Appendix G.

Management of Livestock Grazing in the Recovery of the Southwestern Willow Flycatcher

A. Introduction

Breeding habitat for the southwestern willow flycatcher is restricted to riparian ecosystems. As a result of multiple factors, southwestern riparian ecosystems are among the most endangered in North America. In arid western North America, livestock overgrazing has detrimental effects on riparian ecosystems (Ames 1977, Knopf and Cannon 1982, Kaufman and Krueger 1984, Skovlin 1984, Fleischer 1996, Ohmart 1996, Belsky et al. 1999), including many of the attributes of southwestern willow flycatcher nesting habitat (USFWS 1995). However, the effects of livestock grazing vary over the range of the flycatcher, due to variations in grazing practices, climate, hydrology, ecological setting, habitat quality, and other factors. Also, other stressors affect the flycatcher's habitat to varying degrees, including water management practices, stream channel control, recreational use, and agricultural activities. In some situations, these and other factors may aggravate livestock impacts, and are sometimes difficult to separate from grazing effects. Livestock grazing has been a prevalent industry in the region for 200 years or more, but there exists a limited body of rigorous industry records or scientific research that documents livestock grazing affects on the environment (Larsen et al. 1998). Most of the available research has shown negative impacts to a host of biological resources. Addressing the issue of livestock management in the context of recovery of the southwestern willow flycatcher is therefore complicated.

Ideally, this issue would be approached by examining information that specifically compares the effects of various grazing practices on the southwestern willow flycatcher and its habitat. Because this information remains to be researched, the Technical Subgroup was compelled to approach the question indirectly by reviewing literature pertaining to grazing within riparian areas. Questions we tried to address included: What direct effects does grazing have on southwestern willow flycatchers? What are the effects of grazing on southwestern riparian ecosystems? On riparian vegetation specifically? On the plants and other habitat attributes that are key components of flycatcher habitat? On riparian birds that are ecologically similar to the flycatcher?

A large body of literature related to livestock grazing and impacts to riparian habitats, the willow flycatcher, and other riparian birds was reviewed. Much of this literature came from more mesic areas of the West where ecological conditions and riparian recovery potential differ from the arid Southwest. Convincing evidence from within and outside of the flycatcher's range comes from exclosure studies such as the San Pedro River (Krueper 1992), where after major stressors – principally livestock grazing – were removed, the riparian habitat, channel morphology, and riparian bird fauna improved substantially within five years (Figures 1- 4). Although these studies lack experimental rigor, they provide evidence that in riparian habitats where livestock grazing is the major stressor, exclosure may be the quickest method of accomplishing recovery. A critical question for the Technical Subgroup is – after full recovery of flycatcher habitat and occupancy by flycatchers, what level of grazing (other than exclosure) may be compatible with the maintenance of the riparian habitat preferred by flycatchers?

Figure 1. Photopoint 22-B, Highway 90 and San Pedro River, San Pedro Riparian National Conservation Area, July 4, 1987. Photo courtesy of David J. Krueper, BLM.

Figure 2. Photopoint 22-B, San Pedro Riparian National Conservation Area, July 6, 1992, after five years of no grazing. Photo courtesy of David J. Krueper, BLM.

Figure 3. Photopoint 31, Greenbrush Draw and San Pedro River, San Pedro Riparian National Conservation Area, July 5, 1987. Photo courtesy of David J. Krueper, BLM.

Figure 4. Photopoint 31, San Pedro Riparian National Conservation Area, July 17, 1992, after five years of no grazing. Photo courtesy of David J. Krueper, BLM.

While reading this document, it is important to remember that livestock grazing is not a single-faceted activity. Grazing has parameters of extensiveness (wide-spread), intensiveness (number of animals, season of use, various grazing systems), and species-specific (cattle, horses, elk, burros, sheep, goats, llamas, etc.). This discussion is intended to provide general concepts of potential impacts and management measures. The effects of each would vary among these parameters of livestock grazing. Concepts and recommendations expressed herein are derived principally from interpreting research on the effects of livestock on biological resources. The Technical Subgroup acknowledges that, as with domestic livestock, excessive utilization of herbaceous and woody vegetation can occur by ungulates such as elk (*Cervus elaphus*) (Kay and Chadde 1992, Singer et al. 1994, Wagner et al. 1995). Even in the absence of domestic livestock grazing, elk can over-utilize riparian areas if not properly managed (Treadaway et al. 1999), requiring some corrective measures to balance this pressure with maintenance of other ecological functions. Management of ungulates as game animals is the responsibility of State game agencies, and is largely beyond the scope of a livestock grazing review. This issue paper addresses grazing by domestic livestock; grazing and browsing by native ungulates will be discussed in the Southwestern Willow Flycatcher Recovery Plan.

B. How Livestock Grazing Can Impact Southwestern Willow Flycatchers

Impacts of livestock grazing on southwestern willow flycatchers and their habitat fall into several general categories. The primary impacts are on habitat availability and suitability. Of lesser severity are the impacts of destroying nests with eggs or young, and facilitating brood parasitism by brown-headed cowbirds. These impacts are discussed below.

1. Impacts on Habitat Availability and Suitability

Because livestock use riparian vegetation for forage, and because riparian plant structure largely defines southwestern willow flycatcher habitat, grazing can have a variety of effects on flycatcher habitat. Information on this impact exists in a variety of forms, and comes from a variety of sources and perspectives. This information fell into four general categories:

1. Overall effects of livestock grazing on southwestern riparian ecosystems.
2. The effects and/or sustainability of livestock grazing on selected plants.
3. Impacts of livestock grazing on willow flycatchers, other riparian birds, and their habitat.
4. Examples of southwestern willow flycatchers being present where livestock grazing also occurs.

Brief reviews of these information categories follow:

Effects Of Livestock Grazing On Southwestern Riparian Ecosystems

Improper livestock grazing has been a significant factor in the degradation of riparian habitats in arid western North America. Excessive grazing can change watershed hydrology, water quality, aquatic and riparian ecology, and structure and composition of riparian plant communities. In general, excessive grazing results in general drying of riparian areas, reduction in vegetation structure and volume, changes in vegetation composition, soil compaction, increases in sedimentation and water temperature, and other effects (see Bryant et al. 1972, Ames 1977, Carothers 1977, Evans and Drebs 1977, USDA Forest Service 1979, Platts 1982, Knopf and Cannon 1982, Rickard and Cushing 1982, Cannon and Knopf 1984, Kaufman and Krueger 1984, Klebenow and Oakleaf 1984, Skovlin 1984, General Accounting Office 1988, Clary and Webster 1989, Schultz and Leininger 1990, Elmore 1992, Fleisher 1996, Ohmart 1996, Belsky et al. 1999, and others). Excessive livestock grazing activities in uplands contribute to changes in surface runoff quantity and intensity, sediment transport, soil chemistry, and infiltration and water holding capabilities of the watershed; flood flows may increase in volume while decreasing in duration, and low flows may decrease in volume and increase in duration (Brown et al. 1974, Gifford and Hawkins 1978, Johnson 1992). However, Larsen et al. (1998) and Rinne (1999) point out that although a significant body of literature on the effects of grazing on riparian ecosystem components exists, very little of that literature is based on credible experimental research. Common problems include inadequate description of grazing practices under study, weak study design (e.g., lack of replicates, lack of random allocation of treatments, controls either absent or not independent from treatments), and lack of pre-treatment data. The last is an especially pernicious problem, because grazing has been a pervasive land use and recovery may take decades or longer. True controls are difficult to find.

The Technical Subgroup concluded that the preponderance of evidence indicates that excessive grazing is harmful to riparian habitats. Key attributes of southwestern willow flycatcher habitat (dense deciduous vegetation, high water tables) are among the riparian characteristics most affected by livestock grazing. Thus the evidence indicates that excessive livestock grazing is deleterious to flycatcher habitat. However, there are examples of breeding flycatchers existing with livestock grazing (see below). This presents the challenge, addressed by this document, of determining what types of grazing (including grazing intensity, season, and grazing systems) are compatible with conservation and recovery of the flycatcher.

Effects And Sustainability Of Livestock Grazing On Plants

On this topic, development of guidelines for grazing in flycatcher habitat is somewhat limited by lack of directly applicable data. Range science literature tends to examine livestock grazing from the perspective of economic and ecologic sustainability of livestock production, economic sustainability of key forage plants, physiological sustainability of certain forage plants or plant associations, and maintaining or enhancing overall range condition. It is difficult to translate these measurements of grazing into effects on the primary attributes of southwestern willow flycatcher habitat. For example, grazing effects on willows that are physiologically "sustainable" by individual plants may not sustain the type of willow foliage volume and structure that constitutes flycatcher habitat. To characterize a grazing system as "sustainable" by the survival of individual willows says nothing regarding the effects on other key factors such as regeneration, ground cover of herbaceous plants, soil compaction, etc. Further, most literature on grazing effects and sustainability of riparian vegetation originates in regions other than the southwest, where differences in conditions of climate, hydrology, and regional flora limit their application in the southwest. For example, most southwestern willow flycatchers are not found in shrubby willows, but in higher-stature habitats dominated by tamarisk, tree willow, boxelder, or Russian olive. As true for ecosystem levels of assessment, studies on the effects of grazing (heavy versus light or no grazing) on riparian vegetation tend to be compromised by lack of true controls, weak methodologies, and inaccurate or overly broad quantification of grazing intensity and ecological effects (Larsen et al. 1998).

Willows can become a principal source of cattle browse as other more palatable forage resources are depleted or as the palatability of the alternate forage decreases (Kovalchik and Elmore 1992). While in Oregon most browsing damage to willows occurs in late summer (Kauffman et al. 1983, Smith 1982), in the arid southwest such damage may occur at other times, and at greater intensities, because of the more limited alternate forage (Skovlin 1984, Belsky et al. 1999). Willow seedlings may be a preferred forage. As long as palatable herbaceous forage is available in the riparian zone, willow utilization generally remains minor in Oregon (Kauffman et al. 1983). In Oregon, mid- to late-season grazing indicates that cattle begin utilizing the current annual growth on willows when riparian forage use reaches about 45% (4- to 6-inch stubble height), and cattle eat all the willows they can when herbaceous utilization is 85% or more (< 2 inches) (Kovalchik and Elmore 1992). Along the Verde River in Arizona, livestock use of woody shrubs and trees increased during dry winters when herbaceous forage was limited or upland range conditions were poor (Tonto National Forest, unpubl. data). During dry winters use of woody shrubs and trees increased greatly after bud break, which typically occurred in late February to early March (Tonto National Forest, unpubl. data). Cattle display a strong preference for remaining in riparian zones because of the availability of shade, water, and forage. This preference can lead to further habitat degradation that, typically, would not be captured in standard vegetation utilization monitoring. For example, stream bank alteration monitoring by the Tonto National Forest on the Verde River showed that the proportion of alterable stream banks showing degradation (e.g., bank sloughing, compaction, removal of vegetation) reached 100% well before use of woody vegetation by livestock reached the established threshold of 40% (Tonto National Forest, unpubl. data).

The available literature indicates that in some areas and depending on the type of herbaceous forage available, negative impacts on woody riparian vegetation (e.g., willows) can be avoided by not allowing stubble height of herbaceous vegetation to be reduced below 3 to 6 inches (Cook et al. 1967, Cook and Harris 1968, Clary and Webster 1989). Also, cattle generally prefer grasses and forbs to woody vegetation, at least when the herbaceous vegetation is green (Gillen et al. 1985, Holechek and Vavra 1983, Kovalchik and Elmore 1992, Vavra et al. 1980). Therefore, some use of palatable grasses and sedges can occur without undesirable browsing of riparian shrubs and streambank damage (Clary and Webster 1989, Kauffman and Krueger 1984, Kauffman et al. 1983, Kovalchik and Elmore 1992, Platts and Nelson 1989). Damage to stream banks can further be avoided by implementing guidelines established by Fleming et al. (2001). They recommend that the extent of alterable stream banks remaining un-vegetated should not exceed 10%. Alterable stream banks are those portions of banks containing exposed soil or vegetation and that are not composed of bedrock, boulders, or large cobbles.

The applicability of these observations to riparian habitat in the arid Southwest is limited by three factors: 1) The majority of these studies originate outside the Southwest, in more cool and moist climates where upland forage is more abundant; 2) Herbaceous vegetation (understory) was not treated as a significant component of habitat but is sometimes a significant component of flycatcher habitat, so utilization by livestock equates to some reduction in this habitat attribute; 3) These studies concern themselves with avoiding excessive impacts or unsustainable use of woody vegetation. The criteria for defining these concepts (e.g., “excessive” or “unsustainable”) are not always provided, and are not likely to be the same as the criteria for avoiding negative impacts to the woody vegetation component of flycatcher habitat.

Mosley et al. (1997) suggested the following guidelines for stubble heights in riparian systems in Idaho: 1) stubble height of 3 to 4 inches for sedges, tufted hairgrass, and similar species following the growing season; 2) two inches for Kentucky bluegrass; 3) four to 6 inches for large bunchgrasses; and 4) utilization of riparian shrubs should not exceed 50 to 60% during the growing season. However, some researchers caution against recommendations that call for a uniform level of utilization or stubble height to maintain riparian attributes because these recommendations ignore the inherent complexity of riparian systems (Green and Kauffman 1995).

Many riparian shrub species appear to be more tolerant of leaf and twig removal than shrubs inhabiting drier sites. For example, Lammon (1994) reported that planeleaf willow could sustain 58 to 70% utilization. Riparian shrubs are generally more tolerant of browsing because they benefit from greater water availability to support plant growth. However, as noted above, willows that can physiologically sustain these use levels may not ecologically sustain southwestern willow flycatchers. Also, the effect of grazing and browsing on willow reproduction is a concern because willow seeds are short-lived and are not stored in soil seed banks (Brinkman 1974, Densmore and Zasada 1983). First-year willow seedlings can be especially sensitive to browsing. Shoots and roots at this age are generally less than 12 and 8 inches in length, respectively. Browsing of first-year shoots often kills the entire plant, because the plants are easily pulled from the ground or are killed by trampling (Kovalchik and Elmore 1992). However, mature willows have been shown to reproduce well as long as herbaceous utilization in riparian systems does not exceed 70%; at greater utilization willow reproduction is compromised (Mosley et al. 1997).

Excessive livestock grazing can have a considerable effect on vegetation, resulting in depressed vigor, biomass, and altered species composition and diversity (Bryant et al. 1972, Evans and Drebs 1977, Knopf and Cannon 1982). Excessive grazing pressures in riparian zones can significantly reduce herbaceous vegetation (Kauffman et al. 1983, Marcuson 1977) and browse (Kauffman et al. 1983, Knopf and Cannon 1982). Within the riparian zone, livestock use of browse is related to availability and palatability of herbaceous vegetation, and the palatability of the available browse (e.g., tamarisk is generally considered to be relatively unpalatable to livestock). In addition, excessive grazing pressure can prevent the establishment of seedlings (Carothers 1977, Glinski 1977). By high-lining (consumption of forage up to the maximum height of the animal) riparian deciduous shrubs or trees, or removing low-level vegetation altogether, browsing reduces the vegetation's suitability for supporting nests, may increase nest detectability to predators, and reduces foraging options. This may be a greater problem in monotypic, shrubby type habitats than in higher-stature habitats. Changes are somewhat insidious as habitat at a gross scale may persist, and condition or trend may require several years to determine under continued livestock management.

