CHARACTERIZATION OF BALD EAGLE WINTER NIGHT ROOST HABITAT ALONG THE UPPER MISSISSIPPI RIVER

BRIAN C.E. HALL
Department of Resource Analysis, Saint Mary's University of Minnesota, Winona, MN 55987

ABSTRACT

In recent years, winter bald eagle (*Haliaeetus leucocephalus*) populations along the upper Mississippi River have been slowly growing. Ensuring the survival and continued growth of bald eagle populations requires a better understanding of their ecological requirements and behavior. An important element of the bald eagles' life history is suitable areas for winter night roosting. The Minnesota Department of Natural Resources' (MN DNR) Nongame Wildlife Program has been studying the known bald eagle winter night roost sites in the upper Mississippi River valley since 1988. An understanding of why bald eagles favor some sites for winter night roosting may allow for better management of the needs of bald eagles, natural communities, and human communities.

The purpose of this study was primarily to characterize and quantify selected aspects of known bald eagle winter night roost sites, and secondarily to use the results of the analysis as criteria for predicting potential future roost habitat. Five sites with known winter eagle use were studied. Forestry information for each site was collected. Roost sites were modeled in a Geographic Information System (GIS) to permit analysis of several spatial characteristics. Results of analyses were used as parameters in a model to predict additional areas suitable for eagle use.

The roost sites typically had mature forest cover. Roost slopes ranged from flat to 55 degrees. Aspects, where significantly present, were northeast and east. Distance from the roost to

ice-free water was at most 2250 meters. Distance from the roost to the nearest road was at a minimum 120 meters. Known roost sites fell within areas predicted in the model to be potential roost habitat.

Introduction

In recent years, bald eagle (*Haliaeetus leucocephalus*) populations overwintering along the upper Mississippi River have been slowly growing (Bonnie Erpelding, personal communication). Ensuring the survival and continued growth of winter bald eagle populations requires a better understanding of their ecological requirements and behavior. An important element of the bald eagle's life history is suitable areas for winter night roosting.

Stalmaster (1987) defines a roost as “an area where eagles rest and sleep during the night.” Wintering bald eagles congregate in small areas that afford them a degree of protection from cold weather. Roosts are traditionally used for successive years (Stalmaster, 1987). Mature forest stands are preferred, as are forest and landform configurations that provide shelter from cold winds. Suitable roost areas that are closer to the daytime feeding areas reduce the energetic cost of flying to and from the roost. Eagles may switch to satellite roost sites (roosts with aspects or other properties that provide shelter from non-prevailing winds) when cold winter winds blow from unusual directions. Roosts may also have a social function in that younger eagles have a chance to observe and emulate the successful strategies of mature eagles (Stalmaster, 1987).

Previous studies have measured nonbreeding bald eagle roost habitat. A study of bald eagle roost habitat on the northern Chesapeake Bay found that winter communal roosts tended to be in stands with greater canopy height, more canopy cover, and more snags than random sites.

Roost sites were closer to water and farther from paved roads and buildings than random sites (Buehler, *et al.*. 1991).

It is the purpose of this study to characterize five known upper Mississippi River bald eagle winter roost sites so that researchers and managers may have a better understanding of the habitat needs of bald eagles. Another goal is to use the results of the analysis to develop a predictive model that can serve to prioritize areas for further investigation as to their potential for eagle inhabitation.

METHODS

Overview of Analyses

This study conducted analyses at two spatial scales: roost along with immediate surroundings and landscape level. A roost was given a 500 meter buffer, based on the recommendation of Mark Martell (1992), to define the extent for the first stage of analysis. Analysis of the roost and its immediate surroundings included determination of forest composition, slope and aspect. Landscape level analysis consisted of determining proximity to human disturbances (roads and railroads) and distance to ice-free waters.

Findings of the above analyses were subsequently used as the criteria for predicting the suitability of other areas in the upper Mississippi River valley as potential bald eagle winter roost habitat.

