Habitat Use by Beaver Along the Big Sioux River in Eastern South Dakota

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Abstract.—Habitat use by beavers *Castor canadensis* was investigated during 1985 and 1986 in grazed and ungrazed areas along the Big Sioux River in eastern South Dakota. Almost half (48%) of the trees in ungrazed areas were small (diameter at breast height or DBH< 7.5 cm), but a majority (58%) of the trees in grazed areas had large diameters (DBH> 30 cm). Beaver activity was evident on 280 of 2,369 (11.8%) trees (DBH> 2.5 cm) and 756 of 7,794 (9.7%) stems (DBH ≤ 2.5 cm) sampled. A greater proportion ($P \leq 0.01$) of trees were cut by beavers in ungrazed than in grazed areas. Beaver did not select tree species for cutting according to availability ($P \leq 0.01$). Trees cut by beaver were significantly smaller in diameter ($P \leq 0.01$) than uncut trees. Mean distance from water of cut trees was less ($P \leq 0.01$) than for uncut trees. Over half (52%) of the trees damaged by beaver either resprouted or remained alive and standing.

It is broadly accepted that riparian habitat is important in reducing soil erosion, stabilizing river banks, and providing habitat for wildlife. In much of the northern great plains, riparian habitat contains the only naturally occurring trees. In many areas, agricultural activities have degraded these natural forests, at the same time, planted tree claims and shelterbelts have generally declined. Therefore, a prime concern of land managers in South Dakota is the preservation of existing riparian habitat. Along the Big Sioux River in eastern South Dakota, extensive areas of habitat have been degraded or lost due to livestock grazing (Smith and Flake 1983).

Grazing can have negative effects on beaver *Castor canadensis* populations as well as on riparian habitat. After cattle are introduced into riparian habitat, there is often a gradual decline in stands of willow *Salix* spp. because beaver harvest mature woody plants and cattle harvest or trample new regeneration (Munther 1981). Beavers alter riparian habitat by cutting trees and damming streams. These activities slow water currents and create ponds, which can benefit waterfowl (Beard 1953), mammals (Yeager and Rutherford 1957), warmwater fish (Hanson and Campbell 1963), and trout (Gard 1961; Rutherford 1964). The same activities cause beavers to be viewed as pests by forestry personnel and landowners (Miller 1985). It has been suggested that beaver may be adding to the loss of riparian habitat along the Big Sioux River because of their natural activity of cutting trees.

Objectives of this study were to quantify the effects of livestock grazing on riparian habitat, compare habitat use by beaver in ungrazed areas with adjacent areas grazed by cattle, and determine if beaver activity is accelerating the destruction of habitat along the Big Sioux River.

Study Area

The study area was located in Brookings and Moody counties in east-central South Dakota along approximately 23 km of the Big Sioux River, the primary drainage of the Coteau des Prairie. The Big Sioux River originates in Grant county, South Dakota and flows in a southerly direction to enter the Missouri River at Sioux City, Iowa. The river's floodplain is usually inundated each spring by runoff from a large watershed area. Width of the river channel within the study area varies from 15 to 40 m and water depth ranges from 0.3 to 1.7 m. The river bed consists mainly of shifting sand and small gravel, but silt beds are found in quiet backwaters.

The Big Sioux River supports a marginal game fish population consisting of walleye *Stizostedion vitreum* and northern pike *Esox lucius*. The predominant fish species present are bullhead *Ictalurus* spp., channel catfish *I. punctatus*, and carp *Cyprinus carpio*.

Grazing of livestock and cultivation of small grain and corn are the primary agricultural land uses along the Big Sioux River. Grazed areas are characterized by a few scattered large trees with no regeneration and little understory. Ungrazed areas have thick understory growth and an abundance of small trees interspersed with large trees.

Methods

From May to August 1986, the study area was surveyed in an effort to quantify existing riparian habitat and to estimate beaver use of riparian tree and shrub species. Sample plots were defined as variable-length strip transects 3-m wide with their respective lengths being the distance in meters from the shoreline to the edge of wooded habitat farthest from the river. Plots were randomly located along the main river channel, as well as along all backwaters in old river channels.

To survey a plot, I walked toward a fixed point while holding a 3-m rod at its midpoint. All woody plants contacted by the rod were considered to be in the plot and were listed by species. Woody trees and shrubs encountered were grouped according to diameter at breast height (DBH), as stems (DBH ≤ 2.5 cm) or trees (DBH > 2.5 cm). Trees and stems that were alive or had been damaged or killed by beaver were included, but trees killed by disease or flooding were omitted. Actual density (AD = number of trees of species A/hectare), and relative density (RD = number of trees of species A × 100/total number of trees), were calculated for all trees and by tree species for the entire riparian community.

