A COMPARATIVE STUDY OF THE MATING SYSTEM AND RECRUITMENT OF THE KIRTLAND'S WARBLER IN VARIOUS HABITATS: 1992 ANNUAL REPORT

by

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INTRODUCTION

The Kirtland's warbler (Dendroica kirtlandii) is an endangered species that breeds in the jack pine (Pinus banksiana)/ Grayling sand communities in the North Central part of the Lower peninsula of Michigan. The warbler winters in the Bahama Island Archipelago. The specific breeding habitat requirements of this species may contribute to its endangered status. It breeds only in large tracts (>32.4 Ha) of young jack pine, 6-20 years old, which are 1.5-6.0 m in height. The loss of this habitat and the invasion of the brown-headed cowbird (Molothrus ater) caused the decline of this species by 1971. The cowbirds are now trapped and removed, and the warbler population has stabilized. Since 1971 the population has fluxuated closely around 200 singing males (Wienrich 1989), until 1990 when the population increased in response to increased availability of suitable habitat (Weinrich pers. comm.). The most recent census of the Kirtland's warbler counted 393 singing males during the 1992 breeding season (Weinrich pers. comm.).

The Kirtland's Warbler Recovery Plan recommends the management of jack pine plantations to provide suitable habitat for the endangered species (Byelich et al. 1976). Evaluation of

the plantations as suitable habitat is critical to the success of the Recovery Plan. Plantations must serve as habitat sources and not habitat sinks.

The purpose of this project is to compare mating success and reproductive success of Kirtland's warblers in plantations and natually regenerated areas that result from wildfires. The wildfire sites have historically provided habitat for the species and will serve as the guideline for evaluating the plantations. The project is timely because the Mack Lake burn of 1980 is providing much wildfire habitat for warblers, and many plantations are now reaching occupiable age.

As the plantations reach the age of possible occupation, the areas are included in the annual census. The census only provides approximate occupation information (Weinrich 1989), and does not address the mating status of the males counted. Birds may be present but not mated. Probst and Hayes (1987) studied mated status, but only compared the number of mated males to unmated males. Their methods likely did not allow them to discover the proportion of males that were polygynous. At the time it was thought that the species was almost exclusively monogamous (Mayfield 1960, Walkinshaw 1983), with only very rare instances of polygyny (Radabaugh 1972, Walkinshaw 1983). Since then, many polygynous matings have been described (Bocetti unpub.). Since polygynous males have more than one female, occupancy of a site is unclear unless the frequency of polygyny is known. Data on the mated status of males in different

habitats in combination with census data will provide an accurate evaluation of plantation use compared to use of natural areas. In addition to mated status of males, the reproductive success of warblers in the plantations must be known to properly evaluate plantations as suitable habitat.

OBJECTIVES

The primary goal of the study is to determine whether plantations are providing suitable habitat for the Kirtland's warbler. Several objectives must be investigated to evaluate plantations as sources or sinks. The objectives will be compared across site treatments: wildfire with natural regeneration, and plantation with or without burning as a site preparation. The objectives are: 1) to quantify the frequency of unmatedness, monogamy, and polygyny of territorial males; 2) to quantify recruitment of young through fledging; 3) to measure the condition of the nestlings just prior to fledging; and 4) to quantify habitat characteristics.

METHODS

To achieve the objectives of the study, there must be a large population of uniquely marked warblers. I have continued to participate in the late summer banding program conducted by the U.S. Fish and Wildlife Service, which provides many banded birds each year. Some spring banding must be done to identify unbanded warblers on each study site. In the spring, birds are

captured in 10 m mistnets using a playback of the male's song to bring them into the net. Males are captured more readily with playbacks than females, although some females do respond. All warblers are uniquely identified by four bands: one numbered aluminum federal band, and three colored bands, arranged such that two bands are on each leg. The plastic colored bands are sealed with acetone. The colors used include: black, indigo, blue, green, red, yellow, and white.

The projected completion date for the study is June 1993. The field research has been conducted during May through August of 1990-92. Two years of preliminary data on mating success from 1988 and 1989 will supplement the data from the three complete field seasons. The 1990 field season provided comprehensive data on only three study sites, each representing a site treatment. The 1991 and 1992 field seasons were conducted under a new sampling design with several study sites in each site treatment category. Study sites were spread throughout the breeding range of the species.

