LANDSCAPE-SCALE RESEARCH IN THE OUACHITA MOUNTAINS OF WEST-CENTRAL ARKANSAS: GENERAL STUDY DESIGN

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Abstract—A landscape-scale study on forest ecology and management began in 1995 in the eastern Ouachita Mountains. Of four large watersheds, three were within the Winona Ranger District of the Ouachita National Forest, and a major forest industry landowner largely owned and managed the fourth. These watersheds vary from 3,700 to 9,800 acres. At this scale, replicating treatments for statistical uniformity is impossible; this situation requires other approaches to statistical design. One approach is temporal replication, which uses multiple years of baseline measurement both prior to and after treatment as a source of experimental error and hypothesis testing. The second develops models that can be tested using data subsets, or the development of additional reference watersheds for testing models.

INTRODUCTION

The phase III landscape study in the Ouachita Mountains Ecosystem Management Research Project was conceived as a way to deal with questions about forest management that cannot be answered at a stand-level scale, but that can be answered in the context of a watershed that contains many stands (Hornbeck and Swank 1992, Kessler and others 1992, Lubchenko and others 1991, National Research Council 1990, O'Hara and others 1994, Swanson and Franklin 1992). These questions include (1) cumulative management effects on perennial streams, including both hydrology and aquatic ecology; (2) the behavior of organisms whose home range encompasses multiple stands or watersheds; and (3) the degree of change in vegetation in a watershed as a result of a combination of management activities in a subset of the stands in that watershed.

The objectives of research in the phase III study are to

(1) quantify core watershed hydrology through modeling hydrological factors and cumulative hydrological effects, using a series of flumes and uncontrolled cross-section gauging stations

(2) characterize and quantify sensitive and critical elements of aquatic and riparian ecology

(3) quantify terrestrial ecological relationships of vegetation pattern, ecological classification, wildlife, and biodiversity at the landscape scale

(4) characterize the social dimensions of the landscape, including the prehistoric, historic, and current relationships of people with the land.

To achieve these objectives, four watersheds were selected to represent a sequence of initial forest management conditions, from relatively unmanaged to intensively managed.

METHODS

Study Area

Three of the four watersheds are east of State Highway 7 on the Winona Ranger District in the combined Jessieville/Winona Ranger Districts of the Ouachita National Forest in Saline County, AR. These three contiguous watersheds are part of the Upper Lake Winona drainage basin, from which water flows eastward via Alum Creek and its two tributaries, the North Alum Creek and Bread Creek, into Lake Winona. Ultimately, those waters flow southerly to the Saline River of central Arkansas.

The fourth watershed, roughly 10 miles southwest of the others, is west of Highway 7 on land owned and managed by Weyerhaeuser Company. Water flows via the Little Glazypeau Creek into the Ouachita River, below Lake Ouachita but above Lake Hamilton west of Hot Springs.

The Ouachita and Saline Rivers meet in south Arkansas in Felsenthal National Wildlife Refuge. Thus, although the four watersheds are in close proximity and share a similar climatic regime, there are ecological differences between the Ouachita and Saline river systems that might affect comparisons among the watersheds.

Alum Creek Watershed

The Alum Creek watershed (3,700 acres), the unmanaged control in the study, was imposed largely on the Alum Creek Experimental Forest in compartments 1457 and 1460 of the Winona Ranger District. The Government owns virtually all of this watershed. The Alum Creek Experimental Forest has been largely used for upland small-catchment hydrology research. As a result, most of the experimental forest has had no management for two decades. The boundary of this watershed was established using a digital elevation model, which drew the hydrological unit of interest slightly outside the current boundary of the Alum Creek Experimental Forest.

Bread Creek Watershed

The Bread Creek watershed (3,800 acres), east of the Alum Creek watershed, includes compartment 1462 and the south half of compartment 1456 of the Winona Ranger District. The Government owns 95 percent of this watershed, and the balance is owned by Weyerhaeuser Company. The area lies largely within the timber-available area of the

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Citation for proceedings: Guldin, James M., tech. comp. 2004. Ouachita and Ozark Mountains symposium: ecosystem management research. Gen. Tech. Rep. SRS–74. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 321 p.

