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Title: Habitat Requirements of Wood Duck broods on Rivers

Abstract approved: Robert F Clarke

Habitat requirements of Wood Duck broods on rivers were studied from May through August of 1978 and 1979 on the Neosho River in east-central Kansas. Forty-seven percent of the total ducks observed were flightless juveniles. Average brood size was 5.6 with a mean density of 0.24 broods/mile. The estimated rate of brood survival was 50.9%. Protective vegetative cover and rate of water flow were primary limiting factors on productivity in the study area. Slope of the bank was critical in areas where there was no protective cover available on the water. Preferred brood cover was slow, quiet pools of water combined with closely overhanging vegetative cover. Dead drift, exposed roots, and bankside vegetation were substituted in the absence of overhanging vegetation. The rapid release of water in July from Council Grove Reservoir was detrimental to brood survival. Young trees near the water's edge were half-cut in an attempt to produce brood cover. These cuttings were utilized immediately by broods but were not believed to be practical because of their temporary nature. It is believed the planting and pruning of Black Willow shoots along the bank will produce permanent, excellent brood cover.

HABITAT REQUIREMENTS OF
WOOD DUCK BROODS ON RIVERS

A Thesis
Submitted to
the Division of Biological Sciences
Emporia State University

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INTRODUCTION

The purpose of this research was to investigate the habitat requirements of Wood Duck (*Aix sponsa* L.) broods on rivers and streams in Kansas. Preferred habitat was identified and evaluated with reference to estimated duckling survival and movement. Efforts were also made to provide brood cover in areas where the lack of such cover seemed to be the limiting factor on production.

The study was conducted on a 14 mile section of the Neosho River in Lyon County in east-central Kansas. The study area was typical of rivers and major streams that occur in the eastern one-third of the state. The period of study began in early May and continued through late August of 1978 and 1979.

This study was conducted because many vital components of prime brood habitat, as reported by Webster and McGilvrey (1966), McGilvrey (1968), and Hester and Dermid (1973), are not available to Wood Duck broods on Kansas waterways. On major watercourses in the state there is little or no emergent vegetation, and there are few shrubs that grow out over the water surface. Despite this fact, there are a great many Wood Duck broods raised on these rivers and streams, and information indicates the state population is still expanding (Schwilling, 1978). Therefore, adequate substitution of these missing habitat components is made by the hen and her brood.

Bellrose (1978) listed three major breeding populations of the Wood Duck -- the Atlantic, the Interior, and the Pacific (Fig. 1). Kansas is one of 28 states listed as breeding areas of the Interior population. The number of Wood Ducks nesting in Kansas is low in comparison with those found in other states; the state is considered a marginal breeding area. Comprising less than 3% of the annual harvest, the Wood Duck is not one of the major migratory game birds in Kansas (Kraft, 1978). However, it is by far the most abundant nesting duck in the state (Kraft and Schwilling, 1978). The Wood Duck occurs in the eastern two-thirds of Kansas, with the primary breeding area restricted to the eastern one-third of the state.

Various aspects of the life history of the Wood Duck have received long-term study (Stewart, 1957; Decker, 1959; Grice and Rogers, 1965; Trefethen, 1966; Brown, 1973; Hester and Dermid, 1973). When the population of this bird began dwindling in the early 1900's, naturalists expressed fear that the fate which befell the Labrador Duck and the Passenger Pigeon would also overtake the Wood Duck. Completely protected from 1918 to 1941, the Wood Duck has since recovered to be a major migratory game bird of the eastern United States (Bellrose, 1976; Anderson, 1977).

Research has been conducted on the behavior and habitat needs of Wood Duck broods (Sowls, 1955; Beard, 1964; Webster and McGilvrey, 1966; Baker, 1971), but only a small portion has been concerned with broods on streams and rivers or

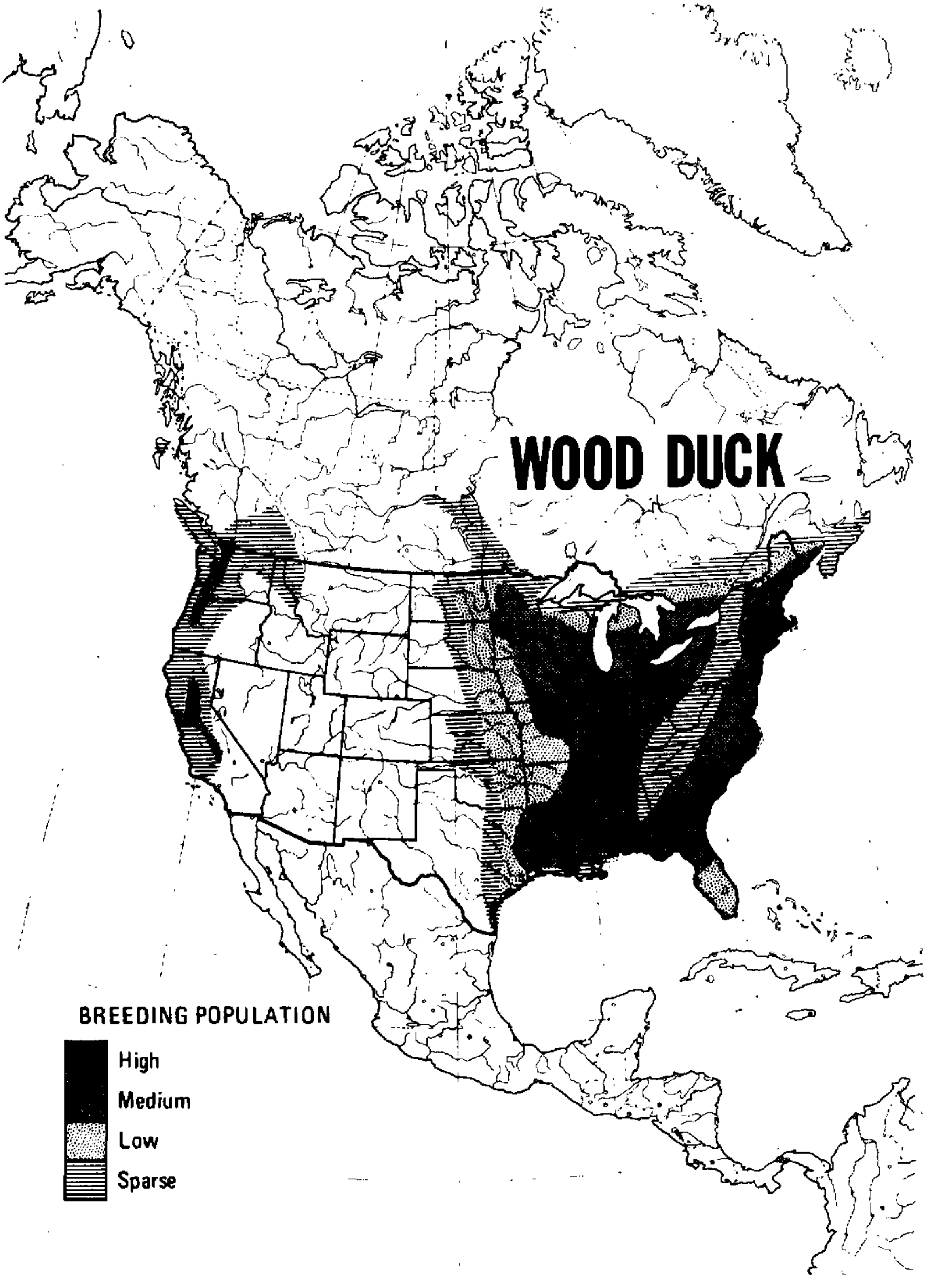

Fig. 1. Distribution of Wood Duck breeding population (from Bellrose, 1978).

with areas west of the Mississippi River (McGilvrey, 1968; Minser, 1968). With the exception of a few studies conducted by the waterfowl section of the Kansas Fish and Game Commission, no literature sources were found concerning Wood Duck broods on rivers in Kansas.

DESCRIPTION OF THE STUDY AREA

The Neosho River headwaters are in the Flint Hills uplands of Morris and Wabaunsee counties in east-central Kansas. Flowing southeasterly through the state, the river eventually empties into the Arkansas River northeast of Muskogee, Oklahoma.

The study area was a 14 mile section of this river in Lyon County, Kansas. This is the same portion of the river used by the Kansas Fish and Game Commission as part of its Wood Duck Stream Float Survey. The upstream boundary was two miles west of the town of Americus where the Neosho flowed under a county road, and was thereby easily accessible. The downstream boundary was near the water pumping station at the northwest edge of Emporia (Fig. 2).

In general, the riparian environment of the study area was similar to that of other major watercourses in the state (Fig. 3). Mature deciduous trees, such as Cottonwood (*Populus deltoides*), Sycamore (*Platanus occidentalis*), Black Willow (*Salix nigra*), and Box Elder (*Acer negundo*) were predominant throughout the area. There was also a variety of low growing shrubs and grasses. No emergent aquatic vegetation occurred, but during periods of high water some of the bankside vegetation became partially inundated.

The density and distribution of vegetation varied widely throughout the study area. There were large areas

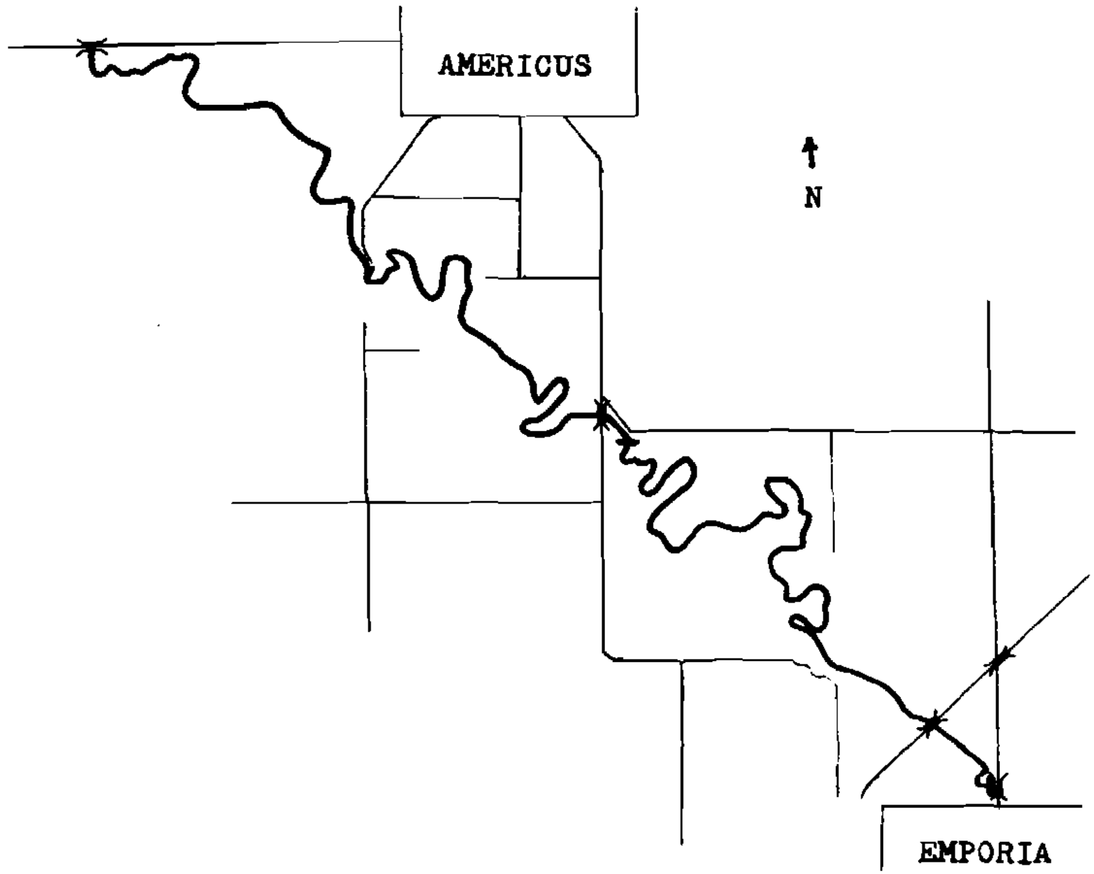

Fig. 2. Map of Neosho River study area in Lyon County, Kansas.

