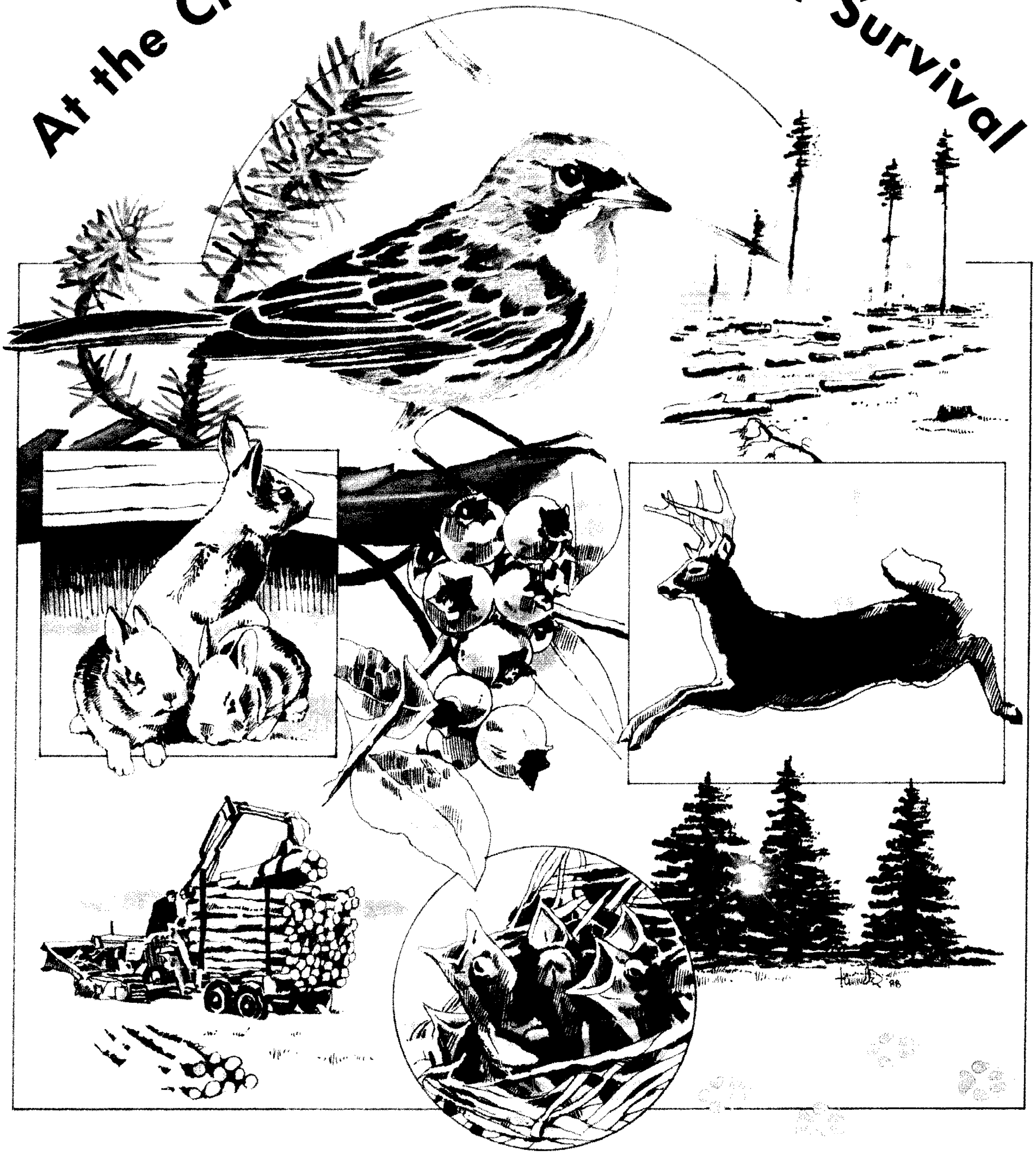
At the Crossroads-Extinction or Survival



Proceedings

Kirtland's Warbler Symposium

February 9-11, 1989
Lansing, Michigan

Forest Service U.S. Department of Agriculture
Huron—Manistee National Forests

KIRTLAND'S WARBLER SYMPOSIUM

HURON-MANISTEE NATIONAL FORESTS

THURSDAY: RECOVERY TEAM MEETING
FEBRUARY 9, 1989

4:30-7:00 P.M. REGISTRATION

5:00-6:30 SOCIAL - Sponsored by
MICHIGAN UNITED CONSERVATION CLUBS
CAPITAL AREA CHAPTER
MICHIGAN AUDUBON SOCIETY

7:00 WELCOMING ADDRESS

JERRY McCORMICK — FOREST SUPERVISOR HURON-MANISTEE NF'S

FLOYD J. MARITA — REGIONAL FORESTER, USFS

JAMES C. GRITMAN — REGIONAL DIRECTOR, USFWS

KAY DODGE — EXECUTIVE DIRECTOR of the CENTER for ENVIRONMENTAL STUDY and MICHIGAN AUDUBON SOCIETY

DAVID F. HALES — DIRECTOR, MICHIGAN DEPT. OF NATURAL RESOURCES

FRIDAY: GENERAL SESSION
FEBRUARY 10, 1989

7:00 A.M. REGISTRATION

KIRTLAND'S WARBLER HISTORY Moderator: JOHN BYELICH

8:00 (1) PERSPECTIVE ON THE KIRTLAND'S WARBLER.
HAROLD MAYFIELD, KIRTLAND'S WARBLER RECOVERY TEAM MEMBER.

8:40 (2) THIRTY YEARS OF MANAGEMENT - RECOVERY TEAM EFFORTS FOR THE KIRTLAND'S WARBLER.
ROBERT RADTKE, USDA, FOREST SERVICE.

9:10 (3) EARLY HISTORY OF THE COWBIRD CONTROL PROJECT AND FLEDGLING SUCCESS OF THE WARBLER. DR. NICKOLAS CUTHBERT, CENTRAL MICHIGAN UNIVERSITY.

9:40 (4) POPULATION VIABILITY AND KIRTLAND'S WARBLERS. RICH BAKER, MINNESOTA DEPARTMENT OF NATURAL RESOURCES.

10:10 BREAK

KIRTLAND'S WARBLER LIFE HISTORY   Moderator: SYLVIA TAYLOR

10:30 (5) DISTRIBUTION OF KIRTLAND'S WARBLERS

1. WINTER HABITAT/RANGE - BAHAMA STORY
   KIRTLAND'S WARBLER ON THEIR WINTERING GROUNDS IN THE BAHAMA ARCHIPELAGO -- A PRIMARY REPORT. PAUL SYKES, US FISH AND WILDLIFE SERVICE.

11:00 (6)

2. WESTERN HABITAT/RANGE - WISCONSIN STORY
   HISTORY OF KIRTLAND'S WARBLER FOUND IN WISCONSIN. RANDY HOFFMAN, WISCONSIN DEPT. OF NATURAL RESOURCES.

11:30 (7)

3. NORTHERN HABITAT/RANGE - ONTARIO, CANADA
   THE DISPERSAL OF THE KIRTLAND'S WARBLER: MYTHS AND REALITY. DR. PAUL AIRD, TORONTO, CANADA.

12:00 LUNCH

4. MICHIGAN-PRIMARY HOME RANGE - Moderator JERRY WEINRICH

   ELEMENTS OF THIS AREA WHICH CONTRIBUTE TO THE SUCCESSFUL PRESERVATION OF THIS SPECIES.

1:00 (8) SPRING MIGRATION OF THE KIRTLAND'S WARBLER. JAMES N. BULL, ANN ARBOR, MICHIGAN.

1:30 (9) MULTIPLE FACTORS APPROACH FOR DELINEATION OF HABITAT. DAVID T. CLELAND, HURON-MANISTEE NATIONAL FORESTS.

2:15 (10) LANDSCAPE ECOSYSTEMS OF THE MACK LAKE BURN AND THEIR OCCUPANCY BY THE KIRTLAND'S WARBLER. CORINNA THEISS, XIAOMING ZOU, DR. BURTON BARNES, UNIVERSITY OF MICHIGAN.

2:45 (11) MILITARY ACTIVITIES IN COORDINATION WITH KIRTLAND'S WARBLER RECOVERY EFFORTS. GREG HUNTINGTON, STATE ENVIRONMENTAL SPECIALIST for the DEPARTMENT OF MILITARY AFFAIRS.

3:15 BREAK

3:45 (12) KIRTLAND'S WARBLER HABITAT MANAGEMENT OF THE HURON NATIONAL FOREST - A MANAGER'S PERSPECTIVE. DAVE KLINE DISTRICT RANGER, MIO RANGER DISTRICT, FS, USDA.

4:15 (13) FIRE AND FIRE'S EFFECTS --- ITS IMPACT ON FOREST VEGETATION FOR KIRTLAND'S WARBLER HABITAT. RON WILSON, MICHIGAN DEPT. OF NATURAL RESOURCES.

FRIDAY EVENING -

6:00 EVENING SOCIAL

8:00 PANEL MY MOST UNUSUAL OBSERVATIONS OF KIRTLAND'S WARBLER
MODERATOR - WILLIAM MAHALAK

DR. NICHOLAS CUTHBERT
DR. CAMERON KEPLER
HAROLD MAYFIELD
DR. JOHN PROBST
PAUL SYKES
DR. LARRY WALKINSHAW
JERRY WEINRICH
MIKE DeCAPITA
WILLIAM IRVINE
SYLVIA TAYLOR
ELAINE CARLSON

SATURDAY
FEBRUARY 11, 1989

KIRTLAND'S WARBLER HABITAT Moderator: WILLIAM IRVINE

8:00 A.M. PANEL - ELAINE CARLSON
DR. CAMERON KEPLER
DR. JOHN PROBST
PAUL SYKES
JERRY WEINRICH

1. GENERAL HABITAT CHARACTERISTICS OR REQUIREMENTS OF AREAS USED BY KIRTLAND'S WARBLERS.

2. SPECIFIC HABITATS USED BY KIRTLAND'S WARBLERS - NATURAL WILDFIRES VERSUS PRESCRIBED BURNS AND PLANTING.

9:30 (14) KIRTLAND'S WARBLER POPULATION PROJECTIONS: ESTIMATES PROVIDED FROM A HABITAT MODEL/THIS IS THE PREDICTION FOR THE FUTURE. JERRY WEINRICH, MICHIGAN DNR, DR. JOHN R. PROBST, NORTH CENTRAL FOREST EXPERIMENT STATION.

10:00 BREAK

10:30 (15) A REINTRODUCTION STUDY FOR THE KIRTLAND'S WARBLER. CAROL BOCETTI, OHIO STATE UNIVERSITY.

11:00 (16) KEY MULTIPLE-USE VALUES OF KIRTLAND'S WARBLER HABITATS. DR. JOHN R. PROBST, RESEARCH WILDLIFE BIOLOGIST, NORTH CENTRAL FOREST EXPERIMENT STATION.

11:30 (17) A REVIEW OF THE PREDATOR-PREY INTERACTIONS VERSUS HABITAT CONSIDERATIONS FOR THE KIRTLAND'S WARBLER. DANIEL S. McGEEN, PONTIAC, MICHIGAN.

12:00 LUNCH

Moderator - GARY BOUSHELLE

1:30 (18) THE OPPORTUNITY COST OF MANAGING KIRTLAND'S WARBLER HABITAT IN MICHIGAN. DR. LARRY LEEFERS and ALBERT MWANGI, MICHIGAN STATE UNIVERSITY.

2:00 PANEL - BUDGETING ISSUES FOR SURVIVAL
TOM WEISE, MICHIGAN DNR
JIM ENGLE, FISH AND WILDLIFE SERVICE, USDI
ROBERT RADTKE, FOREST SERVICE, USDA
KAY DODGE, EXECUTIVE DIRECTOR of the CENTER FOR ENVIRONMENTAL STUDY, AND MICHIGAN AUDUBON SOCIETY

3:00 (19) PREDICTING HABITAT CHANGES DUE TO GREENHOUSE WARMING. AN ANALYSIS OF POTENTIAL EFFECTS ON KIRTLAND'S WARBLER HABITAT. DOUG WOODBY, UNIVERSITY OF CALIFORNIA, SANTA BARBARA.

3:30 SUMMARY - POLICY OPTIONS FOR THE KIRTLAND'S WARBLER: CONCLUDING REMARKS.
DR. PAUL AIRD, TORONTO, CANADA.

KIRTLAND'S WARBLER SYMPOSIUM
February 1989

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PERSPECTIVE ON THE KIRTLAND'S WARBLER

Harold F. Mayfield

Kirtland's Warbler Recovery Team Member
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Toledo, OH 43614

For nearly 400 years our language has had a phrase to describe anything of special interest because of its rarity. We call it a rara avis or rare bird. The epitome of this term in America for more than 100 years has been the Kirtland's warbler.

Its rarity attracts attention. Every year hundreds of birders travel to northern Michigan to see it. Even scientists are not immune to its appeal, and for an additional reason. While the problems of survival in an abundant species may be almost hopelessly complex, these problems are brought into sharper focus when the subject consists of a few individuals in one place. The setting is almost like a laboratory. As a result, the Kirtland's warbler is one of the best-studied birds in America. Three books and hundreds of articles have been written on it. Kristina Huber's 1982 annotated bibliography listed 800 titles, and Amy Stone's 1986 unpublished bibliography listed 291 on migration and wintering alone.

Yet, the bird continues to baffle us. Why is it so rare and difficult to predict and manage? For perspective on these problems, let's look at its history.

Prehistory

The nesting habitat is distinctive but transitory. The warbler nests only on sandy soil in level or gently rolling terrain among extensive stands of young jack pines 2-4 m tall (8-20 years old). These conditions occur naturally only after major forest fires in pinelands of a special kind, and they last only a few years at any spot. These narrow requirements ultimately limit the bird's population and range, and virtually assure us it has been rare for a very long time.

The present jack pine plains of Michigan have existed only since the retreat of the Wisconsin Glacier. Until recently we had assumed that the Kirtland's warbler in former times had found suitable habitat broadly on the sandy outwash plains beyond the foot of the glacier as it advanced and retreated across Ohio and the Prairie states. However, recent pollen analysis has forced us to revise those views. At the height of the last glaciation 18,000 years ago jack pine was virtually absent from the Midwest, and it did not re-enter this region until about 10,000 years ago. However, during this whole glacial period jack pine was abundant in the southern Appalachians and the Southeast coastal plain. Therefore, unless the bird has changed its habitat in recent geologic times, it nested only in a limited portion of the Southeastern coast for about 70,000 years before the present inter-glacial period, migrating in winter to the nearby Bahama Islands, which were vastly larger in extent than at present with the sea level 400 feet lower.

Here again, the Kirtland's warbler may shed light on the history of other songbirds nesting in the North and wintering in the West Indies or beyond (Mayfield, 1988a).

Early Historical Record

This species was first described from a specimen, a male, taken on May 13, 1851, 138 years ago, in the orchard of the distinguished physician and naturalist, Dr. Jared P. Kirtland, on the western outskirts of Cleveland, Ohio. This was at the height of the spring migration of warblers, and the presumption was that it was bound for its nesting grounds somewhere in the Northern forests. But where?

In the next 50 years other individuals were collected at scattered locations in the Midwest and Southeast, and the bird was found repeatedly in winter in the Bahama Islands. The breeding grounds remained a mystery until 1903 when two graduate students from the University of Michigan, fishing on the AuSable River, heard and saw a strange bird and brought it back to Ann Arbor. There Norman Wood, the museum curator, instantly recognized it and hurriedly traveled north to the location. After a search of 7 days he found the first nest on July 8 (Wood, 1904). A monument now marks the spot. Fully 90 per cent of the nests found since that time have been in the drainage of that same stream.

This first eyewitness to the Kirtland's warbler on its nesting ground found it scarce at that time. He said, "It is not, however, every jack pine plain that is the home of a colony, as I examined hundreds of acres where the conditions seemed all right, and found none" (Wood, 1904:10). He continued searching for more than two decades and found other colonies within the same general range, but as late as 1926, in accordance with the views of the day, he saw fire as a threat to the bird rather than its salvation (Wood, 1926:12).

Yet, a little earlier, in the 1880's and 1890's, we have reason to suspect there may have been a temporary surge in the population. At that time specimens turned up in Illinois, Missouri, and Minnesota, well to the west of the normal migration route, where it has not appeared since. Also collectors found it with ease in the Bahama Islands, accumulating 66 specimens in those two decades, but only an occasional specimen before or since that time (Mayfield, 1960:35). Charles J. Maynard took 24 in a few weeks near Nassau in 1884, but no one has seen more than one or two in modern times.

It may be significant that this apparent upsurge in population coincided with the regrowth of jack pines following the wholesale lumbering and burning of the forests of northern Lower Michigan. Without doubt, there was more nesting habitat for the warbler in that period than before or since in historic times.

Cowbird

When the lumberman and the farmer who accompanied him opened the forest, they brought a new threat to the warbler. The Brown-headed

Cowbird, a creature of the central grasslands of the midcontinent, thrived in the newly cleared semi-open country. It spread eastward and northward with the clearing of the land, finding the horses and cows of the farmer good substitutes for the bison it had followed from time immemorial. It probably reached the Kirtland's warbler about 1880.

The cowbird builds no nest of its own but uses the nests of other birds, usually smaller species, laying its eggs in their nests and removing an equivalent number of their eggs. In addition, the cowbird eggs usually hatch first and trample or crowd out many host young. The cowbird found the Kirtland's warbler a perfect host while continuing to use other species nearby. Thus, the warbler could sink to zero without serious detriment to the cowbird. This is a rare example in nature where predatory pressure does not relent when the prey becomes scarce; that is, the pressure is not density-dependent, in the language of ecology.

In the face of this new threat, the Kirtland's warbler is almost defenseless. The longtime associates of the cowbird in the West have developed defenses against it, but many small songbirds of the East like the Kirtland's warbler are highly vulnerable (Mayfield, 1977). Since its arrival in this region the cowbird has steadily increased, putting ever heavier burdens on its hosts. In the 1940's and 1950's the cowbird was depressing the production of fledgling Kirtland's warblers by 50 per cent, but in the late 1960's the toll had arisen to about 70 per cent (Walkinshaw, 1972), an intolerable loss to sustain.

Accordingly, the population of warblers, which had been about 1,000 adults in 1951 and 1961 slipped to 400 in 1971. Immediately, measures to control the cowbirds were initiated on the warbler nesting grounds, and the decline was arrested. The way to remove cowbirds efficiently with little damage to other birds had been discovered by Nicholas L. Cuthbert, using a trap devised by the U.S. Fish and Wildlife Service to control blackbirds where they are pests in farmers' fields. Cowbird trapping was remarkably successful and this enemy was almost completely eliminated from the warbler nesting areas. In 1975 I made calculations based on the Kirtland reproduction rate under recent cowbird pressure and concluded that without protection the last Kirtland's warbler would disappear in 1978. We did not allow that to happen, but the population has not spurted as we had hoped.

Other Problems of Survival

Viewed over the long pull, the population of Kirtland's warblers in the 1970's and 1980's has been remarkably stable. In 18 years through 1988 the mean count of singing males has been 206, with a range of 167 to 242 (Weinrich, 1988). In years of gain, the mean has been 16.8 males or 8 per cent of the mean population, and in years of losses, the mean has been 19.5 or 9 per cent of the mean population. Thus, the mean variance has been less than the probable error of the census method, which has been estimated to be at least 10 per cent of each count.

Rarity itself brings a special set of problems. At some point we would expect a decline in fertility as a result of inbreeding. But if this has occurred in Kirtland's warblers, it has not showed up in field studies. On the contrary, the bird has continued to show excellent production of eggs and fledglings. For example, the production of fledglings in the first 6 years after cowbird control was 3.11 per pair of adults per year (Walkinshaw, 1983:152). This far exceeds the production of Prairie Warblers, a well-studied, widespread, and successful species, which produces 2.2 fledglings per pair per year (Nolan, 1978:419). Also the survival rates for adults from one June to the next is typical for a small songbird with a long migration. The survival rates for adult Kirtland's warblers is about 65 per cent of the previous year's population, exactly the same rate reported for the Prairie Warbler (Nolan, 1978:469). Therefore, if Kirtland's warblers are less successful than other warblers, the reasons must lie with some selective pressure against the young in their first year of life. Here we have little exact information.

In a stable population where the annual survival rate of adults is about 65 per cent and the production of young is 3.11 fledglings per pair per year, the recruitment of yearlings calculates to be about 22 per cent per year, somewhat lower than for comparable birds. This calculation, however, could be astray if a substantial number of males on the breeding grounds are unmated, as has been suggested lately (Probst, 1986). But this idea runs against the experience of a series of past observers who worked intensively for successive years in single colonies and rarely failed to find a female with each male.

Losses of unknown magnitude occur at every stage of the annual cycle: (1) late summer on the nesting ground, (2) fall migration, (3) wintering from October to April in the Bahama Islands, and (4) spring migration. These problems beset all small migrant songbirds, of course, and our puzzle is to discover how Kirtland's warblers are different.

Our field work to date has not detected any special hazards in the summer and winter places of residence, and the adults obviously cope well with vicissitudes of migration, but the migration of birds making their first long-distance trip may present more than ordinary difficulties in this species.

The migration south ought to be relatively easy. The route is mostly over land, and a little straying ought not to be disastrous. Also the target consists of a string of islands almost 700 miles long, with each island in sight of one or more of the others. In the northward migration, on the other hand, the target is small, in recent years shrinking, and perhaps reached by one long nonstop flight (Mayfield, 1988a). If a bird misses it, the individual may find vast expanses of pinewoods beguilingly similar to what it is seeking but devoid of other Kirtland's warblers. Our experience shows that such birds may take up summer residence there but not find a mate. If so, they are wasted, victims of their own rarity (Mayfield, 1983).

Less rare birds do not have this problem. Most long-distance migrants may miss their destinations by hundreds of miles without serious consequences. If they are displaced to left or right by the width of several states, they may still find suitable habitat and mates at the same latitude elsewhere. If the Kirtland's warbler misses by the width of two counties, its nesting potential is lost. Indeed, we know that some miss. In recent years we have found several of these, all of them males and all of them without mates. We have no idea how many are lost by straying, but it is apparent the number is larger than we would have supposed a few decades ago. Determined effort in recent years in the pinelands of Wisconsin and Ontario have turned up examples. The number found may reflect the skill and effort of the observers more than the true number of birds. In 1988, Wesley Jones, a man thoroughly familiar with the bird and its habitat, discovered 8 individuals in Wisconsin alone. It is reasonable to suppose that these strays are mainly yearlings. It is also probable that many strays are females, but being silent, are never found. In any case, the total loss from this cause must be far larger than the number of strays actually counted. Dispersal may have survival value in a widespread species, but it can be costly to a species with narrow habitat requirements.

The warblers traverse the hurricane zone spring and fall, and some people have wondered if storms might jeopardize the species in migration, but we have found no relationship between severe storms in migration season and subsequent counts of the population in Michigan (Ryel, 1981:79-81).

Since the bird seems to be doing so well on the breeding ground, we grope for explanations on the wintering ground, where it spends the larger part of the year. Here the only clue we have is a correlation with rainfall in the Bahamas, a wetter winter presumably yielding more plant and animal food for the birds (Ryel, 1981:81-83).

Habitat

With so many aspects of this bird's life baffling us, we concentrate on what we can see readily. Obviously an ultimate limitation on the population is its nesting habitat. But precisely what are the ingredients in the habitat? From the time of the discovery of the first nest, everyone has recognized the association with the jack pine. But it is equally obvious that trees are not the whole story. Soil and ground cover are involved, although we find it hard to be precise about these. We can describe the situation where we find the bird nesting, but we strain our imaginations sometimes to explain the bird's absence from some jack pine stands, both in Michigan and in other nearby states and provinces. Remember, the jack pine stretches nearly the width of the continent and northward almost to the arctic.

I find it amusing that Norman Wood estimated the suitable habitat to cover 6,000 acres in 1925 (Wood, 1926:13), exactly the same figure I was using 50 years later with much more information. However, I do not place much confidence in such estimates, including my own, because they are based on circular reasoning; the habitat is suitable if it has warblers, and it is not suitable if it does not have warblers. We still need to know what disqualifies tracts elsewhere including Christmas-tree plantations that abound just to the west of the present Kirtland range.

The greatest event in recent Kirtland's warbler history was the Mack Lake fire of 1980, which burned nearly 30,000 acres and promises to produce more habitat for the bird than all the rest combined during the last three decades. However, this should not be regarded merely as a solitary, unrepeatable incident. One has only to drive through the sand country to see thousands of acres of mature trees waiting for conditions to be right for a devastating fire. Remember, in jack pine, fire deferred is more severe when it comes. I have counted 6 fires of more than 15,000 acres each in this region since 1920.