Description of Study Sites

Five areas with known long-term bald eagle roost usage were selected for study. These areas were selected by Bonnie Erpelding, Minnesota Department of Natural Resources, Nongame Wildlife Division. They have been heavily used by wintering bald eagle populations for successive years. These sites can be categorized as 'critical roosts' as they meet one or more of the following criteria (adapted for winter season from Martell, 1992):

- used > 14 nights per season
- used > 14 nights per season by > 15 eagles per night; or
- has been documented as active for more that 5 years

All five study sites occur on or near the upper Mississippi River, between the cities of Red Wing, Minnesota and Guttenberg, Iowa (Figure One).

The northernmost study site lies northeast of Red Wing, Minnesota and is called Colville Park, after the nearby city park (Figure Two). The roost site itself is located on two privately owned islands in the middle of Dead Slough Lake. The surrounding islands are variously part of the Pierce County (Wisconsin) Islands State Wildlife Area, part of Colville Park, or owned by Northern States Power. Islands with floodplain forest vegetation surround the roost site. There are high bluffs 1200 meters south and 3600 meters north of this nearly flat roost site. There is often ice-free water near the site, caused primarily by the heated water discharge of the Northern States Power Prairie Island nuclear powerplant which lies about eleven rivermiles upstream (Galli, 1997, personal communication).

The Wacouta Bay study site lies about five kilometers downstream of Colville Park (Figure Three). The roost site sits on a steep (24 degree slope) northeast-facing bluffside. The main channel of the Mississippi River, Wacouta Bay and several islands are nearby. The nearest ice-free water is part of the same stretch of open water that passes by the Colville Park site. The Wacouta Bay site is privately owned.

The third study site is called Reads Landing, after the Minnesota town across the main channel of the Mississippi River (Figure Four). This nearly flat site lies in an area of islands and backwaters at the confluence of the Mississippi and Chippewa rivers. Ice-free water is caused by the Chippewa River flowing into the Mississippi River, creating an alluvial dam. As the water of Lake Pepin flows through the bottleneck, the water accelerates and ice formation is prevented. Most of the site is public land as part of the Upper Mississippi River Wildlife and Fish Refuge; a small portion west of the Chippewa River is private land.

Downstream of Reads Landing lies the fourth study site, Zumbro Bottoms, named for its location in the floodplain of the Zumbro River (Figure Five). Zumbro Bottoms lies east of Kellogg, Minnesota, close to the confluence of the Zumbro and Mississippi rivers. The Zumbro River flows through the study site, which is made up of mostly floodplain forest. The site is nearly flat. Ice-free water lies roughly three kilometers northeast of the site and is caused by Lock and Dam 4 at Alma, Wisconsin. The site is mostly public land as part of the Upper Mississippi River Wildlife and Fish Refuge.

The last and southernmost study site is called Eagle Valley after the private nature reserve in which it resides (Figure Six). Eagle Valley lies about five kilometers south of Glen Haven, Wisconsin. The roost site is on a steep (24 degree) east-facing slope facing away from the river. The study site is mostly forested land on hilltops, slopes and bottoms. Ice-free water occurred immediately downstream of Lock and Dam 10, which lies westnorthwest of the study site, as well as a few smaller patches of ice-free water closer to the roost site. The site is privately owned by the Eagle Valley Nature Preserve.

Delineation of Study Sites

The specific location and area of the four northernmost roost sites was determined by Bonnie Erpelding (Minnesota Department of Natural Resources, Nongame Wildlife division), based on her familiarity with the sites. The delineation of the Eagle Valley roost site was done by Brett Mandernack, manager of the Eagle Valley Nature Preserve. In each case, the outline of the roost site was drawn onto a color photocopy of a 7.5 minute U.S.G.S. topographic map. Following the recommendation of Mark Martell (1992), the roost sites were given a 500 meter buffer to define the extent of analysis.

Forest Inventories

The Colville Park, Reads Landing, and Zumbro Bottoms sites had their forest composition inventoried during this study. The forest stand mapping methodology was that used by the LaCrescent, MN United States Army Corps of Engineers forestry division. Recent aerial photographs of the sites were used to spatially reference the results of forest inventories.