The territories of males were plotted by following singing males via audio and visual cues and plotting locations on enlarged, low flight, false-color infrared aerial photographs (scale 1 inch: 250 feet). Males were plotted for at least 90 bird-minutes accumulated in at least two days in order to consider the territory boundaries valid.

The mating status of the territorial males was determined by maintaining vigilence for females while plotting territories of

males, watching for specific behavioral changes associated with intersexual interactions, such as changes in song type and song frequency. In addition, territories were cruised, regardless of the male's activity, to look for females. Females have been located this way if they were nest building or feeding young. A minimum of 120 bird-minutes had to be spent with each male, accumulated in at least three days, before the unmated status could be assigned to him. Detection rates were similar among the site treatments. Vigilence for additional females or for movements by males to other territories was continued even after the first female was found. Some cases of polygyny were discovered by knowing the identity of surrounding singing males.

Reproductive success was best determined if nests were located early in the nesting cycle (Mayfield 1961). Nests were often located by following the singing male as he carried food to the incubating female. Once the nest was located, an initial nest visit was conducted to determine the stage in the nesting cycle. All nest checks were walk-by procedures using appropriate precautions, such as maintaining as much distance between the observer and the nest as possible and using a continuous semi-circle path around the nest to avoid a directional scent path for predators. The first nest check provided data on clutch size. A second nest check was conducted on the sixth day of the nine day nestling period to determine the number of nestlings. Since predation causes the loss of the entire nest, the sixth day nestling count provided the number of young fledged if the nest

persisted through fledging. Fledging was determined by the feeding behavior of the adults. The high-noted chipping of the fledglings was indicative of their presence as well. Parents with fledglings usually stayed in the vicinity of the nest for up to two days following fledging.

In some cases, predation could be detected even if the nest was not precisely located. The adult feeding activity would pinpoint the location of the nest to a small core area, and a sudden cessation of such feeding routines indicated the loss of the nest.

The condition of the nestlings prior to fledging was determined by removing nestlings from the nest on approximately the eighth day of the nesting period, weighing and measuring them and returning them to the nest. Nestlings were removed from the nest all at once, processed individually, and returned to the nest all at once. As with nest checks, appropriate precautions were taken when removing and returning young to the nest. The nestlings were always weighed and measured at least 20m from the nest. In 1991, attempts to collect condition data were conducted on approximately the sixth day of the nestling period.

The habitat characteristics were measured using a new sampling design. The same design was used for all three field seasons. Measurements were taken at random locations to compare habitat characteristics across site treatments, and also at every territory to determine if habitat characteristics were preferred within site treatments. Random points were located by placing a

grid (100m X 100m units) over the aerial photographs with the first point in the northwest corner of the study site. Transects were laid out by randomly selecting the starting point on the grid and randomly selecting the azimuth. Each transect was 500 m long with 50 possible points every 10 m. The points along each transect were randomly selected. Each study site had five transects with 10 points per transect, for a total of 50 locations which were all plotted on the aerial photograph. At each point, a modified point-center quarter method was used, selecting one tree in each direction: north, south, east, and west. At each tree the following variables were measured: diameter at 10 cm, height of the first live branch, height of the tree, and distance to the tree. At two of the 10 points along each transect, for a total of 10 points, a 1m X 1m plot was set up with the point as the center. Species composition and percent cover of ground vegetation were measured in each plot. At the center of the plot, a soil auger was drilled to at least 150 cm, a depth at which all soil features that effect the ecosystem are born out (Barnes pers. comm.). The soil features that were measured include: soil textures and depths, depth of organic layer, presence and depth of clay bands, presence and depth of gravel or cobble layers. At randomly selected points on the grid, the density of tree stems was counted in 15 m diameter circular plots with the point as the center, and a patchiness index was measured from the aerial photographs. All of the above habitat characteristics were measured in each territory. The

nest or center of the core area was used as the center point for all measurements. If no nest or core area was located, then the center of the territory was used as the center for all measurements.

RESULTS

The comparison of mated status of males was based on five years of research, 1989 through 1992. Since inferences were being made about site treatments, only the standard error for the primary sampling units (sites) were calculated, assuming unbiased estimates for the secondary sampling units (territorial males). To compare the mean proportion of territorial males in a mating status between site treatments, an unequal variance t-test with Satterthwaite's approximation for degrees of freedom, at $\alpha=0.05$ was used. The data from twelve wildfire sites, and 10 plantations are shown in Table 1.

