

The conservation management of Kirtland's Warbler *Dendroica kirtlandii*

CAMERON B. KEPLER, G. WILLIAM IRVINE, MICHAEL E. DeCAPITA
and JERRY WEINRICH

Summary

Kirtland's Warbler *Dendroica kirtlandii* breeds in young jack pine *Pinus banksiana* forests on sandy soils in Michigan's lower peninsula, where there were 502 censused singing males in 1951 and 167 in 1974 and 1987. An ongoing control programme for the Brown-headed Cowbird *Molothrus ater*, a nest parasite, resulted in immediate and continued improvement in warbler reproductive success which was not, however, matched by an increase in warbler numbers until the 1990s. From three 1,000 ha reserves in the 1960s, currently over 54,000 ha are managed for the warbler. Despite the establishment of managed plantations, over 70% of warblers censused in the past 15 years have occupied habitat created by wildfires. Optimal habitat consists of more than 5,000 trees per hectare in a mosaic of dense patches interspersed with small openings. Nearly 70% of adult and 30% of juvenile warblers departing for the Bahamian wintering grounds return each spring, and the Michigan singing male population increased from 212 (1989) to 397 (1992) as abundant habitat, resulting from a 1980 wildfire, became available at Mack Lake. This suggests that lack of optimal habitat in Michigan has been the species's major problem.

Introduction

Since the discovery of its first nest in 1903, Kirtland's Warbler *Dendroica kirtlandii* has been known to breed only within an area approximately 120×160 km in northern Lower Michigan (Mayfield 1960, Probst 1986). The species is further restricted to young stands of jack pine *Pinus banksiana*, most of which have resulted from wildfires. Although jack pine ranges from Lower Michigan north-west across Canada to south-east Alaska, and north-east to Nova Scotia, Kirtland's Warblers breed only where it grows on or near the porous Grayling and related sands of Michigan (Mayfield 1960, Walkinshaw 1983). Stands of jack pine occupied by the warbler range between 1.7 and 5.0 m in height (Probst 1986) and are normally 6–24 years old.

Studies in the 1930s by van Tyne and Mayfield (Mayfield 1960) led in 1951 to an estimate of the Kirtland's Warbler population, the first for any passerine species: 432 singing males were counted, and the pre-breeding population was estimated at c.1,000 birds. Ten years later the count yielded 502 males, indicating a relatively stable population. Even so, concern for the species led to its inclusion on the first list of rare and endangered wildlife in 1966 (CREWS 1966). The third decennial count (1971) located only 201 males (Mayfield 1972),

a 60% decline. A recovery team, assembled in 1975, completed a plan for the species's long-term survival in 1976 (Byelich *et al.* 1976).

There was much speculation on the causes of the precipitous population decline observed in 1971 (Ryel 1981, Probst 1986, 1991). Research and management programmes, many rooted in the work of Mayfield (1960) and Walkinshaw (1983), were applied, with varying success, to determine how best to manage the small Kirtland's Warbler population. These efforts focused on controlling the Brown-headed Cowbird *Molothrus ater*, providing optimal habitat, and determining if major stresses to the population occurred during migration or on the wintering grounds. Here we examine the accumulation of understanding and application of management programmes over the two decades to 1990.

The Brown-headed Cowbird

Originally a bird of the prairies of central North America, the Brown-headed Cowbird followed agricultural development into Michigan in the nineteenth century. By the early twentieth century, shortly after the discovery of the first Kirtland's Warbler nest, cowbirds were found to be nest parasites on the species. Mayfield (1960) found that 55% of 137 completed clutches (1944–1957) were parasitized, and productivity was reduced by 60%. Walkinshaw (1983) reported that 69% of Kirtland's Warbler nests (1966–1971) were parasitized, with only 0.8 fledglings per nest. When the Kirtland's Warbler population dropped to 201 singing males in 1971 (Figure 1), an interagency cowbird control effort was implemented (Shake and Mattsson 1975).

