

Toward a Defensible Lynx Conservation Strategy: A Framework for Planning in the Face of Uncertainty

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Background

On April 2, 1993, the incumbent U.S. President traveled to Portland, Oregon, to intervene in a national political crisis engendered by public concern over the conservation of native wildlife on public lands. Environmentalists had successfully used existing statutes, most notably the National Forest Management Act and pursuant regulations, to shut down timber industry operations on commercially important federal lands in the Pacific Northwest. Widespread economic dislocations were expected, and the federal courts showed no signs of reversing the decision to suspend timber-harvesting activities. At the core of this enormously divisive legal controversy was the effect of timber management on the viability of northern spotted owl populations—an issue that arguably defined one of the most significant conservation conflicts of this century.

The spotted owl controversy catalyzed heightened concern over the conservation of “sensitive” species on public lands, especially those species thought to be negatively affected by land management practices such as timber harvesting. In 1993, the National Forest System (the land management branch of the USDA Forest Service) responded to this concern by identifying a number of species and species groups with the potential to become conservation issues. Included were a group of Pacific salmon, the marbled murrelet, Mexican spotted owl, northern goshawk, two species of trout, several forest owls, and four forest carnivores—notably including the lynx. The basis for concern over most of these species was their putative association with late-successional forests—the stage of forest development most frequently removed from managed forest landscapes (Thomas et al. 1993). Land managers decided to assess the state of ecological knowledge for each of these species relative to the information needed for defensible conservation planning. In late 1993, scientists in the research branch of the Forest Service were asked to lead these assessments.

The findings of the forest carnivore conservation assessment were published in a report entitled, *The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx and Wolverine in the Western United States* (Ruggiero et al. 1994b). One of the major conclusions of this assessment was that, “Major information gaps exist for these forest carnivores. A sustained commitment to research is needed for developing scientifically sound conservation strategies to ensure the persistence of forest carnivore populations” (Lyon et al. 1994, p. 137). Regarding lynx in the western United States, the Assessment read, “...there is a need for the most basic information on habitat relationships, at any spatial or temporal scale and at any level of measurement. Virtually any new data on habitat relationships involving lynx in the western conterminous 48 states would be a substantive increase in knowledge” (Ruggiero et al. 1994a, p. 142). The state of knowledge was found to be equally inadequate for all other aspects of lynx ecology in the western United States. Although a considerable amount is known about lynx ecology in northwestern Canada, the Assessment concluded that (1) the applicability of this information to ecosystems in the western United States is unknown, and (2) potential ecotypic variation in lynx populations warns against the application of this information in the western United States (southern) portion of the lynx’s range (Ruggiero et al. 1994a).

Knowledge of lynx ecology in the United States has not improved substantially since publication of the Forest Carnivore Conservation Assessment in 1994: there have been no new research findings published on lynx ecology in the United States. Management agencies were thus poorly prepared to deal with the July 8, 1998, “proposed rule” by the U.S. Fish and Wildlife Service (USFWS) to list the lynx as a threatened or endangered species

throughout its range in the contiguous United States. This action by the USFWS followed a long history of public concern, petitions to list the lynx, and lawsuits against the USFWS based on societal responses to perceived declines in lynx populations (see Table 1.1 for an overview of these events). The listing process dictates that unless compelling new evidence emerges to the contrary, the lynx will be designated threatened or endangered in January 2000, 1.5 years from the publication of the proposed rule in the Federal Register (U. S. Fish and Wildlife Service 1998).

In response to this situation, representatives of the USFWS, Bureau of Land Management (BLM), and USDA Forest Service (USFS) met in Salt Lake City, Utah, several weeks before the proposed rule was published. There they discussed how land management agencies could best prepare for the potential listing, particularly the consultation provisions of the Endangered Species Act. If the lynx became a threatened or endangered species, how could management agencies demonstrate to the USFWS that their actions did not jeopardize the continued existence of lynx populations? A decision was made to produce a *conservation strategy* of sufficient detail to direct the actions of land managers such that a “jeopardy opinion” by the USFWS could be avoided. The dilemma, of course, was how to produce a strategy that could reliably evaluate the effects of various management actions on the viability of lynx populations given the paucity of existing information on lynx ecology in the southern portion of its range.

