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RELATIONSHIP OF BEAVER TO FORESTS, TROUT AND WILDLIFE IN WISCONSIN

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WISCONSIN CONSERVATION DEPARTMENT
Madison 1, Wisconsin 1962

COVER:

Typical beaver flowage on a slow-flowing stream. The water, backed up by the dam, is interspersed with areas of sedges, grasses, leatherleaf, and blueberry. This is good habitat for ducks, deer, muskrats, and other wildlife.

RELATIONSHIP OF BEAVER TO FORESTS, TROUT AND WILDLIFE IN WISCONSIN

by

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Edited by Ruth L. Hine

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INTRODUCTION

It has long been recognized that beaver impoundments influence the habitats of hundreds of species of plants and animals, and that this alteration of environment exerts both harmful and beneficial effects on various important wildlife species and lowland plant communities. Although a few objective studies have been made of certain of these interrelating phenomena, the literature for the most part contains general statements based on subjective observations.

In general the researchers of the western and eastern mountain states consider beaver impoundments to be very beneficial to mountain trout streams since the spreading and slowing of the icy waters on these high-gradient streams tend to warm the ponded waters. This increases the volume of trout food and the subsequent growth rates of the trout quite markedly.

On the other hand, the attitude of the investigators in the midwestern states is, in general, that beaver ponds on trout streams exert many damaging effects on trout habitat, with few beneficial effects being apparent. This is due primarily to the fact that most of the streams of this area are of relatively low gradient and have warmer waters than the streams in the mountainous areas. Stream waters arrested and spread over low-gradient floodplains tend to become too warm and toxic for trout on many occasions.

Reference to beaver damage to forests is often made in the literature usually with very little objective data to support the conclusions drawn. This alone tends to indicate that the impact of beaver impoundments on the important timber trees is often noticed but is generally considered to be relatively unimportant except in isolated localities.

The most ample evidence of the beaver's influence on wildlife through habitat change exists in the written statements of many persons who have either done research on the animal or who have had some contact with beaver ponds incidental to other wildlife research. Beneficial influences are stressed, but in a subjective manner.

In Wisconsin there are a very large number of low-gradient streams. Many contain good to excellent trout populations, and many are bordered by lowland timber stands. The state also has a very large well-distributed beaver population, and beaver management problems have constantly occurred which have been complicated by the lack of objective information.

In 1950 a special beaver investigation project was activated in Wisconsin to carry on an intensive study of beaver in this state, including a number of studies of ecological relationships of beaver with various environmental factors. This project was carried on from 1950 to 1958 and findings concerning the effects of beaver activity and beaver impoundments on the habitats of other animals and plants in Wisconsin are presented in this report. Emphasis is placed on the important wildlife species and forest tree species affected.

Although specific relationships in the environmental complexes of widely separated states vary, often quite drastically, we hope that the data, conclusions and principles presented here will be of use to others, as they have been to Wisconsin, in formulating future management plans for beaver.

METHODS OF STUDY

Active beaver colonies were chosen for study in all parts of the state's best beaver range and in as many forest types and topographic types as necessary to provide a relatively random sample (Fig. 1). These were typical beaver ponds (not bank beaver colonies), usually on streams of small to medium size. The locations were first ascertained from maps showing beaver-pond locations prepared by conservation wardens, game management personnel and beaver live-trappers, and later from information obtained from beaver-complaint reports, aerial transects and general field work.

During 1950–58, 353 active beaver ponds were investigated intensively from April through October each year. Few observations could be made in winter on beaver ponds, since they were usually buried under snow and much of the wildlife using or produced on the ponds during the summer had migrated or had taken refuge under the ice and snow. However, some data concerning forest ecology and wildlife food potentials were gathered at this time.

The following observation techniques were used at each beaver pond:

The beaver pond was approached as quietly as possible, usually in the early morning or late afternoon. At the periphery of the pond, observations were made with binoculars for at least an hour, and often longer, in an effort to view the species of wildlife living in or utilizing the water area and immediate environs. At the end of this observation period a complete circuit of the pond was made at the water's edge, and all evidences (sign) of wildlife use, such as droppings, scats, tracks, feathers, dens, feeding areas, nests and lodges, were tallied on a standard form.

Since many of the ponds were large and irregular in outline and since a large number contained grassy and brushy areas, it was impossible to make complete counts of all species and individuals or to tally all the wildlife "sign". A factor of major importance was the disturbance made by the observer in traversing the uneven, wet, brushy pond border. The data on frequency of occurrence and total numbers observed should therefore be considered as minimum.

Before leaving the beaver pond, information was recorded concerning timber and shrub damage, current and potential beaver food supplies based on apparent plant-succession trends, damage to trout habitat, and other miscellaneous data pertinent to a better understanding of the ecological impact of beaver ponds. Observations were also made on inactive, drained beaver ponds (beaver meadows) often discovered while walking to or from the active beaver colonies. These pond basins supplied much information on shrub and tree regeneration, siltation and sloughing of stream banks. The average pond analysis required about 5 hours to complete.

Pond acreages were usually determined by pacing. Those of small beaver ponds (the majority) are quite accurate, while the estimated acreages of larger ponds with very irregular, shallow upper ends have some error. The approximate age of each pond was usually estimated by careful observations of the condition of the tree stumps cut off by beaver, the age of resprouts on beaver-cut stumps and by the amount and age of new shrub growth on the beaver dam. In a few cases the leaf and annual-grass layers covering the chips around cut stumps helped age the ponds. Some beaver ponds of exact age were known by beaver trappers and Conservation Department personnel.

GENERAL ECOLOGY OF BEAVER PONDS

Since beaver ponds bring about many changes in the area impounded above the dam and immediately surrounding the ponds, a description of the typical sequence of these changes in streamside habitat is essential to the understanding of the more specific data and conclusions reported later.

Before Beaver Impoundment

Figure 2 illustrates a typical segment of stream before beaver occupancy. The stream is confined to its natural channel and usually has a discernible flow of water, although this current is commonly quite slow. There are only sparse growths of aquatic plants in the stream proper; however, occasional "rich" streams have rather dense communities of plants (*Ceratophyllum, Myriophyllum, Sagittaria, Potamogeton, Lemna, Fontinalis, Anacharis* and many others).

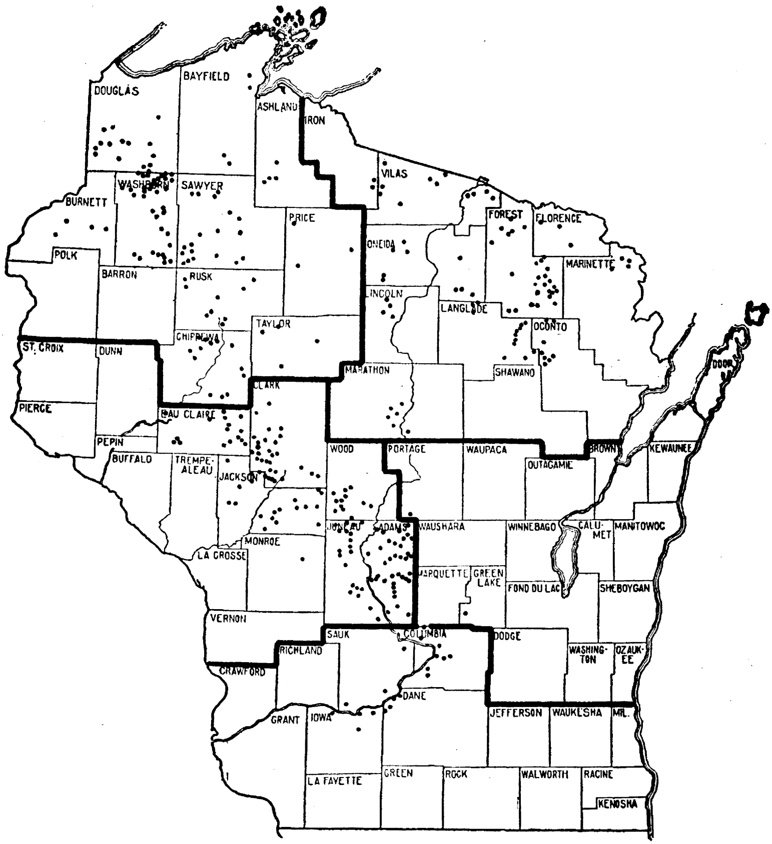


Figure 1. Location of active beaver colonies chosen for study. (The administrative areas are designated, which are referred to in this report as Northwest, Northeast, West Central, East Central and Southern Areas.)

The floodplain is covered by dense stands of shrubs, commonly tag alder *(Alnus incana)* and various bush willows *(Salix spp.)*, with a rather sparse understory of many species of swamp and marsh sedges, grasses and forbs. Often completely "open" floodplains have thick mats of wetland sedges, grasses and forbs due to recent beaver flooding (beaver meadows) or clear-cutting by loggers. Many segments of streams have sparse to dense stands of lowland hardwoods (*Fraxinus, Ulmus, Acer,* etc.) and conifers (*Abies, Picea, Larix,* etc.). The floodplain plant community can be regarded as occupying the niche between typically hydric and more mesic conditions.

The slopes and uplands bordering the stream are covered with many species of grasses, forbs, shrubs and trees of mesic to rather xeric communities.

It is generally agreed that the shrub-type floodplain is poor wildlife habitat. Few wildlife species utilize willow, alder or many of the associated trees for food. These extensive and very dense types offer relatively light crops of grasses, sedges and forbs in their understories and the whole plant complex is probably more used by wildlife for cover than for feeding. The two wildlife species most benefited by alder floodplains are ruffed grouse, which use alder "runs" for brood cover (Dorney, 1959), and woodcock which nest in low swampy situations, but also nest on nearby slopes and uplands. The variety of other species of wild animals found in this floodplain community is relatively small and the densities are low.

Conditions are generally good to excellent for brook trout, since the stream channel is stabilized and the stream bed is usually free of silt. The stream is shaded by the overhanging alders, willows and lowland trees, which help to maintain low water temperatures.

Lowland forest trees can be found in dense, mature stands on the floodplain, or in stands that have begun to reforest a previously denuded floodplain, intermixing and competing with the shrub community. Floodplains can be found in all stages of forest succession in Wisconsin, but due to previous flooding by beaver and clear-cutting by loggers, the percentage of floodplains with mature timber stands is currently low.