Throughout their evolutionary history, willow flycatchers probably inhabited vegetation that was grazed and browsed by large herbivores (Burkhardt 1996, see also Appendix F). More than 20 now extinct large herbivorous mammals (>45 kg) inhabited the Western United States and Mexico during the Late Quaternary (Martin and Szuter 1999). These were in addition to the nine extant large herbivores. Thus, over evolutionary time, large herbivores used riparian zones to an unknown level but probably not to an intensity that significantly reduced habitat suitability. Platts (1991) asserted that prior to European contact, "wild ungulates usually grazed within the carrying capacity of the range. If forage produced by a given range suddenly became scarce or nonexistent, wild grazing animals either moved to more favorable ranges or perished, bringing populations into balance with range capacity." Additionally, migratory herbivores – by their behavior of migration – inherently yield rest periods for their forage (Frank 1998). Perhaps more importantly than forage/consumer feedback mechanisms, predators (including humans [Martin and Szuter 1999]) played an important role in the condition of vegetation. Kay (1998) asserts that during the Pleistocene, herbivores were predator limited, and not food limited. Over much of the West, large predators have been extirpated enabling large herbivores, including livestock, to over-use the range. Predator prey dynamics of large herbivores and carnivores can have marked effects on riparian bird populations mediated through changes in the habitats (Berger and Stacey, In prep.).

The ecological equivalency of native large herbivores during the Pleistocene to domestic livestock is open to debate. Livestock management is characterized by constraints on movement (fencing) and predator control. Cattle are not frequently herded (Platts and Nelson 1989), and thus will concentrate activity in streamside zones during the spring and summer growing periods.

The Technical Subgroup concluded that the scientific literature on browsing of riparian shrubs and trees, in particular, was inadequate to determine levels of browse that are detrimental or acceptable for flycatcher habitat. Shrub and tree survival do not directly equate with suitable willow flycatcher habitat, particularly with consideration of the flycatcher's preference for dense foliage from the ground up. No studies evaluated or tested grazing levels with habitat metrics such as foliage volume or foliage height diversity.

Effects Of Livestock Grazing On Willow Flycatchers, Other Riparian Birds, And Their Habitats

At this time, specific effects of livestock grazing on southwestern willow flycatcher habitat have not been defined through experimental research. The effects are inferred from more general investigations. Southwestern willow flycatcher habitat is generally typified by high plant density and moist conditions; grazing in riparian habitats can result in reduction of plant density and a drying of riparian habitats. Not all riparian areas in the southwest are southwestern willow flycatcher habitats. However, because grazing can negatively impact riparian ecosystems in general, it follows that southwestern willow flycatcher habitat can be affected. Therefore, the Technical Subgroup concludes a negative correlation between prolonged or heavy grazing and presence of quality flycatcher habitat is probable.

Another strategy to help define the impacts of livestock grazing on the flycatcher is to examine the documented effects of grazing on other willow flycatcher subspecies, other riparian birds that are often associated with and/or ecologically similar to the flycatcher, and their habitats. We reviewed published information on the effects of livestock grazing on riparian birds, and evaluated those findings for their relevance to managing for recovery of the southwestern willow flycatcher (Table 1). As noted above regarding the general literature on environmental effects of grazing, the studies summarized are somewhat compromised by inadequate description of grazing practices, including level of grazing, intensity, lack of replication, and lack of pre-treatment data. With that qualification, the studies show that improper grazing is deleterious to many riparian birds. That southwestern willow flycatchers probably fall into the group that are harmed is supported by the fact that the Great Basin willow flycatcher (*Empidonax traillii adastus*) was harmed. Within the range of grazing practices examined, winter grazing and lighter grazing intensities had lesser negative effects than heavier grazing, summer grazing, or year-round grazing. Similarly, riparian habitats were rehabilitated most quickly and/or completely with no grazing (Ohmart 1996), and more quickly with light and/or winter grazing than with heavy, summer, and/or year-long grazing. Certainly, more research is needed to evaluate differences in rates of riparian recovery under total exclusion versus fall-winter, winter, and early spring grazing regimes. As with the literature on overall ecological effects of grazing, much of the literature on effects of grazing on riparian birds originates from outside the Southwest - generally from the Great Basin and Sierra Nevada. However, this literature is considered relevant because riparian habitats in the arid range of the southwestern willow flycatcher are more vulnerable to livestock impacts than these more mesic regions. As shady, cool, wet areas providing abundant forage, they are disproportionately preferred by livestock over the surrounding warm, xeric uplands (Ames 1977, Johnson 1989, Kauffman and Krueger 1984, Belsky et al. 1999). The negative effects of livestock grazing are typically more severe in warmer, drier environments.

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
1,2	Arapaho NWR, Colorado	Elevation: 2,500 m (8200 ft) Sage-brush outside of flood plain. 8 spp of *Salix*.	Avian community response to differences in seasonal (winter vs. summer) grazing patterns. Both seasons experienced heavy grazing.	2-year study, avian community surveys; multiple vegetation measurements at bird-centered and random points	Bird community segregated into groups that were sensitive, insensitive, and benefited by summer grazing. Sensitive species (e.g.,WIFL[a]) used locations based on bush spacing. Grazing impacts primarily through the horizontal patterning of the vegetation community.	WIFL[a] density 0.2/ha in winter grazed, absent in summer grazed. Significant correlations include height of bush (+,2/2), mean height of nearest bushes (+,½), standing biomass of herbaceous layer (-,½), distance to nearest bush (-,2/2), # of dead stems (+,2/2).	Suggests willows in winter-grazed are healthy, summer grazed are decadent; due in part to drier soils and vegetation. BHCOs[b] more common in summer-grazed. Downplays height relationship as biased by territorial behavior, not necessarily important in patch selection.
3	Lower Truckee River, Nevada	Elevation and adjacent vegetation not reported; pictures suggest sagebrush,	Compare breeding bird abundance between 1868 (Ridgway) and 1972-76.	Ridgway's undefined "rare, common, abundant" categories compared with more-clearly defined categories from multiple transect (2x2 km) surveys and 25 km survey.	Both + and – changes in the avifauna, WIFL[a] common in 1868, not detected in the 1970-80 samples.	Identifies multiple assaults on riparian system since 1868. Protection of 1 site from grazing, troubled by persistent trespass, shows some habitat recovery.	Some interpretation problems, lack of any information on livestock grazing intensity, uncontrolled for other practices.
4	Mountain Meadows	generic	literature review and recommendations			Relative to grazing, recommends eliminating grazing or delaying it until mid-August.	

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
5 & 6	Malheur National Wildl. Refuge, Oregon	Southeastern Oregon, fenced and irrigated pastures.	Response of yellow warbler and willow flycatcher[a] abundance to changes in grazing intensity.	Bird density and grazing intensity. Two bird data sets: BBS routes over 10-years and 9 strip surveys for 2 years within pastures under different livestock management.	On Breeding Bird Survey (BBS) routes, abundance of WIFLs[a] increased from nearly 0 during 1st 5 years to 18-30 during last 4 years of a 10-year period when AUM's decreased by about 75% (120k to 30k AUM) over the same period. When the transects are ordered by frequency of cattle grazing on an annual basis, clear negative correlation.	Reduced grazing increases willow production and enhances bird productivity. WIFL[a] #s not substantial until shrub volume > ≈900 m^3 / 100m transect.	Removal of willows by grazing appeared to be the mechanism. WIFL's[a] habit of nesting within 2 m of the ground made them especially vulnerable.
7	Central Sierra Nevada, California	Elevation: 1525-2285m (5000-7500 ft) Montane meadows.	Document livestock grazing impacts and protection measures.	Bird territory and nest monitoring over multiple years in three meadows. Two study sites fenced to restrict livestock except during early spring and late-fall drop-off and round-up.	Livestock directly caused 20% WIFL[a] nest loss, and damaged another 20% post-fledging. Reduced stocking (40%) and delayed on-date (after July 15) for 75% of remaining livestock eliminated nest losses.	Areas grazed intensively for drop-off and round-up provided nesting habitat. Controlling stock numbers and retarding on-dates reduce conflicts apparently because forage remains more abundant away from nesting areas, thus diminishing the attractiveness of the wet meadow area later in the season.	Prior to the grazing management change, WIFL[a] nests were destroyed by livestock from early July through mid-August. Nests were not destroyed earlier in the season, presumably due to the abundance of succulent forage, drinking water and cool climate earlier in the season and the wetness of the meadows earlier in the summer.

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
8	Southeast Wyoming	Elevation: 2225-2380 m (7300-7800 ft)	Compare birds and habitat at two willow riparian sites with different grazing history: 1) AUMs from >5,000 in 1920s to 900 after 1967, July 1- 30 Sept. season of use; 2) currently (and recent) 1,750 AUMs from 6 June to 30 Sept (prior grazing "overuse").	3-year study, random shrubs and bird species-defined shrubs as point centers to compare shrub density and tunneling effects.	Where grazing intense, *Empidonax* spp used shrubs in density the same as available (ca. 950/ha), whereas where grazing lighter, *Empidonax* spp. used shrubs in less dense (mean about 950/ha) areas than available (ca 2000/ha). Tunnel heights lower on lighter-grazed area, but no relationship with grazing discussed.	Suggests that flycatchers select for a patchy distribution of willows, a condition for which livestock can be used to achieve. However, distribution needs to be controlled to prevent detrimental effects.	SPECIES OF EMPIDONAX NOT DISCLOSED. However, other species discussed are WIFL associates. Tunnel floors were covered by grasses and sedges, suggesting the grazing intensity was relatively low.
9	Nevada & Idaho	Elevation: 1875-1966 m (6150-6450 ft) sagebrush surroundings.	Compare birds in 2 paired grazed (grazing intensity not reported) and un-grazed (excluded for 11 years, light trespass grazing) of high elevation riparian zones.	Measured vegetation cover by growth form. Willow clumps recorded average stem diameter and average stem height, biomass estimated by equation. Birds were spot-mapped from > 10 visits both in 1988 and 1989.	Herbaceous plants differed significantly between grazed and un-grazed. Aspen differed significantly. A large difference between willow standing crop biomass was masked by extreme variation. Non-willow, large shrub biomass was significantly greater in grazed than un-grazed. No meaningful differences in bird species richness, total bird density, and bird biomass between grazed and un-grazed. *Empidonax* spp, presumed to be dusky flycatchers had slightly higher (45.3) on grazed vs. (33.8 pairs/40 ha) un-grazed sites.	Mid-to-late summer grazing (intensity unknown) caused significant changes in herbaceous vegetation and aspen regeneration, and perhaps modified willow standing crop. Differences in riparian bird community were slight.	Only one location had willows. By written description and bird species identified, the other area unlikely to have been WIFL[a] habitat. The discussions here refer only to the more potentially suitable pair of study plots. Small mammal communities differed between the grazed and un-grazed areas.

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
10	Carson Range, Nevada	Elevation: 1920 m (6298 ft) Montane meadow, surrounded by lodgepole and Jeffrey pine and white fir.	Compare vegetation structural differences between a 30-year rested and summer-grazed (cattle and sheep, typically 24 cow-calf units) area; both between 25-30 ha. Compare differences in predation rates on active and artificial nests . No grazing during year of study; thus, differences suggested to be the result of grazing-induced habitat change on predators, and not on the presence of the livestock per se.	Cover within quadrants classified by growth form and the height of the top vegetation layer. Nest searches and monitoring at 4-5 day intervals. Artificial nests experiments in three designs; 1) simulating natural placements of habitat generalists [n = 30 ground and 30 above-ground each]; 2) in willows within 15m of channel [15 ground and above-ground each]; and 3) willows distant (>100m) to stream [15 ground and 15 above-ground nests, each]	Willows more abundant within 15 m of stream on un-grazed. Artificial nests were more successful on un-grazed than grazed plot in all above-ground, but not in the on-ground nests in experiment 1 & 2. Real nests were significantly more successful when grouped, but not for on-ground or above-ground categories.	Long-term grazing may alter productivity via changes in predation pressure; i.e., changes in abundance and make-up of predator community; changes in predator behavior or nest detectability; or decreasing the nesting opportunities of nesters.	No replications in study.
11	Multiple	Various	Literature review and meta-analysis of 9 published empirical grazing/breeding bird studies. Grazing intensity not specified.	Species assessed in >1 study; differences between treatments > 25%, and majority in same direction (harm, benefit)	Eight species benefit from grazing, 17 impacted, and 18 unresponsive or inconsistent responses. Species impacted were nesters and/or foragers in heavy shrub or herbaceous ground-cover, and/or vulnerable to nest parasitism.	Grazing (unspecified intensity, system, etc.) has detrimental effects on some riparian species – especially those occupying the vegetation utilized by WIFLs.	Literature review.

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
12	San Pedro River, Arizona	Elevation: 1097-1280m (3600-4200 ft) Ecotone between Sonoran and Chihuahuan Deserts	Case study of riparian community recovery and changes in bird density.	4 years after livestock exclusion, under-story vegetation increased (documented with before/after picture). Spot mapping of bird populations.	No grazing, more under-story vegetation, marked increase (consistent and > 2x) in most (7) of the neotropical migrants studied (10).	Species positively responding in density are likely associates of WIFLs[c]. Remove grazing, habitat improvement measurable within 4 years.	Uncontrolled case study.
13	See 5 & 6	See 5 & 6	Response of avian community to changes in grazing intensity.	See 5 & 6.	Willow volume significant negative correlation with frequency of grazing, positive correlation with the time since last grazing. Passerine abundance correlated with shrub volume and shrub heights between 2-6 m, but not for shrubs 1 m high. Same for bird species richness.	WIFLs[a] only present on 4 areas: most WIFLs[a] (average 14.3-18.0 males) where livestock excluded for 40 years & maximum shrub volume. Second average 10.3-12.3 males) was 6-yeas of exclusion (1 winter graze) and 2nd greatest shrub volume. Other 2 (averages; 3.7-4.0 males and 0.7-1.3 males, respectively) sites were 7th & 4th in terms of shrub volume. No WIFL[a] use in most recently grazed or impacted units.	One site had reduced passerine abundance than expected based on shrub volume. Accounted for by the heavy camping pressure on the site.

Table 1. Summary of literature examining effects of livestock grazing on riparian birds.

