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Missouri Ozark Forest Ecosystem Project

Site History, Soils, Landforms, Woody and Herbaceous Vegetation, Down Wood, and Inventory Methods for the Landscape Experiment

Stephen R. Shifley and Brian L. Brookshire, Editors

Missouri Department of Conservation

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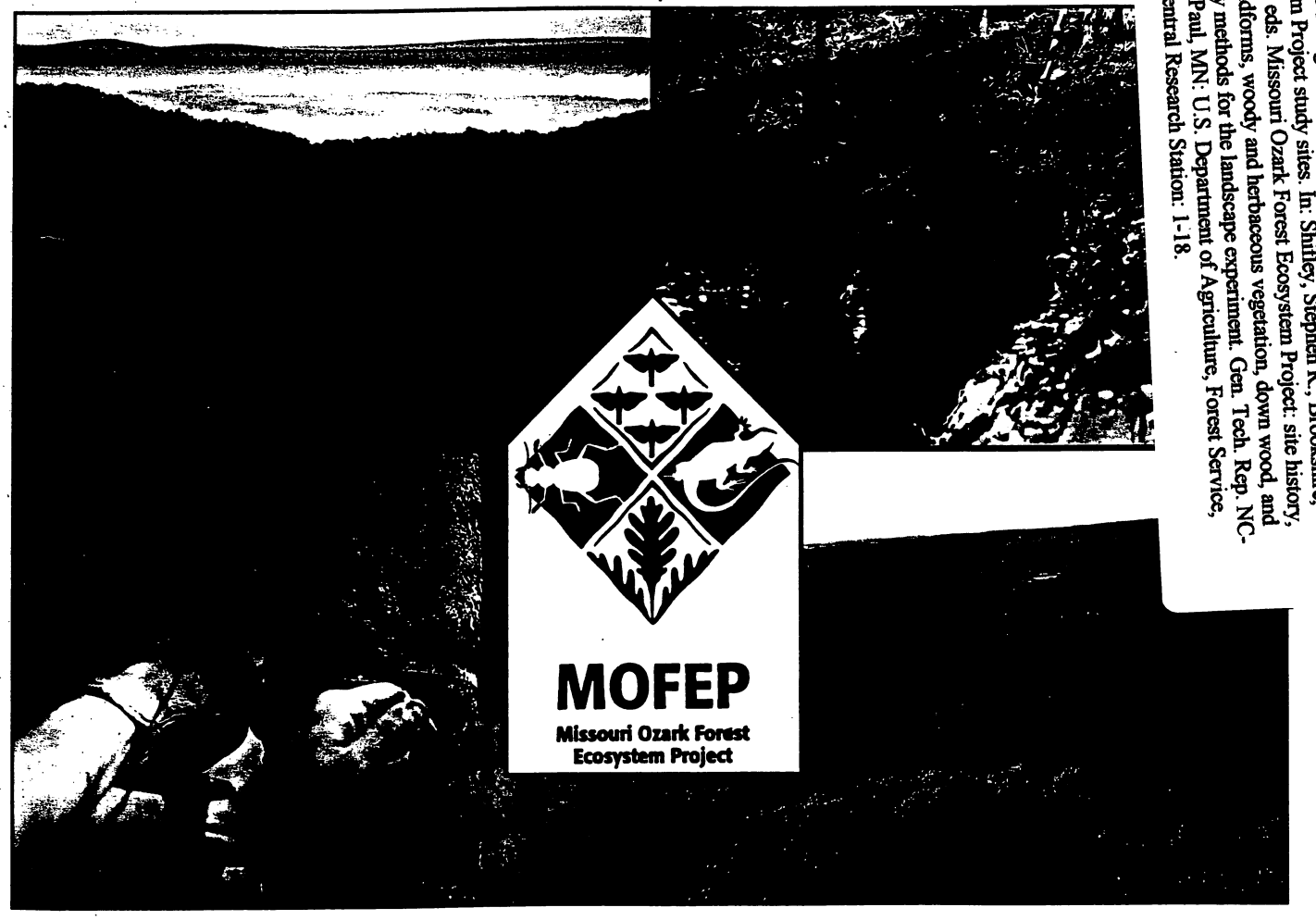

Missouri Ozark Forest Ecosystem Project: Site History, Soils, Landforms, Woody and Herbaceous Vegetation, Down Wood, and Inventory Methods for the Landscape Experiment

Edited by Stephen R. Shifley and Brian L. Brookshire

CONTENTS

Establishment and Data Collection of Vegetation-Related Studies on the Missouri Ozark Forest Ecosystem Project Study Sites

Brian L. Brookshire[1] and Daniel C. Dey[2]

Abstract.—The Missouri Ozark Forest Ecosystem Project (MOFEP) is an experiment designed to determine the effects of forest management practices on important ecosystem attributes. MOFEP treatments evaluated include even-aged, uneven-aged, and no management treatments. Forest vegetation provides a common ecological link among many organisms and ecological processes, and therefore monitoring forest vegetation before and after management treatments is a high priority on MOFEP. Between 1990 and 1994, 645 permanent vegetation plots were established on the nine MOFEP sites to inventory woody vegetation, herbaceous vegetation, and down wood. During 1994-95, woody vegetation and down wood were reinventoried on the original 645 plots, and three additional plots were established in bottomland ecological landtypes. Herbaceous vegetation was inventoried annually from 1993 through 1995. By 1996, all vegetation monitoring was completed to establish baseline information before implementation of the management treatments. We describe study site selection, management treatments, and vegetation sampling methods.

The Missouri Ozark Forest Ecosystem Project (MOFEP) was initiated in 1989 by the Missouri Department of Conservation (MDC) to experimentally evaluate the effects of even-aged, uneven-aged, and no-harvest management on multiple ecosystem attributes in the southeast Missouri Ozarks (Brookshire *et al.* 1997, Brookshire and Hauser 1993, Kurzejeski *et al.* 1993). MOFEP will provide a comprehensive evaluation of the impacts of operational management practices on a wide array of ecosystem attributes. MOFEP includes more than 25 related studies of such diverse attributes as neotropical migrant birds, litter and canopy invertebrates, small mammals, reptiles and amphibians, the physical environment, genetics, and overstory and understory vegetation (Brookshire *et al.* 1997).

Forest vegetation is the common link among all ecosystem components being studied. Therefore, a detailed description of vegetation characteristics and sampling procedures is required to provide a basis for properly interpreting results of the MOFEP experiment. Because MOFEP is a long-term experiment, vegetation sampling protocols and initial site conditions must be fully documented at the beginning. In this paper, we document details of how the MOFEP vegetation study was established and how it supports allied projects.

In total, this volume documents the site history, the physical site characteristics, the composition and structure of the forest overstory, the composition and abundance of herbaceous vegetation, and the volume and size structure of down wood on the nine MOFEP sites before the implementation of management treatments. Subsequent chapters and appendices provide detailed summaries of these characteristics by plot, site, and ecological landtype (ELT). In combination, this information provides a richly detailed profile of a mature forest ecosystem in the Missouri Ozarks.

METHODS

The MOFEP experiment is laid out in a randomized complete block design. Nine sites that range in size from 772 to 1,271 ac were selected as experimental units; these sites are

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sometimes referred to as compartments (Sheriff and He 1997). The nine sites were allocated equally to three blocks based on their spatial proximity to each other (fig. 1). Each of the management treatments (even-aged, uneven-aged, and no-harvest) was assigned randomly to three experimental sites in each block.

The condition of forest vegetation on each site was inventoried and monitored between 1990 and 1995, which provided a pre-treatment baseline before the first management treatments were implemented in 1996. We anticipate the next management treatments will be applied in 2011. Sheriff and He (1997) provide additional detail on the experimental design of the MOFEP study.

