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Beaver lodge distributions and damage assessments in a forested wetland ecosystem in the southern United States

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Abstract

Caddo Lake, USA, a Ramsar Wetland of International Importance, is a lacustrine wetland complex consisting of stands of flooded baldcypress intermixed with open water and emergent wetland habitats. Recently, concern has been expressed over a perceived increase in the beaver population and the impact of beaver on the long-term sustainability of the baldcypress ecosystem. We used intensive beaver lodge surveys to determine the distribution and relative abundance of beaver and the amount, type, and distribution of beaver damage to mature trees and seedlings at Caddo Lake. A total of 229 lodges were located with a combination of aerial and boat/ground surveys. Most lodges were located in open water and edge habitats. About 95% of the lodges were occupied by beaver or nutria. Some form of damage was exhibited by one or more trees near 85% of the lodges. Intensive damage assessments around 35 lodges indicated that most damage to trees, baldcypress in particular, was restricted to peeling or stripping of bark which is believed to have minimal effect on tree survival. Surveys of regeneration indicated that baldcypress seedlings were very abundant; however, over 99.9% were less than 30 cm tall. The lack of recruitment into the larger size classes appears to be a result of high stand densities and water management practices. At this time, the young age and density of the baldcypress forests suggest that recruitment is not a major concern and herbivore damage appears to be having a minimal effect on the forest.

Keywords: *Castor canadensis*; *Taxodium distichum*; *Myocastor coypus*; exotic mammal; regeneration; animal damage

1. Introduction

Caddo Lake, USA, is a lacustrine wetland system located on the border of northeast Texas and northwest Lousiana (Fig. 1). The wetland complex consists of stands of flooded baldcypress (*Taxodium distichum*) trees intermixed with open water and emergent wetland habitats. The lake is considered the only naturally formed large lake in Texas (Russ, 1975). Because of its aesthetic value, uniqueness to the region, and the high-quality habitat the lake and associated wetland habitats provide for migratory birds, the publicly owned portions of the lake (Texas Parks and Wildlife's Caddo Wildlife Management Area and Caddo Lake State Park) were designated a Ramsar Wetland of International Importance.

Recently, local residents expressed concern over a perceived increase in beaver (*Castor canadensis*) damage to the baldcypress trees. The impact that

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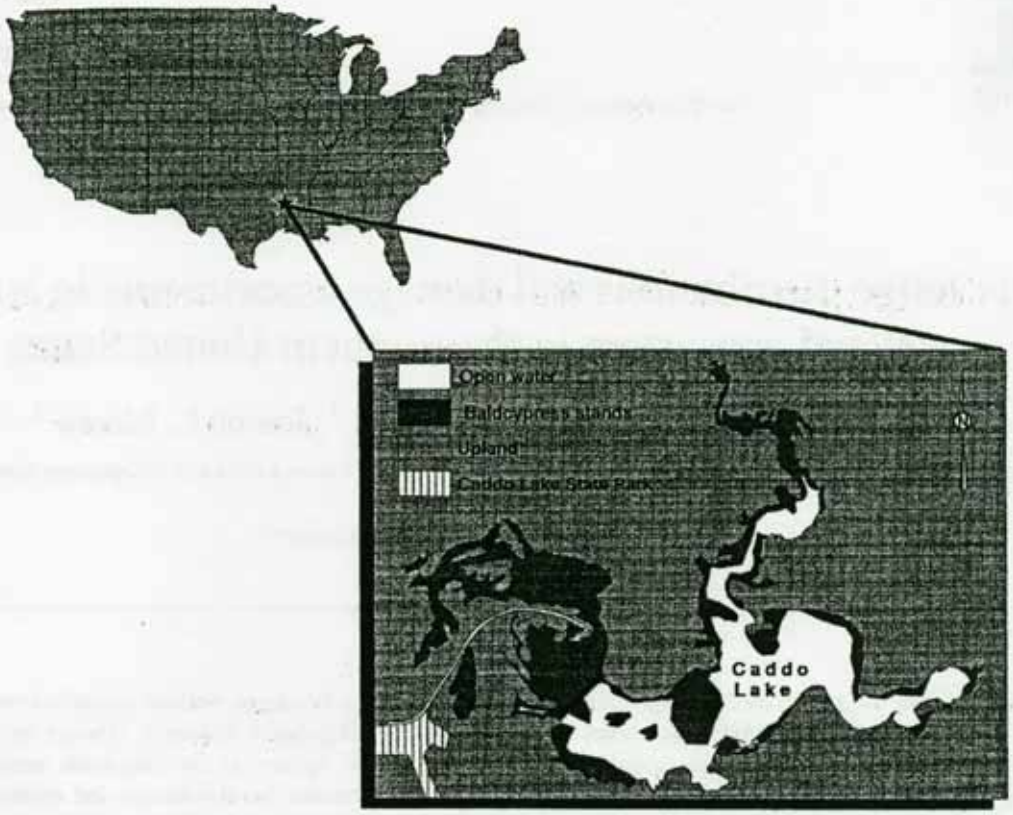

