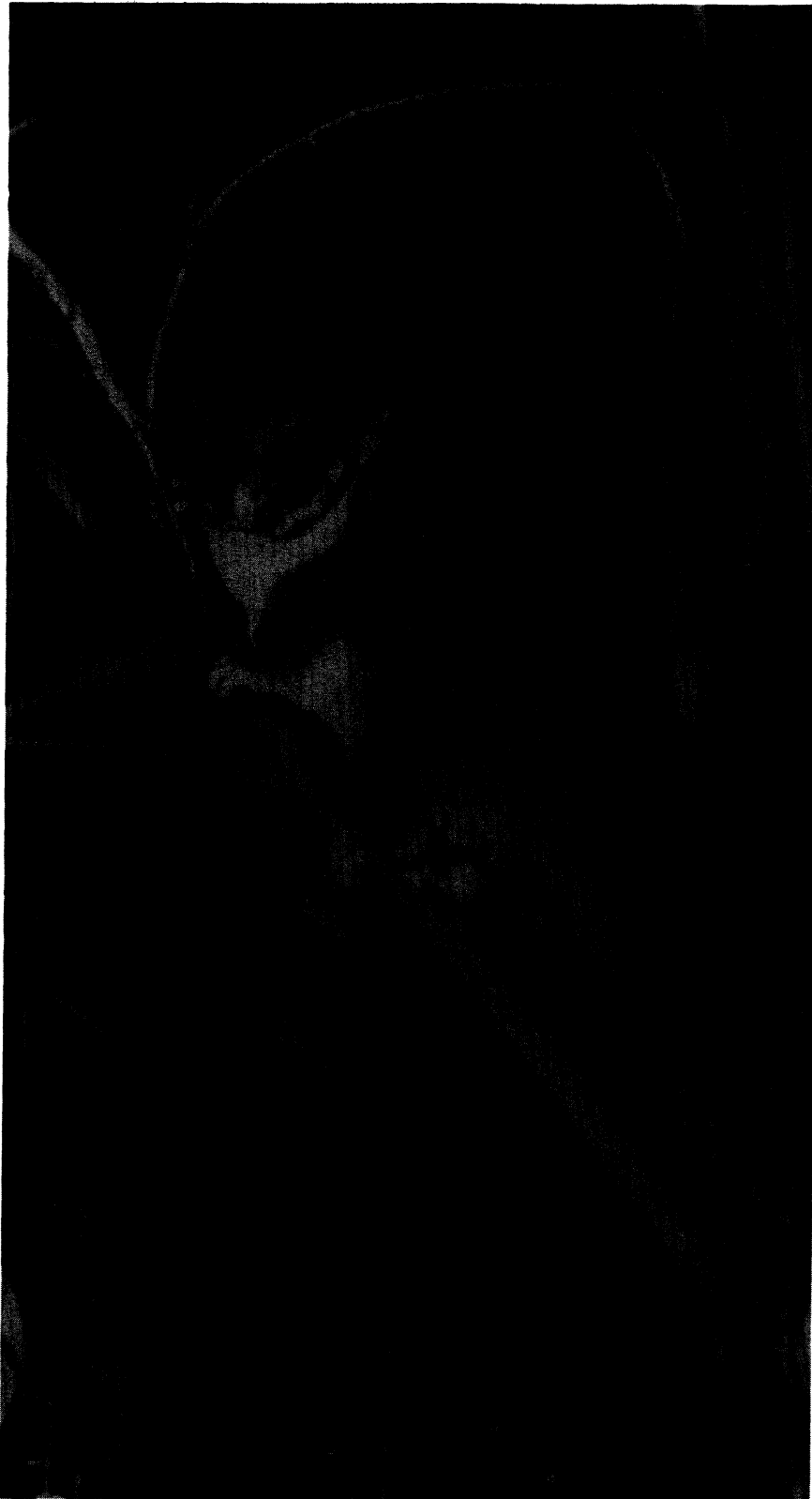


Endangered Species UPDATE

*Including a Reprint of the latest USFWS
Endangered Species Technical Bulletin*

December 1990 Vol. 8 No. 2

THE UNIVERSITY OF MICHIGAN
School of Natural Resources



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The Population Viability Assessment Workshop: A Tool For Threatened Species Management