Scientists from the Research Branch of the USFS, including authors of the 1994 Forest Carnivore Conservation Assessment, were asked to address this dilemma. The course of action these scientists recommended was predicated on the lack of crucial scientific information and included a provisional (interim) reassessment of our understanding of lynx ecology. This process (Fig. 1.1) would build on the 1994 Assessment by: (1) conducting new analyses of lynx distribution (based on new and old information), (2) examining all published and unpublished information that may contribute to our understanding of lynx distribution and ecology in the contiguous United States, (3) reanalyzing existing data using the latest technology, (4) reviewing relevant ecological theory, and (5) attempting to elucidate new insights about lynx ecology based on steps 1-4.

A Lynx Science Team was assembled to implement this process and attempt a useful interpretation of limited information. Through this process, the scientific basis for conserving lynx would be documented and, to the extent possible, resulting insights about lynx ecology would be elucidated for use by land managers. Management biologists and decision-makers would then use the Science Team’s report to produce an *Interim Conservation Strategy*, which would establish and detail management policy. Integral to this strategy would be an explicit program of studies (Chapter 17), which, if

Table 1.1—Overview of events leading to the U.S. Fish and Wildlife Service's proposed rule to list the lynx as a threatened or endangered species throughout its range in the contiguous United States (McMaster, personal communication).

August 22, 1991	A petition to list the "North American" (Canada) lynx in the North Cascades ecosystem of Washington as an endangered species and to designate critical habitat was received by the Fish and Wildlife Service (Service) from the National Audubon Society and 11 other organizations.	August 26, 1994	The Service published a notice (59 FR 44123) indicating that the Service's administrative 90-day finding found that the petition received April 27, 1994, presented substantial information indicating the requested action for the contiguous U.S. population may be warranted, but there was not substantial information to indicate that an emergency listing of a southern Rocky Mountain population was warranted.
October 6, 1992	The Service published a notice of a 90-day finding (57 FR 46007) indicating that the petition to list the "North American" (Canada) lynx in the North Cascades did not provide substantial information. Region 1 (Portland Regional Office) had the lead on the petition because the petitioned area was confined to that Region. Region 6 (Denver Regional Office) had the national lead for the lynx.	December 27, 1994	The Service published a notice (59 FR 66507) indicating that the Service's 12-month finding was listing the Canada lynx in the contiguous U.S. was not warranted. The finding represented the Service's administrative finding as a result of the status review agreed to in the April 28, 1993, lawsuit settlement and the administrative 12-month finding for the petition received April 27, 1994.
Late 1992 or 1993	The Greater Ecosystem Alliance and other organizations sued the Service over the negative 90-day finding announced on October 6, 1992.	January 30, 1996	The Defenders of Wildlife and 14 other organizations and individuals sued the Service in the U.S. District Court, District of Columbia, over the not-warranted petition finding announced in the Federal Register on Dec. 27, 1994.
April 28, 1993	A settlement agreement was reached whereby the Service agreed to reevaluate the negative 90-day finding announced on October 6, 1992, in light of new information that was submitted by the petitioners.	March 27, 1997	The court issued an opinion and order setting aside the not-warranted finding and remanded it back to the Service for further consideration. The Service was ordered to publish a 12-month finding on the status of the lynx within 60 days.
July 9, 1993	The Service published a notice (58 FR 36924) indicating that the negative 90-day finding had been revisited by Region 1, but that there still was not substantial information to support the petitioned action. However, the Service announced in the notice that it believed that sufficient evidence existed to indicate that an in-depth rangewide status review for the lynx should be conducted and that the Service intended to commence this status review.	May 27, 1997	The Service published a 12-month petition finding (62 FR 28643) that the Canada lynx population in the contiguous U.S. was warranted for listing under the Endangered Species Act but precluded by actions on other species of higher taxonomic status. This warranted but precluded finding automatically elevated the Canada lynx to candidate species status.
November 30, 1993	A second settlement agreement was reached. The Service agreed to complete and publish the results of a status review throughout the lower 48 States by November 14, 1994.	September 15, 1997	Defenders of Wildlife, et al., filed suit against the Service in the U.S. District Court, District of Columbia, arguing that the Service violated the Endangered Species Act in finding that listing the Canada lynx population in the contiguous U.S. was warranted but precluded but precluded (published in the Federal Register, May 27, 1997).
February 2, 1994	The Service published a notice (59 FR 4887) indicating that it was soliciting information for a rangewide status review. The Service indicated that it would complete and publish its finding no later than November 15, 1994. Region 6 was given the	December 22, 1997	The court denied the plaintiffs' Motion to Enforce Judgment against the Service's May 1997 finding that listing the Canada lynx population in the contiguous U.S. was warranted but precluded. At the same time, the court set an expedited schedule and hearing date (March 18, 1998) for the lawsuit filed in September, 1997.
April 27, 1994	A petition to list the "North American" (Canada) lynx in the contiguous U.S. and to emergency list the southern Rocky Mountain population was received from the Biodiversity Legal Foundation and four individuals.	February 11, 1998	The Service and the Plaintiffs reached a settlement that calls for the Service to publish a proposed rule to list the Canada lynx in the contiguous U.S. by June 30, 1998. The settlement was submitted to the U.S. District Court, District of Columbia, for
		July 08, 1998	Proposed rule to list the lynx was published (63 FR 36994).

