Habitat Use and Demography of a Wild Turkey Population Subjected to Human-induced Flooding

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Abstract: From 1986 to 1988, we studied the demography and habitat use of an eastern wild turkey (*Meleagris gallopavo silvestris*) population subjected to human-induced flooding along the Roanoke River, North Carolina. A six-month flood from 22 December 1986 to 22 June 1987 resulted in significant shifts in habitat use. Female home ranges during flooding were significantly larger than those recorded during non-flood periods. During non-flood periods, females used bottomland hardwoods more than other available habitats. Habitat use during flooding reflected availability instead of overall resource preference with females moving from bottomland hardwood to upland hardwood hillside to alluvial first ridge habitats as availability changed. Flooding inundated 79% of all nesting habitats used in non-flood periods. No reproduction occurred among radio-transmittered hens during 1987. Hen:poult ratios were 0.5, 6.6, and 0.2 in 1986, 1987, and 1988, respectively. Although some reproduction occurred among non-transmittered turkeys during the flood period, results suggest that flooding significantly reduced turkey recruitment and forced turkeys to concentrate in isolated locations where they were more vulnerable to increased legal and illegal harvest. Management recommendations include negotiation of changes in flow regimes, management of the Roanoke River Basin under suboptimal flow regimes, and better regulation of hunting seasons.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 47:148–162

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In the southeastern Coastal Plain, much eastern wild turkey habitat occurs in the drainage systems of major rivers. Seasonal flooding is often blamed for short-term changes in habitat use and demographic patterns of turkeys inhabiting these systems and may increase their vulnerability to predation or harvest by forcing them to concentrate in isolated areas. Studies of flooding effects on turkeys and other wildlife (Kennamer et al. 1975, Dickson et al. 1978, Kimmel and Zwank 1985, Foote 1989, Bodmer 1990) have concentrated on natural flooding. No research has been conducted on the influence of human-induced river flooding (i.e., a flood event in which the timing, intensity, and/or magnitude is the result of factors not directly related to natural precipitation events) on turkey habitat use or population demography.

We studied the habitat use and population dynamics of a turkey population subjected to varying U.S. Army Corps of Engineers (COE) controlled flood patterns along the Roanoke River, North Carolina, from January 1986 through August 1988 (Cobb 1990). Our objectives were to document baseline habitat use by female turkeys and selected demography of the entire population in non-flood years and to quantify changes in these variables after human-induced, extended spring flooding. We predicted that turkeys would be displaced from their usual home ranges during flooding due to inundation of critical seasonal habitats and that this movement would significantly reduce reproductive success and increase mortality.

This research was funded by the North Carolina Wildlife Resources Commission (WRC) under Pittman-Robertson Project W-57-R, National Wild Turkey Federation, North Carolina Wild Turkey Federation, and National Rifle Association. Additional support was provided by the North Carolina Agricultural Research Service. L. W. Cobb and V. W. Cobb assisted in all phases of the study. J. V. Edwards, E. R. Temple, and J. C. Peoples assisted in annual summer field activities. D. E. Seaman and J. W. Zimmerman provided assistance and computer programs for analysis of telemetry data. The authors thank J. A. Gregory, E. J. Jones, R. A. Lancia, R. Lea, R. E. Mirarchi, K. H. Pollock, D. C. Sisson, R. E. Vanderhoof, J. R. Walters, and anonymous reviewers for helpful comments on earlier drafts of the manuscript.

Methods

Study Area

Background.—The study area was in the Roanoke River basin (RRB) in the northeastern Coastal Plain of North Carolina. The basin is 354 km long, drains 24,812 km^2, and has the largest intact bottomland forest ecosystem remaining in the mid-Atlantic region. Like many similar sized basins in the southeastern Coastal Plain, stage in the Roanoke River is determined by water releases from an upstream reservoir, in this case the John H. Kerr Reservoir which is controlled by the COE.

Under present conditions, human-induced flooding occurs frequently (≥1 flood per 3 years with >1 month average duration) in the RRB, which has one of the most dense populations of wild turkeys in North Carolina (5.8 turkeys/km^2, WRC unpubl. data). When flooding occurs, major regions of the floodplain are inundated for extended periods during the spring turkey nesting and harvest seasons.

