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Avian research on U.S. Forest Service Experimental Forests and Ranges: Emergent themes, opportunities, and challenges

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ABSTRACT

Since 1908, U.S. Forest Service Experimental Forests and Ranges have been dedicated to long-term interdisciplinary research on a variety of ecological and management questions. They encompass a wide diversity of life zones and ecoregions, and provide access to research infrastructure, opportunities for controlled manipulations, and integration with other types of long-term data. These features have facilitated important advances in a number of areas of avian research, including furthering our understanding of population dynamics, the effects of forest management on birds, avian responses to disturbances such as fire and hurricanes, and other aspects of avian ecology and conservation. However, despite these contributions, this invaluable resource has been underutilized by ornithologists. Most of the Experimental Forests and Ranges have had no ornithological work done on them. We encourage the ornithological community, especially graduate students and new faculty, to take advantage of this largely untapped potential for long-term work, linkage with long-term data sets, multiple disciplines, and active forest management.

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1. Introduction

1.1. History and mission of Experimental Forests and Ranges

In 1907 Gifford Pinchot, the first chief of the U.S. Forest Service, approved a proposal for portions of the newly created National Forest System to be set aside specifically for research. A year later the Fort Valley Experimental Forest, the nation's first, was established in Arizona. Since then 115 Experimental Forest and Ranges (hereafter EFRs) have been established; today 80 remain operational (Adams et al., 2008; see http://www.fs.fed.us/research/efr/). Most were established from the 1930s to the 1960s. The 196,300 ha included in this unique system today provides the U.S. Forest Service with the ability to facilitate basic and applied scientific research under controlled conditions (Lugo et al., 2006).

Many of the first EFRs were created to study specific, local forest management issues. For example, the Fort Valley Experimental Forest (Arizona) originally focused on the regeneration of ponderosa pine (*Pinus ponderosa*), the Kane Experimental Forest (Pennsylvania) on silviculture of black cherry (*Prunus serotina*), and the Coram Experimental Forest (Montana) on regeneration of western larch (*Larix occidentalis*). Over time, the research programs of individual EFRs have broadened to address a wide variety of management and ecological questions (Fig. 1). These include topics as diverse as hydrology (e.g., Udell Experimental Forest, MI; Caspar Creek Experimental Watershed, CA; Coweeta Hydrologic Laboratory, NC); grazing management (e.g., Starkey Experimental Forest, OR; Desert Experimental Range, UT), atmospheric deposition (e.g., Glacial Lakes Ecosystem Experiments Site, WY); soils (e.g., Calhoun Experimental Forest, SC), and old growth management (e.g., H.J. Andrews Experimental Forest, OR). Currently, most EFRs host a diverse array of both basic and applied research conducted by both in-house scientific staff and outside collaborators.

1.2. Ecological characteristics of Experimental Forests and Ranges

Today, U.S. Forest Service Experimental Forests and Ranges span a wide geographical range, from Alaska to Hawaii, and from Maine to Saint Croix in the U.S. Virgin Islands (see www.fs.fed.us/research/efr/). Ecologically they are just as diverse, representing 14 of 38 Holdridge Life Zones (Holdridge, 1967) and 26 of the 52 North American ecoregion provinces defined by Bailey (1995). These include tropical rain forest (Luquillo

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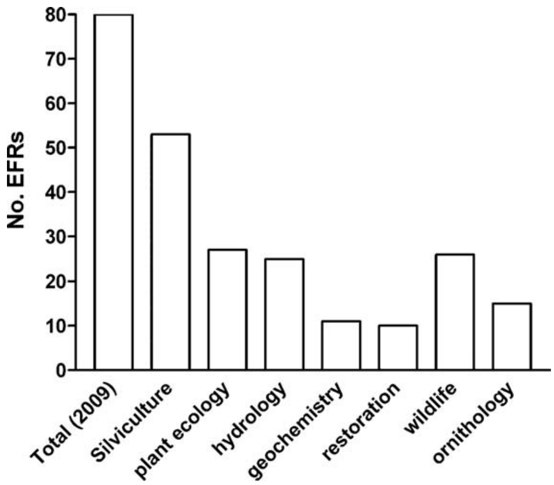

Fig. 1. Research on Experimental Forests and Ranges. Number of current U.S. Forest Service Experimental Forests and Ranges (EFRs), and the number that have hosted research of various disciplines. Note that wildlife includes ornithological research. Information from Adams et al. (2008).

