# Cattle and Elk Herbivory on Arizona Willow (*Salix arizonica*)

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Abstract: Nearly 62 percent of Arizona willow, *Salix arizonica* Dorn, populations in Arizona have experienced reduced size and vigor due to herbivory, yet the identity of the herbivores has been unknown. Ninety Arizona willows were planted at The Arboretum at Flagstaff on the inside and outside of an enclosure surrounded by a 10-foot deer fence to determine whether cattle and/or wild ungulates ate them. The plants inside the deer fence were either protected from herbivory as controls or were exposed to cattle, while those outside were subject to herbivory by elk, *Cervus elaphus*, mule deer, *Odocoileus hemionus*, pronghorn, *Antilocapra americana*, and a variety of rodents and lagomorphs. The results indicate that both cattle and wild ungulates browse the willows. Qualitative observations suggest that elk browse the willows more intensely than either deer or antelope. An analysis of mean plant height, mean total shoot biomass, mean branch length, and total number of branches before and after the experimental time frame concluded that all parameters were lowest in the wild ungulate group, intermediate in the cattle group, and highest in the control. Duration of exposure to herbivory in the wild and cattle groups contributed to the amount of tissue lost during the course of the study.

## Introduction

Arizona willow, *Salix arizonica* Dorn, is protected by the Arizona Native Plant Law and is included on the list of Forest Service Sensitive Species for the Intermountain and Southwestern regions. (See Prendusi et al., this volume, for a complete description of the species status.) Habitat loss, degradation, and other human-related activities are believed to have changed the fragile, high-elevation riparian areas in which the plant lives as well as threaten the long-term status of the species (Arizona Willow Interagency Technical Committee [AWITC] 1995). Herbivory by both cattle and wild ungulates has been implicated as a threat to the species. Associated herd movements also contribute to degradation of the species' habitat, i.e., stream bank erosion, loss of colonization sites, increased stream sedimentation, and trampling of small plants (AWITC 1995). Nearly 62 percent of Arizona willow (*Salix arizonica*) populations in Arizona have experienced reduced size and vigor due to herbivory, yet the identity of the herbivores has been unknown.

Both wild and domestic ungulates can greatly impact riparian areas and the species that live there. In the Southwest, riparian areas form narrow corridors, where plants and animals concentrate because of the need for water (AWITC 1995). Due to the large numbers of animals using riparian areas, impacts can be severe. For example, domestic livestock inhabit 307 million acres of federal land and 212 million acres of private land in 11 contiguous western states (Armour et al. 1994). Large concentrations of animals can adversely affect plant density and vigor. Sites where cattle grazing is common show significantly lower willow densities than ungrazed sites (Bryant and Wieland 1985).

Although factors such as dry weather, lowered water tables, and changes in hydraulic patterns are thought to cause declines in willow communities, herbivory and trampling by native ungulates also have been documented as adversely impacting willows (Singer et al. 1994). Activities associated with wild ungulates, such as trampling and rubbing antlers on the plants, can cause severe root dieback (Medina 1991). It appears that willow herbivory is common in nature, but the magnitude and timing of the herbivory are the critical factors that influence willow populations (Galeano–Popp 1988, Granfelt 1989, AWITC 1995).

Because both wild ungulates and cattle utilize riparian areas in Arizona willow habitat, the impacts of the various species are difficult to separate. Galeano–Popp (1988) stated that Arizona willow was palatable to both elk and cattle, but she did not know whether they were preferentially selected or to what degree this food source was selected; however, she believed the effects of grazing by both wild and domestic ungulates were additive. We established a controlled experiment at The Arboretum at Flagstaff to examine the separate effects of wild and domestic ungulate browsing on Arizona willow growth.

## Materials and Methods

The study was conducted during late July and early August 1995. Arizona willow plants were propagated from stem cuttings taken from parent plants growing in the White Mountains. In August 1994, after plants achieved adequate root mass, they were planted along the Sinclair Wash drainage inside and outside an existing 10-foot fence that was used to exclude the wild ungulates. Plants outside the fence were protected with caging until November 1994, in order to allow them to become established before being exposed to herbivory.

