During the last three years, we did realize one major accomplishment which we felt needed and deserved media attention. On December 23, 1984 we finally captured, banded and color-marked Wisconsin's first Great Gray Owl. After years of chasing down leads and possibilities, we finally succeeded, and of course this event yielded immense personal satisfaction. The most significant thing about banding this bird is that it is now one of however many in Wisconsin's total population that is marked — a bird that if ever encountered again will add to our knowledge of these birds within our state. A second bird was banded on Feb. 19, 1985 in Taylor County. Any number of people can see a bird here or there, but without marking, there is little or no way to tell if it is the same bird. Marking these birds is so very important, with the outcome totally in the best interest of the resource. We encourage anyone who knows the whereabouts of Great Gray Owls to join us in our search for information which ultimately leads to our knowledge of a large but little known bird in Wisconsin.

Acknowledgements

I would like to thank all contributors of sightings, photographs, or information on specimens — your help is so invaluable. I wish also to thank the Wisconsin Society for Ornithology for allowing me to channel research money through them and Mrs. Linda Gabel for assistance with clerical work.

Dedication

To the memory of one of the most sincere and touching human beings I have had the pleasure of knowing, Dr. Ralph Allen and to his widow Ellen, as we remain close friends. The Allens have been very instrumental, through their annual contributions, in allowing us to go afield for part of the year.

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How Much Is An Evening Grosbeak Worth?

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ABSTRACT — Birds consume large numbers of the western spruce budworm (Choristoneura occidentalis), *a forest insect which defoliates economically valuable stands. We estimated the economic value of bird predation on two stands in north-central Washington by substituting the cost to spray with insecticides to produce the same mortality rate as birds cause. It would cost at least $1,820 per square km per year over a 100-year rotation. This figure may be used to appraise the value of individual predator species, such as the voracious Evening Grosbeak* (Heseperiphona vespertina), *to evaluate the cost-effectiveness of biological control with birds, and to access silvicultural treatments and other practices which affect both bird and insect numbers.*

On federal lands, administrative decisions are guided by benefit-cost analyses of management alternatives that maximize the value of the land for society. These analyses require quantitative estimates of benefits and costs associated with proposed alternative actions. Natural resources such as wildlife are difficult to quantify in dollar terms because the values are based upon esthetics or other intangible assets. As a result, wildlife is often undervalued or neglected in federal land-management decisions.

For example, passerine birds are abundant in forests, yet they are rarely considered in benefit-cost analyses. Our work on avian predators of the western spruce budworm suggests that passerines contribute strongly in the natural control of outbreaks of this damaging insect. This article will demonstrate how their value as predators might be quantified.

The western spruce budworm larva is an important defoliator of Douglas-fir *(Pseudotsuga menziesii),* true firs *(Abies* spp.), and spruce *(Picea* spp.). The budworm life cycle begins in early September, when female moths deposit their eggs on conifer needles. Within 10 days, larvae emerge and disperse to overwintering sites under bark scales. In the following summer, the larvae consume new needles and buds and grow to over 2.5 cm in length. They pupate in early August and complete the cycle with adult flight in late August.

Our work focuses on the larval and pupal stages of the budworm from late May through early August. This period is critical for the reproduction of both the budworm and the birds that prey on it.

Study Areas and Methods

Budworm outbreaks in the early 1970s on the eastern slopes of the Cascade Range in north-central Washington led to selection of the Methow and Twisp River drainages as sites for budworm population dynamics studies (USDA Forest Service 1976). When we began our study in 1979, both areas had light to medium defoliation, with late-instar densities of 16 insects per 100 current-year shoots (Torgerson and Campbell 1982).

Our bird census plots overlaid 5-hectare entomological study plots established one year earlier. An 11.25-hectare plot was gridded at the Twisp River site (No. 3); steep topography limited our Robinson Creek plot along the Methow (No. 2) to 9.4 hectares. Both plots were predominantely Douglas-fir and Ponderosa Pine *(Pinus ponderosa).* The Robinson Creek plot was heavily stocked with smaller trees while the Twisp River site contained a heterogeneous mixture of uneven-aged clumps of large and small trees separated by openings with dense shrub cover.

Censuses were conducted during the breeding season on 10 mornings along six 450-meter transect lines. Birds were collected for stomach analysis in areas adjacent to our study plots. The stomachs were examined with a dissecting microscope, and we counted all whole budworm larvae and pupae, larval mandibles, and pupal cremasters. Digestion trials were run on captive birds.

Density of Grosbeaks

Nearly every species censused in 1979 preyed on budworm. The Evening Grosbeak, a flocking passerine with a large bill adapted for seed-eating, was particularly voracious. To estimate the extent of grosbeak predation, we calculated the number of grosbeaks per km^2 and the number of budworms eaten per bird.