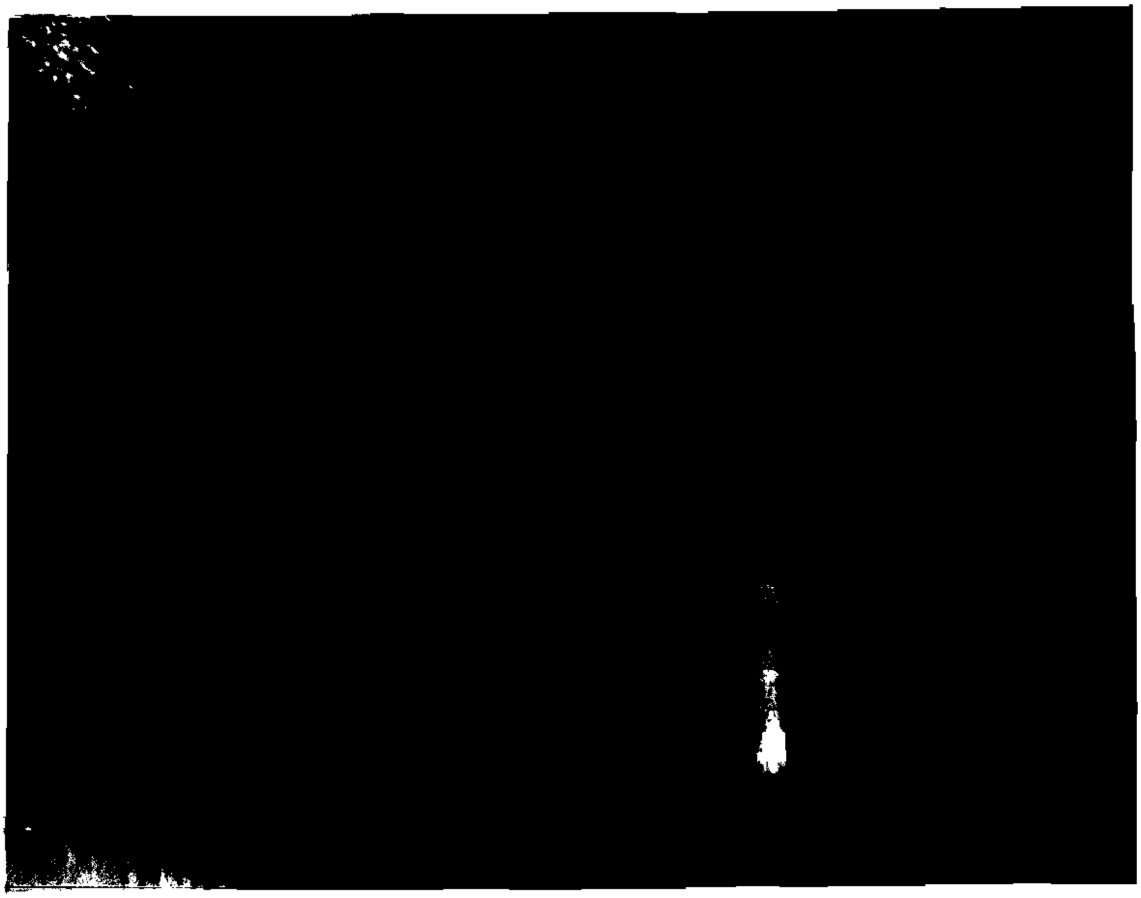

Fig. 3. Typical riparian environment of the study area.

of thick woods with a heavy understory that extended several hundred yards on either side of the river. Woodlots composed of mature trees, but with little grass or shrub growth, were often found in close proximity to farm houses or in areas from which cattle had not been restricted.

The riparian environment had suffered detrimental effects from clean farming. There were portions of the study area where a few scattered trees and shrubs were all that remained between the river and cultivated fields or pastures. Cleared areas were common on either one side of the river or the other, but there were no areas in which both banks had been stripped in such a manner.

The course of the river, amount of vegetative growth, effects of human activity, and presence of cattle influenced the condition and slope of the bank. Tall and eroded mud banks were often found at a sharp turn in the river. When a straight course was followed, banks covered with grasses and shrubs usually sloped gently into the river. Erosion often caused the bank to drop off at an obtuse angle near the water's edge in areas of sparse vegetation.

At two different points in the study area, the bank had been graded to allow vehicular access to the river. Old cars, dishwashers, stoves, concrete, and other junk items had been dumped in some areas in an effort to control erosion. Trash dumping also occurred in areas where nearby roads provided easy public access or where farm house residents disposed of their waste.

Cattle had access to the river channel at several locations in the study area. Trampling and heavy grazing resulted in the elimination of all low growing vegetation near the river in many of these locations. The walking and sliding of cattle in the soft, moist soil also altered the natural slope of the bank near the water's edge.

Water flow varied between sluggish, deep pool areas with depths of four to 20 feet, and swift, shallow riffles, two to 12 inches deep. Substrate in the riffle areas was usually cobble mixed with sand and silt. In other portions of the study area substrate varied between hard-pan mud bottoms and slabs of rocks or boulders from limestone outcroppings.

As with all major watercourses in Kansas, the flow of the Neosho River had been 'controlled' with man-made impoundments. Two reservoirs were constructed on the Neosho by the U. S. Corps of Engineers. Council Grove Reservoir was approximately 20 miles upstream from the study area, and about the same distance downstream was John Redmond Reservoir. Council Grove Reservoir had a profound effect upon the water level in the study area. High water from rains was buffered by the temporary impoundment and gradual release of runoff. However, during July the reservoir water fluctuation program conducted a drawdown which resulted in water levels in the study area raising as much as two to five feet. Water flow during this period was extremely rapid and produced a scouring effect in the river channel.

There was more total rainfall during the spring and summer of 1979 than in 1978 (Table 1). This resulted in higher water levels throughout most of the study period (Fig. 4), and the release of a greater volume of water from Council Grove Reservoir during the drawdown in the summer of 1979 as opposed to 1978. The varying water level caused many changes in physical features, such as bank conditions at the water's edge and the number of quiet pools throughout the study area.

There was a variety of obstructions encountered along the course of the river in the form of drifts and log jams of different sizes. Some were small and extended only partially into the river channel, while others blocked the entire watercourse. Trees sometimes fell across the river channel, impairing both water flow and passage. Periods of high water often changed the location and composition of the drifts, jams, and fallen trees.

A series of low water dams was constructed in the 1910's as checks to the water flow of the Neosho River. One of these was one mile upstream, and two others were within the boundaries of the study area. Upstream, one or two miles from these low water dams, the approaching water became sluggish, causing the river channel to widen. The river was found to be shallow and swift for several miles below each of the dams.

Evidence of human activity was prevalent throughout the study area. Several farm houses were located close to

Table 1. Precipitation in inches recorded at Federal Aviation Administration office -- Emporia Municipal Airport.

MONTH	1978	1979
April	5.23	2.45
May	2.53	2.18
June	2.51	8.06
July	0.49	7.37
August	2.17	1.40

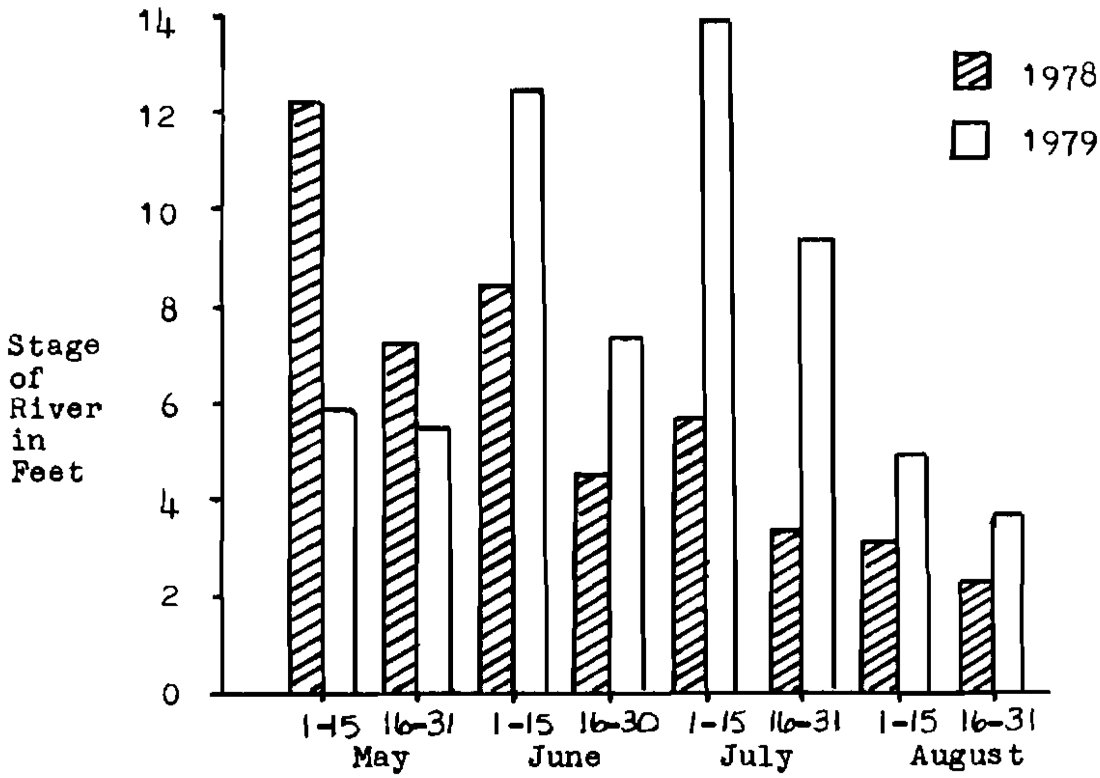

Fig. 4. Mean stage level at Plymouth Station on Neosho River -- 1978 vs. 1979.

the river channel; some were abandoned, but most were occupied. Several roads either crossed or passed close to the study area. These ranged in size and use from an abandoned county road to the Kansas Turnpike.

There was prevalent use of the study area by fishermen throughout the summer. Some fished from the bank while others set limb lines which were checked with motorized john boats. Travel in such boats was noisy and disruptive to the aquatic environment but was restricted to small areas of the river by riffles, drifts, and low water dams.

Near the downstream boundary, the Neosho had been straightened and channelized during the construction of the Kansas Turnpike in 1955. This channel was nearly half a mile long and was bordered primarily by stands of Black Willow. The channel was wide and flow was sluggish, due to the presence of a low water dam less than one mile downstream.

METHODS AND MATERIALS

Research was conducted during the period May 1 through August 31 of 1978 and 1979. These dates encompassed the normal annual brooding period of the Wood Duck in the midwest (Goss, 1891; McGilvrey, 1968; Bellrose, 1978). It is during these months that flightless juvenile ducks must rely upon the existing water conditions for their needs of water, food, cover, and loafing areas. Once sustained flight is achieved, the former strong dependency upon these conditions is either greatly reduced or absent. Observations began before broods were on the water and ended when flightless juveniles were no longer found.

Observations were made during early morning float trips down the river in an aluminum canoe. This technique had been used by other researchers for observing and estimating populations of Wood Ducks (Hardister, et al, 1965; Minser, 1968; Kraft, 1978). Progress downstream was made by either paddling, use of an electric trolling motor, or both. It was necessary to portage around obstructions such as drifts, jams, and low water dams when passage was otherwise impossible.

Trips were started as soon as there was enough light to see adequately in the river environment. This time was usually 15 to 30 minutes before sunrise, depending upon cloud cover and fog. Trips were made alone or with one or two additional observers when possible. Initially, trips were made every five to seven days, but this schedule was changed to approximately once every two weeks. Sufficient data could be collected after this change, and the possibility of harassment and increased brood mortality was reduced.