The U.S. Fish and Wildlife Service (FWS) began trapping and removing Brown-headed Cowbirds from Kirtland's Warbler nesting areas during the 1972 breeding season, and the programme continues to this day (Kelly and DeCapita 1982, DeCapita 1991). Standard cowbird traps, also known as decoy traps or modified Australian crow traps (Shake and Mattsson 1975), are stocked with white proso millet on a screen tray, water, and about 12 live colour-marked cowbird decoys. Cowbirds and other bird species, attracted by the food and decoys, land on top of a recessed entry panel, fold their wings, and drop through into the trap. Three FWS employees each travel c.200 km daily to tend the traps from mid-April through June each year. Cowbirds and other birds in the trap are removed by herding them out through a square opening into a portable wire cage attached to the outside of the trap. Cowbirds are dispatched by asphyxiation or cervical dislocation and their bodies used in other programmes. Non-target birds are banded and released.

From 1972 through 1992, 84,937 cowbirds were removed from Kirtland's Warbler nesting areas, at an average of 117.8 cowbirds per trap (Table 1). Although the local breeding population is almost completely removed each spring, these data indicate that cowbirds repopulate the affected areas in large numbers each year.

From the beginning, trapping had a positive effect on the reproductive success of Kirtland's Warbler. Walkinshaw (1983) documented an immediate decrease in nest parasitism and an increase in warbler fledglings. Nest parasitism declined to 6.25% of 32 nests the first year of large-scale cowbird

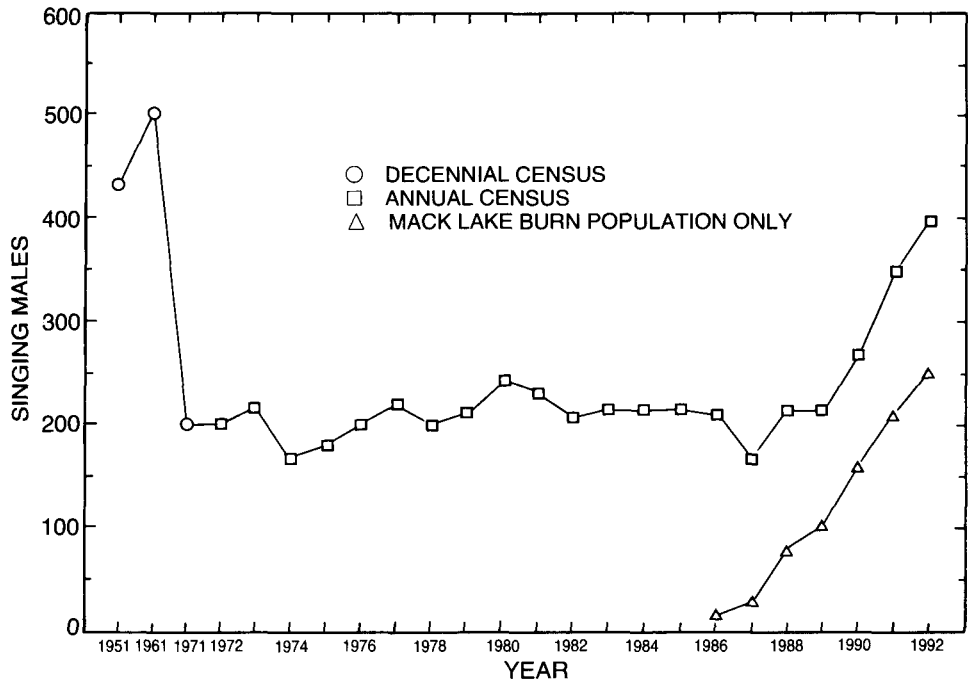


Figure 1. Census of singing male Kirtland's Warblers, 1951–1992.

removal, and fledglings per nest increased to 2.72, while combined data from 1972–1977 showed that 6.1% (14 of 230) of nests were parasitized, with 2.67 nestlings fledged per nest (Walkinshaw 1983). A 2% nest parasitism rate was found in 48 nests studied in 1989–1991 (Bocetti 1994).

Most biologists are convinced that the Kirtland's Warbler owes its continued existence to the cowbird control programme. However, in spite of the greatly augmented reproductive output by the warbler, there was no concomitant increase in its numbers until 1990. Each year since 1971, censuses of all known Kirtland's Warbler colonies were organized by the Michigan Department of Natural Resources (MDNR) and the U.S. Forest Service (FS). Between 1971 and 1989, the number of singing males averaged 207, ranging from 167 to 243, a fluctuation of less than 20% over the 19-year period (Figure 1).