Plainly the warbler needs more than trees. At one time we thought the character of the ground cover might be crucial, because the bird does much of its food foraging there and conceals its nest there. But each time we think we have identified features of the ground cover that are essential, we find examples that are different. Nevertheless, it must not be tall and dense unless it consists of small pines.

The first question a novice asks is how about the warbler's food? Inquiries in this direction have led us nowhere. The warbler seems to eat whatever is abundant at the time in the trees and the ground cover. Indeed, the small amount of time the bird spends in food searching suggests that it lives in the midst of a smorgasbord of invertebrates and berries on its summer range, except perhaps during the first chilly days of May when it arrives on the nesting ground.

If the Kirtland's warbler suffers more than other small songbirds from predators and competitors, we have not seen it. On the contrary, it seems to me the bird has chosen relatively depauperate regions both for summering and wintering grounds. The jack pine barrens in Michigan are so nearly devoid of life that the prehistoric Indians avoided them. The other birds found there in nesting season all seem to do better elsewhere. Predators are rare, and observed instances of predation are few. Likewise, the Bahama Islands are the most barren of the West Indies. Hence, it appears that this unsuccessful, relict species has survived by finding a sanctuary both in winter and summer.

Habitat embraces the total environment: vegetation, soil, competitors, predators, and climate. All of these except climate have received attention for decades. Now Burton V. Barnes and his students have focused their attention on the microclimates at nest sites, finding significant differences according to soil and elevation. It appears the warbler may not nest successfully in spots where early June days bring below-freezing temperatures at ground level. This may help explain why many tracts that look right to our eyes have no nests. Also it may explain why Kirtland's warblers utilize only the southernmost of the jack pines in North America.

Conclusion

Finally, as we weigh the fate of the "Kirtland's warbler at the crossroads - extinction or survival," I think it is clear that we have a greater need for ideas than for trees.

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KIRTLAND'S WARBLER MANAGEMENT

Robert Radtke, G. Wm. Irvine, and John D. Byelich

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Note: The following had been presented as a slide presentation

Currently, there are only 207 singing males or about 414 individuals left in the known nesting range. This endangered songbird is dependent upon extensive areas of --- young jack pine of survival. It is confined to one small spot on our globe nesting only in young jack pine forests in Michigan. Almost all nests are located on the Huron-Manistee National Forests and adjacent State Forest lands.

This wood warbler is perhaps the first songbird for which a complete census of the population has been conducted throughout its range. It is also the first songbird for which intensive forest management has been undertaken. This presentation will describe:

--Habitat management efforts on State and National Forest lands
--Protection and control efforts by the Fish and Wildlife Service
--and cooperative Federal, State and private efforts to save the Kirtland's.

Efforts to protect the Kirtland's began in 1903 when the nesting area of the Kirtland's was first discovered near the Au Sable River.

Harold Mayfield and others undertook studies in the 1940's and 50's on this songbird, with the results reported in Mayfield book, "This Kirtland's Warbler." Mayfield undertook the first complete census in 1951--using the fire records from the State and Forest Service. The 1951 census recorded 432 singing males.

Habitat management efforts began in 1956, with 3 areas formally being established by the Michigan Department of Conservation. Each was 4 square miles in size (7,680 acres) and located in several counties, each with a different habitat. Special plantings were made using jack pine, red pine, and white spruce. In 1962, the 4,010-acre Kirtland's Warbler Management Area was established near Mack Lake on the Huron National Forest. The combined State and Forest Service areas of almost 12,000 acres provided an area where the Kirtland's would receive special management in future years. These State and National Forest areas were established; not as preserves for the Kirtland's, but as areas where intensive forestry would be practiced to obtain the type of habitat required by the Kirtland's. They have been managed through commercial timber harvest. In fact, commercial harvest of timber makes possible the economic development of these areas. Each area is large enough to maintain the various stages of jack pine ranging from recent cutover areas to mature jack pine, ready to cut. A portion of each area would provide suitable habitat at all times. The objective of all habitat management efforts has been to develop a system of sound forestry practices to meet the requirement of the warbler. These early efforts set the direction for future management for the Kirtland's. The areas provide an excellent example of multiple-use, a basic principle guiding use of both State and National Forest lands. Suitable habitat for this songbird is extensive stands of jack pine, generally over 80 acres in size. The Kirtland's is found only in large homogeneous blocks of jack pine which are from 5 to about 15 feet in height and occurring in a patchy conduction, with dense stands mixed with small openings. The lower branches of the jack pine must reach the ground, where the Kirtland's nest.

Historically, jack pine has resulted from wildfires. Extensive areas of suitable habitat followed the logging era at the turn of the century and wildfires which burned over much of northern Michigan. Jack pine is a fire species that has declined because of efficient fire control efforts. Heat is required to open the cones of jack pine releasing the seed for a new forest. To create the essential habitat requires controlled or prescribed burning along with special planting techniques. This shows the opposed wave planting to create dense stands, with scattered openings. Almost all suitable habitat for the Kirtland's existing today is located on lands specifically managed for the Kirtland's or as a result of wildfires. Few wildfires reach a size large enough to develop productive habitat. A series of wildfires occurred in the spring of 1946 near Mack Lake. They provided much of the suitable habitat during the 1950's and '60's. Wildfires, however, are underdesirable. Prescribed fire under controlled conditions, is possible. In 1964, operation "popcone" was the first extensive prescribed burn undertaken for the Kirtland's on the Huron National Forest. This area was later planted and produced suitable habitat during the '70's. It is now passing its prime as new areas come into suitable habitat.

Cowbird nest parasitism has always been a major threat to warbler survival. The Forest Service and State entered into an agreement with Dr. Nicholas Cuthbert of Central Michigan University to conduct a study on cowbird control methods. This research provided the basis for the control techniques used today. The cowbird traps are effective. Through 1988 almost 60,000 cowbirds have been removed from habitat occupied by the Kirtland's. Nest parasitism has declined dramatically from about 60% in the early 1970's to less than 5% today. The number of young warblers fledged per nest increased from .8 to 2.8. Today the Fish and Wildlife Service, in cooperation with the State, Forest Service, Audubon Society, and others operates an extensive network of cowbirds traps throughout the occupied range. The trapped cowbirds have been used to feed young peregrines. There is a concern that the bluejay may also adversely affect Kirtland's survival. The cowbird control program may have prevented the warbler from becoming extinct during the 1970's when suitable habitat reached a low.

The 1970 Kirtland's census showed an alarming drop in numbers from 1961 prompting a Federal, State, private effort to save this songbird. The Forest Service and State initiated a meeting of interested groups, resulting in the establishment of Kirtland's Warbler Advisory

Committee. The Michigan Audubon Society, Pontiac Audubon Society, Detroit Audubon Society, and Michigan Natural Areas Council signed a Cooperative Agreement with the Forest Service to help in this effort. These actions were strengthened with the passage of the Endangered Species Act in 1973. Following the passage of the Endangered Species Act, an Interagency Recovery Team was appointed by the Secretary of Interior to help guide management efforts. A Kirtland's Warbler Recovery Plan was prepared outlining steps designed to achieve recovery of this endangered species. The objective of the Recovery Plan is to: Reestablish a self-sustaining population throughout its former range, a minimum of 1,000 pairs. Recovery will be accomplished by:

1. Developing 36-40,000 acres of suitable nesting habitat on a sustained basis. This will require 130,000 acres of jack pine.

2. Protect the Kirtland's on its wintering grounds and along the migration route from Michigan to the Bahamas.

3. Reduce factors adversely affecting reproduction and survival.

4. Monitor breeding populations to evaluate responses to management. We will continue the annual breeding bird survey.

5. Study possible introduction of Kirtland's into other areas.

To implement the Recovery Plan the Forest Service and State developed a detailed habitat management plan, approved in 1981. To develop the plan, all potential habitat was identified and examined. Twenty-three management units were established, each about 2,000 acres in size with cutting blocks of about 200 acres. The Plan identifies 128,000 acres of jack pine to be managed for the Kirtland's; 54,000 acres on the Huron National Forest and 74,000 acres on 3 State Forests. Each of the 23 management areas has a detailed cutting schedule. Stands will be managed by cutting some 2,500 acres per year; prescribed fire,about 1,500 acres per year; site prep and planting, 1,500 acres per year. This will provide the 36-40,000 acres of suitable nesting habitat on a sustained basis. These areas will produce wood, recreation (everyone likes blueberries), and other wildlife values and is of economic benefit to local communities.

The public has taken a strong interest in recovery of the Kirtland's. Currently, all occupied nesting areas are closed to public entry during the nesting season, protected under the Endangered Species Act. Guided tours are available by the Fish and Wildlife Service (FWS) and Forest Service to see this bird. People from all 50 states and 17 nations visited the area last summer.

In spite of intensive management and increased productive success through cowbird control, the Kirtland's breeding population has only remained stable since 1972. It reached a low of 167 singing males in 1974 and 1987. In '88 there were 207 males on the known breeding grounds. Research by the FWS, North Central Forest Experiment Station (NCFES), and others will continue until we fully understand the habitat needs of the Kirtland's. Research undertaken to date has provided important information for management.

This meeting will provide a forum for determining future habitat research needs. Research by the FWS on the wintering grounds has indicated that habitat in the Bahamas may not be a problem. The FWS has shifted their research to the nesting grounds. The survival of the Kirtland's warbler remains in doubt and will require our continuing effort to achieve recovery. We do know that if it had not been for efforts in the 1950's, '60's, and '70's, this species would probably not exist today. Although its future is unknown, we believe the people of Michigan, and the nation working together, will make a united effort to ensure its survival. It's a time for action, so that future generations can see this colorful songbird. We can accomplish this because there are people who care, and to care for the least of them is to care for life itself.

POPULATION VIABILITY AND THE KIRTLAND'S WARBLER

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Introduction

The field of population viability is young and still heavy on theory (as new disciplines tend to be). It draws from a wide variety of subjects, including ecology, genetics, and population biology, and in this short paper I can only scratch the surface. However, I will try to cover three things. First, I'll review the concept of population viability and what is behind it. Next, I want to discuss how this concept is being applied in the form of population viability analysis. Finally, I'll try to look at what population viability might say about the management of the Kirtland's warbler.

First, a note on history. The concept of population viability more or less grew out of its inclusion in the Planning Regulations of the National Forest Management Act of 1976 (36 CFR 219). This document stated that "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area." Since that time, much effort has been devoted to clarifying this mandate and exploring its implications. Mark Shaffer (1981), now with the U.S. Fish and Wildlife Service, conducted some of the first work on population viability on the grizzly bear population in the yellowstone ecosystem. More recently, the concept of population viability has been applied to the management of the red-cockaded woodpecker and the spotted owl. A book on the subject (Soule 1987) came out last year. Just the same, population viability is in its infancy.

The Concept of Population Viability

Let's start with a definition that I've synthesized from several recent sources. Population Viability can be thought of as <u>the probability that, given a certain set of conditions, a population will be secure for a period of time from factors that threaten its persistence</u>. In other words, viability is a measure of the risk of extinction, and the goal of managing for a viable population is to prevent the decline and eventual extinction of that population. A typical description of the viability of a population might say that "Populations X, given current conditions and thus-and-such management, has a 95% probability of persistence for 100 years."

There are many forces in nature that affect the risk of a populations extinction, and contributors to the field have come up with subtly different ways of organizing them. Shaffer (1987) has combined these factors into four groups: genetic uncertainty, demographic uncertainty, environmental uncertainty, and natural catastrophe.

Genetic Uncertainty affects the amount of genetic variation found a population's gene pool (Table 1). This genetic variation is important for several reasons. For one, the offspring of a population with greater genetic variation may be better able to survive and reproduce than the offspring of a population that has reduced genetic variation. Additionally, the ability of a population to adapt to changes in its environment depends in large part on the amount of genetic variation it has in its gene pool. These abilities to produce offspring (known as "fitness") and to adapt to change are important to a population's viability. Two phenomena are the principal causes of loss of genetic variation. These are inbreeding, where the mating of close relatives results in the loss of genetic variation; and genetic drift, where random changes in the gene pool through time result in the loss of variation. A viable population must have a large enough effective population size to avoid the effects of inbreeding and drift.

Table 1.

Genetic Uncertainty

Examples:	*** inbreeding** *** genetic drift**
Affects viability by:	*** reducing genetic variation**
Resulting in:	*** lower reproduction** *** reduced survival of young** *** reduced ability to adapt to environmental change**

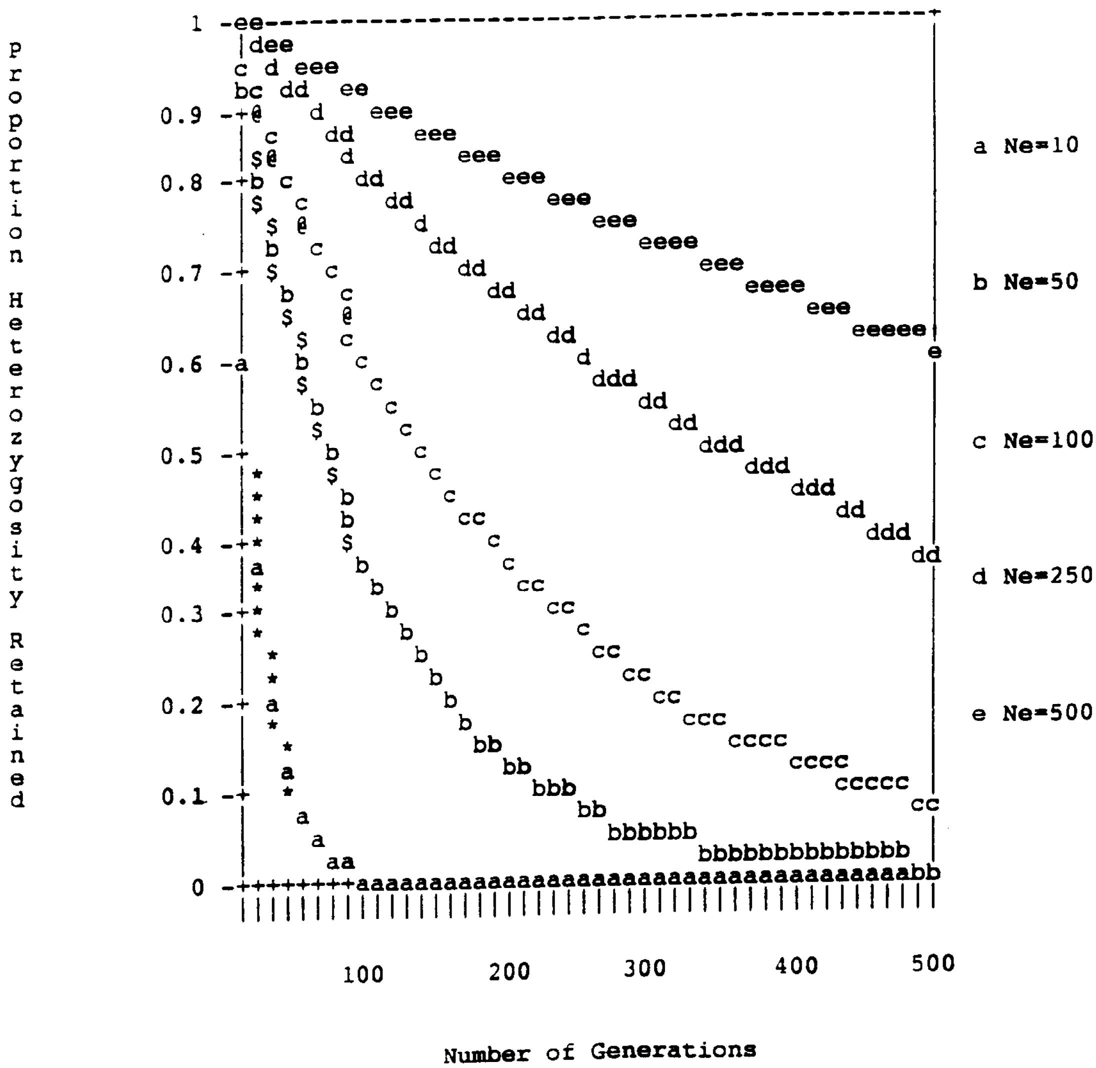
Notice that I said effective population size rather than census population size. We normally talk in terms of census population size, which is the actual number of individuals one would count. A census, however, doesn't reflect how the population responds to inbreeding and drift. By calculating an effective population size (N_e), we can adjust for these factors. Basically, it takes into account the fact that not all individuals in a population contribute the same number of genes to the next generation's gene pool. In addition to inbreeding and drift, reasons for this include uneven sex ratio, unequal survival of young, and changes in population size. Imagine a simplistic example where some individuals in a population don't mate, others produce offspring that die, and those that do produce surviving offspring don't produce the same number. As a result, several individuals are not contributing to the next generation's gene pool, and some are contributing much more than the others. These factors will often translate a census population size into an effective population size half as large.

Population genetics gives us models for estimating the rate at which genetic variation is lost in a population (Figure 1). An effective population size of 500, according to theory, would lose only 1% of its genetic variation after ten years, 10% after one hundred years, and 40% after five hundred years. By comparison, an effective population size of 100 would lose 5% after ten years, and 40% after one hundred years. The loss of 40% of a populations genetic variation might seriously jeopardize its ability to adapt to change beyond 100 years. However, genetic uncertainty is most critical either in the short term for very small populations or in the very long term for large populations.

Figure 1.

LOSS OF GENETIC VARIATION

(AS HETEROZYGOSITY) DUE TO DRIFT



Demographic Uncertainty is the second set of factors that can threaten viability (Table 2). For any individual in a population, there is always a chance that in any year, it will die or have no surviving offspring. In a large population, this doesn't present a problem, but in a small population, the cumulative effect of this possibility can have devastating consequences. As an extreme example, there is always a chance that in a population of 20 individuals, there will be no reproduction in a certain year, or all offspring will be of one sex. Clearly, in a population that reproduced only once, this would result in extinction. However, this example demonstrates that demographic uncertainty is actually only important to the viability of very small, closed populations, since the chance of such random events decreases quickly as a population grows.

Table 2.

Demographic Uncertainty

Examples:	*** low number of offspring** *** skewed sex ratio in offspring**
Affects viability by:	*** reducing reproductive potential of next generation**
Resulting in:	*** vulnerability to genetic uncertainty** *** vulnerability to further demographic uncertainty**

Environmental Uncertainty is a group of influences on viability that affects the birth and death rates of entire population (Table 3). It includes such things as climatic change, reduced habitat quantity or quality, and increased predation, competition, and parasitism. Unlike demographic uncertainty, these factors influence viability independently of population size.

Natural Catastrophe, like environmental uncertainty, affects the birth and death rates of an entire population regardless of size (Table 4). Natural catastrophes include climatic change, disease, fire, flood, drought, and windstorm. There is a general consensus that environmental uncertainty and natural catastrophe are the most critical to viability of all but very small populations, since only a very large population size or a very widely distributed population can protect against such unpredictable events.

Table 3.

Environmental Uncertainty

Examples:	*** reduced habitat quality * reduced habitat quantity * increased predation, competition, parasitism**
Affects viability by:	*** reducing resource availability * reducing birth rate * reducing survivorship**
Resulting in:	*** reduced population size * vulnerability to demographic uncertainty**

Table 4.

Natural Catastrophe

Examples:	*** drought * flood * fire * climatic change**
Affects viability by:	*** reducing habitat quality and/or quantity * reducing population size**
Resulting in:	*** vulnerability to environmental uncertainty * vulnerability to demographic uncertainty**

All of these factors are interconnected so that they not only contribute to each other, but some may lead to others (Figure 2). For example, a natural catastrophe such as a drought may stimulate an event of environmental uncertainty, such as a decrease in habitat quality or resource availability. This in turn could knock a resident population down to a small size, at which point it may become susceptible to the effects of genetic or demographic uncertainty. A recent article (Gilpin

The first step in the spotted owl PVA was to assemble all available information on the biological and ecological characteristics of the species. As with most species, in some areas such as distribution and habitat use, a great deal was known, while in other areas, like demography, there was relatively little information. Along with biological and ecological information, it was necessary to assemble information on the status of the owl's habitat, its current and future quality and quantity, and any current and anticipated activities affecting the population and/or its habitat.

Once all this information had been assembled and reviewed, it was possible to conduct the actual analysis. For the spotted owl, there was interest in assessing viability in each sub-population. In addition, the Forest Service wanted to obtain an estimate of viability over five different time periods. These were 0, 15, 50, 100, and 500 years into the future. The assessment involved evaluating, one by one, the effect of genetic uncertainty, demographic uncertainty, environmental uncertainty, and natural catastrophe on each combination of population, condition, and time.

Genetic uncertainty was investigated by estimating the effective population size of each sub-population. The formula used accounted for unequal sex ratio, dispersal distribution, reproductive success, overlapping generations, fluctuating population size, and inbreeding. The resulting value was used to determine in which cases loss of genetic variability would be unacceptable. Demographic uncertainty was evaluated by constructing a Leslie matrix to model change in the size of each sub-population. Computer simulations were then run to see if a sub-population would fall below an acceptable density. Finally, the effects of environmental uncertainty and natural catastrophe were "assessed subjectively", to quote the EIS. For each of the four factors, different conditions were determined to result in very high, high, moderate, low, or very low viability, the definitions of which are shown in Table 5. The results allowed them to produce a table depicting the viability of each option (Table 6 is an example). This is what they are using to help them choose between their management alternatives, along with other considerations.

Population Viability and the Kirtland's Warbler

Thus far, I have tried to give you a glimpse of what population viability is and how it is applied in management decisionmaking. I'd like to finish by exploring with you the implications of this concept for the Kirtland's warbler. Obviously, the spotted owl PVA involved a great deal of work on the part of a large staff of experts. Just the same, it has received a lot of criticism for its shortcomings (e.g. Lande 1988). I want to make it clear that I have not attempted to conduct a Population Viability Analysis for the Kirtland's warbler. However, I think we can learn something from speculating about the population viability of this species.

Table 5. Following are Definitions of the Probability Levels Used in the Viability Rule Set (Table B-14) (From USDA-FS, 1988)

VERY HIGH:	Continued existence of a well-distributed population on the planning area at the future date is virtually assured. This is likely even if major catastrophic events occur within the population, research finds that the species is less flexible in its habitat relationships, or if demographic or genetic factors are more significant than assumed in the analysis.
HIGH:	There is a high likelihood of continued existence of a well-distributed population in the planning area. There is limited latitude for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic or genetic factors than was assumed in the analysis.
MODERATE:	There is a moderate likelihood of continued existence of a well-distributed population in the planning area at the future date. There is no latitude for catastrophic events affecting the population or for biological findings that the population is more susceptible to demographic, genetic, or habitat distribution factors than was assumed in the analysis.
LOW:	There is a low likelihood of continued existence of a well-distributed population in the planning area at the future date. Catastrophic, demographic, genetic, or habitat distribution factors are likely to cause elimination of the species from parts or all of its geographic range during the period assessed.
VERY LOW:	There is a very low likelihood of continued existence of a well-distributed population in the planning area. Catastrophic, demographic, or genetic factors are highly likely to cause elimination of the species from parts or all of its geographic range during the period assessed.

