EFFECTS OF CATTLE GRAZING SYSTEMS ON WILLOW-DOMINATED PLANT ASSOCIATIONS IN CENTRAL OREGON

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ABSTRACT

Early fur trappers reported seeing extensive willow stands throughout western rangelands. By the early 1900's, many of these stands were severely damaged or eliminated through cattle overuse. The Taylor Grazing Act of 1934 helped improve upland range conditions, but rangeland management strategies have been slow to improve willow riparian zone conditions, a factor largely due to grazing systems that include mid- and late-summer use. Eleven common cattle grazing systems are ranked by their impacts on willow plant associations.

INTRODUCTION

Riparian zones are identified by the presence of vegetation that requires free or unbound water or conditions that are more moist than normal (fig. 1) (Franklin and Dyrness 1973). Riparian zone plant associations on the National Forests of central Oregon were described by Kovalchik (1987). That study described 54 common riparian plant associations and community types, six of which are dominated by tall willows, usually with sedges dominating the ground layer (table 1). Other "rare" willow-dominated associations are not described in this paper. The classification system provides a useful framework by which research and management experience can be applied to specific riparian sites and plant associations and communities.

Better information about the effects of grazing systems on riparian vegetation is needed. Past recommendations have often been general, failing to account for extreme variation in site and vegetation associated with riparian zones. Findings from experiments in small pastures may not apply to large pastures and grazing systems appropriate for one vegetation type may not work on another. To better address riparian management, we have reviewed willow literature and combined pertinent information with practical experience to describe grazing system effects on willow-dominated plant associations in central Oregon. The conclusions are applicable to willow-dominated plant associations in other areas of western rangeland.

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STUDY AREA

Effects of grazing systems on willow plant associations were observed within 4,500,000 and 8,300,000 acres of land managed by the Forest Service and Bureau of Land Management (BLM). The area extends from the crest of the Cascade Mountains from Mount Jefferson in the north to the California border in the south and eastward through the Deschutes, Winema, Ochoco, and Fremont National Forests and the Prineville, Burns, and Lakeview Districts of the BLM.

Annual precipitation ranges from about 9 to 60 inches, except in the Cascades where it rises to over 100 inches along the crest. In general, precipitation is substantially less than in areas west of the Cascades due to orographic effects. Most precipitation falls as winter snow. Summers are droughty.

Elevations range from approximately 2,000 to 11,500 feet in an area with remarkable diversity of geology and landforms, including volcanic peaks, fault block mountains, pluvial lake basins, flat-lying and tilted plateaus, outwash plains, and deeply dissected volcanic uplands. Volcanoes and fault block uplifts and tilting have dominated the geologic history of the area for the past 40 million years (Chitwood 1976).

Vegetation types are diverse. Juniper (*Juniperus occidentalis*) and sagebrush (*Artemisia tridentata*) steppe dominate foothills and large intermountain basins and valleys. Ponderosa pine (*Pinus ponderosa*), lodgepole pine (*P. contorta*), Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), white fir (*Abies concolor*), mountain hemlock (*Tsuga mertensiana*), Engelmann spruce (*Picea engelmannii*), and subalpine fir (*A. lasiocarpa*) are prominent forest types in the mountains.

IMPORTANCE OF RIPARIAN ZONES

Riparian zones are a minor landscape component in the extensive, dry uplands of the Western United States (Thomas and others 1979). They generally comprise less than 2 percent of the total area. Periodic flooding, coupled with biotic interactions, has produced heterogenous ecosystems of riparian plant communities varying in age class and seral stages (Kauffman 1987). Riparian ecosystems are rich in plant, animal, and aquatic life (Platts and Nelson 1989; Skinner and others 1986; Thomas and others 1979).

Riparian zones provide preferred habitat for both domestic and wild ungulates because they contain:

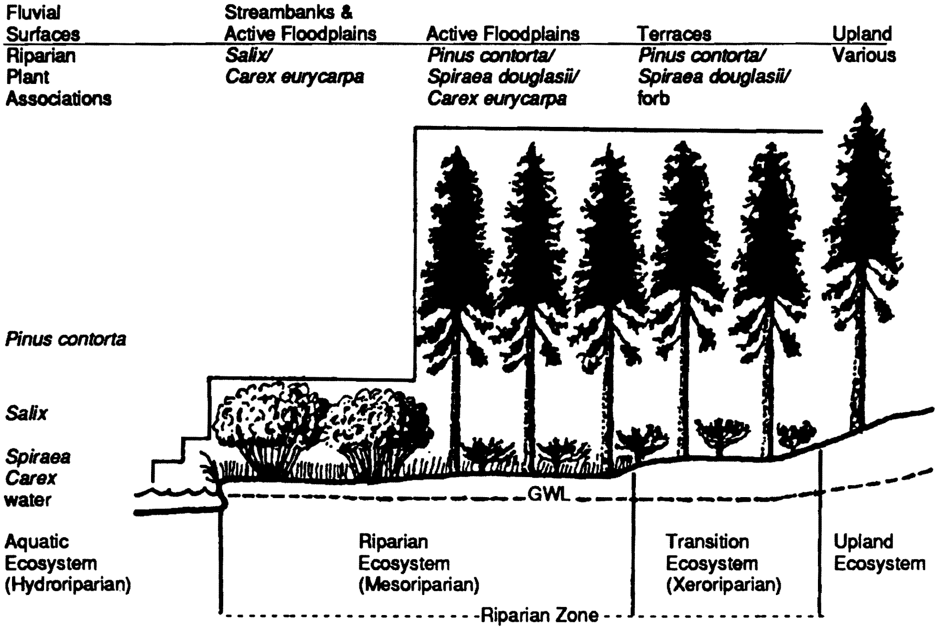

Figure 1—Riparian zones are identified by the presence of vegetation that requires free or unbound water or conditions that are more moist than normal.

Table 1—Constancy[1] and average cover[2] of important plants on six willow-dominated plant associations in central Oregon

	Plant association and number of plots					
Plants	**Willow/ Kentucky bluegrass (7)**	**Willow/ wooly sedge (7)**	**Willow/ widefruit sedge (19)**	**Willow/ aquatic sedge (7)**	**Willow/ Sitka sedge (11)**	**Willow/ beaked sedge (6)**
All shrubs	10(50)	10(63)	10(66)	10(36)	10(64)	10(49)
Bog birch (*Betula glandulosa*)	1(t[3])	......	6(6)	5(4)	5(18)	......
Booth willow (*Salix bebbii*)	......	7(26)	5(25)	5(9)	......	7(32)
Bog blueberry (*Vaccinium occidentalis*)	......	......	3(5)	......	4(9)	......
Douglas spiraea (*Spiraea douglasii*)	......	......	7(10)	......	7(7)	......
Eastwood willow (*Salix eastwoodii*)	......	......	2(6)	......	2(10)	......
Geyer willow (*Salix geyeriana*)	10(32)	7(7)	8(19)	3(5)	6(22)	8(15)
Lemmon willow (*Salix lemmonii*)	3(7)	4(24)	1(t)	3(13)	4(9)	......
All grasses	10(42)	10(16)	10(6)	10(12)	6(2)	10(7)
Kentucky bluegrass (*Poa pratensis*)	10(37)	10(12)	5(1)	7(1)	1(t)	5(1)
All sedges	9(13)	10(38)	10(47)	10(55)	10(61)	10(61)
Aquatic sedge (*Carex aquatilis*)	3(1)	1(1)	......	10(35)	......	2(3)
Beaked sedge (*C. rostrata*)	......	3(1)	5(3)	2(1)	3(6)	8(44)
Inflated sedge (*C. vesicaria*)	1(t)	1(t)	3(3)	......	1(t)	2(6)
Sitka sedge (*C. sitchensis*)	......	......	3(3)	......	10(55)	......
Widefruit sedge (*C. eurycarpa*)	1(t)	......	10(38)	2(1)	2(2)	......
Wooly sedge (*C. lanuginosa*)	3(1)	10(29)	1(1)	2(t)	1(t)	2(2)
All forbs	10(30)	10(28)	10(13)	10(39)	10(8)	10(19)
Common horsetail (*Equisetum arvense*)	1(t)	1(t)	2(t)	2(t)	4(2)	2(t)
Glabrate monkeyflower (*Mimulus guttatus*)	1(t)	1(t)	2(t)	7(2)	......	3(1)
Largeleaved avens (*Geum macrophyllum*)	9(4)	9(2)	4(1)	10(3)	......	5(2)
Longstalk clover (*Trifolium longipes*)	1(3)	3(1)	1(t)	3(5)	......	7(2)
Northwest cinquefoil (*Potentilla gracilis*)	7(2)	4(1)	......	3(1)	......	5(1)
Small bedstraw (*Galium trifidum*)	......	......	5(2)	3(t)	4(1)	5(1)
Starry solomonplume (*Smilacina stellata*)	6(1)	4(2)	2(1)	5(1)	1(t)	3(1)
Sweetscented bedstraw (*Galium triflorum*)	......	6(4)	1(t)	2(t)	1(t)	2(2)
Watson's willowweed (*Epilobium watsonii*)	3(1)	......	3(t)	10(2)	3(t)	7(1)
Western yarrow (*Achillia millefolium*)	9(3)	6(2)	3(1)	7(1)	......	......