Habitat

Most endangered species have been seriously stressed by habitat loss, and while the majority of them occupy stable habitat in later successional stages, Kirtland's Warbler nests in an early stage of a pioneer forest type that develops shortly after fire. There is historical evidence that jack pine forests in Michigan burned about every 30 years (Simard *et al.* 1983). The frequency of fires in northern Lower Michigan increased soon after Michigan's logging era began in the mid-nineteenth century, and culminated in the great fire of 1871 which burned about 400,000 ha (H. Mayfield, pers. comm.). Because of the subsequent

Table 1. Summary of Brown-headed Cowbird trapping results in Kirtland's Warbler nesting areas, 1972–1992.

Year	Brown-headed Cowbirds				Traps	Catch per trap
	Adult male	Adult female	Juvenile	Total		
1972	1,621	619	21	2,261	15	150.7
1973	2,006	1,214	125	3,345	19	176.1
1974	2,195	1,717	163	4,075	22	185.2
1975	2,026	1,463	161	3,650	28	130.4
1976	2,193	1,994	112	4,299	38	113.1
1977	1,845	1,405	34	3,284	38	86.4
1978	1,754	1,639	18	3,411	40	85.1
1979	1,954	1,721	16	3,691	35	105.5
1980	1,538	1,429	0	2,967	37	80.2
1981	1,770	1,085	1	2,856	36	79.3
1982	1,568	893	38	2,499	35	71.4
1983	2,128	2,196	0	4,324	35	123.5
1984	2,183	1,936	0	4,119	31	132.9
1985	2,644	2,082	14	4,740	30	158.0
1986	2,328	1,781	75	4,184	31	135.0
1987	2,291	1,549	60	3,900	38	102.6
1988	2,932	2,589	19	5,540	41	135.1
1989	2,907	2,881	2	5,790	42	137.9
1990	3,818	3,771	6	7,595	38	199.9
1991	2,576	2,088	6	4,670	43	106.3
1992	2,003	1,730	4	3,737	49	76.3
(21)	46,280	37,782	875	84,937	34 ^a	117.8 ^b

^aMean traps per year (721/21)

^bMean birds per trap per year (84,937/721 "trap years")

From DeCapita 1991 and M. E. DeC. Unpubl. Data.

increase in young jack pine, Kirtland's Warbler populations probably peaked late in the nineteenth century (Mayfield 1960). The amount of suitable habitat then began to decline with the advent of fire suppression. Increasingly effective fire suppression, coupled with higher than normal precipitation between the mid-1950s and mid-1960s, limited the number of large fires in jack pine stands. As a result, there were only about 4,100 ha of suitable nesting habitat in 1971 (Probst 1986). This may have been a major reason for the 60% decline in the Kirtland's Warbler population from 1961 to 1971 (Figure 1). To sustain the species's habitat, management programmes evolved within the state and national forests in northern Lower Michigan.

History of habitat management

In 1955 the first Kirtland's Warbler reserves were advocated (Mayfield 1963). A formal proposal for a preserve was submitted to the Michigan Conservation Commission in July 1956. Thereafter, a committee appointed by the Michigan Audubon Society worked with the Game and Forestry Divisions, Michigan Department of Conservation (later MDNR) to select three 1,000 ha management areas in Crawford, Ogemaw and Oscoda counties (Radtke and Byelich 1963).

The management of early successional stages of native ecosystems requires a dynamic, pro-active programme. The three sites were managed in different ways. The grass/sedge Crawford site was planted with jack pine on a 4×6 spacing – trees four feet (1.4 m) apart in rows six feet (1.8 m) apart – in strips about 18 m wide alternated with 27 m of unplanted strips. The Ogemaw site had been burned in 1946, and part of it held a good population of warblers in 1956. An extensive area had not regenerated, however, and this was planted in the same manner as the Crawford site. Strip clear-cuts were started on the Oscoda site in 1963 prior to a scheduled burn, but a wildfire (April 1964) burned 365 ha before the cutting had been completed, and jack pine regenerated extensively in the uncut areas.

