# BEHAVIORAL RESPONSES OF WINTERING BALD EAGLES TO HUMAN ACTIVITY

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*Abstract*: The effects of human activity on wintering bald eagles (*Haliaeetus leucocephalus*) were studied in Washington for 2 yr. Tolerance to disturbance was determined by analyzing eagle distribution in relation to human activity and by measuring flight distances of eagles from simulated human disturbances. Human activity was found to affect eagle distribution and behavior adversely. Distribution patterns were significantly ($P < 0.001$) changed, resulting in displacement of eagles to areas of lower human activity. Older birds were more sensitive ($P < 0.001$) to disturbances. Flight distances were highest for simulated disturbances in water and on gravel bars, intermediate on land, and shortest under a vegetation canopy. Habituation to normal activities seemed to occur. Reduced human interferences, creation of vegetation buffer zones, and establishment of activity restriction zones are recommended for wintering grounds.

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Declines in bald eagle populations have been attributed, in part, to direct human disturbance (Sprunt 1969). Urban sprawl, recreational developments, and increasing outdoor activity in prime eagle habitat have directly and adversely affected the bald eagle (Sprunt and Ligas 1966). Evaluations of the effects of disturbance on nesting eagles are difficult to generalize. Mathisen (1968), Grier (1969), Grier and Fyfe (in press), and Newman et al. (1977) found no evidence of human activity disrupting reproductive success. Juenemann (1973) and Grubb (1976*a*), however, have shown an indirect relationship between human activities and nesting success. Concern over the sensitivity of wintering populations to human interferences has also been expressed (Shea 1973, Servheen 1975, Steenhof 1976, Spencer 1976, Stalmaster 1976). Quantitative information on the avoidance responses of eagles to disturbance is lacking. The purpose of this study was to measure the effects of human disturbance on the behavior of wintering bald eagles in northwest Washington.

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## STUDY AREA

Bald eagles winter along the Nooksack River in northwest Washington feeding on spawned-out salmon (*Oncorhynchus* spp.). The Nooksack River drains the northwestern slopes of the North Cascade Range, an area of approximately 1,671 km$^2$. The primary study area was a 40-km segment of the river. The river there was braided with numerous gravel bars and anastomosing side-channels, and provided optimal spawning habitat for salmon, thereby supporting large numbers of eagles.

Riparian vegetation in the study area consisted primarily of red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), western red cedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and bigleaf maple (*Acer macrophyllum*). Sur-

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Table 1. Criteria used for classifying high, moderate, and low human activity types in the Nooksack River study area.

| Activity types | | |
|---|---|---|
| High | Moderate | Low |
| Human activity frequently within sight of eagles. | Human activity occasionally within sight of eagles. | Human activity unlikely within sight of eagles. |
| High recreational use; sport fishing common. | Moderate recreational use; sport fishing occasional. | Low recreational use; sport fishing rare. |
| Heavily traversed roads paralleling river; bridges; easy access to river. | Roads paralleling river with some vegetation buffer zone; good access to river. | Roads not paralleling river and/or extensive vegetation buffer zone; poor access to river. |
| Habitat altered; numerous human developments. | Habitat slightly altered; occasional human developments. | Habitat largely undisturbed; human developments absent. |
| Activity almost always encroaches on flight distance. | Activity occasionally encroaches on flight distance. | Activity unlikely to encroach on flight distance. |

rounding forests were composed of Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western red cedar.

Human activities along the Nooksack River have increased in intensity and frequency in recent years. The major influences are logging, housing, mining, and recreation. Primary and secondary roads parallel most of the river. Recreational use is common and numerous recreational land developments are present. Sport steelhead (*Salmo gairdneri*) fishing is popular in the study area.

## METHODS

Data on eagle avoidance behavior were collected during the autumns and winters of 1974–75 and 1975–76. Analyses of these responses were made by correlating the distribution of eagles in relation to existing human activities and by measuring the flight or flushing distances of birds from simulated disturbances.

The 40-km study area was divided into 100 units of either high, moderate, or low human activity types. The criteria for classifying the extent of activity (Table 1) was similar to that of Mathisen (1968). Each unit consisted of 0.8 km of bank on 1 side of the river. Eagle distribution recorded during censuses was correlated with each activity type.

