Report of a Workshop to Develop a North
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REPORT OF A WORKSHOP TO DEVELOP A NORTH AMERICAN RAPTOR MONITORING STRATEGY

Authored and Edited by the Workshop Participants (Appendix A)

Available at: http://www.im.nbs.gov/raptor/raptor.html

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1. NEED FOR A RAPTOR MONITORING STRATEGY

1.1 Introduction

The purpose of the workshop held in Boise, Idaho on 12-13 August 1996 was to begin development of a comprehensive North American program for monitoring the population status of diurnal raptors. Approximately 35 people (Appendix A) from the U.S.A., Canada, and Mexico attended the two day workshop hosted by the Raptor Research and Technical Assistance Center, National Biological Service.

Monitoring data are required to evaluate the status and trends of raptor populations, including those of endangered and threatened species, at the state, provincial, territorial, national, and international levels. However, reviews of survey and monitoring methods revealed that, in many cases, current programs do not provide government and regulatory agencies the information required to assess raptor population status. At the same time, broad data bases that have the potential to provide basic data necessary to monitor many raptors species in North America are available and are continually updated and improved. Workshop participants discussed the available monitoring and counting methods, survey designs, statistical analyses, and proposed cooperative efforts that could be applied at state/provincial, regional, or continental levels to achieve the goal of monitoring the population status of diurnal raptors in North America.

1.2 Goals and objectives

The participants endorsed the need for a North American Raptor Monitoring Strategy. The goal of this strategy will be to monitor the status and trends in continental and regional populations of Nearctic diurnal raptors in Canada, Mexico, and the U.S.A. For the purpose of this strategy, diurnal raptors are defined as birds of prey in the taxonomic orders Falconiformes and Strigiformes, whose primary activity pattern is diurnal. The three objectives of this strategy will be:

1) To ensure, at a minimum, the ability to detect a 50% reduction in population size over a 25 year period with alpha = 0.10 and beta = 0.20; with the expectation that power to detect trends for the majority of species would be much greater.

2) To identify the best combination of monitoring techniques for each species.

3) To recommend improvements in data collection efforts, analysis methods, and regional coverage for each species and monitoring technique.

1.3 Justification

Most raptors are high-trophic-level predators, and as such influence and are influenced by many biotic and abiotic components of the communities in which they occur. Compared to most other vertebrate species, they occur at relatively low densities. As predators, they are highly influenced by prey availability, and during the breeding season densities are sometimes limited by distribution and abundance of suitable nest sites. Because they are high-trophic-level predators, they have the potential to serve as indicators of community or ecosystem condition, and have served as sentinels of ecosystem health in the past. For example, population declines of Bald Eagles and Peregrine Falcons in the decades following World War II were instrumental in enlightening the public about the effects of pesticides in the environment. Recent mass poisoning of Swainson's Hawks in Argentina has recently become a major media and public issue. Changes in raptor populations may be indicative of natural or anthropogenic perturbations in the communities and ecosystems in which they occur, and are likely to be evident prior to changes at lower trophic levels.

The protection of raptors is required under the Migratory Bird Treaty among Canada, Mexico, and the U.S.A. Raptor conservation is also compatible with the 1992 Biodiversity Convention in Rio de Janeiro. All three countries have national and international mandates to conserve raptors as part of their indigenous biodiversity. However, basic information regarding population status and trends is lacking for most species, and developing a comprehensive raptor monitoring strategy is a critical first step in raptor conservation.

Raptors also have great public appeal. Many people watch raptors for recreation, and reintroduction programs and other recovery efforts for endangered species have received high levels of public support. For example, the Peregrine Fund, the private organization responsible for the reintroduction of the Peregrine Falcon into many parts of the species' former range, has been supported in significant part by private donations.

Because of public concern, many government agencies and organizations also are concerned with the management of endangered species and their habitats. Some raptors are already listed as endangered or threatened in part or all of their range. The recovery of endangered species is very expensive and can result in conflicts between conservation and development. If species declines can be noted through an effective monitoring program, and action taken to prevent populations from reaching levels where endangered or threatened designation is necessary, management agencies will save resources. Consequently, the implementation of an integrated continental monitoring plan will be cost effective and will promote conservation goals.

The development of a raptor monitoring strategy will be the first step in the coordinated conservation of raptors in North America. Similar conservation programs are already underway for waterfowl (North American Waterfowl Management Plan and Flyway Councils) and shorebirds (Western Hemispheric Shorebird Reserve Network). A conservation strategy for diurnal raptors can complement existing programs:

- The Partners in Flight program is the largest and newest conservation program dedicated to the conservation of all landbirds. PIF has U.S.A., Canadian, and Mexican branches with partnerships already being built among government agencies and non-government organizations. To date, Partners in Flight has not specifically addressed the conservation and monitoring needs of raptors. A comprehensive raptor monitoring strategy can help set conservation priorities within the Partners in Flight program and a raptor monitoring strategy will provide the basis for a Partners in Flight program for raptors.