Data were collected and recorded on a standard sheet (Appendix I) which accompanied a detailed map of the study area. The time, air and water temperature, wind conditions, and cloud cover were recorded at the start and finish of each trip. A pair of 7 X 50 binoculars was used, when feasible, for sex identification of some adult birds, but it was found that direct observation was more convenient and just as accurate under most circumstances.

The sighting of either juveniles, adults, or both was recorded, and the number of that sighting (as shown on the data sheet) was marked on the map at that location. When only adults were sighted, their number, sex, and time of the sighting were recorded. A greater amount of data was recorded each time a brood was encountered. Time, number of juveniles in the brood, and the number and sex of any accompanying adults were recorded. Age of the ducklings was estimated by noting individual size and both the undisturbed and pursued behavior of the brood. This technique is based on a field method of aging Wood Duck broods detailed by Dreis (1954).

Preferred brood habitat was determined by recording the type of nearby vegetation, the proximity of this vegetation to the water, water velocity, slope of the bank, and other pertinent information concerning the river environment in the immediate vicinity of the brood sighting.

A list of birds and mammals seen during the float trips was compiled at the end of the study (Appendix II). The recorded data described above were compiled for each summer and compared with each other and with information obtained from literature sources. A student T-test at p=.05 was used to analyze data statistically where applicable.

In the spring of 1979 a program of habitat manipulation was undertaken in an attempt to increase productivity in the study area. The fourth quarter of the study area was chosen as the target area for the program. It was hoped that production could be encouraged by providing artificial nesting habitat and by creating brood cover.

Twelve nest boxes were constructed of weathered barn siding by selectively combining portions of detailed plans published by Bellrose and Crompton (date unknown) and the U. S. Fish and Wildlife Service (1976). Plans from the latter source are provided in Appendix III. The finished nest boxes were placed on mature trees at various locations throughout the study area (Fig. 5). Since Wood Ducks have been reported to nest in close proximity when given the opportunity, eight of the boxes were placed in the target area in two clusters of four boxes each, within 100 yards of each other (Fig. 6).

Fig. 5. Nest box constructed of weathered barn wood.

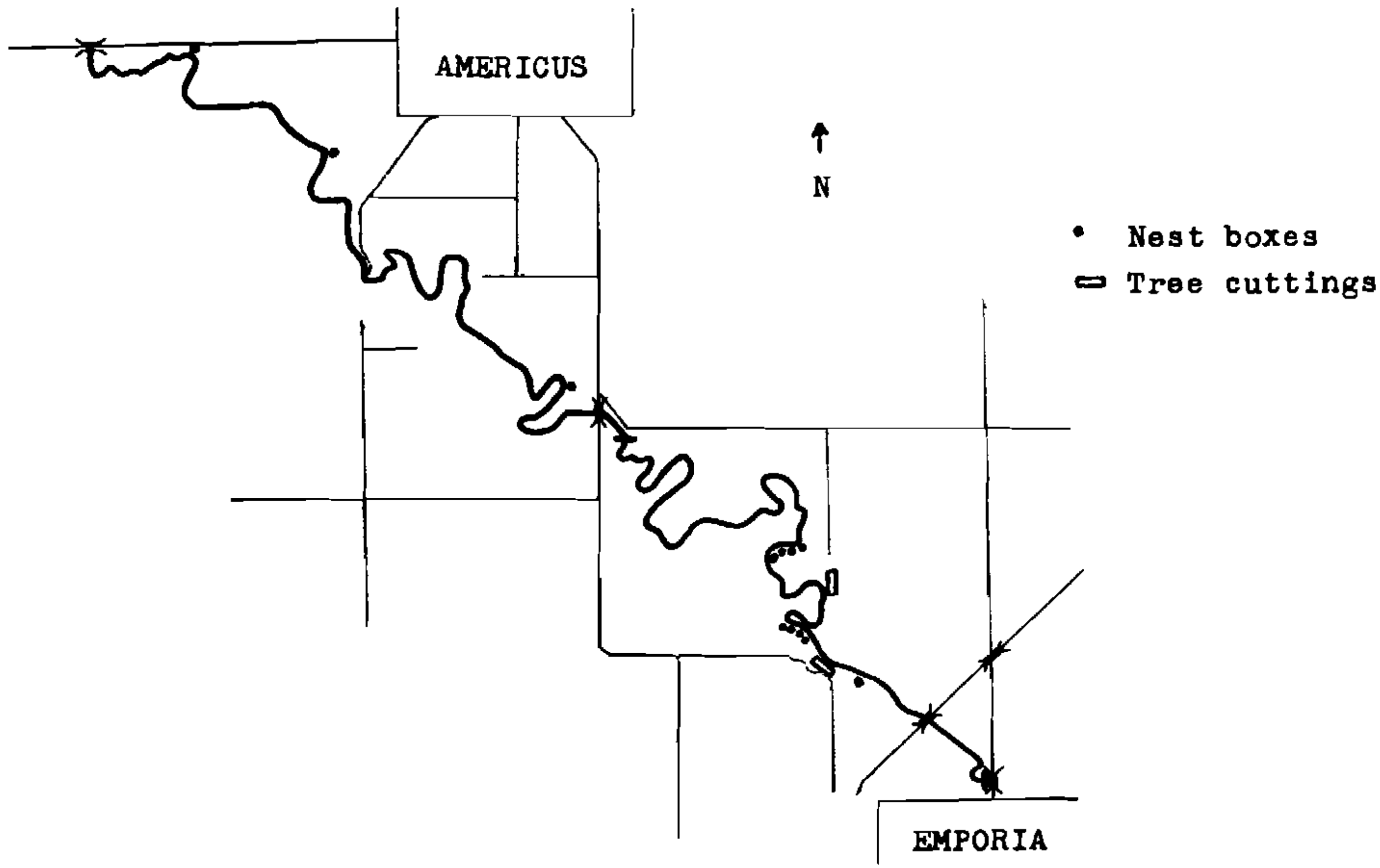

Fig. 6. Location of nest boxes and tree cuttings in Neosho River study area.

Young trees, up to nine inches in diameter and near the water's edge, were half-cut in an attempt to create brood cover. Trees were cut in a manner that caused them to fall on the water, resulting in a tangle of leaves, limbs, and other vegetation (Fig. 7). By half-cutting the trees, it was hoped they would remain alive and thus provide cover for several generations of Wood Duck broods. Two clusters of this type of brood habitat were created at separate locations in the target area (Fig. 4). Tree species that were chosen for cutting were Black Willow, Box Elder, and Sycamore. These species were abundant in a variety of growth stages and provided much leafy vegetative cover when laid over on the water surface.

Fig. 7. View from river bank showing trees after half-cutting.

RESULTS

Eighteen float trips, lasting from three to six hours in duration, were made during the period of study. The average length of time for each trip was just under five hours. The total time involved was 48 hours in 1978 and 36 hours in 1979.

Approach of the canoe caused the brood to flee toward protective cover. Methods used to escape pursuit varied between broods of different ages. Class I broods (0-2 weeks old) skittered as a group across the top of the water or dived and surfaced in or near cover. Stewart (1958b) found that one-day-old Wood Ducks had substantial locomotory ability and that ducklings stayed submerged as long as 13 seconds and traveled as far as 16 feet under the water. Skittering across the water was also believed to be a valuable escape method, with day-old ducklings attaining a velocity of nearly six miles an hour over a distance of 17 feet.

Class II broods (2-4 weeks old) scattered as they swam toward the bank, then either hid in exposed roots or ran on the bank into vegetation. Ducklings of this age did not stay in such a tight group when fleeing the canoe's approach as did the younger ducks, and neither did they do as much diving. If escape cover was not immediately available, the ducklings swam low in the water near the bank and remained as inconspicuous as possible.

Class III broods (4-6 weeks and older) that could not yet fly reacted to the canoe's approach in much the same manner as Class II broods. However, at six to seven weeks of age juveniles had developed the ability to fly short distances and utilized flight as their means of escape. Eight to 10 weeks is the average age at which Wood Ducks achieve sustained flight (Bellrose, 1978).

Regardless of age, if a flightless brood was accompanied by a hen, she usually feigned injury in an apparent attempt to draw the intruder's attention away from the brood as it fled for cover. The female accomplished this by repeating a distress call while thrashing the water with her wings and swimming a serpentine path in front of the canoe. This act continued downstream until the canoe was well past the concealed brood, at which time the hen 'recovered' and flew away. If the canoe returned to the general area of the brood, the hen also returned and began her act anew. Several times hens exhibited this 'broody' behavior when no young were observed. In such instances it was assumed there were broods hidden closeby. Injury feigning has been documented in the Wood Duck and also in several species of puddle ducks (Saunders, 1937; Sowls, 1955; Stewart, 1958a; Hester and Dermid, 1973).

Generally, the amount of injury feigning seemed to be dependent on the quality and accessibility of brood cover, as well as the age of the brood. If the brood was in or near good cover, the hen performed her act for only a short distance (10-50 feet). However, if a brood was discovered in an area devoid of cover, the hen often feigned injury for several hundred feet downstream. As the summer progressed and the average age of broods increased, less time and energy were devoted to injury feigning by most hens.

Upon approaching one brood of four ducklings, just as the hen began to feign injury, a second hen flew from the woods and joined the first. They continued their simultaneous display until the brood was concealed. The hens then flew off in different directions. Although no record of this behavior was found in the literature, Clawson (1975) reported two hens that incubated the same clutch, called from the nest, and swam off with a single brood.

A total of 633 Wood Ducks was observed during the two year study. Of this total, 300 (47.4%) were flightless and assumed to be juveniles. Although the method used to record data made it difficult to distinguish Class III ducklings from molting adults, it was presumed that no molting adults occurred in the study area. This presumption is based on Stewart (1958a), who stated that in early June adult males congregated in large groups and moved to remote and densely vegetated areas to molt. The molting period for females occurred at a later date than that of the males, usually late summer, and they too sought areas that were more secluded than most portions of the study area.

Peak numbers of flightless ducks were observed during the latter half of June (Fig. 8). Generating a parabolic

