(Halle Flygare, personal correspondence, Banff National Park; staff of Yoho National Park, British Columbia, personal correspondence), mule deer, Odocoileus hemionus (8,9), moose, Alces alces (10), and caribou, Rangifer tarandus (11), although pronghorn antelope, Antilocarpa americana (8) refuse underpasses.

A crossing structure of some type was deemed necessary to protect goats and humans. An overpass for goats was ruled out because of the Canadian experiences with safety problems. This information coupled with limited observations of mountain goats using a confined space under the Snowslide Gulch Bridge in 1975 (2) suggested that goats would likely accept an underpass. In addition, it was concluded that degree of acceptance of an underpass was likely to increase if it was not confining (9), if it was accompanied by restrictive lead-in fencing (8,9), if it was situated on a goat movement route (12), and if conifer covering or other shielding was present in the underpass approaches (2). The construction plan for US-2 followed these guidelines as closely as was feasible and resulted in very high (99.4 percent) acceptance of the two underpasses. In addition, a significant decrease in disturbances to the mountain goats was achieved.

Three design questions are posed by the 1981 observations of mountain goats using the two underpasses:

1. How critical was conifer cover near the bridges?
2. Was construction of the Goat Bridge necessary or would all goats have used the new Snowslide Gulch Bridge?
3. What were the minimum size dimensions for the Goat Bridge?

Conifer cover was a critical factor during highway crossings in 1975 (2), but with the reduction in disturbances in 1980 and 1981, goats made more use of the exposed approach routes. Cover on the downhill approach to the Goat Bridge still appeared to be important to at least some goats (7). The Snowslide Gulch Bridge and the Goat Bridge were used about equally in 1981, but the Snowslide Gulch Bridge was only about two-third the height and one-seventh the width of the Goat Bridge. This initially suggests some of the space under the Goat Bridge was superfluous. However, the overall visual window under a bridge may be more critical than that for the crossing path. The overall dimensions of the Snowslide Gulch Bridge are far greater than the Goat Bridge because goats cross on a relatively small bench near the west abutment of a large (60 ft high x 60 ft wide) crossing of the Snowslide Gulch. Only 3 percent of goats in 1975 used the Snowslide Gulch Bridge, but 50 percent used it in 1981.

It is not possible to predict if all goats would have used the Snowslide Gulch Bridge thereby precluding building the Goat Bridge. Longer fencing to the west would likely have been required. Additional fencing would have been expensive, and fencing in this area requires maintenance because of frequent avalanching. Previous experiences and learning during construction were apparently critical to route preferences by goats. Use of the Snowslide Gulch Bridge by goats developed slowly but steadily during construction in 1980 as other avenues of access were alternately blocked. Thus, if goats had been forced around the far western end of the fences during construction, that tradition might have proved difficult to break even after the Snowslide Gulch Bridge and all structures were later in place.

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REFERENCES

1. FHWA, U.S. Department of Transportation. Final Environmental Statement, Montana Forest Highway 13, U.S. Route 2 Along Middleford Flathead River, Region 8, Denver, Colo., 1977, 131 pp.
2. F.J. Singer. Behavior of Mountain Goats in Relation to U.S. Highway 2, Glacier National Park, Montana. Journal Wildlife Management, Vol. 42, No. 3, 1978, pp. 591-97.
3. A.L. Ward, J.J. Cupal, A.L. Lea, C.A. Oakley, and R.W. Weeks. Elk Behavior in Relation to Cattle Grazing, Forest Recreation and Traffic. Trans. North American Wildlife Conference, Vol. 38, 1973, pp. 327-37.
4. F.J. Singer. Behavior of Mountain Goats, Elk and Other Wildlife in Relation to U.S. Highway 2, Glacier National Park. Final Report. FHWA and Glacier National Park, West Glacier, Montana, 1975.
5. Compilation of the Administrative Policies for the National Parks and National Monuments of Scientific Significance of the National Park System. National Park Service, U.S. Department of the Interior, 1920.
6. FHWA, U.S. Department of Transportation, Proposal and Contract. Montana Forest Highway 13-3(4) and F1-2(13) 179, Columbia Falls-Glacier Park Highway. Special Provisions, Bid Schedule, Contract and Bonds. 1980.
7. F.J. Singer and J.L. Doherty. Management of Mountain Goats at a Highway Crossing. Wildlife Society Bulletin, Vol. 13, No. 3, Sept. 1985.
8. A.L. Ward, N.E. Fornwalt, S.E. Henry, and R.A. Hodorff. Effect of Highway Operation Practices and Facilities on Elk, Mule Deer, and Pronghorn Antelope. Report FHWA-RD-79-143. FHWA, U.S. Department of Transportation, 1980.
9. D.R. Reed, T.N. Woodard, and T.M. Pojar. Behavioral Responses of Mule Deer to a Highway Underpass. Journal Wildlife Management, Vol. 39, No. 2, 1975, pp. 361-67.
10. V. Van Ballenberghe. Final Report on the Effects of the Trans-Alaska Pipeline on Moose Movements. Special Report 23. Joint State/Federal Fish and Wildlife Advisory Team, Anchorage, 1975.
11. K.N. Child. Reaction of Caribou to Various Types of Stimulated Pipelines at Prudhoe Bay, Alaska. In The Behavior of Ungulates and Its Relation to Management. Edited by V. Geist and F. Walther. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland, 1974, pp. 805-812.
12. D.R. Klein. Reaction of Reindeer to Obstructions and Disturbances. Science, Vol. 173, No. 3995, 1971, pp. 393-98.

