Vegetation Monitoring at Kennesaw Mountain National Battlefield Park, Cobb County, Georgia: A Report on the Summer 1994 Field Season

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Contents

Abstract

Twelve 0.1 hectare (20 x 50 m) permanent vegetation plots were marked and sampled in Kennesaw Mountain National Battlefield Park. Selection of monitoring sites was based on monitoring requirements identified by Park personnel.

Five of the plots were situated in examples of the granite outcrop habitat. These areas are frequented by large numbers of visitors annually and human pressure may be impacting the plant species.

Three of the plots were located in wooded lowland areas. Chinese Privet (Ligustrum sinense) has been identified as a highly successful invasive species, particularly in the lower and wetter areas of the park.

The remaining four plots were placed on the wooded slopes of Kennesaw and Little Kennesaw Mountain. At these higher elevations and slope positions, Privet is less abundant, but it grows well even on the open ridge tops of Kennesaw and Little Kennesaw Mountains.

Future work at Kennesaw Mountain National Battlefield Park should include a complete inventory of the vascular plant species of each granite outcrop, a larger number of monitoring plots on all aspects of Kennesaw and Little Kennesaw Mountains, more extensive sampling of the lowland wooded areas, and an evaluation of the extent to which Privet is displacing native species.

Introduction

Kennesaw Mountain National Battlefield Park is located near Marietta in Cobb County, Georgia. It was authorized in 1917 as a National Battlefield Park, to commemorate and preserve the site of the 1864 battle. The primary resource is 1,201 hectares of protected lands adjacent to the metropolitan areas of Kennesaw, Marietta and, further afield yet visible from Kennesaw and Little Kennesaw Mountains, Atlanta (Basic Operations declaration Kennesaw Mountain National Battlefield Park).

This report is a detailed account of field work conducted during two trips to Kennesaw Mountain National Battlefield, between the dates of July 23 through July 31, 1994, and August 18 through August 26, 1994, respectively.

Project Objectives

The purpose of the work was:

(1) To contribute to a comprehensive long-term vegetation monitoring plan for Kennesaw Mountain National Battlefield Park

and

(2) To establish permanent plots in order to:

describe the rate and trajectory of vegetation change, including change in vegetation structure, composition, and dynamics;
assess the impacts of particular threats;
assess the response of sensitive resources;
gauge the significance of vegetation changes for park management goals;
help define research questions that will assess the causes of change;
help define research that will evaluate alternative management strategies;
build an understanding of ecosystem processes so that future changes can be better predicted;
establish field research sites that will attract additional research studies;
and promote participation in regional and international monitoring networks.

The field work reported here was part of a project carried out in five NPS units in the southeast: Chickamauga and Chattanooga National Military Parks, Georgia and Tennessee; Kennesaw Mountain National Battlefield Park, Georgia; King's Mountain National Military Park, South Carolina; Russell Cave National Monument, Alabama; and Shiloh National Military Park, Tennessee. For each area we sought to establish a preliminary set of monitoring plots organized around the highest priority

natural resource issues and to suggest the priorities for fuller development of a vegetation monitoring program. Implications for park management policies and practices are also considered.

Only the highest priority natural resource issues could be addressed in this preliminary phase of vegetation monitoring, such as the spread of the exotic shrub Privet, and the impact of park visitors on granite outcrop areas (Langdon, no date). Also, in large areas of relatively uniform habitat, such as the lowland wooded areas and the wooded slopes of Kennesaw and little Kennesaw Mountains, specific threats are not currently the issue, but monitoring is required at many locations in order to detect changes over time in these habitats (see above project objectives).

The flora and vegetation of Kennesaw Mountain National Battlefield Park

The current list of vascular plants (inventory) at Kennesaw Mountain National Battlefield Park has been compiled from three sources (Bostick, 1994). Three individuals, Peter (Ed) Bostick, Scott Ranger and Marie Mellinger have made observations that are compiled into the current flora list. Plants encountered in our work that are new to this list are preceded by the letter "n" in the Species Code List (Appendix A-10). Additions to this list are likely, however, as detailed surveys of the type described in this report are carried out, particularly in some of the less botanically attractive areas, such as the lowland woods around, and south of, the Cheatham Hill area.

There are, broadly, three main vegetation types within the park.

First are the wooded lowland areas below Kennesaw and Little Kennesaw Mountains and throughout the rest of the park. In many places these areas are quite narrow, being bordered by residential development. These areas are further dissected by hiking trails. Many visitors, particularly joggers, use these trails but generally restrict their activities to the trails. The wooded lowlands are characterized as mature successional stands dominated by Pines (Pinus taeda and some Pinus echinata) and Tulip poplars (Liriodendron tulipifera). There are three permanent monitoring plots distributed throughout this vegetation type.

Second, the wooded slopes of Kennesaw and Little Kennesaw Mountains are a large area that is mostly free from recent human impacts. These slopes appear to be more successionally mature than the lowlands and are dominated by Hickories (Carya alba and C. glabra), Chestnut Oak (Quercus prinus), and Black Oak (Q. velutina). There are four permanent monitoring plots distributed throughout this vegetation type.

Third, and perhaps the most biologically significant, are areas on the ridge and slopes of Kennesaw and Little Kennesaw Mountain where outcropping granite supports a fragile but diverse plant community. The areas of exposed rock or very thin soil prevent the establishment of a closed canopy. The elevation and openness of these granite outcrops afford excellent views of the surrounding landscape. Several of the larger outcrops are located close or adjacent to trails. As such these areas are subjected to heavy human pressure. The occurrence of rare species in these outcrops (Bostick, 1994) and the pressure of visitors on them is cause for concern. The woody vegetation bordering and sporadically within the outcrops is dominated by Hickories, Winged Elm (Ulmus alata), Oaks (Q. prinus and Q. marilandica), Winged Sumac (Rhus copallina) and Fringe Tree (Chionanthus virginicus). The open area grades from exposed rock through moss cover to a mostly herbaceous vegetation. There are five permanent monitoring plots located in these outcrops.

In a general sense, the purpose of the vegetation monitoring plots is to obtain baseline data so that changes in the health and condition of these natural resources can be detected (see Project Objectives, above). The importance of monitoring is well detailed in Sutter, Rollins & Livingstone (1994) and Sutter et. al. (1994). As human impacts grow, both in terms of the numbers of people who use the Park and as such human influences as pollution of air and water increase with the growth of adjacent human population, it is anticipated that this will be reflected in changes in the natural areas of the park.

The 1994 field work

The remainder of this report is divided into three sections and accompanying Appendices.

The Methods section describes the procedures used to carry out this study. This section is divided into three parts: Site Selection Criteria (basic elements of sampling design); Sampling Protocol; and Site Locations and Descriptions (a description of the means for relocation of permanent plots).

The Results section presents preliminary summaries of each plot (raw data are included in Appendix A). The location of each plot is illustrated in annotated sketch diagrams, as figures, that accompany the text. Soil samples information is included in Appendix C.

The Discussion section draws together the findings for each of the areas studied and suggests priorities for future work.

Methods

The design for this project consists of stratified random sampling,.using a plot size of 20 x 50 m (0.1 ha). This rectangular plot is further divided into ten standard 10 x 10 m subplots (in this report, the 20 x 50 m units will be termed "plots", the 10 x 10 m units will be termed "subplots" and the smaller units (e.g., 1 x 1 m) will be termed "quadrats"). This general plot design has been widely used in the woodlands of the eastern United States, in all but the lowest density old growth stands, where plot sizes of 0.4 to 1.0 ha are used (e.g., the work of P. White and R. Busing in old-growth hemlock-hardwood stands of Great Smoky Mountains National Park), and in the highest density stands, where plot sizes of 0.01-0.04 ha have been used (e.g., in the plots designed by P. White and others for the spruce-fir acid rain studies in the Smokies). We note that even the studies that used larger or smaller overall plot sizes, employ the 10 x 10 m subunits employed in the current study, as well as similar methods of measurement for these units.

The rationale for the basic sampling strategy is developed in White and Busing (1992). The importance of nested sampling for species presence and for documentation of the various scale dependencies that are common in vegetation data is described by Palmer and White (1994), Busing and White (1993), and Reed et al. (1992).

The plot design used here is similar to that widely implemented by the North Carolina Vegetation Survey, but is more completely monumented and more intensively sampled.

Site Selection Criteria

The process used to determine sites for monitoring follows three steps.

The first step in the selection of study sites is consideration of park monitoring objectives as identified in various sources.

The second step, if appropriate for a particular monitoring situation, is stratification of the factors thought to control the variation in the resources to be monitored.

In the last step, the available sampling effort is allocated to the potential sampling sites identified by the stratification parameters and sample locations are chosen in the field.

These steps are described in more detail below.

Monitoring objectives. The initial selection process was based upon threats to park resources or monitoring requirements

outlined in the park's Resource Management Plan, the Regional Action Plan, and the Inventory and Monitoring Needs Assessment (Langdon, no date), and from consultation with regional agencies (State Heritage Programs and The Nature Conservancy, South East Regional Office), local experts (Bostick, pers. comm.), park personnel (Cissel and Hanks, pers. comm.), and observations made during reconnaissance of the park. Certain sites were selected for their importance as natural resources, regardless of the presence of immediate or suspected threats. Nonetheless, they were considered important as part of a comprehensive survey of all a park's natural areas, in line with Project Objectives.

The inventory and monitoring needs assessment (Langdon, no date) and park personnel identified two major monitoring objectives at the Kennesaw Mountain (Cissel and Hanks, pers. comm.). The first major concern is the rapid spread of Privet (Ligustrum sinense) and Japanese Honeysuckle (Lonicera japonica), both exotic woody plants that are spreading rapidly through areas of the park. Both are dispersed by birds. This presents the greatest problem in lowland areas, particularly in the mesic zones around creeks and in floodplains (Langdon, no date). It does, however, occur throughout the park, even in the much more xeric ridgetop granite outcrops. Japanese Honeysuckle is widespread, particularly affecting some of the dry ridge top areas (Langdon, no date).

