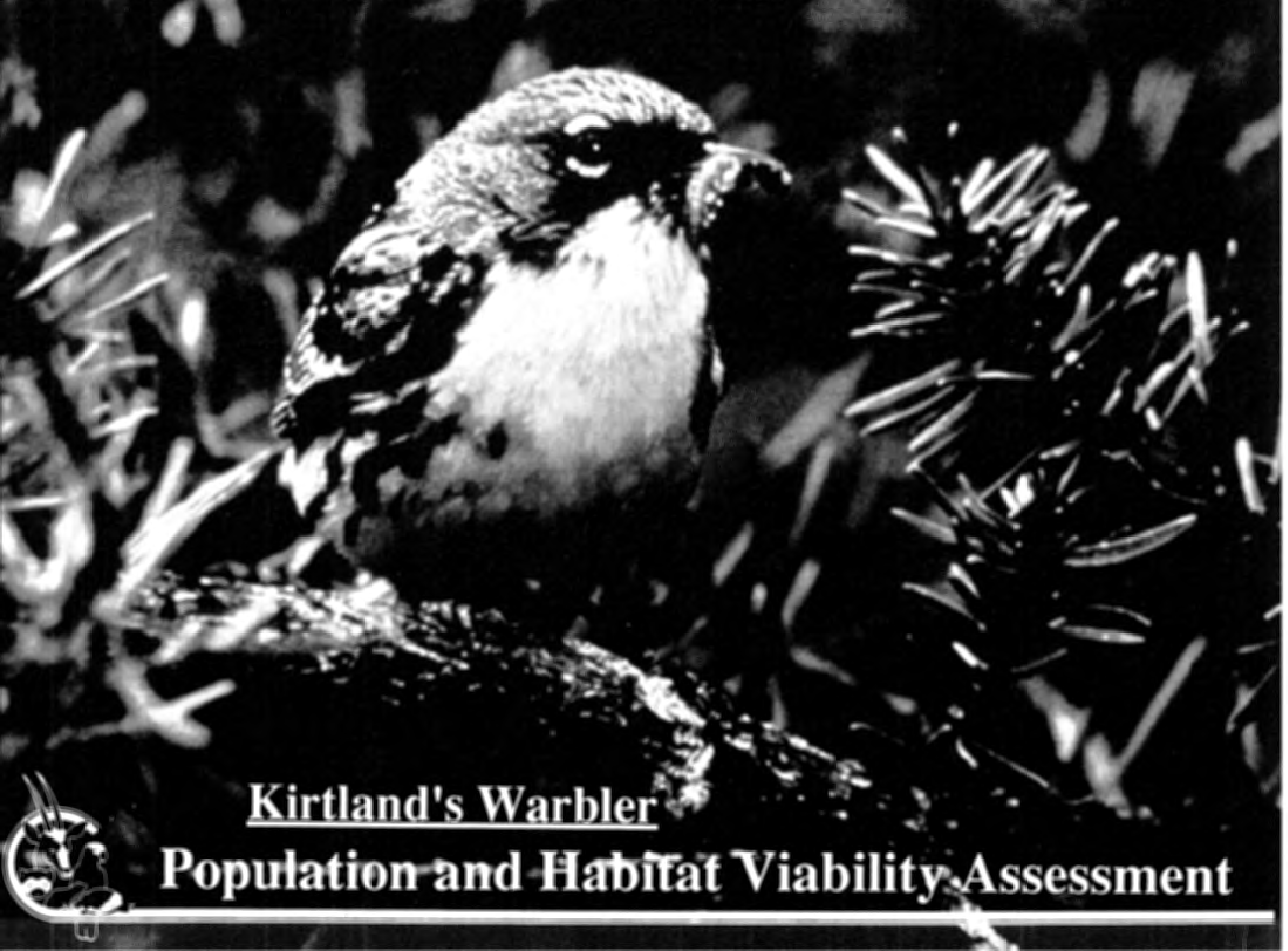

Kirtland's Warbler
Population and Habitat Viability Assessment

KIRTLAND'S WARBLER

(Dendroca kirtlandii)

POPULATION AND HABITAT VIABILITY ASSESSMENT

WORKSHOP REPORT

U. S. Seal, Editor

A Collaborative Workshop of

US Fish & Wildlife Service

IUCN/SSC/ Conservation Breeding Specialist Group

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3 April 1996

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(Dendroca kirtlandii)

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SECTION 1

Executive Summary and Recommendations

Executive Summary

When a species, such as the Kirtland's warbler (*Dendroica kirtlandii*), is reduced to one small population, its demise can be the result of random events. The events leading to extinction can be varied and they may interact in what is known as an extinction vortex (Lacy 1992). The recovery team for the Kirtland's warbler reviewed the species' extinction risks in a Population and Habitat Viability Assessment workshop (PHVA) held at Minnesota Valley National Wildlife Refuge on January 7-9, 1992. The PHVA provided a frame-work for asking difficult questions about managing habitat for the warbler's future. The Kirtland's warbler may be one of the most well-researched warblers in North America, but many questions concerning its management remain. The workshop was a cooperative venture between the USDI, Fish & Wildlife Service, Division of Endangered Species, Region 3, and the Conservation Breeding Specialist Group of the Species Survival Commission / World Conservation Union (CBSG/SSC/IUCN).

VORTEX, a computer population simulation modeling software program used for the analysis, was developed by Dr. Robert Lacy of the Conservation Biology Department of the Chicago Zoological Park. The model was set up to act like a population of Kirtland's warblers. The simulated population had the same life history parameters, such as clutch size and mortality rate, that were calculated for the real Kirtland's warbler population. The population was run through a gauntlet of risks, like increased cowbird parasitism, habitat destruction, and drought, for 50 years.

The PHVA environment allowed workshop participants to integrate their experience and research results to analyze the projected future of the Kirtland's warbler. After repeated simulations of multiple scenarios, participants could view and compare the extinction probabilities and population trajectories of a multiple permutations and combinations of parameter values. The model is a well-developed thought experiment allowing the recovery team to try "what-if" scenarios within various management strategies. It is possible, through modeling, to project and test effectiveness of management strategies at reducing species risk of extinction, based upon current knowledge.

The data analysis, modeling and management process is never complete; the workshop was an introduction to the technique of modeling using VORTEX. By the end of the PHVA Workshop the recovery team decided to include population modeling as part of their future meetings. The model will be continuously updated as they gain new knowledge about Kirtland's warbler population biology and management.

The single Kirtland's warbler population is limited by breeding habitat and threatened by cowbird parasitism. The recommendations were based on the history of the population and the dynamics of small populations and were made with the assumption that the recovery plan's goal is a Kirtland's warbler population that is as self-sustaining as possible. With the exception of cowbird control, financial and political considerations of the scenarios are not explored.

Recommendations

1. Brown-headed cowbird control should continue at no less than 75% of the current level.

2. At least one person on the recovery team needs to be responsible for having a working knowledge of the current research on cowbird behavior relative to landscape patterns. We suggest that one or more features of the existing landscape attracting cowbirds could possibly be modified.

3. A second, distinct, population of Kirtland's warblers needs to be fostered in appropriate habitat. This would be an excellent opportunity to develop techniques for establishing and maintaining warbler populations. To establish a second population, more research needs to be focused on cross-fostering, captive-rearing, and over-wintering birds in captivity.

4. We suggest that habitat be managed by controlled burns rather than through plantations. We endorse the recovery team goal of 37,500 acres (15,000 ha) of annually available suitably aged habitat to support approximately 1000 pairs of Kirtland's warblers. Plantations seem to be less that "average" habitat from the perspective of the Kirtland's warbler. Although, natural regeneration has been poor on most areas where prescribed burns were done, the resulting habitat will likely be more suitable.

5. The recovery team needs to continue to monitor Kirtland's warbler demography and the species response to different habitat types through annual censuses of singing males and capture-recapture efforts.

6. We support the recovery team's decision to include population modeling as a tool at each meeting.

KIRTLAND'S WARBLER
(Dendroca kirtlandii)

POPULATION AND HABITAT VIABILITY ASSESSMENT

7-9 January 1992

WORKSHOP REPORT

SECTION 2

POPULATION BIOLOGY AND SIMULATION MODELING

Population Biology, Life History Characteristics and Simulation Modeling

Working Group: Bruce Brewer, Cameron Kepler, Sharon Moen, Carol Bocetti, Paul Sykes

Kirtland's Warbler Overview

The Kirtland's warbler (*Dendroica kirtlandii*) is a small (15 gm) passerine associated with young forests of jack pine on Grayling sand in the upper part of the lower peninsula of Michigan. The first specimen was collected in Cleveland, Ohio by Charles Pease in 1851. Pease gave the specimen to Dr. J. Kirtland who in turn gave it to S. Baird, the man who named the species. The first nesting colony was not discovered until 1903. Although the warbler has probably been rare for at least a century, it is now one of the best known songbirds in the world.

The coloration of males and females is similar, but distinctive. Dorsally plumage is blue-gray with black streaks. Below plumage is yellow with black spots or streaks on their sides. Males have a blackish mask. Kirtland's warblers persistently jerk their tails. Males have a loud, low pitched song that starts with several staccato notes and continues with a higher-pitched chattering that ends abruptly.

The species nests on the ground in thick vegetation, such as blueberry or sweetfern. The female incubates a clutch of five and sometimes six eggs for 14 days, the longest incubation period reported for any North American warbler. Hatching success is about 85% (Mayfield 1960). Although the male does not incubate the eggs, he feeds the incubating female and helps rear the young. The population migrates to the Bahama Island chain for winter.

Population censuses began in 1951 with counts of singing males on the breeding ground in Michigan, U.S.A. At that time, 432 males were counted. Between 1961 and 1971 the number of singing males dropped from 502 to 201 (about 20% per year rate of decline) prompting the initiation of annual censuses. These annual censuses indicated the population was rather stable with about 200 singing males until 1989. The species was listed as federally endangered in 1967. In 1990 and 1991 the number of singing males began to increase as an area burned in 1980 by a run-away fire began to rejuvenate (Fig. 1). The annual rate of increase was at least 25% in 3 of 4 years (1988 was a drought year).

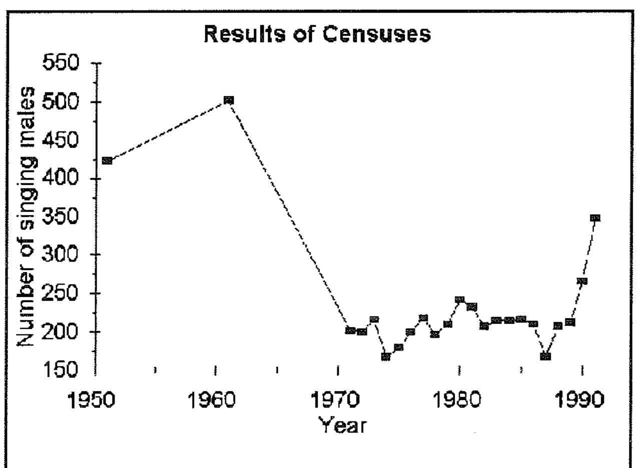

Figure 1. Results of singing male censuses.

Limiting Factors

At least two major limiting factors have contributed to the Kirtland's warblers endangered status. Kirtland's warblers depend on extensive tracts of young jack pine (*Pinus banksidna*) forest, preferably the regrowth that occurs about ten years after a major forest fire. Fire suppression and development has reduced available habitat to approximately 129,250 acres (51,700 hectares) in Michigan, United States of America. Along with habitat reduction, an increase in nest parasitism by brown-headed cowbirds (*Moluturus afer*) threatens this warbler population. Brown-headed cowbirds have become more abundant because of shifting land-use patterns since European settlement. A third factor that possibly influences their low numbers is the warblers' response to weather conditions during migration and on the wintering grounds in the Bahama Islands and nearby Caicos Islands and Dominican Republic. Each of these limiting factors can be modelled as a catastrophe event.

Demographic Parameters

The following demographic parameter values provide the standard input for the computer simulations. These parameter estimates were distilled and refined from information presented at the PVHA workshop to reflect the biology of the Kirtland's warbler. Participants reviewed the values before leaving the workshop. The values were developed in the context of the population model VORTEX and serve as the template for further simulations exploring the vulnerability of the Kirtland's warbler to extinction.

Mortality

Mortality values originated from unpublished data of Kepler and Sykes. Only data for the years 1987, 1988, and 1989 were used for the calculations; in prior years the sample sizes are low and in 1990, 5% of the birds may not have been counted. The raw data suggested females have a lower survival rate than males. This skewed mortality probably is an artifact because females are more difficult to detect in the field and harder to catch in mist-nets. Presumably, male and female mortality rates are equal. However, the possible ramifications of differential female mortality are discussed later in this document. Based on data for males, **juvenile birds have a mortality rate of 62.2% ± 4.2% (s.d.)** from fledging to one year of age and **adults have an annual mortality rate of 35.5% ± 20.7% (s.d.).**

Polygyny

Although male Kirtland's warblers are primarily monogamous, about 20% breed with two females simultaneously. Kirtland's warbler males do not inseminate a large number of females per breeding season. Since polygyny appears to be limited in Kirtland's warblers, **in the context of these simulations Kirtland's warblers were considered to be monogamous.**

Polygyny could buffer the population from extinction but could increase the rates of inbreeding and genetic drift and decrease the effective population size.

Nest success

From Bocetti's data (n=50), 16% of all nesting attempts failed (1st and 2nd attempts combined). However, as Mayfield (1961, 1975) pointed out, the time of nest detection within the breeding cycle affects estimates of the rate of nest losses. Often a failed first nesting attempt is followed by a second attempt. However, there are years, such as the drought year of 1988, when no renesting attempts were observed.

Fledging data were used as an indicator of nest success. The distribution of fledglings per nest was calculated in years after cowbird control was implemented using Walkinshaw's and Bocetti's data combined. The combined data indicated that 27.4% of nests produced no fledglings.

Assuming about 80% of females that fail at their first nesting attempt of the season renest and that renesters have the same success rate and fledgling distribution as first nesters (true only if early enough in the season), there is an overall female reproductive failure rate of about 10%. Since 10% of nesting females produce no fledglings, the distribution of fledglings per nest was reapportioned to the remaining 90% of females. The final corrected distribution are tabulated in Table 1 below.

Number Fledged	Percent of Total
0	10.00
1	00.52
2	10.79
3	15.94
4	28.28
5	33.93
6	00.54

This distribution would yield an average of 4.0 fledglings per nest for nests with fledglings. Calculated over all nests the number of fledglings would be 3.6 per nest attempt. A crude estimate of the potential rate of increase of the population can be made using the unadjusted or uncorrected data. Thus if for 100 nests (100 pairs of adults) 73 nests produce an average of 4 fledglings each for a total of 292 fledglings and 38% of these survive to one year then about 110 one year-olds would return. Also with an adult survival rate of 64.5%, then 130 of the adults would return. This would yield an adult population of 240 for a crude rate of increase of 20% which is approximately what has been observed in growth years. These calculations provide an initial internal consistency check on the values for the demography.

Males in breeding pool

All males have the potential to breed. However, Bocetti's and Probst's data indicated that only about **80% ± 29.4% (s.d.) of the males breed in any one year**. This figure is an average across wildfire and plantation habitats.

Inbreeding

Inbreeding effects were not included in the simulations. The inbreeding levels and effects of inbreeding are unstudied but are not considered threatening to the Kirtland's warbler population at this time. Censuses of singing males indicate that the population dipped to a probable low of 167 breeding pairs twice within 20 years. Considering stochastic events, the extended low population number, and the potential for polygyny, it may be useful to consider the impact of a low level of inbreeding in further work.

Correlated environmental variation

It is likely that the direction of annual **variation in reproductive success is not strongly correlated with annual variation in the survival** of Kirtland's warblers. Kepler and Sykes' banding/sighting data and compilation of Bocetti's and Walkinshaw's data support the independence of these events.

Carrying capacity

The current area targeted for Kirtland's warbler management has increased from 11,700 acres (4676 hectares) in the early 1960's to approximately 129,250 acres (51,700 ha) of state and federal land. The Kirtland's Warbler Recovery Plan (1985), developed under authority of the Endangered Species Act of 1973, calls for regenerating jack pine habitat through harvest followed by burning and planting or seeding. The plan suggests that approximately 37,500 acres (15,000 ha) of suitably aged habitat should be made available every year to support a population of 1000 pairs. Jack pine stands are generally harvested on a 50 year commercial timber rotation although Kirtland's warblers are the primary resource management objective within their designated habitat.

Projections indicate that 15,400 acres (6155 ha) of suitably aged jack pine habitat will be available in the 1993 breeding season. Between 585 and 862 adult Kirtland's warblers (292-431 pairs based upon counts of singing males) are expected (Table 2). The number of individuals is based on the average male density (1.9 males/100 acres) from 1984 in all occupied stands in wildfire and plantation areas. This represents the expected density of Kirtland's warblers occurring in a low to moderate quality, plantation-dominated jack pine forest. The upper limit for the 1993 carrying capacity is based on the density of males in four wildfire areas after 13-15 years of regrowth (2.8 males/100 acres). Experts predict a density of 2.8 males/100 acres in high quality plantation habitat (optimal stem density, large cutting blocks, optimal biogeographic distribution of suitably-aged stands), and most wildfire-generated habitat.

Table 2. Carrying capacity estimations for total population of male and female adult birds.

Year	Acres	N at Low K	N at High K
1993	15,400	584	862
2002	29,750	1139	1679

Carrying capacity was initially set at 724 ± 138 (s.d.) birds. Seven hundred twenty four is the average of 584 and 862. The standard deviation was calculated as follows:

$$([(863-584)/2]/724) * 100 = \text{s.d. in } K = 19\%$$

This is a rough estimate for the carrying capacity's standard deviation.

Trend in K

Managers predict that the habitat available each year will increase from 15,400 acres (6155 ha.) in 1993 to 29,750 acres (11,990 ha.) by 2001. This is an increase of about 93% over 9 years. The additional habitat is expected to come from three sources:

1). 2700 acres (1080 ha.) per year from plantations on a 50 year rotation (1600 acres MIDNR, 1100 acres FS),

2). 100 acres (40 ha.) per year from regeneration on the area affected by the Mack Lake fire,

3). 200 acres (80 ha.) per year from putting 5000 acres of FWS land on 25 year cycle.

No additional habitat is expected to become available after 2002. **The rate of increase of the carrying capacity is predicted to be about 10.55% each year for ten years.**

Standard Input Results

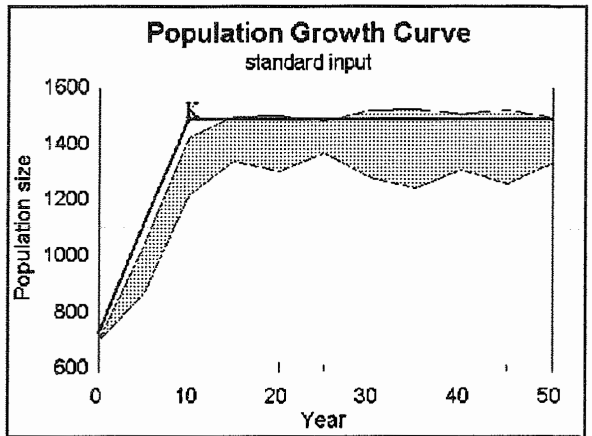

Figure 2. Population growth with the base scenario. Highs and lows reflect the standard deviation of 100 iterations.

The results of 500 iterations of the standard input file for the base scenario (Table 8, file 026) indicate the Kirtland's warbler population has a relatively high stochastic intrinsic rate of increase (r_{stoc} = 0.278 ± 0.291) with a high variance. The high rate of increase allows the population to fill the habitat as it becomes available (Fig. 2). Like the actual census data, the model suggests that Kirtland's warblers are presently limited by the amount of suitable breeding habitat. Assuming that the predicted increase of suitable breeding habitat occurs and *all other variables remain constant with no catastrophes*, the Kirtland's warbler population can persist for the next 50 years; the model results suggest the population has 100% chance of surviving and should retain about 98% of its current heterozygosity under these ideal conditions. Fifty years was chosen as the time frame in which to study the population since this is about 20 warbler generations and since PHVA participants thought that predicting funding for habitat and cowbird management beyond 50 years was not possible.

Although the immediate future, based upon current management practices, appears favorable for the Kirtland's warbler, the intense effort required to maintain habitat and remove cowbirds make the population vulnerable to the uncertainties of funding, politics and the unexpected. The fact that there is only one known population makes the species vulnerable to natural catastrophic events and global climate conditions. It is useful, at this point, to explore the sensitivity and vulnerability of the species to different management schemes, changes in demographic parameters, and catastrophic events. To do this, it is important to understand the relationship between population growth and extinction.

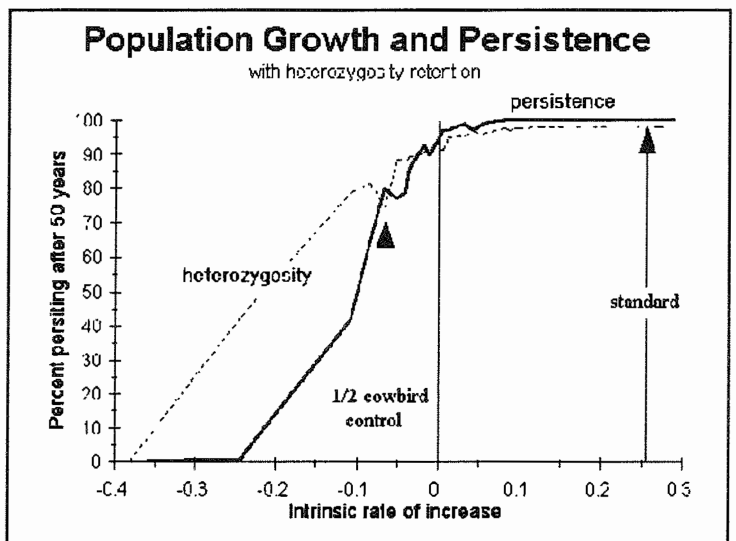

Figure 3. The relationship between "r" and population persistence.

A negative deterministic "r" value means the population is decreasing and will eventually become extinct. However, the intrinsic rate of increase does not have to become negative for Kirtland's warblers to be at risk of extinction within 50 years, even with an increasing amount of breeding habitat (Fig. 3). Multiple simulation scenarios using different levels of population growth indicate that when r_{det} falls below 0.10 and the r_{stoc} below 0.034 the population has about a 10% probability of extinction in 50 years. When r_{det} falls below 0.005 and r_{stoc} below -0.08, the species has only a 50% chance of surviving for 50 years (Tables 4-15). Alterations in cowbird control, catastrophic events, and changes in demographic values could produce a such a negative rate of increase.

Cowbird Parasitism

An average of approximately 4000 brown-headed cowbirds have been removed annually since 1972 from Kirtland's warbler habitat, with a substantial financial outlay (see briefing document). Nest parasitism by cowbirds is currently considered under control although a residual 5% parasitism rate remains and is included in the fecundity values of the general model. It is feared that budget difficulties could reduce or possibly end cowbird control. The consequences of scenarios of reduction or cessation of cowbird control were explored by altering fecundity rates (Table 3, Figure 4). When a nest is parasitized by a cowbird, no Kirtland's warbler fledglings are produced; in effect, the nest fails even though a cowbird chick is raised.

Mayfield (1961) found about a 40% loss of nests to cowbirds, while Walkinshaw (1975) later put the loss at about 70%. Discussions at the PHVA workshop resulted in the consensus that the Walkinshaw's figure of 70% is more realistic than Mayfield's earlier estimation because of increases in the size of cowbird population in recent years. Using Walkinshaw's estimation, the group altered fecundity to reflect half-cowbird and no cowbird control (Table 3).

Table 3. Effect of cowbird control levels on fecundity. Percent of nests that produce 0, 1, 2, 3, 4, 5, or 6 fledglings.

CASE	Number Fledged						
	0	1	2	3	4	5	6
Full Control	10	.52	10.8	15.5	28.3	33.9	.99
No Control	75	.14	2.9	4.3	8.2	9.46	0
1/2 Control	40	.35	6.9	10.4	19.5	22.8	0

If cowbird control were reduced by half, the population has approximately a 20% chance of becoming extinct in 50 years, but the surviving populations are declining in size. Because the rate of increase becomes negative when cowbird control is halved, all iterations of the warbler population would eventually become extinct if time were extended (Fig. 4). The species has little hope for persisting even 10 years without at least some cowbird control (Fig. 4, Table 5).

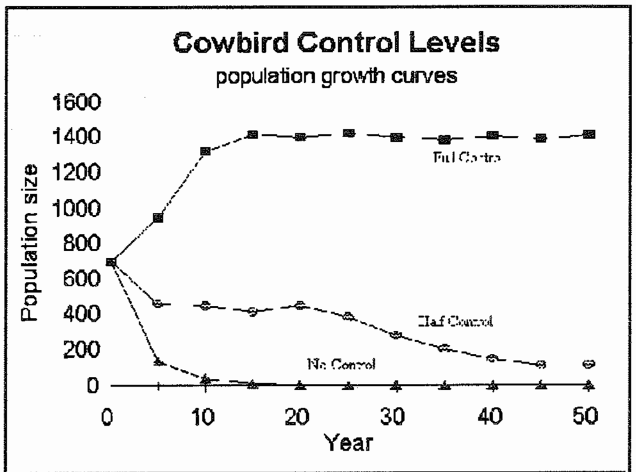

Figure 4. Effects of cowbird control on population growth.

