Integrating Land and Resource Management Plans and Applied Large-Scale Research on Two National Forests

Callie Jo Schweitzer, Stacy Clark, Glen Gaines, Paul Finke, Kurt Gottschalk, and David Loftis

ABSTRACT

Researchers working out of the Southern and Northern Research Stations have partnered with two National Forests to conduct two large-scale studies designed to assess the effectiveness of silvicultural techniques used to restore and maintain upland oak (*Quercus* spp.)-dominated ecosystems in the Cumberland Plateau Region of the southeastern United States. We based both large-scale studies on approved Land and Resource Management Plans (LRMP), but the projects being studied have been implemented under separate authorities. On the Bankhead National Forest, the District Ranger and staff have worked with a formal forest liaison board to gain interest and acceptance of the new Forest Health and Restoration Project to be implemented under traditional Forest Service authorities. The impetus for the Daniel Boone National Forest study was also consistent with the LRMP developed in collaboration with interested publics, but the study projects were implemented using authorities granted by the Healthy Forest Restoration Act of 2003. In both studies, researchers are assessing response to silvicultural techniques used to control species composition and alter habitat for wildlife and restoration purposes, including intermediate treatments (e.g., thinning and prescribed burning) and regeneration harvests (e.g., shelterwood). Forest managers and researchers are interested in modeling changes in overstory cover and composition, fuel loading, residual tree health and vigor, available light, and understory regeneration. In addition, the response of the herbaceous component, the response of the avian and herpetological populations, and the response of habitats will be assessed using a multidisciplinary approach. We will use results from these studies to help forest managers monitor and predict forest response and to develop habitat and regeneration models for each forest system. We discuss the logistics, challenges, and triumphs of implementing such large-scale projects, and joint efforts for science delivery.

Keywords: silviculture, oak regeneration, national forests, fire

This paper was published in: Deal, R.L., tech. ed. 2008. Integrated restoration of forested ecosystems to achieve multiresource benefits: proceedings of the 2007 national silviculture workshop. Gen. Tech. Rep. PNW-GTR-733. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 306 p.

Callie Jo Schweitzer and **Stacy Clark** are research foresters, Southern Research Station, Upland Hardwood Ecology and Management, PO Box 1568, Huntsville, AL 35811; **David Loftis** is a research forester and project leader, Southern Research Station, Upland Hardwood Ecology and Management, 1577 Brevard Road, Asheville, NC 28806; **Glen Gaines** is the District Ranger, National Forests in Alabama, Bankhead Ranger District, PO Box 278, Double Springs, AL 35553; **Paul Finke** is a Forester on the Daniel Boone National Forest, 1700 Bypass Road, Winchester, KY 40391; **Kurt Gottschalk** is a research forester and project leader, Northern Research Station, 180 Canfield St., Morgantown, WV, 26505.

INTRODUCTION

Increased human population densities, loss of the American chestnut (***Castanea dentata*** L.), and a variety of land-use changes have caused current forest ecosystem composition and structure in the southeastern United States to vary widely from that thought to exist in pre-Columbian times (Levitt 2002). Attempts to restore ecosystems in the region to a former state or to manage these ecosystems in their current state will require a thorough understanding of how various environmental factors affect ecosystem characteristics.

Oak-dominated forests are the most abundant cover types in the Southern Appalachian Highlands hardwood region (Johnson et al. 2002). Silvicultural practices to regenerate hardwoods have been the subject of much research (Loftis and McGee 1993; Johnson et al. 2002; Hannah 1987; Roach and Gingrich 1968; Sander 1977, 1988). The clearcutting method, variations of the shelterwood method, and uneven-aged methods can be applied to regenerate upland hardwood stands in both research and operational settings, but these approaches have not been uniformly successful in restoring native oak species, particularly on more mesic sites (Beck 1988).