Wildlife Use of Roadside Woody Plantings in Indiana

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ABSTRACT

The Indiana Department of Natural Resources began a program of right-of-way plantings for wildlife in 1976. By 1983 almost 950,000 shrubs had been planted along 4-lane highways. The use of these plantings by wildlife was studied from June 1983 to January 1984. Shrub-planted study areas and grassed control areas were identified along four highways. All areas were walked four times during the study period and observed birds, mammals, and roadkilled wildlife were recorded. Incidence of roadkill was not affected by the plantings. The number of rabbits was increased only slightly by the presence of shrubs. Planted areas were used by a greater number of bird species and by a much greater number of individual birds than the grassed areas. The shrub plantings were important to birds as nest sites. Right-of-way plantings are an important addition to wildlife habitat.

Indiana is rapidly losing wildlife habitat to intensive farming, urbanization, industrialization, and highway development. Clean farming practices such as fencerow removal or reduction, continuous rowcropping, chemical control of weeds, and fall plowing are destroying wildlife habitat. Thousands of miles of state and Interstate highway right-of-way (ROW) are predominantly monocultures of closely mowed grasses and are of little benefit to wildlife.

Indiana Department of Natural Resources (IDNR) biologists recognized the detrimental effect of habitat loss and implemented a program of ROW wildlife plantings to partially replace lost wildlife habitat. From 1978 through 1983, IDNR planted various species of trees and shrubs along certain 4-lane highways.

Wildlife use of these plantings was unknown. A literature search indicated that little research has been done on wildlife habitat development, using woody plants, on highway ROW in Indiana or in surrounding states.

The objectives of this study were to determine the following:

1. Do IDNR-planted experimental plots attract a greater number of birds and mammals than unplanted control plots?
2. Is there a difference in species diversity for experimental plots as compared to control plots?
3. Is there a significant difference in the number of bird nests found on experimental plots as compared to control plots?
4. Is there a significant difference in the number of roadkills found on and adjacent to experimental plots as compared to control plots?

LITERATURE REVIEW

The need for and importance of highway ROW as wildlife habitat has been discussed by many researchers. Leedy (1) and Leedy and Adams (2) stated that nationwide there is an area the size of the state of Indiana in vegetated highway ROW--an area large enough to merit serious consideration in wildlife management. Leedy (1) indicated that few studies have been conducted of highway ROW as wildlife habitat per se. He recommended that the value of ROW should be determined, not only for pheasants, waterfowl and other game birds, but for songbirds and other wildlife as well.

The potential for improving ROW as wildlife habitat has been known for some time by wildlife managers. Michael (3) discussed research conducted in the 1940s that estimated that 75 percent of highway areas in the contiguous 48 states were providing food and cover for wildlife, and that, on approximately 75 percent of these lands, it was economically feasible to improve the quality of the habitat. Rongstad (4) stated that work done by Aldo Leopold indicated a high diversity of flora and fauna on old grown-up roadsides, whereas mowed and otherwise altered roadsides had few species. Dambach (5) stated that Ohio's highway ROW, then totaling 250,000 acres--an area larger than the state forests in Ohio, have a part in conservation, and he indicated that mile for mile and acre for acre, Ohio's roadsides, next to fencerows, probably are the most productive wildlife lands in the state.