The second major threat to the park's natural resources is human impact on the granite outcrops. The excellent views of Atlanta and the surrounding area, and the vantage point for birders, make these areas very popular. As early as 8 a.m. on weekend days people can be found settling in for a days birding here. Unmapped trails can be seen meandering through the outcrops that attract some of the more adventurous visitors. The wear and tear of feet on the outcrop vegetation is probably why there is so much open rock in them. This reduces the area available to colonization by outcrop species. Bostick (1994) inventoried, mapped and established monitoring for the populations of Arabis missouriensis, Draba aprica, Pycnanthemum curvipes and Zanthoxylum americanum.

Stratification and plot placement. Once the resources to be monitored are selected, the next step is to determine the range of natural variation in those resources and to develop a sampling scheme that encompasses that variation. Stratification is used to block the variation present into levels or categories, thus ensuring the range of variation is sampled and the sample variation is distributed among plots. Plots are then randomized within stratification blocks.

Stratification is used to produce an efficient sampling scheme in the sense that plots are allocated to the range of variation present in a systematic way. This also allows for a straightforward approach to replication, since replicates are

chosen within the stratification parameters. Stratification normally employs variables that influence vegetation composition, structure, and dynamics, including topographic variables (elevation, slope aspect, slope steepness, slope shape, slope position), soils, and disturbance history.

Stratification was used at Kennesaw Mountain for Privet monitoring by sampling in the lowlands and at mid and high elevation on the slopes of Kennesaw and Little Kennesaw Mountains. Characterization of the vegetation of the slopes of Kennesaw and Little Kennesaw Mountains is begun, with plots at low and high elevation on the northwest and southeast slope, but should be completed with more plots at low and high elevation on the northeast and southwest slopes.

Plot locations. Once the stratification blocks are established, generalized plot locations are selected on topographic maps. The actual position of each plot is randomized within the area that fits the stratification criteria. However, many factors constrain the true randomness of the application of the plot.

First, the size of the sample area may be no larger, or possibly smaller, than the size of the plot (20 x 50 m). In such cases it is then only possible to center the plot on the sample area.

Where the sample area is sufficiently large to allow a random plot site assignment there are still constraints that must be considered. For example, the stratification assumes that the plot itself is characterized by the stratification parameters--e.g., it has one dominant slope aspect and does not have major breaks in topography, disturbance history, or soils. In this study, we position plots in intact forest not recently disturbed by tornado damage or other large windstorms.

Another factor in the positioning of the plot is slope inclination. We sought to position plots such that plot long-axis be close to parallel with the slope contours.

Sampling Protocol

The technique used to survey the 0.1 ha plots is described in this section (see also White and Busing 1993). It is similar to the sampling procedures of the North Carolina Vegetation Survey. The current protocol is a more detailed survey method that more precisely depicts the community structure. The increased detail allows greater resolution of the changes that take place through time. One major difference is the assignment of an absolute value to diameter-at-breast-height (dbh) of all trees, as opposed to a visual estimate of tree diameter and the grouping of trees into size classes. The diameter values are obtained using a steel tape measure graded in centimeters multiplied by

pi, such that a direct reading could be taken from the tape. Other differences from the North Carolina Vegetation Survey plot technique is the sampling of all ten of the 10 x 10 meter subplots for herb and shrub cover, rather than just four, and the sampling of all stem sizes for trees--e.g., including tree seedlings and saplings. More effort is spent to mark the plots in the field and to map plot locations from landmarks.

The basic layout of the plot is a 50 x 20 meter rectangle. See the plot tree maps in Appendix A-3 for a graphic description of the plot layout. It is marked along the center-line by 30 cm metal stakes placed every ten meters. The perimeter of the plot is not marked except temporarily at the corners and 10 meter points during the survey. The plot is slope corrected in the field. The following elements of the survey technique will be described individually: nested survey, herb cover and tree seedling density survey, shrub cover and tree sapling density survey, and tree survey.

The layout of the plot, including how the different quadrat sizes are nested within each other, and a brief description of how data from the plot are recorded, is provided in Appendix D.

Plant names and codes. In the field, plants were identified using the checklist of Kennesaw Mountain National Battlefield Park prepared by Bostick (1994) and Radford et. al. (1968), or were collected for later examination. Unknown plants were assigned a temporary identification that often included key characteristics of the plant. Plant identifications were carried out in the herbarium at the University of North Carolina at Chapel Hill (NCU), using Radford et. al. (1968), Gleason and Cronquist (1991), Cronquist (1991) and Isely (1991). Voucher specimens will be stored at NCU and have Barnett-Lawrence collection numbers. The taxonomy used throughout this study is that of Kartesz (1994).

Species codes were used throughout the surveys. These are derived from the scientific name of the species observed. The species code uses the first four letters of the genus followed by the first three letters of the species epithet from this name. A list of the species codes used is in Appendix A-10

Nested sampling for species presence. Vascular plant presence in the plot is recorded using a nested series of quadrats in four of the 10 x 10 subplots, finally expanding to the full 20 x 50 m plot area. See Figures 1 and 2 in Appendix D for a visual representation of this.

The survey begins in the smallest quadrat of each of four 10 x 10 m subplot, and continues through successively larger quadrat sizes, with species added in the sequence that they are encountered. Each species is recorded (by code), along with a numeric denoting the quadrat size or level in which it is first

found. Plants that are not found in any of the 10 x 10 m subplots but first encountered in the remaining area of the 0.1 ha plot after sampling of the 10 x 10 m units, are then recorded. The numerics for quadrat sizes are:

-2 (0.01 m^2 or 10 x 10 cm)
-1 (0.1 m^2 or 32 x 32 cm)
0 (1.0 m^2 or 1 X 1 m)
1 (10.0 m^2 or 3.2 x 3.2 m)
2 (100.0 m^2 or 10 x 10 m)
3 (1000 m^2 or 20 x 50 m).

In this manner, six areal orders of magnitude are scored for species presence. Variables are: subplot number (i.e., which 10 x 10 m subplot the quadrat is in), species code, and quadrat size numeric (-2 to 3 as described above).

The nested survey of the 0.1 ha plots begins in the 10 x 10 subplots numbered 4, 5, 6 and 7, (See Figures 1 and 2 in Appendix D, and Appendix A-3, Plot Tree Maps, for diagrams of the layout of these nested quadrats) and proceeds from small to larger quadrat sizes.

Nested survey data are listed in Appendix A-9.

Herb cover and tree seedling density sampling. This is conducted in a 1 x 1 meter quadrat in each of the 10 x 10 subplots according to the layout in Appendix A-10. Tree seedlings are considered to be stems of tree species less than 1 meter in height. Variables are: subplot number (i.e., which 10 x 10 m subplot the quadrat is in), species code, and either herb cover class (for herbs) or number of stems (for tree seedlings).

Cover is estimated by gauging the total amount of bare ground obscured by a particular species. Even if there is more than one layer of a plant, the area of overlap within the species is not added to the total area. Cover classes are used. Presence of a species that has negligible cover (e.g., <0.01% if measured accurately) is still counted in the base cover class of 3%. Overall totals for cover may exceed 100%.

The percent cover of mosses and lichens, rock, bare area, fallen logs, and standing water is also estimated. Unaccounted for area is assumed to be leaf litter.

Cover classes are:

0-5% cover = 3
5-25% = 15
25-50% = 37
50-75% = 62
75-95% = 85
95-100% = 97

Herb cover data summaries are listed in Appendix A-7, tree seedling data summaries in Appendix A-8.

Shrub cover and tree sapling density sampling. This is conducted in a 3.2 x 3.2 meter quadrat, nested upon that which is used for the herb cover survey, in each of the ten 10 x 10 meter subplots. Variables are subplot number (i.e., which 10 x 10 m subplot the quadrat is in), species code, and shrub cover class (for shrubs) and number of stems (for tree saplings). Cover classes are the same as for herbs.

Tree saplings are recorded in two size classes; those between 1 meter and 1.4 m tall (breast height, bh) and those greater than 1.4 m tall but less than 1 cm in diameter at this height (<1 cm dbh).

Shrub cover data summaries are listed in Appendix A-4, below-breast-height sapling data summaries are listed in Appendix A-5, and above-breast-height sapling data summaries in Appendix A-6.

Tree sampling. All live woody plants greater than or equal to 1 cm at breast height (>=1 cm dbh) are measured using a steel tape measure marked off in centimeters x pi. Standing dead trees greater than or equal to 10 cm at breast height (>=10 cm dbh) are recorded. All trees, dead or alive, greater than or equal to 10 cm at breast height are mapped as circles (sized approximately proportional to dbh) on a diagram of the 0.1 ha plot. Dead trees are marked with an "x" in the circle. Fallen logs >=10 cm in diameter are also sketched in on the maps. Other features, such as rock outcrops or pools of water, are added to the sketch maps.

The tree sampling is conducted one 10 x 10 m subplot at a time. This aids in the mapping of the trees and also for the calculation of the frequency of occurrence of each woody plant species.

As well as being mapped, all trees >=10 cm dbh are assigned a dominance class between 1 and 5:

1 - dominant canopy tree rising well above average canopy height
2 - co-dominant canopy tree reaching average canopy height
3 - subdominant tree below average canopy height
4 - strongly suppressed, unhealthy or damaged tree
5 - standing dead tree

Raw tree data are listed in Appendix A-2, tree data summaries are listed in Appendix A-1, and plot tree maps are in Appendix A-3.

Soil samples. Soil samples are taken by collecting approximately 100 grams of soil from five points along the plot center-line. It is very important that the soil not be taken from within the nested series of quadrats that begin at the center-line in each 10 x 10 subplot. Rather, soil should be taken from the side of the center-line opposite the one where species presence was scored.

The humus layer and that part of the soil surface with large amounts of recognizable organic debris are removed and the soil sample taken. These layers should be replaced after soil removal. The soil should be stored in either paper or cloth bags. Plastic bags do not allow efficient drying of the samples. After being air dried the five samples from a single plot are pooled, mixed, and a subset of this sent for analysis. The soil samples must not be oven dried since this will change the composition of the sample.

