1988

Bald Eagle Investigations

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PERFORMANCE REPORT

STATE:	VIRGINIA	PROJECT NO.:	W-77-R-5
PROJECT TYPE:	Research and/or survey	STUDY NO.:	I
PROJECT TITLE:	NONGAME AND ENDANGERED SPECIES INVESTIGATIONS	JOB NOS.:	A-F

STUDY TITLE: BALD EAGLE INVESTIGATIONS

JOB TITLE: BALD EAGLE INVESTIGATIONS

PERIOD COVERED: July 1, 1987 - June 30, 1988

JOB I-A OBJECTIVE: To make a winter inventory of bald eagle numbers including age composition of this population.

JOB I-B OBJECTIVE: To determine hatching and fledging success of eagles in Virginia.

JOB I-C OBJECTIVE: To identify ownership of nesting areas and concentration areas of bald eagles during the summer and winter season and to develop management agreements and protection strategies where possible for these areas. These areas will be monitored regularly as deemed necessary.

JOB I-D OBJECTIVE: To band and color mark a major proportion of each year's cohort of young eagles.

JOB I-E OBJECTIVE: To map existing and potential eagle nest sites.

JOB I-F OBJECTIVE: To provide other states with young eagles for recovery and re-establishment efforts.

SUMMARY:

Aerial and ground surveys resulted in the location of 81 active bald eagle nests and three additional occupied territories. A total of 118 young hatched. This resulted in a production of 1.46 fledglings per active nest and 1.82 fledglings per productive nest. Eighty percent of the active nests were productive.

Shoreline surveys were conducted regularly of two summering populations, one each on the James and Potomac Rivers.

An aerial mid-winter survey of eagles was conducted in January, resulting in the location of 262 birds. The mid-winter population consisted of 150 adults and 112 immatures.

Habitat analysis studies were completed during the year.

JOB I-A - To make a winter inventory of bald eagle numbers including age composition of this population.

WINTER SURVEYS

Project personnel conducted a survey throughout Eastern Virginia in January to locate wintering eagles. All major tributaries were covered. Inland impoundments were covered both by ground and by boat by volunteers. For purposes of comparison, data for 1986, 1987, and 1988 are shown in Table 1.

Table 1. Bald eagles observed during mid-winter surveys, January, 1986, and 1987, and 1988.

Area	Adults 1986	Adults 1987	Adults 1988	Immatures 1986	Immatures 1987	Immatures 1988
James-Chickahominy Rivers	36	24	39	34	20	46
Rappahannock-Piankatank Rivers	58	42	55	54	31	43
Potomac River	37	39	33	34	40	16
York, Pamunkey, Mattaponi Rivers	8	14	16	1	2	4
Eastern Shore-Lower Tidewater	5	4	4	3	1	2
Inland Impoundments	8	2	3	9	1	1
Totals	152(53%)	125(57%)	150(57%)	135(47%)	95(43%)	112(43%)

The ratio of adults to immatures was exactly the same 57% : 43% as observed in 1987. Total count for the state was up 19% above the level of 1987. Mid-winter population numbers appear closely correlated with weather patterns. The seasonal variation seen in the three years probably has little population significance. It does appear that both the James and Rappahannock Rivers continue to support a large number of bald eagles in the winter. One of the largest winter concentrations on the Rappahannock River is along the shoreline of Portobago Bay. The large development planned there was commented on in the last annual report. This development is well underway at the present time. The impact of this activity on wintering eagles will be evaluated in the future. Another development currently planned for the Fones Cliffs area of the Rappahannock is on an area of the river which is utilized heavily by eagles in the winter. The increasing number of cases of habitat loss in concentration areas emphasizes the need to acquire these areas.

SUMMERING CONCENTRATION

Potomac River

The summering eagle population along the Potomac River in King George County has been monitored for several years in view of the state ownership of a major unit of property, Caledon Natural Area, which supports a large population of eagles in the summer. In a continuing assessment of the possible impact of human visitation on the bald eagles of Caledon, weekly shoreline surveys have been conducted since 1986. Numbers of eagles appear to be down in 1988 but this may well be a seasonal variation.

James River

The James River has replaced Caledon as the most significant summer concentration point for bald eagles in Virginia. A standard 7 1/2 mile census route on both sides of the James River is conducted approximately once per week during June and July. The route is an area encompassing a major roosting area. Although the roost area recently was acquired by the Nature Conservancy, the shoreline which is used for foraging is still subject to a number of development pressures. The shoreline surveys are intended to establish a seasonal pattern of use for the shoreline on both sides of the James River. All data have been accumulated and plotted for the season in accordance with 1/2 mile shoreline intervals. Census numbers for 1985, 1986, and 1987 are indicated in Table 2.

Table 2. Eagles seen on shoreline census, James River roost area, 1985-1987.

