 2007*	13	0	72	85
November 2007	15	2	51	68
April 2008	8	0	2	10

*Livestock were not permitted during these periods (except 25 head within Scott Ranch Allotment).

TABLE 14.—Permitted AUMs for grazing allotments.

Allotment	Total AUMs permitted on Reclamation lands	Approximate monthly AUMs based on a 9.2-month grazing season
Bruton River Allotment	1,800	196
Milligan Gulch Allotment	211	23
Scott Ranch Allotment	804	87
TOTAL	2,815	306

Fecal Analysis

The botanical composition of fecal material, as determined from microhistological analysis, for monthly samples from November 1999 through February 2001 is shown in

Table 15. When the percent relative composition of the total diet was averaged for the three sampling units (East, West, and Delta) over the entire sampling period, grasses (63 percent) were the major food items, followed by forbs (20 percent) and trees/shrubs (17 percent). The most abundant grasses in the diet were dropseed (*Sporobolus* sp.), bluegrass (*Poa* sp.), grama (*Bouteloua* sp.), and bluestem (*Andropogon* sp.), with the grasses having an overall relative percent range from 32.6 percent in February 2000 to 83.8 percent in June 2000 (Figure 31). Studies by Uresk and Lowery (1987) and Uresk and Painter (1985) consistently show a significant decrease in the cattle usage of grasses and forbs in the fall with an increase in tree and shrub utilization. This was not the case for grass utilization on this reach of the Rio Grande. The period with the most continuous extensive use of grasses occurred between June 2000 and February 2001, when the relative percentage was continuously above 60.

The dominant forbs in the cattle's diet included croton (*Croton* sp.), globemallow (*Sphaeralcea* sp.), wild buckwheat (*Eriogonum* sp.), and locoweed (*Astragalus* sp.). The overall relative percentage range for forbs was between 7.4 percent in February 2000 and 43.9 percent in May 2000. The spike of forb usage in May 2000 was primarily due to a significant increase in the intake of croton (38.7 percent).

The dominant trees and shrubs utilized were willow and mesquite (*Prosopis* sp.), with only a trace of cottonwood (*Populus* spp.) utilized in November through February. The overall relative percentage range for trees and shrubs was from 1.8 percent in June 2000 to 60.1 percent in February 2000. The spike in woody species usage in February was due to an increase in willow to 34.1 percent and mesquite to 25.7 percent. These were the highest values recorded for both species during the study period. Willow was found in 42 of 48 (87.5 percent) of the composite sampling unit results, with the average monthly relative percentage for all the sampling units being 11.4 percent (Table 16). The period of lowest willow utilization occurred between May and August 2000 when the average utilization was 2.3 percent, with a range of 1.3 to 4.4 percent. The overall dietary composition of shrubs for the entire sampling period of 17.6 percent is consistent with the findings of Uresk et al. (1984), who evaluated the percent of trees and shrubs (20 percent) from samples collected in the Black Hills of South Dakota. Several woody species that were documented at the exclosure data collections micro-plots (with less than 1 percent utilization) did not occur in the fecal analysis results. These species were saltcedar, seep willow, squaw waterweed (*Baccharis sergiloides*), and arrowweed (*Pluchea sericea*).

Lateral Browsing

Statistical differences were found in lateral cover density at Exclosure 2 from January 2004 to January 2007, where lateral cover was significantly greater inside than outside the exclosure (Table 17). Table 18 shows the average percentage of lateral cover density at Exclosures 2, 4, 5, 6, and 7 from 2004 to 2008.

The height of coyote willow within Exclosure 2 also remained statistically greater than the outside since 2001 (see Table 3). The primary reason for the lack of growth in the

TABLE 15.—Monthly botanical composition (%) of cattle diets.