Soil sample data are located in Appendix C.

Site Locations and Descriptions

This section describes the means used to mark plots and documents plot locations for resampling. The process of "mapping in" a plot is also outlined.

Where possible (e.g., except on rock outcrops--exceptions are noted on maps and data sheets), plots are marked at the 0 m end of the center-line with a one meter long piece of 1.9 cm steel re-bar. At least two feet of this bar project above the litter layer. Where possible, a 30 cm length of steel tubing is placed in the ground at the 50 m end. 30 cm long pieces of PVC pipe are placed in the ground at the 10, 20, 30 and 40 m points along the center-line, unless the substrate at that point prevented it. A combination of steel and PVC markers are used to control costs and to ensure that, in the event of a fire, the location of the plot is not obliterated. The nature and position of the stakes is always indicated on plot maps and data sheets.

When plots are located far from any easily located landmark, trees are tagged with 2.5 cm numbered aluminum disks and "mapped" to the plot. This requires taking a bearing from the tagged, or "witness", tree to a specified point within the plot. This is usually the 0 m center-line stake. The distance from the witness tree to the stake is measured and included with the bearing in the vector (note that no correction to true North was used; compass angles were recorded directly from magnetic North). Witness trees are tagged and vectors calculated as necessary to form a chain linking a permanent landmark with the plot. This process is known as "mapping in" the plot.

In the event that witness trees fall it is still possible to use the bearings and distances to find the points from which to

that the means of locating one of the plots is a means to locate the others.

Results

In this section each of the twelve 20 x 50 m plots is briefly described. The plot descriptions include all permanent markers and detailed instructions on how to locate each plot. The vegetation is briefly characterized based on the data summaries in Appendix A. Dominant species are those with importance values and relative importance values of at least ten percent. Species are listed from most dominant to least dominant.

Plot Descriptions

Figures 1 and 2 are scanned portions of USGS topographic map: Marietta quad (USGS 7.5 minute series). For additional plot information, such as photograph frames shot, canopy height and inclination, see Appendix E.

Plot KEM01

In this plot the canopy is dominated by *Pinus taeda*, *Liriodendron tulipifera* and *Liquidambar styraciflua*. The sub-canopy is mostly *Cornus florida*. This plot is located in a wooded lowland area close to Ward creek. It was selected as a site for the monitoring of Privet (*Ligustrum sinense*). See figures 2 and 3 for location instructions.

Plot KEM02

In this plot the canopy is dominated by *Pinus taeda* and *Quercus prinus*. The sub-canopy is mostly *Cornus florida*. This plot is located in a lowland wooded area north of Old Highway 41. This area receives very little human pressure, but may develop a high Privet density. A sapling of *Magnolia acuminata* occurs in the plot. See figures 1 and 4 for location instructions.

Plot KEM03

This plot is located in a granite outcrop. As one walks from the parking area on the Mountain Road, along the trail south to Little Kennesaw Mountain, it is the first large outcrop encountered on the east side of the trail. The outcrop is easily accessible with an easily detected trail. The outcrop is subject to considerable human pressures, partly because the city of Atlanta may be seen from it. One of the markers attached to the rock is very close to where the trail enters the outcrop proper. There is no consistent canopy, much of the area being open, but dominant trees are *Carya glabra*, *Ulmus alata* and *Carya alba*. Other woody cover includes *Rhus copallina* and *Ptelea trifolia*. See figures 1 and 5 for location instructions.

Plot KEM04

Dominant canopy trees are *Quercus prinus*, *Carya alba* and

Quercus velutina. Diospyros virginiana is dominant in the understory. This is one of two plots that begin to characterize the vegetation of the northwest facing slopes of Kennesaw Mountain. Plot KEMO5 is part of this pair of plots. See figures 1 and 6 for location instructions.

Plot KEMO5

Dominant canopy trees are Quercus prinus and Carya glabra. The subcanopy dominant is Asimina triloba. This is one of two plots that begin to characterize the vegetation of the northwest facing slopes of Kennesaw Mountain. A scorpion was seen in this plot. Plot KEMO4 is part of this pair of plots. See figures 1 and 6 for location instructions.

Plot KEMO6

Dominant canopy trees are Pinus taeda and Liriodendron tulipifera. The understory is dominated by saplings of Acer rubrum. This is a wooded lowland plot primarily intended for Privet monitoring. There are two old trees near the plot next to a small creek. These trees may predate the battle at Kennesaw and certainly were left as shade trees, possibly for a nearby house site. The trees are mapped in to the plot. See figures 2 and 9 for location instructions.

Plot KEMO7

This is a granite outcrop plot. The trail from Kennesaw to Little Kennesaw Mountain passes through this outcrop, slightly upslope and to the west of the plot. This granite outcrop is subject to considerable human pressures. Witness tree #29 is adjacent to the east side of the trail. This tree was used as a marker for work carried out in Bostick, 1994 (and Bostick pers. comm.). The tree is mapped, along the trail, to a knob on the back of the barrel of the nearest (northernmost) of three cannons marking a gun emplacement on the crest of the hill. Much of the area is open but common trees are Ulmus alata, Chionanthus virginicus and Carya glabra. See figures 1, 8 and 10 for relocation instructions.

Plot KEMO8

This plot is one of two that begins to characterize the vegetation on the southeast facing slopes of Little Kennesaw Mountain. The canopy is dominated by Quercus prinus, Carya alba and Quercus velutina. The understory is mostly Sassafras albidum. KEMO12 is part of this pair of plots. See figures 1, 10 and 11 for relocation instructions.

Plot KEMO9

This plot must be located using some of the same instruc-

tions as for KEMO8. It is a granite outcrop plot in an outcrop that does not suffer any human impact. The inclination of the plot is considerable. Great care must be taken when moving around on the rock face. Much of the area is open but common trees are Carya alba, Carya glabra, Quercus prinus and Quercus marilandica. Another common woody plant is Vaccinium arboreum. See figures 1, 10 and 11 for relocation instructions.

Plot KEMO10

This is a granite outcrop plot. This outcrop is subject to considerable human pressures. Much of the area is open but significant woody cover comes from Ulmus alata, Carya glabra, Fraxinus sp. and Chionanthus virginicus. Witness tree #36 is mapped in, along the trail, to a knob on the back of the barrel on the northernmost of three cannons that mark a gun emplacement beside the trail. The east side of witness tree #35 serves as the 0m point (see figure 12). An aluminum tag was adhered to the rock at the 30m point. It will be necessary to locate this plot in order to find plot KEMO11. See figures 1, 10 and 12 for location instructions.

Plot KEMO11

This is a granite outcrop plot. This outcrop is connected with the one in which plot KEMO10 is located. The part of the outcrop in which KEMO11 is located appears to be less frequented by visitors to the park. KEMO10 must be located in order to locate this plot. Much of the area is open but significant woody cover comes from Fraxinus sp., Juniperus virginiana, Ulmus alata and Chionanthus virginicus. See figures 1, 10 and 12 for location instructions.

Plot KEMO12

This plot is part of a pair, with KEMO8, that begin to characterize the vegetation of the southeastern slopes of Little Kennesaw Mountain. The canopy is dominated by Carya alba, Quercus prinus and Quercus velutina. The subcanopy is mostly Sassafras albidum. It will be necessary to gain access to a gated Park road, that runs along the eastern foot of Little Kennesaw and Kennesaw Mountains, to reach this plot. See figures 1 and 13 for location instructions.

Discussion

Over 40 species were found that are not on the current checklist. A careful search of all areas in the park should be carried out to complete the species inventory. A short search near the trails south of Cheatham Hill found Cypripedium sp. and Malaxis uniflora, two orchids that are not on the current checklist. Other plants new to the current checklist are preceded by the letter "n" on the Species Code List (Appendix A-10).

Granite outcrops

The highest priority monitoring requirement for Kennesaw Mountain is the granite outcrops. These have high natural value because of their uniqueness and high diversity. All of the outcrops should all be identified and numbered and a complete floristic inventory with establishment of permanent sample plots should be undertaken. To date, the work has been focused only on rare species and more accessible outcrops.

Human impacts on the granite outcrops remains a potentially serious problem. The areas of thin soil and moss cover that surround the rock are easily damaged, leading to soil erosion and an increase in the bare rock. This makes the outcrop more attractive to visitors, thus accelerating the changes.

There are many outcrops on the flanks of both Kennesaw and Little Kennesaw Mountain that are far from the heavily traveled trails. These areas may be very difficult, even hazardous, to reach. A complete inventory of all extant outcrops is essential in assessing the extent to which this resource is threatened. It is possible that the full range of granite outcrop diversity is represented in, and thus protected by, currently inaccessible outcrops.

The extent to which the communities are impacted by park visitors is being monitored for the rare species (Bostick, 1994). The outcrop flora as a whole, however, may be deteriorating. Protection standards should be set for the currently non-visited outcrops. This may ultimately provide information for the possible future restoration of the impacted areas.

Certain exotic species occur on the outcrops, notably Commelina communis, less so Digitaria sanguinalis. These may both respond to human disturbance and compete with native plant species.

There are five permanent monitoring plots located in granite outcrops: KEM03, KEM07, KEM09, KEM010 and KEM011. Plots KEM03, KEM07 and KEM010 are located in the outcrops that suffer the most impact from visitors. Plot KEM09 is far off the beaten track and is unlikely to receive much visitor pressure. Plot KEM011 is intermediate.

The species inventory should be accompanied by the establishment and sampling of at 20 x 50 m permanent plots in each outcrop. These plots have proved to be a particularly thorough means of detecting species presence, as they require a painstaking examination of areas flora in a systematic manner. Moreover, the plots would allow assessment of changes in the vegetation.

The completion of a set of monitoring plots could be carried out in one field season. It would require one leader/taxonomist-ecologist (1 full-time position for six months to allow data curation, summary, and analysis) and a field assistant for plots, data entry, and management of herbarium specimens (1 full-time position for four months). All outcrops should be visited in each season and a full set of voucher specimens collected for each.