Prescribed burning and thinning are intermediate treatments that when applied in oak-dominated stands can improve forest health, increase the abundance and size of oak regeneration, and control species composition. A more site-specific method to increase oak regeneration potential is the use of herbicides to alter the light environment in the understory to enhance the survival and growth of oak seedlings (Loftis 1990). However, prescriptions for herbicide use were developed specifically for use on sites of higher than average productivity, and herbicide use on National Forests is often administratively restricted. Generally, a combination of various techniques (herbicide treatments, prescribed fire, thinning, and shelterwoods) applied at intervals (depending on vegetation response and site characteristics) may have the most profound effect on community structure and composition (Franklin et al. 2003; Loewenstein and Davidson 2002; Lorimer 1992; Nowak et al. 2002). However, the interactions of these techniques are largely unknown.

The main problems limiting the adoption and use of silvicultural techniques by National Forest System (NFS) managers are administrative constraints, social influences on management decisions, and imperfect transfer of the knowledge from researchers to forest managers. Researchers can assist NFS managers by conducting collaborative research with them and by sharing up-to-date technology. If researchers and NFS managers jointly test the effectiveness of new or modified silvicultural techniques on National Forest lands, it will likely enhance the ability of NFS managers to predict the outcomes of management practices and efficiently meet their forest management objectives.

We implemented two large-scale studies on the Daniel Boone and William B. Bankhead National Forest in the Cumberland Plateau Region of Kentucky and Alabama. The overall goal of the studies was to determine the effects of various silvicultural techniques on restoring or maintaining the oak component of the forest. The studies are still ongoing, but in the process of establishing the studies we learned many practical lessons about conducting large-scale, long-term research projects on National Forest lands.

The first study we discuss was implemented on the William B. Bankhead National Forest (BNF) in north-central Alabama. Decline and death of southern yellow pines due to the southern pine beetle (***Dendroctonus frontalis*** Zimmermann) has provided impetus for this study, which examines the effectiveness of the BNF's current management techniques, as detailed in their latest Forest Health and Restoration Project (FHRP) (USDA Forest Service 2003), in restoring the oak component. The second study we discuss was implemented on the Daniel Boone National Forest (DBNF) in south central Kentucky. The forest may soon be affected by gypsy moth and the often-related disease complex, oak decline, and these impacts would reduce the ability of managers to provide expected benefits derived from the forest. This study was implemented under the auspices of the Healthy Forest Restoration Act of 2003 (HFRA) and was designed to examine the effectiveness of various silvicultural techniques in restoring and maintaining the oak component and improving forest health conditions on the DBNF. The use of these silvicultural techniques is described in the DBNF's LRMP (USDA Forest Service 2004).

The purpose of this paper is to discuss the research goals and general experimental design of each study, the challenges and successes of study implementation, and lessons learned through participation in cooperative research projects of the NFS and Research branches of the Forest Service. We hope to provide general guidelines for other large-scale replicated research projects implemented on NFS lands.

METHODS

Study Areas

William B. Bankhead National Forest

The BNF, established by proclamation in 1914, has a long history of repeated logging and of soil erosion caused by poor farming practices during the Depression era. The 180,000-acre BNF is in the Strongly Dissected Plateau sub-region of the Southern Cumberland Plateau, within the southern Appalachian Highlands (Smalley 1982). In 1975, the 12,000-acre Sipsey Wilderness Area in the northwestern portion of the forest was established to preserve a natural forest environment. Today the Sipsey Wilderness totals 25,202 acres. The forest contains the Black Warrior Wildlife Management Area and the Sipsey Wild and Scenic River. Base age 50 site indices for loblolly pine (*Pinus taeda* L.), red oaks (*Quercus rubra* L., *Q. velutina* Lamarck, *Q. coccinea* Muench., *Q. falcata* Michx.), and white oaks (*Q. alba* L., *Q. prinus* L.) are 75 ft, 65 ft, and 65 ft, respectively (Smalley 1982).