Fig. 1. Location of Caddo Lake, Louisiana and Texas, USA. Caddo Wildlife Management Area, owned and operated by Texas Parks and Wildlife Department, encompasses most of the area west of the bold line and north of the Caddo Lake State Park.

beaver can potentially have on their environment is well known. Novak (1987) noted that "no other animal in North America has such an obvious and dramatic impact on their environment as the beaver". In the southern United States, beaver damage to hardwood timber results in tremendous economic losses annually (Godbee and Price, 1975; Arner and DuBose, 1982).

Although the beaver is the most intensively studied furbearer in North America (Novak, 1987), no published studies have investigated beaver in southern lacustrine systems. Effective management and control of beaver requires an understanding of beaver habitat characteristics, beaver abundance and distribution patterns, and other population parameters (Yeager and Rutherford, 1957; Hill, 1982). The objectives of this study at Caddo Lake were to: (1) gather baseline information on the relative abundance of beaver; (2) determine the extent of beaver damage to trees, particularly baldcypress; and (3) assess the abundance and composition of tree regeneration and discuss implications for long-term management of the baldcypress forest.

2. Study area and methods

2.1. Study area

Caddo Lake has a drainage basin of about 7000 km^2 and a surface area of 10,850 ha when water levels are at the spillway elevation of 51.4 m national geodetic vertical datum (United States Army Corps of Engineers, 1992). Approximately 85% of the lake has been classified by the National Wetland Inventory (NWI) mapping program (United States Fish and Wildlife Service, National Wetlands Inventory Map, Potters Point LA–TX), with palustrine forested (59%) and lacustrine limnetic (37%) being

the dominant wetland types (Fig. 1). The tree component of the palustrine forested wetlands is dominated by baldcypress. Water elm (*Planera aquatica* Walt. ex J.F. Gmel.), buttonbush (*Cephalanthus occidentalis* L.), water lilies (*Nymphaea* spp.), hydrilla (*Hydrilla verticillata* (L.F.) Caspary), and water hyacinth (*Eichhornia crassipes* (Mart.) Solms) are other common plants. Dense mats of Spanish moss (*Tillandsia usneoides* L.) are frequently found on the branches and boles of the trees, particularly on baldcypress.

2.2. Lodge surveys

We assessed the relative abundance of beaver at Caddo Lake by using aerial surveys to determine the number of beaver lodges within various habitat types. Surveys were conducted in February 1995 when foliar canopy was at a minimum. Two observers simultaneously recorded sightings from a Cessna 172 flying at 152 m. Uniform coverage of the study area was achieved by following linear transects 1.2 km apart.

To provide a second estimate of beaver activity, we conducted two boat/ground surveys of Caddo Lake between May–September 1995 and June–November 1996. Dense stands of aquatic vegetation (e.g., water hyacinth, hydrilla, and buttonbush) prevented a complete survey; however, a significant portion of the lake ($\geq 90\%$) was surveyed each year.

At each lodge, the presence of beaver or other herbivores and the presence of herbivore damage were recorded. Lodges were classified as active or inactive based upon sightings and/or signs of activity (e.g., freshly cut sticks, fresh mud slides, tracks). The habitat surrounding each lodge was classified into one of five categories: (1) edge—less than 25 m from forest, bank, or open water; (2) open water—greater than 25 m from forest or bank edge; (3) forest—greater than 25 m into the forest from bank or open water edge; (4) canal—within a man-made canal; and (5) bank—on the bank of a canal.

