WOOD DUCK BROOD MOBILITY AND UTILIZATION OF BEAVER POND HABITATS[a]

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Abstract: During 1975-1976, 9 wood duck (*Aix sponsa*) hens with broods were tracked via radio telemetry on beaver (*Castor canadensis*) pond habitats in the piedmont region of South Carolina. The mobility of all broods was greatest during the first week of rearing, and decreased thereafter. The size of the area utilized was also greatest during week 1 and with the exception of 2 broods, decreased in subsequent weeks. Cumulative home range size stabilized for 3 broods during the third and fourth week, whereas for others, it increased throughout the rearing period. Total home range size varied greatly among broods, but broods consistently utilized a major portion of the potential available habitats. Wood duck broods utilized all habitat types within the respective beaver ponds, but were seldom observed in the non-vegetated, open water sections. The use of small beaver ponds (0.03-0.50 ha) by wood duck broods was significantly less than the use of large beaver ponds (1.51-3.80 ha). Non-beaver pond wetlands were used primarily for the purpose of traveling from one beaver pond habitat to another.

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Successful production of waterfowl requires suitable habitat for both nesting and brood rearing. The nesting requirements of wood ducks have been well documented (Leopold 1951, Klein 1955, Decker 1959, Bellrose et al. 1964, Grice and Rogers 1965, and Luckett 1977) but little quantitative data are available on the actual utilization of various types of aquatic habitats by broods throughout the rearing period. Webster and McGilvrey (1966), however, censused brood utilization of impoundments in Maryland and demonstrated that areas with early season cover of downed timber and shrubs were utilized most frequently by wood duck broods. Ball (1973) also discussed the dependence of broods on heavy cover created by a combination of shrubs and emergent herbaceous vegetation.

In the spring of 1975, research was initiated to study the brood rearing characteristics of wood ducks nesting on beaver ponds located in the piedmont region of South Carolina. Beaver impoundments were used because of their abundance in the area (Woodward et al. 1976), their suitability as waterfowl habitat (Beard 1953, Speake 1955) and their use locally for nesting by the resident population of wood ducks (Luckett 1977).

The objective of the study was to document the extent that wood duck broods utilized the beaver pond habitats and to describe the factors which made them important for brood rearing.

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METHODS AND MATERIALS

Wood duck nest boxes were maintained on several beaver impoundments in Anderson, Oconee and Pickens Counties, South Carolina (Luckett 1977). The main study area (320 ha) was located in the Clemson University Experimental Forest, 8.0 km southeast of the town of Clemson (Fig. 1, Area C). Two additional broods were monitored on beaver ponds located outside of the main study area. Brood 7606 (number: year-brood designation) utilized a small beaver pond (0.5 ha) adjacent to Hartwell Reservoir, approximately 6.7 km northwest of the main study area (Fig. 1, Area A), while brood 7607 utilized a beaver pond 3.2 km north of the main study area on Eighteen Mile Creek (Fig. 1, Area B).

To discourage nest abandonment, incubating hens were captured in the nest boxes just prior to or during hatching. All radio-marked hens were equipped with an adjustable back-mounted radio transmitter (SM1, AVM Instrument Co., Champaign, Ill.), which

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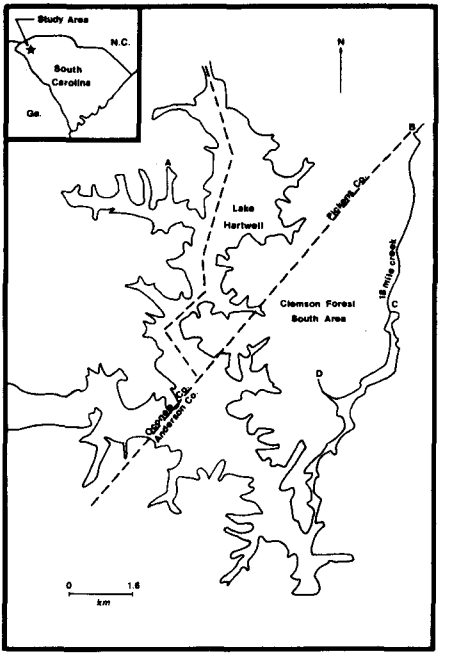

Fig. 1. Map of the overall study area including the location of the four wood duck nesting areas.

was modified by attaching a metal clasp to the neck loop posterior to the hen's head (Dwyer 1972 and Derrickson 1975). This prevented the hens from slipping out of the harness, but permitted neck extension during flight. The total transmitter package weighed 10-11 g, had a life expectancy of 114 days, and a range of 0.4 to 0.8 km depending upon vegetation and/or topography.