by
Tim W. Clark, Gary N. Backhouse, and Robert C. Lacy

Introduction

Population viability assessment (PVA) is a procedure that allows managers to simulate, using computer models, extinction processes that act on small populations and therefore assess their long-term viability. In both real and simulated populations, a number of interacting demographic, genetic, environmental, and catastrophic processes determine the vulnerability of a population to extinction. These four types of extinction processes can be simulated in computer models and the effects of both deterministic and stochastic forces can be explored. In turn, the outcome of various management options, such as reducing mortality, supplementing the population, and increasing carrying capacity can also be simulated. Thus, PVA provides managers with a powerful tool to aid in assessing the viability of small populations and in setting target numbers for species recovery as a basis for planning and carrying out recovery programs. In addition, having performance-based management programs enables progress to be quantified and assessed. PVA also offers managers a powerful strategic planning and policy tool when vying for limited financial resources. This paper describes a PVA workshop that used a stochastic computer simulation to model small populations of, and explore management options for, six threatened/endangered wildlife species in Victoria, Australia.

The Workshop

The workshop was co-sponsored by the Department of Conservation and Environment (DCE), Victoria, and the Zoological Board of Victoria (ZBV), in

cooperation with the Chicago Zoological Society (CZS) and was held at the Arthur Rylah Institute for Environmental Research (DCE), Heidelberg, Victoria, from May 28 through June 1, 1990.

The objectives of the workshop were to: 1) examine the adequacy of data on the six threatened species; 2) simulate the vulnerability to extinction by using PVA; 3) examine outcomes of various management options to restore the species; 4) estimate population tar-



Mountain pygmy-possum

Photo by Ian McPherson

gets needed for recovery planning; 5) evaluate the potential of PVA as a teaching aid to illustrate extinction processes and management options.

The six species were: mountain pygmy-possum, *Burramys parvus*; leadbeater's possum, *Gymnobelideus leadbeateri*; eastern barred bandicoot, *Perameles gunnii*; long-footed potoroo, *Potorous longipes*; orange-bellied parrot, *Neophema chrysogaster*, and helmeted honeyeater, *Lichenostomus melanops cassidix*.

The 32 people attending the workshop represented experienced field biologists and wildlife managers with detailed knowledge of these and other threatened species. A month prior to the workshop all participants were provided with background reading material (e.g. Shaffer 1981, Brussard 1985, Samson 1985, Gilpin 1989, and Lacy and Clark 1990). A questionnaire on life-history parameters to be completed on each species as a basis for entering values into the computer was also provided. Following an introduction and overview of PVA, the participants formed teams and commenced work. Simulations, analyses, and discussions were ongoing over the next five days. The first week concluded with a report and review of each team's progress. During the following week, teams further refined their simulations and commenced preparation of a final report with management recommendations.

Population Viability Analysis: The Vortex Model

The workshop used a computer program, VORTEX, to simulate demographic and genetic events in the history of a small population (<500 individuals). VORTEX was written in the C programming language by Robert Lacy for use on MS-DOS microcomputers. Many of the algorithms in VORTEX were taken from a simulation program, SPGPC, written in BASIC by James Grier (Grier 1980a, 1980b, Grier and Barclay 1988). See Lacy et al. 1989, Seal and Lacy 1989 and Lacy and Clark 1990 for earlier uses of VORTEX.

Life table analyses yield average long-term projections of population growth (or decline), but do not reveal the fluctuations in population size that

would result from variability in demographic processes. When a population is small and isolated from other populations of conspecifics, these random fluctuations can lead to extinction, even in populations that have positive population growth on average. Fluctuations in population size can result from several levels of stochastic effects. Demographic variation results from the probabilistic nature of birth and death processes. Therefore, even if the probability of an animal reproducing or dying is always constant, the actual number reproducing or dying within any time interval would vary according to the binomial distribution with mean equal to the probability of the event (p), and variance given by $Vp = p*(1-p)/N$. Demographic variation is thus intrinsic to the population and occurs in the simulation because birth and death events are determined by a random process (with appropriate probabilities). Environmental variation (EV) is the variation in the probabilities of reproduction and mortality that occur because of changes in the environment on an annual basis (or other timescales).