In the standard population, an average of 3.57 fledglings are produced per nesting pair. According to analysis of historical data at the PHVA workshop, without cowbird control an average of only 0.99 fledglings would be produced per nesting pair. How low can fledging success become before reducing the viability of the species? Assuming all other base scenario parameters remain constant, a fledging success of less than about 2.3 $\pm$ 0.2 birds per pair would yield a negative rate of increase, thus driving the population size towards zero (Fig. 5). This would occur if on average 35% of the Kirtland's warbler nesting attempts failed due to the combined effects of predation, abandonment, and parasitism.

Habitat

The basic scenario described above has an initial carrying capacity of 724 adult birds that increases to almost 1500 birds in ten years based upon a 10.5% annual increase in habitat. Such a situation might be overly optimistic in representing the actual habitat.

Simulations run at a constant carrying capacity of 500 birds for 50 years produce similar extinction probabilities but predict lower levels of heterozygosity and allelic retention in extant populations (Table 5).

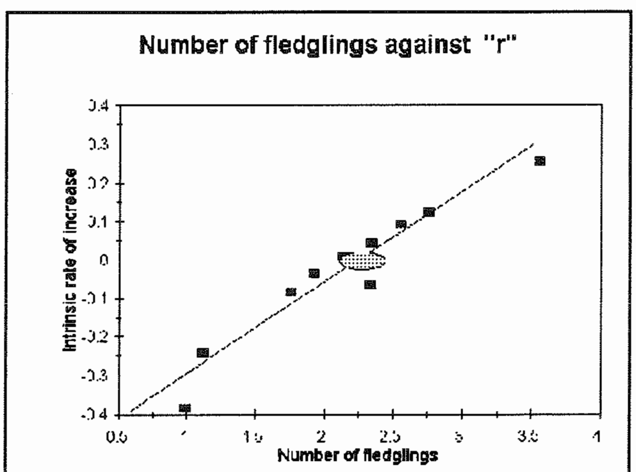

Figure 5. Number of fledglings affects on "r".

Because the bulk of the warbler's managed habitat is owned by three separate agencies, several events could reduce the amount of habitat available for Kirtland's warblers. The regeneration of jack pine forest type on Forest Service land, with reduction in funding, could be reduced to 1000 acres (400 hectares) per year from 2002 through 2021. This would reduce the carrying capacity by approximately 7% for 19 years. If the Michigan Department of Natural Resources loses funding for habitat management, 1000 acres (400 hectares) of suitable habitat would be lost each year. If the U.S. Fish and Wildlife Service land is not managed, 200 acres (80 hectares) would be lost per year after 2002.

The loss of habitat after 2002 was modeled as a 5.25% reduction in an initial carrying capacity of 1500 birds for 10 years. Again, extinction probabilities were similar to those derived from the standard input. Not surprisingly, the loss of habitat increases the loss of genetic diversity assuming that all the members of the initial population had unique alleles. The level of heterozygosity after 50 years is similar to that calculated from the standard input (Table 5).

Additional habitat might become available after 2010 based on management starting in 2000. A shorter rotation period (25 years) for jack pine on Michigan DNR lands could result in 2400 rather than 1600 new acres annually. This increases total available habitat to 38,000 acres (15,200 hectares) and hence increases the carrying capacity by 26.7%.

Catastrophes

Catastrophes might influence the long-term survival of the Kirtland's warbler. A number of features of the breeding and winter habitats make the single population vulnerable to rare events with large repercussions. For instance, jack pines do not release seeds unless the resin in the cones is first softened by fire (Ahlgren & Ahlgren 1960) or intense direct sunlight. Pressure to suppress fires in Kirtland's warbler breeding habitat is strong, especially after a run-away prescribed burn in 1980 that destroyed nearby homes and killed one person. For the Kirtland's warbler, such a catastrophic event was beneficial because it created many acres of warbler habitat.

Based on historical data there is on average, one 10,000 acre (4000 hectare) burn and three 5,000 acre (2000 hectare) burns per decade in northern lower Michigan. There is about a 50% probability that these fires will affect Kirtland's warbler breeding habitat. Thus, on average natural wildfires create 1,250 acres (500 hectares) of warbler habitat annually. Conversely, about once a century a fire might burn 20% of the occupiable habitat during the breeding season.

Twenty-eight major storms have been recorded in 19 years on the wintering grounds. Based on this information there is a 68% chance of a major storm (hurricanes, etc.) occurring each year. Historical data have shown that these storms do not appear to affect Kirtland's warbler numbers. The probability that a major storm would negatively impact the warblers is presumed to be low.

Insects such as the gypsy moth, forest tent caterpillar, and jack pine budworm have a low probability of affecting the warbler population. Both the gypsy moth and the forest tent caterpillar are in warbler habitat and have caused no major problems. The forest tent caterpillars could affect ground cover and the gypsy moth may affect the foliage of the pines. However, both of these insects would only feed in jack pine stands if they had already depleted surrounding deciduous forests or if the warbler habitat was mixed with deciduous trees. Gypsy moth and forest tent caterpillars have spines so would probably not be a significant food source for the birds. The budworm tends to attack mature stands of trees. Afflicted trees would be stunted and might actually benefit the Kirtland's warblers. Additionally, the budworm would be a food source for the birds. There is no planned spraying for insect pests in warbler habitat.

About once every 20 years there might be a drought in the summer habitat. The reproductive success of the Kirtland's warblers during these droughts is projected, by the participants, to drop by 50%. The impact of a catastrophe such as drought is modeled along with release efforts. The effects of drought on the wintering ground appear to be negligible (Ryel 1981).

There have been no documented reports of disease epidemics in Kirtland's warbler populations. However, experience with Nashville warblers demonstrated a potential for 30% mortality in captivity (Bocetti 1989). This type of mortality in a captive population of Kirtland's warblers could be modeled as a catastrophic event. If there is a decision to bring birds into captivity or attempt translocation efforts, then the effects of disease should be explored further.

Increased human settlement increases the number of domestic cats, off-road vehicles and vandals in the area as well as local resistance to burning. These human factors may play a significant role in the future of the Kirtland's warbler. Further information needs to be gathered concerning their impact.

The PHVA participants thought there was a 5% chance that all funding would be cut within the next 50 years. This funding cut would include money for both habitat management and cowbird control. This would mean that if the population was able to withstand the devastating effect of uncontrolled cowbird parasitism, after 20 years wildfires and commercial operations would be the sole generators of appropriate nesting habitat.

Less predictable events that might affect the Kirtland's warbler include the impact global warming could have on the occurrence of wildfires and jack pine growth and the impact of construction of lighted towers which might cause significant mortality during migration. Also a large portion of the population could move to an area not managed by Provincial, State, or Federal agencies. Political constraints, such as the size of habitat blocks, the number of fire breaks, and animal rights concerns about cowbird control could influence the population's survival.

Capture and Release

Serious consideration needs to be given to establishing a second population of Kirtland's warblers in a suitable, but separate, location. Probably the quickest way of establishing a second population is through a capture and release program coupled with creation of habitat in a disjunct location. Young of the year would be taken from the original population and overwintered in captivity. The following spring they would be released at the chosen site. A pilot study with Nashville warblers indicates that over-wintering warblers is possible (Bocetti 1989). Simulation modeling can be used to explore the success of establishing a new population.

Simulations suggest that removing 10 to 30 pairs of birds in one year will not significantly affect the demography of the existing population. The population's high growth rate makes the effects of such minimal removals undetectable in the overall population trajectory (Fig. 6). (Note: In Figure 6, R=year of removal and P=number of pairs removed x 10). Even in a situation where the carrying capacity is declining, removing 60 warblers from a population of 1000 has no significant impact (Table 6).

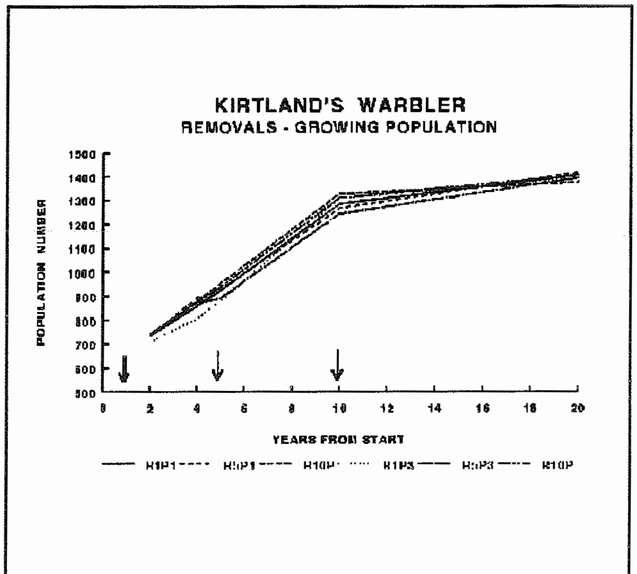

Figure 6. Removal of 10 to 30 pairs.

These scenarios for a release program make several identified assumptions. First, warblers must be successfully overwintered and then released. It is assumed that the over-wintered warblers will remain in the area where they are released. It is assumed that the progeny of the released population will return to their natal colony after migration to the wintering grounds. It is assumed that the new population has the same demographic parameters as the original one.

Simulation models were run with four basic scenarios:

S10--a single release of 10 pairs,
S30--a single release of 30 pairs,
M10--10 pairs released for four consecutive years,
M30--30 pairs released for four consecutive years.

Releasing 10 pairs into an environment with a carrying capacity of 200 birds may succeed in establishing a new population if all of the assumptions are met and no catastrophes occur.

Past experience with release programs make all of these favorable outcomes with a single release highly unlikely. The loss of heterozygosity in 20 years would be greater with just one release of 10 pairs than if 30 pairs were released or 10 birds were released annually for four consecutive years.

In a perfect environment, a translocated warbler population would fare well. Adding risk, like drought, to the scenarios, however, increases the likelihood that the release efforts would fail. Models were run assuming a catastrophic event had a 50% chance of occurring each year. Five levels of catastrophic circumstances were explored:

C0--event has no impact of fecundity or survival,
C1--event reduces fecundity by 50% and survival by 10%,
C2--event reduces fecundity by 20% and survival by 20%,
C3--event reduces fecundity by 50% and survival by 20%,
C4--event reduced fecundity by 50% and survival by 50%.

In all cases, multiple releases buffer the impact of a catastrophic event (Table 7, Fig. 7). The level of heterozygosity after 20 years is highest when 30 pairs are released for four consecutive years (H=0.82 to 0.96). If 10 pairs are released for one year, heterozygosity can dip to 0.63 (Table 4) and rapid inbreeding would provide an additional and unnecessary risk for failure.

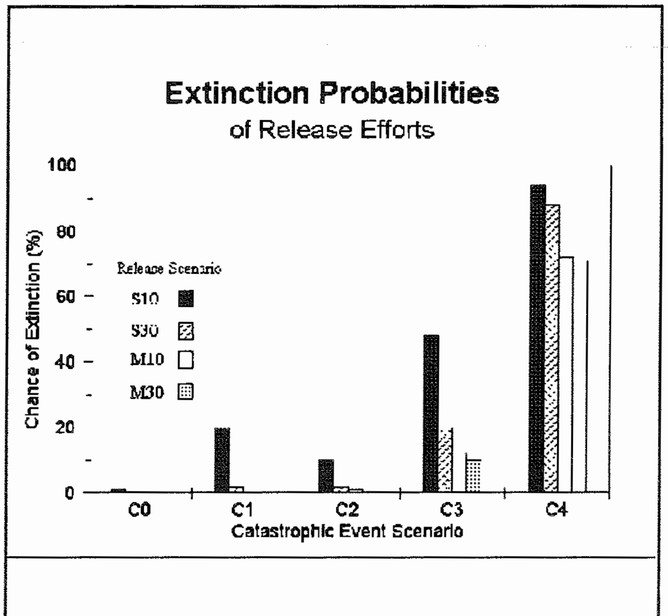

Figure 7. Success of release efforts after 20 years.

Demographic Factors

There is a possibility that females have a higher mortality rate than males. The Kirtland's warbler has a relatively long incubation time in nests that are on the ground. Nesting females, which do all of the incubation, could be more vulnerable to predators than males. A series of simulations were run including this increased female mortality (Tables 1). These simulations suggest the adult female mortality rate would have to almost double before the intrinsic rate of increase becomes negative (Fig. 8).

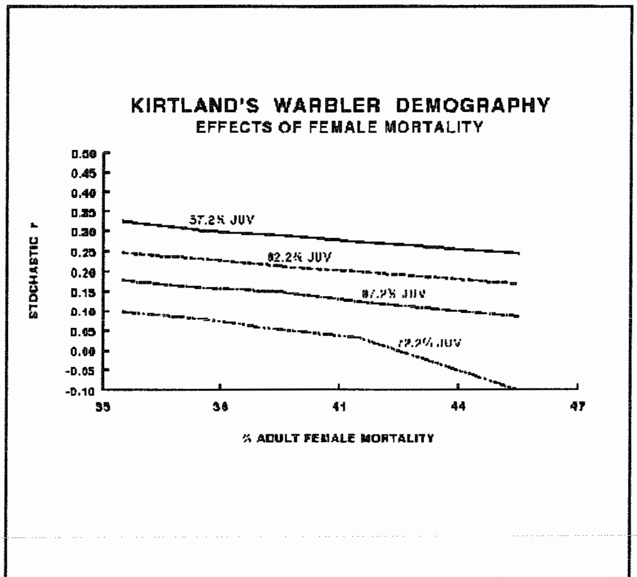

Figure 8. Female mortality effects on population growth rate.

Factor Interactions and Sensitivity Analysis.

1. Juvenile and adult mortality interact with additional mortality from catastrophes to produce systematic declines in population growth rates (Figures 9-13, Table 8). The proportion of females not having a successful nest was set at 10% (on average) and 4.2 fledglings were produced. Growth rates do not become negative until the average annual juvenile mortality reaches 74% and adult mortality exceeds 42% (Fig. 13). The inclusion of catastrophes in the scenarios accelerates the process (Figs. 9-12) so that adult mortality of 38% is a critical value. Although variance for the demographic parameters has been included in these scenarios, the processes are approximately linear within the range of values tested. The probability of extinction was less than 2% until juvenile mortality exceeded 70% and adult mortality was less than 38% (Table 8).

The loss of heterozygosity was 4-5% juvenile mortality reached 70% and adult mortality exceeded 38% (Table 8). Fifty years is about 20 warbler generation so that a 5% total loss is about .25% per generation. This is a higher rate of loss than wanted (0.1% or less loss per generation is better for the population. One goal for the population would be a population sufficiently large to allow genetic variation lost by drift to be replaced by new mutations. This will require a population size of about 2,000 birds (1,000 pairs of adults). For long term viability this would be a minimum population size.

2. Increasing the proportion of females failing to successfully nest to 16% annually decreases the growth rate of the population (r) by about 0.05 to 0.06 under a given set of mortality conditions with no catastrophes (Figs. 14-16, Table 10). An increase to 22% of females with nest failure (Figs. 16-17, Table 12) decreases the growth rate by about 0.03 on

average. Increasing the nest failure rate to 28% (Figs. 18-19, Table 14) again decreases the simulated population stochastic growth rate by about 0.03.

Mean surviving population sizes projected to 50 years (Figs. 20-23, Tables 9 & 10) are lower the higher the proportion of females reproductive failures. Thus at 16% of females = 0, on average, nearly all populations are declining when juvenile mortality exceeds 62% (Fig. 23). Heterozygosity (Figs. 24, 26, & 29) is lost more rapidly with increasing rate of nest failure and this loss accelerates with increasing juvenile mortality (Fig. 29). These declining populations have an increased probability of extinction as well (Figs. 28 & 31) which appears to increase rapidly with juvenile mortality greater than 70%.

Reduction in the fledging rate by 5% or from 4.2 to 4.0 fledglings per nest further systematically decreases the population growth (Figs. 32-35, Tables 9, 11, 13, 15). The population cannot easily sustain a juvenile mortality rate of 76% with this decline in reproductive rate. Systematic and linear reduction in the proportion of females with successful nests (Figs. 39-40) reduces the population growth rate, final population size, and increases the risk of extinction.

Recommendations

The single Kirtland's warbler population is limited by breeding habitat and threatened by cowbird parasitism. These recommendations are based on the dynamics of small populations and are made with the assumption that the recovery program's goal is a Kirtland's warbler population that is as self-sustaining as possible. Financial and political considerations are not explored.

1) Brown-headed cowbird control should continue at no less than 75% of the current level. Less effort will lower fecundity rates and consequently lower the species ability to fill new habitat. Potentially, less intensive cowbird control will result in a negative growth rate for the population and lead to species extinction.

2) At least one person on the recovery team needs to be responsible for having a working knowledge of the current research on cowbird behavior relative to landscape patterns. There is a growing body of information dealing with brood parasitism and habitat patterns that may have relevance to Kirtland's warblers and the way in which their breeding habitat is currently managed.

We note that the number of cowbirds removed in one year does not appear to reduce the number of cowbirds removed in the following year. We suggest that there are one or more features of the existing landscape attracting cowbirds that could possibly be modified.

3) A second, distinct, population of Kirtland's warblers needs to be fostered in appropriate habitat. Not only would this remove the hazard of placing all expectations of species

survival on one small area but would be an excellent opportunity to develop techniques for establishing and maintaining warbler populations. To assist establishing a second population, more research needs to be done on cross-fostering, captive-rearing, and over-wintering birds in captivity.

4) We suggest that habitat be managed by controlled burns rather than through plantations. The recovery team calls for 37,500 acres of suitably aged habitat to support approximately 1000 pairs of Kirtland's warblers. We endorse this goal and at the same time note that based on workshop data between 570 and 840 pairs are expected by the year 2002. The low-end figure (average habitat) falls short of the team's goal by 43% and probably reflects reality more closely than the high end figure (optimal habitat). Plantations seem to be less that "average" habitat from the perspective of the Kirtland's warbler; they apparently have greater numbers of unmated males and lower polygyny values than wildfire areas. Although, to date, natural regeneration has been poor on most areas where prescribed burns were done, the resulting habitat will likely be more suitable.

5) The recovery team needs to continue to monitor Kirtland's warbler demography and the species response to different habitat types through annual censuses of singing males and capture-recapture efforts.

6) The recovery team's decision to include population modeling at each meeting will provide a valuable tool for adaptive management and continued testing of the changing management scenarios.

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KIRTLAND'S WARBLER
(Dendroca kirtlandii)

POPULATION AND HABITAT VIABILITY ASSESSMENT

7-9 January 1992

WORKSHOP REPORT

SECTION 3

HABITAT AND THREATS

Habitat

Participants: John Probst, Jerry Weinrich, Charlene Gieck, Richard Urbanek, Tom Weise, Philip Huber, Jan Eldridge, Ron Refsnider

Between 1957 and 1961, 4 areas totalling 11,690 acres (4,676 ha.) -- one in the Huron national Forest and 3 on State land in Michigan -- were set aside specifically for preserving the Kirtland's warbler (Mayfield 1963). The State areas were to be planted, and the federal areas were to be burned and planted as necessary (Radtke and Byelich 1963). With one exception (stand #10, Fig 1, all prescribed burning has failed to provide natural regeneration. The current area targeted for Kirtland's warbler management has increased to 143,000 acres. The Kirtland's Warbler Recovery Plan (developed under authority of the Endangered Species Act of 1973) calls for regenerating jack pine habitat through harvest followed by burning on 78,000 acres State land and 65,000 acres federal (USFWS, USFS) land so that about 29,600 acres suitably aged habitat will be available every year. This habitat will be regenerated at the rate of about 2960 acres per year in 17 state forest and 8 federal management areas (Fig. 4). These stands are generally on a 50 year Kirtland's warbler management and commercial timber rotation; Kirtland's warblers are the primary resource objective. We estimate minimum habitat carrying capacity for 584 individual (290 male) Kirtland's warblers in 1993 based on the 1984 average male density among all wildfire and plantation stands, and a maximum of 860 males based on peak densities (2.8 males/100 acres) in wildfire habitat.

In total, there are 143,000 acres available with state, Federal, and Military, land.

We will use three categories:

1). 2700 acres per year on 50 year rotation (1600 acres MIDNR, 1100 acres FWS)

2). Regenerate on an additional 100 acres per year from new habitat at Mack Lake

3). Create an extra 200 acres per year by managing 5000 acres (FWS land) on 25 year cycle

These three categories will result in the annual development of 3000 acres (beginning in 1992), achieving an available habitat acreage of 30,000 in 2002.

In 1993 there will be 15,400 acres of occupiable habitat.

1994-1996	2410 additional acres per year 480 acres lost each year _______________ 1930 acres added per year	
1997-2001	2410 additional acres per year 1680 acres lost each year (mainly loss of Mack Lake habitat) _______________ 730 added annually for five years	

After 2001 there will 30000 acres available or approximately 50% increase from 1993 level.

Translated into carrying capacity:

The low value is based on 1.9 males/100 acres

The high value is based on 2.8 males/100 acres

The low value is based upon using average male densities from 1984 in all occupied stands in the two primary habitat classes (wildfire and plantation). 1984 male data were used because the birds were unevenly dispersed throughout 23 stands. This figure is believed to be representative of the density level that would occur in a low to moderate quality, plantation-dominated situation.

The high male density value was estimated from peak male densities (13 to 15 years stand age) in four major wildfire areas. This density level is anticipated to occur in high quality plantation habitat (optimal stem density, large cutting blocks, optimal biogeographic distribution of suitably-aged stands), and most wildfire-generated habitat

These values were multiplied by total acreage and then doubled to include females.

		Individuals (males and females)	
Year	Acres	low	high
1993	15400	584	862
2002	30000	1140	1680

After 2002 available habitat is constant at 30,000 acres per year.[1]

This also assumes continued availability of NF jack pine for harvest after 2018. At that time there will be no jack pine of 38 years or older, thus, no jack pine suitable for harvest based upon current markets. (This is due to 1980 Mack Lake fire regenerating more than 7900 unanticipated habitat acres, throwing regeneration off schedule; see attached Age Class Distribution diagram for HMNF.) The figure of 30,000 acres assumes market conditions at that time will allow harvest of younger jack pine, and continuation of FS regeneration of 1200 acres annually. Scenario 2, below, is presented to prevent the occurrence of a deficit of available merchantable timber in 2018 by reducing harvest beginning in 1992.

Rate of change per year = 10.6% for low value

High rate of change per year = 10.5% for high value

We will make progressive refinements in male density estimates for calculating carrying capacity in two principle ways: 1) an ongoing analysis of past biogeography patterns of habitat utilization will be applied to future habitat distribution patterns. 2) census data and research (NCFES and OSU) will document expected increases in utilization of larger plantation complexes with better local habitat quality. Finally, we will work toward productivity estimates as coefficients for the male density numbers. If possible, productivity estimates will ultimately reflect major changes documented with stand-age trends on biogeographic context.

<u>VORTEX Scenarios, Based Upon Habitat Effects</u>:

1. The basic scenario described above, using high and low numbers for K.

2. Reduction of FS regeneration to 1000 acres per year, through the year 2021, or 10,000 acres over the decade. This will reduce available habitat by 2000 acres, reducing K by approximately 7% between 2002 and 2021. After 2021 available habitat would be 30,000 acres, as in the basic scenario.

3. Worst case scenario for MIDNR lands - loss of funding. This reduces DNR acreage

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[1] Estimated suitable habitat of FWS land will be 0 through 2001 and increase 200 acres/year until a stable acreage of 2000 acres is reached in 2012. Because this acreage is relatively small, for purposes of simplifying the scenario for modelling by Vortex, it was assumed the stable level of 2000 suitable acres would be achieved by 2002, the same time point at which a stable acreage would be achieved by planned management according to the current recovery plan.

by 90%. The resulting habitat reduction can occur at any time after 2002. The reduction in available habitat would be 1000 acres for each year without funding.

4. No management on FWS lands. This eliminates 200 acres per year that would otherwise be available beginning in 2002.

5. Shorter rotation management on DNR lands, resulting in creation of 2400 acres annually instead of 1600. This increases total available habitat acres to 38000, and increases K by 26.7%. This shorter rotation could not begin until 2010, based on increased management starting in 2000.

Cowbird Parasitism on Kirtland's Warbler

Participants: Chuck Kjos, Wes Jones, Mike DeCapita, and Harold Mayfield

Our original thought was to consider cessation of cowbird control a catastrophic event. After running VORTEX with modifications only to the clutch size and fledgling numbers variables, it appears that the catastrophic classification is not necessary. We presume an end to cowbird control would be a result of governmental budget difficulties. Scenarios developed for partial cowbird control are presumed to result from budget cuts that still allow some control, but do not allow for protection of the entire KW population.

Cowbird parasitism is currently under control. A residual 5% parasitism rate is included in general production loss (Case 1) by the modeling team. The first case in the table below reflects clutch/nestling (litter) sizes with full cowbird control developed by the modeling group.

We used two figures for loss to production caused by cowbird control. Mayfield found about a 40% loss, while Walkinshaw later put the loss at about 70%. We developed clutch size variables for each of these with no cowbird control and for each with 1/2 cowbird control. The 1/2 control cases simply reduced the total production loss by 1/2. Discussions during runs of these variables resulted in a consensus that the Walkinshaw loss to production of 70% would be more realistic than Mayfield's earlier figure. The reason is the increase in cowbird population since Mayfield developed his figure.