- The Important Bird Areas program of BirdLife International is in the process of identifying critical breeding, migration, and wintering areas for North American birds. A comprehensive raptor monitoring strategy can contribute data that will determine the most important geographic regions for raptors. Conservation efforts can then be targeted at these ecologically sensitive areas.

1.4 Scope and scale

Management agencies require monitoring techniques that detect declines in raptor populations at continental, regional, and local scales. The raptor monitoring strategy will be designed to track raptor populations with a range of techniques so that population trends will be apparent at several geographic scales. Each raptor species should be monitored at the continental level. Although initially this may not be possible for all species, concentrations at migration sites and/or detection on continental surveys (Christmas Bird Counts, Breeding Bird Surveys) will allow tracking of continental populations for some species. The networking of programs at the regional and local scales is necessary to monitor the most common species. The strategy will identify the techniques that provide coverage at as many combinations of geographic scale, season, and species as possible, and will identify gaps in techniques and data that need to be improved upon to provide more complete monitoring in the future.

In some cases, it will not be feasible to conduct monitoring annually because the application of some techniques is expensive. Some raptor species are long lived and have traditional nesting areas. Consequently, it may not be necessary to monitor these species annually. The strategy will identify techniques that can be applied periodically and still provide useful population monitoring data.

At this time, the strategy is expected to include all species of diurnal raptors that breed in Canada and the U.S.A. but will not include neotropical species that breed only in Mexico. The species coverage will include some neotropical raptors with established populations in the southern U.S.A. and Mexico, and future versions of the strategy should attempt to include more neotropical species that breed in Mexico.

1.5 Funding strategy

There is no single agency with the resources to fund a comprehensive continental raptor monitoring strategy. Some support in the U.S.A. might be available under the Endangered Species Act. The ESA provides for the funding of candidate conservation programs that prevent the need for later species listings. Because raptors are a major component of recreational bird watching, non-game and tourism funds could be attracted to the program. Non-traditional sources of funding could include Commission for Environmental Conservation of NAFTA, U.S. AID, Canadian International Development Agency (CIDA), and the World Bank.

Funding and monitoring must be a carefully coordinated and cooperative effort. Implementation of the strategy will occur through the existing programs and through new programs of various government and private organizations that contribute to development and implementation of the strategy. Individuals involved in the strategy will be able to identify funding needs and appropriate contributions for their employing agencies and partners. The strategy will provide a structure for continued communication and coordination and for the calculation and reporting of trend information compiled during implementation phases.

2. CURRENT MONITORING TECHNIQUES

2.1 MIGRATION MONITORING

2.1.1 Introduction

The utility of migration counts for monitoring population trends has been much debated. Migration counts represent indices to true population size. To track population change, a constant proportion of the index to the true population size must be maintained, or the proportion must be estimated. Migrant raptors have been counted at over 1000 locations throughout the U.S.A. alone, yet the differences in count methods has severely limited the value of counts at most sites. The Hawk Migration Association of North America (HMANA) has been a critical player in the effort to make raptor migration counts (RMCs) a more effective population monitoring tool. HMANA has coordinated the collection and compilation of RMC data for two decades, and has coordinated an international network of people interested in hawk migration. HMANA's support, leadership, coordination, and cooperation will be critical in creating RMCs that are effective at monitoring North American raptor populations.

2.1.2 Strengths of raptor migration counts

At migration sites many species may be surveyed at a single location by the same observers. Many sites have seasonal counts in the hundreds or thousands. Some species

and populations (e.g., accipiters, Northern Harrier, Merlin, Broad-winged Hawk, and Osprey) seen regularly at migration sites breed or winter in remote areas, and are poorly covered by other monitoring techniques such as Christmas Bird Counts (CBC) and the Breeding Bird Survey (BBS). RMCs also integrate population data from broad geographic regions that are the source of migrants. For some species, it is possible to record gender and age statistics, which may suggest the cause of any documented population declines.

RMCs receive a high level of public interest and participation, attracting numerous volunteers and contributions. They are a great means of educating the public about raptors, migration, ecological principles, and bird conservation. Given volunteer involvement, RMCs can be fairly cost effective. In addition, the potential exists for extending activities at some count sites to include raptor banding studies.

Long-term data sets already exist for certain sites. Well developed analytical methods are available for analyzing RMC data (e.g., BBS and CBC analytical techniques may be appropriate for examining raptor count data).

2.1.3. Weaknesses of raptor migration counts

Although RMCs may provide large geographic coverage, the breeding and wintering areas for many of the migrants are poorly defined and likely cannot ever be completely delineated. The unknown origin of raptors that pass through these sites makes combining information among sites difficult. In addition, there are geographic gaps in current coverage of the U.S.A. (e.g., the Midwest and the South) and very little attention or resources have been devoted to RMCs in Canada or Mexico.