Those trees or stems that had been damaged by beaver were separated by extent and type of cutting: (1) trees felled recently (fresh cuts), (2) trees felled in previous years (old cuts), (3) alive and standing but damaged, and (4) cut with resprouting. Fresh cuts were defined as cuts occurring in the post-winter period of the current year as determined by the observer. Old cuts were defined as those trees that were cut by beaver in a previous year and did not survive due to the damage. The third category included trees that had suffered obvious beaver damage but were not killed by this activity. Examples were large trees that had been cut only partially through the trunk and trees that had been stripped of bark. Trees or stems that had been cut by beaver

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often exhibited regrowth around the stump, and those encountered in the sample were grouped as cut with resprouts.

Relative cuts (Cr = number of trees of species A cut × 100/total trees cut) were calculated for all tree species. Chi square analysis was used to test if beaver selected tree species in proportion to their availability in the study area. If there were significant differences, confidence intervals were constructed around the proportion of observed use of the tree species to determine selection or avoidance (Neu et al. 1974; Byers and Steinhorst 1984). A chi square test was also used to test if beaver were cutting trees in equal proportions in both land use categories. Analysis of variance was used to determine if there was a difference in DBH and distance from water of all trees between land use categories and to determine size of trees and distance from water of trees selected for cutting by beaver.

Results

Habitat Conditions

A total of 509 plots, which had a combined distance of 24.8 km and encompassed an area of 7.42 hectares, was sampled. In the study area, 55% of the forest was not grazed, 39% was grazed, and 6% was farmed. Eleven species of trees were encountered (Table 1). Sugar maple (*Acer saccharinum*) and russian olive (*Elaeagnus angustifolia*) are not considered further in this paper due to small sample size. Because of the small amount of area farmed, we will limit our discussion in this paper to ungrazed and grazed land use categories.

Grazing activity has changed the forest community structure. Grazed areas had a low AD (173 trees/hectare) and were characterized by scattered large trees with few young trees present. In ungrazed areas, AD was high (452 trees/hectare) with an abundance of small trees interspersed with large trees. All species except peachleaf willow (*Salix amygdaloides*) had a higher AD in ungrazed areas than in grazed areas. Green ash (*Fraxinus pennsylvanica*), peachleaf willow, and hackberry (*Celtis occidentalis*) had a higher RD in grazed areas than in ungrazed areas. All other species had a greater RD in ungrazed areas than in grazed areas (Table 2).

Analysis of variance indicated that there was a significant difference in DBH between categories of land use ($P \leq 0.01$). Analysis of least square means showed a significant difference ($P \leq 0.01$) in DBH between grazed areas (37.7 cm) and ungrazed areas (20.4 cm). In ungrazed areas almost half (48%) of the trees had a DBH under 7.5 cm, while a majority (58%) of the trees in grazed areas had a DBH greater than 30 cm (Table 3). Sandbar willow *S. exigua* was the most common species in the stem category, comprising 90% of all stems encountered. Stems were abundant in ungrazed areas, but few stems were located in grazed areas.

Beaver Cuts

Beaver activity was evident on 280 (11.8%) of 2,369 trees and 756 (9.7%) of 7,794 stems sampled. Ungrazed areas (13.8%) had a significantly higher percentage ($P \leq 0.01$) of trees cut than grazed areas (5.2%). Number of trees cut/hectare was also higher in ungrazed (62.0) areas than in grazed (9.1) areas. Green ash was the most utilized tree species, comprising nearly 69% of those trees cut by beaver. Chi square analysis (Table 4) indicated that beaver did not select trees for cutting according to their availability ($P \leq 0.01$). Green ash was selected for, but both boxelder (*Acer negundo*) and hawthorn (*Crataegus mollis*) were selected against (Table 4).

Analysis of variance showed a significant difference ($P \leq 0.01$) in mean DBH between trees that were cut (13.7 cm)

Table 1.—Species, numbers, and percentages of trees sampled along the Big Sioux River in eastern South Dakota in three land use categories: ungrazed (NG), grazed (GR), and farmed for crop production (F).