The density of grosbeaks was estimated by multiplying the density of grosbeak groups censused on one plot by average group size and by a correction factor for young of the year. Mean group size, determined from counts of groups observed visually, was 1.36 (SE = 0.133) and 1.62 (SE = 0.064) at sites 2 and 3. The correction factor is included to account for fledglings which are not censused on line transects but consume as much as adults during the breeding season (Skutch 1946). Thus, one censused bird represents itself and half of its offspring. Grosbeaks have an average of 3.5 young so that each grosbeak sighted during a census represents 2.75 birds (Gage et al. 1970).

Because grosbeaks are regurgitative feeders, digestive tracts collected during the 14-day nestling period contain prey for both the bird and its young. Also, during the 14-day incubation the female is fed by the male. Therefore, for 28 days of the approximately 55-day period when budworms are vulnerable to avian predation, grosbeak juveniles do not forage for budworm and are represented by increased larvae or pupae in the esophagus of the adults. For the rest of the summer, a correction must be made for juveniles. The correction for the total grosbeak consumption including juveniles would be 2.75 X (27/55) = 1.35. The total number of grosbeaks that consumed budworm was 115 per km^2 at Robinson Creek (SE = 50) and 707 per km^2 at Twisp River (SE = 233).

Budworm Consumed by Grosbeaks

Average consumption by one grosbeak was calculated from stomach samples. The number of budworms per stomach was divided by the digestive passage rate (1.2 h, SE = 0.08) to convert consumption to budworms per hour. To estimate budworm consumption through one summer, we assumed the birds had 16 hours of daylight to forage each day over the 55-day period of budworm availability. On the basis of the average number of budworms per stomach, 36.2 (SE = 0.54) at site 2 and 1.4 (SE = 1.58) at site 3, an individual grosbeak consumed from 12,600 budworms on site 3 (SE = 5,240) to 26,400 on site 2 (SE = 9,020) in 1979.

Total budworm consumption is the product of the number of birds and budworms consumed per bird. In 1979, total Evening Grosbeak predation over a square kilometer was estimated to be 3,036,000 budworms on site 2 (SE = 1,761,000) and 8,900,000 on site 3 (SE = 4,900,000). Similar calculations for other bird species yielded estimates of total consumption by all birds of 7,000,000 budworms on site 2 and 12,700,000 budworms on site 3. Therefore, Evening Grosbeaks were responsible for 43 percent and 70 percent of the bird predation at sites 2 and 3, respectively.

Value of Avian Predation

Birds consume large numbers of budworm larvae and pupae. Therefore, they reduce the defoliation caused by the insect on conifers. Since the amount of foliage on a tree determines its radial growth, birds actually reduce timber losses. The value of avian predation may be estimated by comparing the growth of a stand to a hypothetical stand where birds are absent.

Entomological studies by Torgerson and Campbell (1982) on our research sites showed that birds and ants were the two major natural enemies affecting budworm numbers. In this analysis, we have separated the mortality attributed to birds from the compensatory mortality of ants, other predators and parasites. When birds alone were excluded from branches in a manner which still allowed other natural enemies to act, budworm survival increased tremendously. Birds decreased budworm densities by 66 (site 2) and 72 percent (site 3) in 1979. The following example is based on bird predation alone, after compensatory mortality where both predators are acting is accounted for. In some areas, ant predators may compensate for much more of the bird mortality, and our estimates of bird predation would need to be adjusted accordingly.

Aerial spraying of insecticides is the most widely used control for budworm. More than 11.5 million acres were sprayed to combat the western spruce budworm between 1949 and 1979 (Dolph 1980, Fellin and Dewey 1982, Fellin 1983). Cost-benefiting analyses for northern Washington forests indicated that spraying would be beneficial at larval densities we studied (USDA Forest Service 1978). Effectiveness varies widely (Fellin 1983), but one typical study indicated that spraying with Sevin-4-oil, a major insecticide, decreased budworm survival by 80 percent at a cost of $1,820 per km^2 (Mounts et al. 1978). Spray mortality corrected for natural mortality with Abbot's formula was 73 percent (USDA Forest Service 1978). This mortality rate is nearly the same as that of bird predation. Thus, because the benefit-cost ratio for spraying is greater than one, the cost to spray may be substituted to conservatively estimate benefits from birds as $1,820 per km^2 in 1979. Grosbeak consumption alone was worth $790 per km^2 at site 2 and $1,270 at site 3. When the number of grosbeaks on each site is considered, predation by one grosbeak is equivalent to investing $1.80 (site 3) to $6.80 (site 2) in spraying each year.