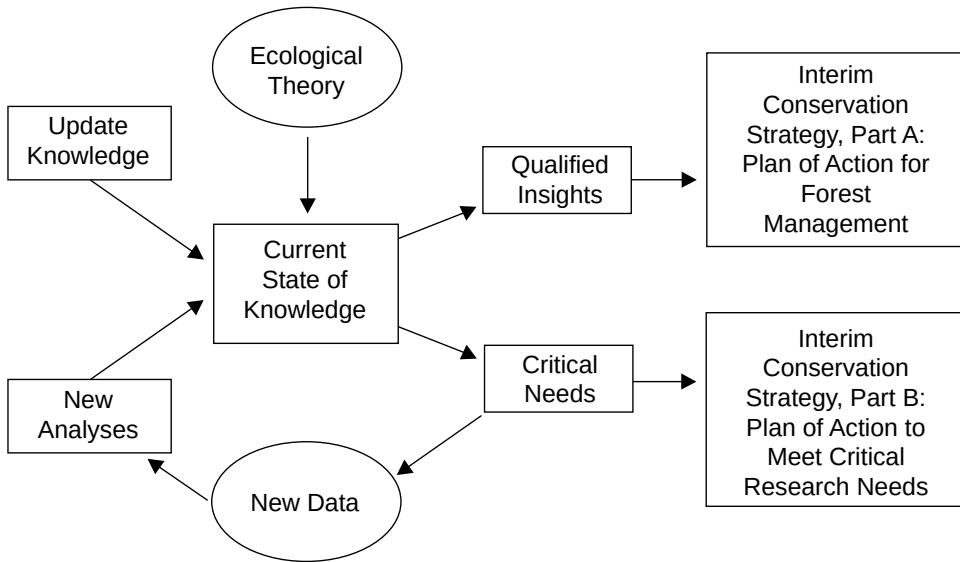


Figure 1.1—Process for developing an interim conservation strategy given that current understandings are extremely limited.

implemented, would provide the information needed for more substantive and defensible conservation planning. This book is the formal report of the Lynx Science Team.

Scientific Context

We face the dilemma of conserving lynx without adequate knowledge of lynx ecology. We do not yet understand many of the factors that determine lynx distribution and abundance; hence, we do not have a very sophisticated understanding of how human activities affect the persistence of lynx populations. Indeed, the entirety of published research on lynx in the United States comes from only seven studies (Chapters 10 and 13). Similarly, there are few published studies on the ecology of the snowshoe hare, the lynx's primary prey, in the contiguous United States (Chapter 7). A substantial amount of research has been conducted on both species in Canada and Alaska (Chapters 6 and 9) but, as discussed above, the applicability of these studies to lynx conservation in the southern portions of its range is unknown.

This situation has three important ramifications for any attempt to elucidate the scientific basis for lynx conservation. First, this book is not a

substitute for reliable knowledge gained through a sustained commitment to scientific research. Hence, Chapter 17, “An Action Plan to Fill Critical Knowledge Gaps,” must be viewed as a critical part of any conservation strategy based on information contained herein. The second and corollary ramification is that any management strategy based all or in part on the information contained in this volume must be clearly identified as *interim*. A more enduring strategy is contingent upon the acquisition of additional knowledge about lynx ecology and greater understanding of factors influencing the persistence of lynx populations. Finally, because the insights offered here embody a poorly developed “state of the art,” we use the term *qualified insight* to remind the reader of this limitation and to stress the need for cautious, conservative decision-making.