The harvest season for turkeys in the RRB begins and ends on the first Saturday in April and May, respectively. The WRC sets season lengths, and it closed areas to hunting within 461.5 m of flood waters (G.S. 113-134; 113-291.2) until 1991. However, the Roanoke River was not considered to be at flood stage until it reached a stage of 9.5 m at the Scotland Neck, North Carolina, gaging station, a level defined by the COE. Therefore, until 1991 the harvest season was not closed in this area even when river flooding reached levels thought to unduly increase legal and illegal turkey harvest levels by inundating major portions of the floodplain and forcing turkeys to more isolated locations. In addition, the turkey harvest season coincides with striped bass (*Morone saxatilis*) spawning up the Roanoke from the Albemarle Sound. Although it was known that some striped bass fishermen illegally killed turkeys roosting over the river during floods, manpower and fiscal constraints often prevented WRC enforcement officers from apprehending other than the most flagrant violators. The laws pertaining to wild turkeys exposed to flooding in the RRB were, therefore, unenforceable. Manooch and Rulifson (1989) described other aspects of the history and hydrology of the RRB.

Location/Description.—The 5,660-ha study area was along the Roanoke River in Martin and Bertie counties, North Carolina, from River Mile (RM) 54 to RM 62. The study area included tracts owned by the WRC, Union Camp and Georgia-Pacific Corporations, and private individuals. To avoid possible dependence of habitat preference analyses on habitat distribution patterns and an arbitrary study area definition (Porter and Church 1987), habitat blocks within these tracts that were >40.5 ha and not used by transmittered turkeys were excluded, (i.e., the study area was defined only by the habitats included in turkey home ranges).

The study area was classified into 12 habitats based on elevational and vegetational characteristics, including bottomland hardwoods, electrical transmission-line corridors, agricultural fields, hardwood plantations, pine plantations <10 and >10 years old, mixed pine/hardwood stands, tupelo gum (*Nyssa aquatica*)/bald cypress (*Taxodium distichum*) backswamps, alluvial first ridges (portions of the bottomland hardwood levee >5 m mean sea level (MSL), hardwood second ridges (areas >4 m MSL between the alluvial levee and the transition zone into agricultural fields, Fig. 1), logged bottomland hardwoods, upland hardwood hillsides (hardwood dominated transition zone between bottomland hardwood habitats and agricultural fields, Fig. 1), and the Roanoke River. The area is transitional between mixed alluvial hardwood, and gum/cypress backswamp communities. Topographic features on the Martin and Bertie County sides of the river (Fig. 1) included: alluvial first ridges paralleling the river, tupelo gum/bald cypress backswamps alternating with hardwood second ridges (on the Bertie County side only), an

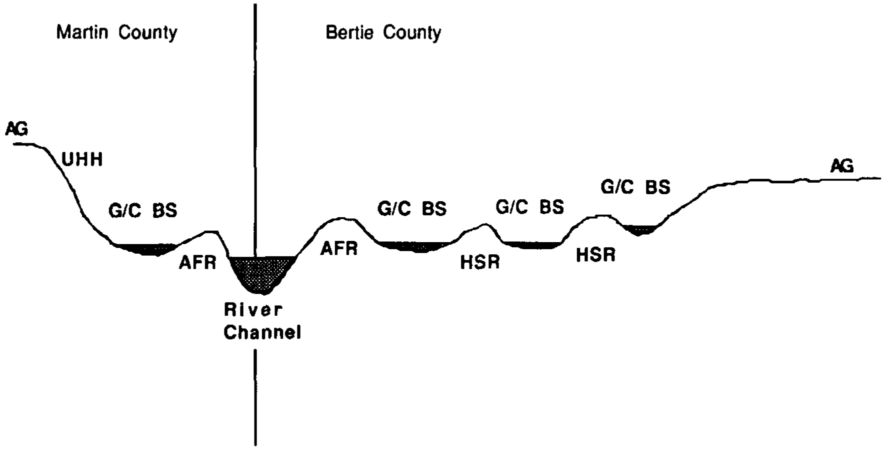

Figure 1. Cross section of the Roanoke River floodplain (AFR–alluvial first ridge; AG–agriculture; G/C BS–gum/cypress backswamp; HSR–hardwood second ridge; UHH–upland hardwood hillside).

upland hardwood hillside in Martin County, and mixed agricultural areas. Vegetative habitats were distributed among these topographic classes.