Genus	Common name	Nov 1999	Dec 1999	Jan 2000	Feb 2000	Mar 2000	Apr 2000	May 2000	Jun 2000	Jul 2000	Aug 2000	Sep 2000	Oct 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001	Avg
Graminoids																		
Agropyron	Wheatgrass	1.56	2.12	0	1.74	3.62	0.95	0	0	0	0	0.28	0	0	0	1.22	1.22	0.79
Andropogon/ Schizachyrium	Bluestem	4.26	3.23	4.77	5.53	7.38	2.28	3.44	8.98	19.18	4.47	13.86	11.24	5.41	10.88	16.15	1.07	7.63
Botriochloa	Silver beardgrass	0	0	0	0	0	0	0.17	0	0	0	0	0	0	0	0	0	0.01
Bouteloua	Grama	4.79	24.17	7.07	3.13	6.57	16.13	3.85	25.64	17.86	10.73	25.63	1.15	1.75	7.55	5.71	2.48	10.26
Bromus	Brome	0	0	0	0	0	0	3.86	0.28	2.11	0.98	0.89	2.99	1.67	4.10	1.14	3.12	1.32
Carex	Sedge	0.53	4.48	0.56	2.78	0.31	0.63	0.97	1.78	4.26	0	0	0	0.78	0.28	3.24	0.29	1.31
Distichlis	Saltgrass	0	0	0	0	0.27	0	0	0	0	0	0	0	0	0	0	0	0.02
Eleocharis	Spikerush	0	0	0	0	0	0.32	1.25	3.06	7.05	0.25	0.60	1.52	1.59	0.57	0.59	1.24	1.13
Equisetum	Horsetail	0	0.32	0	0	0	3.43	1.87	1.06	0.29	0	0	0.30	4.13	2.60	0	0.90	0.93
Erioneuron	Hairy tridens	13.75	4.06	9.81	4.82	11.36	8.92	0	0	0	0	0	0	0	0	0	0	3.30
Eriophorum	Cottongrass	4.66	0.30	1.21	0	0.32	3.44	0	0	0	0	0	0	0	0	0	0	0.62
Juncus	Rush	0	0.58	0	0	0	1.85	0.84	0.24	2.32	0.31	0.31	2.20	8.57	0.59	5.73	6.26	1.86
Poa	Bluegrass	6.24	7.74	11.80	0	0.93	4.85	1.23	4.74	2.37	7.92	12.91	20.01	42.71	17.20	12.40	19.70	10.80
Poaceae family	Unidentified seed/glume	4.54	6.02	17.98	11.21	21.77	7.17	4.02	2.29	3.83	4.09	1.54	3.73	7.17	4.20	10.94	12.98	7.72
Poaceae family	Unidentified grass	0	0	0	0	0	0	0	6.77	0	0	0	0	0	2.14	0.30	0.92	0.63
Polypogon	Rabbitfoot grass	5.76	4.04	4.61	2.45	4.01	0	0	0	0	0	0	0	0	0	0	0	1.30
Sporobolus	Dropseed	0.30	1.59	0.95	0	2.09	4.06	18.20	28.31	5.23	51.49	10.62	12.05	0.89	7.70	15.25	4.07	10.18
Stipa-Oryzopsis	Needlegrass/ ricegrass	0	3.34	1.18	0.89	0.27	0	0.97	0.63	1.45	0.58	6.08	4.82	3.64	2.40	8.16	5.30	2.48
Typha	Cattail	0.30	0	0	0	0	0	0.60	0	4.14	0	0	0	0.30	1.44	0.30	2.17	0.58

Genus	Common name	Nov 1999	Dec 1999	Jan 2000	Feb 2000	Mar 2000	Apr 2000	May 2000	Jun 2000	Jul 2000	Aug 2000	Sep 2000	Oct 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001	Avg
Graminoid Total		46.69	61.98	59.94	32.55	58.90	54.04	41.27	83.78	70.08	80.83	72.71	60.01	78.61	61.64	81.13	61.72	62.87
Shrubs																		
Atriplex	Saltbush	0	2.08	0.32	0	0	0	0	0	1.49	1.25	0.28	4.62	0	0.31	0	0	0.65
Berberis	Barberry	0.30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Ephedra	Morman tea	3.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.19
Fallugia	Apache plume	0	0.31	0	0	0	0	0.61	0	0.26	0	0	0	0	0.28	0	0	0.09
Lycium	Wolfberry	0	0	0.28	0	0	0	0	0	0	0	0.30	0	0	0	0	0	0.04
Populus	Cottonwood	0	0	0	0	0	0	0	0	0.28	0	0	0	0.28	0.89	0.32	3.46	0.33
Prosopis	Mesquite	0	3.46	10.25	25.68	4.45	0	10.39	0	3.09	0	0	1.22	0	3.91	0.53	7.09	4.38
Rhus	Sumac	0.32	0.63	0	0.29	0	0	1.56	0.51	0	0.59	0.59	0	0	0	0	0.60	0.32
Salix	Willow	18.98	4.16	10.66	34.11	19.61	13.29	2.22	1.34	4.42	1.30	6.02	22.52	6.09	19.18	3.86	15.85	11.48
Yucca	Yucca	0	1.81	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11
Shrub Total		22.63	12.45	21.51	60.08	24.06	13.29	14.78	1.85	9.54	3.14	7.19	28.36	6.37	24.57	4.71	27.00	17.60
Forbs																		
Abutilon	Velvetleaf	1.50	0	0	0	0	0	0	0.23	0	0.20	0	0.92	0	0	0	0.61	0.22
Argemone	Prickly poppy	0	0	0	0	0	0	2.25	0	0	0	0	0	0	0	0	0	0.14
Aster	Aster	0	0	0	0	0	0.32	0	0.53	0	0	0	0	0	0	0	0	0.05
Asteraceae family	Unidentified plant	0	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0	0.06
Asteraceae family	Unidentified seed	2.47	0.63	0.31	0.51	0.56	1.00	0	0.65	0.54	0.31	3.77	1.79	0	0	0	0	0.78
Astragalus	Locoweed	1.56	0.31	0	0.75	0	9.70	0	1.95	0.56	0.82	0	0	0	0	0.91	0	1.04
Chenopodium	Goosefoot	0	0	0	0	0	0	0	0	0	0	0	0	0	0.31	0	0	0.02
Cirsium	Thistle	0.64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04

