ASSESSMENT OF RECREATIONAL SITE IMPACT AT THE UPPER KIAMICHI RIVER WILDERNESS

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CHAPTER I

INTRODUCTION

Wilderness Definition and Mandate

In 1964, the United States Congress passed the Wilderness Act (P. L. 88-577). This Act enabled Congress to preserve untamed areas of federal land by designating them as "wilderness." The primary purpose of this Act was to preserve the "enduring resource of wilderness." The Act stipulated that "wilderness classification" was a unique management designation and this classification could only be placed on land areas that had a unique characteristic of nature as the primary influencing factor. The author of the Act, Howard Zahniser, defined wilderness as an area of undeveloped, "untrammeled" federal land that consisted of at least 5000 acres. Additionally, this Act established the National Wilderness Preservation System and it created the mandate for these wildland areas. By definition, these areas contain unique attributes of solitude, and provide opportunities for a primitive and unconfined type of recreation. In short, they are places where an individual may visit but the influence of this intrusion is negligible.

In 1975, Congress passed another law that influenced society's perception of wilderness purity. Prior to 1975, there were very few wilderness areas on federal lands east of the 100th parallel. Realizing the need for creating wilderness areas nearer to highly populated areas, Congress passed the Eastern Wilderness Act (P. L. 93-622) (Browning *et al.* 1988, Hendee *et al.* 1990). The Eastern Wilderness Act reduced the restrictions for wilderness designation on areas east of the 100th parallel. This action diluted the original "wilderness" stipulations of the 1964 Wilderness Act, allowing smaller areas and/or areas of previous development to be preserved as "Wilderness" (Hendee *et al.* 1990).

Originally, arguments were made that areas created through the Eastern Wilderness Act would be called "wild areas," distinguishing them from the previously created "wilderness areas" (Hendee *et al.* 1990). However, Congress decided to group the two different "wildland" types into one classification falling back on the original term of wilderness.

Many researchers argued that the difference of nomenclature was irrelevant because true wilderness is a "state of mind" (Nash 1982, McCool 1988, Driver *et al.* 1990). Regardless, wilderness areas provide unique recreational opportunities for visitors, and wilderness pursuit is a type of recreation not likely found anywhere else (Stankey and Schreyer 1987, Manning 1988, Taylor 1990).

Management Concerns to Control Impact

The 1964 Wilderness Act, and subsequently the 1975 Eastern Wilderness Act, proposed that wilderness areas would provide recreational, scenic, scientific, educational, conservation, and historical resources where applicable. Further, while providing these resources, wilderness managers are required to maintain the area as wild and natural as possible, negating human influence. Through management's attempts to provide recreational resource opportunities, impacts occur. Both social and physical impacts affect wilderness character, influencing an area's "wildness." Most wilderness managers and researchers found that among all resources provided by wilderness areas, the single most impacting resource was recreation (Hendee *et al.* 1990). Additionally, of all the resource opportunities provided by wilderness, the resource most subject to management is recreation (Cole 1987, Cole 1994a).

Recreational impacts are a significant problem in most wilderness areas today (Cole 1987, Hendee *et al.* 1990, Cole 1994a, Cole and Trull 1992, Cole and Landres 1996), with the most common problems being deterioration of campsites, and trail degradation (Cole *et al.* 1987, Hendee *et al.* 1990, Washburn and Cole 1983). These impacts are inevitable (Cole 1994a). However, the degree to which an area becomes impacted before remedial steps are taken is at management's discretion (Cole 1987, Cole 1994a). Consequently, the wilderness visitor is no longer considered as a non-consumptive user (Marion 1991).

Through management plannng, recreational impacts in wilderness can be controlled to an acceptable level (Cole 1987). In order to comply with their mandate, wilderness managers endeavor to correct situations when amounts of impact on wilderness areas are deemed too severe. The degree of this "acceptable level of impact" varies among areas. Individual standards are based on the use and physical traits of the wilderness.

Importance of Measurement of Use and Monitoring Change

Managers play an important role in backcountry management. They make decisions about management based on knowledge gained through research. These decisions influence the type of use and user perception in a given area.

Management decisions are derived from all factors that are associated with an area. Visitor traits influence the amount of impact in wilderness, and these traits include frequency of use, type of behavior, and season of use. Managers need to understand the traits of their visitors to focus their management on specific times, places, and people.

Additionally, visitor's wilderness perception is important for managers to measure (Christensen and Davis 1985). Visitor traits and perceptions are highly variable between wilderness areas. Importance of visitor perception is that visitors enact coping behaviors to achieve their desired experience. Keuntzel and Heberlein (1992) found that coping behaviors are enacted to change the experience to an acceptable level, and both social factors and physical site characteristics influence these perceptions. As an area becomes impacted, visitors may conclude that an area is over-crowded. Regretfully, the primary coping behavior response to over-crowding is displacement, either from one site to another within a specific area, or from one wilderness to another (Keuntzel and Heberlein, 1992). However, the characteristics of individuals are not static, as they change over time (Stankey and Schreyer 1987). Therefore, routine evaluations of visitor use and perception are important for management decisions.

Environmental condition is the other important factor that influences amount of impact and management decisions. Due to environmental conditions, some wilderness areas are very tolerant to use, however, some areas are severely impacted through very little use (Phelps 1989). Impact levels are influenced by a site's resistance and resilience which are unique to each area (Hammitt and Cole 1987). These environmental conditions include vegetation type, soil characteristics, geologic elements, and other climatic conditions, like average annual temperature and rainfall. Additionally, managers need to know the relationship between amount of use and amount of impact, and they need to consider differences of durability between various vegetation types and soil types (Cole 1993c).

The objective of any wilderness manager is to maintain the natural and pristine condition of the area. Today, the primary method to evaluate the amount of impact on a wilderness area is through the establishment of a management plan and continual monitoring, as monitoring is the key to any management plan (Stankey *et al.* 1985, Roggenbuck and Lucas 1987, Phelps 1989, Petersen and Harmon 1993, Manning 1988). Monitoring reveals the amount of impacts that have occurred on campsites and trails, and is used to calculate change over time. This allows managers to evaluate the natural condition, identify problem areas, make remedial prescriptions, and evaluate the impact of the remedial prescriptions.

Statement of the Problem

In 1988, Congress passed the Winding Stair Mountain National Recreation and Wilderness Area Act (P. L. 100-499) that in part designated the Upper Kiamichi River Area as Wilderness (hereafter referred to as UKRW). The UKRW is an area in the Ouachita National Forest in southeastern Oklahoma (Figure 1, page 5). Through this designation, the managers of the UKRW were mandated to create recreational opportunities and maintain its pristine nature and primitive setting.

In 1992, the Upper Kiamichi River Wilderness Management Implementation Plan (U. S. Forest Service 1992) was drafted, and a Limits of Acceptable Change (LAC) management

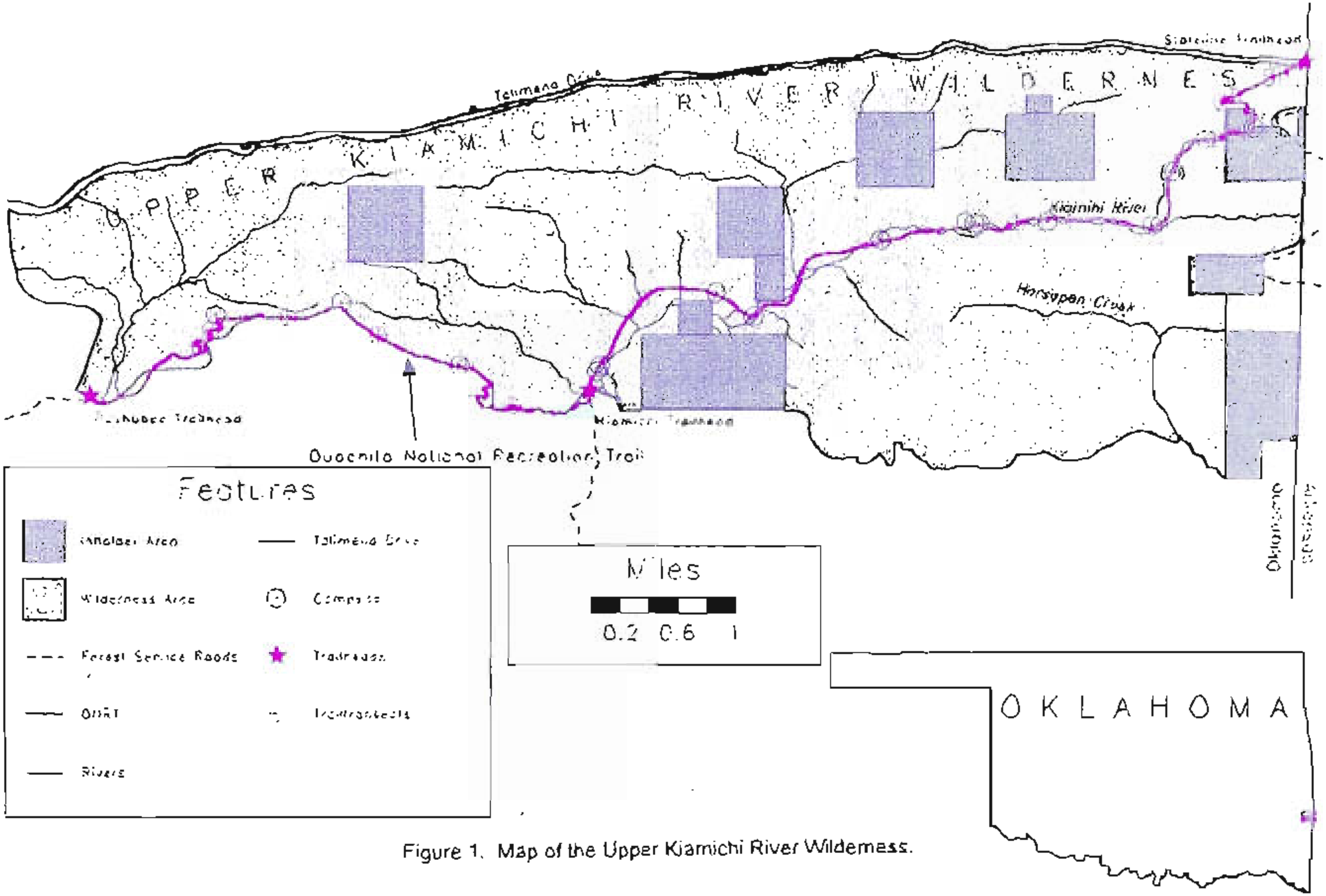


Figure 1. Map of the Upper Kiamichi River Wilderness.

system was adopted. The managers also incorporated a zoning system that helped focus impact management in certain areas due to varying use conditions (Haas *et al.* 1987). Through this zoning system, the area was divided into four Opportunity Class Zones in which varying amounts of use and impacts were tolerated. The primary zone of use was labeled Opportunity Class Three which consisted of a corridor surrounding the Ouachita National Recreation Trail (referred to as ONRT). This zone has the highest tolerance for use and impacts. This zone was the primary study area for this project.

In 1993, Kuzmic evaluated use, use patterns, and perceptions of the UKRW visitors. Data were collected to better understand these visitors, and through evaluation, use patterns and user traits were analyzed and established.

This study was an assessment of the impacts caused through recreational activities of the UKRW visitors. The UKRW needed an impact study and assessment for two reasons. First, the UKRW's LAC plan proposed a monitoring system, and this was the initiation of that system. Secondly, the LAC plan required a comparison of the current condition of specific parameters to their standards. The UKRW managers wanted to know current conditions of both campsites and the ONRT, to locate problem areas, and to have recommendations of appropriate remediation prescriptions.

Prior to this study there was no formal documentation of any type of impact. The ONRT needed evaluation to assess the impact of the trail and potential for trail deterioration. This study established baseline data both for the ONRT and campsites within the area. Since this was the first impact study, campsite data were also collected and compared to control site data to infer the amount of change that had occurred. All appropriate data were compared to the LAC standards as described in the LAC plan of the UKRW, and evaluations were made.

Purpose: the purpose of this study was to;

A.) Collect campsite data from all known UKRW campsites, as a baseline for future impact monitoring studies.

B.) Collect trail transect data to provide a baseline for further trail monitoring studies.

C.) Evaluate the amount of impact that had occurred by comparing campsites to nearby controls.

D.) Compare the campsite characteristics to standards stipulated in the UKRW's LAC plan.

Objectives: the following objectives were to;

1.) Evaluate campsite conditions by analyzing differences between campsites and controls. The parameters measured were percent vegetation cover, percent exposed mineral soil, number of trees, tree damage, tree root exposure, soil compaction, and both instantaneous and saturated infiltration rates.

2.) Evaluate campsite density by calculating number of campsites per trail mile.

3.) Measure distance from each campsite to the nearest water source.

4.) Measure distance from each campsite to the ONRT.

5.) Evaluate trail condition by examining trail damage.

6.) Inventory the amount of litter on trails.

7.) Evaluate trail damage of trails located in old roads.

8.) Evaluate the overall condition of the ONRT and UKRW campsites.

9.) Compare the data to standards delineated in the LAC plan for the UKRW.

10.) Recommend potential remediations for problem areas.

Glossary of Terminology

The following are definitions of terminology used throughout this study. These terms are defined in the context of this study.

Barren Core Area - a calculation of the total area (ft^2) of the campsite that is completely denuded of vegetation and organic matter through trampling or other human induced activities.

Campsite - a place where recreational overnight camping occurs. Distinguished by evidence of trampling, fire scars, fire rings, benches, racks, and/or other human developed facilities.

Campsite Area - a calculation of the total area (ft^2) of the campsite as affected by trampling or other impacting actions caused by human recreational use.

Campsite Impact Index Rating - rating system used to evaluate the overall condition of the site, based one nine impact variables.

Cleanliness - rating system of the lack of trash, human feces, horse feces, and campfire remnants.

Day-use - use of the UKRW for recreational pursuits during the day, but not used for camping or staying overnight.

Fixed Point - two threaded pipes located on both sides of the trail, established for present and future trail transect evaluations.

Impact - all non-natural changes caused to the physical, ecological, and aesthetic elements of wilderness through recreational use.

Indicators - defined variables by the UKRW managers that reveal the overall wilderness character.

Inholding - a parcel of privately owned land within the UKRW boundary.

Instantaneous Infiltration Rates - inverse period of time (min.) elapsed for water to penetrate dry soil, reported as a rate of centimeters per minute.

Landform - the physio-graphic structure of the site, categories were defined on the "campground impact form" (Appendix C).

Litter - any human or domestic animal waste product left in the wilderness, includes paper, metal, plastic, and feces.

Overnight Use - use of the UKRW for recreational pursuits while spending at least one evening camping there.

Percent Vegetation Cover - percent measurement of vegetation ground cover within the campsite boundary.

Percent Bare Mineral Soil / Soil Exposure - the percent of campsite area that has no vegetation and little or no duff or organic matter.

Quadrate - one meter by one meter square grid, used in determining percent vegetation cover and percent bare mineral soil exposure.

Recreation-Recreational - any personal, voluntary pursuit or activity that occurs during leisure, with inherent satisfaction and that is wholesome and socially acceptable.

Resilience - the ability of an ecosystem to recover rapidly after a disturbance.

