EFFECTS OF MANAGED LIVESTOCK GRAZING ON POTENTIAL HABITAT OF SOUTHWESTERN WILLOW FLYCATCHERS IN WEST–CENTRAL ARIZONA

By

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3. ABSTRACT

The southwestern willow flycatcher (*Empidonax traillii extimus*; hereafter SWFL) is an endangered subspecies of willow flycatcher that inhabits dense riparian ecosystems of the southwestern United States. Many factors, including improper livestock grazing practices, are thought to have influenced the decline of this species although few studies have sought to quantify the effects of managed livestock grazing on SWFL habitat. The main goal of my study was to investigate how carefully managed (i.e., time–controlled), seasonal livestock grazing and episodic flooding affected potential SWFL habitat throughout the year. I monitored vegetation responses to livestock grazing in 3 pastures in west–central Arizona throughout 2015 and 2016. The 3 pastures encompassed 17.5 km of a riparian area that was potential habitat for SWFL but was unoccupied. I measured canopy cover (%) of the primary woody plant species; relative biomass (%) of the dominant plant life forms (both herbaceous and woody plants); density (number/m²) of the primary woody seedlings; and relative and total utilizations (%) of herbaceous and woody species. Conservative stocking rates, paired with relatively short seasonal grazing periods that were followed by longer periods of rest, resulted in very light levels of utilization on both herbaceous and woody plants for all sampling periods. Utilization levels were well below the recommended guidelines cited in the USFWS SWFL Recovery Plan for herbaceous and woody vegetation. Species compositions of herbaceous and woody plants were not adversely affected by the grazing management practices implemented in this study. Mean density of woody seedlings declined from 2015 to 2016 mostly in response to 3 consecutive flooding events in late 2015. My results are consistent with previous case studies that have demonstrated that proper livestock grazing practices can be compatible with maintaining SWFL habitat in the southwestern United States.
4. LITERATURE REVIEW

A. SOUTHWESTERN WILLOW FLYCATCHER (SWFL)

The southwestern willow flycatcher (*Empidonax traillii extimus*; hereafter SWFL) is an endangered subspecies of passerine in the family Tyrannidae that was federally listed under the Endangered Species Act in 1995 (USFWS 1995). It is 1 of 4 subspecies (*E. t. brewsteri*, *E. t. adastus*, and *E. t. traillii*) of willow flycatcher best distinguished from the other 3 by genetics (Paxton 2000), song (Sedgwick 2001), and plumage coloration, with SWFL being the palest of the subspecies (Unitt 1987). However, subspecies determinations can only be made by taxonomic experts comparing collected individuals to study skins, so field identification of subspecies can be insufficient (USFWS 2002).

SWFL abundance in the southwestern U.S. is typically highest in continuous mesic habitats that contain dense woody vegetation (Sanders and Edge 1998). SWFL breeds in dense riparian ecosystems of the southwestern U.S. (e.g., Arizona, southern California, southern Colorado, southern Nevada, western New Mexico, western Texas, and southern Utah) from about May through August (Figure 1; Sogge et al. 2010). Then, it migrates to Latin and South America, where it winters along the southern coastal region of Central America (e.g., Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama) and the northwest region of South America (e.g., Colombia, Ecuador, Peru, and Venezuela) from about October through March (Figure 2; Sogge et al. 2010). Very little is known about the distribution, habitat use, and vegetation structure and composition of wintering habitats because of the paucity of research from these countries (Lynn 2003, Paxton 2011). More is known about SWFL summer breeding habitats in the southwestern U.S., which will be discussed in detail in Section B of this literature review. SWFL mainly consume true bugs (Hemiptera), flies (Diptera), and beetles (Coleoptera),
but leafhoppers (Homoptera), spiders (Araneae), bees and wasps (Hymenoptera), and dragonflies and damselflies (Odonata) are also common in their diet (Drost 2003, Wiesenborn and Heydon 2007).

![Figure 1. Approximate breeding and wintering ranges of the 4 subspecies of the willow flycatcher (Sogge et al. 2010).](image)

![Figure 2. Approximate breeding and migration chronology for SWFL (Sogge et al. 2010).](image)
SWFL was determined to be endangered by the USFWS in 1995, primarily due to extensive habitat loss. The reasons cited for SWFL habitat loss included: construction of dams and reservoirs, diversions and groundwater pumping, channelization and bank stabilization, phreatophyte control, improper livestock grazing practices, recreation, fire, agricultural development, urbanization, lack of adequate protective regulations, changes in abundance of other species, vulnerability of small populations, brood parasitism by brown–headed cowbirds (*Molothrus ater*), migration and winter range stresses, and other natural or manmade factors (USFWS 1995, 2002).

Although the direct and indirect effects on SWFL habitat have been thoroughly described, the reasons for SWFL decline can be complex. For example, during a 2–year study, Siegel et al. (2008) intensively surveyed Yosemite National Park by visiting 71 sites that accommodated 1709 call stations. They concluded that no willow flycatchers were breeding in Yosemite National Park even though most of the Park’s high–quality riparian ecosystem had been protected from livestock grazing for many decades. Extirpation of willow flycatchers from Yosemite suggests there are multifaceted local and regional causes for the decline of SWFL beyond the effects listed above.

**B. HABITAT CHARACTERISTICS**

Critical habitat is defined as “the specific areas within the geographical range occupied by the species on which those physical or biological features essential to the conservation of the species are found and may include areas that are not currently occupied by the species but that will be needed for its recovery” (ESA 1973, Fig. 3).
SWFL is a riparian obligate species meaning its breeding activities occur mostly in dense riparian areas dominated by woody plants along rivers, streams, or other wetlands, where densely growing trees and shrubs are established near or adjacent to surface water or saturated soil (USFWS 2002). SWFL habitat has been partitioned by the USFWS (2002) into 3 vegetation types (i.e., native vegetation–dominated, exotic vegetation–dominated, and mixed native and exotic vegetation), and 2 elevation types (i.e., low– to mid–elevation sites, and, high–elevation sites).

Common tree and shrub species at SWFL low– to mid–elevation sites include many species of willows (*Salix sp*.), cottonwoods (*Populus sp*.), seepwillow (*Baccharis sp*.), ashes (*Fraxinus sp*.), boxelder (*Acer sp*.), buttonbush (*Cephalanthus sp*.), and alders (*Alnus sp*.) (USFWS 2002). Dense tree canopies and shrub layers may be comprised of multiple species or can be distinctly monotypic. Dense foliage usually begins within 4 m of ground level and can be comprised of shrubs, trees, or both life forms. Heights of shrubs and trees ranged from 2 to 30 m with taller vegetation (5–30 m) occurring at low– to mid–elevation sites. However, canopies tend to be a mixture of woody plants of various sizes, ages, and classes. Average canopy cover
from sites across multiple southwestern states ranged from 75 to 90% (Spencer et al. 1996, Stoleson and Finch 1999, Uyehara et al. 2000), but was recorded as low as 50% and as high as 100% (McKernan and Braden 1999). Occupied sites had greater foliage density, canopy cover, and number of woody species than unoccupied sites (Stoleson and Finch 1999).