Citation	Location	Site information	Study objectives	Methods & parameters measured	Conclusions	Relevance to southwestern willow flycatcher habitat	Other
14	Western US	Various	Summarize impacts of livestock grazing on fish & wildlife resources of riparian habitats.	Literature review & pertinent personal observations.	Demonstrable effects of grazing on all forms of wildlife. Suggests impacts to migrants as well as residents (unsupported).	[page 270] "The best way to manage riparian habitats is not to graze them. [Page 272] "With total rest, most systems…show tremendous change within 8-10 years. & "with managed grazing riparian healing time is twice and maybe 4 times longer than exclusion."	Brief discussion of livestock as management tool – but notes that examples of [well] managed riparian grazing are so few and [poor] unmanaged grazing so common that this tool is meaningless. Identifies a couple of cases of good riparian habitat under some grazing regimes.
15	Northeast California, Northwest Nevada	Great Basin	Compare bird and small mammal densities in "heavily" grazed and un-grazed examples of 6 habitat types; one of which (Aspen) appears (based on plant and animal species encountered) to be possibly relevent to WIFLs[a]. The un-grazed Aspen site had livestock exclusion for 87 years.	Vegetation sampled in twenty 1m^2 plots every 5 m along line transects. Height and species composition of the canopy, mid-story and under-story, % cover and count of rooted species. Birds inventoried on 1-mile strip census on 3 consecutive mornings.	Relative to grazed site, un-grazed had lush 1-m deep under-story of forbs. Young aspen and willow in the mid-story. Mid-story almost absent on grazed. Litter 2x as deep on un-grazed site compared with grazed. *Empidonax* sp. density was 21/100 acres on un-grazed, and 8/100 acres on grazed. Total avian density was 792 and 385 birds / 100 acres on the un-grazed and grazed site, respectively. Both treatment and control had a group of unique species.	"Heavy" grazing eliminated the mid-story (shrubby vegetation. Bird species community reflected these changes.	Sites were paired based on its equivalent site potential (as per Daubenmire), not proximity. No replicates. Besides "heavy," grazing not quantified.

[a] Great basin willow flycatcher, *Empidonax traillii adastus*

[b] Brown-headed cowbird, *Molothrus ater*

[c] Southwestern willow flycatcher, *E. t. extimus*

1. Knopf et al. 1988.
2. Knopf, F. 1999. Pers. comm
3. Klebenow and Oakleaf 1984
4. Sanders and Flett 1989.
5. Taylor and Littlefield 1984.
6. Taylor and Littlefield 1986.
7. Valentine et al. 1988.
8. Krueger and Anderson 1985.
9. Clary and Medin 1992.
10. Ammon and Stacey 1997.
11. Bock. et al. 1993.
12. Krueper 1993.
13. Taylor 1986.
14. Ohmart 1996.
15. Page et al. 1978.

Southwestern Willow Flycatchers Coexisting With Livestock Grazing

In some locations, southwestern willow flycatchers breed at sites which experience some degree of livestock grazing. The sites described below are located in exceptionally large floodplain riparian areas, where riparian conditions are of distinctive quality and extent. These examples indicate that under certain circumstances, flycatchers can exist with livestock grazing. Although both livestock and flycatchers occur together, specific data on grazing practices are not yet available, effects on riparian vegetation are not documented, and long-term trends (>10 years) of the resident flycatchers are either fluctuating or unknown. The lack of experimental data on the impacts of grazing to habitat and consequent responses by flycatchers leaves questions of coexistence, suitability, and compatibility unanswered. Translating these examples into refined management prescriptions that allow both grazing and flycatcher recovery will require improved documentation and monitoring of grazing practices, research into effects on riparian habitats, and continued monitoring of flycatcher populations.

The South Fork of the Kern River, California

A relatively large population of southwestern willow flycatchers occurs on the Kern River in south-central California. This population has fluctuated from 44 pairs in 1989 to 27 pairs in 1992, 38 in 1997, 26 in 1998, and 12 in 2000 (Whitfield et al. 1998 and pers. comm.). The variation in these numbers, and that they have been supported in part by cowbird trapping since 1993 (Whitfield et al. 1998), suggest that while the population persists, it may not be stable. The South Fork of the Kern River presents a nearly ideal setting for extensive, high-quality flycatcher habitat. It is a low-gradient broad floodplain with perennial stream flow and a high water table. Riparian habitat is present as a kilometer-wide cottonwood-willow forest with extensive marshy conditions. The Kern River Preserve was established in 1981, and grazing was significantly reduced in that year. Harris et al. (1987) believed that terminating grazing along parts of the South Fork of the Kern River resulted in increases in riparian vegetation and, consequently, nesting southwestern willow flycatchers (Figures 5 and 6).

Livestock presence now varies from year to year with roughly 70% of the flycatcher population occurring in areas grazed at least occasionally. All flycatcher areas that have grazing have light to moderate winter grazing. Except for removing spring/summer grazing, researchers do not believe that flycatcher numbers were significantly affected by the different grazing regimes (M. Whitfield pers. obs.). Data from grazed and ungrazed areas on the Kern River are not comparable because the areas are intrinsically different. Three components of this situation merit mention. First, grazing at the Kern River Preserve is not part of an annual grazing scheme but is conducted at the preference of the Preserve Manager, who determines ecological conditions, as well as on and off dates for livestock. Second, the Preserve comprises 1,127 acres which allows close monitoring of ecological conditions and efficient removal of livestock when conditions warrant removal. Third, forage production of perennial grasses on property adjacent to the Preserve has been measured at a level of biomass that is rarely found in other riparian systems within the range of the southwestern willow flycatcher. During a recent “wet” year, production estimates from a wet meadow on this property were approximately 4,000 and 11,000 pounds/acre in April and June, respectively (M. Whitfield pers. comm.). In the same year, production estimates from an alkaline meadow on the property during April and June were about 2,700 and 2,400 pounds/acre, respectively.

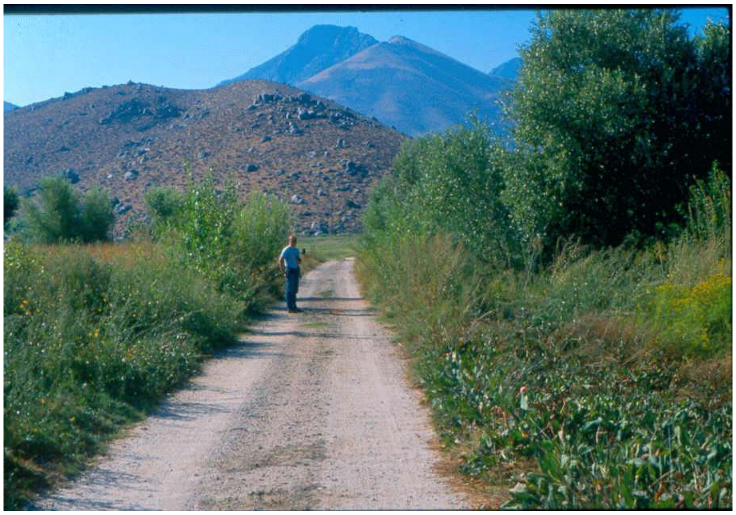

Figure 5. Kern River Preserve driveway in 1988 following about 6 years of no grazing. Photo courtesy of M. Whitfield, Kern River Preserve.

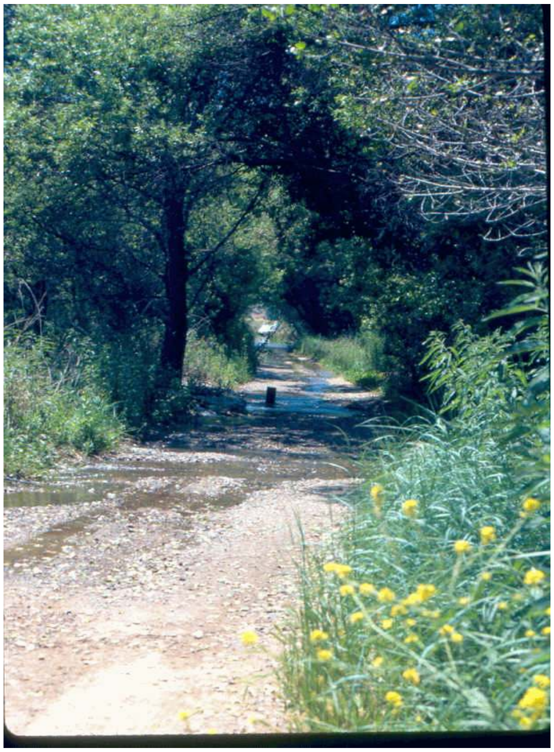

Figure 6. Kern River Preserve driveway in 1998 following about 16 years of no grazing. Photo courtesy of M. Whitfield, Kern River Preserve.

The Cliff-Gila Valley, New Mexico

In the Cliff-Gila Valley of the Gila River in southwestern New Mexico, the largest known population of southwestern willow flycatchers exists. With roughly 200 nesting pairs, this area constitutes a substantial portion of the subspecies' total numbers. This reach of the Gila River presents a unique combination of natural and manmade factors affecting flycatcher habitat. The area has highly favorable hydrological conditions for flycatcher habitat - a broad floodplain with perennial low-gradient streamflow. Some streamflow is diverted onto the floodplain to irrigate pastures, and ranch operators have allowed extensive riparian vegetation to develop along field edges, irrigation ditches, and return flow courses (Figure 7). Although water is diverted from the Gila in this area and upstream, the river is not regulated by dams upstream. Significant floods occur periodically, as in the El Niño events of 1979, 1983, and 1993, and a 1997 flood caused by Pacific typhoon Nora (Stoleson pers. obs.). Thus, natural hydrological functions like floodplain wetting, scouring, flushing of salts, and sediment deposition still occur. During the 1997 event for example, streambanks were damaged in a few areas but in general much sediment was deposited, which has resulted in substantial regeneration of riparian vegetation. Some sediment beds from earlier floods support more advanced regeneration, some of which has become occupied by flycatchers recently (S. Stoleson pers. comm.).

The majority of the Cliff-Gila population is contained in 20 riparian patches on a private ranch. Of these, two are grazed nearly year-round, seven are in a pasture grazed in late fall and winter, and the remaining 11 have had grazing excluded since approximately 1993 but are adjacent to pastures that are grazed periodically throughout the year (S. Stoleson pers. comm.). It is difficult to characterize the grazing in this area. It is closely managed; there are no fixed rotations or stocking rates, rather cattle are rotated among pastures based on visual assessments of range quality. Half of the floodplain pastures are used for off-season grazing only, and the other half are used year round. Pastures are a variety of irrigated permanent pastures, dry pastures, and fields planted in forage crops. The relative proportions of these pasture types varies from year to year. It is possible that the irrigated pastures, which are used extensively in the dry months of May and June, provide the cattle with better quality forage than they might extract from riparian vegetation. Cattle often seem to enter the riparian patches only to drink and seek shade, but not to forage (S. Stoleson pers. comm.).

A significant change in management that provided a potential short-term benefit to flycatcher habitat was the increase in water diversions to irrigate pasture and forage cropland. In approximately 1993, ranch operators experienced an increase in water available for diversion. The additional water was used to rehydrate old irrigation ditches to irrigate several pastures and fields. Stoleson (pers. comm.) suspects that any increases in flycatchers in recent years are directly related to the increase in hydration of the floodplain and corresponding changes in vegetation. The two habitat patches with the most flycatchers (49 and 41 pairs in 1999) are adjacent to irrigated fields where water runs off and produces a densely vegetated, swampy area.

Figure 7. Cliff-Gila Valley, New Mexico, October 1998. Photo taken by S. Sferra, USBR.

The Technical Subgroup is unable to conclude that the livestock management activities at the Kern River and Gila Valley are, on the whole, either detrimental or beneficial to the flycatcher. Similarly, it is unclear whether current management will sustain suitable habitat in the long-term. It is difficult to draw conclusions in the absence of better quantitative and/or experimental data. In both situations, livestock operators have access to alternative pastures in addition to the riparian areas discussed, so their ability to relieve pressure on the riparian areas is increased. Water is relatively abundant in both areas. This factor illustrates that with sufficient water, options for managing flycatchers and other resource uses are substantially increased, and conflicts are likely to be reduced. With sufficient water, riparian and aquatic ecosystems are more resilient and more capable of supporting multiple demands. Despite the above uncertainties, the Technical Subgroup commends these landowners and livestock managers for considering the flycatcher in decisions regarding grazing. The current grazing programs appear to be compatible with the current flycatcher population levels. The Technical Subgroup also commends these managers for enabling researchers to study these important populations. These areas present opportunities for continuing and refining very important research.

2. Destroying Nests with Eggs or Young

In some habitats, livestock may contact flycatcher nests or supporting limbs while watering, foraging, shading, or resting in riparian areas. This may result in destruction of the nest, or loss of eggs or nestlings. This impact is probably most common in high-elevation (1800 m or 6000 ft), low-stature monotypic willow stands. In the Sierra Nevada (the little willow flycatcher, *Empidonax traillii brewsteri*) Valentine et al. (1988) observed four of 20 studied nests destroyed by livestock prior to the young fledging. Additionally, four other nests were destroyed by livestock within days after they fledged young - demonstrating that more nests were susceptible. Strikingly, some of the losses occurred in cattle exclosures that were not adequately maintained. Susceptibility of the nests to livestock was attributed to their low height within the shrubs (approx. 1.5 m or 5 ft), small diameter of their supporting limbs, proximity to water, low branch density near the nests, and proximity to shrub edges. However, the height to which livestock can affect willow flycatcher nests is unknown (Valentine et al. 1988). Loft et al. (1987) illustrated that heavy grazing can reduce the cover attributed by willow up to at least 1.5 m (5 ft). Because southwestern willow flycatcher nest heights vary considerably, so does the magnitude of this threat. For example, southwestern willow flycatcher nests have been reported at heights from 0.6 to 18 m (1.9 to 59 ft) (Sogge et al. 1997). Herbivores have probably always grazed riparian zones over the willow flycatcher's evolutionary history, suggesting that the source of loss is not unique to domestic livestock; however, its frequency may now be out of the species range of variation, especially in low stature habitats. The grazing intensity over that pre-European contact period may well have been sufficiently different from that experienced under current livestock management. Clearly, the biological significance of livestock toppling of nests is large when the entire flycatcher population is low and the number of habitats occupied is few.

3. Facilitating Brood Parasitism by Brown-headed Cowbirds

Livestock grazing can facilitate brood parasitism by brown-headed cowbirds (*Molothrus ater*). Livestock grazing in and adjacent to riparian habitat may provide cowbirds with greater access to southwestern willow flycatcher nests, improve foraging opportunities, and establish foraging areas closer to flycatcher nesting areas. Cowbirds can impact southwestern willow flycatcher productivity even when the grazing is remote (> 8 km or 5 mi) from the flycatcher's nesting habitats (Curson et al. 2000, Rothstein et al. 1984). However, these impacts are variable and site specific. Because cowbird parasitism varies geographically and temporally, data on cowbird abundance, distribution, and levels of nest parasitism must be gathered locally. These data are essential to determine the extent to which cowbird control or cowbird habitat management via livestock management efforts are justified (see Appendix F; cowbird parasitism and management).

C. Measures That Can Be Taken To Alleviate Livestock Impacts

The fundamental approach to recovering an endangered species is to remove the threats to its existence, whether they are contamination, persecution, loss of habitat, or others. In the case of livestock grazing and the southwestern willow flycatcher, our approach was to examine the available information to determine as specifically as possible the degree and the conditions under which livestock grazing is compatible or incompatible with flycatcher recovery. This effort was undertaken because of a desire to avoid recommending undue or unnecessary restrictions on a widespread, traditional land use industry.