VORTEX models population processes as discrete, sequential events, with probabilistic outcomes determined by a pseudo-random number generator. VORTEX simulates birth and death processes and the transmission of genes through the generations by generating random numbers to determine whether each animal lives or dies, whether each adult female produces broods of size 0, 1, 2, 3, 4, or 5 during each year, and which of the two alleles at a genetic locus are transmitted from each parent to each offspring. Mortality and reproduction probabilities are sex-specific. Mortality rates are specified for each pre-reproductive age class and for reproductive-age animals. Fecundity is assumed to be independent of age after an animal reaches reproductive age. The mating system can be specified to be either monogamous or polygynous. In either case, the user can specify that only a subset of the adult male population is in the breeding pool (the remainder being excluded perhaps by social factors). Those males in the breeding pool all have equal probability of siring offspring.

Each simulation is started with a specified number of males and females in each pre-reproductive age class and the breeding age class. Each animal in the initial population is assigned two unique alleles at some hypothetical genetic locus. The user specifies the severity of inbreeding depression which is expressed in the model as a loss of viability in inbred animals. The computer program simulates and tracks the fate of each population and then produces summary statistics on: the probability of population extinction over specified time intervals; the mean time to extinction of those simulated populations that went extinct; the mean size of populations not yet extinct; and the levels of genetic variation remaining in any extant populations.

A population carrying capacity specified by the user is imposed by a probabilistic truncation of each age class if, after breeding, the population size exceeds the specified carrying capacity. The program allows the user to model trends in the carrying capacity, as linear increases or decreases across a specified number of years.

VORTEX models environmental variation simplistically (which is both an advantage and disadvantage of simulation modelling), by selecting at the beginning of each year the population age-specific birth rates, age-specific death rates, and carrying capacity from distributions with means equal to the overall averages specified by the user, and with variances also specified by the user. Unfortunately, rarely do we have sufficient field data to estimate the fluctuations in birth and death rates, and in carrying capacity, for a wild population. The population would have to be monitored long enough to separate sampling error statistically from demographic variation in the number of births and deaths, from annual variation in the probabilities of these events. Such variation can be very important in determining the probability of extinction, yet we rarely have reasonable estimates for most populations of conservation concern. If data on annual variation are lacking, a user can try various values, or model the fate of the population in the absence of any environmental variation.

Endangered Species UPDATE

A forum for information exchange on endangered species issues
December 1990
Vol. 8 No. 2

Alice Clarke and Joel Heinen...Editors
Dr. Terry Root.....Faculty Advisor
Jon Jensen.....Staff Advisor

Instructions for Authors:

The Endangered Species UPDATE welcomes articles related to species protection in a wide range of areas including but not limited to: research and management activities for endangered species, theoretical approaches to species conservation, and habitat protection and preserve design. Book reviews, editorial comments, and announcements of current events and publications are also welcome.

Readers include a broad range of professionals in both scientific and policy fields. Articles should be written in an easily understandable style for a knowledgeable audience. Manuscripts should be 10-12 double spaced typed pages. For further information, contact the editors at the number listed below.

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Cover:

Leadbeater's possum
(*Gymnobelideus leadbeateri*)
Photo by Jim Cooper

The views expressed in the Endangered Species UPDATE are those of the author and may not necessarily reflect those of the U.S. Fish and Wildlife Service or The University of Michigan.

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VORTEX can model catastrophes as events that occur with some specified probability and which reduce survival and reproduction for one year. A catastrophe is determined to occur if a randomly generated number between 0 and 1 is less than the probability of occurrence (i.e. a binomial process is simulated). If a catastrophe occurs, the probability of breeding is multiplied by a severity factor that is drawn from a binomial distribution with a mean equal to the severity specified by the user. Similarly, the probability of survival for each age class is estimated in a similar manner.