The Colville Park study area was partially inventoried on 7/14/97 and 7/15/97. The roost site itself and the connecting lands were not inventoried due to the inability to contact the landowners. The Wacouta Bay study area was not inventoried during this study. However, the land was qualitatively described in 1991 and 1992 by Hannah Dunevitz, a plant ecologist with the Minnesota Department of Natural Resources. This information was used for characterizing the forest composition of the site. The Reads Landing study area was inventoried in June and October 1997. A small portion of the Zumbro Bottoms study area was not inventoried. Zumbro Bottoms inventories were performed in June 1997. The Eagle Valley study area was outside of the operational range of the USACE forestry division, and so was not inventoried. However, the Eagle Valley Nature Preserve in 1996 commissioned a master plan which included forest cover characterization. All forestry information for Eagle Valley in this report is derived from the master plan (Anderson *et al.*., 1996).

The forest inventories used an adaptation of standard field stand mapping. A forest inventory team of two to four members would walk to a chosen point in the study area and reference their location on an aerial photograph. The crew would take a set of measurements, described below. When measurements were completed, the crew would pace out 5 chains (100.6 meters) in a prescribed direction. The new location would be referenced on the aerial photograph to the best of their ability. A new set of measurements would be taken, and the process repeated in coordination with other crews until the entire study area had been inventoried.

At each location the following measurements were taken (complete forest inventory results are in Appendix A):

- Basal area per acre: This was determined by using the Bitterlich method.
- Percent crown cover: This was determined by using a densiometer.
- Number of snags: Snags (dead but standing trees) taller than breast height were counted.
- First, second and third dominant overstory species: For each, the number, average diameter breast height, and average height were recorded. Species dominance ranking was estimated in the field. Diameter at breast height was estimated using a Biltmore stick. Height was estimated using an angle gauge at a distance of one chain (20.1 meters).

For every identifiable forest stand, one dominant overstory tree was cored to obtain an estimate of growth in the last ten years and the age of the tree. This figure was used to represent the age of the forest stand.

The data collected in the field were taken to the USACE office in LaCrescent, MN. There, the locations on the aerial photograph were grouped into stands sharing dominant characteristics. The stands were given identity codes and were digitized by USACE staff into a geographic information system (GIS) using ArcInfo software developed by Environmental Systems Research Institute. The resulting forest inventory coverages were zoom transferred onto topographic base maps to remove photo distortion. Forest stand summary data were added to the coverage by the author.

Database Development

Data for the project were stored and manipulated on a SUN Ultra 2 Creator workstation with a UNIX operating system. Coverages were created, attributed and manipulated using ArcInfo version 7.1. Further analysis and graphic output were done using ArcView version 3.0b with the Spatial Analyst extension.

All coverages for the project used the Universal Transverse Mercator projection, Zone 15, Datum NAD83 with units in meters. In addition to being a common and familiar projection, UTM was chosen because it has minimal distortion of area and distance.

Digital Raster Graphics (DRG), which are digital, georeferenced images of 7.5 minute U.S.G.S. topographic maps, were selected as the basemaps for this project. Where spatial discrepancies between the DRGs and other data existed, such as land/water boundaries, the 1:24,000 scale DRGs were used as the standard of accuracy.

Data Layers

The following data layers were used in the first stage of analysis:

- Digital Raster Graphics (DRG): These were produced by the United States Geological Survey (USGS) and obtained from the Environmental Management Technical Center (EMTC), Onalaska, WI.
- Roads, railroads, and miscellaneous transportation: Shapefiles representing vectorized roads, railroads and miscellaneous transportation features at a scale of 1:100,000 were obtained from the EMTC. These were merged into one coverage for each feature class covering the entire study area.
- Slope and Aspect: Polygon coverages with slope and aspect attributes were created from 1:24,000 scale Digital Elevation Models (DEMs). These consist of a regular spacing of points with elevational data and were obtained from the USGS Eros Data Center in Sioux Falls, South Dakota. These DEMs were created using the first generation "level one" methodology and contain errors which result in a banded look to topography. Yet, they were the best data available at the time of the study.
- Visible Areas: The goal was not only to analyze the closest human features, but also to determine which of those features were likely to be in the eagle's line of sight from the roost. Visibility was calculated using the average canopy height for each roost as the elevation of the observation point. No distance limitation was included. Any area not visually obstructed by intervening terrain was considered to be a visible area.
- Open Water: Open water coverages estimate the minimum extent of ice-free and thus huntable water during the coldest part of the year. These areas were estimated by Joan Galli, Minnesota Department of Natural Resources, nongame wildlife division. Galli has flown numerous times over the Mississippi River valley examining bald eagles and their habitat. Open

water areas for the Eagle Valley site were estimated by Brett Mandernack. The estimations of ice-free waters were heads-up digitized using the DRGs as a backdrop.