We know some basic things about lynx ecology. For example, we know lynx are well adapted to living in cold climates with deep snow, they are closely associated with coniferous forests, and they rely on the snowshoe hare as a primary source of food. However, we don’t understand why lynx are not very abundant in some places where these requirements appear to be met (e.g., southwestern Colorado and western Wyoming). This lack of understanding underscores the inadequacy of our knowledge about the factors controlling lynx abundance and distribution.

Similarly, conventional wisdom holds that a landscape dominated by coniferous forest will support lynx if it: (1) produces adequate numbers of snowshoe hares, (2) includes a small amount of old forest needed for den sites, and (3) includes a mixture of forest age classes dominated by early successional stands. The key ingredient here appears to be snowshoe hares, and prime hare habitat is described as regenerating, dense young forest. This paradigm enjoys such broad acceptance that many acres of public land will be modified to fit this description in the name of lynx conservation (e.g., Envriodata Systems Inc. 1993; Washington Department of Natural Resources 1996). Based on this concept of lynx habitat, most timber harvest activities would be considered beneficial and, given that trapping no longer occurs in the United States outside Montana, we might expect lynx populations to be stable or increasing throughout their range. It is hard to reconcile this with the perception that lynx numbers and distribution in the United States are so sparse as to warrant listing under the Endangered Species Act (U. S. Fish and Wildlife Service 1998).

We believe it is critically important to recognize the risks associated with management decisions made in the face of this kind of uncertainty. Management-induced landscape changes, when based on untested hypotheses, can result in conditions antithetical to their stated purpose. An interim strategy has special properties in this regard. Interim direction will be altered within

a specified time period, and actions taken during the interim period must not foreclose options for future management. Interim management actions must also be conservative in order to reflect the poorly developed knowledge base upon which they were developed. Unfortunately, the sociopolitical pressure to “do something” usually precludes this conservative approach. Rather, in natural resource management, decisions based upon the best available knowledge tend to treat that knowledge as if it were complete, even when it is woefully inadequate. It is within this context that this book seeks to reexamine existing knowledge, search for new information, and generate qualified insights that can be used to build an interim conservation strategy for the lynx.

The need for action in the face of uncertainty is not unique to the lynx. Our knowledge concerning many organisms is even more limited, and the processes of habitat destruction continue. The ongoing alteration of the natural world ensures a large queue of threatened organisms for the legal machinery of the Endangered Species Act to process. We hope that the approach embodied in this book will be of value in other conservation planning efforts.

Conservation Planning and Uncertainty

Our inability to completely understand ecological processes will always result in varying degrees of uncertainty when planning for species conservation. We are often uncertain about the details of a species' status even when conservation action is clearly appropriate. Comparative census data are usually lacking and, even when such data are present, we are often uncertain about how to interpret population changes relative to natural fluctuations. If we decide that a population is in decline, there will often be uncertainty about the causes of the decline and perhaps additional uncertainty about appropriate restoration efforts. For species with broad historical ranges such as the lynx, these uncertainties increase, as do the consequences of poor decisions. The potential listing of the lynx under the Endangered Species Act, for instance, could impact 16 States.

In conservation planning there is often a fundamental mismatch between the state of knowledge, the feasibility of obtaining specific knowledge, and the actions that society would have land managers take towards species conservation. Land management agencies are asked difficult and very specific questions, such as how the construction of a road or a timber sale will affect the viability of a lynx population. In asking these questions, society (1) presupposes highly sophisticated ecological knowledge, (2) assumes these questions have unequivocal answers, and (3) believes that land managers

can develop plans that will solve the problem. Unfortunately, these suppositions are rarely true, and conservation planning always occurs in the face of varying degrees of uncertainty.

There is much society can do to reduce uncertainty and thus improve conservation planning. We have the tools to improve our understanding of ecological systems in almost all cases—it is the political will to do so that is often lacking. Nonetheless, the reality of uncertainty has given rise to several approaches to conservation planning. If uncertainty is limited and quantifiable, a number of stochastic simulation (Noon and McKelvey 1996; Akçakaya and Raphael 1998; Marshall et al. 1998) or formal fuzzy logic (Todd and Burgman 1998) approaches can be used. In most cases, however, uncertainty is addressed less quantitatively. Here, we briefly discuss two widely accepted approaches, then present the alternative approach embodied in this book.