Ouachita National Forest. Within the past 20 years, only one small part of this watershed has been clearcut and replanted with genetically improved shortleaf pines, mostly in the eastern part of the watershed that was heavily damaged by a tornado in 1980. Other parts of the watershed have been thinning and burned by prescription. In this study, these treatments collectively represent a relatively low intensity of management.

North Alum Creek Watershed

The third watershed is North Alum Creek (9,800 acres), which lies north of the Alum Creek and Bread Creek watersheds in compartments 1445, 1446, 1447, and the north half of compartment 1456 of the Winona Ranger District. About half of this watershed is in national forest ownership, and Weyerhaeuser Company owns and manages the other half. Most of the industry land has been clearcut in the past 30 years and reforested with genetically improved loblolly pine. The majority of the national forest land lies within the timber-available land base and has been managed like the Bread Creek basin. For this study, the watershed represents a moderate intensity of forest management.

Glazypeau Watershed

The fourth watershed is the Glazypeau watershed (5,600 acres), approximately 4 miles southwest of Jessieville in Garland County, AR. Weyerhaeuser Company owns about 95 percent of this watershed, and the balance at the lower end of the drainage is in national forest. The area supported mixed shortleaf pine and pine-hardwood forests prior to the company's acquisition of the land in the late 1960s. Currently, a large portion of the Glazypeau watershed consists of genetically improved loblolly pine plantations established within the past 30 years. As such, it represents the most intensively managed watershed in the study.

Experimental Design

A key question in watershed research is how to quantify experimental error among watersheds. Experimental replication of watersheds of this size is impractical, because the variety of topographic, edaphic, and physiographic conditions in these watersheds invalidates the underlying assumption of homogeneity required to apply parametric statistical tests. Even if watersheds might have been identified that would have met this assumption, resources available to the project prohibit covering a larger area. As a result, alternatives to replication are needed to quantify treatment effects among watersheds.

Several different approaches to experimental design will be used in this study, depending on the particular resource variables and elements of interest. The first is to study baseline conditions in watersheds for several years prior to execution of the treatments, then to study conditions after treatment for a similar number of years. In this way, changes from baseline conditions can be compared across a number of years. This approach will generate valid statistical tests for some parameters, but will result only in descriptive information about other parameters. Yet given the size of the watersheds and the length of time over which measurements will occur, descriptive information will be valuable both for the scientific community and for land managers in the region.

A second approach is to subdivide watersheds into smaller units, and replicating those. Some elements of the research objectives will be met using small-scale studies within watersheds. For these, traditional parametric statistical analyses can be used. The elements for which this approach is feasible will vary among different research objectives.

A third approach is to use portions of the four watersheds to develop models of ecosystem attributes, and then to validate the models in the remaining parts of the watersheds. Work on model development will proceed by either subdivision of the existing watersheds or the establishment of separate watersheds for use in model validation. The use of locations outside the watershed boundaries that meet specific study objectives will be appropriate in some cases.

Finally, some of the results from the study will be published with the acknowledgment that data are descriptive rather than replicated; for some unique and less-intensively studied attributes or variables, descriptive data will be highly informative.

RESEARCH GROUPS AND EXPERIMENTAL APPROACHES

Wildlife Research

The wildlife research group has installed nearly 2,000 sample plots in 4 sets of 500 plots over 4 years. This sampling design serves as the pretreatment plot network for both the wildlife and the vegetation groups. The wildlife group measured habitat variables, and sampled populations of neotropical migrant and resident birds and herpetofauna.

Vegetation Research

The vegetation research group conducted annual pretreatment baseline surveys on the plot network established by the wildlife group. The resulting quantitative vegetation data base quantifies stand structure within and between watersheds. Vegetation measurements include overstory and midstory woody vegetation, as well as shrub and herbaceous vegetation. Because the vegetation and wildlife research measured the same plots, they may analyze data jointly if research dictates an interdisciplinary approach.