Although HMANA forms have offered some standardization of RMCs, many reports from different sites are still lacking in completeness. Omitted data and inconsistencies in both reporting style and field methods limit the comparability of current RMC data among sites. Collection of weather data is also not standardized among RMC sites. Even within a single site, field methods may be poorly defined or may have changed over time, and the effect of site-shifting that occurs at some stations needs to be determined or eliminated. The effects on count data of observer skill and experience, observer training and evaluation, number of observers, observer fatigue, and observer turnover are incompletely understood and need more careful study. To support statistical analyses of RMCs, well-documented protocols need to be developed and implemented at each count site.

RMCs can be affected profoundly by local and regional weather patterns as well as by natural or anthropogenic changes in the local landscape. Shifts in wintering or breeding ranges, or migratory short stopping may have large annual effects on RMCs, and the count can change over time if migration routes change.

Although limited or indirect efforts to assess the validity of migration counts indicate that this technique reflects population changes, at least qualitatively, there is no known method

to directly validate trends derived from migration counts, and the relationship between the population and the count at a particular site is unknown.

2.1.4. Improving the effectiveness of raptor migration counts

In light of the above weaknesses, the effectiveness of RMCs as a population monitoring tool can be enhanced by:

1) Designing and implementing validation studies for RMCs.

2) Establishing or improving coordination/communication among RMC site managers.

3) Standardizing field methods at each RMC site and standardizing data reporting at the continental level.

4) Managing data sets at a central organization to increase attention to error detection and data verification, providing a central storage location, and expediting analysis and interpretation of results.

5) Identifying gaps in coverage by species, populations, or geography. Increased banding and use of satellite telemetry of migrating raptors will enhance techniques for addressing this need.

6) Addressing special research needs, such as studies on observer bias, bias in identification, etc..

7) Improving statistical methodology for analyzing RMC data. Assessments of statistical power for the detection of trends for the various proposed analytical procedures are needed, as are ways to incorporate weather and observer effects. Such studies may provide ideas on how survey methodology may be modified to enhance the utility of RMCs as a monitoring tool for raptor populations.

2.2 BREEDING SEASON SURVEYS

2.2.1 Breeding Bird Survey (BBS)

Though many raptor species are detected on BBS surveys, the BBS appears best suited to monitoring populations of open-country raptors. However, many species are encountered at low frequencies, which may limit usefulness of the data to long-term estimates of population change. BBS data are also limited by roadside bias, poor coverage of species in the north (i.e., boreal and arctic Canada, Alaska and Greenland), unknown relationship to population size, and the lack of habitat specificity. As with most index monitoring

and prairie regions. Boat surveys are used to monitor species that nest near water (e.g., Bald Eagles and Osprey). However, there are few data for assessing the accuracy of float surveys. The main disadvantage is that only certain habitats are surveyed, and the view is restricted to a narrow strip of land. Even when species typically nest near water, there are cases where a few nests, and occasionally many nests, occur inland.

2.2.5 Nest box use

American Kestrel use of nest boxes can be used to monitor local populations of this species.

2.3 NON-BREEDING SEASON AND WINTER SURVEYS

2.3.1 Christmas Bird Count (CBC)

The Christmas Bird Count program provides the largest and longest running data set on winter raptor populations. Most winter raptor species occur frequently on these counts. Interpretation of these counts is hindered by observer-chosen sampling locations, uneven effort, observer effects, and miscalculations of observer effort (party hours, miles, and number). The technique has been shown to be highly correlated with BBS results, but raptor-specific analyses have not been completed.

2.3.2 Road counts

Some open country species have been surveyed from roads in winter. In some habitats, road counts can be used to estimate population size by adjusting for birds that are undetected. However, road surveys suffer from several potential biases, including location of roads relative to distribution of habitats and the influence of linear structures (e.g., above-ground utility lines) that often parallel routes.

2.3.3 Roost counts

Many falconiformes and strigiformes in North America use communal roosts. Post-breeding season counts at roosts may be possible for the Turkey Vulture, Northern Harrier, Snail Kite, and Ferruginous Hawk. Counts at migratory staging areas may be used to monitor Swallow-tailed Kites. The most common method of enumerating individuals in a roost is by directly counting the number of birds. Sometimes, several counters stationed around the roost are required when birds depart in different directions. However, roost counts suffer from several disadvantages. Changes in numbers of individuals may not reflect changes in the population, and many factors influence counts at roosts, including weather and shifts in prey abundance.

2.3.4 Bald-Eagle mid-winter survey

Since 1979, annual mid-winter counts of Bald Eagles have been conducted throughout the U.S and are being used to monitor the continental population of this species. These surveys are done using a variety of methods (aerial and boat surveys, road counts, etc.). Methods have been standardized on some routes; however, existing routes were not randomly selected. Efforts to standardize routes are continuing. The technique may be useful for other rare species or species with aggregated distributions in well-defined areas.