Forest vegetation

For the general monitoring of the park, in areas around the slopes of Kennesaw and Little Kennesaw Mountain, a total of 25 more plots should be added, stratified by elevation, topography, disturbance history and community type. This is a moderate priority.

The completion of the general monitoring program, Privet monitoring program, and floristic inventory could be done in one season. This work would require one leader/taxonomist-ecologist (1 full-time position for five months to allow data curation, summary, and analysis) and a field assistant for plots, data entry, and management of herbarium specimens (1 full-time position for three months).

Wooded Slope Flora. The wooded slopes range from areas dominated by Hickories to those that are dominated, almost exclusively, by Chestnut Oak. The understory is in places very sparse, in others dominated by Sassafras or Sparkleberry (Vaccinium arboreum). Some open understories support a well developed herb layer that has many species similarities with the granite outcrops. Much of the area is inaccessible to the average park visitor and is undisturbed. The history of the area, however, is reflected in the common occurrence of several exotic species. Some of these exotics were cultivated on the slopes before and after the battle at Kennesaw.

There are four permanent plots located on the slopes of Kennesaw and Little Kennesaw Mountain: KEMO4, KEMO5, KEMO8 and KEMO12, located on northwest and southeast aspects at low and high elevation.

Further characterization of the wooded slopes of Kennesaw and Little Kennesaw Mountain would provide a baseline for the

long term measurement of the effects of air pollution, and changes that may be taking place in the composition of the canopy.

The stratification of the expanded monitoring should include low, mid and high elevation, more aspects (such as northeast and southwest), and different times since disturbance. The areas heavily damaged by a recent tornado provide ample space for several 0.1 hectare plots.

Lowland Woods Flora. Privet is a major problem particularly in the lowland areas of the park. The current 3 plots in the lowlands should be expanded to 10 to determine the impact on the native species. There may be some areas that Privet has not yet colonized, and that are good representations of the native flora. These areas must be identified.

The lowland woods are perhaps the least floristically interesting of the natural areas at Kennesaw. The stands are successional, with little or no remnants of preexisting forest. Two apparently old trees were found near Plot KEM06. These could be the legacy of past farmers having left them as shade trees. It is difficult to estimate the age of these trees but it is probable that they were present at the time of the battle at Kennesaw Mountain. There may be a few other such trees scattered throughout the lowlands of the park

Other monitoring issues

In order to continue general monitoring of the current plots it is recommended that they be resampled every five years. If a specific threat is associated with a plot, if change appears rapid, or if mechanisms of change must be discovered, then the resampling should be carried out on an annual basis.