Forty-four semiweekly censuses were made during 1975–76 at predetermined dates and at approximately the same time each census day. Counts were conducted by driving or walking to 30 observation points along the river. We assumed that a large percentage of birds were migratory transients, thus reducing the frequency of repeated observations of the same birds; however, some repetition was unavoidable.

Simulated human disturbances consisted of approach toward a single eagle on foot by a single investigator and observation of the avoidance behavior. Three types were used: (1) *Vegetation zone*—approaching an eagle under a heavy vegetation canopy where the observer was partially and intermittently visible to the bird; (2) *Riverbank*—approaching an eagle in open meadows adjacent to the river's edge; and (3) *River channel*—approaching an eagle along gravel bars or in the river (wading). Both *Riverbank*

Table 2. Distribution of bald eagles in the 3 human activity types in the Nooksack River study area.

| | High activity | | Moderate activity | | Low activity | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Human activity units | 23 | 23 | 41 | 41 | 36 | 36 |
| Juveniles and subadults[b] | 42 | 9 | 269 | 60 | 135 | 30 |
| Adults[b] | 60 | 7 | 447 | 55 | 311 | 38 |
| Total[a] | 102 | 8 | 716 | 57 | 446 | 35 |

[a] $P < 0.001$.
[b] Age-class difference significant ($P < 0.025$).

and *River channel* types were in open areas where the disturbance was initially visible to the bird between 400 and 600 m. Subjects of the *Vegetation zone* disturbances were initially aware of the investigator between 75 and 100 m. All 360 simulated disturbances were conducted during full daylight on birds perched on trees along the river. Disturbance experiments were made intermittently throughout the 1974–75 and 1975–76 wintering seasons and on different stretches of the river to allow sampling of different birds. We suspect repetition to be minor by this process. Some birds were subjected to repeated disturbances, but only responses to the first disturbance were used in the analyses.

In addition, approaches were made to groups of eagles where 2 or more different age-classes were present.

Flight distances of eagles were recorded during all simulated disturbances and used as a measure of the disturbance reaction (Hediger 1968:40–41). Distances over 500 m were not recorded due to the likelihood of an unknown factor eliciting the escape response. A Rangematic, Mark V, optical range finder was used to measure distances.

Eagles were aged by plumage coloration as initially described by Southern (1964, 1967) and further verified by Servheen (1975). Aging is most reliably done by combining as many plumage characteristics as possible; however, some birds are difficult or impossible to age (Servheen 1975). Only birds positively aged by this method were used in the disturbance experiments. Some individual variations were evident, but we feel that our classification errors by this method were minor.

We have presented data grouping eagles into 3 age-classes and also into 6 age-classes; however, results of the statistical analyses were similar for both methods. Birds in their 1st year (1-year-olds) are referred to as juveniles; whereas, 2- through 5-year-olds are grouped as subadults. Six-year-olds (Southern's plumage F) and older birds were recorded as adults.

Statistical analyses were performed according to Zar (1974). Differences in the distribution patterns for totals and age-class dissimilarities were tested with chi-square goodness of fit tests and contingency tables, respectively. Analyses of covariance were used to compare regression line elevations and slopes among the 3 disturbance types. Where birds were grouped as juveniles, subadults, and adults, a $3 \times 3$ factorial design was used to evaluate differences among the 3 disturbance types and the 3 age-classes. The Newman-Keuls multiple range test determined if differences were significant between 2 specific types. Mean life expectancy, longevity, and hence mean

Table 3. Comparison of the distribution of bald eagles along riversides where the human activity types differed for adjacent sides of the river.

| Distribution | Juveniles and subadults[b] | | Adults[b] | | Total[a] | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| On high activity side | 53 | 31 | 87 | 22 | 140 | 25 |
| On low activity side | 118 | 69 | 300 | 78 | 418 | 75 |

[a] $P < 0.001$.
[b] Age-class difference significant ($P < 0.05$).

adult age are unknown for bald eagles (Brown and Cade 1972). To facilitate statistical analyses, adults were grouped as 10-year-olds.

## RESULTS AND DISCUSSION

### Distribution in Relation to Human Activity

The distribution of bald eagles on the Nooksack River reflected the effect of human activity. There was a lower ($P < 0.001$) number of eagles in units of high activity compared to the units of moderate activity (Table 2). Distribution in the low activity units was near the expected level. Where the activity classification differed for adjacent sides of the river, a greater ($P < 0.001$) number of birds were observed on the riverside with lower human disturbance (Table 3).