	Week Number	1	2	3	4	5	6	7	8	9	10	11	12
1985	Date	5/10	5/15	5/27	6/10	6/15	6/2	6/28	7/1	7/10	7/17	7/21	7/22
	Adult Eagles Observed	7	9	14	11	9	7	15	15	18	19	17	20
	Imm. Eagles Observed	8	7	15	15	20	19	30	26	29	23	27	22
	Totals	15	16	29	26	29	26	45	41	47	32	34	42
	Week Number	1	2	3	4	5	6	7	8				
1986	Date	5/2	5/21	5/29	6/13	6/27	7/8	7/16	7/25				
	Adult Eagles Observed	7	23	23	33	23	29	23	21				
	Imm. Eagles Observed	5	27	18	32	46	38	44	42				
	Totals	12	50	41	65	69	67	67	63				

	Week Number	1	2	3	4	5	6	7	8	9
1987	Date	5/14	5/21	5/27	6/10	6/19	6/26	7/5	7/16	7/24
	Adult Eagles Observed	10	25	19	23	21	40	29	29	34
	Imm. Eagles	14	34	30	34	39	38	59	61	54
	Totals	24	59	49	57	60	78	88	90	88

In 1987, there appeared to be a large movement of eagles into the are in mid-July with the largest number of eagles recorded since the inception of studies on this area. Thus far, the highest number recorded in 1988 ha been 63 birds. Two areas which have been identified as the highest use areas in the survey area have been suggested as sites for development activities. In view of the importance of this section of the river for foraging by eagles, a comprehensive management plan for both the roost are and the adjoining river shore should be developed in the future.

JOB I-B - To determine hatching and fledging success of bald eagles in Virginia.

HATCHING AND FLEDGING SUCCESS

Aerial surveys were conducted in February, March, and May to locate active nesting territories and to determine the number of young produced. May surveys were conducted after young were large enough to be observed with more certainty from the air. Surveys were conducted throughout Tidewater Virginia, the Eastern Shore, and Kerr Reservoir

Aerial surveys resulted in the location of 81 active nests and three additional occupied territories in which the females of the pairs were not observed to produce eggs. All active nests were plotted on 7 1/2 minute topographic sheets. The location and fate of each active nest is shown in Table 3.

Table 3. Location and productivity of active, bald eagle nests in Virginia, 1988.

County	Nest Number	No. of Young Fledged
Accomac	Ac.80-01	1
Accomac	Ac.87-01	2
Accomac	Ac.88-01	0
Caroline	Ca.86-01	2

Table 3 - continued

County	Nest Number	No. of Young Fledged
Charles City	CC.85-01	0
Charles City	CC.87-01	2
Charles City	CC.88-01	2
Charles City	CC.88-02	3
Essex	Es.78-01	2
Essex	Es.88-01	2
Essex	Es.88-02	1
Fairfax	Ff.80-01	2
Gloucester	Gl.88-01	2
Gloucester	Gl.88-02	0
Halifax	Hf.85-01	1
Henrico	He.88-01	3
Isle of Wight	IW.86-01	0
James City	JC.87-01	2
James City	JC.87-02	1
James City	JC.87-03	3
King George	KG.82-02	1
King George	KG.84-02	2
King George	KG.84-04	1
King George	KG.87-01	0
King George	KG.87-02	2
King George	KG.87-04	1
King George	KG.87-05	0
King George	KG.87-06	2
King George	KG.87-07	0
King William	KW.79-01	2
King William	KW.80-01	3
King William	KW.85-01	3
King and Queen Courthouse	KW.87-01	1
Lancaster	La.75-01	2
Lancaster	La.88-01	0
Middlesex	Mi.77-01	1
Middlesex	Mi.86-01	3
Middlesex	Mi.87-01	0
Middlesex	Mi.87-02	2
Middlesex	Mi.88-01	3
New Kent	NK.79-04	2
New Kent	NK.83-01	1
New Kent	NK.86-01	2
Newport News	NN.87-01	1
Northampton	Nt.87-01	0
Northampton	Nt.87-02	1
Northumberland	Nd.86-01	0
Northumberland	Nd.86-02	2
Northumberland	Nd.88-01	1
Prince George	PG.61-01	2

Table 3 - continued

County	Nest Number	No. of Young Fledged
Prince George	PG.86-01	2
Prince George	PG.87-01	2
Prince George	PG.88-01	2
Prince William	PW.87-01	2
Richmond	Ri.84-02	2
Richmond	Ri.86-04	0
Richmond	Ri.87-01	3
Richmond	Ri.87-02	0
Richmond	Ri.88-01	2
Richmond	Ri.88-02	2
Richmond	Ri.88-03	2
Stafford	St.82-01	2
Stafford	St.85-01	1
Stafford	St.87-01	1
Stafford	St.87-02	1
Suffolk	Sk.86-01	2
Surry	Su.82-01	1
Surry	Su.87-02	1
Westmoreland	We.78-05	2
Westmoreland	We.79-04	2
Westmoreland	We.83-01	1
Westmoreland	We.83-03	2
Westmoreland	We.83-04	2
Westmoreland	We.84-01	2
Westmoreland	We.84-04	2
Westmoreland	We.86-01	2
Westmoreland	We.88-01	0
Westmoreland	We.88-02	0
Westmoreland	We.88-03	0
York	Yk.86-01	2
Totals	81 nests	118

Of the active nests, 65 were productive and 16 were unproductive. No young were known to be lost between the last aerial survey and fledging but all nests were not followed to the end of the pre-fledgling period.

Assuming that all young fledged successfully,average production was 1.46 young per active nest. This production was virtually identical to the level of 1.47 young per active nest achieved in 1988.