A model LA 12 receiver (AVM) with an attached 3 element hand-held Yagi antenna was used to locate the hens by triangulation from 2 or more ground positions. In some instances, broods were observed visually. Each day's locations were plotted on base maps constructed from aerial photographs of the study area.

An analysis of beaver pond vegetation was made during the early spring and late summer of 1976. Two sampling periods were used, so that the habitats utilized by both early and late nesting hens for brood rearing were described. Data were taken following a modification of Daubenmire's (1959) method. Permanent transects were set up and positioned perpendicular to the stream channel of the pond, and were spaced one-fourth the width of the pond apart. Further details are given in Hepp (1977).

Minimum home range estimates were made by computing the area enclosed by connecting the outermost locations (Mohr 1947). Changes in size of the cumulative home ranges were determined by using a modification of Odum and Kuenzler's (1955) "observation area curve". To analyze temporal changes in the size of the area utilized by a brood, minimum area estimates were made for every 7 day period. A *corrected* home range was also calculated. This eliminated all upland areas from the final calculation, and provided a more realistic figure of the area utilized by the broods within each type of aquatic habitat. A geometric center of activity (GCA) was calculated for each brood's weekly and cumulative home ranges (Hayne 1949). The distance from each observation to the GCA was measured and called an "activity radius". The weekly frequency distributions of the activity radii in 0.08 km intervals from the GCA were analyzed to determine temporal changes in brood mobility, while the overall frequency distribution provided a quantitative measure of brood mobility during the rearing period (Dice and Clark 1953, Ables 1969).

Habitat use was based on the proportion of *brood days* spent in a particular habitat type (Hepp 1977). A brood day was a 24 hr period and represented from 1 to 8 observations. Preference for a habitat type was implied by comparing the proportion of a habitat available to a brood (only that area within the brood's home range) to the proportion of brood days recorded in a given habitat type.

Statistical tests were based on procedures outlined in Steel and Torrie (1960) and were performed on the Clemson University IBM System/370, Model 158 Computer using the statistical analysis system (SAS) developed by Barr and Goodnight (Service 1972).

RESULTS

Wetland Classification

In order to categorize wood duck brood habitat utilization, a wetland classification system for beaver ponds was devised based on vegetative parameters. Each beaver pond was divided into sections and placed into a wetland type based on the mean percent areal coverage of the plant species. The classification was dependent upon the dominant vegetation within each section. A *dominant* was defined as an uppermost layer of vegetation which possessed an areal coverage of greater than 30 percent (Cowardin et al. 1976). A wetland section in which plants comprised less than 30 percent of the coverage was referred to as a non-vegetated wetland. Each beaver pond (BP) wetland type is described briefly below.

1) Deciduous Forested Wetland (1BP)—This wetland was dominated by trees (woody plants which at maturity were 6 m or more in height and usually with a single trunk), such as, water oak (*Quercus nigra*), sweet gum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*). It occurred most often on the edges of the beaver ponds and comprised only a small portion of the study area.
2) Deciduous Shrub Wetland (2BP)—This wetland was dominated by shrubs (woody plants less than 6 m tall and usually having several erect stems), such as, tag alder (*Alnus serrulata*), buttonbush (*Cephalanthus occidentalis*), and privet (*Ligustrum sinese*). Dead standing vegetation of sufficient size was also included in the shrub category.
3) Emergent Vegetation Wetland (3BP)—This wetland was dominated by a mixture of emergent aquatic vegetation, such as, asiatic dayflower (*Aneilema keisak*), rice cutgrass (*Leersia oryzoides*), and soft rush (*Juncus effusus*). This type predominated in the silted sections of older beaver ponds and along the margins of some ponds.
4) Bur-reed Wetland (4BP)—This wetland was dominated by bur-reed (*Sparganium americanum*). This type comprised a very small portion of the study area, but in places it occurred in very dense stands.
5) Rice Cutgrass Wetland (5BP)—This wetland was dominated by rice cutgrass. It occurred over much of the study area, primarily in sections where the water was shallow and still. In some cases, where it was found in dense stands, it was unsuitable for brood rearing.
6) Submergent Vegetation Wetland (6BP)—This wetland was dominated by submergent vegetation, such as, pondweed (*Potamogeton confervoides*). It occurred mainly in the shallow sections of the beaver ponds.
7) Non-vegetated wetland (7BP)—These were all permanently flooded non-vegetated substrates (a stand of plants comprised less than 30% of the substrate). This wetland type was usually associated with the deeper sections of the beaver ponds and comprised a major portion of the study area.