Research concerning wildlife and highway ROWs is not limited to the United States. Laursen (6) studied bird use of road verges (ROW) and the influence of summer mowing on birds in Denmark. He found that different parts of the road verges are used for foraging, and that the road verge provides nesting habitat for species such as Skylark, Alauda arvensis. Way (7) discussed the need for research concerning road verges and habitat conservation in England. Kelcey (8) in reviewing the potential value of road verges for wildlife, indicated that wildlife and wildlife habitat have received little consideration during and after highway development.

Several studies have been conducted on the use of herbaceous plantings along roadsides. Michael (3) researched wildlife use of roadside cover plantings in West Virginia. He suggests that the ROW should be managed to attract species that pose no threat to vehicular traffic, while encouraging the attraction of species that are aesthetically pleasing. Wiegers (9) surveyed bird use of nesting cover along roadsides in Nebraska and found most pheasant and quail nests were found in brome grass (Bromus sp.). David and Warner (10) studied the development of nesting cover for pheasants along roadsides in east-central Illinois. They suggest that the roadside can be managed as a principal source of nesting habitat for pheasants. Joselyn and Tate (11) studied the management of roadside cover for pheasant and indicated

that delayed mowing of roadsides, to allow pheasants to leave the nest, is an important factor in roadside management. Oetting and Cassel (12) investigated waterfowl nesting on highway ROW in North Dakota. However, studies involving the use of woody plants in ROW management are limited in numbers.

Highway development can have a beneficial or detrimental effect on wildlife by destroying habitat or creating new habitat. The impact of highway development on wildlife has been recorded by Leedy (1), Adams and Geis (13,14), Bruner et al. (15), and Getz et al. (16). Stapleton and Kiviat (17) studied vegetation management of railroad ROW and its effect on breeding birds. They stated that life histories of target bird species need to be considered when planning the management of ROW.

During the planning and design of highways, usually little or no consideration is given to wildlife. Leedy and Adams (2) discussed the planning and development of highway corridors with consideration given to wildlife.

Various researchers have studied the effect of highway ROW on a particular animal species or on the animal community in general. Ferris (18) found that red-tailed hawks (Buteo jamaicensis) and American kestrels (Falco sparverius) were observed within the highway ROW more frequently than would be expected by random distribution. He indicated traffic did not appear to have an adverse effect on hawks, and thus the ROW represents undisturbed habitat. Michael et al. (19) studied the effects of highway ROW vegetation and adjacent ecotonal vegetation on bird species, placing special emphasis on passerine birds and diurnal birds of prey. They recommended the development of highway ROW to increase the number of birds. Ferris et al. (20) investigated the ecological impact of a major highway in Maine on birds and mammals. Oxley et al. (21) found that the highway ROW habitat provided a ready supply of grass that allowed some Microtinae rodents to flourish and expand their ranges. Clark and Karr (22) concluded that the existence of highway ROW with extensive grass habitat and scattered shrubs in east-central Illinois should enhance breeding success and increase population density of red-winged blackbirds (Agelaius phoenicus). Ferris (23), in studying the effects of a major highway on breeding birds, found the presence of an edge component was reflected in increased species diversity.

Best (24) recorded use of fencerows and found that continuous tree and shrub fencerows have a higher number of species and greater numbers of birds as compared to herbaceous fencerows and fencerows with scattered trees and shrubs. Wandall (25) discussed the need for woody plantings in the development of songbird habitat. Using control areas having Osage-orange (Maclura pomifera) hedgerows, he found twice as many bird nests in planted areas of multiflora rose (Rosa multiflora), elderberry (Sambucus sp.), hazelnut (Corylus sp.), and dogwood (Cornus sp.).

In 1974 IDNR wildlife biologists participated in a statewide study to determine wildlife use of highway ROW plantings in Indiana [Machan (26)]. Data collected indicate that a greater number and greater diversity of birds and mammals use the tree-shrub planted areas. There was greater evidence of reproductive attempts (nests) on tree-shrub areas than on grassed areas. More animals were roadkilled adjacent to grassed areas than adjacent to planted areas. Machan concluded that wildlife numbers on ROW will increase without an attendant increase in roadkills if ROW are planted with trees and shrubs. Zewadski (27) suggested that unfortunately the Interstate fauna may be the predominant fauna of the future, and further research needs to be done on the impact of highway plantings on wildlife populations.