The number of fledglings per productive nest was 1.81, a slight increase from 1987. Of the 65 successful pairs, eight produced three young each, 37 produced two young each, and 20 produced one young each.

Data on productivity trends for the period 1977-1988 are summarized in Table 4.

Table 4. Bald eagle productivity in Virginia for the period 1977-1988.

Year	Total Active Nests	Total Prod. Nests	Total Unprod. Nests	Percent Nest Prod.	Total Young Fledged	Fledglings Productive Nest	Fledglings Active Nest
1977	33	13	20	39	18	1.38	0.54
1978	37	14	23	38	18	1.29	0.54
1979	33	15	18	45	20	1.33	0.61
1980	35	23	12	66	35	1.52	1.00
1981	39	27	12	69	40	1.48	1.02
1982	45	28	17	62	41	1.52	0.93
1983	52	31	21	60	51	1.68	0.98
1984	60	34	26	57	58	1.68	0.97
1985	65	47	18	72	84	1.79	1.29
1986	66	43	23	65	83	1.93	1.26
1987	73	61	12	84	107	1.75	1.47
1988	81	65	16	80	118	1.82	1.46

Data on productivity of bald eagles in Virginia by river systems are indicated in Table 5. One of the most interesting areas in 1988 was the York River drainage where all 10 nests were productive. As recently as 5 years ago, eagles on this drainage were producing few young. The James River continues to increase in importance as both a nesting and concentration area with the breeding population having gone from one pair in 1978 to 17 pairs in 1988.

Table 5. Bald eagle productivity in Virginia for 1988 by River System or Area.

River System or Area	No. of Active Nests		Percent Nests Productive		No. of Fledglings Produced		Fledglings per Productive Nest		No. of Fledgings per Active Nest	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988

Table 5 - continued

River System or Area	No. of Active Nests		Percent Nests Productive		No. of Fledglings Produced		Fledglings per Productive Nest		No. of Fledglings per Active Nest	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
York, Pamunkey Mattaponi Piankatank Rivers	10	12	80	92	14	21	1.75	1.91	1.40	1.75
James, Chickahominy Rivers	16	17	75	88	22	19	1.83	1.93	1.38	1.71
Potomac River	21	23	76	74	26	29	1.63	1.70	1.24	1.26
Rappahannock River	21	23	86	79	37	33	2.06	1.83	1.76	1.43
Eastern Shore-Reservoirs	5	6	100	67	8	6	1.60	1.50	1.60	1.00
Totals	73	81	84	80	107	118	1.75	1.81	1.47	1.46

JOB I-C - To identify ownership of nesting and concentration areas of bald eagles during the summer and winter season and to develop management agreements and protection strategies where possible for these areas.

Several summer and winter concentration areas have previously been identified, including the roost area on the James River identified in Job I-A. Land ownership around this roost has been recorded. This site recently was acquired by the Nature Conservancy. A number of development projects are proposed for areas in close proximity to this roost. One of these areas has actually experienced increased eagle activity due to habitat modification. This suggests that the roost area may be enhanced for eagle usage through active management. The Virginia Department of Game and Inland Fisheries will be working closely with the final recipient of this area towards the development of a long-term management strategy both for the roost area and the James River corridor around which the roost is located.

As part of the job on protection and management strategies, response was made to 56 inquires regarding land use projects which might have an impact on an eagle nest or concentration area. Inquires came from both state and federal agencies as well as individual landowners. Seven site visits were made to provide management recommendations regarding bald eagle nesting areas. Seven site visits were made to verify reports of nesting eagles.

JOB I-D - To band and color mark a major proportion of each year's cohort of young eagles.

No activity in this job occurred since it was determined by the NWF and cooperating states to discontinue the study after 10 yrs.

JOB I-E - To map existing and potential eagle nest sites.

Job completed - see Appendix A.

JOB I-F - To provide other states with young eagles for recovery and re-establishment efforts.

No activity in this job during the year as no requests were received for young eagles.

TARGET DATE FOR COMPLETION: Continuing

STATUS OF PROGRESS: On Schedule

SIGNIFICANT DEVIATIONS IN PROGRESS: NONE

RECOMMENDATIONS: Continue Study

COST THIS SEGMENT: Federal $28,419 State $9,473 Total $37,892

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August 1, 1988

Appendix A

STATE:	VIRGINIA
PROJECT TYPE:	RESEARCH AND/OR SURVEY
PROJECT TITLE:	NON-GAME AND ENDANGERED SPECIES INVESTIGATIONS
PROJECT NO.:	W-77-R-4
STUDY TITLE:	DESCRIPTION AND MAPPING OF EXISTING AND POTENTIAL BALD EAGLE NESTING HABITAT IN VIRGINIA
STUDY NO.:	I
JOB TITLE:	DESCRIPTION AND MAPPING OF EXISTING AND POTENTIAL BALD EAGLE NESTING HABITAT IN VIRGINIA
JOB NO.:	I-E
PERIOD COVERED:	15 AUGUST 1986 TO 1 JULY 1988
STUDY OBJECTIVE:	TO DESCRIBE AND MAP EXISTING AND POTENTIAL EAGLE NEST SITES

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INTRODUCTION

The bald eagle (Haliaeetus leucocephalus) breeding population in Virginia, Maryland and Delaware is recognized as a distinct population based on existing and historical East Coast breeding ranges (Taylor et al. 1982). Population productivity declined drastically during the 1940s and 1950s, reaching a low in the early 1960s. The number of pairs attempting to breed showed a similar decline. A slow but steady recovery in productivity and numbers began in the mid-1970s and continues today (Cline 1986). This decline and recovery was observed in most of the bald eagle breeding populations in the conterminous United States, and has been attributed to the widespread use of the organochlorine insecticide, DDT, and its subsequent ban in 1972. In 1987, 136 occupied nests were observed in the three-state region, a 25- year high. Sixty-eight of those nests were in Virginia, which plays a crucial role in the recovery of this endangered species.