2.3. Beaver damage to trees and seedlings

From July to September of 1995, 35 of 175 active lodges were randomly selected and the surrounding area was intensively assessed for beaver damage to surrounding trees and to determine the effects of beaver on forest structure. We identified and measured diameter-at-breast height (DBH) of all trees within a 10 m radius surrounding selected lodges. Beaver damage was recorded as follows: (1) none; (2) stripping or gnawing—bark had been peeled from the tree or the tree had been chewed on, respectively; and (3) felled—tree was cut down. No distinction was made between beaver damage and damage inflicted by other herbivores; however, this should only impact category 2 as nutria do not fell trees.

To assess damage to the surrounding forests, a series of three transects was established on the nearest shoreline from 30 randomly selected lodges. Each 30×4-m transect was oriented perpendicular to and centered on the shoreline. The first transect was established at the nearest point on land from the lodge; the other two transects were established parallel to and 50 m on either side of the first transect. if land was > 100 m away from the lodge, transects were established at a random azimuth and distance (0–100 m) from the lodge.

Species, DBH (trees only), and associated beaver damage were recorded for all trees and seedlings along the transects. Initially, height of seedlings was not recorded, but we refined or techniques in the field and seedlings were then classified into one of three height categories: Class I (0–0.3 m); Class II (> 0.3–1.0 m); and Class III (> 1.0 m tall; < 2.54 cm DBH).

3. Results

3.1. Lodge surveys

Only 22 beaver lodges were identified from the aerial surveys. The ground surveys, however, resulted in the identification of 175 beaver lodges in 1995 and an additional 54 lodges in 1996, for a 2-year total of 229 lodges. Lodges were most frequently located in open water (49.3%; $n = 111$ of 225 classified lodges) and edge habitats (30.7%; $n = 69$) (Fig. 2). Based upon sightings and signs, about 95% ($n = 217$) of the lodges were classified as active. A total of 122 beaver were observed at 61 different lodges over the two year period. In 1995,

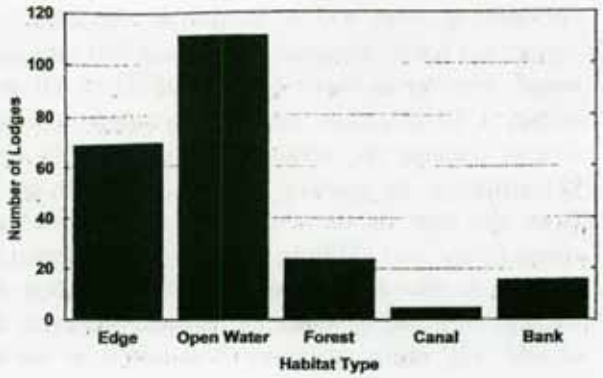

Fig. 2. Distribution of beaver lodges within habitat types at Caddo Lake, Louisiana and Texas, USA. Habitats were defined as follows: (1) Edge, < 25 m from forest, bank, or open water; (2) Open water, > 25 m from forest or bank edge; (3) Forest, > 25 m into the forest from bank or open water edge; (4) Canal, within a man-made canal; and (5) Bank, on the bank of a canal.

87 beaver were seen at 44 lodges. In 1996, only 35 beaver were seen at 22 lodges, but beaver were heard at 33 additional lodges. Nutria (*Myocaster coypus*) were also commonly observed. In 1995, 16 nutria were spotted at 5 lodges, but in 1996, 41 nutria were seen at 13 lodges. Twelve nutria, including ten kits, were observed at a single lodge in 1996. The difference in nutria numbers between 1995 and 1996 should not necessarily be interpreted as an increase in the nutria population, however, as it may simply be a result of more intensive searching for nutria and greater observer experience as well as other factors.

3.2. Beaver damage to trees

3.2.1. Circular lodge plots

Of the 175 lodges located in 1995, damage was present on trees within a 10-m radius at 84% of them. Greater than 50% of the trees at 12 of the 35 intensively studied lodges exhibited some type of damage. Baldcypress comprised 80.1% of the trees within a 10 m radius around the 35 beaver lodges; 61.6% of these trees ($n = 348$) exhibited no damage and < 1% ($n = 3$) were felled. For all species combined, 62.9% of the trees exhibited no damage and only 2.6% ($n = 18$) were felled.