During Beaver Impoundment

The same stretch of stream is shown in Figure 3 after construction of the beaver dam. The flowage created is deepest just above the dam, since beaver obtain "fill" adjacent to and above it. A deep trench in the pond is created by the now submerged stream channel. The water becomes gradually more shallow from flowage center to flowage edge and from the dam to the upper end of the pond.

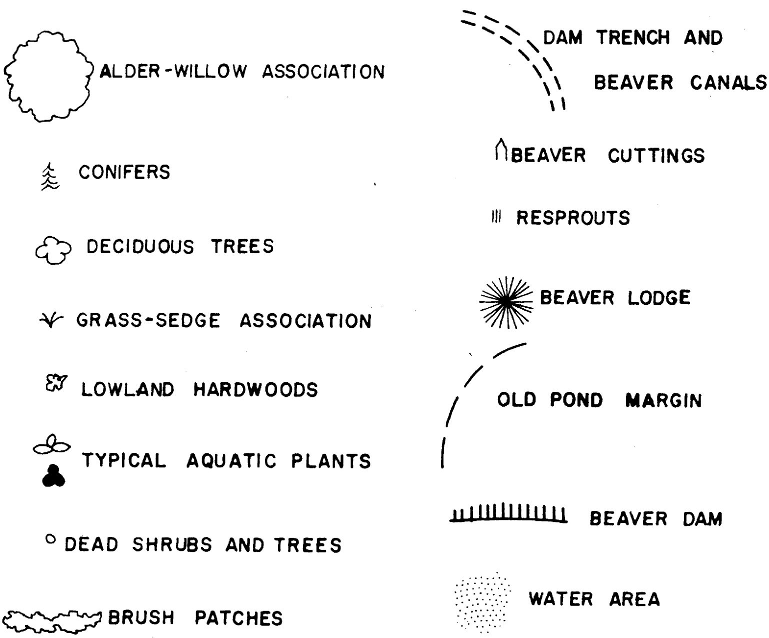
The area of the shallow water is a function of the gradient of the stream, the width of the stream's floodplain, and the height of the beaver dam. Geologically young streams with steep gradients and narrow gorges, when dammed by beaver, form small impoundments with abrupt changes from the deep areas to the narrow shallows. On the other hand, when geologically old, meandering streams with very gradual gradients and wide floodplains are dammed, water is often backed up for one-quarter to over one-half mile, and in these cases many acres of floodplain are involved in habitat transformation. Most of the impounded area on such streams has relatively shallow water. Beaver ponds covering up to 75 acres have been recorded in Wisconsin, but the majority are under 10 acres.

Most species of floodplain trees and shrubs cannot tolerate complete, long-term inundation of their roots and begin to die a few months after the beaver dam is completed. They are completely killed after a year of inundation. Beaver ponds may offer stable water levels for as long as 8–10 years, at least as long as they are active. Some ponds retain stable water levels for a number of years after the beaver have abandoned them, especially in heavy soil areas. In sandy areas beaver must constantly repair their dams in order to maintain their ponds at proper levels. During the first few years the ponds are filled with standing shrub and tree skeletons, but the dead shrubs usually fall over within three years, while the dead trees may remain standing throughout the life of the ponds.

As the beaver ponds age and "open up", aquatic plants of many species invade the water area. The more acid, dark-water ponds of the swamp areas in our northern beaver range produce less dense stands of aquatic plants than do the ponds occurring on our less acid, light-

Diagrams of the typical ecological changes occurring on a stream impounded by beaver.

Legend:



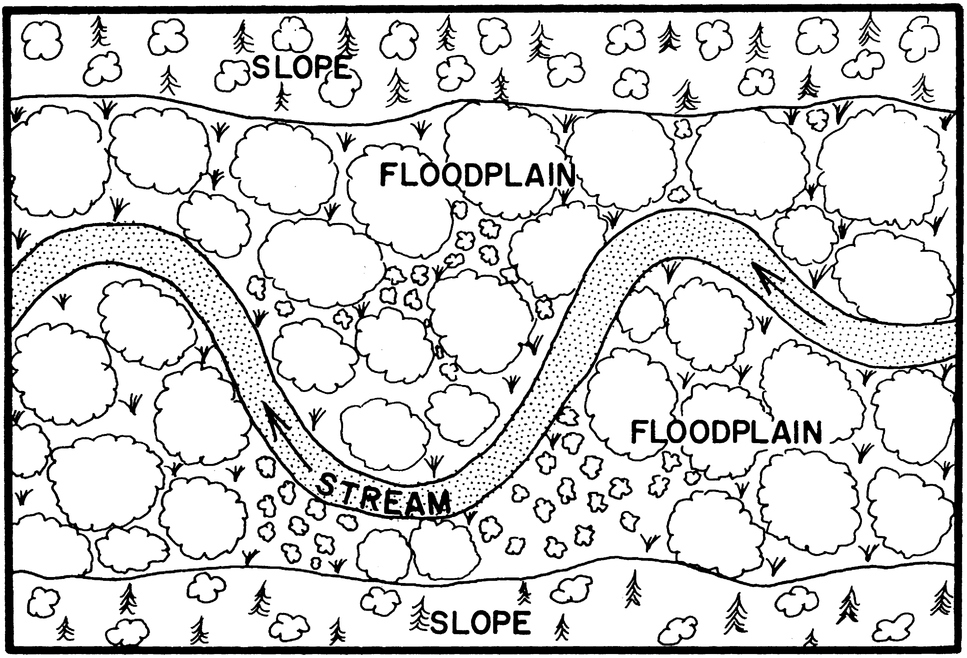


Figure 2. Before beaver impoundment.

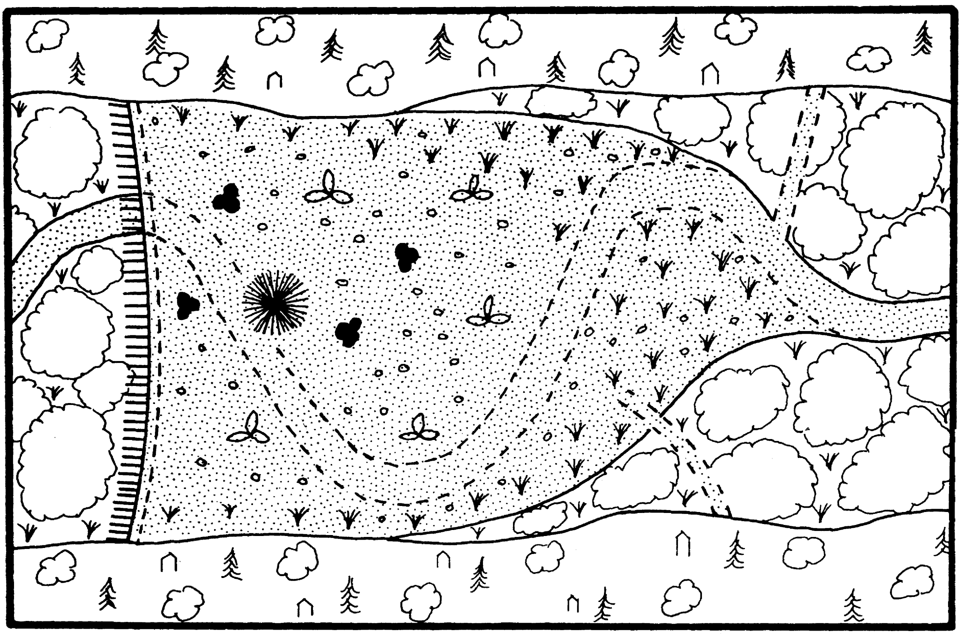


Figure 3. During beaver impoundment.

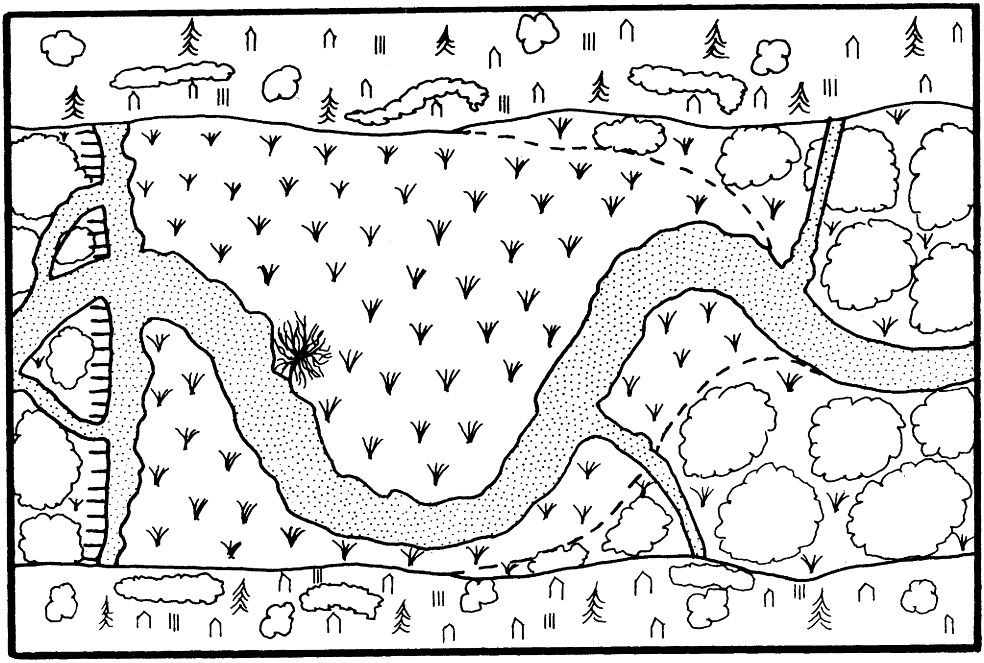


Figure 4. After beaver impoundment.