We propose to modify the clutch size variable to account for changes in cowbird parasitism as indicated in the following table where fledged nestling clutch size, L, is 0, 1, 2, 3, 4, 5, and 6. Clutch variable L0 in Cases 2 - 5 was determined using the Mayfield or Walkinshaw loss figures combined with the base L0 from Case 1, but modified downward slightly to allow for compensatory loss. The clutch variables L1 - L6 in Cases 2 - 5 were derived by simple proportion from Case 1, which represents the non-parasitized population. This derivation is preliminary, and may be modified after further consideration. During discussions, there was a suggestion that the parasitized clutch sizes might be more accurate if derived from field data in the same manner that the Case 1 figures were developed. (The values were revised slightly from the original 01/08/92 version.)

In the circumstance of partial cowbird control, two populations might be considered, a protected population and an unprotected population. For example, with limited funds in 1992, Bald Hill and Mack Lake might receive cowbird control, all other nesting areas would be left unprotected.

CASE	Clutch Size Variables (%) Simulated						
	L = 0	L = 1	L = 2	L = 3	L = 4	L = 5	L = 6
1. Full Control	10	.52	10.79	15.49	28.28	33.93	.52
2. No Control (Mayfield)	48	.30	6.23	8.95	16.34	19.6	.3
3. No Control (Walkinshaw)	75	.14	3.	4.3	7.86	9.42	.14
4. 1/2 Control (Mayfield)	25	.43	9.00	12.9	23.57	28.27	.43
5. 1/2 Control (Walkinshaw)	40	.35	7.19	10.32	18.85	22.62	.35

Catastrophic Events

Participants: Paul Aird, Mark Spreyer, Rex Ennis, Tom Weise, Mark Nelson, and Peregrine Wolff

Primary Catastrophe

1. Fire:

I. Based on historical data on the number of fires that have occurred over the past century (see Table A) It is predicted, that on a catastrophic basis over a decade, there will be one 10,000 ac burn/decade and three 5,000 ac. burns/ decade for a total of 25,000 ac. burned /decade. The probability of these burns affecting KW habitat is 50%. Thus, wildfires may create 1,250 acres of warbler habitat annually. This is based on the following calculations.

25,000 ac. of jack pine/decade with a 50% chance that this will be in KW habitat. At this probability 12,500 ac of KW habitat could be affected. Thus, over the decade an average of 1,250 ac. of KW habitat could be created due to wildfires.

Table A:

Average annual acres burned over the century past

1920's	9,000	1960's	1,300
1930's	7,000	1970's	1,600
1940's	3,000	1980's	3,000
1950's	500	1990's	6,000

From: Forest Service report of Mack Lake burn; Mitchell, J.A., D. Robson. 1950. Forest fire and forest fire control in Michigan.

II. It is predicted that one time per century, there will be a fire that will burn 20% occupiable of habitat during the breeding season.

Example:
30,000 ac. of occupiable habitat
X 20% loss = 6,000 ac.

III. There is a 100% chance that Mack Lake will go out of production in 10 yrs. If this were to happen, approximately 75 to 120 pairs would be displaced. This could potentially result in a 50% decrease in reproduction by these displaced pairs. See Habitat Section for further discussion of Mack Lake habitat.

2. Storms: Using data that recorded 28 storms in 19 yrs. we have predicted that there will be a 68% chance of a storm (hurricanes, etc.) occurring each year. Historical data have also shown that there has been little effect from these storms. Thus, we feel that the probability of this catastrophe having a negative impact on the warblers is low.

3. Oil & Gas:

Essential Kirtland's warbler habitat is being subjected to the effects of leasing for mineral rights. There is potentially an impact from this development on the species. We have attempted to predict the effect of this catastrophe. Predictions are based on the figure that 30% of the habitat would be affected (see Fig. B). It is also probable that during the development of oil and gas, some development companies will comply with the new proposed recovery plan guidelines.

100% chance that 15% of the habitat could be reduced by 10%. This would result in a loss of 450 acres.

100% chance that 15% of the habitat could be reduced by 2.5%. This would result in a loss of 112 acres.

Based on an occupancy rate of 1.9 - 2.8 pairs/100 ac., 11 -16 pairs would be displaced by oil and gas development.

0% of MDNR habitat is available for oil and gas development
50% of FS habitat is MDNR owned mineral rights
50% of FS habitat is FS owned mineral rights, thus

50% of FS surface ownership will result in a potential for 30,000 ac. of KW habitat to be impacted by oil and gas development.

Table. B

143,000 Essential KW Habitat

MDNR	78,000 ac.
FS	60,000 ac.
USFWS	5,000 ac.

There is a concern that leaks of toxic gas (e.g. hydrogen sulfide) may occur around oil and gas wells that would affect birds. To date however, there are no documented reports of Kirtland's warblers dying due to development of oil and gas wells.

4. Insects and Tree Disease:

- Gypsy moth
- Forest tent caterpillar
- Jack pine budworm

This is believed to have a low probability of causing a catastrophe. Both the gypsy moth and the forest tent caterpillar are presently in warbler habitat and have currently caused no major problems. It is felt that the forest tent caterpillar would affect ground cover and the gypsy moth may affect the foliage of the pines. However, both of these insects feed in jack pine stands only if all surrounding deciduous habitat has been depleted or if the jack pine is mixed with deciduous trees. It is believed that neither caterpillar would be a significant food source for the birds due to the presence of spines. The budworm tends to affect more mature stands of trees. However stunting of the trees caused by the worms may actually benefit the birds. It is felt that warblers would feed on the budworm. There will be no planned spraying for insect pests in warbler habitat. Thus, it is felt that the positive and negative effects of these insects would balance each other out.

5. Droughts:

More exact climatological data is required, but it has been predicted that in 1 out of every 20 yrs. there may be a drought in the summer habitat. The reproductive success of the warblers during these droughts is projected to drop by 50%. The effects of drought on the wintering ground appear to be negligible (see Ryel, L.A. 1981. Population change in the Kirtland's warbler. Jack-Pine Warbler. 59:76-91.) A complete portrayal of the climactic data is available from David Cleland, Huron - Manistee National Forest. This is part of the Ecological Land Type Phase.

6. Bird Disease:

There have been no documented historical reports of catastrophic events caused by disease in Kirtland warbler populations. A review of the published Kirtland's warbler literature (Mayfield, Walkinshaw) and unpublished literature (Kepler,1992) reveal no catastrophic events caused by disease. However, experience with the captive population of Nashville warblers has demonstrated that there is a potential for 30% mortality in captivity (Bocetti,Masters thesis,1991). This potential mortality in a captive population of Kirtland's warblers would be a catastrophic event. If there is a decision to bring birds into captivity or attempt translocation efforts, then the affects of disease should be further explored.

7. Increased Human Settlement:
   - Domestic cats
   - Local resistance to burning
   - Off Road Vehicles
   - Vandals

   It is felt that these factors may play a significant role and that further information needs to be gathered, concerning their impact before a probability of impacts can be assigned.

8. Funding:

   It is felt that there is a 5% chance that there will be a 100% loss of funding within the next 50 yrs. This would include a total cessation in the funding for habitat management and cowbird control. The effect of this would be, that in 20 yrs there would be no new habitat except that provided by wildfires and commercial operations.

Secondary Catastrophe

1. Climate change - possible effects of global warming and the potential changes this could have in location, frequency, and size of wildfires.

2. Illuminated tall structures - effects of these structures causing significant mortality on birds during the migration.

3. Shift of species to new unmanaged area.

4. Political constraints - Size of habitat blocks, fire breaks, animal rights concerns.

KIRTLAND'S WARBLER
(Dendroca kirtlandii)

POPULATION AND HABITAT VIABILITY ASSESSMENT

7-9 January 1992

WORKSHOP REPORT

SECTION 4

ADDITIONAL FIGURES AND TABLES

Figure Legends

Figure 9. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 62%*, 10% of females unsuccessful and 4.2 fledglings.

Figure 10. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 66%*, 10% of females unsuccessful and 4.2 fledglings.

Figure 11. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 70%*, 10% of females unsuccessful and 4.2 fledglings.

Figure 12. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 76%*, 10% of females unsuccessful and 4.2 fledglings.

Figure 13. Sensitivity Analysis: Interaction of Juvenile Mortality and Adult Mortality on growth rate with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 6 with placement of Juvenile Mortality on the x-axis.

Figure 14. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings.

Figure 15. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 8 with placement of Juvenile Mortality on the x-axis.

Figure 16. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *22% of females unsuccessful* and 4.2 fledglings.

Figure 17. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *22% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 10 with placement of Juvenile Mortality on the x-axis.

Figure 18. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *28% of females unsuccessful* and 4.2 fledglings.

Figure 19. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on growth rate with *No Catastrophes*, *28% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 12 with placement of Juvenile Mortality on the x-axis.

Figure 20. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Population Size at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings.

Figure 21. Sensitivity Analysis: Interaction of Juvenile Mortality and Adult Mortality on Population Size at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 6 with placement of Juvenile Mortality on the x-axis.

Figure 22. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Population Size at 50 years with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings.

Figure 23. Sensitivity Analysis: Interaction of Juvenile Mortality and Adult Mortality on Population Size at 50 years with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 6 with placement of Juvenile Mortality on the x-axis.

Figure 24. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Heterozygosity remaining at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings.

Figure 25. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Alleles remaining at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings.

Figure 26. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Heterozygosity remaining at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 18 with placement of Juvenile Mortality on the x-axis.

Figure 27. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Alleles remaining at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings. Same data as in Figure 19 with placement of Juvenile Mortality on the x-axis.

Figure 28. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Probability of Extinction at 50 years with *No Catastrophes*, *10% of females unsuccessful* and 4.2 fledglings.

Figure 29. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Heterozygosity remaining at 50 years with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings.

Figure 30. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Alleles remaining at 50 years with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings.

Figure 31. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality on Probability of Extinction at 50 years with *No Catastrophes*, *16% of females unsuccessful* and 4.2 fledglings.

Figure 32. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 62%*, 10% of females unsuccessful and *4.0 fledglings.*

Figure 33. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 66%*, 10% of females unsuccessful and *4.0 fledglings.*

Figure 34. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 70%*, 10% of females unsuccessful and *4.0 fledglings.*

Figure 35. Sensitivity Analysis: Interaction of Adult Mortality and Catastrophes on growth rate with *Juvenile Mortality = 76%*, 10% of females unsuccessful and *4.0 fledglings.*

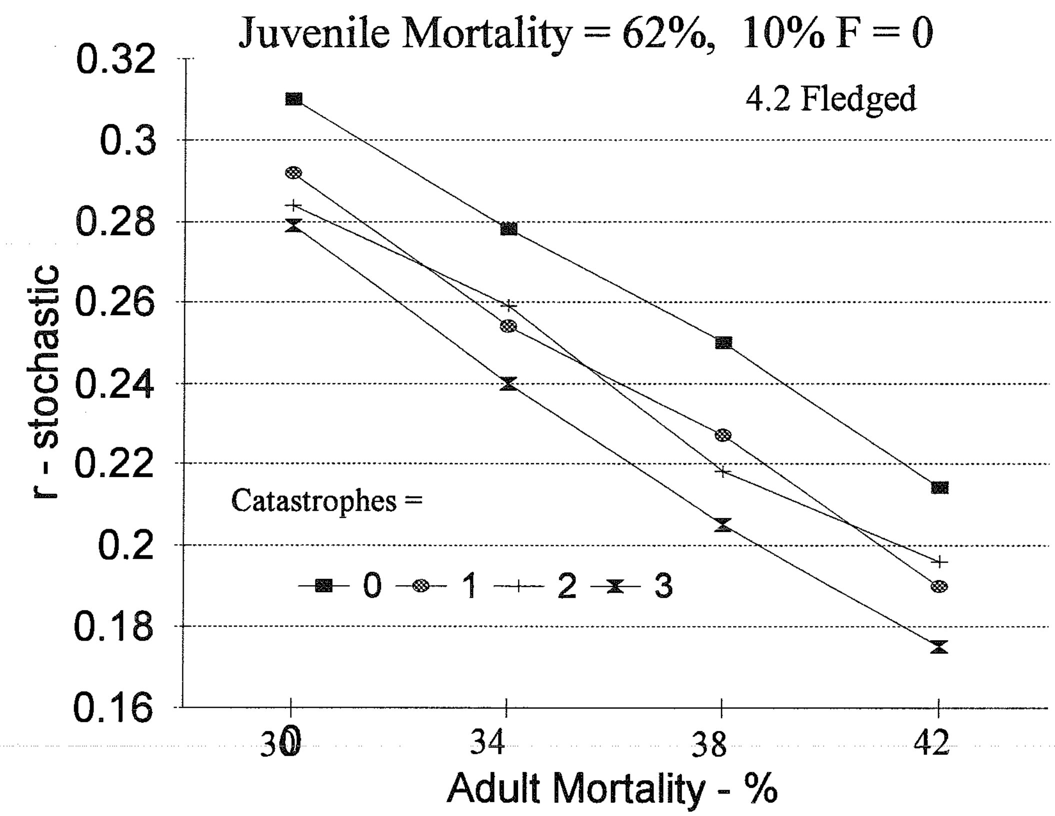
Figure 36. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality with no Catastrophes on growth rate, 10% of females unsuccessful and *4.2 fledglings.*

Figure 37. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality with no Catastrophes on growth rate, 10% of females unsuccessful and *4.0 fledglings.*

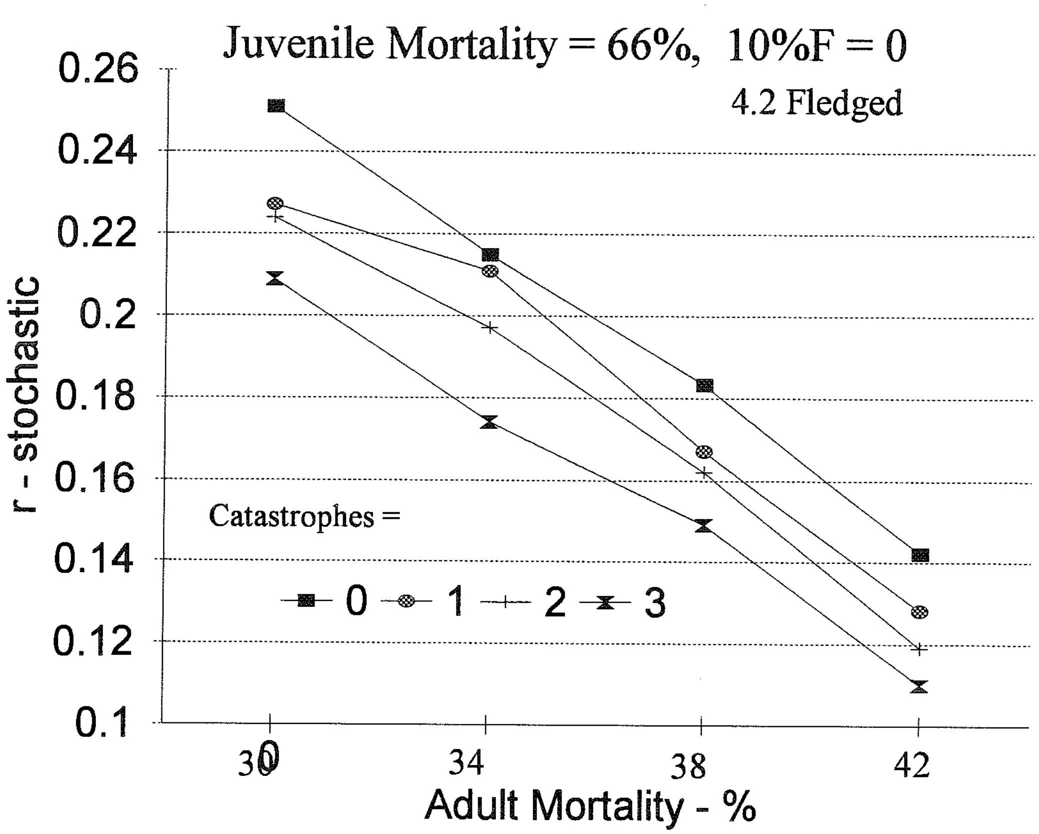
Figure 38. Sensitivity Analysis: Interaction of Adult Mortality and Juvenile Mortality with no Catastrophes on growth rate, *16% of females unsuccessful* and *4.0 fledglings.*

Figure 39. Sensitivity Analysis: Interaction of Adult Mortality and % of females unsuccessful with 66% Juvenile Mortality and no Catastrophes on growth rate, and *4.2 fledglings.*

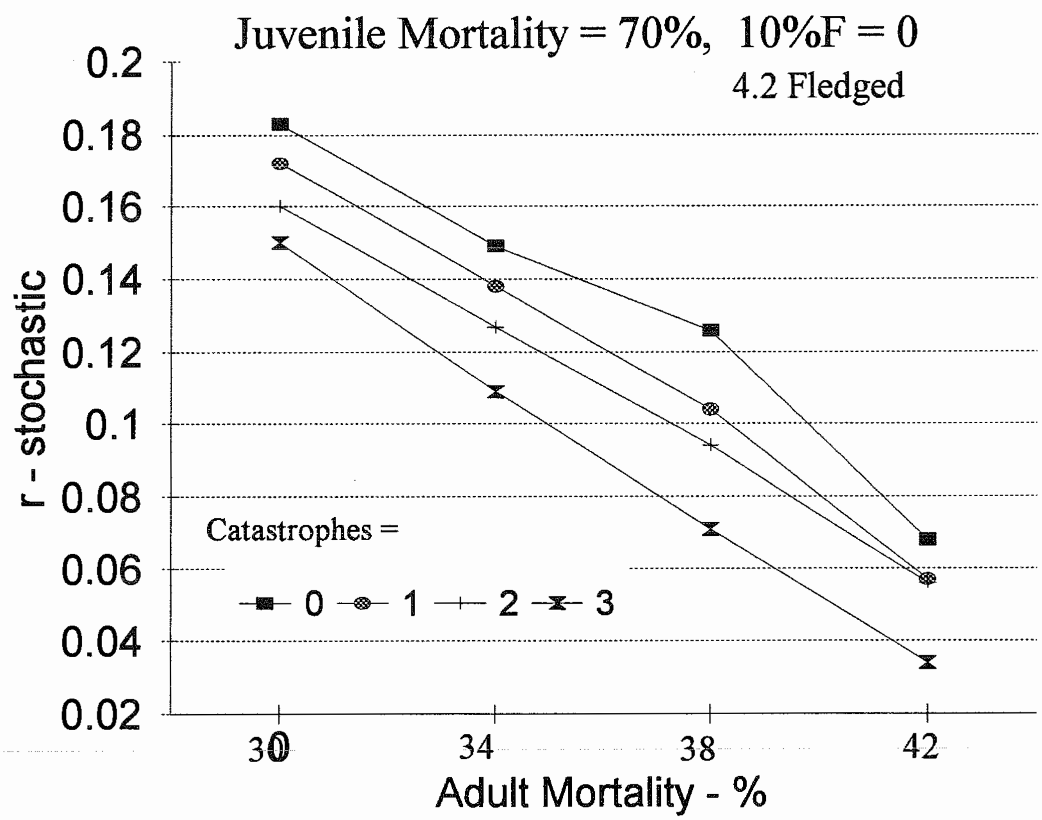
Figure 40. Sensitivity Analysis: Interaction of Adult Mortality and % of females unsuccessful with 66% Juvenile Mortality and no Catastrophes on growth rate, and *4.0 fledglings.*

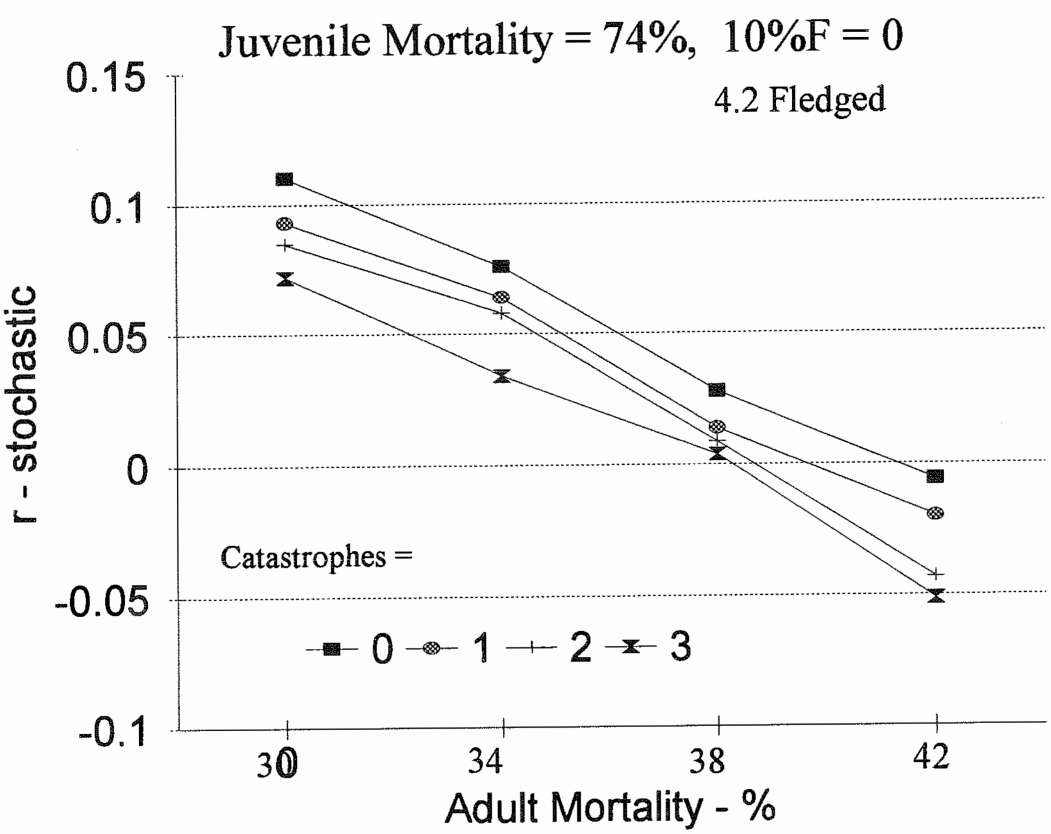


Juvenile Mortality = 62%, 10% F = 0
4.2 Fledged
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
r - stochastic
Catastrophes =
0
1
2
3
30
34
38
42
Adult Mortality - %

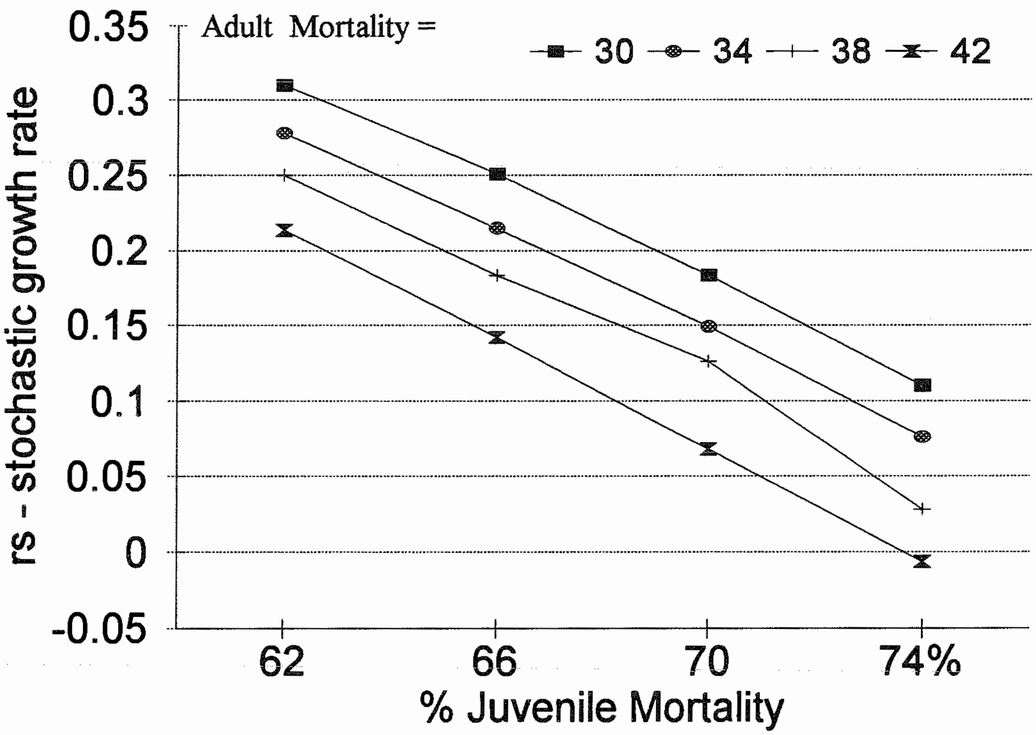


Juvenile Mortality = 66%, 10%F = 0
4.2 Fledged
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
r - stochastic
Catastrophes =
0
1
2
3
30
34
38
42
Adult Mortality - %

