ECONOMIC AND ENVIRONMENTAL IMPACTS OF BEAVERS IN NORTH CAROLINA

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ABSTRACT
In 1984, a postal survey of landowners and managers was conducted in North Carolina concerning the presence of beavers (Castor canadensis) on their property. Major objectives of the survey were to determine: (1) current distribution and relative abundance of beavers in North Carolina, (2) the economic and environmental impacts from an apparently increasing beaver population, and (3) landowner attitudes toward these increasing populations. Of the 1,069 questionnaires returned, data was compiled from 456 landowners (43 percent) who confirmed the presence of beaver activity on their property during 1983. A significant increase in beaver numbers and distribution has occurred throughout much of North Carolina during the past thirty years and currently the species inhabits 80 of 100 counties. Beavers affect a minimum of 35,858 hectares of bottomland in North Carolina. Total estimated damage loss to forestry and agricultural interests in 1983 exceeded benefits by $275,000. Cooperative efforts in administering a beaver management program between the North Carolina Wildlife Resources Commission and other state agencies centers on landowner education and technical assistance in the form of inspection and demonstration, with referral to professional trappers for aid in controlling nuisance animals.

INTRODUCTION
With few exceptions, in each southeastern state where significant beaver populations exist, the status and ecology of this species has been investigated (e.g. Bailey 1954, Engle 1954, Beshears 1967, Larson 1967, Arner et al. 1969, Linscombe 1974, Godbee and Price 1975, Woodward et al. 1976). North Carolina appears to be one of the exceptions. No results of any formal research on beaver populations in North Carolina have been identified in the literature. However, brief accounts have reported the history of beavers in North Carolina including the apparent elimination of the species, C. c. canadensis, from the state by 1897 (Brimley 1944-46). This extirpation is believed to have occurred from intense trapping pressure and the clearing of land for crop production. Subsequent attempts at reintroduction of beavers by various public agencies and private individuals have also been documented (Brimley 1944-46, Taylor 1953, Smith et al. 1960), although a number of transplant efforts were unsuccessful. In 1939, a successful introduction of 29 beavers of Wisconsin stock C. c. canadensis Kuhl) via Pennsylvania was made by N. C. Department of Conservation and Development biologists to the Hoffman State Park (Sandhills Wildlife Management Area) in Richmond county (T. Critcher, pers. comm.). By 1959, the population in that and neighboring counties was estimated at 1,000 animals. Small numbers of beavers from the Sandhills population were subsequently relocated throughout North Carolina by Wildlife Commission personnel upon requests from landowners during the period 1951-1956. In 1957, fifteen 'Carolina' beavers (C. c. carolinensis) were obtained from Alabama and successfully introduced into Umstead State Park, near Raleigh (F. S. Barkalow, pers. comm.). In addition, other agencies, such as...
the U. S. Forest Service and various branches of the military establishment, have engaged in both the intra- and interstate movement of beavers. Beavers from the adjacent states of South Carolina, Georgia, Tennessee and Virginia have also dispersed into North Carolina via several of the major river systems. A recent compilation of mammal distribution records at the Museum of Natural History in Raleigh listed 31 counties from which specimens had been obtained. The report further stated that beavers are distributed "apparently statewide but uncommon and scattered on (the) outer coastal plain..." (Lee et al. 1982).

As beaver populations increased across North Carolina during the 1960's, state game laws, passed in 1929 prohibiting the taking of beaver by any method, were amended to allow the regulated trapping of beavers in counties where landowners complained of damage. A statewide trapping season on beavers was established in 1963. Harvest levels in North Carolina have averaged only several hundred animals per year for the past decade. Such low harvests, not only in North Carolina but throughout the southeastern United States, undoubtedly reflect the reduced demand for shorthaired furs, and beavers in particular, in international markets (Hill and Novakowski 1984).

Several of the natural resource agencies in North Carolina have received an increased number of inquiries relating to beaver damage problems in recent years. Apparently, population levels in North Carolina have increased to the point where in many areas the beaver is considered a pest animal. Although it has been shown in the Southeast that beaver pond habitats may produce beneficial results, excessively high numbers of beavers can cause significant losses to forestry and agribusiness production (Hill 1982, Arner and Dubose 1982, Woodward 1983, Hill and Novakowski 1984, Spencer 1985). Because there was no information regarding the current status of beavers in North Carolina, a project was initiated at North Carolina State University to determine the distribution, economic and environmental impacts, and landowner attitudes toward resident beaver populations. This paper summarizes the results of an extensive questionnaire survey of North Carolina landowners and managers conducted in 1984.