Disturbances in high activity units were beyond the tolerance limits of most wintering eagles. Moderate human activity seemed to be tolerated; however, the shift in distribution resulted in a greater number of birds displaced to marginal habitat and confined the population to a smaller area. Since the major feeding grounds were disproportionately located in high and moderate human activity units, the number of birds in low activity units was lower than expected. On the Nooksack River, the shift in distribution was evident only in high and moderate units and prevented effective use of all feeding sites. Many unsuccessful feeding attempts were observed to occur in these units due to the existing human activities.

Human activity had a significant influence on the feeding behavior of eagles. Mathisen (1968) stated that human activity could interfere with food gathering and possibly cause general unrest among an eagle population. However, Steenhof (1976) suggested that tolerance levels were high on preferred feeding sites. Feeding behavior on the Nooksack was disrupted by the mere presence of humans. Disturbed birds did not return to the same feeding area until several hours after the disturbance occurred and only when the disturbance no longer persisted. Compared to other eagle activities, feeding birds were most sensitive to human interferences.

A comparison of juvenile and subadult to adult distribution indicated a significant difference in tolerance to existing human activities (Tables 2, 3). Adults were more sensitive to disturbance than younger birds and preferred units of lower activity. Proportions of adults were lower in areas where activity was particularly prevalent.

### Reaction to Simulated Disturbances

*General Effects.*—Variations in the flight distances of the entire population were high, but distances were generally

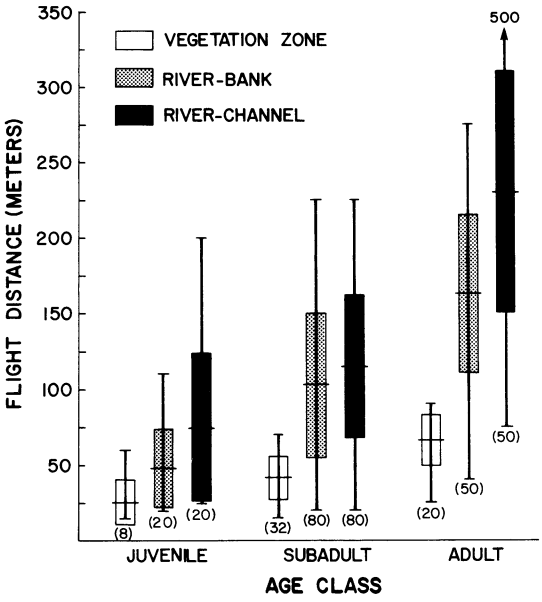


Fig. 1. Comparison of the responses (flight distances) of juvenile, subadult, and adult bald eagles to *Vegetation zone*, *Riverbank*, and *River channel* simulated disturbance types. Mean ± standard deviation, range, and sample sizes (in parentheses) are presented.

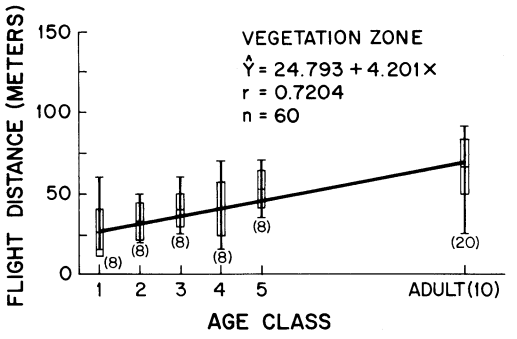


Fig. 2. Relationship of the responses (flight distances) to the 6 age-classes of bald eagles for the *Vegetation zone* simulated disturbance type. Mean ± standard deviation, range, and sample sizes (in parentheses) are presented.

between 25 and 300 m (Table 4). The mean flight distance in open areas (*Riverbank* and *River channel* combined) was 196 m for adults and 99 m for juveniles and subadults. We suggest using flight distances to determine sensitivity to disturbance and to establish boundaries for activity restriction zones.