- Forest Inventory Data: Each study site has a polygon coverage which conveys relatively homogenous forest stands. These polygons were attributed with all forest inventory data collected. Unsurveyed areas of Colville Park and Reads Landing have no attribute information.

Analysis Procedures

All data themes were imported into an Arcview project. For each study site, distances from the roost polygon to the nearest open water, the nearest human features, and the nearest visible human features were measured using the Arcview measure tool. Slope and aspect values were summarized for each roost polygon. The attribute tables of the forestry coverages were queried to summarize the forestry characteristics of each roost and study area, where data existed.

The second stage of analysis attempted to locate other areas in the upper Mississippi River Valley that share some of the characteristics of the study sites. This stage of analysis covered an area extending 10,000 meters from the approximate centerline of the Mississippi River from Hastings, MN to Dubuque, IA. These areas may warrant further investigation regarding their suitability for winter bald eagle use. Data layers used in this stage included:

- Roads: the same coverage as explained above.
- Open Water: This coverage represents the author's estimation of where there is ice-free water in the Mississippi River in January. This coverage includes the open water coverages described above as well as additional open water sites placed immediately below dams.

- Small scale landcover: This 1:250,000 scale coverage came from the U.S.G.S. Geographic Information Retrieval and Analysis System (GIRAS) files. Although source dates ranged from mid 1970s to early 1980s, this was the most recent small-scale landcover data available. Land use was classified according to the Anderson classification system (Anderson *et al.*., 1976) which is a hierarchical system of general (level 1) to more specific (level 2) characterization.

This model was run as follows:

- Since the small-scale landcover data only noted the presence or absence of forest landcover with no further detail, the first step in the predictive model was to extract only those areas which were identified as having forest landcover.
- Next, all forested tracts within the study area were attributed according to their distance from the nearest ice-free water. This was done using Arcview spatial analyst. These attributes were converted to an interval ranking system where areas closer to ice-free water had a higher rank.
- Each area was also attributed according to its distance from the nearest road. These attributes were converted to an interval ranking system where areas further from roads had a higher rank.
- Lastly, the rankings for distance from ice-free water and the distance from roads were summed, with the distance from ice-free water ranks receiving a weighting factor of approximately four. This was to reflect the general consensus found in the literature that it is more important for roosting bald eagles to be nearer ice-free waters than to be away from roads. The summed score represented a predicted bald eagle roost habitat suitability score on an ordinal scale.

Results

The Colville Park study site encompassed an area of 1710.4 hectares. The roost consisted of 62.3 hectares, of which 3.4 hectares were land. The roost site was essentially flat (slope of 0.097 degrees), meaning there was no significant aspect. The roost was about 115 meters from estimated ice-free water. The roost was about 760, 680, and 830 meters from the nearest road, railroad line, and power transmission line, respectively. All of these features were estimated to be visible to an eagle perched in the middle of the roost. Forest composition data for the roost were not available. Study site-wide forest composition indices include dominant overstory species of silver maple (*Acer saccharinum*), with average diameter at breast height (dbh) of 16.3 inches (range: 15 -19. N = 3), and average height of 72.3 feet (range: 71 - 75. N = 3). Other indices include an average basal area of 314 square feet per acre (range: 30 - 124. N = 4), average understory cover of 71.25 percent (range: 29 - 100. N = 4), and average age of forest of 56 years (range: 43 -73. N = 3) (See Table One).

Table One. Geographic and spatial characteristics of the five roost sites.