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Figures

Figure 1: Locations of Plots KEMO2-KEMO5 and KEMO7-KEMO12

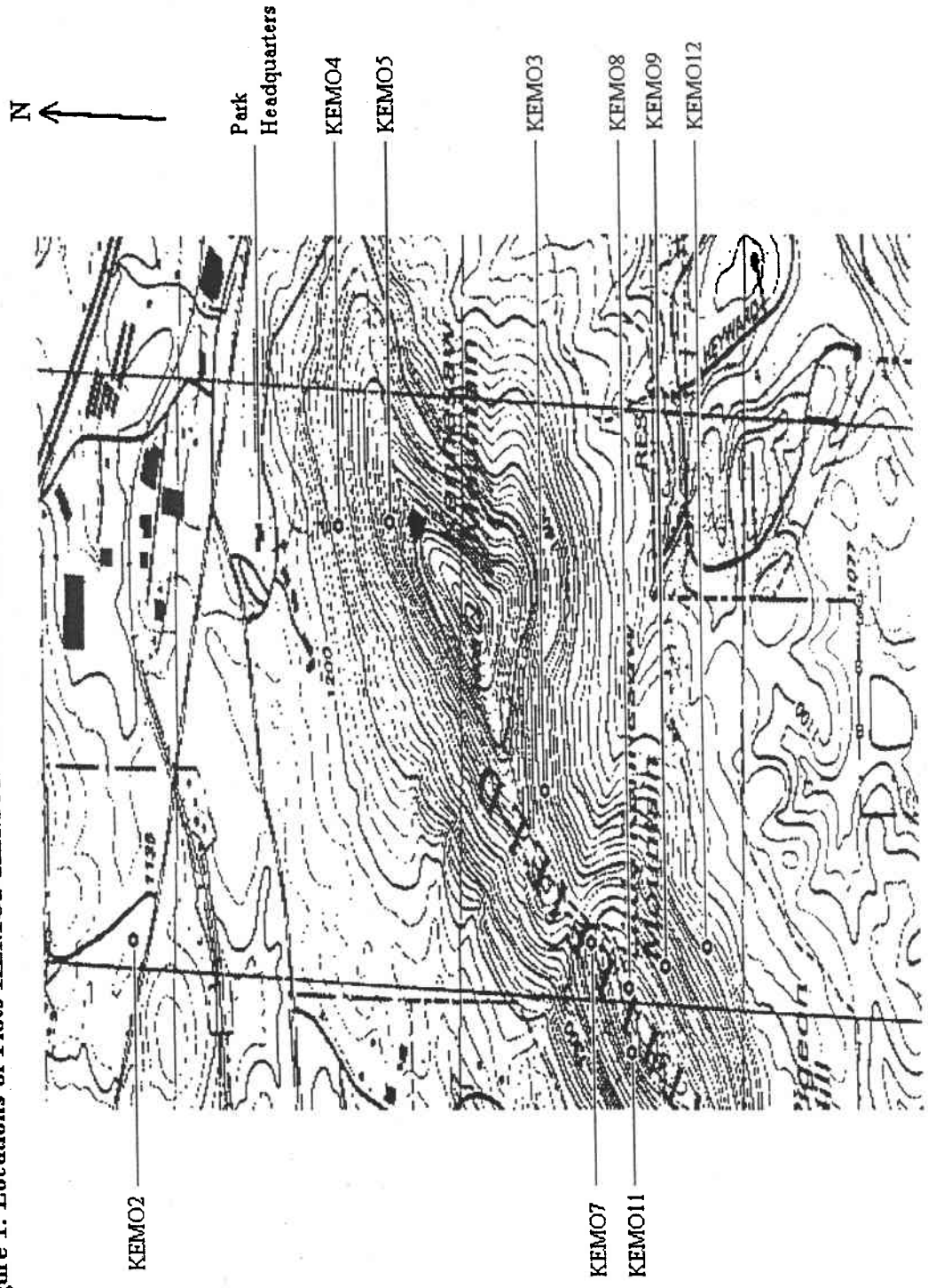


Figure 1: Locations of Plots KEMO2-KEMO5 and KEMO7-KEMO12

Figure 2: Locations of Plots KEMO1 and KEMO6

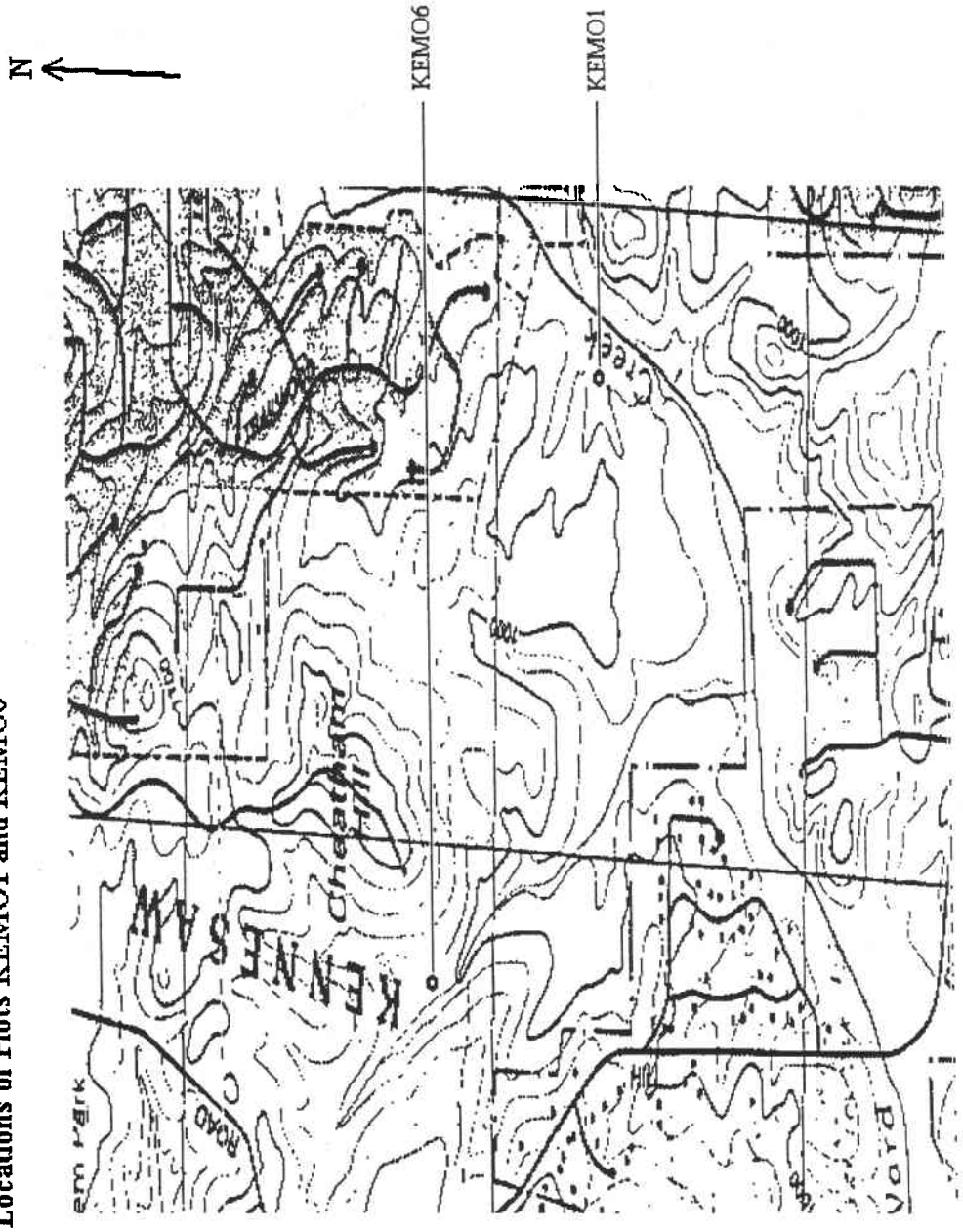
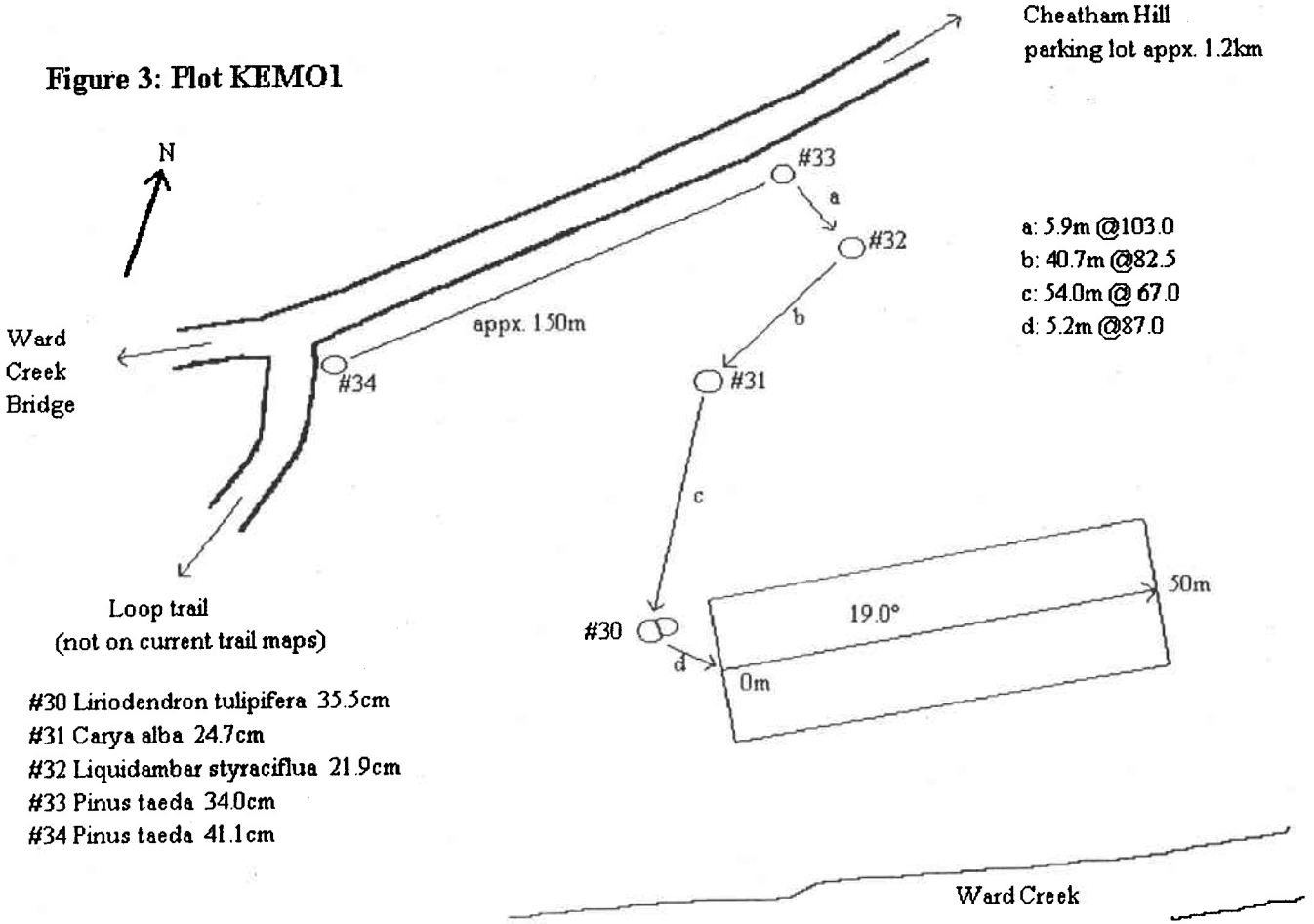


Figure 2: Locations of Plots KEMO1 and KEMO6

Figure 3: Plot KEMO1



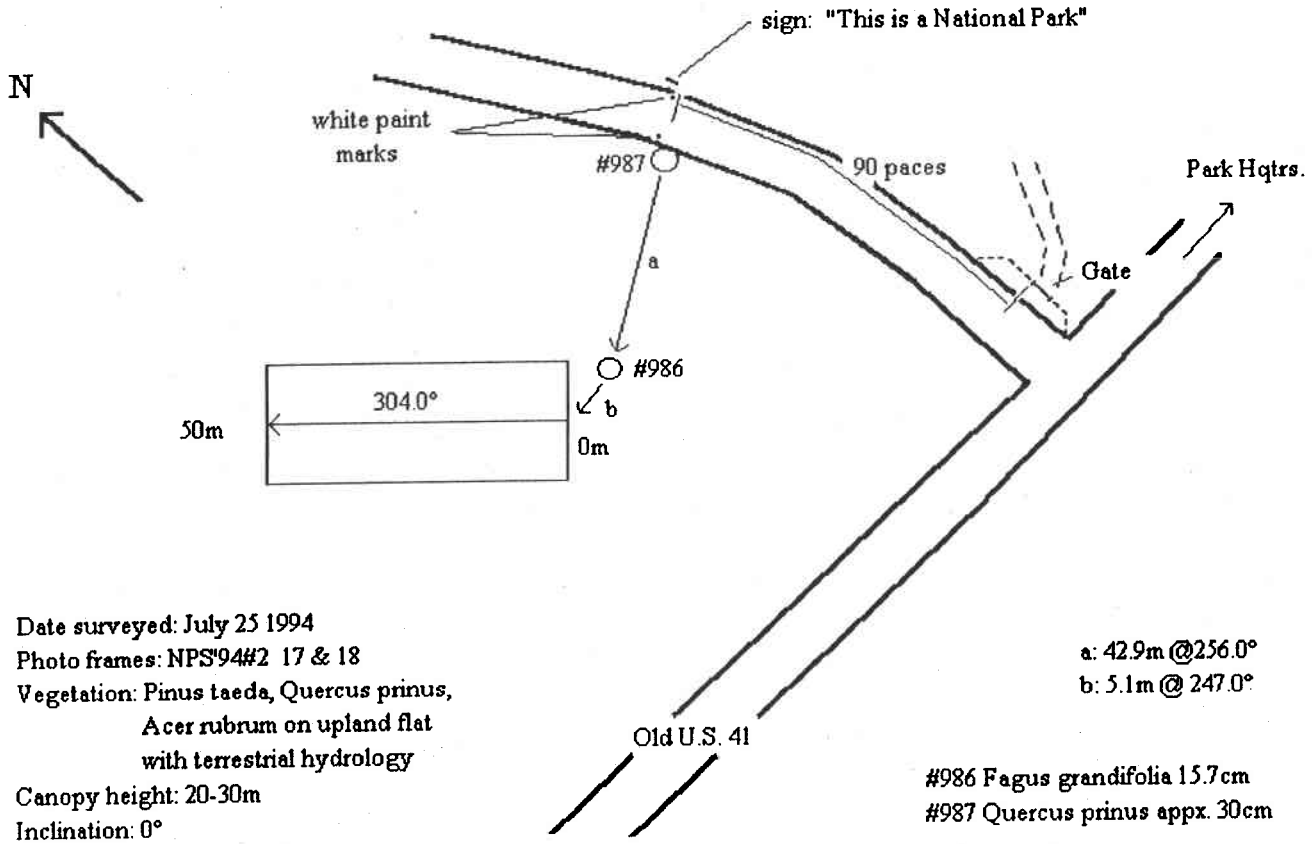
#30 Liriodendron tulipifera 35.5cm
#31 Carya alba 24.7cm
#32 Liquidambar styraciflua 21.9cm
#33 Pinus taeda 34.0cm
#34 Pinus taeda 41.1cm

Sampling date: July 24 1994 Photo frames: NPS'94 #2 10&11
Vegetation: Pinus taeda, Liriodendron tulipifera, Liqudambar styraciflua on alluvial flat with terrestrial hydrology

