Record of the Snowmobile Effects on Wildlife: Monitoring Protocols Workshop

April 10-12, 2001
Denver, Colorado

Volume One

Edited by Tabitha Graves and Virginia Reams
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Foreword

In fall 2000 the science and resource management staff of the Biological Resources Management Division (BRMD) of the National Park Service contacted the Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU) at the University of Montana about conducting an expert workshop to summarize the state-of-science on monitoring the effects of snowmobiles on wildlife in national parks and surrounding lands. National issues have demonstrated the need for knowing how to quantify the effects of snowmobile use on wildlife behavior, survival, population dynamics, reproduction, and physiology.

We formed a Steering Committee of NPS managers, representatives from the BRMD, RM-CESU, US Geological Survey, University of Montana, and the Fish and Wildlife Service to design the workshop and select participants. In advance of the workshop we worked with researchers at University of Idaho to design a Web-based survey to query scientists and managers about the issues that needed to be addressed. The workshop was held in Lakewood, Colorado in April 2001 and included experts from federal agencies, state agencies, and universities.

Volume One of the proceedings of the workshop summarizes 1) the presentations made during the plenary session of the workshop, 2) results of the electronic survey, 3) discussions and conclusions of the work groups, and 4) research recommendations. Volume Two will include the monitoring protocols recommended by the work groups. These documents form the basis for a research and monitoring plan that can be implemented by agencies interested in documenting wildlife effects of snowmobiles.

– Kathy Tonnessen, RM-CESU

Acknowledgements

The Snowmobile Effects on Wildlife Workshop was made possible by funds from the Biological Resource Management Division (BRMD) of the National Park Service (NPS). Many people helped to make this workshop a success. Craig Axtell, BRMD Director, provided the impetus for the workshop. Mike Coffey, technical contact with BRMD, reviewed documents and provided focus.

Kathy Tonnessen, Research Coordinator for the Rocky Mountains-Cooperative Ecosystem Studies Unit housed at the University of Montana, guided survey and workshop coordination, incorporating knowledge of successful workshop organization through years of planning and attending meetings. She provided office space, moral support, participant suggestions, facilitation skills, and presentation of the workgroup charge at the workshop.

The steering committee included representatives from the Intermountain, Alaska, Pacific West, and Midwest regions of the National Park Service, and a representative from the U.S. Geological Service Biological Resources Division. John Sacklin, Mary Rasmussen, Shannon Podruzny, Margaret Wild, and Dan Licht astutely advised on objective development, survey questions, agenda organization, workgroup charge elucidation, and a myriad of other details. Gordon Olsen and Dave Reynolds assisted in survey question and document reviews.

Perry Brown, Dean of Forestry at the University of Montana, supported the workshop and advised inclusion of representatives from the University of Idaho to conduct the pre-workshop survey. Troy Hall, Ed Krumpe, and Nick Sanyal worked hard to develop, distribute, and analyze the survey in a short time period. Their professional techniques greatly informed the workshop. Their efforts are much appreciated.

Chris Servheen, Grizzly Bear Recovery Coordinator for the U.S. Fish and Wildlife Service, and also advisor for my M.S. candidacy in Wildlife Biology, provided substantial assistance with suggestions for workgroup leaders and participants, document review, and participation in the bear workgroup.

The workgroup leaders and facilitators, listed under each section, kept the discussions moving ahead, accomplishing much in a short time period. The recorders noted important details on a computer file, permitting the quick publication of this document. The participants contributed knowledge of species, techniques for monitoring potential recreation impacts, and/or managerial experience to create this compilation of available and potential techniques for addressing these issues.

Virginia Reams contributed many hours of review and editing and kept a pleasant attitude throughout. Her efforts permitted the release of this work in a timely manner. Thanks to all who contributed.

– Tabitha Graves, Event Coordinator

Contents

Expert Views on Monitoring Snowmobiles and Wildlife: Results of a Delphi Process

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Introduction

Concern about the potential effects of recreation on wildlife has grown over recent years. Although the effects are diverse, depending on both the type of recreation and species of interest, executive direction has prompted NPS researchers to examine the specific effects of snowmobiles. Although overall in the United States, snowmobiling participation has remained constant at about 2-3% over the past 20 years (Kelly and Warnick, 1999), snowmobiling is "the second most popular major winter sport" (Bowker, English and Cordell, 1999, p. 328), occurs in national parks and other public lands from Alaska to California to New England, and appears to be on the rise in certain areas. Given this wide territory and the different purposes (e.g., recreational or hunting) and styles (e.g., road riding or high-marking) of snowmobiling, the potential for interactions with and impacts to wildlife are myriad.

Existing studies of recreational impacts on wildlife are limited, and studies of snowmobile effects are especially rare. Nevertheless, managers routinely make decisions that affect public access to public lands, in the name of resource protection. Such decisions should not be taken lightly, and must be based on the best available knowledge. Monitoring of wildlife responses to snowmobiles is therefore critical, and the development of efficient, reliable, meaningful protocols for that monitoring is essential.

Many scientists working for federal or state agencies, universities, or private organizations have considerable knowledge about the species that inhabit areas where snowmobiling occurs. Although few have studied snowmobiles directly, their combined expertise about these animals' traits and responses to disturbance are relevant to the issue. Thus, an important first step in developing monitoring protocols is to poll wildlife biologists and managers about the state of knowledge. This report presents the findings of such an effort. The following section presents the methods used in some detail, because they may not be familiar to many readers. That is followed by a presentation of the results obtained and a general discussion of conclusions and implications.

Objectives

In anticipation of a need to promulgate recommendations for monitoring snowmobile impacts on wildlife, the BRMD of the NPS requested a study that would poll all interested and knowledgeable scientists about the state of knowledge pertaining to monitoring. This information was intended to inform a workshop convened April 10, 2001, to develop monitoring protocols. Through a series of deliberations, several research questions emerged:

1. What do interested parties see as the most important issues related to snowmobiling and wildlife?

Although the focus of the overall project, including the April workshop, was narrowly confined to monitoring snowmobile effects on wildlife, all participants recognized that that was only one of many important issues. Stakeholders have wider concerns, for example, about air quality, possible conflicts between snowmobile users and other recreationists, and the social and economic repercussions of regulating or not regulating snowmobiles, to name a few. We felt it was useful to identify the range of concerns, in order to understand the specific issue (snowmobile effects on wildlife) within a larger context.

2. What species are affected by snowmobiles, which species should be monitored, and why?

Many species utilize habitat that overlaps with snowmobile use. These species are known to exhibit different responses to disturbance and utilize habitat for different functions and behaviors. Managers cannot monitor all wildlife species; they must therefore select those deemed most important or that best indicate overall ecosystem health. The rationale for selecting species can have many bases; we wished to know the criteria that biologists and managers consider to be most relevant.

3. Do experts believe that adequate scientific data exist currently to determine whether or not an impact (be it positive or negative) occurs to wildlife?

Although managers have proceeded with recommendations about snowmobile management in some parks and public lands, there is considerable debate about whether scientific data are adequate to make a confident determination about the nature of snowmobile impacts to wildlife. We wished to know whether those with the greatest expertise about the species occurring in these areas believe that adequate scientific data exist.

4. What protocols exist that could be used or adapted to monitor snowmobile effects?

The overall goal of this project was to develop protocols that could be used to monitor snowmobile effects on wildlife. The April workshop was intended to bring experts together to describe and recommend specific protocols. Therefore, it was important to review the types of protocols that researchers and managers currently use to monitor such effects.

5. What biological scale of information is most useful or needed?

Disturbance can affect wildlife at various scales. Individual animals may exhibit behavioral or physiological responses, such as moving out of an area or increased heart rate. Whether these changes are detrimental in their own right, or whether they only warrant concern if they lead to cumulative population-level impacts, is a much needed and in some cases hotly debated preliminary discussion. Whether one wishes to monitor for micro versus macro level impacts will have considerable implications for the type and extent of monitoring required.

6. Do biologists and managers differ in their responses to the above questions?

Biologists and resource managers/administrators may differ in their views about the seriousness of problems and informational requirements for decision-making. Managers are charged with making decisions in the face of whatever information is available, however limited it may be, and with balancing competing goals and values while upholding their agencies' missions. Biologists, on the other hand, are judged on the scientific merit of their work, and strive to minimize the influence of extraneous factors on research design and conduct. Thus, those occupying different roles may have different views on the adequacy of knowledge and different recommendations for monitoring.

Methods

Overview of the Delphi Approach

Obtaining considered responses to the above questions requires techniques that allow opportunities for respondents to reflect and deliberate. Standard mail surveys were deemed inappropriate for this project, as they presume that the categories of responses are already known and easily defined in brief written text. Such conditions did not hold in the present case. Standard mail surveys would also have taken far more time than was available (three months from inception of research to presentation of results).

The decision was made to adapt a Delphi approach to collect responses, using an electronic (web-based) format. Delphi studies are commonly used to poll experts about complex topics (Schuster, Frissell, Baker and Loveless, 1985; Kaynak, Bloom and Leibold, 1994; Egan, Jones, Luloff and Finley, 1995). The electronic format allowed rapid turnaround and provided all the space needed for extended responses (Young and Jamieson, 2001). A Delphi study typically begins with an open, exploratory round that elicits a full range of responses on a topic. The research team categorizes these responses and then circulates them back to the same participants for ranking. Often a subsequent round returns the consolidated data to the group for a final round that seeks to verify or further explain results. This type of approach allows experts to consider others' perspectives and use this knowledge to refine their own views and recommendations. The electronic format permits sharing among geographically distant individuals at a very low cost.

Questionnaire Development and Presentation Format

Specific question wording, format, and order were discussed and refined by the University of Idaho research team as well as the NPS steering committee. It was agreed that there would be two rounds of questions, with the first round including the more general, open-ended questions and the second round eliciting rankings and ratings of issues derived from the first round.

The first round included questions about the following:

1. Respondents' position and place of employment
2. The issues considered important in relation to snowmobiles, in the broadest sense
3. Species of concern and reasons for nominating each species. Space was included for respondents to nominate up to eight different species.
4. Respondents' evaluations of the adequacy of current knowledge relating to snowmobile effects on wildlife.

These questions were open-ended, with no constraints as to the number or type of issues or reasons described. After the conclusion of the time limit for responding to Round 1, each member of the UI research team read responses in their entirety. They generated a list of mutually exclusive topics addressed in response to each question. Each respondent's answers were then classified according to this list of topics.

Because the second round of questions were intended to help prioritize points of discussion for the April workshop, it was necessary to translate responses from the first round into questions asking for specific information needs related to monitoring snowmobile impacts on wildlife. Therefore, issues (question 1) and reasons (question 3) were combined and examined to identify specific information needs associated with each of seven guilds of species. (The guilds were ursids, ungulates, forest carnivores, canids, avian species, small mammals, and aquatic species.) These information needs ranged from very specific (e.g., do chemicals from snowmobiles accumulate in body tissues?) to higher-order information needs (e.g., do snowmobiles increase predator threats to ungulates through the creation of travelways?). Each information need may have been mentioned by only one person or by several individuals.

Round Two of the Delphi process presented the list of information needs by guild and asked respondents to rank the importance of the top six information needs within each guild. The number of items ranged from three (for ursids) to eleven (for ungulates); in those guilds with fewer than six items, individuals ranked all items. In those with more than six items, individuals were instructed to select and rank only the top six. A respondent could rank needs within each of the seven guilds or only those about which he/she felt knowledgeable.

For each information need ranked, respondents also determined the scale at which information is needed in the context of providing managerially useful monitoring information. They were asked "at what scale is it most useful" to collect monitoring data. The options from which respondents could choose were individual behavioral, individual physiological, individual cumulative, and population.

Round Two included two final questions. The first explored whether respondents felt that different scales of information are needed for different land management agencies or for species with different status. The last question asked whether respondents felt they have sufficient or insufficient public support, authority, and/or information to make decisions to manage snowmobiles.

Round One (see Appendix A) occurred between January 10 and January 29, 2001. Round Two (see Appendix B) occurred between February 15 and March 9, 2001. These short time windows, although not ideal, were necessary to meet the deadline posed by the April workshop.

Respondents

The nature of the questions asked, especially in Round Two, required a relatively high level of expertise among respondents. Ideally we hoped to include all individuals with relevant knowledge employed by public land management agencies (both state and federal) and universities. We began by developing a list on the basis of publications and the collective knowledge of the steering committee. In addition, a list was compiled of all national park units where snowmobiling occurs. If specific individuals involved in wildlife monitoring were known at each park unit, they were included by name on the list. If not, we invited both the park superintendent and the Chief of Resources to participate. Tables 1 to 3 display the public land management units from whom responses were obtained. In addition to these, responses came from several regional offices and interagency coordinating bodies. Clearly, the issue of snowmobiling is of interest to a wide range of land managers.

Table 1. National Forests from Which Responses Were Obtained

Apache-Sitgreaves	Flathead	Lewis & Clark	Shasta-Trinity
Beaverhead-Deerlodge	Gallatin	Medicine Bow-Routt	Shoshone
Bidger Teton	Gifford Pinchot	Modoc	Sierra Nevada
Bighorn	Grand Mesa	Nez Perce	Stanislaus
Bitterroot	Gunnison	Okanogan	Tahoe
Boise	Helena	Pike & San Isabel	Uinta
Caribou-Targhee	Hiawatha	Plumas	Uncompahgre
Clearwater	Humbolt-Toiyabe	Rio Grande	Wenatchee
Comanche & Cimmaron NG	Idaho Panhandle NFs	San Bernardino	White Mountain
Dixie	Kootenai	San Juan	White River
Eldorado	Lassen	Sawtooth	Winema

Table 2. National Park Service Units from Which Responses Were Obtained

Appalachian Nat. Scenic Tr.	Grand Teton NP	Rocky Mountain NP
Bighorn Canyon NRA	Isle Royale NP	Sleeping Bear Dunes Nat. Lakeshore
Cedar Breaks NM	Kenai Fjords NP	St. Croix Nat. Scenic Riverway
Denali NP	Lassen Volcanic NP	Theodore Roosevelt NP
Dinosaur NM	Martin Van Buren NHS	Western Arcting Nat. Parklands
Ft. Union Trading Post NHS	Minute Man NHP	Wrangell-St. Elias NP
Gates of the Arctic NP	Mt. Rainier NP	Yellowstone NP
Grand Portage NM	Pictured Rocks Nat. Lakeshore	

Table 3. Other Public Land Management Units from Which Responses Were Obtained

BLM	US FWS	State
Alaska BLM	Iroqois NWR	AK Fish & Game
Colorado BLM	Kenai NWR	CO Div. Of Wildlife
Idaho BLM	Silvio O. Conte NWR	ID Fish & Game
Nevada BLM		ID Parks & Rec
New Mexico BLM		MN DNR
Oregon BLM		MT Fish, Wildlife & Parks
Wyoming BLM		ND Game & Fish
		SD Game, Fish & Parks

To alert potential participants in the opportunity to participate, an email message was sent, informing them of the nature of the inquiry and providing the website address where the questions were located. Emails sent to park managers included a request to forward them to the most appropriate staff member or members. Additionally, Round One asked respondents to send us the names and email addresses of others who would be appropriate to include.

During the first round, 570 individuals were invited to participate, and 158 did so. During the second round, 92 individuals responded. Although most of those in Round Two were people who had also responded in Round One, 29 individuals joined the discussion after the conclusion of Round One, and therefore only responded during Round Two. Thus, a total of 186 different individuals participated in some or all of the process.

Results

Round One

Respondents' Position and Place of Employment

The majority of those responding in Round One were field biologists (Table 4). Another 25 biologists, who were serving in administrative roles such as program director or interagency coordinator, also replied. Nineteen leaders of other administrative areas, primarily recreation and trails, also responded. The perceived urgency of the issue of snowmobiling was underscored by the participation of 36 administrative line officers. The remaining respondents tended to be from environmental or recreation organizations. Specific details about those respondents' affiliations are not given, in order to protect their anonymity.

Table 4. Positions Held by Respondents in Round One

Position	Number of Respondents
Field Biologist	68
Refuge Manager, Forest Supervisor, Park Superintendent	36

Biologist in Administrative/Coordinating Role	25
Other Administrative Leads	19
Other	10
Total	158

In terms of agency or organizational affiliation, the largest group was Forest Service employees, followed by National Park Service staff (Figure 1). Relatively few academic biologists participated in the study.

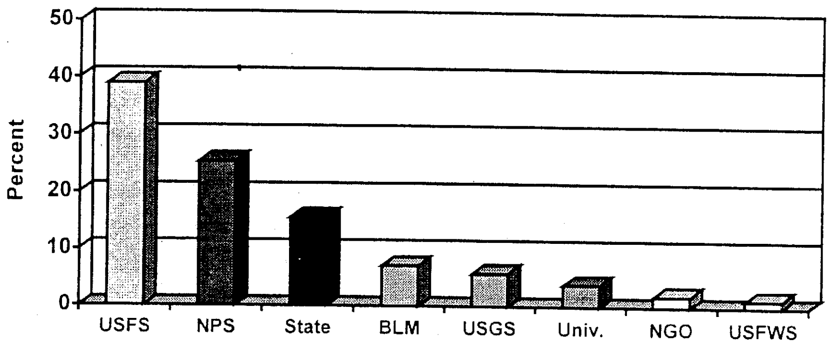

Figure 1. Agency or Organizational Affiliation of Respondents in Round One

Issues Raised Pertaining to Snowmobiling

The issues raised in response to the general question about snowmobiling were quite varied (Figure 2). Individual respondents often described many different issues, and people varied in the depth with which they described the issues. This presented some challenges in coding and categorizing the answers, and the research team went through several iterations to develop a final set of categories. Each discrete issue was then assigned to a category.

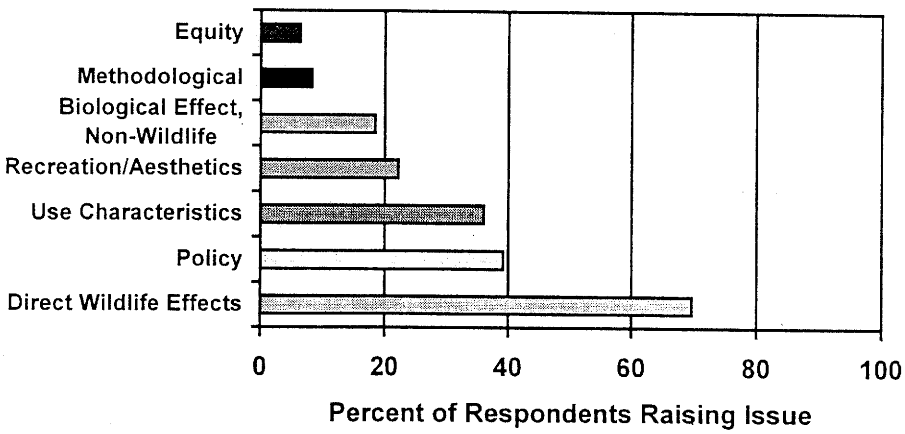

Figure 2. Issues Pertaining to Snowmobiles Identified in Round 2

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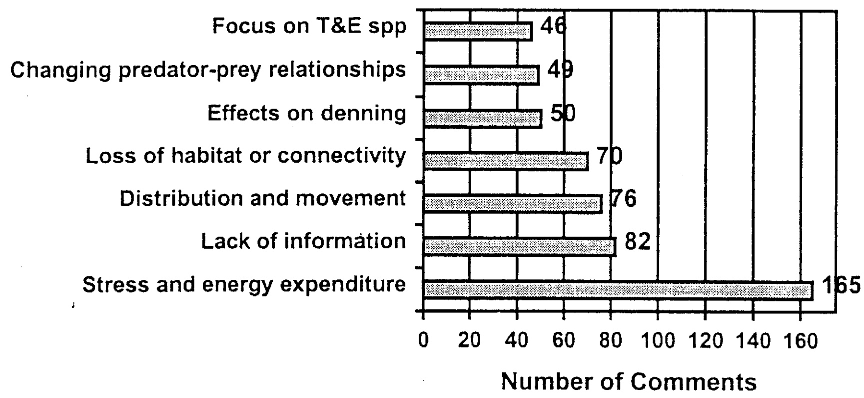

Figure 3. Wildlife Effects Issues Raised in Round One

Not surprisingly, given the nature of the study and the way it was presented to respondents, the most commonly mentioned issue was impacts to wildlife (see Figures 2 & 3). Most of these comments pertained to adverse effects snowmobiles may have in causing stress and energy expenditures, especially during times of the year when animals are already under stress. Other wildlife concerns were at larger biological scales, for example the potential cumulative effect of snowmobiles in fragmenting habitat or altering the distribution and movement of animals. Interestingly, the second most commonly raised issue pertained to the lack of available information to draw conclusions about snowmobiles' effects on wildlife. Clearly, many biologists are concerned that insufficient evidence exists to know definitively whether there is a problem. This sentiment arose in responses to other questions as well.