The U.S. Fish and Wildlife Service's Chesapeake Bay Bald Eagle Recovery Plan (Taylor et al. 1982) identified the pressures of human population growth — habitat destruction and human disturbance — as limiting factors for the recovery of this Chesapeake Bay bald eagle population. Between 1950 and 1980, the human population in Chesapeake Bay's watershed increased by 4.2 million and is expected to reach 14.6 million by the year 2000. The largest population increases are expected in the Potomac and James river basins; the highest rates of increase are expected in the York (43%) and Rappahanock (40%) river basins (U.S. Environ. Prot. Agency 1983). Virginia's bald eagle breeding population is currently concentrated in the coastal plain area of these river basins (see Figs. 1 and 2).

Human population growth results in an increase in construction activity; intensified agriculture, industry, timber harvesting, and urban and residential development; waterfront development; and recreational boating. Negative impacts on bald eagle habitat have been identified for each of these activities (Taylor et al. 1982), however, the impacts of population growth on Virginia's available bald eagle habitat are not well understood. Some agricultural and timber harvest practices may, in fact, be creating bald eagle nesting habitat in the state (Andrew and Mosher 1982, Taylor et al. 1982). The bald eagle recovery team recognized that identifying available bald eagle habitat, both existing and potential, was an essential step in developing habitat management plans (Taylor et al. 1982).

The purpose of this project is to describe existing and potential bald eagle habitat in Virginia. The results will provide the Department of Game and Inland Fisheries' wildlife managers with information necessary to manage bald eagle habitat in the state. Managers can use the results in at least two major ways: 1) to identify current nest site characteristics that should be protected, and 2) to provide a measure of the potential significance of coastal plain Virginia for nesting. Whenever development is planned for eastern Virginia, managers can refer to this document to identify how important those areas may be to the future of bald eagle nesting populations. If the areas appear to provide potential nesting habitat, managers can then ground-verify these results.

STUDY AREA

The study area consisted of the Coastal Plain Province of Virginia (Fig. 1) as defined by lower Coastal Plain and upper and middle Coastal Plain soils on the U.S. Department of Agriculture, Soil Conservation Service General Soil Map of Virginia. All or a portion of 32 counties and the remaining municipalities east of the Fall Line were included. Sixty-seven of 68 bald eagle nests known to be occupied in 1986 were located in the Coastal Plain. One occupied nest and one suspected nesting attempt in the Piedmont Province (Halifax and Loudoun counties, respectively) were not included in this study.

The Coastal Plain of Virginia north of the James River lies in the Atlantic Slope section of the Oak-Pine Forest Region (Braun 1974). Plant associations in this region include white oak (Quercus alba), yellow poplar (Liriodendron tulipifera), northern red oak (Q. rubra), loblolly pine (Pinus taeda), Virginia pine (P. virginiana), and loblolly pine-hardwood. The study area south of the James River lies in the Southeastern Evergreen Forest Region (Braun 1974). Plant associations include loblolly pine, loblolly pine-hardwood, bald cypress (Taxodium distichum), and water tupelo (Nyssa aquatica). Major land uses in the study area include timber harvesting; agriculture; recreation; and urban, suburban and industrial development.