Site Selection

The MOFEP sites are located in Carter, Reynolds, and Shannon Counties in the southeast Missouri Ozarks (fig. 1). This part of Missouri is approximately 84 percent forested. The area has not been glaciated, and most soils have been exposed for more than 250 million years. Physical site characteristics are presented in detail by Meinert *et al.* (1997) and Kabrick *et al.* (this volume). Selected sites had to be: (1) at least 600 ac in size; (2) in contiguous tracts with minimal edge; (3) largely free from manipulation for at least 40 years (i.e., less than 5 percent of area disturbed) and preferably longer; (4) owned by MDC; (5) located in the southeast Missouri Ozarks; and (6) in close proximity to each other. Sites were selected after a search of MDC inventory records, discussions with local site managers, and numerous aerial and field evaluations (Kurzejeski *et al.* 1993). Most overstory trees on the sites range from 50 to 70 years old; trees older than 100 years occur on all sites and a few trees are older than 140 years. Additional description of the study area is provided by Brookshire *et al.* (1997), Brookshire and Shifley (1997), Brookshire and Hauser (1993), and Meinert *et al.* (1997).

Vegetation Plot Establishment

Each MOFEP experimental site was divided into areas of common slope and aspect and ecological landtypes were identified and mapped (see fig. 2 in Brookshire *et al.* 1997). Ecological landtypes were further divided into stands that averaged approximately 16 ac in size (fig. 2). Stand sizes ranged from 0.4 to 154 ac; the smallest stands were typically established around unique features (e.g., sinkholes) and the largest stands were located on sites scheduled to receive uneven-aged management (where large stand sizes did not present obstacles to prescribing management activities).

MOFEP site boundaries and internal stand boundaries were drawn on 1:15,840 topographic maps. In the office, initial vegetation inventory plot locations were randomly assigned within each site (or compartment) until each stand received at least one plot. Then, the number of plots by ecological landtype was calculated and additional plots were added to randomly assigned locations in the ecological landtypes that were underrepresented on an area basis. In the field, sample plot locations were eliminated if they:

- fell on a narrow shoulder ridge or narrow glade that caused the plot to encompass two distinctly different ecological landtypes,
- fell on a trail and there was insufficient room to fit a plot to the side of the trail without it falling outside the stand, or
- fell within two chains of a disturbance such as a road, food plot, or site boundary.

During initial plot establishment, plot locations were shifted slightly if that would correct one of the conditions listed above and retain the plot within the same stand. In some cases, a stand classified as predominantly one ELT had small inclusions of another ELT (e.g., multiple aspects occurred within a stand). If a plot location included aspects of more than one ELT, the plot was shifted slightly so that it fell within the primary ELT for the stand.

A total of 645 permanent vegetation plots was established during 1990-92 (table 1) (Sheriff and He 1997). Plot center and subplot centers were permanently marked with steel rods to aid in relocating the plots. During 1994-95, woody vegetation and down wood were reinventoried on the original 645 plots, and three additional vegetation plots were added in 1995 to intensify sampling in bottomland areas. Therefore, 648 vegetation inventory plots now exist on the nine MOFEP sites with between 70 and 76 plots per site (fig. 2).

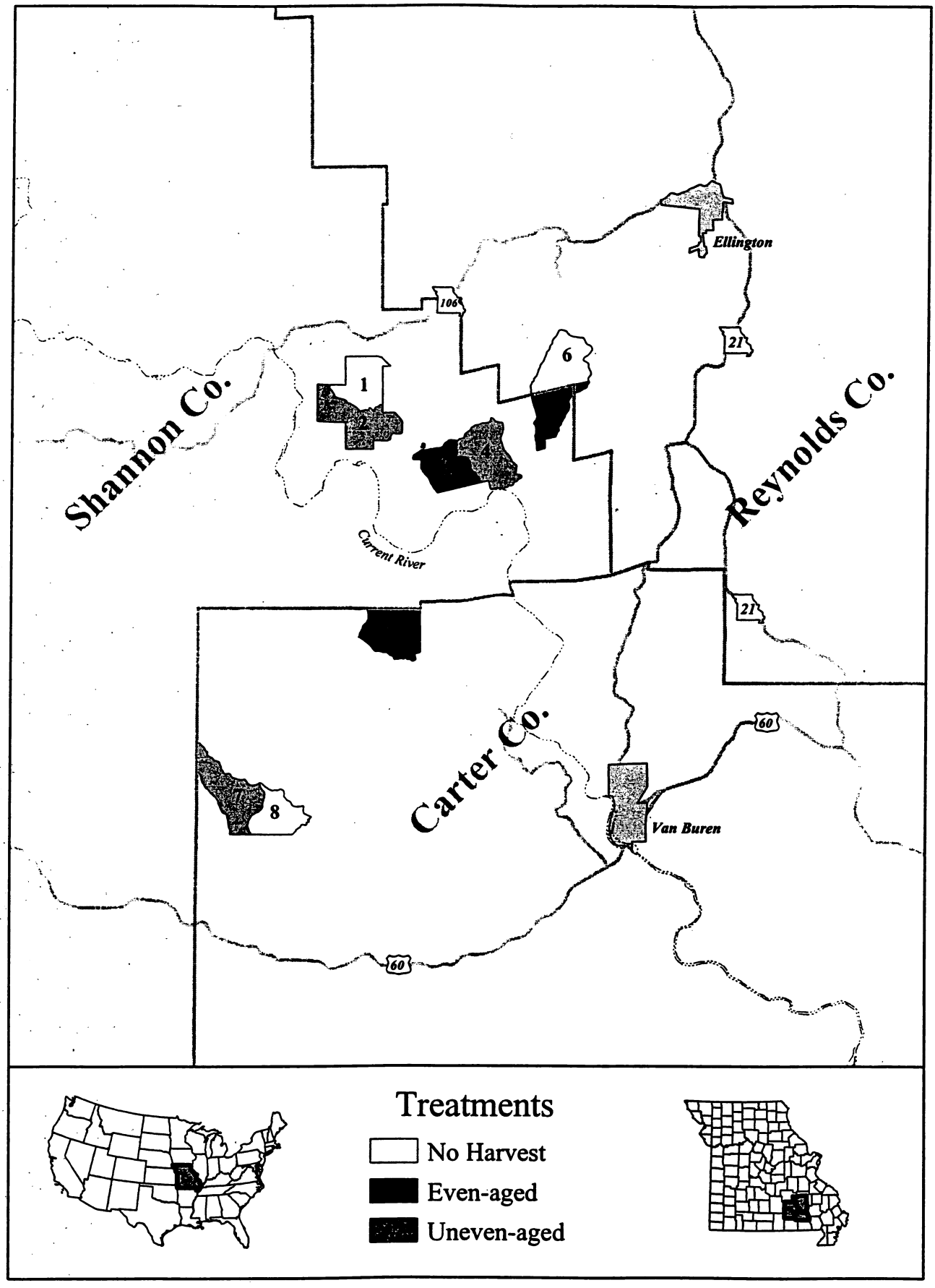


Figure 1.—*Location of the nine MOFEP experimental sites (compartments) and their assigned treatments.*

Table 1.--MOFEP vegetation plot measurement history by year, 1990 to 1995.

	1990	1991	1992	1993	1994	1995
Site 1		Established 73 permanent plots Measured 73 overstory plots	**Summer:** Measured 73 herbaceous plots **Fall:** Measured 73 herbaceous plots	**Summer:** Measured 73 herbaceous plots	Established 3 permanent plots Measured 8 overstory plots	Measured 68 overstory plots
					Summer: Measured 73 herbaceous plots	**Summer:** Measured 76 herbaceous plots **Fall:** Measured 76 herbaceous plots
Site 2		Established 73 permanent plots Measured 73 overstory plots	**Summer:** Measured 73 herbaceous plots	**Summer:** Measured 73 herbaceous plots	Measured 8 overstory plots	Measured 65 overstory plots
					Summer: Measured 73 herbaceous plots	**Summer:** Measured 73 herbaceous plots
Site 3		Measured 43 overstory plots	Measured 29 overstory plots	**Summer:** Measured 72 herbaceous plots	Measured 8 overstory plots	Measured 69 overstory plots
			Summer: Measured 72 herbaceous plots		**Summer:** Measured 72 herbaceous plots	**Summer:** Measured 72 herbaceous plots
Site 4			Established 74 permanent plots Measured 74 overstory plots	**Summer:** Measured 74 herbaceous plots	Measured 8 overstory plots	Measured 69 overstory plots
			Summer: Measured 74 herbaceous plots **Fall:** Measured 74 herbaceous plots		**Summer:** Measured 74 herbaceous plots	**Summer:** Measured 74 herbaceous plots