The FS, with 384,475 ha in the Huron-Manistee National Forest, established a 1,623 ha Kirtland's Warbler management area near Mack Lake (Oscoda County) in 1960. A management plan was approved in 1962. Two 202 ha blocks were commercially cut in 1963 and 1965, leaving some 37 seed trees per hectare. The block cut in 1963 was prescribe-burned in 1964. The seedlings germinated but did not survive a drought, so the area was planted in 1968 and 1969 using various configurations such as straight strips and "opposing wave" strips that left selected openings. The east half of the block cut in 1965 was burned in 1966 and regenerated naturally; the west half was left to regenerate naturally without burning.

The importance of habitat management was demonstrated in 1971, when 40% of singing male Kirtland's Warblers were found on these MDNR and FS management areas, and throughout the 1970s an average of 42% of the singing males were found there (Ryel 1979). By the early 1980s most of these early habitat management areas were too mature for Kirtland's Warbler. Fortunately, wildfires had created enough new habitat to maintain the population.

After the 1971 census there were efforts to create "instant" nesting habitat, mostly by identifying stands on which larger trees were overtopping jack pine seedlings of the right size and density. The overstorey trees were removed, but success was limited. A few cut jack pine stands were burned and planted, but they were too small and planted at less than the 5,000 pines/ha density now recommended (Probst 1988) to create optimal habitat. Kirtland's Warblers did not use them, but there was resistance within MDNR and FS to increase the management of jack pine plantations for the species. Burning and new planting procedures were expensive, and no additional funds were available until the passage of endangered species legislation in the 1970s.

The effect of the Endangered Species Act (1973)

With the passage of the U.S. Endangered Species Act in 1973 and the Michigan Endangered Species Act in 1974, new impetus was given to the management of Kirtland's Warbler. In 1975 FWS appointed a Recovery Team composed of representatives from FWS, FS, MDNR and the ornithological community. The team's charges were to develop a Recovery Plan for the species and to provide direction and oversight to the land managing agencies.

The Recovery Plan (Byelich *et al.* 1976) addressed five goals: (1) to monitor singing males, and the amount of habitat of suitable quality in Michigan; (2) to

protect warblers from predators, parasites, human disturbance, and from habitat destruction or degradation; (3) to study the feasibility and desirability of reintroduction techniques (see Bocetti 1991); (4) to identify winter and migration habitat requirements, availability, and status; and (5) to manage nesting habitat. The Recovery Team recommended that FWS, FS and DNR continue cowbird trapping, close nesting areas to unauthorized entry during the nesting season, census singing male Kirtland's Warblers annually, provide guided tours in selected areas to allow the public to view the species during spring and early summer, and develop and protect habitat.

The Recovery Team concluded that a wild population of at least 1,000 nesting pairs of Kirtland's Warblers was needed to assure the species's survival, and that at least 12,141 ha of suitably aged habitat would be needed to accommodate them. Because the warbler uses only young jack pine stands for nesting, a 30-year rotation could provide this habitat. The team decided, however, to recommend a commercial timber rotation of 45 to 50 years in order to accommodate the wildlife values and commercial uses of older jack pine stands. Timber harvesting, which allowed a recapture of some management costs, played an important role in this decision. Opting for a longer, but ecologically, sociologically, and economically more desirable, rotation required the team to recommend the management of 54,630–60,700 ha for Kirtland's Warbler. It was clear that many new management areas would be needed. The true magnitude of the species's needs was becoming clear.

The Recovery Team established guidelines for identifying new Kirtland's Warbler habitat management areas. They were to contain Grayling sand or closely associated soil types, and have jack pine, or be capable of supporting it. They could contain some oak, but not significant levels of aspen, willow, cherry or other non-characteristic vegetation. Areas must have had a history of use by Kirtland's Warbler and were to be about 130 ha or larger, preferably where five or more sites lay within two miles (3 km) of each other. Smaller tracts (≥ 30 ha) in close proximity to the larger tracts were acceptable. Lands had to be in public ownership, offer limited development potential, and have relatively level topography (Byelich *et al.* 1976, 1985).