All Coastal Plain river systems in North Carolina were evaluated for their usefulness as a control area for this study. None of these systems were similar to the Roanoke in either history, hydrology, current management, large scale vegetative composition, or status of the turkey population therein. Therefore, instead of making comparisons between dissimilar areas, tests were made between years (i.e., flood vs. non-flood) within 1 study area.

Data Collection

Location, nesting, and demographic data were collected from turkeys trapped and instrumented with radio transmitters from 2 January to 31 March of each year from 1986 to 1988. Birds were captured using rocket nets or 2-2-2 tribromoethanol (Evans and Goertz 1975) and fitted with a 70- to 80-g back-mounted radio package (Telonics Inc., Mesa, Ariz.) containing a motion-mortality sensor. All transmitters were functional at the onset of breeding.

We considered telemetry data to be independent when an individual turkey had the opportunity to temporally select any habitat within the study area between successive locations. Based on the extreme mobility of turkeys and the size of our study area, we used 24 hours as the minimum period between collection of individual locations. This criterion is more conservative than that of White and Garrott (1990) who suggested that an animal need only be able to traverse its home range between successive locations for telemetry data to be considered independent. From 2 January to 31 March birds were located an average of 3 times per week. Otherwise, birds were located at least 5 times per week in random order.

Telemetric locations were used to identify the onset of incubation and general nest locations. To reduce the chance of abandonment, nest-site use was confirmed by visual observations after 20 days and at the completion of incubation. Tests for clutch size and the number of poults hatched per clutch between ages and years were performed with the Wilcoxon Rank Sum test (Hollander and Wolfe 1973).

Nest site overstory and understory characteristics were sampled in 0.04- and 0.004-ha circular plots, respectively, centered on each nest. Understory vegetation was identified to species and visually assigned a rank value for each species' % cover in the plot: 0 = absent, 1 = trace (<1%), 2 = 1% to 5%, 3 = >5% to 10%, 4 = >10% to 20%, 5 = >20% to 40%, 6 = >40% to 60%, 7 = >60% to 80%, and 8 = >80% to 100%. Independent estimates by 2 observers were averaged for each species. Herbaceous vegetation analyses were conducted using numerical classification techniques with the PC-ORD computer programs (McCune 1987) with the group average linkage method and Czekanowski's index (% similarity) as a distance measure. Nest sites were assigned to an overstory habitat type and elevational gradient based on their location on cover-class maps and U.S. Geological Survey topographic maps. Tests for significant variations in nesting elevation between 1986 and 1988 were conducted with the Wilcoxon Rank Sum test. The relationships between floodplain inundation patterns and river stage were quantified from aerial and ground truth mapping. Turkey behavioral and habitat use characteristics associated with specific inundation patterns pinpointed stage thresholds above which turkey population dynamics were significantly influenced. A flood event was defined as an increase in river stage to the point at which the gum/cypress stands began to refill (2.1 m MSL at Hamilton, N.C.) and the maintenance of >2.1 m MSL such that typically non-flooded areas became inundated. Associations between river stage, nesting habitat use during non-flood years, and floodplain inundation patterns were used to produce a rule curve (Fig. 2) to predict the percentage of nesting habitat available at various river stages.

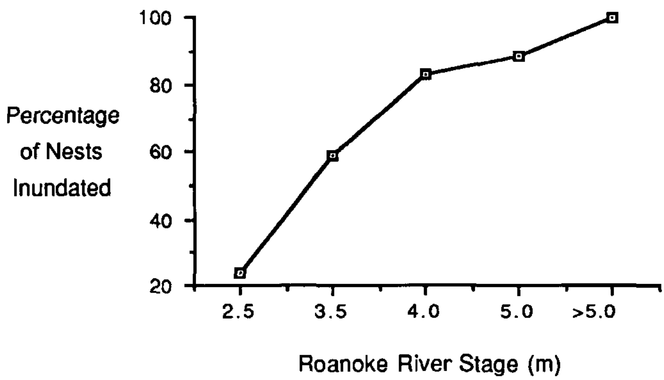

Figure 2. Turkey nesting rule curve for the Roanoke River study area, Martin and Bertie counties, North Carolina, 1986–1988.