VORTEX also allows the user to supplement or harvest the population for any number of years in each simulation. The numbers of immigrants and removals are specified by age and sex. VORTEX outputs the observed rate of population growth (mean of $N[t]/N[t-1]$) separately for the years of supplementation/harvest and for the years without such management, and allows for reporting of extinction probabilities and population sizes at whatever time interval is desired (e.g. summary statistics can be given at 5-year intervals in a 100-year simulation).

Overall, the computer program simulates many of the complex levels of stochasticity that can affect a population. Because it is a detailed model of population dynamics, often it is not practical to examine all possible factors and all interactions that may affect a population. The user, therefore, must specify those parameters that can be estimated reasonably, leave out of the model those that are thought not to have a substantial impact on the population of interest, and explore a range of possible values for parameters that are potentially important but very imprecisely known. A companion program, VORPLOTS, was used at the workshop to produce plots of mean population size, time to extinction, and loss of gene diversity from simulation results.

Equipment Required

VORTEX requires an MS-DOS microcomputer with at least 640K of memory. A math co-processor speeds up the program substantially. The

VORPLOTS plotting program produces files in the Hewlett Packard Graphics Language (HPGL), for use on an HP plotter or equivalent.

A Kodak Dataview EGA enabled projection of a computer display via an overhead projector onto a large screen so that all participants could observe demonstrations of VORTEX during initial training.

Computers were used during the daily sessions primarily for exploratory analyses with relatively few runs (100 or fewer) of a simulation; more extensive analyses were run overnight. A test with 100 runs would take from 15 minutes to 3 hours, depending on the machine used and the size of the population being simulated.

The Workshop Results

Each team documented its activities and provided a preliminary report of the simulations completed, conclusions, an assessment of the conduct of the workshop, and the usefulness of the PVA process. Results will be published in peer-reviewed scientific journals by each team.

All cases showed similar results. First, most species and populations were highly susceptible to local extinction. Any further habitat loss or fragmentation or reduction in population size and density would result in rapid extinction. Second, in all cases, more field data would have been helpful. Third, management options to stave off extinction were identified and results simulated. Options included strict habitat protection, enhancement of existing habitat or restoration of lost habitat, captive breeding, and reintroduction of animals to existing habitat patches in which the species has become extinct in recent decades or to newly created habitat. Various combinations of management strategies were recommended for future management. Fourth, the simulations demonstrated that if proactive conservation management had been undertaken even 5 to 10 years ago when populations and habitats were considerably larger, the task of present day managers would be much more tractable. And fifth, improved conservation management for all six

species is expected to result from the PVA exercise, enhanced research, and subsequent on-the-ground management. Three cases illustrate these conclusions: the mountain pygmy-possum (Mansergh et al. in prep.), eastern barred bandicoot (Myroniuk and Patrick in prep.), and orange-bellied parrot (Brown et al. in prep.).

Mountain Pygmy-Possum: The mountain pygmy-possum is a small marsupial restricted to alpine and sub-alpine (>1500m altitude) rock screes and boulderfields with heathlands. The species has been well studied and much information is available on its ecology (Mansergh 1989). Diet consists of invertebrates, seeds, and fruits. Breeding occurs from September to December, with litter size of 3 to 4. The young become independent by mid-January. Females can breed in their first year, and can live up to 9 years. An unusual feature of the life history of *Burramys* is the fact that sexes are segregated during the non-breeding season. The adult population is heavily biased towards females (6F:1M) because of the very high mortality experienced by males post-dispersal.

The current total population is estimated to be 2,300 breeding adults of which 80% are females. The species is regarded as vulnerable in Victoria and rare in New South Wales. The species is also susceptible to climatic changes associated with global warming.