Table 1. Proportion of territorial males in two habitat treatments: wildfire/naturally regenerated areas and plantations, that are unmated, monogamous, and polygynous. Abbreviations for study sites are defined in Appendix 1.

WILDFIRE SITES				PLANTATION SITES			
SITE	UNMAT	MONOG	POLYG	SITE	UNMAT	MONOG	POLYG
MLB22 $_4$	0.143	0.776	0.082	OMU21 $_2$	0.091	0.818	0.091
MLB16	0.000	0.750	0.250	WBU	0.333	0.667	0.000
MLB11	0.000	0.667	0.333	FPK	0.000	1.000	0.000
MLB5	0.000	0.800	0.200	PRU5	0.500	0.500	0.000
BHS $_2$	0.000	0.680	0.320	BLP	1.000	0.000	0.000
BHF	0.000	0.333	0.667	SHP $_2$	0.466	0.466	0.066
SBB	0.000	1.000	0.000	CLU	0.333	0.333	0.333
MLB12	0.000	0.833	0.167	CLN	0.286	0.714	0.000
MLB14	0.000	0.500	0.500	FPC	0.333	0.667	0.000
MLB15	0.000	1.000	0.000	OMU28	0.300	0.700	0.000
MLB17	0.250	0.750	0.000				
NBH	0.500	0.333	0.167				
mean	0.074	0.702	0.224	mean	0.364	0.586	0.049
se	0.045	0.063	0.060	se	0.085	0.088	0.033

A subscript following a study site indicates the number of years the site was studied. Reported values are means for those sites.

The mean proportion of unmated males in wildfire areas is significantly different from that in plantations ($p=0.01$). The power (p') of the test was 0.83 when the true difference (d) is 0.3. There are fewer unmated males in wildfire areas compared to plantations.

The mean proportion of polygynous males in wildfire areas is also significantly different from that in plantations ($p=0.02$, $p'=0.97$ when $d=0.3$). There are more polygynous males in wildfire areas compared to plantations.

The mean proportion of males from all 22 sites that are polygynous is 0.144 with a standard error of 0.040. The mean proportion of males from all 22 sites that are unmated is 0.206 with a standard error of 0.053.

The comparison of nesting success between site treatments is based on three years of research, 1990-92. The same test is used for nesting success comparisons as for mating success comparisons. Nesting success was broken down into clutch size and number of young fledged. Nests were found in 10 wildfire sites and seven plantations. Data for clutch size is shown in Table 2, and data for number of young fledged per nest is shown in Table 3.

Table 2. Mean clutch size within sites and then averaged over the sites in each site treatment. Abbreviations for study sites are defined in Appendix 1.

WILDFIRE SITES				PLANTATION SITES			
SITE	mean	s^2	n	SITE	mean	s^2	n
MLB22	4.56	0.50	9	SHP	4.50	0.33	4
MLB5	5.00	0.00	1	OMU21 $_2$	5.00	0.00	4
MLB11	4.50	0.33	4	WBU	4.00	0.00	1
BHF	4.00	0.00	1	FPK	4.00	0.00	1
SBB	5.50	0.50	2	CLN	5.00	0.00	2
MLB12	4.50	0.33	4	FPC	5.00	1.00	3
MLB14	4.00	0.00	2	OMU28	4.50	1.00	4
MLB15	4.00	0.00	1				
MLB17	5.00	0.00	2				
NBH	5.00	0.00	1				
mean	4.61			mean	4.57		
se	0.16			se	0.17		

The subscript following a study site indicates the number of years the site was studied. The reported value combines data from the multiple years.

A comparison of mean clutch size in wildfire areas and plantations failed to show a significant difference ($p>>0.20$). The power (p') of the test is greater than 0.97 when the true

difference (d) is one. In fact, the test was robust enough to show a true difference in clutch size of 0.942 eggs.

The overall clutch size for all 17 sites is 4.59 eggs. The standard error is 0.115.

Table 3. Mean number of young fledged per nest within each site and then averaged for each site treatment. The abbreviations for study sites are defined in Appendix 1.