Table 6. (From USDA-FS, 1988)

Summary of Relative Security From Threats to Population Viability by Year and Alternative [1]

Olympic Peninsula

(This assumes isolation because of distance from the Washington Cascades)

	Planning period			Projections beyond planning period	
Year:	0	15[2]	50[5]	100[5]	150[5]
Alternative					
A	H	M	L	VL	VL
C[3]	H	M			
D	H	M			
F[4]	H	M	M	M	L
G	H	M			
M	H	H			
L	H	H	H	M	M

[1] *See "Relative Security From Factors That Could Threaten Population Viability" in the text for an explanation of this table and definitions of security ratings.*

[2] *Period of Forest Plans.*

[3] *No Action Alternative.*

[4] *Preferred Alternative.*

[5] *Projected ratings of security from factors that could threaten viability beyond year 15 are based on the assumption that both the alternative and planning directions on other ownerships are continued in subsequent planning periods. This is purely hypothetical. The ratings are shown only for Alternatives A, F, and L to portray the estimated range of possible future conditions. Ratings in years beyond the current planning period (first 15 years) would depend on decisions made for those future planning periods. For example, a decision to protect additional spotted owl habitat after year 15 would shift the ratings in future years toward those portrayed for Alternative L.*

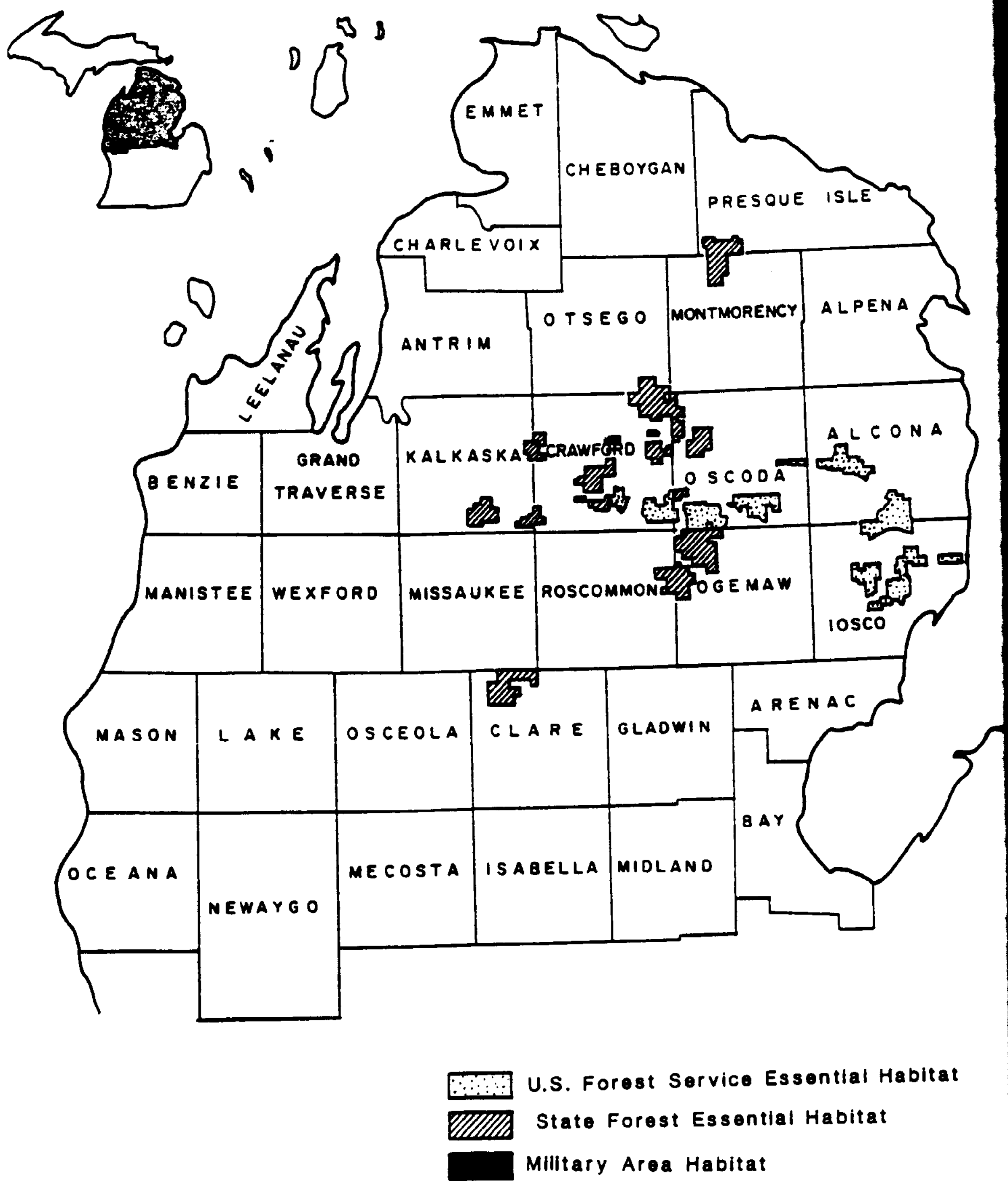
If we were to conduct a PVA, we would begin by formulating the equation we want to solve. Unlike the spotted owl case, we don't have a set of management alternatives we need to decide between. Instead, we have a recovery plan, which provides us with some givens. Recognize that I am simplifying things quite a bit here. Regarding probability of persistence, I think it is fair to say that the goal of the recovery plan is to insure the persistence of the species into the future. To interpret this literally, "insure" means 100% probability of persistence. Since we all know that nothing is certain in this world, we might want to think in terms of a very high probability of persistence. Time could also be considered infinite in the context of the recovery plan. That is, the goal of the plan is to insure viability for as long as possible. For our purposes, however, we might want to take the lead of the spotted owl PVA, and ask about population viability in the short term, say 5-15 years (a realistic planning interval), and in the long term of, say 500-1,000 years (a period that could reflect fitness and adaptability). Regarding condition, there's a fair bit known about the current situation. The recovery plan provides a lot of information about anticipated condition, in terms of habitat management and the like. We could also use the recovery plan's population goal of 1,000 pairs in the equation. Conversely, we could base our analysis on the current population size of about 210 pairs. Thus, there are possible values available for all the variables. Alternatively, a PVA could be used to test the effects of other values for any of the variables. For example, we could construct the formula to ask how much a larger population goal would improve viability, or how additional habitat would affect it, or what the viability looks like for year 1000.

I have not done any of these. But I would like to look briefly at the possible effects of each class of factors on the viability of the Kirtland's warbler in the short term. As I've explained, genetic uncertainty is directly tied to effective population size. In the genetic context, given the species' breeding distribution (Figure 4), the entire species would seem to be a single population. This is true because the results of large juvenile dispersal distances can be assumed to result in a population that mixes at a rate that produces essentially one large gene pool. Consequently, we would want to calculate the effective population size of the entire population.

Several characteristics of this species will produce an effective population size less than the census population size, most importantly, polygamy and unmated males. It seems that there is not sufficient information on sex ratios, reproductive success, or other factors to calculate an accurate effective population size as was done for the spotted owl, but it would not be unrealistic to assume that the effective population size in somewhere around half the census population size. This seems to be true for many bird species (Barrowclough 1980). If this were true, then it would give us an effective population size of 210. According to theory, this population size would retain 98% of its genetic variation after ten years, 79% after one hundred years, 56% after two hundred fifty years, and 30% after five hundred years. Thus, if maintained at this population level for 250 years, the loss of less than half its genetic variation would not be catastrophic. Once the population reached the goal of 1,000 pairs, it would retain 78% of its

genetic variation after 500 years, and 61% after 1000 years, both easil
acceptable rates of loss.

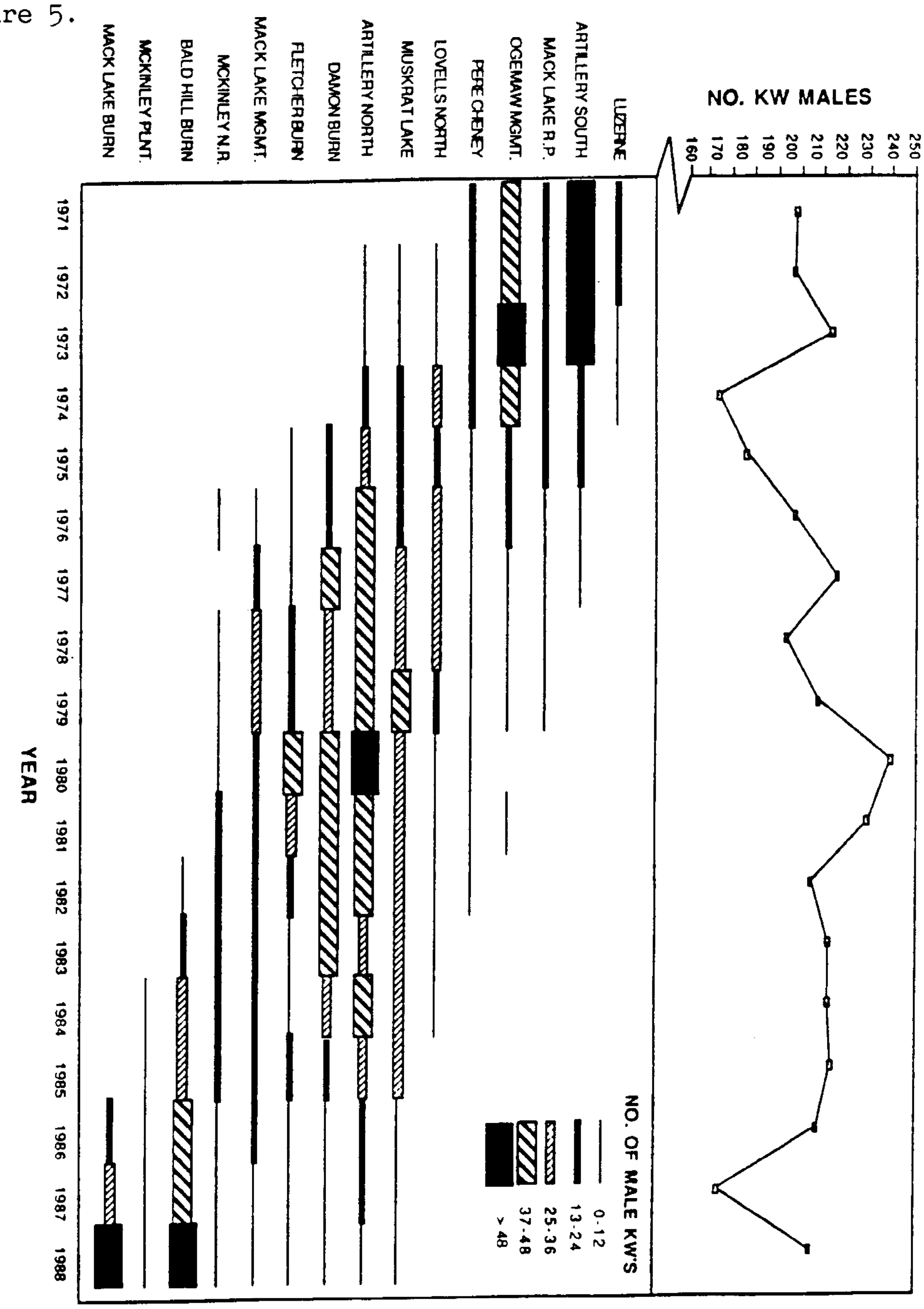
Figure 4.



KIRTLAND'S WARBLER HABITAT IN MICHIGAN

Regarding demographic uncertainty, we could similarly consider the entire species to be one population. If we assume that what we call colonies are established through juvenile dispersal, then any demographic events that result in the extinction of one colony would have little effect on the rest of the population. Although individual colonies may blink in and out of the picture over time (Figure 5), as long as there are sources of dispersers, suitable vacant habitat should be reoccupied as it becomes available. With regard to both genetic and demographic uncertainty, it is also possible that the species has existed at relatively low population levels for so long that it is somewhat adapted to cope with these factors.

Figure 5.



Environmental uncertainty and natural catastrophe are less easy t dismiss. Since habitat quality and quantity varies among management areas, each colony must be considered a separate sub-population, each subject to the effects of these factors. So the question must be, ho does environmental uncertainty and natural catastrophe affect the viability of each colony. The recovery team was clearly aware of environmental uncertainty in focusing their efforts on the habitat acquisition and improvement, cowbird control, and other activities. a result, environmental uncertainty is being kept under control by th recovery plan. But, it is critical to the viability of this species that the recovery plan be faithfully carried out into the future. Th is plenty of evidence that reduced habitat quality or cowbird predati at a number of colonies could easily knock the population down to a level at which it would become vulnerable to a serious species-wide population decline. Predation, increased habitat fragmentation, an overabundance of marginal habitat, or a synchronous decline in habita quality are other examples of sources of environmental uncertainty th could have a serious impact on the species. It will remain important continue to monitor all sources of environmental uncertainty and resp to them with management as necessary.

However, my biggest concern about the population viability of the Kirtland's warbler regards natural catastrophe. While environmental uncertainty can be more or less anticipated and combated through management, natural catastrophe occurs when and where you least expec it. The only way to counteract the effects of natural catastrophe on population viability is to make sure that the population is so widely distributed that the entire population is never going to be hit by th same catastrophe. Given the current distribution of the Kirtland's warbler, a natural catastrophe could have a devastating effect on the species. At present, there are two main colonies, at McKinley Plantation and Mack Lake Burn (Figure 5). If a fire were to burn through one of these during breeding season, viability of the species could be seriously threatened. Again, the solution to reducing the r of natural catastrophe is to increase the distribution of the species This could be done by taking advantage of surplus reproduction and relocating juveniles to unoccupied suitable habitat, especially if th would otherwise be dispersing into marginal habitat. Additional habi could be acquired and restored to fill in some of the gaps that currently exist between management areas, thereby improving dispersal among sites. Since, in the context of natural catastrophes, disjunct sites would be most effective in providing refuge, this would best be done beyond the current range of the species. Finally, to counter th threat of natural catastrophe like drought and hurricane on the wintering ground, it appears critical that work be continued on the development and implementation of captive breeding techniques. I kno that most of these suggestions would be very expensive, and none woul insure success, but I believe that it is critical to the viability of this species that steps in this direction be continued.

I'd like to leave you with a note of idealism. Notice that I hav not referred to <u>Minimum</u> Viable Populations, which is a term you may h heard. As you can now see, a general rule is that the larger and mor widely distributed the population, the greater is its viability. We used to talk about minimum viable populations, probably in part because the acronym MVP is so catchy. However, the word minimum has been dropped more recently, and not for simple semantic reasons. As Soule (1987) has pointed out, in the same way that physicians prescribe the optimal conditions for health, not the minimal ones, the resource manager should plan for a robust and bountiful population, not a minimum. The point is that population viability analysis does not provide a magic number above which a population is safe from extinction. I would encourage you to manage for robust and bountiful population of the Kirtland's warbler.

Acknowledgment

I would like to thank John Probst for his most helpful discussions, suggestions, and review of this paper, and for the use of Figure 5.

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KIRTLAND'S WARBLERS ON THEIR WINTERING GROUNDS IN THE BAHAMA ARCHIPELAGO--A PRELIMINARY REPORT

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Surveys for the Kirtland's warbler (Dendroica kirtlandii) were conducted on 15 islands in the Bahama Archipelago in 1985 and 1986, and at least 6 individuals were located. Emphasis in 1986 concentrated on the island of Eleuthera to examine habitat, foraging strategies, food habits, and site tenacity. The species spends approximately 44% of the year on the wintering grounds throughout the archipelago. The warblers (N=149 records, 1878-1988) used 5 biotic communities, but appeared to favor second growth coppice 3-10 feet in height, or low virgin scrub on the more arid southern islands. Individuals (N=2) foraged over an area of approximately 15 acres and exhibited strong site tenacity.

A survey of Eleuthera revealed that at least 2% (4 square miles) of the island's uplands had high potential as winter habitat for Kirtland's warbler. If this percentage is extrapolated to the archipelago as a whole, there is a minimum of 112 square miles of available winter habitat. In reality, however, available winter habitat probably greatly exceeds this speculative figure.

Foraging behavior of two individuals studied consisted of 75% gleaning, 13% probing, 7% hover-gleaning, and 5% other foraging techniques and took place from the ground up to 12 feet. Food items (N=448 observations of 2 individuals) consisted of 59% small fruits (83% of which were of a single species), 20% arthropods, 1% seeds, and 20% undetermined. Based upon this limited work in the islands and preliminary results of banding returns in Michigan, the factor or factors suppressing the Kirtland's warbler population do not appear to be on the wintering grounds.

HISTORY OF KIRTLAND'S WARBLER FOUND IN WISCONSIN

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Prior to a 1978 survey for Kirtland's warblers in Wisconsin, there were only nine verifiable records for the species since the 1840's. All of these sightings occurred from mid to late May and these birds were presumed to be migrants which eventually ended up at their Michigan nesting grounds. In June, 1977, a single territorial male was found in Ontario. This prompted the Wisconsin Department of Natural Resources to conduct a survey to determine if there were any Kirtland's warblers present or nesting in Wisconsin. This 1978 survey; produced two territorial males, one of which was banded six years earlier near Grayling, Michigan. One of these birds was at the same location in June, 1979 and 1980. Random searches thereafter produced no records through 1987. A 1988 survey of Wisconsin jack pine stands produced eight territorial males (two banded) in three different counties.

Historic Data From Wisconsin

Prior to the 1978 survey there had been only 9 verified records of Kirtland's warbler in Wisconsin. The 1978 survey discovered two unmated males in Jackson County. One bird was recorded from the same area in 1979 and 1980. Thereafter this bird could not be relocated by birders, with no further sightings until the 1988 survey.

Survey Methods-Habitat Delineation

The Kirtland's warbler breeding habitat is most specific where it is found in Michigan. Therefore, locating and delineating potential nesting areas in Wisconsin was the first component of the organizational process for the 1988 statewide survey. Based upon the previous statewide survey done in Wisconsin, three major criteria were used to identify potentially suitable Kirtland's warbler breeding habitat. These criteria were: forest type, soils, and topography. A brief description of these criteria follows.

Forest Type: In nearly all cases in Michigan, the Kirtland's warbler breeding habitat was situated in 8 to 20 year-old jack pine stands of at least 80 acres in size. In addition, the jack pines were occupying at least 60 percent of the growing space. The understory vegetation is in general sparse.

Soils: Nearly all the nesting habitat in Michigan is found on Grayling Sands, which are extremely well-drained soils found on glacial outwashes or lake plains. The Wisconsin soils most similar are Plainfield loamy sands and Vilas, Omega, and Hiawatha sands. These soils were formed as deposits associated with glacial lakes and outwashes.

Topography: The habitat in Michigan is characterized by a gener level to gently undulating topography. The sandy soils which support the large jack pine forests of Wisconsin are found on the same level gently undulating conditions.

In order to locate potentially suitable breeding habitat for the Kirtland's warbler, state and county reconnaissance records from the Wisconsin DNR - Bureau of Forestry were used. The assistance of Coun Liaison Foresters was also used in those counties where habitat was likely to be found. The guideline to determine potential habitat was that given for Forest Type as stated above. Both natural stands and plantations were among the stands selected.

Once the data from the reconnaissance records were computed, coun plat maps were drawn up giving exact location and delineated approximated stand locations. Reconnaissance records identified 116 stands of potential habitat located in 8 counties. The stands identified for each county were Bayfield (7), Burnett (18), Douglas (7 Jackson (27), Juneau (26), Marinette (5), Washburn (20), and Vilas (6 Although Adams, Clark, Eau Claire, Monroe, and Oneida Counties had searches conducted in 1978, there were no potential stands which met criteria in 1988. (Map 1)

Survey Methods-Organize and Conduct Survey

In order to have a successful statewide survey for 1988 the help volunteers and other professionals were enlisted. Volunteers were solicited from persons experienced in bird surveys. Among the groups solicited for volunteers were State universities, the Wisconsin Socie for Ornithology, Wisconsin DNR Wildlife Managers, and various environmental organizations with member interest in bird surveys. Th volunteers were notified of the survey and asked to give preferred counties or areas which they would like to survey. They were then mailed appropriate maps and instructions for conducting the survey

The surveys were conducted from June 3 through June 19, 1988 from sunrise to 11:00 a.m. The days were to be clear, free from precipitation, with wind not exceeding 12 m.p.h. Listening stations were set up near the center of every forty-acre block. At each statio a recording of the Kirtland's warbler territorial song was played for seconds. The surveyor(s) then listened for a response for two minute The procedure was repeated before moving to the next station. If a Kirtland's warbler was heard, a positive visual identification of the bird was to be made. Upon positive identification, the site was to be marked and the location identified on a map. The Bureau of Endangered Resources was to be notified immediately. Once the surveys were completed, the survey forms and cover maps were sent to the Bureau of Endangered Resources. In the event a Kirtland's warbler was identifie the U.S. Fish and Wildlife Service had directed Mr. Wesley Jones to capture, measure, weigh, and band the bird(s) with colored bands issue by the USFWS.

Results

All 116 potential stands were assigned to be surveyed. One hundred four of these identified stands were surveyed in 1988. In addition, 20 additional stands which were known to or discovered by participants were also surveyed. These were primarily in Douglas and Bayfield counties. Twenty participants were involved in the 1988 survey. Nine professionals surveyed 64 stands and 11 volunteers surveyed 60 stands.

Eight male Kirtland's warblers were found in the 1988 survey. Two birds each were located in Douglas and Washburn Counties. Although in different counties one bird from Douglas County and one bird from Washburn County were located within one mile of each other. Four birds were also found in Jackson County, with three birds seen on the same day within a two-mile stretch.

Another surveyor in Jackson County had responses to taped songs at two separate locations far removed from the other Jackson County sightings. In both cases a response was elicited upon playing of the tape of the songs continued for a substantial time. However, in both cases a bird could not be visually identified.

Two birds were netted and banded with colored leg bands. Wesley Jones captured and banded one male in Douglas County on June 3, 1988 and one male in Jackson County on June 18, 1988.

Discussion

The 1978 survey provided insight into the dispersal patterns of the Kirtland's warbler. This 1988 survey provides additional information valuable in determining where Kirtland's warblers go. Eight confirmed male birds found in widely separated locations is encouraging and intriguing.

While the results of the survey were gratifying, several items of concern arose during the summer. These concerns concentrate mostly on logistics: 1) Foremost is the need to get the bander to the site as soon as possible after a sighting. 2) The need to give professional participants more lead time to alleviate scheduling problems. 3) Recruitment of more volunteers is needed. 4) A survey of all of the stands is a priority.

Further surveys are needed to determine: 1) Which stands birds may or may not return to. 2) To get complete banding coverage to allow tracking of individuals. 3) And to monitor very closely and intensely any singing male's territory for the presence of females or evidence of nesting.

THE DISPERSAL OF THE KIRTLAND'S WARBLER: MYTHS AND REALITY

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Truth is a Myth, Fact is a Fable - Till We Learn the Difference

The Kirtland's warbler (Dendroica kirtlandii Baird) has become known during this century as a species that breeds in the jack pine (Pinus banksiana Lamb.) forests of Michigan, winters in the Bahamas and nearby islands, is seen occasionally in migration between these points, and exists in such low numbers that it is among the world's most endangered species.

Some Kirtland's warblers have been observed in Ontario and Wisconsin, several hundred kilometers from the expected migration route. Usually, these strays were seen for a few days at most, and were simply classified as accidental visitors. It was assumed that they were either blown off course, and were returning to Michigan, or were disoriented.

While tracing the sight records of these visitors to Canada, I postulated that they were not accidental. Perhaps there was a pattern to the dispersal of the species from the Michigan breeding centre, and the following hypothesis emerged:

Since the jack pine habitat of the Kirtland's warbler may be suitable for nesting for only about 20 years, the dispersal of the Kirtland's warbler to establish new nesting grounds, beyond the known Michigan centre, must be inherent in the species and evident in its behaviour.

This hypothesis was opposed to the prevailing theory that the Kirtland's warbler range diminished as the population fell. In Michigan, the counties occupied by the bird had fallen from 13 to 6, as the population diminished by about one-half. But according to my hypothesis, the dispersal of the Kirtland's warbler beyond the Michigan centre was inherent in the species, and would continue, irrespective of the size of the population.

In 1977, I decided to search for the Kirtland's warbler in Ontario. The known sight records of the species contributed greatly to the early success of the project.

The first record of a Kirtland's warbler sighted in Canada occurred in 1900, when a bird was shot on Toronto Island by J. H. Samuel (1900). This specimen was collected three years before the species was known to breed in Michigan. The mounted specimen was sold to John Lewis Childs of Floral Park, New York; then to Arthur T. Wayne of Charleston, South Carolina; then to J. E. Keays of London, Ontario; and then to W. R.

Campbell of Lobo, Ontario. In 1922, the Royal Ontario Museum bought
Campbell collection, including this bird.

Another confirmed sighting was of a pair feeding young in 1945 ne
Barrie, about 100 km (60 miles) north of Toronto (Speirs 1984). Both
this sighting and the Samuel sighting were south of the jack pine forest.

Among about twenty Ontario sightings known to us when the search began, only four were in jack pine stands: two by Lake Huron, near D
Bay and Pointe au Baril, and two by the Ottawa River, near Petawawa (Figure 1).

Figure 1. The Kirtland's warbler summer range based on confirmed sightings in jack pine stands since 1958 (Numbers 1 to 9) the winter range based on confirmed sightings in the Baha (Number 10) and unconfirmed sightings at Palenque and Veracruz (Numbers 11 and 12): 1. Kazabazua; 2. Petawawa; 3 Severn Bridge; 4. Pointe au Baril; 5. Dyer Bay; 6. Mio; 7. Gwinn; 8. Black River Falls; 9. Spooner; 10. Bahamas; 11 Palenque; 12. Veracruz.

The range of jack pine in Ontario and Canada is extensive. Our search for the Kirtland's warbler was concentrated along the southern edge of the jack pine range, to approximate the relative position of the breeding areas in Michigan's jack pine.

The search began in young jack pine stands on National Defence's Canadian Forces Base at Petawawa, Ontario. The species had been observed there by Paul Harrington (1939) in 1916, 1939, and, as we learned later, in 1947 (Harrington 1947).

We found our first male Kirtland's warbler at Petawawa in 1977, and it returned again in 1978. Also in 1978, a male was found near Kazabazua, Quebec. It had been banded four years earlier as a nestling in Michigan.

An independent search was organized in 1978 in Wisconsin, where Nancy Tilghman (1979) found two male birds near Black River Falls. One of these had been banded six years earlier as a nestling in Michigan (Walkinshaw 1983).