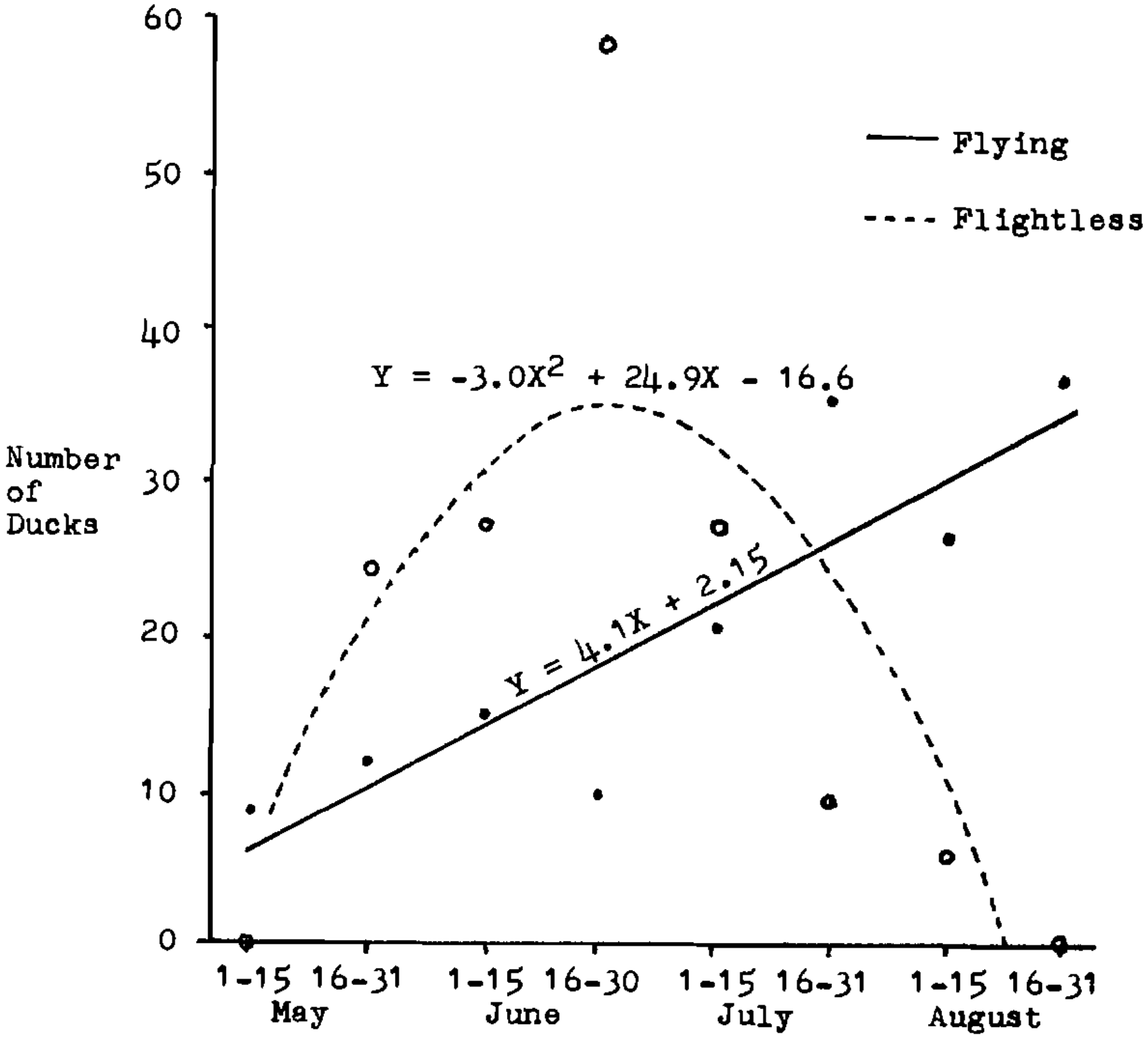

Fig. 8. Average number of flying vs. flightless ducks observed per trip -- 1978 and 1979.

curve, their numbers increased from early May to mid June and then declined from early July through August. Numbers of flying ducks in the study area gradually increased as the summer progressed.

A pair of Mallard ducks was observed several times in 1978. Although Mallards are known to breed in the state, this pair was never seen with a brood. They flew if closely pursued, but were always initially sighted in the same vicinity.

A greater number of Wood Ducks of all ages was observed in 1979 than in 1978, despite the fact that fewer float trips were made during the summer of 1979 (Fig. 9). Peak numbers of ducks were found in late June and early July of both years, the period during which maximum numbers of juveniles were observed. Numbers of ducks observed diminished sharply during July and August of both years. Although differences between the two years were almost double in some categories, there was no difference at the p=.05 level of significance.

Seventy-three (21.9%) of the flying ducks observed were positively identified as males, while 104 (31.2%) were females. The remainder were unidentifiable, either due to their flushing range or because they were juveniles. At p=.05 the difference between numbers of males and numbers of females was not significant.

Table 2 presents data regarding the density of total ducks and broods. Although the mean values of all

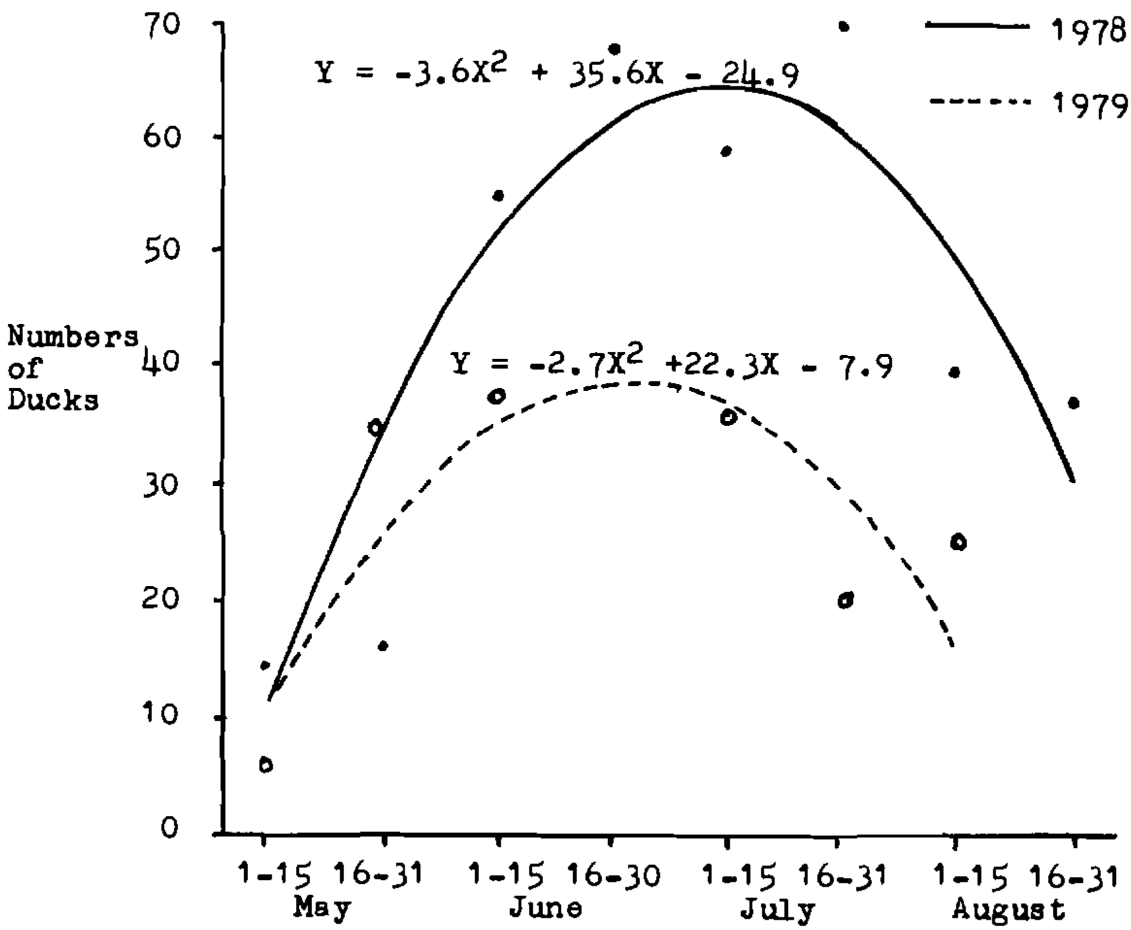

Fig. 9. Average number of total ducks observed per trip -- 1978 vs. 1979.

Table 2. Densities of total ducks and broods observed during 1978 and 1979.

	$\bar{X}_{78}$	$\bar{X}_{79}$	$\bar{X}_{tot}$	Range	$\bar{X}_{fg}$*
Ducks/Trip	27.30	45.00	35.17	1 - 70	47.00
Broods/Trip	2.20	4.88	3.39	0 - 11	3.80
Ducks/Mile	1.95	3.21	2.51	0.07 - 5.00	3.36
Broods/Mile	0.16	0.35	0.24	0.00 - 0.79	0.27

*Data drawn from Kansas Fish and Game stream survey reports provided by Marvin Kraft.

categories were larger in 1979 than in 1978, there was no significant difference between them at p=.05. The Kansas Fish and Game results were compiled from float trips that were conducted once a year for five consecutive years (1973-1977). All of these Fish and Game floats were made during late May or early June, which probably accounts for the high averages in comparison to the results of this study. However, results of this study for the same time period produced means of 4.0 broods/trip and 0.29 broods/mile.

The mean value of 0.24 broods/mile during the entire period of this study indicates that the area was slightly above the state average of one brood for every five miles of stream in Kansas (Kraft and Schwilling, 1978). However, the 2.6 broods/mile found by Minser (1968) on the Holston River in Tennessee indicates that Wood Duck production in Kansas is limited.

Of the 12 nest boxes erected in 1979, only one was used by a Wood Duck. This was the box located approximately one-half mile upstream from the mid-way point of the study area. On May 27 the hen was interrupted as she called her brood from this box. There were seven ducklings on the water directly below the nest box, and instead of feigning injury the hen swam quietly into vegetative cover while the brood fled. Once the canoe had passed, the hen was observed returning to the nest box.

The brood sizes of different age groups as well as the overall brood size for the study period are given in Table 3. A survival rate was estimated from an assumed average clutch size of 11 (Bellrose, 1978). The brood bond begins to weaken at five weeks of age and results in intermixing between different broods (Jessen et al, 1966; McGilvrey, 1969). This intermixing causes brood counts for older ducklings to be inflated and probably accounts for the larger sizes found in Class III broods.

The average brood size (5.6) for the study period compared closely with results of Decker (1959), Baker (1971), and Ball et al (1975). These researchers reported brood sizes ranging from 5.1 to 5.6. Similarly, the estimated survival rate of 51% correlated well with findings of 53% by McGilvrey (1969), 56% by Baker (1971), and 52% by Brown (1973).

Brood size decreased as summer progressed (Fig. 10). This was due to the combined effect of juvenile mortality plus the breaking down of the brood bond at seven to eight weeks of age. In addition, late summer is typically a dry period in the midwest, and water levels on most rivers drop to relatively low levels. This occurred in the study area in late July and August of both years and resulted in large portions of vegetative cover being left high and dry on the bank and inaccessible to ducklings.

Location of broods in the study area is shown in Figure 11. These results represent 80% of all flightless

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Table 3. Size of flightless broods of various ages and estimated survival rates.

	$\bar{X}_{78}$	$\bar{X}_{79}$	$\bar{X}_{tot}$	Range	Survival Rate (%)
Class I	7.8	6.3	7.1	1 - 11	64.5
Class II	5.7	4.9	5.2	1 - 10	47.2
Class III*	4.3	6.4	5.9	1 - 15	53.6
Total	6.0	5.3	5.6	1 - 15	50.9

*These results are probably inflated due to mixing of broods of this age.

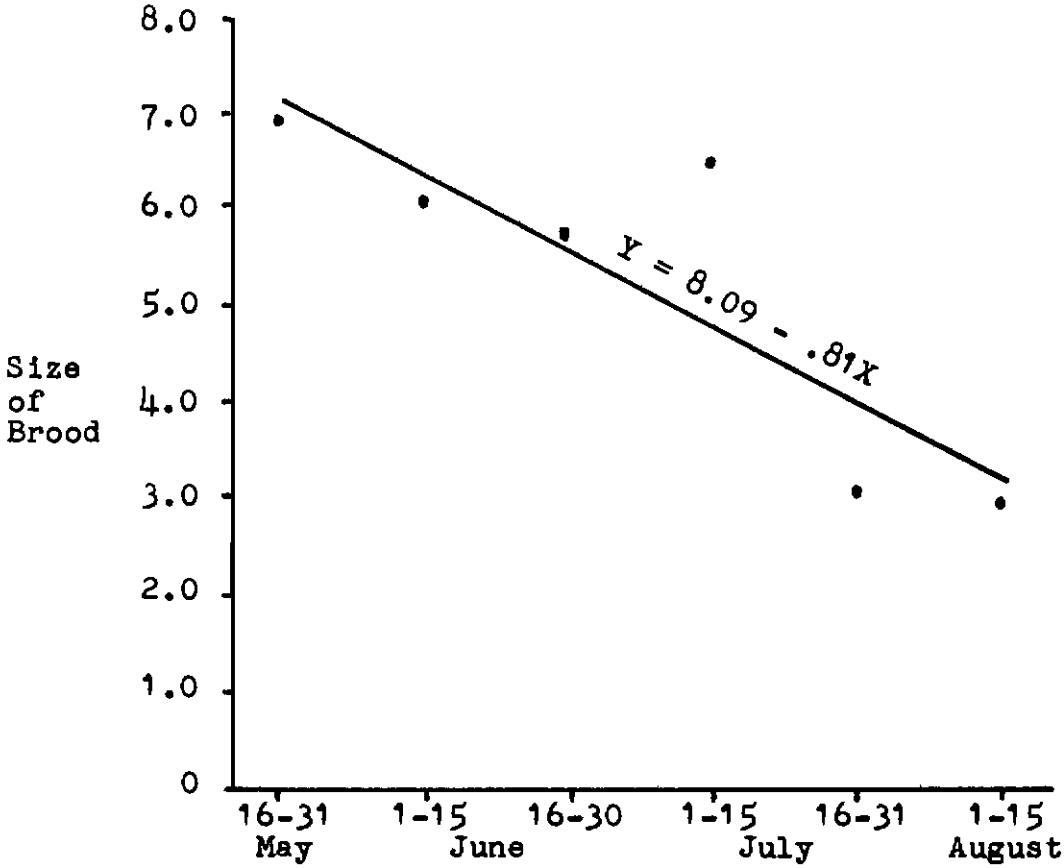


Fig. 10. Brood size vs. progression of summer -- 1978 and 1979.