Habitat Use

Telemetric locations and habitat composition data were digitized using ATLAS*DRAW software (Strategic Locations Planning, Inc. San Jose, Calif.), and home range working maps were constructed using the Minimum Convex Polygon method (Mohr 1947). Frequency of use data for each habitat type in all home ranges were tallied for testing habitat preference. Habitat availability was based on proportional composition of each type in the study area. The Wilcoxon Rank Sum test was used to test for significance in home range size.

A priori chi-square tests for significance between expected and observed habitat use based on availability were performed. Where significance was found, simultaneous Bonferroni confidence intervals (Neu et al. 1974, Byers et al. 1984) for observed habitat use based on telemetric locations were constructed to identify habitat types that were preferred or avoided annually by either females not subjected to flooding ($N = 26$) or females subjected to flooding ($N = 9$).

Demography

Annual and weekly survival schedules for the poult (<3 months old), hatching-year (HY, >3 months, but <1 year old), and after-hatching-year (AHY, >1 year old) segments of the female population were calculated using the Kaplan-Meier technique modified for staggered entry of animals (Pollock et al. 1989). Insufficient annual samples precluded analysis of male survival schedules. Tests of significance between female survival schedules were conducted with a log rank test. Observational data were systematically collected along radio telemetry routes from 15 May to 1 September each year and used to calculate a hen:poult ratio for relative analysis of annual variations in reproduction. Harvest data were collected using daily reconnaissance, check stations within the study area, WRC cooperator check stations, and information from hunt club presidents. Annual legal data were cross-checked with data collected from transmitted turkeys. Illegal harvest data was also collected from transmitted turkeys. Data from all turkeys harvested within the study area were analyzed using standard contingency table techniques to test for independence between years. As described by Cobb and Doerr (1991), a parsimonious, deterministic computer model was written to simulate the relationship between hydrological cycles in the Roanoke system during the study and the population dynamics of turkey populations in the floodplain, thereby allowing analyses of the influences of flooding beyond the temporal boundaries of this study.

Telemetry Error

Telemetry error for the 3 principal field observers (A, B, C) was quantified using 50 known radio locations distributed in all habitats and at distances representative of actual location distances for turkeys. Each observer recorded as many azimuths as possible in 15 minutes using the location technique employed in this study. Error data were recorded as mean deviation from a true azimuth. Significance among observers was tested and 95% confidence arcs constructed.

Results

Transmitters were placed on 50 females and 14 males (20 and 6, 12 and 4, and 18 and 4 during 1986, 1987, and 1988, respectively), and 55 poults (6 broods during 1988).

Flooding occurred during this study from 23 December 1986 to 22 June 1987 inundating all portions of the study area <5 m MSL (72%); no flooding occurred during 1986 or 1988. All or portions of 11 habitats were not inundated: 100% of the field, alluvial first ridge, hardwood plantation >10 years old, upland hardwood hillside, and clear-cut; 63% of the mixed pine/hardwood; 47% of the hardwood plantation <10 years old; 28% of the hardwood second ridge; 22.5% of the logged bottomland hardwood; 4.6% of the bottomland hardwood; and 2.4% of the tupelo gum/bald cypress backswamp types, respectively. Except for an 8-day period in April, the stage of the river was >5 m MSL at Hamilton, North Carolina, during the harvest and nesting season. By the beginning of the harvest and nesting seasons, birds had been isolated along the alluvial ridge and displaced out of their usual habitats. Isolation occurred at a river stage of approximately 4 m MSL.

Nesting

Eleven (55%), 2(17%), and 10(56%) of the 50 hens outfitted with transmitters initiated incubation during 1986, 1987, and 1988, respectively; the proportion nesting was lower ($P < 0.025$) in 1987. Median hatching date for turkeys in non-flood years was 29 May, with a range of 19 May to 13 July ($N = 10$). AHY females nested more frequently (74%) than HY females, (33%), with 65% and 67% completing incubation, respectively. Both of the nesting attempts during flooding were interrupted by predation from domestic dogs (*Canis familiaris*). Mean clutch size and number of poults hatched per clutch was 10.4 eggs/clutch (SE = 0.58) and 8.7 poults/clutch (SE = 0.94), respectively. Neither variable fluctuated significantly between non-flood years (1986 vs. 1988, $P > 0.50$) or female groups (AHY vs. HY, $P > 0.50$) However, observed hen:poult ratios were considerably lower in non-flood years (0.5 and 0.2 for 1986 and 1988, respectively) than in 1987 (6.6).