STUDY AREAS

Study areas included four central Indiana highways (US-31, I-65, I-69, and I-70) that had IDNR roadside plantings. The US-31 study area included 31.5 miles between State Road 16 and County Road W 13th in Miami, Fulton, and Marshall counties. The I-65 study area was a 12-mile portion of highway in Tippecanoe and Clinton counties between State Road 38 and State Road 28. The I-69 study area included 5 miles in Delaware and Grant counties between State Road 28 and State Road 26. The I-70 study area included 24 miles in Hendricks, Morgan, and Putnam counties between the intersections of US-231 and State Road 267.

Barnes (28) divided Indiana into zoogeographic regions. He described the Northeastern Lakes region, the area having most of the US-31 study area, as a region in which potholes, marshes, lakes, and streams offer edge cover for wildlife. The I-65 study area is in the Prairie Fringe region. This region is generally rolling and lower in productivity than the regions to the east and west. The Central Tipton Till Plain region encompasses the I-69 study area and is a gently rolling fertile plain in which intensive agricultural practices limit wildlife habitat. The I-70 study area is within the Prairie Fringe and Central Tipton Till Plain regions.

Fourteen species of wildlife shrubs and trees were planted in the four study areas (Table 1). With the exception of Autumn Olive planted along I-65 in 1975, all study plantings were accomplished in 1978.

TABLE 1 Shrubs and Trees Planted by IDNR on Study Plots

Species	US-31	I-65	I-69	I-70
Autumn Olive, *Elaegnus umbellata*	X	X	X	X
Flowering Dogwood, *Cornus florida*				X
Shrub Dogwood, *Cornus* sp.	X	X		X
Amur Honeysuckle, *Lonicera maackii*			X	X
Flowering Crabapple, *Malus* spp.	X			X
Hawthorn[a], *Crataegus* spp.	X	X	X	X
Redbud, *Cercis canadensis*		X		
American Hazelnut, *Corylus americana*	X		X	
Smooth Sumac, *Rhus glabra*		X	X	
Japonica Lespedeza, *Lespedeza bicolor japonica*	X	X		
Ninebark, *Physocarpus opulifolius*	X		X	X
Bristly Locust, *Robinia hispida*	X	X		
Common Elderberry, *Sambucus canadensis*				X

[a]Two species of Hawthorn, Washington Hawthorn, *Crataegus phaenopyrum* and Downy Hawthorn, *Crataegus* sp., were planted by IDNR, but were not identified to species in this study.

MATERIALS AND METHODS

Plots 100 m long were selected along the four highways. Plot width ranged from 15 to 40 m. Plot width was from right-of-way fence line to the near edge of the highway. Mean plot width was 22.4 m. Experimental plots were located within the IDNR plantings. Control plots were in grassed ROW. Control and experimental plots were interspersed along each highway with a gap between plots. Plots could occur on either side of the highway. Plots were marked with orange flagging on fence posts and with paint on the highway. A brief description of adjacent habitat and dominant plant species on the plots was recorded.

A total of 156 plots, 79 experimental and 77 control plots, was surveyed during each study period. US-31 had 21 experimental and 21 control plots; I-65 had 20 experimental and 20 control plots; I-69 had 17 experimental and 15 control plots, and I-70 had 21 experimental and 21 control plots.

A census was taken along each highway during four study periods: (a) the last 15 days of June 1983, (b) the last 15 days of July 1983, (c) the last 15 days of September 1983, and (d) the last 10 days of December 1983 and the first 10 days of January 1984. A census was conducted of each highway once per study period. Birds and mammals observed on plots were recorded. Fence-sitting birds were recorded as being on the plot. Each bird nest was counted then marked with orange flagging at the base of the tree or shrub to avoid counting the nest twice. Other observed animal signs (tracks, feces, gnawings) were recorded. A census of control plots was conducted by a single observer. A census of experimental plots with tall, dense foilage was conducted by two observers, each on opposite sides of the tree-shrub plantings. Time expended conducting a census of a plot was about 10 min. Each survey began at sunrise and ended when the census for all plots for that highway had been completed. Usual finish time for a given highway was early afternoon. Each survey began with the same plot and traveled in the same direction during each study period (e.g., US-31 surveying began on plot 1 and ended with plot 42 for each study period).

