TRENDS IN WILDLIFE HABITAT RESEARCH

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Abstract: Wildlife habitat research in the Southeast has undergone several changes in direction since its beginning in the 1920's. Most recently, it has been marked by increased emphasis on special, seasonal habitat requirements; species other than major game animals; application of computer technology; habitat evaluation procedures; and methods of managing for wildlife diversity. These areas will continue to be emphasized in the 1980's. The broadening nature of habitat research and demands for quick answers to immediate problems will challenge the ability of the profession to maintain scientific credibility and research programs to develop basic knowledge needed for the future. Old lines of research on species requirements must be continued. High priority should be given to analysis and synthesis of the literature and to technology transfer.

Proc. Ann. Conf. S.E. Assoc. Fish & Wildl. Agencies 34:536-544

Basic elements of wildlife habitat may be broadly classified as (1) food, (2) cover (those constituents providing concealment from predators and man and shelter from adverse weather), (3) special features (sites for reproduction, breeding-display, roosting, ridding external parasites, and other special needs), (4) water (for drinking and sustaining vegetation), and (5) substrate (soil). Early research described wildlife use of these elements, and, as knowledge increased, studies became more quantitative and detailed. Vast changes in land use and increased public interest in species other than game and furbearers have led to a new direction in wildlife conservation.

The objectives of this paper are to put the present state of knowledge in historical perspective and suggest future directions in habitat research and management, with emphasis on the southeastern United States. We appreciate the helpful reviewer comments on the manuscript by J. L. Buckner, R. L. Carlton, P. E. Hale, R. L. Marchinton, D. W. Speake, and L. E. Williams, Jr.

HISTORICAL TRENDS

Hunting is an important facet of the culture of the South, and private landowners have practiced game management efforts at least since the early 1800's (Elliott 1859, Ghodes 1967). Wildlife management began to develop on a scientific basis in the early 1900's. One of the most significant achievements of that period was the Cooperative Quail Investigation (Stoddard 1931), which provided much information on bobwhite *(Colinus virginianus)* food and cover requirements and ways to enhance habitat by proper burning, timber cutting, plowing, and planting. This was possibly the first description of a comprehensive program of management for a species based on scientific research. Many years elapsed before comparable information was provided for other wildlife.

Habitat management and other aspects of wildlife management were not presented as a system of general principles until publication of Leopold's classic textbook in 1933. With the scientific perspective provided by Leopold's book, increased attention was devoted to determining habitat requirements of game species, analyzing habitat conditions to identify limiting factors, and manipulating habitat to control these factors.

Wildlife research and management gained great momentum during 1935-1937. The Federal Aid in Wildlife Restoration Act and the Cooperative Wildlife Research Unit

program began providing support and direction for research, and the Journal of Wildlife Management and the North American Wildlife Conference and its Transactions provided better means of communicating research results. Although the importance of year-round food and cover requirements was recognized, it was generally assumed that late-winter food supplies were most critical, and there was much emphasis in the 1930's and early 1940's on planting foods to overwinter and concentrate game during the hunting season (e.g. McAtee 1941, Pearson and Sturkie 1944). Food habits studies received much attention, especially by the U.S. Bureau of Biological Survey (summarized by Martin et al. 1951) and the Alabama Cooperative Wildlife Research Unit, where A. M. Pearson and associates published more than 20 papers on food habits of bobwhite quail and other game species. Farm game was emphasized during this era because rural lands were primarily small farms, and hunting was mostly for small game because deer *(Odocoileus virginianus)* and wild turkey *(Meleagris gallopavo)* had been extirpated from most of the South. However, interest in forest and wetland wildlife was reflected in food habits work and important monographs on white-tailed deer (Ruff 1939) and wild turkey (Mosby and Handley 1943, Wheeler 1948).

Research and management in the early 1940's were impeded by World War II, but progress resumed soon after the war. The Southeastern Association of Game and Fish Commissioners, formed in 1947, spurred improvements in some state wildlife agencies and developed cooperative programs, while the Proceedings of its meetings provided an outlet for reporting results of habitat management and research.

During the late 1940's and the 1950's, as many people left the farms and moved to the cities, marginal crop lands were retired and left to natural succession or planted to pines *(Pinus* spp.) with the assistance of federal programs such as the Soil Bank. At this time most states intensified programs to restock deer and turkey in areas where their populations had been extirpated (Mosby 1959, Blackard 1971), and there was a corresponding increase in research on these species. This trend toward increasing emphasis on research on forest wildlife habitat at the expense of farm game continued through the 1970's.