In 1977, it seemed reasonable to consider that the Petawawa bird could be a remnant of an Ontario population of the Kirtland's warbler, perhaps separate and distinct from the Michigan race. But in 1978, this theory was demolished by the finding of birds in Quebec and Wisconsin that had been banded as nestlings in Michigan.

Prior to these 1977-78 findings, it had been generally assumed that Kirtland's warblers could not be found by systematically searching beyond Michigan, because there was no pattern to their dispersal. But in reality, Aird (Aird and Pope 1987) and Tilghman (1979) had each found Kirtland's warblers, by deliberately searching for them in jack pine habitats that resembled the known breeding areas.

It had also been assumed that these outlying birds were temporarily off course and would return soon to the Michigan breeding centre. But the male Kirtland's warbler found at Petawawa, Ontario, defended a territory for more than five weeks in 1977, and returned to the same territory for more than six weeks in 1978.

Likewise, at least one of the birds found by Nancy Tilghman (1979) near Black River Falls, Wisconsin, in 1978, and a bird found by John Probst near Gwinn in Michigan's Upper Peninsula in 1982 (Walkinshaw 1983), had each established a territory where first observed, and returned to it the following year.

The theory that the Kirtland's warbler population had imploded into a smaller range within Michigan was exploded by these findings. Male warblers on territory in Ontario, Quebec, Wisconsin, and Michigan's Upper Peninsula have therefore confirmed part of the original hypothesis, i.e., the dispersal of the Kirtland's warbler to establish new nesting grounds, beyond the known Michigan centre, must be inherent in the species and evident in its behaviour. But these results have not yet confirmed that nesting beyond the Michigan centre is accomplished.

Since the spring of 1977, fifteen male Kirtland's warblers ha found on territory in jack pine stands beyond the Michigan centre:

1977 - Petawawa, Ontario - 1 bird.
1978 - Petawawa, Ontario - same bird returned.
1978 - Kazabazua, Quebec - 1 bird.
1978 - Black River Falls, Wisconsin - 2 birds.
1979 - Black River Falls, Wisconsin - 2 birds (one a return).
1982 - Gwinn, Michigan - 1 bird.
1983 - Gwinn, Michigan - same bird returned.
1985 - Severn Bridge, Ontario - 1 bird.
1988 - Black River Falls, Wisconsin - 4 birds.
1988 - Spooner, Wisconsin - 4 birds.

The four birds found in Ontario, Quebec, and Wisconsin in 1978 represented 2.0 percent of the census for that year, evenly split e and west of the Michigan centre. The eight birds found in Wisconsi 1988 represented 3.7 percent of the census, all on the western side equivalent number should be on the eastern side, yielding a theoret outlying population of 7.4 percent. But the small amount of area covered in these extralimital searches suggests a larger outlying population than this.

Though fifteen males were found from 1977 to 1988, no females w associated with them. This has suggested that the males are more wide-ranging than the females. But in reality, we do not know. Si the females do not sing, they are much more elusive, and could be ju as wide-ranging as the males, but located in different areas.

The confirmed summer range of the Kirtland's warbler now stretch east-west from Kazabazua, Quebec, to Spooner, Wisconsin, a distance about 1250 km (750 miles). The north-south extension is about 215 k (130 miles). At the centre of this region lies the only known breedi range for the species, near Mio, Michigan, with an east-west range of about 115 km (70 miles), and a north-south range of about 60 km (35 miles).

The winter range for the species in the Bahamas and nearby island has been well documented by Mayfield (1960) and Walkinshaw (1983). I stretches at least from Abaco Island in the north to the Caicos Islan in the south--an east-west range of about 670 km (400 miles), and a north-south range of about 600 km (365 miles).

The winter range of the Kirtland's warbler may extend further west into Mexico. Lane (1975) reported sighting a male and an immature or female near Veracruz in November 1974. Based on personal corresponde provided by a Canadian wildlife biologist, a male Kirtland's warbler w observed near Palenque, at the base of the Yucatan Peninsula, in February 1977. These Mexican sightings may be of wandering birds. Bu we should also consider the possibility that the winter range for the species may extend from the Caicos Islands to Veracruz, a distance of about 2500 km (1500 miles).

The statement that the Kirtland's warbler migrates solely between Michigan and the Bahamas now appears to be a myth. In reality, it migrates to Quebec, Ontario, and Wisconsin as well. Perhaps its summer range extends further east in Quebec, New York or Vermont, and further west to Minnesota, while its winter range may extend from the Bahamas through Cuba to Mexico.

In summary, there are severe limitations to conducting research on an endangered species. It is far easier to generate research data and research dollars for an abundant than a rare species. But if research on an endangered species can help to sustain or enhance its existence on earth, then there can be no greater reward.

Since 1977, we have learned that fifteen male Kirtland's warblers have established territories far beyond the Michigan breeding centre; at least three of these returned the following year to the same territory; some defended two territories as much as one-half mile apart; their habitat may include jack pine trees up to 18 m (60 feet) tall, or jack pine on rock outcrops; the summer range now extends at least 1250 km (750 miles), from Quebec to Wisconsin, and perhaps beyond; and the winter range may extend from the Bahamas into Mexico.

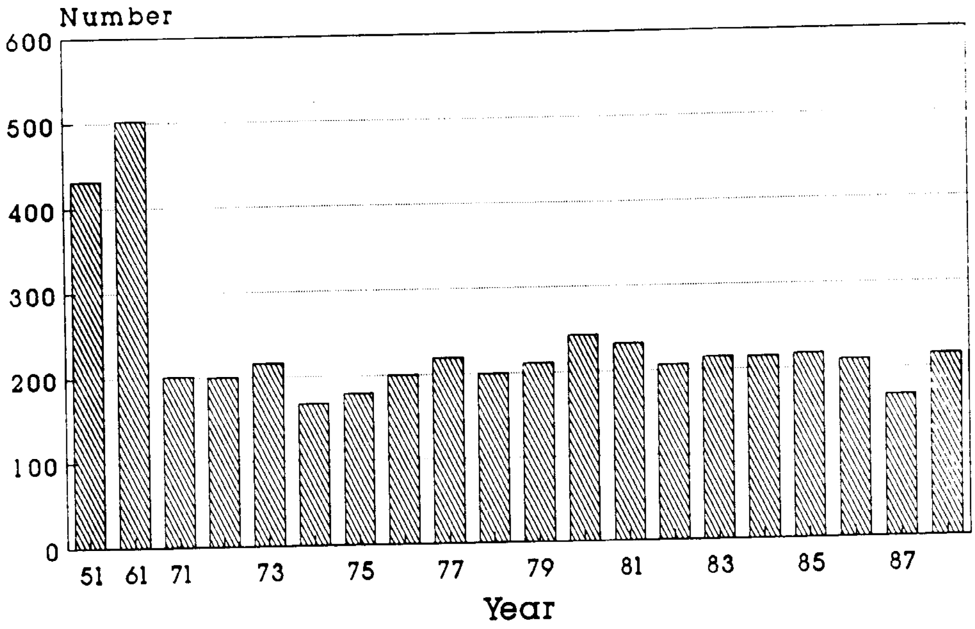
As an associate of the Kirtland's Warbler Recovery Team for the last decade, I have strongly supported the plan to manage the species in its natural habitat, without taking any birds into captivity. Providing enough suitable habitat to sustain the species is a priority item. At the same time, I have strongly supported the need for more research to add to our knowledge and understanding of the dynamics of this endangered species and, by extension, of other endangered species.

In my judgment, more research effort is urgently needed to study the outlying population of Kirtland's warblers. Someday, someone will find another breeding area. Most likely, it will be in Michigan, or close by. It will consist of a few breeding pairs that can be managed to increase their numbers substantially. But if we do not search and find them, we will lose this opportunity.

The research to establish the range of the Kirtland's warbler in Ontario, Quebec, and Wisconsin, which led to the 1988 finding in Wisconsin of more than three percent of the male population, suggests that a new breeding area will be found soon. With proper management to increase the population in the new area, some of the young will disperse back to swell the Michigan core, as some from the core disperse and add to it.

The Kirtland's Warbler population has remained relatively stable since 1971 (Figure 2). The continuing plight of the species justifies the need to examine all opportunities to build up the population. To find and manage a new breeding area may be the key needed to restore the Kirtland's warbler species to normal numbers throughout its range.

Figure 2: Annual Census Data of Singing Male Kirtland's Warblers



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This paper is a contribution of the Faculty of Forestry, University Toronto, Toronto, Ontario M55 1A1.

Migrating Warblers are Attracted to Bright Lights
A Conservation Note

It is well known that night-migrating birds of some species are attracted to bright lights. They may swirl around the intense light beams in a frenzy, crashing into the lighted structure, into the light face, and into each other.

The largest bird kills tend to occur in autumn during conditions of low cloud, fog, drizzle, or moonless nights. The inexperience of young birds on their first migratory flight may add to the problem.

During the first weekend of September 1981, more than 10,000 birds were killed in Ontario by two floodlit smokestacks 653 feet tall and 33 feet wide at the top (Weir and Aird). Half of the 49 species attracted to their death were warblers.

If the Michigan Conservation Clubs, the Michigan Audubon Society, and others could lobby to turn off the vanity lights on chimneys, towers and tall buildings, or to replace them with red beacons or pulsating strobe lights if needed for aircraft safety, then they would contribute to the conservation of electrical energy, to the conservation of migratory birds and, perhaps, to the conservation of the Kirtland's warbler.

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SPRING MIGRATION IN THE KIRTLAND'S WARBLER

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While Clench (1973) has summarized Fall Migration in the Kirtland's Warbler and Walkinshaw (1983) and Mayfield (1960) included sections on migration, little has been done to summarize Spring migration records of this species with regard to habitat and behavior. This paper is a preliminary attempt to summarize Spring migration records for the Kirtland's Warbler. This paper also summarizes two days of observations of the behavior of a migrating male Kirtland's warbler during May of 1983 in Michigan City, Indiana.

Michigan City, Indiana Observations

At 0700 hours on 22 May 1983, Tim Coslett identified what he believed to be a Kirtland's warbler. Since he was a beginning birder, he almost didn't report this sighting thinking nobody would believe him. Ken Brock, regional bird record compiler for Indiana Audubon Society, confirmed this identification at 0830 hours. The bird was on the sidewalk which was located between a narrow Lake Michigan beach on one side and a sand strip on the other. Beyond the sand strip was a yacht basin. The sidewalk connected a municipal parking lot with a pier.

I arrived at the pier at 1000 hours and observed the bird until 1215 hours, and then again from 1400 to 1600 hours when a storm hit with driving rain. I again observed the bird from 0630 to 2100 hours on 23 May 1983. The black lores and clear white eye stripe identified this bird as a male Kirtland's warbler. I also noted that this bird had light speckling on the breast (almost forming a light necklace) and a large black spot just to the right of the center of its breast. Based on conversations and observations of the several Kirtland's warblers at Mack Lake with Craig Orr in the summer of 1977, I originally thought that the light speckling suggested that it was a first year bird. John Probst's studies indicate that aging Kirtland's warblers may not be that simple. The bird frequently bobbed its tail up and down characteristically. Its song was distinctive as it moved up and down the sand strip feeding, sometimes singing with its mouth full of insects. The bird moved mostly by hopping on the ground.

It fed on insects gleaned off the short herbaceous vegetation growing in the sand. Many times it popped up off the ground to glean insects from the leaves of these plants. It would jump straight up in the air and straight back down to the same place with its wings closed. Other times the bird hovered briefly in the air like a helicopter. Still other times the insect catching was by a hop in an inverted "U". It hopped as high as 2 feet, but most often the hops or "popping up" was just between 2-8 inches. Occasionally the bird flew to a perch in willow (Salix interior) or cottonwood (Populus deltoides) sapling. these perches it sailed out like a flycatcher to catch insects a f times. Only once did the bird fly to high perch, first on a tele or electric line and then in the upper branches of a black willo niger), and this was when a bulldozer was started up and began excavating part of the sandy strip. When the bulldozer quit, the came back to the sandy strip.

This bird seemed oblivious to the many people walking along o sidewalk, regardless of how loud they were talking. Several notic this bird which seemed so tame. In fact it hopped out onto the si several times. When a little girl jumped toward the bird with bo it flew just a few feet away from the sidewalk and continued feedi singing.

Between 0730 and 0930 on 22 May, Ken Brock noted that the Ki twice chased a yellow-rumped warbler for 50-75 feet.

The last time I saw this bird it was resting on perch about 5 high in a cottonwood tree, on 23 May 1983. By the time I left a hours it was almost too dark to see. When I returned the next m the bird was nowhere to be found. I had hoped to get a bearing o direction of travel when it took off across Lake Michigan to see seemed to head East toward Michigan or West toward Wisconsin.

Summary of Spring Migration in the Kirtland's Warbler

From its discovery in 1841 and description from a species ta Ohio during migration in 1851 until 1903 (a period of over 50 yea Kirtland's warbler was known only from migration records. There high interest in using these migration records to help find the b areas. Speculation turned early to Northern Michigan or "points (Stejneger 1899).

Figure 1 clearly shows that the distribution of Spring migrat records is heavily skewed to the North. Except for one Florida r in 1934 and one South Carolina record in 1925, all the records fo Southern states occurred between 1886 and 1908. Table 1, which s the number of migration records for each state and province, sho same trend--many more migration records in the North. It is uncl whether this is because the Kirtland's doesn't rest until further or because fewer birders are familiar with the Kirtland's in the The number of migration records seems to parallel the population the warbler, although no cause and effect relationship can be ass It can be seen in Table 2 that the most Spring migration records occurred in the decade from 1900 to 1909 which was also the deca which habitat was most abundant (Mayfield, p. 26). The number of has probably increased since 1920, according to Mayfield, but bet fire suppression methods decreased the total acreage burned dramatically. Anecdotal information suggests that this decade w the time in which the Kirtland's warbler was most abundant. Lo more closely at the last half of the twentieth century, Table 3 s that the population trend for the Kirtland's warbler is almost e paralleled to the number of Spring migration records, with great numbers in the 1950's and 60's than in the 70's and 80's. In both cases there is a slight increase in numbers for the 80's over the 70's. This similar trend does not prove cause and effect, but it is reasonable to suggest that there are likely to be more migration records in a time when the population is larger. Perhaps when the number of migration records increases the singing male count will increase as well. This is a crude index at best, but one worth noting.

Figure 1. Spring Migration Records of the Kirtland's Warbler

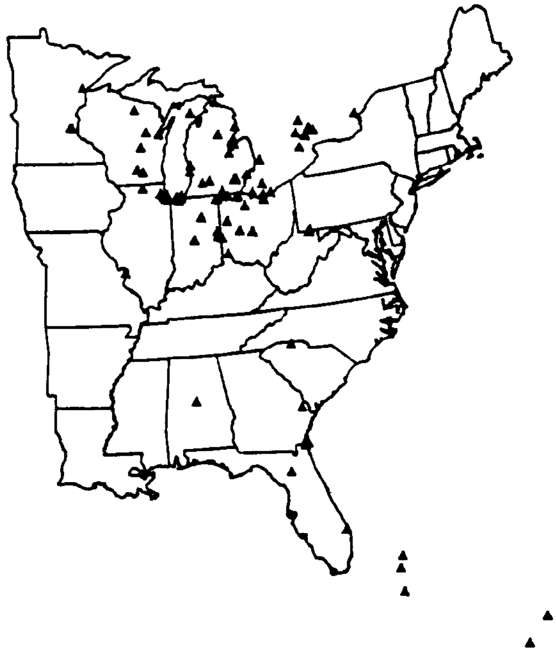


Table 1. Numbers of Spring Migration Records of the Kirtland's Warbler by State and Province

MI	25
OH	25
ONTARIO	15
IN	12
ILL	10
WI	7
GA	5
S.C.	6
MO	3
MINN	3
FLA	3
ALA	1
MA	1

Table 2. Plot of Spring Migration Records by Decade

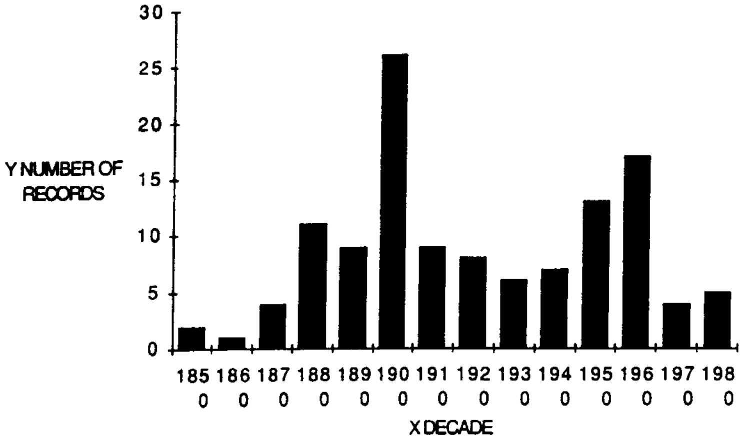
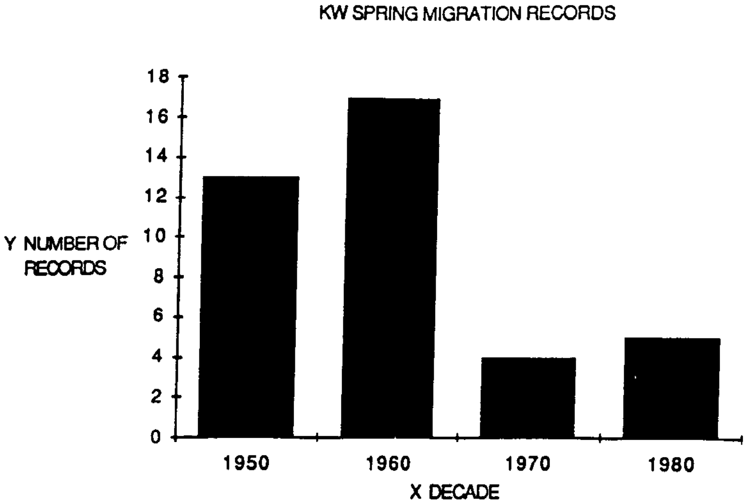
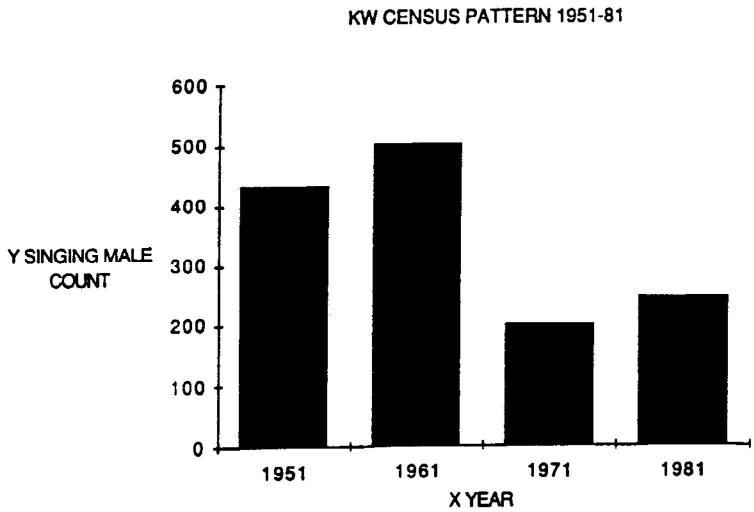


Table 3. Comparison of Number of Spring Migration Records with Sin
Male Census for 1950-1981





The Kirtland's warbler arrives on the nesting ground between May 3 and May 12 (Mayfield 1960). The earliest migration record for the Kirtland's is April 12 in Georgia. The latest migration record is June 17 in Hamilton, Ontario, in 1960. The latter record might seem to be record of a bird on territory, but my information indicates that this bird was found in residential area and did not remain in this area. While the Kirtland's has been seen on the nesting ground as early as May 3rd, the earliest migration record in Michigan is May 6. Surprisingly there is one migration record for April 27 in Illinois!

Lincoln (1979) indicates wood warblers travel more in mixed company than other groups of birds. Mayfield (1960) indicates that males arrive on the breeding ground first, followed very soon by females, with the caveat that females may be there but may go unnoticed. One's attention is easily called to the males singing from exposed perches. The female is more secretive and quiet. It may be that the females are not noticed until courtship begins. It is interesting to note in this regard that the earliest migration record in which the sex of the bird was clearly identified is for a female, April 14, 1903, in Georgia (Table 4). By comparison the earliest male record is April 27, 1904, also in Georgia. The latest record is also for a male in Hamilton, Ontario, referred to above. It is possible that these late migrating males are first year males who may not have as great a chance to breed as older birds, and are not as experienced in migration. Although some have said that older birds migrate first in the Spring followed by younger birds, Lincoln cites data for passerines which seems to suggest this is not the case.

Table 4. Earliest and Latest Spring Migration Records by State and Province

STATE	EARLIEST	LATEST
Fla	April 19	April 27
GA	April 12	April 27
ALA	May 10	May 10
S.C.	April 27	May 7
W.Va.	May 9	May 18
Ohio	May 2	May 23
Mo	May 4	May 20
Ill	April 27	May 25
In	May 4	June 3
WI	May 19	May 26
Mn	May 13	May 22
Ont	May 10	June 17
Mi	May 6	May 30

Mayfield (1960) suggests that one reason that there are more Sprin than Fall migration records is that males sing, which suggest that mal would be seen more often. This is in fact the case with 40% of the migration records representing male birds, while only 13% were females (Table 5). Unfortunately 47% of the migration records leave out any reference to the sex of the bird. In at least one case the same recor is reported in literature as both a male and a female (Zimmerman and V Tyne 1959, Wood 1951, Merriam 1885). I have yet to find the specimen (thankfully this record is from a specimen).

Table 5. Earliest and Latest Male and Female Kirtland's Warbler Durin Spring Migration

Earliest Female	**April 14,1903**	**GA**
Latest Female	**June 3,1910**	**ILL**
Earliest Female	**April 27, 1904**	**GA**
Latest Male	**June 17, 1960**	**ONT**

There is only one record of Kirtland's singing in which the sex i not identified. That record is a highly questionable one from Minnesota. Table 6 summarizes sex data for Spring migration. The NI column is for record in which the sex was "not indicated." The Kirtland's seems to sing throughout its migration route, although no of the records in Florida indicate that the bird was singing. It may that as the birds get closer to the breeding ground that singing increases. Seventeen of the 52 reported males were definitely singin which is 32% of the male records (Table 7). There were three records which specifically noted that the male birds were not singing. Sixty-two percent of the male records did not indicate if the bird w singing or not.

Table 6. Kirtland's Warbler Migration Records by Sex

MALES	**52**	**40%**
FEMALES	**17**	**13%**
SEX NOT REPORTED	**63**	**47%**

Table 7. Kirtland's Warbler Migration by Sex and State

	Males	Singing Y/N	Females	NI
MI	11	3	6	8
MN	2(1)	1/(1*)		(2)
ONT	7	3		8
ILL	4	2	1	5(6)
IN	3	3	3	7
WI	1		1	6
MO	1			2
OH	11	4/1	3	18
W.VA				3
GA	1	1		3
S.C.	5	1	1	
ALA	1	1		
FLA				3

() indicates questionable records
*** reported "no singing" but did not indicate sex of the bird.**

While it may be useful to know how the Kirtland's warbler behaves during migration and what kind of habitat it uses, only 35 and 34 records, respectively, out of 133 give this kind of information (Table 8). Of the behaviors noted, foraging, tail wagging, and tameness were reported most often. The latter two behaviors are characteristic of this species and contrast it with most other wood warblers. All of these behaviors were noted in the May 22-23, 1983, Indiana observation reported above. One record indicated that the bird was "tame to the point of idiocy." Feeding, tail-bobbing, and tameness seem to be noted throughout the Spring migration route (Table 9). Flycatching, which was also a behavior I observed in Indiana, was noted for three other migrating Kirtland's warblers. Four other records besides the Indiana one indicated that the song was unusually loud, which is characteristic of the species on the breeding grounds. One record noted that the song was much softer than on the breeding ground. The hopping behavior described above was noted in only one other observation, although the reference was rather terse. One other record indicated that the bird darted for insects in the air, which may have been the hopping behavior or it may have been flycatching. Only one other observer reported that the bird both sang and fed at the same time, although this is common on the breeding grounds. The 1983 Indiana observation included an altercation with a yellow-rumped warbler. Feeding with a flock of white-throated sparrows was the only other inter-specific interacti noted during Spring migration. The Indiana bird was alone, which is true for most observations. Only two records indicate that a male female were seen at the same time. Nine other observations indicat there were two or three birds present. The most unusual record in regard (Ford 1956) which reports six Kirtland's in hawthorn trees n La Grange, Il. There is no descriptive data about what the birds l like or about their behavior. I do not count this record as a confi one and consider it highly questionable.