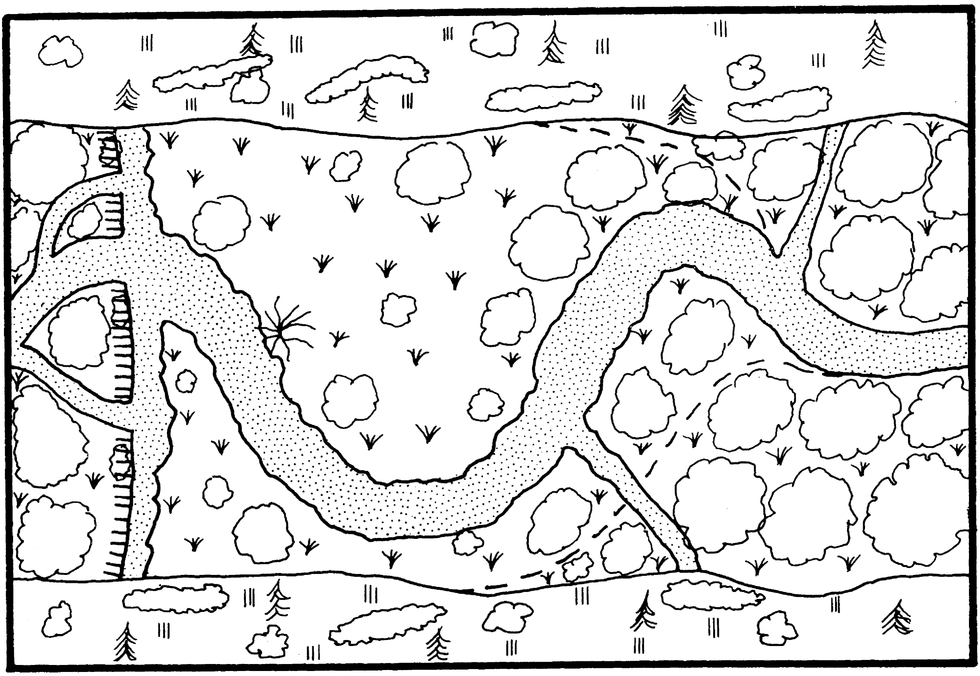


Figure 5. After a longer period of drainage.

water streams draining less swampy watersheds. The ponds with the greatest variety and densities of aquatic plants are usually those located on streams draining light-water lakes. This is due to less acidity, better light penetration, and in many cases to the good seed source in the lake upstream.

The deeper waters of the beaver ponds are occupied by *Myriophyllum, Ceratophyllum, Nymphaea, Nuphar, Brasenia, Utricularia, Anacharis,* various species of *Potamogeton,* etc., with some of these plants also being found in the shallow water areas.

The shallower waters support many species of water-tolerant grasses and sedges, and various species of *Typha, Scirpus, Sagittaria, Pontederia, Dulichium, Sparganium, Alisma, Lemna, Arum, Juncus, Ranunculus, Calla, Nasturtium* and other plants of less common occurrence.

At the pond margins, and especially at the upper end of the pond, the zone between the truly aquatic habitat and the more mesic wet-marsh habitat is usually quite extensive, with complex interspersions of these two habitat types. This important fact was brought out in Beard's study (1953) in Michigan. As more mesic conditions are encountered farther upstream, other species of lowland plants enter the community until the rather broad tension zone is reached, above which the original floodplain plant community is found.

Due to the wide variation between Wisconsin streams in water chemistry, gradient, silt depths and soil types on pond bottoms, amount of decaying floodplain vegetation in the pond, etc., there is much diversity in the plant communities and the changes which can be expected to occur in and around different beaver ponds.

Wildlife is readily attracted to beaver ponds, with the appearance in the flooded areas of so many new aquatic plants of real importance to many species as food. In many cases certain wildlife species such as muskrats and ducks, increase significantly.

In this flooded condition it is, of course, obvious that timber species and shrubs cannot exist and large areas of lowland forest can be completely killed.

It is at this stage that the beaver impoundment imposes many damaging effects on trout habitat in Wisconsin, which will be discussed later.

After Beaver Impoundment

Figure 4 illustrates the third stage of the floodplain habitat after the beaver have abandoned the pond and it is drained. If the abandoned dam is strong and has been "mortared" with heavy soils and

This new dam and pond is inundating the willow-shrub floodplain which will soon be killed, leaving no shade for the trout stream. The aspen in the background will soon be cut for food and building materials.

roots, the water may remain in the pond for a number of years and the pond will remain essentially as it was during beaver occupancy. Eventually, however, a portion of the beaver dam will wash out and the pond will drain. The sketch shows that the original stream channel has been widened by "sloughing" of the stream banks. The banks cave in because the fibrous root systems of the original floodplain vegetation have died and rotted away leaving the mineral soil without binding. This tends to cause the stream to become shallower also. The trench above and parallel to the beaver dam, as well as the beaver canals, have been widened and filled in by "sloughing" and they often contain water right up to the streamside slopes, as lateral extensions of the main stream channel.

After drainage the pond bottom is exposed and exists briefly as a mud flat, except on peaty or highly acid soils where the mud flat may persist for a considerable period of time. Within a year sedges, grasses and forbs generally take over in dense stands and effect the change to a typical verdant beaver meadow. This is often the only extensive

This beaver pond had been abandoned for three years but was still holding from six inches to one foot of water. The rock elm clone was killed but the pond produced two broods of ducks and numerous muskrats. Note the excellent escape cover for ducklings.

opening in large areas of forest cover, and offers relatively important wildlife habitat.

The pond conditions affecting many trout streams so adversely now no longer exist, but the lack of shade, the widened stream, and the silted-in holes are still detrimental to trout in many cases.

At this early stage of drainage, sufficient time has not elapsed for lowland timber species and important lowland shrubs to gain a foothold.

After a Longer Period of Drainage

Thick mats of sedges and grasses for years occupy almost every drained beaver pond basin. The pH rating of the soil is so low after drainage of the ponds that tree and shrub species cannot invade the basin until the soil is freshened by many years of percolating rain water and snow run-off. Wilde and Hovind (1950) concluded that the toxic substances generated in the soils of beaver ponds by the impounded water cause partial destruction of mycorrhizal fungi on the roots of shrubs and trees. The low negative values of the oxidation-reduction potentials obtained from beaver ponds and the fixation of phosphorus in insoluble form also lead to unhealthy conditions for tree and shrub regeneration on the drained beaver-pond basin, according to these authors. These conditions remain the longest on peat and muck soils, while on well-drained coarse sands recovery of the basin to "normal" is much more rapid.

It is also possible that the sedge-grass community with its fibrous root mat is often so thick that its physical presence alone offers severe competition to roots of tree and shrub seedlings. To test this theory, three recently abandoned beaver ponds with lush sedge-grass mats were chosen in 1950 for a planting experiment. Two black spruce and two balsam fir seedlings were planted on each of the basins after a sedge-grass "plug" 18 inches in diameter was removed. In 1952 and 1953, nine of the original twelve seedlings were alive, with healthy "leaders", but grasses were growing right to the bases of the trees. This was a very limited experiment but suggests a possible method for the reforestation of drained beaver ponds.

Whatever the causes, it is abundantly evident that the recovery of beaver meadows to shrub and tree cover is very slow. Observations on beaver pond basins indicated that:

(1) Beaver ponds drained for two to five years had no woody plant recovery if there was a 100 per cent initial killing of trees and shrubs.

(2) Beaver ponds drained for up to ten years often showed only slight recovery of woody plants as evidenced by sparse stands of young willow and tag alder. Many ponds showed no recovery as late as ten to twelve years after drainage.

(3) Recovery of woody plants takes place with greatest rapidity at the edge of the pond basin and at the upper end of the basin where the tension line between drowned and surviving woody plants occurs. This is due to resprouting from roots of nearby living woody plants and is similar to the invasion of long fallow fields by species of *Rhus, Rubus* and *Populus.*

Figure 5 shows the final, or recovery, stage of the beaver pond basin, as woody plants slowly invade the old beaver meadow. At this stage the pond basin can still be classified as good wildlife habitat, as it is essentially an opening, producing more "edge" per unit area than is found in the surrounding forest.

At this stage the pond basin is somewhat farther along in the succession of events that will eventually improve the stream conditions for brook trout and the basin conditions for lowland timber production. The invading shrubs will offer shade to the stream and help stabilize

Here willow and alder from the edge of the pond basin are slowly invading the beaver meadow during the "recovery stage".

its banks while they will also thin the sedge-grass mat by shading and thus aid shade-tolerant timber species to gain a foothold in the pond basin.

EFFECTS OF BEAVER ACTIVITY

Forests

Damage

Information on the prevalence and importance of general beaver damage (flooding and cutting) to timber was obtained from reports of beaver damage made by Conservation Department field personnel from 1935 to 1959. No information concerning beaver damage to timber prior to 1935 was available. Damage complaints for the period 1935–38 are summarized in Table 1. There were less beaver state-wide during this period than during the following two decades, hence complaints were fewer in number.

About 25 per cent of 162 complaints concerned timber damage and the majority concerned cutting rather than flooding of timber. During this period the counties of northeastern Wisconsin registered the most timber complaints (and total complaints) while northwestern Wisconsin was next, and central Wisconsin recorded the smallest number of complaints. This agrees well with the recent history of the beaver population in Wisconsin, since the northern one-third of the state had a widely distributed, fast-growing beaver population at this time, while the central area was still introducing beaver in an effort to create a trapable population. The southern part of Wisconsin had practically no beaver and there was a corresponding absence of beaver complaints.

During the next decade (1939–1949), the beaver population increased very markedly in northeastern, northwestern, central and southern Wisconsin and the complaints naturally rose drastically. However, the frequency of occurrence of timber damage complaints during this period remained at approximately 25 per cent.

In Table 2 the frequency of occurrence of all types of beaver damage, state-wide for the period 1950–59, is shown.

Timber damage ranked third highest in frequency of occurrence for all years from 1950 to 1958 and was second highest in 1959. The frequency of occurrence of timber damage per year varied from 14 per cent to 23 per cent of the total number of complaints, with an over-all

Sometimes, however, recovery of the pond basin is very slow, and the beaver meadow may remain a long time as "open" wildlife habitat. This meadow still exists nine to ten years after the abandonment of the pond.

TABLE 1

Frequency of Occurrence of Beaver Damage Complaints, 1935–38

Damage Type	1935	1936	1937	1938	Total
Agricultural	10	10	7	6	33
Timber	15	6	11	8	40
Fish	5	2	7	2	16
Roads	5	3	0	2	10
Railroads	3	1	2	2	8
*Private Property	20	15	8	2	45
Miscellaneous	3	4	2	1	10
Total	61	41	37	23	162

*Also includes some timber damage (usually shade trees).

frequency of 18 per cent. The northeastern counties had the highest frequency of ocurrence of timber damage each year.

During this decade the frequency of occurrence of timber damage had decreased slightly state-wide since beaver had spread into the less wild areas of Wisconsin, thus increasing the frequency of agricultural and road complaints. In many instances beaver colonies recurred on basins where the timber had been previously killed by beaver colonies; hence at this later date there was no basis for a timber complaint. Many tracts of lowland timber have been removed by loggers in the past 20 to 30 years and these currently open areas are flooded without the complaint of the landowner.