Hydrology Research

The hydrological network includes a series of nested, uncontrolled cross sections, three in each core watershed. These sampling stations gauge streamflow, which will allow scientists to quantify stage-discharge relationships. The study collects data on water quality as well as quantity in each watershed.

Aquatic Ecology Research

Aquatic ecological relationships are important in the overall landscape study design. Studies that quantify those relationships were established in streams within and between watersheds, as well as off the core watersheds. This research group studies the nature and composition of fish communities, the trophic relationships throughout the aquatic systems, and the changes in aquatic ecological relationships over time within and between watersheds.

Social Science Group

The social science group works primarily outside the core watersheds. Key responsibilities include studies on decision making and community involvement, advisory organizations, and forest users.

WATERSHED TREATMENTS

The study is designed to evaluate practical approaches to forest management on national forest lands. National forest and ranger district staff worked with research scientists to identify the desired future conditions proposed as treatments in this study. This process yielded more than four sets of desired future condition, so the three contiguous watersheds were subdivided for imposition of treatment conditions.

Baseline data collected prior to treatment versus data collected after treatment quantifies differences within and between watersheds as a result of treatment.

The unmanaged South Alum Creek watershed will support two desired future conditions. The first is an unmanaged control condition in the west half of the watershed, which will be maintained as an unharvested control block. In the east half of the watershed, a large contiguous block of single-tree selection will be imposed. Monitoring and research will be conducted to quantify the effects of this desired future condition across a large area in one operation.

The Bread Creek watershed will not be subdivided and will support continued management according to standard Forest Service practice. Reproduction cutting in this block will emphasize the seed-tree and group selection methods, and intermediate treatments will emphasize thinning. Prescribed fire in both immature and mature stands is a hallmark of standard operational practice on the Ouachita National Forest, and these stands will be subject to prescribed fire as called for in operational practice.

The North Alum Creek watershed will be subdivided into three subwatersheds that reflect different desired future conditions. In the first, reproduction cutting using the group selection method will be imposed using large groups between 2 and 10 acres, in which some groups will retain overstory trees and others will not. In the second, reproduction cutting under the group selection method will use small groups < 2 acres; again, some groups will have no residual trees, while others will. These group selection treatments are intended to create conditions appropriate for sampling wildlife species, especially birds, in openings of varied size and with different within-opening structures. The final treatment in a subunit of this large watershed is shortleaf pine-bluestem habitat restoration; this prescription reduces overstory density and midstory vegetation, and reintroduces prescribed fire to the landscape.

The Glazypeau watershed will not be subdivided. Standard industrial forest management practices will continue in this basin according to schedules and procedures of Weyerhaeuser Company. In this way, the effects of intensive forest management on a landscape will be quantified.

Scientists and managers will ask several questions as these treatments are imposed. For example, national forest management tactics shifted in the past decade from entries in individual compartments across a district to one larger scale entry in several contiguous compartments in a given year. The effect of concentrating management activities on terrestrial and aquatic ecosystems is not well documented. The phase III study can address elements of this question, such as quantifying the differences from baseline levels in each watershed. In many ways these treatments in the phase III landscape will represent the most intensive intervention within an agency project because they involve a concentrated action conducted across a large area in a short time frame.

On both national forest lands and forest industry lands in the phase III study, treatments will occur in an operational context. Within the national forest, treatments are planned according to standard agency practice. All reproduction cuttings and thinning will be prepared as commercial timber sales by the ranger district staff, subject to guidance by the research group only for meeting specific research objectives in residual stand condition. All timber sales were scheduled for the summer of 2000. Site preparation, prescribed burning, and treatment monitoring will commence when treatments have been completed.

SUMMARY

The phase III landscape-scale study was established to answer specific questions about forest management at scales larger than an individual stand. Because of difficulties with assumptions required to apply parametric statistical tests, the study uses several different sample designs. These include sampling over a number of years, discrete smaller studies of a more traditional statistical design, and subdivision of existing watersheds or identification of new watersheds for validation testing of models developed in the core watersheds. Treatments in the watersheds will be implemented as operational practice by national forest and industry land managers. Results from the phase III study will provide valuable guidance for land managers concerned about effects of forest practices at the landscape scale.

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