2.3.5 Float surveys

Boats and rafts have been used occasionally outside the breeding season. However, as with breeding season surveys there are few data for assessing the accuracy of float surveys in the non-breeding period. Non-breeding season river surveys might be possible for the Black Vulture and Sharp-shinned Hawk.

2.3.6 Checklists

Checklists that are completed by field observers are being used to monitor songbird populations. Their value to monitor raptors needs to be explored with further analysis of existing data sets. Biases inherent in checklist projects are not well understood.

2.3.7 Atlases

Atlases of breeding birds have been conducted in many provinces in Canada and states in the U.S.A. In Great Britain, both breeding season and winter bird atlases have been produced. When these are repeated through time, and standardized for effort, they can show changes in species distribution. Most atlases do not currently have a component to estimate population size and do not standardize effort.

3. MONITORING STRATEGIES FOR INDIVIDUAL SPECIES

The purpose of the North American Raptor Monitoring Strategy will be to provide data adequate to monitor diurnal raptor populations at a variety of geographic scales. The previous section on current monitoring techniques discussed the need to standardize and develop survey techniques. Workshop participants also addressed the monitoring needs and adequacy of existing monitoring techniques for each diurnal raptor species, and identified where new techniques were required (Table 1). The text in Appendix B elaborates on the information in the table.

TABLE 1 EXISTS AS A SEPARATE DOCUMENT (RAPTABLE.DOC)

4. STATISTICAL ISSUES

4.1 Introduction

A reasonable goal in developing a monitoring program is to understand the long-term trajectory of a population, including trends (an interval specific measure of rate of change), cycles, and perturbations. The credibility of raptor monitoring programs depends on their ability to provide unbiased and precise estimates of attributes such as population size or population change. Unfortunately, for many raptor monitoring programs, it is difficult to assess bias, underlying populations are poorly defined, and controversy exists about proper analysis procedures. In this section, we review some issues in the statistical analysis of raptor monitoring programs.

4.2 Index vs. adjusted population estimate

Large-scale surveys are useful for monitoring distribution changes or estimating population changes at the landscape level. Most large-scale surveys, such as CBC, BBS, and migration counts, collect data that serve as indices, representing some fraction of a population. Indices cannot be used to estimate population size unless the detection rate (proportion of the index to the population size) can be determined. An index is often sufficient to estimate trends, but generally there is a need to verify the assumption of constant detection rates. If an actual population estimate is needed (e.g., for management purposes or when legal questions will be addressed using the survey results) an estimate of detection rate is required to calculate the adjusted population estimate. Distance methods, capture-recapture, or other statistical methods are generally used to estimate the detection rate. Smaller-scale surveys implemented in local or regional areas are often needed to provide information on actual population sizes and other demographics, but it is unlikely that large-scale monitoring of survival and reproduction can be implemented.

4.3 Validation

No large-scale survey has been validated by comparison with known populations. Corroboration (documentation of consistency with other large-scale surveys) has been documented for BBS, CBC, and migration counts.

4.4 Defining populations

To estimate population size or trends, a population must be defined. It is easiest to do this for breeding population surveys. For wintering populations, the population in a region may change from year to year due to weather effects on distribution. Migration counts are the most problematic, as the population monitored can change from year to year.

4.5 Statistical methods

Several statistical methods, including simple regression, multiple regression, LOESS smooths, estimating equations, and over-dispersed multinomial procedures exist for trend estimation and have been implemented for raptor populations. All of these procedures have strengths and weaknesses and the statistical method of choice will depend on the goals of the analysis and may change with ongoing investigations of these techniques.

4.6 The impact of bias

It is important to evaluate possible sources of bias in survey procedures. Comments on sources of bias were presented in the techniques sections above.

5. NEXT STEPS

An e-mail discussion group has been created to help disseminate information on the development of a North American Raptor Monitoring Strategy. Anyone can join and receive announcements, listen in, or participate in discussions. To sign on send an e-mail message to:

listproc@rana.im.nbs.gov

In the body of the message (not the subject line) put:

subscribe raptrend <your name>

We have also requested that Partners in Flight establish a committee to coordinate the preparation of a "white paper" or draft the North American Raptor Monitoring Strategy. Authors can then volunteer to draft sections of the strategy. Because migration monitoring is an essential component of raptor monitoring, we hope members of the Hawk Migration Association of North America will join this committee.

The North American Raptor Monitoring Strategy will need to address the various methodological and species-specific issues identified in this report. In particular, there is a need to develop meta-analysis techniques to integrate the results of separate raptor monitoring data sets. In addition, we encourage testing and validation of raptor monitoring techniques. Nocturnal owls need to be incorporated into the strategy and a workshop has been suggested to the conveners of the 2nd International Conference on Owls of the Northern Hemisphere in Winnipeg in February 1997. In addition, other raptors that occur in Mexico should be incorporated into the strategy. The monitoring strategy should also be the topic of a workshop at the 1997 annual meeting of the Raptor Research Foundation.