Two other wetland types present on the study area were temporary wetlands (TW) and riverene wetlands (R). Temporary wetlands were areas in which water covered the land surface for half the year or less. Riverine wetlands were those areas directly influenced by the flow of water from Eighteen Mile Creek. The vegetative classes used to classify beaver ponds were also utilized for these non-beaver pond wetlands (i.e. Deciduous Forested (1), Deciduous Shrub (2), etc.).

Brood Mobility

During the 1975 and 1976 nesting seasons, 617 telemetry locations were recorded from 9 radio-equipped hens with broods. All hens nested in boxes located over water. Many of the broods (67%) were highly mobile during the first 24 to 48 hours after leaving the nest (Table 1), even though they did not have to travel in order to reach an aquatic habitat. The distance traveled by these broods to the first wetland that was used for

Table 1. Home range data for radio-tagged female wood ducks with broods in the piedmont region of South Carolina.

Brood no.	*Tracking Time (days)*	*No. Locations*	*Maximum length (m)*	*Home range size (ha)*	*Corrected Home range (ha)*	*Percent of potential wetland habitat utilized*	*Distance to the first wetland used for 24 hours or more (km)*
7501	31	49	1,006	13.40	8.80	46	3.35
7502	51	55	991	16.10	11.9	62	0.60
7601	48	141	1,097	22.0	15.7	75	1.03
7602	7	20	305	—	—	—	2.9
7603	18	52	259	2.90	2.90	76	0
7604	10	25	1,067	29.6	12.3	62	0.95
7605	9	31	495	—	—	—	3.50
7606	43	120	207	0.77	0.53	76	0
7607	43	124	266	2.70	1.90	72	0

24 hours or more ranged from 0 to 3.5 km (1.4 $\pm$ 1.5 km). In all cases, hens utilized waterways, (creeks, lakes and temporary wetlands), when moving their broods from one beaver pond to another. Consequently, they were not subjected to the various decimating factors associated with terrestrial travel (Ball et al. 1975).

In 3 instances (broods 7501, 7602 and 7605) the initial movements were from a series of small beaver ponds less than 0.23 ha (Fig. 1, Area D) to larger beaver ponds (3.25 ha) situated along Eighteen Mile Creek (Fig. 1, Area C). Every radio-monitored brood that fledged from these ponds moved immediately to ponds along Eighteen Mile Creek.

The remaining 6 broods were variable in the distance and the location of their initial movements. Three broods (7603, 7606 and 7607) did not move from the nesting pond during the first week. The others moved an average of 0.86 km, but no apparent pattern was established for the moves. Brood 7604 traveled from a large beaver pond (3.8 ha) to a small pond (0.6 ha) which was used for 4 days, but during the second week, returned to the nesting pond. Brood 7601 moved to a less vegetated pond, similar in size to the nesting pond, but also came back to the original nesting area during the second week of rearing. Brood 7502 traveled to a pond similar in size to the nesting pond during the first week, but which had more vegetative cover.