With the southwestern willow flycatcher, the effort to fine-tune recovery recommendations with respect to livestock grazing is worthwhile, as livestock operators, biologists, and management agencies increasingly learn that much can be accomplished by working together. However, the primary responsibility of the Technical Subgroup is to chart the recovery of the southwestern willow flycatcher. The goal of a recovery plan is to recommend actions that will bring about recovery of a species. The evidence and field examples indicate that with respect to livestock grazing, southwestern willow flycatcher recovery would be most assured, and in the shortest time, with total exclusion of livestock grazing from those riparian areas that are deemed necessary to recover the flycatcher and where grazing has been identified as a principal stressor. There is also evidence that under the right circumstances, certain types of grazing are likely to be compatible with recovery. While the data are insufficient to identify specifically what grazing systems are compatible in which specific circumstances, exploring the levels of grazing that may be compatible with maintenance of suitable flycatcher habitat is warranted.

During five separate meetings with Implementation Subgroups associated with the Recovery Team, individuals representing the ranching industry repeatedly underscored the importance of maintaining flexibility within livestock management operations. Evaluation of the current system of public lands grazing leads to the conclusion that there is little or no flexibility because allotments are either all committed to permittees or have been withdrawn from grazing for various conservation or other purposes. When permittees find themselves in a situation where the allotment needs rest, their choices may be limited to selling their livestock, finding alternative pastures or private land to graze, and/or continuing to graze the allotment. There is no grass bank for public lands grazing. Also, contemporary public land managers are frequently compelled to manage livestock grazing and a variety of other resource uses and values without adequate staff and funding. In some cases, livestock grazing is conducted in the context of management unit boundaries that may be constraining to flycatcher recovery and inappropriate for the complexities of modern ecosystem-based resource management. Modifications to these management unit boundaries may be necessary to achieve recovery goals. Therefore, in addition to specific recommendations (Table 2), the following general recommendations are made, encouraging Federal land managers to undertake a major conservation planning initiative to:

1. Identify the most important riparian areas for the recovery of the southwestern willow flycatcher and riparian and aquatic organisms in general.
2. Identify the most appropriate areas for permitting livestock grazing given the biodiversity concerns for the particular land management unit.
3. Reconfigure grazing pasture boundaries to reflect the true productivity of rangelands associated with important flycatcher recovery areas, and allow differential management of units of varying ecological sensitivity.
4. Exclude livestock from sites where exclusion would result in the greatest ecological improvement and least economic loss.
5. If monitoring is less than annual, establish livestock use numbers based on drought years, not the average or wettest years, to provide for livestock operations that are viable given this region's propensity to experience prolonged drought. With annual monitoring, adjust livestock levels in response to reduced forage availability, poor vigor and physiological stress on forage plants, and/or decreased cover brought on by drought conditions.
6. Establish an adequate number of ungrazed areas at different elevation and geomorphic settings. These will provide land management agencies and researchers with a much-needed series of sites against which to compare the condition of grazed watersheds (Brinson and Rheinhardt 1996) (see #8 below).
7. Institute and/or improve record-keeping and documentation of grazing practices, retroactively where possible, so that the ecological effectiveness of various grazing practices can be more scientifically evaluated (see #8 below).
8. Work with state universities, private colleges, and research institutions to fund and facilitate research that better defines the ecological and hydrological effects and sustainability of livestock grazing in southwestern ecosystems, particularly southwestern riparian ecosystems.

These recommendations strive to promote flexibility within the confines of conserving willow flycatchers. With flexibility and proper grazing management, grazing may be compatible with recovery and conservation of the southwestern willow flycatcher and other riparian species. This conservation planning effort and adjustment of managing public lands grazing should be completed within the next five years. In the interim, the Technical Subgroup is challenged with providing specific recommendations that will begin the process of recovery. After thoughtful and thorough review of the scientific literature, and much deliberation, the Technical Subgroup is confident there is common ground between the needs of the livestock manager and the southwestern willow flycatcher. Both prosper from efforts that sustain the quality of the landscape. The preponderance of evidence indicates that conservative stocking rates and light-to-moderate utilization levels are generally effective in maintaining range condition while increasing individual animal (livestock) performance (Johnson 1953, Klipple and Costello 1960, Paulsen and Ares 1962, Martin 1975, Houston and Woodward 1966, Holechek 1992, Winder et al. 2000). In all cases, the uniqueness of each area needs to be recognized and considered in developing a management strategy.

Accepting that conservative management is a logical beginning point, the Technical Subgroup recognizes that the spatial and temporal flexibility remaining within the context of conservative management will, by necessity, be further reduced for purposes of recovering the critically endangered southwestern willow flycatcher and the riparian habitats upon which it depends. Recommendations the Technical Subgroup believes will begin the process of recovery while promoting ecologically sustainable grazing practices are presented below (Table 2). A precept of these recommendations is that grazing has been identified as the major stressor, or one of the major stressors. Recommendations are based on the best information available on the effects of livestock on southwestern riparian ecosystems, on selected plant types, and on willow flycatchers and other riparian birds. Because of the impacts discussed in this document, this information in general points toward cessation of grazing to accomplish recovery. However, the information reviewed here also suggests some degree of compatibility between grazing and flycatcher recovery, under certain circumstances. This table explores the variability in southwestern willow flycatcher habitats, grazing systems, and ecological considerations of plant phenology. Southwestern willow flycatcher habitats are allocated to two broad categories. These are the lower stature willow habitats often found at higher elevations (>1,830 m or 6,000 ft), and taller stature habitats found at lower elevation typically comprised of willow, cottonwood, boxelder, tamarisk, and associated trees and shrubs. Grazing is separated into growing season and non-growing season of woody riparian vegetation (non-growing season is from leaf drop to bud break of common woody riparian species).

The recommendations do not address the myriad other grazing variations. This issue paper does not address specific locations where these recommendations should be implemented, but rather identifies management for general categories of sites. Therefore, the recommendations for domestic livestock grazing presented in Table 2 should be interpreted as general guidelines that should be applied according to site-specific conditions (see summary on page G-31). Specific watersheds or portions of watersheds for implementation of recovery actions are identified in the main body of this plan, in the form of recovery goals (e.g., total number of flycatchers, acres of habitat, and distribution of these across the range).

The intent of these general grazing guidelines is to promote recovery of the southwestern willow flycatcher while allowing conservative livestock grazing where appropriate and to provide flexibility for adaptive management in order to maintain or enhance southwestern willow flycatcher habitat. We recognize that private lands will play an important role in the recovery of the flycatcher, and that coordination and cooperation with private landowners and public grazing permittees is critical to the success of this recovery effort. In order to provide incentives for private landowners and public grazing permittees to improve and manage for southwestern willow flycatcher habitat, flexibility through adaptive management must be an integral part of the recommended grazing guidelines. Therefore, if a particular grazing system is improving southwestern willow flycatcher habitat (e.g., grazing system is not preventing regeneration of woody and herbaceous riparian vegetation), then that particular grazing system should be allowed to continue provided it is appropriately monitored and documented.

Table 2. General guidelines for domestic livestock grazing in southwestern willow flycatcher habitat.

Site Conditions			**Site-Specific Guidelines**	
Habitat Status	**Flycatcher Status**	**Season**	**Low-Stature Habitat: 3-4m shrubby willow**	**All other habitat types ≤1830 m or 6000 ft elevation**
1. Restorable or Regenerating Habitat[1]	1A. Unoccupied	Growing Season[2]	No grazing.	No grazing.
	1B. Unoccupied	Non-Growing Season	No grazing.	Provisional grazing[3] (assumes grazing is not a major stressor).
2. Suitable Habitat	2A. Unoccupied	Growing Season	No grazing.	No grazing, but at discretion of USFWS, provision for a limited number of small-scale, well-designed experiments to determine levels of pre-breeding season grazing that do not adversely affect southwestern willow flycatcher habitat attributes. Grazing not to exceed 35% utilization of palatable, perennial grass or grass-like plants in uplands and riparian habitats, and extent of alterable stream banks showing damage from livestock use[4] not to exceed 10%.[5]
	2B. Unoccupied	Non-Growing Season	Conservative grazing with average utilization not to exceed 35% of palatable, perennial grasses and grass-like plants in uplands and riparian habitats, and extent of alterable stream banks showing damage from livestock use not to exceed 10%. Woody utilization not to exceed 40% on average.	Conservative grazing with average utilization not to exceed 35% of palatable, perennial grasses and grass-like plants in uplands and riparian habitats, and extent of alterable stream banks showing damage from livestock use not to exceed 10%. Woody utilization not to exceed 40% on average.
	2C. Occupied	Growing Season	No grazing.	No grazing until research in comparable unoccupied habitat demonstrates no adverse impact; if unoccupied habitat becomes occupied habitat, continue existing management (grazing should not exceed 35% of palatable, perennial grasses and grass-like plants in uplands and riparian habitats, and extent of alterable stream banks showing damage from livestock use not to exceed 10%).

Table 2. General guidelines for domestic livestock grazing in southwestern willow flycatcher habitat.

	2D. Occupied	Non-Growing Season	No grazing.	Conservative grazing with average utilization not to exceed 35% of palatable, perennial grasses and grass-like plants in uplands and riparian habitats, and extent of alterable stream banks showing damage from livestock use not to exceed 10%. Woody utilization not to exceed 40% on average.
3. Uplands & Watershed Condition [6]	3. Occupied & Unoccupied	For any season of use	Average utilization of palatable, perennial grasses and grass-like plants not to exceed 30-40%. Use stubble height guidelines: 3" for short grass, 6" for midgrass, 12" for tall grass. Determine monitoring species prior to grazing.	Average utilization of palatable, perennial grasses and grass-like plants not to exceed 30-40%. Use stubble height guidelines: 3" for short grass, 6" for midgrass, 12" for tall grass. Determine monitoring species prior to grazing.

[1] "Restorable" means riparian systems that are degraded but have the appropriate hydrological and ecological setting to be restored to suitable flycatcher habitat, and could be restored with reasonable costs and actions. Lack of regeneration due to grazing is one factor contributing to habitat degradation; conditions in each habitat should include adequate plant regeneration to ensure habitat sustainability into the future. At these sites, flycatcher habitat is precluded largely or solely by livestock impacts. "Restorable" habitats are those that would be suitable if not for grazing, alone or in combination with other major stressors. This means cessation of grazing is a necessary, but not necessarily a sufficient action.

[2] Growing season is defined as bud break to leaf drop for cottonwood and willow species. Non-growing season is defined as leaf drop to bud break for cottonwood and willow species.

[3] Grazing should only be conducted if it is not a major stressor and does not preclude satisfactory progress toward suitability.

[4] Damage to stream banks from livestock use includes: bank chiseling, trampling, trailing, soil compaction, breakage of vegetation, bank sloughing, etc.

[5] Alterable stream banks are those portions of banks containing exposed soil or vegetation and not composed of bedrock, boulders, or large cobbles (Fleming et al. 2001).

[6] Uplands and watersheds, or portions of watersheds, associated with areas identified as restorable, regenerating, or suitable southwestern willow flycatcher habitat. General guidelines should be implemented unless site-specific data clearly indicate that deviation from the guidelines will not prevent or slow progression toward suitability and/or maintenance of suitable habitat conditions.

The guidance provided in Table 2 is based on the current endangered status of the southwestern willow flycatcher. Flexibility will increase with the eventual downlisting of the flycatcher to threatened status. Overall, the best available information suggests that flycatcher recovery is most assured with no grazing in its habitat during the growing season. In some situations, some light to moderate levels of grazing during the non-growing season may be compatible with flycatcher recovery , if carefully managed and closely monitored. Where grazing is indicated in Table 2, the following set of conditions apply:

1. All grazing is to be accompanied by monitoring. If funding is not sufficient to allow monitoring, then grazing should be discontinued. Monitoring should include exclosed areas, where possible, in riparian habitat on allotments or pastures where grazing has been discontinued, as well as allotments or pastures where grazing is allowed to continue.
2. The target for total utilization of palatable, perennial grasses and grass-like plants should not exceed 35% (±5% to accommodate sampling error) in upland and riparian habitats. Utilization of 35% not only includes direct consumption, but also includes other factors associated with herbivory (e.g., trampling, trailing, bedding). With monitoring, stocking rates may be adjusted to current forage production each year (White and McGinty 1997).
3. Stubble height baselines should have a forage/acre figure associated with them, if possible, so the baseline is not established for areas that are too poor to graze.
4. Annuals are excluded from the forage base because reliance on annuals indicates overuse of perennial grasses and grass-like plants and woody riparian vegetation.
5. The target for utilization of woody vegetation at the pasture level is 40% (±10% to accommodate sampling error), meaning the removal of 40% of the biomass of the current year's growth. This not only includes direct consumption but also includes other factors associated with herbivory (e.g., trampling, breakage of vegetation).

Consideration of uplands is essential. Elmore and Kaufman (1994) reported that "simply excluding the riparian area (from grazing) does not address the needs of the upland vegetation or the overall condition of the watershed. Unless a landscape-level approach is taken, important ecological linkages between the uplands and aquatic systems cannot be restored and riparian recovery will likely be limited." Livestock grazing may alter the vegetation composition of the watershed (Martin, 1975, Savory 1988, Valentine 1990, Popolozio et al. 1994). It may cause soil compaction and erosion, alter soil chemistry, and cause loss of cryptobiotic soil crusts (Harper and Marble 1988, Marrs et al. 1989, Orodho et al. 1990, Schlesinger et al. 1990, Bahre 1991). Cumulatively, these alterations contribute to increased erosion and sediment input into streams (Johnson 1992, Weltz and Wood 1994). They also contribute in changes to infiltration, water holding capacity of the watershed, and runoff patterns, thus increasing the volume of flood flows while decreasing their duration (Brown et al. 1974, Gifford and Hawkins 1978, Johnson 1992). As a result, groundwater levels may decline and surface flows may decrease or cease (Cheney et. al. 1990, Elmore 1992).

1. Narrative Interpretation of Table

Row 1A (Unoccupied restorable habitat in growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

At sites where the goal is to restore habitat to suitable for flycatchers no grazing is recommended, because most of the nesting structure is within the zone of direct livestock impact. This habitat type is highly susceptible to direct impacts, and slow to recover due to the short growing season. With a goal of restoring habitat, the best possible conditions for hydrological recovery, regeneration, and growth of vegetation are desired. The literature indicates exclusion of grazing will facilitate this. For this habitat and the next three (through row 1B), note that the transition from “restorable” habitat to “suitable” habitat will be a regulatory decision made by USFWS with input from land managers, based on habitat attributes discussed in Appendix D.

All other habitat types < 1,830 m or 6,000 ft.

At sites where the goal is to restore habitat to suitable for flycatchers, no grazing is recommended. With a goal of restoring habitat, the best possible conditions for hydrological recovery, regeneration, and growth of vegetation are desired. The literature indicates exclusion of grazing will facilitate this.

Row 1B (Unoccupied restorable habitat in non-growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to restore habitat to suitable for flycatchers. No grazing is recommended, because this habitat type is highly susceptible to impacts. With a goal of restoring habitat, the best possible conditions for hydrological recovery, regeneration, and growth of vegetation are desired. The literature indicates exclusion of grazing will facilitate this.

All other habitat types < 1,830 m or 6,000 ft.

The goal is to restore habitat to suitable for flycatchers. No grazing is preferred, but provisional grazing is considered possible if grazing is not a major stressor. With a goal of restoring habitat, the best possible conditions for hydrological recovery, regeneration, and growth of vegetation are desired. Grazing must not preclude satisfactory progress toward suitability. In situations where other significant stressors occur, those should be removed, and the significance of grazing as an additive or synergistic stress should be considered.