Generally, the complaint reports from 1935 to the present show that although the frequency of occurrence of timber damage is relatively

TABLE 2

Frequency of Occurrence of Beaver Damage Complaints (State-wide, 1950–59)

Year	Type of Damage							Total Complaints	Timber Complaints (Per Cent)
	Agric.	Timber	Lake	Fish	Roads	Railroads	Misc.		
1950	145	72	22	26	135	10	16	426	17
1951	91	50	38	16	108	11	23	337	15
1952	94	73	18	11	130	9	14	349	21
1953	30	28	21	7	66	7	4	163	17
1954	67	33	22	8	99	2	7	238	14
1955	69	48	34	17	120	8	13	309	16
1956	102	81	25	27	165	12	26	438	18
1957	81	74	27	14	185	14	19	414	18
1958	104	97	25	19	171	20	26	462	21
1959	73	89	27	30	152	9	3	383	23
Total	856	645	259	175	1,331	102	151	3,519	18

high (usually 1 timber damage complaint to 5 or 6 general complaints), the total damage to timber is relatively low. The following facts support this conclusion: foresters and beaver live-trappers have rarely kept accurate tallies of timber damage; most foresters with whom I've talked agree that currently the damage is light to moderate with regularly occurring exceptions; damage complaints are usually exaggerated by the complainant for rapid action; beaver and beaver dams are often removed before the complainant's timber is killed; most of the lowlands along our streams currently are in the open marsh, shrub-swamp or inferior lowland timber stage.

The literature concerning beaver-forestry relationships carries statements based largely on subjective observation with little pertinent data presented to indicate whether quantitative analyses had been made. From this lack of information one might infer that the impact of beaver impoundments on the important timber trees and their environment is considered to be of minor significance. According to Hodgdon and Hunt (1955, p. 70), "It is estimated that the 18 timber companies (interrogated) own well over half the 17,000,000 acres of timberland in the state (Maine). It is important to note that they feel there is so little damage to timber from the state's beaver population." Shaw (1948) in Massachusetts likewise maintained that timber lost by cutting, girdling and flooding was generally considered not serious in Massachusetts. He further concluded that beaver impoundments aid forests by retaining water, thus helping to keep up the moisture content of forest soils, and by acting as firebreaks and reservoirs of water for fire-fighting crews.

On the other hand, Moore and Martin (1949) stated that destruction of timber in Alabama was important.

In Wisconsin, Hovind (1948) concluded that over 50 per cent of the total damage to timber recorded during a Marinette County study was caused by only 20 beaver dams. He recommended that this type of extensive destruction is the type to look for and that beaver should be restricted to less valuable forested streams.

Wilde, Youngberg and Hovind (1950) in a study of drained beaver ponds in Wisconsin, listed a number of chemical changes in the soil of the pond basin induced by beaver impoundments and explained how these changes are often harmful to rapid regeneration of forest shrubs and trees on these drained pond basins. They recommended that it might be more advisable to try and prevent beaver settlement in locations where they are undesirable from a forestry standpoint than to remove established dams.

An administrative report of the Wisconsin Conservation Department entitled Beaver-Trout-Forest Relationships (1961), combining all the data available in Wisconsin, points out that in specific areas of valuable lowland timber stands beaver impoundments can cause local, serious damage, and these areas should be observed annually, and beaver controlled. A compilation of the replies received from all forestry personnel indicates that damage from beaver activity and beaver ponds in general is of minor importance at this time in Wisconsin.

Since quantitative data on timber damage other than frequency of occurrence were not available, more specific information on damage was gathered during the beaver-pond studies and is presented in the following sections.

Flooding

The majority of beaver impoundments involve segments of floodplain with timber stands of little or no importance growing upon them. Of the tree and shrub communities inundated by beaver ponds, alder-willow associations occurred 195 times, lowland and upland hardwoods 79 times and lowland conifers 39 times in the 326 ponds studied (Table 4). In 102 cases, trees and shrubs were not identified due to the almost complete openness of these ponds, although it is certain that willow and alder would have predominated here too. Since both of the tree communities occurred often on many ponds, the total occurrence of these types is higher than 326 (Table 3).

TABLE 3
General Vegetation Types Inundated by Beaver Ponds*

	No. Ponds With Dying Vegetation			No. Ponds With Dead Vegetation			
Area	Open	Semi-Open	Closed	Open	Semi-Open	Closed	Total Ponds
Northeast	20	11	5	34	9	3	82
Northwest	20	26	1	23	23	0	93
West Central	48	23	4	34	22	0	131
Southern	10	7	0	2	1	0	20
Total	98	67	10	93	55	3	326

*"Open" refers to impounded areas covering a sedge–grass and/or an alder–willow floodplain with very sparse tree growth. "Semi-open" refers to a relatively open sedge–grass and/or alder–willow floodplain with more abundant tree growth, but still scattered enough to prohibit timber acreage estimates. "Closed" refers to impounded areas having a dense covering of lowland timber, such as a heavy stand of swamp conifers or hardwoods.

This 2-acre pond was drained after spruce, tamarack and rock elm were drowned by beaver. Deer grazed and loafed regularly in this opening.

The acreage involved in timber damage on 332 beaver ponds was minimum, since only the dense, closed lowland timber stands and a few clone-like stands in semi-open ponds had drowned timber that could be estimated with accuracy (Table 5). Ponds having relatively small amounts of timber damage, up to a few dozen trees per pond and therefore of little economic importance, were classed as those with "negligible" damage. About 115 acres of timber were destroyed on 332 beaver ponds for an average of .35 acres of timber per beaver pond. Since the lowland stands involved are often of poor quality and low value, total damage to lowland timber by drowning is of minor importance. We cannot, however, overlook the fact that certain extensive, valuable lowland stands are occasionally killed.

TABLE 4

Tree-Shrub Communities Inundated by Beaver Ponds

Area	Alder-Willow	Lowland and Upland Hardwoods	Lowland Conifers	Mostly Open	Total Ponds
Northeast	49	19	25	23	82
Northwest	65	20	10	24	93
West Central	76	39	4	50	131
Southern	5	1	--	5	20
Total	195	79	39	102	326

TABLE 5

Acreage of Timber Damaged on 332 Beaver Ponds

Area	Timber Damaged No. Ponds	Timber Damaged No. Acres	No. Ponds With Negligible Damage*	No. Ponds Without Damage	Total Ponds
Northeast	19	35	17	51	87
Northwest	32	35	12	48	92
West Central	20	24	20	93	133
Southern	2	3	0	18	20
Total	73	97	49	210	332

*Damage amounted to approximately 20 acres.

Slope and upland timber, because of its higher position along the creeks, is not inundated over large areas by beaver ponds. The lowest trees on the slope are sometimes killed by drowning, but are more often cut by the beaver since they are the easiest trees to procure for food and building materials.

Once the beaver pond is established, the trees on the slopes just above the newly raised water table are benefited temporarily by a better water supply. However, they tend to lose their taproots and develop shallow root systems, so that after drainage of the ponds and the subsequent drop of the water table, these trees are subjected to a "droughty" condition which reduces annual growth increments (Wilde *et al.,* 1950).

In the extensive, low, marshy areas of central Wisconsin where slope and upland species are often only a few feet above the normal marsh water table, raising of this water table by beaver ponds can kill larger areas of timber (usually aspen in this part of the state). Areas such as Crex Meadows in the Northwest and Ackley Township in the Northeast are affected in a similar manner.

Cutting

The number of trees cut at individual beaver colonies varies greatly due to many factors, the most important of which are: number of beaver in the colony; season of the year; density of *all* utilizable woody plants; composition (intermix) of the woody-plant community; whether the beaver colony is newly established or old; amount of non-woody vegetation available for food and building materials; whether the colony is a typical pond colony or a bank-beaver colony; and the average size-class of the woody plants available.

The cutting of large trees (more than 12″ d.b.h.) often results in great waste, for they lodge against one another when cut or are held high off the ground by their heavy crown branches when completely felled. Also, large trees very often cannot be cut completely through by the beaver and are left standing, fully girdled, and eventually will die.

Conversely, the majority of small trees in a stand (seedlings to 3-inch saplings) can be more fully utilized by the beaver for if they "hang up", as they often do, they can be pulled down.

When new dams and a new lodge are built, many more trees are cut than are needed for food alone. At this time the beaver uses food trees as well as non-food trees in these structures and there is considerably more damage done than in following years.

Cutting of trees is accomplished mostly on the slopes and uplands. Cutting of lowland timber species is unimportant since these species are drowned before the beaver has a chance to cut many of them and most of these are not eagerly sought for food by beaver, at least as long as ample aspens remain on the uplands. Willow, alder and occasionally black ash *(Fraxinus nigra)* above and below the impounded area are sometimes cut in large quantities, but the former two shrubs have no timber value.

Counts were made of all cut stumps of trees at approximately 128 beaver colonies visited in late fall and winter. Only stumps of trees cut during the past spring, summer and fall were tallied. The following facts emerged from this study:

Species of the genus *Populus* were cut most often, with the genus *Salix* next. Once the beaver colony was established, the trees that were cut consisted of a very high percentage of food species, usually aspens, willows, alders, maples, birches and ashes in the Northeast and Northwest Areas, with the same groups plus oaks, cottonwoods and hackberries in the Central and Southern Areas of the state.

The peak of cutting activity occurred in October at which time the beaver colony was again firmly established. Spring, summer and early fall cutting of trees was minimal and more scattered since there are so many grasses, forbs, leaves and aquatic plants available to the beaver.

The total number of trees cut during spring, summer and fall varied tremendously: from 80 to 2,300 trees per colony. Established colonies had cut from 80 to over 500 trees with an average of 293 (based on 96 colonies). Newly constructed colonies had cut between 376 and 2,300 trees, with an average of 522 (based on 32 colonies). Only rarely did colonies cut over 1,000 trees but an exceptionally large dam in Adams county accounted for the cut of 2,300 trees in one season!

Bradt (1947) in his Michigan study on new colonies concluded that one beaver will cut 216 trees per year, including food trees and building materials, and stressed that this figure was subject to considerable variation. For an average colony of 5 beaver this would be 1,080 trees cut per season. This amount of cutting probably exceeds that found under average Wisconsin conditions.

The average established beaver colony in Wisconsin will clear-cut the equivalent of about .5 acres of timber per year. This is based on the fact that good "pole stands" of timber often have up to 500 stems per acre and the average established colony cuts almost 300 trees per year. New colonies may often clear-cut the equivalent of an acre or more. In very young aspen stands such as occur often on recent burns, the stems per acre may reach into the thousands, and an adjacent beaver colony may cut only a small fraction in a season. An over-all average cut would be just about .5 acres per year per colony.