WILDFIRE SITES				PLANTATION SITES			
SITE	mean	s^2	n	SITE	mean	s^2	n
MLB22	3.22	3.94	9	SHP	4.25	0.25	4
MLB5	5.00	0.00	1	$OMU21_2$	4.25	0.25	4
MLB11	3.00	4.67	4	WBU	4.00	0.00	1
BHF	3.00	0.00	1	FPK	4.00	0.00	1
SBB	5.50	0.50	2	CLN	2.50	12.50	2
MLB12	4.00	0.67	4	FPC	3.00	4.00	4
MLB14	2.00	8.00	2	OMU28	3.25	4.92	4
MLB15	2.00	8.00	2				
MLB17	3.00	2.00	2				
NBH	5.00	0.00	1				
mean	3.57			mean	3.61		
se	0.40			se	0.26		

The subscript following a study site indicates the number of years the site was studied. Reported value as in Table 2.

A comparison of mean number of young fledged per nest in wildfire areas and plantations failed to show a significant difference ($p>>0.20$, $p'=0.50$ when $d=1.0$). The power of the test is regrettably low. However, at a respectable power of 0.81, this comparison would detect a true difference of 1.42 fledlings per nest.

The mean number of young fledged per nest for all 17 sites is 3.59 young. The standard error is 0.249.

The loss of young due to predation is incorporated into the mean number of young fledged per nest. However, it is useful to directly compare predation rates between site treatments. The data for predation loss from 73 nests and core areas is shown in Table 4.

The proportion of nests and core areas lost to predation in wildfire areas is not significantly different from that in plantations according to the Fisher's Exact Test. After the first two years of research, the difference in mean predation rates (0.23 in wildfire sites and 0.03 in plantation sites) was nearly significant ($p=0.06$). The mean predation rates for **all** habitats were similar in each year (0.14 in 1990 and 0.12 in 1991), and the proportions were similar for the two years. However, the mean predation rate for **all** habitats in 1992 was 0.27, and the proportions (0.20 in wildfire sites and 0.39 in plantations) were not similar to the first two years, and in fact show the reverse trend.

Table 4. Number of nests and core areas and the proportion depredated (assuming that a failed nest was due to predation), in each site and averaged over each site treatment.

WILDFIRE SITES			PLANTATION SITES		
SITE	TOT.#	# LOST (PROP)	SITE	TOT.#	# LOST (PROP)
MLB22	14	3 (0.214)	$OMU21_2$	8	0 (0.000)
SBB	3	1 (0.333)	SHP_2	6	1 (0.000)
BHF	3	1 (0.000)	PRU5	2	0 (0.000)
MLB16	1	0 (0.000)	FPK	3	0 (0.000)
MLB11	4	1 (0.250)	WBU	2	0 (0.000)
MLB5	4	1 (0.250)	CLN	3	2 (0.667)
MLB12	5	0 (0.000)	FPC	4	1 (0.250)
MLB14	2	1 (0.500)	OMU28	4	1 (0.250)
MLB15	2	1 (0.500)			
MLB17	2	0 (0.000)			
NBH	1	0 (0.000)			
mean prop.		0.216	mean prop.		0.167
se		0.058	se		0.082

The subscript following a study site indicates the number of years the site was studied.

A cowbird egg was found in a nest at Mack Lake Burn section 5 on 24 June 1991. The egg was either laid after the warbler young fledged or was infertile when it was laid. The cowbird egg did not affect the hatching and fledging of the warbler eggs. A cowbird egg was found in a sparrow nest at the Fletcher Road (sp.?) plantation in Crawford County on 11 June 1992. Both sites were trapped for cowbirds at the time.

The condition of the young was only measured in 1990. Attempts were made in 1991 to approach nests, but the young either fledged or the female could not be captured according to protocol. The variance of weight and tarsus length measurements is quite small within nests. A mean is calculated for each nest (secondary sampling unit), and those values are averaged for each site (primary sampling unit) for the two response variables: weight and tarsus length. Sample sizes are too small for valid statistical analysis. The data for two sites are shown in Table 5.

Table 5. Mean nestling weights and tarsus lengths for two plantations: OMU21 (with burn site preparation) and SHP (without burn site preparation.

SITE	MEAN WEIGHT	S^2 WEIGHT	MEAN TARSUS	S^2 TARSUS
OMU21				
nest 1*	12.15 g	0.147	21.98 mm	0.562
nest 2	14.00 g	0.070	22.20 mm	0.010
mean	13.10 g	1.710	22.09 mm	0.024
SHP				
nest 1*	12.52 g	0.061	21.98 mm	0.052
nest 2*	14.25 g	0.002	22.80 mm	0.000
nest 3*	12.97 g	0.044	21.03 mm	0.020
mean	13.25 g	0.810	21.94 mm	0.785

*nest of polygynous male

The comparison of habitat characteristics between site treatments and within site treatments is based on three years (1990-92) of research. The data has not been analyzed yet.