Experimental Forest, PR), taiga (Bonanza Creek Experimental Forest, AK), pine barrens (Silas Little Experimental Forest, NJ), red pine forest (Cutfoot Sioux Experimental Forest, MN), coastal redwoods (*Sequoia sempervirens*, at Redwood Experimental Forest, CA), bunchgrass/scabland (Starkey Experimental Forest, OR), and many others. Their sizes also vary considerably from the huge Desert Experimental Range in Utah (22,500 ha) to the 47 ha Kawishiwi Experimental Forest in Minnesota. Numerous EFRs participate in other large-scale research networks. Twelve EFRs are included in the UNESCO Man and the Biosphere system of biosphere reserves, and five are NSF Long Term Ecological Research (LTER) sites. In addition, select EFRs contribute to the National Atmospheric Deposition Network (NADP) or are sites of the National Ecological Observatory Network (NEON; Keller et al., 2008; Purcell, this issue) or International Biome Project (IBP; Purcell, this issue).

2. Ornithological research on Experimental Forests and Ranges

The diverse research topics explored on Experimental Forests and Ranges include ornithology. At least 16 EFRs have hosted field research on avian ecology, habitat use, censusing methods, and conservation (Adams et al., 2008). This research includes both short-term, focused studies, primarily by external cooperators, as well as studies integrated into a broad-based, interdisciplinary research program on ecosystem patterns and processes (e.g., Oliver and Powers, 1998; Holmes, this issue).

In addition to the work highlighted in this issue, several other major ornithological research programs on EFRs should be noted because of their integrated nature, long-term approach, or both. Considerable work on the endangered northern spotted owl (*Strix occidentalis caurina*) was conducted on the H.J. Andrews Experimental Forest in Oregon due to its extensive old growth Douglas-fir (*Pseudotsuga menziesii*) forests (e.g., Spies et al., 1994; Swindle et al., 1999), and helped lead to current management guidelines for the species. In the Southeast, the Escambia, Hitchiti, and Santee Experimental Forests provided many of the research sites for studies of the ecology, demography, and management of the endangered red-cockaded woodpecker (*Picoides borealis*; e.g., Allen et al., 1993; Hanula et al., 2000; Hooper et al., 1991). Several decades of work on avian community structure and silvicultural effects on forest birds have been conducted at the Fernow Experimental Forest in West Virginia by Whitmore, Wood, their students and collaborators (e.g., Duguay et al., 2000; Maurer et al., 1981; McDermott and Wood, 2009; Seidel and Whitmore, 1982). George and Zack (2008) and Zack and George (2002) worked at Blacks Mountain Experimental Forest in northern California to address questions of how forest succession affects avian communities and snag availability. McClelland et al. (1979) conducted a series of studies on cavity-nesting species on the Coram Experimental Forest in Montana. And finally, avian ecology has been an integral component of multidisciplinary studies of the effects of natural and anthropogenic disturbances on forest communities by Greenberg and her colleagues at Bent Creek Experimental Forest in North Carolina (e.g., Greenberg and Lanham, 2001).

Other than the work presented in this issue, those noted above, and a few isolated studies, no other ornithological research that we are aware of has been conducted on Experimental Forests and Ranges. Ornithological research in general has been underrepresented in the tremendous body of scientific work produced by EFRs: at least 60 of the 80 current EFRs have had no published bird work done at all (Fig. 1). In part, this may be due to the early focus on local silviculture and forest management topics by Forest Service Research and Development (Lugo et al., 2006). However, recent decades have witnessed a tremendous increase in the range, complexity, and scale of research conducted, often by collaborative teams. We argue that the system of EFRs represents a valuable resource that has been underutilized by the ornithological community that offers numerous opportunities for basic and applied research.

3. Opportunities afforded by Experimental Forests and Ranges

The U.S. Forest Service's system of Experimental Forests and Ranges has several characteristics that should attract and facilitate more ornithological research (adapted from Lugo et al., 2006). We describe these below and illustrate specific concepts with examples from the papers in this Special Issue.