Table 8. Singing in Male Kirtland's Warbler Spring Migrants

MALES	**52**	
SINGING	**17**	**32%**
NOT SINGING	**3**	**6%**
NOT REPORTED	**32**	**62%**

Table 9. Number of Spring Migration Records Noting Behavior and Hab

NOTES ON BEHAVIOR	**35/133**
HABITAT NOTED	**34/133**

Consistent with the 1983 Indiana observation, most Spring migran of this species have been seen on the ground, in shrubs or the lower branches of a tree (Table 10). Of the records in which habitat was noted, ten did not indicate the vertical location of the bird. Two observations indicated the bird was high in a tree. The bird in Ind did fly to high perches on high tension wire and on the upper branch of a black willow, but this was only for a brief period. The bird s over 90% of the time it was observed on the ground or in low vegetat

Table 10. Kirtland's Warbler Behavior During Spring Migration

Feeding	**12**
Tail bobbing	**12**
Tameness	**16**
Fairly silent	**3**
Flycatching	**3**
Still long time	**6**
Song loud	**4**
Sings with head tilted back	**2**

Table 11. Kirtland's Warbler Spring Migration Behavior by State

	Feeding	Tail bobbing	Tameness
MI	4	4	3
MN	1	1	
ONT	1	1	2
ILL	2	1	2
IN	3	1	3
WI		3	2
MO		1	
OH	1		3
S.C.			1
	12	12	16

Table 12. Vertical Location of Kirtland's Warbler Spring Migrants

Low (on ground, shrubs, or lower branches of tree)	22
Height not noted	10
High in tree	2

The Canada migration records take on more interest now that there is a published report of the Kirtland's warbler nesting in Ontario during 1946 (Spier 1984). Although the author of this record seems to have good natural history credentials, whether this nesting report will be accepted as authentic remains to be seen.

Corrections of Two Records

Walkinshaw (1983) lists two sightings of the Kirtland's warbler in migration for Tazewell County, Illinois. When I went to the original record (Ford et al. 1934) I found that these two records are actually for Porter County, Indiana. The confusion must have come because this record is in a publication of the Chicago Academy of Sciences entitled Birds of the Chicago Region. Since nearest town is given as Tremont, and there is no Porter County, Walkinshaw must have looked up the town of Tremont, IL, and found that is indeed in Tazewell County. It might seem a reasonable assumption that the name of the county had changed. Walkinshaw would not have known that Porter County, Indiana (the Indi Dunes area), is considered by the Chicago Audubon Society and the Chicago Academy of Sciences to be within the Chicago Region. In fact the Chicago Audubon Society participates in the Christmas count in th Indiana Dunes area (This would be similar to Detroit Audubon listing birds found at Point Pelee, Ontario, as being in the Detroit Region).

Concluding Comments

The observation of a migrating male Kirtland's warbler at Michiga City, Indiana, on 22 and 23 May 1983 has the most complete behavioral data than any other record to date. This data will be reported more thoroughly elsewhere. The male in Indiana was found in the Northern tier of states where most migration records have been recorded. It w characteristically tame, singing loud and tail-bobbing, which is consistent with past records. Also consistent with past records is t fact that it spent most of its time on or near the ground.

It is unfortunate that so many migration records do not indicate sex of the bird or describe behavior or habitat. Although I am not s how to get the word out to amateur birders, it would be helpful to encourage them to not just document the presence of an unusual specie but to spend time taking notes on its behavior and surroundings. It would be well worth sacrificing putting more species on the list that day. The quality of the observation can more than make up for the decrease in quantity of observations.

The most Spring migration records come from the decade from 1900 1909 which also coincides with the greatest abundance of breeding habitat and perhaps of the species itself. During the time period i which migration data can be compared to the Singing Male Census (195 present) this same trend is evident. If the number of Spring migrat records is related to the population size, as it appears to be, the larger number of migration records in the early 1900's would support Mayfield's belief that this was the time of the Kirtland's warbler's greatest abundance.

While I had hoped, as noted in the abstract, to complete statist analysis of this data, including regression, to help shed light on t pattern of migration in this species, that work is not yet completed Results so far are inconclusive and more variables must be taken int account before this work is done. I will report on that later investigation of this data at a future time if results warrant it.

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The references for the Spring migration data themselves take up 8 pages. Those references will be published with a more complete version of this report.

USE OF THE ECOLOGICAL CLASSIFICATION SYSTEM FOR DELINEATING AND MANAGING KIRTLAND'S WARBLER HABITAT

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An Ecological Classification System is being implemented on the Huron and Manistee National Forests. This system uses climate, geology, soils, and vegetation in classifying landscapes and developing management interpretations. Ecosystems have been sampled at 200 locations across the Huron and Manistee National Forests. Ecological land units have been defined using multivariate and field verification techniques. Regional climate appears to be an overriding constraint on forest succession in landforms inhabited by the Kirtland's warbler, followed by disturbance regimes, and finally soil-lower vegetative conditions. Management strategies for perpetuating or expanding the range of suitable habitat need to consider the interaction of frost frequency, soil moisture, and associated stress tolerances of local flora.

LANDSCAPE ECOSYSTEMS OF THE MACK LAKE BURN AND THEIR OCCUPANCY BY THE KIRTLAND'S WARBLER

Dr. Burton V. Barnes, Corinna Theiss, Xiaoming Zou

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The habitat of the Kirtland's warbler in the high plains of the northern Lower Peninsula of Michigan has typically been described in terms of jack pine (coverage, height, and pattern of occurrence), vegetation associated with jack pine, and the dry sandy soil (chiefly Grayling sand). This project was initiated in response to calls for a more detailed understanding of warbler habitat. For example, what kind of habitat attracts the first immigrant warblers, and what kind would support the highest density of warblers? Thus, the overall objective was to establish a framework of landscape ecosystems for the Mack Lake burn as a basis for understanding warbler occurrence and behavior. Landscape ecosystems are recurring geographic units of an area having similar physiography, climate, soil, and biota. Field seasons of 1986 and 1987 were devoted to determining the landscape ecosystem types, sampling plots in each type, and developing a classification.

The area was subdivided into two major physiographic types: a low-level outwash plain in the northern part of the burn and high-level outwash terraces and ice-contact terrain in the southern part. Eleven landscape ecosystem types were identified and described -- five in the low-level outwash plain and six in the high-level outwash/ice-contact area to the south. Ecosystem types were distinguished by differences in physiography, soil, microclimate, and vegetation. Major differences in groundcover vegetation were observed between the low-level outwash plain and the high-level terrain and among ecosystem types in each of these areas.

Occupancy of the burn by the Kirtland's warbler in both 1986 (the first year of significant occurrence) and 1987 was greater in ecosystems of the high-level outwash and ice-contact terrain than in those of the low-level outwash plain. Warbler sightings and nests were associated with relatively tall and dense jack pine stands of patchy (contagious pattern) occurrence. Depressions, in both landscapes, were not occupied by the warbler.

Results of a quantitative study of the pattern of occurrence of jack pine regeneration (contagious vs. random vs. regular) indicated that pines typically exhibited a contagious pattern in areas of known warbler occurrence--especially in the high-level area. In contrast, the pattern tended to be random in ecosystem types where the warbler was not observed.

The landscape ecosystem approach, demonstrated at the Mack Lake burn and extended to the Bald Hill area in 1988, provides a framework for mapping favorable warbler habitat at either the broad physiographic level or the more detailed ecosystem-type level. The sequence of colonization of favorable habitat (from one physiographic type or ecosystem to another) can be predicted using the ecosystem framework. This approach also provides an ecological framework for detailed stu of the biology and behavior of the warbler on any given area. Finall the landscape ecosystem approach indicates that the pattern of warbl occurrence in space and time is related in the basic glacial geology the landscape and the closely related features of topography, soil, microclimate, and vegetation.

MILITARY COOPERATION IN THE KIRTLAND'S WARBLER RECOVERY EFFORT

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Within the Kirtland's warbler range, jack pine succession through fire has been most prevalent in the vicinity of Camp Grayling, a Michigan National Guard training site located in Crawford, Kalkaska, and Otsego counties. Historically the installation has provided nesting habitat for approximately 30% of the existing species.

The Guard, having produced this ideal nesting habitat incidental to field training exercises, has been placed in the ambivalent position of creating habitat for an endangered species in the midst of disruptive training activities. Complicating matters is the fact that the nesting season and peak training times are essentially the same.

To resolve this long-standing conflict, a mutually-acceptable management plan has been developed. Both the military and the Department of Natural Resources have signed a cooperative agreement which binds them to prescribed goals and objectives which not only protect the bird but also provide for the crucial military training.

A MANAGER'S PERSPECTIVE

David Kline

District Ranger
Mio Ranger District
Mio, MI 48467

The Huron National Forest contains 53,000 acres that are managed as Kirtland's warbler nesting habitat. This requires the harvesting and reforesting of around 1,000 acres of jack pine per year. In recent years timber markets have been good, so reaching the harvest goals has not been a problem. This has not always been the case, nor is it guaranteed for the future. The pine is grown on a 50-year rotation which is a fairly standard commercial rotation for jack pine. Habitat block size can be up to 370 acres, but more commonly involves complete clearcuts of 200 to 300 acres followed by machine planting.

Public tours, cowbird trapping assistance, signing, road and area closure and maintenance, prescribed burning, coordination of oil and gas activities, and fire break construction and maintenance are some of the other recurring activities involved. The tours are conducted during nesting season out of our office in Mio and the Fish and Wildlife Service in Grayling. Since the areas are closed to public entry, these escorted tours provide an opportunity to view the warbler in a controlled setting. Cowbird trapping and removal is done by the Fish and Wildlife Service to reduce nest parasitism. The prescribed burning program involves only a block or two per year since most areas are now whole tree harvested and chipped with no slash fuel remaining.

Alternative approaches for habitat management such as prescribed burning of overstory stands for natural seeding, strip cutting, artificial seeding, roller chopping of slash, and shortened turnover of prime nesting blocks have been tried, or suggested, in the past with variable results. Wildfires have historically created the best, longest lasting habitat, but mimicking these is extremely difficult logistically and unacceptably risky from a liability standpoint. Due to stand age, weather, and other variables, none of the wildfires on the Huron Forest since 1981 have resulted in good nesting habitat. Shorter rotation turnover of the better habitat blocks may become more viable due to developing markets for small diameter trees as fuelwood chips for electrical generating plants.

However, no matter how it is done, harvesting and replanting jack pine is a less than marginal operation from a straight cash flow, market economics standpoint under current economic conditions. It costs over $200 per acre in direct costs to plant and present stumpage returns after 50 years are usually less than this amount. The attitude might be that direct cost/benefit is irrelevant when the objective is to perpetuate an endangered species, but we live in a world where budgets are not infinite and public funds are allocated among many competing interests.

The Kirtland's warbler program is also not universally popular, particularly among some local residents. Large clearcuts, poor economics, area and road closures, and the ragged look of jack pine combine to make the whole effort less than endearing to some. The endangered species program has been trivialized to some extent by u little-known species to curtail large popular projects. The inevit result is some erosion of public support which results in vandalism violation of regulations becoming socially acceptable. Improved vi management coordination and emphasis of the benefits to other speci from warbler management could help turn this around.

The Mack Lake Fire which resulted from an escaped prescribed bu 1980 did not increase the popularity of either the Forest Service o Kirtland's warbler. The fire burned 25,000 acres which included so private land and forty structures in the subdivision along the west of the lake. It cost the U. S. Government about five million dolla damages, claims, and suppression costs and the life of our Wildlife Technician, Jim Swiderski. The fire created over 10,000 acres of suitable nesting habitat which is now being colonized. In 1988 abo 40% of the warbler population nested in this burn. Another result the fire has been more reliance on whole tree harvesting to elimina slash, and less reliance on prescribed burning.

Another problem which has caused a good deal of shifting around habitat blocks is the impact of the jack pine budworm. This native insect operates on about a 15-year cycle which in the Mio area was 60's, early 80's and, predictably, mid 90's. The result is moderat severe mortality of infested stands over about age sixty which incl most of the second growth jack pine. Whether such stands are salva or unsalvaged, they still look pretty rough, and may be left under-stocked for a long period before replanting, which causes some publi concern.

There are many unanswered questions regarding the use of fire, economic limits, coordination of other resource values, timing and desirability of salvage, and the response of the warbler and the management agencies to the large infusion of habitat at Mack Lake. need to avoid a lock step approach to warbler management and be will to alter the effort based on the best information available. We als need to avoid the "management with a vengeance" syndrome which igno costs and other resource sacrifices in the pursuit of "perfect" habi even on marginal areas. The bottom line is number of warblers on a sustainable basis which may, or may not, equate to dollars spent or acres managed.

FIRE AND FIRE EFFECTS - ITS IMPACT ON FOREST VEGETATION FOR KIRTLAND'S WARBLER HABITAT

Ronald L. Wilson

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Fire is a dynamic force, never the same, always changing. Because of this, all the effects of fire are difficult to describe and even predict with any degree of certainty.

We can predict fire behavior with a resonable degree of accuracy, both for prescribed burning and for wildfires. With these predictions we can determine the fire intensity, the rate of spread, the flame length, the size of a fire in a given time frame, if we can expect spot fires, and the probability of having a crown fire. By looking at these predictions some assessment of fire effects can be made even before the fire occurs.

There are a few very obvious effects: the reduction in the amount of litter, duff, and slash; the mortality of residual trees and shrubs in clearcut areas; the mortality of whole stands where a crown fire burns through unharvested timber; and the opening of serotinous cones and the resulting seed dispersal.

There are other effects which may not be quite so obvious, particularly right after a fire, which could either enhance the site or detract from the site's suitability for nesting habitat for Kirtland's warbler (Dendroica kirtlandii): the change in plant species diversity; the removal of soil nutrients by hot fires during a period of drought; and the enhancement of some shrub and brush species.

Ahlgren's statement, "Very few generalizations can be determined from the literature concerning plant succession following fire, since so many conditions in addition to actual burning come into play as factors in the process," is certainly true.

There have been several studies to determine the effects of fire on species composition or species diversity. One I will refer to in the following information was completed by Abrams and Dickman in 1982, which looked at the early revegetation of burned and unburned clearcut jack pine (Pinus banksiana) sites in northern lower Michigan. They found that burning increased the number of plant species after a fire for two to three years, then the number of species declined to similar numbers and composition to the unburned sites. After six years, the species composition and successional trends were fairly similar on burned and unburned sites.

FIRE AND FIRE EFFECTS - ITS IMPACT ON FOREST VEGETATION FOR KIRTLAND'S WARBLER HABITAT

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Adequate regeneration of jack pine in Kirtland's warbler habit
areas just from burning has not proven successful, except in insta
of stand replacing crown fires such as the Fletcher Fire in Kalkas
County in 1968.

Since we would like to harvest as much merchantable material f
the mature jack pine stands as possible, we do not encourage the u
stand-replacing fires for developing Kirtland's warbler breeding
habitat.

John Probst reported in 1987 that recent studies indicated tha
percent of canopy cover was more important in determining suitable
breeding habitat for Kirtland's warbler than species diversity ind
by burning. So then why do we use prescribed burning and what are
benefits?

Prescribed burning is the skillful application of fire to natu
forest fuels, under exacting conditions, in a predetermined area t
achieve accomplishment of certain planned benefits to one or more
objectives in forest management, wildlife management, or hazard
reduction.

There are three major objectives accomplished by prescribed bu
in Kirtland's warbler management areas:

1. Site preparation
2. Hazard reduction
3. Training fire control personnel

Site preparation has achieved varied results. Seed-tree burns
tried in several areas with good seed release after the burns but
quite poor seedling survival. Seedbed preparation for direct seedi
achieved the same poor results. But, site preparation for plantin
been very positive. The slash reduction makes it easier for equip
operators to see where to drive while planting; they can avoid tre
stumps and usually the planting time is reduced.

Prescribed burning also kills residual trees which reduces
competition with the new seedlings and reduces the overstory which
prime situation for the jack pine budworm (<u>Choristoneura</u> <u>pinus</u>).

Hazard reduction is another prime objective of prescribed burni
Once the hazardous slash fuel is removed, if a fire did start in th
are, it would be easier to control and would be less likely to spre
and destroy adjacent established breeding habitat.

Training fire control personnel is the third major objective.
Through prescribed burning, firefighters can observe the fire behav
and be better able to predict what will happen in a wildfire. They
also be practicing burnout techniques during the ignition process.
equipment used during the prescribed burn is the same as used for f
suppression and they will become familiar with the operation of the
suppression equipment and learn more about its capabilities and

limitations. This training will make them more capable to protect the breeding habitat that we already have established.

Michigan's prescribed burning program for Kirtland's warbler habitat development has been in operation since the early 1970's. These burns have taken place in six counties: Crawford, Kalkaska, Montmorency, Ogemaw, Oscoda, and Roscommon; all located in the north central portion of Michigan's Lower Peninsula, the primary nesting area for the Kirtland's warbler. We have completed treatment on over 4,500 acres at a cost of just over $18.00 per acre. These accomplishments are below the desired goal.

There are some major hindrances to being able to accomplish our prescribed burning goals in the Kirtland's warbler habitat area. Ideal weather for these prescribed burns is also weather very conducive for wildfires. The people and equipment necessary to conduct the prescribed burns also have to be available for wildfire control. The number of days per year when the weather is suitable for conducting the prescribed burns is limited. An unpublished study in the mid 1970's indicated there were only about 20 days per year that were suitable for prescribed burning in the jack pine fuel complex. Areas to be burned near highways, towns, airports, high-use recreation areas, and other smoke-sensitive areas are further limited by specific wind direction requirements in the weather prescription. But these restrictions normally do not preclude prescribed burns being done in those areas.

Summary

Fires, both wildfires and prescribed burns, have certain effects on forest vegetation, both beneficial and devastating in managing and developing Kirtland's warbler breeding habitat. For positive effects, fire opens serotinous jack pine cones, induces seed dispersal, prepares the site for seeding or planting, reduces hazardous fuels, removes residual trees on harvested areas, and for the short term, increases species diversity. Some of the negative effects at times are very obvious. Major wildfires can be devastating to established breeding habitat and to the whole Kirtland's warbler recovery program. These major wildfires can upset the rotation of available breeding habitat for many years if a number of them occur within a short time span.

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Probst, J. R. Kirtland's Warbler breeding biology and habitat management. A paper presented to the Society of American Forester Conference at Minneapolis, October 21, 1987.

PREDICTING KIRTLAND'S WARBLER POPULATIONS BY HABITAT CONDITIONS

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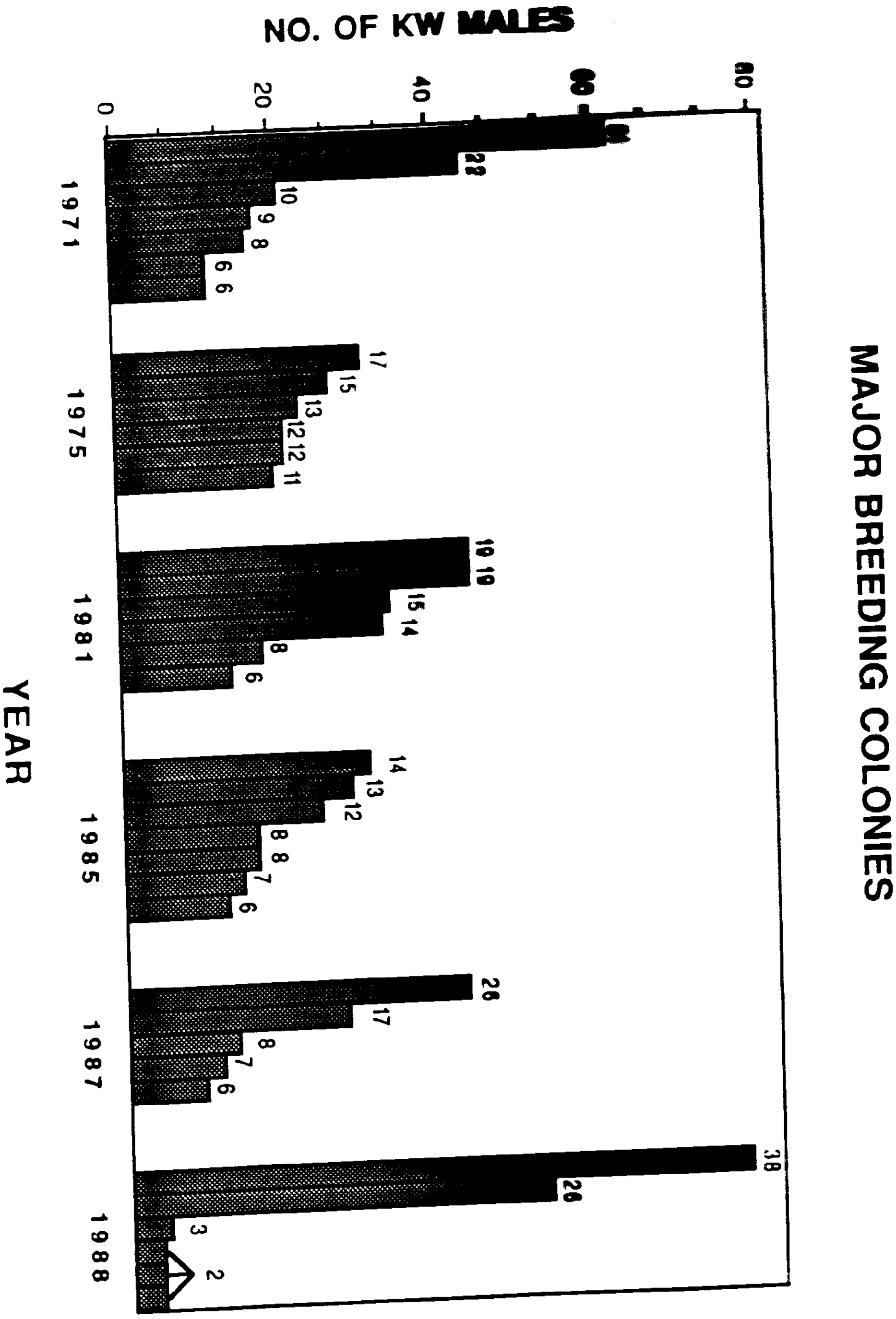
Kirtland's warbler habitat suitability is well-defined in respect to soil type, site quality, forest type, tree height, and stocking density. Habitat is utilized during a 10 to 15-year period, and populations peak in the middle period of occupancy in habitat adequately stocked for Kirtland's warblers. If Kirtland's warblers are strongly limited by breeding habitat, it is possible to make crude estimates of carrying capacity based on stand characteristics of site index, tree height, and jack pine canopy cover. Stand colonization may also be influenced by area and insularity of habitat. Continued research and monitoring will lead to more refined population estimates based on habitat area, stand chronology, stand area, stand ages, and stocking diversity within stands.

Future carrying capacity was estimated by applying past average densities of male warblers (1) in suitable habitat during 1984 (1.9 males per 40 ha), (2) in four wildfire areas censused annually between 8 and 20 years of stand age (2.1 males per 40 ha), and (3) in four wildfire areas censused during peak occupancy, 13 to 15 years of stand age (2.8 males per 40 ha) to 6160 ha of suitable habitat in 1993. We estimate a 1993 Kirtland's warbler population between 300 and 430 males. The higher estimate may be more accurate because more than half of the suitable habitat in 1993 will be at or near the age of optimum Kirtland's warbler densities. Much of this 6160 ha of habitat will be overmature by the end of this century and will be replaced by a larger number of smaller stands planted for Kirtland's warblers (there will be a lower proportion of wildfire habitat present after 1998 unless there are major fires in 1989 or 1990). We have little data on age-specific population trends in plantations relative to wildfires and we are uncertain about the population effects of habitat turnover toward the end of the century.

Success per nest may be quite similar in different habitats since cowbird control was implemented, but productivity per male may be substantially lower in stands that are smaller, younger, more isolated, or of lesser quality than optimal habitat. Our provisional estimate of productivity in less suitable habitat is about 25 to 35 percent that of the 3.1 fledglings per pair estimated by Walkinshaw in optimal habitats. Lower productivity in marginal habitat is related to later settlement times, territorial abandonment, and lower pairing success of males relative to more suitable habitat. Later settlement times reduce opportunities for second nesting and re-nesting attempts by those males are successful in attracting mates late in the breeding season. Refined estimates of productivity can be coupled to revised estimates of survivorship from color-banding studies to produce a habitat model that ked to total population size and other important demographic s.

owledge of Kirtland's warbler biogeography and the role of source ats can be applied to research and conservation management for species in both mature and early succession habitat. Maintaining eloping such habitats is critical to the long-range viability of rare or even common species.



- extensive ventilation system (4 air exchanged per hou
- air filter to reduce dust and reduce bacteria or fung
- heating system - temperature maintained @ 72° F
- lighting system to mock natural photoperiod (can adju the minute)
- attempted visual and <u>audial</u> isolation (audial reduced eliminated)
- each unit is 10' x 4' x 8' and has:
  - artificial veg. (birds spend a great deal of time he
  - 4 roosting platforms
  - 1 feeding platform by removable window - for access
  - 3 bowls (washed daily): prepared food (added fruit).

