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Research Approaches and Management Concepts

NORTHERN GOSHAWK ECOLOGY: EFFECTS OF SCALE AND LEVELS OF BIOLOGICAL ORGANIZATION

JOHN J. KEANE AND MICHAEL L. MORRISON

Abstract. We develop a conceptual framework that addresses the effects of scale and levels of biological organization on ecological studies. We specifically consider Northern Goshawk (*Accipiter gentilis*) ecology relative to this framework. Traditionally, ecological studies have emphasized phenomenological, rather than mechanistic, explanations of ecological phenomena. Emphasis has focused on describing the general patterns of "how" an animal interacts with the environment. Less effort has been directed towards determining "why" we observe particular patterns; that is, what are the basic biological and ecological reasons for the phenomena that we observe? In our study area in the Sierra Nevada, California, we observed both individual and seasonal variation in the size of goshawk home ranges. We are developing an energetics model for goshawks and conducting detailed studies of the prey species used by goshawks. We will use these data to build up from an intensive understanding of the factors influencing an individual to explain the patterns at the more extensive scales. We argue that the intensive and extensive data needs that are required to develop conservation strategies should be based on a mechanistic understanding of the patterns observed. Predictions derived from phenomenological models assume that the conditions on which the model was constructed do not change. However, conservation planning requires quantitative predictions for systems that are often dynamic in both space and time, such as forests managed for timber production. Thus, emphasis should be placed on developing a mechanistic understanding of particular ecological phenomena to improve the predictive ability of conservation planning.

Key Words: *Accipiter gentilis*; conservation planning; home range; levels of biological organization; Northern Goshawk; Sierra Nevada; temporal and spatial scale.

Data needs for conservation planning require intensive and extensive field studies (Verner 1992). Addressing these needs will require studies that are conducted over various spatial and temporal scales and at different levels of biological organization. For example, spatial scales can vary from the microhabitat of a specific foraging site up through the landscape level. Temporal scales can vary from the duration of a foraging bout up through annual and geologic time scales. Additionally, levels of biological organization can vary from individuals through populations, communities, ecosystems, and landscapes. Correspondingly, interpretations of the observations we make will vary depending upon the scale and level of biological organization investigated (O'Neill et al. 1986, Wiens 1989, Gavin 1991, Levin 1992, Morrison et al. 1992). Indeed, differing interpretations of ecological phenomena that result from research conducted at different scales and levels of organization have impeded ecological advancement (Wiens 1986, 1989). Therefore, it is imperative that researchers explicitly identify the scale and level of organization that they study and define the domain to which their results are applicable. Our objectives are to (1) present a conceptual overview that considers the effects of scale and level of biological organization on ecological studies, (2) develop a conceptual framework that addresses Northern Goshawk (*Accipiter gentilis*) ecology, (3) present an example of a study design for investigating goshawk ecology, and (4) make recommendations for future research.

CONCEPTUAL OVERVIEW

The choice of scale and level of organization to be studied depends on the question being asked and should correspond to the natural scales of the phenomenon being studied (O'Neill et al. 1986, Wiens 1989). For example, to determine the geographic breeding range of the Northern Goshawk in California, a researcher would be concerned with a regional spatial scale. Similarly, if the question of interest was related to the daily activity budget of a goshawk, then one would be concerned with detailed observations of individuals. If the question was related to the role of goshawk predation in structuring forest wildlife assemblages, then a community level approach might be most appropriate.

Any phenomenon can be studied from a variety of perspectives at different scales. For example, goshawk nest sites can be studied from a microhabitat perspective that might consider the structure, composition, and stand size of the forest immediately around a nest. Alternatively, goshawk nest sites could also be studied from a perspective that considers the abundance and distribution of suitable nest stands over the landscape. Although these examples are not mutually exclusive, they illustrate the need to define clearly the objectives and scale at which the results will apply.

The questions asked in ecological studies can be fundamentally classified as "how" and "why" questions (Gavin 1991). "How" questions focus on how organisms interact with the environment and address the proximate cause of an observed phenomenon. For example, there are numerous studies on how animals forage, and what types of prey they consume. Alternatively, "why" questions focus on why an organism behaves or is structured as it is and what the effects of these traits are on survival and reproductive success. "Why" questions address ultimate causation (Gavin 1991). Here, we are asking why the animal uses (or selects) the prey that it does—what are the basic, biological and ecological reasons for the phenomenon that we observe?