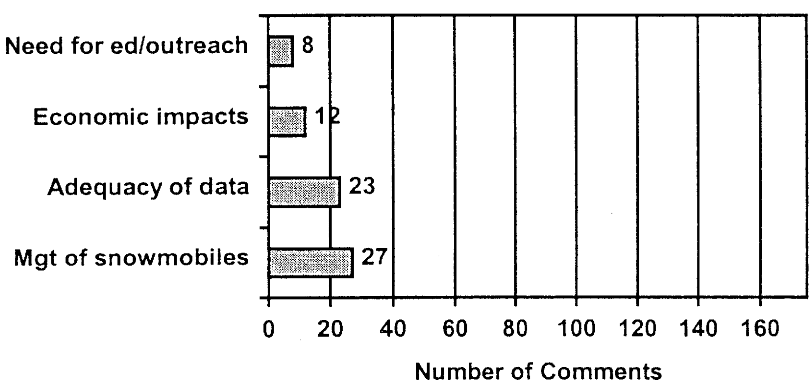

Figure 4. Policy Issues Raised in Round One

The second most common type of issue raised pertained to policy concerns (Figure 4). Several respondents were concerned about management of snowmobiles – whether and how it should be done. In this category fell comments related to managers' ability to base policy recommendations on adequate data and what might constitute adequate data in the first place. Twelve people mentioned that the economic implications of managing snowmobile use should be taken into consideration when making policy recommendations, and a few suggested that educational efforts should be considered as part of the solution.

Comments pertaining to the activity of snowmobiling itself were the third most commonly described issues (Figure 5). Many respondents questioned whether it is the behavior of snowmobilers (high-marking, chasing wildlife) that might affect wildlife adversely, rather than sheer numbers of visitors. Several potentially important aspects of use were described, including the timing and frequency of use, the predictability of use, deliberate or unintentional harassment of wildlife, the speed at which the snowmobiles travel, and whether or not the snowmobile use is confined to trails. A few respondents, mainly from areas where hunting and trapping are significant land uses, mentioned the issue of snowmobiles providing increased access for extractive uses (labeled "types of use" in Figure 5). Seven comments described concerns that snowmobile management actions (e.g., the recent ban in Yellowstone) may displace snowmobilers to other areas where they may have adverse effects.

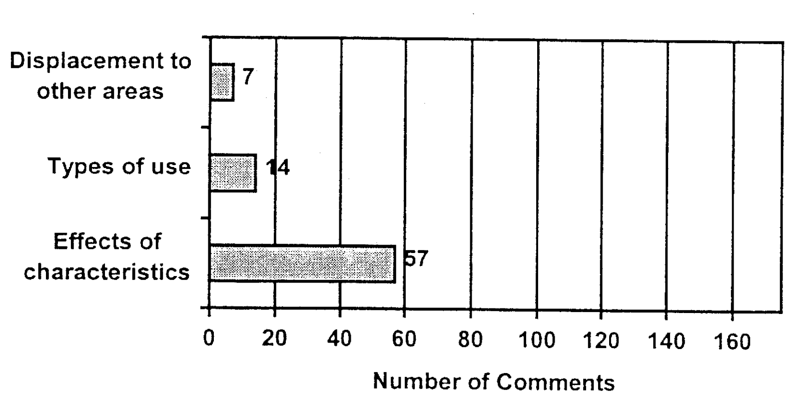

Figure 5. Snowmobile Use Characteristics Issues Raised in Round One

Recreation and aesthetic issues were the next most common type of issue (Figure 6). Several respondents said the noise of snowmobiles and the conflict that arises when they come into contact with other recreational users (namely, cross-country skiers) are significant problems, and some said these problems far outweigh wildlife concerns. On the other hand, some respondents noted a need to protect a range of opportunity types across public lands.

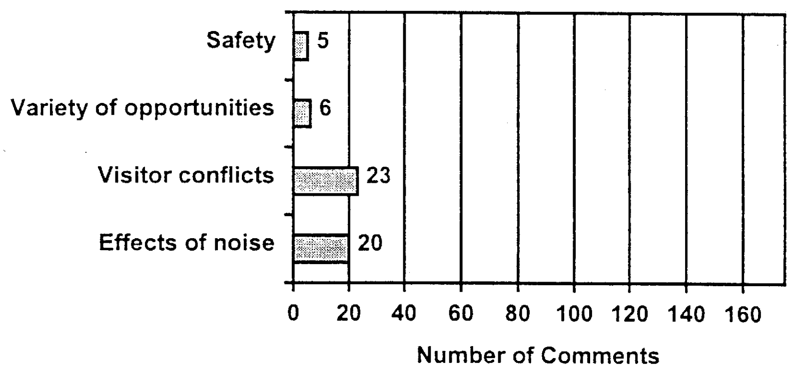

Figure 6. Recreation/Aesthetic Issues Raised in Round One

The next category of issues concerned biological impacts not directly related to wildlife (Figure 7). The primary issue here was water pollution caused by runoff or direct contamination with petroleum products. A small number of people were concerned that snowmobiles might direct affect vegetation in areas where snow depths are shallow.

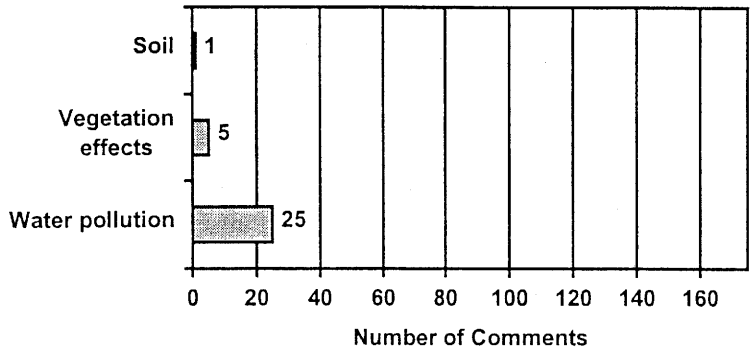

Figure 7. Other Biological Issues Raised in Round One

Methodological issues are depicted in Figure 8. Although some of the issues raised in the category of impacts to wildlife were methodological, this category captures issues raised at a larger or more general scale. For instance, a few people mentioned the need to develop non-invasive or low-impact monitoring protocols, while others mentioned the need to be able to maintain flexibility in adopting site-specific protocols. Three wondered how monitoring would be able to discern the effects of snowmobiles, when much of the impact may have occurred before monitoring could be started.

The last type of issue raised, though least in number of comments, is among the most difficult to address. Some respondents were concerned about issues of equity in focusing on snowmobiles (Figure 9). In general, the comments questioned whether it was discriminatory to focus solely on snowmobiles, when other motorized vehicles use the same areas at other times. A few wondered whether the focus on snowmobiles presumed a problem where none had been established. It is interesting that so few respondents mentioned this, given the large number who said that we do not currently have enough data to know whether snowmobiles pose a problem for wildlife.

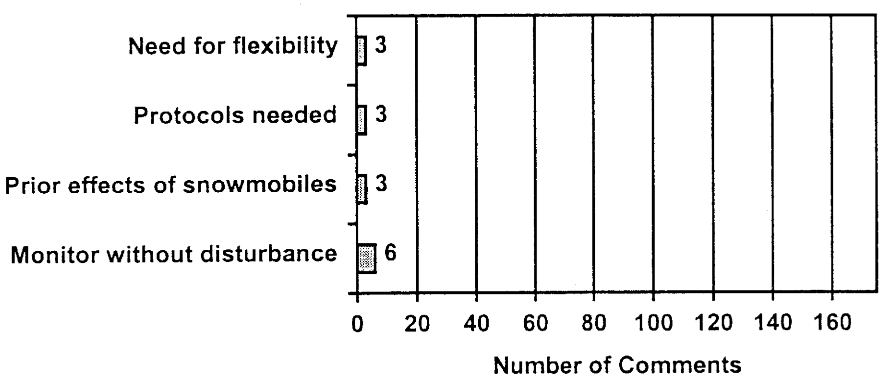

Figure 8. Methodological Issues Raised in Round One

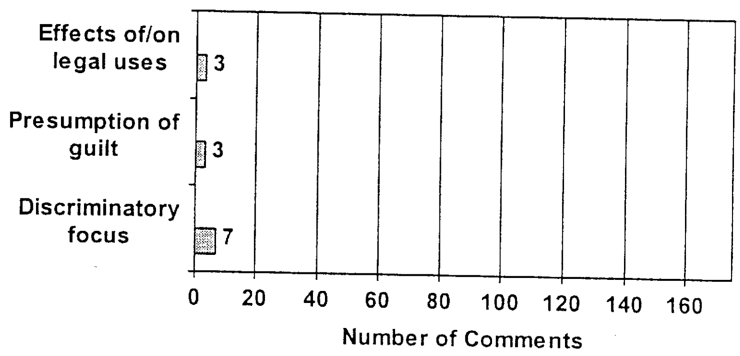

Figure 9. Equity Issues Raised in Round One

Species of Concern and Reasons for Nomination

The first round of questions had several questions that identified species of concern. One question asked respondents to list up to eight species they felt should be monitored. Additionally, many respondents listed species of concern in their responses to the general question about issues of importance (Question #1). In presenting results about species, both types of responses were included. That is, if a respondent listed a given species in either place, that was counted as a "vote" for that species. Figure 10 shows six species groups and the percent of respondents that felt they should be monitored. Forest carnivores and ungulates received the most nominations (80% and 68% respectively), followed by small mammals (28%) and avians (27%). Ursids were nominated by 19% and aquatic species by 11%.

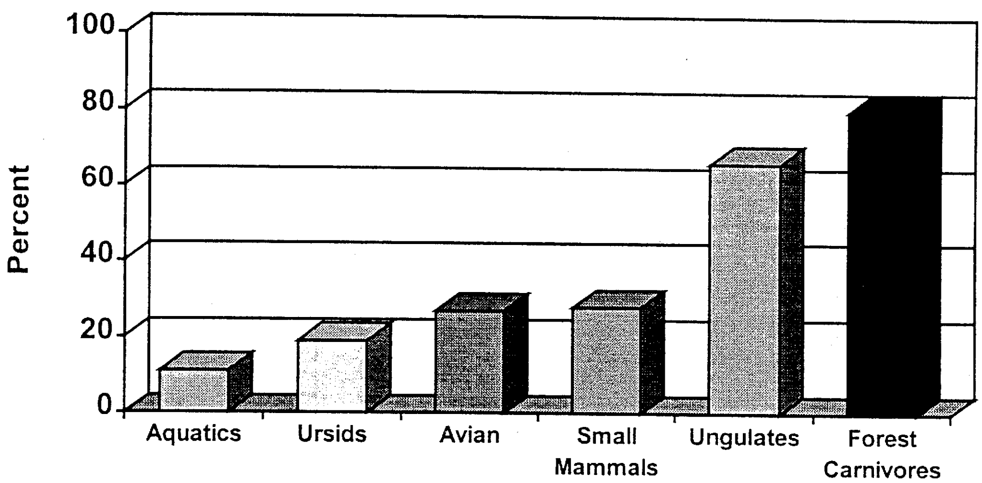

Figure 10. Species Identifies as Needing Monitoring

Judgements about Adequacy of Data

For each of the species they listed, respondents were asked whether they believed adequate scientific data exist to determine the effects of snowmobiling on the species. They chose one of the following statements to describe the adequacy of existing scientific data about snowmobile impacts:

- Inadequate scientific data exist to determine effects on this species
- Adequate scientific data exist to show species is adversely affected by snowmobiles
- Adequate scientific data exist to show species IS NOT adversely affected by snowmobiles

The following Figures 11 through 17 show the species groups or guilds and the number of respondents who thought existing scientific data were inadequate to determine snowmobile effects, adequate data exits to show the species is adversely affected, or adequate data exists to show the species is not adversely affected by snowmobiles.

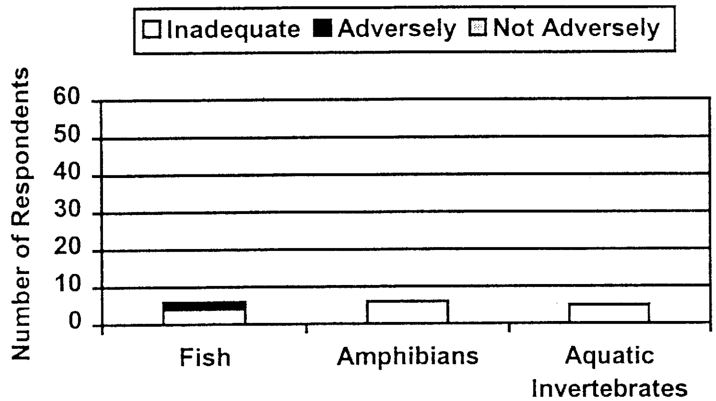

Figure 11. Aquatic Species Identified as Needing Monitoring

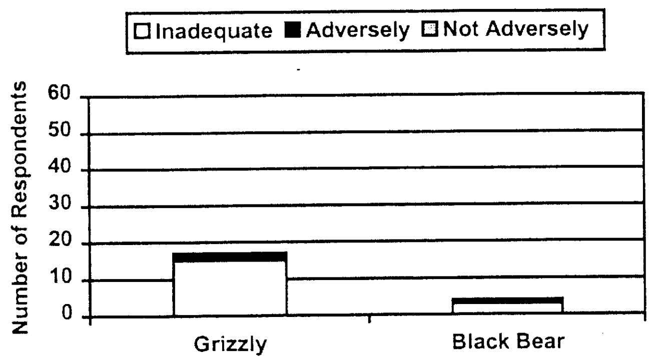

Figure 12. Ursid Species Identified as Needing Monitoring

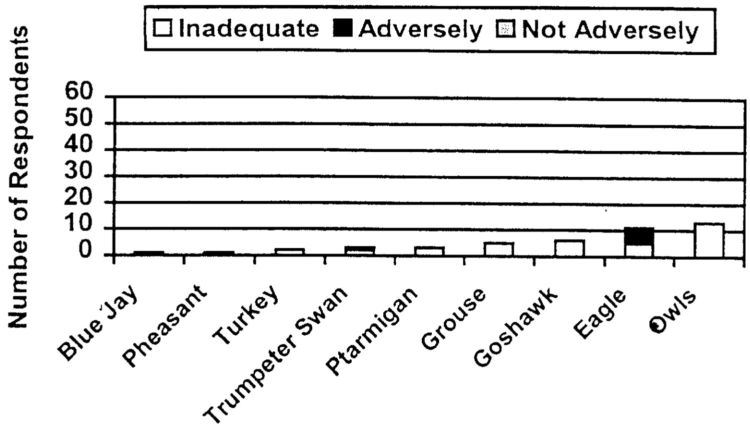

Figure 13. Avian Species Identified as Needing Monitoring

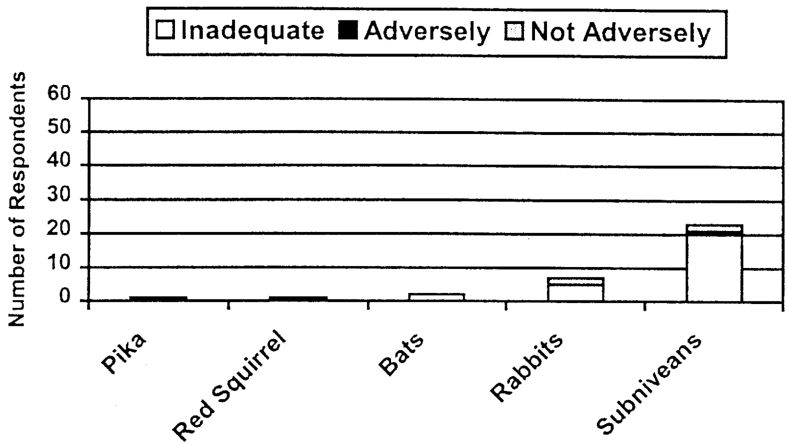

Figure 14. Small Mammal Species Identified as Needing Monitoring

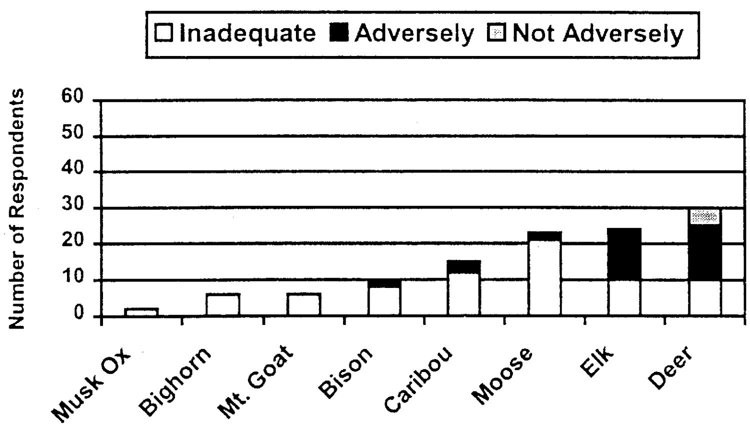

Figure 15. Ungulate Species Identified as Needing Monitoring

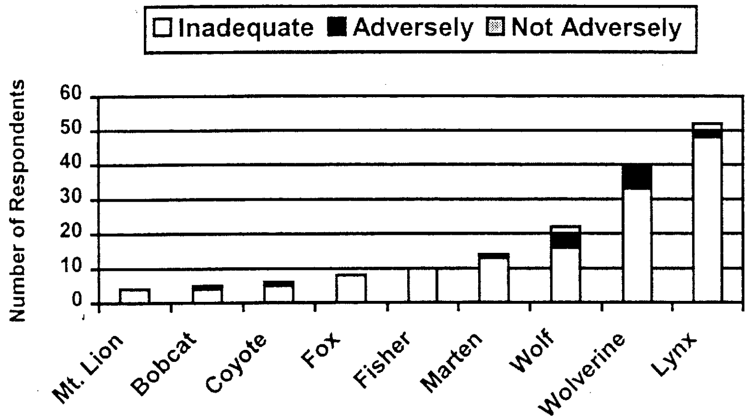

Figure 16. Forest Carnivore Species Identified as Needing Monitoring

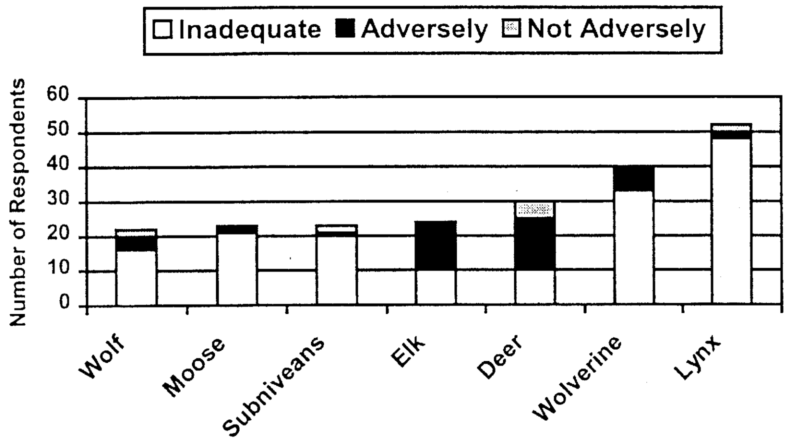

Figure 17. Species Receiving at Least 20 "Votes"

Round Two

Ranking of Information Needs

In the second round of the Delphi questionnaire, respondents were asked to rank the most important information needs for designing a program to monitor the effects of snowmobiles on wildlife for each of the seven species or guilds. Figures 18 through 24 display the mean rank participants assigned the information needs (6 = most important, 1 = least important). Instructions in the questionnaire (Appendix B) asked that respondents use each number only once. In the second round, several respondents did not understand these instructions and gave multiple items the same ranking. Therefore, results presented here are based only on those respondents who correctly followed the procedure for ranking the information needs from 1 through 6.