The first inventory demonstrated that there was less potential acreage than thought, and more intensive effort was needed to identify suitable areas. The FS and MDNR found additional acreage and developed a formal plan, approved in 1981, for managing it (USDA and MDNR 1981). The plan designated nearly 51,700 ha of public lands for Kirtland's Warbler habitat management (30,000 ha of state forest lands in 16 management areas in nine counties, and 21,700 ha of national forest land in seven management areas in four counties). Although the areas were about 2,830 ha short of the Recovery Team's goal, it was hoped that additional sites would be added through land acquisition, plan revisions, and the designation of other appropriate state-owned lands, such as those controlled by the Michigan Department of Military Affairs (MDMA). In 1985, a cooperative agreement between MDMA and MDNR established a Kirtland's Warbler habitat unit of 1,100 ha on MDMA lands. Nearly 4,400 additional hectares had been obtained by 1989 by the FS, MDNR and FWS.

Commitments to warbler habitat management were slow in coming from the FS and MDNR. Available funding was the primary constraint. In spite of

cooperative agreements that qualify Michigan for matching federal Endangered Species funds from FWS at a one to nine ratio, there has often been a shortage of available federal money. The state has also had difficulty providing its share. As a result, significant federal Endangered Species Act money was not allocated for warbler management until 1980. Although there has been substantial money each year since, it has not been enough to achieve the goals set by the Recovery and Habitat Management Plans. The FS, largely due to a different funding source, has generally come closer to achieving its prescribed habitat goals.

Habitat management

The Kirtland's Warbler habitat management programme often involved the use of fire and was expensive. Site preparation and planting cost more than US\$500 per hectare in 1989 (Kline 1989). Nearly 57,200 ha of jack pine was set aside as essential habitat for Kirtland's Warbler. With a 50-year rotation for each site, more than 1,100 ha of new pine forest must be generated annually. An effort to make the programme more cost-efficient is predicated on a commercial rotation of jack pine. Fluctuating markets and agency appropriations, however, made it difficult to keep habitat work flowing evenly. An average of c.500 ha were added per year during the first 15 years of this programme (1975–1989), about 45% of the goal.

The lack of adequate rainfall or shade limited efforts to establish jack pine forests through natural regeneration or direct seeding. Because these techniques proved to be inefficient, the method of choice was to plant seedlings. Although there were some failures with this method, improved handling of planting stock and the use of a V-plow to produce a wide scalped area increased success. Attacks on jack pine seedlings by the jack pine budworm caused some damage to plantations, but had little overall effect on young trees.

A major problem was the inability to carry out prescribed burns. There are only a few days each year when burning conditions allow a safe and successful burn. Since Kirtland's Warbler management was superimposed on the general programmes of the state and national forests, it meant that other work had to be suspended in order to accomplish the burn, and this did not always happen.

Up to 1980, FS had conducted 26 prescribed burns totalling 1,603 ha in Kirtland's Warbler management areas. Fire had escaped seven times, but the fires were controlled with small losses (23.5 ha). On 5 May 1980 a prescribed burn on the Mack Lake Management Area escaped and became a wildfire (Simard *et al.* 1983). It was finally contained after 10,032 ha had been burned. Property losses (44 dwellings and other structures) were about US\$1,800,000, and other resource loss amounted to around US\$2,200,000. The suppression cost was US\$500,000. One wildlife technician was killed in the suppression effort. The FS lost its credibility because of this fire, public support eroded, and some local people became hostile. Some resistance to the Kirtland's Warbler programme also grew among FS personnel, and the negative effects continue to this day. Similar reactions were experienced within MDNR.

A moratorium was placed on prescribed burns for two years until training, equipment and organizational standards were met. Although prescribed burning resumed in 1982, only nine burns were completed by FS through 1989.

Table 2. Total number of singing male Kirtland's Warblers by habitat 1979–1989

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1979–1989
Wildfire	149	191	181	154	149	158	139	143	119	165	161	1,709
Plantations	28	22	14	16	28	23	41	42	39	38	50	341
Natural regeneration (not burned)	33	29	37	36	33	34	36	25	9	4	1	277
Total population	210	242	232	206	210	215	216	210	167	207	212	2,327

From MDNR (pers. comm.).

There was greater emphasis on alternative site preparation methods, such as piling and burning of slash, mechanical scalping, and planting without further site preparation in clear-cut areas where trees were totally utilized. Scalping and planting in heavy slash without site preparation do not appear to produce suitable habitat. Although MDNR was not put under a burning moratorium, the Mack Lake incident did result in caution, a planting slowdown, and similar changes in its programme.