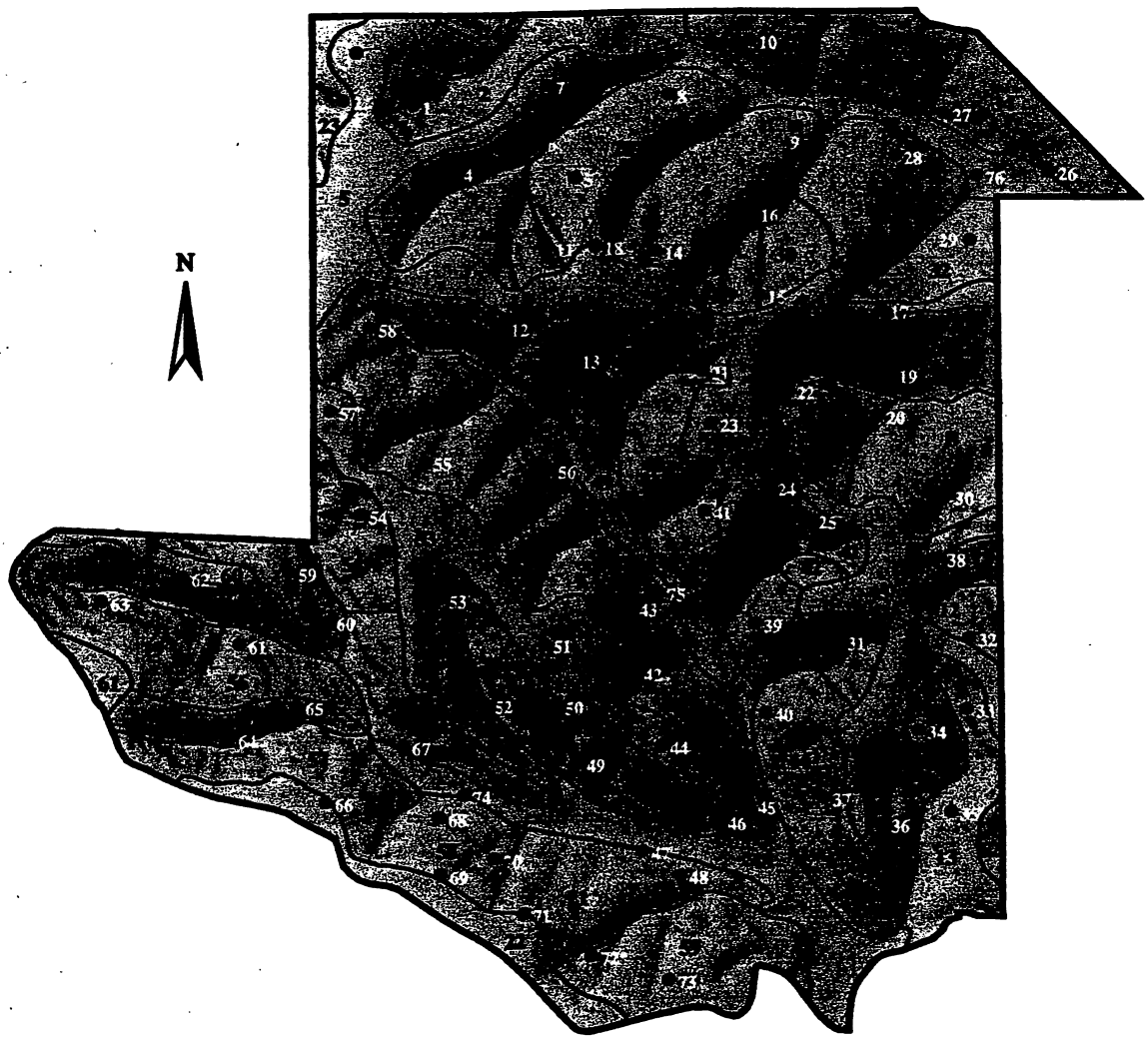
(Table 1 continued on next page)

(Table 1 continued)

Site 5			Established 70 permanent plots Measured 70 overstory plots	**Summer:** Measured 70 herbaceous plots	Measured 8 overstory plots	Measured 70 overstory plots
			Summer: Measured 70 herbaceous plots		**Summer:** Measured 70 herbaceous plots	**Summer:** Measured 70 herbaceous plots **Fall:** Measured 70 herbaceous plots
Site 6			Established 71 permanent plots Measured 71 overstory plots	**Summer:** Measured 71 herbaceous plots	Measured 8 overstory plots	Measured 63 overstory plots
			Summer: Measured 71 herbaceous plots		**Summer:** Measured 71 herbaceous plots	**Summer:** Measured 71 herbaceous plots
Site 7		Established 71 permanent plots Measured 71 overstory plots	**No Sampling**	**Summer:** Measured 71 herbaceous plots	Measured 8 overstory plots	Measured 63 overstory plots
		Summer: Measured 71 herbaceous plots			**Summer:** Measured 71 herbaceous plots	**Summer:** Measured 71 herbaceous plots
Site 8	Established 45 permanent plots Measured 45 overstory plots	Established 25 permanent plots Measured 25 overstory plots	**No Sampling**	**Summer:** Measured 70 herbaceous plots	Measured 8 overstory plots	Measured 64 overstory plots
		Summer: Measured 70 herbaceous plots			**Summer:** Measured 70 herbaceous plots	**Summer:** Measured 70 herbaceous plots
Site 9		Established 71 permanent plots Measured 71 overstory plots	**No Sampling**	**Summer:** Measured 71 herbaceous plots	Measured 8 overstory plots	Measured 64 overstory plots
		Summer: Measured 71 herbaceous plots			**Summer:** Measured 71 herbaceous plots	**Summer:** Measured 71 herbaceous plots

Stand Boundaries
Site 1

(No Harvest Management)



0.25 0 0.25 0.5 Miles

Map Scale 1:15,840
1 inch = 1/4 mile

Note: White Numbers (Vegetation Plots)
Black Numbers (Stand Numbers)