The 18 nests located for vegetation sampling during 1986 and 1988 occurred in 6 habitat types (bottomland hardwood, hardwood plantation <10 years old, hardwood second ridge, logged bottomland hardwood, transmission line corridor, tupelo gum/bald cypress backswamp) and 5 elevational gradients. Twelve percent of all successful nests were associated with a habitat ecotone; 76% with disturbed habitats. Three forested habitats were not used by nesting hens: alluvial first ridge, mixed pine/hardwood, and hardwood plantation >10 years old. Numerical classification of herbaceous data did little to delineate nesting habitat. Dendrograms for 1986 and 1988 nests had 40% and 64% clarity (Gauch 1982), respectively, suggesting that nest sites were dissimilar in understory vegetation. Mean nesting elevation increased ($P = 0.032$) from 1986 (3.25 m) to 1988 (4.10 m). Seventy-nine percent of all nesting habitats used during non-flood years were inundated during 1987.

Habitat Use

Annual female home range during non-flood years ranged from 125 to 1,441 ha. Female home ranges in 1986 and 1988 were similar ($P = 0.319$; Table 1) so data were combined for comparison to home range sizes for females subjected to the 1987 flood. Annual home ranges for 1986 and 1988 were smaller ($P = 0.001$) than those in 1987. During 1987, 3 birds moved permanently out of the floodplain and remained in the creek systems into which they had dispersed. No movement out of the floodplain occurred during non-flood years.

Use of habitat types by females during both flood and non-flood years was out of proportion to their availability ($P < 0.001$). During non-flood years, females used bottomland hardwood and transmission line corridor types more than would have been expected at random; and field, hardwood plantation <10 years old, mixed pine/hardwood, and tupelo gum/bald cypress backswamp types less than would have been expected at random (Table 2). During 1987, females subjected to flooding used alluvial first ridge, bottomland hardwood, and upland hardwood hillside types more than expected; and logged bottomland hardwood and tupelo gum/bald cypress backswamp types less than expected (Table 2).

Demography

Poult survival during the first week of life was 21%. HY and AHY survival schedules were similar during all 3 years of the study. Yearly comparisons were not significant in any case ($0.5 > P > 0.1$ – 86 vs. 87, $0.5 > P > 0.1$ – 86 vs. 88, $0.9 > P > 0.5$ – 87 vs. 88). Legal harvest mortality rates of transmittered males were 0.33 and 0.40 for 1986 and 1988, respectively.

Weekly harvest (i.e., all harvest within the study area) was not independent in the overall analysis ($P = 0.5$). Total harvest during 1986, 1987, and 1988 was 24, 35, and 22 birds, respectively. For 1986, weeks 2 and 4 contributed significance to the overall test. In 1986, harvest followed the typical bimodal pattern seen with many game species, with peaks during the first and last weeks of the season. During the 1987 season, which was officially closed by the WRC, 68% of the har-

Table 1. Female wild turkey home ranges in the Roanoke River study area, Martin and Bertie counties, North Carolina, 1986–1988.

Year	Home range (ha) $\bar{X}$	Home range (ha) SE	Wilcoxon rank sum statistic	P	N
1986	459.0	86.6	118.00[a]	0.011	10
1987	903.0	138.9	2.88[b]	0.002	9
1988	418.0	79.5	0.47[c]	0.319	16
1986 and 1988	434.0	58.2	2.98[d]	0.001	19

[a] 1986 vs. 1987
[b] 1987 vs. 1988
[c] 1986 vs. 1988
[d] 1987 vs. 1986 and 1988

Table 2. Simultaneous Bonferroni confidence intervals for habitat use by female wild turkeys in the Roanoke River study area, Martin and Bertie counties, North Carolina, 1986–1988.