SWFL habitat is generally associated with lentic riparian environments adjacent to slow-moving streams of relatively low gradient. Lentic riparian areas occur in wide and expansive floodplains as opposed to narrow and confined canyons with steeper gradients. However, due to the extreme variability in hydrological disturbances inherent to southwestern riparian areas, the amount of water present in SWFL habitat can vary greatly within and among years. Water may occur in the form of sub–subsurface moisture that merely dampens the soil, as above–ground surface pools and overland flow, and occasionally, as episodic floods during high rainfall events. The unpredictability and variability in hydrological functions and disturbance events is reported to be vital to the transformation of potential to suitable SWFL habitat and for the perpetuation of established SWFL habitats (USFWS 2002).

C. EFFECTS OF EPISODIC FLOODING ON SWFL HABITAT

Flood pulse theory postulates that all rivers are prone to periodic flooding, but moderate-duration flooding at regular intervals promotes the highest biodiversity and ecosystem health compared to short- and long-duration floods (Johnson et al. 1995, Boudell and Stromberg 2008). Thus, floods can naturally range from small, yearly events to large, 500–year events. Small floods may limit the vegetation’s ability to reproduce while large floods may stunt vegetation growth (Sher et al. 2002). Damming of waterways, increased water diversion, and flow
regulation have led to decreases in flood duration or intensity, which in turn, have led to declines in riparian woody species (Johnson et al. 1995, Boudell and Stromberg 2008).

Most desert riparian systems are prone to regular hydrological disturbances, primarily as fluvial (e.g., overbank or flash) flooding, that can quickly change the entire morphology of a watershed (Swanson et al. 1998, Murle et al. 2003). Large flooding events can be highly unpredictable in both size and frequency (Ely et al. 1993, Rumsey 2015) making it difficult to assess both the immediate mid–, and long–term effects they may have on the landscape. Flood size and frequency correlate positively with the amount and degree of modification to a watershed, which can have multiple ecological functions (e.g., killing many organisms, altering existing ecosystems, or creating new ones through resource redistribution (Poff 2002)).

Although floods may have a negative connotation amongst the public, they are fundamental as ecological processes. Many riparian plants and animals depend upon periodic flooding for their survival (Stromberg 1993). A single flood can create new SWFL habitat, or, can make occupied habitat, unsuitable (USFWS 2002). The dynamic nature of southwest riparian ecosystems means that SWFL habitat can change quickly making it challenging to predict future habitat conditions for riparian obligates.

D. LIVESTOCK GRAZING PRACTICES

According to the USFWS Recovery Plan (2002), habitat degradation is listed as the number one cause for SWFL being listed as endangered, with improper livestock grazing cited as 1 of 6 possible causes of SWFL habitat degradation. Improper livestock grazing practices can play a significant role in the modification and loss of riparian areas and their ecological functions via alterations in stream channel morphology (Knapp and Matthews 1996), stream bank
vegetation (Green and Kauffman 1995), and associated decreases in avian abundance, diversity, and species composition (Taylor 1986, Stacey 1995, Belsky 1999). These studies have clearly shown that improper management of livestock numbers, duration and season of use, and animal distribution can have detrimental impacts in riparian areas. Continuous or heavy grazing of riparian areas throughout the majority of the growing season can be particularly damaging to vegetation within floodplains (Kauffman and Krueger 1984). Below, I discuss how grazing management practices and principles (i.e., animal numbers, duration of use, animal distribution, and season of use) could be used as tools to mitigate negative impacts in SWFL breeding habitat.

**Animal Numbers and Duration of Use**

Animal numbers and duration of use, when combined, comprise a stocking rate for a particular unit of land being grazed by large, ungulate herbivores (Scarnecchia 1985a, Holechek 1988, Galt et al. 2000). Stocking rates can influence the total biomass of forage removed (i.e., intensity of grazing) and the number of times individual plants are grazed (i.e., frequency of grazing) during a growing season. Higher animal numbers combined with longer periods of grazing result in higher stocking rates and may cause both higher intensity and frequency of biomass removal in rangeland plant communities (Ralphs et al. 1990, Taylor et al. 1997, Gillen et al. 1998). The opposite effects generally occur when animal numbers and/or duration of use are reduced. Ehrhart and Hansen (1997) argue that rangeland plants can tolerate longer grazing periods during winter and early spring when plants are dormant or in the early vegetative stages of growth. Conversely, plants can tolerate shorter grazing periods during summer and fall when plants are metabolically active, especially after their growing points are elevated just before going to seed (known as the “boot” stage in perennial grasses).
Central to understanding the impacts of animal numbers and duration of use on rangeland vegetation is to determine how forage intake of ungulate herbivores relates to stocking rate. Dry matter forage intake rates for ruminant herbivores can range between 1.5–4% of their body weight per day (Cordova et al. 1978, Holechek 1988). Cattle and larger ruminants consume closer to 1.5–2.5% of their body weight (Holechek and Vavra 1982, Hakkila et al. 1987), whereas smaller ruminants consume closer to 2.5–4% (Holechek 1988). Smaller ruminants typically have higher metabolic rates and select plants and plant parts that are more nutritious than do larger ruminants (Demment and Van Soest 1985, Hofmann 1989). Larger ruminants must consume more total forage each day than smaller ruminants. When rangeland forage is young, green, and digestible, ruminants exhibit high daily intake rates; the converse is true when forage is mature, dry, and less digestible (Streeter et al. 1974, Olson et al. 1989, Kloppenburg et al. 1995). Lactating animals eat more than pregnant animals; pregnant animals eat more than open animals (Conway 1973, Allison 1985, Provenza 1995). Horses (non–ruminant, hind–gut fermenters) have higher intake rates (up to 30% higher than ruminants of the same weight) due to their hind–gut, morpho–physiology (Demment and Van Soest 1985, Duncan et al. 1990, Menard et al. 2002).