The question we are fundamentally interested in answering is what determines survival and fitness in an individual (Martin 1992). The acquisition of energy and nutrients is obviously a basic determinant of these parameters—but how do we best measure them? Most studies in wildlife ecology, citing time and budgetary limitations, search for indirect measures of these parameters. Conventionally, researchers have measured a subset of an animal's habitat, usually vegetation, and derive correlative relationships between habitat variables and their use by an animal or the presence (or abundance) of the animal. These studies examine habitat use and describe the habitats irrespective of how they contribute to fitness (i.e., habitat quality). In this paper we adopt the definition of habitat use described by Hutto (1985), as not connotating a conscious choice by an organism, but merely indicating the distribution of individuals through some mechanism.

Ecological studies have traditionally emphasized correlative or phenomenological, rather than mechanistic, explanations of ecological phenomena (Wiens 1992). A pattern is observed and is explained in terms of a theory that predicts a linkage between pattern and process. Whereas the pattern is empirically measured, the explanation of the process is inferential (Wiens 1992). Applications of predictions derived from phenomenological models are constrained by the range of spatial and temporal variation encompassed in the data from which the model was constructed. If a phenomenological model is based on a narrow range of spatial and temporal conditions, then predictions from the model are limited because they assume that conditions do not change and that the phenomena on which the model is constructed adequately represent the underlying causal mechanisms (Koehl 1989). Further, most studies center on a specific scale, usually without reference to any other scale.

We can thus recognize research as a process involving different levels of inquiry and scale along a continuum, from intensive to extensive, and micro- to macro-scale. The finer the resolution of the study (i.e., the finer the scale), the closer we address the ultimate reasons, or "why", an animal is doing what it does. A knowledge of "why" organisms behave as they do, based on an intensive, mechanistic understanding of a phenomenon, should be the ultimate goal of research (Gavin 1991). Correlative, descriptive studies are initially necessary to determine patterns, but should serve as starting points for developing a more mechanistic understanding of a phenomenon. An intensive, mechanistic understanding of "why" individual organisms behave as they do will provide a foundation in which to interpret processes at higher levels of organization (Gavin 1991), and to increase the predictive ability of models developed for conservation planning. However, a mechanistic understanding of cause and effect cannot be inferred from correlative studies. Cause and effect relationships can only be proven through controlled experimental manipulations (Sokal and Rohlf 1981, Morrison et al. 1992). Unfortunately, due to the complex nature of most ecological systems, it is difficult to conduct controlled experimental manipulations. Thus, field researchers are often limited to correlative, descriptive studies.

Conservation planning requires quantitative predictions over relatively long time intervals and often must focus on systems where conditions are dynamic (e.g., changing spatial patterns of forests related to management practices). Thus, the key to successful habitat management is to understand what specific components of a species habitat most directly influence survival and reproduction (Kenward and Widén 1989, Martin 1992, Morrison et al. 1992). As discussed by Martin (1992), fitness parameters provide insight into the evolutionary basis for habitat requirements and choices, the effects on population recruitment and demography, and the life history traits of species and their implications for management. Information on survival and reproduction can be gained from detailed, intensive study of the habitat relationships of individuals. Long term demographic studies of marked individuals can provide measures of survival and reproductive output that can address habitat quality. Similarly, intensive studies of individuals can provide insight into the specific components of a habitat that explain the observed patterns of habitat use. For example, Newton (1986) experimentally determined that the addition of food to female European Sparrowhawks (*Accipiter nisus*) in food-poor areas during the pre-laying period resulted in a significant increase in clutch size and earlier laying dates. Earlier laying dates were associated with higher nest success rates relative to pairs that layed later. Thus, intensive study of individuals can provide direct measures of survival and reproduction that would not be evident from correlative vegetation-abundance studies. Additionally, processes that occur at the level of the individual can produce the patterns observed at higher levels of biological organization (Koehl 1989, Real and Levin 1991).

NORTHERN GOSHAWK ECOLOGY: CONCEPTUAL FRAMEWORK

Rather than fluctuating randomly, raptor populations are usually regulated either by resources (e.g., nest sites, habitat, food supply) and/or human factors (e.g., pollutants, disturbance, persecution) (Newton 1979, 1989a, 1991). There is no present information indicating that pollutants have had a significant effect on goshawk populations in North America (Snyder et al. 1973). The major threat to goshawks is the loss or degradation of mature forests used for nesting and foraging, primarily due to timber harvesting, as well as to livestock grazing in aspen nest stands (Bloom et al. 1986, Reynolds 1989, Reynolds et al. 1992). In this section we consider Northern Goshawk ecology relative to the conceptual overview developed above to identify the knowledge that can be gained from ecological studies at the various scales and levels of inquiry.