Ninety plants were established that were randomly assigned to one of three groups. Control plants were selected by placing plant numbers into a hat and having a non-biased observer extract the numbers. The three groups constituted 30 control plants that were caged or fenced from herbivory, 30 cattle plants that were exposed to cattle herbivory but not wild ungulate herbivory, and 30 wild plants that were exposed to wild ungulate herbivory but not cattle herbivory.

Populations of this willow on the Apache–Sitgreaves National Forest are exposed to wild ungulates all year and to domestic ungulates on a rotating basis for 10–30 days under current management. To imitate the natural exposure plants have to herbivory, plants in the wild ungulate group were exposed to herbivory for 10 months and plants in the cattle group were exposed for 10 days.

The area outside the 10-foot fence is visited by elk, *Cervus elaphus*, mule deer, *Odocoileus hemionus*, pronghorn, *Antilocapra americana*, and a variety of rodents and lagomorphs. These animals are seen on a regular basis in the large meadow where the experimental Arizona willows were planted. During the course of the experiment, tracks and scat found in this area were noted to attempt to identify any wild animals feeding on Arizona willow.

To expose these plants to a controlled level of cattle herbivory for a controlled duration, three cows were contained in approximately 3 acres with 30 exposed Arizona willows for ten days. The study plot was designed to mimic the environment encountered by the cows in their natural grazing areas. A 3–acre pen was constructed using barbed wire and T-posts, enclosing an area with ample amounts of shade from ponderosa pine trees, a watering trough near the willows to provide an optimal supply of water, and ample vegetation for browse. Besides Arizona willows, other plants found in the study plot included smooth brome (*Bromus inermis* Leyss), Arizona fescue (*Festuca arizonica* Vasey), deergrass (*Muhlenbergia rigens* (Benth.) Hitchc.), ponderosa pine (*Pinus ponderosa* Lawson), *Carex* spp., and a variety of herbaceous plants. After caging the control plants within the pen, three cows were put into the pasture. The cows were all females, and one was a calf that had not been completely weaned; therefore, there were effectively two and a half cows.

Plant height, total number of branches, and total branch lengths were measured in October 1994, both before the arrival of the cows on July 21, 1995, and after 10 days of exposure to cattle herbivory. Total shoot biomass was calculated by dividing total shoot lengths per plant by 6.25, the mean shoot length of 1 gram of willow (Maschinski, unpublished data). Throughout the cattle visit, we noted the different plants that were eaten and approximate order of preference of other exposed plants. Data were statistically analyzed using a repeated measures analysis of variance.

## Results

Both cattle and wild ungulates browsed Arizona willows under the experimental conditions imposed. Plant height was equal in all groups in August 1994, but was significantly decreased in the wild group by June 1995 and in both the wild and cattle groups by July 1995 ($F = 11.94$, $p < 0.0001$, Figure 1) after exposure to both cattle and wild ungulates.

Similarly, the total number of branches was equal across groups in August 1994, but was significantly decreased in all groups by June 1995 ($F = 3.83$, $p = 0.005$, Figure 2). By July 1995, the cattle and wild groups had 64 percent and 57 percent fewer branches than controls, respectively (Figure 2). While control plants increased mean branch length from August 1994 to June 1995 and maintained equal branch length until July, mean branch length decreased by a significant 19 percent in the cattle group and 16 percent in the wild group by July 1995 ($F = 5.29$, $p < 0.0005$, Figure 3).

Total shoot biomass varied across measurement time and group ($F = 7.80$, $p < 0.00001$, Figure 4) significantly. At the beginning of the study, in August 1994, control plants had 15 percent less total shoot biomass than the cattle group, while the wild group had slightly, but not significantly less total shoot biomass than the cattle group.