3.2.2. Belt transects

A total of 1568 trees of at least 17 species (plus five unidentified specimens) were examined for damage along shoreline belt transects at 30 lodges. Nearly 82% of trees of all species had no damage and only 2.2% were felled. Of all the trees, 72.5% were baldcypress, most of which exhibited no damage. Water elm ($n = 217$), buttonbush ($n = 71$), and persimmon (*Diospyros virginiana* L.; $n = 61$) were the other major species (> 50 trees) on the belt transects.

3.3. Regeneration and stand structure

A total of 9669 seedlings of 23 species (plus 37 unidentified seedlings) were recorded on the shoreline belt transects. Of these, about 48.1% were classified into height categories. Baldcypress seedlings were encountered most frequently (55.3%), followed by water elm (22.2%), buttonbush (11.9%) and persimmon (4.9%). Relatively few seedlings (i.e., $n <$ 100) of other species were present. Of the 3661 baldcypress seedlings classified into height categories, 99.1% were Class I seedlings. Of the four most common species, only buttonbush and persimmon had > 50% of their seedlings in Class II and III height categories.

Overall, the shoreline stands had a mean density of 1361.6 ± 1112.2 stems/ha (mean $\pm$ 1 s.d.) and a basal area of 58.6 ± 31.4 m^2/ha. Baldcypress trees located within the belt transects had a distinctly unimodal diameter-frequency distribution with the greatest concentration of trees in the 10–15 cm size

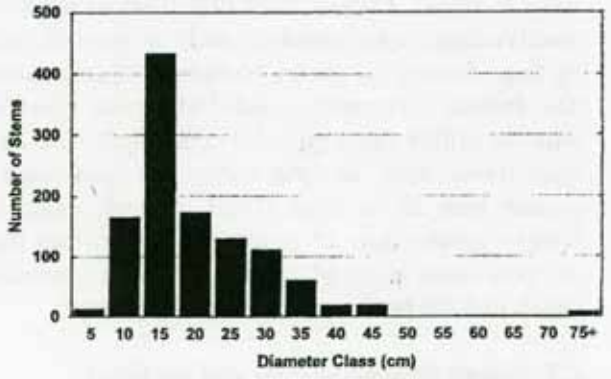

Fig. 3. Diameter-size class distributions for baldcypress trees (*Taxodium distichum* (L.) Richard) located at Caddo Lake, Louisiana and Texas, USA. Trees were censused at 32 lodges along 3 belt transects (30 m × 4 m) established on the nearest shoreline from each lodge.

class. Baldcypress was poorly represented in the sapling size class and size classes larger than 50 cm DBH (Fig. 3). This type of size class distribution is common among shade intolerant and/or even-aged tree populations (Lorimer and Krug, 1983).

4. Discussion

Our poor success with aerial surveys relative to boat/ground surveys is disappointing but not surprising. Aerial surveys have been used in northern regions to provide a rapid, accurate, and relatively inexpensive assessment of densities of beaver populations (Hay, 1958; Robel and Fox, 1993). The results of these surveys, however, are often highly variable because of differences in pilot and observer experience, type of plane used, canopy coverage, altitude, and other factors (Novak, 1987). The poor success with aerial surveys in our study was likely a result of a combination of factors with canopy coverage, the presence of dense mats of Spanish moss and altitude being very important. As noted from the habitat classifications, most lodges were located in flooded cypress habitats. Even with no leaves on the trees, branches from the trees and Spanish moss likely occluded lodges from the view of observers at an altitude of 152 m.