Daniel Boone National Forest

Two separate tracts were merged and proclaimed as the DBNF in 1966. The area proclaimed as the Cumberland National Forest in 1937, a narrow strip along the western edge of the Cumberland Plateau, contains the study area. The rugged eastern area is maturely dissected and characterized by narrow, winding ridgetops, steep sideslopes, and narrow winding valleys (Smalley 1986). Within the forest are 18,000 acres of designated Wilderness and 19 miles of Wild and Scenic Rivers. Base age 50 site indices for shortleaf pine (*Pinus echinata* Mill.), red oaks (*Quercus rubra* L., *Q. velutina* Lamarck, *Q. coccinea* Muench.) and white oaks (*Q. alba* L., *Q. prinus* L.) are 60 ft, 55 ft and 60 ft, respectively (Smalley 1986).

The study was implemented on the Cold Hill Area of the London Ranger District of the DBNF. The treatment units are located on the Central Escarpment (221 Hb) landtype association, which is transitional between the Highland Rim and the Cumberland Plateau (Taylor et al. 1997; USDA Forest Service 2004).

Study Design

William B. Bankhead National Forest

The BNF study employs a randomized complete block design with a 3 by 3 factorial treatment arrangement and four replications of each treatment. The treatments are three residual basal area treatments (50 ft^2a^{-1}, 75 ft^2a^{-1}, and an untreated control) with three fire frequencies (frequent burns every 3-5 years, infrequent burns every 8-10 years, and an unburned control; Table 1). Each treatment is replicated 4 times, for a total of 36 treatment units. Treatments are representative of management practices described in the BNF's FHRP for restoring oak forests and woodlands.

Table 1--Disturbance treatments for silviculture research on the Bankhead National Forest, Alabama

	DISTURBANCE TREATMENTS
1	No Burn and No Stand Density Reduction
2	No Burn and 75 ft^2a^{-1} Residual Stand Density
3	No Burn and 50 ft^2a^{-1} Residual Stand Density
4	Infrequent Burn (8-10 yrs) and No Stand Density Reduction
5	Infrequent Burn (8-10 yrs) and 75 ft^2a^{-1} Residual Stand Density
6	Infrequent Burn (8-10 yrs) and 50 ft^2a^{-1} Residual Stand Density
7	Frequent Burn (3-5 yrs) and No Stand Density Reduction
8	Frequent Burn (3-5 yrs) and 75 ft^2a^{-1} Residual Stand Density
9	Frequent Burn (3-5 yrs) and 50 ft^2a^{-1} Residual Stand Density

Criteria for stand selection were based on species composition, stand size, and stand age. Treatment units for the study were located on upland sites currently supporting 20 to 35-year-old loblolly pine plantations with a significant hardwood component in the understory. Treatment units were at least 22 acres in size with basal areas ranging from 80 to 140 ft^{2}a^{-1}.

Prescribed burning was conducted during the dormant season (December-February) using backing fires and strip headfires to ensure that only surface fire occurred. Commercial thinning was conducted by marking from below smaller trees or trees that appeared diseased or damaged. Hardwoods were preferentially retained. Stand density reduction treatments were completed prior to the initiation of the burning treatments (thinning conducted from June through November).

Daniel Boone National Forest

The study design for the DBNF study was a randomized complete block design with a 2 by 5 factorial treatment arrangement with two site types (dry-mesic and dry-xeric) and five disturbance treatments (shelterwood with reserves, oak shelterwood, B-line thinning, oak woodland, and a control; Table 2). The treatments were replicated three times, for a total of 30 treatment units.

Criteria for stand selection and treatment assignment were based on several factors including administrative constraints, proximity to road infrastructure, stand history, ownership boundaries, topography, soil type, and species composition. All treatment units were located on broad ridges, were dominated by oak species, had basal areas ranging from 70 to 150 ft^{2}a^{-1}, and were occupied by stands between 70 and 150 years old.