Figure 2a.—*Stand boundaries and vegetation plot locations for MOFEP Site 1.*

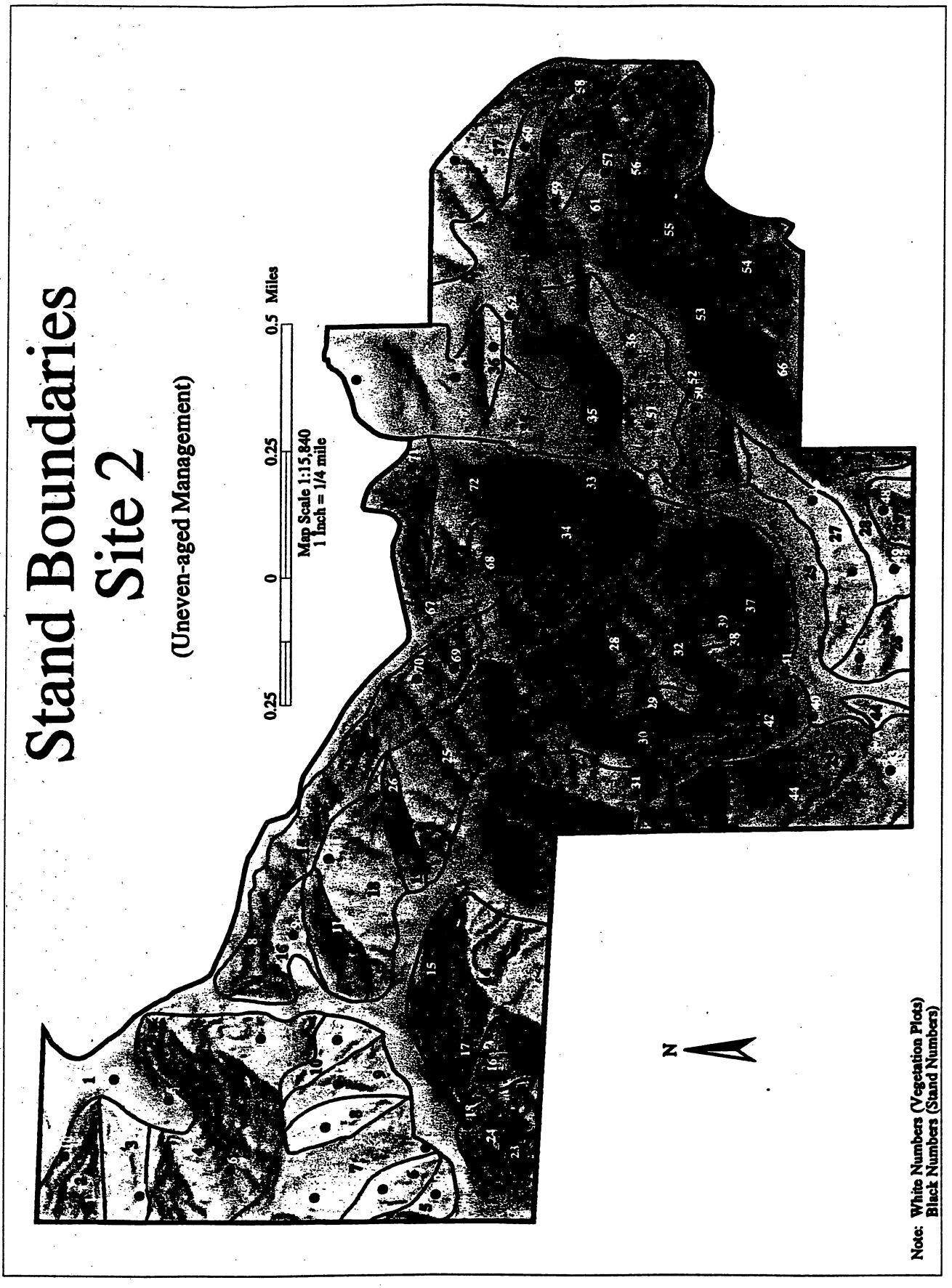


Figure 2b.—*Stand boundaries and vegetation plot locations for MOFEP Site 2.*

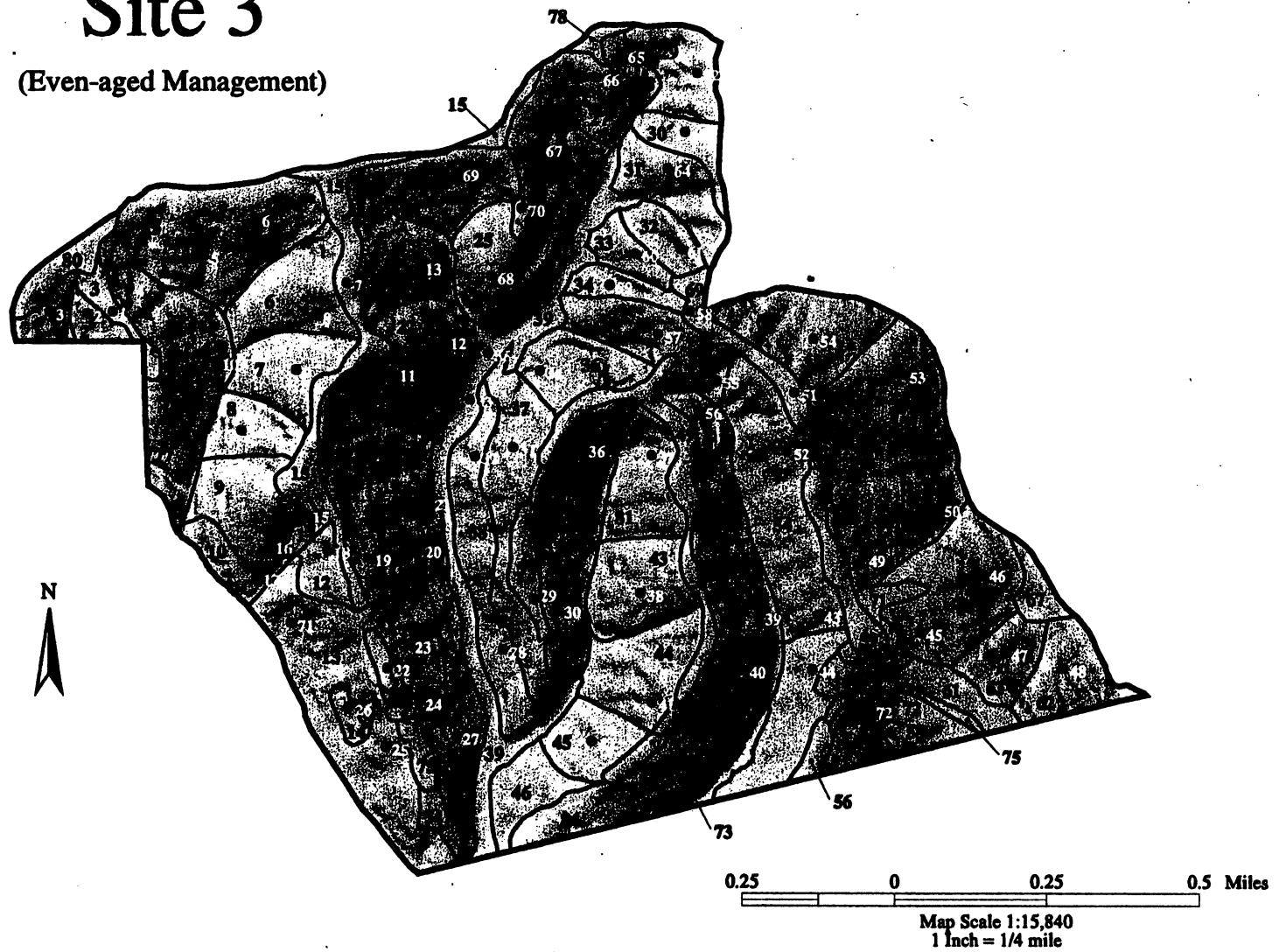