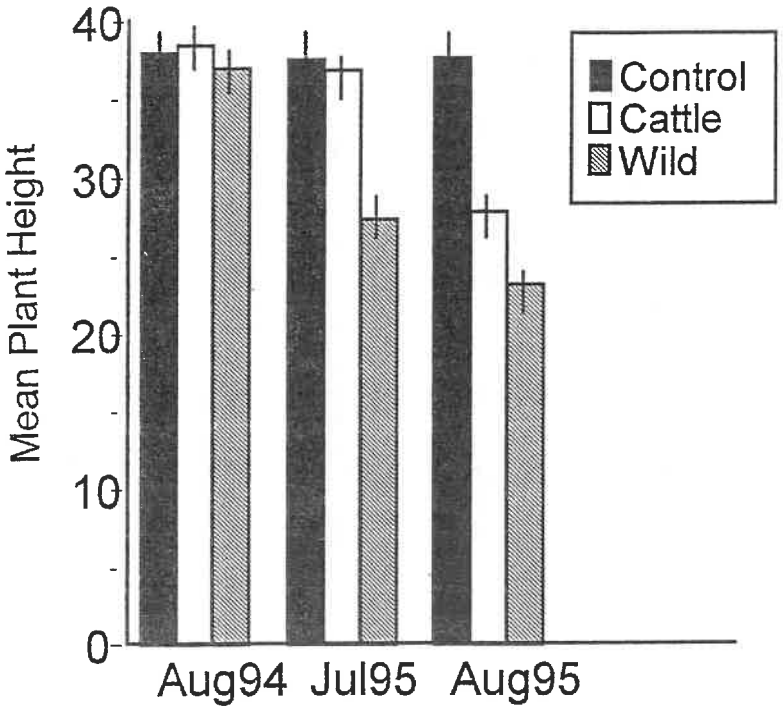


Figure 1. Mean plant height of Arizona willow plants in control, cattle, and wild groups measured at three different times. Note that cattle group plants were exposed to cattle herbivory for 10 days between July 95 and Aug 95 readings, whereas wild group plants were exposed to wild ungulate herbivory from November 1994 to August 1995.

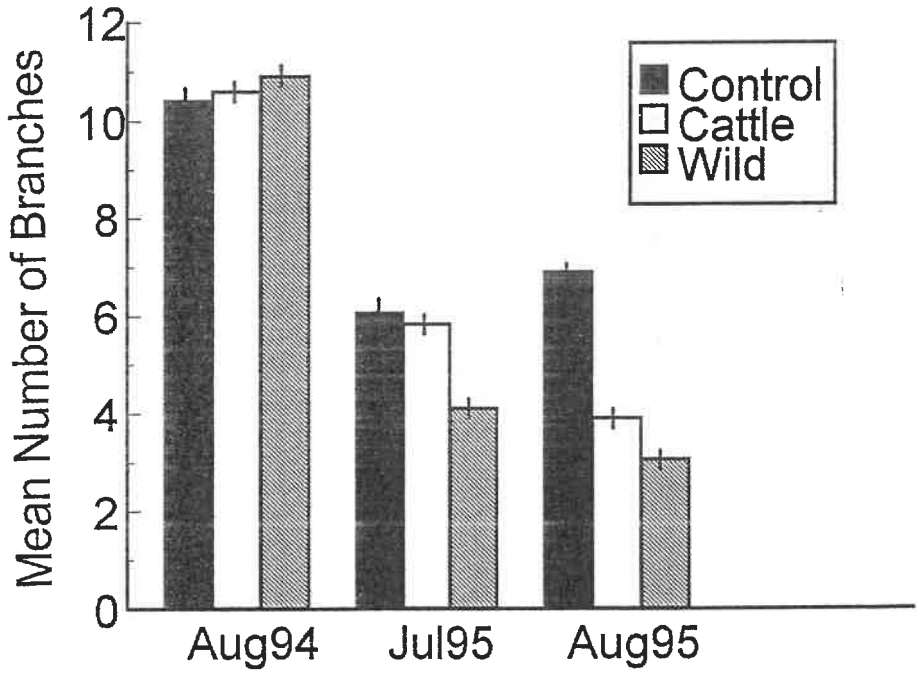


Figure 2. Mean number of branches per Arizona willow plant in control, cattle, and wild groups measured at three different times. Note that cattle group plants were exposed to cattle herbivory for 10 days between July 95 and Aug 95 readings, whereas wild group plants were exposed to wild ungulate herbivory November 1994–August 1995.

