

LARRY HALVERSON
BOX 252, VQA 1M0
RADIUM HOT SPRINGS, B.C.

EVALUATION OF AVIFAUNA AS INDICATOR SPECIES
AND
DISCUSSION ON THE FUTURE OF
AVIFAUNA MONITORING
IN KOOTENAY NATIONAL PARK

MARCH 1, 1993

Prepared by: John Dunlop
Heritage Resource Conservation
Kootenay National Park

1.0 INTRODUCTION

The Canadian Parks Service (CPS), as well as many other resource conservation agencies, have recently shifted their focus towards Ecosystem Management. As part of this process, new avenues are being explored in order to improve and update, as well as complement, environmental management techniques presently in place.

In this paper, I explore the feasibility of using avifauna as indicators of ecological change within Kootenay National Park (KNP) and surrounding area. Avian indicator species have been used extensively by various agencies over the past two decades. Both individual species and the guild concept are defined and evaluated.

The utility of an avifauna monitoring program is also discussed including the relative merits and limitations of Breeding Bird Surveys (BBS), Christmas Bird Counts (CBC), the Monitoring Avifauna Productivity (MAP) Project, and the Forest Bird Monitoring Program (FBMP). Avifauna monitoring programs presently in place in the park are examined and evaluated. Monitoring programs from other jurisdictions are also looked at in reference to their applicability to KNP. Recommendations are made as to how Heritage Resource Conservation (HRC) can implement a long term avifauna monitoring program and integrate results with other consistent data sources.

Conclusions are based upon library research and consultation with experts in the field of avian biology.

2.0 AVIAN INDICATOR SPECIES AND GUILD CONCEPTS

2.1 Avian Indicator Species: A Definition

Morrison (1986:430) defined a biological indicator as "... an organism or ecological community so strictly associated with particular environmental conditions that its presence is indicative of the existence of these conditions."

Zimmerman and Noss (N.D.:3) stated that "Indicator species are species that, if adequately protected in viable populations, would assure that many other species (and hence, whole communities) are maintained as well."

These are the two most common ideas behind the indicator species concept; that a species can be indicative of environmental conditions (i.e. environmental health), and, that a species can be used to determine the ongoing success (or lack thereof) of other species.

The following are characteristics used in selection of avian indicator species (Sidle and Suring 1986; Szaro and Russell 1982):

- 1) are sensitive to habitat-induced stress;
- 2) have limited adaptability to different environments;
- 3) have population parameters that correlate directly with local habitat conditions;
- 4) have population parameters that are readily quantified; and,
- 5) are conspicuous by sight and sound and can be recognized in the field without capture.

The assumption then is that by monitoring a limited number of species, a resource manager can accurately determine the general health of the environment and/or the well being of an assortment of other wildlife species. Though initially involving an in-depth study of species suitable as indicators, the premise is that it will yield the desired data while reducing overall monitoring costs.

2.2 The Guild Concept: A Definition

Root (1967:335) defined a guild as a "group of species that exploit the same class of environmental resources in a similar way." The idea then of guild management is to identify a group of species that utilize similar resources and are thus expected to respond in a similar manner to environmental changes.

Numerous methods have been used to delineate avian guilds (eg. Roberts 1987; Short and Burnham 1982; Verner 1984). The generally accepted practice is to develop a two-dimensional guild matrix with the axes identifying the primary feeding and breeding/nesting zones. These zones are identified by various levels from the soil layer and snags through to understory and overstory canopy (Roberts 1987). An example of this process would be to group into a guild foliage-gleaning insectivores that feed and nest in the shrub layer.

Severinghaus (1981) promoted the idea of using guild indicators. Once guilds have been delineated, the impact of an environmental change on an individual species would be representative of the impacts on other guild members. This was believed to improve on the perceived oversimplification of indicator species by using a more focused approach.

Verner (1984) rejected the use of indicator species (including guild indicators) but believed that whole guilds (guilds delineated and monitored in entirety rather than monitoring one guild member) could be used to indicate the capability of habitat to support populations of other wildlife species.