At the broadest scale goshawks are associated with forests and woodlands throughout the Holartic (Brown and Amadon 1968). Within North America, goshawks are found in a variety of forested vegetation types (Palmer 1988). Extensive studies conducted at this scale are typically concerned with estimating population density or home range sizes in various vegetation types. For example, Reynolds and Wight (1978) reported the density of nesting goshawks in three study areas in Oregon. Similarly, Crocker-Bedford (1990) reported the density of nesting goshawks on the Kaibab plateau in Arizona. The results of these types of studies are quantitative descriptions of the observed patterns, often explained in terms of an unmeasured factor such as prey abundance or distribution. Thus, these types of studies provide the necessary initial description of the pattern. However, because they are not based on an understanding of the underlying mechanisms, the predictive ability of models derived from these data will be constrained by the amount of spatial and temporal variation encompassed in the data set. If the complete range of conditions have been described, then the model should have some predictability. If the study is time- and site-specific, then the predictability of the model will decrease as conditions change from those upon which the model is based.

Newton et al. (1986) provided an example of an extensive study that incorporated a wide range of spatial and temporal variation. Additionally they measured factors that seemed important in explaining the observed patterns. They determined that the nesting densities of European Sparrowhawks varied between 12 study areas. Additionally, the variation was correlated with variation in prey density, which was related to land productivity, which in turn was associated with elevation and soil type (Newton 1986, 1989a).

Within a vegetation type, researchers typically focus on the use of various plant associations by goshawks relative to their abundance within some spatial area, such as the home range. In this paper we define vegetation type based on structure and general composition (e.g., mixed conifer forest type) and plant association as based on the dominant genera or species (e.g., a stand of white fir [*Abies concolor*] within the mixed conifer forest type). Studies at this scale usually present data as a proportion of time spent within different plant associations. Interpretations of such data are thus based on the scale at which the plant associations are defined. They do not necessarily have any direct relation to why the goshawk is using this vegetation; they are thus describing a pattern rather than addressing the cause for the behavior. The use of plant associations by goshawks could be related to the distribution and abundance of prey, microclimatic factors, concealment from predators, as a buffer from human disturbance, and/or various other factors. Thus, studies that do not address these phenomena at the appropriate level of inquiry relative to the question asked will certainly fail to tell us why goshawks are behaving in the manner that they do.

What we need, then, are studies that explain why the phenomena that we observe occurred. The only way to do this is to determine the ultimate reasons for the behaviors. Such studies require intensive analysis at the scale of the individual. Such an approach has a higher probability of being applicable to a range of plant associations and vegetative types than any other approach. This is because this fine level of inquiry addresses factors that directly influence the survival and fecundity of an individual bird—

habitat selection, energy balance, nutrient status, and the like. Such factors are likely to apply broadly to goshawks across their range; at least within a subspecies, all individuals will fall within a similar range of physiological abilities.

Intensive analyses address the specific, direct causes for a behavior, rather than acting as surrogates of the behavior as is the case for vegetation type. For example, what is the relationship between the size and type of prey available, and the energetic requirements and health of a goshawk? Does a female goshawk require a certain fat level to breed successfully? Such questions likely determine survival and fitness. For example, Kenward and Widén (1989) demonstrated that, given adequate hunting perches, food appeared to be the main factor determining winter habitat use by goshawks in central Sweden. In woodland habitat, goshawks foraged more often along woodland edge zones that were the preferred habitat of their prey, brown hares (*Lepus europeas*) and pheasants (*Phasianus* spp.). In boreal forest habitat, goshawks did not show a preference for edges and tended to hunt more in large patches of mature forest. The main prey in the boreal forest were squirrels (*Sciurus vulgarus*), which were most common and more evenly distributed in mature woodland. By adopting an intensive approach, Kenward and Widén were able to determine the main factor (prey distribution) that influenced habitat use and gain insight into why they observed the patterns of habitat use by goshawks that they did.