During the 1950's habitat research continued to develop along lines already well established, but the 1960's brought improved technology and greater sophistication to wildlife research. Perhaps the most significant technological development in the history of wildlife research was radio-telemetry. Although initially radio-telemetry diverted attention from habitat research to studies of home range size and activity patterns of animals without regard to habitat influences, biologists quickly recognized its potential for providing data on habitat use not previously obtainable. In perhaps the earliest successful use of radio-telemetry in the Southeast, Jeter and Marchinton (1964) showed the influence of habitat features on movements and activity patterns of white-tailed deer in Florida. Subsequent studies employed radio-telemetry to reveal preferred habitat for nesting (Williams et al. 1968) and brood-rearing (Hillestad and Speake 1970) of turkeys, escape cover for deer (Sweeney et al. 1971), denning for bears *(Ursus americanus)* (Johnson and Pelton 1979) and other needs.

Another area of increased research effort, especially by U.S. Forest Service biologists, was deer range inventory and analysis, and estimation of habitat carrying capacity (Ripley and McClure 1963, Shaw and Ripley 1965, Blair and Epps 1969). But, increased interest in population analysis, harvest and other mortality factors, radio-telemetry and the accompanying need for improved capture methods, and concern over the effects of pesticides and other contaminants generally resulted in a decrease in the proportion of research effort devoted to habitat problems.

There was great acceleration and diversification of wildlife research during the 1970's. Most biologists continue to concentrate on a species or group of species, but there was increasing specialization along other lines such as habitat analysis and evaluation, compu-

ter applications to modelling, and specific habitats (e.g. wetlands, pine plantations, rights-of-way). Environmental awareness and the National Environmental Policy Act resulted in many studies of environmental impacts of nearly every type of land use. Expansion in intensive forest management by industries and growing recognition of its potential significance to wildlife management stimulated research on the effects of silvicultural practices on wildlife and ways of coordinating wildlife and timber management (see Schemnitz 1976 and Harris 1978 for summaries). Impacts of other land-use practices such as stream alteration (Ferguson et al. 1975, Gray and Arner 1977) and strip mining (Utz 1976) also received much study.

The Endangered Species Act of 1973 indicated a public concern for declining organisms as well as an appreciation by Americans for nongame animals in general. The amount of work on songbirds, small mammals, raptors, and other non-game wildlife is staggering and cannot be summarized here, but if the most significant change in wildlife research in the 1970's were singled out, it would be the nongame movement. Most wildlife agencies began nongame research programs, and in many instances the traditional concerns of wildlife biology were joined with those of other disciplines.

Songbirds and small mammals were studied in many forest types, and much information was obtained on the effects of intensive forestry on these species (DeGraaf 1978, Harris 1978). These studies generally focused on the bird or small mammal community as the unit of study, with species diversity often being the major indicator of habitat quality. Studies of individual species of nongame animals dealt mainly with rare or declining animals. The habitat needs of the red-cockaded woodpecker *(Picoides borealis)*, for example, were explicitly defined (Jackson 1979). Management recommendations for that species and certain others were summarized in a symposium (Odom and Landers 1978). Objectives for management on federal lands began to emphasize a variety of species. The community as the unit of management was suggested in a study of management needs of sandhill reptiles (Landers and Speake 1980).

Game animal research expanded to include species that had received little emphasis previously. Habitat studies of species such as black bear, raccoon *(Procyon lotor)*, fox squirrel *(Sciurus niger)*, woodcock *(Philohela minor)*, and ruffed grouse *(Bonasa umbellus)* followed expressed needs for management recommendations. There was also increased interest in seasonal habitat needs. Studies of various species showed that a variety of habitat conditions are needed to meet needs that vary with season of the year (e.g. Harlow and Hooper 1971, Landers et al. 1977), age and reproductive status (Kirkpatrick 1975, Landers et al. 1977), and year-to-year differences in food conditions (Weber 1975; McRae et al. 1979; Landers et al. 1977, 1978). Other studies indicated that brood habitat is often a limiting factor for upland gamebirds. Insect production within proper cover was shown to be of major importance to broods of bobwhite (Hurst 1972) and turkey (Barwick et al. 1973).