2.3 Limitations of Avian Indicator Species and Guilds

In recent years the use of avifauna as bio-indicators has been critically reviewed (Morrison 1986; Strong 1990; Temple and Wiens 1989; Verner 1984). Szaro (1986:681) said that "the extrapolation of impact from one species to another, and from one ecosystem to another, might yield erroneous conclusions." Some authorities still promote the use of birds as ecological indicators, though they do note their limitations (Koskimies 1989; Sidle and Suring 1986).

The same applies to the guild concept. Szaro (1986:681) stated that "The whole concept of guild management needs much more research and development before it can be recommended as a management tool." Even Verner (1984:1), who promotes the guild concept, concedes "... much testing must be done before it is widely applied."

Perhaps Szaro (1986:687) put it most aptly when he stated "No ecological situation is as simple as we wish to perceive it for management considerations."

Major problem areas associated with avian indicator species and the guild concept are broken down into the following categories:

A) Measurement of Gross Habitat Changes

If we are interested in monitoring trends in habitat capabilities, it would be more cost effective to measure the habitat. It seems quite apparent that gross changes are more readily quantified through direct measurement of those changes (eg. quantity of habitat, succession), rather than measuring the reactions of the fauna to the perturbations (Morrison 1986; Szaro 1986).

B) Selection of Indicator Species and Guilds

All results and conclusions from the use of these tools are dependent on this level of the process. As van Horne (1983:893) stated "Accuracy at this level is dependent upon an intimate understanding of the demography of the species and of the factors influencing population levels through their influences on survival and production...".

A problem common to both indicator species and guilds is the a priori approach to selection (Morrison 1986; Szaro 1986). Most resource management agencies rely on extensive literature searches and local biological expertise for their selection of indicator species (Sidle and Suring 1986; Szaro and Balda 1982). Though avifauna are well studied in general, our knowledge of specific species requirements is often poor (van Horne 1983). Quinlan et al. (1990) recognized the need for additional basic research into many species before selections were made. In addition, information derived from the literature may not be

pertinent to local conditions. A lack of empirical data on the response of individual species to environmental perturbations makes this approach suspect (Morrison 1986; Szaro 1986).

As stated previously, most guilds are selected by using a two-dimensional matrix with the axes identifying the primary feeding zones and the breeding/nesting zones (Roberts 1987). As only two niche dimensions are being looked at, it is highly likely that this is an oversimplification.

Guilds are often constructed by using closely related species which utilize the same general resources. Specialization tends to occur among closely related species resulting in them utilizing different segments of the same habitat and resources. Therefore it is not surprising that one species will not be a good indicator of other members of its group (Verner 1984).

Szaro's (1986) evaluation of functional (emphasizing the functional relationships of species in a guild - i.e. aerial forager, picker and gleaner) and structural (utilizing primary feeding and nesting zones) guilds as a predictive tool did not yield promising results. His study (1986:683) concluded that there were "... no consistent patterns between individual species' densities in their respective guilds and either structural or functional guild densities." Szaro (1986:685) went on to note that the whole guild-indicator concept is "... seriously flawed by the fact that members of the same guild can be differentially affected by the same habitat modification." This eliminates any possibility of predicting the response of guild members as a whole by monitoring the abundance of a single guild indicator species (Szaro 1986; Verner 1984).

C) Interpretation of Results (Cause and Effect)

The greatest problem with both indicator species and guilds is interpretation of the results. Once the species and/or guilds have been selected and monitored, and population fluctuations have occurred, can we link these changes to the causal factor(s) (Morrison 1986; Temple and Wiens 1989)? Even assuming that species and guilds had been selected through the most thorough process possible, this is difficult. As Temple and Wiens (1989) noted "Unless one can establish an unambiguous statistical connection between an environmental change and an observed change in a bird population, little more than speculation is possible." Even if a statistical correlation is shown it does not necessarily prove a cause and effect relationship.