When reviewing the following tables the reader should keep in mind that the information needs that display a long bar on the bar graph display a higher mean number (e.g. 5 or 6) and were the most important, while those that displayed a shorter bar received a lower mean number (e.g. 1 or 2) and were the least important. For example, in Figure 18, the most important information need for aquatic species was to determine the "indirect effects of chemicals on amphibians/fish," while the least important information need was to determine the "effects of noise on organisms."

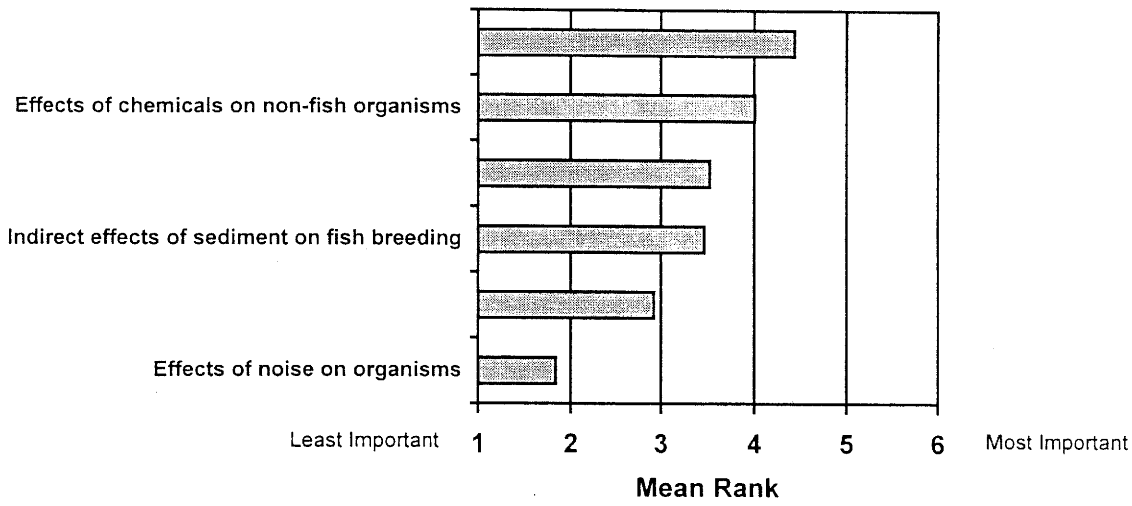

Figure 18. Ranking of Information Needs for Aquatics

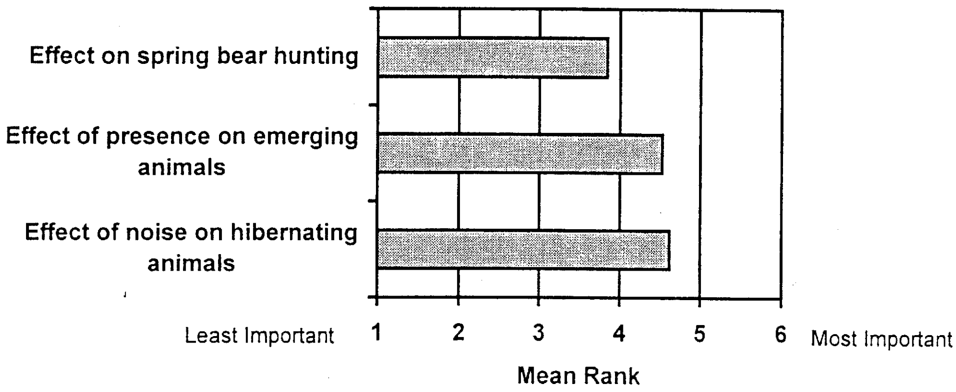

Figure 19. Ranking of Information Needs for Ursids

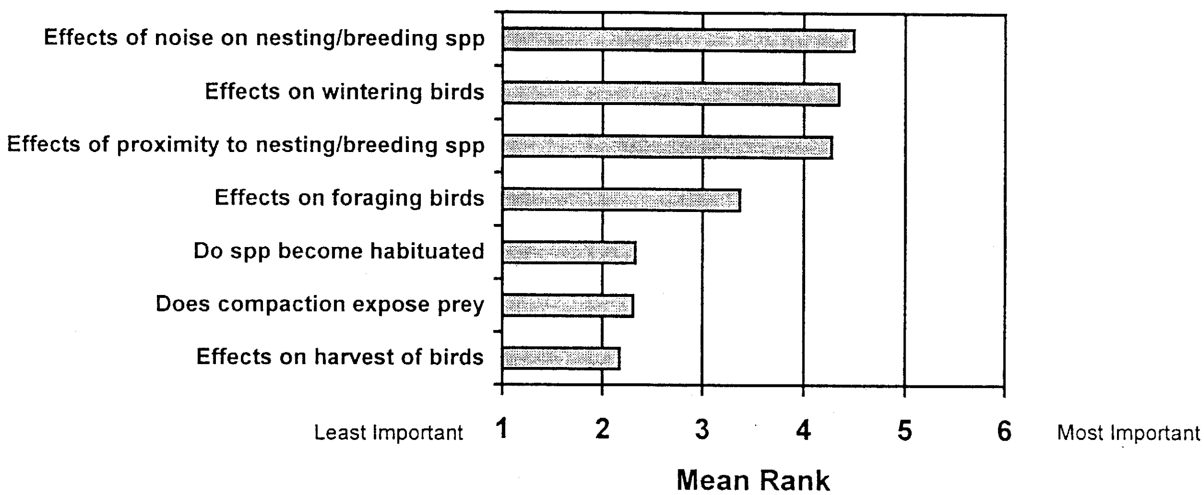

Figure 20. Ranking of Information Needs for Avian Species

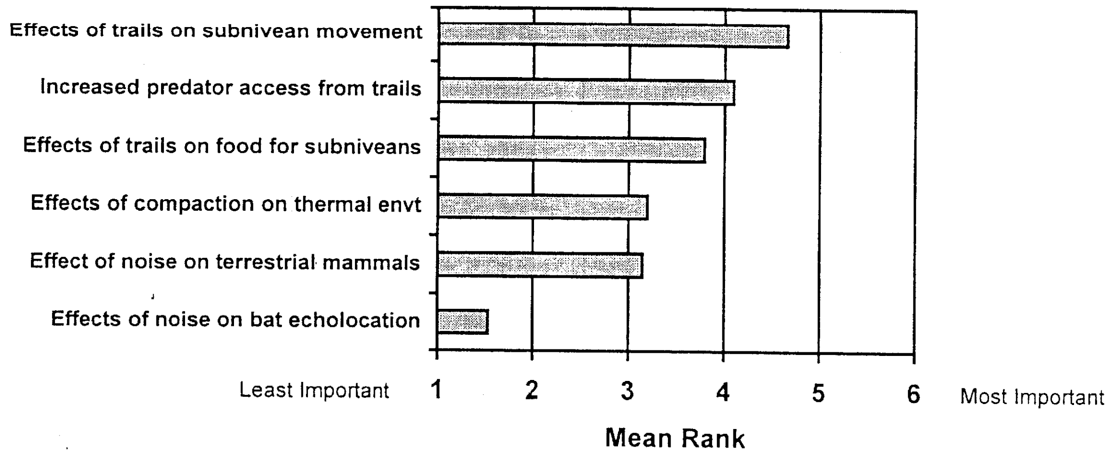

Figure 21. Ranking of Information Needs for Small Mammals

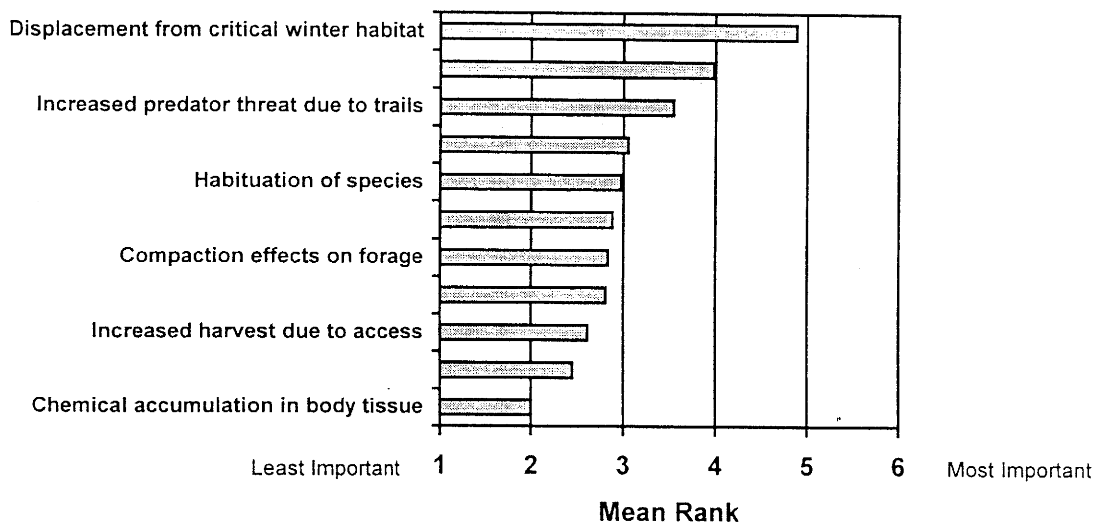

Figure 22. Ranking of Information Needs for Ungulates

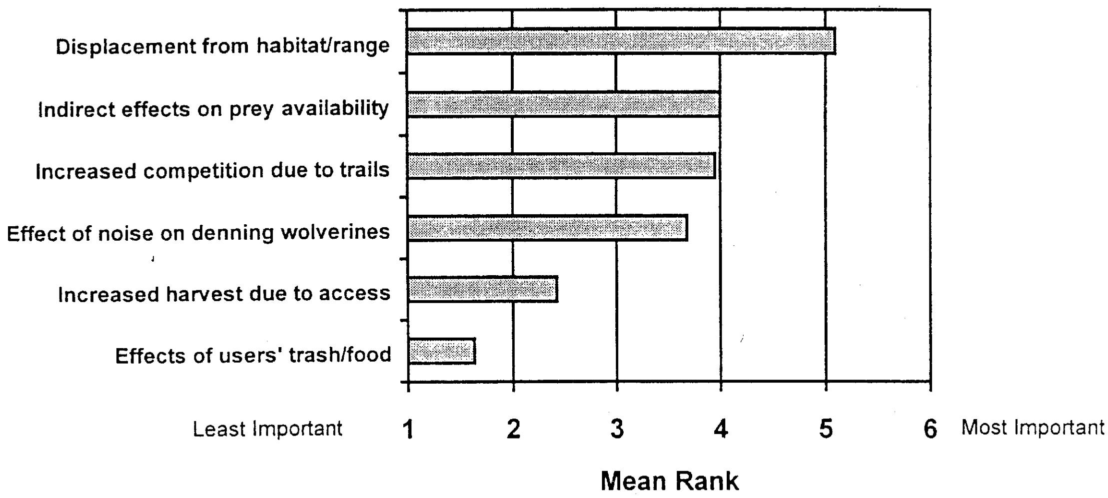

Figure 23. Ranking of Information Needs for Forest Carnivores

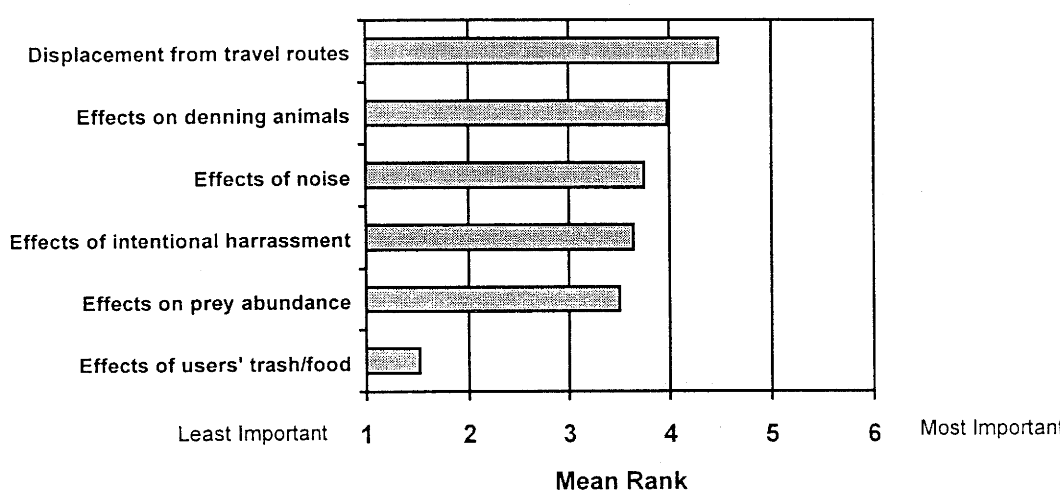

Figure 24. Ranking of Information Needs for Canids

Biological Scale

After respondents ranked each species they were then asked to check the biological level at which it would be most useful to collect each type of information. The biological levels were at the individual behavior level, individual physiological level, individual cumulative level, and at the population level. Respondents were given a working definition of each biological level (displayed in Table 5).

Table 5. Definitions of Biological Levels

Individual Behavior	Individual behavioral effects include immediate responses to snowmobiles such as flight, changes in activity budgets, or habitat displacement.
Individual Physiological	Individual physiological effects include relatively proximate changes in key physiological variables, such as higher heart rates or higher stress hormone levels than animals that are not exposed to snowmobiles.
Individual Cumulative	Individual cumulative effects include reduced weight, habituation, reduced reproduction, or mortality.
Population	Population effects include changes in the abundance, distribution, or connectivity of the species at the population level.

The biological levels at which it would be most useful to collect information for each species or guild are displayed in Figures 25 through 31. For example, Figure 25 shows that for aquatic species, for each of the six information needs information respondents believed that it would be most useful to collect information at the population level, while information at the individual behavioral level was generally deemed least useful.

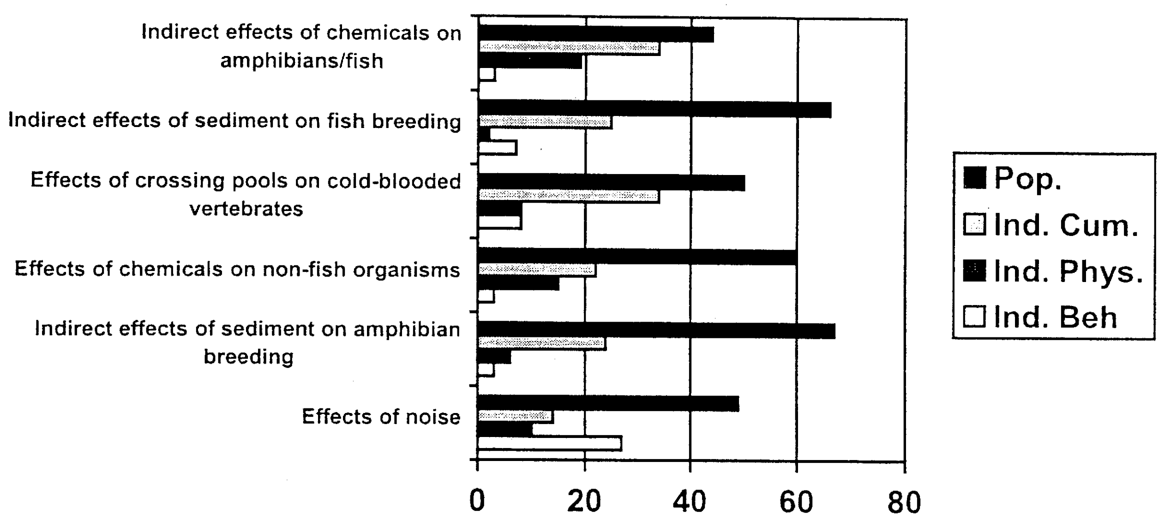

Figure 25. Level of Data Most Useful for Aquatic Species

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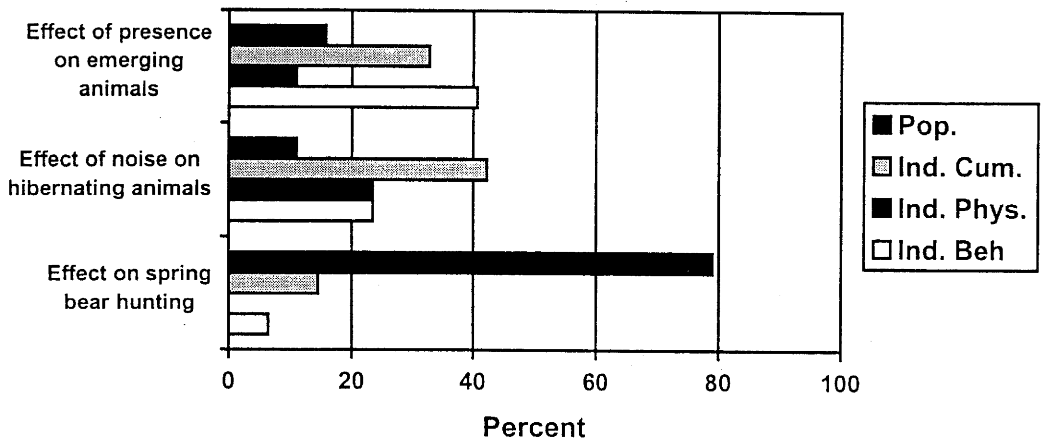