Prior to the 1980 Mack Lake burn it appeared that the amount of suitable habitat would be at a low ebb in 1986 and 1987 (Probst 1986, 1991), and indeed the population dropped to 167 singing males in 1987 (Figure 1). However, the Mack Lake burn produced nearly 4,000 ha of high quality habitat which became suitable to Kirtland's Warblers in the late 1980s, and this, augmented by later burns and habitat development, had by 1990 more than tripled the amount of potentially suitable habitat. By 1992 the new habitat was occupied by nearly 400 breeding pairs, and J. R. Probst (pers. comm.) estimated that habitat for 500 breeding pairs would be available by 1996. Most of the habitat developed by planting on management areas appears less suitable than the wildfire habitats such as those at Mack Lake. In the 11 years 1979–1989, over 73% of Kirtland's Warbler singing males occupied wildfire sites (Table 2). In 1991 fewer than 25% of the warblers used the planted habitats (Weinrich 1991); 60% of the birds were found in the 1980 Mack Lake burn area (Figure 1). When these habitats become densely occupied, it will be necessary to accelerate the development of new habitat to maintain the higher population.

Habitat research

Research to determine the specific habitat requirements of Kirtland's Warbler has been undertaken in the past 15 years (Smith 1979, Probst 1985, 1986, 1988, Probst and Hayes 1987, Probst and Ennis 1989, Probst and Weinrich 1989, Nelson 1992, Zou *et al.* 1992). Optimal habitat consists of dense stands of jack pine (7,500 stems per hectare) interspersed with small openings, which produces high foliage volume and 35–65% canopy cover (Probst 1988). It also may include up to 20% canopy cover by *Quercus ellipsoidalis* and other deciduous hardwoods, which are used by the warblers for foraging and as cover for nesting. In optimal habitat created by fires, jack pine stem densities generally exceed 5,000 per hectare; sufficient canopy cover can be created by plantations with as few as 3,000 stems per hectare (Probst 1988). Logged stands that have naturally regenerated without fire normally contain about one-third the tree

density of fire-generated stands (Probst 1988) and affect habitat use by Kirtland's Warbler (Table 2). Probst (1988) noted that the relative proportion of habitat with high stem density in Kirtland's Warbler areas had declined since 1951, with a corresponding decrease in male Kirtland's Warbler occupancy from 3.0/40 ha in 1961 to fewer than 2.0/40 ha in 1984 (Probst and Weinrich 1989). Thus relatively more birds were attracted to marginal habitat, but only some 60% of singing males obtained mates, compared to about 95% in optimal habitat. Small (less than 32 ha) or isolated stands also decreased the number of males which obtained mates (Probst and Hayes 1987).

Probst (1988) recommended that jack pine stem densities in plantations be increased to 5,000 per hectare using a 1.3×2.0 m spacing pattern. Openings are created in plantations by planting trees in undulating rows ("opposing waves"). Probst (1988) recommended that these openings be reduced in size to match natural conditions more closely. This could be accomplished by reducing the amplitude of the opposing waves. Management areas should be clustered in space, and adjacent units within them planted in sequence to facilitate their discovery and use by Kirtland's Warblers. Forest Service and MDNR land managers are experimenting with interplanting trees in older plantations and changing planting layout to move toward these goals.

Wintering grounds

Kirtland's Warbler spends most of the year on migration or on its wintering grounds in the Bahama archipelago. Although this has been known for more than 100 years, little is known of potential stresses when the species is away from the breeding grounds. Factors that have seriously hindered efforts to study the species in winter include its inconspicuous behaviour on migration and in winter and its small population distributed over 2,000 islands and cays (Mayfield 1960, Radabaugh 1974, Emlen 1977). This has led to speculation that the Kirtland's Warbler population may be depressed by hurricanes, drought, habitat loss, or predation by feral cats in the Bahamas (Mayfield 1960, Radabaugh 1974, Morse 1989), or poor navigation during migration (Mayfield 1983).