The majority of avian studies yield an estimate of density due to the relative ease and minimal expense of data collection. Biologists often assume that the density of a species is a direct measurement of habitat quality (van Horne 1983). This appears to be a gross oversimplification. As birds respond to many influences from within their environment, changes in their populations can result from any one of a number (or combination)

of factors. Among the factors commonly overlooked in data analysis are the influence of competition and predation (van Horne 1983) as well as climatic conditions (Temple and Wiens 1989) on species density. Additionally, density may temporarily increase in one area due to a loss of habitat in adjacent areas (Alan Dibb pers. comm.).

A change in density could be the expression of a primary or secondary causal agent or the synergistic effect (van Horne 1983) of two or more factors. If we determine that a particular species is experiencing a downward population trend, is it the direct result of environmental contamination (primary) or did that contamination affect the species' food source (secondary)? Or did the decrease in population occur from a combination of the environmental contamination of the food source and a loss of habitat (synergistic)?

In addition, time lags between the causal factor and its manifestation in the population can separate the cause from the effect in a temporal manner, making the process of drawing a conclusion difficult (Morrison 1986; Temple and Wiens 1989).

Most environmental changes initially have an effect on primary population parameters (fecundity, death rate, dispersal) before changes in secondary population parameters (density, population size, range, habitat occupancy) become apparent (Temple and Wiens 1989). The Peregrine Falcon (*Falco peregrinus anatum*) is a prime example of this. A number of years of almost zero recruitment went virtually undetected. The adult population seemed stable until it aged and rapidly declined to almost nil over a few years (Cade et al. 1988).

Local population size and density may be buffered by the effect of density-dependent processes on basic population rates. This may result in significant changes in primary population parameters occurring without an immediate and obvious change in secondary parameters (those that are likely to be quantified). An example of this is the potential for increased survival and immigration to mask the impact of a local decrease in fecundity on population density (Temple and Wiens 1989).

2.4 Utility of Avian Indicator Species and Guilds

In spite of all the negative aspects associated with the indicator species and guild concepts, they may be of some value. However, the usefulness of these tools does not necessarily lie in the immediate future. It will require an a posteriori approach whereby through intensive study of avian species, we can determine how they react to a perturbation and then monitor for that reaction. The pre-technological people of Western Africa came to realize that the Gau-tree (*Acacia albida*) was an indication of good soil (Zonneveld 1982) and present day agrologists recognize foxtail barley (*Hordeum jubatum*) as a sign of over-grazing. These conclusions were drawn after-the-fact

from careful observation and not through prediction or conjecture. Any use of avian indicator species and guilds must be based on solid facts or conclusions based on their use will be highly suspect.

Certain avian species may have some potential for use as indicator species and this will be due in part to the extent to which they have been studied. If we have an intimate understanding of a species' biotic and abiotic requirements it will hold greater potential. However, it is cautioned that there must be some form of assessment of their ability to perform as indicator species before conclusions are drawn from any monitoring of their population parameters. Additionally, the scope of their use should be narrowed to specific areas rather than to use them as overall environmental indicators. An example of this is the work taking place in Jasper. It has been hypothesized that rafting activity has adversely affected local Harlequin duck (*Histrionicus histrionicus*) populations. The American Dipper (*Cinclus mexicanus*) utilizes aquatic food and the same stream habitat as the Harlequin but appears to be unaffected by rafting activity. If Harlequins are absent in their traditional nesting and breeding areas, but Dippers are present, it can at least be assumed that the habitat is adequate and that there is some other cause for the absence of Harlequins (i.e. rafting) (Geoff Holroyd pers. comm.).

Szaro (1986), in his evaluation of avian guilds as a predictive tool, felt that response guilds had potential, though he cautioned that guild management needs more research before it can be recommended as a management tool. He did find patterns between individual species' densities when guild selection was based on species response to environmental perturbations.