Surveys were conducted on days of little or no precipitation with wind velocity less than 10 mph. Ambient air temperature, wind velocity, and percent cloud cover were recorded at the beginning and end of each survey day.

Statistical treatment involved an analysis of variance and covariance with repeated measures. A probability value of 0.05 (P=0.05) was used in analyzing data.

RESULTS

The Red-winged blackbird was the most abundant bird species on both experimental and control plots. American goldfinch (Carduelis tristis), house sparrow (Passer domesticus), song sparrow (Melospiza melodia), American robin (Turdus migratorius), and common grackle (Quiscalus quiscula) were some of the more commonly observed birds. On control plots with more than three individuals of each species sighted, eastern meadowlark (Sturnella magna), house sparrow, and field sparrow (Spizella pusilla) were the most abundant species. Twenty-five bird species, with flycatchers Empidonax spp. being counted as a single species, were observed on experimental plots. Seventeen bird species were observed on control plots (Tables 2,3). Rabbit sign found on 38 experimental plots and on 22 control plots was significantly more often present on the planted plots (Table 3). Deer sign occurred on three experimental plots and seven control plots. This was not a significant difference. No determination was made of the number of deer or rabbits actually using a plot.

Eastern cottontail (Sylvilagus floridanus) was the most abundant species observed (Table 3). The 24 mammals observed on the experimental plots were not a significantly different number than the 15 observed on control plots (Tables 3,4). Three mammalian species, excluding the unidentified sightings, were observed on both control and experimental plots.

Experimental and control plots had the same number of roadkilled animals (Tables 3,5). Raccoons (Procyon lotor) were the most common roadkill.

Tree-shrub planted areas contained a much greater number of bird nests per individual highway and in total (Tables 3,6). Autumn olive and Crataegus spp. were the IDNR plantings that held most of the bird nests found. Multiflora rose held the greatest number of bird nests on control plots (Table 7).

DISCUSSION

The IDNR plantings were made to provide an ecotonal habitat that would attract wildlife. Do experimental

TABLE 2 Birds Observed on Experimental and Control Plots

Species	Experimental	Control	Total
Red-winged Blackbird, *Agelaius phoeniceus*	155	63	218
American Goldfinch, *Carduelis tristis*	56	12	68
House Sparrow, *Passer domesticus*	23	40	63
Unknown	47	10	57
Song Sparrow, *Melospiza melodia*	41	8	49
Unknown Sparrow	23	12	35
American Robin, *Turdus migratorius*	21	6	27
Common Grackle, *Quiscalus quiscula*	18	6	24
Mourning Dove, *Zenaida macroura*	7	4	11
Eastern Meadowlark, *Sturnella magna*	3	8	11
Indigo Bunting, *Passerina cyanea*	5		5
Gray Catbird, *Dumetella carolinensis*	5		5
Field Sparrow, *Spizella pusilla*	1	4	5
American Tree Sparrow, *Spizella arborea*	4		4
Northern Cardinal, *Cardinalis cardinalis*	2	1	3
Dark-eyed Junco, *Junco hyemalis*	3		3
White-crowned Sparrow, *Zonotrichia leucophrys*	3		3
Unknown Flycatcher, *Empidonax* spp.	2		2
Brown Thrasher, *Toxostoma rufum*	2		2
Northern Bobwhite, *Colinus virginianus*		2	2
Eastern Kingbird, *Tyrannus tyrannus*	1	1	2
Ruby-throated Hummingbird, *Archilochus colubris*	2		2
Starling, *Sturnus vulgaris*	1	1	2
Common Yellowthroat, *Geothlypis trichas*	2		2
House Wren, *Troglodytes aedon*	1		1
Philadelphia Vireo, *Vireo philadelphicus*	1		1
Northern Oriole, *Icterus galbula*		1	1
Blue Jay, *Cyanocitta cristata*		1	1
Horned Lark, *Eremophila alpestris*		1	1
Downy Woodpecker, *Picoides pubescens*	1		1
Yellow Warbler, *Dendroica petechia*		1	1
Yellow-billed Cuckoo, *Coccyzus americanus*	1		1
Total	431	182	613

TABLE 3 Analysis of Data Using ANOVA and Covariance With Repeated Measures

Categories	P-Value
Bird nests	<0.0001[a]
Bird numbers	<0.0001[a]
Rabbit sign	0.0065[b]
Deer sign	0.1455
Roadkills	0.9785
Mammal numbers	0.1547

[a]Indicates a highly significant difference between experimental and control plots.
[b]Indicates a significant difference between experimental and control plots.