Row 2A (Unoccupied suitable habitat in growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes. No grazing is recommended, because this habitat type is highly susceptible to fragmentation and impacts. With a goal of maintaining and enhancing habitat, the best possible conditions for maintaining hydrological integrity, and maintenance, regeneration, and growth of vegetation are desired. The literature indicates exclusion of grazing will facilitate this.

All other habitat types < 1,830 m (6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes. No grazing is recommended, because with a goal of maintaining and enhancing habitat, the best possible conditions for maintaining hydrological integrity, maintenance, regeneration, and growth of vegetation are desired. The literature indicates exclusion of grazing will facilitate this.

Regarding grazing research, the intent is to collect information that may allow changes in these recommendations, if appropriate. This grazing research offers a reasonable complement to excluding grazing from most of the sites in this category, and is crucial to refining our understanding of grazing effects on riparian ecosystems. Here as elsewhere, documentation and monitoring of grazing systems and effects is important.

Row 2B (Unoccupied suitable habitat in non-growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes while providing an alternative to no grazing. Grazing is allowed at specified intensities because literature from the Pacific Northwest and other areas indicates these rates of utilization on herbaceous and woody plants can be sustained by the plants. Effects on flycatcher habitat characteristics are not known. Grazing utilization rates must be monitored with emphasis on collecting data that will provide an opportunity to modify this and other recommendations in the future.

All other habitat types < 1,830 m (6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes while providing an alternative to no grazing. Grazing is allowed at specified intensities because literature from the Pacific Northwest and other areas indicates these rates of utilization on herbaceous and woody plants can be sustained by the plants. Effects on flycatcher habitat characteristics are not known. Grazing utilization rates must be monitored with emphasis on collecting data that will provide an opportunity to modify this and other recommendations in the future.

Row 2C (Occupied suitable habitat in growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes, and protect nesting flycatchers. All current breeding flycatchers are important to recovery. No grazing is recommended, because this habitat type is highly susceptible to fragmentation and impacts, and flycatcher nests are vulnerable to direct disturbance. The literature indicates exclusion of grazing will avoid these impacts.

All other habitat types < 1,830 m (6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes, and protect nesting flycatchers. All current breeding flycatchers are important to recovery. No grazing is recommended, because effects of heavy grazing are known to be deleterious. Effects of light or moderate growing-season grazing on flycatcher habitat are not specifically known. The literature indicates exclusion of grazing will avoid these impacts. Some field examples (e.g., Cliff-Gila Valley) indicate that under some circumstances, flycatchers persist with grazing during the growing season. However, the general effects are unknown. Research is needed to define the relationships and thresholds involved. If research is completed on comparable unoccupied sites, grazing may be considered, at intensities below thresholds that degrade flycatcher habitat.

Row 2D (Occupied suitable habitat in non-growing season):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes. All current breeding sites are important to recovery. No grazing is recommended, because this habitat type is highly susceptible to fragmentation and impacts. This habitat type may be particularly vulnerable in the non-growing season when snow covers alternate forage plants. Effects of heavy grazing even in non-growing season are known to be deleterious. Effects of light or moderate grazing on flycatcher habitat are not specifically known. The literature indicates exclusion of grazing will avoid these impacts.

All other habitat types < 1,830 m (6,000 ft)

The goal is to maintain and/or enhance flycatcher habitat attributes. All current breeding sites are important to recovery. Conservative grazing is allowed at specified intensities because literature from the Pacific Northwest and other areas indicates these rates of utilization on herbaceous and woody plants can be sustained by the plants. Effects on flycatcher habitat characteristics are not known. Several field examples (e.g., Kern River) demonstrate that flycatchers persist with this grazing system in some situations.

Row 3 (Uplands and watershed condition, all seasons):

Low Stature Habitat: 3-4 m monotypic shrubby willow at high elevation (> 1,830 m or 6,000 ft)

The goal is to rehabilitate and maintain uplands and watersheds in conditions that will facilitate restoration of southwestern willow flycatcher riparian habitat. Evidence suggests this conservative grazing regime will achieve this goal (see Table 1). Monitoring species must be determined prior to grazing, and monitoring must take place.

All other habitat types < 1,830 m (6,000 ft)

The goal is to rehabilitate and maintain uplands and watersheds in conditions that will facilitate restoration of southwestern willow flycatcher riparian habitat. Evidence suggests this conservative grazing regime will achieve this goal (see Table 1). Monitoring species must be determined prior to grazing, and monitoring must take place.

2. Summary:

This issue paper does not address specific locations where recommendations contained herein should be implemented, but rather identifies management for general categories of sites. Because of the variability associated with riparian systems, these recommendations should be interpreted as guidelines that must be applied according to site-specific conditions. The uniqueness of each area needs to be recognized and considered in the development of site-specific management strategies. Specific watersheds or portions of watersheds for implementation of recovery actions are identified in the main body of this Recovery Plan (e.g., total number of flycatchers, acres of habitat, and distribution of these across the range).

The Technical Subgroup recommends against growing-season grazing in southwestern willow flycatcher habitat. Within the range of grazing practices examined, winter grazing and lighter grazing intensities had lesser negative effects than heavier grazing, summer grazing, or year-round grazing. Similarly, riparian habitats were rehabilitated most quickly and/or completely with no grazing, and more quickly with light and/or winter grazing than with heavy, summer, and/or year-long grazing. Research is needed to define the relationships and thresholds involved. A reasonable complement to excluding grazing is to provide for a limited number of small-scale, well-designed, and adequately funded experiments to determine appropriate levels of pre-breeding season grazing. This grazing research is crucial to refining our understanding of grazing effects on riparian systems.

Development of refined management prescriptions that allow both grazing and flycatcher recovery will require improved documentation of grazing practices. The need for monitoring is fundamental. The Technical Subgroup recommends that grazing be discontinued if not accompanied by monitoring. Monitoring should include exclosed reference areas in riparian habitat, where possible, on allotments or pastures where grazing has been discontinued, as well as allotments or pastures where grazing is allowed to continue.

D. Literature Cited

Please see Recovery Plan Section VI.

Appendix H.

Exotic Plant Species in Riparian Ecosystems of the US Southwest

A. Introduction

Species that have recently established in a new ecosystem as a result of human intervention are referred to as exotic, introduced, or alien species. There are an estimated 5,000 exotic plant species in U.S. natural ecosystems, compared with about 17,000 species of native plants (Morse et al. 1995, Morin 1995). Management of exotic species has become an issue of great regional, national, and international concern.

Many exotic species cover only small areas and do not appear to be spreading. Others have become thoroughly enmeshed in native ecosystems and are referred to as being naturalized. Those that continue to spread rapidly and widely are referred to as invasive. Invasive exotics have brought about various types of ecological changes, some of which are perceived as being negative (Simberloff 1981, Williamson and Brown 1986). Economic losses attributed to widespread invasives are high (Sell et al. 1999). A great amount of effort is spent on controlling undesirable exotic species, often with little success.

In response to this problem, the President of the U.S. in February of 1999 issued an Executive Order on Invasive Species, which among other things, created an Invasive Species Council and Advisory Board. Ideally, these bodies will reaffirm the need to approach exotic species management from a rational, scientific perspective. Many aspects of the exotic species issue have become steeped in myth and misinformation, and some management approaches are ill-advised. Some of the beliefs about the causes and consequences of exotic species spread do not hold up under scientific scrutiny (Treberg and Husband 1999). Also, some exotic plant species, including *Polypogon monspeliensis (*now common in riparian zones of the U.S. Southwest*)* are becoming endangered in their native countries, requiring that management actions take on a more global perspective (Jefferson and Grice 1998).

There are fundamental questions to address before formulating exotic plant management plans. Which species and sites warrant management attention? What are the root causes that facilitate the spread of the undesirable exotics? Can we address these root causes and restore conditions that allow native species to proliferate? In addition to attempting to *control* the exotic species, it is paramount to *restore* the desired ecosystem components and functions. In this issue paper, we address these questions from the perspective of restoring habitat quality for the endangered southwestern willow flycatcher within riparian ecosystems of the U.S. Southwest. A more complete discussion of habitat restoration is provided in Appendix K (habitat restoration).

Exotic Species in Riparian Habitats

There are hundreds of exotic plant species in the riparian west. For example, 25% of 340 vascular plant species along the Hassayampa River in central Arizona are exotic, as are 34% of 185 species along the Snake River in Idaho (Wolden et al. 1994; Dixon et al. 1999). Many riparian exotics cover only small areas and are encountered infrequently, but others have become regionally widespread and locally dominate channels or flood plains.

It is beyond the scope of this paper to provide information on the relative risks, invasiveness, or abundance of all the exotics in the many different biotic communities occupied by the flycatcher, although this would be a valuable exercise (Dudley and Collins 1995). In Table 1, we list some of the exotic plant species present in riparian and wetland ecosystems within the range of the southwestern willow flycatcher. Note that classification of a species as exotic or native is not always clear cut, and not all “weeds” are exotic. Sometimes, it can be difficult to determine how long a species has been present in an area. For example, we omit cocklebur (*Xanthium strumarium*) from Table 1 because it appears naturally to be a circumglobally distributed disturbance species.

Many of the species in Table 1, such as Bermuda grass (*Cynodon dactylon*), rabbits foot grass (*Polypogon monspeliensis*), and red brome (*Bromus rubens*), are grasses or forbs that dominate the ground layer of actual or potential habitat for southwestern willow flycatchers. Some, such as athel tamarisk (*Tamarix aphylla*) and pepper tree (*Schinus molle*) have become invasive in other countries (Griffin et al. 1989), but do not cover large areas or spread rapidly in riparian zones of the U.S. Southwest despite having been widely planted in the region. While these and other exotics may be neutral or exert only a minor or localized negative effect, or in some cases, perhaps a positive effect on habitat suitability for Southwestern willow flycatchers, a notable few are highly invasive trees, shrubs, or tall grasses that now constitute the main structural layer in many Southwestern riparian habitats. In this paper, we concentrate our attention on three of these, and devote particular emphasis to tamarisk:

1) *Tamarix ramosissima* (and closely related species) are large shrubs to small trees native to Eurasia. They were sold by U. S. nurseries as early as 1820 and marketed as landscape plants; and escaped cultivation in the late 1800s (Tellman 1997). Some tamarisks (saltcedar) were intentionally planted along the Rio Grande and Rio Puerco in the 1920s to stabilize eroding surfaces (Robinson 1965). Over the past century, tamarisk expanded its distribution, while native forests of Fremont cottonwood, Goodding willow, and mesquite declined (Harris 1966; Everitt 1980). By the mid-1960s, tamarisk covered an estimated one million acres of flood plains and stream beds in North America (Robinson 1965). Tamarisk is abundant along many of the low-elevation, hot desert rivers of Arizona and southern Nevada, such as the lower Colorado, Gila, and Virgin Rivers (Bowser 1957). It also is abundant along several higher elevation rivers including the Rio Grande and Pecos River of New Mexico and Texas, Brazos River in Texas, Green and Colorado Rivers of Utah, and Gunnison River of Colorado. Tamarisk can dominate the canopy or form an understory layer to taller cottonwoods and willows.

2) Russian olive *(Elaeagnus angustifolia)* is a small Eurasian tree that has escaped from cultivation and become naturalized along riparian areas in the western U.S. (Knopf and Olson 1984, Shafroth et al. 1994, Olson and Knopf 1986.). Russian olive is common along many rivers of the Colorado Plateau and other high elevation sites, including the Rio Grande and San Juan River. Russian olive often forms a mid-canopy layer under taller cottonwoods, but at some sites dominates the canopy.

3) Giant reed (*Arundo donax*) is a tall, perennial grass introduced to the Southwest in the 1800's for use as a source of thatch for roofs and for erosion control along canals. It is highly invasive, and spreads rapidly through dispersal of fragmented rhizomes during flood events. Although it produces flowers, sexual reproduction by giant reed is unknown in the areas to which it has been introduced (Bell 1997). In contrast to native woody species in which seedlings become established as flood waters recede, giant reed propagules become established when floods are at or near maximum levels, facilitating invasion into stands of mature vegetation. Rhizomes can sprout from depths of up to 100 cm below the soil surface; but adequate moisture must be present for several months for successful establishment (Else 1996, Dudley 2000). Once established, giant reed forms large, dense rhizome masses up to a meter thick, with stems up to 8 m tall. The established plants are relatively resistant to dessication, and can dominate the canopy layer of riparian sites, replacing willows, cottonwoods, and *Baccharis salicifolia* (mulefat or seep-willow). It has become particularly abundant along the waterways of southern California, including the Santa Ana, Santa Margarita, and San Luis Rey rivers, and is currently perhaps the greatest proximate threat to preservation of California’s remaining native riparian habitat (Bell 1997).

Table 1. A partial list of exotic plant species present in riparian and wetland ecosystems within the range of the Southwestern willow flycatcher.

Scientific name	Common name	Growth form
Ageratina adeonophora	-	shrub
Agrostis stolonifera	creeping bent grass	perennial grass
Agrostis viridis	bent grass	perennial grass
Ailanthus altissima	tree-of-heaven	clonal tree
Alhagi camelorum	camel-thorn	shrub
Arundo donax	giant reed	perennial grass
Avena fatua	wild oats	annual grass
Bassia hyssopifolia	smother-weed	annual forb
Bromus catharticus	rescue grass	annual grass
Bromus diandrus (*B. rigidus*)	brome	annual grass
Bromus rubens	red brome	annual grass
Brassica nigra	black mustard	annual forb
Centaurea melitensis	star-thistle	annual forb
Chenopodium album	lamb’s quarters	annual forb
Chenopodium murale	goose-foot	annual forb
Cirsium arvense	Canada thistle	perennial forb
Conium maculatum	poison hemlock	biennial forb
Cortaderia jubata	-	perennial grass
Cortaderia selloana	pampas grass	perennial grass
Cynodon dactylon	bermuda grass	perennial grass
Cytisus scoparius	Scotch broom	shrub
Digitaria sanguinalis	crab grass	annual grass
Echinochloa colona	jungle-rice	annual grass
Echinochloa crus-galli	barnyard grass	annual grass
Elaeagnus angustifolia	Russian olive	tree
Eragrostis cilianensis	stink grass	annual grass
Eragrostis lehmanniana	Lehmann's love grass	perennial grass
Foeniculum vulgare	fennel	perennial forb
Galium aparine	goosegrass bedstraw	annual forb
Gnaphalium luteo-album	cud-weed	annual forb

Table 1 *continued*. A partial list of exotic plant species present in riparian and wetland ecosystems within the range of the Southwestern willow flycatcher.