When disturbed, eagles flew avoidance flights between 50 and 500 m and rarely left the river system. Flight was usually directly or quartering away from the disturbance. Only 1 simulated disturbance elicited apparent aggressive behavior. An adult made 6 diving flights between 10 and 20 m at the observer and vocalized extensively. Nesting eagles commonly exhibit aggressive behavior (Grier 1969,

Table 4. Percentages of bald eagles responding at designated flight distances for the 3 simulated disturbance types.

| | | Flight distances (m) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age-class | *N* | 15–50 | 51–100 | 101–150 | 151–200 | 201–250 | 251–300 | >300 |
| Vegetation zone | | | | | | | | |
| Juveniles | 8 | 88 | 12 | | | | | |
| Subadults | 32 | 84 | 16 | | | | | |
| Adults | 20 | 20 | 80 | | | | | |
| Total | 60 | 63 | 37 | | | | | |
| Riverbank | | | | | | | | |
| Juveniles | 20 | 65 | 30 | 5 | | | | |
| Subadults | 80 | 15 | 39 | 31 | 12 | 3 | | |
| Adults | 50 | 2 | 14 | 28 | 38 | 16 | 2 | |
| Total | 150 | 17 | 30 | 27 | 19 | 6 | 1 | |
| River channel | | | | | | | | |
| Juveniles | 20 | 45 | 35 | 10 | 10 | | | |
| Subadults | 80 | 8 | 34 | 36 | 18 | 5 | | |
| Adults | 50 | | 8 | 8 | 20 | 34 | 18 | 12 |
| Total | 150 | 10 | 26 | 23 | 17 | 14 | 6 | 4 |

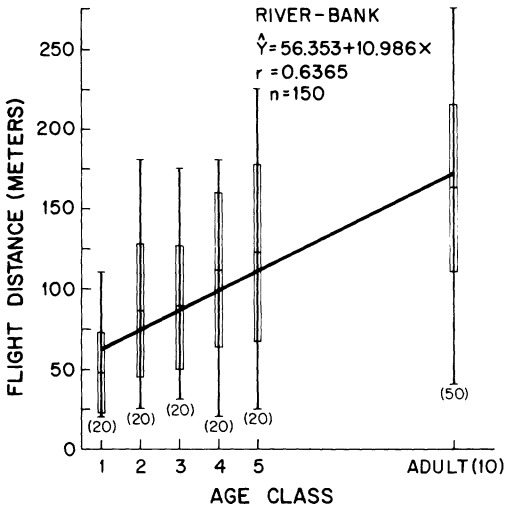


Fig. 3. Relationship of the responses (flight distances) to the 6 age-classes of bald eagles for the *Riverbank* simulated disturbance type. Mean ± standard deviation, range, and sample sizes (in parentheses) are presented.

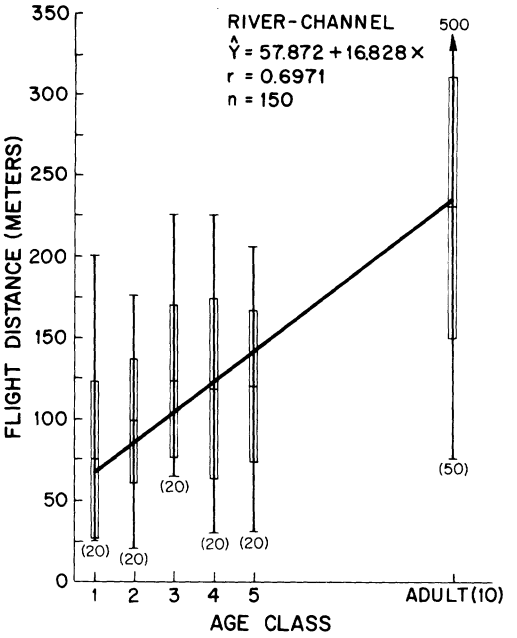


Fig. 4. Relationship of the responses (flight distances) to the 6 age-classes of bald eagles for the *River channel* simulated disturbance type. Mean ± standard deviation, range, and sample sizes (in parentheses) are presented.

Grubb 1976*b*); however, no documentation of this type exists for wintering birds.

Repeated disturbances were made to the same individual in several instances. Responses were similar in both the flight distance and the distance of the avoidance flight.

Normally occurring auditory disturbances were not unduly disruptive to eagle behavior. Gunshots were the only noises that elicited overt escape behavior. Edwards (1969) found that gunshots could be used effectively in flushing birds from their roosts. Eagles were especially tolerant of auditory stimuli when the sources were partially or totally concealed from their view.