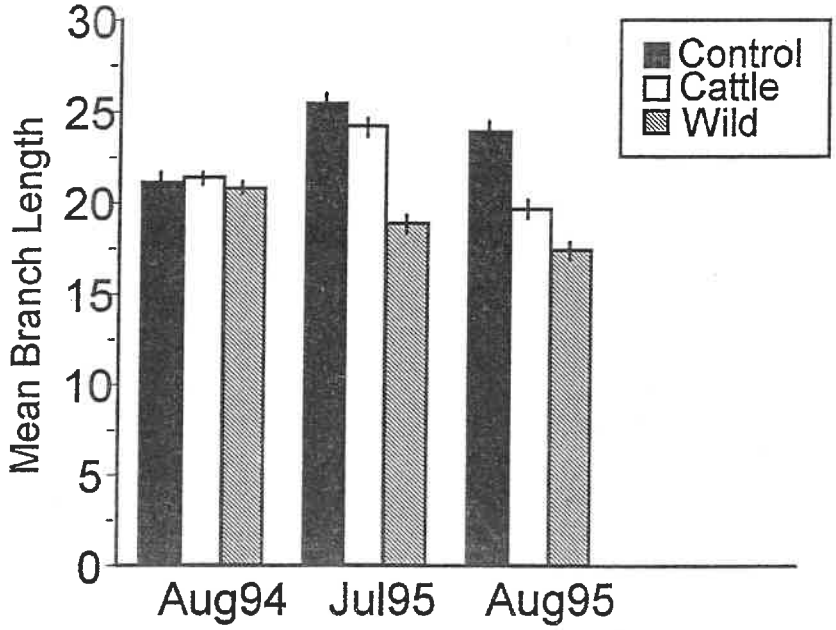


Figure 3. Mean branch length per Arizona willow plant in control, cattle, and wild groups measured at three different times. Note that cattle group plants were exposed to cattle herbivory for 10 days between July 95 and Aug 95 readings, whereas wild group plants were exposed to wild ungulate herbivory from November 1994 to August 1995.

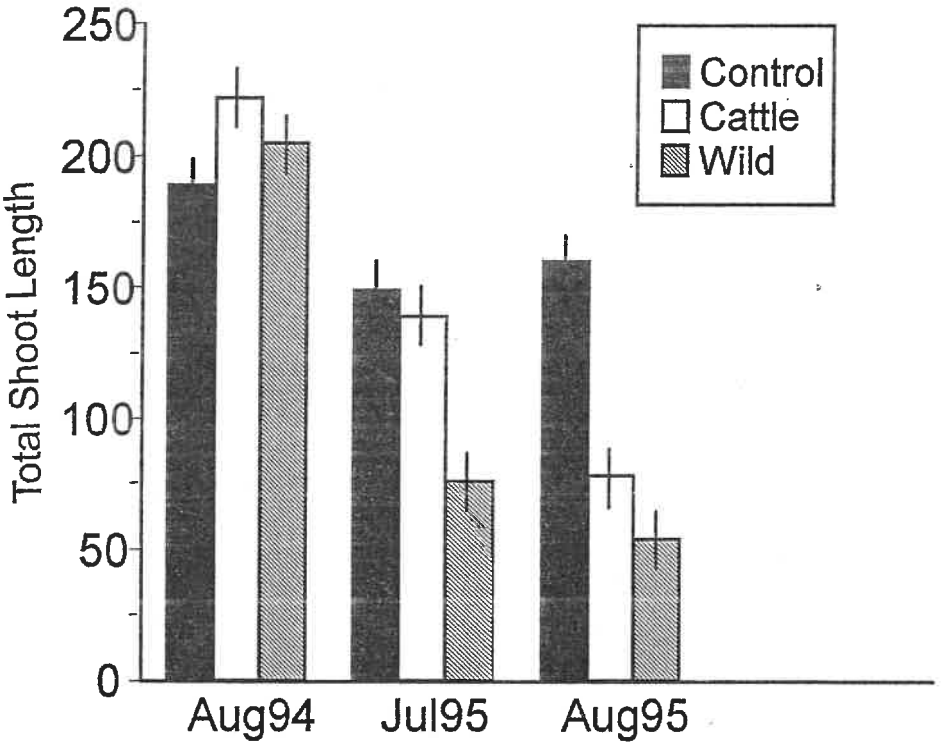


Figure 4. Total shoot biomass per Arizona willow plant in control, cattle, and wild groups measured at three different times. Note that cattle group plants were exposed to cattle herbivory for 10 days between July 95 and Aug 95 readings, whereas wild group plants were exposed to wild ungulate herbivory from November 1994 to August 1995.