TABLE 4 Mammals Observed on Experimental and Control Plots

Species	Experimental	Control	Total
Eastern Cottontail, *Sylvilagus floridanus*	17	11	28
Eastern Chipmunk, *Tamias striatus*	2		2
Unknown mammal	4	1	5
Vole, *Microtus* spp.		2	2
Woodchuck, *Marmota monax*	1		1
House Cat, *Felis catus*		1	1
Total	24	15	39

TABLE 5 Roadkills Along Experimental and Control Plots

Species	Experimental	Control	Total
Raccoon, *Procyon lotor*	6	2	8
Unidentified mammal	3	1	4
Eastern Fox Squirrel, *Sciurus niger*		2	2
Thirteen-lined Ground Squirrel, *Citellus tridecemlineatus*		2	2
Red-winged Blackbird, *Agelaius phoeniceus*		2	2
Striped Skunk, *Mephitis mephitis*	1		1
Norway Rat, *Rattus norvegicus*		1	1
Woodchuck, *Marmota monax*		1	1
Virginia Opossum, *Didelphis marsupialis*	1		1
Bat	1		1
Dog, *Canis familiaris*		1	1
Brown Thrasher, *Toxostoma rufum*	1		1
Unidentified Bird		1	1
Total	13	13	26

TABLE 6 Bird Nests Found on Experimental and Control Plots

Highway	Experimental	Control	Total
US-31	44	2	46
I-65	40	1	41
I-69	17		17
I-70	33	8	41
Total	134	11	145

TABLE 7 Trees and Shrubs With Bird Nests

Species	Experimental	Control	Total
Autumn Olive, *Elaeagnus umbellata*	76		76
Hawthorn, *Crataegus* spp.	20		20
Multiflora Rose[a], *Rosa multiflora*	14	3	17
Ninebark, *Physocarpus opulifolius*	7		7
Amur Honeysuckle, *Lonicera maackii*	5		5
Flowering Crabapple, *Malus* spp.	4		4
Red Mulberry[a], *Morus rubra*	2		2
Common Elderberry, *Sambucus canadensis*	2		2
Red Cedar[a], *Juniperus virginiana*	1		1
Willow[a], *Salix* spp.		1	1
Japonica Lespedeza, *Lespedeza bicolor japonica*	1		1
Common Catalpa[a], *Catalpa bignoniodes*	1		1
American Hazelnut, *Corylus americana*	1		1
Sumac, *Rhus* spp.	1		1
Ash[a], *Fraxinus* spp.		1	1
Trumpet Creeper[a], *Campsis radicans*		1	1
Cherry[a], *Prunus* spp.		1	1
Box Elder[a], *Acer negundo*		1	1
Total	135	11	143

[a]Indicates volunteer plants—not planted by IDNR.

plots attract a greater number of birds and mammals than control plots? The results of this study indicate that they do. The results in Tables 2 and 4 indicate that 455 (70 percent) of the birds and mammals were observed on experimental plots, whereas 197 (30 percent) of the birds and mammals were observed on control plots. The data in Table 3 indicate that there is a highly significant difference in bird numbers on experimental and control plots. The IDNR planted plots provided food and cover for birds that were not available on control plots. There is no significant difference in mammal numbers on experimental and control plots. Although there was no difference in actual mammal numbers, there was a significant difference in rabbit sign on experimental and control plots. The closely spaced IDNR plantings provided cover for rabbits. Gnawings observed during the winter study period indicated that rabbits used these planted areas for feeding as well as for shelter during heavy snow. Wildlife numbers were greater on experimental plots, indicating that these areas are providing a better habitat than grassed ROW.

The second objective of this study was to determine if there is a difference in species diversity between experimental and control plots. The ecotonal habitat produced by the tree-shrub plantings attracted eight more bird species. The IDNR plantings attracted bird species that are commonly found in old field habitat. Brushland bird species such as indigo bunting, gray catbird, and American tree sparrow were observed in experimental plots, but not in control plots. Eastern meadowlark, a grassland species, was observed more often in control plots. Red-winged blackbirds were abundant on both experimental and control plots. Evidently, redwings have adapted to the ROW habitat whether planted or not. Many red-winged blackbird nests were found in the experimental plots. Redwings used IDNR plantings as perch sites as well as nesting sites. Redwings were commonly observed in control plots perched on the fence.