*Age-Class Variation.*—Sensitivity to human disturbance increases with age. Flight distances of older birds were greater ($P < 0.001$) than younger birds for all 3 simulated disturbance types (Fig. 1). A gradual increase in distance was apparent among the subadults, but a steep rise occurred with adults ($P < 0.001$ for all 3 disturbance types) (Figs. 2, 3, 4). This differential sensitivity was supported by distribution patterns (Tables 2, 3) and by the upper limit in the range of flight distances exhibited by juveniles and subadults (Table 4). The tolerance of juveniles (1-year-olds) was relatively high, whereas, adults were highly sensitive to human approach.

The accuracy of our ground censuses may have been affected by this differential response behavior. The more easily displaced adults may have been duplicated in our counts, whereas juveniles and subadults were more easily missed due to their sedentary behavior and less conspicuous plumages.

When approaches were made to groups of eagles, the oldest bird flushed first 81 percent of the time ($P < 0.001$). This further confirmed the contention that older birds were more sensitive to disturbance. Young birds seemed to react to the flight

behavior of their older counterparts when disturbed and not to the observer, thus elevating their flight distances. Possibly, young eagles were sensitized to human activity by the behavior of older birds on the wintering grounds.

*Vegetation Zone Effect.*—Wintering bald eagles were more tolerant when human disturbances were partially obscured from their line of sight by buffers of vegetation. When birds were approached through heavy riparian vegetation (*Vegetation zone*), flight distances were significantly shorter than distances recorded in open areas (compared to *Riverbank*, Fig. 1, $q = 12.51$, $P < 0.001$ or Figs. 2, 3, $q = 15.51$, $P < 0.001$). Increasing sensitivity with age was also evident for *Vegetation Zone* (Fig. 2, $r = 0.72$, $P < 0.001$). We expected juveniles and subadults to respond at the same flight distance as adults since the observer was initially visible to the birds at between 75 and 100 m. At this distance in open areas, flight had usually occurred, but this was not observed in *Vegetation zone*. This diminished response pattern in vegetation zones was probably related to the eagles' reliance on visual identification of the disturbance before flight.

Vegetation buffer zones on wintering grounds can be effective in reducing the disturbance caused by human activities. Buffer zones are used to protect nesting territories on lands administered by the U.S. Forest Service (Juenemann 1973). Strips of vegetation, which efficiently reduce line-of-sight contact, will allow a closer presence of human activity and also provide perching and roosting trees. Based on flight distance information (Table 4 and Fig. 2), we recommend zones 75 to 100 m in width to protect critical wintering grounds where disturbances are common.

*Habituation to Activity.*—Wintering eagles can become habituated to routine human activities. Birds on the Nooksack were more easily disturbed by approaches that occurred on the river channel than from adjacent farm meadows where activity was common. Flight distances were longer for the *River channel* simulated disturbances than for the *Riverbank* type (Fig. 1, $q = 7.99$, $P < 0.001$ or Figs. 3 and 4, $q = 7.36$, $P < 0.001$). This aspect was particularly prevalent with adults as evidenced by comparison of the regression line slopes ($q = 4.60$, $P < 0.05$) for these 2 types.

Habituation is the temporary or permanent waning of responsiveness by animals to repetitious stimuli (Marler and Hamilton 1966:642–644). In bald eagles, habituation to human activity has been suggested by Grier (1969) and Edwards (1969). Grier contended that birds accustomed to activity were less disturbed by nest climbing. Edwards found that approaches could be made closer at roosts which were closer to usual activity. Eagles on the Nooksack were also easier to approach when the approach was made from areas regularly high in activity (*Riverbank*).

Tolerance to human activity is related to the location of the disturbance. Our data indicated that activities involved directly on the channel of the river, such as boating and fishing, were most disturbing if activities did not regularly occur there. Normal daily activity patterns were changed by human presence.

Activity restriction zones are suggested for bald eagle wintering grounds. In open regions where activities are common (*Riverbank*), boundaries of 250 m would be sufficient to protect 99 percent of the population (Table 4). Similarly, boundaries on river channels of 250 m would protect 90 percent of the birds. A combination of both activity restriction zones

and vegetation buffer zones is desirable. Establishment of sanctuaries with these elements is encouraged. Variations of tolerance between populations is likely; therefore, we suggest monitoring of adult eagle behavior in developing management recommendations since they are most sensitive to human presence.

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