Habitat type	Expected use (Availability)	Observed use (P_i)	CI on P_i
1986 and 1988 (N = 1,050 radio locations from 26 turkeys)			
Bottomland hardwood	0.190	0.399	$0.357 < P_i < 0.442$[a]
Transmission line corridor	0.002	0.012	$0.003 < P_i < 0.022$[a]
Alluvial first ridge	0.045	0.036	$0.020 < P_i < 0.052$
Hardwood second ridge	0.039	0.051	$0.032 < P_i < 0.071$
Logged bottomland hardwood	0.110	0.115	$0.088 < P_i < 0.143$
Upland hardwood hillside	0.015	0.017	$0.006 < P_i < 0.028$
Field	0.061	0.038	$0.021 < P_i < 0.055$[a]
Hardwood Plantation < 10 years old	0.076	0.018	$0.007 < P_i < 0.030$[a]
Mixed pine/hardwood	0.059	0.022	$0.009 < P_i < 0.035$[a]
Tupelo gum/bald cypress backswamp	0.402	0.290	$0.251 < P_i < 0.330$[a]
1987 (N = 744 radio locations from 9 turkeys)			
Alluvial first ridge	0.045	0.090	$0.062 < P_i < 0.119$[a]
Bottomland hardwood	0.191	0.292	$0.246 < P_i < 0.338$[a]
Upland hardwood hillside	0.015	0.088	$0.059 < P_i < 0.116$[a]
Field	0.061	0.072	$0.046 < P_i < 0.098$
Hardwood second ridge	0.040	0.057	$0.034 < P_i < 0.080$
Hardwood plantation < 10 years old	0.076	0.076	$0.050 < P_i < 0.103$
Mixed pine/hardwood	0.059	0.043	$0.022 < P_i < 0.063$
Logged bottomland hardwood	0.110	0.016	$0.003 < P_i < 0.028$[a]
Tupelo gum/bald cypress backswamp	0.403	0.266	$0.222 < P_i < 0.311$[a]

[a] Significant at $P < 0.05$.

vest occurred during the first week. Harvest in weeks 1 and 3 was greater and less than expected with independence, respectively. Harvest was greatest in the first week of 1988 and steadily decreased thereafter.

As reported by Cobb and Doerr (1991), results of computer simulation modeling suggested that during population recovery after flooding, high poult production was a larger contributor to the overall population size than was the number of AHY males or females, as neither of the latter age/sex classes recovered in 5 year model runs, a time frame much longer than the usual dry period.

Telemetry Error

Observer A collected 100%, 90% and 98% of radio locations used to analyze female home range dynamics in 1986, 1987, and 1988, respectively. Observers B and C collected 10% and 2% of radio locations used to analyze female home range dynamics in 1987 and 1988, respectively. Data collected by observers A and B were negatively biased ($\bar{X}$ = 4.8°, SE = 1.7°, $\bar{X}$ = 0.9°, SE = 2.0°, respectively). Azimuths recorded by observer C were positively biased ($\bar{X}$ = 6.2°, SE = 1.3°). Error for observer C was significantly larger than for either of the other observers. Considering the negligible relief and large habitat tract size in the study area, proximity of most transmittered turkey locations to telemetry stations (>90%, <2 km), and the preponderance of data collection by observers A and B (99.4%) who did not differ in their telemetry error ($P = 0.1451$), we feel that error did not significantly affect our interpretation of the telemetry data.