We would like to thank the following North Carolina organizations for help in distributing beaver questionnaires: Agricultural Extension Service (Chairmen), Forestry Association, Society of Consulting Foresters, Farm Bureau Federation, Wildlife Federation, Wildlife Resources Commission (Enforcement), County Forestry Associations and the U. S. Soil Conservation Service. We also appreciate the technical assistance of R. Raudbaugh, M. McKeeler, E. Vaca, G. San Julian, and the North Carolina Wildlife Resources Commission District Biologists. Financial support was provided by a grant from the Renewable Resources Extension Act through the N. C. Agricultural Extension Service. We extend special thanks to the hundreds of landowners who completed the beaver questionnaires that provided the information on which this paper is based.

METHODS

A questionnaire was prepared by the modification of a survey form written by the senior author for a similar study conducted in South Carolina (Woodward 1977). Special efforts were made to design the questions so that responses could be indicated by a check mark or by providing a numerical value. Questions covered a variety of potential interactions between the landowner, his property, and the resident beaver population. We were primarily interested in obtaining information on the statewide distribution of beavers, benefits and/or damages received, types of habitats and number of hectares of land affected, economic impacts, control efforts attempted and success rates, and the overall attitudes of landowners toward beavers. Addi-
tional information requested included:
years beavers had been present on the
property, length and name of stream(s)
habited, types and amounts of con-
struction activities, number of col-
onies estimated to be present and the
major land-use practices on the pro-
perty of each respondent reporting
beaver activity. A copy of the ques-
tionnaire is available upon request
from the senior author.

A total of 10,929 questionnaires
were forwarded to the various organi-
zations listed in the acknowledgement
section above. Each organization, in
turn, distributed the survey forms to
their membership or to landowners and
managers believed to have beavers on
their property. Duplication of effort
was often minimized by the close
working relationships under which many
of these groups routinely function. A
postage-free, self-addressed envelope
was enclosed for return of the form.

Individuals who returned incomplete
questionnaires were recontacted by
mail or telephone. The data from each
survey form was entered onto disk with
a microcomputer. Compilation of data
was accomplished by uploading to a
mainframe system utilizing programs
prepared by B. P. Gaffney. Although
the information was tabulated by
county, the following results are
presented on a statewide basis.

With the exception of including
the "miscellaneous" group (e.g.
electric power companies, state parks,
national forests, wildlife refuges,
branches of the military, etc.) and
timber company returns in the
discussion of total hectares (ha)
affected by beavers in North Carolina,
the results reported in this paper are
limited to data compiled from 430
private landowners who returned the
questionnaire. The primary reason for
not including the two former groups in
most of the data analyses was because
few of these large landowner/managers
could provide specific information
concerning their resident beaver
populations.

It is important to emphasize that
not all landowners in North Carolina
with beavers on their property
were contacted. The following
results, therefore, reflect variable
efforts in attempting to contact as
many landowners as possible with
resident beaver populations and should
be interpreted as representing minimum
rather than total state values. We
also recognize the biases associated
with damage/benefit estimates as many
of the forms were given to property
owners with known beaver problems. To
determine the magnitude of such
biases, a companion study, called the
"Intensive Stream Survey", is pre-
sently in progress at North Carolina
State University. The primary objec-
tive is to develop an index of the
difference between actual (on-the-
ground) versus landowner estimated
economic and environmental effects
from beaver activity. Impacts from
beaver activity are being measured
utilizing aerial photography over a
two county area with comparisons to
estimated impact data compiled from
completed questionnaires describing
the same tracts of land.

RESULTS
Allocation and Return of Questionnaires
Of the total 10,929 questionnaires
forwarded to public and private orga-
nizations for distribution to land-
owners, 1,069 (10 percent) were re-
turned to North Carolina State Univer-
sity for analysis. Of this number,
456 landowners (43 percent) reported
beaver activity on their property. A
total of 430 forms were from private
landowners. The remaining 26 returns
were comprised of 11 questionnaires
from the "miscellaneous" group and 15
returns from the major timber com-
panies in North Carolina.

