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DESIGNING AND PRESENTING AVIAN RESEARCH TO FACILITATE INTEGRATION WITH MANAGEMENT

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Abstract. Both avian scientists and managers are responsible for the results of management decisions and the consequent effects that field applications have on bird communities. However, communication gaps arise between management and research as the two disciplines continue to specialize. Researchers must make an effort to bridge these gaps by designing studies with management utility and presenting results in a form that will reach a wide audience including managers. Basic research increasingly is shifting towards applied problems and applied research has moved towards basic ecological theory, thereby diminishing distinctions between the two. Avian scientists should continue to use the hypothetico-deductive method when performing research, but should emphasize scales and problems relevant to management. Once projects are completed, researchers should present results as quickly as possible, especially at meetings where scientists and managers interact. Adaptive resource management represents a new opportunity for the integration of research and management because, by definition, it requires that the two endeavors work together. I include a case study of an interdisciplinary and coordinated research effort conducted on the Savannah River Site in South Carolina. The research is developed in a theoretical framework designed to answer broad ecological questions but retains its applicability to avian management.

Key Words: adaptive resource management, avian, bottomland forest, communication, group selection, management, research, scale, scientific method.

Natural resource managers must integrate use of forest resources with changing ecological values (Sharitz et al. 1992). Natural resource scientists must apply sound scientific principles to solve problems that arise during management of natural resources, and, therefore, should be judged by how well their efforts increase manager success. Interaction between scientists and managers is required for the problem identification and resolution process to be effective and complete. However, poor communication between researchers and managers is a common phenomenon that leads to inefficiency in both endeavors (Stoltenberg et al. 1970, Hanley 1994).

Communication gaps between researchers and managers arise from a lack of mutual understanding of the other's responsibilities and goals (Macon 1967). Resource managers point out that researchers often are narrowly focused, impractical, slow to arrive at solutions, and difficult to understand. In contrast, researchers object that managers do not use research results effectively and expect oversimplified solutions to complex problems, and that research is chronically underfunded relative to manager expectations (Hanley 1994). Researchers and managers have different functions and goals, and as each continues to specialize, the number of people with both research and management experience will continue to dwindle. Effective communication between researchers and managers becomes increasingly important as management decisions become more complex and research continues to specialize (Macon et al. 1970).

Avian scientists increasingly are working with forest and wildlife managers to improve understanding of the relationships between forest management practices and avian ecology. Birds are a diverse and readily sampled group and avian habitat specialization based on physical characteristics of the environment is well documented (e.g., MacArthur and MacArthur 1961, Anderson and Shugart 1974, Holmes et al. 1979). These characteristics of bird communities and recent declines of some bird species in association with human influences (e.g., Terborgh 1989) have made applied avian research a priority topic. Consequently, avian scientists must strengthen communication with land managers and design research that facilitates integration with management operations.

RESEARCH DESIGN

Fretwell (1972) stated that scientists adept at both theory and field work were most likely to make advances in ecology. However, opportunities for these types of scientists have been rare because of the substantial gap between applied and basic research. The primary function of applied science is to provide knowledge to manage species for commercial, ecological, and/or aesthetic value, while basic science strives to understand nature for understanding's sake (Romesburg 1991). Purely basic research, because it is so specialized, appears narrow and often has no direct utility to management (Stoltenberg et al. 1970). Recently, many natural resource scientists have attempted to narrow the gap between basic and applied research. Sources of funding for basic research have dwindled and scientists are increasingly required to justify their research in terms of its applicability (Brown 1992). Basic researchers have moved to applied problems and applied problems have shifted toward more basic ecological questions (Hanley 1994). Distinctions between basic and applied science are diminishing and increasingly irrelevant (Nudds 1979, Sharitz et al. 1992, Wiens 1992, Hanley 1994, Moffat 1994). Research that advances theory applicable to management is ultimately the most useful research for management.