STUDY DESIGN: AN EXAMPLE

Currently we are conducting a study of Northern Goshawk ecology in the Lake Tahoe region of the Sierra Nevada, California. Our study area is ca. 1000 km ^{2} and ranges between 1700–2275 m elevation. Forest types at lower elevations range from dry, open stands of Jeffrey pine (*Pinus jeffreyi*) to mixed conifer stands composed of Jeffrey pine and white fir along with various site-specific combinations of sugar pine (*P. lambertiana*), incense cedar (*Calocedrus decurrens*), and red fir (*Abies magnifica*). These forest types are replaced at higher elevations by red fir and white pine (*P. monticola*). Lodgepole pine (*P. contorta*) stands occur on sites with higher soil moisture (Orr and Moffitt 1971).

As discussed above, interpretations of ecological phenomena can vary depending upon the scale and level of biological organization investigated. Thus, our approach is to examine goshawk ecology over a range of extensive and intensive scales and levels of inquiry. For example, at an extensive level we are quantifying the breeding density and home range sizes of goshawks over the landscape. Goshawks in our study area remain on their territories throughout the year, with increased home range sizes in the nonbreeding period. Radio-telemetry data from five pairs of goshawks during 1992 illustrated a range of both individual and seasonal variation in home range sizes (Table 1). Ninety-five percent minimum convex polygon home ranges averaged 18.8 km^2 (range 11.4–29.5) during the breeding period and 83.6 km^2 (range 13.4–154.3) during the nonbreeding period for males, whereas female home ranges averaged 12.8 km^2 (range 6.9–32.8) during the breeding period and 31.8 km^2 (range 12.2–40.1) during the nonbreeding period.

Home range sizes were compared between sexes within each season and within sex between seasons using Mann-Whitney U-tests (Zar 1984). The nonparametric Mann-Whitney U-test was used because the data did not meet the assumptions necessary for a parametric test (Zar 1984). No significant differences in home range size were found for male versus female breeding season ($P = 0.20$), male versus female nonbreeding season ($P = 0.20$), male breeding versus nonbreeding season ($P = 0.10$), and female breeding versus nonbreeding season ($P = 0.05$). However, the results of three of these tests were strongly influenced by an individual data point. For example, the pair #4 female had a breeding season home range of 32.8 km^2, whereas the other four females had breeding home ranges between 6.9–8.4 km^2 (Table 1). This female moved approximately eight km away from the nest area during the post-fledging period of the nesting cycle for 2–3 weeks and returned to the nest area just as the one fledgling was dispersing. The other females moved out of the immediate nest area but continued to return for prey deliveries during the post-fledging, pre-dispersal period (Keane, unpubl. data). Thus, the tests comparing male versus female breeding season and female breeding versus nonbreeding season were influenced by this data point. When this data point was excluded from the analyses, significant differences were found for both male versus female breeding season ($P = 0.02$) and female breeding versus nonbreeding season ($P = 0.02$) comparisons.

Therefore, other than for the pair #4 female, males had larger home ranges than females in the breeding season and females had larger home ranges in the nonbreeding season than in the breeding season. Similarly, the test for male breeding versus nonbreeding season home range size was strongly influenced by the pair #3 male, who decreased his home range size in the nonbreeding period (Table 1). We are not sure of the reasons why this was observed. The other four males increased home range size in the nonbreeding period (Table 1). If the nonbreeding season value for the pair #3 male is excluded from the analysis, then males had larger nonbreeding than breeding season home ranges (P = 0.02).

In summary, males had larger breeding season home ranges than females, except for the pair #4 female. There were no significant differences in home range size between sex during the nonbreeding season. All individuals except one (pair #3 male) increased home range size in the nonbreeding period. Although females increased home range size in the nonbreeding period, they continued to return to, and center, their activities near the nest area (Keane, unpubl. data).

To understand why we observe the patterns of home range and habitat use that we do, we are adopting an intensive approach to identify the factors that influence individuals. Our goal is to understand the energy requirements of individual goshawks, their diets, and the distribution, abundance, and habitat relationships of prey in the study area to be able to build up from the intensive level to explain the patterns observed at the extensive scales and levels of inquiry.

We are attempting to construct a model of goshawk energetics to estimate the energy required both for survival and for breeding. Three methods that have been used to estimate energy requirements are time-budget models (Walsberg 1983), allometric scaling models (Nagy 1987), and the doubly-labeled water technique (Nagy 1987, Tatner and Bryant 1989). Time-budget models are based on determining the proportion of time spent by an organism in various activities and then summing the energetic cost of each activity to yield an estimate of energy expenditure. Allometric scaling models predict energy demands based on body mass, diet, and habitat. The doubly-labeled water method measures metabolic rate by determining the turnover rate of hydrogen and oxygen isotopes, injected in the form of water, through water and CO_2 loss from the organism.