Fieldwork

June 1986

My advisor, Jon Bart, and I came to Michigan to evaluate <u>breeding habitat</u> for Nashville Warblers in order to select ca release sites (don't want birds to leave after released simply the habitat was inadequate.) We defined the optimum breeding as:

- 12' to 21' jack pine understory
- patchy distribution of densely stocked trees
- 10-15% cover of tall overstory trees (40-60') - any spp.

Captures sites - general area was defined in Northern Oge Southern Oscoda counties but sites were selected as needed and by J. Weinrich.

Release sites - Iosco Co. (65 km [40 miles] to E of capture 15 selected (5 sites in 3 major locations).

July 1986

- return to MI to begin capture work
- goal was to catch 40 NW's - we wanted to release 15 pairs birds) so catch 30% more to compensate for:
  - mortality
  - possible skewed sex ratio

* recall decided to work with juveniles (can't accurately sex juveniles)

- catch birds using mist nets - skull them and note molt patt determine the age
- usually ran ~15 nets from dawn to 10:00-11:00 when conditio become adverse and catch/effort declines
- continued to refine the methods by which birds are brought i captivity!
- I've been very successful with the latest method - probably now bring adults into captivity (but already decided to work juveniles).

- once a bird is brought into captivity, it's monitored for several hours
- after ~3 hours - make decision: keep or release (with present method I'm keeping a large proportion of birds brought in)
- if decide the bird is a "keeper", I band it to uniquely ID!
- then I give the bird a 24 hr. adjustment period - so it can cue in on food dishes and settle down.
- while I continue catching rest of 40 birds, "keepers" are kept in 2 places: 50% kept in holding cages, 50% kept in release cages on the release sites to give them an opportunity to cue in on:
  - skyline; orientation of stars
  - earth's magnetic field
  - or whatever else is important

* trying to address question of whether juveniles select breeding territory before or after migration. (Haven't been able to adequately test yet - low sample size - shuffled birds).

Finish capture work near end of August 1986. Transport all birds to Columbus Zoo - been very successful with transport technique (haven't lost a single bird - 5 7-hr trips).

I did conduct observations while birds in zoo aviary

- looking at behavior in captivity, purpose is to
  - describe "normal" behavior
  - help detect sickness
  - evaluate seasonal changes (more aggressive in spring)

While in aviary - birds stayed on natural schedule

- put on fat (too much!)
- began pre-nuptial molt synchronous with wild birds

I "paired" birds in April - difficult: sexing was ambiguous I was not confident that I had pairs.

Birds were kept in aviary through mid-May:

- survivorship was 69% (27 birds/39) - almost twice natural survivorship for juveniles. Before I could take birds to MI in spring - had to build release cages so late April and early May 1987 - myself and 5 others built 12 cages and completed 3 used the previous fall.

Release cages are modified cowbirds traps. (16'x16'x6')

- have to build panels
- take them to site (stacks)
- select trees to be enclosed (want 50% cover)
- dig trench (predator guard; stability)
- put panels together; walls; then roof
- line with 1/4" mesh netting
- hang shelves

Once cages built - finally got birds back to MI. May 16, 1987, - arrive release sites with 27 birds.

- put "pair" into each cage - intending to conduct at least 10-day soft-release program.
- <u>however</u>, T-storms for 10 days straight and Memorial Day weekend (~30 F) very cold.
- lost 10 birds (8 of which were males)
- thought I only had 3 pairs!
- soon, 5 birds ID'd as females began to sing (late coming in to breeding condition - so not showing CP before this - now do!)
- so really had <u>8</u> pairs! At this point so far behind schedule - didn't even have time to work with that many pairs.

Before each pair could be released - clear area of local NW's.
Reason: 1) mimic KW situation
2) eliminate competition thus eliminate 1 variable for possible failure of pair

Since investing time to remove local NW's, decided to work with 1 cage area at a time - releasing pairs until the first successful pair stayed in the area.

To <u>clear</u> <u>area</u>:

- first define territories of local singing males around the cage
- clear 2 territories adjacent to cage:
  - remove dominant male
  - at least 1 female per territory
  - several "floater" males
- did this using mist-nets and playback tapes
  - screech owl tape (saw-whet owl decoy)
  - hoping birds would mob
  - moderately successful
- Nashville Warbler singing male tape
  - very successful

In 1987, over 40 birds removed from territories (banded and transported N and released, returned from 20 mile - so transport 40 miles - some return) now I put them in one of unoccupied release cages.

Note: 1987 - 3 males did not respond to tape and weren't netted; subsequently - removed with shotgun!

Once site was cleared of local birds - we released our birds and followed them:

- to follow: visual and audio cues only (much too small for transmitter)
- if able to follow: record some data
  - direction and distance from cage (map territory
  - height, and species of tree and location in tree
  - other observations: song freq., copulation, forage data

Results from 8 pairs released in 1987.

- Five pairs released in breeding condition
- All 5 males set up territories, only 1 appeared to have a mate.
- One female nested successfully - 4 nestlings lost to predation.

After 1987 release work finished I immediately started capturing birds for 2nd replication - again want 40 birds and again place 50% in holding cages and 50% at release sites.

August 1987 - 2nd group of NW's taken to Columbus Zoo.
That winter - we faced many disease problems.
- successfully fought coccidia
- couldn't fight virus (~Merek's Disease in chickens)
- couldn't fight mycotic pneumonia

Above problems artifact of crude aviary - <u>not</u> conditions the endangered species would be subjected to, but <u>must</u> recognize the <u>possibility</u> of disease problems in captivity.

May 1988 - 34% survivorship (~mother nature)

5 pairs from the aviary released. As an alternative technique - we also caught 4 pairs of wild birds from the capture sites that <u>spring</u> and simply translocated them the 65 km to release sites-only release 2 pairs of these (mortality). So in 1988 - release 7 pairs. Results - avairy birds: 5 pairs released in breeding condition - 2 males set up territories - one of which had a mate and nested. One female mated - nested; - wild caught pairs: failed.

The spring translocation hasn't worked at all - perhaps birds caught too late (already established territories and made significant investments on capture site).

Also in 1988 work on release sites saw no birds from 1987! Only saw 1 of 40 local birds that were banded when removed so not as site-tenacious as thought!

August 1988 - 3rd replication - 40 NW's brought to Columbus Zoo put in fresh, sterile aviary (fumigated) and doing quite well. Only lost 3 birds (97% survival) all winter - <u>until</u> Wed. and Thurs. (8 & 9 Feb) - lost 4 more (fluke at Zoo - lost power all night and got cold - sick birds couldn't handle it).

<u>Summary</u>

Obj. 1: capture and holding technique
- we've shown that bringing birds into captivity is successful and have really fine-tuned the technique. Over-winter holding of birds has great potential for increasing the survivorship of juveniles - provided the proper facility is used. I've ironed out many of the requirements and specifications for such an aviary.

Obj. 2: release techniques - will birds survive, remain, reprod
- prolific nature of NW caused problems in answering the questions
- takes excessive amount of time clearing territories be release; it gets to be late in breeding season, which decreases the chance of success; also couldn't totally eliminate competition. Won't have this problem with Kirtland's warblers.

though sample sizes very small, we can at least say "y is possible that birds will remain and reproduce. In 100% of males released in breeding condition set up territories yet in 1988, only 40% set up territories. have seen reproduction! Females are a black box! May they're still there and not seen; maybe they are not t because pair bond not established due to shuffling of (better chance with Kirtland's warbler since many bird released at once and therefore birds have own choice o selection.

Obj. 3: Will birds return?
- Nashville Warbler is not good surrogate to test this - site tenacious in this area - so probably won't be able answer. Gut feeling - Kirtland's warblers very site tenacious and probably would return to release site.

Overall, I feel optimistic that technique will work - hopefull replication will give the numbers to support that.

MULTI-RESOURCE VALUES OF KIRTLAND'S WARBLER HABITAT

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Kirtland's Warbler habitat is valuable for diverse resource uses such as timber production, recreation, and other wildlife management objectives. Hunting and wildlife observation provides opportunities for both consumptive and non-consumptive recreationists. Game or furbearer species that occur or have occurred include white tailed deer, black bear, snowshoe hare, coyote, wild turkey, sharp-tailed grouse and spruce grouse. In addition to Kirtland's Warbler, prairie warbler, Pine Warbler, and Connecticut Warbler are found in different ages of jack pine or pine-oak habitats. Other non-game birds of interest include Eastern bluebird, black-backed woodpecker, upland sandpiper, marsh hawk, short-eared owl, long-eared owl, olive-sided flycatcher, lincoln's sparrow, and clay-colored sparrow. A lucky observer may encounter a badger, a nesting Blanding's Turtle, or an Eastern Smooth Green Snake. Wintering birds include Northern Shrike, Red Crossbills, Rough-legged Hawks, and other raptors. A variety of interesting wildflowers and other plants are found in this unusually dry habitat.

Most wildlife objectives are compatible with timber harvesting because the majority of desired or unusual species are found in open country. Species associated with fire include Eastern bluebird, black-backed woodpecker, prairie warbler, and sharp-tailed grouse. Most of the rare plants are ephemerals found only after fire has removed competitors or provided nutrients enrichment.

Optimum wildlife management of jack pine habitat requires consideration of spatial needs of species such as suitable area of homogeneous habitat, interstand distances, habitat interspersion, size and area of permanent openings, and local habitat requirements of different species. Temporal considerations include timber harvest scheduling, useful life of temporary openings, and planning around unpredictable wildfires. Maintenance of permanent openings adjacent to Kirtland's Warbler Management Areas could establish permanent populations of sharp-tailed grouse, upland plovers, common nighthawks, badgers, shrikes, and open country raptors.

A REVIEW OF THE PREDATOR-PREY INTERACTIONS VERSUS HABITAT CONSIDERATIONS FOR THE KIRTLAND'S WARBLER

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I've been interested in the cowbird-host relationship since I was 10 or 12 years old. That means for a period of 60 or so years. Forty years ago I studied intensively the cowbird interaction with the Yellow Warbler and with the Song Sparrow (McGeen 1972). They appeared to be two separate types of hosts as far as value to the cowbirds go. Extending to the literature, other small warblers, vireos, and sparrows fell into the same pattern with the Yellow Warbler, while larger hosts whose eggs and young were better able to compete for heat, food, and parental care with their cowbird nest mates were, like the Song Sparrow, in a different pattern, which reflected these facts (MS). But significantly both patterns showed a parallelism of fledging success for host and cowbird above a certain pressure level, indicating feed back, and a precisely tuned homeostatic regulating system--like the high and low thermostats on a heating system (Figure 1).

Cowbird pressure is the mean of the incidence (percent nests parasitized) and the intensity of parasitism. The intensity is the percent of total cowbird eggs which are laid as multiples, i.e. with other cowbird egg nest mates. No other method of measuring cowbird interference can give the precision that this one does, for these two components can be widely variable in different studies and even different seasons within a study (Figure 2).

A few studies have the number of cowbirds as well as hosts, and both of their egg layings and fledging successes, as well as losses to cowbirds observed. These are the blue ribbon studies. With their data we can calibrate our pressure scale into cowbird females laying per 100 pair of hosts--their frequency or density with reference to hosts. Apparently 100 pressure is caused by 40 cowbird females per 100 pair of hosts. Thus cowbird pressure (C.P.) equals 2.5 C. Frequency and C.F. equals .4C. pressure (Figure 3). With this information when the low count of 201 males in 1971 came in we were able to construct a model which duplicated the drop from 502 pair in 1961. Radabaugh's data on pressure was used, then Walkinshaw's on a younger area to get a beginning pressure, thus the number of cowbird females for 502 pair of hosts. Reasonable inputs for egg production for cowbird and host and for adult and juvenile annual survival were used from the literature. We found that as pressure increased warblers went down as expected from the pattern's feedback (Figure 4). The directional force was the 8% per year phase out I recognized on the two large areas involved--Canada Creek and Mack Lake. Twenty-five years was the complete length of use on these two areas. That is 2-3 times Mayfield's (1960:p15) reported use period on smaller, less variable areas. If the down-turn's length is 12 years, the loss is 8% per year.

Figure 1. The good host cowbird interaction pattern. Left Y ax
of eggs which produce fledgings, for host (H) solid li
cowbird (C) interrupted line. Right Y axis is % loss
cowbirds of eggs and nestlings. X axis is cowbird pr
the mean of incidence and intensity (% multiple eggs)
parasitism. With adequate sampling and steady state
upper 40% of egg and nestling production are lost to
universal hazards which affect host and cowbird alike
forms of predation, weather, etc. Note the peak at t
50 pressure for the cowbird--an Allee effect. Chi sq
T tests supported these patterns.

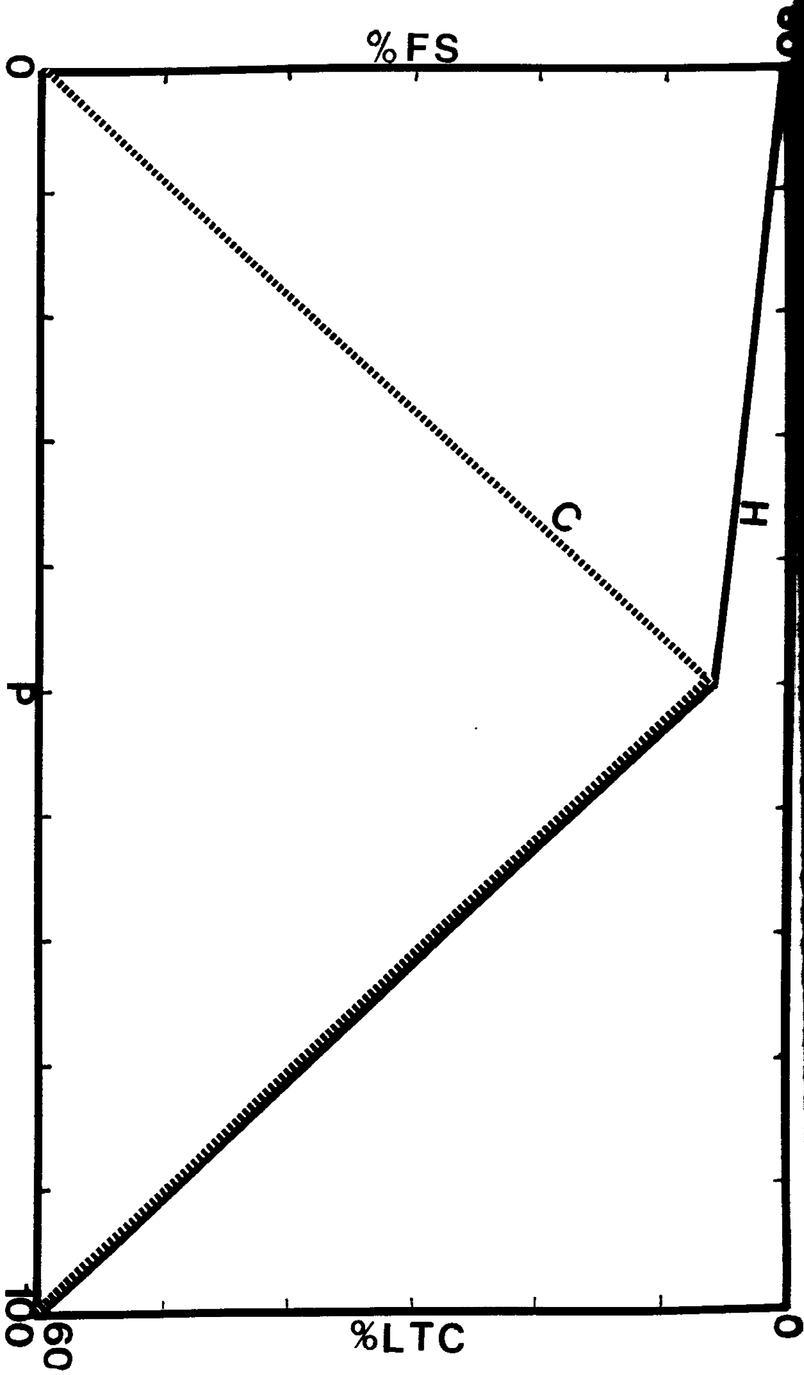


Figure 2. Variation in components (% incidence (I) and multiple eggs (M) of the pressure index (P) between the 1930 and 1934 seasons on the Interpont Song sparrow study (Nice 1937).

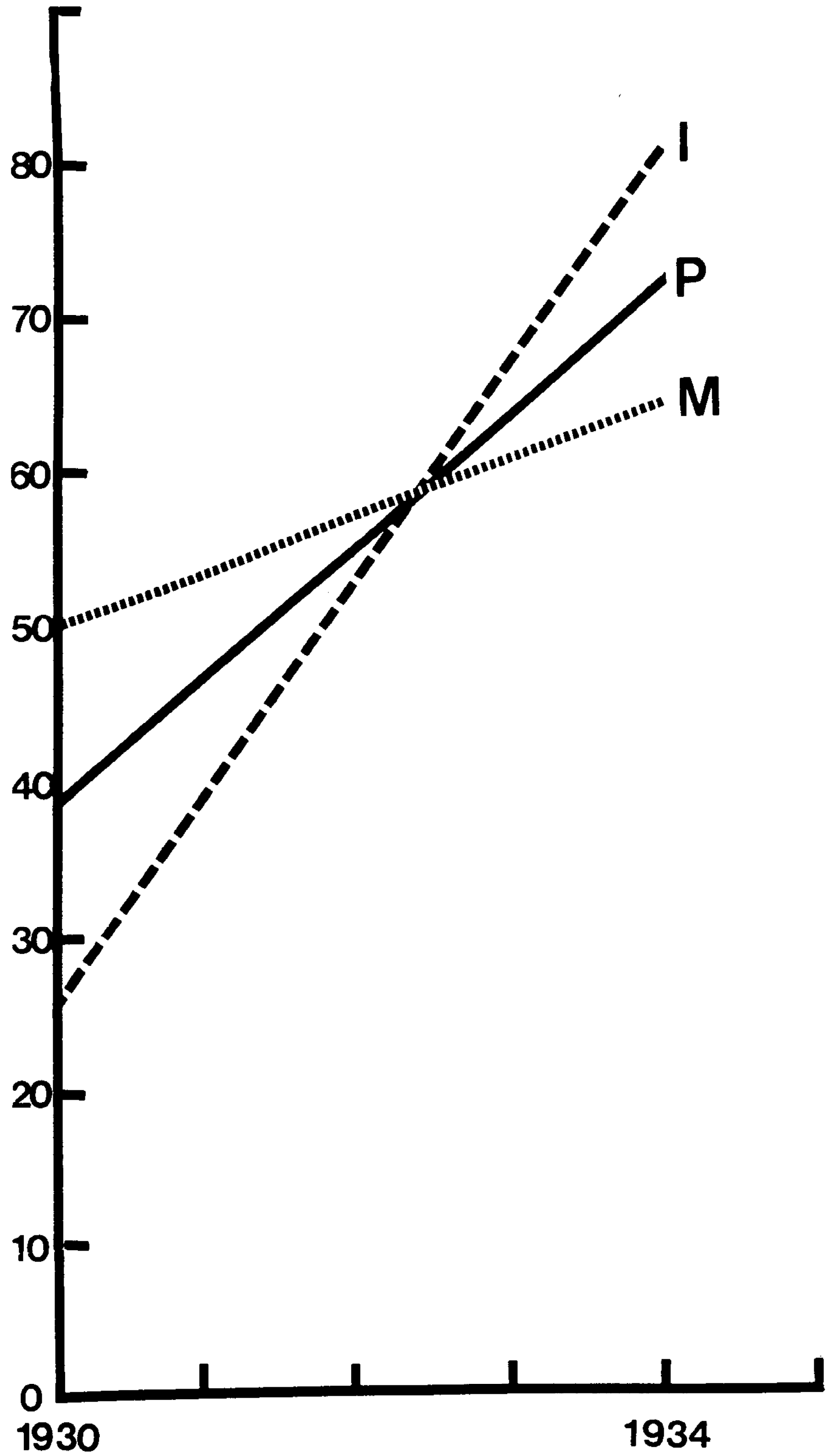


Figure 3. Frequency or number of cowbird females apparently laying per 100 pair of hosts (Y axis). Cowbird pressure on X axis. Solid line is expected, broken line is regression line of the observations. Example: Zimmerman (1966, p. 5-[illegible]) noted 5 cowbird eggs appeared in one Dickcissel nest in one day! At least 5 females laying on his area therefore. That number plus the mean number of host females (1[illegible].2) actively pair bonded for 10 day periods were used to find number of cowbird females per 100 pair hosts (35.2) at the [illegible] pressure involved.

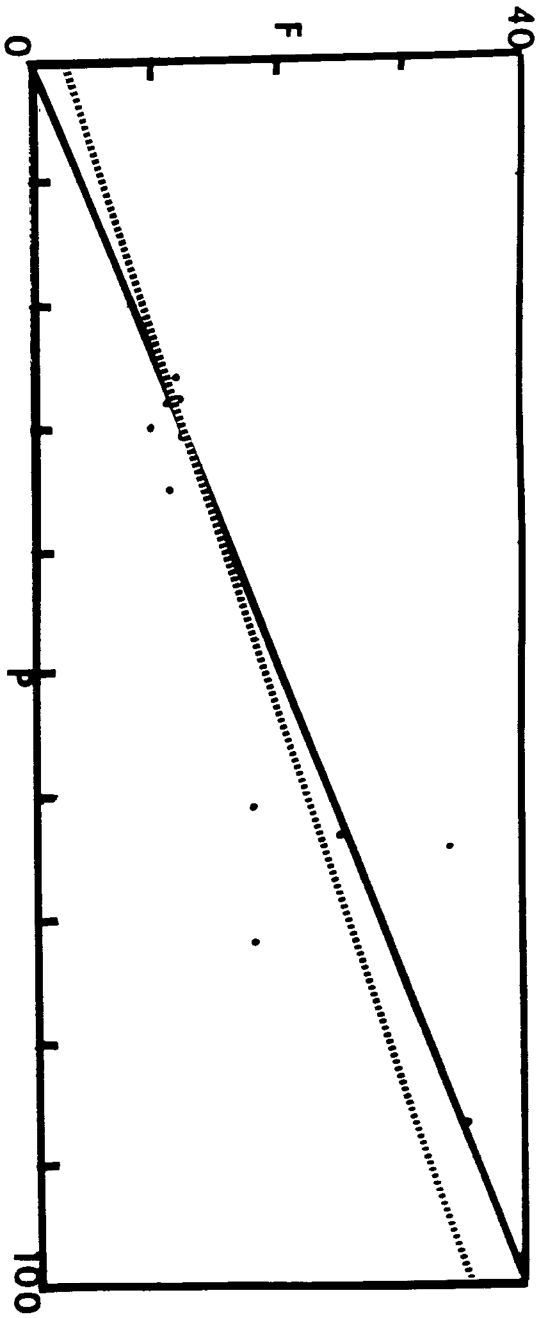
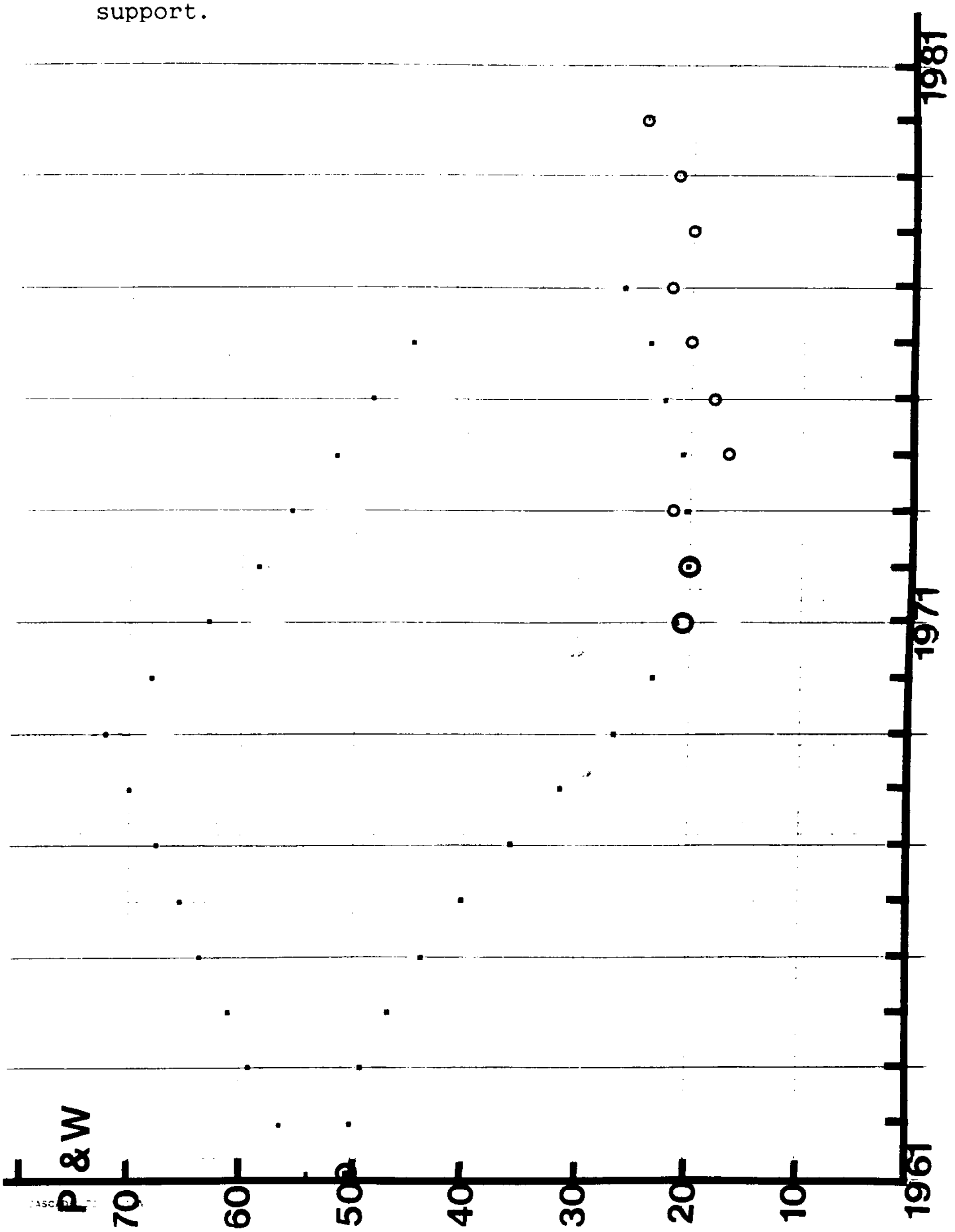


Figure 4. Experimental components model of Habitat-Kirtland's Warbler-Cowbird interaction from 1961 count to and through 1971 and 1972 counts (large circles). Cowbird pressure Y axis, K.W. counts on Y axis times 10, time on X axis. Note limit pressure point of 72 reached in 1969, a reversal of competitive advantage reversed the cycle and pressures began descending, while the warbler numbers bottomed and began to ascend (small squares) without the help of predator control. The small circles are counts subsequent to predator control. Note how the model predicts the slope of gain for the 4 years after the drop at the end of the 1973 season, due in part to predator control raising more young than the habitat would support.