[1]Constancy is the percent of plots in which the species occurred. Code to constancy values: 1 = 5-15 percent, 2 = 15-25 percent, 3 = 25-35 percent, 4 = 35-45 percent, 5 = 45-55 percent, 6 = 55-65 percent, 7 = 65-75 percent, 8 = 75-85 percent, 9 = 85-95 percent, 10 = 95-100 percent.
[2]Average canopy cover (in parentheses) is calculated for all plots in each willow-dominated plant association.
[3]t = trace of cover.

- Easily accessible water.
- More favorable terrain.
- Hiding cover.
- Soft soil.
- A more favorable microclimate.
- An abundant supply of lush palatable forage (partially from Behnky and Raleigh 1979; Krueger 1983; Platts and Nelson 1989; Skovlin 1984).

A study in eastern Oregon and Washington found that 1 acre of moist meadow had a grazing capacity equal to that of 10 to 15 acres of upland (Reid 1946). These meadows comprise 1 to 2 percent of the total land area, yet produce about 20 percent of the available summer forage. In a study of a Blue Mountains cattle allotment, Roath and Krueger (1982) found the riparian zone covered 2 percent of the area and produced 20 percent of the summer forage, yet provided 81 percent of the total forage consumed. In this case, utilization was high, as the cattle used 75 percent of the current year's herb growth and 30 to 50 percent of the current year's willow growth in the riparian zone.

IMPORTANCE OF WILLOWS IN RIPARIAN ZONES

Willows are prominent in several riparian plant associations (Kovalchik 1987) (table 1), and they help establish and maintain physical stability and biological diversity in riparian zones (Smith 1980). Willow roots help protect streambanks from erosion while aboveground stems and foliage bend during high flows and dissipate flood energy, thus protecting floodplains from scour erosion (Crouch and others 1987; Crouch and Honeyman 1986; Elmore and Beschta 1987; Platts and others 1987; Skinner and others 1986). Willows also filter overland water flow, trapping sediments from upstream erosion and surface flow from adjacent uplands (Platts and others 1987). In our opinion, streambank stability is largely a function of the effectiveness of riparian vegetation in performing these functions, especially in lower gradient valleys.

Status of Riparian Zones

Fur trappers and explorers reported extensive broadleaf woody vegetation on the floodplains of central Oregon in the early 1880's (Claire and Storch 1973; Storch 1979). With beaver trapping came the first changes caused by people in the structure and function of riparian zones (Kauffman 1987). The elimination of beavers from streams altered site hydrology with subsequent changes in stream processes and riparian habitat. Today, the presence of water, diversity and productivity of plant and wildlife communities, and attraction of people and livestock to the riparian zone continue to cause conflict between various resource uses such as timber harvest, livestock grazing, road location, recreation, mining, and water use (Thomas and others 1979). These uses have greatly altered riparian zones in the past 150 years (Kauffman 1987; Kindschy 1985).

Of these uses, unwise use by livestock is considered the most common cause of deteriorated riparian zones in western rangelands (Knopf and Cannon 1981). Overuse of rangeland in central and eastern Oregon began in the 1860's and first became apparent in the 1880's when severe winter conditions, coupled with depleted forage supplies, resulted in widespread livestock mortality (Kindschy 1987). Livestock abuse was highest during the 1920's as a result of post-World War I reconstruction and increased again with increased red meat demand during World War II (Claire and Storch 1977).

The days of unregulated open range came to an end with the Taylor Grazing Act of 1934. The Act made it possible to control and regulate range use on public lands (Behnke and Raleigh 1979). Improved upland grazing systems were introduced and livestock numbers and length of grazing seasons were reduced (Claire and Storch 1977). Upland range conditions improved in many areas, but not generally in riparian zones. Grazing systems designed for uplands (such as deferred and rotation grazing) have not been effective in riparian zones and are bringing public agencies to legal confrontation with the public over riparian grazing strategies (Behnke and Raleigh 1979).