Time-budget models can provide accurate measures of energy expenditure, but require the use of measured energy equivalents for each of the various activities, as well as detailed knowledge of the thermal environment around the organism (Weathers et al. 1984, Buttemer et al. 1986, Nagy 1989). Time-budget models that do not empirically determine energy equivalents for each activity, and use estimates derived from the literature, are subject to errors of 20–40%, which may be no better than the rough approximations available from allometric models (Weathers et al. 1984). We plan to measure time-activity budgets (Widén 1984) and to use the doubly-labeled water technique to measure the energetic requirements of breeding adult Northern Goshawks. This information, along with the caloric value of the various prey species, will enable us to estimate the amount of food necessary to support a pair of breeding goshawks.

TABLE 1. Estimated Size (km^2) of Home Ranges for Five Male and Five Female Northern Goshawks in the Lake Tahoe Region, California, during the Breeding and Nonbreeding Seasons, 1992–1993. Home Range Sizes Estimated as Minimum Convex Polygons from Radio Telemetry Data. Breeding: June–15 August 1992; Nonbreeding: 15 August 1992–March 1993

		Season			
		Breeding		Nonbreeding	
Pair no.	Sex	95%	100%	95%	100%
1	Male	15.6	22.8	39.4	164.2
	Female	8.4	10.1	37.1	42.4
2	Male	21.9	36.7	154.2	160.7
	Female	8.3	13.7	40.1	97.2
3	Male	15.8	25.6	13.4	58.1
	Female	6.9	9.2	38.5	90.3
4	Male	29.5	33.7	96.1	129.3
	Female	32.8	36.4	12.2[1]	29.5
5	Male	11.4	19.6	114.8	148.8
	Female	7.8	9.7	31.3	42.6

[1] Contact was lost with this individual on 22 December 1992.

In addition to measuring energetic requirements, we are conducting inventories of the prey species to measure their distribution, abundance, and habitat relationships. On six sites within goshawk home ranges on our study area we have established a grid of sample points 300 m apart along transect lines in the various plant associations present. About 300 points have been established throughout the study area. We are conducting monthly point counts to measure bird and Douglas squirrel (*Tamiasciurus douglasii*) abundance at about 175 of the sample points, chosen to represent the range of plant associations present. We also are studying the foraging behavior of avian prey species of goshawks to quantify their microhabitat use patterns. Small mammal live-trapping is being used to sample squirrel and chipmunk distribution, abundance, and habitat relationships. Pellet counts are being used to determine relative abundance and distribution of snowshoe hares (*Lepus americana*).

Data on prey abundance, distribution, and habitat relationships will be compared with data on home range size and foraging habitat use to determine if they explain the patterns that we observe. For example, changes in prey abundance could be the reason why goshawks expand home ranges in the nonbreeding season. Similarly, prey abundance could explain the use of the various plant associations, as well as annual variation in goshawk productivity. However, it must be noted that measures of prey abundance and distribution do not necessarily provide a direct measure of prey availability (Hutto 1990). Hutto (1990) concluded that a fundamental obstacle to understanding the relationship between habitat use and food availability requires identifying the possible constraints on what subset of habitats and foods it is possible for a bird to use. By constructing an energetics model for goshawks we will be able to determine caloric needs and possible energetic constraints that influence goshawk ecology.

FUTURE DIRECTIONS IN GOSHAWK RESEARCH

We concur with Verner (1992) that both intensive and extensive field studies are needed to provide the critical data needed for conservation planning. We suggest that, rather than trying to synthesize the results of numerous time- and scale-specific studies at sometime in the future, coordinated efforts and funding be directed into a smaller number of more comprehensive studies that consider goshawk ecology over both intensive and extensive scales and levels of inquiry. Explicit within this approach would be a clear definition of goals and objectives that would serve to standardize procedures both within and between studies. Over the long term, this approach would increase efficiency in terms of funding expenditure and the generation of the critical data needed for conservation planning.