3.0 CURRENT LARGE SCALE MONITORING METHODOLOGY

3.1 Breeding Bird Surveys (BBS)

The BBS is a cooperative program jointly sponsored by the Canadian Wildlife Service and the United States Fish and Wildlife Service (Robbins et al. 1986). The program has been active in Canada since 1966 (Erskine 1978). It provides information, both locally and on a continental scale, on: short-term population changes (correlated with specific weather incidents); recovery periods following catastrophic declines; normal year-to-year variations; long-term population trends; and, invasion of exotics (Robbins et al. 1986). For most land birds it is the only continent-wide survey for which over 20 years of comparable data exist (Erskine et al. 1992).

BBS data are used to produce detailed computer maps of the relative abundance of individual species. This can be used to demonstrate year to year changes in distribution and relative abundance, or the average over a period of years. This

information can be utilized as base-line data that can be compared to more intensive local studies (Robbins et al. 1986).

The BBS can also be used to reveal whether major population changes of a given species are representative of a continental decline or are merely a result of population shifts within the breeding range (Robbins et al. 1986).

The data are primarily collected by volunteers, though there is some professional involvement (Erskine et al. 1992). BBS routes are conducted on existing roadways and consist of 50 3 minute counting locations, 0.8 km (0.5 mile) apart (Bystrak 1981). These counts are run one morning each year at the height of the breeding season, starting 0.5 hour before sunrise. The observer stands near their vehicle and records the total number of each species heard, or seen (within 400 m) on prepared forms. Various weather conditions are also recorded at the beginning and end of each route. These forms are submitted and input into a central database for statistical analysis. Further information on the BBS can be found in articles by: Bystrak (1981); Erskine (1978); Geissler and Noon (1981); and Robbins, Bystrak and Geissler (1986).

3.2 Christmas Bird Counts

Christmas Bird Counts (CBC) have been conducted since 1900 and results have been published since 1901. This is an annual project and involves a one day count of the number of individuals of all observed species within a CBC circle. Count circles are discrete and are defined as the area contained within a circle of 24.1 km (15 mile) diameter. Counts are conducted on a single calendar day within a two week period centered around Christmas Day by volunteers. Results are submitted on standardized forms which include details on weather, number of participants, hours afield and at feeding stations, and miles covered (Drennan in: Temple and Wiens 1989).

The main strength of the CBC lies in its quantity. Avian population trends cannot be determined from isolated counts, even with utilization of the most rigorous statistical methods. However, in combination with other avifauna monitoring programs they can be used to determine spatial and temporal patterns in avian geographical ecology (Drennan in: Temple and Wiens 1989).

It must be emphasized that CBC data should be used with caution due to the lack of standardization of its application. The data are better indicators of patterns among common and well dispersed species than for rare and/or highly social species (Bock and Root 1981). See articles by: Arbib (1981); Bock and Root (1981); and Drennan (1981), for a more complete treatment of the CBC.

3.3 Monitoring Avian Productivity (MAP) Project

This program was initiated by The Institute for Bird Populations

in California in 1989. The intent of this cooperative effort among bird-banders is to establish a continent-wide network of constant effort mist-netting stations. These will be conducted during the breeding season and will provide estimates of annual post-fledging productivity, estimates of annual adult survivorship, and estimates of annual adult population levels (DeSante n.d.).

This program is intended to fill gaps left in the BBS and CBC by separating the effects of productivity (birth rate) from the effects of survivorship (death rate). In other words, it will provide specific information on primary population parameters that will allow the testing of hypotheses to account for observed population changes (secondary population parameters) (DeSante n.d.).

Prerequisites for participation in the program include the use of at least six permanent net-sites at a station. These are to be operated in a standardized manner on at least one day during each of ten consecutive 10 day periods from May until August. Continuation of the study for a minimum of five years at each station is strongly urged (DeSante n.d.). For further information on methodology and participation see the article by DeSante (n.d.).