Figure 26. Level of Data Most Useful for Ursids

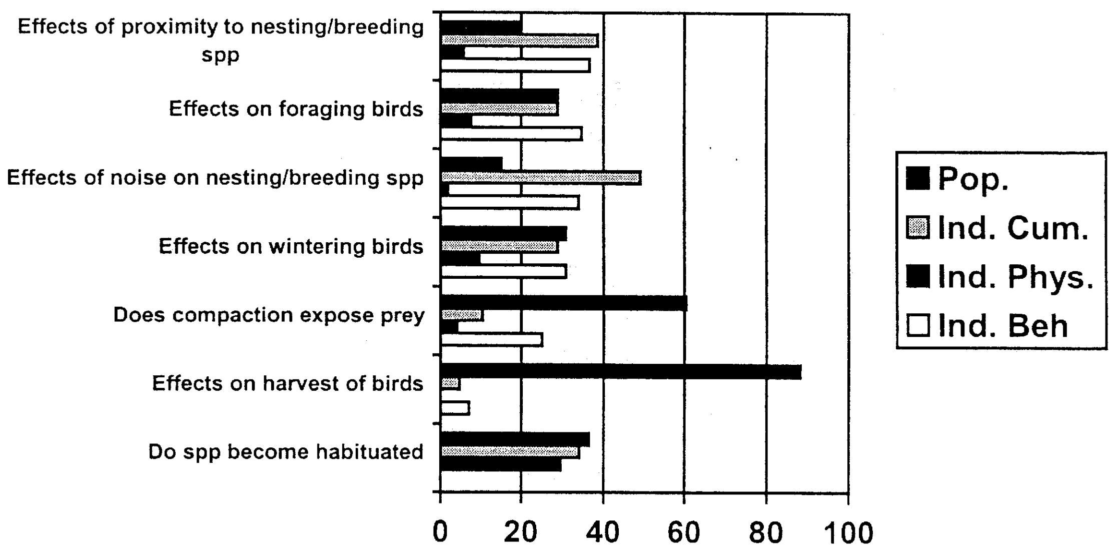

Figure 27. Level of Data Most Useful for Avian Species

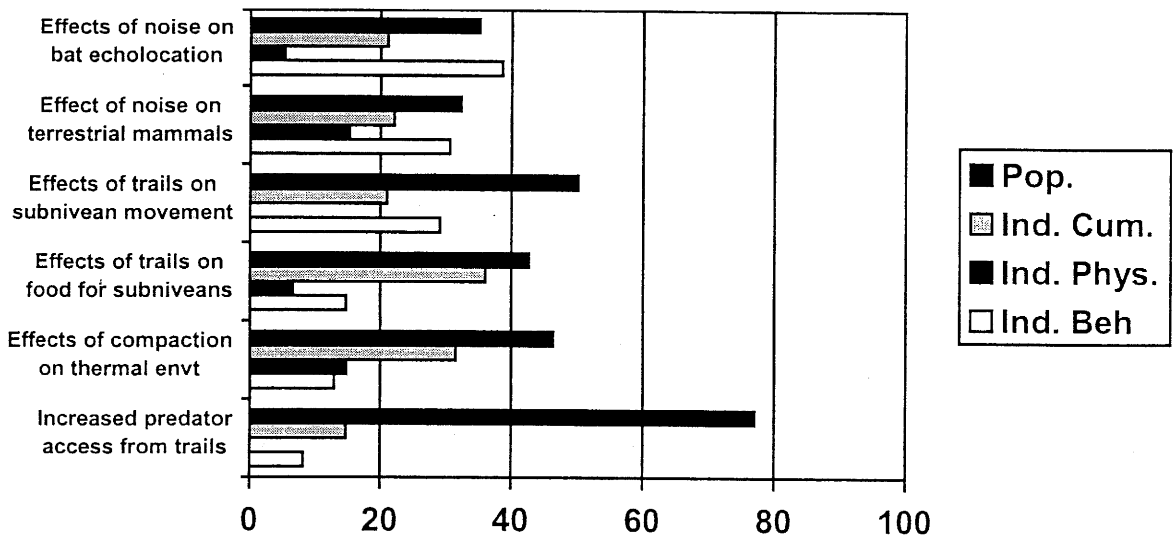

Figure 28. Level of Data Most Useful for Small Mammals

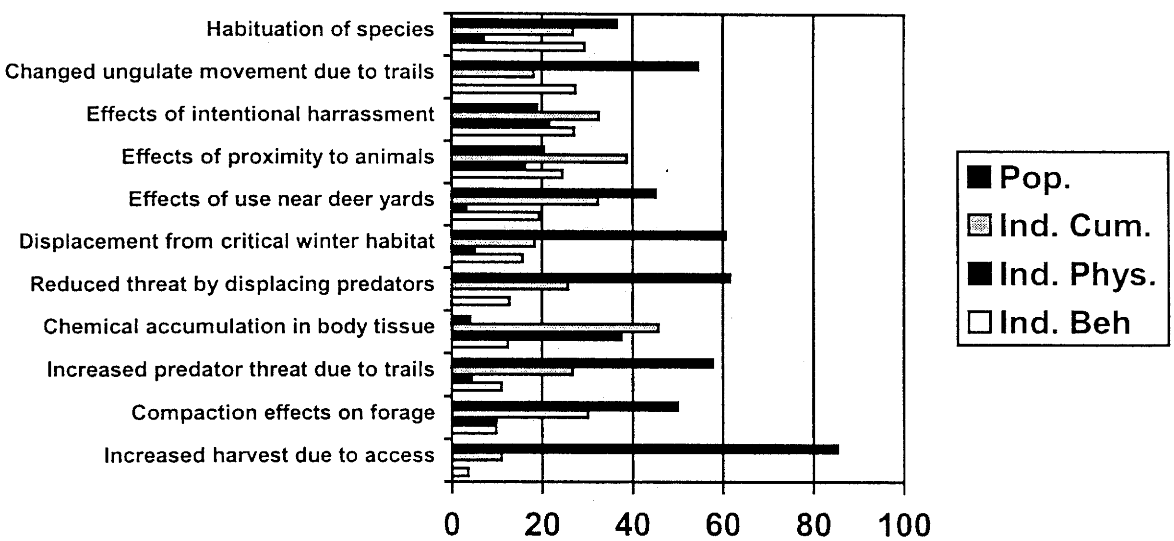

Figure 29. Level of Data Most Useful for Ungulates

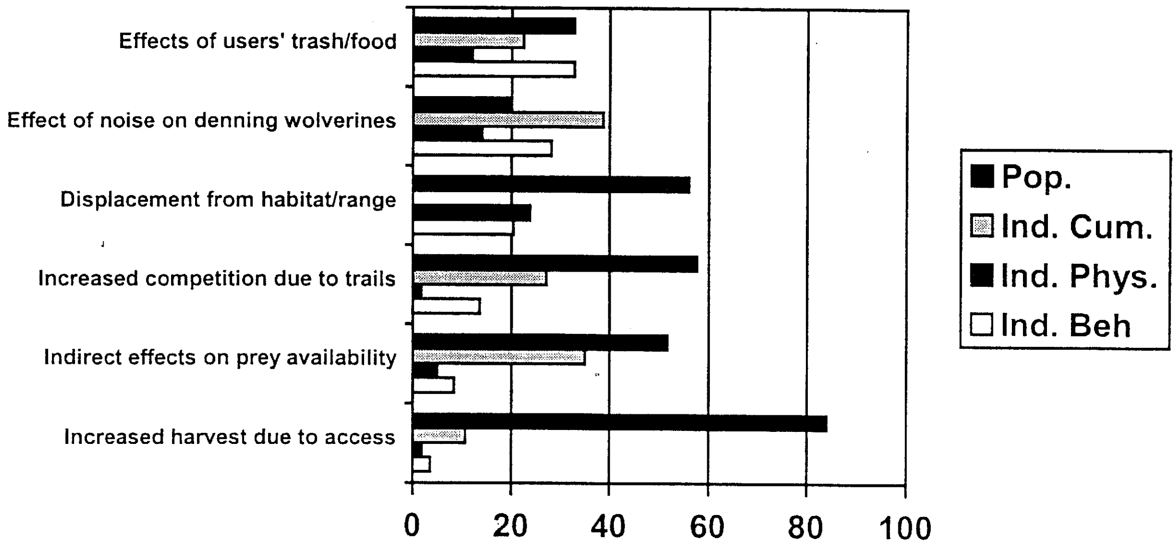

Figure 30. Level of Data Most Useful for Ungulates Forest Carnivores

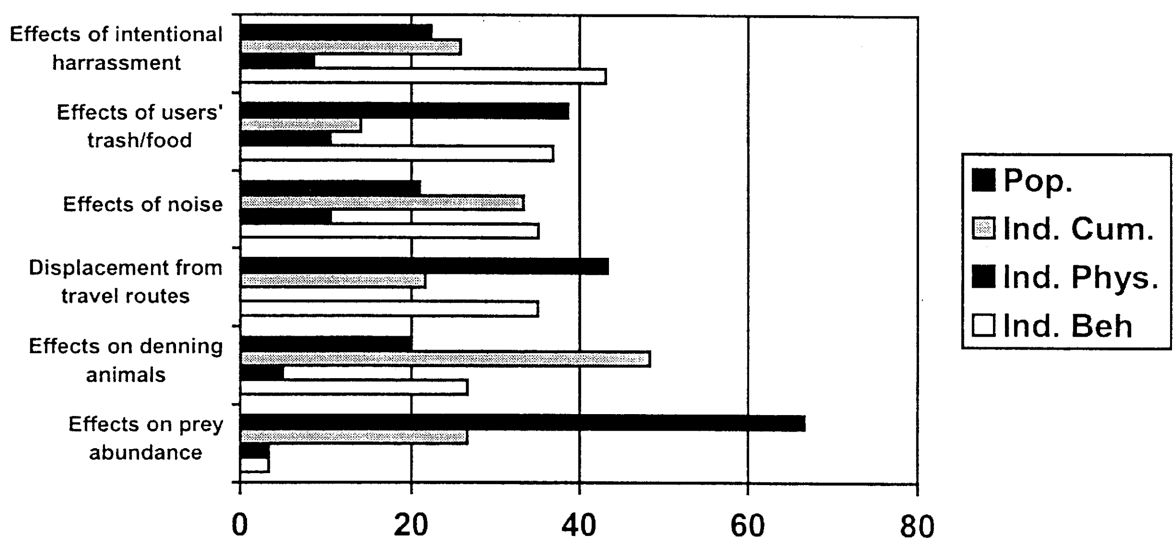

Figure 31. Level of Data Most Useful for Canids

Respondents' Overall Views on Snowmobile Management

Across all respondents, the issue of snowmobile impacts to wildlife varied considerably in importance, when taken in context of all natural resource management issues respondents face in their land management unit (Figure 32). For very few individuals does the issue rank as very high; for most it is of moderate to high importance.

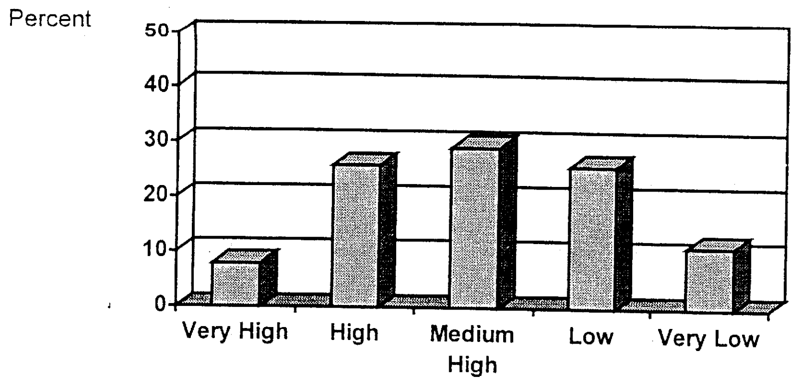

Figure 32. Where the issue of snowmobile impacts to wildlife ranks among all natural resource issues

Despite feeling that the issue is generally important, most respondents do not feel that they have sufficient information to "manage snowmobiles to minimize impacts to wildlife" (Figure 33). Nor does the majority feel that they have sufficient public support to do so. Even more problematic, a majority of respondents do not believe that they have sufficient authority to manage snowmobiles in a way that would minimize impacts, even if there were sufficient information available to do so.

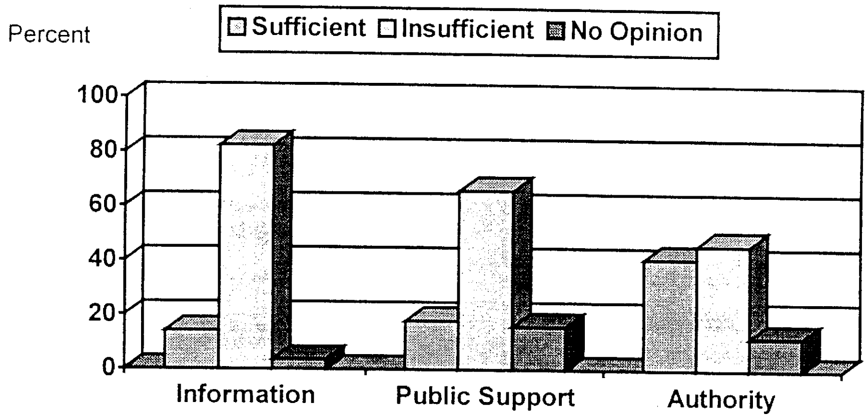

Figure 33. Sufficiency of Information, Public Support and Authority (Responses to the question, "Do you have sufficient information, authority, and public support to manage snowmobiles to minimize impacts to wildlife?")

Discussion and Conclusions

Primary issues and species

The primary issues raised in this study naturally pertained to wildlife impacts. The large majority of these issues related to immediate individual-level effects such as increased energy expenditure or behavioral changes. Concerns about snowmobile impacts on denning animals were also a significant issue. However, many of the wildlife issues raised dealt with larger-scale, complex processes, such as the indirect effects snowmobile use might have through its effects on predators or moving populations of animals into different territories.

The primary species of concern were carnivores, especially lynx, wolverines, and wolves. It is important to remember that respondents in this research were drawn from across the United States, and generally responded pertaining to the species with which they work. Therefore, the relative importance of each guild and species is certainly influenced by the people who chose to participate.

Conclusions about monitoring

The wide range of information needs identified by experts in the field present a significant challenge to those attempting to develop a uniform package of possible monitoring techniques. Information needs appear to be guild or species-specific.

Respondents generally feel that population-level effects are most important or useful to study, followed by individual behavioral effects. The primary exception to this is for threatened or endangered species; respondents apparently believe that identifying any adverse individual level effects would be sufficient grounds for making management decisions. Unfortunately, it appears that most of the limited evidence available to date pertains to individual effects; a significant need therefore exists for basic research and monitoring of population-level effects.

Need for Monitoring or Need for Basic Research

Experts in the field of wildlife (and wildlife reactions to disturbance) are uncomfortable passing judgments on whether snowmobiles adversely (or, for that matter, positively) affect wildlife. Even under circumstance with the best available information, the question of when an impact becomes serious enough to warrant taking action is a subjective value judgment, and many respondents recognized this. But the majority felt that insufficient data exist to even begin to understand the issue. Only for ungulates are some scientists willing to say data are adequate, but even for these commonly studied species, most respondents have serious concerns.

This raises the question about whether monitoring is the place to focus agency efforts. Clearly, more basic research is needed. It is difficult to know what the best monitoring protocols would be when it is not clear about what effects should be monitored. Nevertheless, the NPS is under a mandate to develop monitoring protocols, and we feel that it is important to begin monitoring, however basic, as early as possible. Too often monitoring is left until problems become severe; at that point it is quite difficult to discern the extent to which conditions have changed in the absence of baseline data. Therefore, we encourage researchers and managers to move forward with the development of monitoring protocols, and to continue to refine them as more information becomes available.

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Legal Framework: Snowmobile Use in National Parks

John Sacklin

NPS Organic Act – 1916
To conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same and by such means as will leave them unimpaired for the enjoyment of future generations.

NPS Management Policies – 2001, Impairment of Park Resources
Impairment is an impact, in the professional judgment of the responsible NPS manager, that would harm the integrity of the park resources or values, including the opportunities that would otherwise be present for the enjoyment of those resources and values.

General Authorities Act, as amended - 1978 (16 USC 1a-1)
The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided for by Congress.

National Parks and Recreation Act – 1978 (16 USC 1a-7)
Directs that management plans be prepared for all units of the national park system that include, but are not limited to: (3) identification of and implementation commitments for visitor carrying capacities for all areas of the unit.

Clean Air Act
Section 160 states one of the purposes of the act is "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value;"

Section 162 mandates the designation of national park areas greater than 6,000 acres and wilderness areas greater than 5,000 acres as Class I as of August 7, 1977. Congress deemed these areas deserved the highest level of air quality protection; Yellowstone and Grand Teton national parks are mandatory Class I areas.

Section 169(A) states that "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I Federal areas which impairment results from any manmade air pollution.

Regional Haze Rules (64 FR 35714)

On July 1, 1999, EPA promulgated final regulations for regional haze. The rule calls for the States to establish goals and emission reduction strategies for improving visibility in all 156 Mandatory Class I national parks and wilderness areas. The rules specifically include addressing haze-causing pollutants (mainly fine particulates) from truck and auto emissions. (As noted in the regulations, the National Academy of Sciences addressed visibility in their 1993 report, "Haze in National Parks and Wilderness Areas" (National Research Council, National Academy Press, Washington, D.C. 1993). Their report concluded that "In the West ... an effective control strategy would have to cover many source types, including ... gasoline and diesel vehicles..." (p. 241). The report also states that "current scientific knowledge is adequate and control technologies are available for taking regulatory action to improve and protect visibility." (p. 242).) (available on the internet at http://books.nap.edu/books/)

E.O. 11644 - February 8, 1972 (President Nixon)

"Use of Off-Road Vehicles on the Public Lands:" Areas and trails shall be located in areas of the National Park System only if the respective agency head determines that off-road vehicle use in such locations will not adversely affect their natural, aesthetic or scenic values.

E.O. 11989 - May 24, 1977 (President Carter)

The respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the soil, vegetation, wildlife, wildlife habitat or cultural or historic resources of the particular areas or trails of the public lands, immediately close such areas or trails to the type of off-road vehicle causing such effects, until such time as he determines that such adverse effects have been eliminated and that measures have been implemented to prevent future recurrences.

DOI prepared an EIS in 1976 - Departmental Implementation of Executive Order 11644, as amended by E.O. 11989, pertaining to use of off-road vehicles on the public lands clearly defines use of snowmobiles on roads as an off-road vehicle.

36 CFR 2.18

The use of snowmobiles is prohibited, except where designated and only when their use is consistent with the park's natural, cultural, scenic, and aesthetic values, safety considerations, park management objectives, and will not disturb wildlife and damage park resources.

36 CFR 2.15

Consistent with applicable legislation and Federal administrative policies, and based upon a determination that such action is necessary for the maintenance of public health and safety, protection of environmental and scenic values, protection of natural and cultural resources, aid to scientific research, implementation of management responsibilities, equitable allocation and use of facilities, or the avoidance of conflict among visitor use activities, the superintendent may:

(1) Establish, for all or a portion of a park area, a reasonable schedule of visiting hours, impose public use limits, or close all or a portion of a park area to all public use or to a specific use or activity.

(2) Designate areas for a specific use or activity, or impose conditions or restrictions on a use or activity.

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Consolidated Appropriation Act – 2001 (December 21, 2000), Section 128
None of the funds provided in this or any other Act may be used prior to July 31, 2001 to promulgate or enforce a final rule to reduce during the 2000-2001 or 2001-2002 winter seasons the use of snowmobiles below current use patterns at a unit of the National Park System; Provided, That nothing in this section shall be interpreted as amending any requirement of the Clean Air Act; Provided further, That nothing in this section shall preclude the Secretary from taking emergency actions related to snowmobile use in any National Park based on authorities which existed to permit such emergency actions as of the date of enactment of this Act.