Discussion

Although telemetered females dispersed to areas at highest elevations during flooding, no successful nesting occurred. Vegetative analyses of nest sites used during non-flood years suggested that most floodplain habitats can provide suitable areas for nesting as described by Speake et al. (1975), Healy (1981), and Lazarus and Porter (1985). A consistent feature of successful nests is their association with either a disturbance or habitat ecotone, as reported by Wheeler (1948) and Porter (1977). The habitats into which telemetered females dispersed during flooding were not used by nesting hens during non-flood years in our study. Movement into these types of habitat placed birds in what we believe to have been atypical nesting areas compared to that used during non-flood years. These areas comprised the sharp transitional zone from floodplain habitats through the upland hardwood hillside type into agricultural areas (Fig. 1). Transmittered males in this study also dispersed into this region (WRC unpubl. data). Because the onset of nesting coincided with opening of the spring harvest season, the concentration of male turkeys in the same zone as females concentrated hunter activities in the only areas available for nesting in 1987. Poor reproduction by telemetered birds could have been due to increased hunter disturbance of hens, the vegetative unsuitability of this zone for nesting when compared to habitats used for nesting during non-flood years, increased opportunities for predation by feral animals, human disturbance due to this zone's easy access and proximity to dwellings, and/or annual stochasticity. Our study demonstrated that nesting by turkeys forced by flooding to disperse into these suboptimal nesting habitats was significantly reduced. We believe that the magnitude of flood events was as important as timing because it directly influenced suitable habitat availability. Initiation of flooding prior to onset of incubation did not negate negative impacts on reproduction.

During non-flood years, habitat use patterns reflected the utility of the transmission line corridor type for nesting and the lack of food and cover requisites used by turkeys throughout the year in the bottomland hardwood type (Bromley and Carlton 1981). As flooding progressed in 1987 and birds were concentrated along the alluvial ridges, they spent more time during the initial weeks of flooding feeding in trees similar to patterns described by Kimmel and Zwank (1985). Birds then dispersed to the habitats at highest elevations, typically the alluvial first ridge, bottomland hardwood, and upland hardwood hillside types. Shifts to greater use of these habitats may have been an artifact of changes in habitat availability, not necessarily resource preference.

Nesting data support the assertion that female turkeys in the study area reproduce adequately to maintain the population in non-flood years. Accepting the underlying assumptions of this study, we suggest, however, that water management strategies by the COE at Kerr Reservoir significantly altered nesting habitat availability and population recruitment for the wild turkey population and that the net effect of these alterations was negative. Although some variation in reproductive variables measured in this study were undoubtedly due to the inherent stochasticity seen in turkey populations, annual variations were more extreme that those summarized by Vangilder (1992).

Legal harvest varied throughout the study. The 1986 harvest reflected a traditional pattern with harvest being highest during the first and last weeks of the season. The harvest rate of telemetered males during the 1987 season increased 14% over 1986 despite the fact that the WRC had closed the area to hunting. This change possibility reflected the increased vulnerability of males resulting from concentration during flooding. Since all harvested, birds were reported in 1987 to cooperator agents, these data were analyzed as legal harvest. However, these data may actually represent the magnitude of illegal harvest that took place during flooding. We believe that harvest patterns in 1988 reflected the increased difficulty experienced by some hunters during the 1987 flood, which resulted in increased effort during the first half of the 1988 season. The 1988 harvest data also reflected the change in age structure of the population as HY males are typically easier to harvest, so most hunters filled their quota earlier in the 1988 season.

It is not surprising that survival schedules did not differ significantly with the severity of flooding because the survival functions were based on data from females who were not subjected to legal harvest. Further, this finding suggests that flooding did not increase natural mortality rates of females. Turkey populations along the Roanoke were affected most by significant reductions in reproductive success and by significant increases in the harvest of males.

Simulation results (Cobb and Doerr 1991) suggest that flooding caused a shift in the structure of the male segment of the population from one with a high percentage of adults to one that was dominated by immature birds, and the total number of harvestable males will not recover to the pre-flood level unless flooding intervals are greater than 5 years. To turkey hunters, this structural shift in the population reflects a decrease in availability of turkeys as a harvestable resource. Based on recent historical records, the Roanoke system seldom experiences more than a 3-year dry period. Short-term management to maintain resource availability to sportsmen by the WRC or other agencies responsible for managing ecosystems like the RRB must, therefore, address population structure as well as size.

The agreement between the COE, Virginia Power Company, and the WRC for regulation of augmentation flows for fish from Kerr Reservoir was amended in 1989 to allow for maximum flows of 13,700, 11,000 and 9,500 cfs at Weldon, North Carolina, for the periods 1–15 April, 16–30 April, and 1 May–15 June, respectively (Manooch and Rulifson 1988). In order to manage the turkey population in the RRB to its fullest recreational and biological potential, we suggest that the maximum flows should be reduced to 8,000 cfs at Weldon, North Carolina, for the period 1 March–15 June to avoid the negative effects of flooding on wild turkey population dynamics and habitat availability in the floodplain. Although derived independently, this value corresponds to the mean annual pre-impoundment discharge reported by Fish (1959).