3.4 Forest Bird Monitoring Program (FBMP)

The program was initiated in 1987 by the Canadian Wildlife Service (CWS) in Ontario. The pilot project, conducted in the same year examined the feasibility of a volunteer based forest bird trend monitoring program. Welsh (n.d.:1) stated that the FBMP "... was designed to describe changes in numbers over time for all forest songbirds, to develop a forest habitat specific inventory of forest birds (species composition and relative abundance), and to develop regionally accurate habitat association profiles for all common forest birds." Additionally, it was intended to augment the broad regional base of the BBS (Welsh n.d.).

All data collected will be habitat specific. This approach is most valuable at local and regional levels and can provide habitat association and monitoring information (Welsh n.d.).

Sites are selected to be representative of major forest habitats and each site contains five sampling stations. These stations are to be located at least 100 m from the forest edge and at least 250 m apart. A minimum area of 25 ha is required to meet these guidelines. Stations are clearly marked to facilitate re-location in subsequent years (Welsh n.d.).

Observers record all birds seen and heard during a 10 minute sample period at each station. Care is taken to ensure each individual is only counted once and all observations are recorded on map sheets which also minimizes duplicate records (Welsh n.d.).

The program was initially designed specifically for Ontario, though the FBMP has potential to expand nation-wide in time. Analysis is presently underway to determine if there is a need for FBMP outside of Ontario. Initial comparisons to BBS data from similar habitats show significant correlation between the two programs (Loney Dickson pers. comm.). This is important in that it lends credibility to both monitoring methodologies. For a more detailed account on the entire program consult the paper by Welsh (n.d.).

4.0 CURRENT AVIFAUNA MONITORING IN KNP AND OTHER JURISDICTIONS

4.1 Avifauna Monitoring in KNP

The extent of avifauna monitoring in KNP at present is very limited. One BBS route has been conducted annually by Larry Halverson (Heritage Communications) since 1981 with the exception of two years, 1991 and 1992. This route extends 50 miles into the park and starts at the West Gate (L. Halverson pers. comm.). Christmas Bird Counts have been conducted annually from 1978 to the present. The count circle, 24.1 km in diameter, is centered in the town of Wilmer and extends into the Redstreak and Dry Gulch areas of KNP (L. Halverson pers. comm.). This provides a good data source for this unique area though it is not representative of the park as a whole.

The Ecological Land Classification (ELC) Volume II: Wildlife Resource, (Poll et al. 1984) provides a thorough inventory of avian species within KNP. Notes on status and distribution as well as habitat are given on each species encountered.

4.2 Avifauna Monitoring in Other National Parks

The mountain parks in general, lack organized, up-to-date avifauna monitoring programs. The extent of monitoring in place in Revelstoke/Glacier, Yoho, Jasper, and Banff National parks is summarized below. Elk Island National Park is in the process of implementing a comprehensive monitoring program and is also presented below.

Jasper National Park

- No comprehensive, formal monitoring program in place.
- Monitoring of Harlequin ducks is being done to ascertain the effect of rafting on their productivity.
- Informal inventory of new and traditional osprey nesting locations. In addition, as part of the Northern Rivers Study, blood samples are being collected from osprey chicks within the park to be analyzed for pollutant content.
- Source: Wes Bradford (pers. comm).

Banff National Park

- Diurnal raptor and waterfowl surveys are conducted every five years. The programs were initiated in 1984 and involve roadside surveys during the spring and fall migration period (Ledwidge 1984).

Yoho National Park

- 3-4 years of Christmas Bird Counts conducted by Kevin Van Tighem but no formal monitoring plan in place or anticipated.
- Source: Harry Abbott (pers. comm).

Revelstoke/Glacier National Park

- anticipated involvement in MAP program.
- use of faunal guilds (including avian species) as part of Ecosystem Management.
- Source: John Woods (pers. comm).

Elk Island National Park

- Owl monitoring conducted annually since 1987. Surveys conducted between February and April using recorded owl calls to elicit responses which are then documented. May not be implemented in 1993 due to a shortage of funding.
- Red-necked Grebe survey conducted every second year.
- Colonial bird (cormorants, herons) conducted annually.
- Roadside survey for spring arrivals conducted annually. Includes all observations of songbirds, waterfowl, raptors, waders, etc..
- Roadside survey for fall departures may be implemented in the near future by CWS.
- Breeding bird transects are expected to be put in place in the near future, pending approval of funding.
- Source: Norm Cool (pers. comm).