Overall, wood duck broods demonstrated a high degree of mobility during week 1, when compared to the remainder of the brood rearing period (Fig. 2). During this first week, 58 percent of the broods' locations were greater than 0.08 km from the weekly

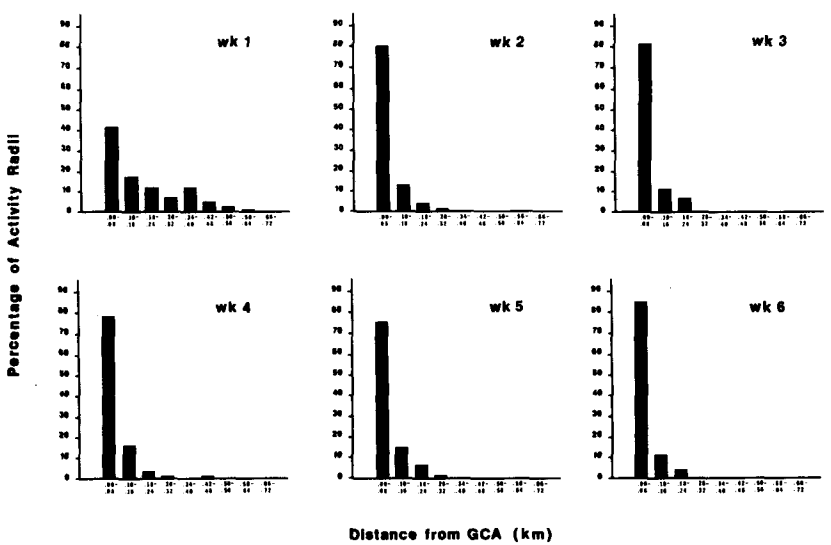

Fig. 2. Mean weekly frequency distribution of activity radii of wood duck broods in the piedmont region of South Carolina.

GCA. As the brood rearing period lengthened (wks 2-6), only 19.8 (± 3.5) percent of the radio locations were greater than 0.08 km from the weekly GCA. It was evident, therefore, that the broods' mobility decreased after a suitable rearing area was located.

An analysis of the overall frequency distribution of the activity radii demonstrated that 77 percent of the total locations during the rearing period were within 0.16 km of the brood's overall GCA (Fig. 3). This suggested that, although mobility was greatest during week 1, it decreased substantially later in the rearing period, so that overall, wood duck broods had a relatively stable range. Since their ranges were stable and had definite boundaries, expressing them as area measurements (i.e. hectares) was justified. If an animal's range is not stable, it is better to express it as an activity radius (Dice and Clark 1953).

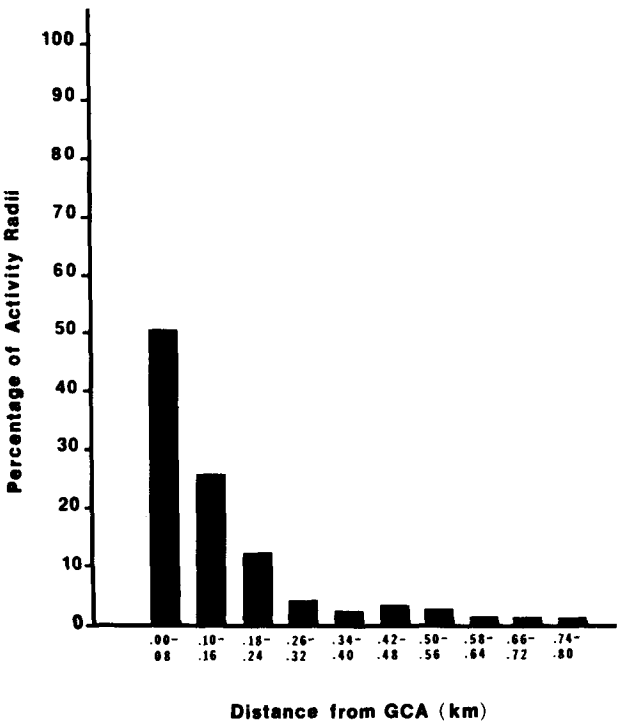

Fig. 3. Mean overall frequenly distribution of activity radii of wood duck broods in the piedmont region of South Carolina.

Home Range

Two hens with broods (7602 and 7605) failed to meet the minimum criteria needed to calculate a home range (a brood must have been monitored for at least 10 days for a total of 25 locations). Consequently, they were excluded from the data set for home range analysis. The 7 remaining broods were tracked an average of 32.0 (± 14.0) days for 81 (± 46) locations which was a mean of 2.5 (± 0.6) locations per day.