Applied-basic science is basic science conducted in an applied area (Romesburg 1991). In this transition zone, basic information is screened for possible application (Macon et al. 1970). Historically, applied research and management have worked together closely, while each benefited from basic research peripherally (Hanley 1994). Basic and applied researchers should work jointly in developing scientific knowledge of ecological processes, while managers benefit from advances in science by revising their analytical tools accordingly (Hanley 1994). Increased competition for limited numbers of positions, advanced education requirements, and diversification of job applicants in the resource manager's field have raised the qualifications of managers occupying existing positions. Therefore, managers should be able to understand relevant ecological theory and handle the additional responsibility of implementing sound research into management practice. However, this should not free scientists from responsibility to apply sound scientific principles to solve problems and perform research that is applicable to real-world situations.

A priori decisions regarding problem selection, experimental design, and site selection should be made with the manager's needs in mind. There is a long time span between research and implementation, so research problems should be timely and contemporary. The problems must have important application to management and also be favorable to developing predictive theory. Scientists funded by management institutions often take on broad and ambiguous problems and those funded by basic research institutions investigate more specialized problems (Hanley 1994). The most useful research is a compromise between these extremes.

The present needs of management and the shortcomings of the management status quo can be identified through communication with field personnel and/or inventory and population monitoring. For example, field personnel might have pertinent information concerning which bird species are declining locally and theories relating to the causes of the declines. Regional and larger-scale population trends can be obtained from long-term monitoring programs like the Christmas Bird Count, Breeding Bird Survey, and Breeding Bird Census. Using retroduction, asking questions about these trends and/or examining the results of previous research, especially qualitative studies (Romesburg 1981), scientists can identify pressing research needs.

Unless natural resource scientists use rigorous scientific procedures following the hypothetico-deductive method (Romesburg 1981), our understanding of the processes underlying the relationships between birds and management will stagnate. Once management decisions are made and implemented, they cannot be retracted. Therefore, decisions based upon poorly designed research could be detrimental to the wildlife meant to be conserved. Researchers must develop and test several alternative hypotheses (Chamberlain 1897). Testing of a single alternative model may lead scientists to become attached to the "pet hypothesis," resulting in incomplete and biased conclusions. Induction, which is based on observations of associations and correlations, cannot give knowledge about the processes that drive nature (Romesburg 1981). Instead, during hypothesis formulation scientists must ask *Why?* and *How?* rather than *What?*. Applied-basic research should be done in a theoretical framework because it aids proper application of the scientific method (Nudds 1979).

However, the scientific method is difficult to apply in ecology because stochasticity, complexity, and unobserved or uncontrollable variables are common (Loehle 1987). Temporal variation in avian habitat selection can be annual or seasonal and spatial variation can occur at the territory, stand, or landscape level. Individual variation can interact with both spatial and temporal variation to compound errors. Predictions defined in ways that can be tested unambiguously (Hanley 1994) and proper replication and controls aid in efficiently accounting for variability.

The utility that research has to management is partially determined by the scales, both temporal and spatial, at which it is performed. Historically, wildlife management decisions targeted individual species rather than the entire community and its system (Wagner 1977). However, the present trend is toward management of ecosystems and the maintenance of biological diversity (Sharitz et al. 1992). In practice, managers must continue to manipulate at spatial scales equal to or larger than the size of existing stands and plan at temporal scales equal to the rotation lengths of those stands. Stand sizes and rotation lengths can be changed, but this usually takes time. Conversely, manipulative experiments, in which replication and control are important, usually are carried out on a small scale because the scientific method becomes increasingly difficult at larger scales (Hanley 1994). Logistics, especially the effort required to measure habitat variables and the difficulty of accounting for variability at larger scales, limit the scale of experiments.