Resistance - the ability of the ecosystem to resist change when it is disturbed.

Root Exposure - exposure of tree roots on campsites caused through non-natural phenomenon.

Saturated Infiltration Rates - inverse period of time (min.) elapsed for water to penetrate the soil, reported as centimeters per minute. This measurement is the average time elapsed for penetration of 5 centimeters of water.

Significance Level - the probability of rejecting the null hypothesis when it is true. The significance level for this study is at 0.05, or five percent.

Social Trail - formation of additional access trails to nearby attractions such as water source, satellite sites, other points of interest, other trails, or vistas.

Soil Compaction - soil penetrometry, the pressure taken to insert a rod a given distance into the soil, reported as kg/cm^2.

Standards - specific tolerance levels of acceptable impact.

Trail Bare Ground Width - length of visible trampling damage which has resulted in removal of all vegetation cover.

Trail Profile - the cross-sectional area (ft^2) between the tread surface and the bracket placed over the trail, between two fixed points.

Trail Slope - the percent departure of the trail from a level plane, recorded as a percent.

Trail Tread Depth - the greatest depth of trail tread in respect to the cross-sectional profile.

Tree Damage - any human caused damage to the primary stem or branches of the tree. May include carving, hatchet marks, nails, or tree removal.

Use - The pursuit of recreation by people.

User - a visitor, or an individual who recreates in the wilderness.

Visitor - a person who goes to wilderness for recreational pursuits.

Wilderness - any designated federal land, mandated to provide unique opportunities of recreation, while maintaining the areas pristine nature.

CHAPTER II

LITERATURE REVIEW

Trends of Wilderness Use

Since the designation of federal wilderness areas in 1964, people have enjoyed many resources provided by these areas. Today, wilderness areas are used extensively and the amount of use is expected to increase. Past researchers argued that interest in recreational opportunities in wilderness was decreasing due to decreasing growth rates of use levels. They stated that wilderness areas were experiencing increased use, but the rate of increase was presently declining (Cordell *et al.* 1990).

However, Cole (1996) stated that wilderness use was at an all time high in 1994. He found that use trends were understated due to primarily two reasons. First, among the various agencies managing these areas, there was no uniform method to calculate use. Reported use levels varied among most agencies, and a single use rate was hard to derive. Second, and more importantly, Cole found that due to the increase of the total land area of the National Wilderness Preservation System, specifically with the inclusion of Alaskan wilderness, the rate of growth was understated, due to a large increase of land area. Excluding the little used Alaskan wildernesses, the rate of recreational use has had a steady increase since the passage of the 1964 Wilderness Act (Cole 1996).

Cordell and others (1990) reported that there are primarily two factors that influence trends in the time and duration of use in wilderness areas today Since the 1960's, an interstate system was established, and manufacturers increased the fuel efficiency of automobiles. By easing visitor accessibility to these areas, the amount of use increased, thereby increasing the level of impact occurring in wilderness areas.

Changing work schedules and work patterns of visitors, has also changed the patterns of their visits. Since the 1960's, people have been changing their work schedules by working more through the week and taking off two to three days on the weekends. As a result, visitation trends of going more often and stay shorter lengths of time were developed. This has had an adverse affect on wilderness areas. Use patterns have evolved in which many wilderness areas receive a concentrated amount of impact in relative short periods of time (Cordell *et al.* 1990, Cole *et al.* 1995).

Weekends and holidays are the primary times that concentrated amounts of recreational use are observed in wilderness areas today. Recreational areas in general are most intensively used during late spring, summer and early fall months, starting at Memorial Day and continuing through to Labor Day (Cordell *et al.* 1990). Most accumulation of impact on recreational resource occurs during this time, although some variation has been shown.

Today, an increasing number of visitors go to wilderness during the day, as a result day-use of most wilderness areas has increased over the last ten years (Roggenbuck *et al.* 1994). Many feel that day-use has become more important to measure and manage because day-use is different from overnight use both in management goals and types impacts incurred (Cole 1996, Roggenbuck *et al.* 1994).

Kuzmic (1993) reported UKRW use trends of time and duration which affected social and physical impacts. Over 85% of all visitors visit the UKRW on weekends. The length of stay for over 80% of the overnight visitors was two days or less, and for over 34% of these visitors, the stay was one day. Concentration of use was found on the weekends as short duration of stay was the use pattern characteristics for the UKRW (Kuzmic 1993). Additionally, Kuzmic (1993) found that over 75% of all visitation occurred during Spring and Fall months, with 34% in the Spring and 41% in the Fall. The high number of visitors in the Fall were attributed to the hunting season and the leaves turning color in autumn.

Management Prescriptions to Control Impact

The term "wilderness management" is a paradox. Wilderness managers do not manipulate wilderness to gain a desired outcome; they manage people. Hendee and others (1990) stated wilderness managers were forced into the role of "guardians and not gardeners." Many researchers and managers realize that impacts are inevitable, and managers should prepare to manage their resource to meet their desired goal (Hammitt and Cole 1987, Cole 1993a, Cole 1994a). Managers need to monitor visitor traits, number of visitors, and level of use, to justify a management plan. This may include the implementation of regulations or fees to sustain the desired level of wilderness character (Hendee *et al.* 1990).

Light-handed management schemes are the desired management conditions of wilderness areas (Lucas 1982, Christensen and Davis 1985, Cole 1989c, Kuzmic 1993). Often, the first management option, and the most light handed method, is visitor education. However, managers of popular wilderness areas often establish permit systems to control wilderness use levels. Permit systems required recreationists to pre-register to obtain permits before they gain wilderness access. The amount of visitors to these areas are restricted according to an identifiable daily quota. In some cases visitors are denied access as quotas are met due to the limits on visitor numbers.

Many feel that this method is "heavy-handed" in its approach. However, some managers feel it is necessary to maintain the pristine conditions. This is a volatile issue for many as they feel wilderness access should be made available for spontaneous people who make spontaneous decisions to visit the "wilds" and get away from everyday societal pressures (Lucas 1982, Cole 1989c). However, for some high-use areas this method was the only option available to maintain the area's character (Merriam 1986).

Subsequently, wilderness managers were forced to initiate regulations for wilderness access that identify an acceptable amount or duration of use. Most wilderness visitors accept varying degrees of regulation. This acceptance for regulation is due to the realization that to maintain the integrity of most wilderness areas some regulation of use is necessary.

Wilderness managers continually face a major dilemma in prescribing regulations. Cole (1993a) discussed the issue of managers attempting to generate quick fix answers to complex problems in wilderness areas. He argued that often managers made prescriptions to remedy highly impacted areas, but in doing so, they sometimes created worse situations. The basis for wilderness management planning programs should be a process that is rational and considerate of the entire wilderness area. Managers create problems when they focus remediation techniques on specific impacts at a single location, while ignoring the causal elements of damage in other locations of the same wilderness. Cole (1993a) stressed that managers needed to get away from treating the "symptoms" and start working on the "disease."

Good management is dependent upon adequate planning, knowledge, implementation, and monitoring. Monitoring is incorporated into management plans to increase management's knowledge of which remediation techniques accomplish their the purpose and which ones fail. Management decisions and recovery prescriptions should be tested and re-evaluated routinely through continual monitoring. This requires a full-time effort.

In 1988, Reed and others reported that only twenty-six percent of all wilderness areas had full-time managers and only sixteen percent of all wilderness areas had systematic visitation counts. Considering these numbers, managerial prescriptions for many wilderness areas were based on "best guesses." Additionally, only thirty-seven percent of all wilderness areas were investigated for environmental research on the effects of human use on fish, wildlife, vegetation, soils, geology, air, and water (Reed *et al.* 1988).

Wilderness managers need to continually monitor and evaluate the current condition of a wilderness. Remediation prescriptions are based on amount of impact occurring on wilderness, and its current level of use. Wilderness managers need to consider all aspects of impact. Through the combination of comprehensive impact evaluation and incorporation of appropriate management prescription, wilderness managers should be able to effectively manage the area (Cole 1993a).

Two primary methods for managing visitor use in wilderness have evolved since the 1960's, they are carrying capacity method and Limits of Acceptable Change (LAC). The carrying capacity concept was adapted by recreation managers from the range management profession. Carrying capacity was a method by which the management was based according to the amount of use. Managers tallied the number of visitors of an area and made management decisions and prescriptions solely from this aspect.

However, managers found that this method was not universally appropriate (Marion *et al.* 1985). Some recreation managers found that areas within wilderness continued to receive unacceptable amounts of impact, while remaining within the limits of their visitor carrying capacity. They felt that they needed to consider not only amount of use, but also the type, location, and season of use. Day-hikers tended to cause different types and levels of impact than over-night campers, and over-night campers typically caused less impact than the pack-stock campers (McClaran and Cole 1993, Roggenbuck *et al.* 1994).

In 1985, the Limits of Acceptable Change (LAC) concept was introduced. The LAC method of wilderness management is a multi-staged process by which an area is continually monitored after the initiation of the process (Stankey *et al.* 1985). Through this process, indicators are defined, standards are established, monitoring schedules are enacted, and remedial prescriptions are made. The indicators are wilderness specific, based on what the planning committee perceived to affect the wilderness experience. The standards, also wilderness specific, define the degree by which indicators are allowed to deteriorate before remedial prescriptions are initiated. Through continual monitoring, the existing conditions in the wilderness are compared to the standards. If standards are exceeded, managers implement prescriptions to remedy problem sources.

The LAC management system was derived from the actuality that wilderness areas exhibited varying degrees of type, location, season, and amount of uses. Managers of wilderness areas needed a "dynamic continuing process," or a changing management ideology, due to these changes of use (Stankey *et al.* 1985).

The LAC process has been implemented at several U. S. National Forest wilderness areas. This method has been widely accepted because managers found that the system addressed the needs of specific areas. Stankey *et al.* (1985) proposed no general indicators or standards in their initial articulation of LAC plan. Indicators and standards for a LAC plan are dependent upon the social and physical character and influence of distinct wilderness areas on an area by area basis.

Wilderness Expectation and Coping Behaviors

Wilderness visitors typically have expectations for their wilderness experiences. These expectations are very individualistic, dependent upon the background, knowledge, and experience of the person. Expectations are often goal-oriented and visitors expect a diverse range of outcomes from visiting wilderness areas. These outcomes range from introspection such as seeking solitude and nature study, to very physically demanding experiences that include hiking and rock-climbing (Taylor 1990). Wilderness visitors pursue a wide diversity of activities in wilderness settings and often experience more than one during each wilderness visit.

Due to varying visitor motives and expectations, the degree of solitude varies between different groups entering a wilderness and this degree varies among members within that group. Watson and Cronn (1994) found that the more people go to wilderness, the higher the degree of solitude they expect. In their study, wilderness visitors that went into a wilderness for the first time more than two years ago reported more social problems than those on their first trip less than two years ago. They also stated that overnight visitors reported more resource impact than day users. Visitors that stayed longer durations in a wilderness area were more sensitive to human impacts (Watson and Cronn 1994).

Wilderness purism has been a continual topic of debate among wilderness researchers and users. The degree or definition of a "true wilderness setting" is influenced by one's personal biases and ideology. Wilderness purity refers to the amount of remoteness, naturalness, solitude, or "wildness" an area provides, as perceived by individuals.

As an individual's "purity" expectation increases they tend to become less tolerant of impacts and invasions of solitude in wilderness. The primary concerns that affect wilderness purity are deteriorating campsite and trail conditions, and area litter accumulation. In 1987, wilderness managers reported that 76% of wilderness visitors complained about trail deterioration, and 72% complained of campsite conditions (Cole *et al.* 1987). Further, 65% of their visitors objected to the amount of litter, while over-crowding problems were also evident to 51% of wilderness visitors.

Additionally, the perception of wilderness purity is more definitive as recreationists become more educated about appropriate wilderness characteristics (Hammitt and Patterson 1991). Today, due to environmental education, wilderness visitors have a greater expectation of environmentally sound practices in wilderness areas, than anywhere else (Petersen and Harmon 1993).

In 1991, Hammitt and Patterson investigated coping behavior techniques to avoid contact with others in wildland settings. They found that physical coping behaviors were used more than social behaviors as a way to avoid visitor interactions and maintain wildland privacy. The use of physical coping behaviors was strongly influenced by the importance of solitude and "congruent encounter norms." They found that privacy in wilderness goes beyond number of visitor encounters. They stated that coping behaviors to reduce impact perception, is only one of the variables at play. Regretfully, these physical coping behaviors tended to displace visitors, either from one site to another, or from one wilderness to another (Hammitt and Patterson 1991, Kuentzel and Heberlein 1992).

The UKRW visitor population has an unique motive and expectation profile. Kuzmic (1993) reported that visitors felt that the UKRW provided a high quality wilderness character, and the scenic beauty of the area was the most outstanding characteristic provided. Additionally, these visitors reported that the problems of the UKRW were the amount of litter, deteriorated campsites, conflicts with hunters, and noisy people camping nearby. Many of these conflicts occur as the level of use increases. However, the conflict with hunters was highest during the fall season when hunters and other recreationist visited the area. They also saw a need for management to plant trees on old roadways, to require visitors to pack out all litter, to require campsites to be located more than 200 feet from the trail and streams, and to have rangers patrol for enforcement of these rules (Kuzmic 1993).

Trends of Wilderness Campsite Impacts

Human induced impact typically is one of the most significant traits influencing the overall appearance of wilderness. Kuzmic (1993) found that conditions of individual sites within the UKRW were perceived by visitors to affect wilderness character more than encounters with other visitors.

Campsite conditions are very complex and these complexities are based on the inter-relationship of soil, geology, vegetation, climate, and use trends (Cole 1989c). Four primary factors affecting the amount of impact on campsites are frequency, type, and season of use and environmental conditions (Hammitt and Cole 1987, Cole 1994a). Environmental conditions play a major influence on areas and they need this evaluation for a complete analysis of the conditions affecting the sites. When evaluating the impact on a wildland area, investigators need to consider the vegetation type, soil type, and geological conditions. These environmental conditions are used to define the resistance and resilience of the site (Cole 1986).

Climatic factors also have a major influence on an area's tolerance. Climatic factors include mean annual temperature, length of growth season, and amount of precipitation. These factors, in combination with the site's physical factors, determine a site's overall impact tolerance.

There are certain trends associated with impact. These trends can be categorized into the following classes: spatial impacts, temporal trends, visitor use, and characteristics of impacts on specific variables.

Spatial Impact Trends

Manning (1979) first described impact to occur in a pattern of "nodes and linkages." He argued that most of the impact that occurred on sites happened on the trails and campsites. Trails serve only as links to traffic visitors to back-country sites while the campsites themselves are the activity nodes. This wilderness impact trait helps managers focus prescriptions for remediation on specific areas. Managers found it easier to manipulate and monitor fewer areas while they maintained the pristine order and overall appearance of an entire wilderness area. Closure of few seriously impacted sites is easier than closure and rehabilitation of many sites (Hammitt and Cole 1987, Cole 1994a).

Campsites are the areas of wildernesses that experience the highest amount of use (Hendee *et al.* 1990). Many managers feel that establishing designated sites is a method by which impact is focused by the camper on a few specific campsites and additional impacts are minimized in other areas (Hammitt and Cole, 1987).