Total home range size varied greatly between broods (range = 0.77 to 29.6 ha), but there was no apparent single reason for this variation (Table 1). Although, in some cases, the amount of suitable habitat available to a brood may have limited the size of the home range, broods consistently utilized most of the potential wetland habitats (67.0 ± 11.0%) that were available to them (Table 1). Examination of the weekly increase in home range size revealed that the sizes of 3 of the 7 home ranges stabilized during the tracking period (Fig. 4, broods 7502, 7601 and 7607). A home range was defined as having stabilized when there was less than a 5 percent increase in area.

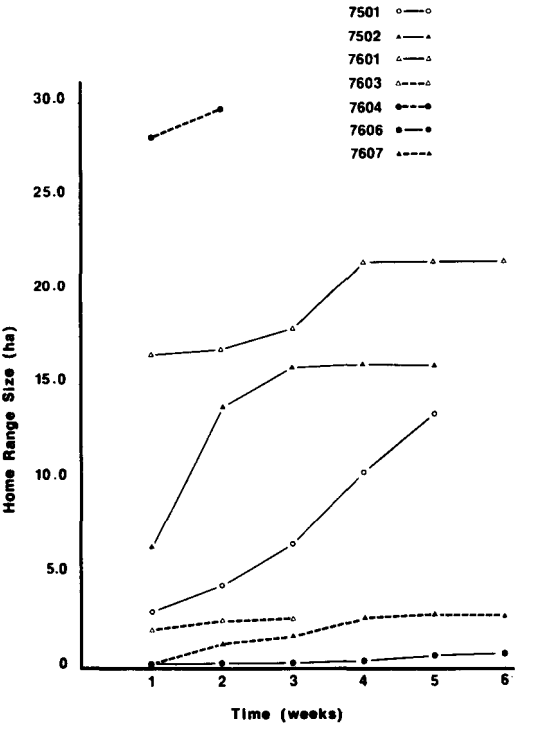

Fig. 4. Cumulative home ranges of wood duck broods in the piedmont region of South Carolina.

Corrected home ranges decreased the home range estimate by 29.7 (± 16.9) percent (Table 1). These estimates better represented the area actually utilized by the brood, because only wetland areas were designated as available to the brood during the rearing period.

Habitat Utilization

Wood duck broods demonstrated a preference for most beaver pond habitats (Table 2). Although the differences were not significant, broods showed a high degree of pref-

Table 2. Utilization of wetlands by wood duck broods and the preference (+) or avoidance (-) of the different habitat types.

Habitat type	*1BP*	*2BP*	*3BP*	*4BP*	*5BP*	*7BP*	*1TW*	*2TW*	*5TW*	*7TW*	*5R*	*7R*
No. of broods having habitat type available	1	7	8	2	5	8	3	5	6	1	2	4
Mean percent of observed brood days (+) (S.D.)	4.0 –	26.7 (26.1)	33.6) (7.9)	0	24.5 (28.5)	19.4 (13.6)	6.5 (6.4)	12.4 (10.3)	5.3 (4.8)	1.0 —	12.5 (14.8)	1.5 (2.4)
Mean Percent of expected brood days (-) (S.D.)	3.7 –	17.4 (14.9)	32.5 (22.7)	0.6 (0)	8.6 (8.3)	22.0 (11.0)	4.6 (2.1)	13.7 (9.3)	16.9 (10.0)	21.0 —	23.9 (8.7)	8.8 (1.2)
Mean Difference (%)	+0.3	+9.3	+1.1	-0.6	+15.9	-2.6	+1.9	-1.3	-11.6	-20.0	-11.4	-6.3
t value	—	0.82	0.13	—	1.31	0.42	—	0.21	2.6 a	—	—	5.5b

Habitat types: BP = beaver pond; TW = temporary wetland; R = riverine
a Significant at 0.05 level
b Significant at 0.01 level

erence for rice cutgrass (type 5BP) and deciduous shrub (type 2BP) dominated beaver ponds, but tended to avoid those beaver ponds classified as bur-reed (type 4BP) and non-vegetated (type 7BP).