Status of Willows in Riparian Zones

Willow-dominated plant associations in good condition (dominated by willows and sedges) produce large amounts of forage (2,000 to 5,000 dry pounds per acre, we estimate), yet livestock grazing systems often do not maintain these communities (Smith 1983). Improper use by livestock, sometimes in conjunction with poorly managed big-game herds, has degraded the majority of willow-dominated sites, decreased forage production, and reduced or entirely eliminated willows from many suitable habitats (Kindschy 1985; Kovalchik 1987; Munther 1981; Swenson and Mullins 1985) (figs. 2 and 3). Many older willow stands are dead or dying and little natural regeneration is occurring on poorly managed range allotments.

Figure 2—Silver Creek, Ochoco National Forest, showing streambanks anchored by a good-condition willow/wooly sedge plant association. Geyer and Booth willows dominate the tall shrub layer. The association continues across a wide active floodplain.

Figure 3—Egypt Creek (near Silver Creek), showing severe change in composition due to many decades of season-long grazing. Big and silver sagebrush, Kentucky and Cusick bluegrass, and annual grasses and forbs dominate the now xeric floodplain. Nebraska sedge dominates the dished stream bottom. The vegetation potential is the same as Silver Creek.

WILLOW RESPONSES TO LIVESTOCK GRAZING

Sheep find willows very palatable, but do little damage to stands if good herding practices are followed. Cattle prefer willows less than do sheep, but are more destructive when they congregate in riparian zones (Smith 1982). Since cattle do more damage, the remaining discussion focuses on their grazing.

Mature Willow Responses

Cattle damage willow stands by both browsing and physically breaking lower branches as they seek summer shade and other palatable forage (Knopf and Cannon 1981). Willows become a principal source of cattle browse as other more palatable forage resources are depleted or as the palatability of the alternate forage decreases. Therefore, most browsing damage to willows occurs in late summer (Kauffman and others 1983; Smith 1982). There is little change in protein levels in the twigs of willows (about 7 percent) from early to late summer (Thilenius 1990). Early season upland grasses have crude protein levels of 15 to 17 percent, but levels fall below 5 percent as grasses mature. As this occurs, cattle increase the amount of available palatable forbs and browse in their diets and soon move into the riparian zone. Then a shift to willows occurs as riparian forage supplies become exhausted, usually toward the end of the grazing season. Willow use can also occur earlier in the summer if a range allotment is overstocked for too long. As long as palatable herbaceous forage is available in the riparian zone, willow utilization will remain minor (Kauffman and others 1983).

Our observations for mid- to late-season grazing indicate that cattle begin using the current annual growth on willows when riparian forage use reaches about 45 percent of total available forage (4- to 6-inch stubble height). Use increases again at 65 percent (2 to 4 inches), and cattle eat all the willows they can when utilization is 85 percent or more (<2 inches). Overused willow stands show a "grazing line" where all young shoots have been grazed. With continued overuse, dead and dying plants suggest former willow abundance. Excessive grazing may eliminate a willow stand within 30 years (Kovalchik 1987).

Willow Seedling Responses

First-year willow seedlings are very sensitive to grazing. Shoots and roots at this age are usually less than 12 and 8 inches in length, respectively (authors' observation). Browsing of first-year shoots often kills the entire plant, because the plants are easily pulled from the ground or are killed by trampling. Sites otherwise suitable for willow establishment and growth may be poorly stocked with willow regeneration under inappropriate grazing systems, such as season-long grazing. Poor willow recruitment can retard succession from immature to mature willow stands. Without recruitment, willow stands develop unbalanced age structures and eventually die (Kauffman 1987).

Site Response to Eliminating Stands

Natural erosion of streambanks is a long process and usually occurs in equilibrium with bank rebuilding (Platts 1984). Changes in streambank geomorphology occur as erosion-resistant dominants are replaced by more xerophyllic species such as Kentucky and Cusick bluegrass, big and silver sagebrush, and annual forbs and grasses (fig. 4). Without willow plant associations and their sedge undergrowth, stream channel processes and functions are severely altered (Smith 1980). Under excessive cattle use during the past century this balance has been upset and banks are eroding faster than they can be built. Hydrologic changes in response to altered community composition and grazing include:

- Soil compaction, lower soil infiltration rates, and increased surface erosion.
- Accelerated loss of streamside and instream cover with increasing bank and streambed erosion.
- Increased stream channel capacity with less dissipation of flood energy over the floodplain.
- Straightening of the stream channel resulting in higher water velocity, especially at headcuts and cut meanders.
- Increased peak flow and lower summer flow.
- Increased flood energy causing either downcutting or (if bedrock is near the surface) braiding.
- Lowered floodplain water tables and reduced availability of soil moisture.
- Increased silt deposition on spawning gravels and invertebrate food production areas.
- Increased water temperature (Behnke and Raleigh 1979; Kauffman and Krueger 1984).