Genus	Common name	Nov 1999	Dec 1999	Jan 2000	Feb 2000	Mar 2000	Apr 2000	May 2000	Jun 2000	Jul 2000	Aug 2000	Sep 2000	Oct 2000	Nov 2000	Dec 2000	Jan 2001	Feb 2001	Avg
Croton	Croton	5.10	9.63	14.20	2.77	6.99	9.03	38.75	3.72	10.36	6.85	8.84	3.19	14.48	12.63	12.07	7.73	10.40
Descurania	Tansy mustard	0	0	0.30	0	0.32	0	0	0	0	0	0	0	0	0	0	0	0.04
Eriogonum	Wild buckwheat	0	0.91	0.30	0.59	0	1.91	0.31	0.88	0.90	5.64	0.59	3.86	0	0	0.31	0.85	1.07
Hoffmanseggia	Hog potato	0	0	0	0.24	0.31	0.32	0.31	0	0.93	0.62	3.82	0	0	0	0	0.59	0.45
Lesquerella	Bladderpod	0	0	0	0	0	0	0	0	0	0.45	0	0	0	0	0	0.31	0.05
Opuntia	Cactus	0	0	0	0	0	0	0	0	0	0	0	0	0	0.59	0	0	0.04
Polygonum	Knotweed	0	0	0	0	0	0	0	0.59	0.58	0	0	0	0	0	0.27	0	0.09
Ratibida	Prairie coneflower	0	0.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.06
Sphaeralcea	Globe-mallow	9.36	4.64	1.21	1.39	0	9.43	0.75	0	0	0	0	0.96	0	0	0	0.30	1.75
Unknown	Unidentified forb	0	0.60	0	0	0	0	0	0.63	0	0	0	0	0.28	0	0	0.89	0.15
Unknown	Unidentified seed 1	8.26	7.29	2.23	1.12	8.86	0	0	0.58	0.85	0	3.12	0	0.26	0.28	0.60	0	2.09
Unknown	Unidentified seed 2	0	0	0	0	0	0.96	1.58	4.61	5.66	0	0	0	0	0	0	0	0.80
Verbascum	Mullein	1.79	0.63	0	0	0	0	0	0	0	1.15	0	0	0	0	0	0	0.22
Forbs Total		30.68	25.58	18.55	7.37	17.04	32.67	43.95	14.37	20.38	16.04	20.14	11.64	15.02	13.81	14.16	11.28	19.54

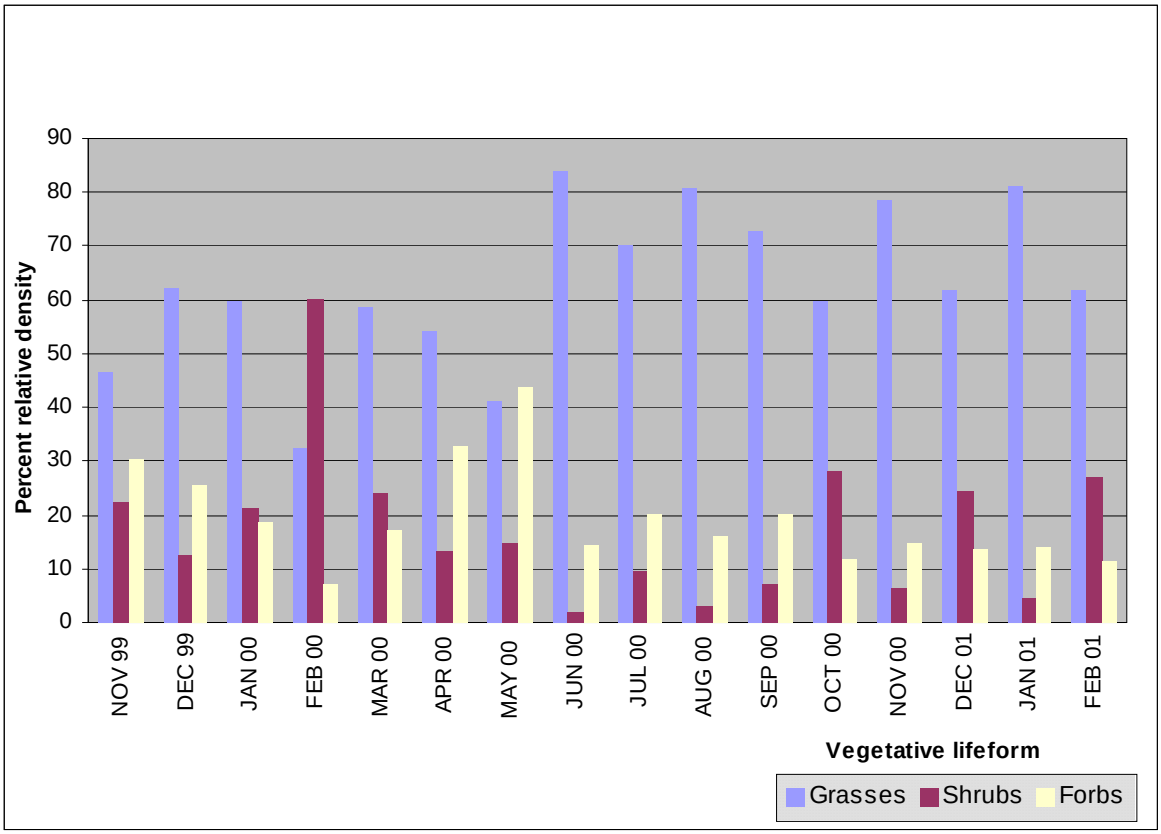

FIGURE 31.—Cattle diet for combined sampling area.