Calculating animal demand based on intake rates is a highly complex and dynamic endeavor. Scientists have developed conversion factors to estimate forage demand of various species of rangeland herbivores and the potential impacts of ungulate herbivory on rangeland vegetation. An Animal Unit (AU = 1.0) is typically defined as a 454 kg cow with a calf (Vallentine 1965, Scarnecchia and Kothmann 1982, Scarnecchia 1985b). Thus, a 454 kg cow consuming 2.5% her body weight would eat, on average, 11 kg of dry weight forage per day, or about 341 kg per month. The amount of forage an AU consumes in a month is expressed as an
Animal Unit Month (AUM). An Animal Use Equivalent (AUE) is a conversion factor used to convert forage intake of an animal that weighs more or less than a 454 kg cow (i.e., 1 AU). For example, a 681 kg bull would have an AUE of 1.5 and would consume about 17 kg dry weight forage per day, while a 91 kg ewe would have an AUE of 0.2 and would consume about 2.3 kg of dry weight forage per day. Both examples assume a 2.5% intake rate relative to body weight which typically varies from 2–4% for rangeland ruminants.

Animal numbers can be converted to AUMs by multiplying the total number of animals x the AUE x the number of months of grazing. Similarly, animal numbers can be converted to AUDs by multiplying the total number of animals x the AUE x the number of days of grazing. The AUMs or AUDs can then be expressed as a ratio relative to the land area (usually acres or hectares) available for grazing (e.g., unit of land/AUM, unit of land/AUD, or their inverses). These components (i.e., number of AUs, number of months or days, and unit of land) provide the 3 factors necessary to express a stocking rate (i.e., number of AUs x duration of use/unit area of land).

**Animal Distribution and Timing of Grazing (Season of Use)**

Livestock distribution refers to where on the landscape ungulate herbivores spend their time grazing and loafing. Animal distribution patterns are influenced by accessibility to and availability of resources (forage, cover, and water), type or breed of animal, temperature, wind, biting insects, time of day, time of year, or any combination of these and other factors (Bailey et al. 1996). Generally, cattle congregate in riparian areas more during summer because of flatter terrain, higher density of forage and shade, moderate temperatures, and water availability in these ecosystems compared to surrounding uplands (Roath and Krueger 1982, Gillen et al. 1984, Myers 1989). Concentrated livestock distribution patterns can lead to excessive forage use on
gentle terrain near water during hotter months, while abundant forage in rugged terrain and areas far from water may be left unused. Cattle preference for and use of riparian areas may decrease during the cooler months of fall, winter, and spring when animals tend to disperse across the uplands (Bryant 1982, Parsons et al. 2003).

Rangeland and livestock operators have attempted to address cattle distribution problems by providing alternative water and shade resources (McIlvain and Shoop 1971, Zuo and Miller–Goodman 2004, Davison and Neufeld 2005), locating salt and other supplements in underutilized areas (Martin and Ward 1973, Bailey et al. 2001, Bailey and Welling 2007), fencing or herding animals (Hoover et al. 2001), adjusting in time and timing of grazing, all with varying levels of success. Successful summer and fall grazing in riparian pastures may involve using a combination of these tactics, along with integrating proper animal numbers, duration, and timing of grazing into a long–term grazing management strategy.

Timing of grazing (also known as season of use) refers to when grazing occurs within a year or growing season (i.e., spring, summer, fall, or winter). Clary and Webster (1989, 1990) suggested riparian forage–use guidelines in the Intermountain West of up to 65% during winter–spring and ≤ 30% during late summer–early fall. Their rationale for these seasonal forage–use guidelines was that plants are more tolerant of grazing and other disturbances during the dormant season when metabolic activity is lowest (winter). In addition, grazing during the dormant season is the least detrimental time of year for perennial grasses because carbohydrates have been mostly stored in the root system. Early seasonal grazing followed by deferment from grazing during late spring and summer provides more time and resources (i.e., moisture and sunlight) for plants to recover than does grazing near end of the growing season (late summer/early fall). Ehrhart and Hansen (1997) concurred that grazing in riparian areas during
the hotter months of summer and fall was generally more detrimental than grazing during winter or early spring. Early grazing following by deferment must also be integrated with proper stocking rates when soils are saturated to mitigate the potential effects of soil compaction. These kinds of grazing management practices that integrate duration of grazing with season of use and animal numbers to mitigate negative impacts in riparian and other critical areas are referred to as “time–controlled grazing” practices (Manley et al. 1997, Holechek et al. 2000).

Stubble height is another metric of forage utilization that is often evaluated in riparian areas (Clary and Leininger 2000). Clary and Webster (1989, 1990) suggested that time–controlled grazing can take place in riparian areas during summer and fall provided stocking rates achieved an average stubble height of 7.5–10 cm for perennial grasses. Again, these guidelines were for the cold deserts of the Intermountain West and are not applicable in ephemeral desert riparian systems, where annual grasses and forbs dominate the herbaceous understory. Ehrhart and Hansen (1997) recognized the disparate productivity of various riparian ecosystems across space and time and suggested setting utilization guidelines for seasonal riparian grazing based on the unique ecological potential of a site.

E. CONNECTION TO STUDY

Due to the dynamic and interconnected nature of all the possible factors (manmade and natural), listing SWFL as endangered is a very complex issue that cannot pinpoint a single cause for this species’ decline. In my Literature Review, many reasons were cited as possible explanations for why SWFL is facing population declines, with habitat loss being listed as the most significant factor. Related to habitat loss, many reasons were cited as possible explanations, including (but not limited to) improper grazing practices within their breeding
habitat. Keeping in line with the complexity of this issue, grazing management can also be broken down into several factors (type of animal, number of animals, animal distribution, timing of grazing, and duration of grazing). I have just listed 3 tiers of possible factors directly related to SWFL decline, which allows the reader to grasp the difficulty in recovering this endangered species or any endangered species, for that matter.

Because every factor can be broken down into essentially infinite causes and every possible cause for a specific factor can have an endless number of explanations, I narrowed the focus of my study to one explanation of one cause of one factor related to SWFL population decline. My study focuses specifically on grazing management practices (i.e., number of animals, timing of grazing, and duration of grazing) in potential SWFL habitat because of the financial importance of the livestock industry to the state of Arizona (Kerna et al. 2014), and the ecological importance of riparian areas to the southwest United States. Number of animals, timing of grazing, and duration of grazing are the specific grazing factors I am focusing on because of the documented effects improper livestock grazing management practices have on riparian areas, most closely associated with these 3 factors. In addition to grazing practices, I will also look at precipitation and flooding events in SWFL habitat to better assess the differences between manmade and natural factors affecting SWFL habitat.