Figure 2c.—*Stand boundaries and vegetation plot locations for MOFEP Site 3.*

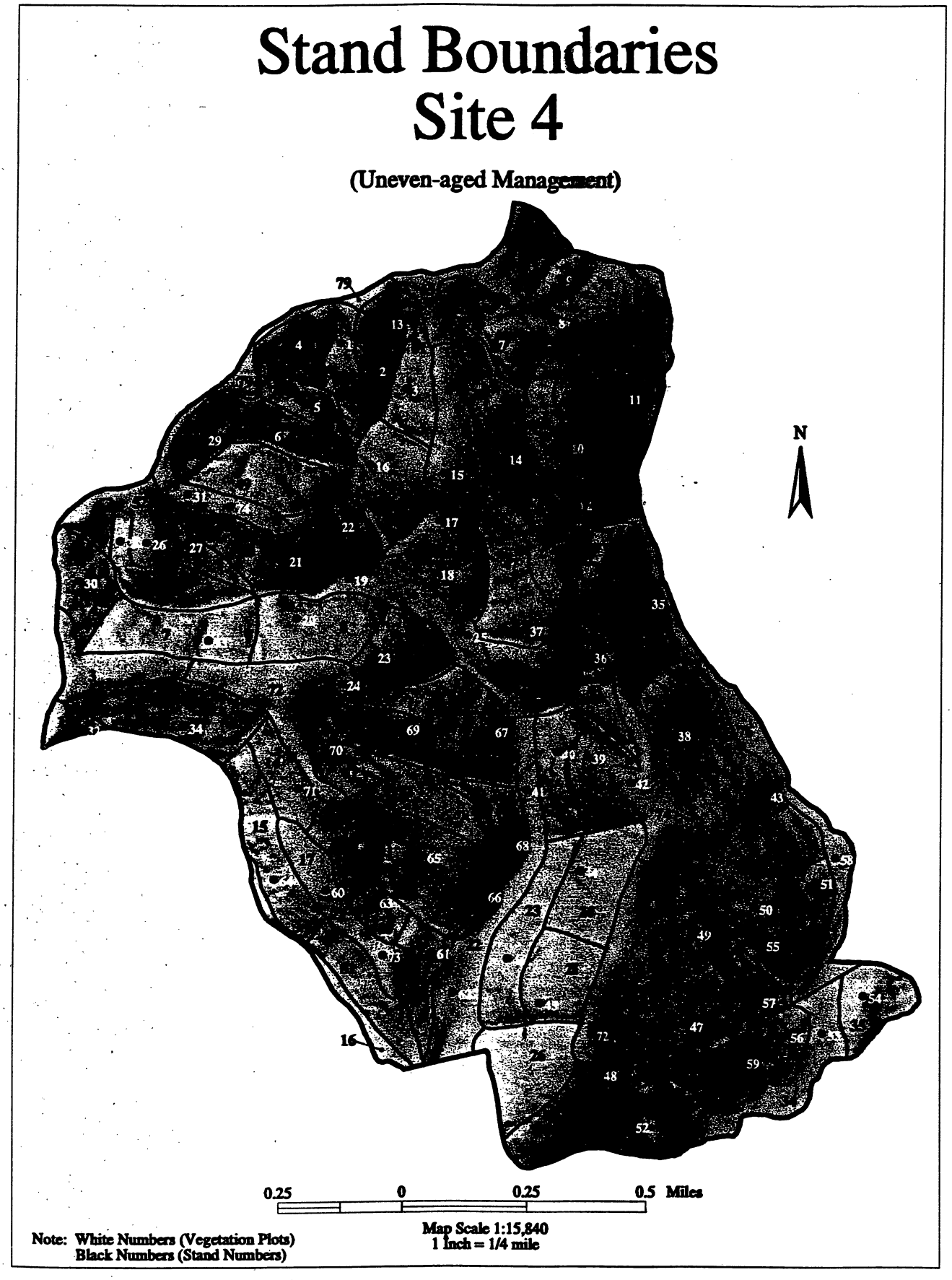


Figure 2d.—*Stand boundaries and vegetation plot locations for MOFEP Site 4.*

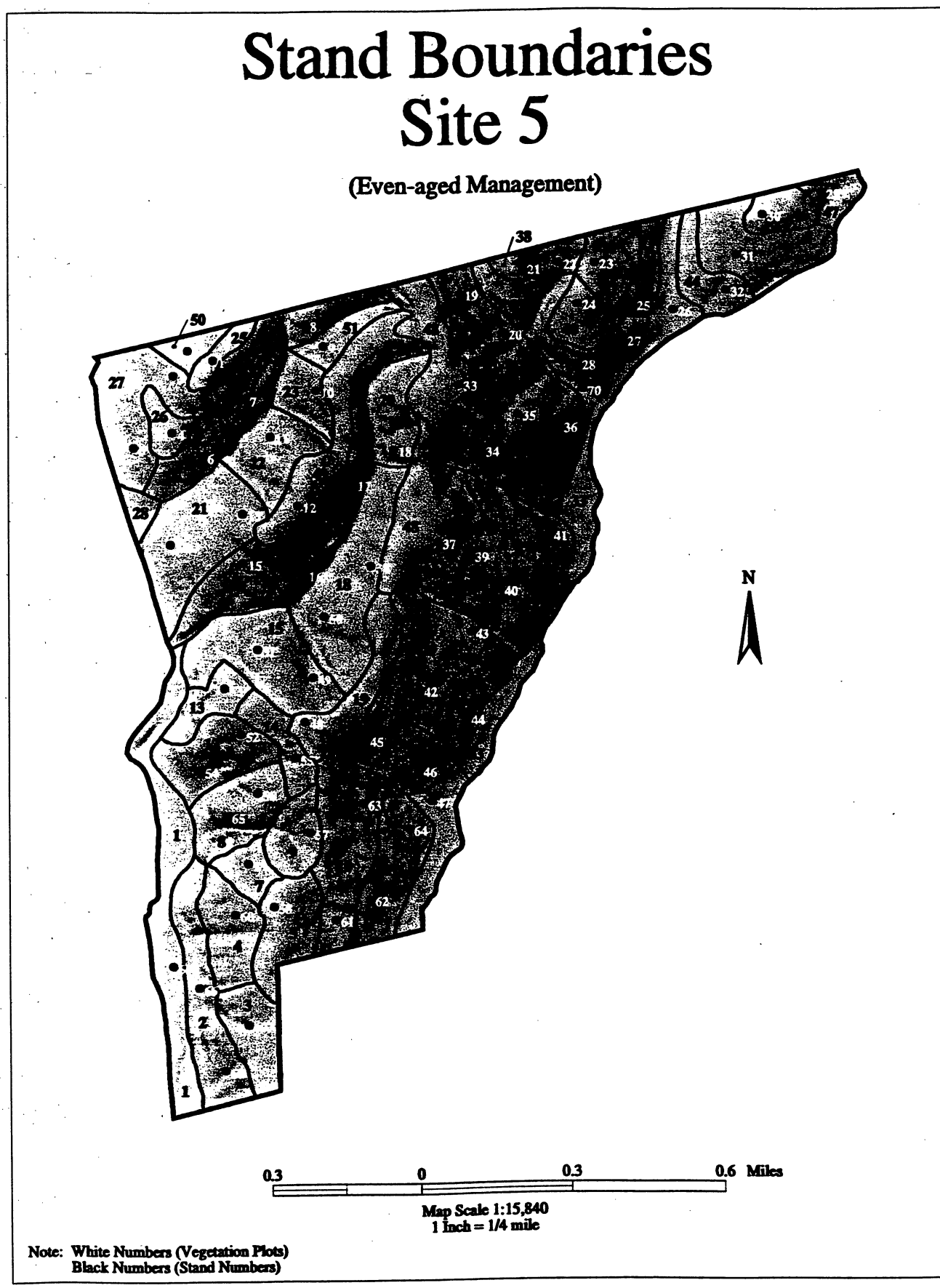
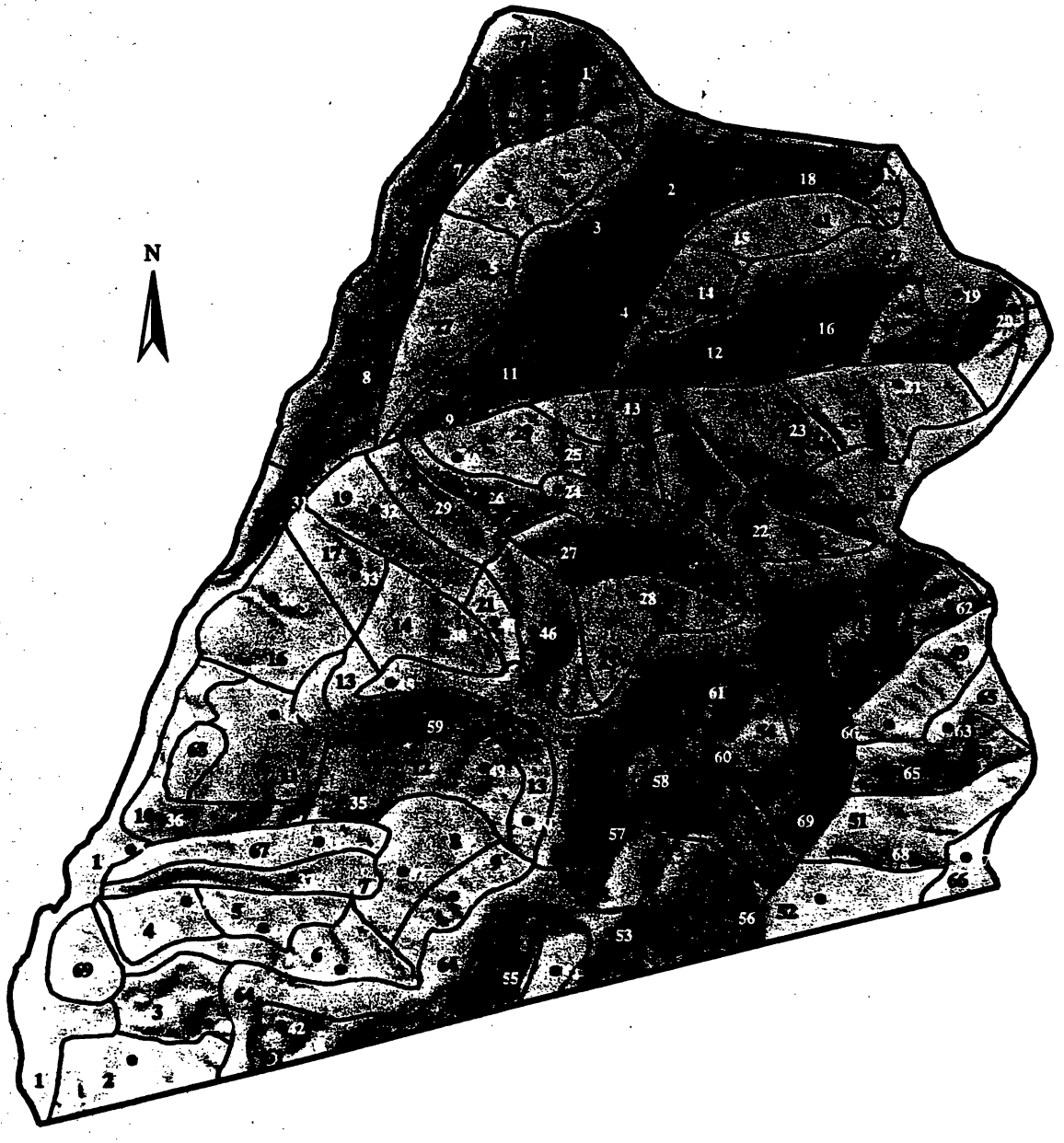