TABLE 16.—Average percent composition, numbers, and percent frequency of plant species found in fecal samples of cattle (n = 48 samples).

Common name	Genus	Percent composition	Frequency in samples (%)
Willow	*Salix*	11.40	42 (87.5)
Dropseed	*Sporobolus*	10.90	35 (73)
Croton	*Croton*	10.67	42 (87.5)
Bluegrass	*Poa*	10.65	41 (85)
Grama	*Bouteloua*	10.24	46 (96)
Bluestem	*Andropogon/Schizachyrium*	7.63	34 (71)
Unidentified grass seed	*Poaceae* family	7.13	41 (85)
Mesquite	*Prosopis*	4.32	19 (40)
Hairy tridens	*Erioneuron*	3.30	12 (25)
Needlegrass/ricegrass	*Stipa-Oryzopsis*	2.45	27 (56)
Unidentified seed 1	Unknown	2.15	22 (46)
Globemallow	*Sphaeralcea*	1.78	13 (27)
Rush	*Juncus*	1.70	19 (40)
Brome	*Bromus*	1.47	17 (35)
Rabbitfootgrass	*Polypogon*	1.36	10 (21)
Sedge	*Carex*	1.29	24 (50)
Spikerush	*Eleocharis*	1.18	18 (37.5)
Wild buckwheat	*Eriogonum*	1.07	16 (33)
Locoweed	*Astragalus*	1.04	11 (23)
Horsetail	*Equisetum*	0.93	15 (31)
Unidentified composite seed	*Asteraceae* family	0.78	16 (33)
Unidentified seed 2	Unknown	0.74	6 (12.5)
Wheatgrass	*Agropyron*	0.72	13 (27)
Saltbush	*Atriplex*	0.65	7 (15)
Cottongrass	*Eriophorum*	0.62	6 (12.5)
Unidentified grass	*Poaceae* family	0.60	6 (12.5)
Cattail	*Typha*	0.58	9 (19)
Hog potato	*Hoffmanseggia*	0.43	8 (17)
Cottonwood	*Populus*	0.33	6 (12.5)
Sumac	*Rhus*	0.32	9 (19)
Mullein	*Verbascum*	0.22	5 (10)
Velvetleaf	*Abutilon*	0.20	6 (12.5)
Mormon tea	*Ephedra*	0.19	1 (2)
Prickly poppy	*Argemone*	0.14	1 (2)
Unidentified forb	Unknown	0.13	5 (10)
Yucca	*Yucca*	0.11	1 (2)
Apache plume	*Fallugia*	0.09	4 (8)
Knotweed	*Polygonum*	0.09	3 (6)
Prairie coneflower	*Ratibida*	0.06	1 (2)
Unidentified composite	*Asteraceae* family	0.06	1 (2)
Aster	*Aster*	0.05	3 (6)
Bladderpod	*Lesquerella*	0.05	2 (4)
Thistle	*Circium*	0.04	1 (2)
Tansy mustard	*Descurainia*	0.04	2 (4)
Prickly-pear cactus	*Opuntia*	0.04	2 (4)
Goosefoot	*Chenopodium*	0.02	1 (2)
Barberry	*Berberis*	0.02	1 (2)
Wolfberry	*Lycium*	0.02	2 (4)
Saltgrass	*Distichlis*	0.02	1 (2)
Silver beardgrass	*Bothriochloa*	0.01	1 (2)

TABLE 17.—Statistical comparison of lateral densities inside and outside of exclosures; data were collected in January from 2004 to 2007. Alpha = 0.05.

	2004	2005	2006	2007	2008
Exclosure 2	In >Out[1] P=0.046	In >Out[2] P=0.002	In >Out[2] P=0.014	In >Out[2] P=0.015	In=Out[2] P=0.176
Exclosure 4	In=Out[2] P=0.710	In=Out[2] P=0.798	In=Out[2] P=0.480	In=Out[2] P=0.122	In=Out[2] P=0.654
Exclosure 5	In=Out[2] P=0.412	In=Out[2] P=0.128	In=Out[2] P=0.279	In=Out[2] P=0.396	In=Out[2] P=0.485
Exclosure 6	In=Out[1] P=0.284	In=Out[2] P=0.653	In=Out[2] P=0.215	In=Out[2] P=0.838	In=Out[2] P=0.597
Exclosure 7	In=Out[1] P=0.983	In>Out[2] P=0.010	In=Out[1] P=0.578	In=Out[1] P=0.681	In=Out[1] P=0.890

1 = Student's t-test: 2 = Mann-Whitney W test
Highlight = significant difference at the 95% confidence level

TABLE 18.—The average percentage of lateral cover density at Exclosures 2, 4, 5, 6, and 7 from 2004 to 2008.