Species	Land use category NG	GR	F	Number of trees	Percent
Green ash *Fraxinus pennsylvanica*	712	270	8	990	41.1
Boxelder *Acer negundo*	453	69	13	535	22.2
American elm *Ulmus americana*	196	55	14	265	11.0
Peachleaf willow *Salix amygdaloides*	132	110	3	245	10.2
Hawthorn *Crataegus mollis*	207	24	0	231	9.6
Tartarian honeysuckle *Lonicera tatarica*	54	12	0	66	2.7
Hackberry *Celtis occidentalis*	26	9	0	35	1.5
American plum *Prunus americana*	23	3	3	29	1.2
Cottonwood *Populus deltoides*	10	4	0	14	0.5
Sugar maple *Acer saccharinum*	3	1	0	4	0.0
Russian olive *Elaeagnus angustifolia*	2	0	0	2	0.0
Total	1,818	557	41	2,416	100.0

Table 2.—Actual density (AD = trees/hectare) and relative density (RD = trees of species A × 100/total trees) of nine tree species along the Big Sioux River of eastern South Dakota by land use category.

Species	Ungrazed AD (RD)	Grazed AD (RD)
Green ash	178 (40)	84 (49)
Boxelder	113 (26)	21 (12)
American elm	49 (11)	17 (10)
Peachleaf willow	33 (7)	34 (20)
Hawthorn	51 (11)	8 (5)
Tartarian honeysuckle	13 (3)	4 (2)
Hackberry	6 (1)	3 (2)
American plum	6 (1)	1 (0)
Cottonwood	3 (0)	1 (0)
Total	452 (100)	173 (100)

Table 3.—Size-class distribution of nine tree species based on diameter at breast height (DBH) in grazed and ungrazed areas along the Big Sioux River in eastern South Dakota in 1986.

DBH (cm)	Grazed N (%)	Ungrazed N (%)
2.5-7.5	90 (16)	880 (48)
7.6-15.0	39 (7)	251 (14)
15.1-30.0	107 (19)	257 (14)
30.1-50.0	175 (32)	224 (12)
50.1 and over	145 (26)	201 (11)
Total	556 (100)	1,813 (100)

and those uncut (25.8 cm) by beaver. For all species combined, beaver selected trees of smaller diameter to cut (Figure 1). The mean DBH of cut trees was less than that of uncut trees for all species except hawthorn and significantly lower ($P \leq 0.01$) for green ash, boxelder, and peachleaf willow (Table 5). The mean DBH (11.8 cm) of cut trees in ungrazed areas was significantly less ($P \leq 0.01$) than the mean DBH (21.7 cm) for uncut trees. The mean DBH (31.0 cm) of trees cut by beaver in grazed areas was smaller, but not significantly so ($P = 0.14$) than the mean DBH (38.7 cm) of uncut trees. Trees cut by beaver were significantly larger ($P \leq 0.01$) in grazed areas (DBH = 31.0 cm) than ungrazed areas (DBH = 11.8 cm).

Table 5.—Comparison of least square means of diameter at breast height (DBH) and distance from water of nine tree species cut by beaver along the Big Sioux River of eastern South Dakota.

	Mean DBH (cm)		Mean distance from water (m)	
Species	Uncut	Cut	Uncut	Cut
Green ash	30.3	14.2[a]	25.7	6.8[a]
Boxelder	22.8	9.8[b]	21.4	6.0[a]
Cottonwood	88.5	0	38.8	0
Peachleaf willow	54.3	18.3[a]	21.7	6.4[a]
American plum	5.3	0	23.9	0
Tartarian honeysuckle	3.0	2.5	23.6	1.0
American elm	9.5	7.5	27.9	7.7[a]
Hawthorn	8.3	9.7	36.4	13.3[a]
Hackberry	20.5	15.3	20.7	2.8

[a]Significant at $P \leq 0.01$
[b]Significant at $P \leq 0.05$

Table 4.—Tree species selection or avoidance (95% confidence interval) by beaver along the Big Sioux River in eastern South Dakota. Incidences of trees cut among tree species differed significantly (Chi square test; 8 d.f.; $P \leq 0.01$).

Tree species	Proportion of trees available (N)	Proportion of trees cut (N)	95% CI on proportion observed
Green ash	0.41 (990)	0.689[s] (187)	$.618 < P_1 < .760$
Peachleaf willow	0.10 (245)	0.105 (30)	$.058 < P_2 < .152$
American elm	0.11 (265)	0.091 (26)	$.047 < P_3 < .135$
Boxelder	0.22 (535)	0.062[a] (18)	$.025 < P_4 < .099$
Hawthorn	0.10 (231)	0.035[a] (10)	$.006 < P_5 < .064$
Hackberry	0.01 (35)	0.011 (4)	$.004 < P_6 < .016$
American Plum	0.01 (29)	0.004 (1)	$.000 < P_7 < .010$
Cottonwood	0.01 (14)	0.000 (0)	
Tartarian honeysuckle	0.03 (66)	0.000 (0)	

[a]avoidance (proportion of available trees > upper confidence limit);
[s]selection (proportion of available trees < lower confidence limit).