The species or community in question may limit the scales that can be used in experimental approaches. For example, a landscape that is heterogeneous to a Prairie Warbler (*Dendroica discolor*) may be contained within a homogeneous patch from the perspective of a Cooper's Hawk (*Accipiter cooperii*). Research that documents characteristics of Hooded Warbler (*Wilsonia citrina*) nest substrates (e.g., substrate height and number of limbs at point of nest placement), while providing valuable knowledge concerning the ecology of the species, has little practical value to large-scale land management. Although managers continue to advance their ability to manipulate habitats at multiple scales, it may be impractical to control the height or growth patterns of a single substrate species. Instead, managers would have to adjust these fine-scale results to a more coarse-grained scale (i.e., % cover of substrate species). Because results of small-scale experiments may not be relevant to larger systems (Carpenter 1996), scientists increase the utility of their research by targeting the scales at which management issues will be addressed and the habitat variables controllable by managers when they formulate hypotheses, make predictions, and develop an experimental design. Results from studies conducted at multiple scales will more likely identify patterns of change between scales (Wiens 1989) and may be more easily incorporated into management prescription.

Unless dealing with game species (e.g., harvest regulations), managers manipulate bird communities by manipulating their habitats. Therefore, research that provides direct linkages to habitat creation and manipulation will have the most relevance to management operations. Scientists also can increase the utility of their research by making linkages to previous research or ongoing research projects. A series of short-term projects with a common tie can partially substitute for long-term research projects (e.g., Kilgo et al. *this volume*). Coordination of several specific studies may be used to answer a larger, more general question (Stoltenberg et al. 1970).

Adaptive Resource Management

Scientists can address large-scale questions by using management or natural manipulations as scientific experiments (Macnab 1983, Walters 1986, Walters and Holling 1990, Sinclair 1991, Lancia et al. 1996). This approach, termed Adaptive Resource Management (ARM), integrates learning about a system and its mechanistic processes with ongoing management operations (Walters 1986, Lancia et al. 1996). ARM encourages that research and management be conducted simultaneously as one coordinated endeavor and that the two collaborate to take better advantage of planned management actions and manipulations (Lancia et al. 1996). Within a landscape, several alternatives are tested simultaneously and as inferior alternatives are replaced by more proven ones, the direction of management is altered coincidentally (Irwin and Wigley 1993). By definition, ARM promotes increased communication and collaboration between researchers and managers. Rewards are shared equally by ecological science and wildlife management and distinctions between managers and researchers blur as the two are compelled into closer working associations (Macnab 1983). Lancia et al. (1996) suggested an interdisciplinary approach to adaptive management and the forging of partnerships among professional societies with conservation interests. Such a coordinated effort could stimulate more creative hypothesis development by researchers (Romesburg 1991) and operation on a more challenging professional level by managers (Macnab 1983).

Researchers may have to accept some compromise in the development of experiments in coordination with ongoing management, especially because of constraints on randomization and replication (Lancia et al. 1996). Additionally, scientific monitoring at such large scales may be limited by common logistical problems such as shortages of manpower and funding. Two main challenges to the design of adaptive management experiments are the development of technical advancements and imaginative methods to sample ecological processes at large scales, and the establishment of administrative arrangements that would allow for long-term investigations by researchers (Walters and Holling 1990).

Scientists and managers responsible for setting waterfowl harvest regulations already have begun implementation of ARM (Johnson et al. 1993, Williams and Johnson 1995) with some initial success (Williams et al. 1996). Due to the uncertainty of the effects that harvests have on waterfowl populations, establishment of these regulations is a difficult task. Uncertainties arise from the complexity of regulatory options offered, the inconsistencies of regulations from year to year, and the large geographic range covered by waterfowl populations during the annual cycle (Williams and Johnson 1995). Williams and Johnson (1995) described the general process used by waterfowl managers and researchers to implement ARM. First, the objectives for harvest management are established through communication between several cooperating groups, including state wildlife agencies, the U.S. Fish and Wildlife Service, Canadian and Mexican governments, and the public. The status of waterfowl populations is determined with monitoring programs, and the effect harvests have on populations from year to year is assessed. Data acquired from harvest surveys and population monitoring are used to update models that predict optimal harvest regulations. Eventually, uncertainty is reduced to the point that the most appropriate model for describing population dynamics is identified. Despite potential obstacles, active adaptive harvest management offers considerable benefits, including stronger links between migratory bird management and research (Williams and Johnson 1995).