The most effective organizations
in locating property owners with
resident beavers were: (1) County Ex-
tension Chairmen, 123 returns (27
percent), (2) Soil Conservation
Service, 82 returns (18 percent), (3)
Intensive Stream Survey (see Methods
section), 77 returns (17 percent), and
(4) N. C. Forestry Association, 50
returns (11 percent). The return rate
from the "Intensive Stream Survey" was
considered good with 157 out of 272
(58 percent) total questionnaires returned with 77 (49 percent) of the returns positive for beaver activity. This result was expected due to the high probability of contacting landowners with beavers on their property along streams known to have high densities of beavers.

Current Range in North Carolina

The beaver's range in North Carolina has increased markedly since the dozen or so counties were repopulated with "out-of-state" animals during the period 1940-1960. We have documented that beavers are currently present in a minimum of 80 counties in the state. There may be additional counties which have beaver colonies, but if so, we believe their population levels are low and their effects minimal. The major river basins with beaver populations are the Chowan, Roanoke, Tar, Neuse, Cape Fear, Lumber, Yadkin-Pee Dee, Hiwassee, Little Tennessee, and New-Watauga (Fig. 1). With the exception of one historic site in Buncombe County, few if any beavers were reported from the Pasquotank, Catawba, Broad, and French Broad River basins.

Land Resources Survey and Categories Affected

The total number of hectares owned or managed by the 456 questionnaire respondents was 1,579,323 ha and ranged from 0.01 ha to 242,820 ha per return. To facilitate comparisons, the land areas were placed into one of eight size classes (Table 1).

<table>
<thead>
<tr>
<th>Size Class (hectares)</th>
<th>Number of Landowners</th>
<th>Landowners (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20 (&lt;50)</td>
<td>55</td>
<td>12</td>
</tr>
<tr>
<td>21-40 (51-100)</td>
<td>67</td>
<td>14</td>
</tr>
<tr>
<td>41-101 (101-250)</td>
<td>104</td>
<td>23</td>
</tr>
<tr>
<td>102-202 (251-500)</td>
<td>86</td>
<td>19</td>
</tr>
<tr>
<td>203-404 (501-1000)</td>
<td>55</td>
<td>12</td>
</tr>
<tr>
<td>405-1214 (1001-3000)</td>
<td>44</td>
<td>10</td>
</tr>
<tr>
<td>1215-4047 (3001-10000)</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>&gt;4047 (&gt;10000)</td>
<td>26</td>
<td>6</td>
</tr>
</tbody>
</table>

A relatively even distribution of tract sizes was noted with 80 percent of the total number of properties smaller than 404 ha each.

Figure 1. The distribution of beaver (shaded area) in North Carolina as determined by a 1984 questionnaire survey of landowners. (Base map prepared by John Teel, U.S.G.S, Raleigh)
Respondents were asked to indicate land-use practices on their property. Of the 430 private landowner returns, crop production was checked by 285 people (66 percent); followed by timber production, 205 (48 percent); livestock, 113 (26 percent); and other 60 (14 percent). A majority of the property owners indicated their land was used for multiple commodity production.

Because beavers often forage over land to locate food and construction material, landowners were asked to estimate both the amount of area flooded (Table 2) and the total area affected by beaver activity. Timberlands comprised 2,718 ha (66 percent) of the 4,112 ha flooded by beavers on 238 tracts of land. Estimates from 89 respondents indicated a minimum of 1,045 ha of cropland flooded (25 percent of total).

<table>
<thead>
<tr>
<th>Land-Use Type</th>
<th>Number of Respondents</th>
<th>Total Hectares Flooded</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber</td>
<td>238</td>
<td>2,718</td>
<td>66</td>
</tr>
<tr>
<td>Crops</td>
<td>89</td>
<td>1,045</td>
<td>25</td>
</tr>
<tr>
<td>Pasture</td>
<td>62</td>
<td>231</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>31</td>
<td>118</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>430</td>
<td>4,112</td>
<td>100</td>
</tr>
</tbody>
</table>

1Includes power line right-of-way, roads, etc.