Bob Marshall Wilderness had recreational patterns where campsites increased in overall area (Cole 1983b, Marion and Merriam 1985, Cole and Hall 1992).. Further, as use increased, the campsite area increased. This is a trend that most wilderness areas have.

Cole studied the way by which campsite density was increased (1993b). Campers that went to a wilderness area sought a campsite at a scenic or ideal location. If there was not a campsite where they preferred or if all campsites were full, visitors tended to create new campsites to accommodate their needs. In addition to increased physical impact, this is a social impact due to over-crowding.

Managers influenced the trend of campsite pioneering through their desire to maintain a minimally impacted resource. Managers educated visitors on good "no trace ethics" for camping. Through this education, managers described what should be expected when people visited these areas. When campers visited an area and encountered a site that had been severely impacted by previous campers, they moved on to find a more primitive area, creating a new site in the process (Cole, 1993b). In this case, campsite proliferation was caused by management techniques in educating the public.

Temporal Impacts

Cole (1982) described the general trend by which the amount of impact occurs as use continues. He found that impact occurs rapidly at first and then increases but at a decreasing rate. His graph illustrated the relationship of amount of impact as use continued through time (Figure 2).

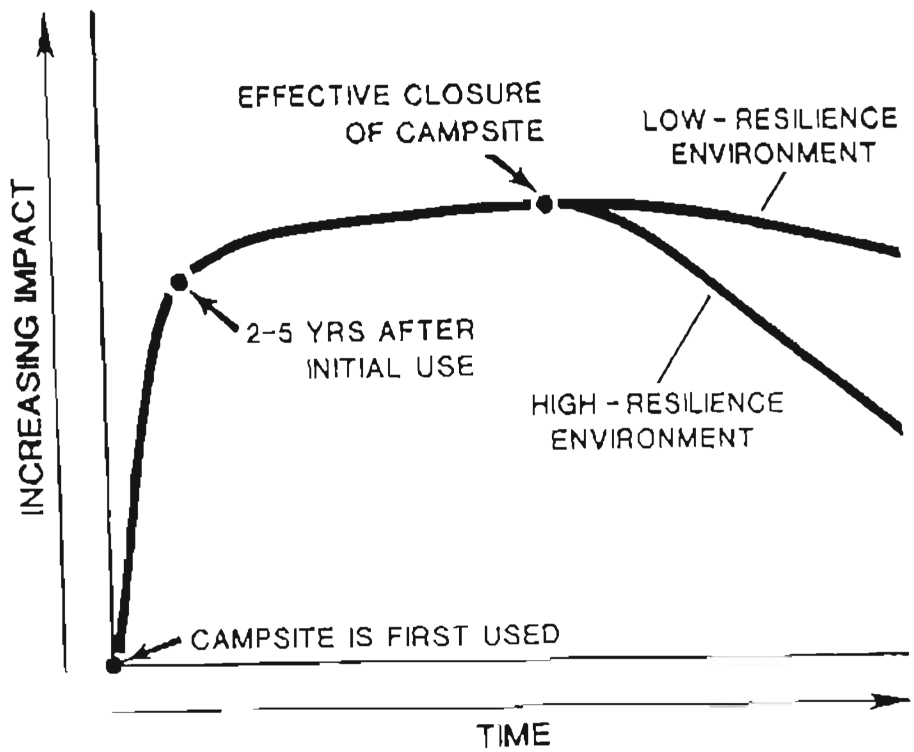


Figure 2. Relationship of the Total Amount of Impact Through Time at Wilderness and Backcountry Sites (From Cole 1993a).

He described this relationship not as a linear relationship, but as an asymptotic relationship. Three impact stages are defined within this figure as development stage, dynamic equilibrium stage, and recovery stage. The slope of the curve is individualistic of each wilderness due to the environmental factors associated with the wilderness, and this rate varies among campsites within that wilderness (Hammitt and Cole 1987). However, the trend associated with all wilderness in most settings is that impacts occur rapidly at first and as use continues the impact rate of change decreases.

Cole (1994a) illustrated that low rates of impact caused at the developmental stage of use had a potential for high levels of impact. As use continued, the rate of impact reached an equilibrium where, for a time, use had little increase on the amount of impact. After closure of the site, campsite recovery was initiated and the rate of recovery was based on the campsite's resilience.

As a result, conclusions were made that it was wiser to maintain fewer high-impacted sites than many low-impacted sites. This premise was based on the fact that campsites impacted at low rates, rapidly become highly impacted sites, further, highly impacted campsites have little increase in impact rates (Hammitt and Cole 1987). Cole (1986) found that greater deterioration, or a higher rate of change, occurred on the low-use campsites than on the campsites that had sustained high-use. However, after campsite closure, low-use campsites recovered at a faster rate than those of high-use (Cole 1986). Therefore, to minimize impact increases, it was better to maintain few highly impacted sites and discourage new campsite creation (Hammitt and Cole 1987)

The over-riding problem is that although impact happens in a relatively short amount of time, the recovery of a site takes a long time (Hammitt and Cole 1987). Regardless of the tolerance and/or resilience of a campsite, recovery always takes longer than the actual impact. Many researchers feel that some highly impacted sites may never recover completely given these sites use levels and environmental conditions.

Visitor Use Trends

The potential for impact varies according to party size, type of use, duration of use, distribution of use, and mode of travel (Hammitt and Cole 1987). Regardless of the use factors the amount of impact occurs rapidly at first (Figure 2). As use factors become more intensive, the amount of impact increases. These increases are shown by higher soil compaction, increased percent vegetation loss, increased percent bare mineral exposure, larger barren core areas, and/or larger campsite areas. Any combination of these impact variables could become more severe depending on the use trends and the environmental characteristics of the site.

Impacts in wilderness setting are synergistic. Little impact is caused by single individuals but the total impact amounts are a result of the vast number of campsite visitors (Hammitt and Cole, 1987). As campsites in a wilderness setting are used by visitors, the relative amount of impact increases. Visitor observance of the sum of these impacts is wilderness manager's primary concern.

Impact Trends on Specific Variables

Many of the impact parameters are interrelated in the causation of impacts. The removal of vegetation through trampling increases the bare ground area and increases soil compaction. The increase in soil compaction also decreases vegetation cover, increases bare ground area and both instantaneous and saturated infiltration rates. Additionally, the removal of vegetation may influence or be influenced by decreases of infiltration rates.

Vegetation impact is one of the most noticed impacts in wilderness. Reduced vegetation coverage is a parameter that is caused by removal and/or killing of vegetation through recreational use. Vegetation trampling occurs in three progressive steps. As the number of passes increase, the vegetation goes through light scuffing, removal of vegetation and organic matter, and lastly soil compaction which leads to lower soil aeration and moisture

(Cole 1982, Cole 1983b, Hendee *et al.* 1990, Cole and Hall 1992, Marion and Cole 1996, McEwen *et al.* 1996).

Vegetation impact tolerance also varies among vegetation types. Tolerance is dependent on the vegetation type, vegetation height, level of use, and climatic conditions (Cole 1985, Leonard *et al.* 1985, Cole and Trull 1992, Cole 1993c, and Cole 1995). Therefore, as impact increases, the vegetation species that are least tolerant to impact are removed or killed first, and as use continues the remaining species are removed in order of their tolerance (Hammitt and Cole 1987). This results in a decrease in the diversity of species on the campsites area.

The amount of vegetation loss is an individual characteristic of each wilderness. Comparison of percent vegetation losses for amount of impact across wilderness areas may not be appropriate due to differences in tolerance. However, most studies evaluate the amount of change of the campsite to a control as this measurement evaluates the differences between locations. Cole and Hall (1992) reported that Eagle Cap Wilderness in Montana had a vegetation loss of 45%, and Bob Marshall Wilderness had a vegetation loss of 52%. These were comparisons of mean vegetation loss of the campsite to a control, which considered the difference of the optimal condition.

McEwen and others (1996) studied the impact conditions of four wilderness areas in southeastern United States. They found that among the areas they studied, Caney Creek Wilderness in Arkansas had a significantly higher average vegetation loss of 52%. The remaining wilderness areas had lower vegetation losses. They reported that Upper Buffalo Wilderness in Arkansas had 27% loss, Hercules Glades Wilderness in Missouri had 29% loss, and Garden of the Gods Wilderness in Illinois had an average vegetation loss of 23%. In this study, Arkansas' Caney Creek wilderness exhibited significantly higher impact levels, while the other three wilderness areas had comparatively similar levels of impact.

Many have documented that an increase in bare ground area is also a trend influenced by recreational use (Cole 1982, Cole 1983b, Hammitt and Cole 1987, Marion and Cole 1996).

This parameter is influenced in combination with vegetation cover loss and soil compaction. . Bare ground area is increased through not only the removal of vegetation cover, but also removal of the duff layer and/or the organic matter from the campsite area. Another way bare ground area is increased is by clearing an area for a campfire, or just burning the area (Cole and Dalle-Molle 1982). Factors affecting the percent of bare ground area are tolerance of vegetation, soil type, and use trends (Hammitt and Cole 1987).

Soil compaction is a measurement made to test the soil's resistance to penetration. Manning (1979) first described the relationship of soil impact cycles. Further, Hammitt and Cole (1987) found that trampling of vegetation and scuffing of leaf litter leads to the loss of organic matter and an increase in soil compaction. As impact occurs, soil becomes more compacted reducing the interstitial spaces within the soil. This leads to decreased soil air and water which in turn causes stress on the plant and sometimes results in mortality. Additionally, as water permeability into the soil is decreased, there is an increase in water runoff which leads to an increase in soil erosion (Hammitt and Cole 1987).

Soil compaction varies according to soil type, texture, depth, and geologic conditions (Hammitt and Cole 1987). Among these, the primary soil trait that influences tolerance to soil compaction is soil texture. Soil texture is the proportion of the different sized particles in a given soil, specifically sand, silt, and clay. Sandy soils are the hardest to compact due to large interstitial spaces. Generally, soil compaction is highest on loamy soils with low organic content that are wet during trampling (Hammitt and Cole 1987).

Hammitt and Cole (1987) described four methods by which soil compaction is measured. Penetrometry is the amount of force taken to insert a rod a given distance into soil. Bulk density is another measurement of soil compaction, and it is measured by calculating weight to volume ratios. Permeability is a measure of how rapidly water flows into a soil, and conductivity is a measure based on the transmission of electricity or gamma rays through the soil.

A site's soil texture, moisture, depth, and type affect the amount of soil compaction. This varies not only from area to area but from season to season, and according to level of use. As an example, in 1981, the Bob Marshall Wilderness had an average bulk density of 3.3 kg/cm^2 on the campsites with an average bulk density of 2.3 kg/cm^2 on it's controls (Cole and Hall 1992). However, they found that in 1990, the Bob Marshall Wilderness had an average of 2.4 kg/cm^2 on campsites and 1.7 kg/cm^2 on controls. The change in the amount of campsite impact can be attributed to level of use, but why the change on the level of soil compaction on the control? This can only be addressed by changes in the overall condition from season to season. These differences are due to the varying climatic conditions, specifically annual differences in precipitation amounts and extremes in temperatures.

Additionally, other areas yield a surprisingly different result. The Grand Canyon National Park was found to have an average soil compaction rate of 2.7 kg/cm^2 on its campsites and 0.70 kg/cm^2 on its controls (Cole and Hall 1992). The average difference among these campsites were considerably higher than on Bob Marshall campsites. These higher rates could be attributed to soils more susceptible to compaction or higher use rates.

Soil infiltration rates, or soil permeability, decrease as soil compaction increases. Usually this parameter is measured as the instantaneous rate and the saturated rate. The instantaneous rate is the time taken for the first centimeter of water to penetrated the soil. This rate tends to be higher than the saturated rate because the top layers of soil rapidly absorb water. Reduced infiltration rates cause increased run-off, reduction of water penetrating the soil, hence increased soil erosion (Hammitt and Cole 1987).

Hammitt and Cole (1987) also defined various impacts on trees. They divided tree damage into conscious and unconscious damage. Conscious damage occurs when someone physically altered a trees condition. Examples were, removal of tree limbs, driving nails into a tree, peeling bark off a tree for kindling or as a souvenir, and felling trees for tent poles or firewood. Unconscious tree damage occurred without the visitor intentionally affecting the tree. Examples of this impact are scarring by lantern and root exposure. Tree damage can also occur through severe soil compaction whereby the reduced soil moisture and air causes the tree mortality.

Use patterns at the UKRW exhibit most all of the trail patterns listed above. Specifically, the UKRW exhibited harmful use patterns like Manning's (1979) nodes and linkages phenomenon and concentrated duration's of use in the Spring and Fall months (Kuzmic 1993). Ninety-three percent of the UKRW visitors hiked or walked along the primary trail (Ouachita National Recreational Trail) and all surveyed visitors camped on an identified campsite within the area. Concentration of use was found in the immediate corridor surrounding the ONRT, and less than 7% used the larger portion of the area (Kuzmic 1993).

Methodologies of Campsite Impact Measurement

Monitoring the change of impact is the basis of any wilderness management plan (Stankey *et al.* 1985). The major steps of a monitoring plan are; 1.) Establish the need for a campsite monitoring system, 2.) Identify the most serious types of campsite impact, 3.) Identify the types of information a monitoring system needs to provide, 4.) Evaluate funding and work constraints, and 5.) Decide among alternative approaches to monitoring (Cole 1989a).

Three general techniques or methods used to evaluate impacts on wildland campsites are photographic techniques, condition class estimates, and measurements on permanent point sampling units.

Photographic Techniques

Photographic techniques were initiated in 1965 and the methods were to establish permanent points to take repeat photos (Cole 1989a). Brewer and Berrier (1984) documented photographic methods to measure impact on campsites. Through observation of photographs, the amount of change that had occurred over time is estimated. They stated that color photos were most appropriate because it is easier to distinguish the live plants from the dead ones. Additionally, slides and hard copies are used for presentation and identification of sites in the field. However, the assumption that all impacts were detected through this technique was inaccurate. Photographs did not tell all that was needed for a complete analysis. However; photos were indispensable to reaffirm the correct campsite location. This technique took an average of 30 to 60 minutes per campsite to analyze change of impact (Brewer and Berrier 1984).

Impact Classification Method

Condition class techniques were initiated by Frissell in 1978. Frissell's method was one by which management would very rapidly estimate campsite condition and evaluate need for management. Delineation of various impacts was the technique to estimate amount of change (Table 1). His condition class method established five categories to separate various classes of impact and management techniques to remedy the degree of problems. This method typically took investigators 1 to 3 minutes per campsite (Frissell 1978).

TABLE 1

CONDITION CLASS DEFINITIONS[a]

Condition Class	Condition Class Definitions
Condition Class 1	Ground vegetation flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
Condition Class 2	Ground vegetation worn away around fireplace or center of activity
Condition Class 3	Ground vegetation lost on most of the site, but humus and litter still present in all but a few areas.
Condition Class 4	Bare mineral soil widespread. Tree roots exposed on the surface.
Condition Class 5	Soil erosion obvious. Trees reduced in vigor or dead.

[a] Frissell's (1978) Condition Class campsite assessment definitions.