	2004		2005		2006		2007		2008	
	In	Out	In	Out	In	Out	In	Out	In	Out
Exclosure2	75.90	59.13	84.54	55.74	79.63	53.37	79.70	55.49	79.94	61.56
Exclosure4	97.25	98.38	97.73	92.48	93.29	94.06	93.24	95.20	96.73	95.74
Exclosure5	97.60	93.94	99.30	97.56	98.08	94.31	96.21	96.81	95.98	93.79
Exclosure6	77.15	84.45	80.45	86.90	72.87	94.15	82.83	86.8	76.78	87.14
Exclosure7	62.46	62.27	82.35	59.04	62.52	56.97	54.77	58.92	57.60	59.08

coyote willow community outside this exclosure was believed to be due to the excessive livestock browsing which occurred in 2001. The difference in the lateral cover density from 2004 to 2007 appeared to be attributed to grazing impacts. The drier than normal conditions at this site also limited the vegetation's ability to recover. Lateral cover density outside of the exclosure did increase enough in 2008 to become statistically equal to that inside, however, which indicated some level of recent recovery.

Lateral cover was also found to be significantly greater inside than outside of Exclosure 7 in January 2005. This difference was not obviously linked to grazing impacts. The heights of coyote willow were also greater inside than outside of Exclosure 7 from November 2002 to November 2007; however there does not appear to be a correlation with height since differences were found in lateral cover in only one of these 6 years. Frequency of browse exceeded the threshold in 2004 (the grazing season that would be captured in 2005 lateral cover data), which may have caused a reduction in lateral cover. However, this threshold was exceeded in 2005 to 2007 as well, and did not correlate with a reduction in lateral cover for those years. There was a problem with differentiating

between woody material and decadent stems of yellow sweet clover (*Melilotus officinalis*) in the digital photos on some of the micro-plots inside of Exclosure 7 in the 2005 data collection period. Yellow sweet clover stems may have increased the total percentage of lateral cover inside the exclosure. This was the only limitation of this methodology for assessing livestock grazing that was noted in this study.

The lateral cover densities at the remaining monitoring sites were not significantly different between inside and outside the exclosures. Results therefore indicated no impacts from grazing on the lateral density of willows at any of the exclosures with the probable exception of Exclosure 2.

CONCLUSIONS

Livestock Exclosures

Several conclusions were developed over the 10-year period of study related to the data gathered from within and outside the livestock exclosures. These conclusions are presented below and are followed by a supporting narrative discussion.

Conclusion 1: Limited livestock browsing of native *Salix* spp. and *Populus* spp. had no major adverse effects. Excessive livestock browsing resulted in short-term and/or long-term impacts.

Conclusion 2: Livestock browsing can stimulate growth of native *Salix* spp., increasing overall density, when hydrologic conditions are favorable.

Conclusion 3: Ground water and surface hydrology play a critical role in the vegetation's ability to recover from excessive browsing events. If hydrology is favorable, vegetation can withstand excessive browsing and the resulting impacts are short-term. However, when hydrology is not favorable the impacts are more long-term. Since it is not possible to sustain ideal hydrologic conditions over long periods, particularly in arid environments, proper livestock management is a critical component to sustained forage production and habitat development.

Conclusion 4: The 35 percent frequency of browse threshold appeared to be a sound estimate for determining the degree to which livestock were allowed to browse without limiting the growth and development of native *Salix* spp. and *Populus* spp. The threshold only applied to younger age classes and/or vegetation <2m in height.

Conclusion 5: If Elephant Butte Reservoir had not declined, it is difficult to predict the possible impacts to the developing vegetation in the vicinity of the livestock exclosures. Receding reservoir levels, which resulted in the development of early-successional stage grasses, forbs, and shrubs in the newly exposed areas, altered livestock use patterns, attracting livestock away from exclosures.

In 1998 and 1999, meetings were held to discuss the potential impacts of livestock grazing within Elephant Butte project lands on flycatchers and their habitat. Through coordinated efforts of the USFWS, BLM, Reclamation, New Mexico Grazing Task Force, and local livestock grazing lessees it was agreed that livestock grazing would continue on a seasonal basis (August 1 to May 6)—excluding the primary flycatcher breeding season. As a condition for livestock grazing within Elephant Butte project lands, monitoring of livestock impacts to developing cottonwood/willow stands was required. Thresholds were also established to provide limits to the potential livestock impacts. A threshold of 35 percent frequency of browse was agreed upon as that standard.