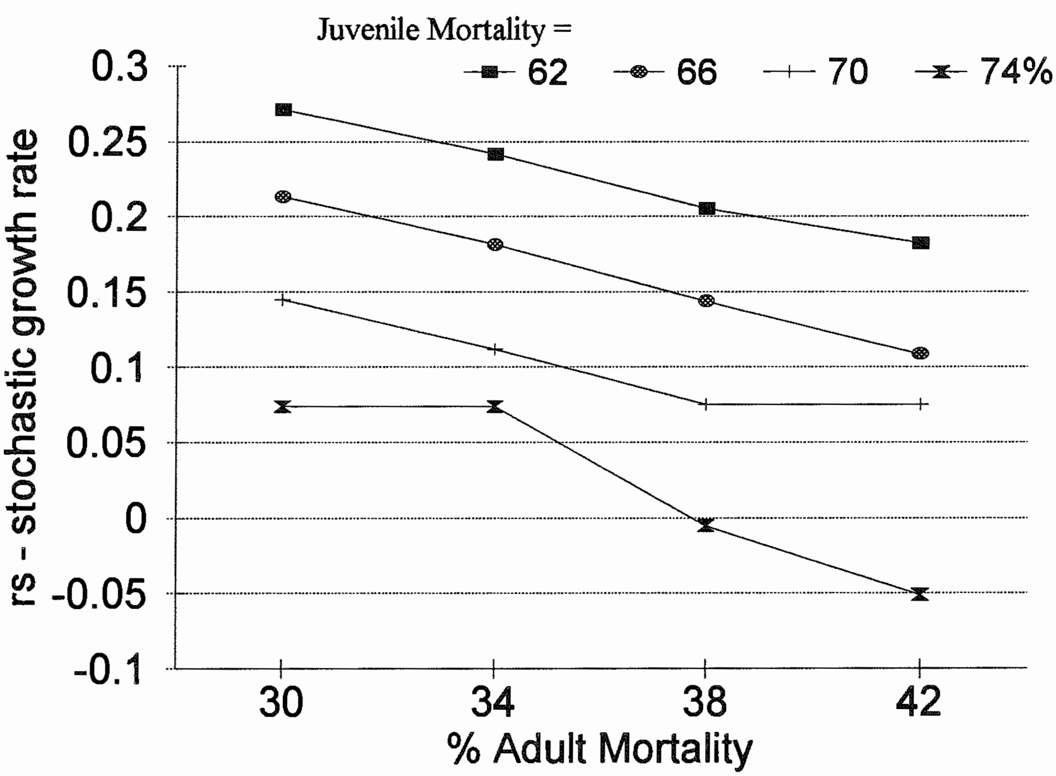

Juvenile Mortality = 70%, 10%F = 0
4.2 Fledged
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
r - stochastic
Catastrophes =
0 1 2 3
30
34
38
42
Adult Mortality - %

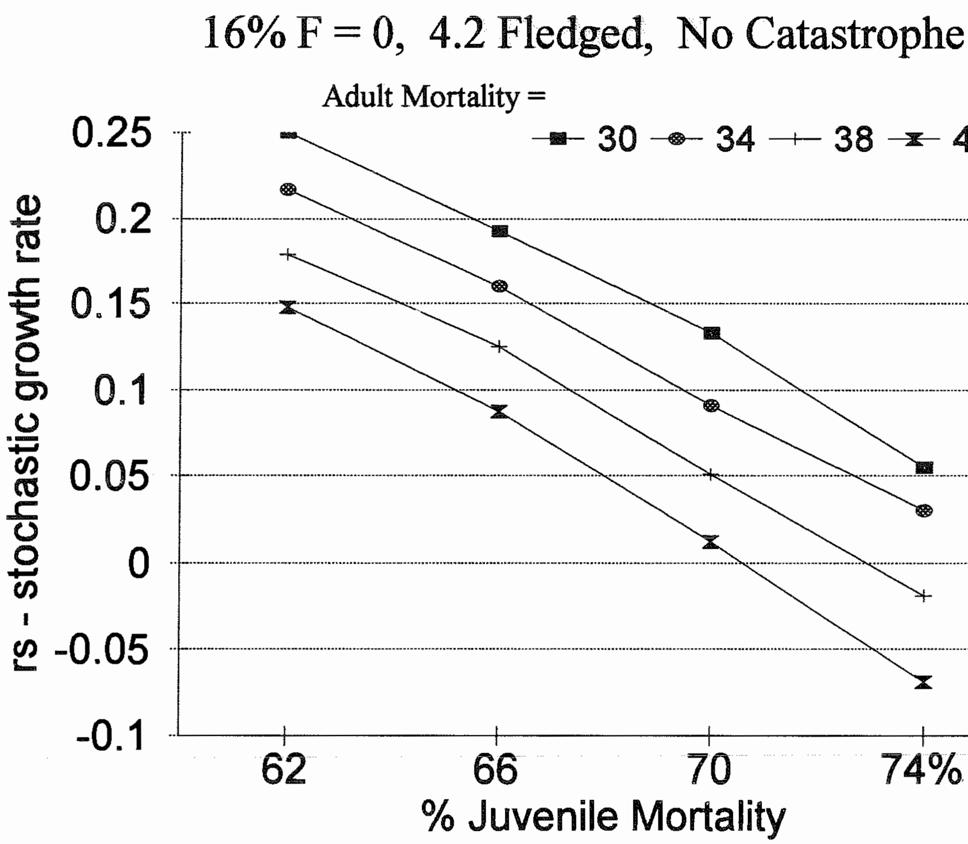

Juvenile Mortality = 74%, 10%F = 0
4.2 Fledged
0.15
0.1
0.05
0
-0.05
-0.1
r - stochastic
Catastrophes =
0 1 2 3
30
34
38
42
Adult Mortality - %

10% F = 0, 4.2 Fledged, No Catastrophe

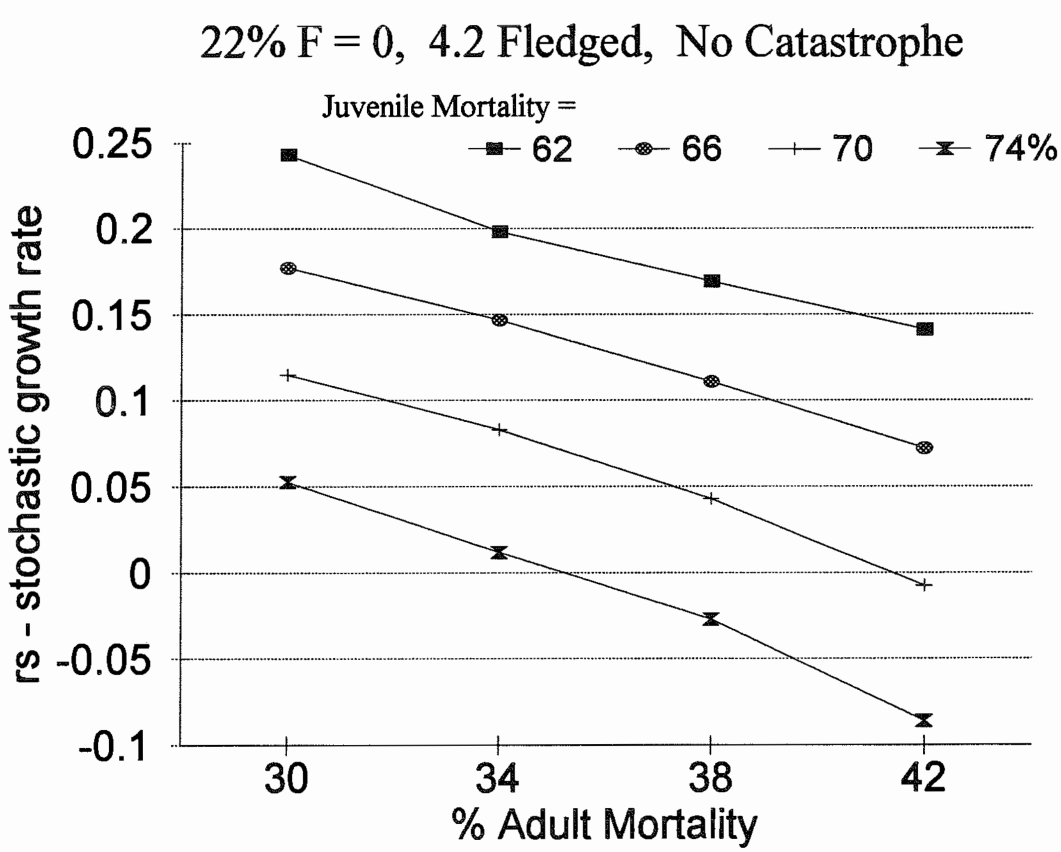


16% F = 0, 4.2 Fledged, No Catastrophe

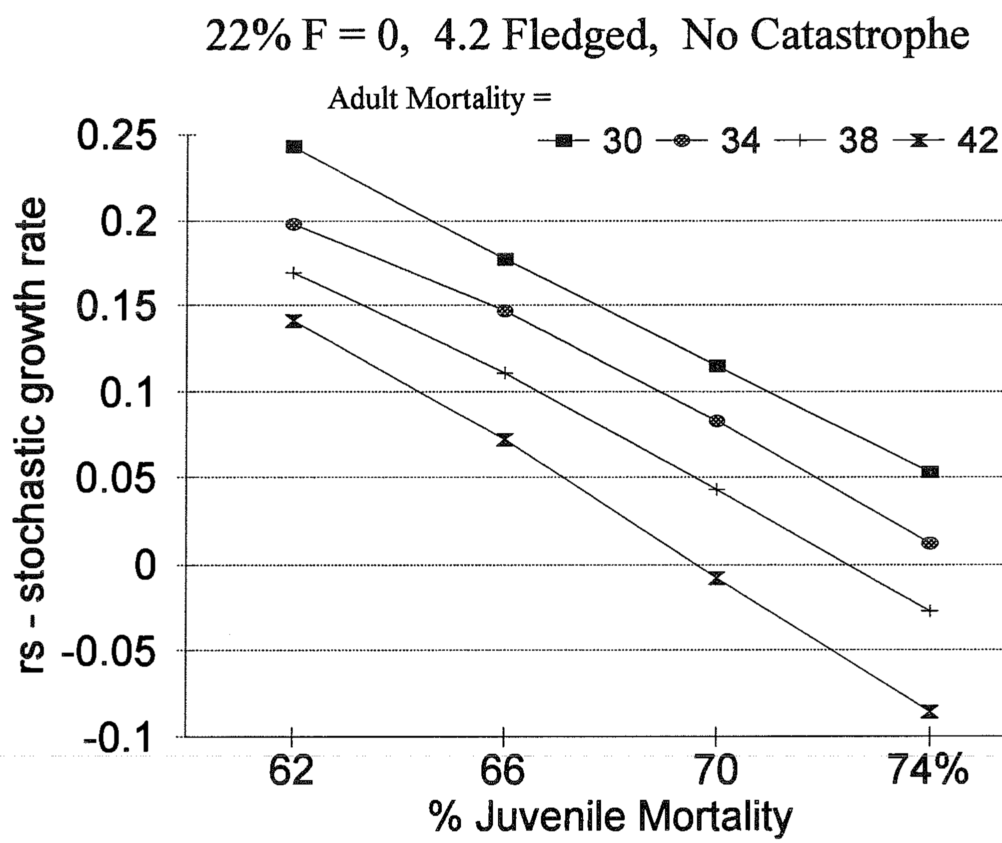


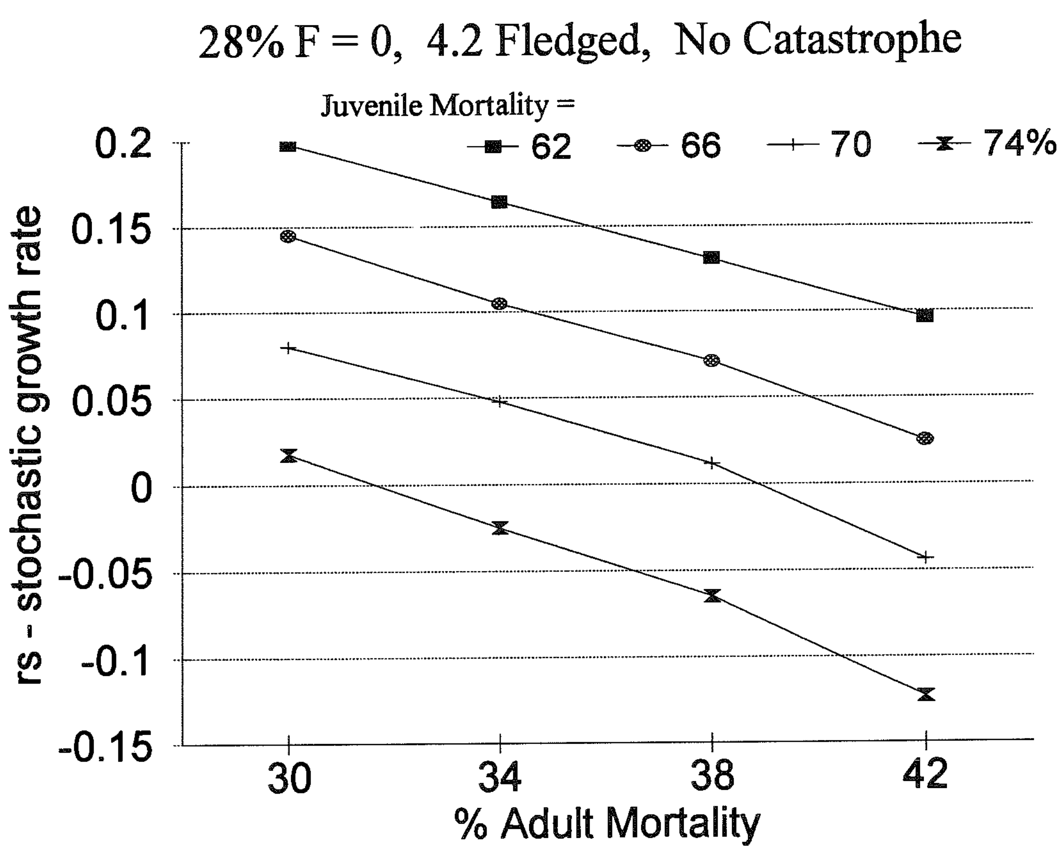


16% F = 0, 4.2 Fledged, No Catastrophe
Adult Mortality =
30
34
38
42
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
rs - stochastic growth rate
62
66
70
74%
% Juvenile Mortality

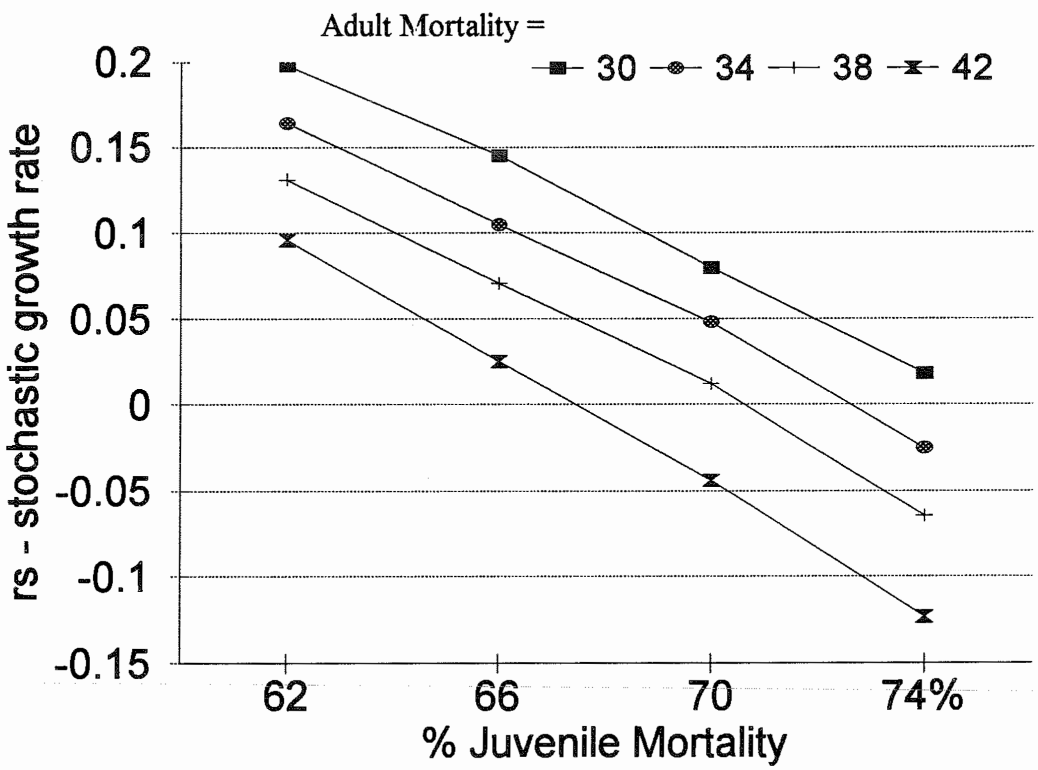


22% F = 0, 4.2 Fledged, No Catastrophe
Juvenile Mortality =
62
66
70
74%
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
rs - stochastic growth rate
30
34
38
42
% Adult Mortality

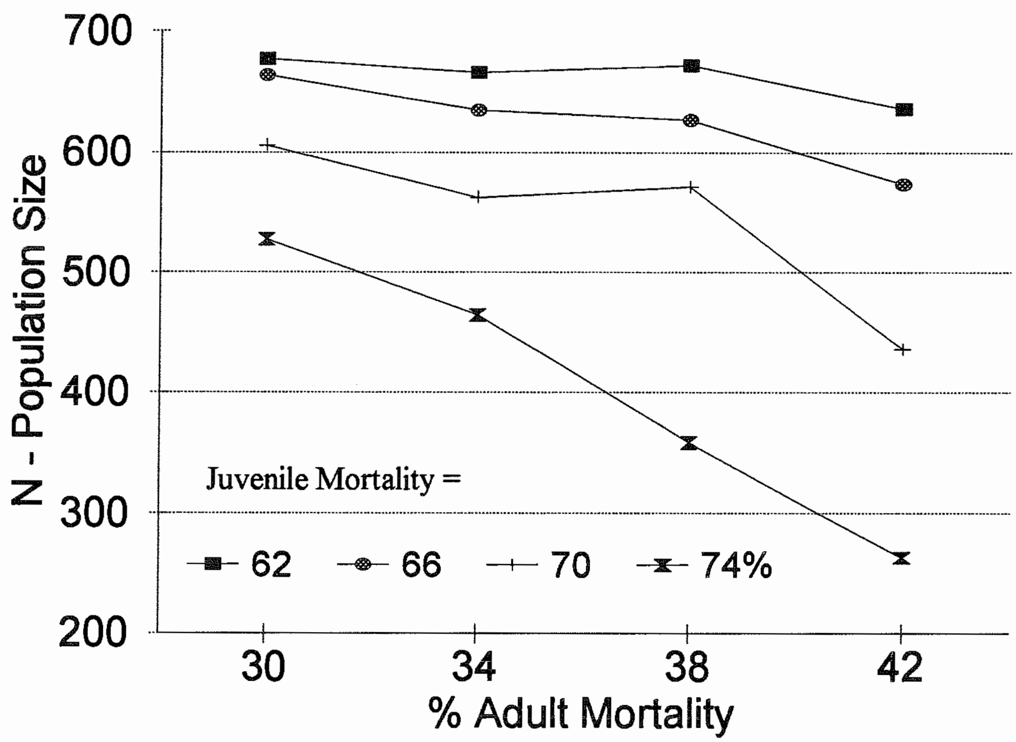

22% F = 0, 4.2 Fledged, No Catastrophe
Adult Mortality =
30
34
38
42
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
rs - stochastic growth rate
62
66
70
74%
% Juvenile Mortality

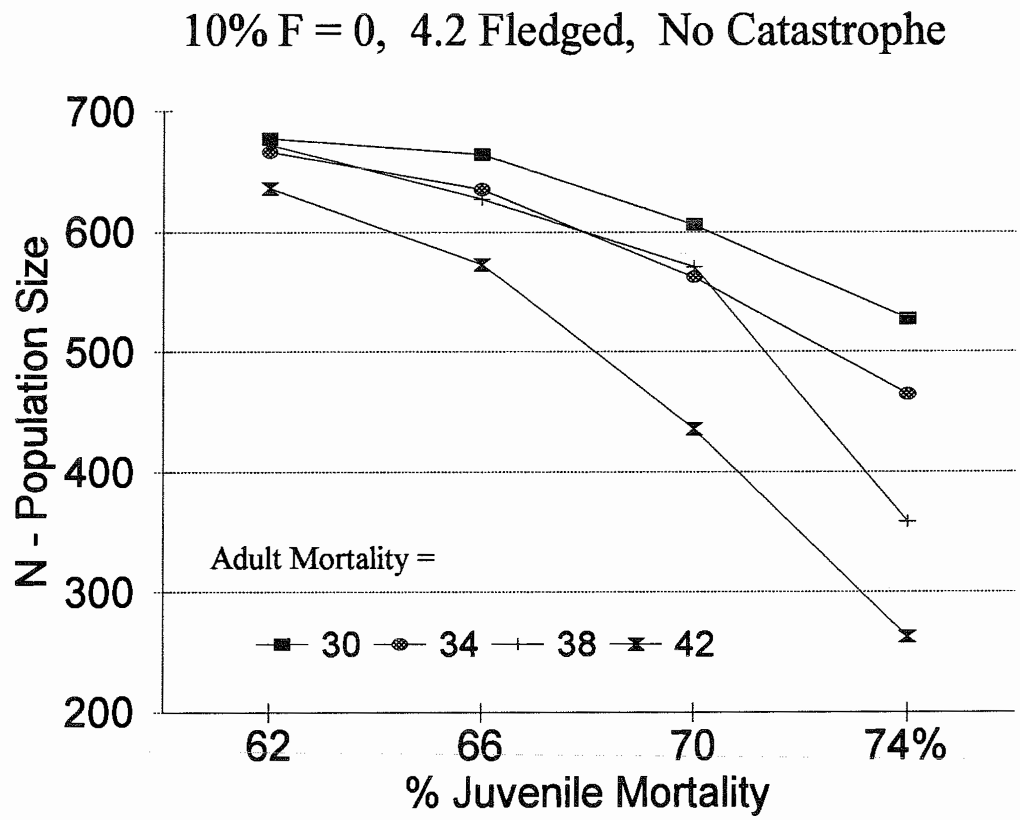

28% F = 0, 4.2 Fledged, No Catastrophe
Juvenile Mortality =
62
66
70
74%
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
rs - stochastic growth rate
30
34
38
42
% Adult Mortality