Before I go into detail about the main goal, design, and sites of this study, I would like to note that the original proposal was to have an experimental study with controls, but this was not logistically feasible for participating ranches. Therefore, my thesis involved a 2–year case study where I documented how routine grazing practices affected important vegetation characteristics in suitable, but unoccupied SWFL habitat.
5. GOAL OF STUDY

The main goal of my study was to investigate how carefully managed (i.e., time–controlled), seasonal livestock grazing and episodic flooding affected potential habitat for SWFL throughout the year. Currently, the only grazing practice allowed in the USFWS Recovery Plan for SWFL is dormant season grazing. This limits livestock operators’ flexibility, and ultimately may limit participation in the Working Lands for Wildlife SWFL Initiative. There is a lack of information concerning the potential impacts of seasonal livestock grazing on vegetation attributes critical to SWFL habitat. Of interest is how rotating time–controlled grazing during the summer growing season with other seasons might affect SWFL riparian habitat attributes during various stages of plant phenology. Other treatments examined in this study included time–controlled grazing during the fall, winter, and spring seasons.
6. STUDY SITES

My study was conducted in native vegetation–dominated, low– to mid–elevation sites. None of the ranches I visited during 2015 and 2016 could adhere to the NRCS/USFWS constraints or my experimental study protocol. However, 2 ranches located near Congress, Arizona agreed to allow collection of vegetation data in response to their routine grazing practices in riparian areas.

Ranch 1 was located at 910 m elevation about 40 km northwest of Wickenburg, Arizona (Figs. 4 and 5). Ranch 2 was located at 810 m elevation about 8.5 km southwest of Ranch 1 (Figs. 6 and 7). Both ranches routinely graze livestock in pastures that contained suitable, but unoccupied SWFL habitat, which collectively encompassed approximately 17.5 km of Date Creek (Figs. 8–10).

Ranch 1 grazed cattle in a 130–ha pasture (hereafter Pasture 1), which included 110 ha of riparian vegetation and 20 ha of desert upland vegetation (Fig. 8). Pasture 1’s woody plant species consisted primarily of Fremont cottonwood (*Populus fremontii*) and Goodding’s willow (*Salix gooddingii*) in the canopy, and seep willow (*Baccharis salicifolia*) and burrobush (*Hymenoclea salsola*) in the midstory. Less dominant woody plants included Bonpland willow (*Salix bonplandiana*), Arizona ash (*Fraxinus velutina*), honey mesquite (*Prosopis glandulosa*), and Tamarix spp. (*T. ramosissima, T. aphylla*). The understory consisted of various species of annual and perennial grasses (e.g., *Cynodon dactylon*, *Polypogon monspeliensis*, *Bouteloua aristidoides*, *Aristida adscensionis*) and forbs (e.g., *Veronica anagallis–aquatica*, *Eriogonum deflexum*, *Eriogonum polycladon*, *Echinochloa colona*, *Amaranthus palmeri*, *Amaranthus fimbriatus*, *Conyza canadensis*, *Melilotus indica*, and *Polanisia dodecandra*).
Ranch 2 grazed cattle and horses in 2 pastures (hereafter Pastures 2 and 3) that included both upland and riparian vegetation (Figs. 9 and 10). Pasture 2 totaled 365 ha (345 ha of desert upland, 20 ha of riparian); Pasture 3 totaled 15 hectares (9 ha of desert upland, 6 ha of riparian). Riparian woody and herbaceous vegetation in Pastures 2 and 3 (Figs. 9, 10) were similar to Pasture 1 (Fig. 8).

Figure 4. Ranch 1 location [A] (34.267148° N, 112.950849° W).
Figure 5. Typical riparian vegetation on Ranch 1 (photo taken 11 July 2015).

Figure 6. Ranch 2 location [B] (34.226547° N, 113.027903° W).
Figure 7. Typical riparian vegetation on Ranch 2 (photo taken 5 Aug 2015).

Figure 8. Pasture 1 was 130 ha consisting of riparian (110 ha) and desert upland (20 ha) vegetation. Sampling plot arrangement consisted of 6, 50 x 50 m plots (P1a–P1f) randomly–located within the densest riparian area in the pasture.
Figure 9. Pasture 2 was 365 ha consisting of riparian (20 ha) and upland (345 ha) vegetation. Sampling plot arrangement consisted of 1, 20 x 125 m plot (P2), randomly–located within the densest riparian area in the pasture. One control plot (12.5 x 25 m, not shown) was located near the 50 m\(^2\) sampling plot in 2016.

Figure 10. Pasture 3 was 15 ha consisting of riparian (6 ha) and upland (9 ha) vegetation. Sampling plot arrangement consisted of 1, 50 x 50 m plot (P3), randomly–located within the densest riparian habitat in the pasture. One control plot (12.5 x 25 m, not shown) was located near the 50 m\(^2\) sampling plot in 2016.
7. MATERIALS AND METHODS

A. SAMPLING DESIGN

Pasture 1

I selected an area within Pasture 1 that contained the densest woody vegetation near perennial water (i.e., highest potential SWFL habitat) and then systematically located 6, 50 x 50 m study plots within that portion of the pasture (Fig. 8). Each 50 m² plot was subdivided into 4, 12.5 x 50 m quadrants that were bisected by a 50 m transect tape. This provided 1, 200 m transect within each 50 m² plot (i.e., 4 transects, 50 m each). Starting points for laying out the transect within the 4 quadrants were randomly selected during each sampling occasion.

Pastures 2 and 3

I randomly located 1, 50 m² study plot in both pastures within their densest riparian vegetation. I established only 1 study plot in Pastures 2 and 3 because riparian vegetation was much more limited in those pastures compared to Pasture 1. Pasture 2’s study plot was configured as a single 50 m² (20 x 125 m) rectangle that contained 10, 20 m transects, collectively providing 1, 200 m transect (Fig. 9). The rectangular configuration of this study plot encompassed the smaller and narrower spatial distribution of riparian vegetation within this area of Date Creek (Fig. 9). Pasture 3’s study plot was configured as a single 50 m² square because the riparian vegetation was somewhat broader in this area of Date Creek (Fig. 10). This 50 m² study plot was subdivided into 4, 12.5 x 50 m quadrants that were bisected by a 50 m transect tape, providing 1, 200 m transect (Fig. 10).

Control Plots

Control plots were not established in 2015 because it was not feasible for either ranches’ logistical operations. In July 2016, I constructed 2, 12.5 x 25 m control plots (electric–fenced
cattle exclosures) near the 50 m² study plots established in Pastures 2 and 3 (i.e., 1 control plot was established alongside both study plots). Control plots were not randomly selected because of concerns regarding: 1) safety to ranch workers and livestock during heavy precipitation/flooding, 2) inability for electric fences to remain intact during heavy precipitation/flooding, and 3) access to sunlight for solar generators. Electric fences delineating control plots were activated to exclude livestock immediately before they occupied Pastures 2 and 3; electric fences were deactivated after livestock were moved from these pastures. Control plots were bisected by 1, 25 m transect tape during sampling occasions. Because control plots were not randomly selected they were used only to compare utilization levels of herbaceous and woody plants inside and outside controls. They were not used for comparison against species composition or woody seedling density estimates outside of control plots.