	Colville Park	Wacouta Bay	Reads Landing	Zumbro Bottoms	Eagle Valley
Slope, average (degrees)	0	24	1	1	24
Slope, min-max (degrees)	0 - 0	18-30	0 - 4	0 – 4	3 – 42
Aspect, average (degrees)	None	33	None	None	95
Aspect, min – max (degrees)	None	19 - 56	None	None	34 – 354
Distance to Open Water (meters)	120	460	190	2250	740
Distance to Nearest Road/Nearest Visible Road	760/760	810/1070	620/620	470/470	120/320

(meters)					
Distance to Nearest Railroad/Nearest Visible Railroad (meters)	680/680	980/3000	550/550	1310/1310	140/410
Distance to Nearest Power Transmission Line/Visible Powerline	830/830	320/1590	1900/2670	1810/1810	6160/6160 (landing strip)

The Wacouta Bay study site encompassed an area of 110.6 hectares. The roost consisted of 1.95 hectares, all of which is land. The roost slope averaged 24 degrees, with a range of 18 to 30 degrees. The roost aspect is generally northeast, averaging 32 degrees, with a range of 19 to 55 degrees. The roost was about 460 meters from estimated ice-free water. The roost was 810, 980, and 320 meters from the nearest road, railroad line, and power transmission line, respectively. However, the nearest visible human features were 1070, 3000, and 1590 meters distant for road, railroad line, and power transmission line, respectively. The results of Hannah Dunevitz's inspection of the Wacouta Bay site in 1991 and 1992 revealed the dominant and subdominant overstory species of the roost to be sugar maple (*Acer saccharum*) and basswood (*Tilia americana*), with 24 and 13 inch average dbh (diameter at breast height), respectively. The average age of the roost forest is estimated to be 121 years. The floodplain portion of the study site had dominant overstory species of silver maple and cottonwood (*Populus deltoides*), with 11 and 35.1 dbh respectively.

The Reads Landing study site encompassed an area of 194.97 hectares. The roost encompassed 28.8 hectares, of which 24.8 hectares were land. The roost was basically flat with an average slope of 1.2 degrees (range: 0 to 4.2), making the aspect negligible. The roost lies

190 meters from the estimated ice-free water. The roost was 620, 550, and 1900 meters away from the nearest road, railroad line and power transmission line, respectively. The nearest power transmission line visible from the roost was 2670 meters distant. Forest composition indices for the roost include silver maple as the dominant overstory species, with an average height of 77 feet. Crown closure ranged from 51 - 75 percent. The forest averaged 69 years old. The basal area averaged 101 square feet per acre. Snags averaged 10.75 per acre. For the entire study area, the basal area averaged 59 square feet per acre.

The Zumbro Bottoms study site encompassed an area of 188.0 hectares. The roost encompassed 21.8 hectares, of which 14.8 hectares were land. The roost was basically flat with an average slope of 1.1 degrees (range: 0 to 4.2). This makes the aspect negligible. The roost lies 2250 meters from the estimated ice-free water. The roost was 470, 1310, and 1810 meters distant from the nearest road, railroad line and power transmission line, respectively. All of these were estimated to be visible from the roost. Forest composition indices for the roost include silver maple as the dominant overstory species, with an average height of 84 feet. The subdominant overstory species was cottonwood with an average height of 89 feet. Crown closure ranged from 76 to 100 percent. The forest averaged 47 years old. The basal area averaged 120 square feet per acre. Snags averaged 5.5 per acre.

The Eagle Valley study site encompassed 150.2 hectares. The roost encompassed 6.8 hectares, all of which is land. The slope of the roost averaged 24 degrees (range: 3 - 42 degrees). The aspect was generally to the east, averaging 94 degrees (range: 34 to 354 degrees). The roost lies 740 meters from the estimated ice-free water. The roost was 120, 140, and 6,160 meters distant from the nearest road, railroad, and power transmission line, respectively. The nearest road and railroad that was estimated to be visible from the roost lay 320 and 410 meters distant, respectively. Red oak (*Quercus rubra*) and white oak (*Quercus alba*) are the dominant overstory species in the roost. Subdominant overstory species included sugar maple and bigtooth aspen (*Populus grandidentata*). The basal area for the roost was 162 square feet per acre. The density was 145 trees per acre.

Three sites had no slope, and two (Wacouta Bay and Eagle Valley) had average slopes of 24 degrees. The maximum slope was 42 degrees at the Eagle Valley site. Three sites had no important aspect, and two had aspects generally northeast and east. The site closest to ice-free water was Colville Park, at 120 meters. The site most distant from ice-free water was Zumbro Bottoms, at 2250 meters. The closest road to a roost site was at the Eagle Valley site, at 120 meters. However, this road is not visible from the site. The nearest visible road is at the Eagle Valley site, at 320 meters.