4.3 Use of Indicator Species and Guilds

The USDA Forest Service is required by law to use Management Indicator Species or MIS. The MIS concept was developed in response to requirements of the Forest Management Act of 1976 (Sidle and Suring 1986).

This practice is also common in the Canadian forestry industry. Weldwood (Hinton, Alberta) utilizes indicator species as part of its Integrated Management of Timber and Wildlife Resources on the Weldwood Hinton Forest Management Agreement Area (Bonar et al. 1990). Their plan typifies that of other forestry companies in that the use of indicator species is prescribed as a method of determining whether predefined wildlife and habitat goals are being met.

Until recently, even Weldwood (perhaps one of the most progressive forest resource extraction companies in the business) has ignored the current scientific literature which casts doubt on the use of avian indicator species and guilds. Bonar (1990)

cited Temple and Wiens (1989) (among others) for a review of available approaches (i.e. indicator species and guilds) even though their review of the use of these tools was a negative one. However, even in the forestry industry this simplistic management scheme may be coming to an end. A new report is presently being produced by Bonar for Weldwood. It will set forth a more holistic approach to resource and wildlife management and will work from more of an ecosystem perspective (Rick Bonar pers. comm.).

5.0 RECOMMENDATIONS FOR IMPROVED AVIFAUNA MONITORING IN KNP

5.1 General Recommendations

The first step in the development of an avifauna monitoring program is to determine the information needs it is intended to address. As part of the overall Ecosystem Management (EM) program, it would be useful to have EM specialists from the mountain parks come together to identify these information gaps and to develop a coordinated approach.

We should work towards an improved scheme of interagency cooperation including federal and provincial as well as private sector agencies. Most organizations are in a period of economic restraint and the use of available funding must be optimized. By working together effectively we may be able to reduce each others overall costs. Certain agencies have a greater expertise in the field of avian ecology, specifically CWS. CPS could participate in monitoring to meet CWS needs and in turn receive valuable advice on developing an effective monitoring program once our information needs are identified. At present there is a great deal of cooperation between the two branches (CWS, CPS) at Elk Island National Park (EINP) and this is reflected in the thoroughness of EINP's avifauna monitoring program.

Perhaps the most important recommendation I can make is that a cooperative effort among the four contiguous mountain parks and Mount Revelstoke/Glacier and Waterton Lakes national parks should be implemented. At present there is no coordinated effort and additionally, none of these parks have comprehensive avifauna monitoring programs. Coordination would eliminate unnecessary duplication of certain studies, provide standardization of techniques to improve comparabilty of data, increase overall sampling effort, and save the time wasted "re-inventing the wheel" that would occur if each park were to formulate its own monitoring program. Input from other parks should also be obtained; especially those with progressive monitoring programs presently in place, eg. EINP.

Intensive local studies of bird populations are required to increase our knowledge base on the biotic and abiotic conditions that they require and respond to. A better understanding of the effects of intra and interspecific competition, predation, and

legitimate tool and, if so, to study the response of avifauna to various management practices to facilitate guild selection. This may hold particular promise in analyzing the effects of management practices on those lands surrounding KNP.

In many parks the gathering of avifauna data has been conducted by Heritage Communications (HC). If this is to continue, there should at least be a consensus between HRC and HC as to who will be gathering the information, what information is required, and how it can be coordinated with the other mountain parks.

At present, there appears to be a general lack of birding skills amongst HRC staff which is a limiting factor to the implementation of many simple monitoring programs. Though it is beneficial to utilize volunteers and outside agencies to conduct some aspects of the monitoring, improvement of the birding skills of full-time or seasonal wardens in the Wildlife shop would allow us to carry out certain tasks ourselves. Birding skills could be improved by participating in various ornithological training sessions or by inviting HRC staff that are knowledgeable in bird identification to conduct workshops.