There are 4 to 5 acres of timber exposed to the possibility of cutting by beaver around the average colony. Thus if the bordering stands are mostly aspen it would take up to 10 years for some beaver colonies to remove their food supplies, and with annual renewal this period would be even longer.

In years of high beaver populations Wisconsin may have as many as 6,000 to 8,000 beaver colonies. These colonies would cut the equivalent of 3,000 to 4,000 acres of timber (mostly aspens) per year, which would run into tens of thousands of cords of current and potential timber and pulp trees.

Cutting is considerably more important than flooding in causing timber damage on a state-wide basis. While certain beaver impoundments causing extreme flooding damage may be discovered and removed to alleviate the destruction of timber, it will be impossible to reduce cutting damage without general area-wide reductions of the beaver populations involved.

Timber Species Affected: Aspen. Vast expanses of the central, northeast and northwestern parts of Wisconsin are covered by quaking aspen *(Populus tremuloides),* often intermixed with bigtooth aspen *(P. grandidentata).* Since these species are preferred foods they form the bulk of the timber species cut by the relatively dense beaver populations in these areas. Aspen stands are only locally common in southern and east central Wisconsin. Well-drained marsh areas with "drainage-ditch" beaver and slopes along creeks sometimes have good clones of aspens but they constitute only a small fraction of the woody plants cut by beaver in these areas.

Typical forest tree destruction by cutting.

The slopes and uplands covered by aspen monotypes, or intermixed stands predominated by aspens, generally reseed or resprout readily when clear-cut by beaver. These new stands are often very dense and the young trees grow rapidly. Thus in many cases a new generation of competing aspens replaces an old, nearly "stag-headed" stand that has been removed by beaver.

Aspens, however, more commonly grow in association with jack pines, paper birches, various oaks and other species in the central area and with red and hard maples, paper birches, balsam firs, and other species in the northeast and northwest. As the beaver selectively cut these aspens, the associated species are speeded toward their eventual dominance. The long-term trend of succession in aspen stands is toward dominance by more shade-tolerant subclimax and climax trees and this trend is hastened by the selective cutting of aspens by beaver on a state-wide basis.

Cottonwood. The cottonwood *(Populus deltoides)* is a primary beaver food, but it occurs abundantly only along the Wisconsin and Mississippi rivers and other smaller rivers and lakes in the southern one-third of Wisconsin. Where it grows in pure stands it is often clear-cut by beaver and subsequently reseeds or resprouts. Where it is intermixed with maple, elm, ash, hackberry etc., the selective cutting of it by beaver tends to hasten its extirpation in these stands. However, since new sand bars and alluviums are constantly created by the "braided" Wisconsin and Mississippi rivers (Martin, 1932), cottonwoods regularly pioneer in new stands which assures their survival in this important segment of Wisconsin's beaver range.

Due to their large size some cottonwoods are fully girdled by the beaver but are not felled, and therefore are completely wasted. This species is capable of resprouting from the fall-cut stump in which case many succulent shoots are produced. This is advantageous in that beaver prefer these tender sprouts; hence they attack fewer adult trees once a number of stumps have regenerated these food supplies.

Maple. Silver maple *(Acer saccharinum),* sugar maple *(A. saccharum),* red maple *(A. rubrum)* and ash-leaved maple *(A. negundo)* are cut rather extensively by beaver, especially after aspens have been removed by previous cutting.

Sugar maple is most commonly cut in the north while silver maple and ash-leaved maple are more often cut in the central and southern areas. Reproduction of these species by reseeding or resprouting takes place regularly after being cut by beaver, and they therefore maintain themselves well against the beaver.

Birch. Paper birch *(Betula papyrifera)* and red birch *(B. nigra)* are cut by beaver, but in large quantities only after other more preferred foods become rare. Paper birch is cut in the northern and central areas while red birch is cut in the southern area. Since it is quite common for beaver colonies in the north to move out after the aspens have been cut from among associated paper birch, monotypes of birch are often developed.

Ash. Black ash *(Fraxinus nigra)* in the north and green ash *(F. pennsylvanica* var. *lanceolata)* in the central and southern parts of Wisconsin are regularly felled by beaver for food. Resprouts are preferred by beaver and it is common to find uncut mature trees in stands where there is a good supply of succulent stump shoots.

Oak. Red oak *(Quercus borealis),* black oak *(Q. velutina),* pin oak *(Q. ellipsoidalis),* white oak *(Q. alba)* and bur oak *(Q. macrocarpa)* are cut and eaten by beaver when the other prime food species have been depleted. Reseeding and resprouting occur regularly and the supply of oaks is not much altered by the rather light beaver utilization. Swamp white oak *(Q. bicolor)* is the most preferred of all oaks

Resprouting of soft maple, repeatedly cut by beaver: an "extended" food supply.

but is common only along the rivers of southern Wisconsin where it is cut in abundance. Whole clones have been removed in a season's cutting, but the stumps resprout profusely and an excellent future food supply is thus assured.

Miscellaneous Species. Other deciduous timber species such as hackberry, elms, hickories, etc. are cut by beaver, but often sparingly. Hackberry may be extirpated in local stands but the others maintain themselves well against the minor impact of the beaver.

Shrub Species. There are numerous shrub species in Wisconsin that are cut and eaten by beaver but the most important are sand bar willow *(Salix longifolia)*, tag alder *(Alnus incana)* and red-ozier dogwood *(Cornus stolonifera)*. The former species is by far the most eagerly sought by beaver where it occurs and maintains itself very well by resprouting and reseeding on new alluviums. The latter two resprout profusely but are often drowned over large areas since they occur along smaller streams that are more apt to be dammed. Sand bar willow is usually most abundant along the large rivers where beaver dams do not occur.

These shrubs are important as "buffer" species since their abundance protects countless timber trees annually. Sand bar willow is important too from the standpoint of sand bar stabilization. Its extensive fibrous root system protects the sand bars from washing and eroding and allows time for cottonwoods and other bottomland timber species to become established.

Conifers. Rarely cut by beaver in Wisconsin, the conifer species are little affected in a negative way by this animal. On the contrary, they are often benefited by being "released" as beaver selectively cut competing deciduous trees.

Benefits

The most important benefit derived by forests from beaver activity is the selective cutting of aspens and other species from mixed stands with valuable timber seedlings and saplings in their understories. Oaks, jack pine *(Pinus banksiana)*, white pine *(P. strobus)*, Norway pine *(P. resinosa)*, balsam fir *(Abies balsamea)*, maples etc. are "released" each year on hundreds of acres of beaver range in Wisconsin.

Beaver ponds act as firebreaks and very often as water reservoirs for pumper trucks during forest fires.

In certain topographical types where water tables are raised by beaver ponds a narrow band of timber on the slopes and uplands may be benefited by an increased water supply. This would apply in country with relatively high lands along creeks.

Trout and Other Fish

Damages to Trout Habitat

The detrimental effects of beaver ponds on trout streams have been frequently mentioned in the literature. Although some good objective studies have been made (Evans, 1948; Salyer, 1935; Cook, 1940; Patterson, 1950; Adams, 1954), most of the information presented by many other authors is based on subjective observations.

Statements in the literature indicate that beaver ponds: retard stream flow and spread water over large shallow areas which causes a general rise in water temperature, often to the lethal point for brook trout; cause the destruction of shade-producing trees and shrubs by drowning; cause siltation which covers trout redds and kills trout eggs; act as barriers to spawning runs of trout; reduce spring flow due to "head pressure", because of their raised water levels and accumulated silts; create toxic conditions and have a high oxygen demand due to decaying vegetation; increase fish diseases and parasites; often become too cold in winter and kill trout eggs because of small volumes of inflowing water; are beneficial for 2 to 4 years after which period of time they become detrimental to trout habitat. It is usually stressed that there is much variation in the above effects and that they do not all occur on every beaver pond.

Data gathered during this study add support to many of the above statements and are presented below.

Streambank and streambank cover. Beaver ponds induce sloughing of streambanks by the destruction of fibrous root systems of floodplain plants. Over 75 per cent of the abandoned ponds visited showed

Beaver speed up plant succession by opening up the canopy and favoring the understory, often composed of subclimax and climax species. Here beaver have thinned the aspen stand and all ages of fir trees are "taking over". However, this will be poor potential beaver habitat in the future.

that the stream within the area of previous flooding had widened considerably. This was determined by comparing the average stream width above and below the abandoned colony with the stream width within the original pond area. The effect of this widening was to slow the volume of flow, create shallower water and consequently raise the temperature of the stream.

Beaver ponds destroy the immediate streambank cover by flooding. Based on data from 326 active beaver ponds, floodplain plants within the impounded area of 151 ponds (46%) were completely killed. Floodplain plants in the rest of the ponds (175) which had been more recently inundated were beginning to die or were nearly dead. In most of the ponds in this latter group the floodplain plants would die since beaver ponds are usually long-lived. It is my opinion that over 90 per cent of all beaver impoundments kill all lowland trees and shrubs, plus other floodplain plants, within their deeper water areas. Since the streambanks are always under the deepest waters of the pond, the shade plants along these banks will be killed first. Alder and alder-

Typical trout stream damage: 100 per cent destruction of shade and a widening of streambanks by sloughing.

willow associations, very valuable shade-producers for trout streams, are the most common woody plants killed by beaver impoundments.

Siltation. By constructing dams on streams beaver create ponds which are collectors of silt. All pond bottoms can be classified as potential siltation sites. Samples of silt layers were taken on 15 typical beaver ponds in northwestern Wisconsin in 1952, and in each case a layer of silt measuring from ½ inch to over 2 inches was found. Subjective observations of all ponds subsequently studied indicated the same.

Mineral silt is constantly being deposited on every pond bottom, but organic debris often forms the bulk of the total deposit. Mineral silts, the more dense of the two types, occur in thicker layers on high gradient streams where they do less harm. Conversely, the "organic silts" accumulate in thicker layers on the low-gradient streams.

A beaver pond begins to collect silt as soon as it is established and the amount collected varies with the age of the pond, the amount of aquatic vegetation in the pond area, the amount of deciduous vegetation above the pond and the amount of silt normally carried by the stream. When the pond is drained the silt will flush away near the dam site first and then gradually upstream. Some stream channels retain silt for a long period of time. When a beaver pond is abandoned, a new channel is often formed below the dam if the break in the dam is out of line with the old channel. This causes excessive displacement of silt which is deposited farther downstream.