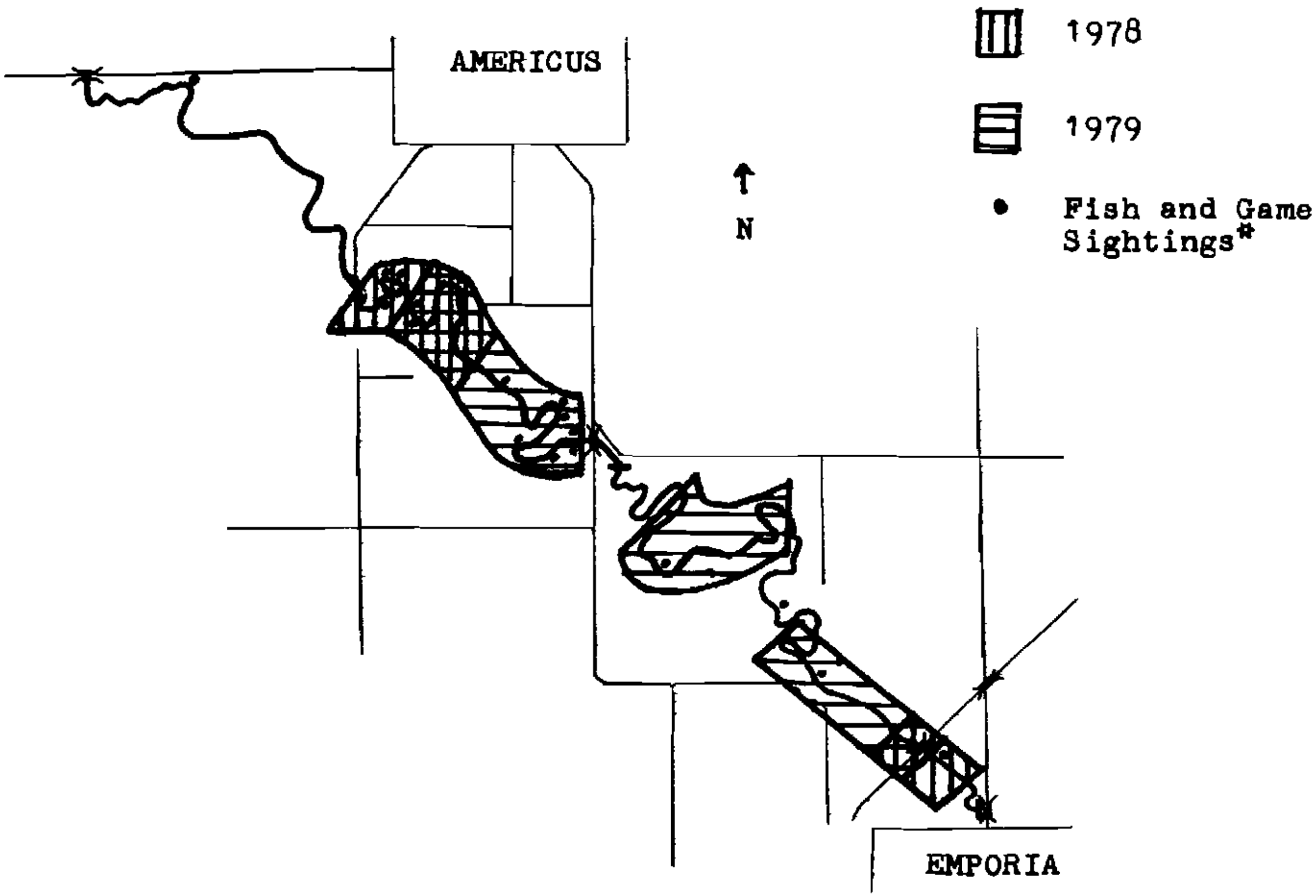


Fig. 11. Locations of regular brood usage from observations in 1978 and 1979.

* These data estimated from stream survey reports 1973-1977.

broods observed and indicate those portions of the study area that broods preferred to use. There were numerous brood sightings in areas upstream from the two low water dams. In the upper half of the study area, broods were well distributed for several miles; in the lower half broods were usually observed within one mile of the low water dam at the lower end of the area.

There was a shift noted in the location of broods between 1978 and 1979. During the summer of 1979, broods were generally more widespread in the study area. Broods were found to be more widely dispersed throughout the upper half of the study area in 1979 than in 1978. A substantial number of broods was also found in the third quarter of the study area in July of 1979 during the high water levels which resulted from the drawdown at Council Grove Reservoir. Broods readily adapted to the tree cuttings that were made in the fourth quarter of the study area. Use of this area is evidenced by the larger region of brood sightings in this section during 1979 float trips.

When the water level rose in July of both years, a drastic change occurred in the study area environment. Water current became much faster throughout the area, leaving only a few pools of quiet water. Swiftness of the current is indicated by the fact that float trips lasted only three to four hours during this period, as compared to the mean time of five hours per trip for the entire study. Higher water levels flooded portions of bankside vegetation, and during this time a few broods were observed in areas where they would not have normally been found. However, overall there were fewer broods and fewer adults observed during this two-week period of each summer.

Young Wood Ducks require high amounts of protein for proper development (Johnson, 1971). Although adults feed primarily on vegetative matter (Coulter, 1955), animal matter comprises 70-100% of the diet of juvenile Wood Ducks (Coulter, 1957; Hocutt and Dimmick, 1971). Animal matter consumed is mostly insects, such as water striders, midge larvae, and several varieties of flies. Feeding is done in an opportunistic manner; whatever is available is eaten. There was an abundant supply of insect life, particularly mayflies and water striders, distributed throughout the study area during both summers.

Dead or fallen trees, submerged stumps, and exposed rocks provided an abundance of loafing sites for use by both broods and adults. These sites were also used by other birds and turtles as sunning spots with no aggressive interspecific behavior observed. Adults preferred dead trees and tall stumps, while broods were limited to those sites that were near the water's surface.

Broods were found to prefer quiet pools of water with overhanging vegetative cover close at hand (Fig. 12). If such vegetative cover was not readily available, exposed roots or dead drift were often used instead. In the absence

Fig. 12. Closely overhanging vegetation was a main component of preferred brood cover.

of adequate cover on the river itself, the broods ran up the bank to hide in dense stands of grasses and shrubs.

The water speed of areas in which broods were sighted ranged from less than 0.1 feet/second to 0.9 feet/second, which is well under the three miles per hour maximum given as necessary for optimum brood cover by McGilvrey (1969). Broods were not found in areas where there was no quiet water, even when there was an abundant amount of vegetative cover.

An essential function of protective cover was to conceal the brood from predators such as snapping turtles, large fish, and raptorial birds (Anderson, 1977). Of all these, the Great Horned Owl is considered to be the primary predator of juvenile Wood Ducks in Kansas (Schwilling, 1978). As a brood scattered ahead of the canoe, an owl often swooped from the trees in an attempt to secure a duckling. Although the actual catching of ducklings was never witnessed, a Great Horned Owl was observed flying upstream with a downy duckling clutched in its talons.

Densely overhanging vegetation within one to two feet of the water surface was the preferred form of protective cover. Willow, Cottonwood, Sycamore, and Box Elder were the common plants that comprised this vegetation. The species of plant did not seem to matter, but rather it was the proximity of this vegetation to the water that was of primary importance.

Roots that had been exposed by erosion of the bank or tangles of drift and fallen trees were also used by broods for concealment. Although this type of cover was sometimes effective, overall it provided a poor quality of brood cover.

Within days of half-cutting trees in the target area, two broods were found using the newly created vegetative cover (Fig. 13). However, within a few weeks most of the leaves had been stripped from the trees, and they appeared to be dying. Broods continued to use the area because the intertwining limbs still provided some protective cover. High water in July swung the trees back toward the bank, and it appeared the cover would not be available to broods raised during the following seasons (Fig. 14).

Fig. 13. Brood cover created by half-cutting selected trees.

Fig. 14. Condition of half-cut trees following high water.

DISCUSSION

Juvenile Wood Ducks have basic needs of water, food, cover, and loafing sites. The young leave the nest within 24 hours of hatching, and the brood is moved by the hen toward the nearest favorable brooding area (Beard, 1964; Hardister et al, 1965). It has been found that 60 to 80% of all duckling mortality occurs in the first few days of life -- the time when the brood is moving from the nest site to brood rearing areas (Leopold, 1951; Jessen et al, 1966; McGilvrey, 1969). Studies have also shown that nests located close to optimum brood cover will produce broods with higher duckling survival rates (Ball et al, 1975).

Requirements for good brood rearing habitat include an abundant supply of invertebrates, permanent water of varying depths, a multiple number of loafing sites, and dense overhead vegetation composed of low growing shrubs and emergent aquatic plants (Webster and McGilvrey, 1966; McGilvrey, 1968; Hester and Dermid, 1973). Emergent vegetation, such as lotus, smartweed, and arrowhead, is considered by these authors to be an integral component of good brood cover and reportedly should comprise at least 50% of the existing habitat. The remainder of the habitat is composed of shrubs, fallen trees, and open channels of water.

Results of the study indicated the area was one of average production in comparison with other Kansas rivers and streams. The density of broods was normal for Kansas even though it was fractional in comparison to brood densities found in major production areas in the southeastern United States. Despite the fact that emergent vegetation, an essential component of optimum brood cover, did not occur, estimated brood survival compared favorably with literature citings. Figure 10 exhibited a 55% decrease in brood size as the summer progressed. This indicated an observed survival rate of 45%, which closely corresponded with the estimated brood survival rate of 50.9% given in Table 3. However, due to the nature of these data, a statistical analysis could not be made of this correlation.

Rate of water flow played an important role in the occurrence and distribution of broods in the study area. Broods were not found in areas where the rate of flow was greater than one mile an hour. Heavy brood usage occurred in areas up to three miles upstream from low water dams. These dams slowed the rate of flow of approaching water, forming deep, sluggish pools that were favored by young Wood Ducks. Riffle areas that were formed below these low water dams occurred at the beginning and mid-way point of the study area. Broods were not observed in these areas even where there was vegetative cover, indicating a tendency to avoid shallow, fast moving water. Rate of water flow was believed to be the primary limiting factor in distribution of broods within the study area.

Water level of the river also played a role in the occurrence of broods. A definite shift in location of broods was noticed between 1978 and 1979. In general, there was a wider distribution of broods in 1979 than 1978. There were certain reasons for the shifting of broods in different portions of the study area. Wider distribution of broods in the upper half of the study area in 1979 was probably due to somewhat higher water levels during most of that summer than had occurred in 1978. In some areas this water inundated some of the bankside flora, which resulted in temporary stands of 'emergent' vegetation. A substantial number of the broods observed in 1979 were utilizing such areas.

Observation of several broods in the third quarter of the study area in 1979 occurred during mid-July when the drawdown at Council Grove Reservoir caused water levels to be extremely high. This portion of the study area was normally barren and void of vegetative brood cover, but the high water level flooded dense stands of grasses and shrubs, which resulted in excellent protective cover and also slowed the rate of flow along margins of the river.