The shelterwood with reserves treatment (1) will leave trees that will promote good forest health conditions and improve habitat for wildlife and plant species that benefit from open, low basal area forest conditions. In the oak shelterwood treatment (2), triclopyr ester will be applied as a thinline basal bark treatment to trees less than 3 inches dbh, of undesirable species. Trees greater than 3 inches dbh in the mid- and understories will be treated with stem injection. Undesirable tree species include red maple, which has little benefit to wildlife, and trees with unhealthy stems and/or crowns. Thinning to B-line (3), based on the Gingrich (1967) stocking chart, will reduce tree density and allow residual trees to take advantage of improved growing conditions. The oak woodland treatment (4) will be conducted by first thinning to 30-50 ft^{2}a^{-1} and then conducting prescribed burning every 3-5 years. White oaks will be favored as residual trees to increase hard mast production. Enhancement of spatial and vertical heterogeneity will be an objective of the treatment. The final treatment (5), a control, will not receive a silvicultural treatment, and will be used as a basis of comparisons and evaluations.

Table 2—Disturbance treatments for silviculture research on the Daniel Boone National Forest, Kentucky

	DISTURBANCE TREATMENTS (X= dry-xeric; M= dry-mesic)
1	X- No Burn and No Stand Density Reduction
2	X- Shelterwood with Reserves (10-15 ft^{2}a^{-1}) Residual Stand Density
3	X- Oak Shelterwood (60-75 ft^{2}a^{-1}) Residual Stand Density
4	X- B-Line Thinning following Gingrich's Stocking Chart
5	X- Oak Woodland (30-50 ft^{2}a^{-1}) Residual Stand Density and Frequent Burn (3-5 yrs)
6	M- No Burn and No Stand Density Reduction
7	M- Shelterwood with Reserves (10-15 ft^{2}a^{-1})Residual Stand Density
8	M- Oak Shelterwood (60-75 ft^{2}a^{-1} Residual Stand Density
9	M- B-Line Thinning following Gingrich's Stocking Chart
10	M-Oak Woodland (30-50 ft^{2}a^{-1})Residual Stand Density and Frequent Burn (3-5) yrs

IMPLEMENTATION

We established five 0.2-acre vegetation measurement plots (BNF) or twenty 0.1-acre vegetation measurement plots (DBNF) in each treatment unit and measured plots prior to and just after treatment implementation. All plot centers are permanently marked with rebar, flagging, and GPS coordinates. We permanently tagged all trees 1.5 inches and greater diameter at breast height (dbh) with aluminum tags. We measured and recorded tree species, dbh, crown condition, tree grade, canopy cover, and tree height. In each plot, we also created a 0.01-acre plot where we enumerated regeneration (trees < 1.5 inches dbh) by species and height class. We tagged 5 representative seedlings per regeneration plot and recorded species and measured height and basal diameter (immediately above the root collar). In the BNF study, we sampled fuel loading using line transects and employed electronic recording devices and temperature sensitive paints to quantify fire behavior during burns. We revisit plots once a year near the end of the growing season to document recruitment and tree growth.

Stand selection and data collection for the BNF began in the summer of 2004, and to date, three of the four replications of thinning and burning treatments have been implemented. The final replication will be completed by the winter of 2008. Stand selection and data collection for the DBNF began in the summer of 2005 and treatments should be implemented by summer of 2008.

DISCUSSION

The goal of both studies is to increase the knowledge of silvicultural prescriptions used by forest managers to create and sustain desired habitat conditions. These two studies represent unique opportunities not only to increase the knowledge base, but also to increase collaboration and trust between the two branches of the agency. Researchers learn about how NFS operations such as harvesting and burning are conducted. NFS personnel have personal access to up-to-date research to assist in answering questions and concerns about management strategies. The synergy created by these two projects outweighs the constraints presented.

Although the studies were only recently initiated, we have already gained a great deal of practical experience about coordinating large, long-term research projects between the research and land management branches of the Forest Service. First, we learned it can be done successfully- at least through study establishment in our case. We also learned that it isn't always easy, and sometimes things that seem obvious to one group are not at all obvious to others.