The beaver population at Caddo Lake is well-established and is inflicting minor, but highly visible, damage to the baldcypress trees and seedlings. Beaver damage to mature trees was extensive, although the damage was seldom intensive around any given lodge. Most damage was restricted to stripping or gnawing of the bark which is thought to have little impact on tree survival (Chabreck, 1958). In bottomland hardwood trees (e.g., various *Quercus* spp., *Liquidambar styraciflua* L., *Celtis laevigata* Willd.), bark removal by beaver can result in heart rot which weakens the trees and reduces their timber value, but observed mortality rates of beaver-damaged trees are still relatively low (Toole and Krinard, 1967). Bark stripping and gnawing is highly visible at Caddo Lake because the cambium of baldcypress is bright yellowish-white and creates a vivid contrast with the dark bark even at great distances. Since most of the lodges were located at the edge of open water and forested habitats, lodges and associated tree damage are easily and frequently observed by the public. Furthermore, damage around a beaver lodge was usually not confined to the area immediately around a lodge. Damaged trees were often found scattered throughout the lake. As a result of the type, visibility, and widespread distribution of damage around the lake, the intensity and impact of beaver damage to the baldcypress trees can be overestimated by casual observation.

The effects of beaver on the baldcypress forest at Caddo Lake appear to be minimal at this time. Our regeneration data indicate that baldcypress seedlings are abundant and few are damaged by beaver and nutria. The lack of seedlings within larger size classes and saplings in the smallest diameter class, however, indicates constraints on regeneration. Successful regeneration of baldcypress requires an adequate seed sorce, overhead light, a moist seed bed, and an absence of herbivory (Mattoon, 1915; Demaree, 1932; Conner et al., 1986). Furthermore, the seedlings must have sufficient height to prevent being overtopped by floodwaters, as complete submergence for even 2–3 days during the growing season can result in near total mortality (Williston et al., 1980). We believe the relatively young, dense forest stands (Keeland, unpublished data) and the water management practices at Caddo Lake are the major factors affecting baldcypress recruitment at this time. Baldcypress is a shade-intolerant species (Wilhite and Toliver, 1990) and the stand densities and basal areas we observed at Caddo Lake suggest that lack of light may be limiting recruitment of saplings. Furthermore, while the lake's water level generally reaches an annual low during late summer (i.e., August–September) providing an excellent seed bed for germination of baldcypress seeds, the mean water level gradually increases throughout the fall and winter by up to 0.46 m (Fig. 4; unpublished data, USACOE), which would submerge most of the existing seedlings.

The effects of water-level management and light availability on baldcypress regeneration may have masked the potential impacts of beaver and nutria on baldcypress recruitment. Beaver damage to saplings was seldom observed, but saplings were also scarce. Results of experimental studies at three separate sites on the lake, however, indicate that about 86% of planted baldcypress saplings that were not protected with tree protectors were either missing or killed by

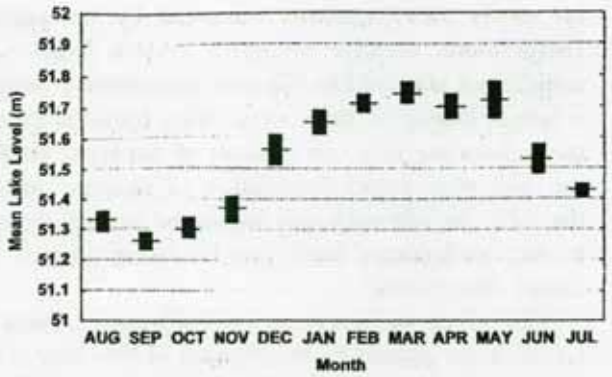

Fig. 4. Mean monthly lake levels (±1 S.E.) for Caddo Lake, Louisiana and Texas, USA from 1959–1996.

beaver or nutria after a 2-year period (Keeland, unpublished data).

The impacts of nutria on baldcypress regeneration may have been underestimated in our study. Nutria can decimate baldcypress regeneration and are a major factor limiting baldcypress regeneration in swamp forests of Louisiana (Conner et al., 1986; Conner and Toliver, 1990; Myers et al., 1995). Nutria damage to baldcypress most frequently consists of pulling up the seedlings and eating the bark from the tap root, although they will occasionally clip the seedlings (Blair and Langlinais, 1960; Conner et al., 1986). Clipped seedlings would have been captured by our sampling techniques; however, uprooted seedlings would likely have been overlooked unless they were uprooted a few days prior to sampling.