Figure 2e.—*Stand boundaries and vegetation plot locations for MOFEP Site 5.*

Stand Boundaries Site 6

(No Harvest Management)



Note: White Numbers (Vegetation Plots)
Black Numbers (Stand Numbers)

Figure 2f.—*Stand boundaries and vegetation plot locations for MOFEP Site 6.*

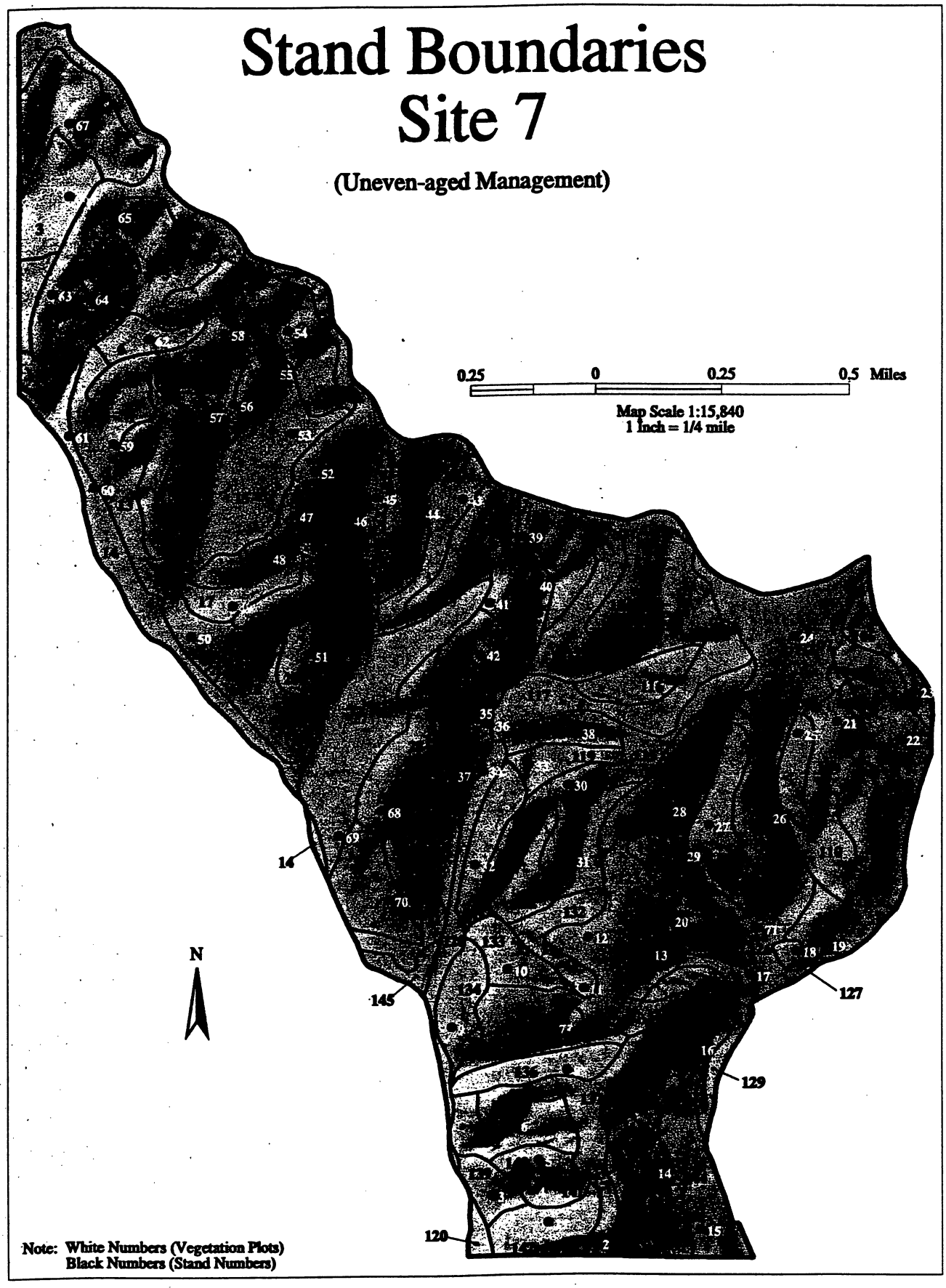
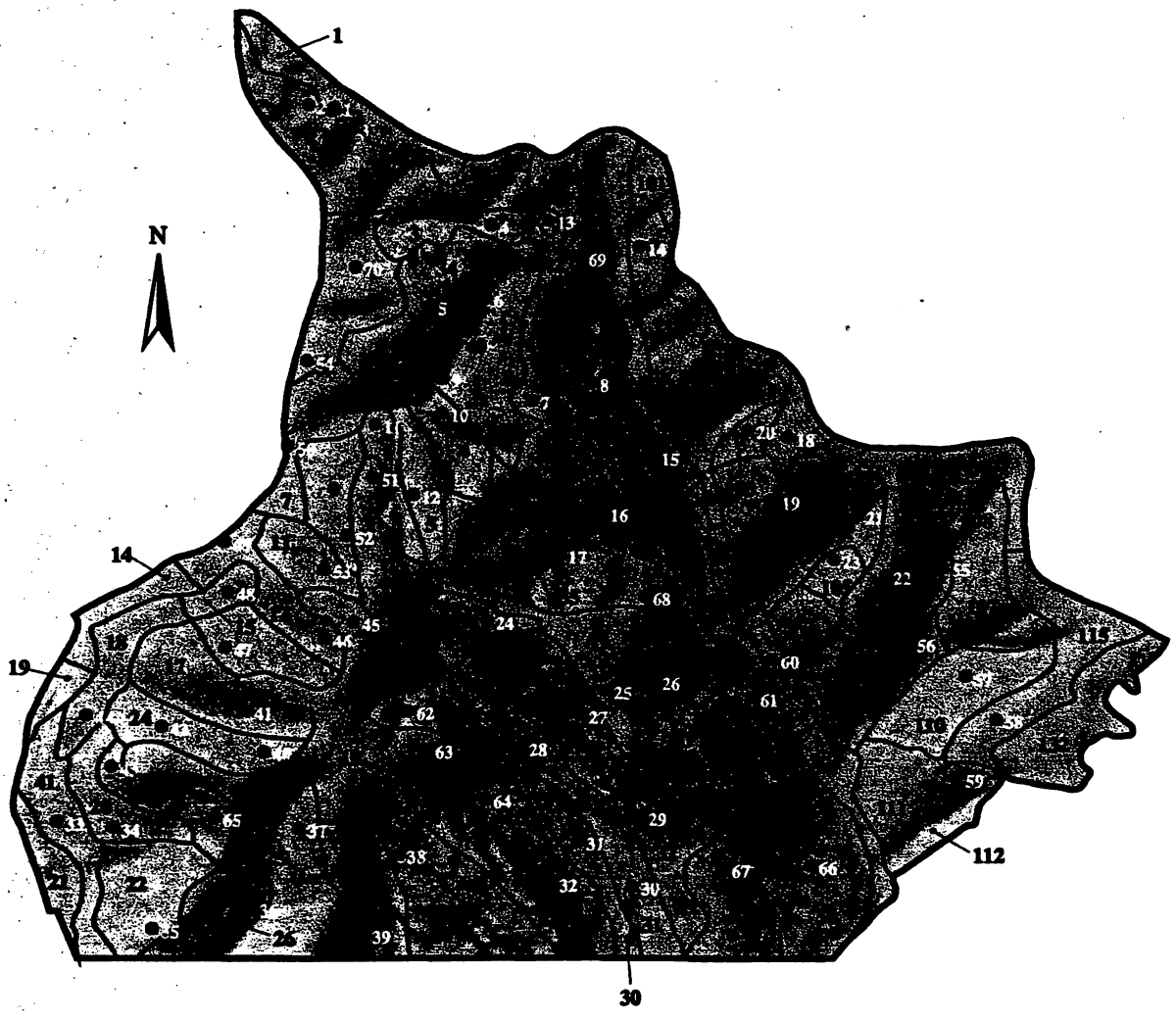