In 1980, Parsons and MacLeod documented their condition class monitoring procedure. Similar to Frissell, they established a condition class assessment method. However, they change the method of campsite classification where they based their classes on eight criteria; density of vegetation, composition of vegetation, total area of the campsite, barren core of campsite, campsite development, litter and duff, social trails and tree mutilations. For each of their criteria there was a rating from 1 to 5, based on pre-set descriptions. The condition class was then averaged into a rating to the closest integer between one and five (Parson and MacLeod 1980). The increased emphasis of categories of impact made the Parson and MacLeod method a little more precise (Cole, 1989a). This technique took an investigator about 3 to 5 minutes to conduct at a site.

Another variation of this system was one in which Cole (1983b) modified Parson-MacLeod's system. Cole increased reliability by using more precisely defined terms, deleting the vegetation composition measurements, separating the mutilation parameter of stem damage and root damage and separating the campsite development and cleanliness variables. Originally, this system consisted of ordinal measurement, however, it was changed to consist of interval estimates. After campsite measurement, the interval data was grouped and ranked into ordinal classes for summary ratings. Given that some parameters were more impacting than others, parameters were assigned a weighted value to multiple by, to emphasize the most important parameters. These products were summed, and divided by the number of parameters measured to provide a ranking. A single summary rating for each parameter on each campsite was recorded to calculate the campsite index for each campsite. This technique took an investigator about 15 minutes to several hours per campsite, depending on parameters measured.

Today, many managers use this method because of the relative short time required to complete the inventory. Additional consideration is given as to the selection of impact parameters based on importance to their wilderness monitoring plan. Wildland managers are able to adopt a unique campsite "index rating" parameters by including or excluding certain impact variables, producing a unique rating system for their wilderness.

Permanent Point Sampling Method

Monitoring of permanent sampling points was an approach by which a number of impact parameters on permanently located sampling units were measured. Once the permanent site was established, repeat measurements could be done to evaluate changes of impact on the site over time. Some parameters measured were vegetation cover, vegetation composition, bulk density, mineral soil cover, number of damaged trees, and more. The parameters measured were based on the managers' objectives, or standards for the wilderness. This system is the best technique when estimating changes in impact over time (Cole 1989a).

The permanent sampling procedure called for a nail to be buried in the center of the campsite. From this point the distance to the edge of the barren core and to the perimeter of the obvious disturbed site was measured along sixteen fixed radial transects. From these numbers the investigator calculated the area of the barren core and the total area of the campsite. Trees were counted and evaluated for the degree of tree damage and root damage that had occurred on them (Cole 1989a).

Four transects were positioned within the camp for further analysis of soil impact and/or vegetation impact. Approximately fifteen quadrants were established along these four transects. Within these quadrants the vegetation cover, vegetation composition, exposed mineral soil and organic matter depth was measured. The mean for each of these parameters was calculated for the campsite as a whole. Four soil samples were then taken from the central part of the site for bulk density, moisture content and chemical composition (Cole 1989a).

On campsites that had not previously been measured, control plots were established. The amount of change over time was calculated from the comparison of the campsite conditions to the control conditions. This technique took an average of 1 to 3 hours per site (Cole 1989a).

Method Selection

There is no single method universally accepted for campsite monitoring. Wilderness managers and steering committees establish the limits and goals for distinct wilderness areas. From those limits and goals, the managers of wilderness areas need to derive the best method of study for their wilderness area monitoring. In many cases, managers adopt attributes from one or several methods listed above. Many methods are based on ocular estimation, or personal opinions. The trained eye is good enough in most management schemes. The most accurate method is the permanent sampling point method. This method derives data through actual measurement, negating ocular estimations. However, most wilderness managers cannot incorporate this method due to limited funds, and time taken to complete analysis.

Trends of Trail Impacts

The primary reason for trail impact problems is improper placement of trails during trail construction (Burde and Renfro 1986, Leung and Marion 1996). Helgath (1975) argued that trail erosion was attributable to improper location of trails. When selecting the placement of a trail an area's land form, vegetation type, and slope needs to be evaluated. Trail slope is strongly correlated to managerial problems of trail erosion (Helgath 1975, Cole 1985, Cole 1991). Trails located on steep slopes are prone to erosion through increased run-off, while trails on flat areas are prone to puddling due to lack of drainage which leads to trail broadening by visitors evading the water.

Regardless, trails are impacted through use. Cole (1983a) stated that trail widths were significantly greater on more heavily used trails. Burde and Renfro (1986) stated that trails they studied increased in width and depth at a rate of 2.5 cm per year.

The placement of a trail is the primary factor influencing the potential for trail degradation. Leung and Marion (1996) stated that some trails in the past were placed along old roads, logging roads, fire access routes, wagon roads, and other roads to old homesteads, or fire towers. Most often these roads were not placed in the ideal location for limited impact as the initial road placement was based on the premise that the shortest distance between two points is a straight line. As managers placed trails along old road areas, they unknowingly placed them in poor trail locations.

Cole (1978) argued that the most appropriate location for trail placement was in meadows. These area tend to have deep, rich soils and they usually have vegetation species that are tolerant to trampling. The primary reason trails are not often placed in meadows is that they are an obvious indication of impact and could be obtrusive to wilderness experience, diminishing an areas "unaffected by human influence" definition.

Methodologies of Trail Impact Measurement

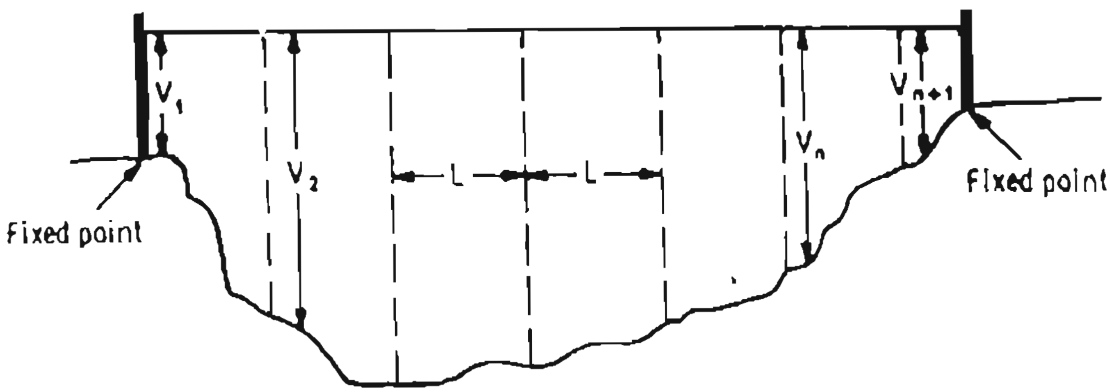
Cole (1983a) listed methods by which trail impacts were monitored. The replicable measurement technique incorporates repeat measurements at a distinct location to evaluate change over time. Cole went on to described two strategies of establishing points. The first was the establishment of a trail transect at an interval of a given distance. The second was just to measure problem areas on the trail.

The trail profile bracket method which measures the cross-sectional area between tread surface of a trail is the most common way of measuring impact on trails over time (Figure 3). The trail profile bracket was a method used by many in the past. The types of profile brackets were a rod bracket, and a simple line. Cole (1983a) found that precision was greatest when the line was elevated high enough above a fixed point to clear vegetation and microtopography along the trail. Other factors that affect precision were the tension of line, and the use of a plumb bob and level to ensure vertical measurements. The distance of departure from the bracket to the trail was measured along a given distance of the bracket. Then the cross-sectional area of the trail was calculated by using the formula in Figure 3, page 32.

When trail transects were re-measured, relocation of the fixed points used previously was necessary and the positioning of the bracket was in exactly the same place. The precise location was established by a sketch map giving distance and direction to at least three reference points (Cole 1983a).

Another method was a rapid survey technique by which trail was measured for basic parameters at a given distance. Distances varied from 164 ft to 500 ft to 1640 ft. Most common measurements included width of trail, width of bare ground, and maximum depth of trail tread. Erosion ratings, with written descriptions for each class, were evaluated according to the amount of damage at each sample site. This system did not utilize the replication technique, and it was done rapidly to generalize the overall trail condition (1983a).

Cole (1983a) derived a census technique which incorporated elements of the rapid technique, but the entire trail was subdivided into sections. Each section was rated and given a trail condition based on that rating. Measured parameters varied among rating systems.



$$A = (V_1 + 2V_2 + 2V_3 \ldots\ldots + 2V_n + V_{n+1} \;/2) \times L$$

Where A = Cross sectional area.

V_1 to V_{n+1} = Vertical distance measurements starting at V_1, and ending with V_{n+1}.

L = Interval of distance between measurements.

Figure 3. Trail Transect Profile Bracket and Formula for Calculating Trail Cross-Sectional Area (from Cole 1983a).

Remediation of Highly Impacted Areas

As wildland managers determine that their area has unacceptable levels of impact, they are required to seek remedial prescriptions. Additionally, most managers attempt to prescribe light-handed management, as well they should (Lucas 1982, Christensen and Davis 1985, Cole 1989b, Kuzmic 1993).

Often, the first management technique to control impact is education. Many prescribe visitor education as the first act to control impact (Lucas 1982, Driver *et al.* 1987, Cole 1989b, Bradley 1993, Douchette and Cole 1993,)

Provided a site had been damaged beyond the standards of a wilderness area's LAC plan, managers initiate a pre-set prescription plan to remedy the unacceptable impacted areas. These prescriptions vary in regulation from light handed actions such as posting of signs to the heavy handed like closure of sites.

Cole (1982) described steps for campsite remediation. The first step to campsite remediation was the removal of fire rings. Fire rings were magnets to campers because they represent a tried and tested site. The presence of fire rings caused repeat visits to these areas when people were looking for a campsite. If the site was still discernible, the next step was to close the campsite by posting signs. The next was removal all extra pieces of firewood that remained on site. Finally, if the area exhibited revegetation problems, some native species were planted on the site to re-establish the vegetation cover back. Popular campsites required closure multiple times in order to remedy the situation.

Another strategy to reduce the need for remediation of campsites was to maintain campsites on locations with high impact tolerance. Cole (1993a) stated that sites located on soil types that tended to be more impact resilient recovered much faster than sites on less resilience soils.

CHAPTER III

PROCEDURES FOR RESEARCH

Delimitation

This study was delimited to the Upper Kiamichi River Wilderness of the Ouachita National Forest. All identifiable campsites in the Upper Kiamichi River Wilderness (UKRW) at the time of the data collection were documented and evaluated for level of impact. Some campsites were known to exist through a previous study (Kuzmic 1993) and some were added that were not in the 1993 study. However, throughout this study, additional campsites were continually sought.

Trail transects were positioned along the Ouachita National Recreation Trail (ONRT) at one mile intervals. Additional trail transects were located along the trail in potential problem areas as perceived by UKRW managers, they were designated as "trouble areas" (Table 7, page 44).

Limitations

Some limitations were considered throughout this project The limitations affected the implementation of techniques involved, as well as inferences in data analysis. The limitations were;

1.) Fieldwork was performed across a single summer. Therefore, data collected served only as a representation of impact and use for that season. Since no prior impact knowledge was known, in the event of a low use season, the level of impact would be understated. Since data were collected over a single season, caution should be given to some results due to season variability.

2.) Campsites condition were not known before wilderness designation. This area had been used and developed prior to 1988. This use included logging, homesteading, in addition to camping and hiking.

3.) This study focused on the campsites and trail conditions in Opportunity Class Three, a corridor around the ONRT. Additional campsites could exist in other areas of the UKRW, although none were found . According to the UKRW plan, none should exist in Opportunity Class One, and very few in Opportunity Classes Two and Four.

Assumptions

1.) In the absence of recreational impact, campsites would appear exactly like their control sites with regard to vegetation and soil condition.

2.) Control sites were not affected by campsite presence or visitors using those campsites.

3.) All documented impacts resulted from human recreational use.

4.) All litter within the area was brought in by recreational visitors.

5.) All impact on trails was caused by recreational visitors who traveled the trail.

Hypotheses

This project's hypotheses were divided into campsite hypotheses (Table 2, page 36) and trail transect hypotheses (Table 4, page 38).

Due to campsite ecological variability, the difference of the campsite from its control was the variable used to analyze each hypothesis. All tests used for data analysis were non-parametric tests due to low number of samples taken and "non-normal distribution" of data. Each test was evaluated as a two-tailed test and the significance level was set at 0.05.

Campsite hypothesis one evaluated the difference of campsites from their controls for each variable v_i (Table 3, page 37). This evaluation compared the measurable campsite difference from its control and tested whether this difference represented a significant change.

Campsite hypothesis two evaluated similarities of each impact variable v_i between riparian campsites and non-riparian campsites. Riparian campsites were 100 feet or less from a water source and non-riparian campsites were further than 100 feet from a water source. This hypothesis assumed that there was no difference between riparian campsites and non-riparian campsites, regardless of the differences in environmental conditions and use levels.

TABLE 2

HYPOTHESES FOR CAMPSITE AREAS[a]

Hypothesis	Statement of Hypothesis
1	H_o: There is no difference in impact variable v_i (Table 3) at campsite n_i when compared to its control site.[b] H_a: There is a difference in impact variable v_i (Table 3) at campsite n_i when compared to its control site.
2	H_o: There is no difference in the impact variable v_i (Table 3) between riparian zone campsites and non-riparian zone campsites. H_a: There is a difference in the impact variable v_i (Table 3) between riparian zone campsites and non-riparian zone campsites.
3	H_o: There is no difference in the impact variable v_i (Table 3) between campsites situated in three vegetation types. H_a. There is a difference in the impact variable v_i (Table 3) between campsites situated in three vegetation types.
4	H_o: There is no difference in the impact variable v_i (Table 3) between campsites situated in three forest types. H_a: There is a difference in the impact variable v_i (Table 3) between campsites situated in three forest types.
5	H_o: There is no correlation between the impact variable v_i (Table 3) and campsite index among the seventeen campsites. H_a: There is a correlation between the impact variable v_i (Table 3) and campsite index among the seventeen campsites.
6	H_o: There is no correlation between the impact variable v_i (Table 3) and distance to the trailhead among the seventeen campsites. H_a: There is a correlation between the impact variable v_i (Table 3) and distance to the trailhead among the seventeen campsites.

[a] Each hypothesis was tested for each of the impact variables v_i (Table 3, page 38).
[b] Each campsite was tested individually for this hypothesis for each of the seventeen campsites.

Campsite hypothesis three evaluated the relationship of each impact variable v_i between sites located in three vegetation types. Classes of vegetation types were defined by the L. S. Forest Service and included forest/ridgetop, forest/lush grass, old homesite, grassland/glade, riparian, and forest/forbs/shrubs. However, only three vegetation types were classified within this area. Assumptions were made that regardless of the vegetation type, the amount of impact difference was the same across the three types.