The drafting committee is encouraged to have a preliminary strategy available for distribution before the meeting. A proposed outline of the North American Raptor Monitoring Strategy is presented in Appendix C.

Appendix A. List of workshop participants.

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Appendix B.

Individual species accounts for raptors to be monitored by the proposed North American Raptor Monitoring Strategy. Each account summarizes the current status of monitoring for the species and suggests potential additional monitoring techniques. This appendix supplements the information in Table 1.

Turkey Vulture:
Probably adequately covered by the BBS. Partially covered by the CBC program. Migration counts provide useful monitoring data (some biases - e.g., flocking, difficult to discriminate between migrants and local birds). Additional development of and use of roost count censuses may be worthwhile for local information.

Black Vulture:
The BBS provides some monitoring information (southeastern U.S.A.; early morning sample misses peak vulture activity period). The CBC also generates some monitoring information during the winter period. Migration is spotty, thus migration counts are of little monitoring value. Current monitoring data are not adequate to evaluate population trends at most geographic scales. Recommend an additional monitoring program; possibly develop non-breeding season road count program (should involve multiple species in southern North America). River surveys or counts at feeding stations might also be considered. Not of management concern except in some locations in the southeast U.S.A. where populations may be declining.

Osprey:
The BBS misses most breeding populations and detections on BBS routes are infrequent. The CBC program provides no data as Osprey winter in South America. Useful trend information is probably collected at migration count sites. Recommend coordination and standardization of existing local monitoring efforts (nest surveys) and use of knowledgeable volunteers.

Swallow-tailed Kite:
Not adequately monitored by any existing technique. Establishment of migration count sites at strategic locations for this species might be feasible. Recommend development of new technique; possible monitoring approaches may include counts at pre-migration staging areas, nest-plot surveys, and sampling along road or river routes.

White-tailed Kite:
The BBS sample sizes are low and detections are infrequent. The CBC provides limited information, but detections are few. New technique needs to be developed, probably a breeding season nest-plot survey or road count would be most reasonable.

Snail Kite:
U.S.A. population is monitored by an endangered species research team. Mexican populations are not covered by any existing monitoring program. Development of a nest-plot survey or roost count program would be desirable south of the U.S.A. Boat surveys may be feasible.

Mississippi Kite:
Currently, BBS data are inadequate, but may provide limited information with expanded effort. Migration counts may provide trend data, if count sites are established in suitable locations. Existing programs (i.e., BBS and migration counts) need expansion or new monitoring methods need to be developed; road or river route sampling may be most feasible during the breeding period.

Bald Eagle:
The BBS is of limited monitoring use. The CBC probably provides some useful monitoring data. Migration counts also probably provide useful trend information. Recommend improvement in coordination and standardization of existing local survey projects (including Mid-winter Bald Eagle Survey and existing local nest-monitoring efforts). Appropriate trend data derived from local sampling programs should be managed, compiled, analyzed, and reported in a timely fashion. There are geographic gaps in the boreal and northern regions, which may affect the validity of using local data to monitor the continental population.

Northern Harrier:
Because of low detection frequencies, the BBS is of unknown value in discerning trends and substantial populations in the north are not sampled. The CBC program probably provides useful trend information. The breeding display period in the spring is a possible time to detect this open country species. Migration counts also probably provide effective data for the evaluation of population change. Because harrier populations have been reported to be declining in some regions, development of additional monitoring capability would be appropriate. Harriers might most effectively be monitored during the non-breeding season. Development of a standardized road count (ideally for monitoring several species not adequately sampled with other techniques) may be the most reasonable approach. Roost counts have also been suggested.

Sharp-shinned Hawk:
The BBS is not effective as a monitoring technique. The CBC probably does not provide useful trend information; detection frequency is low and biases may be a problem (Sharp-shinned Hawks are often attracted to bird-feeding stations in urban areas where most CBCs are conducted). Migration counts probably provide useful trend information (however, identification confusion with Cooper's Hawk may affect existing data). Alternative monitoring techniques should be developed, possibly non-breeding-season road or river counts (some areas). Breeding season nest plot surveys and roadside count

programs have been proposed. Breeding-season monitoring may not be economically feasible.

Cooper's Hawk:
Similar to the Sharp-shinned Hawk, migration counts may provide the best monitoring approach. Breeding-season nest plot or road counts (using broadcasts) are probably feasible, but expensive, for monitoring Cooper's Hawks. Intensive breeding studies may be the only way to monitor local populations of this species.

Northern Goshawk:
The BBS and CBC are not useful for monitoring this species. Migration counts may provide an index of fledgling production in some areas, although there is not consensus regarding whether this approach is feasible. Evaluation of using migration counts to monitor local/regional fledgling productivity should be a priority research need because of the difficulty and expense of monitoring this species by other means. Intensive breeding season surveys, nest plot surveys and/or road and foot broadcast counts are the only known methods available for monitoring this species. This type of intensive breeding-season monitoring is extremely expensive.