Beavers preferred trees close to water for cutting (Figure 2). There was a significant difference ($P \leq 0.01$) between the mean distance from water of uncut trees (26.6 m) and cut trees (3.3 m) in grazed areas and between uncut trees (25.6 m) and cut trees in ungrazed areas (7.5 m). There was no significant difference ($P = 0.29$) between the mean distance from water of trees cut in grazed areas (3.3 m) and those cut in ungrazed areas (7.5 m). Of the 286 trees damaged by beaver, 138 (48%) were killed and 148 (52%) were not killed by cutting activity.

Figure 1.—Number and percentages of trees cut by beaver based on diameter at breast height (DBH) along the Big Sioux River of eastern South Dakota.

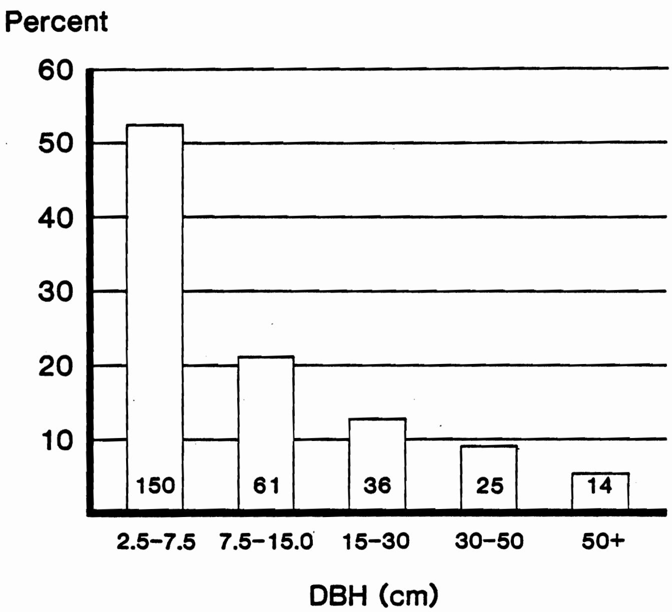
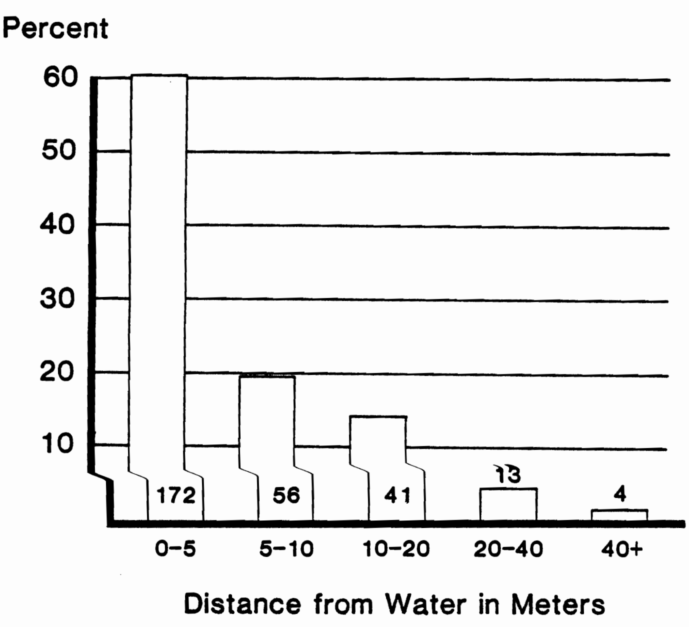


Figure 2.—Number and percentages of trees cut by beaver based on distance of the tree from water along the Big Sioux River of eastern South Dakota.



Discussion

Although detrimental effects of beaver activity on planted hardwood seedlings have been documented in southeastern USA (Krinard and Johnson 1981), negative effects of beaver on riparian habitat are difficult to assess and often become a matter of opinion. In marginal trout waters in the east and midwest USA, beaver activity may be detrimental to trout (Knudsen 1962).

However, along most natural riverine systems, beaver activity is viewed as beneficial. Beaver are being *reintroduced* into high gradient streams in western states in an effort to improve habitat (Brayton 1984). Beneficial effects on fisheries in warm-water streams include slowed currents and increased stream fertility (Hanson and Campbell 1963). In the Big Sioux River, beaver activity had no obvious negative effects on the fisheries. Northern pike were observed frequently in beaver ponds, which provide excellent spawning habitat. The damming of small feeder streams creates productive ponds that provide important habitat for wildlife, especially waterfowl (Beard 1953; Henderson 1960; Knudsen 1962).