However, drawdown at Council Grove had detrimental effects on the overall abundance and distribution of both broods and adults in the study area. During this time in each summer water flow was swift throughout the area, and there were only a few pools of quiet water. Decline in observed numbers of both total ducks and broods reflects the unsuitability of the environment during this period. The result of this drawdown was certainly an increase in brood mortality on downstream areas of the river.

Limited use of nest boxes was not surprising since it is known to take several years to establish substantial usage (Schwilling, 1978) and also because there was an abundance of natural cavities. Availability of nesting cavities was not believed to be a limiting factor of productivity in the study area. However, proximity of nesting cavities to good brood cover was undoubtedly an important factor in terms of brood survival.

Food supply and loafing sites were found to be in abundant supply throughout the study area. Large numbers of mayflies and water striders provided ducklings with ample sources of animal protein that are essential for proper development. Fallen trees, logs, and stumps were used as loafing sites by both adults and juveniles. These two essential components of brood habitat did not limit productivity in the study area.

The half-cutting of trees in an effort to create brood cover accounted for the greater distribution of broods in the final quarter of the study area in 1979. Broods were observed several times using this area after tree cutting was completed. This technique was successful in creating immediate stands of good brood cover and in increasing brood usage in areas where lack of such cover was the limiting factor.

Despite obvious advantages of half-cutting trees, this method of habitat manipulation was not believed to be practical. Indications were that such cuttings would be of use for only one or possibly two brooding seasons. After that, death of trees and effects of high water would make the artificially created habitat unavailable for brood use. Annual cutting of several trees along the river bank that would be necessary to replace the lost habitat could not be justified. Denuding of the river bank and the resulting erosion would, in the long run, outweigh the advantages.

From this study, there were several suggestions to increase Wood Duck production on rivers and streams in Kansas and other midwest areas. Most watercourses in Kansas still have an abundant supply of potential natural nesting cavities. However, the recent trend toward extensive burning of wood for heat may begin taking a heavy toll on those trees that provide nesting cavities for Wood Ducks, as well as several other species of birds and mammals. A program of erecting moderate numbers of nest boxes and widely distributing these on rivers and streams would certainly encourage nesting. By placing these boxes near good brood rearing areas, a significant increase in productivity could probably be achieved.

It is essential that cattle be restricted from access to large portions of the river. A gently sloping bank that provided an emergency escape route was an integral part of brood habitat in many areas. Uncontrolled grazing is known to be detrimental to fish habitat (White, 1971) and also to waterfowl production on ponds and lakes (Berg, 1956). Unlimited access to portions of the study area resulted in destruction of vegetation and soil structure of the bank. This made it virtually impossible for ducklings to escape into vegetative cover on dry gound.

Rapid release of water from Council Grove Reservoir and other impoundments in the state is part of a water fluctuation program designed by the Kansas Fish and Game Commission and executed by the U. S. Army Corps of Engineers. The objective of this program is to improve summer fishing and to encourage growth of plants that are used as food by migrating waterfowl. Certainly this action helps to attract waterfowl during the migration, but at the same time it reduces the productivity of Wood Ducks using downstream portions of the river as brooding areas.

The drawdown of pool levels on reservoirs is essential for success of the water fluctuation program, but a modification of the current timetable could be made without altering the primary objective of the program. It is proposed that release of water during this drawdown period be extended over a longer period of time in order to moderate changes in water level and rate of flow on the river downstream. This should decrease the brood mortality significantly and thus increase productivity and occurrence of the most abundant breeding duck in the state.

Although channelization has many detrimental effects on the quality of streamside habitat (Hester and Dermid, 1973; Kraft and Schwilling, 1978), there was heavy brood usage of the channelized portion of the study area. There were two reasons for this: a slow rate of water flow due to the presence of a low water dam downstream and dense vegetative cover primarily comprised of Black Willow plantings.

Black Willow was a commonly occurring tree that provided excellent brood cover in many portions of the study area. Webster and McGilvrey (1966) reported low and spreading Willows to be ideal cover plants in association with various herbs and other shrubs. Portions of the study area, where only a few Willows were growing low out over the water, were used extensively by various broods. When properly pruned every three years, this tree can be designed to be an excellent cover plant (U. S. Forest Service, 1969). Cuttings of Willow that are stuck in the ground readily take root and grow extremely fast in moist environments.

Of the many factors that limit productivity of Wood Ducks on Kansas streams and rivers, the need for protective brood cover was found to be of utmost importance. A long-term program of planting Willow shoots along watercourses would provide excellent permanent brood cover and could sharply increase productivity in areas where the rate of water flow was at an acceptable level. A plan for pruning could be rotational, concentrating on different areas each year. The cost of such a program would be small once the initial planting of the Willow shoots was accomplished.

SUMMARY

Habitat requirements of Wood Duck broods on rivers were studied during the months of May through August in 1978 and 1979. The study area was a 14 mile section of the Neosho River in east-central Kansas.

1. Upon approach, broods fled for vegetative cover or other protective cover while the hen feigned injury. The amount and intensity of injury feigning seemed to be dependent upon the quality of brood cover and age of the brood.

2. Forty-seven percent of the 633 Wood Ducks observed during the study were flightless juveniles.

3. Peak numbers of flightless ducks were observed during the latter half of June. Numbers of flying ducks increased gradually as the summer progressed.

4. The differences between numbers and densities of total ducks, juveniles, males, and females observed during 1978 and 1979 were not significant at the p=.05 level.

5. Thirty-one percent of the flying ducks observed were females and 22% were males. The remaining percentage was unidentifiable due to various reasons.

6. There was a mean density of 0.24 broods/mile found during the study. Average brood size was 5.6 for the two year period. Size of the brood decreased as the summer progressed. The estimated rate of brood survival was 50.9%.

7. Preferred brood cover was slow, quiet pools of water (less than one MPH) with closely overhanging vegetative cover close at hand. Dead drift, exposed roots, and bankside vegetation were substituted in the absence of overhanging vegetation.

8. Protective vegetative cover and rate of water flow were found to be the primary limiting factors on productivity in the study area. Slope of the bank was critical in areas where there was no protective cover available on the water. Nesting sites, food supply, and loafing sites were not believed to be limiting factors in this study.

9. Rate of water flow influenced the distribution of broods in the study area. Heavy brood usage occurred in deep, sluggish pools found upstream from low water dams.

10. Moderately high water levels inundated bankside vegetation and created temporary stands of 'emergent' vegetation that were utilized by broods. However, the extremely high water that resulted from the drawdown at Council Grove Reservoir reduced distribution and abundance of both broods and adults.

11. The half-cutting of young trees produced good vegetative cover that was utilized immediately by several broods. However, such cuttings were not believed to be practical because of the temporary nature of the created brood cover.

12. There are several suggestions for improving production of Wood Ducks on rivers and streams in Kansas

that can be drawn from the results of this study:

A. The erection of moderate numbers of nest boxes near good brood rearing areas will increase brood survival.

B. Cattle need to be restricted from large portions of river in order to preserve the gentle slope of the bank.

C. To moderate the effects of high water caused by the drawdown at reservoirs, the release of water needs to be extended over a longer period of time.

D. The planting of Black Willow shoots near the water's edge and proper pruning of these plantings will produce permanent, excellent brood cover.

Literature Cited

Anderson, G. 1977. Return of the Wood Duck. Kansas Fish and Game Magazine. 34(2):2-6.

Baker, J. L. 1971. Wood Duck (Aix sponsa) production from nest boxes and brood studies on the Noxubee National Wildlife Refuge. Ph. D. Dissertation, State College, Mississippi, 48 p.

Gall, I. J., D. S. Gilmer, L. W. Cowardin, and J. H. Reichmann. 1975. Survival of Wood Duck and Mallard broods in north-central Minnesota. J. Wildl. Mgmt. 39(4):776-780.

Beard, E. B. 1964. Duck brood behavior at the Seney National Wildlife Refuge. J. Wildl. Mgmt. 28(3):492-521.

Bellrose, F. C. 1976. The comeback of the Wood Duck. Wildlife Society Bulletin. 4(3):107-110.

_____. 1978. Ducks, geese, and swans of North America. Stackpole Books, Harrisburg, Pa. 540 p.

_____ and R. Crompton. Nest houses for Wood Ducks. Ill. Dept. of Conservation, Springfield and Ill. Natural History Survey, Urbana. 4 p.

Berg, P. F. 1956. A study of waterfowl broods in eastern Montana with special reference to movements and the relationship of reservoir fencing to production. J. Wildl. Mgmt. 20(3):253-262.

Brown, B. W. 1973. The Big Lake Wood Duck: a two year study of its pre-flight mortality, nesting population, growth and migration, 1970-1971. Proc. Conf. Southeastern Assoc. of Game and Fish Comm. 26:195-202.

Clawson, R. L. 1975. Two female Wood Ducks call brood from nest box. Wilson Bulletin. 87(3):427-428.

Coulter, M. W. 1955. Spring food habits of surface-feeding ducks in Maine. J. Wildl. Mgmt. 19(2):263-267.

_____. 1957. Food of Wood Duck broods in Maine. J. Wildl. Mgmt. 21(2):235-236.

Decker, E. 1959. A four year study of Wood Ducks on a Pennsylvania marsh. J. Wildl. Mgmt. 23(3):310-314.

Dreis, R. E. 1954. A field observation method of aging broods of Wood Ducks. J. Wildl. Mgmt. 18(2):280-281.

Goss, N. S. 1891. History of the birds of Kansas. G. W. Crane and Co., Topeka, Ks. 693 p.

Grice, D. and J. P. Rogers. 1965. The Wood Duck in Massachusetts. Final Report Federal Aid Project W-19-R, Massachusetts Division of Fish and Game. 96 p.

Hardister, J. P., Jr., F. E. Hester, and T. L. Quay. 1965. Movements of juvenile Wood Ducks as measured by web tagging. Proc. Conf. Southeastern Assoc. of Game and Fish Comm. 16:79-75.

Hester, F. E. and J. Dermid. 1973. The world of the Wood Duck. J. B. Lippincott Co., Philadelphia and New York. 159 p.

Hocutt, G. E. and R. W. Dimmick. 1971. Summer food habits of juvenile Wood Ducks in east Tennessee. J. Wildl. Mgmt. 35(2):286-292.

Jessen, R. L., A. D. Geis, F. B. McGilvrey, F. C. Bellrose, G. F. Pushee, and R. A. McAge. 1966. Discussion: Session III. in Wood Duck Management and Research: A Symposium, Wildlife Management Institute, Washington, D. C. p. 108-112.

Johnson, N. F. 1971. Effects of levels of dietary protein on Wood Duck growth. J. Wildl. Mgmt. 35(4):798-802.

Kraft, M. 1978. Personal Communication.

_____ and M. Schwilling. 1978. Kansas ducks. Kansas Fish and Game Magazine. 15 p.

Leopold, F. 1951. A study of nesting Wood Ducks in Iowa. Condor. 53(5):209-220.

McGilvrey, F. B. 1968. A guide to Wood Duck production habitat requirements. U. S. Bur. Sport Fish. Wildl., Resource Publ. 60. 32 p.

_____. 1969. Survival in Wood Duck broods. J. Wildl. Mgmt. 33(1):73-76.

Minser, W. G., III. 1968. Seasonal abundance and distribution of the Wood Duck (Aix sponsa) on the upper Holston River in east Tennessee. M. S. Thesis, University of Tennessee. 77 p.

Saunders, A. A. 1937. Injury feigning by a Wood Duck. Auk. 54(2):202.

Schwilling, M. 1978. Personal Communication.

Sowls, L. K. 1955. Prairie Ducks. Telegraph Press, Harrisburg, Pa. 193 p.

Stewart, P. A. 1957. The Wood Duck, Aix sponsa, and its management. Ph. D. Dissertation, Ohio State University. 352 p.

_____. 1958a. Local movements of Wood Ducks (Aix sponsa). Auk. 75(2):157-168.

_____. 1958b. Locomotion of Wood Ducks. Wilson Bulletin. 70(2):184-187.

Trefethen, J. B. (Managing editor). 1966. Wood Duck management and research: A symposium. Wildlife Management Institute, Washington, D. C. 212 p.