B. VEGETATION SAMPLING

I sampled vegetation during 3 periods: 1) before livestock entered a pasture (pre–grazing), 2) soon after livestock exited a pasture (post–grazing), and 3) at the end of the growing season (end–of–season). Vegetation data was collected in Pasture 1 during each of the 3 sampling periods in 2015, and during 2 of the 3 sampling periods in 2016 (i.e., post–grazing and end–of–season). For Pastures 2 and 3, I collected vegetation data during all 3 sampling periods for both years of the study.

The following vegetation attributes were measured during each sampling period: relative species composition (% canopy cover determined by line–intercept) of the primary woody species, relative species composition (% biomass determined by dry–weight–rank) of the primary woody and herbaceous species; mean density (number/m²) of primary woody seedlings;
and mean utilization (%) of woody and herbaceous species. Monthly rainfall totals (cm) were recorded by Ranch 2.

Species Composition

I used the line–intercept method (Canfield 1941, Smith et al. 2012) to measure canopy cover of woody species along each 200 m transect. Canopy cover was recorded to the nearest 10 cm for each primary woody species. Overlapping canopies of the same woody species were counted only once when they occurred at the same location along a transect. Canopy cover was converted into percent relative species composition estimates for the primary woody plant species.

I used the dry–weight–rank method (Mannetje and Haydock 1963, Smith and Despain 1997, Smith et al. 2012) to estimate dry–weight (biomass) of herbaceous and woody plant species, which were converted to species composition estimates. This method ranks the 3 most dominant species within 40 cm$^2$ quadrats that were placed every 2.5 m along each 200 m transect. This provided 80 biomass estimates of the current year’s growth of herbaceous and woody plants within each 50 m$^2$ study plot.

Density of Woody Seedlings

I used the quadrat method (Smith et al. 2012) to count the total number of woody seedlings in 40 cm$^2$ quadrats every 2.5 m along 200 m transects which provided 80 density estimates per study plot.

Utilization (Herbaceous & Woody)

For herbaceous utilization, I used the landscape appearance method along each transect, which involves visually estimating herbaceous use in the following categories: none (0–5%), slight (6–20%), light (21–40%), moderate (41–60%), heavy (61–80%), severe (81–94%), and
extreme (95–100%) (Interagency Technical Team 1996). I recorded herbaceous use within a 1.25 m radius every 2.5 m along the 200 m transects which provided 80 qualitative observations that were averaged to calculate one herbaceous utilization estimate per study plot.

For woody utilization, I used the grazed class method (Roach 1950) to estimate use in the following categories: 0, 10, 30, 50, 70, and 90%. I recorded woody use of the closest woody plant every 2.5 m along the 200 m transects which provided 80 qualitative observations that were averaged to calculate 1 woody utilization estimate per study plot.

AUE

I used the following animal use equivalents (AUEs) for different classes and types of livestock: cows = 1.0 AUE, bulls = 1.3 AUE, yearlings = 0.6 AUE, horses = 1.3 AUE (Fig. 11; Table 1).
8. RESULTS

A. USE BY LIVESTOCK

Pastures 1–3 were grazed by livestock (i.e., cows, bulls, yearlings, and horses) at various times during 2015 and 2016 (Fig. 11). Pastures 2 and 3 were also grazed by horses in 2016. Overall, Pastures 1–3 were grazed at the following intensities during the 2–year study (Table 1): Pasture 1 (mean = 1.5 ha/AUM; range = 1.3–2.1); Pasture 2 (mean 90 ha/AUM; range = 5.2–305); Pasture 3 (mean 13 ha/AUM; range = 0.83–59). Pastures 1–3 were excluded from livestock grazing an average of 311 (± 29 SE) and 307 (± 6 SE) days, respectfully, during 2015 and 2016 (Table 2).
Figure 11. Mean number of grazing days, animal units (AUs), and animal unit days (AUDs) in Pastures 1–3 during 2015 and 2016. Vegetation sampling (VS) was conducted before livestock entered a pasture (pre–grazing), soon after livestock exited a pasture (post–grazing), and at the end of the growing season (end–of–season). Livestock grazed (G) pastures 2–61 days during the following grazing seasons as defined by the NRCS: Spring = Mar. 1–May 14; Summer = May 15–Aug. 31; Fall = Sept. 1–Oct. 31; Winter = Nov. 1–Feb. 28.

Table 1. Stocking rates (mean and range) for Pastures 1–3 during the 2–year study.

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Stocking Rate Mean (ha/AUM)</th>
<th>Stocking Rate Range (ha/AUM)</th>
<th>Total Pasture Area (ha)</th>
<th>Total Upland Habitat (ha)</th>
<th>Total Riparian ecosystem (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>1.3 – 2.1</td>
<td>130</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>5.2 – 305</td>
<td>365</td>
<td>345</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>0.83 – 59</td>
<td>15</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 2. Total number of days that livestock were excluded from Pastures 1–3 during 4 grazing seasons* in 2015 and 2016.

<table>
<thead>
<tr>
<th>Pasture</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td>1</td>
<td>75</td>
<td>61</td>
</tr>
<tr>
<td>2</td>
<td>74</td>
<td>79</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>98</td>
</tr>
</tbody>
</table>

*Livestock exclusion (non–use) is reported for the following grazing seasons as defined by the NRCS: Spring = Mar. 1–May 14; Summer = May 15–Aug. 31; Fall = Sept. 1–Oct. 31; Winter = Nov. 1–Feb. 28.

B. RAINFALL AND EPISODIC FLOODING EVENTS

Annual precipitation recorded on the Date Creek watershed was 31.1 and 27.7 cm in 2015 and 2016, respectively (Table 3; Figs. 12a), which was slightly below the long–term annual mean (33 cm) recorded in Congress, Arizona. There were 8 daily rainfall events of > 1.27 cm in 2015; half of these resulted in flooding (Fig. 12b). Flooding (similar to what is shown in Fig. 12b) was observed on the following dates in 2015: March 2 (large flood), September 8 (large
flood), October 6 (small flood), and October 20 (large flood). In 2016, there were 7 daily rainfall events of >1.27 cm, however, no significant flooding events were observed that year.

Table 3. Seasonal and total precipitation (cm) recorded on the Date Creek watershed during 2015 and 2016. Precipitation data are presented in relation to the major growing and dormant seasons of plants.