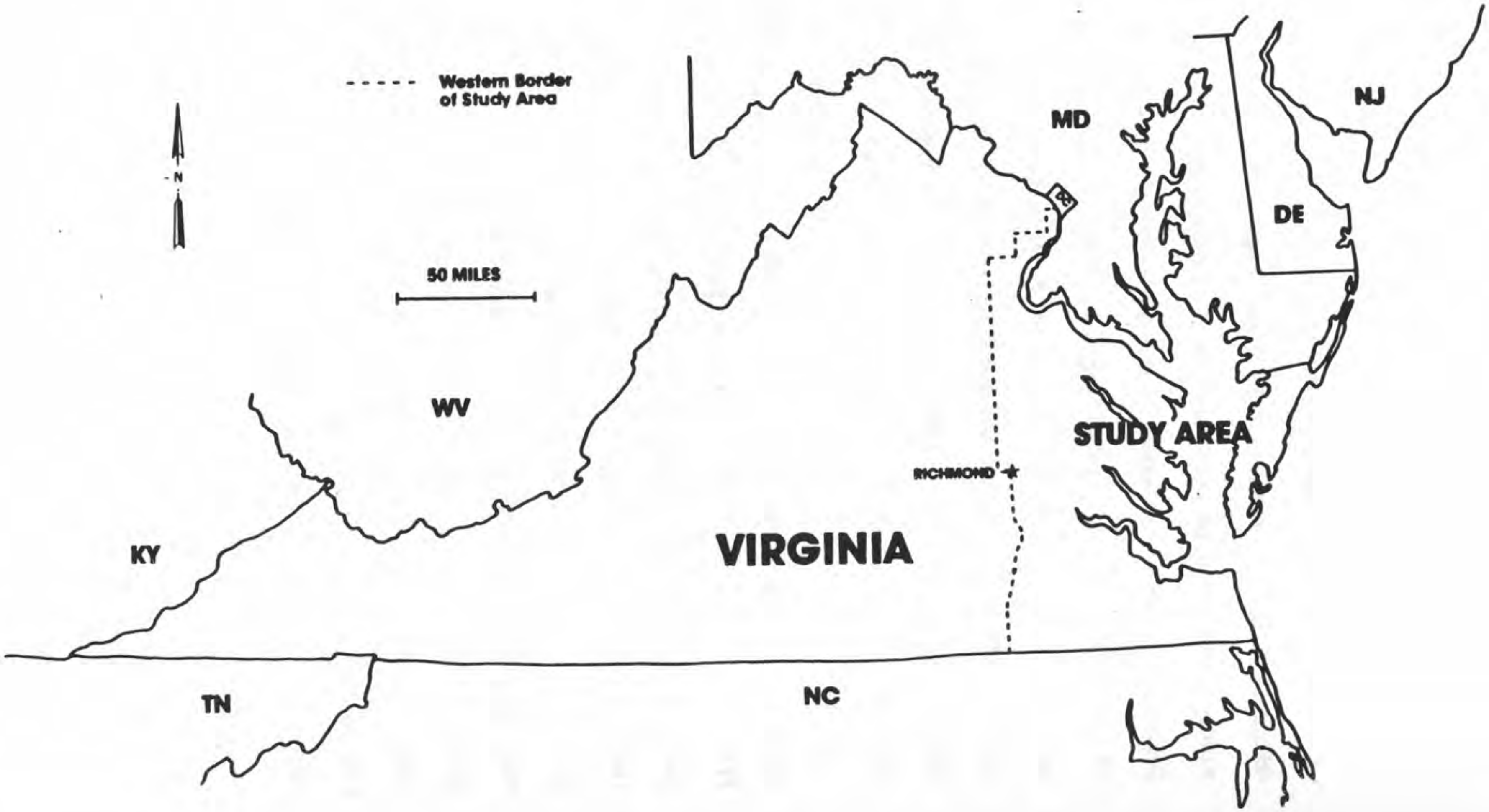

Figure 1. Study area of bald eagle nesting habitat project, coastal plain Virginia, 1988.