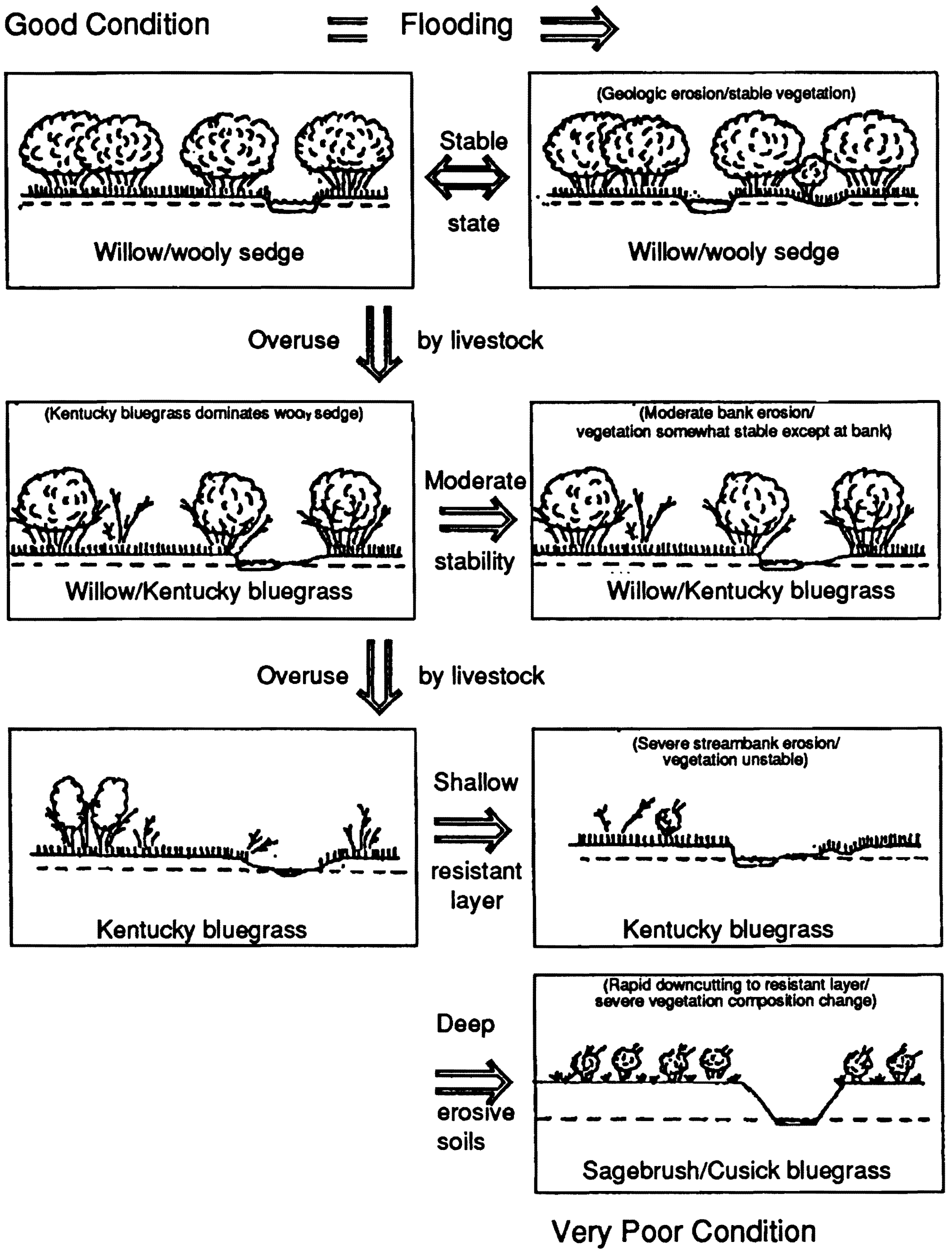

Figure 4—Deterioration of sites supporting the willow/wooly sedge plant association with flooding and improper use by livestock.