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan – Feb</th>
<th>Mar – June</th>
<th>July – Sept</th>
<th>Oct – Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>4.8</td>
<td>11.3</td>
<td>8.8</td>
<td>6.2</td>
<td>31.1</td>
</tr>
<tr>
<td>2016</td>
<td>6.3</td>
<td>4.2</td>
<td>9.2</td>
<td>8.0</td>
<td>27.7</td>
</tr>
</tbody>
</table>

Figure 12a, b. a) Monthly precipitation (cm) recorded on the Date Creek watershed during 2015 and 2016 (Flooding was observed on 4 occasions [*] during 2015), and b) Typical large flooding event on Date Creek (photo taken in January 2017, courtesy of Ranch 2).

C. VEGETATION

Because Pastures 1–3 collectively encompassed 17.5 km of Date Creek, which included similar riparian vegetation species, I report pooled 2015 and 2016 vegetation data from the 8, 50 m² study plots across the 3 sampling periods (i.e., pre–grazing, post–grazing, and end–of–season).
Combined Woody Plant Species Composition by Canopy Cover

The upper canopy was dominated by Fremont cottonwood and Goodding’s willow, whereas the midstory mostly consisted of seep willow and burrobush. These 4 species dominated the upper– and mid–canopy layers across the 6 sampling periods during both 2015 and 2016 (Fig. 13).

![Woody Species Composition](image)

**Figure 13.** Relative species composition (%) of 4 woody plant species (HYSA = burrobush, BASA = seep willow, SAGO = Goodding’s willow, POFR = Fremont cottonwood) on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by canopy cover (line–intercept technique). Other subordinate woody species occasionally detected included Arizona ash, honey mesquite, and salt cedar.

Combined Woody and Herbaceous Plant Species Composition by Biomass

While woody plant species composition was relatively constant throughout the study (Fig. 13), herbaceous plants varied seasonally (Fig. 14).
Figure 14. Relative species composition (%) of herbaceous (ERsp = buckwheat species, CYDA = Bermuda grass, VEAN = water speedwell, POMO = rabbitsfoot grass) and woody (HYSA = burrobush, BASA = seep willow, SAGO = Goodding’s willow, POFR = Fremont cottonwood) plant species on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by current year’s biomass (dry–weight–rank technique).

Individual Woody Plant Species Composition by Biomass

Species composition estimates of 3 of the 4 primary woody plants (Goodding’s willow, Fremont cottonwood, and seep willow) were slightly higher in 2015 than 2016 (Figs. 15–17). Burrobush remained relatively stable across the 3 sampling periods in 2015, was not detected during the pre–grazing sampling period in 2016, and showed a slight increasing trend during the post–grazing and end–of–season sampling periods (Fig. 18). In 2016, all 4 of these woody plants started at their lowest points during the pre–grazing sampling period but then showed a general trend to increase by the end–of–season sampling period (Figs 15–18).
Figure 15. Relative composition (%) of Goodding’s willow on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).

Figure 16. Relative composition (%) of Fremont cottonwood on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).
Figure 17. Relative composition (%) of seep willow on Date Creek in 2015 and 2016 during 3 sampling periods (pre-grazing, post-grazing, and end-of-season) as determined by weight (dry-weight-rank technique).

Figure 18. Relative composition (%) of burrobush on Date Creek in 2015 and 2016 during 3 sampling periods (pre-grazing, post-grazing, and end-of-season) as determined by weight (dry-weight-rank technique).
Individual Herbaceous Plant Species Composition by Biomass

Herbaceous vegetation was dominated by 2 grasses, Bermuda grass, and rabbitsfoot grass, and 3 forbs, water speedwell, and 2 species of buckwheat (*Eriogonum deflexum* and *E. polycladon*) (Figs. 19–22).

Bermuda grass was recorded at its lowest value during the 2 post–grazing sampling periods for both 2015 and 2016 (Fig. 19). Rabbitsfoot grass declined across the 3 sampling periods in 2015 but recovered to its high value by the 2016 post–grazing period (Fig. 20).

![Bermuda Grass Chart]

Figure 19. Relative composition (%) of Bermuda grass on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).
Figure 20. Relative composition (%) of rabbitsfoot grass on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).

Two forb species, water speedwell and buckwheat, were usually subordinate components of the herbaceous plant community compared to the 2 grasses (Figs. 21, 22). An exception occurred when water speedwell was detected at higher levels (~ 23%) than all other herbaceous plants during the 2016 pre–grazing period (Fig. 21). Percent composition of the 2 buckwheat species was < 5% for all sampling periods except during the 2015 pre–grazing sampling period when it was detected at a slightly higher level (~ 11%) (Fig. 22).
Figure 21. Relative composition (%) of water speedwell on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).

Figure 22. Relative composition (%) of 2 buckwheat species on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season) as determined by weight (dry–weight–rank technique).
Density of Woody Seedlings

Only 2 woody species, Fremont cottonwood and seep willow, were observed in significant numbers as seedlings during the 2–year study (Fig. 23). Other woody seedlings detected in trace amounts included Goodding’s willow, Bonpland willow, Tamarix species, honey mesquite, and burrobush.

In 2015, Fremont cottonwood seedlings decreased precipitously across the 3 sampling periods and were not detected in significant numbers throughout 2016 (Fig. 23). Similarly, seep willow seedlings declined sharply between the post–grazing and end–of–season sampling periods during 2015. In 2016, seep willow seedlings were detected at very low levels (< 2 m$^2$) during the post–grazing period.

Figure 23. Seedling density (number/m$^2$) of Freemont cottonwood (POFR) and seep willow (BASA) on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season).
Utilization of Woody and Herbaceous Plants

Percent utilization on woody plants remained very low (< 4%) for all sampling periods throughout 2015 and 2016 (Fig. 24). No woody plant utilization was detected in control plots during the post–grazing or end–of–season sampling periods during 2016.

Figure 24. Percent utilization of woody plants on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season). In 2016, no utilization was detected in control plots (grazing exclosures) during the post–grazing and end–of–season sampling periods.

Percent utilization on herbaceous plant species was light (< 14%) for all sampling periods in 2015 and 2016 (Fig. 25). Very light herbaceous utilization (< 4%) was detected in the control plots during the post–grazing and end–of–season sampling periods in 2016.
Figure 25. Percent utilization of herbaceous plants on Date Creek in 2015 and 2016 during 3 sampling periods (pre–grazing, post–grazing, and end–of–season). In 2016, very light herbaceous utilization (< 4%) was detected in control plots (grazing exclosures) during the Post–grazing and end–of–season sampling periods.
**9. DISCUSSION**

A. EFFECTS OF LIVESTOCK GRAZING PRACTICES ON SWFL HABITAT

Stocking rate is often cited as the most important grazing management decision that rangeland managers make (Galt et al. 2000). This is due to the well-documented effects of excessive stocking rates on resource degradation, declining animal production, and direct and indirect negative impacts on wildlife habitat, particularly in riparian areas (Belsky et al. 1999).