The mountain pygmy-possum exists as a number of discrete populations isolated from each other on mountain tops. A total of seven populations, ranging from 20-850 individuals (representing the situation in the wild) was modelled. High probabilities of extinction were observed in all small (<150 animals) populations at 25 and 50 years; this could account for the absence of the species from apparently suitable habitat within its range. The larger populations had a decreased likelihood of extinction. When modelled with a small but steady decrease in carrying capacity (1% per annum) such as could occur through climatic change with global warming, the probability of extinction increased greatly (to 45% in the case of the largest Victorian population of 850 individuals, over 50 years).

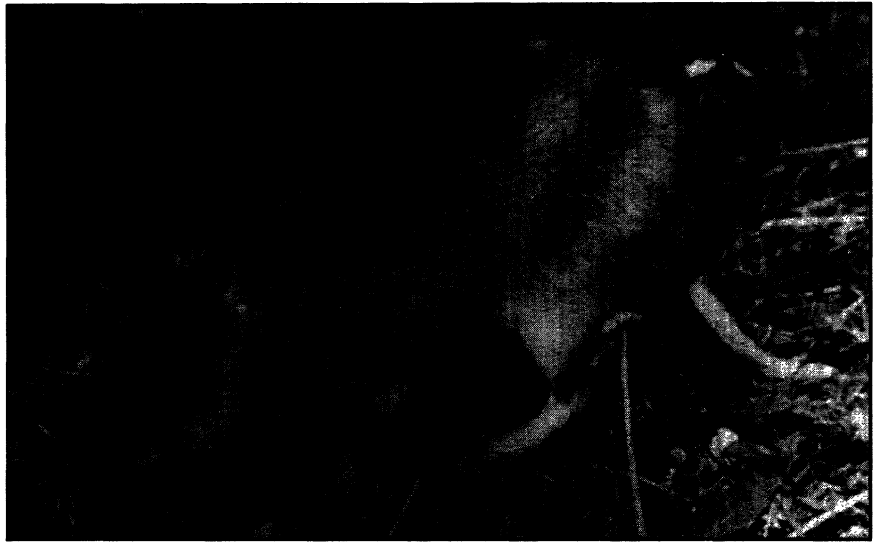
(Continued on UPDATE page 4)

Disturbance to habitat and further fragmentation of populations would increase the likelihood of extinction.

Eastern Barred Bandicoot: The mainland population of this marsupial species was formerly distributed over about 23,000 sq km of volcanic grassland in western Victoria. This population has now declined to 200 or fewer individuals restricted to remnant habitat near Hamilton (Clark and Seebeck 1990). The species is polygynous, with females capable of breeding from 3 months of age and males from 4 months of age. Gestation lasts about 12 days, with litters comprised of 1 to 5 offspring (usually 2-3); young remain in the pouch about 55 days. Females are capable of producing several broods per year. In spite of the very high reproductive potential, the population is believed to be declining at about 25% per annum. Juvenile mortality at dispersal from the nest is very high (> 90% within the first year). The decline of the species is attributed to habitat modification from pastoral activities and predation from introduced predators, including the red fox (*Vulpes vulpes*) and the cat (*Felis catus*).

Wild and captive populations of the eastern barred bandicoot were simulated. Modeling the wild population using available data without any change to current management indicated a 100% probability of extinction within 25 years, with a mean time to extinction of 7.2 years (± 2.1). Doubling the carrying capacity and leaving mortality unchanged had negligible impact on the probability of extinction and increased the mean time to extinction by only 2 years. Doubling the carrying capacity, reducing mortality by 30% and supplementing the wild population with the liberation of captive-bred animals greatly enhanced prospects for survival of the wild population. Under this scenario the probability of extinction was reduced to 0% over 25 years with a mean final population size of close to the carrying capacity of 300 animals. Modeling the existing and proposed captive populations allowed investigation of a variety of scenarios. The existing captive population of 16 pairs has an extinction probability of 83% over 25 years, with a mean time to extinction of

21.5 years. Doubling the number of adult pairs decreased the extinction probability to 0% but the surviving population had very low genetic variability, and there is little potential to harvest juveniles for release into the