However, following winter freezing, all groups experienced a decline in total shoot biomass. In the period between August 1994 and June 1995, the control group lost 22 percent of total shoot biomass, the cattle group lost 37 percent of total shoot biomass, and the wild group lost 63 percent of total shoot biomass. In the period between June 1995 and July 1995, when cattle group plants were exposed to cattle herbivory, total shoot biomass decreased by 43 percent and 29 percent in the cattle and wild groups, respectively, while controls increased by 8 percent in this 10-day period (Figure 4).

Note that the final plant measurements were generally less in the wild group compared to the cattle group and that this is probably due to the amount of time plants were exposed to herbivores: willows in the wild group were exposed to 10 months of herbivory, whereas willows in the cattle group were exposed to 10 days of herbivory.

## Discussion

This study showed that both wild ungulates and cattle browsed the Arizona willow plants. The effects of the herbivory were severe; height, the total number of branches, average branch length, and total shoot biomass all significantly declined when plants were exposed to herbivory.

Several observations indicated that cattle did not preferentially browse Arizona willows in this experimental setting. First, the cattle ate the willows only after all other desirable vegetation had been eaten. Desirable vegetation included: sweet clover *(Melilotus officinalis* (L.)Lam.), deergrass, and Arizona fescue. It wasn't until the sixth day of the experiment that the willows were tried. Secondly, the cows actually would pick grasses out from between the willows or between branches before they would eat the willows. This indicates that Arizona willows in this setting are not the preferred food, but would be selected after the other foods were eaten. Further, these studies indicate that in pastures where cattle remain more than 6 days, willow use will increase.

Observations by the first author suggest that elk are the primary wild herbivores feeding on Arizona willow in this experimental setting. There were elk hoof tracks and feces near the Arizona willows. Personal observations of elk were noted in this area nearly every morning. In contrast, the same evidence of deer or antelope was not found.

This experiment was conducted in an area in which *Salix* spp. are an uncommon food source to both elk and cattle. This may be construed as an artificial environment, but the study was conducted to determine whether cattle and/or elk eat willows. We conclude that cattle do indeed eat willows, but not as a preferred food source. Elk seem to be eating the willows, but we have not captured concrete evidence of the herbivore in action. Evidence of this nature needs to be gained by photography and/or video.

The exposure of Arizona willow to elk and cattle in its native habitats most certainly reduces plant vigor and probably reproductive capacity as well. Here we have documented reduction in four parameters related to plant vigor. In the next 2 years of this study we will be able to document the impact of herbivory in one year on reproduction in subsequent years and we will be able to determine if Arizona willow can compensate for tissue lost to herbivores. Our studies support the management efforts that have been initiated since the signing of the Arizona Willow Conservation Agreement (AWITC 1995), which reduce and/or eliminate the exposure of Arizona willow populations to elk and cattle on the Apache–Sitgreaves National Forest in Arizona and the Fishlake and Dixie National Forests in Utah.

The broader implications of these studies go beyond the "single species" perspective. Negative impacts on one species in fragile riparian zones could inevitably have lasting impacts throughout the ecosystem and through numerous and distant taxa (Armour et al. 1994). As an example, Taylor (1986) showed that there were greater numbers of passerine birds using an undisturbed willow riparian area in comparison to an extensively grazed area. Such ecosystem-level ramifications are possible, but as yet undocumented in Arizona willow habitat. By observing and recording data on the Arizona willow, correlative impacts on a variety of organisms within the ecosystem will be possible in the future.

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# Southwestern Rare and Endangered Plants:

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