5.2 Possible Categories of Avifauna to be Monitored

- A) **Neotropical Migrants:** There is an increased awareness of recent downward trends in populations of neotropical migrants. Though the causes of these trends may not necessarily lie within our parks, it is important to contribute to the global monitoring of these species from an Ecosystem Management perspective. Suggested monitoring includes BBS, participation in MAP program, and breeding bird transects.
- B) **Diurnal Raptors:** This avian group is at the top of the food web and is thus likely to be first to exhibit symptoms of environmental contamination. Suggestions for monitoring include spring/fall migration roadside surveys and monitoring of traditional nesting areas.
- C) **Nocturnal Raptors:** Many species of this category are non-migratory and are thus indicative of local conditions. Monitoring can be conducted through late winter night surveys using recorded calls.
- D) **Waterfowl:** Limited habitat in the park that is suitable to waterfowl. These areas are difficult to survey on a regular basis but could be made part of backcountry patrols. Roadside surveys could be conducted on the Columbia River Valley that would augment CWS data and enhance cooperation between CPS and CWS.
- E) **Non-migratory and Wintering species:** These species are indicative of local conditions. Monitoring techniques could include CBC and winter bird transects.

F) Forest Interior and Old Growth Dependent species: There is potential for numbers of birds in this category to increase in the park as external habitat quality diminishes. Suggested monitoring includes BBS, breeding bird transects, and perhaps response guild analysis.

6.0 SUMMARY

Ecosystem management is an integral component of the overall CPS objective of Ecological Integrity. Though promotion of environmental citizenship will play an important role in our future, our own abilities in effective environmental stewardship will be the cornerstone of maintaining the integrity of this and other parks.

The integrity of KNP, as well as many other national parks, is increasingly subjected to the effects of management practices on the land surrounding the park. It is likely that the avifauna community as a whole, and certain forest interior species in particular, will be adversely affected by logging and other land management activities around KNP. Without a monitoring plan in place as these activities expand, it will be difficult, if not impossible, to determine their effect on avifauna and the ecosystem as a whole.

In order to be effective environmental stewards, we must gain a better understanding of the workings of each and every ecosystem for which we are responsible. Though it is desirable to do this in a cost efficient manner, this goal may initially require a large expenditure of time and funds in order to gather data required to make informed decisions. Herein lies one of the most important reasons for monitoring avifauna in conjunction with habitat, climatic, and other environmental monitoring. Through a thorough knowledge of all aspects of the environment we may one day be able to utilize forms of monitoring that are indeed cost saving measures.

7.0 REFERENCES

- Arbib, R.S. 1981. The Christmas bird count: constructing an "ideal model". Stud. Avian Biol. No. 6:30-33.
- Bock C.E., and T.L. Root. The Christmas bird count and avian ecology. Stud. Avian Biol. No. 6:17-23.
- Bonar, R., R. Quinlan, T. Sikora, D. Walker, and J. Beck. 1990. Integrated management of timber and wildlife resources on the Weldwood Hinton forest management agreement area. Weldwood and Alberta Forestry, Lands and Wildlife. 44 pp.
- Bystrak, D. 1981. The North American breeding bird survey. Stud. Avian Biol. No. 6:34-41
- Cade, T.J., J.H. Enderson, C.G. Thelander, and C.M. White. 1988. Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Inc.. Boise, Idaho. 949 pp.
- DeSante, D.F. n.d. Monitoring avian productivity (MAP) project. The Institute for Bird Populations, Inverness California. 8 pp.
- Drennan, S.R. 1981. The Christmas bird count: an overlooked and underused sample. Stud. Avian Biol. No. 6:24-29.
- Erskine, A.J. 1978. The first ten years of the co-operative breeding bird survey in Canada. Canadian Wildlife Service. Report No. 42. 59 pp.
- Erskine, A.J., B.T. Collins, E. Hayakawa, and C. Downes. 1992. The cooperative breeding bird survey in Canada, 1989-91. Canadian Wildlife Service. Progress Note No. 199. 14 pp.
- Geissler, P.H., and B.R. Noon. 1981. Estimates of avian population trends from the North American breeding bird survey. Stud. Avian Biol. No. 6:42-51.
- Koskimies, P. 1989. Birds as a tool in environmental monitoring. Ann. Zool. Fennici 26:153-166.
- Ledwidge, M. 1984. Methodology, monitoring birds of prey, Banff National Park. Warden Service. 11 pp.
- Ledwidge, M. 1984. Methodology for the monitoring of waterfowl, Banff National Park. Warden Service. 11 pp.