Stocking rates are the product of animal numbers and duration of use commonly expressed as AUDs or AUMs per unit area. The inverse of these ratios (e.g., unit area/AUD or AUM) are commonly used to express stocking rates in arid and semi-arid environments. Overall mean stocking rates in Pastures 1–3 during 2015 and 2016 were as follows (Table 1): Pasture 1 = 1.5 ha/AUM; Pasture 2 = 90 ha/AUM; Pasture 3 = 13 ha/AUM. Pasture 1 contained the highest quantity and percentage of riparian area among the 3 pastures (i.e., 110 of the 130 ha or 85% = riparian ecosystem; Fig. 8). Perennial surface and ground water in riparian areas is strongly correlated with higher forage productivity and quality (DeBano et al. 2003). Pastures 2 and 3 contained only 20 ha and 6 ha of riparian area, respectively (Figs. 9, 10). Pasture 2 was the largest of the 3 pastures (365 ha), however, most of it was desert upland vegetation (345 of the 365 ha, or 95% of the pasture area). Pasture 3 (15 ha) was the smallest pasture and contained the least amount of riparian (6 ha) and upland (9 ha) vegetation.

Managers can increase or decrease stocking rates by adjusting animal numbers and/or duration of use. Stocking rates were maintained at relatively conservative levels throughout this 2-year study by controlling both duration of use (time-control) and animal numbers. For example, of the 16 livestock grazing events that occurred on Date Creek during my 2-year study, 13 of those events averaged 14 AUs (+3 SE) grazing for an average of 16 days (+4 SE). On 2
occasions (one in 2015 and another in 2016), 50 AUs grazed Pasture 1 for 61 consecutive days. These 2 grazing events occurred before or after the summer monsoon season (generally July–Sept) when warm season perennial grasses would have been in the early stages of vegetative growth and before they elevated their apical meristems (May–June 2016), or, when they were dormant (i.e., Nov–Dec 2015). The 3rd heaviest stocking event occurred near the beginning of the summer growing season (July 11–18, 2015) when 266 AUs grazed Pasture 2 for 8 days.

Conservative stocking (i.e., mean = 14 AUs) combined with short grazing periods (i.e., mean = 16 days) for 81% of the grazing events on Date Creek during 2015 and 2016 resulted in low utilization rates on both herbaceous and woody plants for all sampling periods (Figs. 24, 25). Moreover, Pastures 1–3 were excluded from livestock grazing an average of 85% of the time during both 2015 and 2016 (mean = 309 days; Table 2). Utilization of woody plants (Fig. 24) tended to be lower than for herbaceous plants (Fig. 25) which was expected given that cattle were the main domestic herbivore that grazed Pastures 1–3. On 6 occasions in 2016, a few horses (range = 3–9) grazed Pasture 2 (n=2 occasions during the summer monsoon season) and Pasture 3 (1 of 4 occasions during the summer monsoon season) for short periods (range = 2–13 days). Both cattle and horses are classified as grazers and prefer herbaceous over woody plants, especially during the peak growing season when herbaceous plants are green, growing, and abundant (Streeter et al. 1974, Kloppenburg et al. 1995). Combined utilization levels in Pastures 1–3 were never greater than 14% on woody or herbaceous plants during any sampling period (Figs. 24, 25). When relative utilization was analyzed by pasture and by individual sampling period, the highest use level recorded for the entire study was in Pasture 2 during the 2016 “post-grazing” sampling period (i.e., 22% relative use on herbaceous plants, and 19% relative use on woody plants).
Kauffman et al. (1983) studied the effects of late summer grazing (i.e., mid– to late–August through mid–September, for up to 28 days) for 3 consecutive years on an Oregon montane riparian site which averaged 60 cm annual precipitation, more than twice the annual precipitation recorded on Date Creek in 2015 and 2016 (Table 3). Kauffman et al. detected significant changes in species composition and productivity in 4 of the 10 plant communities they studied. Stocking rates in the Kauffman et al. study ranged from 1.3–1.7 ha/AUM which resulted in relative utilization rates as high as 73% in the “moist meadow” plant community. Conversely, during a 6–year study in Colorado, riparian vegetation characteristics, density of flycatchers, and other shrub–nesting birds in cattle–grazed pastures did not differ from control pastures after the grazed pastures had been rested for nearly 3 years (Stanley and Knopf 2002). This study design involved 2 cycles of intensive, late growing season grazing (i.e., Aug.–Sept.) followed by 34 months of rest (Stanley and Knopf 2002). Other Oregon studies on the Malheur National Wildlife Refuge (MNWR) found higher abundance of passerine birds to be correlated with lower cattle stocking rates (Taylor 1986, Taylor and Littlefield, 1986). Stocking rates for the Taylor (1986) study ranged from 0.58–2.32 ha/AUM. Taylor acknowledged that other disturbances (e.g., dredging of meadows, haying, and camping activities) occurring on the MNWR also played a role in the decline of bird abundances.

The overall mean stocking rate during my 2–year study (40 ha/AUM) was several orders of magnitude lighter than the studies in Oregon and Colorado. Consequent relative utilization rates (i.e., post–grazing) were ≤ 22%, and, true utilization rates (i.e., end–of–season) were ≤ 6% (Figs. 23, 24) for both herbaceous and woody plants. Moreover, livestock managers in my study stringently controlled the season and duration of use to mitigate livestock impacts in riparian ecosystems. For example, there were 7 grazing events during this study that occurred during the
hottest part of the summer growing season (i.e., June–Sept.; Pasture 1 = 1 event, Pasture 2 = 3 events, and Pasture 3 = 3 events). However, during these 7 “hot season” events, livestock grazed for an average of $14 \pm 6$ days. The 9 “cool season” grazing events (i.e., Oct.–May) averaged $26 \pm 7$ days but occurred when most plants were dormant or when they would have already completed most of their growth and reproductive cycle.

The 4 primary woody plant species detected in this study consisted of 2 trees and 2 shrubs (Fig. 13). The canopy was dominated by Goodding’s willow and Fremont cottonwood, while the midstory typically consisted of seep willow and burrobush. These 4 woody species consistently dominated the upper– and mid–canopy layers across the 6 sampling periods during both 2015 and 2016 with little change in their relative species composition (Fig. 13). These findings, combined with consistently low utilization levels recorded on woody plants, indicate that seasonal time–controlled livestock grazing at the stocking rates used in this study had little effect on the woody habitat components of potential SWFL breeding and nesting habitat. When the woody plants were examined individually (Figs. 15–18) there was a consistent dip in productivity recorded during the 2016 pre–grazing period for all 4 woody plants. This coincided with the lowest amount of precipitation recorded during March–June in 2016 (Table 3).