Adams and Geis (14) in studying the effect of highways on wildlife in the Midwest found that red-winged blackbirds comprised 50 percent of the bird community adjacent to Interstates and 28 percent of the highway bird mortality. Hewitt (29) in researching red-winged blackbirds along roadsides states that roadsides provide excellent habitat for territorial redwings, with the presence of fenceposts, wire fences, telephone posts, and water-filled ditches.

A highly significant difference was noted in the number of bird nests found indicating that the experimental plots (planted) provided better nesting habitat than control plots. No ground nests were found, which was probably due to observers focusing attention straight ahead to observe flushing birds. Volunteer plants, not planted by IDNR, were found to hold bird nests on both experimental and control plots. Multiflora rose, red mulberry, and red cedar held 17 bird nests on experimental plots (Table 7). The control of mowing and the prohibition of spraying with herbicide allowed the establishment of woody plant species useful to wildlife regardless of plantings made by IDNR. I-70 had eight bird nests on control plots. The control plots on I-70 had more woody vegetation than the control plots on other study areas.

Machan (26) found more roadkills on or adjacent to grassed plots. However, roadkill numbers in this study were the same for experimental and control plots. More than twice as many animals were observed in the experimental plots, yet the incidence of roadkill was the same as along control plots (Table 5). These results indicate that the ROW habitat can be developed with woody vegetation to attract wildlife without an attendant rise in roadkill.

CONCLUSIONS AND RECOMMENDATIONS

This study indicates that IDNR plantings do provide a habitat that attracts a greater number and greater diversity of wildlife, primarily birds. Evidence was found to indicate that rabbits used planted areas more than grassed areas. Nesting attempts suggest that the bird population finds ROW plantings suitable habitat for nesting. The roadkill data demonstrate that ROW can be developed to attract wildlife without an attendant increase in highway mortalities. The use of volunteer plants as bird nest sites suggests that more research is needed on areas that have been allowed to grow without mowing, spraying, or planting with woody species. ROWs have great potential for wildlife habitat development and will need to be used in the future as other areas of wildlife habitat diminish. The following recommendations are made:

1. Continuation of the IDNR planting program;
2. Develop a study to determine bird preference for individual species (i.e., autumn olive) and then discontinue planting of species that attract undesirable bird species (i.e., red-winged blackbirds); and
3. Initiate a study of ROWs that have been allowed to grow up with native woody vegetation because allowing roadsides to grow without spraying or mowing may provide wildlife habitat without the monetary cost of a planting program.