28% F = 0, 4.2 Fledged, No Catastrophe

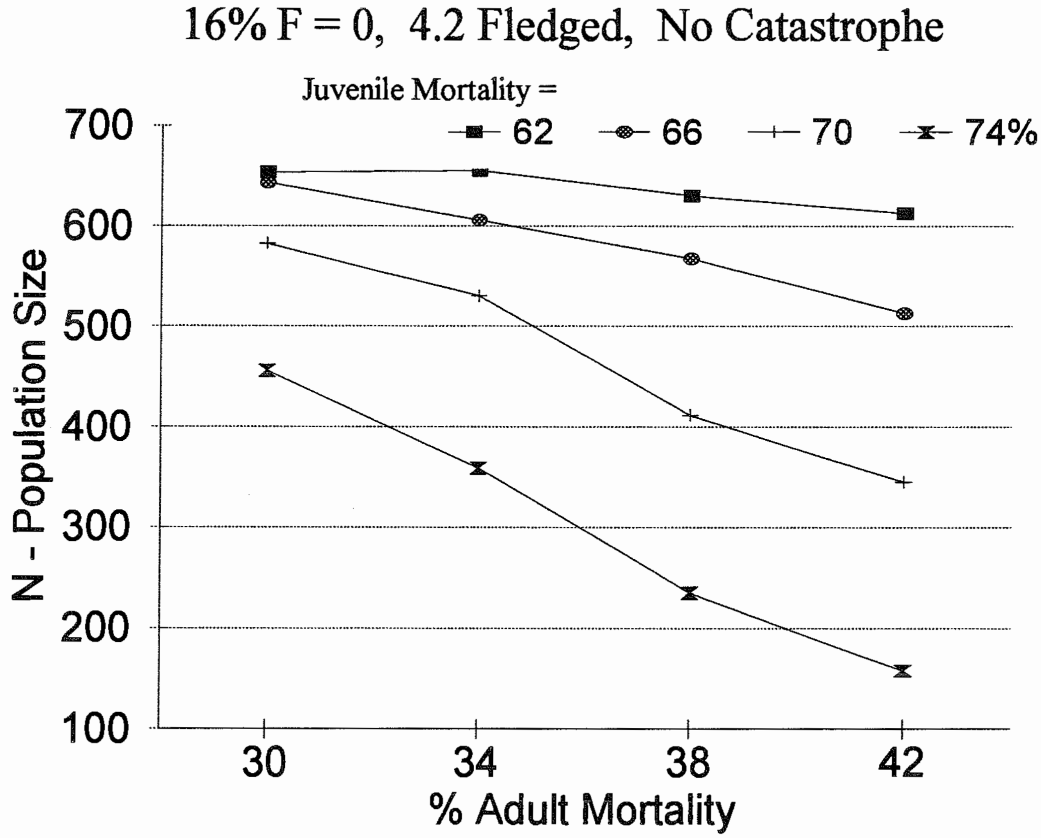


10% F = 0, 4.2 Fledged, No Catastrophe

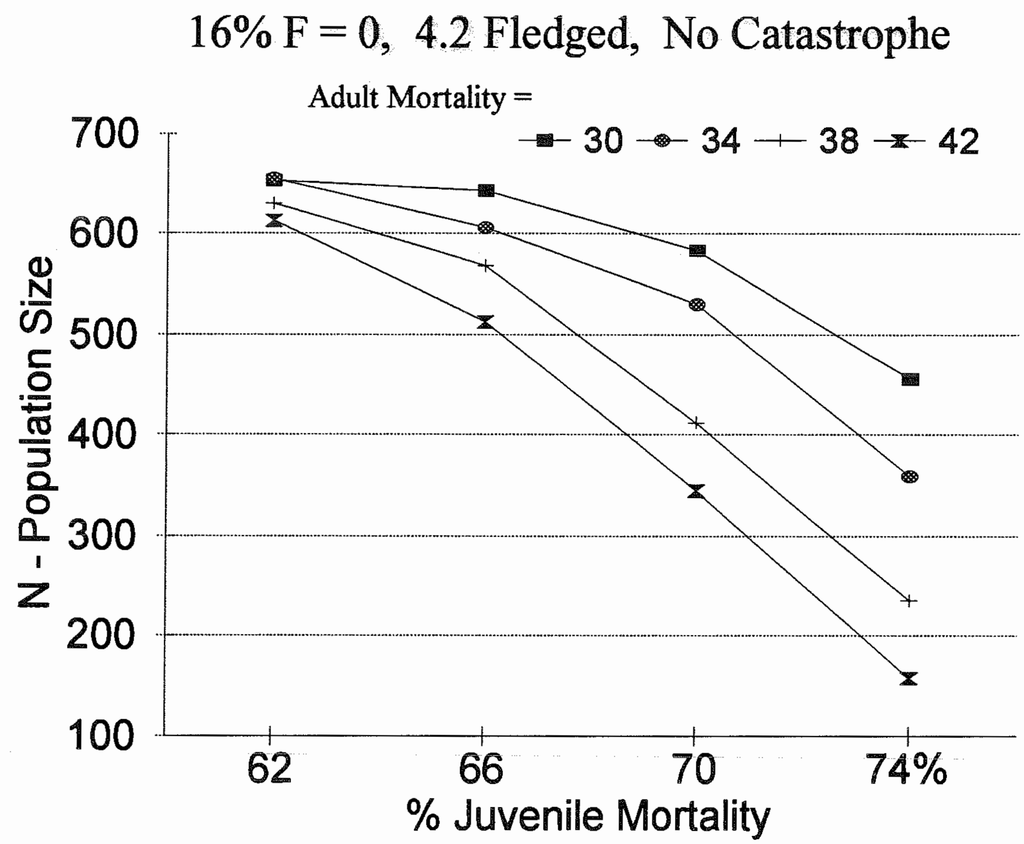


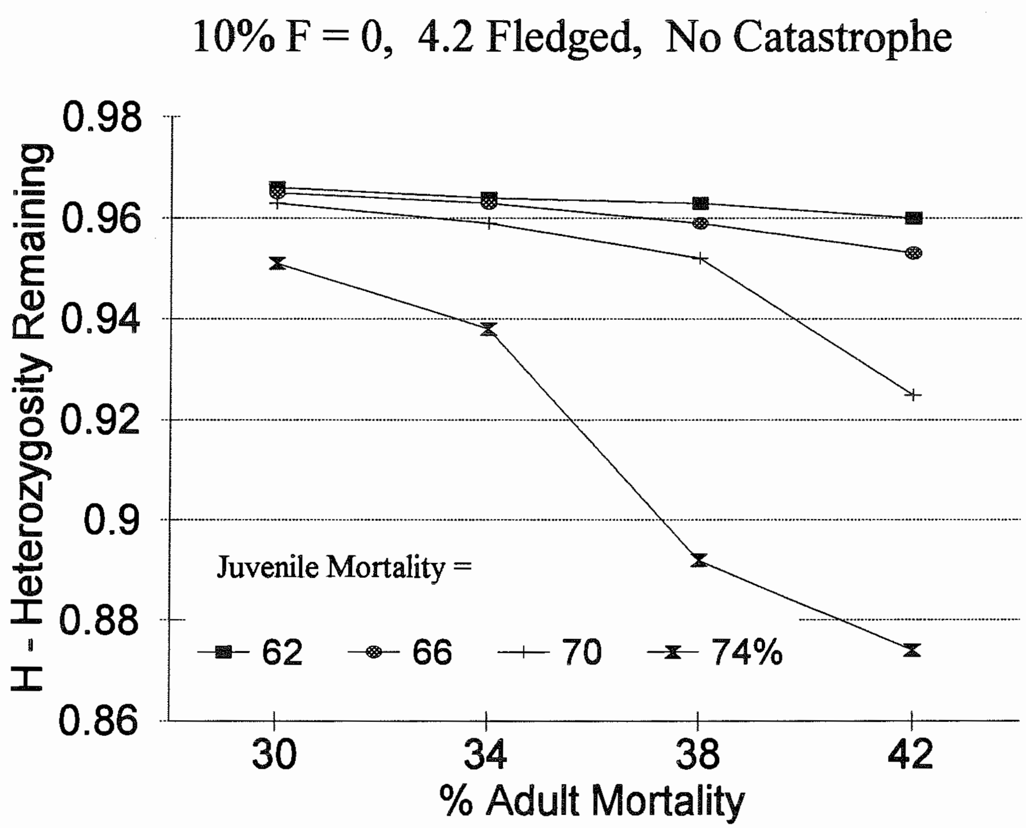


10% F = 0, 4.2 Fledged, No Catastrophe
700
600
500
400
300
200
N - Population Size
Adult Mortality =
30
34
38
42
62
66
70
74%
% Juvenile Mortality

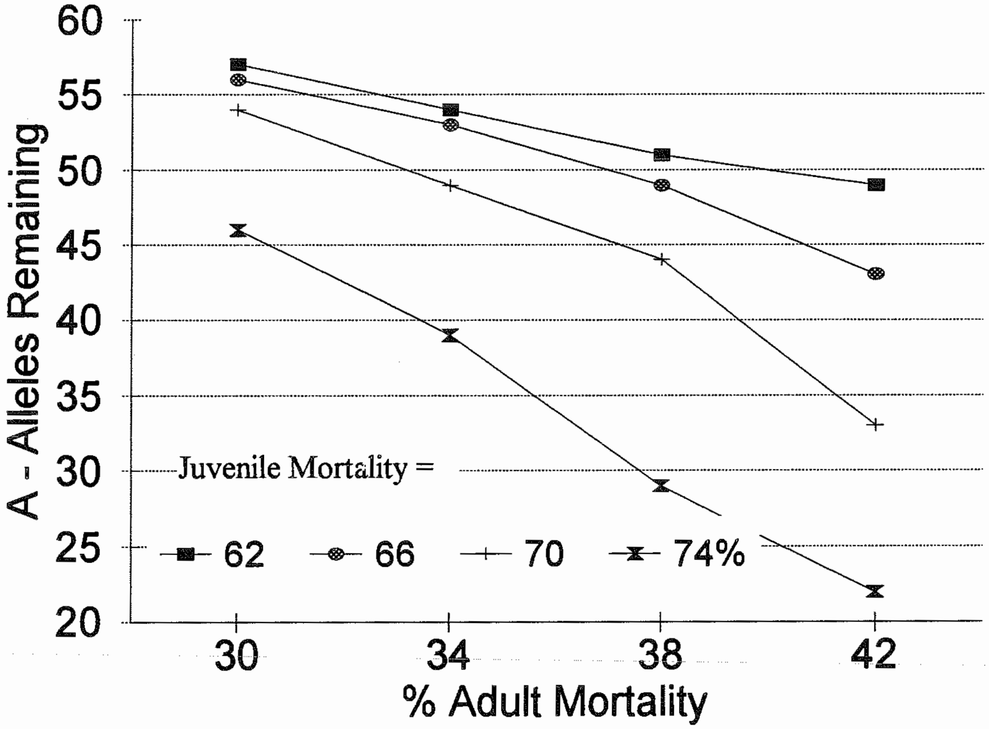


16% F = 0, 4.2 Fledged, No Catastrophe
Juvenile Mortality =
62
66
70
74%
700
600
500
400
300
200
100
N - Population Size
30
34
38
42
% Adult Mortality

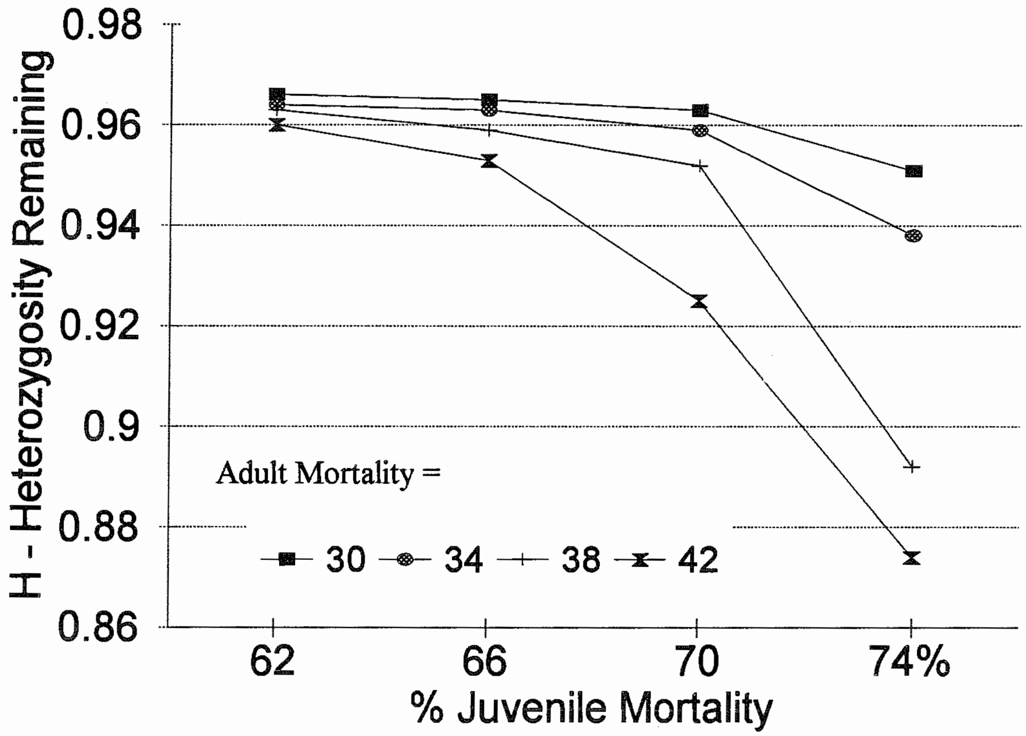

16% F = 0, 4.2 Fledged, No Catastrophe
Adult Mortality =
30
34
38
42
N - Population Size
700
600
500
400
300
200
100
62
66
70
74%
% Juvenile Mortality


10% F = 0, 4.2 Fledged, No Catastrophe
H - Heterozygosity Remaining
0.98
0.96
0.94
0.92
0.9
0.88
0.86
Juvenile Mortality =
62
66
70
74%
30
34
38
42
% Adult Mortality