Eastern barred bandicoot

Photo by J. Seebeck

wild. Increasing the captive population to 62 adult pairs increased genetic variability and the potential to harvest juveniles without jeopardizing the captive population. Maintaining a captive population of 62 adult pairs (in two groups at separate locations to avoid catastrophe but managed as one population) and establishing two semi-captive populations with a capacity for 400 animals gave the best prospects for long term survival, maintenance of genetic variability, and production of sufficient offspring to consider reintroductions to suitable habitat within their former range. The exercise highlighted the need for a combination of management actions, rather than any single action, to prevent the almost certain extinction of the wild population under the existing management regime. Reduction of mortality by predator control and traffic management is essential for the survival of the eastern barred bandicoot. Captive management will be an important part of the recovery program, but with a more intensive program than that currently underway.

Orange-bellied Parrot: The biology and ecology of the orange-bellied parrot is comparatively well known (Loyn et al. 1986). The species is one of the rarest and most threatened birds in Australia, with a total population of

150-200 individuals. The orange-bellied parrot breeds in coastal southwest Tasmania in woodlands adjoining extensive sedgeland. After breeding, it migrates across Bass Strait to overwinter in coastal regions of southern main-

land Australia. The birds feed in a variety of coastal habitats including grassland, saltmarsh, and dune systems, showing strong preferences for particular habitats and food types in different parts of their winter range and at different times of the year. An estimated 40 breeding pairs annually produce a total of 50-70 juveniles. The orange-bellied parrot is considered endangered. Loss of coastal habitat for development and trapping for the aviculture trade are considered to be the primary causes of the species' past decline. Pressures for development on or adjacent to its main wintering areas and habitat alteration are now the main threats to its survival. A captive breeding program is now underway as part of a range of measures undertaken to ensure the future survival of the species.

Populations were modelled using the current carrying capacity (150), a reduced carrying capacity (50), and an increased carrying capacity (500). Simulations which involved varying mortality, capture, and supplementation rates of the wild population were run for all carrying capacities. Simulating the existing population using current data and management regimes indicated that the species would remain extant over the next 50 years at least, and stood a good chance of surviving for 100 years.

Reducing the carrying capacity to 50 under current conditions somewhat surprisingly did not increase the probability of extinction over 50 years, although genetic variability was greatly diminished. As would be expected, increasing the carrying capacity to 500 birds further reduced the prospects of extinction and greatly increased the genetic variability of the population. When modelled with an increased juvenile mortality rate (75% cf 50%), the population with the reduced carrying capacity showed a 70% probability of extinction within 50 years, while the current and increased carrying capacity populations showed extinction probabilities of 20% within that time. Imposing a capture and release captive breeding program on the populations only slightly decreased the extinction probability of the reduced carrying capacity, high mortality population, but greatly improved heterozygosity in the reduced carrying capacity, current mortality population. No extinctions occurred in the current and increased carrying capacity populations even at the high mortality levels, when simulated with supplementation from a captive breeding program. The simulations indicate several points. Juvenile mortality is of great significance to the health of the population. Any increase above the present rate of 50% greatly increases the probability of extinction, even with an enhanced habitat carrying capacity. The captive breeding program is an important back-up to the wild population, and will be extremely valuable if the wild population declines.

Evaluation of the Workshop

An evaluation was considered to be an important part of the workshop. All participants rated the background material supplied prior to the workshop as good to very good. Provision of background material was essential as very few participants had any prior experience with PVA. Organization was rated as very good to excellent by participants. The key to success was the large number of microcomputers available so that 2 to 3 people per computer was possible. Presentations were rated as very good to excellent.

The workshop format was considered to be a highly successful way of presenting PVA. PVA was considered to be a useful tool to aid threatened species management, providing its application and limitations were understood. PVA can focus attention on questions that should be addressed through additional research. PVA can be applied to well-studied taxa, and the general principles can be applied more widely to other taxa providing program characteristics are kept in perspective. All participants would recommend PVA as a management tool.