Methods to Estimate Snowmobile Use

Jerrilyn Thompson, Dorothy Anderson, Mae Davenport, Joanna Rosendahl

STEP 1: FIRST AND FOREMOST: Define your sampling objectives! The methods used and the information collected must be driven by your objectives...

What do I want to estimate?

- Total visitor use numbers (e.g. long-term correlations with mobile species?)
- Spatial extent of visitor use (e.g. using GIS analysis, are there areas of snowmobile use that overlap crucial habitat areas?)
- Snowmobile use in a specific region (e.g. are birds present in localized area given x number snowmobiles?)
- Snowmobile use at a specific site (e.g. how frequently does a snowmobile driving by a nest site flush birds?)
- Use over a specific time period (e.g. how many snowmobiles can go by at night without displacing deer?)

STEP 2: What type of trail system do I have?

- A single controlled access
- Multiple controlled access
- Multiple uncontrolled access

STEP 3: How will I determine or predict use estimates?

- Snowmobile use levels (amount of use)
- Mechanical counters
- Cameras
- Personal observation
- Visitor travel patterns (extent of use)
- Mechanical counters
- Cameras
- Personal observation
- Visitor sample interviews & maps
- Aerial photography of snowmobile tracks

STEP 4: What information do I need to develop a sampling plan?

- Past estimates, if available
- Map of access points
- Classification of relative amount of use at access points and trail segments (high, medium, low)
- Definition of typical snowmobiling season dates and typical weekend vs. weekday use
- Classification of relative amount of use related to time of day

"Path of the Voyageurs": A pilot project at Voyageurs NP to estimate visitor use in a multiple uncontrolled access park; approaching "knowing the unknowable..."

Researchers are currently working with a UMN professor of statistics to develop reliable methods and statistics needed for Voyageurs National Park and other resource areas that have multiple uncontrolled access points. This is a work in progress, but is very promising.

Purpose of pilot study

- Develop an accurate method to count snowmobiles that reflects current level of use
- Calibrate mechanical counters currently used in the resource area
- Interview visitors to obtain travel pattern information in the area
- Develop use estimates for the pilot period and for the season based on mechanical counters and reported travel patterns
- Evaluate the method, and make recommendations for continued development of the method next year

Interviews with Snowmobilers

- Provide baseline information about snowmobile travel patterns in and around the area
- Contact as many visitors as possible
- Within different sections of the area
- At different times of the day
- On weekdays and weekend days
- Identify use patterns and relative levels of use

Group Data recorded on a Response Log; ask one person from each group:

- Route for each day in the area
- Number of people in group
- Number of sleds in group
- Number of miles on route
- Amount of time spent on route
- Starting and ending point
- *Also record: route id #, route date, contact time, date, location, temp & snow conditions, interviewer*

Calibrating Mechanical Counters

- Counts recorded each morning and evening
- "Counter Error Coefficient" determined by comparing mechanical counts with human observations

Visitor Use Estimate Model

$$N = \left[\frac{\Sigma Z_j}{\Sigma z_j}\right] * n = \left[\frac{1582}{778}\right] * 552 = 1121$$

An estimated 1121 (± 5%) snowmobiles were in Voyageurs during the study period, March 8-11, 2001.

Where:

- N = the total number of snowmobiles in the area
- Z_j = the calibrated count observed at mechanical counter j
- z_j = the total route count at counter j represented by the sample of n snowmobiles
- n = the number of snowmobiles represented by the sample

Note: The variance (820.1) and standard deviation (28.6), were calculated using a formula developed by the UMN Statistics Clinic.

Model Application—a 3-step analysis process:

1. Analyze routes to identify use levels at specific counter locations
2. Analyze raw mechanical counter data & calibrate daily totals generated for each counter
3. Model applied to data

Remember:

- A representative sample is crucial in identifying travel patterns. A sample should be sensitive to snowmobile use in different regions, at different times of the day, and on weekends and weekdays. Gather information from visitors about their trip, such as routes, people per group, sleds per group, time spent in area, entry/exit points, and trip dates. For the example shown here, estimates depend on how representative sample is of snowmobiling population at Voyageurs NP.

- Calibration is critical to any sampling scheme based on mechanical counters. Calibration provides a counter error coefficient that will increase the accuracy of the mechanical counter data.

- The benefits of statistical sampling include: convenience and speed, flexibility, fewer people needed to do the work, higher quality and more accurate data, a reduction in visitor burden, the elimination of bias in data collection, and incorporation of probability theory to measure precision of sample results.

Tools for Estimating Snowmobile Use

For all scenarios, estimate use with mechanical counters, cameras, or personal observation. Calibrate mechanical counters/cameras with personal observations. Personal observation can also be used to estimate the number of People Per Vehicle (PPV). Visitor sample interviews allow estimation of use at a more detailed spatial scale, for example a trail segment, and are especially useful under uncontrolled access scenarios. A list of citations that we have found helpful in developing our pilot program can be found in Appendix 2.

Editor's Note: Yuan et al. (1995) is a good reference evaluating the benefits and costs of using mechanical counters, cameras, or personal observation (see Appendix 2)

Air Quality Assessment of Snowmobile Emissions

Mark Scruggs

The principal air quality related issues associated with snowmobile pollutant emissions are compliance with the National Ambient Air Quality Standards, assessment of the allowable air quality deterioration specified by the Prevention of Significant Deterioration regulations, and effects on visibility. Comparing estimated emissions with EPA emission standards, one could make a qualitative assessment of need for monitoring of MTBE, or any hazardous pollutant. If EPA efforts to remove MTBE from gasoline are successful, then such monitoring need not be conducted.

Snowmobile Emissions

Snowmobile emissions are most appropriately determined using emission factors developed under laboratory conditions. These emission factors are multiplied by appropriate numbers, representing the operation of the snowmobile under certain analysis conditions, to get the emission of a specific pollutant. For example, if the carbon monoxide emission factor for snowmobiles is 300 gram/hp-hr (emission factor) and the snowmobile is operated for 1-hour at 50-hp (activity level), its carbon monoxide emissions would be 15,000 grams. The emission data on snowmobiles is limited, but EPA has recently completed tests that have greatly improved emission estimates.

Consequently, detailed information on the number and speed of vehicles in an area or passing down a trail, queue-up at an entrance station or idling at a park feature, and the amount of time each vehicle spends in the different mode of operation is crucial to getting good estimates of emissions.

Also, because the question will be forthcoming, it is a good idea to also estimate the emissions from other types of vehicles operating in the park throughout the year, e.g., automobiles, RVs, and trucks. Comparison of the relative contribution of snowmobile and non-snowmobile emissions can then be made.

Ambient Measurements

For purposes of these proceedings it is assumed that relevant existing ambient air quality data in or near the NPS unit do not exist. In any case, it is unlikely that monitoring equipment will have been sited to assess snowmobile impact. It is more likely sited to assess regional influences on park air quality. However, if such measurements were available, they would provide an indication of current air quality levels and might serve as benchmarks with which to qualify contributions from snowmobiles, or other sources. Also, if the measurements were made with EPA reference methods, indication of compliance with National Ambient Air Quality Standards would be possible. Therefore, they would be useful to indicate a need for further analysis and possible regulatory action under the Clean Air Act.

If monitoring does not exist or needs to supplemented, new measurements would have to be undertaken. Long-term and event, or short-term, monitoring efforts should comprise carbon monoxide, particulate matter ($PM_{2.5}$ and PM10), and visibility. Monitoring should be conducted in congested areas, areas with high traffic, areas where poor air dispersion is expected, and areas where the vehicle operation would be expected to cause maximum emissions. The air quality modeling analyses should be conducted as a complement to the monitoring activities. These analyses could provide some insight on desired monitoring locations and a means of assessing the effect of management alternatives.

Several strategically placed monitors would be required to accurately assess the air quality associated with existing conditions or a particular management alternative. Monitoring equipment should include continuous monitoring of carbon monoxide, 24-hour sampling of particulate matter, continuous sampling of key meteorological variables, and time-lapse video for documenting the impact to visibility. Federal Reference Methods should be used where applicable and possible. The monitoring program would suffer from the difficulty in evaluating the effect on ambient concentrations from changes in use patterns and it would not be definitive in distinguishing between snowmobile emissions and other sources. If monitoring is required, estimates can run from $25,000 to $100,000 for one season.

Air Quality Modeling
The data collection identified above concerning emissions and activity patterns and levels would have to take place to do reasonable air quality modeling. On-site meteorological data would need to be collected as well as accurate vehicle count and activity patterns and levels. The modeled concentrations will be directly proportional to the emission data that is used as input. The available data indicate that the emissions vary greatly depending on the engine speed and operating conditions.

Even with all the aforementioned data, there will be a lot of uncertainty in the results. Also, the air quality models available for simulating snowmobile particulate emissions are not necessarily well suited to the task. A number of assumptions need to be built in to the analysis, any of which can unduly influence the outcome of the analysis. This is not unique to snowmobile analyses, but is a factor that should be considered.

The current visibility models are primarily set up to look at the impacts of point sources over at least tens of kilometers. Calculating the air quality contribution of snowmobiles to ambient conditions therefore necessitates some adjustments and non-traditional application of typical visibility models. It is anticipated that the "plume" from snowmobiles would be relatively small and might not be well simulated by the model.

The advantage of modeling is that a greater number of situations can be examined in terms of meteorological conditions and in terms of throughput scenarios and use patterns. The model can also be used to calculate concentrations at a number of locations and to assess projected changes in snowmobile activity. One of the challenges with using the model will be to accurately specify the emissions and use patterns. Without further data collection as described under new measurements, the reasonableness of the assumptions used in the model cannot be verified.

Assessment Approach

Because each assessment will be unique, it is impossible to adopt or recommend a one-size-fits-all approach. The general guidelines and data needs have been outlined above. In general the park staff will have to assist with the collection of the activity data, working closely with those responsible for estimating the emissions and conducting modeling analyses (contractor, Air Resource Division). Ambient monitoring will, of course, require assistance of park staff with siting and servicing the instruments.

Noise issues relevant to snowmobile effects on wildlife

Rick Ernenwein

There are a few details about noise and noise measurement that might significantly affect the design of studies primarily focused on wildlife response. It doesn't make sense to measure the noise before you establish that it is having an important effect. However, once you establish that noise has an important effect on a species, you have to know quite a bit about the noise itself before you can say much about why it is having the effect or what might be done to mitigate the effect.

What is noise?

Noise is a very complex phenomenon. A single decibel level reading does not provide adequate information to assess an animal's noise exposure. Sound energy from a noise source forms a complex pattern of energy levels across a broad spectrum of sound frequencies. Animals tend to be most sensitive to discrete portions of the frequency spectrum (i.e., for different types of communication, predator/prey detection/avoidance, etc.). Noise also varies greatly over time and space, and in the case of snow machines, it also varies with such factors as operator behavior, terrain, vegetation, meteorology, power settings, other sound sources, and a host of other variables (most of which are difficult or impossible to control).

To assess the effects of noise on the various species groups you have to know something about the sensitivity of the species groups to various portions of the frequency spectrum. Then, you must compare the species' sensitivity to the portions of the frequency spectrum where the noise from various types of snow machines tends to concentrate. I believe this is the only way to begin to get a sense for where the most likely and most serious impacts will be, and also where it might make the most sense to concentrate mitigation (e.g., reduce noise in the most critical portions of the frequency spectrum).

Noise effects are probably species-specific, not only because of variations in hearing ranges between species, but simply because of different species' sensitivity and adaptability: a nervous marmot compared to an oblivious bear, for example. However, I am fond of telling aviation groups who see considerable habituated wildlife around airports that in national parks where we are supposed to preserve unimpaired natural conditions, habituation can be a serious impairment of the resource!

Another complicating issue relates to inaudible low frequencies, including vibration. These low frequencies could induce similar effects to those caused by audible noise, and again, are probably species-specific (e.g., infrasound products for getting rid of moles in your yard and mice in your house). Measurements must be taken over a very wide frequency range to address both low-frequency noise and vibration to very high frequency vocalization and even ultra (to humans) sound (e.g., dog whistles, bats).

Defining sampling plans
What noise measurers probably need most from the biologists are: the species that are present in a study area (by time of year), their activities that could be disturbed (by time of year), their hearing frequency ranges and sensitivities, and any known or suspected noise effects, even if done without collection of noise data. Then, knowing the "needs," the acousticians could better define specific sampling plans for the noise component, and integrate the noise component with the wildlife effect component of a study.

Status of water quality monitoring method development

Mark Van Mouwerik

Protocols for monitoring water quality for the presence (and effects) of snowmobile contaminants are currently under development. The Water Resources Division's (WRD) initial research into this area encountered a paucity of literature on the sampling and assessment of low-level hydrocarbon contamination in environmental media from snowmobiles. Basic questions remained, such as: do snowmobile contaminants even enter receiving waters at levels above background; if so, when during snowmelt do they enter and how long do they persist in the water column; do they bind to sediment and remain there, and if so, for how long; what is the best way to collect samples (e.g. grab samples, semi-permeable membrane devices (SPMD), composite samples, etc.); how many samples must be collected to be statistically valid and make the data defensible; can similar contamination from other sources be separated out; etc.

To address these questions, WRD is currently co-developing with the USGS-BRD, Columbia Environmental Research Center, study plans that will define the occurrence of snowmobile contaminants in the environmental media of snow, water, sediment, and soil (some or all of these). Based on these findings, a water quality monitoring protocol will be developed for use in Parks.

The protocol will include guidance on:

- What contaminants to test for.
- What environmental media to sample (e.g. snow, water, sediment, soil)
- How to collect samples (grab samples? SPMDs? Composite samples? Where in the water column? Containers and holding times, etc.)
- What "clean techniques" to use (Decontamination procedures, etc.) Detection levels for polycyclic aromatic hydrocarbons (PAHs) will be in the parts-per-trillion range (current state-of-the-art), so clean technique is crucial.
- How many samples to collect.
- When to sample (During melt—beginning, middle, end? Before and after melt? Throughout the year?)
- Where to sample (Areas of greatest possible impact only? In-trail puddles?)
- How to collect good background data for comparison.
- Differentiating, if possible, snowmobile contamination from other sources like cars/trucks and other air pollution deposition.

Characteristics of a good monitoring protocol

Steven G. Fancy

Why do we need Monitoring Protocols?

A well-developed, field-tested, and reviewed monitoring protocol is a critical component of quality assurance for any monitoring program. Quality assurance can be defined as "the policy, procedures, and systematic actions established for the purpose of providing and maintaining a specified degree of confidence in data integrity and accuracy throughout the lifecycle of the data, which includes input, update, manipulation, and output." The whole purpose of monitoring is to detect and document change over time. When attempting to scientifically detect and document change based on resource sampling, we must use a very consistent and exactly repetitive method of collecting and recording data. Otherwise, it is not possible to determine if the changes observed within the sample data are a result of the method by which the samples were obtained or of actual changes in the resource being monitored. This requires that very detailed and exacting monitoring protocols be established at the start of any long-term monitoring project. Monitoring protocols are:

- A key component of quality assurance of a monitoring program to ensure that data meet defined standards of quality with a stated level of confidence;
- Necessary for the program to be credible, so that data stand up to external review;
- Necessary to detect changes over time and for the program to survive turnovers in personnel;
- Necessary to allow comparisons of data among places/agencies.

What should be included in a good Monitoring Protocol?

If a protocol is to meet the objectives listed above, it needs to be much more than a detailed description of field methodology. A good monitoring program will be well thought out and have a high probability of detecting change in the resource being monitored. It is important to make a large up-front investment in the development of the monitoring program and to clearly represent this investment in the protocol document. It has been said that designing a monitoring project is a lot like getting a tattoo–you want to get it right the first time, because making major changes later can get messy and will be painful. Careful documentation of the questions being asked; the sampling framework; step-by-step procedures for collecting, managing and analyzing the data; and expectations on how the data will be presented and used are all part of "getting it right the first time." A good monitoring protocol will include extensive testing and evaluation of the effectiveness of the procedures up front, before they are accepted for long-term monitoring.

No matter how much advanced planning goes into protocol development, minor changes and improvements in such things as methodology and approaches to data analysis and reporting are to be expected, and periodic reviews and improvements to protocols should be a part of the program. For this reason, it is recommended that a monitoring protocol consist of three parts:

1. The Protocol Narrative: An overview of the various components of the protocol, including the resource issue being addressed, measurable objectives, sampling design, field methodology, data analysis and reporting, personnel requirements, training procedures, and operational requirements. Details for the various components should be provided in the SOPs.
2. A series of Standard Operating Procedures (SOPs) that are periodically updated and that present the details on how all aspects of the components described in the narrative will be carried out. The SOPs should be written in the form of instructions, with step-by-step details of how to carry out the procedure. One of the SOPs should explain the procedure for making revisions to the protocol and archiving previous versions, and each SOP should include its revision history. Data sets should also indicate which version of the protocol was being used when the data were collected. The number and content of the SOPs are determined by the principal investigators who develop them.
3. Supplementary materials such as example databases, maps and photographs.

Recommended Format for the Protocol Narrative:

- Background and Objectives
    - Background/history—describe resource issue being addressed
    - Rationale for selecting this resource to monitor
    - Measurable objectives
- Sampling Design
    - Rationale for selecting this sampling design over others.
    - Site selection
        - Criteria for site selection—define the boundaries or "population" being sampled
        - Procedures for selecting sampling locations—stratification, spatial design
    - Sampling Frequency and Replication
        - Recommended number and location of sampling sites
        - Recommended frequency and timing of sampling
        - Level of change that can be detected for the amount/type of sampling being instituted.
- Field Methods
    - Field season preparations and equipment setup (including permitting/compliance procedures)
    - Sequence of events during field season
    - Details of taking measurements, with example field forms
    - Post-collection processing of samples (e.g., lab analysis, preparing voucher specimens)
    - End-of-season procedures

- Data Handling, Analysis and Reporting
  - Metadata procedures
  - Overview of database design
  - Data entry, verification and editing
  - Recommendations for routine data summaries and statistical analyses to detect change
  - Recommended report format with examples of summary tables and figures
  - Recommended methods for long-term trend analysis (e.g., every 5 or 10 years)
  - Data archival procedures
- Personnel Requirements and Training
  - Roles and responsibilities
  - Qualifications
  - Training procedures
- Operational Requirements
  - Annual workload and field schedule
  - Facility and equipment needs
  - Startup costs and budget considerations
- References

Acknowledgments: The content of these guidelines is based largely on work by Lisa Thomas of the Great Plains Prairie Cluster LTEM program of the NPS and Karen Oakley of the USGS/BRD working with the Denali NPP LTEM program. Their contributions are appreciated.

Workgroup Charge

The purpose of this workshop was to examine and discuss a series of protocols for land managers to monitor snowmobile effects on wildlife. The University of Idaho conducted a survey to define and prioritize management information needs. This information and all other background described below was put in a reference binder for each workgroup.

The teams were charged to:

- Focus specifically on the management needs assigned (from the survey).
- For each need, assess what scientific evidence is available.
- For each need, decide whether the need can be met currently. If so, is the need best met through monitoring, research, or both. The Need Assessment forms provided were to be completed for each need.

For those needs best met through monitoring:

- Focus initially on acute effects.
- Focus on how to measure wildlife responses primarily, rather than specific techniques for monitoring the dose (number of snowmobiles, noise, water quality, or air quality.) Request assistance from experts in those areas to develop the dose aspect of your protocol if it does not already exist.
- Consider whether current techniques can be adapted to meet the need.