Scientific name	Common name	Growth form
Hedera helix	English ivy	woody vine
Hordeum murinum	wild barley	annual grass
Lactuca serriola	wild lettuce	annual forb
Lepidium latifolium	perennial pepperweed	perennial forb
Lythrum salicaria	purple loosestrife	perennial forb
Marrubium vulgare	horehound	perennial forb
Melilotus albus	sweet clover	biennial forb
Melilotus officinalis	sweet clover	biennial forb
Nasturtium officinale	water cress	perennial forb
Nicotiana glauca	tree tobacco	large shrub/small tree
Paspalum dilatatum	Dallis grass	perennial grass
Pennisetum spp.	fountain grass	perennial grass
Phalaris aquatica	harding grass	perennial grass
Phleum pratense	timothy	perennial grass
Plantago major	plantain	perennial forb
Poa pratensis	Kentucky bluegrass	perennial grass
Polygonum aviculare	knotweed	annual forb
Polygonum lapathifolium	knotweed	annual forb
Polypogon monspeliensis	rabbit's foot grass	annual grass
Ricinus communis	castor bean	shrub
Rosa multiflora	multiflora rose	woody vine
Rubus discolor	Himalayan blackberry	shrub
Rumex crispus	curly-leaf dock	perennial forb
Salsola iberica	tumbleweed	annual forb
Schinus molle	pepper tree	tree
Sisymbrum irio	tumble mustard	annual forb
Sonchus asper	sow-thistle	annual forb
Sonchus oleraceus	sow-thistle	annual forb
Sorghum halepense	Johnson grass	perennial grass

Table 1 *continued*. A partial list of exotic plant species present in riparian and wetland ecosystems within the range of the Southwestern willow flycatcher.

Scientific name	Common name	Growth form
Tamarix ramosissima & *T. chinensis*	tamarisk, saltcedar	large shrub/small tree
Tamarix parviflora	tamarisk, saltcedar	large shrub/small tree
Tropaeolum majus	nasturtium	ann. or per. forb
Ulmus pumila	Siberian elm	tree
Verbascum thapsus	mullein	biennial forb
Veronica anagallis-aquatica	water speedwell	perennial forb
Vinca major	periwinkle	perennial herb
Tamarix aphylla	athel tamarisk	tree

Why the concern?

Exotic species that are of greatest management concern are those that are highly invasive and that strongly modify their environment. The relationship between exotic species and community structure and function is complex, and determining causes and effects is difficult. Following, we identify some types of general impacts, and speculate about specific impacts on southwestern willow flycatchers:

Simplification of ecosystems. Generally, when plant species diversity declines, ecosystem functions, such as provision of animal habitat, decline as well. Functions can be reduced as monotypic stands of exotics (or natives) replace more diverse mosaics and mixes of species. For example, reduced diversity of the woody species in the canopy layer may reduce habitat quality for southwestern willow flycatchers by decreasing the number of vegetation layers and nest site areas.

It can be difficult to determine whether exotic plant species are directly reducing habitat quality or whether the cause of the impairment is management-related simplification of the ecosystem. Many management actions simplify the plant community and select for one or two species (often exotic) adapted to a particular combination of stresses and disturbances. For example, livestock grazing can cause a diverse mix of native grasses and forbs to be replaced by monotypic stands of bermuda grass. River regulation and flood suppression reduce channel dynamics and can result in a simplified community dominated by dense tamarisk thickets with little understory vegetation. Without flood disturbance, dense piles of leaf and twig litter accumulate on the forest-floor and little light penetrates to the understory, conditions unfavorable for many understory species. Some reports of low diversity of understory plant species in tamarisk stands may be due to the interaction of tamarisk and river regulation actions (Brock 1994). Along freely flooding rivers, in contrast, fluvial dynamics create many niches and allow for high species diversity. Floristic understory diversity in tamarisk stands along the frequently flooded San Pedro River was not lower than in nearby cottonwood stands (Stromberg 1998b). There are other cases, however, in which biodiversity has increased after removal of tamarisk (Barrows 1993), indicating the complex and context-dependent nature of ecological interactions.

Loss or replacement of functions supplied by native species. Each species has particular functional values that can only partially be duplicated by another species. Examples of ecological functions include provision of food, nesting substrate, shade, and cover for animals, nutrient cycling, production of organic matter, and erosion control. From the perspective of the southwestern willow flycatcher, some exotic plant species are strongly inferior replacements, while in other cases or situations, exotic plants assume some of the functions of native riparian species (Brown and Trosset 1989, Westman 1990, Ellis 1995, Stromberg 1998b). Throughout its range, over 50% of the confirmed southwestern willow flycatcher breeding sites are in sites that are either dominated by or co-dominated by exotic woody species. Among the habitat-suitability factors that can differ between the native and exotic-dominated vegetation types are presence of suitable branching structure for nest placement, quality and quantity of the insect food base, thermal environment (microclimate), and abundances of parasites and predators.

Southwestern willow flycatchers have not been reported nesting in any vegetation patches that are dominated by *Arundo donax*. *Arundo donax* does not itself produce the physical structure required for southwestern willow flycatcher nest building, in that it does not produce small, forked branches. It has been speculated that insects are sparse in sites dominated by *Arundo donax*, because of the abundance of chemical defense compounds produced by the plants (Bell 1997). *Arundo*-dominated sites provide poor habitat for songbirds, partly because of the extremely high density of the plant stems (Morrison et al. 1994).

In contrast, some tamarisk stands do mimic, to some degree, the riparian woodland structure once provided by willows. In the absence of willows, southwestern willow flycatchers nest in tamarisk at numerous river sites (and in some cases preferentially use tamarisk even when willows are present). Southwestern willow flycatcher have been reported to nest in tamarisk at sites along the Colorado, Verde, Gila, San Pedro, Salt, Santa Maria, and Big Sandy Rivers in Arizona (McCarthey et al. 1998, McKernan and Braden 1999), Tonto Creek in Arizona (McCarthey et al. 1998), the Rio Grande in New Mexico (Hubbard 1987, Maynard 1995, Cooper 1995, S. Williams, New Mexico Department of Game and Fish, pers. comm.), and the San Dieguito River in California (Kus and Beck 1998). Along the Lower Colorado River and immediate tributaries, about 40% of the flycatcher nests were in tamarisk in 1998 (McKernan and Braden 1999). In Arizona in 1998, three-quarters (194 of 250) of the flycatcher nests were in tamarisk (Paradzick 1999). Tamarisk stands provide habitat for other birds, as well as for insects, mammals, and even fish, although they often do not support the same species richness, guilds, and population sizes as do native stands of cottonwood-willow (Glinski and Ohmart 1984, Hunter et al. 1988, Ellis 1995 and 1997, Converse et al. 1998). For example, cavity nesters and timber gleaners were present in cottonwood forests but rare or absent from the tamarisk patches studied on the Rio Grande (Ellis 1995).

Flycatcher productivity in tamarisk-dominated sites has been variously found to be equal to or lower than in sites dominated by native willow species (*S. exigua, S. goodingii*) (Sogge et al. 1997, McKernan and Braden 1999). One possible cause for between-site differences in nesting success is difference in food availability, in terms of total insect biomass or biomass of particular insects. While flycatcher distribution appears to be unrelated to insect biomass at the native-dominated Kern River (Whitfield et al. 1999b), we do not know whether food availability limits the abundance or breeding success of Southwestern willow flycatchers in tamarisk vs. native-dominated sites. Insect diversity and biomass are lower in some tamarisk-dominated stands than in some native riparian forests (Drost et al. 1998). Finch et al. (1998) found that willow patches along Rio Grande low-flow conveyance channels had greater total numbers of arthropods and of certain high-quality prey items (dipterans and hymenopterans; data were not reported on lepidopterans, another possible high quality item) than did tamarisk patches. Miner (1989) reported similar findings for the Sweetwater River in California, where tamarisk ranked low relative to natives with regard to arthropod abundance and diversity. The insects in the tamarisk patches tend to be small, which presumably require more expenditure of foraging energy by the flycatchers. More information is needed on the relationships between flycatcher breeding success and insect abundance, and between insect biomass and diversity, vegetation biodiversity and productivity, and surface water availability.

Extreme thermal environments can limit reproductive success and habitat suitability for some bird species. McKernan and Braden (1999) found that tamarisk patches were marginally hotter and sometimes more humid than cottonwood-willow stands. They also report that the flycatchers nest in a wide range of microclimates. Additional research would be valuable on the role of microclimate on flycatcher breeding success; such studies should measure maximum temperatures in addition to mean temperatures.

Not all tamarisk stands are the same with respect to southwestern willow flycatcher habitat suitability. Among sites with tamarisk, highest quality habitat is provided where the tamarisk is intermixed with other trees and shrubs (i.e., there is a high degree of plant species diversity and habitat complexity of the flood plain) and where tamarisk is tall and dense. Flycatchers nest in the low stature tamarisks in the understory of cottonwood-willow forests as well as the very tall (6-10 m) mature saltcedar that have dense canopies. The presence of natural flood regimes, ample water, and beaver activity are among the site factors that favor high species diversity and habitat complexity. Site factors that favor tall height of the tamarisk and dense vegetation structure include ample water (e.g., high soil moisture availability, shallow groundwater, or frequent surface inundation) and warm air temperatures. Dry soils and frequent burning reduce canopy height and habitat quality.

Russian olives also provide an appropriate branching structure for nest building by southwestern willow flycatchers. In New Mexico, a few southwestern willow flycatcher nests have been found in Russian olive trees along the Zuni River, Rio Grande (upper and middle), and Gila River (Cooper 1997). Overall, the number of nest sites in Russian olive trees is far less than the number in tamarisks. Generally, the Russian olive nest trees are part of a diverse riparian forest. Along parts of the Rio Grande, for example, Russian olive and coyote willow (*Salix exigua*) form a canopy layer below the cottonwood overstory. Along the Gila River in Cliff Valley New Mexico, Russian olives grow with several other tree species (Stoleson and Finch 1999). At this site, there were fewer flycatcher nests in Russian olive trees than in boxelder (*Acer negundo*) or willow trees (*Salix* species). However, Russian olive and boxelder were used more frequently than expected relative to their abundance, suggesting an active preference at this site for these trees over the willow. Nest success rate in the Russian olive and willow were lower than in boxelder and Fremont cottonwood.

Indirect effects of exotics on willow flycatcher habitat. Exotic riparian plant species have the potential to modify habitat indirectly by altering disturbance regimes, (e.g., fire regimes), hydrologic conditions, geomorphic processes (e.g., erosion and sedimentation rates), and species abundance and diversity patterns. Here again, we note that the functional role of the exotic species should not be assessed independently of river management actions. For example, fire size and frequency tend to increase on sites dominated by tamarisk and giant reed, with consequences for vegetation structure (see Appendix L; fire management). The probability of fire, however, is enhanced by river regulation because of the propensity for flammable biomass to accumulate on regulated, flood-suppressed rivers (Busch 1995, Shafroth 1999). Similarly, the potential for tamarisk to increase the salinity of soil water, and thereby contribute to the decline of salt-sensitive willows and cottonwoods, is enhanced when farmers or water managers release salty water into river channels or prevent the release of salt-flushing flood flows. Along the undammed middle San Pedro River, salts are no higher under tamarisk stands than under cottonwood forests (Stromberg 1998b).

Some reports suggest that tamarisks can contribute to the decline of native riparian plants by contributing to river dewatering or lowering of water tables (e.g., Thomas 1963). The suspected mechanism is greater rates of transpiration by tamarisks than by native riparian species. Higher transpiration could arise due to higher per-plant water use rates or greater density of plants. On a per-leaf area basis, various studies report that tamarisk transpires the same amount or less water than the native shrub *Salix exigua*, and less than cottonwood trees (Sala et al. 1996, Cleverly et al. 1997, Smith et al. 1999). Based on its high sap-flow rates, Smith et al. (1999) conclude that tamarisks have greater stand level water use than cottonwood and willows. However, there is little direct data at the stand level comparing water use rates of native and exotic woodlands and forests. Such stand level comparisons, for plants growing in similar conditions, would help to shed light on this issue. Transpiration rates of riparian plant species vary with many factors including depth to ground water, stand density, and patchiness of the habitat (Devitt et al. 1997; Devitt et al. 1998).

Along the Virgin River, Cleverly et al. (1997) report that young stands (<10 years old) of riparian plants were vegetated by a mix of tamarisk and native shrubs and trees (*Salix exigua, Pluchea sericea, Prosopis pubescens*), and that older stands (50-60 years) were dominated by tamarisk. The apparent loss of the natives from the older stands was attributed to increasing stresses from salinity and dessication in the older stands and to direct competitive effects of tamarisk. On the middle San Pedro River, the oldest woodlands (>50 years) were dominated by cottonwoods, middle-aged woodlands (10-40 years) were dominated by tamarisk, and the younger stands (<10 years) were again dominated by cottonwoods. Stromberg (1998a) attributed this shift to changes in river flows and grazing stresses during the times of establishment of the different-aged stands, which led to different initial stand compositions. Salinization and dewatering effects were not apparent at this site. Clearly, further research is needed to determine the environmental contexts under which tamarisks do and do not exert physical and biotic stresses on native plants.

Direct competitive interactions can occur between tamarisks and native riparian plants. Busch and Smith (1995) observed that removal of tamarisks from around willow trees improved the water relations and growth of the willows, indicating competitive effects of mature tamarisk on willow. In contrast, studies of competition between seedlings show that tamarisks can decline when cottonwoods and willows are present (Sher, unpubl. data). Competitive outcomes may vary with water availability, with the natives out-competing the exotics under wet conditions.

With respect to the southwestern willow flycatcher, a key question is, is habitat quality impaired in the area dominated by the exotic species? Although it may be relatively easy to determine whether quality is impaired, it can be harder to determine the causes. The changes in habitat quality may be due to loss of the natives, presence of the exotics, or to synergies of species composition, site conditions, and management-influences. There are few rigorous comparisons of function between stands of exotics and natives growing under similar site conditions, partly because of the difficulty in finding appropriate spatial controls (Parker and Reichard 1998).

B. Why Are Exotics So Abundant In Riparian Ecosystems?

If we desire to improve riparian habitat quality by controlling or eradicating exotic plant species, we must understand the mechanisms and factors contributing to their presence and spread. This can be a difficult task, despite the considerable amount of research investigating the mechanisms and conditions under which exotic native species replaced natives (Vitousek et al. 1996, D'Antonio et al. 1999). Identification of the root causes of the native species replacement speaks directly to the type of management approaches that should be undertaken.

One school of thought holds that exotics have proliferated because we have created physical conditions that allow them to be more successful than the natives. For example, altered disturbance regimes can favor some exotic species. Other schools hold that the exotics are actively displacing the native plants due to biotic factors. These biotic factors including release from herbivorous insects and other natural 'enemies', introduction of exotic herbivores such as domestic livestock, continuous input of seeds, and self-favoring mechanisms produced by the exotic plants. Certainly, there may be multiple mechanisms operating at any given time. The mechanisms differ between different exotic species, and may vary between locations within the range of a particular exotic.

There is ongoing debate about the mechanisms that have allowed for the proliferation of tamarisk. Many researchers point to human-alterations to physical conditions as the primary factors that have allowed this particular species to thrive in the western US. D'Antonio et al. (1999) state that "In the almost complete transformation of floodplain forests in the Colorado River basin in the United States over the past 50 years, it is the combination of decreased water table, increased soil salinity, and reduced vigor of native species as a result of alterations in natural disturbance regimes, that have led to massive invasion by tamarisk". Tamarisks are well-adapted to conditions now prevailing in many southwestern riparian areas, allowing them to gain particular prominence along regulated and intensively exploited rivers. Under water stress, salinity stress, flood flow alteration, livestock grazing, and recurring fire, tamarisk can outcompete cottonwoods and willows and, perhaps, hasten their demise (Horton 1977, Smith et al. 1998). Under extreme stress, if water tables are too deep, soils are too salty, or spring flood flows are circumvented, populations of the native species disappear regardless of competition from the exotic species (Stromberg 1998a, Everitt 1998, Anderson 1998).