Both the NFS and Research branch personnel need to be aware of and prepared for the long time commitment needed to install silvicultural research studies implemented at the stand level. We quickly learned that installation of large-scale, replicated studies requires a significant amount of coordination and communication between NFS managers and researchers. Having designated leaders from both branches facilitates this coordination and communication. The land management plans are an excellent reference for researchers as they develop study plans. NFS must provide the initial leadership in locating potential study stands and in providing the researchers with appropriate information, such as stand history, stand characteristics, location, and any special or limiting circumstances. In our case the NFS managers are solely responsible for all the coordination and implementation of the harvesting and burning. The DBNF personnel were trained by researchers to assist with data collection, and the research work units provided the Forest funding to support these activities. All data on the BNF were collected by the research teams.

Site selection is one of the most important phases of any large-scale research project. The easiest and best procedure for choosing appropriate stands is to have a NFS representative who is intimately knowledgeable with the Forest vegetation and management history work directly with the researchers. We found that the Continuous Inventory of Stand Conditions (CISC) database maintained by each National Forest was not adequate to guide decisions on study site selection. The CISC database was either in a format not conducive to use for analysis, or it lacked information researchers needed. Consequently, substantial amounts of time were spent conducting field reconnaissance and gathering new data for potential study sites. A large time commitment and effort by all parties should be expected and detailed at the inception of the study.

Clear lines of communication are essential. Data collection for these two studies was intensive and expensive, and communication about timing of treatment implementation is important. Researchers should know when treatments are going to be implemented so they can properly plan collection of pre-and post-treatment data. Researchers should communicate with managers the cost and importance of the data being collected so all can feel a sense of ownership and responsibility. We found it helpful to hold meetings once every 3 to 6 months to share findings to date and discuss logistics of treatment implementation and data collection.

Researchers and NFS staff often struggled with basic communication because the two groups used certain terms differently and because areas were not always referred to by names that were understood by all parties. For example, the researchers used "stand" to refer to the treatment units; the NFS staff referred to these same areas as "units" within compartments. We developed a glossary that defined terms and outlined the names of places within the study areas, including the 'local' names of the prescribed burn units. It is imperative that all involved practice patience and take care to explain terms.

Other complicating factors were the administrative and social constraints on management in National Forests that led to non-random assignment of treatments to selected stands. For example, it was postulated that a certain threatened plant existed in several of the study stands after stands had already been randomly assigned to a treatment. Consequently, the study design was altered post-hoc so the threatened plant would not be disturbed. That had the potential to violate underlying statistical assumptions about randomization of experimental treatment. If the possibility that this plant was present was explained prior to stand selection, some stands could have been removed from consideration for the study. However, the presence of the plant represented a fortuitous chance to study a threatened species, and the design could have been altered to test what habitat conditions the plant required. Other constraints in treatment assignment to stands included proximity to roads and houses for treatments that included commercial harvesting and prescribed burning. Researchers should be aware that treatment assignments to stands available for research on NFS lands may not be totally random, and the potential impact of that must be addressed or reconciled prior to study installation.

Communication between researchers and NFS personnel on potential timing of prescribed burns is crucial, particularly when data must be collected during the burn. The NFS personnel should provide the researchers with information on ideal burning conditions and the researchers should be "on-call" to collect burn data with less than 24 hours notice. Research personnel should obtain proper permission to allow their staff to work before or after regular work duty hours to facilitate collection of data about prescribed burns. Another constraint to data collection was that research personnel were not allowed on burn units without proper safety training and testing. It would behoove researchers who may be actively engaged in fire research to obtain all necessary training, certificates, and equipment needed to work on prescribed burning projects.