Burden of Proof Approach to Conservation

Conservation disputes are often resolved in the judicial system, where legal constraints require that an action must be proved harmful to a species before the action is precluded; i.e., the “burden of proof” rests with conservationists (Murphy and Noon 1991; Dayton 1998). This results in reactive conservation, whereby proposed actions become the issue, rather than species’ conservation. In addition, when little is known about species of concern, e.g., those that are rare and/or difficult to study, substantial harm may occur before such proof is possible. It has therefore been suggested that the burden of proof be shifted so that uncertainty favors, or at least is not destructive to, conservation (Dayton 1998).

However, shifting the burden of proof in the judicial process is unlikely to provide sociopolitical solutions to conservation problems. The process is still flawed, the burden has simply been shifted from one side to the other. Proving harm or lack of harm in a conservation context is costly, time-consuming, and often impractical, regardless of where the burden lies. Because the burden-of-proof approach creates an environment in which one side or the other benefits from a lack of information, this approach also devalues the acquisition of new information. Moreover, because decisions are binary (i.e., an action is either allowed or precluded) knowledge gained through this process (or the identification of significant knowledge gaps), may be lost once a decision is made.

The Delphi Approach to Conservation

A second approach for dealing with conservation in the face of uncertainty has been to seek consensus rather than knowledge. Commonly called the “Delphi method” (Ziglio 1996), this approach evolved out of the need to confront the uncertainties associated with multi-species management (Cleaves 1994). The formalized Delphi process adopted by the Forest Ecosystem Management Assessment Team (FEMAT 1993), involved more than 70 experts having special knowledge of individual species or species groups. These experts participated on panels wherein they were given 100 “likelihood points” that were distributed across four outcomes (Meslow et al. 1994). For each species and management plan, the possible outcomes were that the plan would (1) produce a stable, well distributed population, (2) produce a stable but restricted distribution, (3) only produce widely spaced refugia, or (4) lead to extirpation from federal lands (Meslow et al. 1994). The votes from the panel were then summed to represent the group’s collective opinion regarding the quality of each management option.

The Delphi method, in various forms, has become very popular as a means of incorporating scientific input into management decisions (Marcot et al. 1997). This method is popular because it is quick, has proven to be robust in court, and requires no new knowledge. Furthermore, it generally limits decision-making by scientific experts to evaluation of a pre-established set of management alternatives rather than incorporating their input directly into the process of plan development. In short, the value of the Delphi process as applied to conservation planning lies mostly in its expedience.

From a scientific perspective, Delphi processes are inappropriate as a basis for conservation decisions. In the FEMAT example, the only data integral to the Delphi process relates to the opinions of the panel. These data are not reproducible and, perhaps more importantly, the relationship of these data to the ecology of the organisms in question is unknown. The subtle fact that this process results in an assessment of opinion, rather than an assessment of what is known about species’ ecologies, is inevitably lost. For example, in the absence of definitive information, if a panel believes strongly that an organism needs a specific habitat type, conservation planning will likely proceed based on this belief, and management actions or general management policy will be set accordingly. The collective opinion of the group therefore becomes a surrogate for a science-based understanding even though no new information has been brought to bear on the problem. This process might be reasonably benign if the expert opinions reflected the

state of knowledge—that is, if uncertainty in information lead to uncertainty in conclusions. However, this is seldom the case, and the illusion of knowledge-based understanding is created. For instance in evaluating the results of the FEMAT process, Meslow et al. (1994) state: “Some species did not respond to habitat protection on federal lands, i.e., did not fare well under any option.” (p. 26). In truth, the response of these species to protection is unknown. There was no species response. A correct statement would be that in the opinion of the panel, none of the options afforded adequate protection for some species.

To a certain extent, the Delphi process can be altered so that the judgments and opinions are more specific and limited. Marcot et al. (1997), for instance, asked the experts to provide their opinions concerning the basic ecology and species-environment interactions for those species where they had expertise, rather than to evaluate species viability associated with various management scenarios. We believe that this is an improvement because the opinions of the experts will be much closer to their areas of expertise and can, to the extent that these opinions are based on unpublished findings, represent new information. In the final analysis, however, there is no way to determine which inferences are based on data and which on opinion, and the distinction will be lost.