Traditionally, floodplain wetlands in North Carolina were primarily gum/cypress swamps with intermixed stands of bottomland hardwoods. The RRB was no exception and, thereby, probably provided quality turkey habitat. The recent increase in frequency and duration of flooding has changed the hydrology of the floodplain such that many of the habitats that turkeys probably depended on for annual food, cover, and nesting requisites are inundated during critical periods. Statements about changes in turkey population levels under pre- vs. post-impoundment conditions are, unfortunately, impossible. Population density estimates are sketchy and harvest data have been collected for only 12 years. It seems reasonable to assume, however, that changes in hydrology that have adversely affected vegetative components of the Roanoke system also have adversely affected turkey habitat availability and population dynamics. Turkey populations along the Roanoke are presently at a relatively high level. Although the species as a whole was nearly driven to extinction in the 18th and 19th centuries, the remnant population in the Roanoke system persisted, suggesting that populations were protected from man. With changes in the hydrology of the system, we doubt the system's ability to continue buffering RRB turkey populations from exogenous impacts.

Turkey populations have existed in the floodplain for hundreds of years. Pre-impoundment conditions in the floodplain were certainly drier than post-impoundment and therefore should have favored this species. The correspondence of our estimated optimal flow to that of Fish (1959) suggests that we have identified important parameters that influence wild turkey populations in the floodplain and that implementing management suggestions included herein could restore conditions necessary for supplying high quality turkey habitat therein. Although optimal flow levels will vary, the same management principles should apply for other Coastal Plain river systems affected similarly by unnatural flooding.

In river systems similar to the RRB where turkey management is a priority but populations are negatively impacted by flooding, we suggest the following management guidelines if significant changes in reservoir discharge rates are not feasible. First, in areas within the floodplain, annually monitor the number and size of broods as an index to recruitment. Population estimation techniques are unreliable and would be cost and labor prohibitive. Secondly, detailed, annual harvest statistics should be collected, including hunter effort and success. Third, regulations concerning season closure should be written such that they relate river stage at closure to habitat variables and use road systems as boundaries. This change would alleviate the ambiguity of a flood law that relates to distances from flood waters. Fourth, during years with spring floods, the harvest season should be closed if: 1) a sustained flood occurred in immediately previous years, 2) inundation patterns stabilize such that turkeys are isolated prior to breeding, and 3) river stages facilitate poaching. Adequate enforcement of regulations must be provided to ensure actual season closure. Finally, all changes in regulations and interim management should be publicized through both written and visual media. With these management strategies, the deleterious effects of flooding on wild turkeys in the floodplain can be minimized until changes in management of the system's hydrology are negotiated.

As stated, we are confident in our identification of some impacts extreme flooding can have on turkey populations in the RRB. This study did, however, suffer from 3 shortcomings: small sample sizes, unavailability of a control, and short duration. Sample sizes were maximized based on available manpower, temporal trapping "windows" between pre-emptive activities within the study area, and susceptibility of turkeys to capture. As stated, a traditional treatment control-replicated design was not possible. Preclusion of the traditional treatment-control-replicated design did not, however, diminish the importance of studying this problem or invalidate our work or the implications of our results for turkey and ecosystem management. As suggested by Sinclair (1991), many ecosystem-scale phenomenon would remain unstudied if this was the general case. In this study, we made every attempt to overcome our limitations by using simulation modeling to expand temporal scales and by acknowledging that some degree of the annual variation in habitat use and population parameters could have been attributable to inherent stochasticity, but further showing that it was more extreme than annual variations reported in the literature. The flood event through which we recorded data was at that time the flood of record since Kerr Reservoir was constructed. Interestingly, several floods have occurred since that time, with a new flood of record in 1993. If as attempted this study had been extended beyond 1988, significant additional data would be available to corroborate or refute our findings. Under current management of the RRB, demonstration of direct cause-effect relationships against a control on a population level will not be possible. We encourage the continued use of an adaptive management approach, as initiated by this study, to expand our knowledge of the impacts of flooding on all components of the RRB.

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