Canopy height: 40-50m
Inclination: 0°

Figure 3: Plot KEMO1

Figure 4: Plot KEMO2



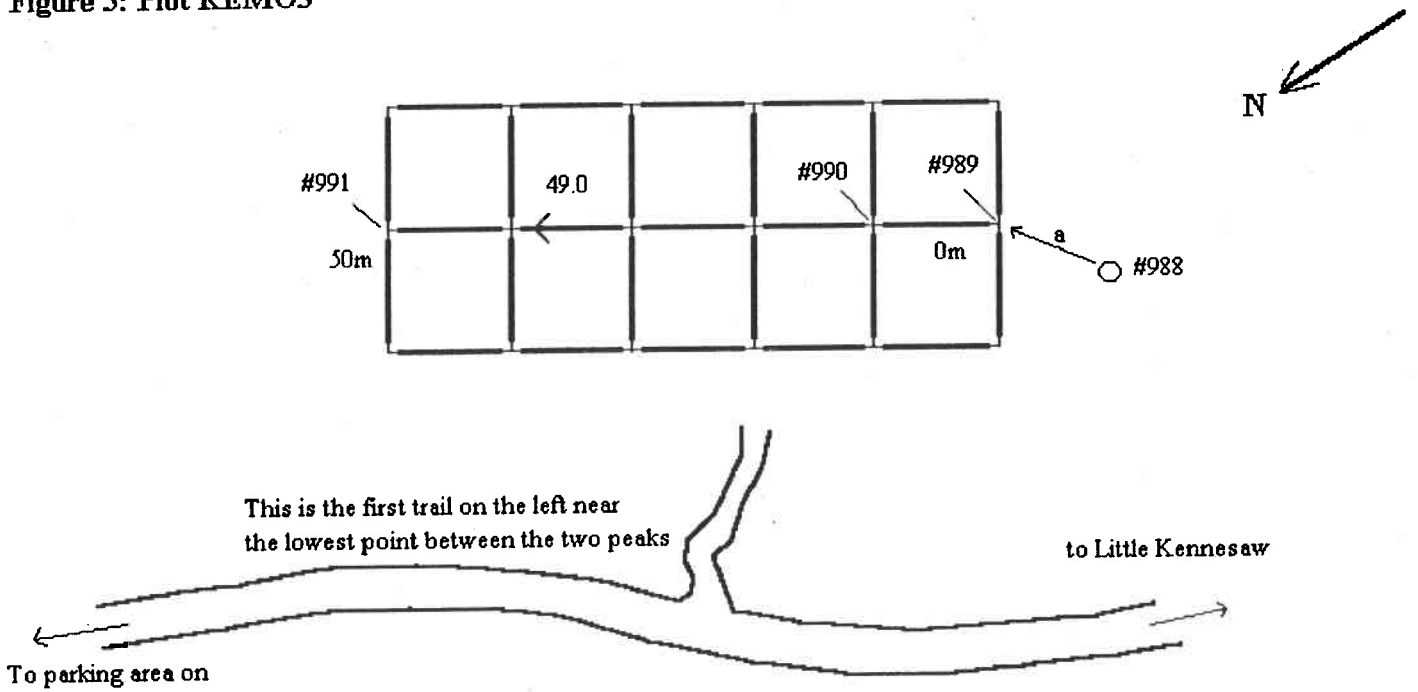
Date surveyed: July 25 1994
Photo frames: NPS'94#2 17 & 18
Vegetation: Pinus taeda, Quercus prinus,
Acer rubrum on upland flat
with terrestrial hydrology
Canopy height: 20-30m
Inclination: 0°

a: 42.9m @256.0°
b: 5.1m @ 247.0°

#986 Fagus grandifolia 15.7cm
#987 Quercus prinus appx. 30cm

Figure 4: Plot KEMO2

Figure 5: Plot KEMO3



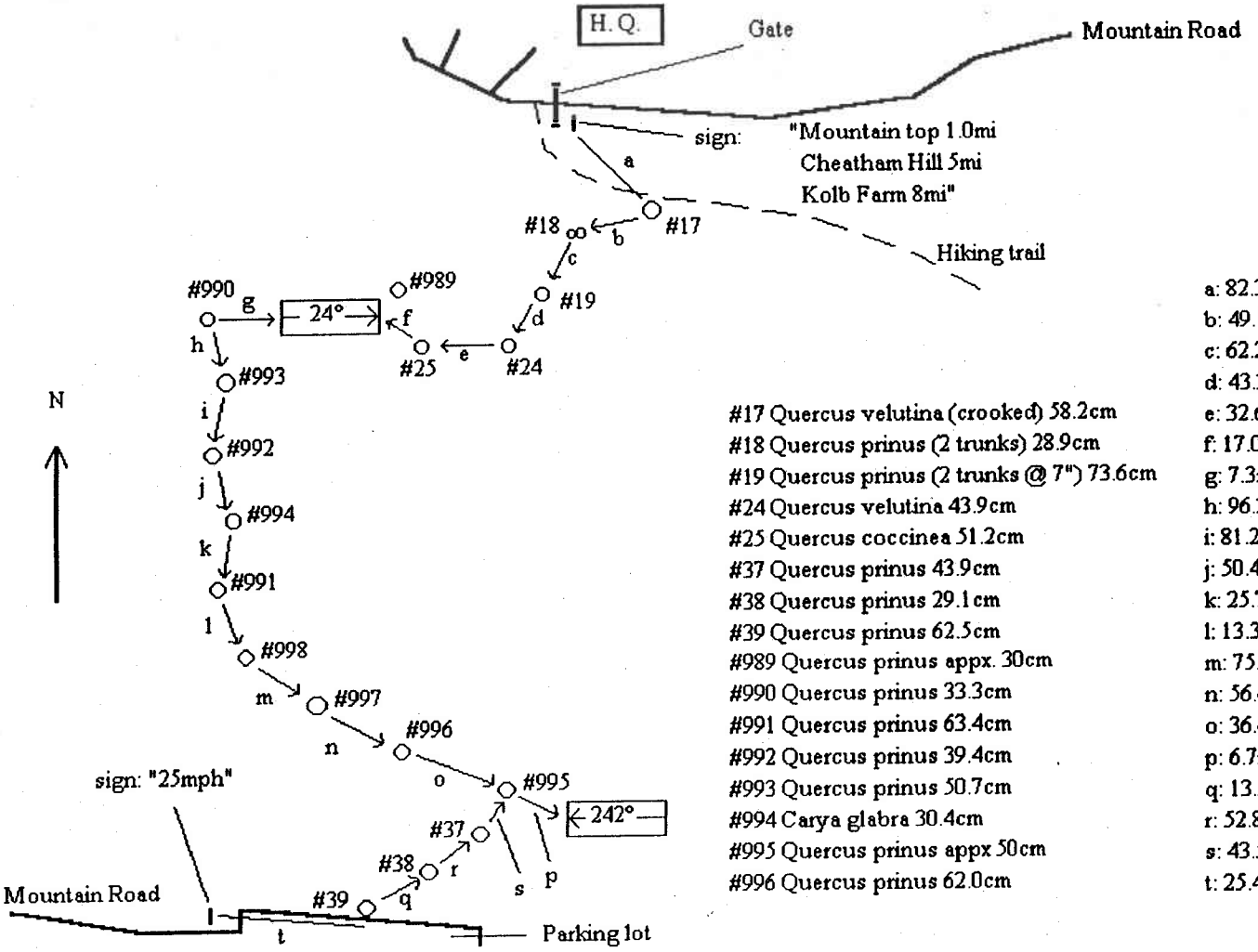
a: 10.1m @ 90.0°

#988 Pinus virginiana 6.5cm
#989, #990, #991 numbered aluminum tags
adhered to rock with silicone

Date surveyed: July 26 1994
Photo frames: NPS'94#2 14, 15 (from 0m),
16 (from 10m)
Vegetation: Carya glabra, Ulmus alata, Carya alba
Rhus copallina, Ptelea trifolia on
granite outcrop on mid slope
with terrestrial hydrology
Canopy height: 0-5m
Inclination: 16°

Figure 5: Plot KEMO3

Figure 6: Plots KEMO4 and KEMO5



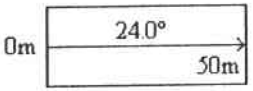
#17 Quercus velutina (crooked) 58.2cm
#18 Quercus prinus (2 trunks) 28.9cm
#19 Quercus prinus (2 trunks @ 7") 73.6cm
#24 Quercus velutina 43.9cm
#25 Quercus coccinea 51.2cm
#37 Quercus prinus 43.9cm
#38 Quercus prinus 29.1cm
#39 Quercus prinus 62.5cm
#989 Quercus prinus appx. 30cm
#990 Quercus prinus 33.3cm
#991 Quercus prinus 63.4cm
#992 Quercus prinus 39.4cm
#993 Quercus prinus 50.7cm
#994 Carya glabra 30.4cm
#995 Quercus prinus appx 50cm
#996 Quercus prinus 62.0cm

a: 82.3m along trail
b: 49.1m @ 171.0°
c: 62.2m @ 203.0°
d: 43.2m @ 201.0°
e: 32.6m @ 252.0°
f: 17.0m @ 269.0°
g: 7.3m @ 63.0°
h: 96.3m @ 169.0°
i: 81.2m @ 190.0°
j: 50.4m @ 174.0°
k: 25.7m @ 195.0°
l: 13.3m @172.0°
m: 75.9m @ 157.0°
n: 56.4m @ 154.0°
o: 36.4m @154.0°
p: 6.7m @ 73.0°
q: 13.5m @ 359.0°
r: 52.8m @332.0°
s: 43.5m @ 337.0°
t: 25.4m along verge

Figure 6: Plots KEMO4 and KEMO5

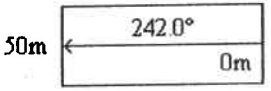
Figure 7: Information for Plots KEMO4 and KEMO5

KEMO4



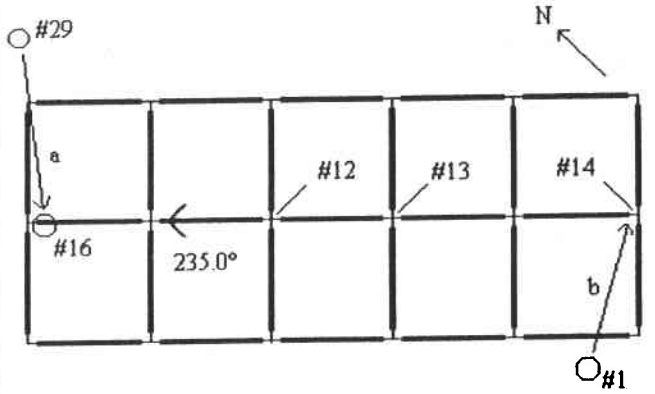
Date surveyed: July 23 1994
Photo frames: NPS'94#3 4 & 5
Vegetation: Quercus prinus, Carya alba, Q. velutina, Diospyros virginiana on mid slope with terrestrial hydrology
Canopy height: 20-25m
Inclination: 23.0°

KEMO5



Date surveyed: July 29 1994
Photo frames: NPS'94#2 21, 22 & 23
Vegetation: Quercus prinus, Carya alba, C. glabra on mid slope with terrestrial hydrology
Canopy height: 15-20m
Inclination: 24.0°