3.1. Land base

Experimental Forests and Ranges comprise an established land base committed to long-term research, distributed across a broad geographic and ecological range. They generally include some unmanipulated lands that function as control plots for experimental treatments or as the focus of natural ecological processes. In this issue, Holmes' work in the unmanipulated watershed at Hubbard Brook revealed an unanticipated degree of dynamism in the forest bird community. The use of unmanipulated areas also has been essential to understand the benefits of old growth (Ralph, this issue), the effects of climate change (Purcell, this issue), and the effects of natural disturbance (Purcell, Wunderle, this issue) for avian populations.

3.2. Long-term data sets

All Experimental Forests and Ranges maintain long-term data sets of various sorts. These often include climatic records, vegetation dynamics, streamflow and stream chemistry, and measurements of other ecosystem components. Such databases often extend back 70 or more years, and some are now accessible online (e.g., climate data at http://www.fsl.orst.edu/climhy/). These provide valuable opportunities to incorporate data on forest processes that occur over long time periods into ornithological research, as described by King et al. (this issue) in reference to snag longevity and cavity-nesting birds. Relatively few EFRs have long-term data on bird or other wildlife, however. Where they do exist, such data sets on bird abundances have provided a framework for predicting how future changes in habitat quality and climate will influence bird populations (Holmes, Purcell, this issue).

3.3. Integration

Experimental Forests and Ranges provide the potential for integrating an ornithological component into controlled manipulative experiments, such as silvicultural treatments, which often are conducted at large scales (e.g., watershed). Much of the development and refinement of silvicultural methods throughout the U.S. has occurred on EFRs, so the practices implemented tend to be innovative and state-of-the-art. Further, experimental treatments generally are not affected by multiple-use mandates, timber market prices, loggers' individual practices or whims, or other unwanted sources of variation that occur on lands not dedicated to long-term research. Treatments tend to be implemented as planned, when planned. These advantages are evident in the avian work done in association with silvicultural research on the Bartlett Experimental Forest (King et al., this issue).

3.4. Facilities

Most Experimental Forests and Ranges include some sort of facilities and other science infrastructure. These often include housing for scientists or field crews, laboratories and storage facilities, classrooms, or computer access that are essential logistical details for conducting scientific inquiries in the field. Many also have extensive road networks that provide easy access to study sites.

3.5. Scientific and support staff

One of the greatest strengths of the EFR system is the presence of a knowledgeable cadre of scientists and technicians in a variety of fields who welcome collaboration. Most often, these Forest Service personnel are involved with studies of vegetation; having those data (or data on streamflow, soils, etc.) collected in-house can leverage an ornithological collaborator's time and resources to allow more focus on the birds themselves. In addition, some EFRs have dedicated support staff to provide logistical support and advice to visiting scientists.

4. Potential unexplored avenues for avian work on Experimental Forests and Ranges

The Louisiana waterthrush (*Seiurus motacilla*), a stream-dependent songbird of conservation concern, is highly sensitive to stream quality and therefore has been suggested as an indicator of stream health (Mattsson and Cooper, 2006; Mulvihill et al., 2008). Several EFRs within the species' breeding range maintain databases on streamflow, water quality and other hydrological variables, often in relation to forest management within a watershed. Examples include Alum Creek Experimental Forest in Arkansas, Coweeta Hydrologic Laboratory in North Carolina, and the Fernow Experimental Forest in West Virginia. Such sites would provide ideal locations to study the effects of those stream characteristics, and the management practices that influence them, on waterthrush habitat selection, nest success, and survival.

As forest management practices evolve to meet changing needs and issues, so will the need to understand the effects of those refined practices on other ecosystem components. Since many of those practices will be developed and refined on EFRs, it makes sense to engage ornithologist collaborators in that research. From the ornithologists' perspective, such collaboration obviates the need to find the funding, permits, and expertise to implement silvicultural prescriptions.

Finally, the extensive system of EFRs may provide a network of sites in which to test any of several large-scale questions. These may range from evidence of shifts in avian distribution or migration phenology due to climate change, to understanding the spread and impacts on avian communities of invasive species across gradients of geography, spread, time, or climate (e.g., hemlock wooly adelgid *Adelges tsugae* in the eastern U.S.).

5. Challenges

As with any type of research site, there exist challenges to conducting ornithological research on EFRs, some of which may be particular to the Forest Service. One challenge is that the size of many of the EFRs (<3000 ha) precludes conducting truly landscape-scale research. This issue can be overcome by including an EFR as one of multiple sites across a larger landscape (e.g., Duguay et al., 2001; McDermott and Wood, 2009). Even large EFRs rarely include the full range of habitats within a landscape, often because they were established originally to address issues specific to a particular forest type. Similarly, the landscapes they occupy tend to be heavily forested, and so may not be appropriate for assessing the effects of forest fragmentation on birds, or for studies of non-forest species.