Consider for each protocol:

- Strengths, weaknesses, and other qualities. Refer to *Characteristics of a Good Monitoring Protocol*. The protocol evaluation matrix was to be completed to evaluate the protocols developed/adapted and to present results.
- How to evaluate the success of this monitoring technique.
- How land-ownership boundaries affect the monitoring protocol (i.e., Should monitoring occur in cooperation with adjacent land-owners? Is snowmobile use on adjacent land affecting the wildlife that you are monitoring?)
- Whether and how to move from monitoring acute effects to effects at larger biological scales (i.e., By tracking population abundance could one move to population level effects?)
- Whether and how to move from monitoring to an experiment (e.g., concurrently monitoring a no or low-snowmobile use area, or monitoring changes in response with changes in snowmobile use or emission patterns.) See Gutzwiller (1991).*

*Gutzwiller, K.J. 1991. Assessing Recreational Impacts on Wildlife: The Value and Design of Experiments. Trans. 56th N.A. Wildl. & Nat. Res. Conf.

Workgroup Needs Assessments

Aquatics

Birds

Small Mammals

Ungulates

Forest Carnivores

Bears

Aquatics

Participants: Robin Calfee-Workgroup Leader, Bob Rossman-Facilitator, Laura Hudson-Recorder, Larry Kallemeyn, Chris Marwood, Debra Patla, Gary Rosenlieb, Jim Tilmant, Mark Van Mouwerik

Issue Overview and Organization

Key Unknowns—What are the fate and effects of snowmobile use and exhaust on aquatic species and how susceptible are species of concern to the sources of impact?

Source of Impact

- What is the stressor?
  - Snowmobiles
    - Potential problems: The release of PAHs into environment due to inefficient use of fuels, nutrient loading due to erosion from snowmobile use, changes in buffering capacity of aquatic systems, BTEX, MTBE, metals, physical impacts, and noise.

Transport Mechanism

- Routing "Fate" How does the contaminant or stressor reach the target organisms?
  - Through Medium: Air, water/snow, proximity, persistence of source in medium (how long is it toxic?), mobility of contaminant (how readily is it available).

Response—Effect on target (species) of concern

- Survival, reproduction, behavior, physiology, population diversity, abundance, distribution, food chain connections

Effect relative to a standard or threshold (LC50)

- This is the lethal concentration of a contaminant at which 50% of the population is affected, based on controlled laboratory studies. Using LC50 values is a standard practice in toxicology. How much source (stressor or contaminant) produces an unacceptable response?

Guidance Statement

- Document the occurrence of impacts from snowmobiles in or on the habitats of concern.

Issue: Effects of Snowmobile Emissions via Chemicals (Sediment/Water) on Fish and their Habitat

Problem Definition:
Snowmobiles emit chemicals with toxic effects on survival, reproduction, behavior, and physiology of fish.

For Species/Guilds:
Brook trout, others

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Adams. 1975.	Effects were reduced stamina for caged fish in ponds; concentrations in fish tissues had physiological effects.
Lots of PAH studies	

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Do snowmobile contaminants as listed* affect the physiology of fish?			X	**If research indicates problems, monitoring should occur.
Do snowmobile contaminants as listed* affect the reproduction of fish?			X	
Do snowmobile contaminants as listed* affect the behavior of fish?			X	
Do snowmobile contaminants as listed* affect the survival of fish?			X	
Toxic and contaminant (as listed*) persistence and mobility in fish habitats?			X	

* Contamination and toxic levels of metals, PAHs, nutrients, acid precursors, BTEX, MTBE.

Issue: Effects of Snowmobile Emissions via Chemicals (Sediment/Water) on Amphibians and their Habitat

Problem Definition:

Snowmobiles emit chemicals with toxic effects on survival, reproduction, behavior, and physiology of amphibians in both terrestrial and aquatic ecosystems.

For Species/Guilds:

Amphibians

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Canadian Wildlife Service. 1989.	Evaluation of the amphibian toxicology literature.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Do snowmobile contaminants* affect the physiology of amphibians?			X	**If research indicates problems, monitoring should occur.
Do snowmobile contaminants* affect the reproduction of amphibians?			X	
Do snowmobile contaminants* affect the behavior of amphibians?			X	
Do snowmobile contaminants* affect the survival of amphibians?			X	
Toxic and contaminant* persistence and mobility in amphibian habitats?			X	
Inventory of breeding habitat for amphibians (area-specific)			X	

* Contamination and toxic levels of metals, PAHs, nutrients, acid precursors, BTEX, MTBE.

Issue: Effects of Snowmobile Emissions via Chemicals (Sediment/Water) on Invertebrates and their Habitat

Problem Definition:

Snowmobiles emit chemicals with toxic effects on populations of invertebrates regarding species biodiversity, distribution, and abundance.

For Species/Guilds:

Invertebrates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Erickson et al. 1999 Forese et al. 1998 Kemball et al. 2000. Sheedy et al. 1998.Ankley, Ingersoll, Little.	PAH effects on invertebrates.

Needs:

Need	Currently Can Be Addressed Via:			
	Cannot	Monitoring	Research	Reason(s)
Do snowmobile contaminants as listed* have toxic properties that affect species biodiversity of invertebrates?			X	If research indicates problems, monitoring should occur.
Do snowmobile contaminants as listed* have toxic properties that affect species abundance and distribution of invertebrates?			X	
Given changes in invertebrate populations, what is the extent of effect on other species in the food chain?			X	
Inventory of invertebrates (area-specific)			X	

* Contamination and toxic levels of metals, PAHs, nutrients, acid precursors, BTEX, MTBE.

Issue: Effects of Sediment Loading (Mechanical/Physical) by Snowmobiles on Amphibians and Fish

Problem Definition:
Snowmobiles cause sediment loading in receiving waters for runoff, which affects habitat components of channel systems.

For Species/Guilds:
Amphibians and fish

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
	Many models on sedimentation, but need the data.

Needs:

Need	Currently Can Be Addressed Via:			
	Cannot	Monitoring	Research	Reason(s)
Inventory sediment source sites where snowmobiles frequent (staging areas), potentially affecting aquatic environments.		X		
Measure sediment loads and scouring adjacent to source sites as they affect biologic components such as spawning, cover habitat, and macroinvertebrate drift.		X		

Issue: Effects of Mechanical Disturbance, Including Noise, on Habitat for Cold-blooded Vertebrates.

Problem Definition:
Snowmobiles can impact wetland and aquatic habitat function.

For Species/Guilds:
Cold-blooded vertebrates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
BLM	Functionality parameters for wetlands.

Needs:

Need	Currently Can Be Addressed Via:			
	Cannot	Monitoring	Research	Reason(s)
Inventory of wetlands/vernal pools.			X	
Develop a working hypothesis for how snowmobiles impact wetlands (riparian vegetation and hydric soils).			X	
How does mechanical disturbance (noise and vibration) affect the breeding habitat and behavior of amphibians?			X	

Research Priorities

1. Determine the presence, persistence, and mobility of contaminants from snowmobiles in aquatic habitats.

    <u>General Methods:</u> Identify susceptible habitats that are exposed to snowmobile emissions. Set up samples to identify concentrations of contaminants moving away from the source.

    <u>Contaminants of Concern:</u>

    <u>PAHs</u>: Deployment of SPMDs (fat bags) during strong runoff in snow and water. Collect sediment core samples. Extract and quantify PAHs (HPLC).

    <u>Metals</u>: Sample collection of snow and water using standard protocols for metals. Focus on metals emitted from snowmobiles. PH (water quality parameters).

2. Determine the level of contaminants that are toxic to fish.

    <u>General Methods:</u> Look at exposure of fish to contaminants in the laboratory environment with field sampled water. Simulate sunlight (UV) exposure based on field levels (photo-induced toxicity). Perform same method with *in situ* caged fish.

    <u>Contaminants of Concern:</u>

    <u>PAHs</u>: Possible endpoints
    - EROD (liver disfunction)
    - Lethality (LC50 assays)
    - Hatching success
    - Developmental abnormalities

    <u>Metals</u>: Possible endpoints
    - Lethality (LC50 assays)
    - Hatching success
    - Developmental abnormalities
    - Behavior
    - PH (water quality parameters)–changes in pH can sequester certain metals

3. Determine the level of contaminants that are toxic to amphibians.

    <u>General Methods:</u> Use contaminated field water and expose amphibian eggs through metamorphosis, then track hatching success, deformities, and mortality.
    <u>Laboratory protocols</u>:
    Simulate sunlight (UV) exposure based on field levels (photo-induced toxicity). Expose "clean" adult amphibians to field collected contaminated water.
    Perform *in situ* analyses on larvae.

Contaminants of Concern:

PAHs: Possible endpoints
- EROD (liver disfunction)
- Lethality (LC50 assays)
- Hatching success
- Developmental abnormalities

Metals: Possible endpoints
- Lethality (LC50 assays)
- Hatching success
- Developmental abnormalities
- Behavior

4. Determine the level of contaminants that are toxic to invertebrate populations.

General Methods: Look at exposure of invertebrates to contaminants in the laboratory environment using field sampled water. Simulate sunlight (UV) exposure based on field levels (photo-induced toxicity).

Contaminants of Concern:

PAHs: Lethality (LC50 assays)
- Reproduction
- Abundance and diversity
- Abnormalities
- Behavior

Metals: Lethality (LC50 assays)
- Reproduction
- Abnormalities
- Behavior

5. Develop a working hypothesis for how snowmobiles impact wetlands (riparian vegetation, hydric soils, introduction of non-native species as habitat concerns).

General Methods: Identify habitats at risk from snowmobile use. Identify specific physical impacts on vegetation, soils (habitat) from snowmobiles. Identify aquatic species of concern related to types of impacts incurred.

Sources of Concern:
Vernal pools, snow/soil compaction, vegetation changes, changes in soil moisture, loss of substrate, and physical loss of vegetation.

6. Determine the extent to which mechanical disturbance by snowmobiles (and groomers) affects the breeding habitat and behavior of amphibians.

General Methods: Identify whether breeding activity occurs at such times when snowmobiles are present. If so, study impacts of noise and vibration on breeding behavior. Do comparative study—unimpacted vs. impacted habitat and population. Use radio telemetry studies to detect avoidance of "used" habitats by amphibians.

Monitoring Protocols

The aquatics group did not identify any monitoring protocols.

References

Adams, Evelyn S. 1975. Effects of lead and hydrocarbons from snowmobile exhaust on brook trout (*Salvelinus fontinalis*). Trans. Amer. Fish. Soc. 2:363-373.

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Forese, K.L, D.A. Verbrugge, G.T. Ankley, G.J. Niemi, C.P. Larsen, J.P. Giesy. 1998. Bioaccumulation of polychlorinated biphenyls from sediments to aquatic insects and tree swallow eggs and nestlings in Saginaw Bay, Michigan, USA. Environmental Toxicology and Chemistry. 17 (3) 484-492.

Kemble, N.E., D.G. Hardesty, C.G. Ingersoll, B.T. Johnson, F.J. Dwyer, D.D. MacDonald. 2000. An evaluation of the toxicity of contaminated sediments from Waukegan Harbor, Illinois, following remediation. Archives of Environmental Contamination and Toxicology. 39(4): 452-461.

Sheedy, B., V.R. Mattson, J.S. Cox, P.A. Kosian, G.L. Phipps, G.T. Ankley. 1998. Bioconcentration of polycyclic aromatic hydrocarbons by the freshwater oligochaete Lumbriculus variegates. 36 (15) 3061-3070.

Birds

Participants: Terry Grubb–Workgroup Leader, Jonathan Bayless–Facilitator, Virginia Reams–Recorder, Clait Braun, Al Harmata

Issue Overview and Organization

For ease of determining monitoring protocols, birds were grouped into the following categories:

- Raptors (eagles, owls, hawks)
- Scavengers (jays, ravens, etc)
- Plant Eaters (grouse, ptarmigan, swans)
- Insectivores
- Piscivorous Waterfowl

The presence of snowmobiles may:

- Alter bird behavior–causing flush/avoidance, attraction, and/or habituation–and affect roosting and prebreeding of birds.
- Cause avian mortality due to collision, predation, or harvest.
- Alter bird habitat due to vegetation damage, trail construction, or snow compaction.
- Release contaminants that affect birds.

Issue: Acute Effects of Snowmobiles on Bird Behavior

Problem Definition:
Snowmobiles disturb avian behavior, which may affect distribution, survival, and productivity.

For Species/Guilds:
Raptors, scavengers, plant eaters, and piscivorous waterfowl

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Delaneyet al. 1999.	Effects of helicopter noise on spotted owls.
Grubb and King. 1991.	Using classification tree models to assess human disturbance on breeding bald eagles.
Grubbet al. 1992.	Responses of breeding bald eagles to human activity.
Stalmaster and Newman. 1978.	Behavioral responses of wintering bald eagles to human activity.
Stalmaster and Kaiser. 1998.	Effects of recreational activity on wintering bald eagles.
McGarigal et al. 1991.	Interactions of humans and bald eagles.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Document winter use patterns (flush/avoidance, attraction, foraging, roosting).		X		Refined consolidation of original survey issues.
Document pre-breeding territory establishment		X		Only "nesting issue" during winter.
What are the effects of snowmobiles on winter use patterns (flush/avoidance, attraction, habituation, foraging, roosting)?			X	Research aspects to determine effects—we don't know if there is an effect.
What are the effects of snowmobiles on pre-breeding territory establishment?			X	Research aspects to determine effects—we don't know if there is an effect.

Issue: Acute Effects of Snowmobiles on Avian Habitat

Problem Definition:
Snowmobiles alter suitability of avian habitat.

For Species/Guilds:
Plant eaters and insectivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Neumann and Merriam. 1972.	Ecological effects of snowmobiles
Wanek. 1971.	Effects of snowmobiles on vegetation, temperatures, and soil microbes.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Document/investigate SM damage to vegetation.		X	X	Loss of forage.
Document/investigate effects of trail creation or widening.		X	X	Loss of habitat.
Document/investigate effects of compaction of snow surface.		X	X	Survival of roosting birds.

Issue: Acute Effects of Snowmobiles on Avian Mortality

Problem Definition:
Snowmobiles induce mortality of birds by collision, predation, and harvesting.

For Species/Guilds:
Raptors, scavengers, plant eaters, insectivores, and piscivorous waterfowl

Previous Monitoring Efforts/Research Addressing This Issue:
None

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Document collisions.		X		Little known, but potential problem.
Document increased vulnerability to predation.		X		Little known, but potential problem.
Document effects of snowmobiles on harvesting.		X		Regulatory issue for game departments.

Issue: Effects of Contaminants from Snowmobiles on Birds

Problem Definition:
Snowmobiles increase contaminant levels in avian habitats, with unknown effects.

For Species/Guilds:
Raptors, scavengers, plant eaters, insectivores, and piscivorous waterfowl

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Yellowstone internal report. Recent.	

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
What are the effects of contaminants on birds?			X	Potentially negative effects of toxic contaminants.

Research Priorities

1. What are the effects of snowmobiles on winter use patterns?
    - on flush/avoidance?
    - on foraging (if unknown locations)
    - on roosting (if unknown locations)
    - on habituation?
    - on attraction?

2. What are the effects of snowmobiles on pre-breeding territory establishment?

3. What are the effects of snowmobiles on vegetation?

4. What are the effects of compaction by snowmobiles on bird habitat?

5. What are the effects of snowmobile trail creation/widening on bird habitat?

6. What are the effects of contaminants from snowmobiles on birds?

Monitoring Protocols

Many of the issues associated with the effects of snowmobiles on birds will require research. In cases where the effect is unknown (effects on winter use patterns and pre-breeding territory establishment, and effects of contaminants) or where the extent of the effect is unknown (damage to vegetation, effects of trail creation or widening, and effects of compaction of snow surface), research is necessary. In the meantime, however, some of the information needs can be addressed through monitoring for changes.

This group defined three monitoring protocols:

- Document changes in distribution and abundance due to snowmobiles over time (includes avoidance/attraction). If locations of roosting and foraging locations are known, then changes can be monitored.
- Document changes in bird habitat (includes vegetation damage due to snowmobile use and effects of trail clearing or widening, and snow compaction).
- Document mortality (includes collision, predation, and harvest).

References

Delaney, D.K., T.G. Grubb, P. Beier, L.L. Pater, and M.H. Reiser. 1999. Effects of helicopter noise on Mexican spotted owls. Journal of Wildlife Management 63:60-76.

Grubb, T.G., and R.M. King. 1991. Assessing human disturbance of breeding bald eagles with classification tree models. Journal of Wildlife Management 55:500-511.

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Stalmaster, M.V., and J.L. Kaiser. 1998. Effects of recreational activity on wintering bald eagles. Wildl. Monogr. 127.

Wanek, W.J. 1971. Snowmobiling impact on vegetation, temperatures, and soil microbes. Pages 117-130 in Snowmobile and off-road vehicle research symposium proceedings. Technical Report Number 8. Department of Park and Recreation Resources, Michigan State University, Lansing, Michigan, USA.

Small Mammals

Participants: Joe Merritt-Workgroup Leader, Ed Krumpe-Facilitator, John Sacklin-Recorder, Bruce Wunder, Tabitha Graves

Issue Overview and Organization

When snow is compacted, the depth hoar may be crushed and thus destroy subnivean runways of small mammals. The lack of runways forms a barrier to movement of small mammals and increases winter habitat fragmentation. This can result in:

- Decreased food availability (access to food for all subnivean species—an acute impact).
- Decreased genetic variation (long-term impact only for those that breed under the snow, but probably not a major issue).
- Increased vulnerability to predators (acute impact—not thought to be a major issue for subnivean species unless they come to the surface).

These physical changes to the small mammal's microclimate can:

- Increase thermoregulatory costs (acute impact for subnivean species but not for hibernators).
- Delay plant phenology (delays food availability when they need it—possible mortality to arousing hibernators (acute impact), interferes with reproduction for subnivean species (long-term impact)).

Compaction of the snow may also:

- Increase surface density, resulting in increased predation (or harvest) of small supranivean mammals (hares and rabbits).

Issue: Decreased Food Availability and Changes in Diet

Problem Definition:

Snow compaction crushes movement tunnels in the depth hoar, forming a barrier to animal movement and increasing habitat fragmentation, resulting in decreased access to the full range of food that would be normally be available. This is an acute impact (starvation) to subnivean species.

For Species/Guilds:

Subnivean herbivores, insectivores, and both supranivean and subnivean carnivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Merritt and Merritt. 1978b.	Food habits below the snow, population ecology, energy, *C. gapperi.*
Marchand. 1996.	General review of the literature pertaining to cold adaptation.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Food habits.			X	There is very little information on what subnivean mammals eat.

Issue: Decrease Genetic Variability

Problem Definition:
Snowmobile trails may compact the snow, crushing movement tunnels, forming a barrier to movement and increasing habitat fragmentation; decreased genetic variation may occur as a result. This is a long-term impact only for those that breed under the snow, but probably it is not a major issue.

For Species/Guilds:
Herbivores (*Clethrionomys* sp)

Previous Monitoring Efforts/Research Addressing This Issue:
None

Needs:

Need	**Currently Can Be Addressed Via:**			**Reason(s)**
	Cannot	**Monitoring**	**Research**	
Look at population genetics of subnivean fauna.			X	No information is available.