Figure 8: Plot KEMO7

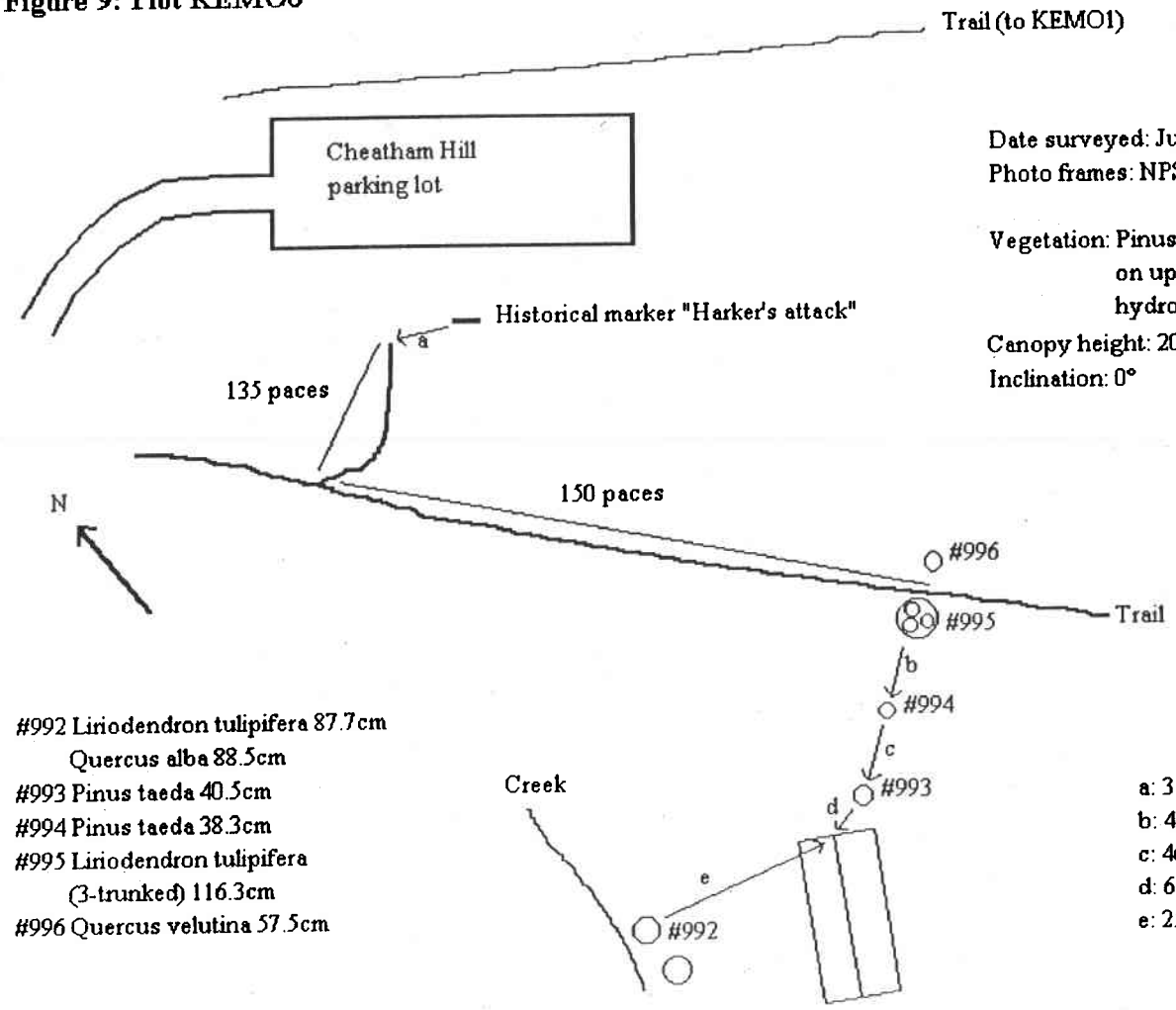


#1 Juniperus virginiana 17.8cm
#12, #13 & #14 are aluminum numbered tags adhered to rock with silicone
#16 Ulmus alata 8.7cm — a: 16.1m @ 279.0
#29 Diospyros virginiana 13.9cm — b: 11.4m @ 155.0

Date surveyed: August 19 1994
Photo frames: NPS'94#2 8 & 9
Vegetation: Ulmus alata, Chionanthus virginiana, Carya glabra on granite outcrop with terrestrial hydrology
Canopy height: 0-5m — Inclination: 9°

Figure 7: Information for Plots KEMO4 and KEMO5 and Figure 8: Plot KEMO7

Figure 9: Plot KEMO6



Date surveyed: July 30 1994
Photo frames: NPS'94#2 19 (behind 0m)
20 (at 0m)
Vegetation: Pinus taeda, Liriodendron tulipifera on upland flat with terrestrial hydrology
Canopy height: 20-25m
Inclination: 0°

#992 Liriodendron tulipifera 87.7cm
Quercus alba 88.5cm
#993 Pinus taeda 40.5cm
#994 Pinus taeda 38.3cm
#995 Liriodendron tulipifera (3-trunked) 116.3cm
#996 Quercus velutina 57.5cm

a: 315 to trail opening
b: 47.5m @ 291.0°
c: 46.8m @ 259.0°
d: 6.6m @ 239.0°
e: 25.2m @ 136.0°

Figure 9: Plot KEMO6

Figure 10: Relative locations of Plots KEMO7, KEMO8, KEMO9, KEMO10 and KEMO11

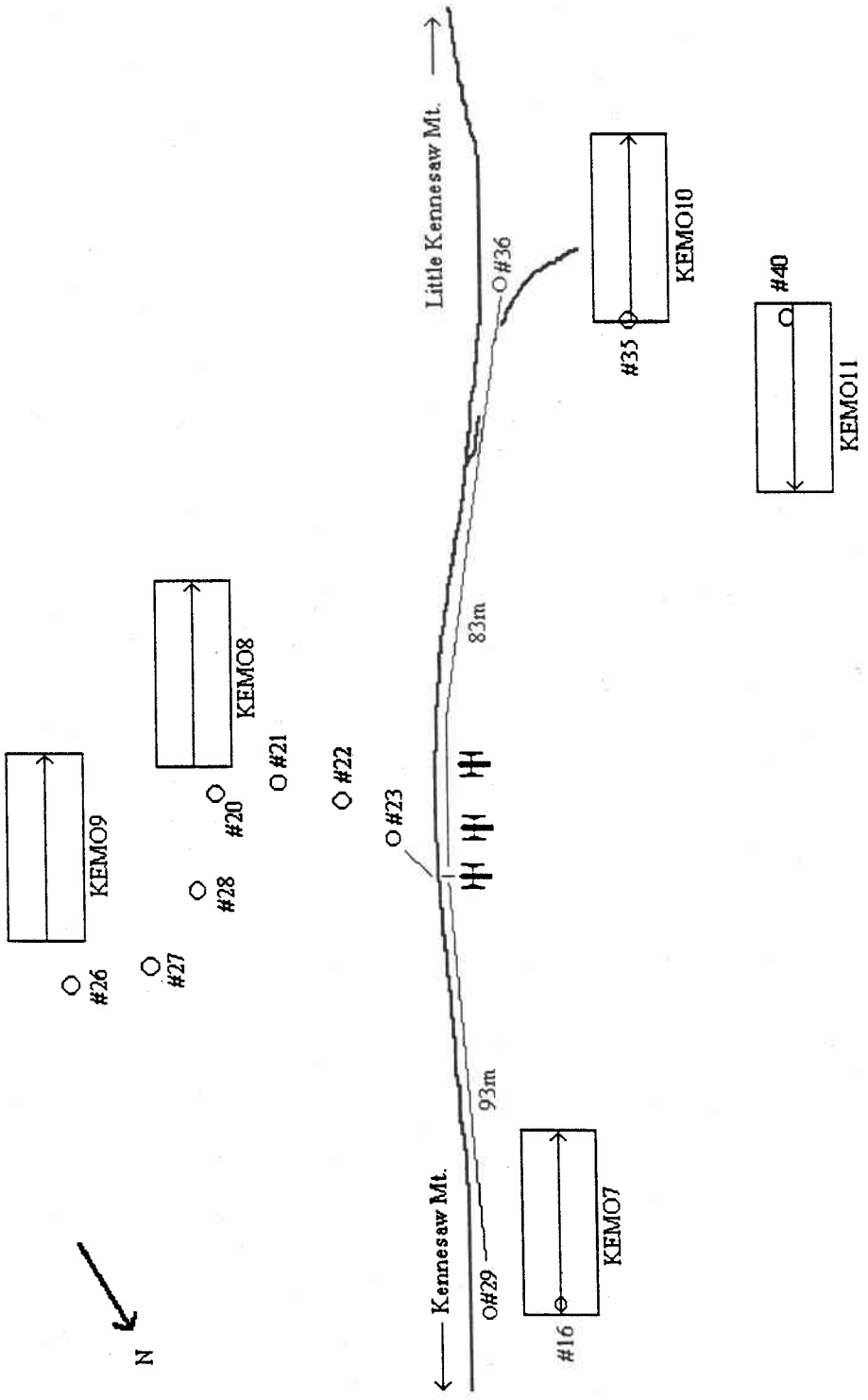
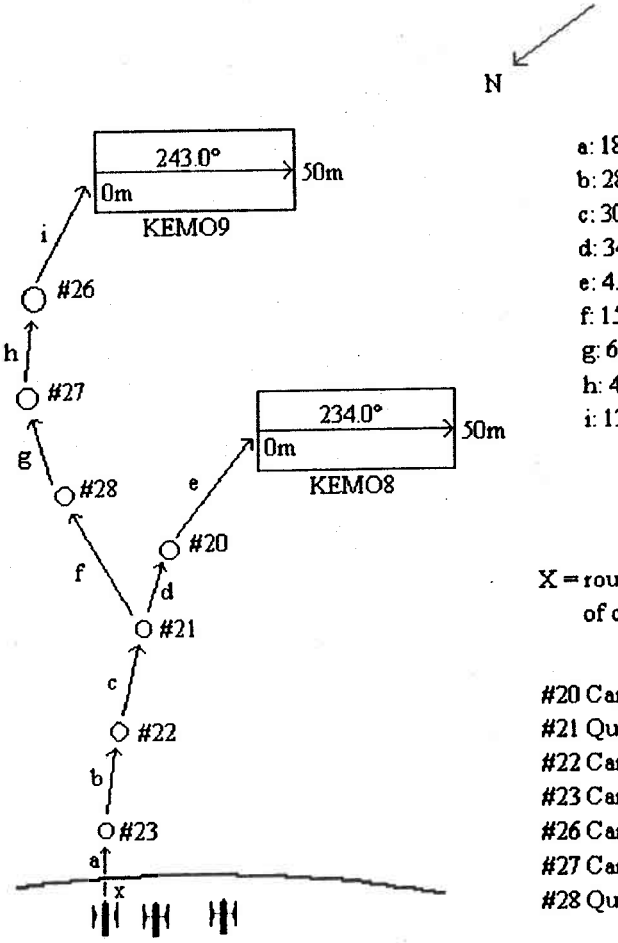