Conclusions

The PVA workshop proved a very useful way of quickly learning a new technique for threatened species management and conservation. PVA was applied to six species allowing a critical, quantitative analysis of extinction probabilities, as well as exploring management options to prevent species loss. PVA results will be used in forthcoming management plans and actions directed towards restoring these species to a status from which they will be relatively immune to extinction from random processes. In the future, it can be expected that PVA's will be carried out on additional endangered species to help manage their recovery.

Acknowledgements

Several people and organizations made this workshop a success. Rod Gowans, DCE; Gerry Griffin, ZBV; Pam Parker and George Rabb, CZS, supported the idea and supplied resources and staff time to permit its realization. Gary Backhouse, DCE, and Amanda Embury, ZBV, organized the workshop. The Wildlife Information Management Unit of DCE acquired and set up the equipment. Each of the species teams contributed information for this paper, and Simon Bennett, DCE, contributed the equipment section. David Baker-Gabb and Andrew Bennett, DCE, reviewed an earlier draft and Denise Casey and Cathy Patrick, Northern Rockies Conservation Cooperative, USA, critically reviewed the final manuscript.

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Migratory Phenomena and Conservation

by Dennis D. Murphy, Kathy Rehm Switky,
and Stuart B. Weiss

In Alaska, tens of thousands of caribou thunder across the arctic plain, migrating from tundra to forest, where snow has not covered their forage. Around the world, hundreds of bird species fly day and night between high latitude breeding sites and equatorial wintering grounds. Monarch butterflies move as far as thousands of miles each autumn from across North America to overwintering groves in California and Mexico. These and other spectacular mass movements of relatively common organisms are unique exhibitions of nature - - and conservation of such migratory phenomena requires foresight and planning.

While migrations of birds are among the most conspicuous, many animals migrate: bats, terrestrial and marine mammals, invertebrates, amphibians, reptiles, fish. Their reasons for doing so vary, but include seasonal changes in resources and climate, breeding and reproductive requirements, and periodic resource scarcity. Not all migrations are spectacular and long-distance. Some are more subtle, like that of Clark's nutcracker, which moves a few miles across elevational gradients in the Sierra Nevada. For each migratory species, interactions between life history strategy, resource availability, and dispersal create a distinct migratory style that poses a conservation challenge.

Migratory phenomena are easily disrupted natural exhibitions. Dispersal pathways, tropical overwintering habitats, and critical stopover points are all vulnerable to habitat loss and stochastic environmental phenomena. Although migrating populations often track wide, non-specific paths, many such paths narrow in areas of limited or restricted resources. For example, millions of migrating shorebirds concentrate in areas such as Delaware Bay, where in a brief period, huge flocks arrive, devour the eggs of the horseshoe crab, then move on. The Bay and other vital

flyway stopovers provide superabundant food to as many as 80% of the North American populations of some species. Habitat degradation and loss in such critical areas along migratory routes may bring an end to the phenomenon of huge numbers of organisms moving *en masse*.

Some migratory species remain widely distributed until they reach their final destination, where individuals concentrate, and thus become vulnerable to habitat destruction. For example, in the spring and summer, monarch butterflies are an everyday sight across much of the nation. By November, however, monarchs have assembled in particular forest groves in California and Mexico. Spectacular overwintering aggregations of millions of monarch butterflies concentrated in relatively small forest patches depend upon the preservation of these circumscribed, critical habitats.

Consider the annual trek of the Porcupine caribou herd through the Arctic Coastal Plain. Virtually all of the migratory route is protected, but the key aggregation and breeding site on the coastal plain remains threatened by oil development. While total extinction of the herd's 180,000 caribou is unlikely, the disruption of the limited extent of breeding habitat could mean the end of one of North America's greatest migratory phenomena. On a continent whose prairies were once dotted with millions of migrating bison, and whose rivers once churned with hundreds of thousands of salmon racing upstream, the threat of this loss is very real. And while caribou, like bison and salmon, are not threatened with extinction, the losses of these migratory phenomena promise significant ecosystem disruption.