The roost sites themselves as well as the wider study area were predominantly covered by mature silver and sugar maples, red and white oak, and cottonwood trees. Forest stands were generally mature, with high crown closure and understory cover (See Appendix A).

The predictive model assigned an ordinal-scale ranking to areas in the upper Mississippi River valley. It made fairly reasonable predictions as to the potential for future roost habitat, as evidenced by the known sites falling within areas of high potential suitability scores (Figure Seven). The predictive model generated an interval scale ranging from 3, the least likely be be suitable for roosting, to 33, the most likely to be suitable. Due to it's coarse resolution and age, the GIRAS landcover data set did not identify land at the Colville Park roost site at all. The other roost sites had predicted suitability values ranging from a low of 18 at Eagle Valley (range 18 – 20), 22 - 25 at Zumbro Bottoms, 26 at Wacouta Bay, and 24 – 31 at Reads Landing.

Discussion

It was thought that slope would be an important factor in the siting of bald eagle night roosts. While slope clearly afforded a degree of protection from winds on the Wacouta Bay and Eagle Valley sites, slope made little contribution to wind protection in the other three sites. As expected, those sites with a significant slope had aspects facing away from the prevailing winter winds. It must also be noted that when wind direction changes, the location of the nights roost may also change. A slope providing protection from a northwesterly wind provides little protection from a southeasterly wind. When the winds shift, eagles may roost in other areas. This is why the predictive model does not select for a certain slope or aspect. Under varying weather conditions, eagles may need a variety of habitats to protect them from the elements.

As indicated in the literature, proximity to ice-free water appeared not to be a limiting factor for eagle roosts. Reported distances from roost sites and food sources range from 0.25 km to 24 km (Chester, *et al.* 1990).

Camp *et al.* (1997) suggest using viewsheds as complements to buffer zones for the restriction of human activity around Golden Eagle (*Aquila chrysaetos*) nesting sites. Camp noted the Dual Disturbance Threshold Model developed by McGarigal *et al.* (1991) which hypothesizes that wildlife responds to approaching humans physiologically (agitation distance) before they respond behaviorally by flushing (flushing distance). Physiological responses (increased heart rate, diverted attention) can have adverse effects on nesting success. Camp *et al.* (1997) suggest using the viewshed as calculated using GIS techniques as an estimation of the agitation distance of wildlife.

Other researchers have found that bald eagles prefer to perch and roost in areas at some distance from human disturbance. Human disturbance types have been variously described as developed or agricultural landcover (Beuhler, *et al.*, 1992), houses, dirt or paved roads, fields, forest harvest areas, major powerlines and campgrounds (Chester *et al.*, 1990).

Chester *et al..* found that bald eagles in North Carolina in the summer perched closer to houses and powerlines and further from paved roads and campgrounds than random sites. This could perhaps be attributed to the inanimate nature of powerlines and (to a lesser degree) houses, and the more active disturbance from active campgrounds and roads. As indicated in the literature, bald eagles prefer mature forest stands and large trees for roosting sites (Martell, 1992; Steenhof, 1980; Chester, 1990; Buehler, 1991).

The predictive model developed an ordinal scale where a greater value indicated a greater predicted potential as roost habitat suitability. The predictive model evaluated areas based on three attributes:

- The presence or absence of forest landcover
- The distance an area was from the nearest predicted area of ice-free waters
- The distance an area was from the nearest road.

The distance from the nearest road factor was given less importance in the model than the distance from the nearest ice-free water factor. This recognizes the relative importance of these two factors (Tom Dunstan, personal communication). The locations of the known roost sites are shown superimposed on the results of the predictive model in Figure Seven. Most known roost sites fell in the middle to upper range of the predicted suitability values.

The predictive model could be improved by employing an up-to-date landcover dataset, as well as one that provided more detail on forest composition. The relative importance of distance from roads compared to distance to ice-free water was an estimation. Further studies into bald eagle reactions to different types of disturbances may help to determine the relationship between the two factors explored in the model.

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