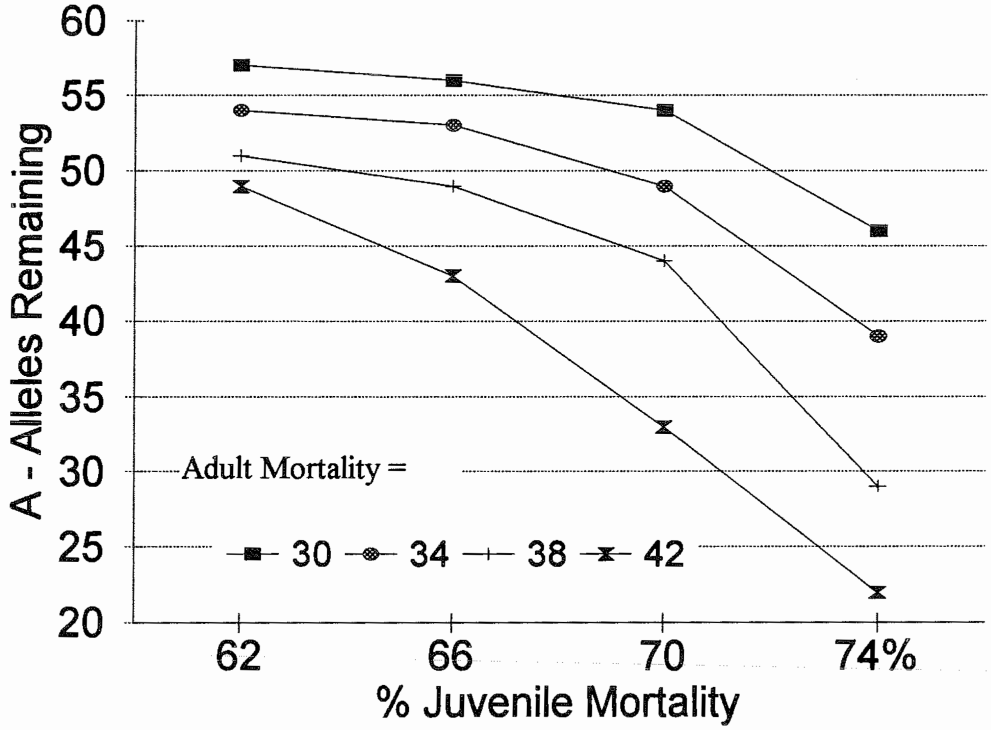
10% F = 0, 4.2 Fledged, No Catastrophe



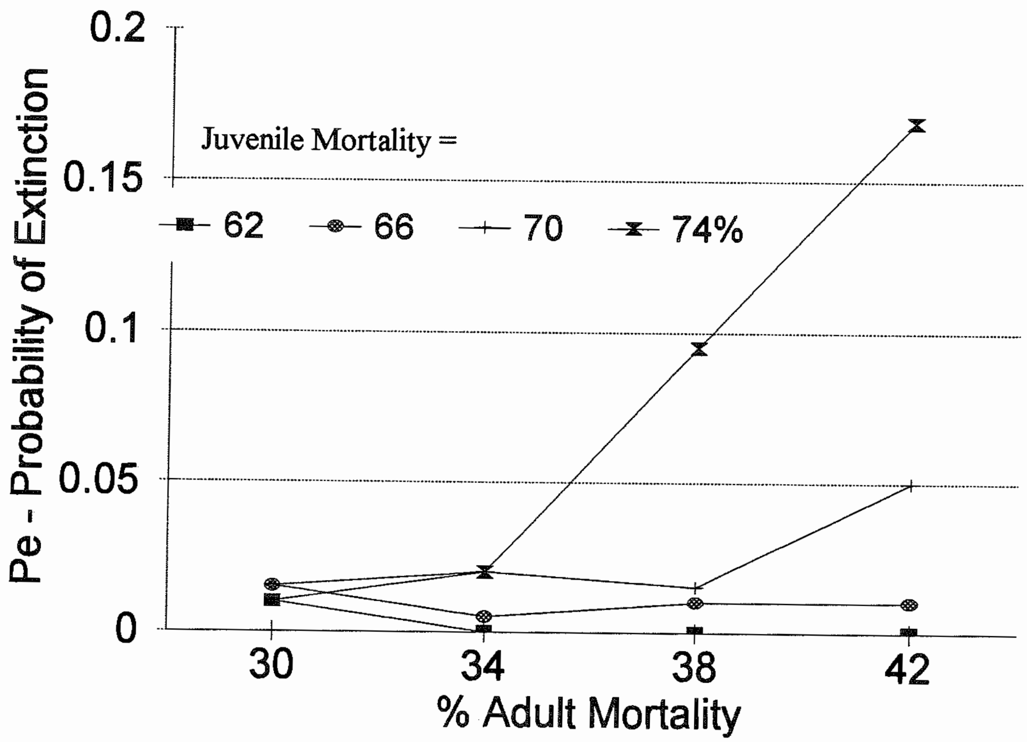
10% F = 0, 4.2 Fledged, No Catastrophe

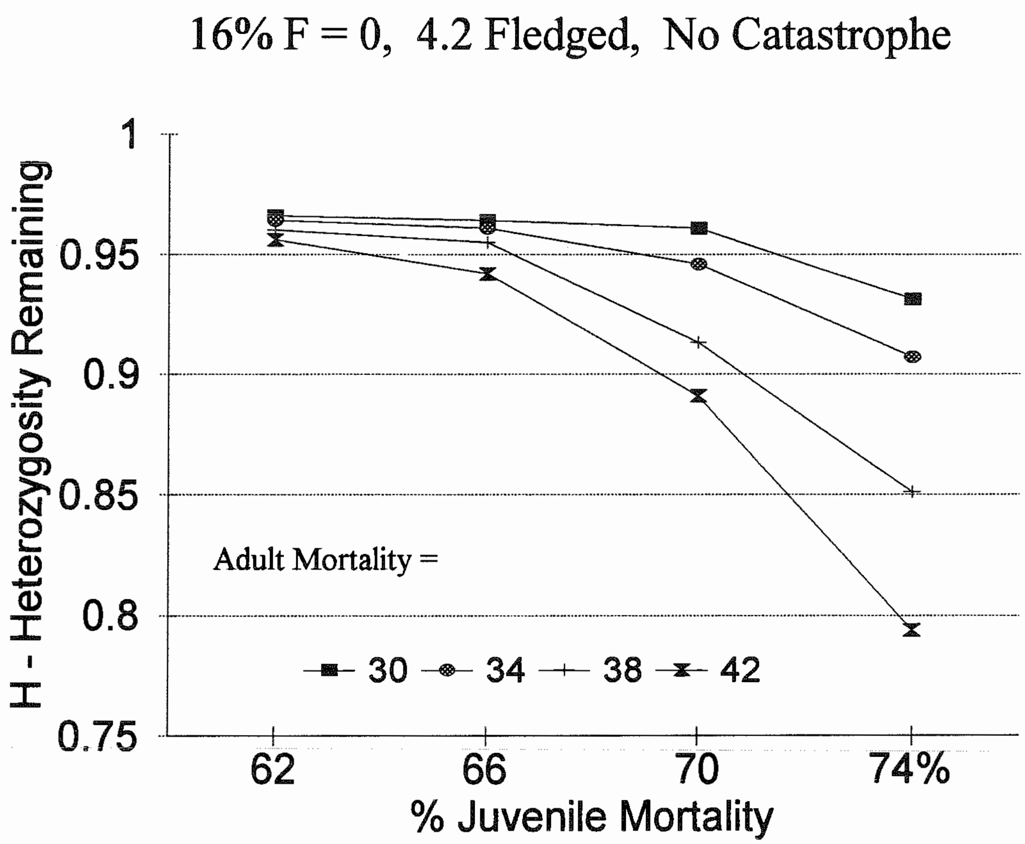


10% F = 0, 4.2 Fledged, No Catastrophe

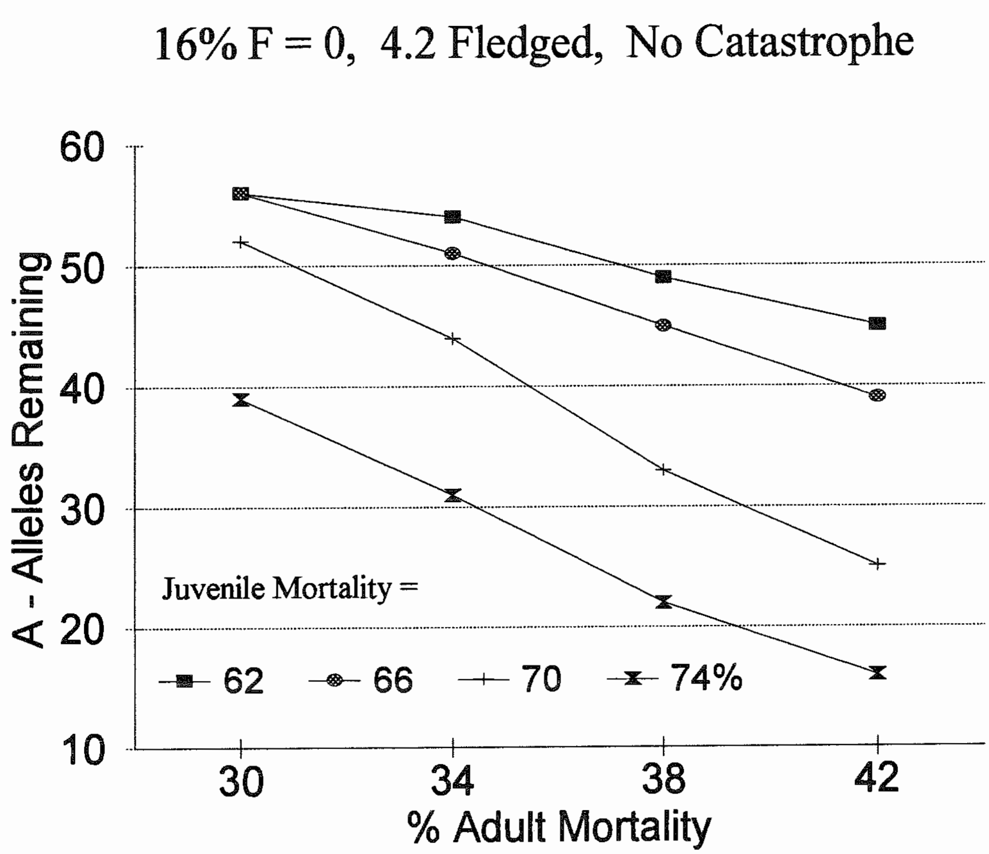


10% F = 0, 4.2 Fledged, No Catastrophe

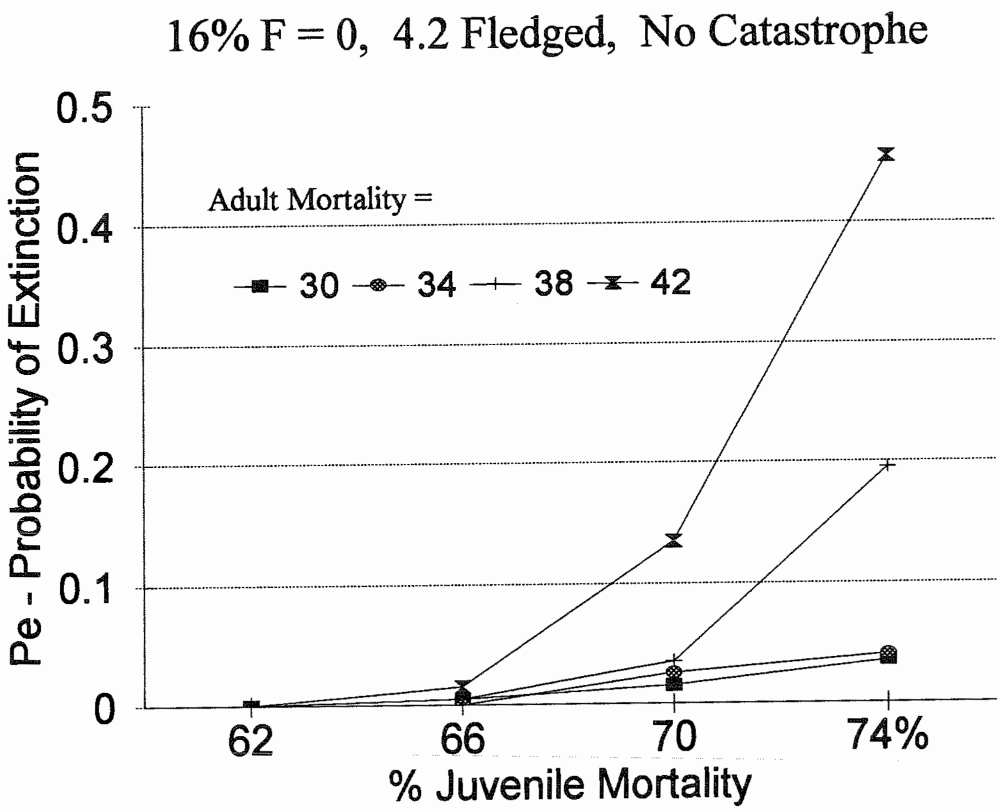


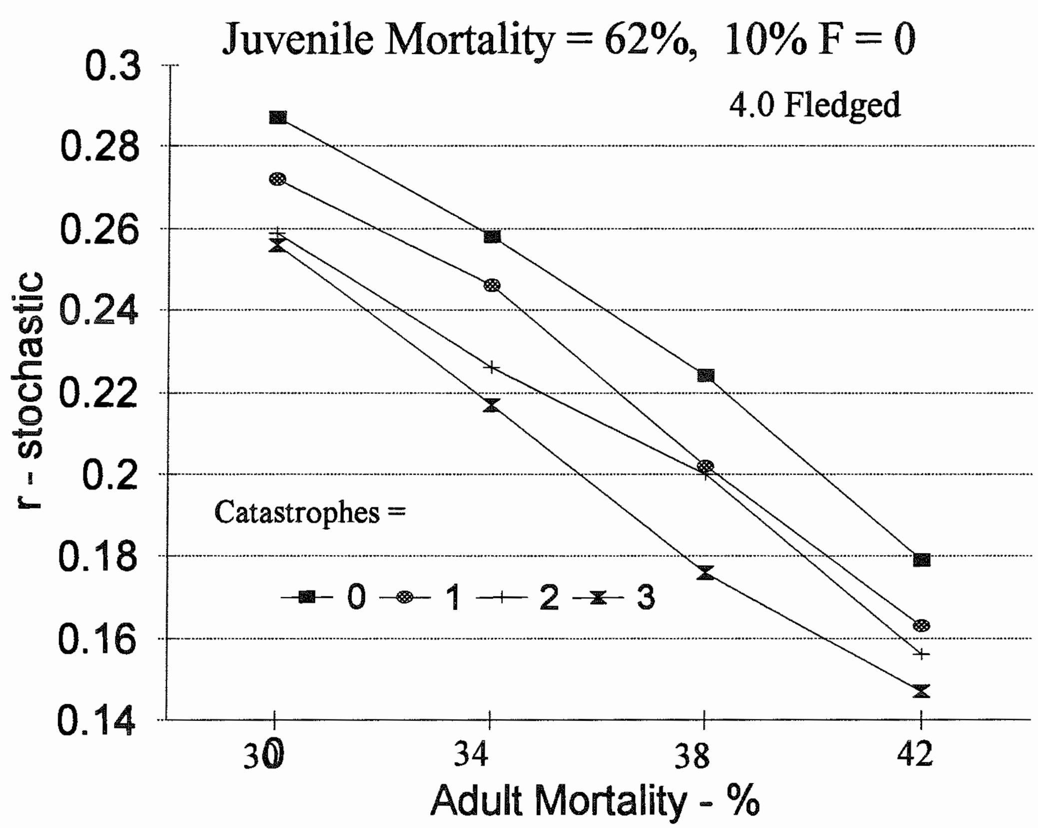


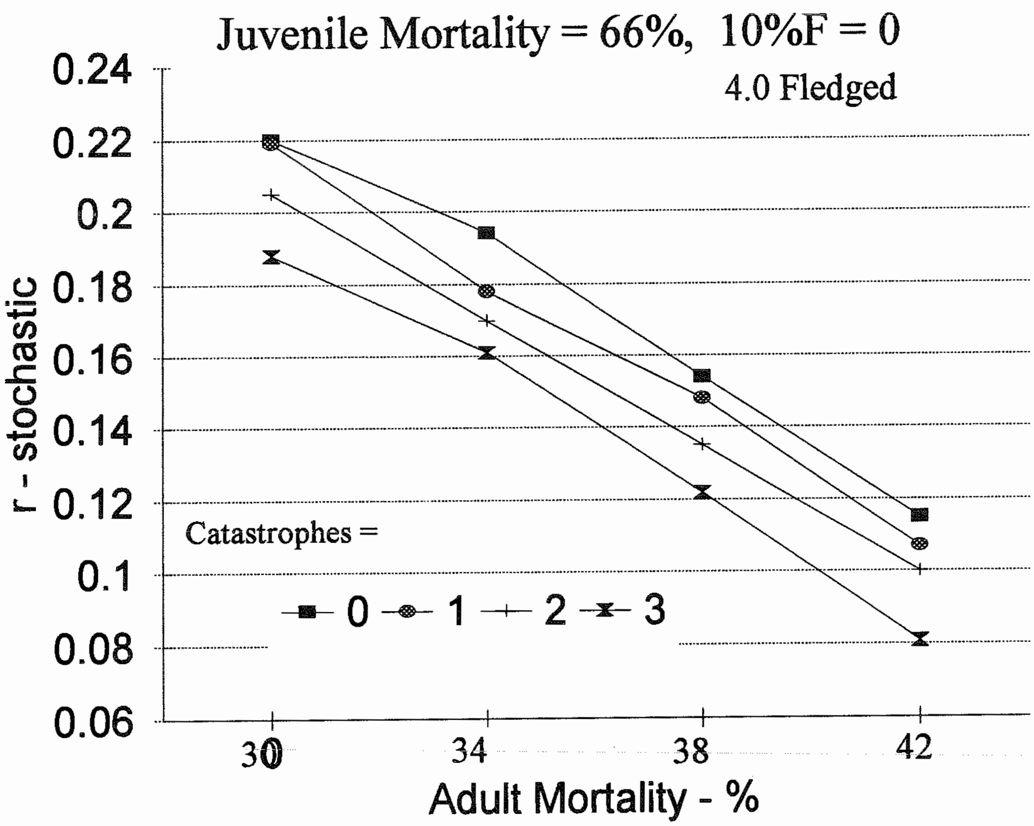
16% F = 0, 4.2 Fledged, No Catastrophe
H - Heterozygosity Remaining
1
0.95
0.9
0.85
0.8
0.75
Adult Mortality =
30
34
38
42
62
66
70
74%
% Juvenile Mortality



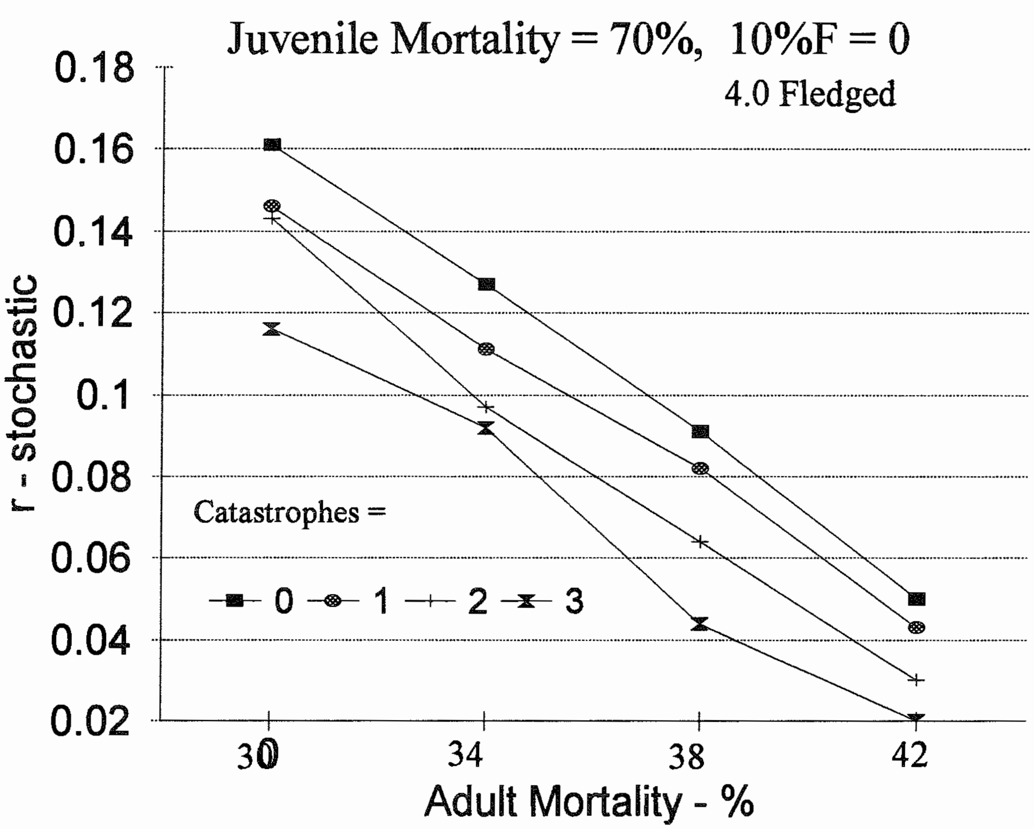
16% F = 0, 4.2 Fledged, No Catastrophe
A - Alleles Remaining
60
50
40
30
20
10
Juvenile Mortality =
62
66
70
74%
30
34
38
42
% Adult Mortality


16% F = 0, 4.2 Fledged, No Catastrophe
Pe - Probability of Extinction
0.5
0.4
0.3
0.2
0.1
0
Adult Mortality =
30
34
38
42
62
66
70
74%
% Juvenile Mortality

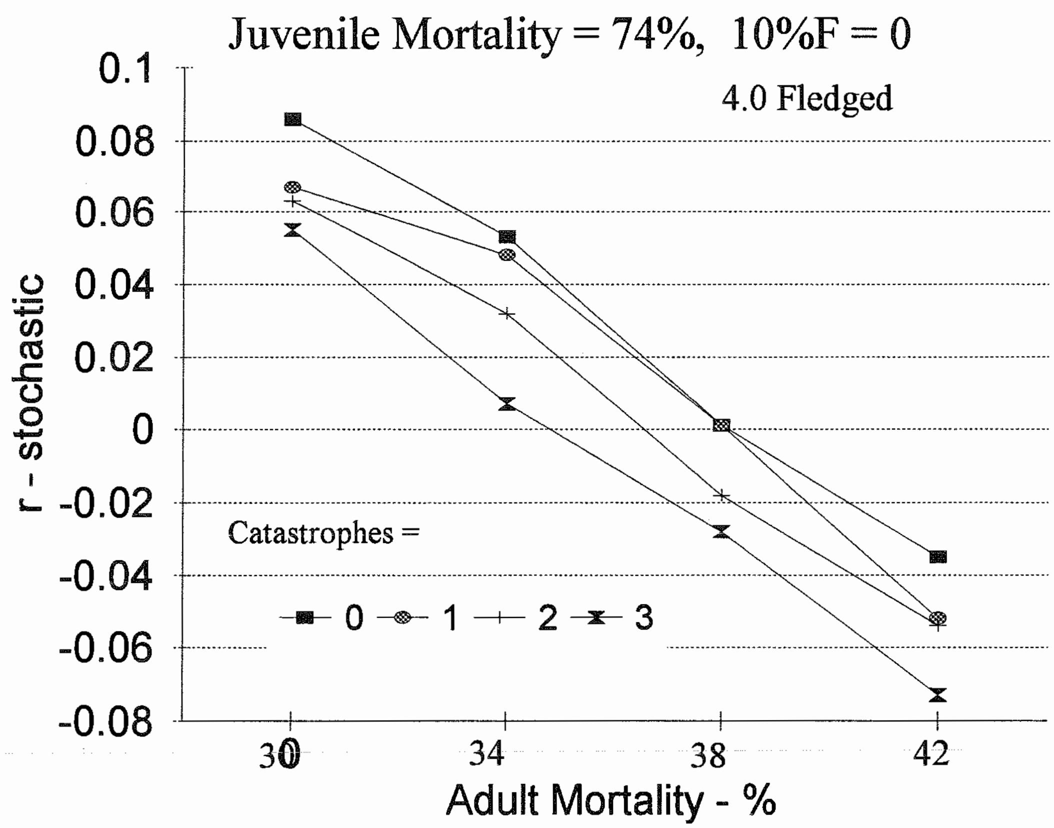

Juvenile Mortality = 62%, 10% F = 0
4.0 Fledged
r - stochastic
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
Catastrophes =
0
1
2
3
30
34
38
42
Adult Mortality - %



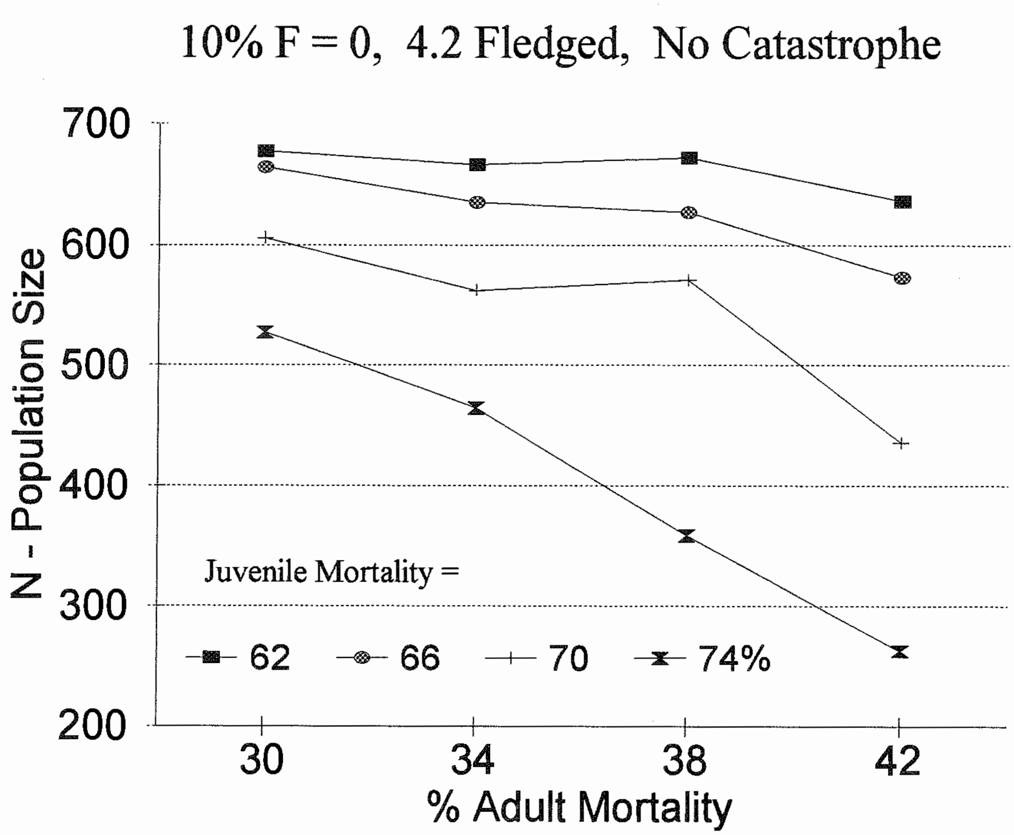
Juvenile Mortality = 66%, 10%F = 0
4.0 Fledged
r - stochastic
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
Catastrophes =
0 1 2 3
30
34
38
42
Adult Mortality - %



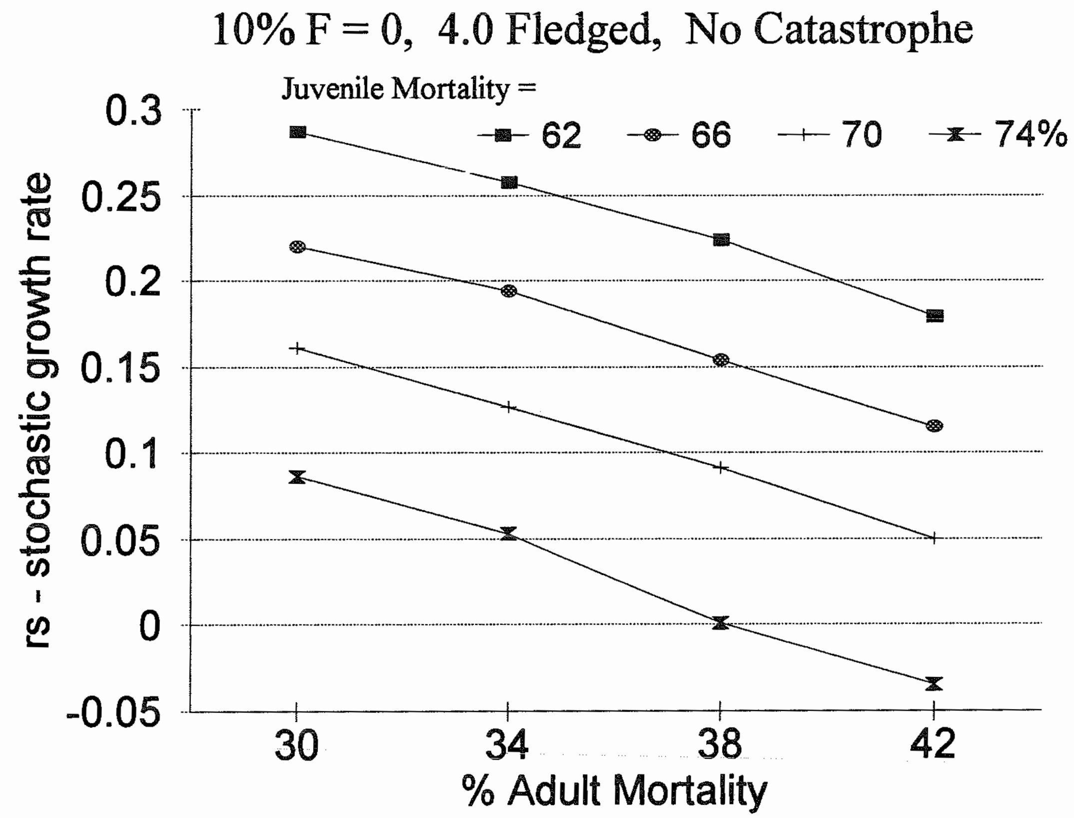
Juvenile Mortality = 70%, 10%F = 0
4.0 Fledged
r - stochastic
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Catastrophes =
0 1 2 3
30
34
38
42
Adult Mortality - %

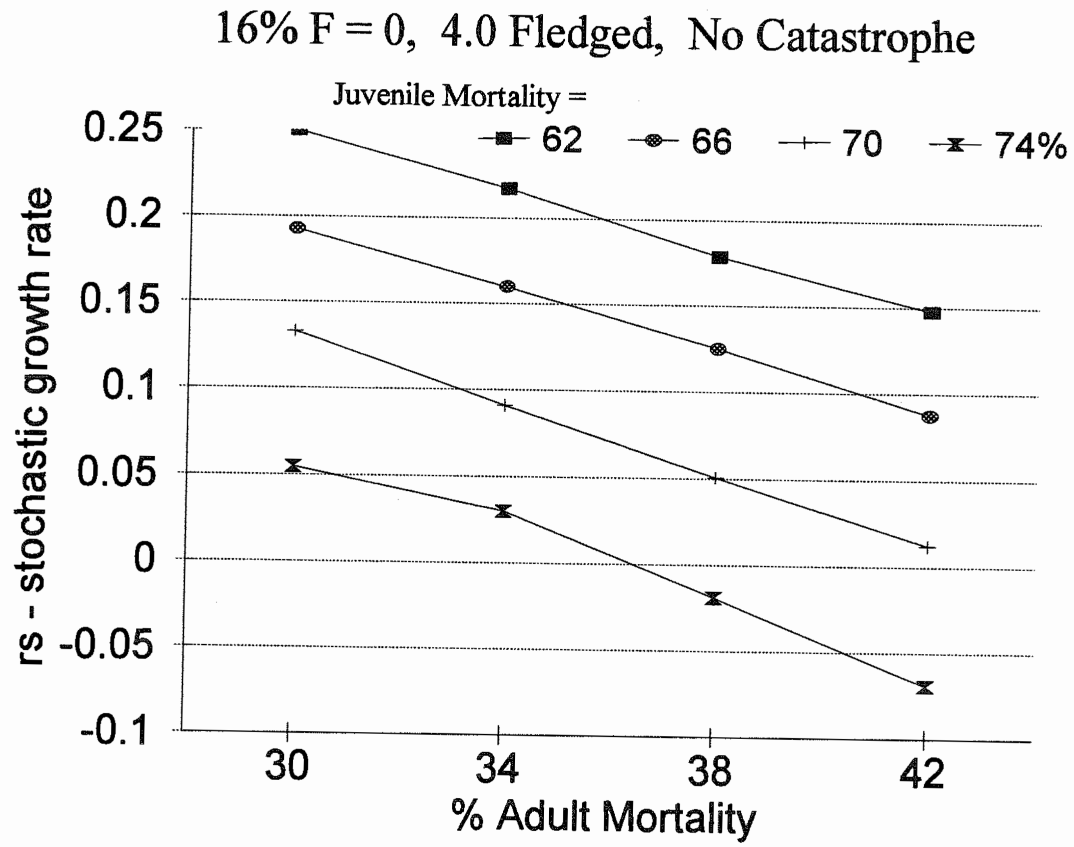


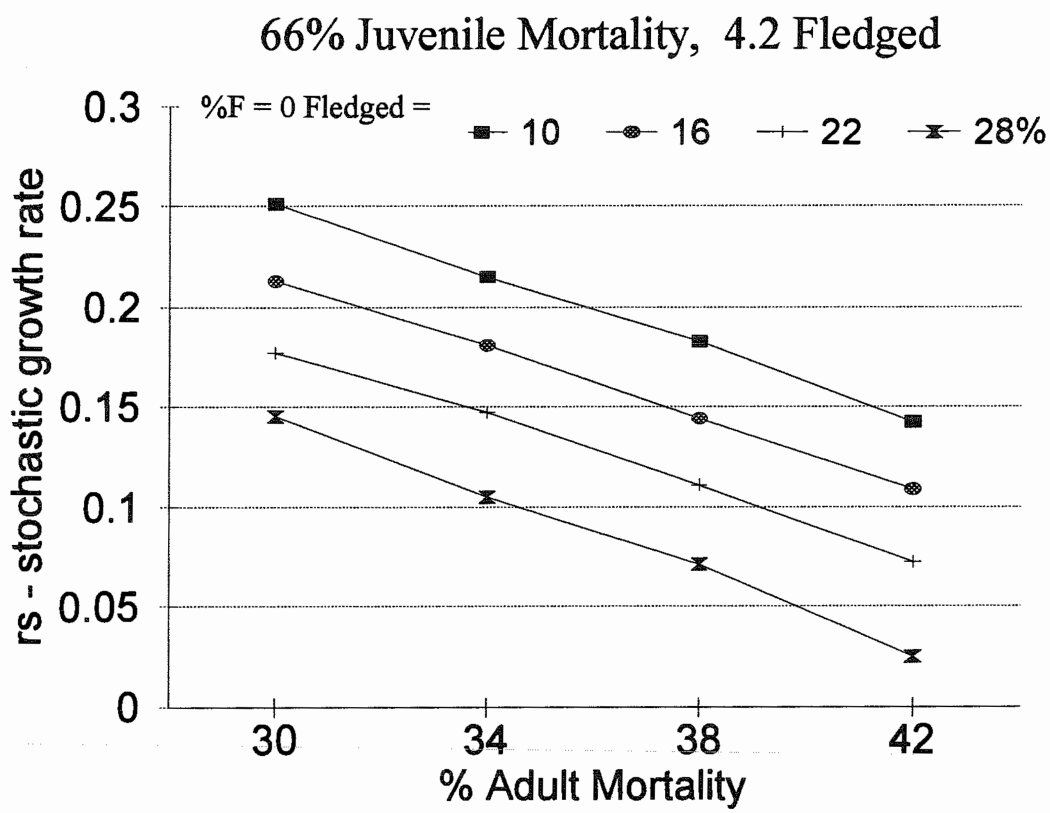
Juvenile Mortality = 74%, 10%F = 0
4.0 Fledged
r - stochastic
0.1
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
Catastrophes =
0
1
2
3
30
34
38
42
Adult Mortality - %



10% F = 0, 4.2 Fledged, No Catastrophe
N - Population Size
700
600
500
400
300
200
Juvenile Mortality =
62
66
70
74%
30
34
38
42
% Adult Mortality


10% F = 0, 4.0 Fledged, No Catastrophe
Juvenile Mortality =
62
66
70
74%
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
rs - stochastic growth rate
30
34
38
42
% Adult Mortality


16% F = 0, 4.0 Fledged, No Catastrophe
Juvenile Mortality =
62
66
70
74%
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
rs - stochastic growth rate
30
34
38
42
% Adult Mortality


66% Juvenile Mortality, 4.2 Fledged
%F = 0 Fledged =
10
16
22
28%
rs - stochastic growth rate
0.3
0.25
0.2
0.15
0.1
0.05
0
30
34
38
42
% Adult Mortality

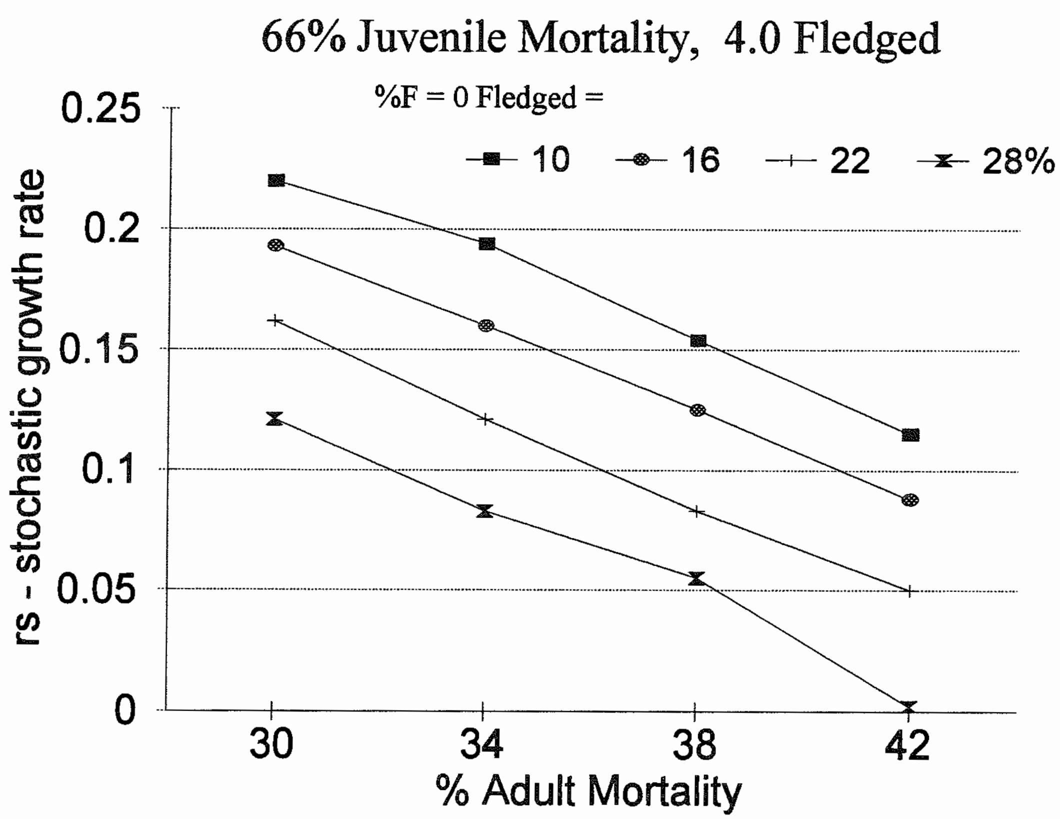

66% Juvenile Mortality, 4.0 Fledged
%F = 0 Fledged =
10
16
22
28%
rs - stochastic growth rate
0.25
0.2
0.15
0.1
0.05
0
30
34
38
42
% Adult Mortality