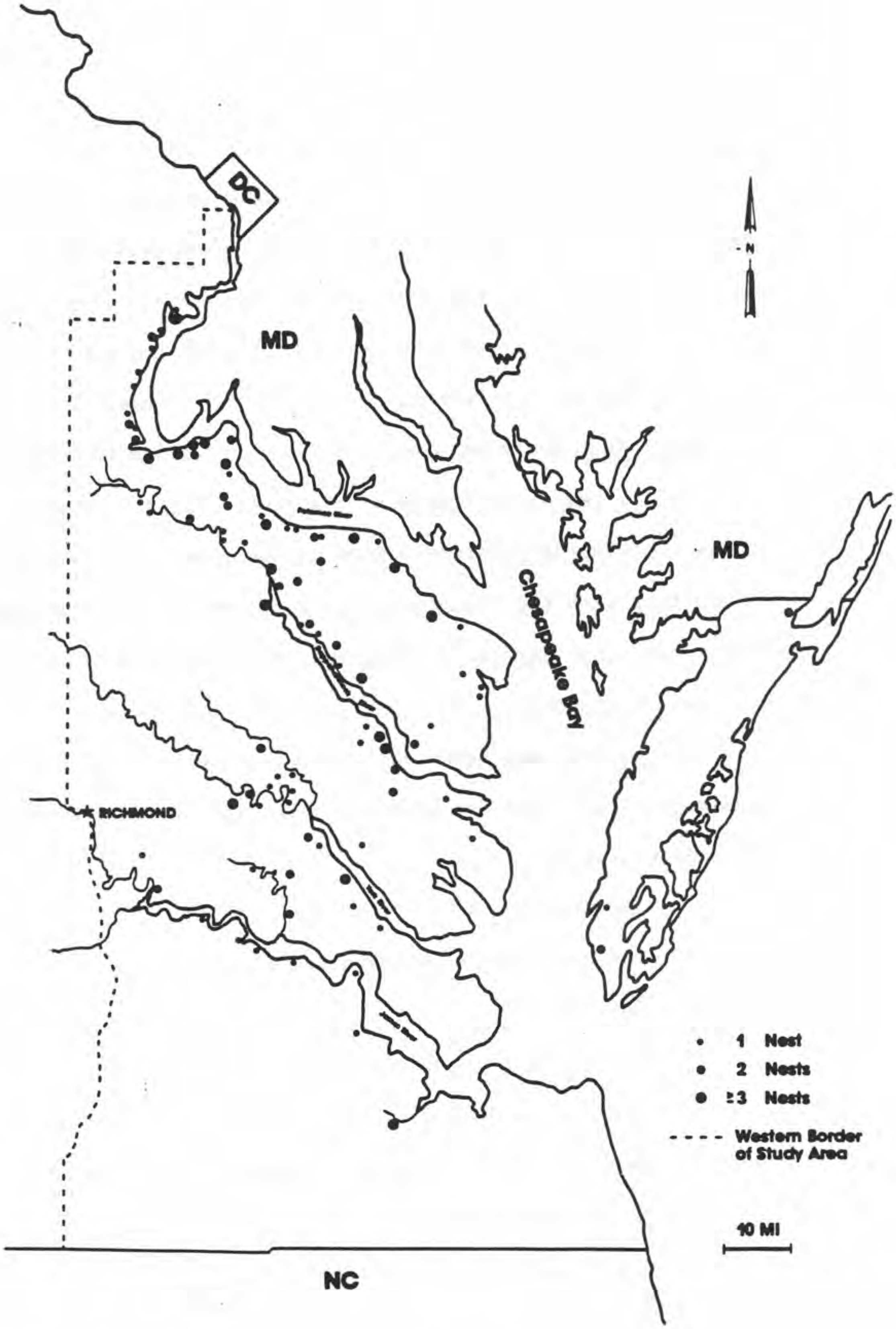

Figure 2. Bald eagle nesting areas in coastal plain Virginia, 1977-1985.

METHODS

Describing Existing Bald Eagle Nest Sites in Virginia

Cline and Clark (1982) described methods used to locate bald eagle nests in this study. One hundred and seventy-seven Virginia bald eagle nests were occupied one or more years during 1977-1986 (Fig. 2). Fifteen nests were not included in this study; 14 nests had inadequate location information, and one was located outside the Coastal Plain. Nests were not grouped by breeding territories.

The 162 nest locations were plotted on 7.5 min. U.S. Geological Survey topographic quadrangle maps during aerial surveys in conjunction with the Chesapeake Bay Bald Eagle Banding Project 1977-1986. Locations were also ground-verified by visits to each nest at the time of discovery.

Nine habitat and human activity characteristics were measured from topographic maps for each nest site and random point (Appendix I). The nine variables were:

Improved roads

Transportation/communication lines

Forests

Water1 (large open water bodies)

Water2 (smaller open water bodies)

Wetlands (forested and nonforested)

Agricultural/open areas

Low human density development

High human density development

These variables were selected because: 1) they were identified as important variables in similar studies (i.e., Jaffee 1980, Taylor and Therres 1981, Andrew and Mosher 1982), 2) they were easily measurable and identifiable on topographic maps, and 3) they were compatible with BOVA (Biota of Virginia) database system and the Land Use and Land Cover Classification System (Anderson et al. 1983).

The distance from the center of the UTM cell in which each nest site fell to each variable was measured to the nearest 100 m. Distances < 100 m were coded as 100 m; those > 9,999 m were coded as 9,999 m. Distances between random points and variables were measured similarly. Data were coded and stored in dBase III+ (Appendix II).

The student's t-test (Sokal and Rohlf 1981) was used to investigate differences in variables between nest sites and random points. Those variables which were not significantly different (alpha = 0.10) between nest and random points were dropped. The six remaining variables were:

Forest

Water1

Water2

Wetland

Agriculture/open area

High density human development

Measuring Variables in Grid Cells

Distances to the six significant variables were recorded in at least part of each of 200 quadrangle maps for coastal plain Virginia. Each map contained more than 150 1000-m^2 grid cells (100 ha [247 acres]). Each cell was identified by the UTM coordinates of the southeast corner of the cell. Variables were measured from the midpoint of each cell, regardless of distance, unless: 1) no forested area $\geq$ 4 ha was present in the cell, 2) the cell was located west of I-95 south of Richmond, Va. (because it was assumed not to be former or potential nesting habitat), or 3) the cell was located within the Franktown, Va. quadrangle which had no forest marked. Topographic maps were not available for six quadrangles in southeastern Virginia: Suffolk, Va.; Lake Drummond N.W., Va.; Deep Creek, Va.; Corapeake, Va. - N.C.; Lake Drummond, Va. - N.C.; and Lake Drummond S.E., Va. - N.C. The cells in these quadrangles were coded from orthophotomaps. Cells farther than 10 km from Water1 were coded but were eliminated from the analysis as no known bald eagle nests have been located farther than 10 km from large open water bodies in Virginia.

Building the Discriminant Function Model

The six variables remaining following t-tests were used in discriminant function analysis (Sokal and Rohlf 1981) to build a habitat suitability model. The discriminant function is a special case of the general linear model and is computed by SYSTAT (System for Statistics) as if it is a one-way multivariate analysis of variance (Wilkinson 1987). Discriminant function analysis builds a model by clustering observations with similar characteristics in pre-defined groups. An observation from an unknown group (test observation) can then be compared to each group to determine the probability that it belongs to a given group.

Eighty-one nest sites and 81 randomly selected points were used to create a model to determine if habitat selection differed from habitat availability. Groups were identified as "nest" or "random point." The remaining 81 nest sites were used to test the predictability of the model.