Issue: Increased Vulnerability to Predation of Small Supranivean Animals

Problem Definition:

Snowmobile trails compact the snow. Compaction increases surface density and provides an energy-efficient way for predators to travel across snow-covered areas to deeper snow. It is easier for them to increase predation on supranivean small mammals, such as rabbits and hares, and mice and voles.

Harvest from hunting or trapping may increase because of easier access to areas via snowmobiles.

For Species/Guilds:

Herbivores and carnivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	**Description**
Neumann and Merriam. 1972.	Snowmobiles, hare & fox distributions.

Needs:

The forest carnivore group identified needs that address this issue.

Issue: Increased Thermoregulatory Costs

Problem Definition:
Snowmobile trails compact the snow, increasing snow density and thermal conductivity of snow, which changes the microclimate of the snow. Also crushed snow tunnels may require reestablishment and significant energy expenditures by small mammals. Compaction changes the microclimate, increasing thermoregulatory costs for the subnivean fauna. This may be an acute impact for subniveans, but probably not for hibernators.

For Species/Guilds:
Herbivores and insectivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Coulianos and Johnels. 1962.	Subnivean environment.
Courtin et al. 1991.	Seasonal snow cover and nest temperatures of voles.
Evernden and Fuller. 1972.	Light alteration.
Formozov. 1946.	Snow cover
Jarvinen and Schmid. 1971.	Snowmobiles, mortality
Johnson. 1954.	Microclimates.
Marchand. 1996.	Review, snow morphology, plants.
Merritt. 1984, 1983.	Winter ecology.
Merritt and Merritt. 1978a.	Population ecology, energy.
Neumann and Merriam. 1972.	Snowmobiles, hare & fox distributions, browse plants.
Pruitt. 1957,1960,1965, 1978.	Snow cover and microclimatic conditions.
Sadler and Conaway. 1971.	Influence of snow and ice on reproduction of rabbits
Sanecki. In prep.	Habitat, modified snowpack.
Schmid. 1971.	Snowmobiles, snow compaction .
Wunder. 1992.	Brown adipose tissue.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Understand the temperature and density gradients in the snow that may increase conductive heat loss for small mammals.		X		We know a great deal about the relationships of temperature and metabolism.
Brown fat analysis.		X		Brown fat is an indicator of the temperature that the animals have been exposed to.

Issue: Delay of Plant Phenology

Problem Definition:

Snowmobile trails compact the snow. Compaction changes the microclimate and may delay plant phenology by creating compacted snow and ice that is retained later in the year. This delays food availability when the emerging hibernators need it, which can cause possible mortality to hibernators (acute impact). This may also interfere with reproduction for subnivean small mammals in terms of breeding under photo-availability cues (long-term impact).

Compacted snow and ice may prevent emergence of animals, especially for those on a circumannular schedule.

For Species/Guilds:

Herbivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Stangl. 1999.	Effects of winter recreation on wildlife.
Salisbury. 1984.	Plant changes below snow.
Marchand. 1996.	Winter ecology: abiotic and biotic factors.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Establish the relationship between plant phenology and snowmobile compaction.		X	X	The relationship is not well understood, but after some research a monitoring mode would work.
Establish the relationship between compaction and emergence.			X	
Establish the relationship between delay of phenology and food stress (mortality and reproduction changes).			X	

Issue: Increased Vulnerability to Predation

Problem Definition:

Snowmobile trails compact the snow. Compaction crushes movement tunnels forming a barrier to movement and increasing habitat fragmentation, which increases vulnerability to predators. This is thought to be an acute impact, but not believed to be a major issue for subniveans because it only occurs when subnivean small mammals come to the surface.

For Species/Guilds:

Subnivean Insectivores, herbivores, and carnivores (plus supranivean species, such as weasels that are predators but become prey to raptors if they go above the surface of the snow)

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	**Description**
Drickamer and Stuart.* 1984.	*Peromyscus;* eastern North America, supranivean movements.
Green.* 2000.	Activity on snow surface.
Sanecki.* In prep.	Habitat, modified snowpack.

*These papers say this is possible; they did not research the topic.

Needs:

Need	**Currently Can Be Addressed Via:**			**Reason(s)**
	Cannot	**Monitoring**	**Research**	
Determine predator/prey relationships for supranivean and subnivean fauna.			X	We are not sure how much is known about predator/prey relationships for supranivean or subnivean fauna irrespective of disturbance factors like snowmobiles.
How do snowmobile trails alter the prey availability for predators? Do the trails cause subnivean fauna to travel supranivean, and does this expose the subnivean fauna to supranivean predation?			X	No research on topic.

Research Priorities

1. How does snow compaction and loss of depth hoar affect food availability for small mammals? Could determine what subnivean animals eat through stomach analysis. Could use capture/recapture and radiotelemetry techniques to determine movement patterns.

2. Establish the relationship between delay of phenology and food stress for hibernators and non-hibernators (mortality and reproduction changes, respectively).

3. Establish the relationship between compaction and emergence of hibernators.

4. Does snowmobile compaction affect accessibility to prey by expanding predators' foraging range?

   We are not sure how much is known about predator/prey relationships for supranivean or subnivean fauna irrespective of disturbance factors like snowmobiles.

5. Is population genetics of subnivean fauna affected by fragmentation due to snow compaction of depth hoar?

6. Establish the relationship between plant phenology and snowmobile compaction.

7. Does compaction of depth hoar affect brown adipose tissue?

8. Do the trails cause subnivean fauna to travel supranivean (subnivean small mammals moving to the surface when they encounter compacted depth hoar), and does this expose the subnivean fauna to supranivean predation by predatory species (e.g., mustelids, canids, felids)?

Monitoring Protocols

Determining specific effects of snowmobiles on small mammals will require research. However some of this research could be conducted in a monitoring context. Methods for monitoring snow characteristics with the potential to affect small mammals have been developed and could be used as an index to evaluate snowmobile effects on small mammals. For stronger inference strength, snow characteristic measurements could be paired with small mammal mark-recapture techniques.

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Ungulates

Participants: Paul Krausman–Workgroup Leader, Troy Hall–Facilitator, Frances Cassirer–Recorder, Shan Burson, Peter Dratch, and Dan Huff

Issue Overview and Organization

The primary issues concerning the effects of snowmobiles on ungulates include:

- Permanent or temporary displacement from winter habitat
- Behavioral disturbance
- Physiological effects of disturbance
- Use of trails by ungulates
- Population level effects of disturbance
- Role of snowmobiles in increasing predation
- Compaction effects on forage
- Chemical accumulation in body tissue

Issue: Permanent or Temporary Displacement from Winter Habitat

Problem Definition:

Winter habitat is often limiting for ungulates. Displacement results in loss of habitat through temporary or permanent abandonment. Movement may be to less preferred or already occupied areas. Movement to alternate areas could also cause direct mortality through increased exposure to predation or cause increased conflicts with humans as animals move to private lands. Displacement can increase energy expenditure through direct movements or through costs associated with occupying areas with reduced forage available or cover.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Dorranceet al. 1975.	Use of radio transmitters to determine home size range, movement, and distance from trails.
Eckstein et al. 1979.	Radiocollared deer tracked from permanent tower. Comparison of home range and activity patterns.
Revelstoke. 1987.	Aerial survey before and after a snowmobile area was developed. Aerial surveys of closed and open areas.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Dose-dependent response.			X	Snowmobile use will probably continue to increase in open areas.
Population effects.	X (?)		X	Multiple factors confound.

Issue: Behavioral Disturbance of Ungulates

Problem Definition:

Ungulates survive winter in cold climates by conserving energy. Changes in activity patterns caused by snowmobiling could negatively impact survival or productivity.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Aune. 1981.	Observation of interactions between snowmobiles and wildlife.
Bergerud etal. 1984.	Study of the demography, movement, and behavior of caribou.
McLaren and Green. 1985.	Measurement of the distance of first reaction to snowmobiles.
Freddy et al. 1986.	Observation and heart rate measurements of deer disturbed by skiers and snowmobiles.
Simpson. 1987.	Study of the compatibility of caribou and snowmobiles.
Tyler. 1991.	Study of the reaction of reindeer to an approaching snowmobile.
Colescott and Gillingham. 1998.	Study of effects of snowmobile traffic on wintering moose.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
How much disturbance is occurring due to snowmobiles?		X		Disturbance impacts unknown.
Establish relationship between behavioral responses and physiological responses.			X	
Which attributes of snowmobiles cause the greatest effects?			X	

Issue: Physiological Effects of Snowmobiles

Problem Definition:

Winter is a limiting period for ungulates. Physiological responses may occur in the absence of or in addition to behavioral responses.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Moen. 1976.	Analysis of energy-conservation adaptations.
Chappel and Hudson. 1980.	Measurement of metabolic rates.
MacArthur et al. 1982.	Measurement of heart rates by telemetry.
Moen et al. 1982.	Measurement of heart rate changes due to snowmobiles.
Fancy and White. 1985.	Measurement of energy expenditure using heart rate telemetry and an analysis of cratering mechanics.
DelGuidice et al. 1994.	Use of chemistry profiles of urine suspended in snow to compare nutritional deprivation.
Creel et al. 2001.	Immunoassays of fecal glucocorticoid levels.
Tomeo. 2001.	Measurement and comparison of glucocortocoid levels in fecal samples.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Effects of snowmobiles on pregnancy rates.		X		
Effects of snowmobiles on stress levels.		X		
Does snowmobile activity near ungulates increase metabolic or energetic costs or decrease foraging opportunities so that physiological condition decreases?		X		
Establish relationship between responses and physiological responses.			X	
Which attributes of snowmobiles cause the greatest effects?			X	
How do glucocoricosteroids vary with age, sex, body condition, seasonality, etc.?			X	

Issue: Use of Snowmobile Trails by Ungulates

Problem Definition:

Snowmobile use creates corridors of compacted snow that may serve as travel routes for ungulates, altering patterns of movement and access to forage.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Richens and Lavigne. 1978.	Study of deer response (movement) to snowmobiles.
Lyon. 1983.	Use of road density models to reflect elk behavior.
Bjornlie and Garrott. 2001.	

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Determine to what extent ungulates use groomed or ungroomed snowmobile trails.		X		
Determine if ungulates use different areas due to the presence of groomed or ungroomed trails.		X		
What effects do roads per se have on travel patterns versus compaction/ grooming?			X	

Issue: Population effects of snowmobiles

Problem Definition:
Winter is a limiting period for ungulates. Snowmobile disturbance or displacement could negatively affect survival or productivity at a population level.

For species/guilds:
All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:
None

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Determine population level effects (e.g., mortality, reproduction) of disturbance by snowmobiles.			X	

Issue: Role of Snowmobiles in Increasing Predation

Problem Definition:

The presence and impacts of snowmobiles may increase predation of ungulates.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Nelson and Mech. 1986.	Capture, examination, and radio-collaring of deer.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Do snowmobile trails lead to increased predation of ungulates?			X	
Does noise produced by snowmachines increase ungulate vulnerability to predation?			X	

Issue: Effects of Compaction by Snowmobiles on Forage

Problem Definition:

Winter is a limiting period for ungulates. Compaction by snowmobiles may negatively affect forage available for ungulates.

For Species/Guilds:

All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Keating et al. 1985.	Analysis of fecal pellets to determine winter food habits and forage selection.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Determine effects of compaction on ungulate forage.			X	

Issue: Effects of Chemicals Released by Snowmobiles on Ungulates

Problem Definition:
The effects of chemicals released by snowmobiles are unknown.

For Species/Guilds:
All ungulates

Previous Monitoring Efforts/Research Addressing This Issue:
None

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Do chemicals produced by snowmobiles accumulate in ungulate tissues?			X	Effects unknown.

Research Priorities

1. Determine population-level effects (e.g. mortality, reproduction) of disturbance by snowmobiles. To isolate snowmobile effect would require multiple replications, experimental controls, and several years.

2. Establish dose-dependent response to snowmobiles (noise, visual, odor).

3. Establish relationships between behavioral responses and physiological responses.

4. Do snowmobile trails lead to increased predation to ungulates?

5. Which attributes of snowmobiles cause the greatest effects?

6. Do chemicals produced by snowmobiles accumulate in ungulate tissues?

7. What effects o roads per se versus compaction/grooming have on travel patterns?

8. Does noise produced by snowmachines increase ungulate vulnerability to predation?

9. How do glucocorticosteroids vary with age, sex, body condition, seasonality etc?

Monitoring Protocols

The following monitoring protocols were outlined by this group:

- Displacement of ungulates
- How much disturbance is occurring due to snowmobiles?
- Physiological responses
  - Monitor pregnancy rates
  - Monitor stress levels
  - Lipid or urea N:creatinine ratio assessment to monitor changes in physiological condition
- Document the extent ungulates use groomed or ungroomed snowmobile trails.
- Document use of different areas due to the presence of groomed or ungroomed trails.
  - Track counts
  - Observation of road utilization

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Forest Carnivores

Participants: Dan Licht–Workgroup Leader, Nick Sanyal–Facilitator, Scott Davis–Recorder, Bryan Aber, Ronn Julian, Kevin Laves, Kerry Murphy, Jim Schaberl, Tanya Shenk, Larry Timchak, Fred Wahl

Issue Overview and Organization

The forest carnivores contain two groups (Canids and Felids/Mustelids) and nine species total. Lynx and wolverine have greater potential to be adversely affected by snowmobiles, while bobcats and mountain lions may be positively affected by snowmobiles.

The primary issues concerning snowmobiles and forest carnivores are:

- Habitat modification
- Compaction of trails
- Habitat alteration
- Effects on prey
- Increased human access
- Disturbance
- Human feeding
- Increased harvest

Issue: Effects of Compacted Trails

Problem Definition:

Compaction of trails by snowmobiles may cause competition for prey between lynx and wolverines, and other carnivores (coyotes, mountain lion, bobcat, red fox, etc.). Interference or social displacement between species may also occur.

For Species/Guilds:

Lynx, wolverine, fisher, pine martin, and mountain lion

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Neumann and Merriam. 1972.	Measurement of snow and air temperature, snow compaction, water holding capacity, snow melting rates, and animal activity
Murray and Boutin. 1991.	Influence of snow on lynx and coyote movements
Murray et al. 1995.	Prey selection
Aubrey. Unpublished.	WA
Krebs. Current.	Wolverine work in British Columbia
O'Donoghue. 1997.	Coyote/lynx responses to snowshoe hare cycle
Squires. Current	Lynx work in MT/WY—grad student beginning project on coyote/lynx use of snowmobile trails
Staples. 1995.	AK work found lynx tolerant of humans.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Do compacted trails result in increased competition?			X	Hypothesis needs testing; lynx have large feet.
Is there interference/ social displacement between species?			X	Hypothesis needs testing; lynx have large feet.
Is there resource partitioning among predators from compacted snow trails? (repeat for 5 species)			X	Hypothesis needs testing, other carnivores in addition to lynx.

Issue: Effects of Compacted Trails on Wolves

Problem Definition:

Compacted trails may cause intra-specific competition among wolf packs for increasing prey of ungulates—possibly reducing availability of ungulates for mountain lion, etc. due to competition and/or interference.

For Species/Guilds:

Wolves

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Mech	Various dates, methods, and locations.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
How do trails influence rate and pattern of this interaction?			X	

Issue: Effects of Habitat Alteration

Problem Definition:

Facilities, trails, and associated features developed to support use of snowmobiles cause habitat losses and/or fragmentation for forest carnivores.

For Species/Guilds:

All forest carnivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Beier. 1993.	Simulated population dynamics.
Thurber et al. 1994.	Radio collaring.
Maehr. 1990.	Remote sensing. Florida panther.
Roe et al. 2001.	
Apps. 2000.	Preliminary analysis of lynx response to roads/trails.
Knight, Gutzwiller	General effects of recreation on wildlife.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Comparison between amount of habitat loss and home range size.			X	Variables need to be tested.
Assessment of significance of habitat loss on population viability due to fragmentation and habitat alteration.			X	

Issue: Effects on Prey

Problem Definition:

Snowmobile use may cause adverse changes in abundance and distribution of prey, and susceptibility of prey, to carnivores (see small mammals group). Problems include reduced reproduction, reduced over-winter survival, and potential disease-spreading from shifts in distribution.

For Species/Guilds:

All carnivores (except fisher, wolverine, and pine marten)

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Neumann and Merriam. 1972.	Measurement of snow and air temperature, snow compaction, water holding capacity, snow melting rates, and animal activity (hares, fox).
Huff. 1970s.	Deer in MN
Halpin and Bissonette. 1988.	Snowdepth and foxes
Murray et al. 1994	Habitat selection by lynx and coyotes in relationship to snow depth
Delguidice et al. 1991	Wolf, deer
O'Donoghue.'1997.	Responses of lynx and coyotes to the snowshoe hare cycle.
Foresman and Pearson. 1999.	Activity patterns of marten, hares, and red squirrels. Remote sensing.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Timing/availability of hibernating animals on compacted snow.			X	
Effects on small mammals and birds (hare, red squirrel, vole, grouse, marmots); threshold levels between where snowmobiles are used and where not.			X	Ungulate information already exists.

Issue: Effects of Human Disturbance on Wildlife

Problem Definition:

Effects of disturbance are wide-ranging, including shifts in spatial displacement; direct mortality from added expenditure of energy, wasted energy, not getting necessary food, or being run over; interference or disruption of reproduction and denning; interruption of breeding behavior; and/or abandonment of dens. Timing of spatial displacement is important.

For Species/Guilds:

All carnivores

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Hornocker. 1969.	Capture, tracking.
Gese et al. 1989.	Radiocollaring.
Copeland. 1996. Magoun and Copeland. 1998.	Wolverines in Yellowstone N.P., WY
Foresman and Pearson. 1998.	Comparison of dual-sensor remote cameras and soot-coated open and covered track plates.
Ruggerio et al. 1998.	Examination of den site characteristics.
Foresman and Pearson. 1999.	Activity patterns of marten, hares, and red squirrels. Remote sensing.
Heinemeyer. 2001.	
Creel et al.	Analysis of fecal glucocorticoid levels to determine physiological stress responses.
Apps. 2000.	Preliminary analysis of lynx response to roads/trails.
Koehler. 1990.	Lynx and hares in Washington.
O'Donoghue. 1997.	Responses of lynx and coyotes to the snowshoe hare cycle.
Squires. Current	Lynx work in MT/WY—grad student beginning project on coyote/lynx use of snowmobile trails
Mowat et al. 2000.	Behavioral responses of lynx to humans.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Need to differentiate effects of snowmobiles and other winter recreationists.			X	
Need to develop disturbance threshold levels for the above problems for all carnivores; study effectiveness of seasonal closures (breeding, denning needs).			X	

Issue: Effects of Human Feeding

Problem Definition:

There is a direct or indirect risk of increased mortality due to danger of collisions with snowmobiles and nuisance control actions. Wildlife behavior may be altered, creating beggar animals.

For Species/Guilds:

Coyotes, pine marten, red fox, wolves, and fisher

Previous Monitoring Efforts/Research Addressing This Issue:

None

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Habituation studies pertaining directly to snowmobilers feeding wildlife (includes trash & direct feeding).			X	Need to educate public on not feeding wildlife or leaving trash; need research to show that practice is bad.

Issue: Effects of Increased Harvest—Both Legal and Illegal

Problem Definition:

Snowmobiles may result in less refugia for what could be source population.

For Species/Guilds:

Wolverine, mountain lion, bobcats, lynx, marten, and fisher

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Krebs. Current.	Wolverine work in British Columbia.
Currier et al. 1977. Murphy. 1983.	Mountain lions in Colorado.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Is population viability affected by increased access provided by snowmobiles?			X	
What is the degree of illegal harvest?			X	

Research Priorities

1. Determine the effect of snowmobile-compacted trails on bobcat and coyote movement patterns into the winter range of lynx.