CONCLUSIONS

The overall conclusions must be reserved until after all data analysis is complete. The conclusions presented here are tentative since they are made prior to the completion of data analysis.

The mating status of males in the different site treatments is significantly different. It appears that fewer males are unmated and more males are polygynous in wildfire areas than in plantations. The magnitude of the difference may be slightly inflated due to the younger age and earlier stage of occupancy in

the plantation sites. However, a range of ages and stages of occupancy are included in both wildfire and plantation sites. It appears that females are selecting to nest in wildfire areas more than in plantations. There may be more nest sites in wildfire areas, where ground cover is likely more diverse and more dense. Also, I expect analysis of the habitat data to show that tree density and patchy distribution of trees is greater in wildfire sites, providing more edge between trees and openings where nests are most often placed.

The number of young produced per nest is not significantly different between wilfire areas and plantations. The power of the tests to compare clutch size and number of young fledged are adequately high to show biologically important differences. It seems that once a nest site has been initiated by the female, the success rate is similar in the different habitats. However, due to the skew in the number of nests initiated based on pairing success, the number of young produced per male is much greater in the wildfire areas than in the plantations.

The predation rates are greater in wildfire sites than in plantations, although this is not statistically different. I believe the greater predation rate in wildfire habitat is due to higher densities of predators, rather than higher encounter rates. One nest in a plantation site was lost due to the death of the incubating female on the nest. Necropsy showed that the female had a broken back, evidently the victim of a predation attempt likely away from the nest.

The condition of the young can not be compared between site treatments (burn site preparation versus no burn) because the sample sizes are much too small for rigorous analysis. However, initial inspection of the means for the sites indicates that there is no difference between the two site treatments regarding the condition of the young. The difference in weight between nests within a study site indicates that some nests had healthier young than other nests in the same study site. The nestlings in the nests of polygynous males always had weights less than nestlings in monogamous nests.

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Appendix 1. Abbreviations and locations of study sites.

ABBR.	SITE NAME	COUNTY	LEGAL DESCR.
Wildfire Sites			
BHS	Bald Hill South	Crawford	T27NR1WS20S1/2
BHF	Bald Hill Flats	Crawford	T26NR1WS28NE1/4
MLB5	Mack Lake Burn,sect.5	Oscoda	T25NR3ES5S1/2
MLB11	Mack Lake Burn,sect.11	Oscoda	T25NR3ES11N1/2
MLB16	Mack Lake Burn,sect.16	Oscoda	T25NR3ES16S1/2
MLB22	Mack Lake Burn,sect.22	Oscoda	T25NR3ES22
SBB	Stephan Bridge Burn	Crawford	T27NR2WS31SE1/4 T27NR2WS32SW1/4
MLB12	Mack Lake Burn,sect.12	Oscoda	T25NR3ES12NE1/4
MLB14	Mack Lake Burn,sect.14	Oscoda	T25NR3ES14SE1/4
MLB15	Mack Lake Burn,sect.15	Oscoda	T25NR3ES15NW1/4
MLB17	Mack Lake Burn,sect.17	Oscoda	T25NR3ES17NW1/4
NBH	North Bald Hill	Crawford	T27NR2WS14S1/2
Plantation/no burn sites			
CLU	County Line Unit	Oscoda	T25NR1ES36NE1/4
SHP	St. Helen's Plantation	Roscommon	T23NR1WS1SW1/4
CLN	County Line North	Oscoda	T25NR1ES25N1/2
Plantation/burn sites			
BLP	Byron Lake Plantation	Alcona	T26NR5ES8NW1/4
FPK	Fletcher Plantation	Kalkaska	T25NR5WS25NW1/4
OMU21	Ogemaw Mgt. Unit,sect.21	Ogemaw	T24NR1ES21NW1/4
PRU5	Pine River Unit 5	Alcona	T25NR7ES29NE1/4
WBU	West Branch Unit	Oscoda	T25NR1ES34S1/2
FPC	Fletcher Plantation	Crawford	T25NR4WS29NW1/4 T25NR4WS30NE1/4
OMU28	Ogemaw Mgt. Unit,sect.28	Ogemaw	T24NR1ES28S1/2