Predicting Potential Nesting Habitat

Distances to variables for each grid cell were processed in the habitat suitability model to predict potential bald eagle habitat. The model assigned each cell two scores: the probability that the cell belonged to the potential nest site group (PROB1) and the probability that it belonged to the random point group (PROB2). Discriminant function analysis classifies observations with PROB1 $\geq$ 0.500 as belonging to group 1 (in this case, potential nest sites). Higher PROB1 scores indicate higher probabilities that the observation belongs to group 1 (i.e., that the sites are potential bald eagle nesting habitat). To further define potential nesting habitat, we classified cells with PROB1 $\geq$ 0.800 as primary potential nesting habitat, those with PROB1 = 0.650–0.799 as secondary habitat, and cells with PROB1 = 0.500–0.649 as tertiary habitat. PROB2 is simply a reflection of PROB1 (i.e. PROB2 = 1 - PROB1) and therefore needs no further discussion.

RESULTS AND DISCUSSION

Student's T-test

Significant differences between nest and random points were found for six of the nine variables (Table 1). In addition, standard errors for all significant variables were much lower for nest sites than for random points indicating that the characteristics of bald eagle nest sites in Virginia are narrowly defined.

As expected, the presence of forest was important to nesting habitat. Although bald eagles throughout the United States have occasionally been known to nest on cliffs or even on the ground, they almost always choose trees (Lincer et al. 1979, Green 1985). In a similar study in Maryland, Taylor and Therres (1981) also found forests to be very common within grid cells containing bald eagle nests. Andrew and Mosher (1982) found that successful nests in Maryland were in relatively dense stands of vegetation. Taylor and Therres (1981) also found that bald eagle nesting habitat generally includes at least 8 ha of forest. Presence of forest may not simply be a reflection of presence of suitable nesting tress which may also be available in agricultural/open areas, wetlands, and high density areas. Eagles may select forests for nesting because they serve as a buffer from disturbance.

Proximity to water is the most common feature of bald eagle nesting habitat. Nearly 100% of bald eagle nests throughout North America are within 3.2 km of water bodies (Green 1985). Bald eagles in our study nested an average distance of 1.15 km from large bodies of water (16 ha or 200 m across) and 0.91 km from smaller bodies of

Table 1. Mean distances from bald eagle nest sites ($\underline{N}$ = 81) and random points ($\underline{N}$ = 81) to selected variables in coastal plain Virginia, 1988.

	Mean distance (m)			
Variable	Nests (SE)	Random points (SE)	$\underline{T}$	$\underline{P}$
Forest	102.47 (2.75)	1040.74 (288.25)	3.280	0.002
Water1	1151.85 (114.00)	3306.17 (407.90)	5.114	0.001
Water2	906.17 (81.78)	2141.98 (236.90)	4.959	0.001
Agriculture	727.16 (64.05)	2402.47 (395.38)	4.208	0.001
Wetland	1114.81 (98.02)	3153.09 (357.15)	5.535	0.001
High Density	2677.78 (160.30)	3374.07 (343.98)	1.844	0.064
Improved Road	841.98 (67.38)	1212.35 (253.43)	1.421	0.153
Low Density	1003.70 (60.82)	1240.74 (182.51)	1.239	0.215
Transport	5587.21 (451.214)	4208.64 (435.02)	0.215	0.825

open water (Table 1).

In his study of bald eagle nesting habitat in Virginia, Jaffee (1980) calculated the mean distance of nests to any open water body to be 0.71 km with most birds nesting within 0.5 km.

Nests in our study were found to be, on average, within 1.11 km of wetlands. Wetlands are important components of nesting habitat in many other areas, including Minnesota (Juenemann 1973), Florida (McEwan and Hirth 1979), and Maryland (Taylor and Therres 1981). Taylor and Therres (1981) considered the best bald eagle nesting habitat to be mostly forested areas adjacent to open marshland or subestuaries.

Bald eagle nests in our study were also located relatively close to agricultural and other open areas ($\bar{x}$ = 0.73 km). Some form of open area or forest discontinuity is often associated with bald eagle nesting habitat (Juenemann 1973, McEwan and Hirth 1979, Taylor and Therres 1981, Andrew and Mosher 1982). Bald eagles in Maryland were found to nest frequently near croplands in association with forests (Taylor and Therres 1981). Apparently eagles tolerate many agricultural activities. In fact, open areas may provide prey in the form of carrion (West 1976, LeFranc and Cline 1983) and may improve eagle accessibility to nest sites.

We found that bald eagle nests were located somewhat closer to areas of high density human development than were random points (P = 0.064). This finding probably does not suggest that bald eagles are selecting for high density areas, as other researchers on the Chesapeake Bay report a negative relationship between bald eagle perch locations and areas of high human density (Buehler et al. 1985). It is more likely that suitable bald eagle nesting habitat in coastal plain Virginia is also highly suitable for human development. The great distance between nests and high density development ($\bar{x}$ = 2.68 km), and other physical barriers (i.e., dense vegetation, topography, water bodies) may buffer nesting eagles from disturbance. However, distances to high density areas that are considerably shorter than the mean begin to exert a negative influence on nesting habitat.

Discriminant Function Model

Ninety-four percent of the 81 nests used in model formation were clustered in a group containing similar characteristics ("nests"). Only 6% of nests exhibited characteristics different enough from other nests to result in their misclassification as "random points." The model grouped 64% of the random points in the "random point" group, but classified 36% as "nests" indicating that their characteristics more closely resembled those of actual nest sites.