Faculty and students from Alabama A&M University are conducting additional research on the BNF plots. This research is in the areas of avian and herpetofaunal ecology, herbaceous characterizations, remotely sensed data analysis, and harvesting operations. The DBNF study also includes additional research conducted by collaborators, including faculty and students from The University of Kentucky, Eastern Kentucky University, and The University of Tennessee. These additional research projects will examine bat ecology, evaluate microclimatic attributes, and establish stand disturbance histories using dendrochronology. Collaborative research greatly benefits all involved parties, but can also greatly complicate design and implementation. We found that we needed to give extra attention to the collaborative partners to ensure that they were cognizant of on-the-ground procedures, such as road and gate usage and safety regulations.

SCIENCE DELIVERY

We found that the science delivery process begins immediately. We have already conducted field tours on both Forests. These tours provide a terrific opportunity for the NFS and Research teams to highlight their partnership, and the breadth and depth of information provided by both teams is impressive. Presentations developed by the research teams have been provided to NFS personnel for additional science delivery. Results are being presented at research conferences and at public and private meetings of lay audiences. Peer-reviewed publications will highlight research results and acknowledge the effort committed by both branches of the agency.

CONCLUSIONS AND RECOMMENDATIONS

We recommend that the following measures be taken when large-scale silvicultural research projects at the stand level are to be implemented on NFS land:

1. Hold frequent meetings and conference calls between researchers and NFS managers, particularly at the beginning of study implementation. Researchers should explain the timing and costs of planned data collection. Managers should explain logistics problems and arrangements, and constraints on implementation of proposed treatments. Take detailed notes and distribute them widely.
2. Both researchers and NFS managers should be clear at the outset about the time required to implement proposed projects. Because these types of studies are generally long-term, the NFS personnel should be prepared to protect and maintain study sites for at least 10 years and to clearly document that necessity through the inevitable personnel changes that will occur over the life of the study.
3. Designate a project leader and alternative from NSF and research. The NFS leader should be knowledgeable about Forest tree species, history, and administrative and social constraints that could affect project implementation. The research leader should be knowledgeable about experimental design, timing and costs of data collection.
4. Researchers should use the LRMP as a starting point in developing study plans. This will ensure that proposed treatments are consistent with the goals and objectives of the Land Management Plan.
5. Clarify terms used frequently, such as stand, unit, and plot. Create a comprehensive study plan with a project glossary that clearly defines both research and NFS terminology used to describe areas in study.
6. Research personnel should obtain required safety training, certificates, and equipment if they are to be on prescribed burn units during burning.
7. Research personnel should obtain proper permission to allow staff to work before or after regular duty hours when necessary (e.g. for collection of prescribed burning data).
8. Researchers should be aware that stands available for treatment may be limited and that assignment of treatments to stands may not be random, which can bias research results. Thus, they may need to revise the study or interpretation of the results accordingly.

ACKNOWLEDGEMENTS

The authors wish to thank the following people and agencies for their assistance in design and implementation of this research: Jeff Stringer, University of Kentucky; Ryan Sisk, Jennifer Rice, Robert Rummer and Susan Loeb, USDA Forest Service, Southern Research Station; Dave Feicht, John Juracko, Brian Simmons and Laura Blackburn, USDA Forest Service, Northern Research Station; John Creed and Allison Cochran, USDA Forest Service, Bankhead National Forest; Amos Stone, Mike Kluempke, Rex Mann, Dan Crockett, David Taylor and Jim Harris, USDA Forest Service, Daniel Boone National Forest; Daryl Lawson, Andrew Cantrell and Luben Dimov, Alabama A&M University.

LITERATURE CITED

Beck, D. E. 1988. Clearcutting and other regeneration options for upland hardwoods. In: Proceedings Sixteenth Annual Hardwood Symposium of the Hardwood Research Council; 1988 May 15-18; Cashiers, NC. 44-54.

Franklin, S. B.; Robertson, P. A.; Fralish, J. S., 2003. Prescribed burning effects on upland *Quercus* forest structure and function. Forest Ecology and Management. 184: 315-335.

Gingrich, S.F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the central states. Forest Science. 13(1): 38-53.

Hannah, P.R. 1987. Regeneration methods for oaks. Northern Journal of Applied Forestry. 4(2): 97-101.