In a two-year study of Kirtland's Warblers in the Bahamas during winter, only about six birds were found. Enough was learned, however, to suggest that winter habitat was not a limiting factor. The species occupies second growth or natural low scrub, which is abundant throughout the archipelago (Sykes 1989). Such limited information, however, meant that another way of assessing overwinter stresses was needed. Because breeding Kirtland's Warblers nest in a restricted area and males are conspicuous, there is a high probability that most members of a colour-marked population can be found each spring, revealing a great deal about overwinter mortality. A major banding programme was therefore undertaken (Sykes *et al.* 1989): 850 Kirtland's Warblers were captured and banded late in the breeding season (15 July–30 September) from 1987 through 1992.

Attempts to identify every Kirtland's Warbler visually each spring, combined with the annual mist-netting effort, have resulted in resighting most surviving banded birds. Preliminary analysis (C.B.K. and P. W. Sykes field notes) indicates that nearly 70% of adult males and females returned to Michigan each

spring 1988–1991, rates nearly identical to those found in earlier studies (Mayfield 1960, Walkinshaw 1983) and for other warbler species (Roberts 1971, Nolan 1978). Walkinshaw (1983) found fewer than 9% of banded fledglings in subsequent years, suggesting that significant mortality was occurring in the first year. About 27% of the first-year birds returned to Michigan each spring, 1988–1991 (C.B.K. and P. W. Sykes field notes), a rate comparable to that known for the non-endangered Prairie Warbler *Dendroica discolor* (Nolan 1978). One-third of the young returned to non-natal colonies; this extensive inter-colony movement by young Kirtland's Warblers undoubtedly confounded earlier attempts to relocate them, especially since over 95% of surviving adults return to their former breeding colonies.

The Kirtland's Warbler breeding population increased more than 25% in 1990 and 1991 (Weinrich 1991), when habitat at Mack Lake became available (Figure 1). These data suggest that Kirtland's Warbler is not limited in most years by stresses during migration or on the wintering grounds, and reinforce Probst's (1988, 1991) hypothesis that lack of optimal habitat in Michigan is the major factor now limiting the species. The banding programme also indicated that Kirtland's Warblers were remaining in Michigan longer than suspected (Sykes *et al.* 1989). In 1989, this led to extending the period when major colonies were closed to public entry from 15 August to 10 September.

Discussion

The management of habitat for Kirtland's Warbler involves some 57,200 ha in northern Lower Michigan. Although this programme is focused on a single species, it is an ecosystem approach to the management of the jack pine community of the dry sand plains, a community that contains a unique assemblage of plant and animal species (Probst and Ennis 1989).

The management of these areas is beset with problems which must be solved. One of the challenges will be to achieve cost efficiency. Otherwise, the cost could be so high it could be difficult to find the funding to sustain the programme. The normal cut–burn–plant method of regenerating nesting habitat is costly but usually successful in establishing jack pine regeneration. A system is needed where jack pine can be safely and dependably regenerated with prescribed fire. Alternative techniques such as partial cutting and burning, as well as regeneration methods without the use of fire, should also be developed, if possible, because public opposition to prescribed burns could inhibit their use, particularly if other costly wildfires were to develop from them.

With the amount of prime habitat that is now becoming available, coupled with the population increases from 1990 to 1992, and the knowledge that the birds are surviving migration and the wintering grounds to sustain that increase, it appears that the lack of optimal nesting habitat has been the major limiting factor. We thus have a sound case for the continuance of the habitat management programme. Habitat suitable in quality, quantity, and spatial orientation must be continuously produced to sustain this species. Fire has been an essential factor in the jack pine ecosystem, and perhaps cannot be completely eliminated if the Kirtland's Warbler is to survive.

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CAMERON B. KEPLER

National Biological Service, Southeast Research Group, Warnell School of Forest Resources, University of Georgia, Athens, Georgia 30602–2152, U.S.A.

G. WILLIAM IRVINE

5121 N. Crosby Rd., Cadillac, Michigan 49601, U.S.A.

MICHAEL E. DeCAPITA

U.S. Fish and Wildlife Service, Manley Miles Building, Room 310, 1405 S. Harrison, East Lansing, Michigan 48823, U.S.A.

JERRY WEINRICH

Michigan Department of Natural Resources, Houghton Lake Wildlife Research Station, Box 158, Houghton Lake Hts., Michigan 48630, U.S.A.