U. S. Forest Service. 1969. Wildlife habitat improvement handbook. Catalog No. FSH 2609.11.

U.S. Fish and Wildlife Service. 1976. Nest boxes for Wood Ducks. Wildlife leaflet 510. 15 p.

Webster, C. G. and F. B. McGilvrey. 1966. Providing brood habitat for Wood Ducks. in Wood Duck Management and Research: A Symposium, Wildlife Management Institute, Washington, D.C. pp. 70-75.

White, R. J. 1971. Stream improvements. in A Manual of Wildlife Conservation, The Wildlife Society, Washington, D.C. pp. 106-110.

Appendix I

DATE ____________

	START	STOP
TIME		
SKY CONDITIONS[1]		
WIND SPEED[2]		
AIR TEMP. °F		
WATER TEMP. °F		

SIGHTINGS

	1	2	3	4	5	6	7	8	9	10	Total
TIME											
ADULT MALE											
ADULT FEMALE											
No. In Brood											
Size of Ducklings[3]											
Undisturbed Behavior[4]											
Pursued Behavior[5]											
Slope of Bank											
Water Speed ft/sec											
Type of Cover											
Vegetation In Vicinity											
Other Comments											

1. SKY CONDITION CODE:

0 - Clear or few clouds	3 - Fog or smoke
1 - Partly cloudy or variable sky	4 - Drizzle
2 - Cloudy (broken) or overcast	5 - Showers

2. WIND SPEED CODE:

No.	MPH	Indicators
0	1	Smoke rises vertically
1	1-3	Wind direction shwon by smoke drift
2	4-7	Wind felt on face; leaves rustle
3	8-12	Leaves, small twigs in constant motion; wind extends light flag
4	13-18	Raises dust or loose paper; small branches are moved
5	19-24	Small trees in leaf begin to sway; crested wavelets form on inland waters

3. SIZE OF DUCKLINGS (Compared to Hen):

1/8 1/4 1/2 3/4 SAME

4. UNDISTURBED BEHAVIOR:

1 - Stay at side of hen

2 - Swim in close proximity to hen

3 - Stray short distances (up to 15 ft.) from hen

4 - Scatter up to 50 feet from hen while feeding

4 - Scatter over 50 feet from hen while feeding

5. PURSUED BEHAVIOR:

1 - Not fly

2 - Fly short distances

3 - Fly long distances until out of sight

Appendix II

Annotated List of Birds and Mammals Observed During Float Trips

MAMMALS

Virginia Opossum (*Didelphis virginiana*)
Florida Cottontail (*Sylvilagus floridanus*)
Fox Squirrel (*Sciurus niger*)
-- red and black color phases
Muskrat (*Ondatra zibethicus*)
Beaver (*Castor canadensis*)
Coyote (*Canis latrans*)
Raccoon (*Procyon lotor*)
White-tailed Deer (*Odocoileus virginianus*)

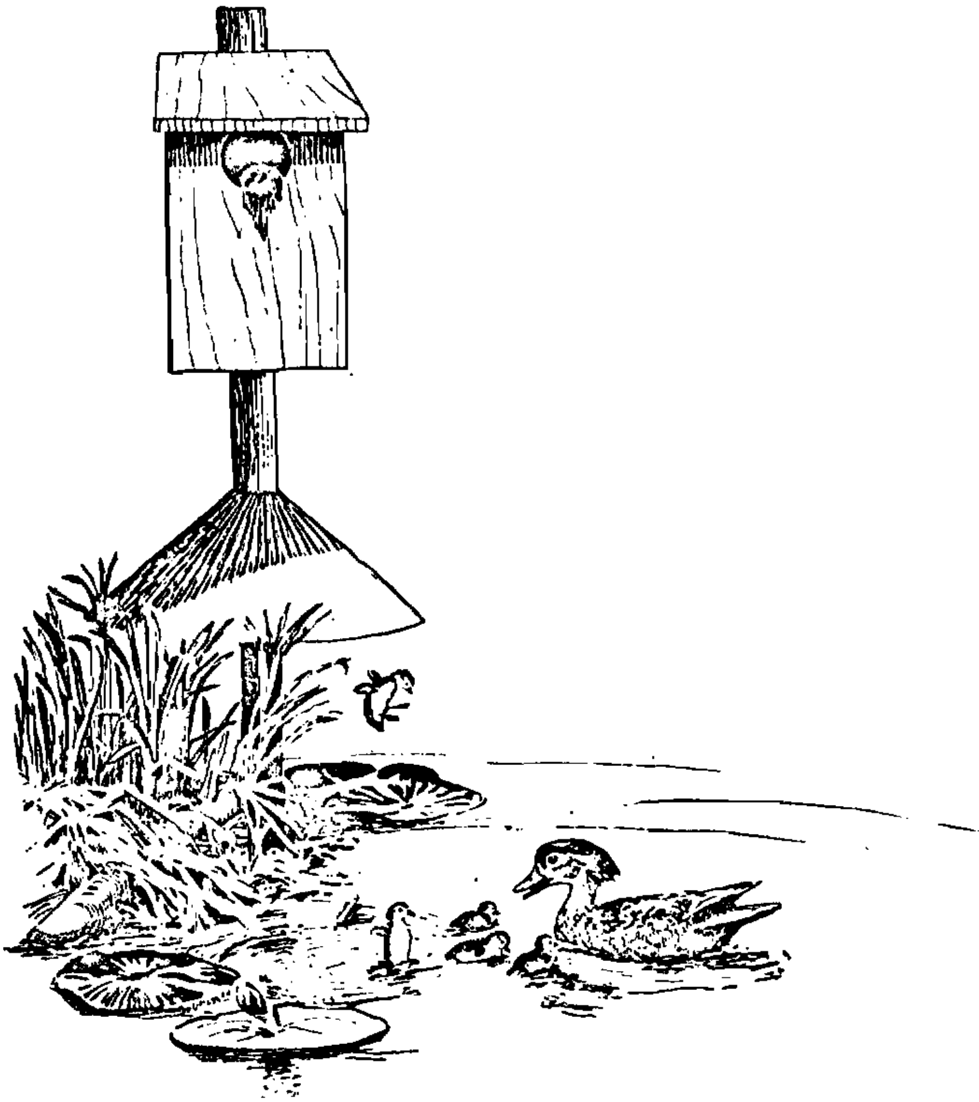
BIRDS

Mallard
Wood Duck
Marsh Hawk
Swainson's Hawk
Red-tailed Hawk
Bobwhite
Great Blue Heron
Little Blue Heron
Green Heron
Spotted Sandpiper
Mourning Dove
Great Horned Owl
Barred Owl
Belted Kingfisher
Common Flicker
Red-bellied Woodpecker
Red-headed Woodpecker
Eastern Kingbird
Eastern Phoebe
Eastern Wood Pewee
Barn Swallow
Bank Swallow
Rough-winged Swallow
Blue Jay
Common Crow
White-br. Nuthatch
House Wren
Mockingbird
Gray Catbird
Brown Thrasher
Louisiana Water Thrush
Starling
Red-winged Blackbird
Common Grackle
Cardinal
Rose-br. Grosbeak
American Goldfinch
Rufous-sided Towhee

Appendix III

NEST BOXES FOR WOOD DUCKS

U.S. Fish and Wildlife Service □ DEPARTMENT OF THE INTERIOR



WOOD DUCK BOXES

This brochure describes the materials and procedures for making and erecting wood duck boxes. It is important to remember that the box is also attractive to many other creatures that will compete with the wood duck for a nest site, and to a greater number of predators that will, given an opportunity, kill the ducks or destroy the eggs. Competitors include squirrels, owls, starlings, and woodpeckers. Predators include snakes, mink, raccoons, opossums, rats, wildcats, housecats, and a host of others. In short, a box improperly erected and unprotected can become a death trap for the wood duck. ***So, it should be done properly or not at all!***

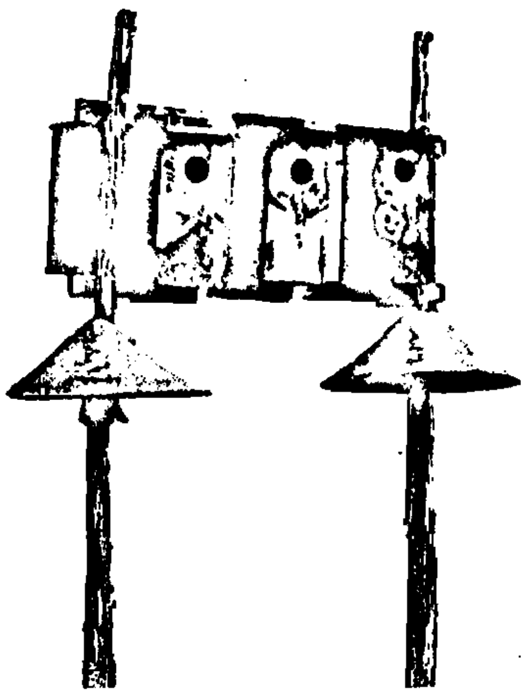
1. Boxes should be erected on posts (wood or metal) but may be put on trees, provided the trees selected can be made as predator proof as posts. Boxes should not be placed on or near trees where they are vulnerable to predators that may reach them from above by means of other trees. Similarly, boxes should always be protected from below by a metal shield. The shield may be flat or conical, but in any case it should extend in *all* directions at least 18 inches from the tree or post supporting the nest box. If flying predators or competitors such as starlings or woodpeckers become troublesome, there may be some relief in changing the design and attitude of the box (figure 1).

2. Ideally, boxes should be placed over or at the edge of a water body and should be about 10 feet above the ground or water surface. If the water level fluctuates, the shield should be at least 3 feet above the high water level. However, ducks will accept boxes at substantial distances from water. When hatching occurs away from the water, the female will immediately lead the young overland to water. Because at that time the ducklings are extremely vulnerable to predators, this factor should be carefully considered in the selection of box sites.

3. Maintenance is extremely important. Since wood ducks do not collect nest materials, a nest base such as sawdust or wood shavings, 3 inches deep, must be furnished. Boxes should be cleaned each year and repaired as needed. The use of boats or of access facilities such as ladders can involve significantly greater maintenance costs as well as potential safety hazards.