Habitats were analyzed at all levels of intensity and scope. Intensive microsite study of vegetation contributed to a better understanding of physical structure preferred by songbirds (DeGraaf 1978) and male grouse (Hale 1978). Comparisons of floristic structure and seed production were used to evaluate effects of management treatments on granivorous animals (Buckner and Landers 1979), and fruit production by shrubs was related to site preparation techniques, fire frequency, and seral stage (Stransky and Halls 1979).

Subjective scoring techniques for general evaluation of habitats also were developed for extensive inventory for environmental impact assessment (Flood et al. 1977) and management planning by agencies such as the U.S. Forest Service (Thomas et al. 1976) and industrial landowners (Buckner et al. 1979).

Methods of even more extensive habitat inventory were developed with the application of remote sensing. Satellite imagery aided in delineating study areas of far-ranging animals

(Varney et al. 1976), classifying habitat according to floristic and faunal diversity (Brabander and Barclay 1977), and inventorying critical habitat of rare species (Diemer 1980).

FUTURE TRENDS

This brief recounting of history illustrates how wildlife research and management have been influenced by human events outside the control of the wildlife profession. Wildlife conservation is considered by most people to be an economic luxury, and support for it is sensitive to vagaries of political mood and economic conditions. Financial support is a major factor determining directions in research, and it is not always related to need. Aside from availability of funds, trends in research are established when new research niches are opened by breakthroughs in theory or technology, when new problems arise from changing conditions, and/or when there is a sudden recognition of the existence of an old problem. There is also an element of fashion or vogue involved, as some researchers simply follow bandwagons. All of these factors are evident in the general trend for the early 1980's that is already well established.

It is clear that the biggest problem in the 1980's will be related to encroachment on wildlife habitat by an increasing human population. Much of the effort to prevent irreversible alteration of wildlife habitat will be in the sociopolitical arena, which is outside the scope of this paper. But, because of diminishing habitat available for wildlife management, habitat research will be emphasized even more than during the 1970's. Much of it will be in response to federal legislation requiring inventory and management of habitats for a variety of species and for assessment of impacts of various land uses. There are indications that a disproportionate effort will be devoted to short-term projects for technological development to meet immediate needs and that the foundation of basic biological knowledge needed for application of the new technology may be neglected.

Although habitat research will be pursued along many lines, some general areas that can be expected to receive considerable attention are development of a conceptual framework for multispecies management, development of general habitat evaluation procedures, intensive analysis of habitat structure, and study of specific habitat requirements of individual species. The latter area is a continuation of well established lines of research with emphasis on a broader range of species. The others are more recently emphasized directions less familiar to wildlife biologists. They reflect an increasing emphasis on the ecosystem approach to management. Incorporation of habitat considerations for a variety of wildlife species into management plans and environmental impact assessments will challenge the capabilities of biologists accustomed to specialization along species lines. Expected trends in habitat research and management raise some general concerns about how the need for quick answers to immediate problems will be balanced against the needs for scientific credibility and development of basic knowledge to meet future needs.

Fashionable ideas and approaches and expedient means of meeting administrative requirements must be evaluated critically.—In our opinion many overly simplistic approaches to multispecies and ecosystem management and habitat evaluation are being accepted uncritically. For example, objectives in multispecies management have generally been stated vaguely. "Diversity" has become a popular management objective and measure of habitat quality, but a useful definition of diversity is yet to be proposed. The term may incorporate numbers and distribution of individuals, species, habitat types, and habitat components within types. Ecologists have proposed various quantitative diversity indices. Some of those commonly used are reviewed by Hair (1980), who pointed out the need for understanding their limitations in wildlife management. The popular Shannon Index treats all components equally and confounds species (or types) and numbers of occurrences. It may be biologically meaningless (Hurlbert 1971), and its usefulness as a

management objective is questionable (Boyce and Cost 1978). And there is the basic question of the desirability of managing for diversity at the expense of rare components.

Because of the complexity of interactions among species and habitat components, use of computer technology in management is increasing. Yet, ironically, computerized management has resulted in oversimplified interpretation of these interactions for the expediency of administration. Important variables are often ignored, arbitrary values are assigned to others, and the dynamic and fickle nature of populations and habitats is ignored. In application, computerized management may be too rigid, not allowing the manager on the ground the flexibility to change directions when necessary.