- Morrison, M. 1986. Bird populations as indicators of environmental change. *Current Ornithology* 3:429-451.
- Poll, D.M., M.M. Porter, R.M. Wershler, and L.W. Gyug. 1984. Ecological land classification of Kootenay National Park, British Columbia. Vol. II: Wildlife Resource. Canadian Wildlife Service report to Parks Canada, Calgary.
- Quinlan, R.W., W.A. Hunt, K. Wilson, and J. Kerr. 1990. Habitat requirements of selected wildlife species in the Weldwood forest management agreement area. Final Report submitted to Weldwood Forest Management Agreement Area Integrated Resource Management Steering Committee. 189 pp.
- Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The breeding bird survey: its first fifteen years, 1965-1979. U.S. Dept. of the Interior, Fish and Wildlife Service. Resource Publication 157. 196 pp.
- Roberts, T.H. 1987. Construction of guilds for habitat assessment. *Environmental Management* 11(4):473-477.
- Sidle, W.B., and L.H. Suring. 1986. Management indicator species for the national forest lands in Alaska. USDA Forest Service, Technical Publication R10-TP-2. 62 pp.
- Strong, P.I.V. 1990. The suitability of the common loon as an indicator species. *Wildl. Soc. Bulletin* 18:257-261.
- Szaro, R.C. 1986. Guild management: an evaluation of avian guilds as a predictive tool. *Environmental Management* 10(5):681-688.
- Szaro, R.C., and R.P. Balda. 1982. Selection and monitoring of avian indicator species: an example from a ponderosa pine forest in the southwest. USDA Forest Service, General Technical Report, RM-89. 7 pp.
- Temple, S.A., and J.A. Wiens. 1989. Bird populations and environmental changes: can birds be bio-indicators? *American Birds* 43:260-270.
- van Horne, B. 1983. Density as a misleading indicator of habitat quality. *Journ. Wildl. Manage.* 47:893-901
- Verner, J. 1984. The guild concept applied to management of bird populations. *Environ. Manag.* 8(1):1-14.
- Welsh, D.A. n.d. An overview of the Ontario forest bird monitoring program. Canadian Wildlife Service, Ontario. 13 pp.

Zimmerman, N. and R. Noss. N.D. Biodiversity conservation strategies: selection and design criteria for British Columbia. Northlands Group, Bowen Island, B.C. 20 pp.

Zonneveld, I.S. 1983. Principles of bio-indication. Environmental Monitoring and Assessment 3:207-217.

Consultation List

Harold Abott, Yoho National Park, British Columbia

Rick Bonar, Weldwood Canada, Hinton, Alberta

Wes Bradford, Jasper National Park, Alberta

Norm Cool, Elk Island National Park, Alberta

Alan Dibb, Kootenay National Park, British Columbia

Loney Dickson, Canadian Wildlife Service, Edmonton, Alberta

Susan Hall, Mount Revelstoke/Glacier National Park, British Columbia (not mentioned in text)

Larry Halverson, Kootenay National Park, British Columbia

Geoff Holroyd, Canadian Wildlife Service, Edmonton, Alberta

Ed Telfer, Canadian Wildlife Service, Edmonton, Alberta (not mentioned in text)

John Woods, Mount Revelstoke/Glacier National Park, British Columbia