Frequency of browse was defined as "the number of individual stems browsed divided by the total number of individual stems within the sample, times 100." This included the individual native cottonwood and willow plants that were browsed over a single grazing season. The percentage of individual stems browsed was cumulative over the entire grazing season. The 35 percent frequency of browse threshold allowed livestock to consume a portion of the native vegetation, but not to a degree which significantly reduced the height, density, or vigor of the overall plant community. Therefore, it was assumed that flycatcher habitat could develop in the presence of livestock grazing as long as the threshold was not exceeded. The threshold became effective at the beginning of the August 2000 grazing season.

As previously mentioned, only five of the seven exclosures provided statistically valid data. Of these five, only one—Exclosure 2—appeared to show long-term adverse effects due to livestock browsing. The remaining four exclosures showed no obvious long-term adverse effects.

Since August 2000, the 35 percent frequency of browse threshold was exceeded at Exclosure 2 in June and November 2001; at Exclosures 4, 5, and 6 in April of 2003 and 2004; and at Exclosure 7 in November 2004, April and November 2006, and April and November 2007.

In June 2001, the frequency of browse threshold was exceeded at Exclosure 2 (39 percent) when a gate immediately upstream of the exclosure was left open and approximately 150 head of cattle fed through the area as they migrated south towards the delta of Elephant Butte Reservoir. The potential for this type of event reoccurring has been minimized with the installation of two locked steel gates in lieu of wire gates. In November 2001, the browse rate, which reflected the rates detected in June, still exceeded the threshold at 43 percent. Data analysis indicated a significant reduction in height ($P<0.001$). Compared to the height within the exclosure, the vegetation outside of this exclosure has not recovered, resulting in long-term adverse impacts.

In April 2003, browsing frequency thresholds were exceeded at Exclosure 4 (43 percent), Exclosure 5 (40 percent), and Exclosure 6 (41 percent,). Both height and density outside of Exclosure 5 had been reduced by the browse experienced during the April 2003 period. At Exclosure 6, excessive browsing had reduced the height of vegetation outside

the exclosure, although densities were unchanged. Data from within Exclosure 4 were not collected for statistical comparison.

Follow-up collection was conducted in July 2003, prior to the August 1 grazing period, from within and outside of Exclosures 4, 5, and 6. Analysis revealed that the height and density of vegetation had recovered (i.e., were statistically equal between inside and outside the exclosures) at all three sites.

During the April 2004 collection period, browsing frequencies of 70 percent, 79 percent, and 62 percent were recorded at Exclosures 4, 5, and 6, respectively. Statistical analysis indicated the average height of vegetation at Exclosures 4 and 5 was reduced following this event. The height of vegetation at Exclosure 6 remained unchanged. The density outside Exclosure 5 was significantly reduced, however, the differences in densities at Exclosure 5 varied throughout the study period and may not have been directly related to excessive browsing. Densities at Exclosures 4 and 6 remained unchanged.

In June 2004 a follow-up collection effort was conducted prior to the August 1 grazing period. The height of willows outside both Exclosures 4 and 5 had recovered by June 2004. The density of vegetation outside Exclosure 4 increased and was found to be significantly greater outside the exclosure. At Exclosure 5, the density of vegetation also recovered.

The results of data collected from Exclosure 2 illustrated the potential for long-term adverse impacts resulting from a single excessive browsing event. During the excessive browsing event of June 2001, the height of vegetation outside the exclosure was reduced and did not recover, although browsing was limited and did not exceed the 35 percent threshold since then. The primary reason for the vegetation's inability to recover was likely a lack of sufficient surface and ground water. These effects would have probably been mitigated had drought conditions not persisted at this site. It is possible that the vegetation surrounding this exclosure may recover at some time in the future. The density of vegetation was not affected in June 2001. Therefore, if hydrologic conditions again become favorable, the vegetation may experience renewed growth.

The potential beneficial aspect of livestock browsing was shown by an increase in density at Exclosure 4 following the January–April 2004 period, when 70 percent of the individual stems were browsed. In this instance, browsing apparently stimulated the plants to resprout which resulted in a density increase. Ground water hydrology likely played a major role in the vegetation's response to browsing at that time. Ground water levels were relatively high during the April–June period which was advantageous to the vegetation. If the ground water levels had been lower or insufficient, the increase in density would likely not have been observed. Also, it is important to note that livestock browsing was entirely absent during the late-spring to mid- summer period (i.e., the vegetation was not subject to further stress as a result of browsing).

Table 19 illustrates the difference between the natural response of seasonal vegetation within Exclosure 4 to that outside the exclosure, which was subject to extensive browsing

TABLE 19.—Comparison of natural seasonal vegetation response inside and outside Exclosure 4.

	4/20/04	6/30/04	Percent Change		4/20/04	6/30/04	Percent Change
Height Inside	202.1cm	171.2 cm	-18%	**Height Outside**	169.9 cm	151.8 cm	-12%
Density Inside	8.37/m2	12.38/m2	+48%	**Density Outside**	11.68/m2	19.78/m2	+69%

from January–April 2004. As shown in this table, a natural seasonal increase of 48 percent density occurred during the April–June 2004 period. (This is not uncommon and has been observed for a number of years. It tends to be a response to the 30–40 percent natural mortality observed during the November–April period.) However, the 69 percent increase in density outside the exclosure was approximately 20 percent greater than inside, which was likely attributed to livestock browsing. The reductions in height, both inside and outside the exclosures, were due to the increased density of younger individuals that reduced the overall average height of the community.