Incorporating the 4 primary herbaceous plant species into the combined woody and herbaceous species composition analysis revealed seasonal shifts in species composition that was apparently related to the dynamic ebb and flow of disparate herbaceous plant life cycles, as well as to short–term responses to livestock grazing (Figs. 14, 19–22). Bermuda grass, a warm season perennial grass, and rabbitsfoot grass, a cool season annual grass, were the most dominant graminoids on Date Creek (Figs. 19, 20). Bermuda grass was at its lowest point during the post–grazing sampling period during both years (Fig. 19) indicating that its relative biomass was
influenced by light levels of utilization immediately after livestock had been removed from a pasture. Rabbitsfoot grass is an opportunistic annual grass that is capable of responding to both cool and warm season precipitation. Although considered an invasive weed by some (Crimmins et al. 2008), rabbitsfoot grass provides palatable, albeit ephemeral forage until a seed head emerges. Rabbitsfoot grass was not detected during the 2016 pre–grazing sampling period (Fig. 20) which as mentioned earlier coincided with the lowest level of seasonal precipitation recorded during the study (Table 3). However, rabbitsfoot grass responded favorably to the highest amount of seasonal precipitation measured (i.e., 11.3 cm during spring 2015 [pre–grazing], Table 3), as well as to favorable summer precipitation (i.e., 8.8 and 9.2 cm, respectively, during the summers of 2015 and 2016 [post–grazing], Table 3).

Water speedwell, a cool season, semi–aquatic forb, was detected at very low levels (< 4%) during all 3 sampling periods in 2015 but was the dominant herbaceous plant (~ 27%) measured during the 2016 pre–grazing period (Fig. 21). This adaptive plant has a broad ecological amplitude and has the flexibility to grow either as a biennial or a short–lived perennial depending on environmental conditions. Water speedwell could have also benefited from the release of competition after woody seedlings were removed following several consecutive flooding events that occurred during fall 2015 (Figs. 12 a, b). These flooding events likely opened space and resources which may have allowed this aquatic forb to quickly establish as the most dominant herbaceous plant detected in early 2016 (Fig. 21).

B. EFFECTS OF EPISODIC FLOODING ON SWFL HABITAT

Different aspects of flooding (e.g., intensity, duration, frequency, and timing) can have various effects on riparian plants, some of which may be beneficial (Molles et al. 1998), and
others that may be detrimental (Kozlowski 1984). Woody seedling density is a potential indicator of recruitment of the kinds of plants which could ultimately provide critical habitat structure to support the breeding and nesting activities of SWFL and other riparian bird species (Capers et al. 2005). Flooding directly affects seedlings by killing them through uprooting or by submerging them for prolonged periods of time. Seedlings can survive periods of submersion but the likelihood of survival decreases as time submersed increases.

Based on woody seedling data (Fig. 23) and my qualitative observations during both years of the study, flooding affected riparian vegetation mostly through the removal of woody seedlings in or near the stream channel. Seedling density was low at the beginning of 2015 (i.e., only 2 species were detected beyond trace levels), and consecutive flooding events during the fall of 2015 (Fig. 12a, b) likely contributed to the decline in density of Fremont cottonwood and seep willow seedlings at the end of the growing season in 2015; these 2 species did not recover to pre–flooding levels in 2016 (Fig. 23).

Established shrubs and trees were also physically affected, mostly through the bending and breaking of branches, although some individuals were uprooted and buried (or partially buried) under stream sediment, and some were completely washed downstream. Plants that were established in or near the stream channel received the most physical damage or mortality compared to plants that had established along the upper riparian banks. Again, consecutive floods during late 2015 (Figs. 12 a, b) paired with lower overall precipitation levels in 2016 (Table 3) could explain the overall trend for the species composition of 3 of the 4 woody plant species to be slightly lower in 2016 than 2015 (Figs. 15–17).
10. MANAGEMENT IMPLICATIONS

The impacts of livestock grazing on SWFL habitat features can vary depending on the animal species and its distribution, the intensity, duration, and timing of grazing, as well as the amount of rest provided for plants to recover from the effects of grazing. Livestock managers have some level of control over all of these things.

During my study, managers typically allowed modest numbers of cattle, and occasionally horses, to graze Date Creek for relatively short time intervals followed by much longer periods of non-use during both 2015 and 2016 (mean = 309 days of non-use/year, Table 2). Grazing periods were shortest during the hottest months of the year (June–Sept.; mean = 14 days) and slightly longer during the cooler months (Oct.–May; mean = 26 days). Hence, livestock typically grazed Date Creek for shorter intervals when riparian plants were metabolically active and for slightly longer periods when plants were mostly dormant. These management decisions (e.g., kind of animal [grazers], low animal numbers, short duration of use, varied season of use, followed by long periods of rest) resulted in low levels of utilization of both woody and herbaceous riparian plants across all sampling periods (i.e., < 14%). The utilization levels measured throughout my study were well below the recommended guidelines cited in the SWFL Recovery Plan, which are respectively ≤ 35% (± 5 SE) and ≤ 40% (± 10 SE) for herbaceous and woody vegetation (USFWS 2002).

When livestock are properly managed, SWFL habitats can be conserved. For example, cattle have been actively grazing the Cliff–Gila riparian valley in southwestern New Mexico for several decades alongside the largest known concentration of breeding SWFL populations in the U.S. (Parker and Hull 1994, Stoleson and Finch 2003). This area is dominated by a canopy of very tall trees including boxelder, Goodding’s willow, and Fremont cottonwood. The second
largest known concentration of breeding SWFL population in the U.S. occurs along the Kern River in south–central California where roughly 70% of the SWFL population breeds in riparian areas that are lightly to moderately grazed by cattle (USFWS 2002). On the Kern River site, livestock and land managers purposefully time cattle grazing to reduce thatch build up ostensibly to protect SWFL breeding habitat from unwanted wildfires. Both the Cliff–Gila and Kern River sites occur in areas with large flood plains and low–gradient perennial stream flows. Such conditions produce highly favorable hydrological environments for SWFL breeding habitat similar to Yosemite National Park where no breeding pairs have recently been detected (Siegel et al. 2008).

Developing conservative stocking strategies and grazing management tactics that seasonally rotate periods of grazing and non–use when plants are growing or dormant could reveal adaptive management options for rangeland and livestock managers that help mitigate livestock grazing impacts in SWFL habitat (Swanson 1997). Proactive management practices can increase flexibility for ranchers and rangeland managers while providing incentives to participate in the Working Lands for Wildlife SWFL initiative. In every case, the uniqueness and ecological potential of an area, as well as the skill and ability of managers, should be taken into account when developing management strategies and tactics (USFWS 2002).
11. LITERATURE CITED


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