Since it is possible for long stretches of gravelly stream bed to be covered by dense silt layers, damage to existing and potential trout redds is probably great on certain streams. Gravel-loving aquatic insects and other invertebrates are seriously affected when their habitat is completely covered by silt (Sprules, 1940). This loss of particular invertebrates, however, is probably offset in many instances by an increase in silt-loving species such as larvae of mayflies and dragonflies.

Water. During July and August extensive, though subjective, observations were made on water temperatures within the beaver ponds. Surface waters were often found to be almost tepid, especially if the stream above flowed through old beaver meadows with widened stream channels and if the pond itself was very wide and relatively shallow. The deep waters above the beaver dam were noticeably cooler at the bottom of the pond than at the top. These observations were made by swimming, wading and hand immersion and are only indicative at best.

Large, warm and relatively stagnant beaver ponds with great quantities of inundated floodplain vegetation create toxic water conditions. This was often substantiated in late July and August when some ponds were found with thick algal scums on them and whose shallow areas actually bubbled with foul-smelling hydrogen sulfide and methane gases as they were waded.

On at least five beaver ponds windrows of dead aquatic insects and their larvae and dead minnows, etc. were found. These were discovered in the hottest periods and were believed to have been the result of the toxic conditions in the ponds.

Spawning runs. Beaver dams function as barriers to spawning runs of trout. The primary beaver dams measured during the study averaged about 4 feet high and about 49 yards long, based on 304 dams. Active dams are usually very solid in areas of heavy soils but often develop large leaks after abandonment. Dams in regions with sandy soils often have many leaks even while the ponds are occupied by beaver. Therefore, barrier effects are often only temporary and relatively short-lived.

Benefits to Trout Habitat

Brook trout increase in number and size for the first few years after a new flowage is established on a stream. Following this initial period, the ponds deteriorate rapidly as trout habitat. High-gradient streams experience the initial benefits for a longer period of time than low-gradient streams. These observations are borne out by the many visits made to beaver ponds of all ages and by the talks with trout fishermen met on the streams during the course of the study. It is obvious that older ponds usually exhibit more profound trout habitat changes than those only a year or two old. There is much variation here too and it appears that many beaver ponds begin to "sweeten" after the dense floodplain vegetation has rotted down due to exceptionally long lives of certain ponds or to repeated drainage and refilling as certain ponds are abandoned and re-inhabited.

Percolation into the substrate, especially from young beaver ponds, may help the immediate water table and often increases the seepage of water immediately below the beaver pond. Many instances were noted where there were strong-flowing cold seepages at the base of beaver dams and on the floodplains just below the dams and at the edge of the slope. This adds cold water and sometimes effects a more even flow of water to the stream below. This may be important in some small streams with little steady flow or with intermittent flow.

In years of severe droughts, beaver ponds may be the only sections of streams containing water and in these instances may function as sanctuaries for the few remaining trout. The ponds may also prolong the period of flow of small streams during drought periods. During aerial surveys of beaver ponds and on field investigations of ponds in the early 1950's many streams were observed in the central part of Wisconsin that were completely dried up, the only water remaining found in the beaver ponds.

Effects on Other Fish

Minnows (Cyprinidae), mud minnows (Umbridae) and many other warm-water fish often increase markedly in beaver ponds due to the much larger volume of water, increased forage space and warmer water. When the pond becomes very toxic, however, these warm-water fish may be affected adversely.

Northern pike sometimes increase greatly in number in very large beaver ponds with abundant shallow, grassy areas. Local beaver ponds frequently are highly regarded by fishermen as places to catch "northerns". For example, by the early 1950's the beaver ponds of Weirgor Creek in northwestern Wisconsin had severely reduced the trout potential of the stream and northern pike became abundant in the beaver ponds. By the mid-1950's the beaver ponds were removed, the trout habitat was restored, and currently this stream is producing good trout catches again. Wedge's Creek in central Wisconsin when

Part of a 65-acre flowage constructed by beaver. It has excellent wildlife potential and is accomplishing free of charge what man is trying to do at sometimes considerable cost!

dammed by beaver, offers fishermen good catches of smallmouth bass which are caught just above the beaver dams.

Beaver dams act as barriers to spawning and migrating fish in streams between lakes. Northern pike and walleyed pike may be affected in this manner. During spring spawning runs, northerns and walleyes were sometimes seen lying below the beaver dams in large numbers and it was evident that they could not get over or around the beaver dam.

Wildlife

Most investigators recognize benefits derived from the beaver pond by many important game and fur species (Beard, 1953; Moore and Martin, 1949; Grasse and Putnam, 1950; Bradt, 1947; Swank, 1949; Hodgdon and Hunt, 1955; Shaw, 1948; and others). In her detailed and valuable study in the Seney National Wildlife Refuge of Michigan, on the effects of beaver ponds on waterfowl and other wildlife, Beard (1953) concluded that six environmental characteristics created or enhanced by the construction of beaver ponds were of high value to the production and protection of waterfowl. She recommended that the management of beaver and beaver flowages take advantage of the benefits offered waterfowl and other important wildlife species.

An analysis of the effects of beaver ponds on wildlife was the primary goal of the beaver-pond study in Wisconsin and much information was gathered. These data will be presented under separate wildlife headings with benefits and damages being discussed simultaneously.

Waterfowl

The data from 333 beaver ponds studied show that these ponds produced 115 duck broods, consisting of at least 764 ducklings (Table 6). This averages one duck brood annually for every 3 beaver ponds or 2.3 ducklings per pond per year. The average beaver pond covered about 3.5 acres; therefore, each acre of beaver pond produced about ⅔ of a duckling. In the West Central Area significantly fewer ducklings were produced per pond, presumably because so many drainage-ditch ponds (small in area) were in these samples. Heavy brush and the difficulty of separating late-summer and fall broods from adult visiting ducks tended to minimize the brood figures; in many cases the ducks in question were considered visiting ducks and are recorded in Table 7.

TABLE 6

Occurrence of Duck Broods on Beaver Ponds

Area	No. Broods	No. Ducklings	No. Ponds	Ducklings Per Pond
Northeast	34	227	87	2.6
Northwest	48	320	113	2.8
West Central	33	217	133	1.6
Total	115	764	333	2.3

About 28 per cent of the beaver ponds observed produced duck broods. Many of the larger, shallow ponds produced 2 broods and a few exceptional ponds produced 3. For the Northeast Area this amounted to 27 beaver ponds out of 87 that produced broods; for the Northwest Area, 37 ponds out of 113; and for the West Central Area, 29 ponds out of 133.

Duck broods almost always frequented the areas of heaviest emergent vegetation at the upper end of the beaver pond, and from this area swam into the open water immediately adjacent. Rarely did the broods swim down to the beaver dam except in recently constructed ponds having drowned brushy areas throughout.

Duck nests were found in the same specific area as the broods. Once a mallard nest was found on an old grass-covered beaver lodge located 15 yards from a newly constructed lodge. Often the nests were on small grassy islands and hummocks, at some distance from the more uniformly dry areas of the upper reaches of the ponds, and this helped protect the nest from land predators.

Since the waters of the beaver pond often produce dense populations of dragonfly larvae, aquatic bugs and beetles and scuds *(Gammarus* and *Hyallela),* and the upper grassy areas produce many more grasshoppers, plant bugs and spiders than they did previous to flooding, the duck broods usually find sufficient supplies of invertebrate foods. Tender aquatic plants and emergents, although usually relatively sparse per unit area, also form important food sources for the ducklings. *Lemna* is the one aquatic genus that can be found on most ponds, growing on some in great quantity. This is considered as fair to good food for ducks, but the insects that abound on the thick "scums" of *Lemna* are probably more important to the ducklings.

During the spring and fall migrations, waterfowl use beaver ponds for feeding and resting. Migrating and breeding ducks were found on 72 per cent of the beaver ponds observed between late April and late October (Table 7).

TABLE 7

Occurrence of Waterfowl on Beaver Ponds

Area	Total Ponds	No. Ponds With Ducks	Per Cent Occurrence	Total Ducks	Ducks Per Pond
Northeast	87	62	71	251	2.9
Northwest	113	87	77	287	2.5
West Central	133	90	68	599	4.5
Southern	20	15	75	133	6.6
Total	353	254	72	1,270	3.6

Actually counted on these 353 ponds were 1,270 ducks, exclusive of ducklings. This is an average of 3.6 ducks using each pond. More ducks were tallied per pond in the southern and west central counties than in the north primarily because of a higher percentage of visits to ponds in these areas during migration periods, when duck use is at its peak.

Black ducks, mallards, wood ducks, blue-winged teal, ring-necked ducks and hooded mergansers were most often observed, especially during the breeding season. Other species of ducks were found in smaller numbers, mostly during the migration periods. Three ponds had snow, blue and Canada geese either feeding or resting on them. Pied-billed grebes and a few other waterfowl species were encountered on the beaver ponds but were not tallied.

There was no evidence of duck use on 99 ponds at the time they were visited.

No objective waterfowl studies were made on the abandoned beaver ponds and pond basins encountered during the study. Many ponds hold varying levels of water for a few years after abandonment and should still produce duck broods and offer feeding and resting areas to migrating ducks. Long-abandoned ponds that have reverted to beaver meadows still on occasion have water-filled canals and dam trenches bordered by good nesting and resting cover. Ducks were often flushed from these canals and other small open-water areas on the pond basin.

Thousands of Wisconsin hunters know that ducks frequent beaver ponds. Evidence of hunter use was sought on 272 beaver ponds and spent shotgun shells, well-worn paths, small blinds, large masses of plucked duck feathers or even duck boats were found on 94 ponds (35%).

It is difficult to see any serious damage that could be done to duck habitat by the construction of beaver ponds. If it exists it is far offset by the benefits.

Ruffed Grouse

The "clear-cut" slopes around beaver impoundments and meadows often revert to dense shrub-brush clones and areas of increased grass production (Fig. 5). Ruffed grouse occur in brushy sites such as these more frequently than in closed-canopy forests with their sparse understories.

Ruffed grouse broods were found in the brushy pond edges at 16 of 293 ponds. This figure is extremely low due primarily to the ability of young grouse to hide, and because a large number of ponds in the sample were observed both before the broods had hatched and after they had matured and dispersed. Adult ruffed grouse, including grown broods in late fall, were flushed on 104 of the ponds (35%).