TABLE 3

LISTING AND DEFINITION OF IMPACT VARIABLES MEASURED ON UPPER KIAMICHI RIVER WILDERNESS CAMPSITES

Impact Variable	Parameter Measured
Percent vegetation cover	Percent vegetation was measured with a one meter by one meter grid and was simply an estimate of the percentage of vegetation cover over the ground.
Percent mineral soil exposure	Percent mineral soil exposure was measured with a one meter by one meter grid and was simply an estimate of the percentage of mineral soil without cover of vegetation or organic matter.
Soil Compaction	Soil compaction was measured with a soil penetrometer, and was recorded in units of kg/cm^2.
Instantaneous Infiltration rates	Infiltration rate was measured with a double-ring infiltrometer and was recorded with units of cm/min. The parameter recorded was the amount of time elapsed for the infiltration of the first centimeter of water into the soil.
Saturated Infiltration rates	Infiltration rate was measured with a double-ring infiltrometer and was recorded with units of cm/min. The parameter recorded was the amount of time elapsed for the infiltration of the first 5 centimeters of water into the soil.
Damage to trees on sites	Damage to trees on site was an estimate of the degree of damage done to trees on the site.

Campsite hypothesis four evaluated the relationship of the each variable v_i between three forest types. Forest type was defined by the dominant species on the site. After data collection the various dominant stands were divided into three classes. These classes were shortleaf pine stand (*Pinus echinata*), mixed hardwood stand, which consisted of black oak (*Quercus velutina*), white oak (*Quercus alba*), and hickory species (*Carya spp.*), and a cove species which was an American beech (*Fagus grandifolia*) stand. Assumptions were made that there was no difference in amount of use, the resistance, and/or resilience of the three stands.

Campsite hypothesis five tested for the correlation of the campsite index rating to the given impact variables v_i. Campsite index rating was derived through the use of a form provided by the U. S. Forest Service (Appendix E).

Campsite hypothesis six tested for the correlating relationship of each impact variable v_i to the distance of the campsite from the nearest trailhead. This hypothesis assumed that amount of impact incurred on the campsite was independent from the distance of that campsite from the trailhead.

The campsite variables and their definitions are listed on Table 3, page 37 and in glossary of terminology, page 8. Each variable was tested among each campsite hypothesis. In each test the campsite's difference from control was the variable measured.

The trail transect hypotheses (Table 4, page 39) evaluated specific trail variables among the various influencing factors. Trail transect hypothesis one tested for variance between riparian and non-riparian transect locations, while trail transect hypothesis two evaluated the old road trails and non-old road trails. These hypotheses tested for a difference between each trail variable (Table 5, page 40), and they assumed that regardless of the river influence, or old road placement, the condition of the trail was not significantly different across trail locations.

Trail transect hypotheses three and four analyzed the correlation of the trail variables to trail slope and distance of the trail transect to the nearest trail head. This test assumed that there was no difference in the level of each trail variable in relation to slope or distance from the trailhead of the transect location.

TABLE 4

TRAIL TRANSECT HYPOTHESES[a]

Hypothesis Number	Statement of Hypothesis
1	H_o: There is no difference in trail variable t_i (Table 5) between riparian trail transects and non-riparian trail transects. H_a: There is a difference in trail variable t_i (Table 5) between riparian trail transects and non-riparian trail transects.
2	H_o: There is no difference in trail variable t_i (Table 5) between old road trail transects and non-old road trail transects. H_a: There is a difference in trail variable t_i (Table 5) between old road trail transects and non-old road trail transects.
3	H_o: There is no correlation between the trail variable t_i (Table 5) and distance to the trailhead among the sixteen trail transects. H_a: There is a correlation between the trail variable t_i (Table 5) and distance to the trailhead among the sixteen trail transects.
4	H_o: There is no correlation between the trail variable t_i (Table 5) and slope among the sixteen trail transects. H_a: There is a correlation between the trail variable t_i (Table 5) and slope among the sixteen trail transects.

[a] Each hypothesis was tested for each of the trail variables t_i (Table 5, page 41). Sixteen trail transects were sampled.

Trail transect hypotheses were tested regarding four basic trail attributes; trail width, depth of tread, area profile and multiple trails (Table 5, page 40).

Riparian and non-riparian trails were defined by the distance of the trail to the nearest water source. Those within 100 feet were riparian trails, those further than 100 feet were non-riparian trails.

The definition of "old roads" was derived from the placement of the trail transect on trails located where roads were prior to wilderness designation. Thus, "non-old road areas" were transects not located on a road.

TABLE 5

LISTING AND DEFINITION OF MEASURED TRAIL VARIABLES AT TRAIL TRANSECTS ALONG THE OUACHITA NATIONAL RECREATION TRAIL

Trail Variable	Parameter Measured
Trail Width	The overall width of the trail measured to the nearest tenth of a foot.
Trail Tread Depth	The overall depth of the trail measured to the nearest tenth of a foot.
Trail Profile Area	The overall area of the profile of the trail measured with a trail profile bracket to the nearest tenth of ft^2.
Number of Multiple Treads	A count of the number of trail treads.

Geographic Location of the Study Area

The study area for this project was the Upper Kiamichi River Wilderness (UKRW). The UKRW is part of Ouachita National Forest in Leflore County, Oklahoma, and is located about 18 miles south of Heavener, Oklahoma, 28 miles east of Talihina, Oklahoma, and 22 miles west of Mena, Arkansas. Management of the UKRW is charged to the United States Forest Service, Choctaw Ranger District, which is headquartered at Heavener, Oklahoma.

Description of the Upper Kiamichi River Wilderness

The UKRW is comprised of 10,819 acres (4381.70 ha) of which 1458 acres (656.10 ha) within this area are owned by private inholders.

The area is rocky and mountainous, and the mountains include Pashubbe Mountain, Wilton Mountain, Pine Mountain, and Rich Mountain (Appendix A). These mountains vary in elevation of 1700 to 2500 feet.

There are three primary rivers or creeks within the area; Pashubbe Creek, Horsepen Creek, and Kiamichi River. The Kiamichi River is initiated by several tributaries within the

UKRW and combines into one primary river. The ONRT is located near this river from Kiamichi River Trailhead to Stateline Trailhead (Figure 1, page 5).

Ouachita National Recreation Trail influenced most recreational trends within the UKRW. The trail existed before the UKRW was designated "wilderness," and it comprised the UKRW boundary from the Pashubbe Trailhead at the area's southwest corner to the Kiamichi River Trailhead (Figure 1, page 5). The ONRT corridor from the Kiamichi River Trailhead to the Stateline Trailhead is completely within the wilderness boundary, and most of this trail closely follows the Kiamichi River. Other trails within the area were found, but they were rarely used, therefore, on these trails, trail transects were not established for future monitoring.

Another influencing factor was the Talimena Drive located along the ridge of Rich Mountain. The noise of cars and trucks traveling on the drive sometimes can be heard in certain places within the wilderness.

The UKRW is divided into four zones each having specific standards for tolerance of human-induced impact. These standards are delineated in the Limits of Acceptable Change plan as described earlier (U. S. Forest Service 1992). Opportunity Class Three (O. C. 3) comprises the corridor surrounding the ONRT, where the highest level of impact tolerated is within O. C. 3. (Figure 4, page 42).

Description of the Study Sites Within the Upper Kiamichi River Wilderness

The campsites studied during this project were all positioned within the Ouachita National Recreation Trail corridor (O. C. 3). Campsites were located at varying distances along the trail and management required no regulation of designated camping areas. All campsites were accessible from the ONRT and were numbered and named for further reference (Table 6, page 43, and Appendix A). The campsite number and name were recorded to distinguish each of the campsites within the UKRW for monitoring purposes. Campsite numbering started at the campsite closest to the Pashubbe Trailhead and continued easterly along the ONRT corridor.

Upper Kiamichi River Wilderness

Opportunity Class Description

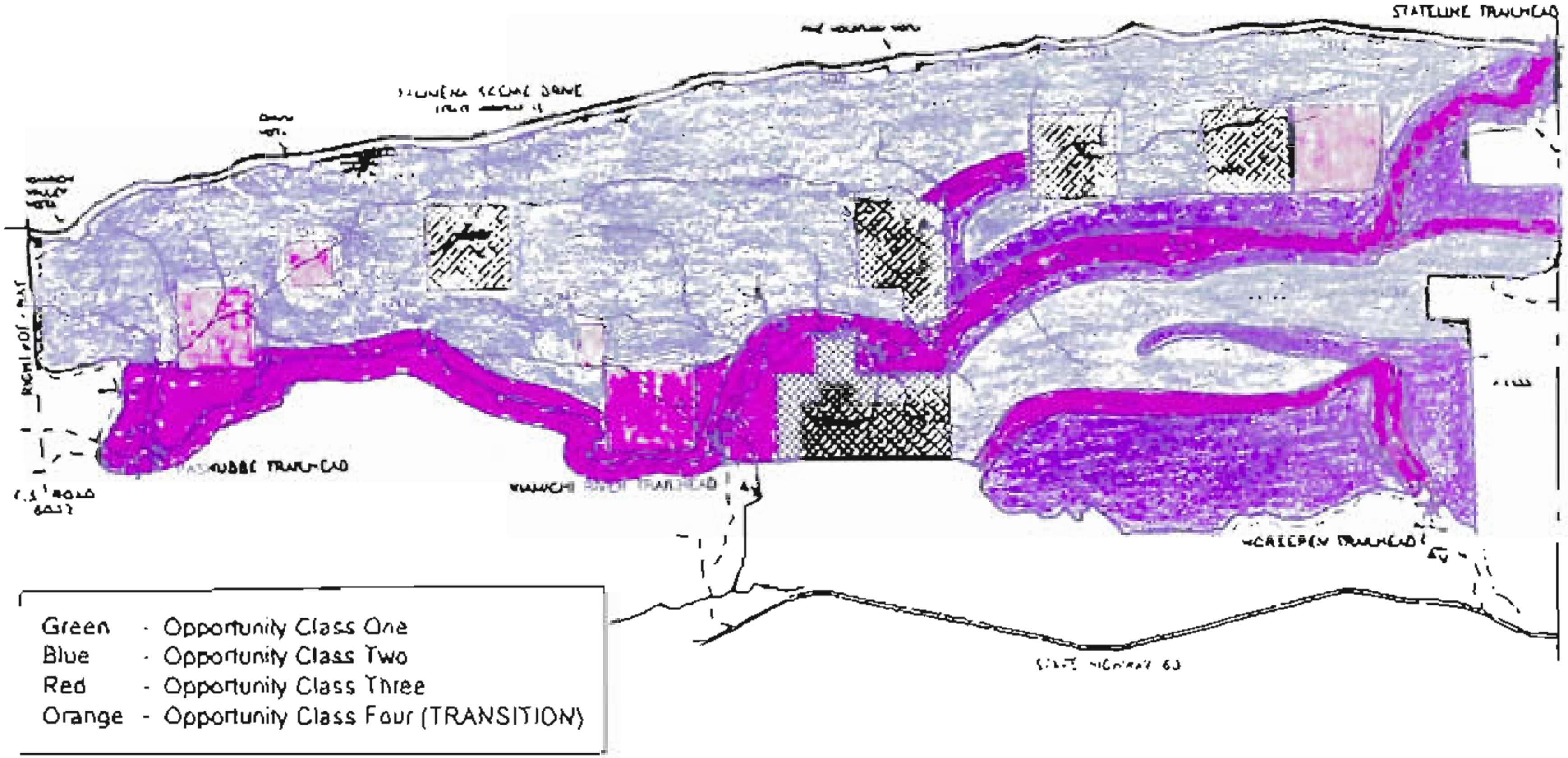


Figure 4 Delineation of Opportunity Class Zones of the Upper Kiamichi River Wilderness.

TABLE 6

NUMBER, NAME, AND CAMPSITE LOCATION IN THE UPPER KIAMICHI RIVER WILDERNESS[a]

Number	Campsite Name	Location
1	Pashubbe Point Camp	Pashubbe ridge between mile marker 35 and 36
2	Wilton Mountain Camp	Wilton Mountain, between mile marker 36 and 37
3	Wilton Point Camp	256 feet North of Wilton Mountain Camp on Wilton Mountain's peak.
4	Mile 38 Camp	Near mile Marker 38, south side of ONRT
5	Kiamichi Trailhead Camp	East of Kiamichi Trailhead
6	Pine Mountain Camp	100 yards east of Kiamichi Trailhead
7	River Sign Camp	In between mile 40 and Big River Camp. Near the Kiamichi River sign.
8	Big River Camp	West of mile marker 41
9	Mile 42 Camp	Near mile marker 42
10	Valley Camp	50 yards west of mile marker 43
11	Mile 43 Camp	Near mile marker 43
12	Island Camp	A quarter mile east of mile marker 43
13	Road Camp	Middle of the road south of mile marker 44
14	Lower Beech Camp	200 yards east of mile marker 44
15	New Camp	Between Upper Beech Camp and Lower Beech Camp. North of Lower Beech Camp 142 feet.
16	Upper Beech Camp	One half mile east of mile marker 44
17	Rehabilitated Camp	One quarter mile west of mile marker 45

[a] For campsite location, and photographic representation see Appendices A and G.

Campsite names were assigned for further distinction, as they were campsite descriptors. The campsite names previously used in Kuzmic's 1993 study, were used in this study. Some campsites have naturally recovered since his study and were omitted from this study. There were additional campsites that were not included in previous studies, or were created since . These campsites were Wilton's Point (camp 3), Pine Mountain (camp 6), Mile 42 (camp 9), Mile 43 (camp 11), Island (camp 12), New (camp 15), and Rehabilitated (camp 17).

Trail transects were located at mile intervals along the Ouachita National Recreation Trail. Some trail transects were easily located, placed near mile markers. However, many mile markers were not found due to vegetation growth or possible vandalism. Transects not located near a mile marker or "trouble areas" transects required a more descriptive reference for re-location. Trouble area transects tended to have either steep slopes and high erosion potential, or were relatively flat areas where water drainage was slow and puddles formed.

Trail transects were identified (Appendix B) and site descriptions and referencing were documented (Table 7) for relocation and repeat measurement purposes for future monitoring. Each trail transect was numbered consecutively, beginning with the transect closest to the western trailhead, the Pashubbe Creek entrance, and preceding east along the ONRT.

TABLE 7

TRAIL TRANSECT NUMBER, TYPE, AND LOCATION ALONG THE OUACHITA NATIONAL RECREATION TRAIL[a]

Number	Type	Location
1	Mile 35	Mile marker 35, emblazoned tree and marker cap on the ground.
2	Trouble Area	500 feet east of mile marker 35.
3	Mile 36	Mile 36 transect, no marker cap found, small tree is marked.
4	Mile 37	Mile 37 transect, no marker cap found, black oak tree is marked.

TABLE 7 (Continued)

Number	Type	Location
5	Mile 38	Mile 38 transect, no marker cap found, switch-back, near a Farkelberry tree.
6	Mile 39	Mile marker 39, emblazoned pine tree, marker cap on the ground.
7	Mile 40	Mile 40 transect, no marker cap found, 1000 feet west of wildlife food plot area.
8	Mile 41	Mile marker 41, marker cap on the ground.
9	Mile 42	Mile 42 Transect, 20 feet past Kiamichi River, near campsite seven, no marker cap found.
10	Mile 43	Mile marker 43, emblazoned tree, marker cap on the ground.
11	Mile 44	Mile marker 44, emblazoned tree, marker cap on the ground and painted rock.
12	Trouble Area	150 feet east of the "Upper Beech Campsite," near tree carved with "JD, DD."
13	Mile 45	Mile 45 Transect, small tree is marked, no marker cap found.
14	Trouble Area	Transect before switchback, near overlook, one third mile west of Mile 46 transect.
15	Mile 46	Mile 46 Transect, between "big boulder" and the "scarecrow tree," no marker cap found.
16	Trouble Area	Marked tree, 100 yards west of Talimena Drive.