The pressure scale calibrated in numbers of cowbird females per hundred pair of hosts as explained leads to an experimental components model, which Walters (1971) described as "realistic and precise". He also states "emphasis in experimental components modeling has been on prediction of the reaction of systems to disturbance and manipulations". Predator control was a disturbance and is a manipulation.

The Kirtland's Warbler is a larger warbler, the largest of its genus actually, and its pattern reflects this fact. It is a good host, and can bear the cowbird burden if it has plenty of optimum habitat. When losses are excessive it is but an indication of insufficient and suboptimum habitat.

Besides the feedback in the system, there is a set point and there are limit points where a reversal of competitive advantage takes place (Ayala 1971). Direction of the cycle then reverses itself and proceeds back through the set point and then to the other limit point (Figures 5 and 5a). All this indicates a well adjusted system comparable to a demostat (Sutton & Harmon, 1973, p. 153, Fig. 8.3). The predator can be seen to have an Allee effect--where a mid-area density permits a higher reproductive rate, therefore higher populations, than higher or lower densities would.

It was the rate of the habitat phase-out that was entered into the two models we presented. One model based on the straight 8% per year loss due to the phase-out fit the 60% drop exactly. The other, the more complicated experimental components model, factored in only half of the -8%, but only after allowing the cowbirds to take their toll. The result was the same, but the curve was of the damped type, at the two extremes. All inputs were from observations of others--only the interaction pattern, which the model is based upon, and the negative habitat factor were my contributions.

The way the observed warbler population paralleled the model's predictions after the drop following the second year of predator control, pointed up its accuracy and validity for analysis and prediction. In Walters' words "it is realistic and precise". This does not mean it won't need fine tuning as we gain more accurate knowledge of the inputs, however.

After 5 years of our insistence that it was the habitat, a report finally admitted there had been a 44% drop in the amount of useable habitat. Concurrently with cowbird control two severe drops to 167 singing males, thus assumed pairs, have occurred. Nearly one-fourth (23%) of the birds disappeared after only one year of predator control, and 20% were lost just when we needed them most for a good jump into the acreage of the Mack Lake VI burn. The genetic bottleneck resulting from these two episodes could have long lasting implications.

So the unproven hypothesis that the problem lay with the predator has been tested by removing it. The primacy of habitat considerations has been highlighted, for there has been no improvement in warbler breeders.

Figure 5. The Habitat-Kirtland's Warbler-Cowbird limit cycle on the good host pressure-frequency (X axis), % fledging success (Y axis) pattern. A and C are host limit points. A and D cowbird limit points. B is a threshold or set point where changes in fledging success take place for both host and cowbird. The amount and optimality of habitat would seem to be the controlling factor in the cycling and its control over host numbers, which in turn control cowbird numbers and frequencies with respect to the host numbers.

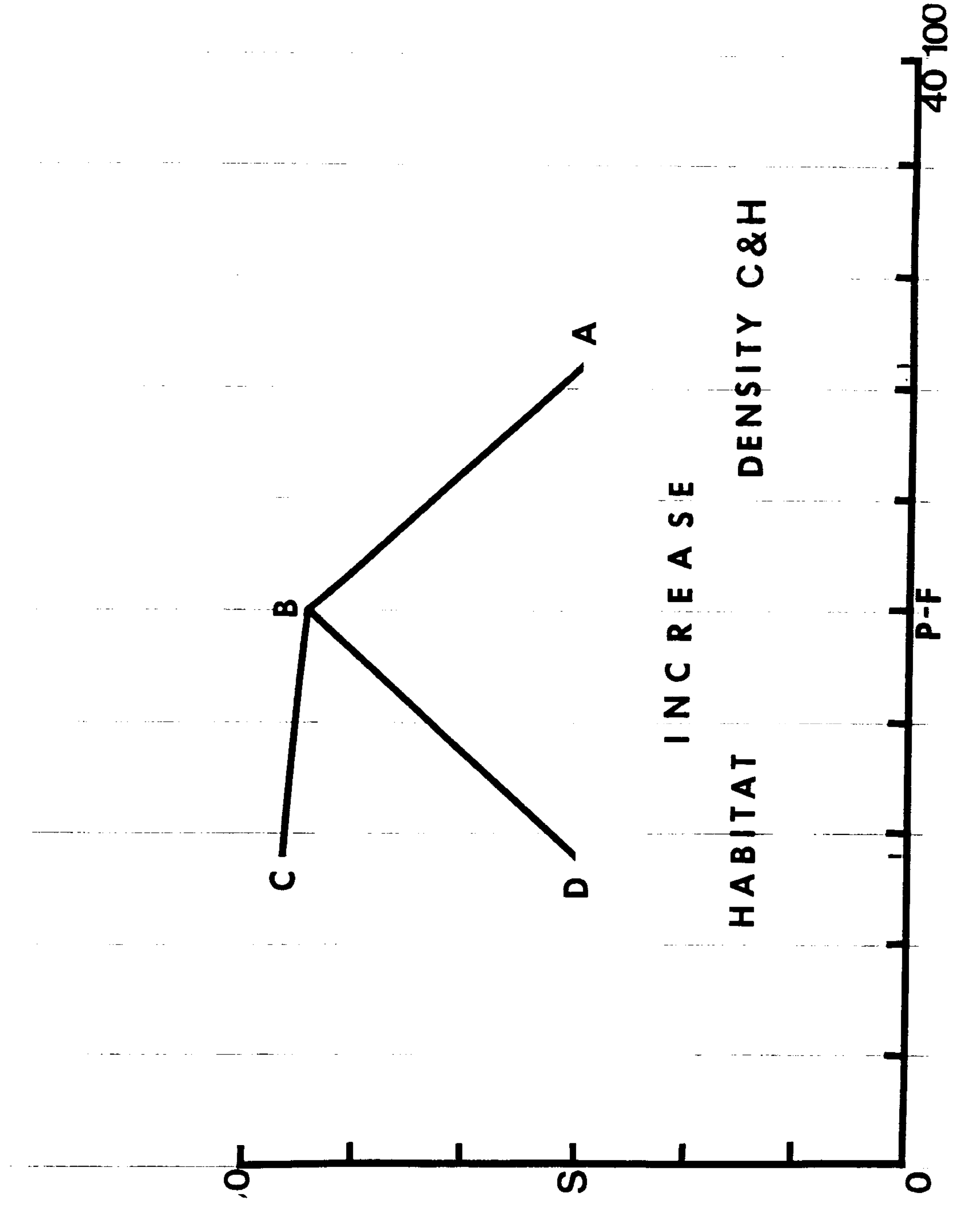


Figure 5a. Warbler fledging success on Y axis. F & P = cowbird frequency and pressure on X axis. Walkinshaw and Faust's (1974) data's confirmation of a reversal of cowbird pressure and cycle direction after the 72 pressure limit point was reached. • = observed fledging success. Arrows indicate direction of cycle. The two far left success points are after cowbird control. A secondary fire's area phasing-in (habitat again) was the cause of the improvement noted and the reversal of direction.

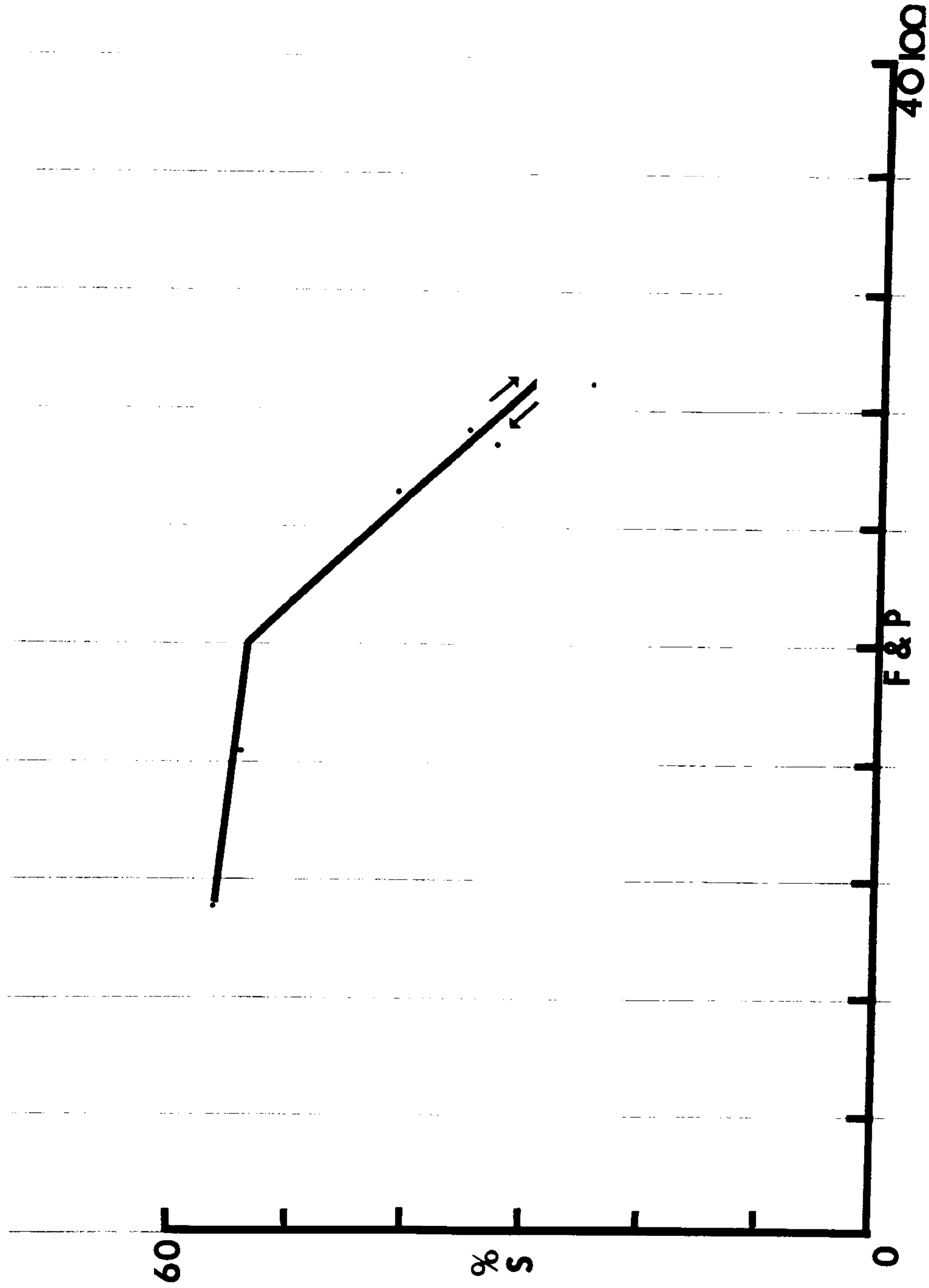


Figure 6. Build up of cowbird pressure (P) interrupted line, on Nice's (1937) song Sparrow population (B) solid line, highly suggestive of half a cycle. Note the drop in pressure after the 72 limit pressure was reached.

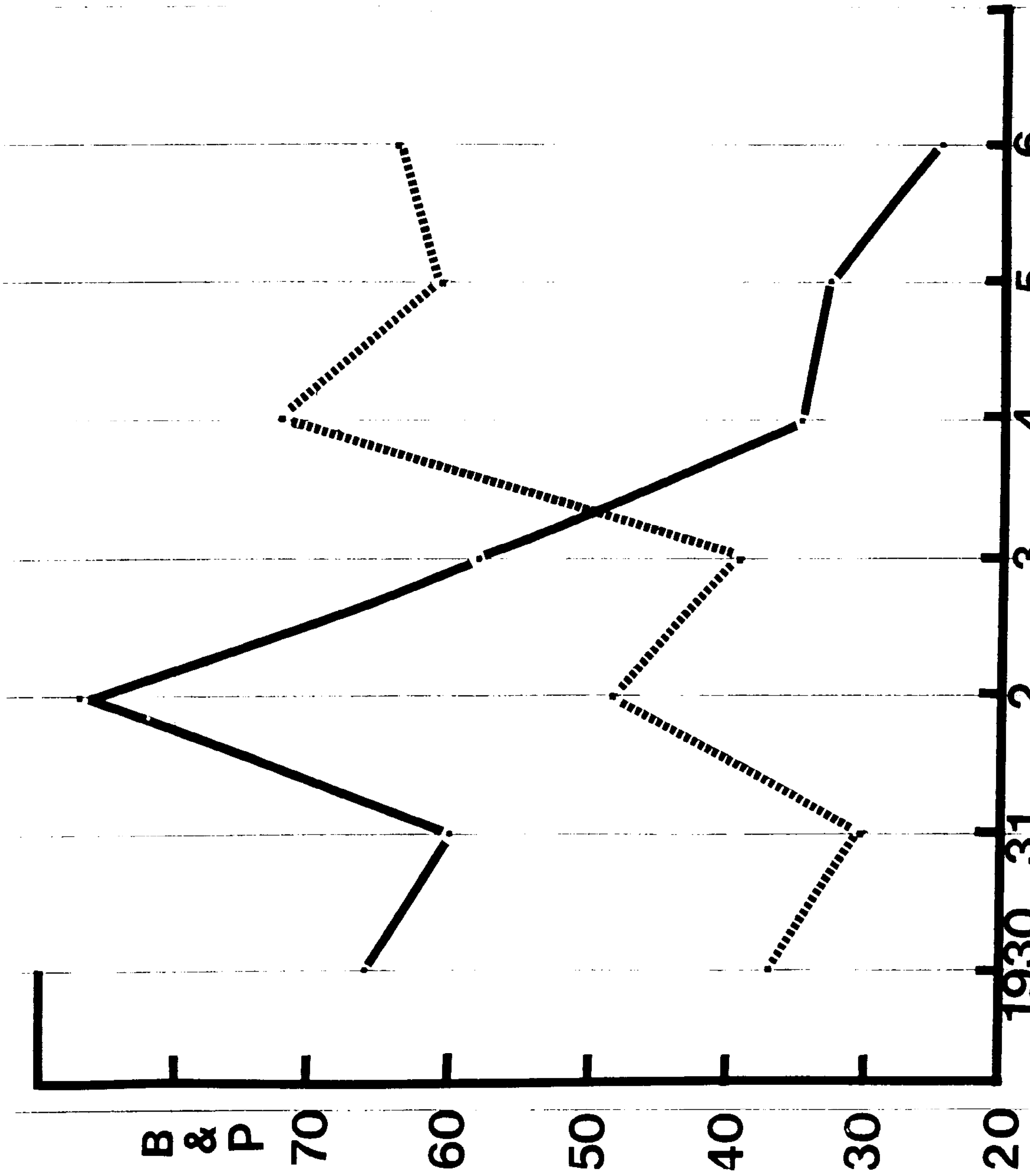


Figure 7. Williams' Ovenbird counts (B) over 18 years in a climax Beech-Maple-Hemlock forest, indicative of half a cycle.

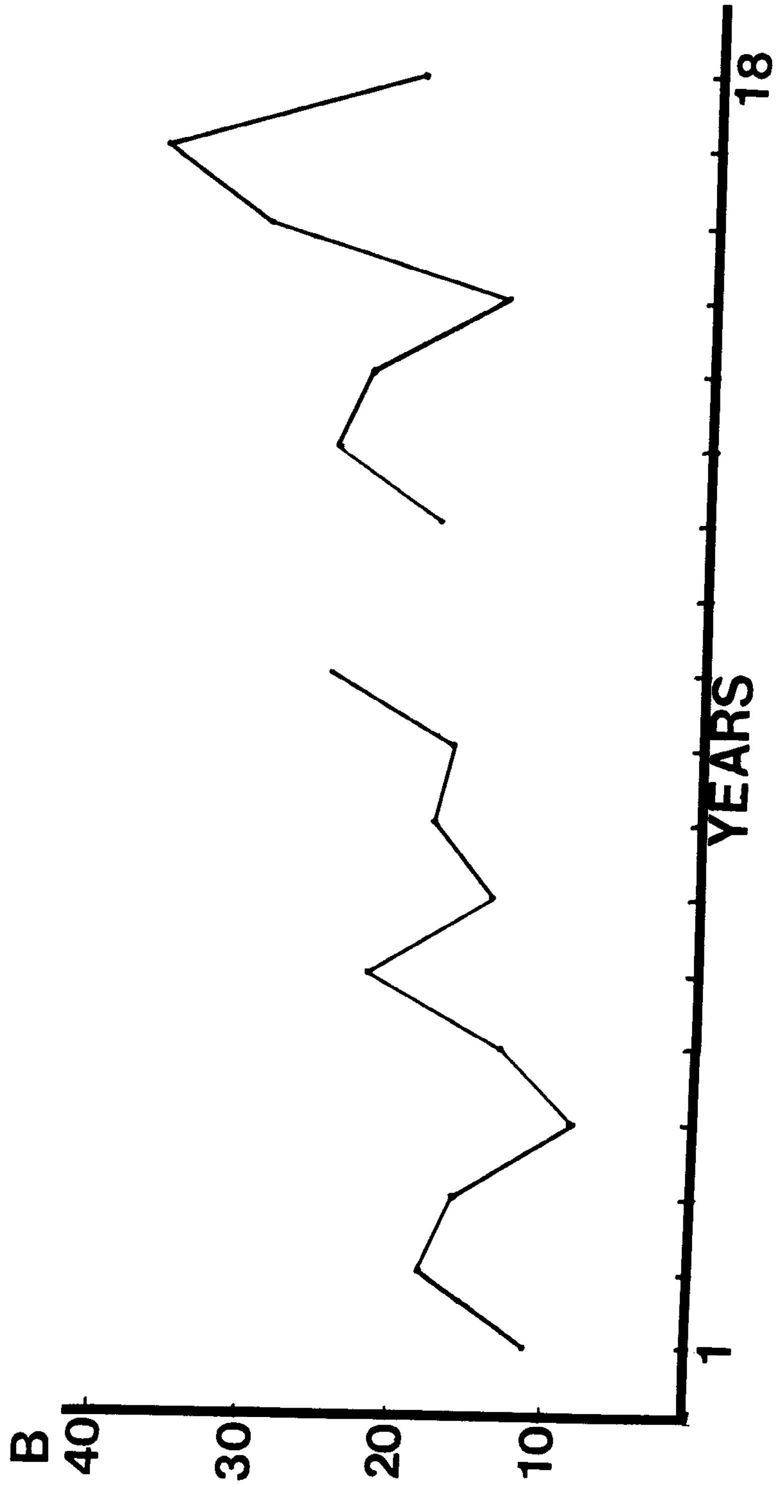
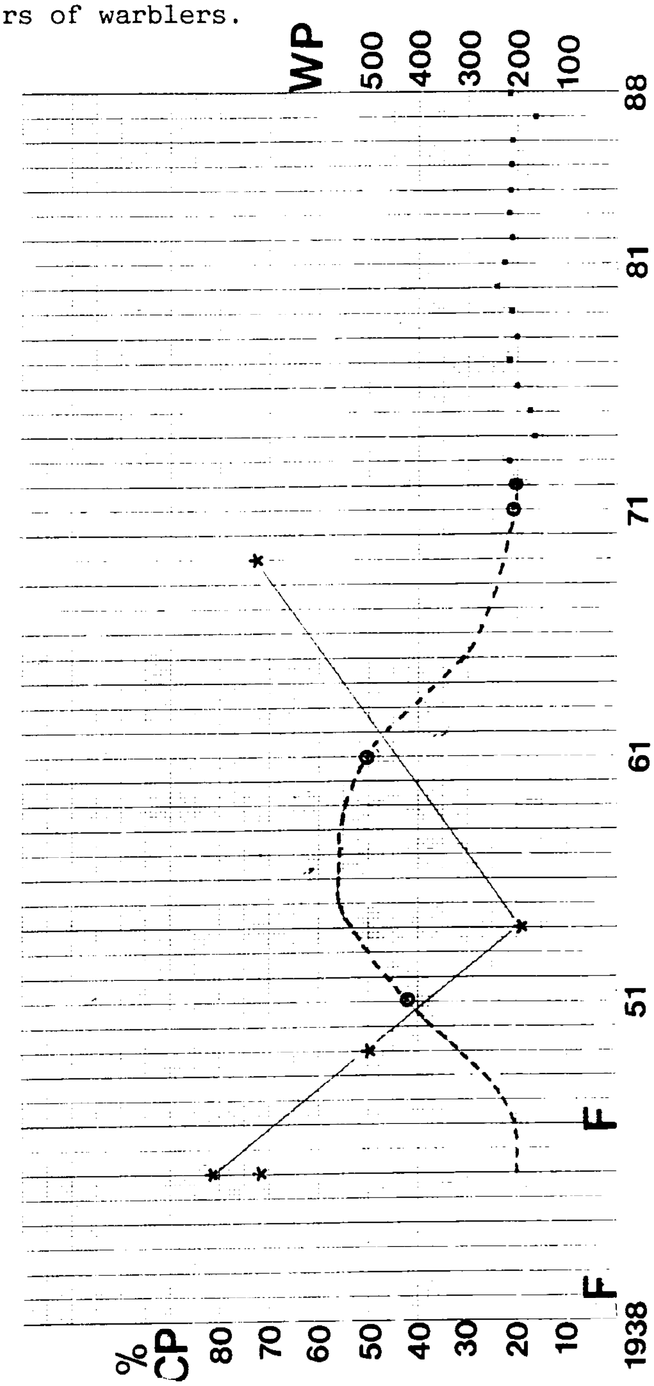


Figure 8. Hypothesized and calculated warbler cycle 1944-1972. Mayfield's percent cowbird parasitism of left Y axis, time on X axis, warbler population on right Y axis, 0 = census counts before predator control, • = census after control, * = limit points or mid-set points, on left from Mayfield 1960 and one on right from our model based on Radabaugh's and Walkinshaw's field work as well as Mayfield's counts. Dashed line is hypothesized warbler population to match these data. Lower limit point on left in 1944 is needed pressure for that limit point to operate. In essence, this is the productive history of two burns, Canada Creek and Mack Lake V on subsistence base of smaller areas before, during and since, supporting ca 200 pairs of warblers.



After all the noise has died down we are still faced with the fact that this large warbler like all other "K" species attempts to raise more young than the "K" or carrying capacity will support except in a limited period of sufficient optimum habitat, until "K" is reached. See A.O.U. report in appendix.

The predators take this doomed surplus. The 16 years of predator control have rejected the hypothesis that it was and is the predators causing the Kirtland's Warbler low. Predator-prey systems are stable, and the stabilizer is the predator. A continuum of proper quality habitat will give a continuum of warblers. Fluctuations in quality and quantity of habitat will be accompanied by fluctuations in warbler numbers. The prey tracks the habitat. The predator but tracts the prey.