Table 4. Population Simulations - Effects of Juvenile and Adult Female Mortality

♀ Mortality		Population Simulations - 50 Years									
0-1 %	1+ %	r	M:F	Gm	Gf	P(E)±sd	T(E)±sd	N±sd	r±sd	H	A±sd
57.2	35.5	.341	.883	2.18	2.18	0		1419±58	.324±.21	.982	100±6
	37.5	.326	.91	2.20	2.13	0		1429±44	.301±.22	.981	
	39.5	.312	.93	2.21	2.07	0		1414±66	.289±.21	.982	
	41.5	.297	.96	2.23	2.02	0		1417±76	.271±.21	.981	
	45.5	.267	1.02	2.26	1.91	0		1397±125	.245±.22	.980	
62.2	35.5	.275	1.00	2.25	2.25	0		1393±109	.246±.22	.982	104±7
	37.5	.260	1.03	2.27	2.19	0		1411±83	.233±.22	.982	102±7
	39.5	.244	1.06	2.29	2.13	0		1351±174	.214±.23	.982	101±7
	41.5	.229	1.10	2.31	2.08	0		1390±142	.200±.23	.981	98±10
	45.5	.197	1.17	2.35	1.97	0		1351±172	.169±.23	.980	96±9
67.2	35.5	.205	1.15	2.34	2.34	0		1332±203	.178±.23	.982	102±10
	37.5	.188	1.19	2.36	2.27	0		1353±178	.160±.24	.982	100±11
	39.5	.172	1.24	2.38	2.21	0		1276±251	.148±.24	.981	97±13
	41.5	.155	1.28	2.40	2.15	0		1248±247	.125±.24	.980	93±14
	45.5	.120	1.38	2.45	2.03	0		1163±386	.086±.25	.972	80±20

Table 4. Population Simulations - Effects of Juvenile and Adult Female Mortality

♀ Mortality		Population Simulations - 50 Years									
0-1 %	1+ %	r	M:F	Gm	Gf	P(E)±sd	T(E)±sd	N±sd	r±sd	H	A±sd
57.2	35.5	.341	.883	2.18	2.18	0		1419±58	.324±.21	.982	100±6
72.2	35.5	.128	1.36	2.44	2.44	0		1217±268	.099±.25	.976	86±22
	37.5	.111	1.42	2.46	2.37	0		1124±357	.081±.25	.977	84±20
	39.5	.093	1.47	2.49	2.30	0.01	37	969±449	.054±.26	.960	69±26
	41.5	.075	1.54	2.52	2.24	.01	45	770±449	.032±.27	.954	58±27
	45.5	.038	1.69	2.58	2.12	.10±.03	44±5	461±452	-.010±.28	.915	39±27
77.2	35.5	.045	1.66	2.56	2.56	.03±.02	40±5.7	637±488	.006±.27	.916	48±32
	37.5	.026	1.74	2.60	2.49	.07±.03	38±10	410±459	-.017±.28	.904	38±29
	39.5	.007	1.83	2.63	2.42	.21±.04	41±7	277±312	-.040±.30	.881	29±23
	41.5	-.013	1.92	2.66	2.36	.23±.04	36±9	234±306	-.051±.30	.885	27±24
	45.5	-.053	2.15	2.74	2.22	.58±.05	32±10	60±79	-.107±.33	.792	11±11

Table 5. Kirtland's Warbler Population Simulations - Effects of Cowbird Parasitism

Fledging Success						Population Simulation Values - 50 Years							
0	1	2	3	4	5	r	Gm	P(E)±sd	T(E)±	N±sd	r±sd	H	A±sd
K = 700: 10 year 10.5% increase													
10	.5	10.8	15.9	28.3	34.5	.275	2.25	0		1396±143	.254±.22	.982	104
30	0	8.8	12.9	21.3	27	.136	2.43	0		1282±256	.125±.24	.980	93
35	0	8.2	12.4	19.6	24.8	.118	2.45	0		1242±309	.093±.25	.976	87±19
40	0	7.7	11.9	17.8	22.6	.082	2.51	.03	40±7	943±422	.044±.27	.968	70±24
45	0	7.2	11.4	16.0	20.4	.045	2.56	.03	37±6	685±461	.011±.27	.950	52±26
50	0	6.6	10.9	14.3	18.2	.005	2.63	.14±.03	36±10	302±330	-.036±.30	.897	33
55	0	6.0	10.4	12.6	16	-.035	2.70	.36±.05	37±8	100±154	-.084±.33	.814	15±16
70	0	4.6	7.9	7.3	10.2	-.177	3.00	.99±.01	24±8	7	-.243±.39	.429	3
K set at 500													
10	.5	10.8	15.9	28.3	34.5	.275	2.25	0		489±43	.252±.22	.956	40
30	0	8.8	12.9	21.3	27	.136	2.43	0		444±91	.127±.24	.951	37
35	0	8.2	12.4	19.6	24.8	.118	2.45	0		409±115	.088±.25	.948	34±7
40	0	7.7	11.9	17.8	22.6	.082	2.51	0		332±145	.051±.26	.935	29±9
45	0	7.2	11.4	16.0	20.4	.045	2.56	.07	36±12	255±159	.010±.28	.902	24±11
50	0	6.6	10.9	14.3	18.2	.005	2.63	.20±.04	34±10	126±16	-.038±.30	.854	16

Table 5. Kirtland's Warbler Population Simulations - Effects of Cowbird Parasitism

Fledging Success						Population Simulation Values - 50 Years							
0	1	2	3	4	5	r	Gm	P(E)±sd	T(E)±	N±sd	r±sd	H	A±sd
K = 700: 10 year 10.5% increase													
55	0	6.0	10.4	12.6	16	-.035	2.70	.49±.05	36±9	76±106	-.085±.33	.748	10±9
70	0	4.6	7.9	7.3	10.2	-.177	3.00	1.00	23±7		-.239±.41		
K = 1500 with 10 year 5.25% decrease													
10	.5	10.8	15.9	28.3	34.5	.275	2.25	0		691±66	.252±.23	.971	62±5
30	0	8.8	12.9	21.3	27	.136	2.43	0		625±130	.125±.24	.970	58±8
35	0	8.2	12.4	19.6	24.8	.118	2.45	0		571±184	.089±.25	.964	52±13
40	0	7.7	11.9	17.8	22.6	.082	2.51	0		526±209	.050±.25	.959	47±13
45	0	7.2	11.4	16.0	20.4	.045	2.56	.02	44±8	371±217	.016±.27	.922	37±17
50	0	6.6	10.9	14.3	18.2	.005	2.63	.07±.03	43±8	209±209	-.035±.28	.899	26±16
55	0	6.0	10.4	12.6	16	-.035	2.70	.31±.05	39±7	91±146	-.079±.32	.846	17±14
70	0	4.6	7.9	7.3	10.2	-.177	3.00	1.00	26±7	0	-.252±.40	0	0

Table 6. Kirtland's Warbler Population Simulations - Removal Effetcs

			HARVEST		Population Simulation Projections							
Pop	K	dK+	Start	Pairs	N-2	N-4	N-5	N-10	N-20	r stoc	H	A±sd
700	700	10.5	1	10	735	860	924	1286	1407	.231±.22	.982	103±8
			5		736	894	926	1267	1418	.220±.23		102±8
			10		736	880	952	1327	1377	.240±.22		104±7
			1	30	713	806	881	1310	1384	.182±.25	.982	102±8
			5		735	878	890	1243	1394	.197±.23		
			10		744	874	938	1311	1406	.212±.23		
1500	1500	-5.25	1	10	1406	1242	1156	781	696	.232±.23	.971	61±5
			5		1407	1253		780	681	.241±.22		
			10		1397	1259	1184	778	678	.238±.23		
			1	30	1406	1248	1175	786	693	.232±.22	.971	63±5
			5		1413	1254	1153	771	695	.193±.24		
			10		1405	1252	1175	774	702	.183±.24		

Table 7. Kirtland's Warbler - Release Scenarios

Prs	K	Catastro	r	P(E)±sd	T(E)±sd	N(2)	N(4)	N(10)	N(20)	r±sd	H	A±sd
Single Release											.000	00±OO
10	200	0	.275	.01	8	35±13	60±33	162±56	193±26	.241±.25	.876	16±5
		50, .5, .9	.137	.20±.04	10±5	27±13	36±233	81±60	111±66	.066±.36	.822	11±6
		50, .8, .8	.117	.10±.03	11±6	27±10	33±22	68±57	104±69	.067±.34	.777	9±5
		50, .5, .8	.032	.48±.05	10±05	23±13	29±25	55±60	66±66	-.048±46	.771	8±5
		50, .5, .5	-.151	.94±.02	6±4	16±10	17±17	27±24	23±25	-.315±.68	.703	6±3
	500	0		.02	6±1	36±13	62±34	285±155	477±73	.250±.25	.891	18±6
		50, .5, .9		.09±.03	11±5	26±11	33±19	86±87	232±173	.086±.35	.813	11±6
		50, .8, .8		.19±.04	12±4	27±12	34±23	65±67	173±174	.051±.35	.804	9±6
		50, .5, .8		.46±.05	11±5	21±12	28±22	50±64	72±106	-.050±.46	.734	7±5
		50, .5, .5		.97±.02	7±4	17±14	17±19	17±25	77±85	-.299±.66	.631	6±3
30	200	0		0		108±29	160±42	190±25	194±24	.256±.22	.944	31±5
		50, .5, .9		.02±.01	14	83±34	103±53	126±64	140±61	.091±.32	.918	22±9
		50, .8, .8		.02±.01	14	74±27	89±49	116±65	127±62	-.065±.31	.888	19±8
		50, .5, .8		.20±.04	14±4	67±35	67±52	68±55	59±55	-.044±.42	.830	12±8
		50, .5, .5		.88±.03	10±4	51±38	44±45	31±31	28±27	-.278±.63	.821	7±4

Table 7. Kirtland's Warbler - Release Scenarios

Prs	K	Catastro	r	P(E)±sd	T(E)±sd	N(2)	N(4)	N(10)	N(20)	r±sd	H	A±sd
	500	0		0		106±31	183±82	441±113	483±48	.250±.23	.960	45±10
		50, .5, .9		.03±.02	17±5	82±32	113±59	192±142	332±159	.090±.32	.929	31±14
		50, .8, .8		.02	12±.7	74±28	87±46	178±133	308±173	.081±.30	.917	25±12
		50, .5, .8		.23±.04	13±4	69±32	76±70	91±107	105±121	-.044±.40	.839	15±11
		50, .5, .5		.81±.04	10±4	51±41	44±48	44±92	47±104	-.257±.64	.746	6±4
Multiple Releases (4)												
10	200	0		0		54±12	140±36	194±28	193±24	.254±.22	.947	34±5
		50, .5, .9		0		46±12	103±37	130±57	148±60	.081±.31	.929	27±9
		50, .8, .8		.01	13	46±11	106±32	139±57	136±56	.080±.30	.936	26±8
		50, .5, .8		.12±.03	15±3	41±12	83±28	87±65	73±65	-.044±.41	.892	17±10
		50, .5, .5		.72±.04		36±14	66±33	40±48	23±30	-.244±.63	.776	7±6
10	500	0		0		54±12	138±40	421±111	489±39	.250±.23	.965	56±8
		50, .5, .9		.01	16	46±11	99±37	221±142	352±167	.099±.30	.951	41±16
		50, .8, .8		.01	14	47±12	105±34	207±145	288±165	.074±.31	.937	34±15
		50, .5, .8		.12	15±6	41±13	87±32	125±117	118±130	-.043±.41	.909	21±14

Table 7. Kirtland's Warbler - Release Scenarios

Prs	K	Catastro	r	P(E)±sd	T(E)±sd	N(2)	N(4)	N(10)	N(20)	r±sd	H	A±sd
		50, .5, .5		.73	13±4	39±16	67±37	50±88	27±31	-.257±.63	.791	8±6
30	200	0		0		123±33	186±29	197±21	192±25	.391±.21	.958	37±5
		50, .5, .9		0		94±29	154±45	154±48	143±57	.088±.30	.946	32±10
		50, .8, .8		0		97±31	149±44	145±54	144±56	.073±.29	.939	29±9
		50, .5, .8		.10±.03	16±3	84±35	121±45	102±60	81±63	-.037±.40	.918	19±10
		50, .5, .5		.71±.05	14±3	75±41	87±49	53±59	26±28	-.232±.62	.828	10±7
30	500	0		0		113±32	243±80	479±68	478±51	.252±.22	.974	69±8
		50, .5, .9		0		95±32	222±12 2	297±158	372±140	.097±30	.964	52±17
		50, .8, .8		0		102±36	178±87	284±163	314±162	.072±.30	.955	45±19
		50, .5, .8		.04±.02	14±2	87±36	139±74	177±159	151±159	-.016±.39	.914	28±19
		50, .5, .5		.68±.05	13±4	72±39	85±51	54±67	52±165	-.248±61	.860	11±9

Table 8. Interaction of Juvenile & Adult Mortality: F0 = 10%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
030	30	0	.346	.310	.285	.01	677	67	.966	57	10
031		2	.333	.292	.293	0	655	124	.965	56	-
032		1	.325	.284	.293	0	662	85	.965	55	-
033		B	.312	.279	.296	0	665	88	.965	56	-
026	34	0	.318	.278	.291	0	666	92	.964	54	-
027		2	.304	.254	.302	.01	648	105	.965	54	34
028		1	.298	.259	.297	0	649	101	.964	53	-
029		B	.284	.240	.308	0	659	99	.963	53	-
034	38	0	.289	.250	.304	0	672	75	.963	51	-
035		2	.275	.227	.313	0	641	109	.961	51	-
036		1	.269	.218	.317	.005	642	117	.960	49	13
037		B	.255	.205	.315	0	615	139	.961	50	-
038	42	0	.259	.214	.309	0	636	117	.960	49	-
039		2	.245	.190	.324	0	600	147	.957	47	-
040		1	.239	.196	.318	0	614	142	.958	47	-
041		B	.225	.175	.339	.01	581	188	.953	43	17
Juv Mort = 66%											
014	30	0	.289	.251	.302	.015	664	101	.965	56	26
015		2	.277	.227	.314	.02	634	128	.965	55	30
016		1	.269	.224	.310	0	643	112	.965	55	-
017		B	.257	.209	.309	0	651	110	.965	54	-
010	34	0	.260	.215	.312	.005	635	125	.963	53	25

File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
011		2	.247	.211	.315	.03	643	116	.964	53	16
012		1	.240	.197	.315	.005	617	137	.962	52	32
013		B	.227	.174	.327	.01	615	125	.961	50	40
018	38	0	.230	.183	.325	.010	627	126	.959	49	18
019		2	.216	.167	.329	.01	611	141	.959	48	3
020		1	.209	.162	.330	.005	607	143	.956	46	27
021		B	.196	.149	.334	.02	600	154	.956	46	19
022	42	0	.198	.142	.334	.01	573	178	.953	43	27
023		2	.185	.128	.346	.01	568	179	.950	42	8
024		1	.178	.119	.348	.015	558	185	.945	40	22
025		B	.164	.110	.354	.02	485	197	.944	40	36
Juv Mort = 70%											
046	30	0	.229	.183	.329	.015	606	148	.963	54	15
047		2	.217	.172	.323	.10	629	127	.964	54	3
048		1	.209	.160	.323	.01	602	163	.961	51	20
049		B	.197	.150	.337	.01	583	165	.960	51	25
042	34	0	.198	.149	.331	.02	562	176	.959	49	18
043		2	.186	.138	.333	.01	556	177	.957	47	41
044		1	.178	.127	.342	.015	560	186	.955	46	24
045		B	.166	.109	.337	.02	528	179	.955	45	16
050	38	0	.166	.126	.342	.015	571	190	.952	44	15
051		2	.154	.104	.353	.02	507	220	.949	42	5
052		1	.146	.094	.351	0	499	219	.935	38	-
053		B	.134	.071	.361	.05	469	238	.915	34	34
054	42	0	.133	.068	.376	.05	436	239	.925	33	30

File	Adl Mor %	C A T.	Results: Population Growth Deter r	Stochastic r	SD	50 Years Pe	N	SD	Heter	All e	Te
055		2	.120	.057	.371	.04	448	241	.9904	30	37
056		1	.113	.056	.370	.055	423	231	.916	31	32
057		B	.100	.034	.381	.10	387	246	.880	28	31
Juv Mort = 74%											
062	30	0	.164	.110	.351	.01	527	195	.951	46	20
063		2	.153	.093	.357	.03	489	226	.942	43	36
064		1	.144	.085	.366	.035	479	220	.926	39	23
065		B	.133	.072	.364	.05	454	226	.941	40	29
058	34	0	.132	.076	.362	.02	465	227	.938	39	18
059		2	.120	.064	.363	.04	457	227	.920	38	31
060		1	.111	.058	.367	.04	411	233	.913	34	26
061		B	.100	.034	.366	.04	384	236	.906	31	35
066	38	0	.098	.028	.392	.095	358	242	.892	29	35
067		2	.086	.014	.404	.11	331	263	.859	24	26
068		1	.078	.009	.391	.135	317	241	.881	26	33
069		B	.066	.004	.387	.12	269	233	.873	24	35
070	42	0	.062	-.006	.408	.17	263	227	.874	22	35
071		2	.050	-.020	.402	.22	214	208	.842	20	37
072		1	.042	-.043	.412	.31	203	207	.841	17	33
073		B	.030	-.051	.426	.35	176	203	.820	16	34

Table 9. Interaction of Juvenile & Adult Mortality: F0 = 10%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
094	30	0	.321	.287	.289	0	678	75	.966	57	-
095		2	.308	.272	.288	0	666	86	.966	56	-
096		1	.300	.259	.293	0	662	97	.966	56	-
097		B	.288	.256	.301	0	655	105	.967	57	-
090	34	0	.292	.258	.288	.01	662	99	.965	55	38
091		2	.279	.246	.292	.01	645	118	.964	54	14
092		1	.272	.226	.302	0	647	100	.963	53	-
093		B	.259	.217	.306	0	620	141	.964	52	-
098	38	0	.262	.224	.305	0	639	124	.963	52	-
099		2	.249	.202	.314	0	634	132	.962	51	-
100		1	.242	.200	.312	0	632	126	.961	50	-
101		B	.229	.176	.318	0	603	140	.960	49	-
102	42	0	.232	.179	.321	.005	611	142	.956	46	37
103		2	.218	.163	.327	0	596	146	.955	45	-
104		1	.212	.156	.326	0	590	165	.955	45	-
105		B	.198	.147	.337	0	544	183	.952	44	-
Juv Mort = 66%											
078	30	0	.266	.220	.305	.005	629	128	.965	56	39
079		2	.253	.219	.311	.01	651	95	.966	56	30
080		1	.245	.205	.308	0	636	125	.965	55	-
081		B	.233	.188	.318	0	643	110	.964	54	-
074	34	0	.236	.194	.309	.005	619	130	.964	53	50

Table 9. Interaction of Juvenile & Adult Mortality: F0 = 10%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
075		2	.223	.178	.323	.02	615	143	.962	52	26
076		1	.215	.170	.316	.01	632	125	.962	51	15
077		B	.203	.161	.323	.01	610	153	.958	50	33
082	38	0	.204	.154	.331	.005	608	156	.955	46	16
083		2	.192	.148	.324	0	595	163	.955	47	-
084		1	.184	.135	.328	.01	581	172	.955	46	26
085		B	,171	.122	.332	.02	537	205	.946	44	34
086	42	0	.172	.115	.340	.015	540	196	.946	41	38
087		2	.159	.107	.338	0	490	210	.945	40	-
088		1	.152	.100	.343	.03	516	208	.942	39	31
089		B	.139	.081	.347	.01	473	225	.932	37	37
Juv Mort = 70%											
110	30	0	.207	.161	.320	.02	606	155	.963	54	27
111		2	.195	.146	.332	.01	586	167	.960	51	36
112		1	.186	.143	.324	.005	574	163	.960	51	12
113		B	.175	.116	.336	.01	527	199	.956	47	14
106	34	0	.175	.127	.329	0	572	179	.956	48	-
107		2	.163	.111	.336	0	561	201	.952	45	-
108		1	.155	.097	.337	.02	540	194	.949	44	33
109		B	.143	.092	.337	.02	505	220	.939	42	25
114	38	0	.142	.091	.346	.025	500	218	.941	40	25
115		2	.130	.082	.346	.01	510	219	.938	39	48
116		1	.122	.064	.352	.03	453	234	.933	36	39
117		B	.110	.044	.365	.04	401	237	.919	32	30

Table 9. Interaction of Juvenile & Adult Mortality: F0 = 10%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	Alle	
118	42	0	.108	.050	.356	.065	414	245	.912	32	28
119		2	.096	.043	.356	.06	379	247	.901	30	18
120		1	.088	.030	.372	.095	367	240	.895	29	30
121		B	.076	.020	.374	.10	382	261	.889	27	38
Juv Mort = 74%											
126	30	0	.143	.086	.348	.005	521	215	.946	42	45
127		2	.132	.067	.354	.05	460	222	.942	42	37
128		1	.123	.063	.360	.03	447	229	.932	38	39
129		B	.112	.055	.354	0	389	230	.936	37	-
122	34	0	.110	.053	.357	.04	432	244	.929	37	26
123		2	.099	.048	.357	.05	391	245	.921	37	38
124		1	.090	.032	.361	.055	372	242	.909	32	39
125		B	.079	.007	.372	.12	311	246	.889	29	33
130	38	0	.075	.001	.397	.20	310	240	.875	25	33
131		2	.064	.001	.380	.14	308	255	.877	26	36
132		1	.055	-.018	.404	.225	261	230	.864	22	32
133		B	.044	-.028	.397	.27	260	215	.849	21	35
134	42	0	.039	-.035	.405	.28	193	199	.822	19	33
135		2	.028	-.052	.408	.41	195	222	.799	17	33
136		1	.019	-.054	.409	.35	155	182	.786	15	34
137		B	.007	-.073	.419	.47	128	150	.816	15	32

Table 10. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All ele	
Juv Mort = 62%											
030	30	0	.309	.271	.286	0	661	90	.966	56	-
031		2	.297	.259	.288	0	658	108	.966	56	-
032		1	.289	.248	.292	0	655	103	.966	55	-
033		B	.276	.239	.295	0	656	90	.965	56	-
026	34	0	.280	.242	.294	0	663	102	.964	54	-
027		2	.267	.221	.291	.01	647	109	.964	54	40
028		1	.260	.220	.296	0	649	109	.963	53	-
029		B	.247	.202	.314	0	639	122	.961	51	-
034	38	0	.251	.205	.306	0	644	123	.961	50	-
035		2	.237	.188	.315	.01	607	148	.960	49	42
036		1	.230	.183	.318	0	620	138	.958	48	-
037		B	.217	.174	.321	0	610	148	.958	47	-
038	42	0	.220	.182	.312	0	615	136	.958	47	-
039		2	.206	.164	.316	0	583	172	.956	45	-
040		1	.199	.155	.322	.005	595	149	.951	44	20
041		B	.186	.126	.339	0	572	184	.944	39	-
Juv Mort = 66%											
014	30	0	.255	.213	.303	0	642	118	.965	55	-
015		2	.243	.194	.312	0	623	130	.964	54	-
016		1	.235	.193	.306	.010	622	136	.964	54	18
017		B	.222	.184	.318	.01	610	144	.964	53	26
010	34	0	.224	.181	.314	.015	619	142	.961	51	24

Table 10. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.2 Fledged												
File			Results									
	Adl Mor %	C A T.	Population Growth			50 Years					Te	
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All ele		
011		2	.212	.168	.310	0	613	141	.962	51	-	
012		1	.204	.156	.319	0	604	146	.957	48	-	
013		B	.192	.144	.330	.01	569	168	.959	48	26	
018	38	0	.193	.144	.326	.010	593	161	.956	46	42	
019		2	.180	.130	.331	.02	575	171	.956	45	10	
020		1	.173	.118	.339	.005	551	180	.945	41	37	
021		B	.160	.101	.344	.01	533	210	.937	38	3	
022	42	0	.161	.109	.341	.015	538	193	.946	40	27	
023		2	.147	.100	.337	.02	549	194	.946	40	24	
024		1	.140	.090	.345	.010	512	212	.926	38	38	
025		B	.127	.067	.350	.03	435	240	.918	32	34	
Juv Mort = 70%												
046	30	0	.196	.145	.324	.005	587	162	.961	51	7	
047		2	.185	.142	.325	.02	585	168	.959	52	42	
048		1	.176	.128	.327	.010	559	194	.956	49	48	
049		B	.165	.114	.340	.04	554	194	.951	46	15	
042	34	0	.165	.112	.331	.010	554	191	.948	45	44	
043		2	.153	.104	.332	.02	543	181	.947	44	36	
044		1	.144	.098	.340	.015	532	202	.947	43	31	
045		B	.133	.089	.340	.01	509	209	.940	39	32	
050	38	0	.132	.075	.358	.02	468	231	.924	36	30	
051		2	.120	.060	.351	.01	421	250	.921	34	40	
052		1	.111	.048	.360	.05	417	236	.919	32	37	
053		B	.099	.035	.368	.05	383	251	.892	29	32	