Eventually, hydrologic changes reach a threshold, after which the stream proceeds into a cycle of gully development or braiding (fig. 4). The opportunity for natural dominants (such as willows) to maintain previous hydrologic conditions and community diversity and productivity is lost. Recovery may take years, decades, or centuries depending on the size and nature of the system and on interim management (Swanson 1989; VanHovern and Jackson 1986).

GRAZING SYSTEMS FOR WILLOW STANDS

To restore forage and willow production in riparian zones, grazing systems must become whole ecosystem-oriented, not just upland-oriented (Kauffman and others 1983; Smith 1981). Most traditional grazing systems were developed for upland grasses and not riparian species (Platts 1986). While grazing systems such as deferred or rotation have improved the condition of most upland range in the last 50 years, they encourage concentrated livestock use in riparian zones during mid- and late-summer periods and have resulted in minimal improvements in riparian conditions (Platts 1986).

Riparian habitats require site-specific management (Platts 1986). Several stream reaches, each with a different mosaic of plant associations and communities, may occur in a single grazing allotment (Kovalchik 1987). These communities have different tolerances to grazing (Behnke and Raleigh 1979). Grazing systems that are compatible with one community may harm another (Kauffman and others 1983). Therefore, to maintain diversity of plant associations along each stream reach, grazing systems must be carefully designed for the communities that are present or desired.

Grazing Systems' Compatibility With Willow-Dominated Plant Associations

In our opinion, the switch from grazing to browsing is the single most important factor in the decline of willow-dominated plant associations to less stable communities (fig. 4). Unless grazing systems allow for sufficient forage height growth during the mid- to late-summer period, they will fail to maintain willow-dominated plant associations. Sufficient forage height acts to prevent excess browsing, provides for regrowth of riparian plants after use, and leaves sufficient vegetation for streambank protection (Clary and Webster 1989).

The degree to which browsing of willows is compatible with long-term stream and plant community maintenance depends on the relative number of willows present. Few willows (where there should be many) should dictate conservative use. Use can be greater where willows are abundant or where management objectives do not call for increased numbers of willows.

The following discussion rates common grazing systems by their effects on willow-dominated plant associations in fair to good condition. The discussion assumes the riparian zone is included within larger upland pastures (except in the cases of corridor fencing and riparian pastures). Discussions refer specifically to ecological requirements of willows and sedges. Rankings partially reflect failures of range managers to effectively manage grazing systems in riparian zones. For instance, incompatible grazing systems might become moderately compatible with willow management if moderate forage height is retained at the end of the summer, an unlikely scenario given past performance.

Highly Compatible Systems

Corridor Fencing—Fencing is the easiest way to obtain rapid improvement in riparian conditions by protecting riparian zones from improper cattle use (Platts and Raleigh 1984). Though fences are expensive to build and maintain, corridor fencing will maintain or restore willow plant associations, even those in poor condition. Fencing may cost less than improper, inappropriately placed, or poorly managed grazing systems (Platts and Raleigh 1984). The BLM has lost only about 8 animal-unit months per mile of fenced stream in central Oregon, an insignificant loss of available forage from grazing allotments (authors' observation).

Response of willow associations to corridor fencing varies greatly between riparian zones. For example, high-sediment watersheds rebuild streambanks more quickly than low-sediment watersheds (authors' observation). An alternative to costly fencing and fence maintenance is to use a willow-compatible grazing system.

Riparian Pasture—Riparian pastures are small pastures set aside to achieve desired vegetation response (Platts and Nelson 1985). Pastures include enough upland to achieve balanced use between upland and riparian forage. Larger tracts of upland can be used only if managers are willing to write management prescriptions based on riparian considerations alone. In small pastures, all forage is reached with normal cattle movement, encouraging them to go to uplands to vary their diets (Platts and Nelson 1985). Grazing can be controlled more easily when compared to larger pastures, and cattle are removed when forage utilization levels or plant phenology stages are reached (Platts 1984).

If managed properly, the system results in better livestock distribution, grazing intensity, and timing. This leads to increased willow and sedge production and reduced effects on stream morphology (Platts 1986). Willow response is better if the riparian pasture is grazed early or after fall "green up" (regrowth of upland grass following fall rains). Close monitoring of forage use avoids the switch from grazing to browsing.