Model validation indicated that the selected variables were very useful in predicting bald eagle nesting habitat. The model correctly classified 96% of the 81 "test nests" as potential nesting habitat, demonstrating a high degree of accuracy. In other words, we can expect the model to correctly classify most of the grid cells. The highly significant Wilks Lamda value indicates that the model discriminates between the groups much better than expected by chance (Table 2).

Canonical coefficients revealed that the degree of variance contributed by each variable was as expected from t-test results (Tables 1 and 2). Water1 and Agriculture/open areas contributed the most to model predictability, suggesting that bald eagles are quite

Table 2. Discriminant function analysis statistics for bald eagle nesting habitat variables using actual nest sites (N = 81) and random points (N = 81) in coastal plain Virginia, 1988.

Variable	Canonical Coefficients	F	P
Forest	0.392	10.727	0.001
Water 1	0.745	26.173	0.001
Water 2	0.378	24.587	0.001
Wetland	0.253	9.987	0.002
Agriculture	0.548	17.708	0.001
High Density	-0.254	3.401	0.067

Wilks' Lamda = 0.635 F = 14.874 P = 0.001

dependent on these land features when selecting nest sites. Andrew and Mosher (1982) also found that the most important characteristics of bald eagle nesting habitat in the Chesapeake Bay were proximity to water and an open, mature vegetation structure.

Nesting Habitat in Coastal Plain Virginia

A total of 23,576 grid cells were coded for each of the six variables. Of these cells, 5,287 were eliminated from the analysis because they did not have enough forest or were not located within 10 km of Water1. Of the remaining 18,289 cells, 9,179 were classified by the model as potential bald eagle nesting habitat (Fig. 3, Appendices III-IV). These potential cells made up 38.9% of the total number of coded cells. This further validated model accuracy, which grouped 36% of random cells in the "nest" group. A total of 2,291 cells were classified as primary potential habitat. Habitat in these areas should receive the greatest degree of protection. Secondary cells, 3,669 of the total, should also receive protection, particularly when grouped near other secondary cells or in proximity to primary cells. The model classified 3,219 tertiary cells, which are potential, but not essential bald eagle nesting habitat.

MANAGEMENT IMPLICATIONS

While the threat of organochlorine pesticides to bald eagles has been reduced, loss of suitable nesting, foraging, and roosting habitat continues. Lack of appropriate nesting habitat may, in fact, become a severely limiting factor to bald eagle populations as eagles seem to be selecting the same habitat for nesting that humans are selecting for development. While the presence of bald eagles will not halt human development, impacts can be mitigated. The degree of protection afforded the potential habitat will depend on a variety of factors: the degree of habitat suitability for bald eagle nesting (primary, secondary, tertiary), the feasibility of protecting the habitat, the availability of nearby alternative nesting habitat, and the range of mitigating strategies available. Protection of suitable bald eagle nesting habitat can include acquiring the land by state or private organizations, purchasing easements, or arranging voluntary management agreements. Once suitable nesting habitat has been located, nest trees and surrounding habitat as well as nearby foraging areas can be protected and enhanced (Patnode and Moss 1987). Where development is inevitable, it can be limited to areas of lesser potential (lower PROB1 values) or carefully planned to minimize disturbance. Buffer zones can be maintained between nesting habitat and people (Stalmaster and Newman 1978) or adjacent areas can be protected (e.g., habitat on the opposite side of a river).

Our study closely links bald eagles to agricultural areas. Currently, organochlorines are not thought to be affecting eagle reproduction, but other commonly used pesticides may prove detrimental.

We recommend that the effects of pesticides, particularly granular pesticides, on raptors be closely studied. Should lethal, sublethal, or chronic effects be discovered, pesticide use in agricultural areas in proximity to potential bald eagle nesting habitat can be restricted.

While the study of eagle nesting habitat data is fundamental, an understanding of the characteristics of wintering and roosting areas is also essential to bald eagle management. Fewer studies have focused on these important aspects of bald eagle habitat, and little is known about such habitat in Virginia. We recommend that studies be conducted to determine the important characteristics of roosting and wintering habitat and that management actions be directed toward protecting and maintaining such habitats.

We also recommend that nesting habitat data be collected throughout the remainder of Virginia and be regularly updated. Such efforts would provide information on potential nesting habitat for bald eagles in the event of range expansion. As development continues along Virginia's major river basins, eagles may be forced to move inland to nest along smaller rivers, lakes, and reservoirs in the Piedmont and Ridge and Valley provinces of Virginia.

This report provides considerable data on habitat characteristics for coastal plain Virginia. Data will prove most valuable over the long term if updated periodically as most of the variables change with time (e.g., high human density). These changes are reflected on updated topographic maps and can easily be incorporated into the database. In areas of special concern, aerial photographs may provide a higher degree of resolution.

Data presented here are valuable not only in relation to bald eagle nesting requirements, but may also be important characteristics for other species. We recommend that additional variables be collected and periodically updated to construct a BOVA-compatible geological information system (GIS) for Virginia. Such a system would increase the value of data already collected in this and other studies.

Lastly, we strongly encourage efforts to increase public awareness of bald eagle habitat requirements and how individuals can protect and manage for these birds. Establishing close working relationship with developers will also help to ensure that the impacts of future development activities are minimized.

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