Table 10. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All ele	
054	42	0	.097	.039	.354	.05	387	243	.904	29	29
055		2	.085	.014	.377	.10	286	233	.873	25	33
056		1	.077	.017	.368	.09	326	238	.889	25	30
057		B	.065	.003	.375	.16	294	235	.886	23	33
Juv Mort = 74%											
062	30	0	.133	.074	.354	.06	477	222	.938	41	29
063		2	.123	.074	.341	.03	487	222	.943	41	25
064		1	.113	.053	.357	.03	427	229	.930	36	32
065		B	.103	.040	.367	.06	377	243	.910	34	30
058	34	0	.100	.042	.362	.06	420	227	.913	34	35
059		2	.089	.028	.357	.04	363	242	.908	31	45
060		1	.080	.020	.369	.08	328	238	.895	29	35
061		B	.069	-.010	.390	.20	241	224	.872	24	36
066	38	0	.065	-.005	.384	.120	266	230	.876	23	36
067		2	.054	-.009	.386	.14	255	234	.863	22	33
068		1	.045	-.026	.399	.23	234	227	.852	20	32
069		B	.034	-.038	.396	.26	190	206	.787	18	35
070	42	0	.029	-.051	.416	.345	159	184	.794	16	34
071		2	.017	-.054	.410	.35	154	180	.773	14	32
072		1	.009	-.066	.423	.435	150	188	.783	14	34
073		B	-.003	-.098	.446	.59	82	123	.741	11	34

Table 11. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.0 Fledged

File	Adl Mor %	C A T.	Population Growth: Deter r	Stochastic r	Stochastic SD	50 Years: Pe	N	SD	Heter	All e	Te
Juv Mort = 62%											
094	30	0	.286	.250	.287	0	653	106	.966	56	-
095		2	.274	.236	.293	0	672	74	.965	56	-
096		1	.266	.233	.290	0	659	91	.966	57	-
097		B	.254	.213	.304	0	653	99	.964	55	-
090	34	0	.257	.217	.288	0	655	91	.964	54	-
091		2	.244	.206	.301	0	648	111	.963	53	-
092		1	.236	.194	.296	.005	646	100	.963	53	16
093		B	.224	.178	.318	0	615	155	.963	51	-
098	38	0	.226	.179	.309	0	630	125	.960	49	-
099		2	.213	.165	.315	0	617	166	.958	48	-
100		1	.206	.162	.313	0	613	146	.958	49	-
101		B	.193	.149	.320	0	590	148	.957	47	-
102	42	0	.195	.148	.316	0	613	140	.956	45	-
103		2	.181	.134	.320	0	567	186	.949	44	-
104		1	.174	.124	.322	.015	555	169	.951	43	21
105		B	.161	.106	.333	0	542	189	.947	40	-
Juv Mort = 66%											
078	30	0	.233	.193	.302	.005	643	121	.964	56	25
079		2	.221	.172	.314	.02	634	128	.963	54	20
080		1	.212	.165	.309	.005	606	149	.962	54	49
081		B	.201	.156	.314	.03	597	151	.963	53	33
074	34	0	.202	.160	.306	0	606	142	.961	51	-

Table 11. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
075		2	.190	.150	.317	.01	593	155	.961	51	44
076		1	.182	.134	.315	0	583	162	.954	48	-
077		B	.169	.126	.319	.01	596	163	.955	47	17
082	38	0	.170	.125	.326	.005	568	175	.955	45	37
083		2	.157	.104	.327	.01	502	205	.942	42	32
084		1	.150	.101	.331	.015	528	193	.949	42	29
085		B	.137	.080	.350	.02	478	222	.938	38	46
086	42	0	.137	.088	.333	.015	513	200	.942	39	30
087		2	.124	.068	.342	.01	452	237	.926	34	40
088		1	.116	.059	.351	.02	439	224	.914	33	19
089		B	.104	.046	.354	.04	408	229	.914	31	34
Juv Mort = 70%											
110	30	0	.176	.133	.317	.015	583	168	.961	52	17
111		2	.164	.113	.331	.01	543	189	.955	48	9
112		1	.155	.107	.328	0	543	195	.955	46	-
113		B	.144	.090	.337	.01	472	204	.951	44	47
106	34	0	.143	.091	.329	.025	530	190	.946	44	31
107		2	.132	.085	.326	.04	512	196	.951	45	29
108		1	.123	.067	.340	.025	471	231	.936	38	41
109		B	.111	.058	.344	.04	440	232	.921	37	42
114	38	0	.110	.051	.348	.035	412	237	.913	33	22
115		2	.098	.043	.351	.04	418	236	.901	33	24
116		1	.089	.032	.359	.07	391	248	.916	31	34
117		B	.078	.019	.363	.06	327	240	.881	26	41

Table 11. Interaction of Juvenile & Adult Mortality: F0 = 16%, 4.0 Fledged

File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	Alle	
118	42	0	.075	.012	.373	.135	345	250	.891	25	37
119		2	.062	-.001	.364	.11	282	232	.879	23	32
120		1	.054	-.014	.379	.16	219	222	.830	19	33
121		B	.042	-.023	.376	.17	209	199	.842	20	41
Juv Mort = 74%											
126	30	0	.114	.055	.353	.035	456	229	.931	39	29
127		2	.103	.049	.344	.03	434	246	.926	36	39
128		1	.094	.033	.358	.07	366	250	.916	33	36
129		B	.083	.028	.364	.06	347	244	.901	31	36
122	34	0	.080	.030	.352	.04	359	249	.907	31	27
123		2	.069	.008	.369	.07	281	224	.885	27	33
124		1	.060	-.007	.378	.160	308	250	.870	25	34
125		B	.049	-.012	.366	.18	286	241	.880	24	35
130	38	0	.045	-.019	.382	.195	235	224	.851	22	37
131		2	.033	-.039	.404	.32	218	245	.840	19	33
132		1	.024	-.050	.396	.33	171	189	.829	18	34
133		B	.013	-.058	.403	.35	156	178	.806	16	35
134	42	0	.008	-.069	.414	.455	158	204	.794	16	35
135		2	-.004	-.088	.419	.49	78	109	.733	11	35
136		1	-.013	-.090	.417	.54	105	147	.776	13	32
137		B	-.024	-.107	.446	.65	108	172	.725	12	33

Table 12. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
030	30	0	.274	.243	.287	0	650	107	.965	55	-
031		2	.261	.228	.288	0	664	87	.965	56	-
032		1	.254	.214	.296	0	628	130	.964	54	-
033		B	.241	.200	.309	0	640	119	.962	52	-
026	34	0	.244	.198	.296	0	642	112	.962	52	-
027		2	.231	.191	.296	0	632	118	.962	52	-
028		1	.224	.182	.298	0	637	122	.962	51	-
029		B	.211	.173	.297	0	629	122	.961	51	-
034	38	0	.213	.169	.306	0	628	126	.959	48	-
035		2	.200	.160	.304	0	616	134	.958	48	-
036		1	.193	.151	.311	.005	604	149	.956	46	46
037		B	.180	.138	.318	.01	596	155	.955	44	49
038	42	0	.181	.141	.314	.005	575	171	.954	44	47
039		2	.168	.112	.332	0	551	189	.943	40	-
040		1	.161	.116	.323	.005	520	188	.950	41	21
041		B	.148	.099	.335	.01	515	197	.932	37	46
Juv Mort = 66%											
014	30	0	.221	.177	.300	0	616	140	.963	54	-
015		2	.209	.170	.310	.01	624	127	.963	53	42
016		1	.201	.157	.310	.01	613	141	.950	51	44
017		B	.189	.142	.317	0	560	165	.959	48	-
010	34	0	.190	.147	.306	0	588	165	.960	50	-

Table 12. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
011		2	.178	.127	.316	.01	602	148	.959	48	5
012		1	.169	.119	.320	0	579	179	.949	45	-
013		B	.157	.111	.323	.02	548	198	.951	44	18
018	38	0	.157	.111	.328	.01	543	185	.945	42	32
019		2	.145	.099	.338	.02	547	203	.942	41	48
020		1	.137	.087	.336	.015	517	208	.939	39	36
021		B	.125	.069	.340	.02	457	227	.936	36	48
022	42	0	.124	.072	.338	.035	490	216	.934	35	32
023		2	.111	.053	.345	.02	419	229	.911	31	46
024		1	.104	.045	.344	.03	396	239	.913	30	34
025		B	.091	.031	.356	.05	347	226	.894	27	38
Juv Mort = 70%											
046	30	0	.164	.115	.325	.035	561	184	.956	49	32
047		2	.153	.099	.326	.01	510	217	.954	47	16
048		1	.144	.094	.330	.01	531	188	.948	44	22
049		B	.133	.080	.334	.01	473	212	.945	42	18
042	34	0	.132	.083	.321	.005	489	231	.944	42	40
043		2	.120	.071	.335	.01	493	225	.936	39	3
044		1	.111	.062	.338	.035	469	223	.940	38	26
045		B	.100	.042	.343	.01	369	224	.896	31	31
050	38	0	.098	.043	.348	.05	425	241	.920	33	40
051		2	.086	.031	.355	.06	307	235	.897	31	36
052		1	.078	.024	.355	.075	361	243	.900	28	33
053		B	.066	-.004	.367	.170	290	222	.884	26	35

Table 12. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.2 Fledged												
File			Results									
	Adl Mor %	C A T.	Population Growth			50 Years						Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e		
054	42	0	.062	-.008	.373	.165	283	249	.844	22		36
055		2	.050	-.022	.376	.25	240	221	.970	19		31
056		1	.042	-.031	.392	.27	207	203	.836	19		35
057		B	.030	-.046	.390	.37	221	222	.787	17		34
Juv Mort = 74%												
062	30	0	.103	.053	.341	.025	448	222	.936	39		41
063		2	.093	.039	.354	.04	382	256	.922	35		28
064		1	.083	.029	.351	.045	348	227	.915	33		37
065		B	.073	.019	.360	.07	321	251	.906	29		38
058	34	0	.069	.012	.362	.085	304	237	.892	27		33
059		2	.058	-.002	.359	.13	302	246	.876	26		36
060		1	.049	-.012	.369	.15	269	243	.874	24		32
061		B	.038	-.030	.384	.23	213	224	.841	21		34
066	38	0	.033	-.027	.385	.195	201	218	.838	19		37
067		2	.022	-.042	.400	.35	258	241	.843	19		35
068		1	.013	-.060	.396	.375	152	174	.802	16		35
069		B	.002	-.070	.406	.43	136	167	.783	16		33
070	42	0	-.004	-.086	.417	.545	115	166	.780	13		34
071		2	-.015	-.081	.411	.47	127	179	.729	12		32
072		1	-.024	-.102	.427	.59	87	128	.751	10		33
073		B	-.035	-.124	.429	.65	26	36	.651	5		31

Table 13. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
094	30	0	.250	.213	.285	0	650	101	.964	55	-
095		2	.238	.200	.282	0	668	72	.966	57	-
096		1	.230	.189	.296	0	634	120	.965	54	-
097		B	.218	.179	.304	0	622	138	.962	53	-
090	34	0	.220	.182	.294	0	627	125	.964	53	-
091		2	.208	.168	.298	0	605	149	.962	51	-
092		1	.200	.158	.302	0	630	122	.960	50	-
093		B	.187	.140	.314	0	608	147	.958	48	-
098	38	0	.188	.145	.304	.01	613	132	.957	47	32
099		2	.176	.132	.316	0	573	167	.956	45	-
100		1	.168	.128	.312	.005	567	178	.951	45	25
101		B	.155	.108	.317	0	537	173	.948	43	-
102	42	0	.156	.107	.319	.005	550	195	.949	42	46
103		2	.143	.087	.330	.01	507	217	.934	36	19
104		1	.135	.090	.327	.01	518	209	.940	38	37
105		B	.122	.072	.333	.01	483	216	.929	34	31
Juv Mort = 66%											
078	30	0	.198	.162	.300	.01	608	147	.963	54	26
079		2	.187	.142	.308	.01	600	160	.963	53	31
080		1	.178	.132	.310	.10	567	179	.958	50	26
081		B	.167	.128	.312	.02	596	164	.958	49	43
074	34	0	.167	.121	.314	.02	570	181	.956	47	30

Table 13. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
075		2	.155	.112	.314	.01	559	175	.956	47	19
076		1	.146	.101	.315	.015	554	191	.949	44	22
077		B	.135	.086	.315	.01	497	200	.948	43	24
082	38	0	.134	.083	.324	.005	494	215	.936	40	24
083		2	.122	.072	.324	0	456	219	.840	38	-
084		1	.114	.066	.337	.035	437	230	.931	36	30
085		B	.101	.051	.338	.02	443	238	.916	34	32
086	42	0	.099	.050	.338	.04	420	223	.928	34	34
087		2	.087	.022	.373	.11	355	229	.905	29	31
088		1	.079	.024	.351	.075	359	222	.904	28	33
089		B	.067	.156	.358	.07	314	252	.876	25	33
Juv Mort = 70%											
110	30	0	.143	.095	.318	0	195	195	.950	46	-
111		2	.132	.082	.333	.02	221	221	.942	44	31
112		1	.123	.078	.328	.035	203	203	.946	44	37
113		B	.112	.059	.334	.04	227	227	.931	40	40
106	34	0	.110	.060	.333	.025	233	233	.935	39	33
107		2	.099	.046	.334	.02	222	222	.924	36	40
108		1	.090	.036	.340	.055	237	237	.926	35	40
109		B	.079	.018	.344	.06	243	243	.890	29	37
114	38	0	.075	.016	.354	.08	326	250	.889	28	32
115		2	.064	.010	.355	.06	303	234	.887	26	35
116		1	.055	-.011	.368	.165	281	241	.869	24	32
117		B	.044	-.012	.372	.18	271	234	.875	24	31

Table 13. Interaction of Juvenile & Adult Mortality: F0 = 22%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
118	42	0	.039	-.021	.368	.155	231	232	.833	20	35
119		2	.028	-.022	.368	.17	242	243	.844	21	37
120		1	.019	-.048	.392	.285	176	199	.773	16	34
121		B	.007	-.053	.379	.27	135	180	.740	13	34
Juv Mort = 74%											
126	30	0	.083	.029	.351	.055	357	238	.911	33	38
127		2	.073	.018	.357	.06	318	243	.894	31	38
128		1	.063	.003	.358	.105	333	255	.888	28	34
129		B	.053	.000	.354	.110	287	226	.907	30	36
122	34	0	.049	-.015	.362	.135	222	216	.859	23	33
123		2	.038	-.034	.370	.23	213	210	.864	22	33
124		1	.028	-.026	.365	.17	217	210	.854	20	33
125		B	.018	-.050	.385	.30	180	206	.821	18	32
130	38	0	.012	-.060	.385	.365	137	172	.812	17	35
131		2	.002	-.058	.395	.40	173	182	.822	17	33
132		1	-.008	-.084	.408	.47	106	160	.778	13	32
133		B	-.019	-.090	.402	.54	100	146	.731	12	34
134	42	0	-.025	-.102	.417	.60	110	160	.747	12	33
135		2	-.036	-.114	.421	.69	92	174	.728	10	33
136		1	-.046	-.137	.432	.765	48	79	.670	7	31
137		B	-.057	-.134	.434	.75	72	105	.661	11	31

Table 14. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
030	30	0	.235	.198	.289	0	646	100	.964	54	-
031		2	.224	.177	.297	0	649	99	.964	53	-
032		1	.215	.176	.293	0	637	126	.962	52	-
033		B	.203	.165	.298	.01	627	122	.962	52	22
026	34	0	.205	.164	.297	0	622	133	.961	51	-
027		2	.192	.147	.297	0	613	144	.960	50	-
028		1	.184	.148	.296	0	605	143	.956	49	-
029		B	.172	.128	.301	0	600	148	.958	47	-
034	38	0	.173	.131	.308	0	592	157	.955	45	-
035		2	.160	.112	.313	.01	569	163	.952	43	33
036		1	.153	.108	.317	.005	554	192	.947	42	10
037		B	.140	.092	.322	0	525	200	.947	39	-
038	42	0	.140	.096	.315	.015	535	200	.943	40	42
039		2	.127	.081	.327	.02	512	196	.936	37	44
040		1	.119	.068	.331	.01	452	225	.923	34	27
041		B	.107	.050	.338	.02	423	217	.910	30	46
Juv Mort = 66%											
014	30	0	.184	.145	.301	.005	602	155	.958	51	20
015		2	.173	.134	.304	.02	588	168	.960	51	34
016		1	.164	.122	.307	0	572	166	.958	49	-
017		B	.153	.108	.316	0	539	186	.954	46	-
010	34	0	.152	.105	.307	.01	550	184	.950	46	50

Table 14. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	Alle	
011		2	.141	.097	.318	.01	541	209	.952	43	24
012		1	.132	.091	.318	.005	514	213	.943	42	4
013		B	.120	.080	.322	.01	486	234	.936	39	48
018	38	0	.119	.071	.325	.03	474	208	.938	38	24
019		2	.107	.058	.327	.02	444	236	.928	34	34
020		1	.099	.048	.332	.02	431	228	.923	33	47
021		B	.087	.035	.333	.03	342	228	.914	31	35
022	42	0	.084	.025	.354	.095	381	237	.895	28	33
023		2	.072	.021	.345	.03	352	229	.899	27	33
024		1	.064	.005	.352	.120	331	256	.880	25	40
025		B	.052	-.009	.362	.13	277	250	.858	19	32
Juv Mort = 70%											
046	30	0	.130	.080	.316	.01	492	218	.947	43	18
047		2	.119	.083	.323	.04	541	188	.943	44	26
048		1	.110	.062	.329	.035	438	227	.934	40	29
049		B	.099	.047	.326	.02	402	218	.930	38	35
042	34	0	.096	.048	.331	.035	460	230	.930	37	40
043		2	.085	.039	.331	.03	405	237	.913	33	30
044		1	.076	.024	.343	.07	403	231	.905	32	36
045		B	.065	.012	.343	.07	319	237	.893	28	36
050	38	0	.061	.012	.348	.06	320	236	.889	27	36
051		2	.050	-.004	.352	.12	284	227	.882	23	38
052		1	.041	-.016	.362	.14	259	241	.847	21	35
053		B	.030	-.024	.370	.20	219	219	.855	20	38

Table 14. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.2 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
054	42	0	.025	-.044	.380	.285	210	224	.821	17	34
055		2	.013	-.048	.382	.26	168	208	.755	15	33
056		1	.005	-.057	.380	.350	164	198	.800	16	35
057		B	-.007	-.082	.391	.49	155	211	.772	14	35
Juv Mort = 74%			.								
062	30	0	.071	.018	.346	.085	333	233	.899	32	35
063		2	.061	.005	.348	.08	307	250	.897	29	41
064		1	.051	-.008	.363	.125	263	234	.871	25	40
065		B	.041	-.017	.349	.19	275	225	.894	26	39
058	34	0	.036	-.025	.367	.215	252	227	.871	25	34
059		2	.025	-.040	.382	.29	183	211	.826	19	38
060		1	.016	-.046	.369	.265	175	200	.820	18	35
061		B	.005	-.058	.378	.37	167	204	.795	16	35
066	38	0	-.001	-.065	.383	.39	153	175	.795	16	37
067		2	-.011	-.086	.404	.53	113	167	.769	13	33
068		1	-.021	-.091	.407	.52	121	171	.749	13	34
069		B	-.032	-.103	.414	.62	121	170	.768	13	34
070	42	0	-.039	-.123	.426	.725	64	123	.757	10	33
071		2	-.050	-.118	.421	.62	88	179	.686	9	31
072		1	-.059	-.138	.426	.770	63	117	.671	9	31
073		B	-.070	-.160	.441	.85	38	52	.611	5	30

Table 15. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
Juv Mort = 62%											
094	30	0	.213	.180	.278	0	639	127	.964	55	-
095		2	.201	.157	.290	0	609	138	.964	53	-
096		1	.193	.161	.289	0	606	147	.963	53	-
097		B	.181	.142	.297	0	607	144	.961	51	-
090	34	0	.181	.140	.289	0	605	145	.959	51	-
091		2	.169	.124	.300	0	545	174	.960	49	-
092		1	.161	.113	.304	.005	545	187	.951	46	47
093		B	.149	.114	.306	0	580	155	.952	45	-
098	38	0	.149	.111	.304	.005	573	169	.954	45	39
099		2	.137	.0082	.317	0	524	197	.941	39	-
100		1	.129	.085	.314	.005	515	211	.940	40	30
101		B	.116	.072	.326	0	510	216	.932	38	-
102	42	0	.115	.069	.314	.005	487	215	.932	36	35
103		2	.102	.054	.330	.01	467	242	.919	32	47
104		1	.095	.040	.336	.045	444	224	.919	32	32
105		B	.082	.027	.349	.07	392	251	.892	28	38
Juv Mort = 66%											
078	30	0	.163	.121	.300	.010	582	163	.961	51	21
079		2	.152	.105	.316	.01	554	192	.956	48	9
080		1	.143	.110	.304	.005	562	184	.956	48	35
081		B	.131	.088	.306	.01	493	212	.952	45	39
074	34	0	.130	.083	.312	.02	526	191	.949	44	29

Table 15. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.0 Fledged											
File			Results								
	Adl Mor %	C A T.	Population Growth			50 Years					Te
			Deter r	Stochastic r	SD	Pe	N	SD	Heter	All e	
075		2	.119	.073	.310	.01	506	200	.949	42	24
076		1	.110	.064	.316	0	504	207	.934	39	-
077		B	.098	.051	.314	.01	434	233	.932	37	38
082	38	0	.096	.055	.323	.020	451	236	.931	35	32
083		2	.084	.034	.336	.05	422	238	.905	32	37
084		1	.076	.026	.338	.035	376	237	.897	29	35
085		B	.064	.009	.341	.08	331	251	.885	27	37
086	42	0	.061	.002	.346	.105	306	236	.875	24	39
087		2	.049	-.004	.349	.11	265	214	.898	24	39
088		1	.040	-.021	.360	.165	250	216	.847	21	37
089		B	.028	-.035	.369	.25	207	226	.836	18	38
Juv Mort = 70%											
110	30	0	.109	.066	.318	.025	483	204	.946	43	27
111		2	.099	.045	.324	.03	406	232	.931	38	37
112		1	.089	.035	.326	.045	412	238	.926	35	37
113		B	.079	.028	.330	.06	380	242	.912	34	28
106	34	0	.075	.027	.330	.07	403	230	.919	34	35
107		2	.064	.010	.342	.08	326	248	.897	28	31
108		1	.055	.004	.338	.075	301	242	.877	27	37
109		B	.044	-.014	.352	.12	264	246	.871	24	38
114	38	0	.040	-.014	.354	.135	253	223	.865	23	32
115		2	.029	-.025	.358	.16	205	196	.815	22	36
116		1	.019	-.039	.368	.250	180	194	.826	19	34
117		B	.008	-.051	.368	.28	165	190	.810	17	36

Table 15. Interaction of Juvenile & Adult Mortality: F0 = 28%, 4.0 Fledged

File	Adl Mor %	C A T.	Population Growth: Deter r	Stochastic r	Stochastic SD	50 Years: Pe	N	SD	Heter	Alle	Te
118	42	0	.003	-.057	.378	.320	156	190	.799	15	35
119		2	-.009	-.079	.388	.47	119	167	.745	12	36
120		1	-.018	-.082	.394	.470	112	141	.747	12	34
121		B	-.029	-.102	.405	.62	96	174	.683	10	34
Juv Mort = 74%											
126	30	0	.052	-.005	.350	.090	278	235	.890	26	37
127		2	.042	-.018	.351	.11	239	218	.870	23	37
128		1	.031	-.029	.361	.225	227	240	.851	23	37
129		B	.022	-.036	.361	.21	153	172	.844	20	33
122	34	0	.016	-.040	.364	.230	169	191	.826	20	36
123		2	.006	-.057	.360	.31	167	198	.816	17	37
124		1	-.004	-.071	.382	.390	118	147	.787	15	35
125		B	-.014	-.090	.386	.50	96	139	.741	13	35
130	38	0	-.021	-.095	.402	.555	102	154	.748	12	35
131		2	-.031	-.095	.400	.55	66	83	.767	11	35
132		1	-.041	-.126	.418	.715	60	104	.704	9	33
133		B	-.052	-.138	.408	.78	38	59	.726	8	32
134	42	0	-.060	-.138	.423	.795	63	131	.672	8	32
135		2	-.071	-.166	.439	.87	39	51	.561	6	29
136		1	-.080	-.152	.431	.820	58	114	.671	6	30
137		B	-.091	-.177	.441	.92	17	20	.585	5	28

KIRTLAND'S WARBLER
(Dendroca kirtlandii)

POPULATION AND HABITAT VIABILITY ASSESSMENT

7-9 January 1992

WORKSHOP REPORT

SECTION 5

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