Spring (Early-Season) Grazing—In the spring, cattle often avoid riparian zones because of cold temperatures, soil wetness, and forage immaturity (Krueger 1983). Therefore, spring grazing encourages cattle to graze uplands where forage maturity and climate are more favorable compared to the riparian zone (Platts 1984). As a result, spring-grazed riparian zones have less than half the cattle occupancy compared to fall use (Krueger 1983). As spring grazing precludes late-summer use, willow browsing is light and seedling survival high.

Response of riparian vegetation is good, even on sites in poor condition. Vigorous willow and sedge regrowth provide excellent streambank protection, and soil and water relationships remain favorable to continued willow and sedge production.

Winter Grazing—Winter grazing is seldom used in mountains because of deep snow. However, it is reasonably compatible with riparian habitat needs and has been used successfully on lower elevation ranges (authors' observation). Riparian forage is not very palatable in the winter and may not receive much use. If used, forage is consumed during the dormant season and there is no regrowth, which results in less sediment trapped during early spring runoff. This potentially negative impact on stream morphology has not been a problem, possibly because soils are frozen and less susceptible to trampling and mass wasting.

Platts (1984) observed little difference between winter pastures and adjacent ungrazed sites except for the larger numbers of willows established on ungrazed sites. Observations vary in central Oregon. Willow seedlings are infrequent on some winter pastures because of browsing and trampling. Best willow establishment and recovery occurs where drainages are colder than adjacent uplands and open south slopes reduce use in the riparian zone.

Moderately Compatible Systems

Two-Pasture Rotation Grazing—Two-pasture rotation grazing is used on BLM lands but apparently not by the Forest Service. The system provides late-summer rest and regrowth on both pastures every year. The very early period of use responds similarly to spring grazing systems.

Use on the critical-season pasture (when the grass flower stalks emerge from the basal meristem) can retard maintenance or recovery of willows if it extends into the hot summer season and results in the shift to browsing.

Pastures respond best to this system if cattle are removed from the critical-use pasture before summer drought, allowing lightly used willows and sedges to regrow through the remainder of the growing season. Two-pasture rotation grazing may not improve pastures in poor condition (authors' observation). Adding years of rest, especially on degraded pastures, and careful monitoring of forage use will increase the effectiveness of the system for willows.

Three-Pasture Rest-Rotation Grazing—Three-pasture rest-rotation allows one pasture to be rested an entire season while the others support the grazing. Sedge communities may respond favorably to this system, as a vegetative mat is left on streambanks in most years (Elmore 1989; Platts 1986). However, the system may not improve either willow or sedge production on pastures in poor condition (Smith 1989). In theory, willows should respond favorably to this system because of the rest period. In practice, 2 or 3 years of willow growth are often removed on the late pasture (Platts 1984).

Smith (1980) and Kindschy (1989) found that less than half of heavily clipped or browsed willow stems survive into the following year. Of the survivors, regrowth was half the growth of ungrazed stems. Therefore, 3 or more years of rest may be necessary for heavily used willows to recover. Adding more rest and removing cattle before 45 percent use of forage in the late-season period will better protect willows when using this system.

Three-Pasture Deferred-Rotation Grazing—Three-pasture deferred-rotation grazing moves cattle from early to critical-season pastures at a predetermined date or at some level of forage use (Platts 1984). The third pasture is used after seeds of upland grasses have ripened, and cattle are removed when desired use of upland grasses is reached. This grazing system seems desirable for sedges because of 2 years of late-summer rest. However, overuse by concentrated cattle may cause sedges to decline, especially if stubble height during spring runoff is too short to resist erosion. In theory, this system is beneficial for willows, with late-season grazing occurring in 1 of 3 years.

Unfortunately, difficulty in managing cattle distribution and forage use often results in a shift to browsing on mid- as well as late-summer pastures, resulting in 2 years of overuse followed by decline in willow cover and vigor (Platts 1984). The system as applied in central Oregon often fails to maintain good-condition willow stands, which degrade to sedge communities or worse. Nor does it improve sites in poor condition. It can be improved for willows by adding more rest and ending mid- and late-season grazing before 45 percent forage use.

Incompatible Systems

Spring-Fall Pastures—Spring-fall pastures are used for a short period in the spring before summer pastures are ready and again in the fall before cattle are moved to winter pasture. Rest occurs during the critical growing season. This system has not maintained or enhanced willow stands in central Oregon because of the late grazing period. If spring-fall grazing is to be effective, attention must be paid to forage use during late-season period.