Product moment correlation coefficients were calculated to examine the relationship between age, number of dead standing trees per ha and the size of the beaver pond on brood utilization. Size of the beaver pond was the only variable significantly correlated with brood usage $\pm$ 0.59 ($P < .01$). In order to analyze this further, beaver ponds were separated into 3 size classes: A = 0.03-0.50 ha; B = 0.51-1.50 ha; and C = 1.51-3.80 ha. Broods significantly avoided use of class A beaver ponds + 0.74 ($P < .01$). This is in agreement with Cline (1965), who stated that smaller woodland ponds received less use by broods regardless of their vegetative composition. Even though broods utilized class C ponds more than classes A and B combined, there were no significant correlations between brood use and these larger ponds.

Wetlands other than beaver ponds were generally avoided by the broods with the exception of the temporary forested wetland (type 1TW) which received moderate use. The temporary emergent vegetation wetland (type 5TW) and the non-vegetated creek (type 7R) were significantly avoided by the broods (Table 2). Although these non-beaver pond wetlands were not utilized for extended periods of time, they were important to the brood for movements between beaver ponds.

DISCUSSION

Brood Mobility and Home Range

Newly fledged waterfowl broods have been reported to travel extensively from nest sites to rearing areas (Berg 1956, Young 1967). These moves were made in relation to the suitability of both the vegetative cover and water permanence. In the present study most radio-equipped wood duck hens (67%) moved their broods from the nesting ponds shortly after fledging. Because all nest boxes were over water, these initial movements were not directed to the nearest aquatic habitat as reported by Bengston (1971). Thirty-three percent of all hens moved their broods from small (< 0.23 ha) deep-water beaver ponds that were sparsely vegetated, to large ponds (3.2 ha) that were shallow and well vegetated. These were the longest movements recorded in this study (3.2 $\pm$ 0.3 km). Movements of the other broods were for different reasons, because in all instances their nesting ponds were large and appeared to have suitable vegetative characteristics for brood rearing.

There were undoubtedly numerous factors involved which caused a hen to move her brood from the nesting pond to another area. The size of the wetland and its vegetative cover were just 2 of the more important variables that were analyzed. Odum (1970) reported that wood duck broods moved from smaller nesting ponds to larger impoundments for rearing. Stewart (1958), however, stated that vegetative cover was more important than the size of the aquatic area for brood habitat. The data from our study suggest that both habitat size and abundance of vegetative cover were important factors determining preferred wood duck brood habitat. The availability of invertebrates as a source of nutrition for brood growth was not considered in the present study, but may be an additional factor influencing the movements of broods from 1 area to another.

Brood mobility decreased substantially after the first week, and with the exceptions of the continuous movements of broods 7501 and 7606, there were no major range extensions after the fourth week. Ball (1973) also reported that mobility of wood duck broods decreased after the first major shift, and that no brood made a major shift after the fourth week of the rearing period. Cowardin (1969) stated that young duck broods were more mobile than older birds. Restriction of mobility was probably beneficial to the broods' survival, because it increased their familiarity with the available resources of the habitat.

Characteristics of brood mobility, for the most part, were interrelated with a brood's home range. For instance, the area utilized by a brood was greatest during the first week of rearing which was clearly related to the high mobility of the brood during this period of time. After the initial week, the cumulative range continued to increase, but at a slower rate. This cumulative increase in home range size was evident throughout the rearing period for 2 broods, but for 3 others the size of the range stabilized after week 4.

Even though home range size increased cumulatively, at least for a portion of the rearing period, broods utilized only a small portion of this range during any 7 day period. Initially, most hens with broods ranged over large areas apparently in search of

suitable rearing locations. Once this area had been located, the hen and brood usually remained in that general area until the end of rearing (as determined by the dissolution of the hen-brood bond).

In this study, the size of the minimum home range was relatively small and varied greatly between individual broods. Ball (1973) also noted that the amount of area utilized by broods was highly variable, and attributed this mainly to the distribution of the vegetation. In our study, broods with a limited amount of suitable habitat available (i.e. not in close proximity to any alternate choices) generally utilized that habitat exclusively during the rearing period. Consequently, the size of their home ranges were smaller. However, broods monitored in areas where more good habitats were available in close proximity to one another were more mobile and therefore had larger home ranges.