However, there are some situations where it is unclear as to what human-caused changes, if any, have contributed to the proliferation of tamarisks (Barrows 1993, Lovich and DeGouvenain 1997, Barrows 1998). In such cases, it can be instructive to ask, were there past actions, such as livestock or burro grazing, now discontinued, that precipitated the invasion? Are tamarisk seed sources now more abundant than those of the natives? Are insect herbivores reducing fecundity or survivorship of the natives but not the tamarisk? As did Everitt in 1980, we make a plea for additional research: We call for regional studies and synthesis to identify present-day characteristics and historical events common to sites where tamarisks are infrequent, where they dominate, and where they have undergone recent decline.

Generally, human actions have contributed to the invasion of exotic plant species in the following ways: We have facilitated the dispersal of species to new locales; and we have created opportunities for their establishment by clearing vegetation, modifying physical site conditions, altering disturbance processes, and disrupting biotic interactions. Following, we review some of the human actions that have allowed exotic species to thrive in riparian areas, the characteristics of the exotics species that have allowed them to do so, and provide general management recommendations.

Introduction and spread of seeds and plants. Many riparian exotics became established in the U.S.

Southwest during the European settlement phase, some as early as the 1500s. Exotics continue to have many opportunities to arrive at, and spread within, riparian areas. Roads and railways often follow rivers, introducing and spreading seeds from distant locales (Frenkel 1977). Many urban centers are located along rivers, providing opportunities for spread of landscape plants. Fertile floodplain soils have been extensively used for agriculture, a practice that spreads accidentally introduced, non-native crop weeds. Almost 100 years ago, McClatchie (1901) warned that wild (foxtail) barley would become a 'problem invasive' in flood plains of the Salt River (Arizona), if no measures were taken to halt its spread from agricultural fields. Today, his prediction has come true.

Other species have been intentionally introduced. Giant reed, Russian olive, and tamarisk were all intentionally planted, to beautify landscapes and/or stabilize soils (Tellman 1997), and continue to be sold by nurseries. Lehmann's lovegrass (*Eragrostis lehmanniana*), a species native to Africa, was seeded in southern Arizona to promote revegetation of overgrazed grasslands, providing an abundant seed source for spread to flood plains (Anable et al. 1992, Bock et al. 1986).

Management actions: It is unrealistic to completely halt the spread of exotics (for example, we cannot re-route all roads out of riparian corridors). There are measures, though, that can be undertaken to reduce the frequency of spread. For example, educational campaigns about landscaping practices could encourage the planting of native species and discourage the planting of exotics, particularly in urban areas and golf courses situated in flood plains. Some municipalities have legally prevented the planting of some exotics, to prevent the landscape use of allergenic plants. Such a ban would be a particularly appropriate means for controlling giant reed by eliminating opportunities for introduction into drainages lacking this exotic, or reintroduction into drainages from which it is being eradicated.

State and federal agencies should utilize native species during revegetation efforts and not fund those that propose otherwise. For example, transportation agencies should use native species to seed road edges, the U. S. Forest Service should use natives to revegetate watersheds after fire, and the National Resource Conservation Service should utilize or promote the use of native species to revegetate degraded rangelands.

Because the spread of exotics in riparian systems is a drainage-wide issue, effective control and eradication requires coordination among multiple landowners and users with diverse interests and management goals. In the absence of such coordination, control efforts are likely to fail as individual sites are reinvaded by exotics present elsewhere in the drainage. “Team Arundo” in California (http://www.ceres.ca.gov/tadn/index.html) is an example of a successful partnership formed to address shared concerns regarding the spread of giant reed, including its impacts on flood control, wildfire, and habitat for endangered species. Consisting of representatives from agencies, conservation groups, academia and the private sector, Team Arundo offers a comprehensive plan for reed eradication by sharing information and funding, coordinating control efforts across a broad range of projects and implementing groups, including volunteer citizen’s groups, providing public education, and promoting research on exotics control. While its primary focus is on giant reed, Team Arundo provides a model for a partnership approach that would benefit control programs targeting other species.

Increased abiotic stress (particularly salinity and drought). Human alterations of habitat have been central to the persistence and spread of many riparian exotics. For example, current management practices in riparian corridors have caused many flood plain soils to become saltier and drier, factors that can favor a new assemblage of stress-tolerant species (DeCamps et al. 1995). Many exotics have broad tolerance ranges for stress factors such as soil moisture, inundation duration, and salinity, and many are unusual in being able to tolerate a combination of abiotic stresses and disturbances. Bermuda grass, for example, has high survivorship of floods, drought, and salinity, and can maintain itself for long time periods through rhizomatous spread. Similarly, giant reed survives and spreads during floods through dispersal of rhizomes, and resprouts rapidly after fire, outgrowing native species. Invasive species with such traits have been classified as "survivors", long-lived individuals resistant to many causes of mortality (Newsome and Noble 1986).

As one of its common names suggests, tamarisks are physiologically adapted to salt levels that would stress or kill most native willows (Shafroth et al. 1995). They also have high water-use efficiency, root deeply, and tolerate prolonged drought (Busch and Smith 1995, Smith et al. 1998). Cottonwood and willow forests thrive where groundwater is less than 3 m deep, but tamarisk woodlands persist where groundwater is up to 7 to 10 m below the surface (Graf 1982, Stromberg 1998a). Tamarisks thus can dominate where diversions and/or ground water pumping have dewatered the river and where salt levels are high due to agricultural return flows, large upstream reservoirs, or naturally high salt levels.

Anderson (1995, 1995, 1998) provides data showing that for many rivers in this region, ground water tables have become too deep and soils too salty to allow native cottonwood and willows to survive, contributing to replacement by stress-tolerant tamarisk. While tamarisks may exacerbate salinity and dewatering stresses in some circumstances, it is not clear that tamarisk removal in and of itself would restore conditions suitable for the natives in the majority of dry sites presently dominated by tamarisk. Such a question could be answered through sophisticated models that compare ground water levels before and after simulated tamarisk removal or thinning; however, such models should take into account water use rates of the native replacement vegetation and should be based on accurate transpiration rates.

Russian olive also has wide tolerance range for several abiotic factors. Relative to cottonwoods and willows, Russian olive is drought tolerant at both the seedling and adult stages. Although not as salt tolerant as tamarisk, Russian olive is more salt tolerant than many cottonwoods and willows (Carman and Brotherson 1982; Shafroth, Auble et al. 1995).

<u>Management actions</u>. Eliminate specific stress factors, such as dewatering and salinity, that are known

to favor the exotics. This will entail a suite of difficult-to-implement actions, such as reducing diversions, managing livestock grazing to increase flood plain water availability, and reducing salt levels in agricultural return flows. Conduct further study on the role of tamarisk as a stressor, to determine the environmental contexts under which tamarisks do and do not exert physical and biotic stresses on native plants.

Alteration of natural disturbance regimes, including flood suppression. Although exotics certainly grow in apparently pristine habitats, alteration of natural disturbance regimes or imposition of new disturbances increase the chances that they will dominate a site (Fox and Fox 1986, Hobbs and Huenneke 1992, Pyle 1995, Parker and Reichard 1998). Natural flood regimes have been altered by dams, diversions, urbanization effects, and watershed degradation (see Appendices I and J). Many rivers flood less frequently and at different times than their climatic legacy dictates, favoring exotic species that are better adapted to the new conditions. Conversely, restoration of natural flooding regimes can sometimes favor the native species. There is evidence, for example, that tamarisk are less tolerant of physical flood scour than are natives. Tamarisk seedlings have less ability to survive flood-borne sedimentation than do cottonwood seedlings (Stromberg, unpubl. data). Small tamarisk trees had greater flood mortality than did small cottonwood and willows at the Hassayampa River (Stromberg et al. 1993). D'Antonio et al. (1999) found that tamarisk was sparse on free-flowing Sycamore Creek in the Sonoran Desert, likely due to frequent (once every 3 year) flood scour; but that it was abundant on another free-flowing stream which had large scouring floods only about once every 10 years. Lowered ability to tolerate flood scour may explain why tamarisk population levels are low relative to the natives on some free-flowing, frequently-flooded rivers, and contribute to its tendency to proliferate on flood-regulated rivers (Shafroth 1999; Dixon and Johnson 1999).

Russian olive similarly may be benefitting from flood suppression. Unlike the native willows and cottonwoods, and similar to tamarisk, it does not depend on spring flooding for establishment. Russian olive exhibits some traits typical of late-successional species, such as larger seed size. This enables it to establish in the understory of tree species such as cottonwood, and allows regeneration to be decoupled from flood disturbance. Together with tamarisk, Russian olive has spread and replaced cottonwoods-willows on spring-flood suppressed rivers including the Rio Grande (Howe and Knopf 1991, Everitt 1998).

Giant reed appears to be insensitive to flood regime: it survives and expands during long periods without flooding through vegetative propagation, but spreads during flood events as well. Giant reed may thus be able to thrive under a broad range of flood regimes.

As floods have decreased, fire disturbance has increased (see Appendix L). Tamarisks can prolifically resprout after fires, as can giant reed; producing a positive-feedback scenario in which the exotics contribute to the type of disturbance that favors their continued dominance.

<u>Management Actions</u>. Strive to restore the natural flood disturbance regime. This means restoring

flood regimes in terms of the magnitude, frequency, and timing of flood flows.

Unpredictability of flood disturbances, including timing of water drawdowns. Besides altering the frequencies of various types of disturbances, we also have changed the timing of disturbances and increased their unpredictability. This, in turn, has selected for generalist species over specialists. Generalists often are better able to compete in a newly fluctuating and less predictable environment. Specialist plant species, in contrast, are quite successful under a fairly narrow range of environmental conditions. For example, tamarisks are reproductive generalists when compared to their native counterparts, which are phenologically adapted to exploit the receding limbs of early spring floods. Like cottonwoods and willows, tamarisks annually produce large crops of tiny, wind-dispersed seeds which require bare, moist soil for germination. Tamarisks, however, flower and disperse seed over a longer time period during the growing season than do cottonwoods and willows. Tamarisks flowered well into October along the Bill Williams River (a tributary to the Lower Colorado River), whereas cottonwoods blossomed only into mid-April and willows into June (Shafroth et al. in 1998). Tamarisks thus can thrive on dammed rivers where high water flow is delayed by the timing of irrigation water storage and release schedules. Tamarisks can also take advantage of the techno-littoral zone of reservoir edges, a new riparian habitat type where potential seed beds are exposed in midsummer during irrigation-driven drawdowns.

Like tamarisk, giant reed is less constrained in the timing of reproductive events than are natives, creating opportunities for establishment that natives cannot take advantage of. Because it does not reproduce sexually, giant reed is not affected by the timing of spring flows, but can establish any time that flood flows carry and deposit rhizomes or stem fragments. It, too, thrives along the margins of reservoirs, irrigation canals, and other structures where the timing of drawdowns is incompatible with maintenance of native species.

Management actions. Generally, conform as closely as possible to the natural river hydrograph. Time flood releases, reservoir drawdowns, and soil disturbances to coincide with the early spring seed dispersal of cottonwoods and willows, thus creating conditions that favor these species.

Other 'new' disturbances. Clearing of channels for water salvage or increased flood water conveyance, plowing of flood plain fields, and channel-narrowing caused by flow-regulation are disturbances that have provided large-scale opportunities for establishment of exotics (Everitt 1998). Many other types of disturbance, such as soil disturbance from vehicles, livestock, and recreationists, have increased in riparian habitats. One net effect has been to select for an increase in ruderals or pioneer species. Ruderals thrive in frequently disturbed areas because they have short life-spans (annuals or biennials or short-lived perennials), rapid growth rates, and high reproductive effort. At the Hassayampa River, for example, 74% of the exotics were ruderals (Wolden et al. 1994). There are many native riparian ruderals as well, particularly where floods disturbances are common. However, each type of disturbance is unique and will select for different species assemblages. When we impose new disturbances, or superimpose other disturbances over the existing framework, there is even greater selection for ruderals and for species that can tolerate multiple disturbances. Ruderals such as brome grass, for example, thrive in response to repeated soil compaction and loss of plant stems and leaves caused by cattle grazing, trampling, or vehicle use (Brothers and Spingarn 1992, Morin et al. 1989).

Floods can enhance invasion opportunities by exotics, because they disperse seeds and create opportunities for species replacement. Natural flood cycles generally help to maintain an abundance of native species and high species diversity (McIntyre et al. 1988, Naiman et al. 1993). However, exotics can rapidly become abundant after floods, particularly if site conditions and selective pressures are altered and nearby seed sources are plentiful (Planty-Tabacchi et al. 1996).

Management actions. Do not clear native riparian vegetation from flood plains or channels. When clearing patches of undesirable exotics, make sure that the site conditions and timing of clearing are favorable for the establishment of the desired native species. Restrict heavy recreational use.

Alteration of herbivory patterns, including increased herbivory from domestic livestock and native ungulates. Domestic livestock grazing, since Spanish Colonial times in some places, has altered vegetation composition throughout the Southwest by favoring unpalatable or grazing-tolerant exotic species. Among the exotic riparian species that increase under grazing are bermuda grass and annual brome grasses (Mack 1986, Billings 1990, Brooks 1995). Tamarisks and Russian olive also appear to be favored by grazing. When browsing among the multi-species patches of seedlings that germinate on bare sediments after floods, livestock feed upon the more palatable cottonwoods and willows. This can favor the tamarisk by allowing them to overtop the native seedlings that might otherwise shade them out (Hughes 1993, Stromberg 1997). Russian olive exhibits several traits that allow it to thrive in grazed habitats, including sharp thorns, which increase in density if the tree is cut back. The large seeds have ample reserves that may enhance the survival of seedlings following browsing (Armstrong and Westoby 1993). These adaptations presumably contribute to the spread of Russian-olive into heavily grazed meadows and pastures.

Management actions. Strive to restore ungulate herbivory levels to those under which the native riparian species evolved, or at least under which the native species retain competitive dominance.

Release from native herbivores and pathogens. There is evidence that insect communities associated with tamarisk stands are less diverse than those associated with native cottonwood and willow stands (Drost et al. 1998, Finch et al. 1998, Miner 1989). Periodically, willow and cottonwood stands undergo extensive defoliation from insect herbivores, and symptoms of wetwood disease are present on many cottonwoods (Hofstra et al. 1999). However, we are not aware of any evidence showing that insect herbivory rates or impacts (e.g., reduced seed production) are lower on tamarisk than on cottonwoods and willows. Perhaps most important from a management perspective, we are not aware of any studies showing that release from natural enemies is a mechanism that has allowed tamarisk to dominate.

Release of biocontrol insects (DeLoach 1991, 1997; Hennessey 1999) is an approach that is being tested to reduce the abundance of tamarisk. There are risks associated with biocontrol of exotic species (Thomas and Willis 1998). Biocontrol has been an effective strategy for reducing the abundance of many targeted non-native plants. However, biotic interactions are complex and introduction of a new species into a food web can produce unexpected and sometimes undesirable results. Callaway et al. (1999) describe a case wherein release of a biocontrol insect *increased* the competitive ability of the targeted exotic plant, due partly to herbivory-stimulated compensatory growth. We are not convinced that the benefits of tamarisk biocontrol outweigh the risks. "In the rush to solve local and acute pest problems, we may be creating diffuse and chronic problems that are harder to solve" (McEvoy and Coombs 1999).