Similar problems exist where habitats are classified and assigned quantitative ratings of their value as habitat for "wildlife". Although simple ratings may be useful in evaluating habitats for individual species (e.g. Buckner et al. 1979), they become arbitrary and nonsensical when confounded with ratings for other species.

Attempts to develop technological solutions to immediate management problems raise biological questions that should be addressed with adequate funding, including support for long-term studies.—Manipulation of the distribution of types and ages of timber stands managed as even-aged units (Siderits and Radtke 1977) can meet the needs of many species. But which species have requirements not determined by successional stage but which must be managed within stands? Does creating a mosaic of small habitat units adversely affect some species with large home range size? What is the minimum effective size of habitat islands required to support breeding populations of various species? What is the maximum distance between habitat units that will still allow free exchange of breeders? More research is needed on interactions of habitat components with each other as they affect reproduction and mortality. For example, if broods of turkeys or wood ducks *(Aix sponsa)* must move long distances from nesting habitat to brood habitat, there may be high losses to predation.

The general concept of "edge effect" is well known among wildlife biologists, and various studies demonstrating higher species diversity and density where habitats meet (McElveen 1977, Strelke and Dickson 1980) support the concept. But Gates and Gysel (1978) showed that, although edge was preferred nesting habitat for songbirds, nest predation and other losses were higher and percent fledgling success was much lower than in the interior of the adjoining habitats. Similarly, Simpson (1978) found early season nesting success of bobwhite quail to be significantly lower in small patches of nesting cover than in larger areas of cover. Habitat conditions such as these concentrate nesting and allow more efficient foraging by predators. What is the significance of these findings to management? Do these habitats increase populations in spite of increased mortality rates or do they create population sinks, or ecological traps, robbing surrounding habitats of breeders?

Habitat evaluation should include measurements of edge, and various methods are available for accomplishing this (e.g. Schuerholz 1974). But qualitative differences among edges formed by different kinds of habitat have seldom been measured. In its effect on wildlife species and communities, how does edge formed by a pole-staged pine plantation and an improved pasture differ from the edge formed by a hardwood swamp and a soybean field?

Old lines of research, especially on species requirements, must be continued.—Regardless of whether habitat evaluation and management is directed at a single species or variety of species, ultimately the critical habitat requirements of individual species must be known. Much remains to be learned about habitat needs of important game species, and researching the requirements of species other than game animals should keep biologists occupied for the next decade! In most cases it appears that management for the various game animals will provide conditions suitable for a complex of wildlife including most

nongame animals. High priority should be given to determining specific habitat requirements of nongame species not provided for by the usual management practices.

For most wildlife we have only scratched the surface on seasonal needs, especially for assuring that adults are in optimum condition for breeding and for increasing the survival of young. The continuing improvements in miniature radios will yield valuable information on juvenile gamebirds and other small animals. Descriptions of vegetation and site factors (e.g. fire history, soil type) should accompany telemetry work, especially when a preferred habitat condition has been identified.

It is clear that major food supplies and even some cover constituents fluctuate from year to year (e.g. with abnormal rainfall and temperature), and alternative provisions require identification through research. For this reason, the development of reliable condition indices (especially for deer) would be helpful in evaluating habitat quality. Nutritional studies of game animals under field conditions are needed to test recent hypotheses arising from laboratory studies (e.g. Robel et al. 1979) and to determine the actual value of plantings that have been used for so long.

Intensive review and analysis of existing biological knowledge should receive greater emphasis.—Because of the tremendous proliferation of literature on habitat and other aspects of wildlife biology during the last decade, one of the greatest needs is for analytical review and interpretation of the literature on specific subjects. Few disciplines devote as little effort to digestion and interpretation of research results as wildlife biology. Although wildlife-habitat relations are so complex and variable from area to area that they often seem to defy expression as general principles, existing knowledge can be organized and interpreted to define the state of knowledge and identify problems and areas where data are lacking. In addition, review papers would make available information from obscure sources and related disciplines, which should result in more efficient planning for use of research funds.

Research results should be incorporated into management recommendations credible and useful to practicing land managers.—Specific recommendations based on quantitative data are necessary if private landowners are to be pursuaded to manage wildlife. Habitat degradation often results from ignorance rather than from intentional destruction. So, perhaps our strongest efforts should be in technology transfer. In the wildlife profession, habitat management lags far behind research, partly because we too often fail to supply management implications from research results. Until better ways are developed for getting information to the land manager in a usable form, researchers will be merely conversing among themselves.

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