Livestock grazing, which has caused a dichotomy in habitat conditions along the Big Sioux River, can influence beaver activity (Munther 1981). Dieter (1987) found 27 (82%) of the 33 active beaver lodges along a portion of the Big Sioux River were located in ungrazed habitat, although only 40% of the study area was ungrazed. Areas unaltered by grazing have an abundance of small trees and stems of common species which are important to beaver populations (Novakowski 1967; Northcott 1971; Jenkins 1975; Pinkowski 1983). Grazed areas have a few large trees and almost no small trees or stems available for beaver use. Willow stems are an important food item for many beaver populations (Hammond 1943; Swenson and Knapp 1980). Livestock activity eliminates willow stems, causing beaver living adjacent to grazed areas to select alternate forage species.

Our study indicated that beaver activity occurring in ungrazed areas was positively related to availability of willow stems and to the higher density of small diameter, preferred tree species. Little beaver activity occurred in grazed areas and the limited cutting of large trees was probably due to availability rather than selection, as larger trees are generally cut only after small ones are used (Johnson 1983).

Small diameter trees near waterways were easier to cut and transport to lodge sites. In ungrazed areas, beaver had an abundance of trees available close to shore and could be selective, using small diameter trees first. Beaver living in grazed areas apparently used whatever size tree was available in close proximity to water. In most cases, beaver did not travel far from water to cut trees in either land use category.

Aspen *Populus tremuloides*, where present, is the preferred tree species of beaver (Hall 1960; Brenner 1962; Northcott 1971), but beavers often thrive where aspen are unavailable (Chabreck 1958; Nixon and Ely 1969). Use of green ash, the preferred tree species by beaver along the Big Sioux River has been documented in other studies (Crawford et al. 1976; Pinkowski 1983).

Less than half of the trees cut by beaver along the river were killed. Some damaged trees remained alive and standing, but in many cases trunks of felled trees and stems resprouted, creating dense woody habitat. Hall (1960) showed that the quantity of willow removed at colony sites by beaver in California was almost totally replaced each year by rapid regrowth. In Oregon, willows used by beaver were able to maintain high growth rates and increased basal diameters similar to those of unused trees (Kindschy 1985). Krinard and Johnson (1981) reported that nearly all hardwoods cut by beaver in Mississippi sprouted back with little growth loss. Periodic fluctuations of beaver populations likely allow recovery of vigor in willow and other woody species (Kindschy 1985).

Beaver damage appears to have been greater in ungrazed areas where approximately 7% of the trees had been killed. However, the majority of tree cutting occurred on small diameter green ash trees, which regenerate rapidly. There was little damage to existing large trees, or any trees over 10 m from water. Damage incurred to trees in grazed habitat may be greater than in ungrazed habitat even though these areas are seldom used by beaver. While only about 3% of the trees were killed by beaver, almost all were large, mature trees and were not being replaced by regeneration due to effects of livestock.

Management Implications

Ungrazed areas were selected for and are most important to beaver populations. Rather than travel farther inland to cut large trees, beaver in grazed areas may move to ungrazed areas which have a greater abundance of stems and preferred trees. Ungrazed areas along the Big Sioux River are capable of sustaining a larger population of beaver than grazed areas and sufficient habitat exists to support beaver populations at current levels with few negative effects. The fact that beaver are being selective for trees by species, size, and distance from water indicates that the habitat is capable of supporting the current population, as a population running short of resources could not afford to be as selective.

Selection of ungrazed habitat by beaver reflects habitat quality. A return of suitable ungrazed habitat would help to distribute the existing beaver population over a greater area. Establishment of areas that will remain free of livestock grazing would benefit beaver populations. Beaver only influence areas of forest near the river, but cattle grazing affects the forest from streamside to its outer edge. Many species of wildlife would benefit from the increased habitat and topsoil erosion would be curbed.

We conclude that natural and prolonged use of habitat by beaver was not accelerating the reduction, deterioration, or loss of riparian tree species along the river. Few, if any trees were cut in grazed areas. In ungrazed areas, beaver activity was not suppressing regeneration. Other factors, especially continual cropping and trampling of regrowth by livestock during the growing season, were involved in limiting the riparian community. Livestock grazing should be restricted within a minimum of 100 m on either side of the river. This would allow for regeneration of areas presently in poor condition.

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