The focus of this research would be the effect of bobcat and coyote movement patterns into lynx winter range on lynx behavior, lynx vital rates, demography, reproduction, mortality, emigration, and rates of interaction.

Experimental design could be for six years, comparing six sites where lynx are present. Three sites would be protected from snowmobiles in the first three years, then have treatments of three subsequent years of snowmobile use and compacted trails. These sites would be compared to three other sites (also with lynx) with no snowmobile use for 6 years.

2. Determination of wolverine den abandonment in relation to snowmobile trails and assorted intensities of snowmobile use.

Approach should be a natural history study, identifying variables that can be correlated to or affecting reproduction. The area of study would include wolverine ecology and reproduction in an area affected by snowmobiles compared to an area with no snowmobile use. The use of snowmobiles would be labeled or categorized as low-moderate-high. Again, emphasis should be on comparing effects on reproduction.

Techniques include observation, telemetry, radio collars, and cameras to determine effects on wolverines during denning season—are snowmobiles causing abandonment or not? Another possibility is to study wolverine physiology with captive wolverines. Determining threshold levels and timing is very difficult to research—perhaps it can't be adequately addressed? There is a concern that wolverine range is almost always near snowmobile use in the lower 48 states. Sample size is very small and few are being recruited. The only time a wolverine has a small range is during denning.

3. Experimentally determine differences in carnivore response to different type of winter snow play activities (i.e. snowmobile, cross-country skiing, snow-shoeing, boarding, telemarking, etc.).

Response variables of carnivores could include anything from an individual to a population. Include distance moved or displaced and heart-rate (question or challenge if changes in a demographic response—could be measurable or even be a key to identify). Can measure a disturbance rate of response.

A definition is needed for "disturbed" and its threshold, i.e "flee" might well vary by agency and location of park, etc. Look at similar habitat areas where there is separation between snowmobilers and skiers. Study one species of carnivore at a time. Consider non-intrusive methods to learn stress responses of animals (scat levels, fecal stress levels, etc).

4. Determine fragmentation (alteration) of lynx habitat due to snowmobile trails and/or the introduction of other predators, such as coyotes and bobcats—if differences were demonstrated from studying the fragmentation of habitat. Recommend adding the procedure for "I" effects to the lynx fragmentation issue. Similar to the wolverine design. Record treatments for high and low use of trails.

5. Develop and improve techniques or calibrate monitoring protocols of long term, track type surveys for index of abundance; presence, absence, and distribution; and for detection of trend data for all carnivores. Emphasis to be on non-invasive methods.

6. Determine the effects of snowmobile use on the distribution, abundance, susceptibility, and hibernation/emergence of forest carnivore prey (hare, red squirrel, marmots, pica, deer, elk, moose, voles).

Monitoring Protocols

The Forest Carnivore group did not identify any monitoring protocols.

"There was considerable debate about the level of rigor needed for assessing the impacts of snowmobiles on wildlife and for making management decisions. This, ultimately, is the primary reason we did not identify any monitoring protocols –i.e., the group determined that there was insufficient data to design a monitoring program. One faction within the group felt strongly that we needed to approach the problem from a rigorous scientific approach involving controls, treatments, hypotheses, statistical analysis, etc. However, another faction felt that monitoring, if properly designed, could identify patterns and trends that would be sufficient for management to make decisions (even if the information wasn't rigorous enough for scientific publication). For example, it was felt by some that a systematic monitoring protocol of scent stations, track surveys, etc. (and of snowmobile use) could detect areas where snowmobiles might be precluding wildlife use; however, this approach was not forwarded." -Workgroup Leader, Dan Licht

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Bears

Participants: Chuck Schwartz–Workgroup Leader, Sarah Creachbaum–Facilitator, Shannon Podruzny–Recorder, Sean Farley, Chris Servheen, Larry Timchak

Issue Overview and Organization

Group assumptions:
1. These research techniques will apply to both grizzly and black bears; however, species-specific protocols will be needed for some methods.
2. The temporal and spatial monitoring of snowmachine use levels will be needed in denning and spring range areas.
3. Snowmachines create noise and are highly visible. The auditory, odor, and visual stimuli from snowmachines to bears needs to be quantified.
4. Snowmachines refer to all motorized, over-snow vehicles.

Group approach:
The ursid group reviewed monitoring and research needs. It quickly became apparent that adequate information to develop monitoring protocols did not exist. Consequently, the focus was on research needs that could be used to develop monitoring protocols.

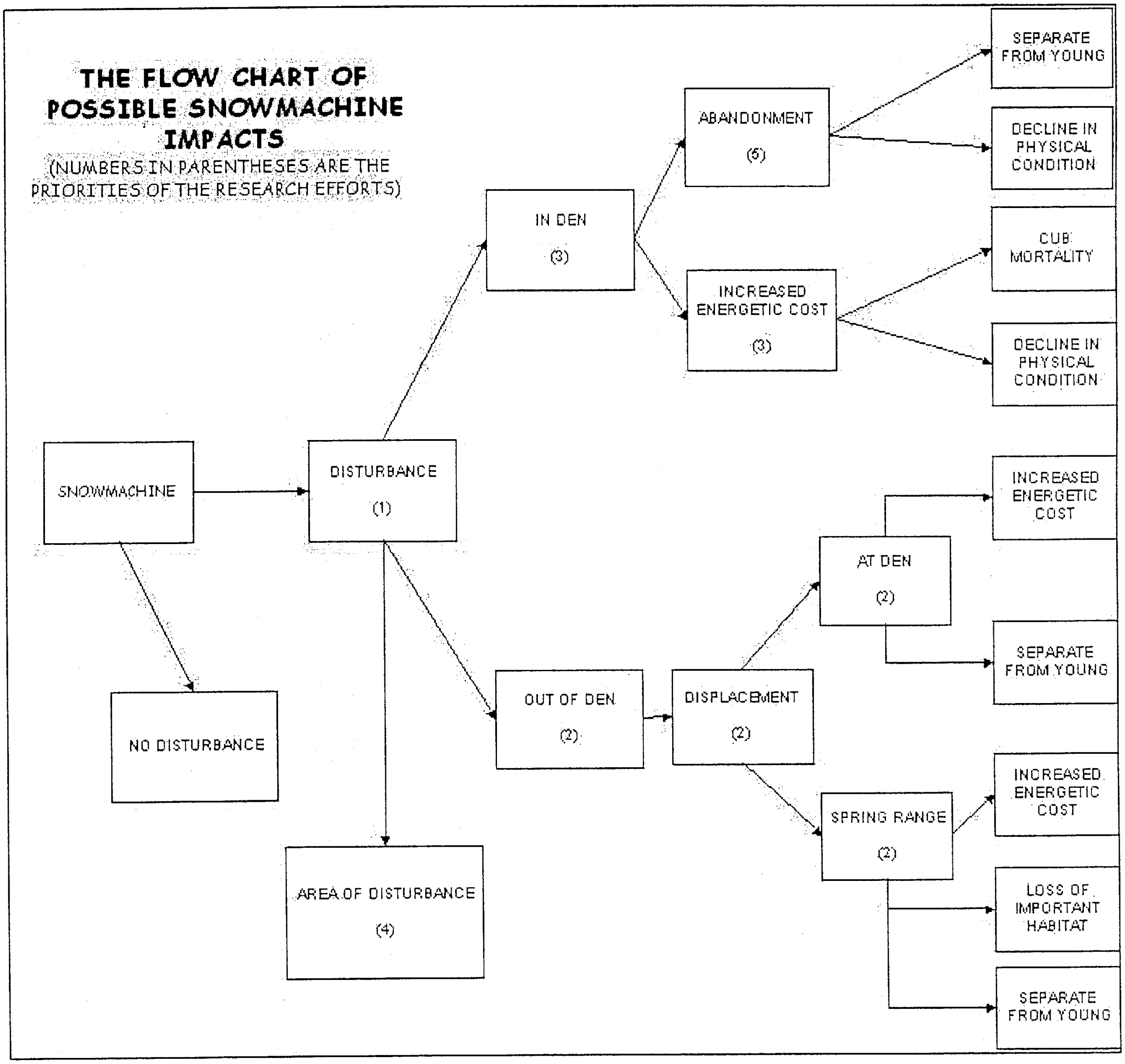
The University of Idaho survey identified three information needs for Ursids: 1) effect on spring bear hunting, 2) effect of presence on emerging animals, and 3) effect of noise on hibernating animals. While snowmachines may have an impact on spring bear harvests, these effects can be mitigated by state wildlife agencies via harvest seasons and bag limits.

The group ranked research priorities (see flow chart) beginning with the need to develop techniques that would demonstrate and measure actual impacts on bears, then addressed the impacts on individuals and populations in the field, and focused on physiological/behavioral responses, mortality, and displacement from habitat. The group determined that there is a high likelihood that impacts on emergent bears are higher than on bears still in the den.

The group had considerable discussion on the need to determine ecosystem-specific locations where conflicts between bears and snowmachines occur. However, this need was ranked as number four of seven research needs, as it is more important to have the ability to quantify disturbance(s) rather than the locations of putative disturbances. The group also discussed the fact that construction of denning and spring habitat models for some ecosystems will require collecting new data on bears. This final issue either can be treated as research or developed as a monitoring program.

Research into den abandonment was given lower priority; however this information would likely be collected during studies measuring the cost of disturbance in dens. Black bear cub mortality can be addressed by monitoring female black bears in the den, but we do not think this is feasible for studies on brown/grizzly bears.

Determining that denning bears avoid snowmachine use areas, although of keen interest, is not likely measurable. Attributing den site selection to learned behavior is practically impossible, as is identifying the precise reason potential denning areas are avoided.



Issue: Effects of Snowmobile Activities on Spring Bear Hunting

Problem Definition:

Concern for increased access via snow-machines in the spring and a corresponding increased vulnerability to harvest.

For Species/Guilds:

Black bears and brown bears

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Pittman and Robertson. Various.	In AK, bear harvests are recorded (sealed) and method of transportation for hunting is recorded. In other states harvest may be subsequent to snowmobile season or highly restricted.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Adapt harvest reporting methods to include location and method of transport.		X		Allows querying databases for numbers of kills associated with snow machine use.

Issue: Effects of Snowmachine Presence on Emerging Bears

Problem Definition:

Snowmachines can displace bears from important habitats in the spring.

Possible effects are:
1) disturbance of family groups before the young are mobile,
2) increased movement and energetic demands, and
3) displacement from important feeding areas when opportunities are limited.

For Species/Guilds:

Black bears and brown bears

Previous Monitoring Efforts/Research Addressing This Issue:

None specifically regarding snowmachines and post-emergent bears

Reference	Description
Linnell et al. 2000.	Review of prior studies, denning bears and disturbance.
Dolan. 1999.	Literature review.
Cherry. 2000.	Literature review.
Blanchard. 1990. Green. 1997. Mace and Waller. 1997. Mattson. 1990.	Habitat use studies.
Mace and Waller. 1996 and 1997. McClellan. 1989. Many others.	Studies showing displacement of bears by motorized activity.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Accurate measure of snowmachine use (quantity, place, time).		X		If we don't know exactly what bears are reacting to, we can't understand their responses or quantify the effects.
Individual responses (by reproductive status) to snowmachines.			X	Responses and impacts will be different between females with cubs and other age/sex classes.
Identification/location of important habitats—denning.			X	This will be of value to know where the impacts are occurring and where management to minimize these impacts should be directed.
Identification/location of important habitats—spring.			X	It is of value to know where the impacts are occurring and where management to minimize these impacts should be directed.
Timing of emergence.			X	Need to know when these impacts could occur.
Quality of spring habitats.			X	

Models based on the above information.			X	Make most use of best available information (existing databases) to produce predictive models of denning and spring habitat. Develop databases on these issues if they do not exist.
Quantify costs of displacement or additional locomotion (physiological/energetic impacts).			X	This is central to understanding exactly what effects occur to individuals.
Document displacement events from spring range.			X	This will provide evidence/lack of evidence/rates of displacement.
Document increases in movement rates and energetic costs.			X	This will provide evidence/lack of evidence/quantification of costs.

Issue: Effects of Noise on Hibernating Bears

Problem Definition:

Possible effects of noise include:
1) den abandonment,
2) loss of young (cub mortality),
3) increased energetic costs in the den (hibernation) or by displacement,
4) death, and
5) learned displacement from suitable denning habitat.

For Species/Guilds:

Black bears and brown bears

Previous Monitoring Efforts/Research Addressing This Issue:

Reference	Description
Reynolds et al. 1986. Reynolds and Hechtel 1980	Movements and habitat utilization of grizzly bears in Alaska.
Alt and Beecham. 1984.	Cub mortality from researcher disturbance.

Needs:

Need	Currently Can Be Addressed Via:			Reason(s)
	Cannot	Monitoring	Research	
Identification of denning habitat.			X	This will be of value to know where the impacts are occurring and where management to minimize these impacts should be directed.
Identification of snowmobile areas.		X		This will identify where possible conflicts may occur.
Measured responses (activity level, body temperature, EKG, heart rate) of specific disturbances.			X	This is central to understanding exactly what effects occur to individuals.
Den sound level (snowmobile).			X	This will provide a direct measure of stimuli for comparison with behavioral/physiological responses.
Level of sound attenuation in bears.			X	This will help determine which stimuli may have an effect..
Cub mortality in black bears (extrapolate to brown based on physiological response).			X	This is central to understanding exactly what effects occur to individuals and populations.
Document displacement events from dens.			X	This will provide evidence/lack of evidence/rates of displacement.

Research Priorities

1. Under controlled conditions, develop methods to quantify physiological and behavioral response of disturbance in and out of the den. Possible variables to measure include:
   - Activity level (via collar-mounted tri-axial accelerometer)
   - Heart rate
   - Body temperature
   - Metabolic costs of locomotion
   - Measure sound in the den/at the bear
   - Other

2. Document whether newly emerged bears are displaced from their den sites and, using techniques developed in item 1, quantify the energetic cost of that displacement. Focus the effort on family groups with cubs-of-the-year. Document similar effects on bears using spring habitat.

3. Quantify the energetic costs of disturbance in the den.

4. Acquire den and spring habitat locations in order to develop a predictive model for the spatial and temporal distribution of each.

-- or --

Based on existing data, develop a predictive model for the spatial and temporal distribution of den and spring habitat.

5. Document den abandonment as a result of disturbance.

6. Quantify cub mortality in or out of the den.

7. Determine if bears avoid areas of snowmachine use (using models developed in #4).

Monitoring Protocols

Although the bear group found preliminary research to be necessary before development of monitoring protocols, identification of den and spring bear habitat areas may be acquired for little additional cost. As bear use areas are identified, the location and presence or absence of snowmobile tracks in the area may be recorded. This would be especially useful if land managers have interest in comparing denning and spring bear habitat distribution to snowmobile use distribution.

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Prioritization of Research Needs

During the closing session of the workshop, workgroups reported the top five research needs for their species guilds. Workshop participants voted for the top five research priorities over all of the guilds. Research needs that ranked highest within individual groups received the most votes overall.

Research Need Description (# votes)

Determine the presence, persistence, and mobility of contaminants from snowmobiles in aquatic habitats. (25)

Examine how snow compaction and loss of depth hoar affect food availability to small mammals. (22)

Establish dose-dependent ungulate response to snowmobiles (noise, visual, odor). (18)

Develop non-invasive monitoring protocol for all forest carnivores to provide more robust estimates of presence and abundance, and correlate with snowmobile use. (16)

Determine effects of habitat alteration on lynx behavior and demographics, and the competitive exploitation and interference by bobcats and coyotes. (15)

Determine effects of snowmobiles on winter use patterns (flush response; roosting and foraging IF sites are unknown and must locate them) of birds. (14)

Determine the physiological and behavioral responses of bears to disturbance under controlled conditions, and the best way to measure these responses. (13)

Compare ecology of wolverines, with emphasis on recruitment, in areas with and without snowmobiles. (11)

Determine what levels of contaminants are toxic at various life stages of amphibians. (8)

Develop a working hypothesis for how snowmobiles impact wetlands (riparian vegetation, hydric soils, introduction of non-native vegetation species as habitat concerns.) (6)

Determine population-level (e.g., mortality, reproduction) effects on ungulates of disturbance by snowmobiles. (5)

Examine bear post-emergence displacement and energetic costs. (5)

Compare carnivore responses at the individual and population level to snowmobile presence to various winter activities. (3)

What attributes of snowmobiles cause the greatest physiological and/or behavioral effect to ungulates? (3)

Establish the relationship between delay of plant phenology and food stress for hibernating and non-hibernating small mammals. (3)

Do snowmobiles trails lead to predation on ungulates? (2)

Determine effects of snowmobiles on vegetation (bird habitat). (2)

Determine and model denning and spring bear habitat. (2)

Establish relationships between compaction of snow and emergence of hibernating small mammals. (2)

Determine what levels of contaminants are toxic to invertebrate populations. (2)

Determine energetic cost of disturbance to bears in the den. (1)

Determine what levels of contaminants are toxic at various life stages of fish. (1)

Determine whether snowmobile compaction affects accessibility to prey (small mammals) by expanding predator's foraging range. (1)

Determine indirect effects of snow compaction on bird habitat. (0)

Determine effects of trail creation and widening on bird habitat. (0)

Document bear den abandonment from disturbance. (0)

Determine effects of snowmobile contamination on birds. (0)

Establish relationships between behavioral responses and physiological responses (ungulates). (0)

Effects of snowmobiles on the distribution, abundance, susceptibility, and hibernation emergence of forest carnivore prey. (0)

Determine whether population genetics of subnivean fauna are affected by fragmentation due to compaction of depth hoar. (0)

Funding Sources

Foundations and interest groups

- Mellon (www.mellon.org)
- Sonoran Institute
- Hines Endowment
- International Snowmobile Manufacturers Association (www.snowmobile.org)
- CD-Rom that lists foundations on web at: www.foundationcenter.org
- National Geographic www.nationalgeographic.com/research/grant/rg1.html
- National Fish and Wildlife Foundation
- Turner Foundation
- Pew Charitable Trust (www.pewtrusts.com)
- Boone and Crockett Club (www.boone-crockett.org)
- Rocky Mountain Elk Foundation
- Foundation for North American Wild Sheep
- National Forest Foundation
- Canon (www.usa.canon.com/cleanearth)
- Unilever (www.unilever.com)

Park-related foundations/associations

- Park friends groups, natural history associations
- Yellowstone Foundation
- Grand Teton National Park Foundation

Solicit volunteers for monitoring assistance from local/regional organizations

- Audubon, etc.
- Unit-by-unit basis

Governmental entities (matching funds/grants)

- NPS: CESUs can link with researchers, who may be able to incorporate monitoring/research needs into their projects with little extra effort.
- NPS: Challenge Cost Share ($\leq$ \$30,000 match)
- NPS: Natural Resource Program Center, DC-based partnership position
- can link a park's wish list to sponsors
- USFWS
- Department of Energy
- National Science Foundation www.nsf.gov/home/grants.htm
- Environmental Protection Agency
- NASA: NPS employee on detail
- Department of Defense (interested in noise and winter issues)
- Soil and Conservation Districts
- State agencies- may be eligible for different grants than federal agencies
- Transportation agencies
- Environmental agencies
- Resource agencies

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Appendix 2: Methods to Estimate Snowmobile Use: A Bibliography

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