Summary

The cowbird host interaction has been studied intensively over a period of 40 years. Where studies have been conducted long enough, limit cycles are beginning to appear as predicted. The habitat-Kirtland's Warbler-cowbird interaction is apparently such a cycle. This nomenclature places the elements in proper order of importance. The habitat is the vehicle, the warbler goes where the vehicle goes, the cowbird rides piggy-back and goes along for the ride. The so-called "classic" predator-prey cycle has never been identified in the field--that is, no predator causes a cycle. The concurrent phase-outs of two very large and important areas, Canada Creek and Mack Lake, were apparently the major cause of the 60% drop in warbler numbers. The hypothesis that it was the cowbirds which caused the drop has been tested for 16 years (that's longer than half a cycle!). It is not accepted.

Either there was not enough habitat provided for a rise in warbler numbers, or there has been continued degeneration of the winter grounds at the hands of man and this latter possibility seems removed by Sykes' report. The possibility still exists that higher intraspecific pressures due to excess warbler production (for the optimality or amount of habitat) caused by predator control may have had something to do with the disappointing results of the predator control program.

The program was effective in removing cowbirds, but not successful in that it gave no improved warbler numbers which was the original intent. It is a failure in that the 400 surplus birds fledged were not used to establish insurance colonies to the west where use if an already known migration route to alternate wintering grounds near Vera Cruz, on the Mexican gulf coast, would be possible.

The insights we now hold would not be possible without the devoted hours of field and laboratory work accomplished by the tireless workers who want this species to continue. We thank them and those who are here who obviously show the same interest and devotion. We wish them all well in their various efforts to save this specialist endangered species. I can assure you my interest and hope is the same as yours.

Thanks to Don Hart, then head of the G.M. computer lab for testing the model in 1972, and to Jerry Couture for programming the model into the computer (It was found to be extremely sensitive in their analysis).

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Appendix

Population biologists say:

Holling, 1964: Thresholds and limits are very important and their commonness in biology give a unique character to these systems.

Ayala, 1971: A shift of competitive advantage occurs at the equilibrium point (i.e. limit point). One only needs frequency dependent species for this to occur.

Pimental, 1961: Genetic equivalence is achieved in only a few generations between predator and prey. (Our model takes advantage of this unassailable truism by making host and cowbird input for egg production per female per year, and also adult and juvenal annual survival, equal at this early stage of modeling.)

Leopold, 1933: Expect surprising and perhaps dangerous results from too great an emphasis on predator control.

The A.O.U. Ad Hoc Committee on Scientific and Educational Use of Wild Birds, Supplement to Auk: 92, July "75 1A-27A. Page 6A: To evaluate the effect of removing birds from a wild population it is necessary to consider the present population levels, to understand that evolutionary processes produce a maximum rate of reproduction within the limitations of available energy resources, and to realize that frequently numbers of individuals are produced in excess of those that die or that the available habitat can support. (Von Hartman, 1971) in Avian Biology Vol I, Edited by Farner & King.

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ECONOMICS AND THE PRESERVATION OF KIRTLAND'S WARBLER

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Abstract--Arguments for perserving species are based often on biocentric, ecologic and economic grounds. After the preservation decision is made, economic analysis focus on questions of economic impacts (employment and income), efficiency (benefits and costs), and cost effectiveness (least-cost management). This paper presents a method for estimating the efficiency of managing Kirtland's warbler habitat on Michigan Department of Natural Resources and USDA Forest Service lands. These estimates must be based on timber stand inventory data provided by the agencies along with information on management strategies, timber yields, costs, and returns. Preliminary data are used to estimate the cost effectiveness of several alternative habitat management strategies. The paper concludes with a discussion of directions for future analysis and planning.

Introduction

The Endangered Species Act of 1973 provides the legislative mandate for preserving threatened and endangered species. From a societal standpoint, however, there are several perspectives related to preservation. When societies decide to preserve endangered species such as the Kirtland's warbler, these perspectives tend to converge. Analysis and planning at this point focus on the wise expenditure of public funds and its associated effects. These analyses are relevant particularly when public funds for natural resource management are limited.

There are four sections to this paper. First, an overview of economic concepts related to preservation is presented. The concepts of opportunity cost and cost effectiveness are emphasized. Second, a method is presented for estimating the efficiency of managing Kirtland's warbler on Michigan Department of Natural Resources (MDNR) and USDA Forest Service (USFS) lands. Third, the cost effectiveness of three habitat management strategies is examined. Finally, directions for future analysis and planning are discussed.

Economics and Preservation

Economists play a major role in analyzing natural resource conservation and preservation decisions. They do so by developing appropriate concepts and theories and by undertaking empirical analyses. Traditional economic concepts include equity and efficiency. Newer preservation-related concepts deal with irreversibilities, uncertainties, and safe minimum standards (Randall, 1987).

Equity concepts center principally on distributional (e.g., who benefits? who loses?) and economic impact (e.g., employment and income created or lost) aspects of natural resource programs. There are six techniques used commonly to assess economic impacts; they are: economic or export base, shift-share analysis, input-output analysis, linear programming, simulation, and econometric analysis. These techniques are described and compared in Propst and Gavrilis (1987).

Efficiency concepts focus primarily on benefits, costs, and intertemporal resource allocation. These concepts are based on individuals' views of value. These views lead to three societal perspectives related to preservation. They are: the biocentric perspective, the ecologic perspective, and the economic perspective (Petulla, 1980). Individuals with a biocentric perspective view the Earth and its natural components as manna from heaven. In this case, nature has value apart from Man. Those with an ecologic perspective espouse the value of species as part of a diverse web of life. Value is not based on the importance of a species' role per se; rather it is based on the fact that it has a role. Utilitarians have generally an economic perspective. They envision wisest and best use as an important management strategy (Petulla, 1980). Economic analysis of trade-offs is a common feature of the utilitarian approach.

With regard to benefits, individuals with biocentric and ecologic perspectives view the Kirtland's warbler as priceless. It is one of Nature's many masterpieces. Some individuals with extreme utilitarian perspectives may feel the warbler is worthless because it has no obvious market value. This financial viewpoint is too narrow for most economists.

Benefits of the Kirtland's warbler management program can be attributed to the warbler, to timber products, and to other resource outputs such as nongame use, game use, and so on. Timber sales yield market benefits whereas the other goods and services provide nonmarket benefits. Costs can be categorized as program costs, habitat management costs, other resource management costs, or opportunity costs. The inclusion or exclusion of particular benefit and cost categories depends on the objective of the analysis being performed.

Economists have developed three nonmarket concepts which are relevant to the preservation of endangered species; they are: existence value, option value, and bequest value. Existence value is based solely on knowing a resource exists irrespective of any use (value) an individual enjoys. People around the world may value the Kirtland's warbler simply because it exists. Individuals who want to maintain their future opportunities to view the warbler are said to have an option value for the resource. That is, people value the option for future use (as opposed to extinction and no future use). Bequest values are attributed to individuals' desires to preserve species for future generations. These values are estimated using appropriate survey techniques and are based on contingent or hypothetical markets (Walsh et al., 1984). The surveys elicit individuals' willingness to pay for preservation.

Data can be gathered from managing agencies related to 1) program or administrative activities, 2) direct habitat management activities and 3) other resource management activities. These cost and benefit data can be used to estimate the cost of opportunities foregone. This is referred to as the opportunity cost or the net benefit (benefits-costs) of the next best alternative (Gittinger, 1982). By defining the next best alternative, the analysis includes the economic efficiency implications with the program versus without the program. If all benefits and costs are quantified, net benefits are positive for acceptable programs and society is better off with the program, assuming distributional aspects are satisfactory.

Unfortunately, all benefits and costs are not readily quantifiable. Cost-effectiveness analysis is used commonly to determine the least-cost means of achieving a given end or management objective. In this case, the objective can be in any relevant unit (e.g., acres of habitat created, miles of road constructed, etc.). The preferred management strategy is the one that minimizes the discounted or present value of future management costs per unit of output.

Newer preservation-related economic concepts involve quantifying benefits and costs in some cases, but they tend to be more overtly normative than the concepts discussed above. One concept, irreversibility, gets at the heart of most concerns regarding endangered species. Extinction is irreversible; therefore, species should be maintained if the cost to do so is not prohibitively high.

Uncertainty and risk are related concepts. Uncertainty is associated with future events for which there is no known probability of occurrence. On the other hand, risk implies that some objective or subjective probability can be assigned to future events (Knight, 1921). Extinction precludes any positive benefits attributed to a species from occurring; the probability of benefits is zero. To maintain options for accruing future benefits, preservation is the appropriate policy option.

Bishop (1978) identified an important operational concept dealing with the economics of preservation; it is the concept of the safe minimum standard (SMS). The SMS approach requires that a population level be maintained at a sufficiently high level to reduce the probability of extinction to an acceptably low level (Randall, 1987). From an analysis standpoint, the preservation decision is viewed in light of program and management costs as well as the cost of opportunities foregone. This approach is imbedded in national forest plans through the maintenance of minimum viable populations.

Once the preservation decision is made, policy makers and managers concentrate on the economic impacts, efficiency, and cost effectiveness of their programs. The next sections of this paper describe the application of efficiency and cost effectiveness concepts to Kirtland's warbler habitat management.

Efficiency and Habitat Management

Olson (1982) developed an economic analysis of the Kirtland's warbler program on USFS and MDNR lands. He examined program costs and costs of jack pine management with and without emphasis on the Kirtland's warbler. An approach for updating and expanding Olson's analysis to include all vegetative types is presented in this section.

The objective here is to analyze timber management with and without Kirtland's warbler habitat requirements. As a result, costs associated with program management, cowbird trapping, trail relocation, and road closure are not included. Further, only timber benefits are included. This partial analysis could be expanded to include additional costs and benefits.

The proposed approach includes five steps:

1. Transfer Operations Inventory (MDNR) and Vegetative Management Information System (USFS) data to a common data base,
2. Update Kirtland's warbler area data,
3. Define current and alternative vegetative management strategies,
4. Gather data for management strategies, and
5. Schedule harvests and habitat creation.

Basically, this approach requires that the Kirtland's Warbler Recovery Plan (1976, 1985) be updated and computerized to provide a basis for the timing of investments.

The first step highlights the need to build a linkage between two mainframe data bases. Microcomputers may provide a sufficient means for this linkage. The MDNR has developed a microcomputer data base for its Kirtland's warbler management areas. The USFS, which is expanding its use of microcomputers, is considering opportunities to do so. This linked data base will provide a systematic means for monitoring habitat conditions across all ownerships. For preliminary analysis included in this paper, data from the MDNR and USFS were loaded into a microcomputer spreadsheet.

The stand-based data noted above has been updated and is awaiting review by field staff. For the MDNR, the update involved splitting acreages of several stands that occur in more than one cutting block. For the USFS, this process entailed the assignment of management area, management unit and cutting block to individual stands in the data base. Tables 1 and 2 present acreage comparison by ownership for vegetative types and jack pine, respectively. These tables do not include the USFS's Mack Lake Management Area. The original area was 10,410 acres; as a result of the Mack Lake fire in 1980, there is a potential to expand this area to 14,350 acres. If the expansion occurs, the total acreage of Kirtland's warbler critical habitat on MDNR and USFS lands will be 136,198 acres.

The guiding habitat management objective is to create habitat through area regulation of each management unit. When aggregated, this insures the regulation of all management areas. Using area regulation with 5 age classes, approximately 27,000 acres should be in each age class. As a result of MDNR and USFS management and the Mack Lake fire, more than 34,000 acres of habitat have been regenerated in the last 10 years. This provides the best opportunity for increasing warbler populations in decades (see table 2). It also raises the question of whether more intensive management should be pursued (i.e., using a 40-year rotation instead of a 50-year rotation). At this time, field review and discussion of management options is needed.

Table 1. Acreage Comparisons by Ownership and Vegetative Type, 1988

Vegetative Type	Ownership MDNR	USFS	Total
Jack pine	68,436	35,442	103,878
Red pine	4,520	3,053	7,573
Oak/Oak-pine	1,333	4,928	6,261
Other	3,649	487	4,136
Total	77,938	43,910	121,848

Note: **Excludes Mack Lake Management Area.**

Table 2. Jack Pine Acreage Comparisons by Ownership and Age Class, 1988

Age Class	Ownership MDNR	USFS	Total
0-9	14,637	9,926	24,563
10-19	7,817	3,681	11,498
20-29	12,404	2,196	14,600
30-39	5,586	3,241	8,827
40-49	6,719	5,601	12,320
50-59	11,429	6,674	18,103
60+	9,844	4,123	13,967

Note: Excludes Mack Lake Management Area.

The third step in estimating management efficiency is to define current and alternative vegetative management strategies. This step has been completed to a large extent. Unlike Olson's (1982) analysis, this step must include conversion of non-jack pine types to jack pine (see table 1). Strategies for managing other types represent a significant component of the opportunity cost.

The fourth step includes gathering specific data on expected timber yields, management costs, and returns. This data has been gathered and can be used for preliminary analysis. The final step in this process is to schedule timber harvest and habitat creation using data and information collected in the first 4 steps. Then a comparison can be made between management which follows the proposed plan and an alternative based on maximizing net returns (i.e., opportunity cost). The scheduling of plan activities must be based on management units whereas the opportunity cost analysis should be based on the entire acreage. The aggregation of management unit schedules provides the basis for a comprehensive habitat management plan. A preliminary analysis of this type has been completed using a spreadsheet-based model developed by Leefers et al. (1988).

By developing the plan in computerized form, the effects of alternative management strategies can be examined. For example, the implications of habitat purchases can be incorporated. Also, the introduction of fuelbreaks could be analyzed from an efficiency standpoint as well as a habitat standpoint. Finally, the results of more intensive management can be assessed.

Cost Effectiveness and Habitat Management

In the preceding section, the third step is to define current and alternative management strategies. As part of this process, cost-effectiveness analysis can be used to determine the least-cost means of creating habitat. Probst (1987) has identified many habitat management strategies for Kirtland's warbler habitat. In this section, the cost effectiveness of three strategies is compared. The strategies are: (1) shelterwood harvesting of jack pine followed by prescribed fire and planting, (2) burning jack pine stands at age 25 followed by planting, and (3) burning jack pine stands at age 50 and assuming natural regeneration. All analyses are based on USFS costs and returns (1988 dollars), a 4-percent real discount rate, and management of a newly regenerated stand. The present value estimates are based on a 50-year time horizon for comparability (see table 3).

The shelterwood strategy includes a partial harvest at age 40, but no final removal at age 50. Instead, site preparation using fire is followed by fill-in planting and a stocking survey. The prescribed fire is assumed to kill the residual stand. At age 40, sale preparation and harvest administration costs are incurred, and seven cords per acre are harvested and sold at $9.33 per cord. At age 50, site preparation (fire) costs $45 per acre, fill-in planting over one-fourth of the area costs $62.50 per acre, and a follow-up stocking survey costs $3 per acre.

The "young burn" strategy assumes that the prescribed fire at age 25 will kill the stand. This is intended to mimic a wildfire. The fire at a cost of $45 dollars per acre is followed by full planting and a stocking survey. This process is repeated in year 50.

The "old burn" strategy at age 50 replicates a wildfire in a mature jack pine stand. The prescribed fire treatment cost is assumed to be

$75 per acre, considerably more than the cost assumed in the other strategies. Complete regeneration is assumed in this case. The fire is followed by a stocking survey.

In cost effectiveness analysis, the "best" alternative is the one that achieves an objective, such as habitat creation, at the least cost. The results are contingent on the assumptions. This analysis is based on very stringent assumptions. For example, fire management costs do not include any allowance for catastrophic, escaped fires. Further, regeneration success is assumed to be high under the shelterwood and "old burn" strategies. By altering the assumptions (including current stand age), different estimates of cost effectiveness can be estimated. Nonetheless, the shelterwood strategy appears to be the most cost effective approach. This lends credence to the philosophy of providing timber outputs as a byproduct of habitat creation. The "young burn" strategy which would be used for intensive habitat management is the least cost effective.

Table 3. Cost Effectiveness of Three Habitat Management Strategies (In 1988 Dollars)

Management Strategy	Present Value of Net Returns	Timing of Return or Cost	Return	Cost
		(Year)		
Shelterwood	-$4.29	40	$65.31	$11.25
		50	---	110.50
Young burn	-76.86[1/]	25	---	298.00
		50	---	298.00
Old burn	-10.98	50	---	78.00

1/ The present value of this strategy is - $153.72; one-half of the net return is reported because critical habitat would have been created twice following this strategy.

Directions for Future Analysis and Planning

Before any comprehensive analysis of Kirtland's warbler habitat management can be undertaken, the Recovery Plan must be updated. Field personnel must review conditions within individual management units and realign cutting blocks if necessary. This will require a coordinated effort between the MDNR, and USFS, and the United States Fish and Wildlife Service.

As part of the updating process, these agencies should develop a merged data base that can be used for monitoring and evaluation. Preliminary analysis of MDNR and USFS databases indicate that habitat creation exceeded planned amounts in the last 10 years. This excess was due principally to the Mack Lake fire. Further, planned harvests were sometimes replaced with stands having insect and disease infestations. As a result, modifications should be made in the current plan. Monitoring in a common database can help guide these adjustments.

In the future, the USFS and MDNR will incorporate geographic information systems in their management and planning processes. Geographic information systems will provide the means to examine spatial and temporal relationships within management areas and management units and between management areas. This will enhance managers' abilities to examine complex habitat management strategies. The Kirtland's warbler critical habitat areas should be a high priority when these systems are implemented.

A process for integrating the Kirtland's Warbler Recovery Plan into USFS and MDNR plans must be developed. Currently, the Huron-Manistee National Forests' plan is being implemented piecemeal through analysis of opportunity areas. These areas are contiguous, and critical habitat areas have been divided among opportunity areas. Coordinated planning of these areas is required to insure proper implementation of the Recovery Plan. The MDNR is developing state forest plans at this time. These plans will be based on forestwide analyses. An updated Recovery Plan can be used to provide "bottom-up" input in these efforts.

Researchers at Michigan State University of Michigan are creating ecological classification systems for the MDNR and USFS. These systems hold great promise for increasing managers' understanding of complex ecosystem relationship. In the future, these systems will be incorporated in all forest planning efforts, including those involving the Kirtland's warbler.

Finally, the establishment of over 34,000 acres of regenerating jack pine in the last decade offers a great opportunity for managers and researchers to explore alternative management strategies for Kirtland;s warbler habitat. This opportunity will be short-lived if more intensive management is not pursued.

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KIRTLAND'S WARBLER AT THE CROSSROADS: EXTINCTION OR SURVIVAL

Dr. Paul Aird

Concluding Remarks

Throughout this Symposium we have been approaching the crossroads -- the point where we must choose which direction to take to manage the endangered Kirtland's warbler (Dendroica kirtlandii Baird) in its natural habitat.

We have been cordially welcomed by McCormick, Marita, Lowry, Dodge, and Bails; skillfully moderated by Byelich, Taylor, Weinrich, Mahalak, Irvine, and Boushelle; and ably addressed by a variety of speakers, panelists, and members of the audience.

We are especially grateful for the opportunity to meet and to learn from those who have devoted so much, in some cases more than a half-century of their lives, to sustaining the existence of the Kirtland's warbler. Without their noble efforts, it is clear that the species would be extinct by now.

The Kirtland's Warbler Recovery Team, which has evolved from their efforts, deserves the nation's highest award for sustaining the Kirtland's warbler on earth, and for setting the pattern to achieve the recovery of other endangered species throughout the world.

This outstanding success is due both to the senior contributors, like Mayfield, Walkinshaw, Cuthbert, Byelich, Radtke, Irvine, and Jones, and to many others, like Carol Bocetti, who is blazing the trail to reintroduce endangered species into their natural habitats.

Humans now dominate the world. Our biomass has grown to about 250 million tons, which exceeds the weight of any other animal species. We were once just a partner with the other life forms on earth. Today, we are their keepers too.

The depletion or the destruction of the genetic diversity of life is the heart of the environmental problems facing us. A reduction in genetic diversity or the loss of a species is irretrievable. While we can often reverse the pollution process, we cannot replenish a diminished gene pool or resurrect an extinct species.

This Symposium has focused on the biology and management of just one of the world's species that is close to extinction -- the Kirtland's warbler. A mere 215 adult males were located in jack pine (Pinus banksiana Lamb.) stands in the 1988 census. By doubling this number, we estimate the world's breeding population at less than 500 birds, threatened by human intrusion, habitat loss, and nest parasitism by the Brown-headed Cowbird (Molothrus ater Boddaert).

Endangered and extinguished species are warning signals. They are bioassays, or bio-indicators of the road to the future. To ignore them is one route to take; to learn from the extinguished Great Auk (Pinguinus impennis L.) and the Passenger Pigeon (Ectopistes migratorius L.), that we must help other species endangered by human interference, is another way.

It is not everyone's task to restore the Kirtland's warbler throughout its former range -- it is our task. It will be accomplished by the people who have participated in this Symposium, with the support of just a few other willing and dedicated partners.

The formal presentations at this Symposium may be divided into 10 parts: 1 part dealing with economics, 2 parts with the life history of the species, 2 parts with habitat research, and 3 parts with habitat management. Mix them together, and you have the key to the survival of an endangered species. It requires a balance between biological research and management to understand the Kirtland's warbler ecosystem, and to manage that system to sustain the genetic diversity of all the species within it.

During this Symposium we have become aware of the need for new partnerships and cooperative efforts. In the case of the Kirtland's warbler, the main lines of cooperation are well established between the federal and state governments, the military base, and some of the conservation groups.

But there are institutional limitations as well. More attention should be devoted to a coordinated program of public education and awareness of the benefits of integrated forest management. The Kirtland's warbler management program is an outstanding example of this, where logging, warbler production, and recreation pursuits occur on the same land at different times in the forest rotation.

Cooperative funding is another aspect that needs further development, not only with our friends in the conservation organizations, but in the corporate arena too.

The black cloud on the horizon is the lack of continuity in funding for habitat management and research. This was mentioned frequently throughout the Symposium. Three of the five speakers that presented the welcoming addresses introduced us to this problem. Further information was provided by other speakers, and through personal interaction at the social gatherings and refreshment breaks.

It has been unsettling to learn:

- that there is not enough money to regenerate the jack pine breeding areas needed to sustain the growing population of Kirtland's warblers after the Mack Lake habitat becomes unsuitable for nesting;

- that the budget for the management of the Kirtland's warbler is likely to be cut further; and

- that the U. S. Fish and Wildlife Service will terminate its Kirtland's warbler research program funded by the Patuxent Research Center, on September of this year, just when it is producing beneficial results. In this latter case, it seems that the interagency partnership is collapsing.

Many people throughout the world are anxiously watching the Kirtland's warbler. We hear of its mellifluous song, and we hear of inadequate funding to sustain the species. We see it as a precious resource, and we see cutbacks in the commitment to sustain it. We are people dedicated to the task -- it's in their souls, but they are deprived of the operational money and the tools to achieve the goal.

Survival of the Kirtland's warbler is still in doubt. We must look beyond the bottom line at the vital issue.

Sylvia Taylor said: "To know it is to love it." Bob Radtke said: "To care for the least of them is to care for life itself." People do care. This is the joy of this Symposium, to be among so many people who care.

Their efforts are rewarding. Harold Mayfield informed us that, without management, the trend line was for the species to be extinct by 1978, caused by human interference. But through wise management, particularly through habitat management, the species still exists, and the trend line is slightly up.

The living resources of a nation are its greatest treasure. The highest priority in the land must be to sustain this treasure -- to keep our options open for the earth's flora and fauna, for the benefit and enjoyment of succeeding generations of people throughout the world.

So in conclusion, let us take Robert Frost's route, the road less travelled by, the road that combines economics with cultural, aesthetic, moral, ethical, and scientific values -- the road to knowledge and understanding that the presence of the Kirtland's warbler on earth justifies its continuing existence. Long live the Kirtland's warbler!

In closing, I offer our thanks to the many contributors to this outstanding Kirtland's Warbler Symposium, including people from the U.S. Forest Service, the U.S. Fish and Wildlife Service, the Michigan Audubon Society, the Michigan United Conservation Clubs, the Michigan Department of Natural Resources, the North Central Forest Experiment Station, the Patuxent Wildlife Research Center, the Michigan Universities, other universities, the Kirtland's Warbler Recovery Team, nature writers, sill others, and especially -- "Rex" Ennis, Cindy Whipple, Horace LaBumbard, Frank Haubry, and Jerry McCormick. The U.S. Forest Service is to be congratulated for organizing this Symposium, and for doing such an excellent job.

I must also offer our thanks to the Kirtland's Warbler species, whose mysterious mating fire brings it north to the jack pine forest each year, and which brought us together for this outstanding Symposium on its behalf.