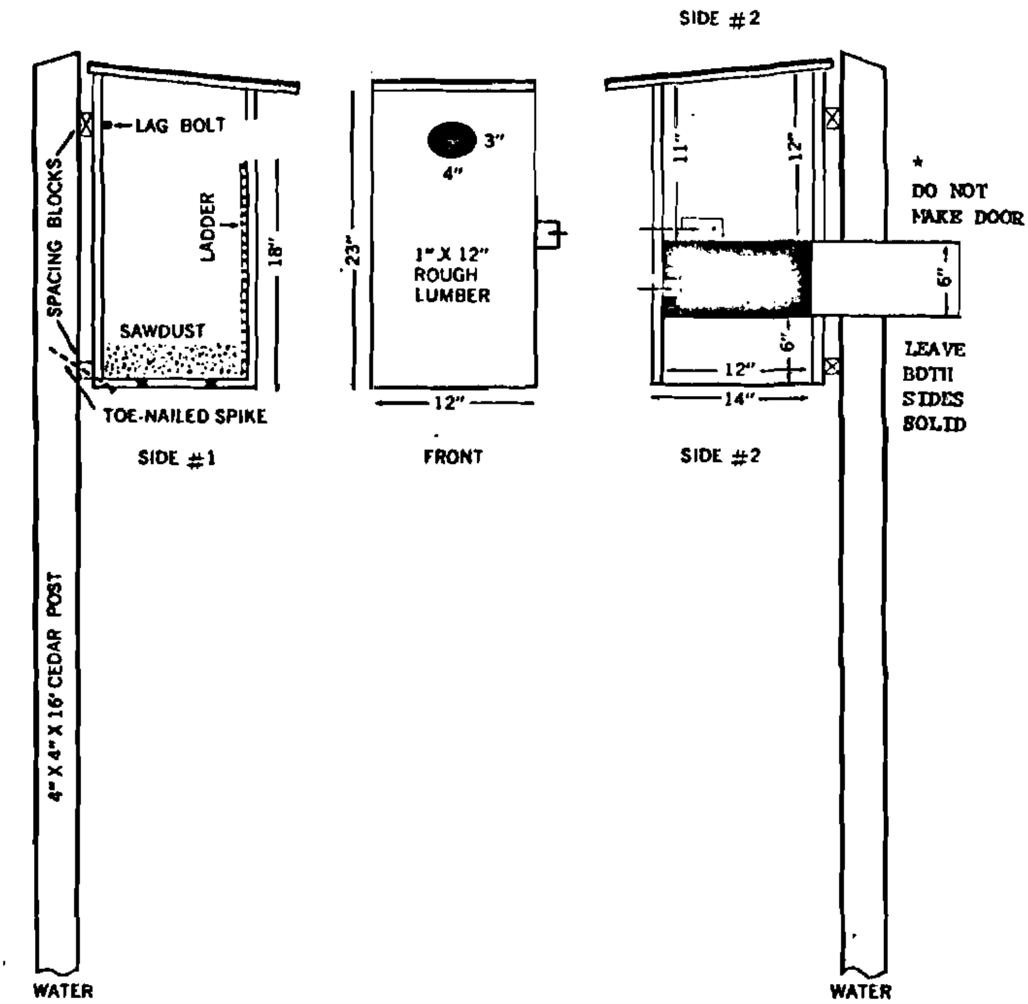
Therefore, the maintenance of large numbers of boxes can be time consuming and expensive. If economics is a factor, the location of boxes on land where they can be reached readily by vehicle is preferable to the more aesthetically pleasing locations over water.

4. Wood ducks, unlike most other ducks, will tolerate close nesting by other wood ducks. Thus, boxes may be placed in clusters, and two or more may even be mounted on the same post without significant negative impact on nesting success.

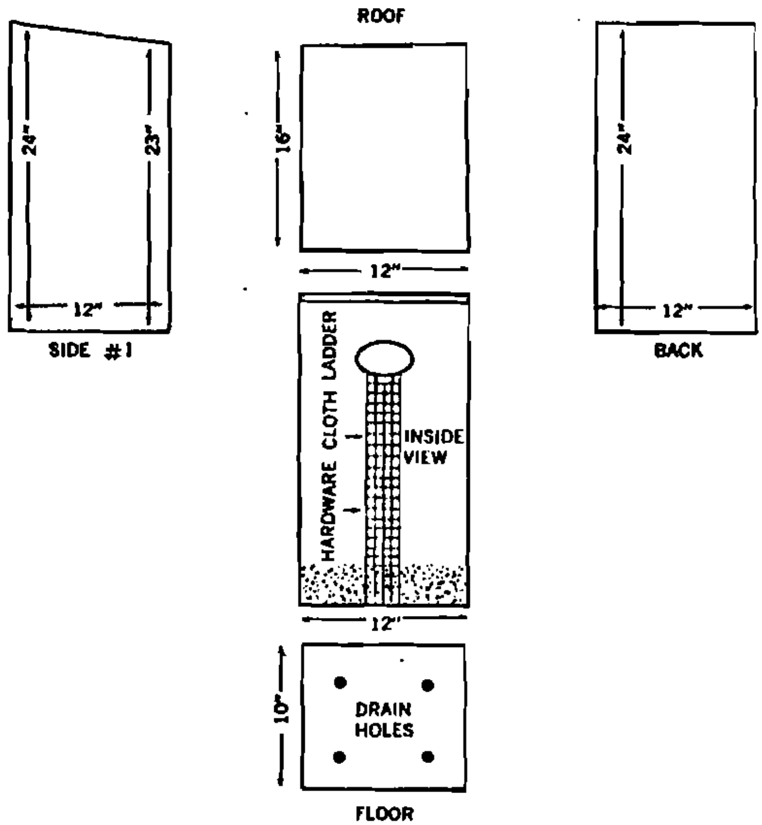


STANDARD WOOD DUCK NESTING BOX

This nesting box is cheap to build, easy to maintain and, properly safe-guarded, inaccessible to such nest predators as raccoons, snakes, and squirrels.



The box should be constructed of unplaned cedar, cypress, or other weather-resistant lumber. It should NOT be painted, stained, or creosoted. As the diagram indicates, the entrance should be oval-shaped with the broadest distance horizontal. On the inside front of the box, beneath the hole, a strip of screen or hardware cloth should be tacked to provide the ducklings a means of escaping the box.



MATERIALS

Nails.	..25—8 or 10-penny, zinc-coated.
Spike	1—4+ inch.
Lag bolt	1—¼-inch, 6 inches long.
Hinge	1—3-inch cabinet + screws.
Hardware Cloth	18-inch strip cut at least 3 inches wide. (All sharp ends should be bent under.)
Post . .	1, 4" X 4", 16 feet long. (Should be cypress, cedar, or a preservative-treated wood.)
Plus	Enough sawdust, wood-chips, or crumbled rotten wood to form a 3-inch nest base in each box.

Use rust-proof screws or nail that are long enough to hold securely despite rough handling and weathering.

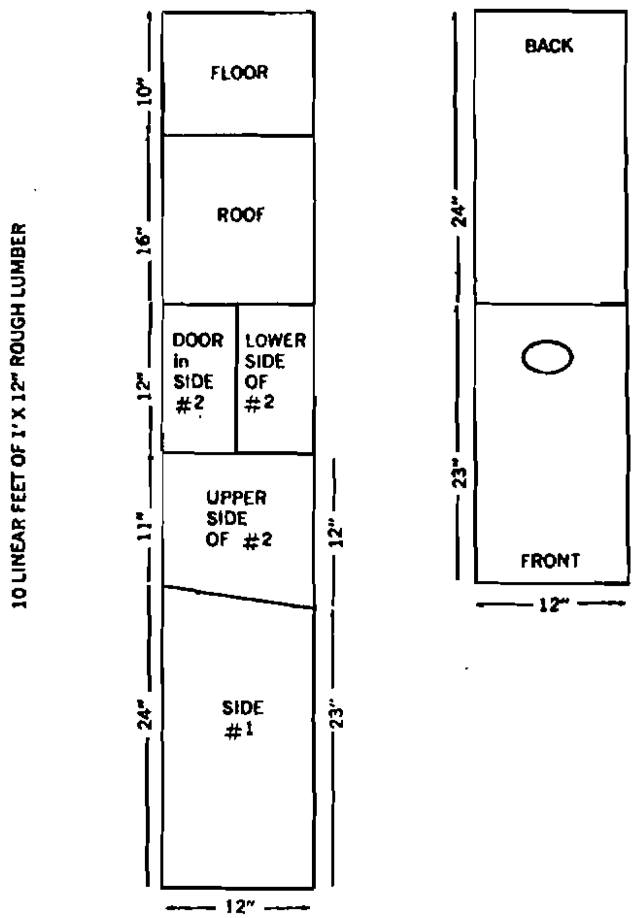
Bore four ¼-inch drainage holes through the floor.

Tack a strip of ¼-inch mesh hardware cloth cut about 18" X 3" from the bottom of the box to the hole. This is necessary in order for the ducklings to be able to climb out the nest.

Spray the inside of the box with lysol or other disinfectant prior to the nesting season to discourage wasp and bees from moving in.

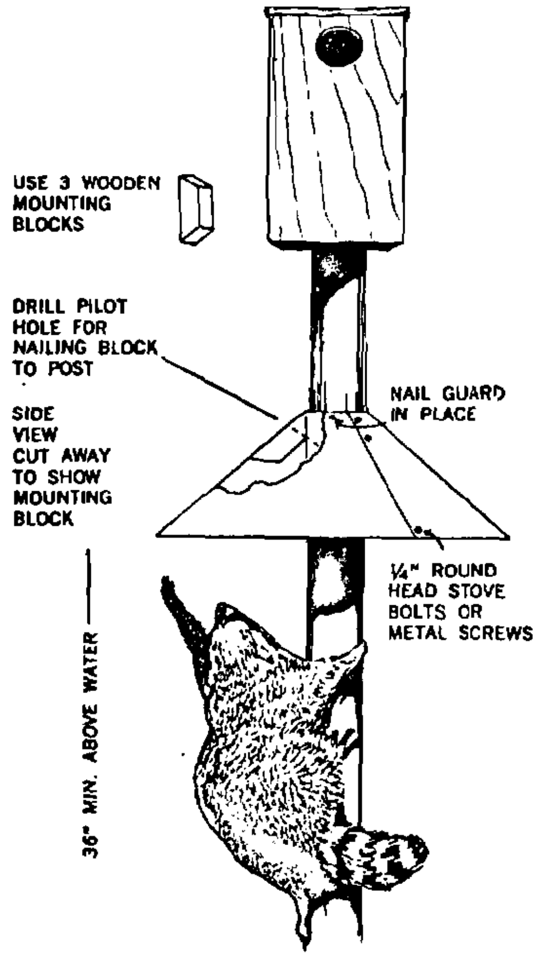
Wood ducks will nest in close proximity, but for the best results, the boxes should be grouped in clusters of half-a-dozen or so spaced so that each is no less than 50 feet from any other.

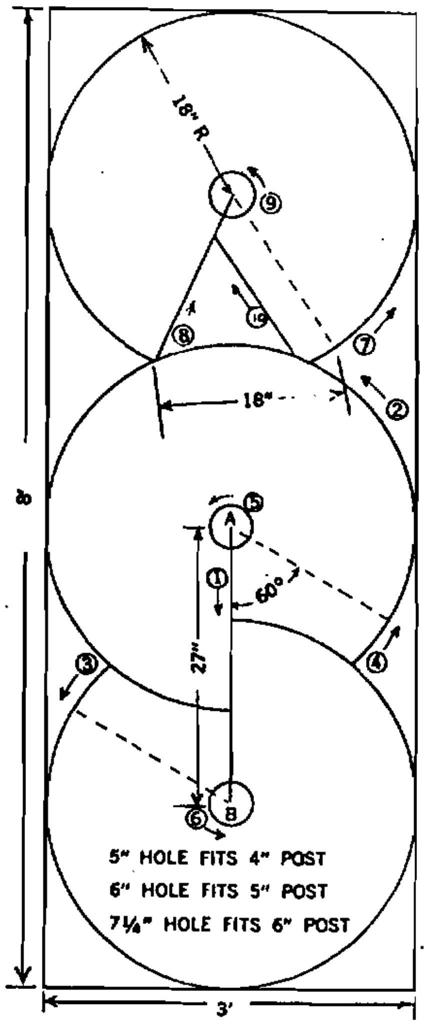
Each nest box must be cleaned and replenished with sawdust or wood chips each January.

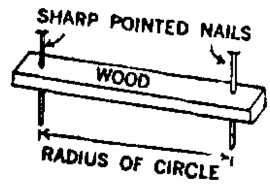

10 LINEAR FEET OF 1' X 12" ROUGH LUMBER
FLOOR
10"
ROOF
16"
DOOR in SIDE #2
LOWER SIDE OF #2
12"
UPPER SIDE OF #2
11"
12"
SIDE #1
24"
23"
12"
BACK
24"
FRONT
23"
12"

PREDATOR GUARD

Cone-shaped, sheet-metal guard for protecting nest structures from predators. At right is layout for cutting 3 predator guards from a 3' x 8' sheet of 26-gauge galvanized metal. When installing the guard, overlap the cut edge to the dotted line. To facilitate cutting (on solid lines only) follow the sequence of numbers. Make circular cuts in counterclockwise direction. To make initial cut on line A–B, make a slot at A with a cold chisel. Use tinsnips and wear leather gloves.







HOME MADE COMPASS
FOR SCRIBING METAL

DEPARTMENT OF THE INTERIOR

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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FOR MORE INFORMATION, WRITE:

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