[a] For trail transect location, and photographic representation see Appendices B and H.

Methods for Collecting Campsite Data

Data were collected for evaluation of campsite impact and identification of severely impacted areas. Several impact parameters were required to achieve a clear representation of the UKRW impact levels. A detailed step by step procedure was created for field operations and data collection forms were made to record the data for analysis (Appendix C).

Campsite impact measurement methods were derived from methodologies obtained from the literature studied and through the "Wilderness Campsite Impact Permanent Sampling Unit Form" provided by the UKRW managers.

Additional documentation was made to reflect the campsite's use type and level or ecological campsite conditions. This data type was divided into categories or classes of ordinal measurement for analysis. The categories or classes listed throughout this study were defined by the "Wilderness Campsite Impact Permanent Sampling Unit Form."

After campsite location, the first step was to locate campsite center point, for current measurement, and future measurements. The campsite's center was located in the campsite's geometric center, and on most campsites, the fire ring was the most appropriate campsite center location. The campsite's center point was then located in reference to three objects not easily removed. The azimuth and distance (nearest tenth foot) from the campsite's center to the object was recorded. Reference markers were trees, marked boulders, mile markers, or other distinct permanent features. Table 8, page 47, lists viable reference objects and recorded information in respect of those objects. Future analysis was dependent upon the re-location of the exact center point that was used in this initial study.

Photographs were taken to establish a photo record for further documentation. Photographs were in the form of slides for easy use in presentations, and a select set of photographs from each campsite was converted to hardcopy form (Brewer and Berrier 1984).

Measured Parameters.

The area of the campsite was determined through Cole's (1987) fixed radial transect method (Figure 5, page 48). Sixteen transects radiate at 22.5° intervals from the center point, starting at 0° and proceeding clockwise. Along each transect the distances from campsite center to the first sign of vegetation and the distance to the perceived campsite boundary was recorded.

Flagging pins were placed along the determined campsite boundary for photographic purposes. The campsite boundary was determined through Marion's (1991) definition of campsite boundaries, which included changes in vegetation cover, vegetation composition, vegetation height/disturbance, topography, organic litter amount and/or organic litter type.

TABLE 8

VIABLE REFERENCE MARKERS, AND NECESSARY DATA
TO COLLECT FOR EACH MARKER

Reference Marker	Data to Collect
Mile Marker	Mile marker number, azimuth and distance from the mile marker to the object in question.
Tree	Species, diameter at breast height, reasoning it was chosen, azimuth and distance to object in question.
Other object	Type of object, why it was chosen, azimuth and distance to object in question.

Two areas that changed the total campsite area as measured through the fixed radial method were undisturbed islands and satellite areas. Undisturbed islands were areas within the established campsite boundaries that were not impacted through recreational use. These areas were subtracted from total campsite area measurements. Satellite sites were areas outside the perceived boundary of the campsite, that were impacted through recreational use and this use tied the satellite site to the campsite, therefore the satellite site area was added to total campsite area. All undisturbed islands or satellite areas were identified and measured. These areas were derived through the geometric method as defined by Marion (1991).

Within the site boundary, the number and location of trees was documented, and the amount of stem damage and root damage was recorded using Marion's (1991) categories and definitions. Through this study, Cole's (1987) tree definition was used, as a tree was a woody species of at least one hundred and fifty-five inches in height.

Soil and vegetation impact parameters were measured through the use of quadrates placed along four transects established on the site. Quadrate placement transects initiated from the campsite center point and continued to the campsites edge. The azimuth for the first quadrate placement transect was randomly determined prior to data collection. There were three subsequent quadrate transects positioned at ninety degrees intervals, rotating in a clockwise direction from the first transect. Quadrates, one meter square, were placed along these transects at a predetermined distance (Appendix D). Quadrate spacing varied along transects, and this spacing was based on the transect length, allowing for the maximum number of quadrates. Quadrate spacing was greater, nearer to the camp's center, to avoid over sampling the campsite's center.

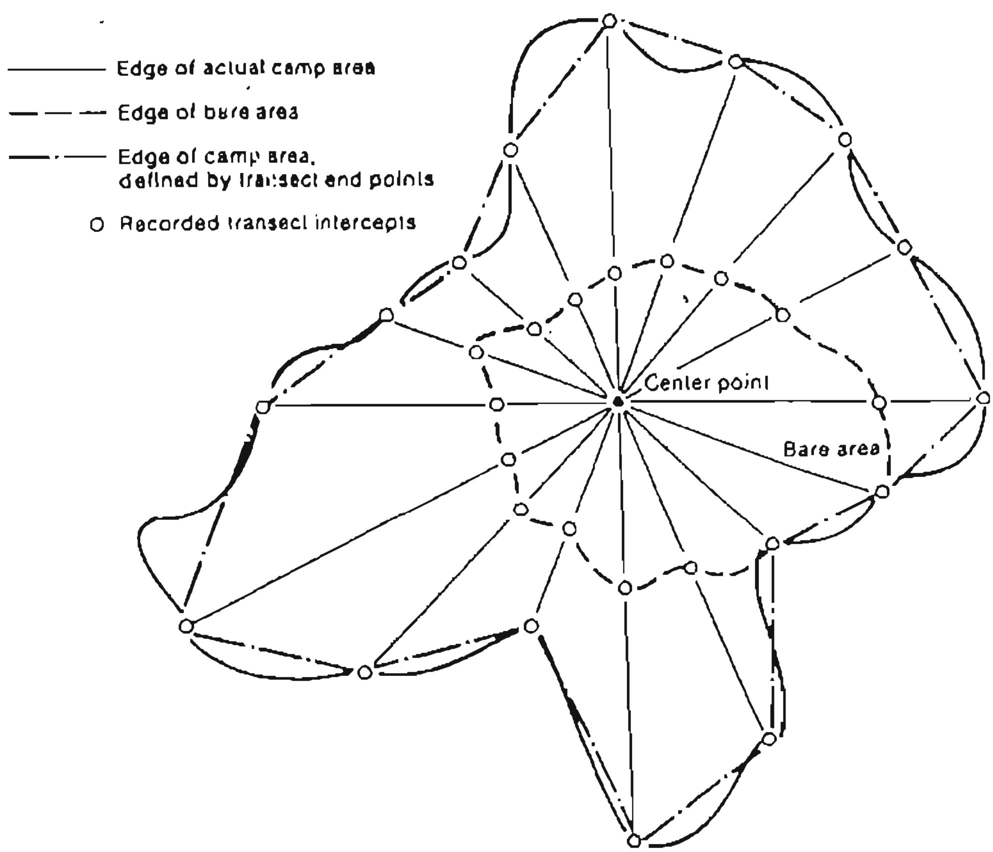


Figure 5. Fixed Radial Transect Method to Evaluate Campsite Area, from Cole 1987.

Vegetation cover was the percent campsite area covered with live, non-woody vegetation. Vegetation coverage was measured through quadrate estimates. Within each quadrate, the percentage of vegetation cover was analyzed. Additionally, measured percentages were placed into one of five categories defined on the "Campground Form."

Bare soil exposure was the percent campsite area with little or no organic litter and no vegetation cover. This parameter was estimated in conjunction with the vegetation cover listed above. This parameter was also divided into five categories for analysis purposes.

Soil compaction was measured with a soil penetrometer, and measurements were taken at the lower right hand quadrate corner, facing from the campsite's center toward the campsite's edge. In the event that the quadrate placement created a potential measurement in an area dissimilar to overall grid conditions, the penetrometer reading was deferred to the lower left hand corner. Measurements were recorded in units of kilograms per square centimeter.

Water infiltration rates were randomly taken twice per site within 1 to 2 meters from the site's center along two site quadrant transects, and were measure with a double-ring infiltrometer. Time (minutes) elapsed for the infiltration of the first 0.39 inch (1 cm) of water was called the instantaneous rate, and was recorded as 1cm / minute. Further, time (minute) elapsed for the first two inches (5 cm) was called the saturation rate, and was recorded as 5 cm/minute.

The distance from campsite's center to the ONRT's edge was measured to find the campsites distance to primary trail. This parameter was compared to Opportunity Class 3's (O. C. 3) standard of 100 feet as noted from UKRW's LAC plan.

The distance from the campsite's center to the nearest water source edge was also measured and compared to this indicator's O. C. 3 standard of 100 feet. This parameter was physically measured only if the water source was closer than two hundred feet. If the nearest water source was greater than two hundred feet the distance was measured on a map.

The distance to the next closest campsite was a parameter affecting the amount of solitude during the stay. If the closest campsite was closer than two hundred feet the distance from one campsite to the other campsite was measured with a cloth tape. Otherwise, the distances were measured on a map.

Qualitative Parameters.

Additional qualitative aspects of campsites were also recorded to evaluate the level of use and the potential for impact. Each of these variable's categories were predetermined through the "campground form" provided (Appendix C). During data collection, the researcher observed the site and decided upon the "most appropriate" category for the estimated parameter. These classifications were at the researchers discretion.

Amount of litter on the site was inventoried. Litter or trash was defined as any human-based article that does not occur naturally in nature and was left in nature. Human waste was also included in the category of Litter/Trash and was defined as either food scraps or fecal matter. The amount of litter was evaluated within the site boundaries and then group into categories described below.

1.) No more than scattered charcoal from one fire ring. No litter.
2.) Remnants of more than one fire ring, some litter or manure. Some litter is a handful up to a two and a half gallon container of litter.
3.) Human waste, much litter or manure. Much litter is more than a two and a half gallon container of litter

The availability of firewood was measured and placed into categories as defined by the form. The categories were;

1.) On site
2.) 50 feet away
3.) 50-100 feet away
4.) More than 100 feet away.

Condition class for the site was recorded for site descriptive assessment and comparison with other sites. Campsite condition assessments were based on Frissell's (1978)

Condition Class definitions (Table 1, page 27).

Dominant species was recorded, and was defined as a simple evaluation of which tree species is most dominant species on the site. Later, this parameter was grouped into mixed hardwood, shortleaf pine, and cove species.

The parameters for the most prominent vegetation type of the site was recorded utilizing six classes of vegetation. These classes included;

1.) Forest/Ridgetop

2.) Forest/Forbs/Shrubs

3.) Forest/Lush Grass

4.) Old Homestead

5.) Grassland/Glade

6.) Riparian

Landform classification was recorded for each campsite into one of the following categories;

1.) North Slope

2.) Creek Bottom

3.) Shelter Bluff

4.) South Slope

5.) Ridgetop

6.) Terrace

The amount of screening was measured both from the campsite to the trail and from the campsite to another campsite. This screening was classified into one of the following categories.

1.) Complete

2.) Partial

3.) None

Data collected for these impact parameters were done through estimation of the degree by which the camp was partitioned from the trail or another campsite. If the trail or campsite could not be seen, this screening was complete, and if the campsite or trail could be seen completely, there was no screening. Any other campsite condition was classified as partial.

The number of social trails associated with the site was another aspect measured.

Maximum party size of the campsite was recorded. This parameter was an estimate of the number of people the site could accommodate. There was no direct way of measuring this variable, as the investigator estimated the number of possible tent pads and place the data into one of the following categories.

1.) 1-2

2.) 3-6

3.) 7-10

4.) 11-15

5.) more than 15

The type of use that had occurred on the site in the past was recorded. "Best guesses" were made and grouped the data into one of the following categories.

1.) Hiker

2.) Horse

3.) Hunter-hiker

4.) Hunter-auto

The type and number of facilities on the site was recorded. Such developments include fire ring, primitive seat, constructed seat, table, shelf, meat rack, hitchrail, or other.

Control Plots

Control plots represented the natural campsite condition, unaffected by human-induced impacts. Each campsite had an unique control plot, which was located on a pre-determined azimuth and distance equal to three times the length of the nearest campsite transect to that azimuth. The control site was perceived as identical to the campsite in landform, vegetation type, slope, and aspect. Great importance was placed in the location of a suitable control plot, due to analysis and statistical inferences made between change levels of campsites and controls. If a control plot was located in an unrepresentative setting, the process was repeated by randomly drawing a new azimuth and moving to a new location. Azimuth and distance was recorded from the campsite center point to the control. Parameters measured on control plots were percent vegetation cover, percent bare ground exposure, soil compaction, soil infiltration rates, and tree damage. Measurement of all parameters for control plots were identical as campsite measurements, with the same quadrant transects as the campsite.

Office Calculations

After returning from the field, areal measurements were calculated. The barren core area and total campsite area was calculated by microcomputer software. Both the total campsite area and barren core area was calculated to the nearest hundredth of squared foot. A map of the campsite was drawn from data taken above (Appendix I).

The "campground impact index" was a generalized gauge to analyze the relative impact that had occurred on the campsite. The index rating conveyed the amount of impact caused under the current level of use. The campsite index rating was the average rating of nine various impact parameters including; vegetation loss, bare mineral soil increase, tree stem damage, tree root damage, developments, cleanliness, number of social trails, camp area, and barren core area. Through the use of the form, the data was placed into one of three defined categories and the average of the parameters was the rating, which ranged from 1.0 to 3.0 (Appendix E).

Measurements were made to determine the campsite's distance from the nearest trailhead and this parameter was recorded for correlation analysis.

Campsite density was also calculated and compared to the standard. Campsite density calculation methods were not found through literature review of past researchers. The overall UKRW campsite density could be found by dividing total number of camps by total distance of

ONRT within the UKRW boundary. While this would demonstrate the UKRW's campsite density, this method would not determine specific campsites that exceeded the standard of one camp per mile. Additionally, due to campsite clustering in riparian areas and few campsites located in non-riparian areas, a mile by mile calculation was not representative of an individual campsite's density. Therefore, a method for calculating individual campsite density was developed. When measuring campsite density for a campsite, distances of two campsites flanking the measured campsite was calculated and then this number was divided into three, as three campsites were present over the distance in question.

Campsites one and seventeen were near a trailhead and the distance from the trailhead to the measured campsite was added to distance of the next campsite down the trail. This calculated distance was then divided into two, as only two campsites were present in this distance.

An example for calculating the density for a campsite two was as follows; the distance between campsite one and campsite two was 1.33 miles and the distance between campsite two and three was 0.048 miles. This distance was added and then divided into three, resulting in a campsite density of 2.17 camps/mile.

Data Collected at Trail Transects

Trail data included the amount of trail litter, trail variables (Table 5, page 40), and additional parameters that may influence trail impact levels. Trail measurements were taken at trail transect, including trail width, trail tread depth, number of trail treads, slope, and trail profile. Trail transects were established at locations previously described on Table 7, page 44.

Litter on the trail was evaluated while traveling along the trail. The amount and location of litter found on the trail was recorded. Office calculations were made to record the amount of litter per mile and overall trail litter.

Trail transects were established primarily for baseline measurements for comparisons in the future. Trail transects were located every mile along the Ouachita National Recreation Trail.

A step-by-step procedure of the trail transect data collection and the trail transect data collection form was created (Appendix F).