Figure 2g.—*Stand boundaries and vegetation plot locations for MOFEP Site 7.*

Stand Boundaries Site 8

(No Harvest Management)

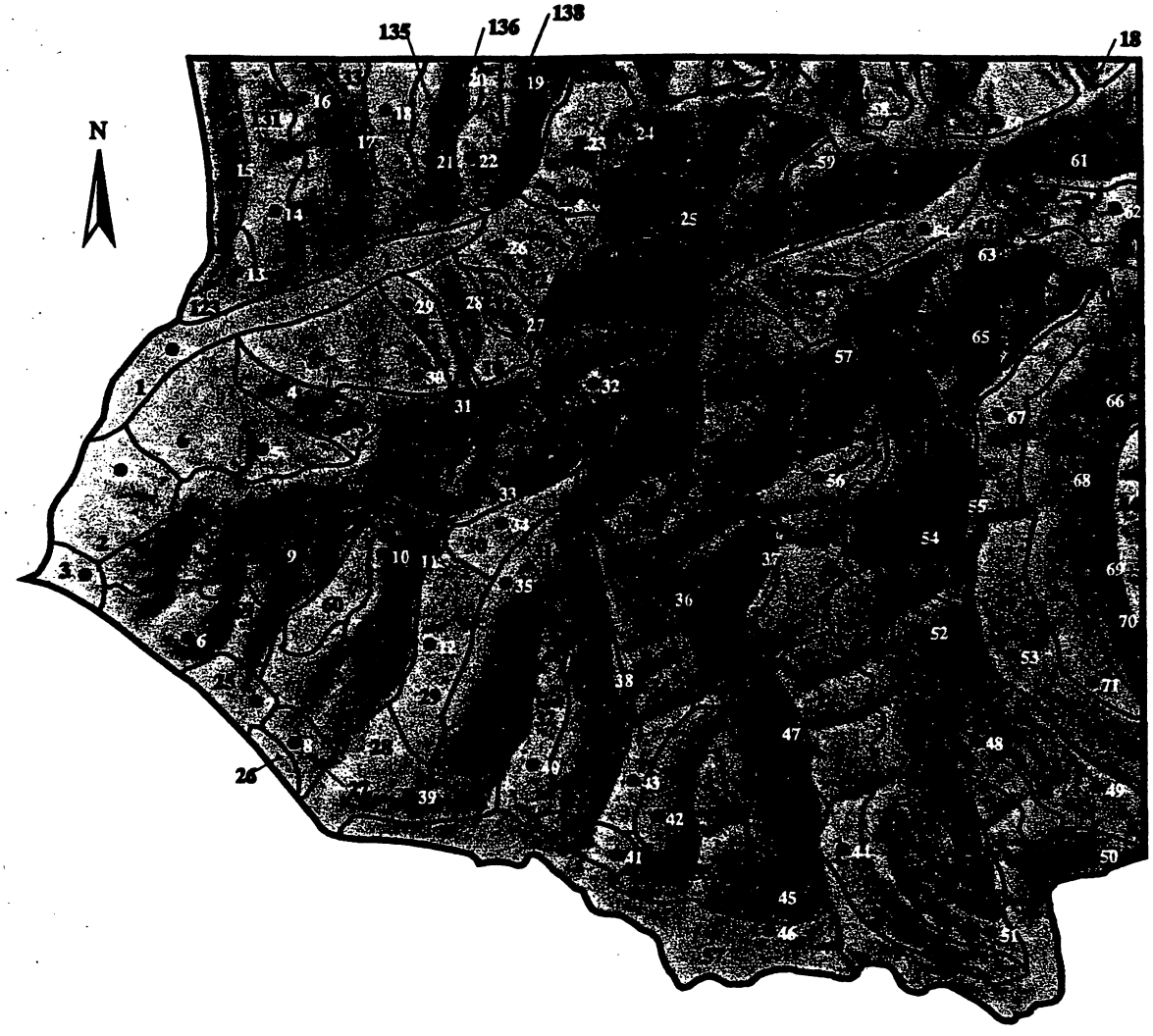


Note: White Numbers (Vegetation Plots)
Black Numbers (Stand Numbers)

Figure 2h.—*Stand boundaries and vegetation plot locations for MOFEP Site 8.*

Stand Boundaries Site 9

(Even-aged Management)



Note: White Numbers (Vegetation Plots)
Black Numbers (Stand Numbers)

Figure 21.—*Stand boundaries and vegetation plot locations for MOFEP Site 9.*

Overstory, understory, down wood, and physical site characteristics were measured on a 0.5-ac circular plot (Appendix A). Within the 0.5-ac plot, all live trees ≥4.5 in. diameter at breast height (dbh; 4.5 ft above ground level) and all standing dead trees ≥8 ft tall and ≥4.5 in. diameter were measured. Live trees and woody vines ≥1.5 in. dbh and <4.5 in. dbh were measured on four 0.05-ac subplots located within the 0.5-ac main plot. Live trees and woody vines ≥3.3 ft tall and <1.5 in. dbh were measured on 0.01-ac subplots nested within each 0.05-ac subplot. On the 0.5-ac main plot, information collected for each tree included species, dbh, crown class, and number and size of dens and cavities (Appendix A). Each tree was permanently marked for future remeasurement. The abundance of down wood was measured on four transects within the 0.5-ac vegetation plot. On average, a two-person crew was able to establish two plots and collect all woody vegetation data in one 10-hour day. Appendix A includes detailed measurement protocols for all woody vegetation.

At different times between 1992 and 1995, 15 overstory trees [five each in the white oak group (*Quercus alba, Q. stellata*), the red oak group (*Q. coccinea, Q. velutina*), and shortleaf pine (*Pinus echinata*)] received additional crown and volume measurements. These included canopy width, tree height, crown ratio, crown volume, merchantable bole volume, stem taper, and merchantable height. Also, site index for each plot was determined from trees adjacent to the plot (within 5 chains). An average of five site index trees per plot were cored and measured. When possible, multiple species per plot were selected from among white oak (*Quercus alba*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*), and shortleaf pine (*Pinus echinata*).

The initial measurement of herbaceous vegetation abundance and percent ground cover was made in 1991 (sites 7, 8, 9) and 1992 (sites 1-6). Herbaceous vegetation was remeasured in the summers of 1993-95 (all sites) (table 1). Fall sampling on selected plots occurred in 1992, 1993, and 1995. Herbaceous vegetation and any woody vegetation <3.3 ft tall was measured on 16 one meter square subplots within each of the permanent vegetation plots (see fig. 1 in Appendix A). Grabner *et al.* (1997) and Grabner (this volume) provide detailed descriptions of initial herbaceous characteristics of the MOFEP sites.