The total area affected by beavers, reported by 456 respondents, was 35,858 ha and represents about 2.2 percent of the total area owned and/or managed by the three groups surveyed (Table 3). A total of 9,196 ha was affected by beavers on the 430 private landowner tracts which was 7.8 percent of the land area owned by this group. Further analysis of area data from this group revealed individual tracts owned ranged from 0.4 ha to 6,070 ha and affected areas ranged from 0.004 ha to 607 ha \( (x = 21 \text{ ha}, \pm 2.9) \). A total of 464 kilometers (km) of stream and/or lake shoreline (range 0.01 km to 35.0 km) were estimated to be inhabited by beavers on 412 tracts.

Damage/Benefit Interactions Reported

Landowners were questioned about 17 potential interactions relating to benefits and/or damages received from the activity of beavers (Table 4).

<table>
<thead>
<tr>
<th>Potential Interaction</th>
<th>Number of Landowners AFFECTED</th>
<th>Percent of Landowners AFFECTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girdled Timber</td>
<td>314</td>
<td>73</td>
</tr>
<tr>
<td>Flooded Timber</td>
<td>226</td>
<td>51</td>
</tr>
<tr>
<td>Blocked Culverts</td>
<td>148</td>
<td>34</td>
</tr>
<tr>
<td>Flooded Crops</td>
<td>105</td>
<td>24</td>
</tr>
<tr>
<td>Fed on Crops</td>
<td>93</td>
<td>22</td>
</tr>
<tr>
<td>Flooded Roads</td>
<td>85</td>
<td>20</td>
</tr>
<tr>
<td>Damaged Fish Ponds</td>
<td>77</td>
<td>18</td>
</tr>
<tr>
<td>Flooded Pasture</td>
<td>59</td>
<td>14</td>
</tr>
<tr>
<td>Decreased Livestock Water</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Provided Waterfowl Hunting</td>
<td>126</td>
<td>29</td>
</tr>
<tr>
<td>Provided Aesthetic Enjoyment</td>
<td>116</td>
<td>27</td>
</tr>
<tr>
<td>Provided Fishing</td>
<td>57</td>
<td>13</td>
</tr>
<tr>
<td>Provided Recreational Trapping</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>Provided Irrigation Water</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>Increased Livestock Water</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>Monetary Return from Fur Sale</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Used Meat for Food</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. Number of private landowners indicating land-use types and area flooded by beaver in N. C.

Table 3. Summary of total hectares affected by beavers in North Carolina in 1983 by type of respondent group.

<table>
<thead>
<tr>
<th>Source (N)</th>
<th>Hectares Owned/Controlled</th>
<th>Hectares Affected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Landowners (430)</td>
<td>117,792</td>
<td>9,196</td>
</tr>
<tr>
<td>Timber Companies (26)</td>
<td>948,414</td>
<td>18,857</td>
</tr>
<tr>
<td>&quot;Misc.&quot; Groups (11)</td>
<td>513,117</td>
<td>7,804</td>
</tr>
<tr>
<td>Total</td>
<td>1,579,323</td>
<td>35,858</td>
</tr>
</tbody>
</table>
To encourage careful reading of each possible interaction, the types were inter-mixed on the survey form. Each possible interaction was checked by at least one respondent. Overall, more damage interactions were checked by a greater percentage of respondents than were benefit types. In particular, girdling and flooding of timber, two of the most readily observed activities of beavers, were reported by 73 and 53 percent of the landowners, respectively. Other significant damages reported included: (1) blocking of culverts (34 percent), (2) flooding of crops (24 percent), (3) feeding on crops (22 percent), (4) flooding of roads (20 percent), and (5) damage to fish ponds, usually by blocking the overflow pipe (18 percent).

Although most returns had one or more damage interactions checked, 126 landowners (29 percent) indicated they had utilized beaver ponds on their property for waterfowl hunting. Also, 116 respondents (27 percent) believed their resident beavers provided them with "aesthetic enjoyment." Fifty-seven landowners used their beaver ponds for fishing. Thirty-four returns had recreational trapping marked as a benefit; however, only eight respondents indicated receiving money from the sale of beaver pelts and even fewer (six returns) had utilized beaver as food.

Economic Impacts of Beavers

For an evaluation of the monetary impacts beavers were having in North Carolina, respondents were asked two questions: (1) "What was the estimated dollar damage caused by beavers on your property during the previous year (1983)?" and (2) "What was the estimated dollar damage for the total number of years beavers have been present on your property?". Of the 430 private landowner returns, 232 respondents (54 percent) gave usable answers (a numerical figure of $0. or greater) indicating damage in 1983 ranged from none to $40,000 per return and a total damage value of $303,230. For the total number of years beavers had been present on their property, 293 (68 percent) respondents estimated a total damage figure of $2.35 million with individual losses ranging from none to $400,000.