Like other active approaches to exotic removal, such as mechanical or herbicidal control, the use of biocontrol insects will be most effective in restoring willow flycatcher habitat if used as part of an overall plan that addresses underlying causes of the loss of the desired native species. Although there are sites that seem to respond favorably simply to the direct removal of tamarisk (Barrows 1993, 1998), this effect is not guaranteed (Anderson 1998). Because biocontrol insects can spread beyond their release sites, potentially throughout the range of the southwestern willow flycatcher, we cannot be assured of net gain in habitat quality. There are risks to the willow flycatcher if the tamarisk stands are not replaced by plant species of equal or higher habitat value, or if the tamarisk stands simply lose quality, for example, by undergoing loss of foliage density. At some tamarisk-dominated sites that support willow flycatcher, such as reservoir edges, the physical conditions (e.g., water, salinity) may be present that allow willows *to survive,* but there is no assurance that reservoir edges will be managed in such a way that allow willows *to establish,* were tamarisk to decline. In other cases, such as along the Rio Grande or Colorado, there is no assurance that reduction in tamarisk density would restore the water levels or salinity levels that allow the natives to thrive.

<u>Management actions</u>. In the absence of a plan to address and correct underlying reasons for the decline of native riparian forests and marshlands in southwest riparian systems, we advocate site-specific approaches to tamarisk control (e.g., local site clearing followed by other restorative measures as needed) rather than region-wide biocontrol.

C. Exotic Species Management Plans

In this section we summarize guidelines for maintaining or restoring habitat quality for southwestern willow flycatchers with respect to the issue of exotic plant species. Our basic approach involves restoring the natural fluvial processes and conditions under which the native species evolved, and thus has ecosystem-wide benefits. We propose two preliminary assessments that should precede formulation of a restoration plan: (1) identification of underlying factors promoting the presence and abundance of exotics in the ecosystem, and (2) the potential for restoration of physical and biotic conditions favoring natives. We then identify four approaches to restoration, based on the outcome of these assessments: (1) no restoration, (2) passive restoration, (3) active restoration, and (4) partial rehabilitation. Finally, we recommend actions to implement each plan. The overall approach is summarized in Table 2, and described in more detail, including case studies, below.

Much additional research is needed to refine management actions and ensure their success. Nevertheless, we make preliminary recommendations here, all of which have a high likelihood of improving habitat conditions for southwestern willow flycatchers and many other native riparian plants and animals. Generally, we recommend adopting an adaptive management approach, and continuing to conduct scientific research to increase our knowledge base.

CONDITION A. Sites that are occupied or unoccupied AND that have healthy riparian plant communities, dominated by natives in all vegetation layers:

We recommend that no restoration of these sites be pursued as long as this condition prevails. Maintain the management status quo, i.e., maintain the conditions that are producing high habitat quality. For example, maintain free-flowing conditions (= no dams), maintain base flows and ground water levels, etc.

Action 1: To avoid potential impacts to flycatchers in occupied sites, do not actively intervene to remove the exotic species unless there is a trend for steady increase in exotic vegetation.

Action 2: Assess vegetation composition annually to detect at an early stage trends of increases in the exotics, and causes thereof.

Action 3: Assess and monitor physical site conditions in the riparian corridor.

Action 4: Monitor conditions in the watershed, such as trends for increased ground water pumpage, that might favor exotics.

Should the above assessments reveal a trend for increase in abundance of exotics, conduct an evaluation of underlying causes, and pursue restoration as described for Conditions B or C (see below).

CONDITION B. Occupied and unoccupied sites that are dominated in the upper canopy layer by exotic plant species of potential habitat value to flycatchers (e.g., tamarisk or Russian olive) .

Preliminary Assessment:

1. Determine the root causes for the dominance of the exotics. Thoroughly assess the hydrologic regime (including timing and magnitude of flood flows, stream base flow rates, and ground water levels), water quality (including salinity levels), fluvial geomorphic regime, and grazing regime. Ask:

a) are there stressors or habitat alterations that are preventing the native species from thriving? (e.g., are livestock favoring the exotics? are ground water depths and salinities precluding survivorship of desired natives? has flood disruption contributed to the establishment of the exotic species?) OR

b) does it appear that the exotics are dominating because of some past chance event or some condition that is no longer in effect, and that current conditions appear suitable for the desired conditions?

2. Assess the potential for restoration and need for different restoration techniques. Ask:

a) are native seed sources naturally available for recolonization or must seed sources or plants be brought on site?

b) are natural processes available to create the opportunities for species replacement or must the sites be manually cleared?

c) are the conditions suitable for the survivorship of a diversity of native species, or is it feasible to restore these conditions?

d) context: what are the conditions up- and down-stream with regard to 1) the presence of the exotic species(s) targeted in the restoration project, and 2) the presence of and distance to a seed source for native species?

Depending on the answers to the above questions, different approaches should be undertaken. For example, if it appears that some stressor is precluding the natives from thriving but that this stressor(s) can be eliminated, and if nearby seed sources are available, and if natural floods still occur, then adopt **Passive restoration**.

Action 1: Remove the stressors and patiently allow for natural recovery. Nearby seed sources and natural processes (e.g., floods) should slowly create opportunities for replacement of the exotics by the natives. Costly revegetation/ planting may be unnecessary. If passive restoration does not appear, to be effective, utilize more active measures.

Case Study for Passive Restoration: This case study demonstrates how process-restoration and stressor-removal can work for some tamarisk-dominated sites. The San Pedro is a free-flowing desert river that flows northward from Sonora, Mexico to the Gila River in southern Arizona. Stream flows vary from perennial to ephemeral depending on local geology and tributary inputs, and on the extent of local and regional groundwater pumping. Flood plain agriculture and cattle grazing are common along the river, but some reaches have been set aside as conservation areas. Tamarisk, Fremont cottonwood, and Goodding willow are all present, but vary in relative abundance depending on site characteristics. Over time, tamarisks have been declining in abundance and cottonwoods increasing in abundance at sites where livestock have been removed, stream flows remain perennial, and upstream groundwater pumping has been reduced (Stromberg 1998). Under these conditions, cottonwoods are able to outcompete tamarisks. Also necessary to this recovery were several winter/spring floods that created opportunities for species replacement. Tamarisks continue to dominate along ephemeral reaches where water tables are 5 to 7 meters below the flood plain surface.

An important caveat must be added to Passive Restoration when giant reed is the targeted exotic. Because of its ability to spread rapidly throughout drainages, it is essential that reed removal be conducted in an upstream-to-downstream manner in order to achieve lasting restoration. Thus, the context of the proposed restoration with regard to the presence of giant reed upstream is a critical determinant of its likely success, and consequently its prioritization relative to other potential restoration efforts.

If it appears that stressors are precluding the natives and that these stressors can be eliminated, but there are no natural mechanisms to allow for species replacement, then pursue **Active Restoration to naturalize processes**. For example, if it is possible to restore base flows and ground water to levels that favor cottonwoods and willows, or possible to reduce high daily fluctuation of water levels, but seed sources are sparse and natural opportunities for species replacement (site clearing) are sparse, one may need active clearing and planting measures. On some river reaches, due to a variety of constraints, processes such as periodic flooding can only be 'naturalized'.

Action 1: First ensure that the stressors have been removed (e.g., water levels restored, livestock removed (see Appendix G), salts reduced, etc.) and that the desired native species will be able to survive.

Action 2: Use fire, earth- and vegetation-moving equipment, or approved herbicides to clear small parcels of habitat. Do not attempt to clear large areas at a time. We propose a guideline of clearing/restoring no more than 5% of the exotic-dominated area per year, followed by a waiting period of 5 years to determine the success of the restoration project. This staggered approach will create a mosaic of different aged successional stands. Plus, it will allow the benefits of an adaptive management approach to be realized: if the restoration effort fails, one will be able to learn from the mistakes and prevent failure on a grand scale. If the site is occupied, make sure that the areas targeted for clearing do not have any endangered species nest sites, and are at least 100 m away from the closest nest site. Clearing and earthmoving should be timed to avoid the breeding season of the flycatcher and other sensitive species (e.g., late March-September).

Action 3: Remove aggraded sediments, if necessary, to create cottonwood-willow seed beds that are within one meter of the ground water table; and/or excavate side channels.

Action 4: Plant or seed with native species if seed sources are not naturally available. Use locally collected seed or seed banks.

Action 5: Release flood ways in a way that mimics the natural hydrograph, to stimulate natural regeneration of desired native species.

Case study 1 for Active Restoration. Along the highly regulated Rio Grande in New Mexico, large scouring floods that would create opportunities for extensive species replacement may not be feasible. Moreover, water levels are too deep and soils too salty in some areas to support native cottonwood-willow forests. However, managers of the Bosque del Apache National Wildlife Refuge are mimicking the effects of large floods by using bulldozers, herbicides, and fire to clear the extensive stands of tamarisk that have developed, at a cost of from $750 to $1,300 per hectare (Taylor and McDaniel 1998). Most importantly, they are then releasing river water onto the bare flood plains in spring, with an appropriate seasonal timing and quantity that mimics the natural flood hydrograph of the Rio Grande, and thereby favors a diverse assemblage of native (and exotic) plant species.

Case study 2 for Active Restoration. On some regulated rivers, including the Bill Williams in Arizona, Truckee River in Nevada, and Rio Grande in New Mexico, water managers are releasing flood flows directly into the channel to restore the riparian habitat (Taylor et al. 1999). Recruitment models have been developed and tested that indicate how waters should be released from dams during spring, and at what drawdown rate, to allow for cottonwood-willow establishment and to favor these species over tamarisk (Mahoney and Rood 1988, Shafroth et al. 1998). We may be able to further manage for natives and against tamarisk by releasing post-germination summer floods that breach tolerance thresholds of the exotics but allow for some seedling survivorship of natives: tamarisk seedlings are less able to tolerate prolonged flood inundation than are seedlings of native willows (Gladwin and Roelle 1998), although they are very tolerant of prolonged flooding when mature (Taylor and McDaniel 1998). Knowledge of tolerance ranges for soil salinity gives us the information we need to determine if, and how often, we may need to release salt-flushing flows (Shafroth et al. 1995). However, constraints remain. On the Bill Williams River, for example, the largest flows that can be released from the dam are an order of magnitude lower than historic floods (Shafroth 1999). With the dam still present, we are not able to naturally produce extensive seed beds for new generations of riparian trees; thus, intervention in the form of mechanical clearing of seed beds in tamarisk-dominated habitat, followed by removal of aggraded sediments, may be necessary.

If there are stressors that are precluding native survival, but these stressors CAN NOT be sufficiently reversed, pursue **Partial Rehabilitation**. For example, if ground water levels are greater than about 3 meters deep and fluctuate by more than about 1 meter annually; if surface water is ephemeral; or if root zone salinity exceeds about 4 g/ l, many cottonwood and willow species will not have a high probability of surviving or thriving (Jackson et al. 1990, Busch et al. 1992, Busch and Smith 1995, Stromberg 1998a, Scott et al. 1998, Glenn et al. 1998). Under these conditions, and given the present state of our knowledge, strive to increase the habitat quality of the exotic stand rather than attempting species replacement. Encourage or implement studies that assess to what degree the exotic itself is acting as a stressor, and if so, what degree of site condition amelioration would occur upon removal of the exotic.

Action 1: Do not remove the exotics. The replacement vegetation (e.g., younger stands of the same exotic, or non-riparian species such as quailbrush *Atriplex lentiformis*) may have lower habitat quality than the initial vegetation.

Action 2: Do attempt actions to increase habitat quality within the exotic stands, such as seasonally inundating tamarisk stands to improve the thermal environment or increase the insect food base.

CONDITION C. Occupied or unoccupied sites dominated by exotics in a mid-canopy or understory layer, but dominated by natives in the upper canopy.

Follow the steps outlined for Condition B, except DO NOT clear any vegetation. Strive for passive restoration or partial rehabilitation.

CONDITION D. Occupied or unoccupied sites dominated by exotics possessing little to no habitat value.

This will typically be the case when giant reed is the exotic species of concern. Pursue passive or active restoration, as appropriate, paying attention to the need to work from upstream-to-downstream. If the site is not restorable and is not occupied by southwestern willow flycatchers, it should nevertheless be cleared so as to prevent the spread of propagules to other parts of the drainage, and to alleviate the impacts of giant reed on flood control, wildfire prevention, and maintenance of roads, bridges, and other structures.

D. Closing Words

Abundance of exotics, to a large extent, appears to be a symptom of the ways in which we have managed our riparian lands and waters. The solution requires a shift of emphasis, away from demonizing exotics and toward re-establishing a functional semblance of the conditions that allow native plants to thrive. We must fully address the root causes that have allowed the exotics to be so successful, and restore those natural processes and site conditions under which the native species are most competitive (Briggs 1996). It is unlikely under such a scenario that exotics would be completely driven out of southwestern riparian systems. But it is also unlikely that simply removing exotics, if that were practically possible, would allow natives to thrive where conditions no longer favor them.

When factors like hydrology and herbivory have been returned to original, natural conditions, there is evidence that native riparian trees can hold their own, remain or reestablish as co-dominants, and outcompete exotics (Horton 1977, Stromberg 1997, 1998a; Taylor et al. 1999). This is not always the case, however. For example, exotic annual grasses and other herbs dominate some riparian sites long after removal of suspected stressors. Along some rivers with naturally high salt loads and infrequent or small summer floods, such as the Virgin River, tamarisk may remain as a dominant even with removal of potential stressors such as water diversions (Williams and Deacon 1998). In such cases, active restoration measures, such as of clearing of exotics accompanied by soil manipulations or reintroduction of native seeds, may be necessary for full restoration. Heavily regulated, diverted, and grazed rivers such as the Colorado and its major tributaries will remain prime tamarisk habitat, and exist as simplified ecosystems, until their management changes to once again favor native species and habitat complexity.

Literature Cited

Please see Recovery Plan Section VI.

Table 2. Recommendations for Habitat Management with regard to Exotic Vegetation

	Habitat Condition			
Restoration Approach	A	B	C	D
	Native-dominated in all canopy levels	Exotics-dominated in upper canopy only	Exotics-dominated in mid-canopy or understory only	Exotics-dominated in all canopy layers (giant reed)
1. Identify root causes of exotics	NA	x	x	x
2. Do current conditions prevent natives or favor exotics?	NA	x	x	x
3. Assess restoration potential: high/low	NA	x	x	x
4. Approach:				
If (2)=no and (3)=high, **Passive Restoration:** -remove stressors, allow natural recovery		x	x	
If (2)=yes and (3)=high, **Active Restoration to Naturalize Processes:** -remove stressors -clear vegetation -remove aggraded sediments -plant or seed with natives		x	Do not clear vegetation	x Active clearing required
If (2)=yes and (3)=low, **Partial Rehabilitation:** -leave exotics in place -enhance habitat quality		x	x	
None -maintain existing management -monitor for conditions favoring exotics, increase in exotics	x			