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REFERENCES

1. D.L. Leedy. Highway-Wildlife Relationships. Vol. 1, A State-of-the-Art Report. Report FHWA-RD-76-4. FHWA, U.S. Department of Transportation, 1975.
2. D.L. Leedy and L.W. Adams. Wildlife Considerations in Planning and Managing Highway Corridors. Urban Wildlife Research Center. Report FHWA-TS-82-212. FHWA, U.S. Department of Transportation, 1982.
3. E.D. Michael. Wildlife Use of Different Roadside Cover Plantings. Research Project 56. West Virginia Department of Highways. Charleston, 1980.
4. O. Rongstad. As an Ecologist Sees Highways and the Environment. Wisconsin Counties, Vol. 34, No. 7, 1972, pp. 7, 32, 34.
5. C.A. Dambach. Roadside Use Has a Part in the Conservation Program. Tenth Short Course on Roadside Development. Department of Landscape Architecture, Ohio State University and Ohio Department of Highways, Columbus, 1951, pp. 16-22.
6. K. Laursen. Birds on Roadside Verges and the Effect of Mowing on Frequency and Distribution. Biological Conservation, Vol. 20, 1981, pp. 59-68.
7. J.M. Way. Roadside Verges and Conservation in Britain: A Review. Biological Conservation, Vol. 12, 1977, pp. 65-73.
8. J.G. Kelcey. Opportunities for Wildlife Habitats on Road Verges in a New City. Urban Ecology, Vol. 1, 1975, pp. 271-284.
9. H.L. Wiegers. A Survey of Roadsides--Their Status and Value to Nesting Game Birds. Project W-32-R-3, Job 160. Nebraska Pittman-Robertson, 1960.
10. L.M. David and R.E. Warner. Update: Roadsides for Wildlife. Outdoor Highlights, Official Publication of the Illinois Department of Conservation, May 1978.
11. G.B. Joselyn and G.I. Tate. Practical Aspects of Managing Roadside Cover for Nesting Pheasants. Journal Wildlife Management, Vol. 36, No. 1, 1972, pp. 1-11.
12. R.B. Oetting and J.F. Cassel. Waterfowl Nesting on Interstate Highway Right-of-Way in North Dakota. Journal Wildlife Management, Vol. 35, No. 4, 1971, pp. 774-781.
13. L.W. Adams and A.D. Geis. Effects of Highways on Wildlife Populations and Habitat: Selection and Evaluation Procedures. Report FHWA-RD-78-92. FHWA, U.S. Department of Transportation, 1978.
14. L.W. Adams and A.D. Geis. Effects of Highways on Wildlife. Report FHWA-RD-81-067. FHWA, U.S. Department of Transportation, 1981.
15. M. Bruner, R. Hine, J.R. March, M.A. Martin, G.R. Miller, D.H. Rusch, F. Stearns, N.G. Tilghman, and R. Vogt. Development and Evaluation of Techniques for Assessment of Impact of Highway Development on Wildlife Populations and Habitats in the Upper Midwest. Final Report Wisconsin Cooperative Wildlife Research Unit, Fish and Wildlife Service, U.S. Department of the Interior, 1978.
16. L.L. Getz, J.R. Karr, W.D. Clark, and B.F. Jones. Effects of Highways on Wildlife--Results of Techniques; Investigation Phase and Recommendation for the Operational Phase. Final Report Urban Wildlife Research Center, Inc., U.S. Fish and Wildlife Service, U.S. Department of the Interior, 1977, 68 pp.
17. J. Stapleton and E. Kiviat. Rights of Birds and Rights of Way. American Birds, Vol. 33, No. 1, 1979, pp. 7-10.
18. C.R. Ferris. Effects of Highways on Red-Tailed Hawks and Sparrow Hawks. M.S. thesis, West Virginia University, Morgantown, 1974.
19. E.D. Michael, C.R. Ferris, and E.G. Haverlack. Effects of Highway Rights-of-way on Bird Populations. Proc, First National Symposium on Environmental Concerns. 1976, pp. 253-261.
20. C.R. Ferris, D.S. Palman, and V.B. Richens. Ecological Impact of Interstate 95 on Birds and Mammals in Northern Maine. Report FHWA-ME-TP-77-12. FHWA, U.S. Department of Transportation, 1977.
21. D.J. Oxley, M.B. Fenton, and G.R. Carmody. The Effects of Roads on Populations of Small Mammals. Journal Applied Ecology, Vol. 11, No. 1, 1974, pp. 51-59.
22. W.D. Clark and J.R. Karr. Effects of Highways on Red-Winged Blackbird and Horned Lark Populations. Wilson Bulletin, Vol. 91, No. 1, 1979, pp. 143-145.
23. C.R. Ferris. Effects of Interstate 95 on Breeding Birds in Northern Maine. Journal Wildlife Management, Vol. 43, No. 2, 1979, pp. 421-427.
24. L.B. Best. Bird Use of Fencerows: Implications of Contemporary Fencerow Management Practices. Wildlife Society Bulletin, Vol. 11, No. 4, 1983, pp. 343-347.
25. W.N. Wandell. Songbird Use of Wildlife Habitat Improvement Plantings. Illinois Wildlife, Vol. 3, No. 2, 1948, pp. 4-7.
26. W. Machan. Wildlife Usage of Highway Right-of-Way. Unpublished Report. Indiana Department Natural Resources, Indianapolis, 1975.
27. R.M. Zewadski, ed. Grackles Nest on Interstates. Report 159. Illinois Natural History Survey, Champaign, 1976.
28. W.B. Barnes. Zoogeographic Regions of Indiana. American Midland Naturalist, Vol. 48, No. 3, 1952, pp. 694-699.
29. O.H. Hewitt. A Road Count Index of Breeding Populations of Red-Winged Blackbirds. Journal Wildlife Management, Vol. 31, No. 1, 1967, pp. 39-47.