History is replete with scientific conventional wisdom, strongly held at the time, but found by subsequent investigation to be false. Holding strong beliefs based on minimal data is a human propensity, but one that is antithetical to the scientific method. Delphi encourages this propensity and, in the process, suppresses the acknowledgment of uncertainty needed to qualify all scientific discourse and to inform sociopolitical processes. Additionally, Delphi methods fail to sufficiently elucidate knowledge gaps and identify the importance and necessity of obtaining new information.

The Inductive Approach: A Science-Based Method

We have chosen an alternative approach that is based on the assumption that knowledge is never complete and never universal. Some research findings are strong enough that they can be assumed to be true. Even in such cases, however, a strict scientific interpretation limits the scope of inference to the specific study site, the specific population of organisms studied, and the time of the investigation. We must also acknowledge that sometimes, in spite of our best sampling efforts, the individuals we study may not be representative of the population inhabiting the study area, thus further limiting the utility of our findings. Peer-reviewed scientific publications generally provide strong local information, but there are limitations to using such knowledge. Statistical inferences apply only to the populations, places,

and times actually studied, and neither the most sophisticated mathematical models nor the most impressive computer-mapping technology can change this.

This scientific reality does not diminish the importance of the information derived through this process. Indeed, this is the nature of scientific investigation; through a gradual accumulation of limited pieces of knowledge, more generalizable interpretations emerge and scientific paradigms are formed. In the interim, if we wish to apply limited knowledge to the solution of large-scale problems, we do so using subjective methods. However, such methods rely on a series of untested assumptions concerning the generalizability of existing knowledge.

These subjective interpretations are an important part of the scientific process. Indeed, the most difficult and often the most important part of the scientific process is the interpretation of research findings within the broader context of “what is known.” This aspect of science is similar to the creative process that gives rise to insights about appropriate and meaningful research questions. The critical component of both processes is to limit one’s interpretations to scientifically defensible inferences based on empirical data. This aspect of the scientific process is evident in thorough research proposals and in the discussion sections of published manuscripts. In both cases, limited knowledge is aggregated and synthesized to derive insights that have scientific merit as judged by the peer-review process.

The qualified insights we are attempting to produce embrace this scientific tradition. What we seek here is a middle ground between demanding certainty and embracing opinion. This middle ground is the result of interpretation, a fundamentally subjective process based on scientific judgment. In taking this approach we acknowledge that judgments are an essential part of the scientific process, but they must be based on empirical data and theory, and they must be specific. It is the specificity of the linkage between data and inference that separates even the most highly qualified of insights from the opinion-based approaches described above. We can, for instance, make qualified insights concerning the probable dietary dependence of lynx on snowshoe hares at the southern periphery of their range. In doing so, we rely on specific data concerning lynx, hares, and the prey communities in areas such as the Great Lakes States or the Rocky Mountains. The inference is qualified: we know a great deal about these relationships in certain areas and we are inferring the degree to which these understandings are transferrable to areas where we lack local knowledge. We cannot, however, make qualified insights concerning how well the lynx would respond to protection on federal lands in the contiguous United States unless we can find a similar body of information from which valid inferences concerning lynx viability can be drawn.

Organization of the Book

Chapters 2 through 5 of this book provide a context for scientific judgments. We review pertinent ecological theory and examine fundamentally important information about relevant ecological systems. Viewed within this context, even scant information about lynx ecology may acquire meaning that would otherwise remain obscure. Moreover, placing data into the context of ecological theory diminishes the data-dependency of the qualified insights. For instance, an important issue in conservation biology is the impact of adult mortality, which is often influenced by human behavior, on population dynamics. Ecological theory tells us that long-lived organisms with low fecundity are more sensitive to adult mortality than are short-lived organisms with high fecundity. By knowing something about the life history of an organism and applying this theoretical understanding, it is possible to infer that increasing adult survival will have a positive effect on the population.