A larger economic value may be attributed to birds when budworm populations are low. Northwest budworm populations have historically fluctuated from endemic (<1.0 budworm per m^2) to outbreak (>80 budworms per m^2) every 28 years or three times in a 100-year rotation. (Dolph 1980). A mean growth rate would be 17 percent per year. This rate is small compared to the budworm's potential growth since a female moth may hatch 66 female offspring (Fellin and Dewey 1982). The population will grow unless 98.5 percent of these offspring are killed before they reproduce.

If the budworm mortality rates due to bird predation observed in Torgerson and Campbell's (1982) study are typical for this region, the average rate of increase of budworm populations would rise from 17 to 280 percent per year in the absence of birds. Budworm populations would increase from endemic to outbreak status in 3.3 years or approximately 30 times in a century without birds. However, the pattern of outbreaks might change in this situation, because in the absence of birds spraying mortality of 65 to 75 percent would not decrease the population below outbreak densities unless spray was applied repeatedly in the same year. The most feasible approach would be to spray every year so that outbreaks would only occur once in 28 years, and then spray twice in the outbreak years. Thus, to duplicate the action of birds would mean spraying 103 times in 100 years. Their value would be the cost to spray at this frequency (without birds) minus the cost to spray every 28 years (outbreak frequency with birds) discounted to present dollars at 4 percent (Row et al. 1981). This simple model suggests net present value of bird predation is $45,500 per square kilometer. One square kilometer of eastern Cascades forests of the type we studied has a net present value of approximately $200,000 (C.W. McKetta, personal communication). Birds are saving 23 percent of that value by consuming budworm larvae.

Managing for Birds

Birds are contributing strongly to western spruce budworm control on the stands we studied in north-central Washington. The number of budworms removed from the stands by birds is 30 to 130 percent higher than Crawford et al. (1983) observed at two stands near Bangor, Main, infested with moderate densities of eastern spruce budworm *(Choristoneura fumiferana).* The birds in these Washington stands are also removing a much larger percent of the budworm population than Crawford et al. observed. Though there are many differences in the bird communities, plant communities, and stand conditions between the two regions, much of the increased predation in north-central Washington can be ascribed to the high numbers of Evening Grosbeaks in 1979.

The highly simplified approach that we have taken here is merely a first stop. A more realistic approach will be made possible by the development of sophisticated simulation models of the forest-budworm-natural-enemy complex (Colbert et al. 1982). It is hoped that such models can be derived from the extensive data being accumulated by the Canada-United States Spruce Budworms Program (CANUSA).

For the forest manager, the present findings raise the question of whether it would be economically beneficial to manage forests to increase bird numbers (Takekawa et al 1982). If budworm mortality due to birds could be increased to 73.5 percent per year, according to our model, the population would never reach outbreak levels in a 100-year rotation. The potential to use birds to regulate budworm has not been studied, but their ability to consume insects at low densities suggests that they may be able to prevent outbreaks entirely if management can increase the number of birds sufficiently to hold the budworm below some escape threshold.

By the present analysis, managers could profitably spend up to the point where the marginal benefit of adding birds equals the marginal cost, a discounted value of \$103 per km^2 annually in this region. In other regions such as the Rocky Mountains where outbreaks have been more frequent and spraying has been done repeatedly in the last 30 years (Fellin and Dewey 1982), the marginal benefit of preventing outbreaks would be much larger. Converesly, in areas such as the coastal Douglas-fir communities of Washington and Oregon which have never experienced budworm outbreaks (Dolph 1980), there would be no marginal benefit.

Managing birds in regions where it would be beneficial might include supplying water sources, providing limiting minerals, or adding supplementary food (Takekawa et al. 1982). Projects which require less frequent maintenance such as snag creation, understory enhancement, and nestbox management could be profitable at 10-year intervals in north-central Washington if costs did not exceed \$1,240 per km^2.

Silvicultural practices such as thinning should be evaluated to determine the effects on birds. Selection harvests that do not change foliage height diversity may actually increase the number of avian predators per unit of foliage while improving stand growth (Franzreb and Omhart 1978).

In the future, controlling destructive forest insects may become increasingly important as intensive management leads to large, homogeneous stands highly susceptible to insect outbreaks. Assigning a dollar value to bird populations is a way of objectively evaluating the feasibility of managing birds and the consequences of losing them.

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CORRECTIONS

For Fall Issue: P. 95 Under Committee Policies - should read "There can be **no** hard and fast rules"...instead of there can be hard and fast rules.

Cover Photo: A prize of one free credit coupon entitling the bearer to his choice of a free penicillin shot, or a soapsuds enema to the first 25 people who correctly identified the mergansers on the Fall cover as Red-breasted and not Common Mergansers.