5. Management implications

At this time, the young age and density of the baldcypress forests suggest that recruitment is not a major concern and herbivore damage appears to be having a minimal effect on the forest. However, as the forest ages and/or natural disturbances create canopy openings, regeneration and recruitment will become more important for forest maintenance. We recommend the establishment of nutria/beaver exclosures at various elevations within high and low light environments. Long-term monitoring of natural and planted baldcypress regeneration within and outside exclosures would enhance our understanding of beaver, nutria, light, and flooding effects on baldcypress regeneration and would facilitate the development of long-term management plans for the Caddo Lake ecosystem. Beaver and nutria population densities should be monitored every 3–5 years to ensure detection of damage that exceeds acceptable limits and to facilitate the timely implementation of management actions.

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References

Arner, D.H., DuBose, J.S., 1982. The impact of beaver on the environment and economics in the southeastern United States. Int. Congress of Game Biol. 14, 241–247.

Blair, R.M., Langlinais, M.J., 1960. Nutria and swamp rabbits damage baldcypress plantings. J. Forestry 58 (5), 388–389.

Chabreck, R.H., 1958. Beaver-forest relationships in St. Tammany Parish, Louisiana. J. Wildlife Manage. 22 (2), 179–183.

Conner, W.H., Toliver, J.R., Sklar, F.H., 1986. Natural regeneration of baldcypress (*Taxodium distichum* (L.) Rich.) in a Louisiana swamp. For. Ecol. Manage. 14 (4), 305–317.

Conner, W.H., Toliver, J.R., 1990. Long-term trends in the baldcypress (*Taxodium distichum*) resource in Louisiana (USA). For. Ecol. Manage. 33–34 (1–4), 543–547.

Demaree, D., 1932. Submerging experiments with *Taxodium*. Ecology 13 (3), 258–262.

Godbee, J., Price, T., 1975. Beaver damage survey. Georgia Forestry Commission.

Hay, K.G., 1958. Beaver census methods in the Rocky Mountain region. J. Wildlife Manage. 22 (4), 395–402.

Hill, E.P., 1982. Beaver. In: Chapman, J.A., Feldhammer, G.A. (Eds.), Wild Mammals of North America. John Hopkins Univ. Press, Baltimore, pp. 256–281.

Lorimer, C.G., Krug, A.G., 1983. Diameter distributions in even-aged stands of shade-tolerant and midtolerant free species. Am. Midland Naturalist 109 (2), 331–345.

Mattoon, W.R., 1915. The southern cypress. United States Department of Agriculture Bulletin 272.

Myers, R.S., Shaffer, G.P., Llewellyn, D.W., 1995. Baldcypress (*Taxodium distichum* (L.) Rich.) restoration in southeast Louisiana: The relative effects of herbivory, flooding, competition, and macronutrients. Wetlands 15 (2), 141–148.

Novak, M., 1987. Beaver. In: Novak, M., Baker, J.A., Obbard, M.E., Malloch, B. (Eds.), Wild Furbearer Management and Conservation in North America. Ministry of Natural Resorces, Toronto, pp. 283–312.

Robel, R.J., Fox, L.B., 1993. Comparison of aerial and ground survey techniques to determine beaver colony densities in Kansas. Southwestern Naturalist 38 (4), 357–361.

Russ, D.P., 1975. The quaternary geomorphology of the lower Red River Valley, LA. PhD Dissertation, The Pennsylvania State University, State College, PA.

Toole, E.R., Krinard, R.M., 1967. Decay in beaver-damaged southern hardwoods. For. Sci. 13 (3), 316–318.

United States Army Corps of Engineers, 1992. Waterwise: The newsletter of the Shreveport to Daingerfield Study, Vols. 1–6. U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, MS.

Wilhite, L.P., Toliver, J.R., 1990. *Taxodium distichum* (L.) Rich. In: Burns, R.M., Honkala, B.H. (Technical Coordinators). Silvics of North America: 1. Conifers. United States Department of Agriculture, Forest Service Handbook. 654, pp. 563–572.

Williston, H. L., Shropshire, F.W., Balmer, W.E., 1980. Cypress management: a forgotten opportunity. United States Department of Agriculture, Forest Service, Forestry Report SA-FR-8, Atlanta.

Yeager, L.E., Rutherford, W.H., 1957. An ecological basis for beaver management in the Rocky Mountain region. Trans. North Am. Wildlife Conference 22, 269–299.