PRESENTATION AND RECOMMENDATIONS

Managers depend on researchers for solutions to problems (e.g., species declines) that arise during management applications. Although researchers may directly address problems and develop potential solutions, most results are presented as scientific publications, which most managers cannot translate into relevant prescriptions. However, there are steps that natural resource scientists can take to make results more available and applicable to wildlife management.

Once research projects are finished, results should be published or packaged for managers as quickly as possible. This usually is mandatory if the funding agency is management oriented. If results and recommendations do not reach the management sector until after the often long and drawn out publication process, their applicability to management may be outdated. It is best to package the results in a form that will reach managers at all levels including government, private industry, and private landowners. Examples of such publications include experimental forest bulletins and Cooperative Extension Service pamphlets. Managers can exhibit publications, reports, and maps resulting from research activities as proof of their dedication to scientific advancement.

Understandably, most research scientists are driven by performance evaluations based primarily on quantities of refereed publications in high quality journals. Time spent producing bulletins and pamphlets would detract from researcher ability to reach goals required for tenure or professional advancement. Goals established by administrators or upper-level management may not be in the best interest of natural resource management. Institutions and agencies that presently do not reward scientists that publish manager-oriented publications should reconsider such a policy or provide personnel specifically funded to link managers with research publications.

When preparing results to be presented specifically to managers, researchers should make recommendations that are cost effective, logistical, and practical. Hanley (1994) stressed that management should be left to translate ecological knowledge into the analytical tools needed for application. However, efforts by researchers to present recommendations in a relevant form will facilitate the process. Researchers should take special care to consider the manager's time and spatial constraints. Economic constraints, beauracratic hurtles, or planning requirements can impede changes in management policy for decades. Researchers must plan for these time lags when making recommendations. During presentations to managers, scientists should be specific with objectives, hypotheses, alternatives, and recommendations. Researchers should reduce the clutter of mathematical jargon present in most scientific publications, but remain careful not to overstep the limits of significance that statistics erect. If research does not have direct applicability to management, scientists should not attempt to assign management utility to results. Invalid conclusions that overstep the boundaries of research applicability can retard the advancement of science and management.

Scientists must actively engage in the logical flow of information (Stoltenberg et al. 1970). Attendance at professional meetings and project planning conferences where researchers and managers interact promotes idea transformation and translation. Written reviews and project progress reports, consulting services to managers, advisory committees to management organizations (e.g., Ducks Unlimited, National Wild Turkey Federation, Partners in Flight), and liaisons also help maintain information flow between scientists and managers. Very little, if any, professional advancement may come from the extra effort taken to create these special pathways between management and research. However, the long-term benefits to avian ecology and conservation may provide more career satisfaction than one more technical publication.

CASE STUDY: THE GAP PROJECT AT SAVANNAH RIVER SITE (SRS)

Several individual research studies, covering diverse taxa, were initiated on SRS in a bottomland hardwood stand in which experimental canopy gaps were created by group selection timber harvest. Six replicates of six gap sizes (0.015, 0.031, 0.062, 0.126, 0.264, 0.503 ha) were created in the stand, and portions of the stand that were left unharvested were used as control replicates. Although the study was originally designed to examine the effects of gap size on herbivory rates on woody and herbaceous plants by white-tailed deer (*Odocoileus virginianus*) and swamp rabbits (*Sylvilagus aquaticus*), the rigorous experimental layout provided the opportunity to study a variety of other ecological processes and species groups.

THEORETICAL FRAMEWORK

Upon learning that Savannah River Institute (SRI) managers were interested in the relationships between the artificial gaps and bottomland bird communities, several local researchers proceeded to identify the important ecological questions and what utility they had to management. Previous studies have documented increased bird use (e.g., species richness and abundance) in natural gaps relative to the surrounding forest (Schemske and Brokaw 1981, Willson et al. 1982, Blake and Hoppes 1986, Martin and Karr 1986, Wunderle et al. 1987). Blake and Hoppes (1986) and Martin and Karr (1986) attributed the increases to higher resource abundance in the disturbed areas. Forest-interior, area-sensitive species such as Kentucky (*Orpornis formosus*) and Hooded Warblers are adapted to internal forest disturbances such as tree-fall gaps (Thompson et al. 1993, Kilgo et al. 1996). Researchers sought to investigate whether these relationships were similar in artificially created gaps, and, if so, for what reasons.