More berries and insects are found in the shrub-brush areas around the beaver pond or meadows with abundant growths of hazel *(Corylus americana* and *C. cornuta), Rubus,* red-osier dogwood *(Cornus stolo-*

nifera), nannyberry *(Viburnum lentago),* etc. and a good ground cover of grass, and adult grouse and broods find plenty to eat here.

Alder "runs", important for good grouse production (Dorney, 1959) gradually invade the older beaver meadows, automatically placing good cover next to good food supplies. Damage to ruffed grouse habitat occurs where most of the alder has been drowned along extensive lengths of floodplain. With the dense growths of brush on the slopes in clear-cut areas, however, this damage may be partially offset. Winter food is increased at many pond sites for the brush invading the clear-cut slopes often contains important food shrubs.

Although there is some destruction of their habitat by beaver impoundments, ruffed grouse probably gain more than they lose by the breaking up of alder monotypes which are often of great length along many creeks.

TABLE 8

Occurrence of Waterfowl on Beaver Ponds

Area	Total Ponds	No. Ponds With Broods	No. Ponds With Adults	No. Adults Seen
Northeast	47	2	20	23
Northwest	113	7	43	61
West Central	133	7	41	65
Total	293	16	104	149

Woodcock

Woodcock or their sign occurred on 30 per cent of the beaver ponds studied. This appears higher than the use along non-impounded sections of streams and judging from the often very dense woodcock sign on shores, dams and mud flats of beaver ponds, woodcock seek out the ponds for feeding sites.

Alder "runs" are very important nesting areas for woodcock, although their nests are also found on slopes and higher lands near wetlands. Since large areas are drowned by beaver ponds, some destruction of nesting cover occurs but this loss is not considered of serious proportions.

Beaver meadows with their narrow, exposed areas along the old canals and dam trench offer feeding areas for woodcock also, and sign has often been noted at these places, although no detailed studies of abandoned beaver ponds were made.

Otter

Otter used 31 per cent of the ponds visited. Otter sign was very noticeable in the vicinity of beaver dams, along the shorelines and especially on small peninsulas of land or logs jutting into the beaver pond. Scats, tracks, "hay piles", scratchings and slides were usually more abundant on the pond areas than on the stream proper either above or below the pond. Otter themselves were seen on a number of occasions diving and playing in the pond and on the dam.

In winter, otter sign was even more abundant around beaver ponds, especially at the beaver dam, for this is often the only place along stretches of stream where otter can find open water. Groups have been observed to live in the ponds and also in beaver burrows and old lodges for rather long periods of time during the frigid weather of January and February. In addition old beaver ponds and beaver meadows attract otter, and on many occasions evidence of regular use of the abandoned lodges and burrows was very noticeable.

The attraction of beaver ponds for otter is well known by trappers, and the ponds aid in the harvest of this difficult-to-trap animal.

Mink

Mink sign was found on 58 per cent of the ponds (Table 9). Mink were very often observed hunting along the beaver dams and along the shores and upper ends of ponds, during the one-hour observation period, especially at dawn and dusk.

TABLE 9

Occurrence of Mink on Beaver Ponds

Area	Total Ponds	No. Ponds With Mink	Per Cent Occurrence
Northeast	87	39	45
Northwest	113	72	64
West Central	133	83	62
Southern	20	12	60
Total	353	206	58

Food abundance, deeper water and more dissected edge and shoreline probably are the prime attractions for mink, for frequency of occurrence and density of sign at beaver ponds were much higher than on the stream above and below the ponds.

Abandoned beaver ponds that continue to hold back good water supplies can be assumed to be as attractive to mink as active beaver ponds. On reverting to beaver meadows the value to mink probably decreases markedly, since the area affected develops more normal, stream-like conditions. The meadow will support more invertebrates and small vertebrates, however, than the previous shrubby floodplain, and this provides more food for the ever-hungry mink.

During winter, active beaver ponds often showed evidence of abundant use by mink, especially in the vicinity of the dam where there is usually access to open water. Abandoned ponds in winter often showed evidence of mink visiting the old beaver lodges and bank burrows, and in some instances it was apparent from very dense sign that mink were living in beaver dams.

Raccoon

Raccoon sign was observed on 55 per cent of the beaver ponds (Table 10). Compared to sections of stream above and below the ponds, the abundance of sign indicated the tendency of raccoons to concentrate at the beaver ponds. Many exposed muddy banks and other bare spots were literally covered with raccoon tracks, and logs and rocks were often covered with scats. From the varying sizes of the tracks, especially in late summer and fall, it was obvious that whole families of raccoons visited the ponds on nightly foraging excursions.

Improved food foraging area and increased food densities were undoubtedly most important in attracting these furbearers. Large aquatic insects (*Benacus, Lethocerus, Dytiscus, Hydrous, Hydrophilus* etc.), crayfish and other invertebrates, frogs, small species of snakes, minnows, etc., were increased in number and spread over the large shallow areas of the beaver ponds, creating excellent new feeding grounds for raccoon. Raccoon scats frequently showed remains of these vertebrates and invertebrates.

The value of beaver ponds to raccoon in winter is negligible since these animals are quite inactive at this time. However, on at least a dozen occasions while visiting beaver ponds during winter thaws, raccoon tracks were seen at the open-water areas below the beaver dam and at otter kills and scat piles lying on the pond ice.

Beaver meadows are probably of high value because of the increase in small animals in these open areas, and are especially important in the extensively wooded areas.

Deer

The value of beaver ponds to deer is evidenced by the fact that on 304 ponds out of 353 (86%) deer or deer sign was found (Table 11).

TABLE 10

Occurrence of Raccoons at Beaver Ponds

Area	Total Ponds	No. Ponds With Raccoons	Per Cent Occurrence
Northeast	87	30	34
Northwest	113	59	52
West Central	133	88	66
Southern	20	16	80
Total	353	193	55

Of the ponds having deer sign 54 per cent showed evidence of above normal to very heavy use by deer as compared to the average deer sign found at beaver ponds. Deer beds were often found in the sedges and grasses of abandoned ponds and in the grassy and brushy areas along the clear-cut slopes of active beaver ponds.

The increased production of sedges, grasses, forbs, aquatic plants and shrubs around beaver ponds creates good grazing and browsing conditions for deer. The open areas produced by the ponds, especially abandoned ponds (beaver meadows), are very often the only openings left in areas of extensive forest cover, and these sites are sought by deer for feeding and for comfort during "fly-time". The various aquatic plants in the upper shallow ends of beaver ponds are frequently heavily utilized by deer, and during hot summer weather it is very common to see deer wading around in the ponds up to their bellies in water.

TABLE 11

Occurrence of Deer at Beaver Ponds

Area	Total Ponds	No. Ponds With Deer	Per Cent Occurrence	Relative "Sign" Densities			
				*	**	***	****
Northeast	87	80	92	31	32	14	3
Northwest	113	103	91	42	32	22	7
West Central	133	114	85	62	33	16	3
Southern	20	7	35	6	1	---	--
Total	353	304	86	141	98	52	13
						163	

*, **, ***, ****Arbitrary ratings of deer-sign densities: normal, above normal, high and very high, respectively.

Typical beaver meadow—grown up after the pond had been abandoned for two years. Very often these are the only openings present in areas of extensive cover, and are frequently visited by deer.

During "open" winters, use of active and inactive beaver ponds by deer is probably important since good food supplies are often available here in the form of browse shrubs, resprouts from previously cut stumps, and grasses and forbs that have become more dense on the "opened" slopes. Dewberry *(Rubus villosus)* commonly grows in profusion on dry, sandy slopes and it is eagerly sought by deer at beaver ponds where it exists. In winters when heavy snows yard the deer, the ponds are of little value unless located at the fringe of the yard.

The degree of destruction to presently known deer yards is considered minor, and since the over-all detrimental effects of beaver ponds on extensive lowland conifer stands is relatively minor, according to the timber damage data, the effect on potential deer yards is also not serious.

In a poll of game personnel concerned with deer management, most believed beaver ponds and beaver meadows were an important welfare factor to deer in heavily forested areas.

Black Bear

Ten per cent of the beaver ponds in the Northeast and Northwest Areas showed evidence of above-normal use by black bear, as compared to the stream proper. These animals grazed on the tender vegetation of the upper ends of the ponds, or used the shallow parts of the ponds as wallows usually in hot weather.

In the Northeast Area 7 beaver ponds out of 87 showed bear use, while in the Northwest Area 13 beaver ponds out of 113 showed bear use. The value of beaver meadows to black bear is unknown, but heavy utilization of the berry-producing shrubs around the active ponds and beaver meadows was noted on many occasions.

Muskrats

The production of muskrats on beaver ponds is often great and constitutes an important portion of the total value of beaver ponds. Muskrat sign, houses, feeding "wharves" and the 'rats themselves were seen on 80 per cent of the ponds (Table 12). Muskrat sign on the majority of ponds was above the average densities of sign along the stream proper, either above or below the pond.

The total of 1,080 muskrat houses amounts to just over 3 houses per beaver pond. Since the average size of a beaver pond approximates 3.5 acres (based on data from 337 beaver ponds in this study) almost one muskrat house per acre of beaver impoundment can be expected state-wide in normal years. This is a minimum figure for on many of the ponds, especially the larger ones with areas of heavy vegetation, it was difficult to count every muskat house, and in summer the houses from the previous fall and winter were flattened and hard to see or were completely destroyed.

Fewer muskrats were found on ponds in the northeast probably due to the fact that this area has more frequent acid-water streams with less dense aquatic plant communities than the other areas. The large shallow ponds with a dense growth of emergent and aquatic plants were generally excellent muskrat producers. For example, a 7-acre pond in southern Wisconsin had 34 muskrat houses, a 5-acre pond in the Northwest Area had 14 houses, and a 3-acre pond in the Northeast Area supported 13 muskrat houses. An exceptionally large, shallow, 65-acre pond in the West Central Area had at least 150 muskrat houses on it. After drainage, this pond reverted to a mere trickle of a stream running through a dry sedge-grass meadow that supported only a few individual muskrats living in bank burrows along the streambank.

The value of active beaver ponds to muskrats in winter is exception-

TABLE 12

Occurrence of Muskrats and Muskrat Houses on Beaver Ponds

Area	Total Ponds	No. Ponds With Muskrats	Per Cent Occurrence	No. Houses
Northeast	87	51	58	156
Northwest	113	103	91	337
West Central	133	109	82	502
Southern	87	18	90	85
Total	353	281	80	1,080

ally high since the water is much deeper and the food more dense per unit area than in the stream channel. "Freeze-outs" and starvation are much less apt to occur within the pond area.