Integrating across scales and levels of organization would be a primary objective of this approach. At the landscape level, recent work indicates the importance of considering demographic rates (mortality, fecundity, dispersal, etc.) relative to the amount, configuration, and dynamics of habitat (e.g., Van Horne 1983, Gilpin 1987, Lande 1987, Pulliam 1988, Harrison 1991, Howe et al. 1991, Pulliam and Danielson 1991). A fundamental question at the population level is to determine the factor or interaction of factors that limit population density or size. As noted by Newton (1991), two populations can have identical demographic schedules even though they can differ significantly in density or size. Given that the probability of extinction due to chance is inversely related to population size (Goodman 1987), it is important to understand the factor or factors that limit population size. For example, Widén (1989) summarized the results of several studies of goshawk nest density and found that densities were higher in areas with greater food availability. He concluded that the evidence strongly indicated that goshawks are normally limited by food availability and that foraging habitat may be more important than nesting habitat for goshawks in boreal forests. Similarly, Doyle and Smith (this volume) documented the importance of annual variation in food availability on goshawk reproduction in boreal forests. Thus, a knowledge of the external factors that limit population size is required if the goal of a particular conservation strategy is to implement management practices to increase population size (Newton 1991). It must be clearly noted that higher levels of organization, such as "populations", are often artifacts constructed by researchers for management purposes. In some cases populations can be defined based on demographic data, particularly in relatively more isolated areas such as the goshawk population on the Kaibab Plateau (Reynolds et al. this volume). However, often the area used to define a "population" is determined by administrative or geographic convenience. For example, we might refer to the goshawk "population" of a specific ranger district without knowledge of immigration or emigration rates.

Studies of variation in demographic rates related to habitat variation clearly indicate the importance of considering the relationship between fitness and habitat quality (Van Horne 1983, Pulliam 1988). As discussed previously, detailed studies of individuals can provide insight into the factors that influence fitness and can be used to interpret processes observed at more extensive scales. At the individual level, the spatial scale of the nesting area and foraging areas are important determinants of fitness. For example, Newton (1989b) documented that territory quality was a major factor associated with lifetime reproductive success in sparrowhawks. Individuals on high quality territories exhibited increased longevity, which resulted in increased lifetime reproductive success relative to individuals on lower quality territories.

Detailed, long-term investigations of individuals are also necessary to determine relationships between habitat quality and fitness. For example, Schnell (1958) and Boal and Mannan (this volume) provide detailed dietary studies from individual pairs of nesting goshawks. Similarly, Widén (1989) investigated habitat use by goshawks in relation to forest structure and prey abundance. Regarding nesting habitat, Woodbridge and Detrich (this volume) addressed habitat quality through a study of marked individuals that considered long-term territory occupancy rates across time and spatial scales that ranged from nest trees to nest stand size to clusters of nest stands.

To implement the approach we advocate would require initiating a long term demographic study of marked individuals. Within this demographic framework, intensive studies of individuals could be conducted that address the factors that influence fitness. This is the approach we have taken in our study of goshawk ecology in the Sierra Nevada. Similarly, Reynolds et al. (this volume) have taken this approach for their study of goshawk ecology on the Kaibab Plateau in Arizona. Based on an understanding of goshawk ecology over a variety of scales and levels of organization it might then be feasible to conduct especially insightful experimental manipulations. Silvicultural prescriptions could then be evaluated in an adaptive management context (Walters 1986, Walters and Holling 1990, Irwin and Wigley 1993) as to their effect on goshawk foraging and nesting habitat at the individual level and to their effect on the population at the landscape level. The results from studies such as that we outline would yield the extensive level data necessary for demographic analyses, as well as, provide the intensive level data needed to understand why goshawks do what they do.

It might be argued that, despite the apparent merits of the approach we outline, funding seldom will be available to support these kinds of intensive studies. Most wildlife research dollars traditionally support graduate students for 1–3 years of work. We argue that it would be better for such students to determine the factors that ultimately relate to survival and reproduction of only a few pairs of goshawks than it would be to produce yet another study of home range that is time- and site-specific. The former addresses ultimate causation and can build towards a more thorough understanding of goshawk biology, whereas the latter provides only a broad-scale, time- and site-specific description of a pattern and must speculate as to the cause and effect relationships.

In conclusion, there is an increased demand for critical data to design conservation plans for the Northern Goshawk. Rather than reinventing the wheel, goshawk researchers should reap the benefits of the valuable lessons learned in conservation planning for the Northern Spotted Owl (*Strix occidentalis caurina*) (Thomas et al. 1990, Carey et al. 1992, Verner 1992, Verner et al. 1992, Harrison et al. 1993), specifically, that the data most vitally needed for conservation planning require both intensive and extensive field studies. In meeting these data demands, researchers should strive to understand the causal mechanisms underlying the patterns observed.

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