After locating the correct trail transect position, the location of the first trail profile bracket's endpoint was established. This endpoint was a 1/2 inch metal threaded pipe, and it was tapped into the ground, where the top of the pipe was level or just below the ground's surface. This endpoint was referenced to three reference points, as documented in the same manner as the campsite's reference points (Table 8, page 46). After the initial endpoint was established the secondary fixed point was positioned, as a transect line between the two fixed end points on either side of the trail was perpendicular to trail travel. The fixed points extended one foot past the determined trail edge and total distance was measured to the nearest whole foot. The azimuth and distance from the first end point and the second end point was recorded. Three photos were taken and a sketch map was provided for future reference.

The trail profile bracket was designed by Thomas Kuzmic at Oklahoma State University, resembling those of previous studies (Cole 1983a, Hammitt and Cole 1987). A PVC pipe was inserted to the fixed point receptacles (Figure 3, page 32). The height of the risers were above the existing microtopography and vegetation. The profile bracket was constructed across the trail. Risers were placed in every place needed to provide a solid level bracket, line levels were used to ensure that the line was level, and the entire distance across the trail was measured.

The trail profile area was computed by measuring the distance from the top of the bracket to the ground. Measurements were taken every six inches (nearest tenth of an inch) and a plumb bob was used to verify a measurement perpendicular to the ground.

Additional measurements were taken, including width of trail, width of bare ground, maximum depth, and number trail treads. The width of trail included the distance of the zone obviously disturbed by trampling (to the nearest tenth of inch). The width of the bare ground was the length from one edge of the zone that lacks vegetation to the other (to the nearest inch). The maximum trail tread depth was documented by measuring the deepest trail tread location. A trail tread count was also made for the number of trail treads. In addition to trail cross-sectional area, additional data was recorded for complete inventory of the area. This data included vegetation type, dominant species, landform, slope of the trail, aspect and slope across the trail. The classification of these categories was grouped into the same classes recorded for the campsites. The slope of the trail, aspect and slope across the trail was measured with a Suunto clinometer. Trail profile area was calculated after returning from the field through the use of the formula described in Figure 3.

Statistical Analysis

The hypotheses, listed in Table 2, page 36, and Table 4, page 39, were evaluated through non-parametric procedures. Campsite hypothesis one was tested with the Wilcoxen Matched Ranked Pairs test which is the non-parametric t-test. This test was treated as a two-tailed test. The second, third, and fourth campsite hypotheses as well as the first and second trail transect hypotheses were evaluated with the Kruskal-Wallis test. The Kruskal-Wallis test is the non-parametric version of the F-test. Finally, campsite hypotheses five and six and trail transect hypotheses three and four were tested for correlation using the Spearman Rank Correlation. Additional comparisons of impacts at the UKRW were presented in tabular outputs and graphs. All statistical analyses were performed at the significance level of 0.05.

CHAPTER IV

RESULTS AND DISCUSSION

Comparison of Impact Parameters Among All Campsites

Data were collected at each campsite in three replications. Data collection periods were May 6 through May 12, June 3 through June 7, and July 17 through July 21, 1996. Seventeen campsites were identified and evaluated. All campsites were located near the Ouachita National Recreation Trail (ONRT) and visitors created no new campsite after the initiation of data collection. Camps within the UKRW were positioned along the ONRT in varying vegetation types and landform types with campsite concentration along the Kiamichi River. Data was pooled from the three replicates for statistical analyses. Due to varying campsite areas, the degrees of freedom for each test varied, based on number of quadrates.

Campsite impact levels as well as impact type varied across the entire wilderness area. Due to variability of soil, vegetation, geologic, and other ecological conditions, each campsite was evaluated by examining differences in conditions to its control. Variability was found among these comparisons, and in most cases campsites were significantly different than controls.

Many impact parameters were interrelated. Generally, campsites that had lower vegetation cover percentages, also had higher bare ground exposures, higher soil compaction, and lower infiltration rates. Percent tree damage across campsites seemed to be independent from other impact variables.

Percent Vegetation Cover

Each campsite had an average percent vegetation coverage significantly different from its control (Table 9, page 59). This parameter varied among campsites and controls. Campsite sixteen had the lowest percentage of 6.79%, as this area was almost completely denuded of vegetation. Campsite seven had the highest average vegetation cover of 92.77%.

Each campsite had significantly lower percentages of vegetation coverage except campsite seven, which displayed a higher average vegetation coverage than was found on its control. This campsite was positioned in an open area surrounded by a dense stand of trees. Therefore, camp seven's control was located in an area with complete enclosed canopy, and had a thick duff layer which led to a low mean vegetation cover percentage. The location of the control was necessary to maintain similarity in soil type, geological conditions, and environmental conditions. Inferences could be made that the campsite was located in an area where trees were removed prior to wilderness designation, and through recreational use, the area was not allowed to develop to its climax condition.

Additionally, campsite two, Wilton Mountain, was located on a forested ridgetop, with a percent vegetation cover of 24.92%. This was a low vegetation cover percentage in comparison to other campsites; however, due to low vegetation coverage on its control, this campsite exhibited the lowest average difference among all campsites with a difference of only 4.13%. The highest difference was found on campsite sixteen where the average vegetation loss was 90.09%.

Comparisons were made between use levels and percent vegetation losses. Each campsite exhibited a degree of impact due to recreational uses. Further, Kuzmic (1993) reported that campsites eight, five, and two were the most heavily used campsites, and these campsites were also camps that exhibited the highest vegetational losses. This suggested that the percent vegetation loss is related to use levels, and as use increased, vegetation losses increased.

There was also evidence of low tolerance levels. Upper Beech Grove camp, was reported to have a moderate use level with 45 camper-nights per year (Kuzmic 1993), and this campsite had the greatest vegetation loss. This suggested that campsites exhibited various levels of tolerance, and this tolerance affected the overall campsite impact level.

TABLE 9

COMPARISON OF PERCENT VEGETATION COVER OF INDIVIDUAL CAMPSITES AND CONTROLS

Campsite Number[a]	Camp		Control		t-value (d. f.)
	Mean	Range	Mean	Range	
	Percent				
1	70.82	10-100	88.9	80-100	13.55[b] (49)
2	24.92	0-80	29.15	5-70	8.65[b] (58)
3	62.24	30-100	88.88	70-100	13.01[b] (48)
4	13.70	0-60	74.68	10-100	12.57[b] (46)
5	6.00	0-60	47.60	10-70	13.49[b] (49)
6	12.02	0-50	75.00	25-100	13.22[b] (52)
7	92.77	60-100	77.59	40-100	14.26[b] (55)
8	9.48	0-50	54.14	20-100	13.70[b] (57)
9	37.75	0-90	99.25	90-100	11.37[b] (39)
10	78.00	50-100	99.71	90-100	11.70[b] (34)
11	74.46	50-100	97.57	90-100	11.73[b] (36)
12	70.91	10-100	97.05	90-100	13.10[b] (43)
13	24.04	0-80	43.19	10-70	12.38[b] (46)
14	25.42	0-90	94.44	80-100	11.22[b] (35)
15	54.33	5-100	97.00	90-100	9.97[b] (29)
16	6.79	0-50	96.88	80-100	15.56[b] (55)
17	17.43	0-70	96.71	90-100	11.06[b] (34)

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Significant difference, $p < 0.0001$; Hypothesis 1 rejected for percent vegetation cover.

Wilderness areas in close proximity tend to exhibit similar traits, and due to climatic, ecological, and vegetation conditions, the UKRW could be compared to similar wilderness areas in the south-central United States. McEwen and others (1996) studied such wilderness areas and they reported these area's average percent vegetation loss. UKRW campsite average vegetation loss was 37.00% which was lower than the percent vegetation loss of 52% on Caney Creek Wilderness campsites but higher than campsites at Upper Buffalo, Hercules Glades, and Gardens of the Gods Wilderness areas with averages ranging from 23% to 29%. This suggested that UKRW campsites had moderate impact trends and/or tolerances and although the area had been impacted, this impact does not require severe management schemes for remediation.

Percent Mineral Soil Exposure.

Each campsite's mean mineral soil exposure was significantly different from its control (Table 10, page 61), and these differences varied across campsites. Campsite eight displayed the highest percent bare ground area with an average of 77.50%, while campsite sixteen had a similar average of 70.71%. These two campsites had the largest barren core area (1184.38 ft^2 and 1600.00 ft^2 respectively), and they were considered the most impacted campsites within the UKRW.

Campsite four exhibited the lowest percent bare ground exposure of only 0.22%. However, this campsite exhibited a significant difference from its control which had no bare ground exposure.

Seven campsites exhibited total campsite areas with less than 10% bare ground exposure. These campsites displayed light use and/or the ability to regenerate themselves after use (Table 10, page 61). The remaining campsites had variable mean mineral soil exposure percentages ranging from 12.96% to 77.50%. The undisturbed control areas displayed a range of percent bare ground area of 0.00% to 3.76%.

TABLE 10

COMPARISON OF PERCENT MINERAL SOIL EXPOSURE OF INDIVIDUAL CAMPSITES AND CONTROLS

Campsite Number[a]	Camp		Control		
	Mean	Range	Mean	Range	t-value (d. f.)
	---------------- Percent ----------------				
1	12.96	0-80	0.15	0-05	13.42[b] (49)
2	22.20	0-90	3.76	0-20	14.26[b] (58)
3	6.33	0-30	0.00	0-0	13.01[b] (48)
4	0.22	0-5	0.00	0-0	8.07[b] (46)
5	37.70	0-100	0.20	0-10	12.85[b] (49)
6	34.42	0-100	0.19	0-10	13.23[b] (52)
7	0.89	5-20	0.17	0-10	26.47[b] (55)
8	77.50	0-100	1.89	0-10	14.21[b] (57)
9	37.13	0-100	0.00	0-0	11.53[b] (39)
10	4.29	0-20	0.00	0-0	12.24[b] (34)
11	2.02	0-10	0.00	0-0	15.73[b] (36)
12	2.95	0-20	0.00	0-0	15.48[b] (43)
13	49.89	0-100	0.00	0-0	12.36[b] (46)
14	48.74	0-100	0.00	0-0	11.17[b] (35)
15	13.00	0-95	0.00	0-0	11.93[b] (29)
16	70.71	0-100	0.36	0-10	14.49[b] (55)
17	53.14	0-100	0.28	0-10	10.71[b] (34)

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Significant difference, $p < 0.0001$; Hypothesis 1 rejected for percent vegetation cover.

By comparing UKRW campsite conditions to other wilderness areas in south-central

United Sates, overall campsite conditions could be inferred. The UKRW had an average percent bare ground exposure of 27.48% which was very similar to Caney Creek Wilderness campsites having a bare ground average of 28%, and higher than sites at Upper Buffalo, Hercules Glades, and Gardens of the Gods Wildernesses which had averages of 21%, 19%, and 14% respectively (McEwen *et al.* 1996).

However, by excluding campsites eight and sixteen from the overall UKRW campsite average, the mean percent bare ground area was only 21.41%, which was similar to Upper Buffalo Wilderness. Again, this suggested that remediation prescriptions may be necessary on specific sites, but the wilderness as a whole was not severely impacted.

Soil Compaction

Campsite soil compaction measurements were significantly different from control measurements (Table 11, page 63). The average soil compaction varied between each campsite and control. Again, campsite sixteen exhibited the greatest impact with an average penetrometer reading of 3.54 kg/cm^2 and a campsite to control difference of 2.56 kg/cm^2. Campsite eight also had an average soil compaction reading relatively close to camp sixteen's with a measurement of 3.48 kg/cm^2, and a campsite to control difference of 2.13 kg/cm^2.

Campsite seven had the lowest average soil penetrometer reading of 1.33 kg/cm^2. This campsite's control had an average penetrometer reading of 0.91 kg/cm^2, which resulted in being the lowest difference among campsites of 0.42 kg/cm^2.

Variability was shown in comparison of studies done in other wilderness areas. Cole and Hall (1992) identified differences of penetrometer readings in two of their study areas. In 1981, Bob Marshall Wilderness had an average reading of 3.3 kg/cm^2 on the campsites with an average of 2.3 kg/cm^2 on controls (difference of 1.00 kg/cm^2). However, in 1990, this same area had an average of 2.4 kg/cm^2 on campsites, and 1.70 kg/cm^2 on controls (difference of 0.70 kg/cm^2). They also found that in 1984, Grand Canyon National Park had an average soil compaction rate of 2.7 kg/cm^2 on its campsites and 0.70 kg/cm^2 on its controls (difference of

TABLE 11

COMPARISON OF SOIL COMPACTION OF INDIVIDUAL CAMPSITES AND CONTROLS

Campsite Number[a]	Camp		Control		
	Mean	Range	Mean	Range	t-value (d. f.)
	---------------- kg/cm^2		----------------		
1	1.90	1.25 -3.0	0.84	0.5-1.25	12.65[b] (49)
2	1.92	1.0 -2.5	1.04	0.5-1.25	13.68[b] (58)
3	1.77	1.25-2.25	0.87	0.5-1.25	12.50[b] (48)
4	1.49	0.75-2.0	1.00	0.5-1.25	9.27[b] (46)
5	1.87	1.5-2.25	1.20	0.75-1.75	12.69[b] (49)
6	2.23	1.5 -4.5	1.05	0.5-2.00	12.69[b] (52)
7	1.33	0.5 -3.0	0.91	0.5-1.5	7.29[b] (55)
8	3.48	1.75-4.5	1.35	1.0-1.75	13.38[b] (57)
9	2.19	1.0 -3.0	1.18	0.75-1.5	11.25[b] (39)
10	1.61	1.0-2.25	0.92	0.5-1.5	10.67[b] (34)
11	1.59	1.0-2.25	0.87	0.5-1.25	10.87[b] (36)
12	1.67	1.0-2.25	1.01	0.5-1.25	11.73[b] (43)
13	2.23	1.0-3.25	0.96	0.5-1.25	12.12[b] (46)
14	2.37	1.0 -4.0	0.88	0.5-1.25	10.65[b] (35)
15	1.74	0.5 -2.5	0.81	0.5-1.25	9.94[b] (29)
16	3.54	2.0 -4.5	0.98	0.75-1.5	13.18[b] (55)
17	2.43	1.75-3.25	0.94	0.75-1.0	10.52[b] (34)

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Significant difference, $p < 0.0001$, Hypothesis 1 rejected for soil compaction.

2.00 kg/cm^2). While in 1989, this area had readings of 2.1 kg/cm^2 on campsites and 0.5 kg/cm^2 on its control. Differences of both campsite and control measurements, between the time measurements were taken, demonstrated the phenomenon of seasonal variability of compaction measurements (Cole and Hall 1992).

Instantaneous Infiltration Rate

Instantaneous infiltration rates were significantly different between campsites and controls, and these rates varied across campsite areas (Table 12). Again the greatest impacted sites were campsite eight and campsite sixteen with 0.09 cm/min and 0.55 cm/min respectively. Remaining campsites had rates above 1 cm/min, ranging from 1.25 cm/min on campsite one to 2.50 cm/min on campsite fifteen. The instantaneous infiltration rate of the controls were all well above 1 cm/min, with the highest rate on control fourteen with 4.16 cm/min.