Spring-fall grazing is acceptable in good-condition riparian zones if early use is ended before the critical growing period, fall use is delayed to forage regrowth on adjacent hillsides, and fall use is ended at 45 percent forage use. Concentrating animals for a short period of time may have the same effect as light grazing and is acceptable for maintaining willow vigor and cover.

Deferred Grazing—Deferred grazing is used where there is a long period of time between the convenience of early season grazing and later maturation of forage plants. For example, sedges may not be convenient for spring grazing because of wet soils, but they continue to regrow and may be used until mid-October or November. If sedge use is ended in September, regrowth can provide substantial cover for streambank protection. However, sites in poor condition (without willows or sedges) have not responded to the deferred grazing system (Smith 1989).

With deferred grazing, cattle soon concentrate in the riparian zone. As riparian forage is overused, use shifts to browsing. Willow stands are converted to sedge communities or worse (Kauffman and others 1983). Removing cattle before 45 percent forage use will improve the usefulness of the system for willows only if willow cover and vigor are already good. Other grazing systems should be used on sites in need of recovery.

Late-Season Grazing—As usually practiced, late-season grazing is not much different than season-long or deferred grazing in its effects on willows (Kauffman and Krueger 1984; Platts 1984). Willow stands soon degrade to sedge communities or worse. Late-season use can be made more effective for willow stands by removing cattle at 45 percent forage use or delaying grazing until regrowth of upland grasses, at which time cool temperatures in riparian zones disperse cattle to uplands.

In theory, the system could be improved by reducing cattle numbers to prevent overuse of riparian forage, a difficult way to reduce riparian grazing at a time when cattle prefer riparian vegetation. The system can be improved for sedges if cattle are removed early enough to allow fall regrowth, thus providing streambank protection during spring runoff. In practice, the system is incompatible with willow and sedge management unless large pastures are grazed solely for riparian objectives and become, in essence, a riparian pasture.

Season-Long Grazing—In the season-long grazing system, livestock are released into an allotment in the early spring (actual time depends on average upland forage readiness and soil conditions) and removed in the fall (Platts 1984). Season-long pastures will not support fair or better condition willow stands. Early use of the pasture is often acceptable for the reasons outlined under spring grazing. However, cattle soon congregate in the riparian zone during the hot summer months. Overuse of riparian forage occurs by mid-summer and cattle use switches to willows, eventually eliminating the stand. In addition, season-long grazing never gives sedges a chance to replace carbohydrate reserves, and they are soon replaced by increaser plants such as Kentucky bluegrass and unpalatable forbs.

Reducing the number of cattle does not counter the negative impacts of the system, it just prolongs the outcome. The system is incompatible with both willow and sedge management.

SUMMARY

Improper cattle grazing has severely affected the stability of riparian zones, especially those once dominated by willows. There is considerable variation in the effects of common grazing systems on the stability of willows and sedges (fig. 5). Spring grazing is a good example of a system that avoids late-summer use and is compatible with willow management. Compatible systems should be considered where willows have significant cover or where managers wish to restore willows. Moderate-impact grazing systems such as three-pasture rest-rotation were designed for uplands and should be used only where their negative effects on willows can be mitigated by strict enforcement of riparian forage use to prevent the switch from grazing to browsing. Otherwise, their use will result in downward condition trends in willow-dominated plant associations. Systems such as late-season grazing are incompatible with willow management because of late-season use and the switch to browsing. Incompatible systems should be discouraged where the goal of management is to maintain or recover willow stands.

Systems highly compatible with willow management

Corridor fencing	Willows ⇑ Sedges ⇑	Riparian pasture	Willows ⇑ Sedges ⇑
Spring grazing	Willows ⇑ Sedges ⇑	Winter grazing	Willows ⇔ to ⇑ Sedges ⇑

Systems moderately compatible with willow management

Two-pasture rotation	Willows ⇔ to ⇑ Sedges ⇑	Three-pasture rotation	Willows ⇔ to ⇓ Sedges ⇑
Three-pasture deferred rotation	Willows ⇔ to ⇓ Sedges ⇔ to ⇑		

Systems incompatible with willow management

Spring-fall grazing	Willows ⇓ Sedges ⇔ to ⇓	Deferred grazing	Willows ⇔ to ⇓ Sedges ⇔ to ⇓
Late-season grazing	Willows ⇓ Sedges ⇓	Season-long grazing	Willows ⇓ Sedges ⇓

⇑ = highly compatible
⇓ = incompatible
⇔ = no change

Figure 5—Generalized relationships between grazing system and willow and sedge response on willow-dominated plant associations.

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