At Exclosure 5, results similar to Exclosure 4 were found. Although, the height and density of coyote willow was significantly reduced during the January–April 2004 period, when the area was extensively browsed, the vegetation recovered in both height and density by late-June 2004. The short-term adverse impacts of livestock browsing were evident during the January–April 2004 period. However height and density of the vegetation outside the exclosure responded well following extensive browsing and fully recovered. Ground water hydrology likely played a major role in the vegetation's response to browsing. Ground water levels were relatively high during the April–June period which was advantageous to the vegetation. If the ground water levels had been lower and insufficient, the increase in density would not have been observed. Also, it is important to note that livestock browsing was entirely absent during this period (i.e., the vegetation was not subject to further stress as a result of browsing).

Table 20 illustrates the difference between the natural seasonal vegetation response within Exclosure 5 to that outside the exclosure, which was subject to extensive browsing from January–April 2004. As shown in this table, a natural seasonal increase of 39 percent density occurred during the April–June 2004 period. (This is not uncommon and has been observed for a number of years. It tends to be a response to the 30–40 percent natural mortality observed during the November–April period.)

TABLE 20.—Comparison of natural seasonal vegetation response inside and outside Exclosure 5.

	4/21/04	6/29/04	Percent Change		4/21/04	6/29/04	Percent Change
Height Inside	146.5cm	146.5cm	0%	**Height Outside**	117.1cm	119.1cm	+2%
Density Inside	16.97/m2	23.58/m2	+39%	**Density Outside**	11.23/m2	20.40/m2	+82%

However, the 82 percent increase outside the exclosure was 43 percent greater than inside and was most likely attributed to livestock browsing. The relatively consistent heights, both inside and outside the exclosures were also an indication of the vegetation's favorable response during this period. Typically, with a significant increase in density, a resulting decrease in the vegetation's overall average height would have been expected.

Recent trends inside and outside several of the exclosures, including Exclosure 5, showed decreasing densities. This was likely due to a dropping water table caused by degradation of the river, although drought conditions persisted over the last few years of the study and may have been partially responsible.

After 10 years of monitoring, the methodology based on frequency of browse thresholds of 35 percent appeared to be sound. When heights and/or densities inside the exclosures were greater than those outside, there was generally a correlation with browsing frequencies that exceeded 35 percent. Several examples included:

- June 2001 Exclosure 2 data—43 percent browse resulted in a reduction in height;
- April 2004 Exclosure 4 data—70 percent browse resulted in a reduction in height; and
- April 2003 and April 2004 Exclosure 5 data—40 percent and 79 percent browse, respectively, reduced both height and density.

Frequency of browse less than 35 percent typically did not significantly reduce height or density. Examples of this scenario include:

- November 1998 Exclosure 2 data—24 percent browse had no significant affect;
- November 2001 Exclosure 4 data—21 percent browse had no significant affect;
- November 1998 Exclosure 5 data—22 percent browse had no significant affect; and
- November 2003 Exclosure 6 data—13 percent browse had no significant affect.

It is important to note that the 35 percent frequency of browse threshold only applied to the younger age classes of native cottonwood and willow. As the vegetation matured, frequency of browse >35 percent would not have likely reduced the overall height to the same degree as younger vegetation. As the height of vegetation increased, there was a greater degree of browsing on the lateral limbs, instead of the apical tips where height would be affected.

Although no obvious long-term adverse livestock impacts were documented during this 10-year study, it is important to consider Elephant Butte Reservoir levels over this same period. Reservoir levels began to decline in 1996 and continued to decline. As the reservoir levels declined, herbaceous vegetation and native seedlings became established throughout the headwaters area, providing a large area for livestock to disperse. As livestock congregated in the areas of developing vegetation further within the conservation pool, the intensity of browsing outside the conservation pool was likely reduced and adverse impacts minimized. If Elephant Butte Reservoir had not declined, it

is difficult to predict the possible impacts to the developing vegetation in the vicinity of the livestock exclosures.

The density, height, and effects of cattle browsing on seep willow and saltcedar were also recorded. These data were not discussed in detail within the report. Cattle were observed occasionally browsing on young saltcedar along the LFCC, but data collected at the respective exclosures indicated that far less than 1 percent of the individual stems were browsed by cattle. Less than 1 percent of individual seep willow stems were also utilized by cattle.

In addition, changes in species composition over the study period favored native vegetation. Data collected from Exclosures 6 and 7 indicated a decrease in exotic saltcedar densities, and increases in native *Salix* spp. and *Populus* spp.

Photo Stations

> **Conclusion:** No significant or obvious livestock impacts were visually identified at any of the 34 photo stations.