Common Black Hawk:
Data from the BBS and CBC are not adequate for monitoring population trends in this species. Breeding-season surveys in riparian areas probably represent the most feasible monitoring approach.

Harris' Hawk:
The BBS is probably not effective for monitoring this species at the current density of survey routes. The CBC probably provides limited trend information (grouping of birds especially in winter introduces excessive variation to count indices). A species-specific technique needs to be developed. The most cost-effective monitoring approach is probably a nest plot survey (nests are comparatively easy to detect).

Gray Hawk:
BBS data are not adequate for monitoring population trends. CBC data may potentially be useful for monitoring populations; more sampling circles should be established in Gray Hawk range. An additional monitoring approach is needed: roadside or foot surveys along riparian areas during the breeding period may be most feasible.

Red-shouldered Hawk:
The BBS and CBC probably provide limited monitoring information in some regions (California and Florida, possibly Texas). Detections are very infrequent in other areas and both the BBS and CBC may not adequately sample key bottomland habitats in regions of most concern (the midwestern and eastern parts of the continent). Migration counts probably provide useful trend information for northern and midwestern populations.

Because this is species of special concern in most regions, additional techniques should be developed. Breeding season (especially during the display period) road/broadcast surveys may represent the most promising monitoring technique for this species.

Broad-winged Hawk:
The BBS provides questionable trend information (most routes may not adequately sample key habitats). Migration counts probably provide useful trend data (some biases, e.g., flocking). Emphasis should be made to develop an improved migration count network for this and other species. Additional surveys should probably be developed; recommend development of breeding season road/broadcast surveys (most effective during the display period).

Short-tailed Hawk:
The BBS, CBC, and migration counts do not furnish monitoring information for this species. Breeding-season nest-plot surveys may be most feasible.

Swainson's Hawk:
The BBS probably provides useful trend information (possible biases - some Canadian and remote western populations may not be adequately sampled). Migration counts could provide monitoring information if count sites are established in suitable locations in Mexico, Texas, or Central America. Because this is a species of current concern, nest-plot surveys (occupancy, productivity, demography, etc., should be monitored) and wintering ground roadside surveys (austral summer) are needed.

White-tailed Hawk:
The BBS probably provides limited regional information on trends. CBC data may be of limited value for monitoring selected populations. Additional techniques should be employed for comprehensive monitoring; nest plot surveys or road transects are recommended.

Zone-tailed Hawk:
The BBS, CBC, and migration counts do not furnish usable monitoring information for this species. Development of a road-survey sampling program is recommended for this species.

Red-tailed Hawk:
The BBS, CBC, and migration counts probably provide reasonably good trend information. No additional monitoring efforts are needed.

Ferruginous Hawk:
The BBS is of limited monitoring value. CBC data probably provide limited trend information in some regions, but detections are infrequent. Detections on migration counts are low--trend value of data may be suspect. Additional monitoring method(s) should be developed. Nest-plot surveys or non-breeding season road surveys would probably be effective. Aerial surveys for nests may also be useful for monitoring populations but must

be conducted before tree leaf-out where Ferruginous Hawks nest in deciduous trees. Ground based survey is likely more cost effective.

Rough-legged Hawk:
BBS data are not adequate for monitoring. The CBC probably provides suitable data to track population changes in some regions, but other parts of the range are not adequately sampled. Selected migration count sites (sites in Great Lakes area) may provide trend information for some populations. Additional monitoring efforts are needed. Arctic nest surveys would be effective, but expensive. Further expansion of the CBC program would be useful. Winter road-count surveys would probably provide feasible data for continental and regional trend analysis.

Golden Eagle:
BBS data are limited for monitoring. The CBC possibly provides limited information, but detections are infrequent (analysis of raw counts may provide best trend information). Migration counts probably provide trend data on migratory populations, but are probably not effective in the Pacific region. Because Golden Eagles are a species of prominent interest, additional monitoring approaches should be developed. Aerial surveys in the breeding season and/or winter road counts would be effective monitoring approaches.

Crested Caracara:
BBS and CBC data have limited potential to monitor trends. An alternative monitoring technique needs to be developed. Nest plot surveys or breeding season road counts are recommended.

American Kestrel:
BBS, CBC, and migration counts cover this species well for monitoring populations. A program to coordinate and compile nest box monitoring data currently being collected could be developed. Otherwise, no additional monitoring effort is needed.

Merlin:
The BBS and CBC are of little value (detections are very infrequent) for tracking population changes. Migration counts provide trend information (however, subspecies cannot be distinguished). Winter monitoring surveys are probably not feasible in the U.S.A. Recommend development of nest plot survey monitoring program. On the prairies, this species is best detected in a brief, three-week period in late March and early April. It may be possible to survey riverine areas by river floats in the prairies (e.g., Green River, Wyoming).