Johnson, P.S.; Shifley, S.R.; Rogers, R. 2002. The ecology and silviculture of oaks. CABI Publishing. 503 pp.

Levitt, J.N. 2002. Networks and nature in the American experience. For. History Today Fall, 2002, pp. 2-11.

Loewenstein, E.F.; Davidson, K.R. 2002. Ecological restoration through silviculture - a savanna management demonstration area, Sinkin Experimental Forest, Missouri. Proc. 11th Biennial Southern Silvicultural Research Conference, Knoxville, Tennessee, 20-22 March, 2002. Outcalt, K. W.; Outcalt, P. A.; Tucker, R. B., (eds). Gen. Tech. Rep., U.S. Department of Agriculture, Forest Service, SRS-48, pp. 490-494.

Loftis, D.L. 1990. A shelterwood method for regenerating red oak in the southern Appalachians. Forest Science. 36(4): 917-929.

Loftis, D.L. 1988. Regenerating red oak in the southern Appalachians: predictive models and practical application. Raleigh, NC: North Carolina State University. 62 p. Dissertation.

Loftis, D.; McGee. E. eds. 1993. Oak Regeneration: serious problems, practical recommendations. Symposium Proceedings: 1992 September 8-10; Knoxville, Tennessee. Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest, Service, Southeastern Forest Experiment Station. 319 pp.

Lorimer, C.G. 1992. Causes of the oak regeneration problem. Pp. 14-39 In: Oak regeneration: serious problems practical recommendations, Loftis, D., and C.E. McGee (eds.) U.S. Department of Agriculture, Forest Service Southeastern Forest Experiment Station Gen. Tech. Rep., SE-84. 319 pp.

Lorimer, C. G. 1989. The oak regeneration problem: new evidence on causes and possible solutions. Forest Resource Analyses, Number 8, R3484. 31 p.

Nowak, S.; Kershaw, G.P.; Kershaw, L.J. 2002. Plant diversity and cover after wildfire on anthropogenically disturbed and undisturbed sites in Subarctic upland Picea mariana forest. Arctic 55:269-280.

Roach, B.A.; Gingrich S.F. 1968. Even-aged silviculture for upland central hardwoods. Agric. Handb. 355. Washington, DC: U.S. Department of Agriculture, Forest Service. 39 p.

Sander, I.L.1988. Guidelines for regenerating Appalachian oak stands. In: Smith, H.C.; A.W Perkey. and W.E Kidd Jr., eds. Proceedings, Guidelines for regenerating Appalachian stands; May 24-26; Morgantown, WV. SAF Publication 88-03. Morgantown, WV: West Virginia University Books: 180-198.

Sander, I.L. 1977. Managers handbook for oaks in the North Central States. Gen. Tech. Rep. NC-37. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 35p.

Smalley, G.W. 1986. Classification and evaluation of forest sites on the Northern Cumberland Plateau. U.S. Departement of Agriculture, Forest Service, Southern Forest Experiment Station, General Technical Report, SO-GTR-60: 74 pp.

Smalley, G.W. 1982. Classification and evaluation of forest sites on the mid-Cumberland Plateau. U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station, General Technical Report, SO-GTR-38: 58 pp.

Taylor, D.D.; Chalfant, G.; MacGregor, J.; Walker, J.; Bergeron, R.; Miller, C.; Bishop, V. 1997. Landtype Associations Narratives- General information (unpublished). Daniel Boone National Forest. Winchester, KY. 189 pp.

U.S. Department of Agriculture, Forest Service. 2003. Final Environmental Impact Statement, Forest Health and Restoration Project, National Forests in Alabama, Bankhead National Forest. Management Bulletin R8-MB 110B. Forest Service Southern Region. 353 pp.

U.S. Department of Agriculture, Forest Service. 2004. Land and Resource Management Plan for the Daniel Boone National Forest. Management Bulletin R8-MB 117A. Forest Service Southern Region, Winchester, KY. 251 pp.