Habitat Utilization

It is generally known that habitats utilized by waterfowl broods must meet both the physiological and the psychological needs of the hen and brood (Webster and McGilvrey 1966). However, little quantitative data have been published on the habitat requirements of waterfowl broods. Current knowledge of habitat utilization by broods is primarily from research conducted on species of waterfowl nesting in the prairie region of North America. Much of this information is based on brood censuses conducted 2 times during the rearing period, with little intensive monitorng of broods on a daily basis. Poston (1969) stated that northern shoveler (*Anas clypeata*) broods utilized most available water areas, but preferred larger, permanent ponds (> 0.61 ha). Mallard (*A. platyrhynchos*) broods preferred permanent stock ponds (0.24-0.40 ha), bordered by willow or aspen, and covered by less than 33 percent emergent vegetation, whereas canvasback (*Aythya valisineria*) broods were located more often on ponds greater than 0.4 ha in size, and which had less than 10 percent coverage of emergent vegetation (Stoudt 1969).

Grice and Rogers (1965) stated that wood duck broods preferred areas with an interspersion of dense cover, open water and stands of buttonbush or muskrat (*Ondatra zibethica*) houses, which provided loafing sites used during the rearing period. Cline (1965) observed broods most often on larger woodland ponds (> 4.05 ha) that were in intermediate stages of vegetative succession. Overall, optimum wood duck brood habitat should consist of 75 percent cover and 25 percent open water (McGilvrey 1968).

In the present study, beaver ponds were the most heavily utilized of the available wetland areas, particularly when they were dominated by rice cutgrass (type 5BP) deciduous shrubs (type 2BP), mixed emergent aquatic vegetation (type 3BP) and/or a combination of these types. This corresponds with the findings of Ball (1973) in Minnesota, who stated that wood duck broods preferred lakes of intermediate succession which were characterized by a transition from herbaceous emergent vegetation to flooded shrubs. The combination of these 2 vegetative types seems to provide most of the requirements needed for good brood habitat. The shrub layer provides cover and security for broods, as well as loafing sites in some cases, whereas the underlying layer of sedges provides additional cover and harbors invertebrates essential as food to young ducklings.

In this study, beaver ponds dominated by rice cutgrass and having an associated shrub layer (or vice versa) were utilized more than those strictly dominated by either shrubs or rice cutgrass. Broods preferred beaver ponds with a diversity of vegetative types. Even though they may utilize one type more than another, broods that had a variety of types available were observed in all types at some time during the rearing period. For instance, broods usually stayed in dense, protective cover for the major portion of the day, but in the early morning or late afternoon, they were located frequently in the less vegetated sections of the ponds. These areas were not recorded as preferred habitats, but it was evident that they had some importance to the brood. Recent evidence showed that waterfowl broods were highly active during the nocturnal hours (Swanson and Sargeant 1972). They utilized the more open areas of the wetlands and fed on the emerging insects (Swanson and Meyer 1973). Because no radio tracking was done at night in our study the importance of these non-vegetated areas may have been underestimated.

Broods significantly avoided the smaller class A beaver ponds (0.03-0.50 ha.) The large beaver impoundments (1.5-3.80 ha) were utilized more (54%) than the 2 smaller types. These larger ponds had a greater diversity of vegetative types, and the increased water area afforded the broods greater security against predators. Cline (1965) stated that larger woodland plots allowed waterfowl a more efficient use of their defensive mechanism for escaping enemies.

Wetlands other than beaver ponds were also important to the overall survival of wood duck broods. These waterways provided a means by which mobile broods could travel safely. All broods that moved from the nesting pond to other wetlands utilized these water areas instead of moving overland. When traveling, the broods confined their movements to the available vegetation whenever possible. Broods that used the non-vegetated creek (type 7R) were observed to remain close to the bank. These movements were made as quickly as possible and usually occurred during the daylight hours, although some broods did make major moves during the night. Even though these areas were only utilized for a brief time, they played an important part in the overall production of wood ducks on the study area.

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