Aplomado Falcon:
The BBS and CBC do not provide population trend information. An alternative monitoring program should be developed. Nest plot or road count surveys could be developed for monitoring.

Peregrine Falcon:
BBS and CBC programs are ineffective for tracking populations. Migration counts probably provide trend information for some regions (subspecies cannot be distinguished); resident populations are not sampled. Breeding/eyrie surveys probably represent the only suitable monitoring technique for some populations. Standardization and coordination of existing local nesting survey efforts may substantially enhance the potential to monitor selected populations.

Gyrfalcon:
A difficult species to monitor. Isolated nest monitoring programs are conducted in the Yukon, the Northwest Territories, and Alaska but these program needs to be expanded and improved in order to ensure that population trends are detected.

Prairie Falcon:
BBS data are not adequate for monitoring trends. The CBC probably yields limited trend information in some regions. Migration counts may provide information, but low numbers are detected at most sites, which may limit power to detect population trends. Perhaps the most effective monitoring technique is a nest-area survey, but this approach is expensive and time intensive. This species will be very difficult to monitor adequately; suitable funds may simply not be available.

Snowy Owl:
The CBC may provide some useful population data. This owl may be monitored through nesting surveys or possibly with winter road counts.

Northern Hawk Owl:
No existing monitoring program is suitable. Road counts during winter may be effective for monitoring.

Northern Pygmy-Owl:
The CBC may provide some effective trend data for some regions. Additional monitoring efforts need development. Winter road counts or broadcast surveys may provide usable data, and nest boxes have been used in Finland by pygmy-owls, providing the potential for using nest boxes as a population monitoring tool.

Ferruginous Pygmy-owl:
No existing monitoring program is suitable. Broadcast surveys may be effective for monitoring purposes.

Burrowing Owl:
The CBC may provide some data usable for monitoring, but needs evaluation. Nesting surveys (nest plots?) would probably be effective for monitoring populations. Road counts during winter should also be evaluated as a monitoring technique.

Short-eared Owl:
The BBS may provide some regional information on population trends. CBC data may provide limited trend information. Road surveys during winter or during the spring display period may have some promise for monitoring trends.

Appendix C. Outline of the North American Raptor Monitoring Strategy

INTRODUCTION

Why monitor raptors
- Preserve biodiversity
- Avoid "train wrecks"
- ESA considerations
- Bio-indicators
- Socio-economic considerations
- Raptors are a commodity, taken for falconry and shot in parts of their range

Justification
- Biodiversity Convention of 1992 (Rio de Janeiro)
- Migratory Bird Treaty Act
- Fish and Wildlife Conservation Act of 1980
- Comparison to North American Waterfowl Management Plan
- Decisions being made now on minimal data that may have long term implications

Scale
- Need data at continental, regional and local scales
- Increasing emphasis on data for finer scale analyses (e.g., trend data for species in a National Park rather than for the continent, annual trend data rather than for longer time periods, etc.)

GOALS AND OBJECTIVES

MONITORING METHODS (Discussion of strengths and weaknesses, needed improvements in techniques, analysis methods, distribution of effort):

Breeding Bird Survey (BBS)
Christmas Bird Count (CBC)
Raptor Migration Counts (RMC)
Other Studies
- Nest surveys
  - Finland plot model
  - Ground based
  - Nest boxes
  - Aerial
- Transects
  - Roadside
  - Other
- Roost counts
- Bait stations
- Other

SPECIES RECOMMENDATIONS (Specify data sources, evaluation of the adequacy of available data, most suitable monitoring methods, identification of needed specific "products" such as coordination of Northern Goshawk surveys, compilation of status information on Bald Eagles, Peregrine Falcons and other well known species, and identifying areas where additional coverage is necessary.)

Falconiformes

- Black Vulture (Coragyps atratus)
- Turkey Vulture (Cathartes aura)
- Osprey (Pandion haliaetus)
- Swallow-tailed Kite (Elanoides forficatus)
- White-tailed Kite (Elanus caeruleus)
- Snail Kite (Rostrhamus sociabilis)
- Mississippi Kite (Ictinia mississippiensis)
- Bald Eagle (Haliaeetus leucocephalus)
- Northern Harrier (Circus cyaneus)
- Sharp-shinned hawk (Accipiter striatus)
- Cooper's Hawk (Accipiter cooperi)
- Northern Goshawk (Accipiter gentilis)
- Harris' Hawk (Parabuteo unicinctus)
- Red-shouldered Hawk (Buteo lineatus)
- Broad-winged Hawk (Buteo platypterus)
- Swainson's Hawk (Buteo swainsoni)
- Red-tailed Hawk (Buteo jamaicensis)
- Ferruginous Hawk (Buteo regalis)
- Rough-legged Hawk (Buteo lagopus)
- Golden Eagle (Aquila chrysaetos)
- Crested Caracara (Polyborus plancus)
- American Kestrel (Falco sparverius)
- Merlin (Falco columbarius)
- Peregrine Falcon (Falco peregrinus)
- Gyrfalcon (Falco rusticolus)
- Prairie Falcon (Falco mexicanus)