TREATMENTS

The three forest management treatments compared in the MOFEP experiment are even-aged management (EAM), uneven-aged management (UAM), and no-harvest management (NHM). These represent the range of silviculture practices applied on private and public lands in Missouri. Treatments are briefly described below and in Brookshire and Hauser (1993) and Brookshire *et al.* (1997). Treatments were implemented in 1996 after completing the 1991-95 pre-treatment inventories described in this volume. Harvest treatments by stand are shown in figure 3 of Brookshire *et al.* (1997) and will be further described in subsequent publications.

Even-aged Management

Even-aged management followed MDC Forest Land Management Guidelines (1986), with a cutting rotation of 80-100 years per site. This results in a regulated harvest of 10-12 percent of the area per entry on a 10-year re-entry period. Under this treatment, 10 percent of each site (i.e., each compartment) is left as "old growth" and reserved from harvest in perpetuity. The desirable tree size class distribution on the remaining area is 10 percent seedlings, 20 percent small trees (2.5-5.5 in. dbh), 30 percent poles (5.6-11.5 in. dbh), and 40 percent sawtimber (>11.5 in. dbh). Harvest prescriptions follow Roach and Gingrich (1968). In general, the total area regenerated by clearcutting was restricted to approximately 10-12 percent of each treated site. Stands at risk of heavy mortality from such factors as oak decline were selected first for regeneration; other stands in need of regeneration were deferred to the next entry. In the remaining stands with site index ≥55 (base age 50 years), intermediate cutting was applied following the guidelines of Roach and Gingrich (1968) provided the stands would yield enough timber for a commercial sale (approximately 2,000 bd ft/ac) without reducing residual stocking of acceptable growing stock below B-level. Glades, food plots, ponds, and other amenities were managed according to the 1986 MDC Forest Land Management Guidelines.

Uneven-aged Management

Uneven-aged management was also implemented using MDC Forest Land Management Guidelines (1986) with stand treatments following Law and Lorimer (1989). Approximately 10 percent of each site was designated as old growth in perpetuity, and the remaining 90 percent was managed using uneven-aged silviculture. Treatments on UAM sites will be timed to coincide with treatments for EAM sites over the next 80-100 years. Each UAM site was divided into management units (usually <25 ac in size), and management objectives were set for largest diameter tree (LDT), residual basal area (RBA), and q-value. The LDT objective was equal to the desired sawtimber size objective for an identical site under EAM. An overall RBA equivalent to B-level stocking was chosen, with adjustments made to anticipate for logging damage (Roach and Gingrich 1968). Q-value objectives ranged from 1.3 to 1.7 (Law and Lorimer 1989). For trees >5 in. dbh, the target tree size class distribution for UAM was identical to the composite size class distribution across the EAM sites. Harvesting was deferred in stands that could not generate a commercial harvest. In 1996, 69 percent of site 2 was harvested, 62 percent of site 4, and 41 percent of site 7.

No-harvest Management

Sites under no-harvest management will not receive timber harvesting. Forest disturbances such as windthrow, fires, or insects and disease outbreaks will occur as they do on any other State-owned forest land, except that salvage harvesting of dead and dying timber will not occur. Wildfires will be suppressed and large-scale damaging insect outbreaks will be controlled. This treatment will serve as the experimental control in this project (Sheriff and He 1997).

DISCUSSION

Because of the magnitude of the MOFEP study, initial vegetation plot establishment occurred over several months. Subsequent remeasurement of plots took less time because plots were already established and more personnel were available to assist in the effort (table 1). Allied studies (i.e., studies on other ecosystem attributes) were initiated at different intervals throughout the pre-treatment phase of MOFEP. Several major allied studies were established during or immediately after initial vegetation plot establishment; others followed depending on funding and scientist interest (table 2, see also Brookshire and Shifley 1997).

The MOFEP vegetation inventory is the largest summary of Ozark forest conditions ever assembled. It includes repeated measurements on more than 96,000 individual trees. The herbaceous inventory tallied abundances for more than 400 individual species. Together, these inventories provide a detailed assessment of Ozark forest composition and structure across all the common ecological landtypes on the MOFEP sites. Characteristics of the forest overstory, the forest understory, and down wood are presented in detail in later chapters of this report.

CONCLUSIONS

Long-term field experiments require detailed documentation of the establishment of the project to withstand the scientific scrutiny that inevitably occurs over time. This report provides detailed descriptions of vegetation inventory and analysis conducted on the MOFEP sites. This information is necessary for those scientists currently conducting studies on the MOFEP sites, and it will be invaluable to scientists who work on the MOFEP sites in the future. The detailed vegetation information provides a common ecological link between various research experiments for scientists conducting allied projects on the MOFEP study sites. The MOFEP vegetation inventory also serves as a comprehensive regional summary of forest structure and composition that can be compared and contrasted with hardwood forests elsewhere.

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Table 2.—*Research studies affiliated with the Missouri Ozark Forest Ecosystem Project. See Brookshire and Shifley (1997) for additional information about these research projects.*

	Principal investigator(s)	Study title
1.	J. Bruhn, J. Wetteroff,, Jr. J. Mihail	Determination of the ecological and geographical distributions of *Armillaria* species in Missouri Ozark forest ecosystem
2.	J. Bruhn, J. Mihail, D. Stokke, S. Burks	Mechanical damage to residual stem root systems associated with forest operations in Ozark forest ecosystems
3.	R. Cecich	White oak acorn production along a slope transect
4.	J. Chen, M. Xu, K. Brosofske	Microclimate characteristics in southeastern Missouri's Ozarks
5.	R. Clawson, J. Faaborg, E. Seon	The effects of selected timber management practices on forest interior birds in Missouri oak-hickory forests
6.	D. Dey, D. Larsen, R. Jensen	Stump sprout response to MOFEP harvest treatments
7.	J. Dwyer	Economic comparisons of harvest practices on MOFEP study sites
8.	J. Dwyer	Tree grading on the MOFEP study sites
9.	J. Dwyer, R. Jensen	Documenting harvest damage to MOFEP study sites
10.	D. Frantz, D. Hamilton	Abundance and production of berry producing plants on MOFEP study sites: the soft mast study (pre-harvest conditions)
11.	D. Frantz, R. Renken	Small mammal communities on MOFEP sites and their response to treatments
12.	J. Grabner, D. Larsen, J. Kabrick	Composition, structure and dynamics of MOFEP ground flora
13.	W. Gram, V. Sork, R. Marquis	Synthesis and integration of pretreatment results from the Missouri Ozark Forest Ecosystem Project
14.	R. Guyette, D. Dey	Historic Shortleaf Pine (*Pinus echinata* Mill) abundance and fires frequency in a mixed oak-pine forest (MOFEP, compartment 8)
15.	L. Herbeck, D. Larsen	Ecological interactions of vegetation and Plethodontial Salamanders in Missouri Ozark forests
16.	R. Jensen	Tree cavity abundance, size and use on MOFEP study sites
17.	J. Kabrick, D. Jensen, S. Shifley	Analysis of MOFEP woody vegetation and environmental data
18.	D. Ladd	Profiling MOFEP Lichen Vegetation
19.	D. Larsen	Simulated long-term effects on the MOFEP cutting treatments
20.	R. Marquis, J. Le Corff	The oak herbivore fauna of Missouri Ozark Forest Ecosystem Project
21.	S. Pallardy	Vegetation analysis, environmental relationships, and potential successional trends in the Missouri Ozark Forest Ecosystem Project
22.	R. Renken	The herpetofaunal communities on Missouri Ozark Forest Ecosystem Project (MOFEP) study sites
23.	S. Sheriff, Z. He	The experimental design of the Missouri Ozark Forest Ecosystem Project
24.	S. Shifley, B. Brookshire, D. Larsen L. Herbeck, R. Jensen	Snags and down wood on upland oak sites in the Missouri Ozark Forest Ecosystem Project
25.	V. Sork, A. Koop, M. de la Fuente, P. Foster, J. Raveill	Patterns of genetic variation in woody plant species in the Missouri Ozark Forest Ecosystem Project
26.	H. Pratt, Jr.	Aspects of carbon and sulfur transformations in MOFEP surface soils
27.	L. Vangilder	Acorn production on MOFEP study sites: pretreatment data
28.	J. Weaver, S. Heyman	The distribution and abundance of leaf litter arthropods

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