Landowners were also asked to estimate the monetary benefits believed to have been gained from beaver activity on their property. Only 15 responses (3 percent) indicated a dollar figure greater than $0. for benefits gained in 1983; the total figure was $21,920 with the range of estimates from $10 to $10,000. Similarly, just 27 landowners (6 percent) gave benefit estimates for total years on property of $170,800 (range $25 to $100,000). It was apparent during the compilation of both damage and benefit figures that a significant proportion of the respondents were either unable or unwilling to provide monetary estimates based on additional comments written on the forms.

Methods of Control

A total of 233 landowners attempted to reduce or eliminate their beaver population using one or more methods of control. The most common method utilized was trapping, with 145 attempts (62 percent) and 27 successes (19 percent) (Table 5). Shooting was the second most attempted (and successful) method of control indicated by 116 respondents. Although dynamite was utilized by one-third of those landowners trying at least one method, few had any success. Nine returns had "poison" marked as an attempted con-
trol but the exact substances used were not identified; apparently these landowners were unaware there are no poisons legally available at the present time for controlling beavers. Methods listed under "Other-successes" (Table 5) included the following: (1) live traps (including box traps), (2) persistent breaking of dams, (3) use of dogs to discourage the presence of beavers, (4) installation of electric fences, and (5) mechanical elimination of food and/or building materials. Of those landowners who attempted to control beavers by trapping, 52 percent used foothold traps and 48 percent used the #330 Conibear.

In response to the question "Do you wish to have beaver removed from your property?", 53 percent of the respondents stated they would prefer to have 'all' beavers removed but 24 percent indicated they wanted no removal. Sixty landowners (14 percent) were undecided. An additional seven percent of the total 428 who expressed their opinion on this question wanted some degree of population control. Of those desiring removal, 56 respondents stated they would be willing to pay an average of $13.84 per beaver (range $1 to $50) and $113.00 per affected hectare (range $24.71 to $370.65) for effective control. Fifty-one landowners indicated they would pay for removal of beavers from their property but did not state an amount.

When asked the question, "Would you be willing to devote some of your land to beaver and associated benefits such as waterfowl hunting, fishing and increased wildlife diversity?", 74 individuals (17 percent) responded positively and of these 54 (73 percent) indicated they would be interested in technical assistance in developing such an area.

DISCUSSION - MANAGEMENT IMPLICATIONS

Our survey has established that beavers have significantly extended their range and increased their populations in North Carolina during the past thirty years. Such a phenomenon has been recorded in many other Southeastern states but appears to have lagged in North Carolina until recently. We believe the environmental and economic impact of this expansion in North Carolina has not been fully realized. Although most river basins with suitable habitat now contain beavers, many of the animals have arrived during the past decade (primarily through natural dispersal) and saturation of available habitats has yet to occur.

Potential and realized losses of bottomland hardwood species may be extensive within the floodplains of the large river systems draining the Piedmont and Coastal Plain regions of North Carolina. Hundreds of hectares of seasonally-flooded lands are presently kept inundated throughout the growing season by beaver dams which are often less than 0.5 meters high. Effective beaver control in these areas is made more difficult by the extended foraging range of the animal. Where forestry and agribusiness production is intensively managed or human safety is involved, beaver numbers will have to be controlled. However, in areas where multi-use educational, environmental, and recreational benefits can be realized, beavers and their activities should be promoted as part of an overall management program.

Currently, the management of beavers in North Carolina is a multi-agency, cooperative effort between the N. C. Wildlife Resources Commission, the N. C. Agricultural Extension Service, the N. C. Trappers Association, and North Carolina State University. A variety of management options are made available to landowners emphasizing: (1) education and information exchange relating to ecology, benefits/damages, effective control methods for, and utilization of both the animal and its activities so that economically and environmentally responsible decisions can be reached, and (2) technical assistance in the form of on-site inspection of impacted areas and demonstration of optional management strategies including the forwarding of names of profes-
sional, licensed trappers when reduction or control of beaver numbers is desired.

LITERATURE CITED