Diurnal Strigiformes

- Snowy Owl (Nyctea scandiaca)
- Northern Hawk-owl (Surnia ulula)
- Northern Pygmy-owl (Glaucidium gnoma)
- Burrowing Owl (Athene cunicularia)
- Great Grey Owl (Strix nebulosa)
- Short-eared Owl (Asio flammeus)

GENERAL CONSIDERATIONS

- Monitoring populations or areas?
- All species need to be monitored at some level of intensity
- Meta analyses or "weight of evidence" approach
- Separating annual fluctuations from trends
- Improve and standardize statistical methods for population monitoring
- Expansion to remaining Nearctic raptors and Strigiformes
- Who has the responsibility?
- Relationship with Partners In Flight
- Establish monitoring working group?
- Role of NGO's
- Need for tripartite international agreement (similar to North American Waterfowl Management Plan)?
- What is the vehicle for the dissemination of information?

TIMETABLE

- Completion of strategy
- Status review of all species
- Frequency of status updates

STATUS OF RAPTOR MONITORING EFFORTS IN NORTH AMERICA

SPECIES'	BBS	CBC	MIGRATION	NEST GROUND	NEST AIR	TRANSECTS ROADSIDE	TRANSECTS OTHER	ROOST COUNTS	OTHER	NEED NEW TECHNIQUES'	COMMENTS
TURKEY VULTURE	YES	YES (LIMITED)	YES					P			
BLACK VULTURE	P	YES (LIMITED)	NO			P (WINTER)			BAIT STATIONS		
OSPREY	NO	NO	YES	P	P						
SWALLOW-TAILED KITE	NO	NO	NO	P		P			PRE-MIGRATION STAGING COUNTS	YES	
WHITE-TAILED KITE	NO	YES (LIMITED)	NO	P		P (BREEDING)				YES	
SNAIL KITE (MEXICO)	NO	NO	NO	P				P	BOAT	YES	
MISSISSIPPI KITE	P	NO	P			P			RIVER COUNTS	YES	
BALD EAGLE	NO	P	YES	P	P			P	MID-WINTER COUNTS		NEEDS BETTER COORDINATION
NORTHERN HARRIER	NO	YES	YES			P (WINTER)			ROOST		
SHARP-SHINNED HAWK	NO	NO	YES	P		P (WINTER)			RIVER COUNTS(?)		
COOPER'S HAWK	NO	NO	YES	P							
NORTHERN GOSHAWK	NO	NO	P	P		P			BROADCAST COUNTS	YES	
COMMON BLACK HAWK	NO	NO	NO						RIPARIAN/BOAT	YES	
HARRIS' HAWK	NO	YES(LIMITED)	NO	P						YES	
GRAY HAWK	NO	P	NO			P (BREEDING)	SPRING/FOOT		RIPARIAN	YES	EXPAND CBC COUNTS
RED-SHOULDERED HAWK	YES (LIMITED)	YES (LIMITED)	YES (REGIONAL)	P		P			BROADCAST COUNTS	YES	

SPECIES'	BBS	CBC	MIGRATION	NEST GROUND	NEST AIR	TRANSECTS ROADSIDE	TRANSECTS OTHER	ROOST COUNTS	OTHER	NEED NEW TECHNIQUES'	COMMENTS
BROAD-WINGED HAWK	NO	P	YES (BIASED?)			P (BREEDING)			BROADCAST COUNTS	YES	
SHORT-TAILED HAWK	NO	NO	NO	P			SPRING/FOOT		BREEDING DISPLAY	YES	
SWAINSON'S HAWK	YES	NO	P	P		P(WINTER)		YES			ROOST COUNTS IN SOUTH AMERICA
WHITE-TAILED HAWK	YES (REGIONAL)	YES (LIMITED)	NO	P		P				YES	
ZONE-TAILED HAWK	NO	NO	NO			P				YES	
RED-TAILED HAWK	YES	YES	YES								
FERRUGINOUS HAWK	NO	P (LIMITED)	NO	P	P	P(WINTER)				YES	
ROUGH-LEGGED HAWK	NO	YES (REGIONAL)	YES (REGIONAL)			P(WINTER)				YES	
GOLDEN EAGLE	NO	P	YES		P	YES (WINTER)					
CRESTED CARACARA	NO	NO	NO	P		P				YES	
AMERICAN KESTREL	YES	YES	YES						NEST BOX STUDIES		
MERLIN	NO	NO	YES	P					RIVER		
APLOMADO FALCON	NO	NO	NO	P		P				YES	
GYRFALCON	NO	NO	NO		P					YES	
PRAIRIE FALCON	NO	YES (LIMITED)	P	P						YES	
PEREGRINE FALCON	NO	NO	YES (REGIONAL)	P	P						NEEDS BETTER COORDINATION