5.1. Concurrent land uses

Numerous EFRs host activities other than pure research, most commonly training courses of various kinds. A small subset of EFRs supports considerable recreational or educational activity; for example, Bent Creek Experimental Forest includes numerous hiking and biking trails, the Lake Powhaten Recreation Area, and the North Carolina Arboretum. The influx of people and vehicles associated with such activities has the potential to disturb the natural behavior of the birds themselves or to disrupt avian surveys. Such problems can be avoided by judicious planning of the research relative to spatial and temporal patterns of alternate uses.

Another issue concerns ownership of Experimental Forests and Ranges. Several EFRs were established on non-Forest Service land, often as a collaborative venture with states, private industry, or other partners. Unfortunately, in such cases continuity depends on the stability of partners. While generally not a problem, recently the status of the Vinton Furnace Experimental Forest in southern Ohio became threatened when its landowner partner, a private industrial forestry firm, was forced to sell off the land due to timber market conditions. Fortunately, the state of Ohio, recognizing the value of the work done at the site for forest management in the state, had the foresight to purchase the land as a cooperative research area.

Several EFRs are at risk because surface ownership and subsurface mineral rights were severed when the lands were first obtained by the U.S. government; this phenomenon is perhaps most widespread in the Appalachians. When this occurs, National Forests, including some experimental forests, do not own or control the minerals under their surface, and so are obligated by federal regulations to allow the subsurface owners reasonable access to their minerals. This issue has been brought to a head by the recent spikes in the price of natural gas and oil, which prompted a surge in the rate and intensity of oil and gas development. Multiple wells have been drilled within two experimental forests, the Kane in Pennsylvania and the Fernow in West Virginia; the latter lost land area in several ongoing experiment. However, our experiences at the Kane have been that most oil and gas developers are very willing to accommodate ongoing research by delaying drilling or shifting locations of wells whenever possible. Such cooperation depends on open and timely communication among the EFR staff, the National Forest managers, and the subsurface owners.

5.2. Management and regulatory issues

Unfortunately, maintaining the system of EFRs and their legacy of long-term research has grown increasingly difficult. Funding has declined for infrastructure maintenance and for long-term data collection and archiving (Adams et al., 2008). Most EFRs face an additional challenge in that the various regulatory mandates for National Forest System lands, such as the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA), were not designed for the special needs and issues of Experimental Forests and Ranges (Adams et al., 2008). The application of those regulations can be unclear and authority for decisions inconsistently applied. Continuation of ongoing, long-term studies has become increasingly complex with regulatory and administrative requirements in recent years (Schuler et al., 2006). As a result, the lag time between the proposal of any experimental manipulation and its actual implementation can be one or more years.

6. Conclusions

The system of U.S. Forest Service Experimental Forests and Ranges represents a valuable resource that has made a substantial contribution to our understanding of many important issues in basic and applied ornithology, yet nevertheless has been underused by the ornithological community. This represents a missed opportunity, because the EFRs remain some of the few places with a land base dedicated to basic and applied ecological research over the long term. Although work on EFRs can be subject to various constraints, as is true for any research site, the advantages are numerous. These include a stable infrastructure and facilities, a long-term commitment to research, potential to integrate research with other disciplines, and the availability of long-term data sets. In addition, the strong ties of EFRs with the National Forest System create a direct conduit to land managers, which gives research an immediate relevancy to management. For all of these reasons we encourage ornithological researchers, especially new faculty and graduate students, to consider Experimental Forests and Ranges for future work.

Forest scientists in other disciplines could benefit by collaborating with ornithologists as well. Birds exhibit a wide range of ecosystem functions, including seed dispersal, pest control and ecosystem engineering (Sekercioglu, 2006). For example, numerous studies have demonstrated that avian foraging on herbivorous insects can reduce damage and enhance plant growth (e.g., Marquis and Whelan, 1994; Van Bael et al., 2003), and that dispersal of seeds by birds can strongly influence patterns and rates of reforestation (e.g., Robinson and Handel, 1993; Wunderle, 1997). Understanding the roles birds play in ecosystem processes would provide a more complete understanding of ecosystems as well as result in a better integration of avian management into land management decisions.

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