Photos from the 34 stations were taken at least once a year since 1997. A visual comparison of all photo stations from 1997 to 2007 can be found in Appendix B. Several of the photo stations within and outside the exclosures were discussed in the previous section. However, several stations were also established to monitor disturbance to the more mature vegetation. Examples include photo stations 17, 20, 21, 22, 25, and 33. None of the photo stations, which were established within dense native riparian vegetation, indicated any significant physical disturbance as a result of cattle trampling or browsing. Many of these sites remained flooded and were inaccessible to cattle during extended periods between November 1997 and April 1999. Due to the limited and/or absence of overbank flooding since 1999, most of the study area became more accessible to livestock. However, herbaceous vegetation continued to be very limited in areas where dense overstory vegetation (i.e., flycatcher habitat) was established and livestock only ventured into these areas on an occasional basis.

The lack of any noticeable differences between the photo stations established inside and outside the exclosures was likely due to the minimal effect that livestock browsing had on the height and density of the native community over the 10-year period of study.

Aerial Livestock Counts

> **Conclusion:** Total AUMs for the three allotments did not appear to have been exceeded during the study period. However, a disproportionately high number of head were routinely observed within the Scott Ranch Allotment and trespass cattle were observed during the summer exclusion period.

Based on the aerial livestock counts that were conducted, it did not appear that collectively the AUMs permitted for the three allotments in the study area were exceeded

during the grazing season. However, a disproportionate number of cattle were typically concentrated within the Scott Ranch Allotment, particularly prior to the fence installment in 2003. Trespass head were observed outside the grazing season (i.e., June 2001–179 head, July 2002–189 head, May 2003–169 head, and June 2004–37 head)—primarily within the Scott Ranch Allotment. It was possible that some of these cattle migrated upstream from an adjacent allotment, and were not entirely trespass cattle from one of the three allotments in the study area. Improved coordination and compliance between the various agencies and the lessees regarding trespass cattle were warranted and have been initiated.

Fecal Analysis

> **Conclusion:** The overall dietary composition of trees and shrubs for the entire sampling period was 17 percent, which was consistent with previous studies (e.g., Uresk et al. 1984). The highest utilization of *Salix* spp. occurred during February and the lowest utilization occurred between May and August.

Grasses were the most important component of the cattle diet with dropseed, bluegrass, grama and bluestem being the most frequently utilized species. Utilization of the grasses remained fairly constant throughout the year, even in the fall and winter when other studies have shown a decline in usage (Uresk and Painter 1985). This high intake of grasses could have been due, in part, to the declining lake levels and expansion of the delta where there was a continuously increasing area of newly established herbaceous vegetation.

Forbs were utilized more frequently early in the growing season in April (32.7 percent) and May (44.9 percent), then remained fairly constant during the summer, fall, and winter of 2000/2001. Other studies (Uresk and Painter 1985 and Uresk and Lowery 1984) have shown that the utilization of both grasses and forbs decreases in the fall, with a corresponding increase in tree and shrub utilization to 37 percent and 36 percent.

The overall dietary composition of woody material, primarily willow and mesquite, was comparatively low with the percent relative composition of the total diet being 17 percent. The period of lowest willow utilization occurred between May and August with an average utilization of 2.3 percent. Willow was the most frequently occurring woody species in the samples and had the highest percent composition in the combined samples for any single species. This usage corresponded with it being the most common native woody riparian species in the study area and did not indicate overutilization

Lateral Browsing

> **Conclusion:** Results were consistent with findings associated with the livestock exclosure data. Lateral densities were not significantly reduced, with the exception of Exclosure 2, which demonstrated that excessive browsing can result in a reduction of lateral density, and long-term impacts, especially when hydrologic conditions are less than favorable.

The lateral browsing study was initiated in 2004 and proved to be a valuable tool in assessing the potential impacts of livestock grazing on riparian vegetation. The study showed that livestock browsing of native woody-stemmed vegetation was not having a significant long-term effect on lateral cover density. This technique had limitations, but had the advantage of the results providing a valid data set. This method also allowed for extensive and accurate records to be kept on an annual basis, for comparisons that were repeatable.

RECOMMENDATIONS

Livestock grazing within the study area should continue to be permitted and managed by the Bureau of Land Management. Stocking rates and season of use had limited adverse impacts to the developing vegetation, and in some instances appeared to stimulate growth and development. Adjustments to both stocking rates and season of use should be considered based on annual forage availability and hydrologic conditions. The intensity and duration of livestock browsing within riparian areas will directly determine the degree of impacts expected on the native riparian community. Reclamation anticipates incidental aerial livestock counts will continue to ensure compliance with the current grazing schedule.

Reclamation recommends terminating the current grazing study. The density of native vegetation at a majority of the exclosure sites gradually decreased, an effect of the receding reservoir, degrading river, and associated decline in ground water table levels. The data collection process became more limited as native vegetation continued to decrease and there were increasingly fewer willow to measure, making it difficult to draw conclusions about the effects that grazing was actually having on vegetation. Ten years of monitoring provided sufficient data to indicate that under the existing management practices, livestock grazing did not appear to have adversely affected flycatcher habitat.

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