Beaver meadows are of little value to muskrats since the water area is once again confined to the stream channel. Increases in grass-sedge-forb food supplies on the meadow are apparent and this may somewhat increase the muskrat carrying capacity along the stream segments involved.

Other Wildlife

No objective data were gathered on other species of wildlife using the beaver ponds and beaver meadows or produced on them. However, subjective observations indicate marked density increases for many animals, and substantial increases in the number of species using most of the ponds and meadows and their environs as compared to the density and variety of species using the stream above and below the beaver pond or meadow. The ponds that stagnate and have extremely low oxidation-reduction potentials usually lose most of their pond life, but this is the exception rather than the rule.

Examples of some of the other wildlife forms that increased in density and variety are: minnows and other small fish; frogs and salamanders; snakes (brown, garter, smooth green, red-bellied and water); many species of marsh birds and songbirds; many species of small mammals (primarily in the beaver-meadow stage); crayfish; large and small aquatic invertebrates; spiders; grasshoppers and other grass-loving insects.

Examples of new groups of birds using the ponds and environs are: many species of shorebirds, swallows, flycatchers, hawks, warblers, sparrows and kingfishers. Ospreys and bald eagles have also been seen using the beaver ponds on several occasions.

EVALUATION AND MANAGEMENT RECOMMENDATIONS

An evaluation of the findings of this study was planned to make possible better multiple-use management of beaver, trout and forests. However, multiple use of specific land areas is simplest when all resources and human interests (economic and aesthetic) are relatively compatible. Such is rarely the case and in this instance the management problems involved are complicated by the fact that beaver are largely incompatible with trout interests in many areas, and are completely incompatible with valuable lowland timber interests. On the other hand, they are sometimes compatible with valuable upland timber interests and are very compatible with many wildlife species. Good forestry programs are beneficial to trout interests. Any economic evaluation attempting to apply monetary values to the various interests involved is immediately exposed to the difficulties of standardization of the analysis.

Using the data from this study combined with other Wisconsin data, a special beaver-trout-forestry committee of Wisconsin Conservation Department personnel (including the author) endeavored in 1961 to make an economic and management evaluation of the total beaver problem. After many analytical approaches to the economic aspects were found to be unsound, a more general analysis was made.

The main points used in this analysis were:

1. In Wisconsin, out of 925,000 licensed fishermen, there are currently about 185,000 that actually fish trout. There are 8,190 miles of trout streams in Wisconsin of which 5,449 miles (67%) are located in the northern third of the state. It is therefore apparent that the trout streams of the north have a tremendous recreational and economic value. These values accrue annually.

2. It is the northern one-third of Wisconsin that has had in the past two decades the most widespread and dense beaver population, and consequently waxing and waning beaver-trout controversies.

3. Currently there are only about 1,000 beaver trappers in Wisconsin; about 3,500 general trapping licenses are sold. During the past 7 years Wisconsin has sold duck stamps to about 125,000 duck hunters annually. The fraction of these hunters that hunt ducks on beaver ponds may run into the thousands since it is common knowledge in the north that beaver ponds are good places at which to hunt local and migrant ducks in years when the beaver ponds freeze over late. The total value per pond, considering the trappers and hunters using it for various fur and game species, is therefore considerable and represents the tangible value.

We can predict what will happen to this area, if and when a beaver moves in—a "who-dun-it" in reverse! A dam across the now snow-covered stream in the foreground will back up the water and flood the willows and alders along the streambank, eventually depriving the beaver of his nearby food supply. On the upland slope in the background, the beaver will cut the aspen and birch first for food and building materials. This will encourage the growth of the invading firs which will replace the deciduous trees. Thus we have an example of how in many areas the beaver is making his own habitat less productive.

The intangible values of the beaver pond are currently quite significant since many people visit accessible beaver ponds every year in tourist areas. The intangible values will without doubt increase as more recreational areas are developed in the northern part of Wisconsin and the beaver population is allowed to increase in specific areas. This value accrues annually.

4. The forest economics of swamp hardwood or conifer stands involve timber species that take 50 to 90 years to mature to merchantible size depending on site and species involved. Therefore, annual values are quite insignificant; highest values accrue every 5 to 9 decades.

5. Assuming active beaver ponds may occupy a given lowland site for 15 to 20 years during a 5- to 9-decade period, it is apparent that their contribution of fur and game to trappers and hunters every year will often outweigh that of the timber that would have been produced

on this site. Since, however, timber is essential to the nation's strength it should be given priority on those areas where forest managers deem it most important.

After much consideration of these and other points, the committee agreed that trout and forest values on specific areas outweigh beaver values, but the over-all economic and aesthetic values of beaver ponds were much greater than had been previously surmised. Therefore, beaver should be kept at optimum population densities in areas where they will not significantly affect either trout habitat or valuable lowland timber stands. It was also agreed that the destruction of timber by beaver cutting could not be greatly reduced except by near extirpation of beaver on a state-wide basis.

The final recommendations of the committee for Wisconsin include the recommendations based on the beaver-pond study, as follows:

1. Classification and inventory of trout and non-trout waters should be carried out by the Fish Management Division. Specific areas in which maximum control of beaver is desired should be determined by this division and delineated on detailed maps. Large areas such as whole or partial watersheds are to be considered, since our ear-tagging studies have shown that natural beaver movement is great on streams. These areas would be called *special interest areas.*

Detailed aerial surveys should be made to determine beaver colony locations and densities within the special interest areas. Special, lenient beaver-trapping seasons should be allowed on these areas, to be followed by "clean-up" operations carried out by state beaver trappers and other cooperating Department personnel. Active colony locations should be posted in strategic places for the information of all beaver trappers.

2. Specific sites on which valuable lowland timber stands are currently growing should be determined by the Forest Management Division. Maximum control of beaver should be effected by liberalized special seasons if a large area is involved, or by special Department effort if the sites are widely scattered. These areas would be called *special problem sites.*

3. The remaining areas within the state's beaver range should be subjected to general trapping seasons as in the past. Seasons should be set annually. These areas would be called *general beaver season areas.*

4. Beaver population densities and trends in all areas should be ascertained primarily by aerial surveys supplemented by ground field observations. These surveys should be undertaken by the personnel of the various divisions whose interests are involved.

5. Special methods of beaver control should be investigated in order to determine which methods are most rapid and economical in specific control efforts.

6. Studies should be made of the effects of beaver removal on the recovery of trout habitat on streams where total removal of beaver has been accomplished. Destroyed trout habitat should be rehabilitated by the Fish Management Division whenever feasible.

7. Studies should be made of possible methods to be used in reforesting abandoned beaver pond basins (beaver meadows).

8. Attempts should be made on special interest areas and special problem sites to manipulate habitat types by forestry methods that will encourage plant communities unfavorable to beaver. On 39 per cent of the beaver ponds studied, the understory composition indicated that stands around these ponds would in the future be composed of a larger proportion of timber and shrub species less favorable to beaver. Thus, much of the beaver habitat in Wisconsin currently indicates a downward trend in future beaver carrying capacity.

SUMMARY

There had been few objective data reported in the literature and little sound information collected in Wisconsin on beaver-trout-forestry relationships. A study was therefore undertaken in 1950 designed to procure data which could be used to better manage these three resources.

During the period 1950 to 1958, 353 beaver ponds were visited and detailed observations were made of many ecological relationships between beaver and trout habitat, forests and other wildlife species. A standard procedure was developed for the study of each pond involving primarily a quiet approach, an observation period of one hour or longer from a good vantage point and then a complete circuit of the pond in order to observe and record pertinent data.

The typical sequence of habitat alterations resulting from beaver impoundments involves four stages of floodplain change. Before impoundment the floodplain is covered with lowland timber and shrubs or open grass areas (beaver meadows or areas that were clear-cut by loggers). Immediately following construction of the beaver dam, the original floodplain tree-shrub-grass communities are drowned and the pond produces typical though usually sparse communities of aquatic and emergent plants. The third stage occurs when the beaver pond is drained and the pond basin reverts to verdant sedge-grass meadow. The fourth stage follows, characterized by the gradual recovery of the floodplain to the shrub community and finally to the original timber community.

It is during beaver impoundment (stage 2) in which the most rapid and pronounced habitat changes occur. Here a paradox exists, for trout habitat is most seriously affected and timber is drowned while at the same time wildlife habitat is improved and wildlife is produced, often in abundance, on the beaver pond.

During the period 1935 to 1949 the frequency of occurrence of beaver damage to timber in Wisconsin by cutting and drowning was approximately 25 per cent of the total number of registered complaints. From 1950 to 1959 this frequency dropped to 18 per cent of all beaver damage complaints.

Timber destruction by drowning in 73 ponds in which damage could be estimated amounted to 95 acres, or .35 acres of timber per beaver pond based on a total of 332 beaver ponds studied. Destruction of timber by flooding was therefore considered negligible, except on certain ponds where large acreages may be involved.

When beaver populations are high, cutting may destroy 3,000 to 4,000 acres of timber per year, amounting to tens of thousands of cords annually. Aspen is the species involved in greatest bulk. Damage by cutting cannot be materially reduced without total reduction of the beaver resource.

Pioneer trees cut by beaver are replaced rapidly by the more shade-tolerant dominants in the understories. In this manner beaver perform a valuable selective-cutting-type management on many hundreds of acres yearly. However, by selecting aspen and thus favoring the growth of less palatable species, beaver are reducing the carrying capacity of their habitat for the future.

The findings of this study support the conclusions in the literature that beaver impoundments on slow-flowing trout streams do much more harm to trout habitat than good.

Beaver ponds were found to be excellent producers of important game species such as ducks and muskrats, and many other wildlife species were found to use beaver ponds much more readily and in greater densities than they used the floodplain either above or below the pond. At a time when Wisconsin is creating many large artificial impoundments to produce wildlife habitat at a cost of thousands of dollars each, the small beaver ponds are being created by the hundreds annually at little expense.

A special beaver-trout-forestry committee of Wisconsin Conservation Department personnel agreed that trout and forestry values on many specific areas outweighed the values of the beaver ponds, but that the over-all economic and aesthetic values of the beaver ponds were much greater than previously believed. This animal, therefore, should be carried at optimum levels in the many areas within its range where it will not conflict to a great degree with trout and forestry interests.

Specific recommendations made by this committee, based on the beaver-pond study, involved a classification of areas in which beaver should be controlled in accordance with fish and forest management interests and areas in which beaver should be kept at optimum numbers.

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