The conservation problem is straightforward: the spectacular - - and ecologically and aesthetically irreplaceable - - nature of migratory phenomena is threatened long before species are reduced to numbers at which

they would be considered for protection under the Endangered Species Act. With current species-based conservation legislation, it is difficult to argue for protection of species that regularly display population sizes that may be orders of magnitude larger than the most conservative estimates of minimum viable sizes.

Protection of critical habitat for huge populations may seem at first inconsistent in a world in which important conservation battles are fought for the very smallest populations and for small remnants of habitat. While most migratory species are not endangered in any classical interpretation of the term, the persistence of many of these spectacular dispersal phenomena depends on preservation of key aggregation sites along migration paths.

These geographic bottlenecks are difficult to protect with our current species-based conservation legislation. Yet, preservation of small portions of migratory routes that provide critical food, climatic conditions, or other resources that support mass dispersal may be the key to saving our most spectacular natural displays. While we rightfully concern ourselves with those species in most imminent danger of extinction, we should also recognize the need to protect large-scale migratory phenomena. We are taking the first necessary steps: numerous salmon runs, such as the winter run chinook in California's Sacramento River, have been proposed for protection under the Endangered Species Act. We must embrace such propositions as examples of responsible stewardship, before masses of migrating animals exist only in history books. These natural displays are the most dramatic demonstrations of our ability to share the landscape with other species.

Murphy, Switky, and Weiss are biologists at the Center for Conservation Biology, Stanford University, Stanford, CA 94305.

Bulletin Board

1990 Special Issue Information

The newly published 1990 ESU Special Issue on captive breeding is available for \$8.00 per copy for the general public and \$5.00 per copy for ESU subscribers, plus \$0.50 shipping and handling for each copy. Bulk orders of five or more copies will be sold at \$4.00 per copy, plus shipping and handling fees given above. We have a limited number of copies available, so please place orders soon. All inquiries about and orders for this and other past issues should be sent to the editors, ESU, at the address given on page 2.

Audobon Camps and Workshops

The Audobon Society will feature several different options for camps and workshops in 1991, including nature photography in South Florida and Yellowstone, international ecology programs in Costa Rica and Trinidad, the Audobon Youth Camp in Maine, and more. For information and a brochure describing all programs, write to Audobon Ecology Camps and Workshops, Dept. A, 613 Riversville Road, Greenwich, Conn. 06831; (203) 869-2017.

Stanford Environmental Law Society

Founded in 1969, the Stanford Environmental Law Society is the oldest student organization of its kind in the United States. Its primary function is to sponsor original research in the field of environmental law. The society relies on contributions, grants, and proceeds from the sale of its publications. For information, contact Stanford Law School, Stanford, CA 94305; (415) 723-4421.

A Changing of the Editors

Suzanne Jones, the editor of ESU for the past year and a half, has left the University of Michigan to begin work for the Fish and Wildlife Subcommittee in the House of Representatives. We wish her well in her transition to this new job and to the excitement of Washington, D.C. Suzanne's dedication was largely responsible for seeing ESU through some difficult financial times and she will be greatly missed. We, the new ESU editors, are Alice Clarke and Joel Heinen, both PhD candidates in the University's Resource Ecology and Management Program. Alice has an

MS in Forest Entomology and an MS in Computer Science, and has worked for the US Forest Service and for a private research firm before returning to graduate school to pursue her PhD. Her current research interests are in human resource use and migration patterns. Joel has an MS in biometry and an MS in zoology, and has worked in national park/protected area policy and management in Nepal for Peace Corps and USAID. His current research interests are in ecology and conservation of vertebrates, especially reptiles and amphibians. We have decided to split the ESU editorial job as neither of us alone has adequate time to do it justice, due to the demands of field seasons and doctoral dissertations. We look forward to serving you and to carrying out the initiatives to support ESU so diligently begun by Suzanne with the help of Terry Root and Jon Jensen, our faculty and staff advisors. We only hope that the work of the two of us together can come close to matching Suzanne's.

Bulletin board information provided in part by Jane Villa-Lobos, Smithsonian Institution.

Announcements for the Bulletin Board are welcomed.

Endangered Species UPDATE

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