MacArthur and MacArthur (1961) documented a positive relationship between bird species diversity and foliage height diversity (FHD). Runkle (1982) determined that with increased gap size, vegetation within gaps increased in woody species diversity, total basal area, and total number of stems. Resource levels (i.e., fruit and insects) also might be higher in gaps because of greater primary productivity associated with increased light levels (Halle et al. 1978). Consequently, habitat heterogeneity and FHD should be greater in the artificially created gaps, especially larger ones, than forested areas without gaps; thereby providing niches for a wider range of species as well as a greater abundance of individuals. Researchers developed two testable predictions from this hypothesis: (1) species richness and individual species abundance will be greater in and around the artificial gaps, especially the larger gaps, than the control areas; (2) species richness and individual species abundance in the gaps will increase with any temporal increase in the structure of the vegetation.

JUSTIFICATION

Between 2000 and 2030, annual hardwood timber removals from southern bottomland hardwood forests are projected to increase from about 22.1 million m^3 to about 36.3 million m^3 (U.S. Forest Service 1988). Group selection is a method commonly used to harvest bottomland timber, and it may adequately simulate the natural disturbances that provide canopy openings and an uneven-aged structure (Pashley and Barrow 1992). Forest fragmentation, resulting from stand-level disturbances, causes declines of some forest-interior species and local extinctions of others (Finch 1991). However, Hamel (1989) determined that Swainson's (*Limnothlypis swainsonii*) and Hooded warblers, both forest-interior species, occurred at higher densities in selection harvests than in clearcut or uncut areas. Therefore, it is possible that there is an area-related threshold where gap-phase disturbances such as those in selection harvesting operations begin to have similar effects as stand-level disturbances. With the relatively continuous range of gap sizes present in the study, the gap size in which early-successional species first appear (low-end threshold) and the size in which forest-interior species begin to disappear (high-end threshold) could be identified. Any information relating to these thresholds and results from the original predictions could be used to provide recommendations on the optimal opening sizes to be used in selection harvest operations.

PRESENTATION

To maintain constructive interaction with managers, researchers presented annual progress reports to SRI personnel and periodic updates at local symposia. Study recommendations were made part of the logical information flow by making presentations of preliminary results at national conferences with both managers and researchers attending and presenting practical and clearly-stated management recommendations in a final report. Hopefully, all conceptual aspects of the research will be published in scientific journals in the future.

The gap project is an exceptional example of an interdisciplinary approach to investigate a broad range of specific research questions and a coordinated effort to address a few general problems. Among the scientists performing research on the gap site are botanists, ecologists, ornithologists, herpetologists, and mammalogists. Among the managers based at SRI are computer specialists, silviculturalists, foresters, and wildlife biologists. The simultaneous presence of the

SRI personnel and the gap-project scientists provides a unique opportunity for productive interaction before, during and after each research project.

CONCLUSION

Avian ecologists have a great responsibility to the future of wildlife management. The success of future management decisions rests as much with scientists as it does with managers. The greatest challenge to research scientists is to conduct research that is developed in a theoretical framework and answers broad ecological problems but also has utility and application to avian management. Adaptive resource management is the potential solution to the problem of integrating research with management in the future. It ensures that managers and scientists jointly make decisions regarding management direction and uses ongoing management to answer research questions. However, ARM will require willingness of basic researchers to operate in a more applied realm and compliance by managers to adjust field prescriptions to meet demands of experimental design. This increased cooperation should reduce the information swamping that managers currently undergo and provide pertinent, unambiguous answers to contemporary management problems.

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