For reasons discussed above, the process we have chosen incorporates all the empirical information we could locate. We critically evaluate all such data; thus, we are free to incorporate data from published as well as unpublished sources. Data may be weak for a variety of reasons, but even weak data will contribute to understanding when viewed in a rigorous analytical framework. We discriminate between weak data and opinions based on weak data. For instance, a picture of a lynx shot in low-elevation rangeland would be considered weak in one sense because it is not part of a representative sample. However, to the extent that we know that a lynx occurred in that time and place, we have a small but legitimate datum to add to our knowledge base. Opinions about why the lynx was there, what it was doing, and whether it may be representative of a population are not based on additional data and, therefore, are not pertinent. Accordingly, Chapters 6 through 13 are dedicated to the review and assessment of existing information and to the presentation of new data about the ecology of lynx and snowshoe hares.

Building on the integration of existing information and relevant ecological theory, Chapters 14 and 15 synthesize existing information and begin to make interpretations relative to lynx conservation. It is here that we attempt to place lynx conservation into the larger context of ecosystem management by considering the needs of diverse vertebrate communities. This synthesis leads directly to a discussion of qualified insights in Chapter 16, and that, in turn, to the use of qualified insights to frame an action plan, as outlined in Chapter 17.

An Ecological Framework

The questions we address through qualified insights must be pertinent to lynx conservation. The science of conservation biology provides a conceptual framework that informs us about the kind of information most critical to this task; these include:

1. Present and historical patterns of lynx distribution.
2. Factors limiting the geographic distribution of lynx.
3. Principal habitat features affecting lynx.
4. Food habits of lynx.
5. Habitat requirements of key prey species.
6. Population dynamics of key prey species.
7. Principal community factors affecting lynx.
8. Principal factors affecting lynx movements and dispersal.
9. Key demographic properties and dynamics of lynx populations.
10. Geographic variation among lynx populations.
11. Direct human influences on lynx.

Our discussion of qualified insights in Chapter 16 is organized according to this framework, although many of these key areas are not mutually exclusive. The ecological relationships implicit in this framework are illustrated in Figure 1.2. We know from the outset that much of this information is unavailable for the lynx, but our task primarily involves developing qualified insights about lynx ecology in those areas where critical information is lacking. In addition, the process of developing insights in these data-poor areas will serve to highlight important knowledge gaps. Thus, Chapter 16 is both a compilation of knowledge-based inferences and a compendium of critical information needs for future research.

Because we cannot depend upon the slow accumulation of independent research findings to provide a foundation for the conservation of lynx, we need to identify a plan of action that will, if followed, close important knowledge gaps in a timely manner. The last and probably the most critical part of our approach to dealing with uncertainty is to use our qualified insights to frame this action plan, as presented in Chapter 17.

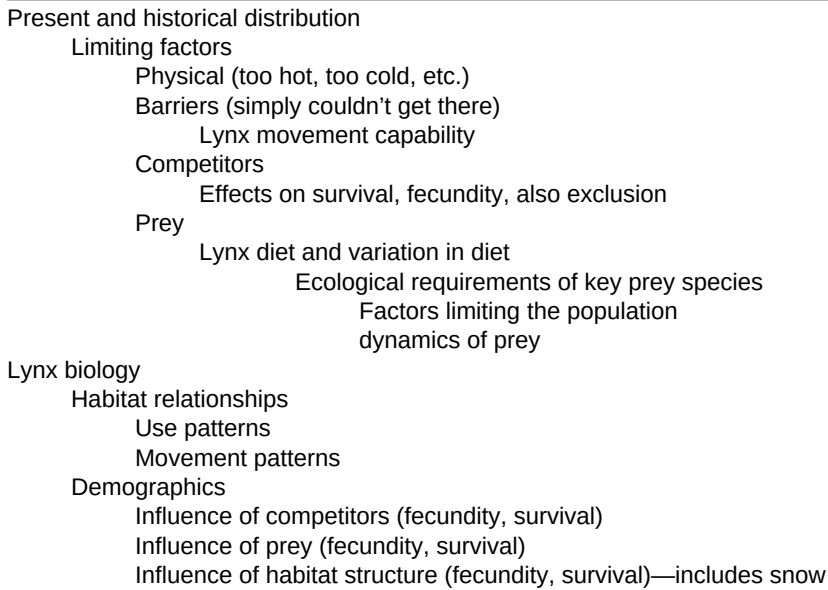


Figure 1.2—Hierarchical representation of key areas of understanding needed for conservation planning.

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