Figure 10: Relative locations of Plots KEMO7, KEMO8, KEMO9, KEMO10 and KEMO11

Figure 11: Plots KEMO8 and KEMO9

KEMO8
Date surveyed: August 20 1994
Photo frames NPS'94#2 4,5,6 & 7
Vegetation: Quercus prinus, Carya alba
C. glabra on mid slope with
terrestrial hydrology
Canopy height: 20-25m
Inclination: 22.0°

KEMO9
Date surveyed: August 22 1994
Photo frames: NPS'94#2 1 & 2 from 10m
3 from 50m
Vegetation: Granite outcrop on mid slope
with terrestrial hydrology
Canopy height: 0-10m
Inclination: 31.0°



a: 18.8m @ 133.0°
b: 28.0m @ 136.0°
c: 30.0m @ 140.0°
d: 34.6m @ 156.0°
e: 4.45m @ 190.0°
f: 15.8m @ 90.0°
g: 63.4m @ 129.0°
h: 45.0m @ 97.0°
i: 13.6m @ 139.0°

X = round knob on back
of cannon barrel

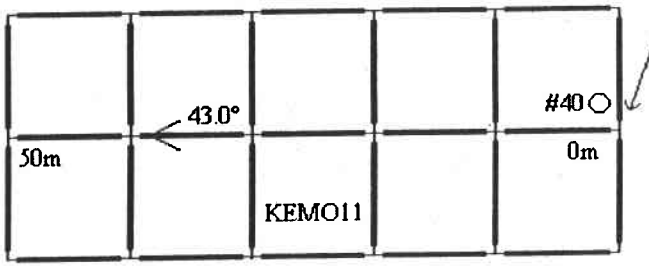
#20 Carya alba 24.5cm
#21 Quercus prinus 49.8cm
#22 Carya alba 34.7cm
#23 Carya alba 25.1cm
#26 Carya alba 33.5cm
#27 Carya alba 46.5cm
#28 Quercus prinus 59.4cm

Figure 11: Plots KEMO8 and KEMO9

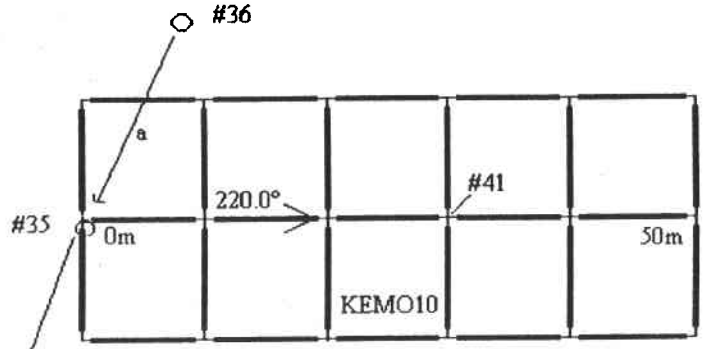
Figure 12: Plots KEMO10 and KEMO11

KEMO10
Date surveyed: August 23 1994
Photo frames: NPS'94#2 12 & 13
Vegetation: Ulmus alata, Carya glabra, Fraxinus sp. Chionanthus virginiana on granite outcrop on mid-upper slope with terrestrial hydrology

Canopy height: 0-10m
Inclination: 17.0°-24.0°



#35 Ulmus alata 15.4cm
#36 Quercus coccinea 27.6cm
#40 Juniperus virginiana 14.7cm
#41 aluminum numbered tag adhered to rock with silicone



b

KEMO11
Date surveyed: August 24 1994
Photo frames: NPS'94#2 26
NPS'94#3 1 & 2 (all from 2m)
Vegetation: Fraxinus sp., Juniperus virginiana, Ulmus alata, Chionanthus virginiana on granite outcrop on mid slope with terrestrial hydrology

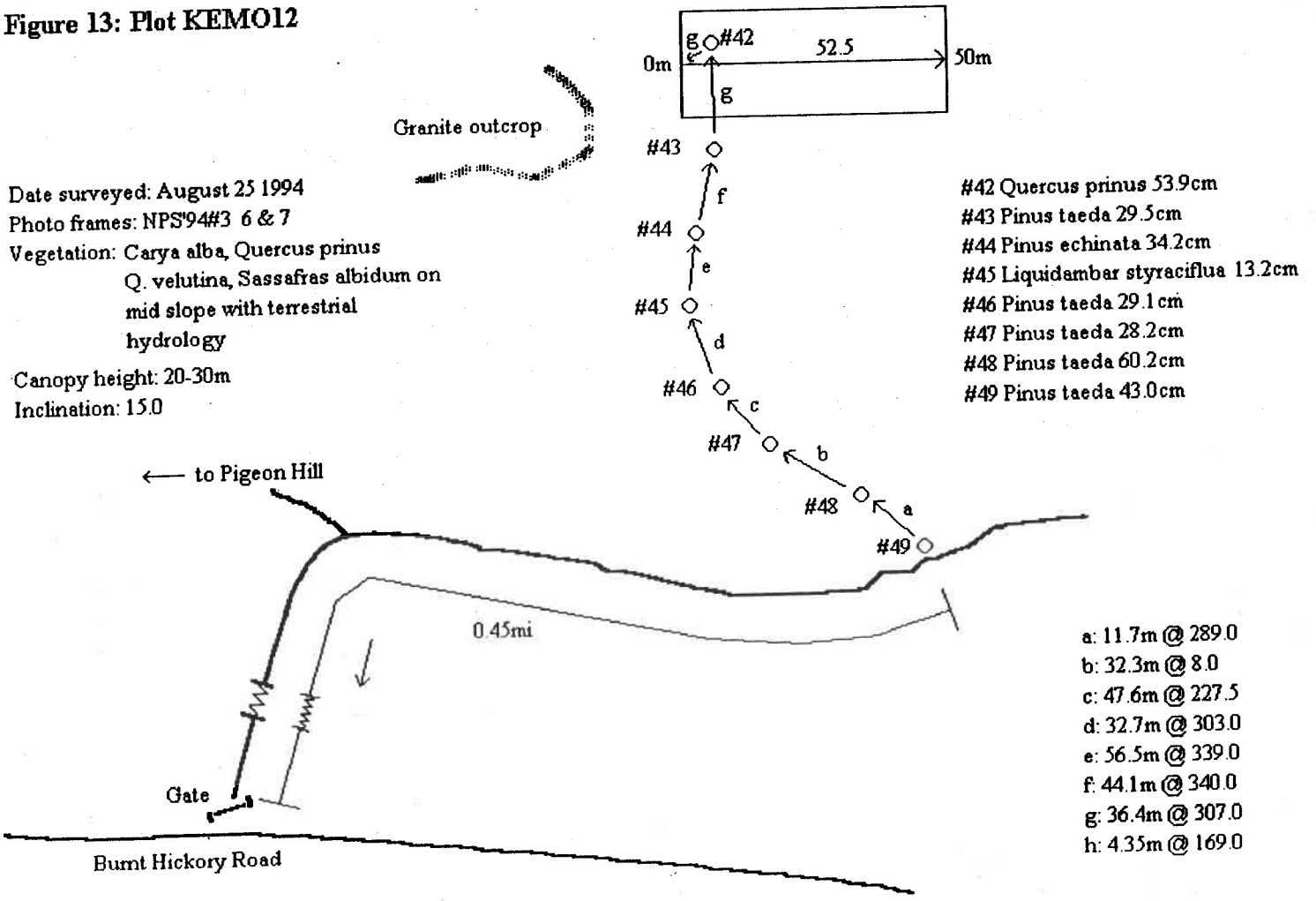
Canopy height: 0-10m
Inclination: 20.0°

N

a: 37.9m @ 306.0°
b: 32.9m @ 292.0°

Figure 12: Plots KEMO10 and KEMO11

Figure 13: Plot KEMO12



Date surveyed: August 25 1994
Photo frames: NPS'94#3 6 & 7
Vegetation: Carya alba, Quercus prinus
Q. velutina, Sassafras albidum on
mid slope with terrestrial
hydrology

Canopy height: 20-30m
Inclination: 15.0

#42 Quercus prinus 53.9cm
#43 Pinus taeda 29.5cm
#44 Pinus echinata 34.2cm
#45 Liquidambar styraciflua 13.2cm
#46 Pinus taeda 29.1cm
#47 Pinus taeda 28.2cm
#48 Pinus taeda 60.2cm
#49 Pinus taeda 43.0cm

a: 11.7m @ 289.0
b: 32.3m @ 8.0
c: 47.6m @ 227.5
d: 32.7m @ 303.0
e: 56.5m @ 339.0
f: 44.1m @ 340.0
g: 36.4m @ 307.0
h: 4.35m @ 169.0

Figure 13: Plot KEMO12