TABLE 12

COMPARISON OF INSTANTANEOUS INFILTRATION RATES
OF INDIVIDUAL CAMPSITES AND CONTROLS

Campsite Number[a]	Camp		Control		t-value	(d. f.)
	Mean	Range	Mean	Range		
	cm / min					
1	1.25	1.59- 1.09	3.23	2.38- 1.49	4.08[b]	(3)
2	1.33	1.49- 1.21	1.59	1.72- 1.43	3.87[b]	(3)
3	1.33	1.72- 1.21	1.59	2.00- 1.43	4.08[b]	(3)
4	1.39	1.72- 1.09	2.22	2.44- 2.08	3.87[b]	(3)
5	1.96	2.38- 1.49	2.63	3.03- 2.22	4.95[c]	(5)
6	1.59	1.92- 1.33	2.44	3.18- 2.08	4.71[c]	(5)
7	1.92	2.33- 1.67	3.03	3.70- 2.50	4.08[b]	(3)
8	0.09	0.15- 0.07	1.45	1.92- 1.15	4.58[c]	(5)

TABLE 12 (Continued)

Campsite Number[a]	Camp		Control			
	Mean	Range	Mean	Range	t-value	(d. f.)
	------------- cm / min -----------------					
9	1.49	1.72- 1.33	2.86	3.70- 2.38	3.87[b]	(3)
10	1.61	1.92- 1.45	2.86	3.33- 2.38	4.08[b]	(3)
11	1.85	2.08- 1.72	2.86	4.00- 2.38	4.08[b]	(3)
12	2.50	3.08- 2.00	3.08	4.00- 2.63	3.87[b]	(3)
13	1.32	1.54- 1.18	2.94	4.00- 2.38	3.87[b]	(3)
14	1.69	2.00- 1.49	4.17	5.88- 3.08	4.58[c]	(5)
15	2.50	3.33- 1.72	3.70	4.00- 3.03	4.87[c]	(5)
16	0.55	0.57- 0.52	2.38	4.00- 1.87	4.64[c]	(5)
17	1.67	2.00- 1.33	2.70	4.00- 2.38	4.58[c]	(5)

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Significant difference, $p < 0.05$; Hypothesis 1 rejected for instantaneous infiltration rates.
[c] Significant difference, $p < 0.01$; Hypothesis 1 rejected for instantaneous infiltration rates.

UKRW campsite average difference for instantaneous infiltration rates was 1 16 cm/min. Highly impacted campsites exhibited greater differences between campsites and controls. However, some variability was found which implied that there were other factors that influenced the sites tolerance to soil compaction. Remarkably, the highest difference was not found on either campsite eight or sixteen, but was found on campsite fourteen with a difference of 2.48 cm/min. Additionally, average differences greater than 1.50 cm/min were found on campsites one, thirteen, fourteen, and sixteen. The lowest differences were found on campsites two and three, with an average difference of only 0.26 cm/min.

The difference between the degrees of freedom among different campsites was due to rain, as some results were omitted. During the first data collection period, the area had precipitation on three of the six days data were collected. This event caused some infiltrometer readings to be significantly overstated, therefore they were omitted for a more representative sample.

Saturated Infiltration Rate

Likewise, saturation infiltration rates varied among all campsites (Table 13). The lowest saturation infiltration rates were found on campsite eight with a reading of 0.17 cm/min and campsite sixteen with 0.43 cm/min. Campsite twelve had the highest reading of 2.19 cm/min. The readings of the control plots ranged from the lowest of 1.12 cm/min on control plot eight to the highest of 2.96 cm/min on control fourteen.

Wilton's Point and River Sign campsites displayed saturated infiltration rates not significantly different from their controls. The remaining campsites were dissimilar from the controls, and significance levels varied. The overall average difference among campsites and controls was 0.69 cm/min. As with the instantaneous infiltration rates, the highest difference was found on campsite fourteen with 2.02 cm/min. The lowest average difference was found on campsite three with a difference of only 0.18 cm/min.

TABLE 13

COMPARISON OF SATURATED INFILTRATION RATES
OF INDIVIDUAL CAMPSITES AND CONTROLS

Campsite	Camp		Control			
Number[a]	Mean	Range	Mean	Range	t-value	(d.f.)
	- - - - - - - - - - - - - - cm / min	- - - - - - - - - - - - - - -				
1	1.36	1.48-1.23	1.87	2.43-1.77	3.87[c]	(3)
2	1.27	1.36-1.23	1.60	1.67-1.54	3.87[c]	(3)
3	1.43	1.71-1.30	1.61	1.71-1.51	2.28[b]	(3)
4	1.37	1.50-1.30	1.57	1.67-1.46	3.87[c]	(3)

TABLE 13 (Continued)

Campsite Number[a]	Camp		Control			
	Mean	Range	Mean	Range	t-value	(d.f.)
	cm / min					
5	1.85	2.07-1.50	2.07	2.22-1.94	4.65[d]	(5)
6	1.29	1.54-1.06	1.67	2.15-1.36	4.64[d]	(5)
7	1.80	1.87-1.75	2.15	2.42-1.81	3.87[b]	(3)
8	0.17	0.25-0.12	1.12	1.30-0.88	4.58[b]	(5)
9	1.48	1.74-1.33	2.13	2.48-1.98	3.87[c]	(3)
10	1.45	1.62-1.33	2.07	2.35-1.87	3.87[c]	(3)
11	1.73	2.22-1.39	2.19	2.40-2.06	3.87[c]	(3)
12	2.19	2.38-1.94	2.38	2.40-2.06	3.87[c]	(3)
13	1.19	1.54-1.05	2.28	2.48-2.10	3.87[c]	(3)
14	0.94	1.02-0.86	2.96	3.76-2.30	4.58[d]	(5)
15	1.49	1.98-1.15	2.74	3.16-2.30	4.87[d]	(5)
16	0.43	0.48-0.40	1.33	1.77-0.93	4.58[d]	(5)
17	1.15	1.23-1.09	1.87	2.30-1.54	4.58[d]	(5)

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Difference not significant, $p > 0.05$.
[c] Significant difference, $p < 0.05$; Hypothesis 1 rejected for saturated infiltration rates.
[d] Significant difference, $p < 0.01$; Hypothesis 1 rejected for saturated infiltration rates.

Tree Damage

Tree damage varied across campsites as percent tree damage ranged from 100% on campsites seven and sixteen, to none on campsites four and nine (Table 14, page 68). Campsites three, ten, eleven, thirteen, and fifteen did not have any trees within their boundaries.

The number of trees damaged on the campsites ranged from zero on a few sites to eleven on campsite eight. In every case, campsites had fewer trees than controls, although this could be considered a campsite selection preference rather than a trait induced through impacting use. Control plot trees displayed no noticeable damage.

UKRW had an average tree damage per campsite of 32.83%. This result was much lower than averages found on Eagle Cap and Bob Marshall Wildernesses (Cole and Hall 1992). Additionally, UKRW also had less average tree damage than the Great Smoky Mountains National Park, which displayed an average of tree damage of 63.00% (Marion and Leung 1996). This indicated lower overall use levels, and hence, lower impacts on UKRW trees.

TABLE 14

COMPARISON OF NUMBER OF DAMAGED TREES
OF INDIVIDUAL CAMPSITE TO CONTROL

	Camp			Control	
Campsite Number[a]	Trees Damaged	Total Trees	Tree Damage(%)	Trees Damaged	Total Trees
	------ number -----		--- Percent ---	------ number ------	
1	3	4	75	0	14
2	3	7	43	0	15
3	0	0	--	0	4
4	0	8	0	0	16
5	3	10	30	0	10
6	4	10	40	0	12
7	1	1	100	0	15
8	11	21	52	0	32
9	0	1	0	0	6
10	0	0	–	0	7
11	1	5	20	0	5

TABLE 14 (Continued)

Campsite Number[a]	Camp		Tree Damage(%)	Control	
	Trees Damaged	Total Trees		Trees Damaged	Total Trees
	------ number -----		--- Percent ---	------ number ------	
12	2	8	25	0	8
13	0	0	--	0	20
14	1	2	50	0	6
15	0	0	--	0	9
16	5	5	100	0	7
17	3	7	43	0	8

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.

Comparisons of Actual Impact Measured to the Standards

There were five indicators described in the plan for this area (U. S. Forest Service 1992). These indicators were barren core area, number of trees damaged, distance of campsite to trail and to nearest water source, and number of campsites per mile. Opportunity Class Three campsite standards were that campsites must have barren core area less than 200 ft^2, less than 4 damaged trees, be further than 100 feet from trail, be further than 100 feet from nearest water source, and exhibit a campsite density equal to or less than 1 campsite/mile.

Campsite area was not outlined as an UKRW indicator of impact. However, campsite area is considered as a major influence to perception of solitude and naturalness of many wilderness areas. Campsite area was included in this study as a comparison to level of impact. This parameter is a proposed indicator for gauging level of impact, with a standard for campsite area of 1000 ft^2. Campsites exhibiting moderate use were usually classified with measures of 500 ft^2 (Cole 1989). However, 500 ft^2 was considered a moderate sized campsite and many studies have reported median campsite size well above 500 ft^2 (Cole 1986, Cole and Hall 1992, Cole 1993b, Marion and Leung 1996, McEwen *et al.* 1996). For this reason the standard of 1000 ft^2 was deemed more appropriate.

Campsite area varied significantly across the campsites (Table 15). The mean campsite area was 915.47 ft^2 (85 m^2), which ranged from 381.81 ft^2 (35.45 m^2) on campsite fifteen to 2395.31 ft^2 (222.40 m^2) on campsite eight. Campsites two, five, six, seven, eight, and sixteen exceeded the proposed standard of 1000 ft^2. The remaining campsite areas varied among campsites.

The average UKRW campsite area was high when compared to other wilderness areas in south-central United States. McEwen and others (1996) reported that the average campsite area for Hercules Glades Wilderness was 80 m^2 (862 ft^2) and this measurement was the highest average campsite area in their four wilderness study area.

TABLE 15

COMPARISON OF CAMPSITE AREA, BARREN CORE AREA, AND NUMBER OF DAMAGED TREES OF INDIVIDUAL CAMPSITES TO THEIR RESPECTIVE STANDARDS

Campsite Number[a]	Campsite Area[b]	Barren Core Area	Number of Damaged Trees
	---------- $feet^2$ ----------		--- number ---
1	810.94[c]	21.88[e]	3[g]
2	1514.96[d]	93.75[e]	3[g]
3	804.69[c]	4.68[e]	0[g]
4	929.69[c]	31.25[e]	1[g]
5	1207.81[d]	793.16[f]	3[g]
6	1104.69[d]	587.50[f]	4[h]
7	1182.81[d]	1.56[e]	1[g]
8	2395.31[d]	1184.38[f]	8[h]

TABLE 15 (Continued)

Campsite Number[a]	Campsite Area[b]	Barren Core Area	Number of Damaged Trees
	- - - - - - - - - - $feet^2$ - - - - - - - - - - - -		- - - number - - -
9	471.88[c]	109.38[e]	0[g]
10	426.56[c]	10.94[e]	0[g]
11	381.25[c]	4.69[e]	0[g]
12	623.48[c]	15.63[e]	2[g]
13	685.94[c]	159.38[e]	0[g]
14	464.75[c]	175.00[e]	1[g]
15	382.81[c]	17.18[e]	0[g]
16	1678.13[d]	1600.00[f]	5[h]
17	497.28[c]	267.28[e]	3[g]

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Campsite area was not designated as an UKRW impact indicator, it was a proposed indicator.
[d] Does not exceed proposed standard for "Campsite Area" of 1000 $feet^2$.
[c] Exceeds proposed standard for "Campsite Area" of 1000 $feet^2$.
[e] Does not exceed standard for "Bare Soil Exposed" of 200 $feet^2$.
[f] Exceed standard for "Bare Soil Exposed" of 200 $feet^2$.
[g] Does not exceed standard for "Number of Damaged Trees" of 4 damaged trees per campsite.
[h] Exceed standard for "Number of Damaged Trees" of 4 damaged trees per campsite.

However, when compared to more popular wilderness areas, the UKRW exhibited a much lower average campsite area. Eagle Cap Wilderness in Montana had an average campsite area of 198 m^2 (2133 ft^2) in 1979, and a mean campsite area of 233 m^2 (2509 ft^2) in 1984 (Cole 1986). Likewise, Boundary Waters Canoe Area Wilderness in Minnesota, had a mean campsite area of 202 m^2 (2176 ft^2) (Marion and Merriam 1985), and Great Smoky Mountains National Park was reported to have an average campsite area, across all campsites of 175 m^2 (1885 ft^2) (Marion and Leung 1996).

Barren core area was an impact indicator on campsites as defined by the UKRW's LAC plan, with a standard of 200 ft^2. The average barren core area was 298.68 ft^2 (27.8 m^2) which ranged from 1.56 ft^2 (0.14 m^2) on campsite seven to 1600.00 ft^2 (148.56 m^2) on campsite sixteen. Campsites five, six, eight, and sixteen exceeded the standard for this indicator.

Average barren core area was also high when compared to other wilderness areas in south-central United States. Among the wilderness areas McEwen and others (1996) studied, the average barren core area, or de-vegetated area was 21 m^2 (226 ft^2) on Caney Creek Wilderness, and UKRW campsites had a larger average barren core area of 28m^2 (302 ft^2).

However, in comparing the UKRW to more popular wilderness areas, the UKRW exhibited a much lower barren core area. Eagle Cap Wilderness in Montana had an average bare area of 86 m^2 (926 ft^2) in 1979, and a mean bare area of 104 m^2 (1120 ft^2) in 1984 (Cole 1986). Great Smoky Mountains National Park had an average barren core area, across all campsites of 55 m^2 (592 ft^2) (Marion and Leung 1996). Additionally, Bob Marshall Wilderness had a mean barren core area of only 41 m^2 (442 ft^2) in 1981, and an average of only 34 m^2 (366 ft^2) in 1990 (Cole and Hall 1992).

The number of damaged trees was also an indicator of the impact on the sites. The standard was 4 damaged trees per campsite. Within the campsite area, the average number of trees was 4.94 trees/site, with an average number of trees damaged was 2.06 trees/site. By omitting campsites that had no trees within their areas, the average number of trees damaged per campsite increased to 2.83. Campsites six, eight, and sixteen exceeded the standard.

The distance of a campsite to its nearest water source was also an indicator of use that is detrimental to the condition of the wilderness's physical character. "Leave-No-Trace" camping practices advocate camping further than 200 feet from the nearest water source (Hampton and Cole, 1988). However, many UKRW campsites exceeded this indicator's standard of only 100 feet. The average distance of the campsite to the nearest water source was 904.00 feet (Table 16, page 73). The range for this parameter among all campsites was 9.80 feet to 4200 feet. However, when omitting all campsites west of the Upper Kiamichi River Trailhead from the calculation, this average was reduced to 78.31 feet. The range for this area was 9.80 feet to 451.09 feet. Campsite five, six, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, and seventeen all exceeded the standard for this indicator.

The trend of camping nearer to water is not unique to the UKRW. Fodor (1989) reported that over 29% of campsites located in the Sequoia and Kings Canyon National Parks were located within 25 feet of water. This result was similar to findings of campsites in the UKRW, as four of seventeen campsites were 25 feet from water (23%), and eleven (65%) were within 100 feet of water. In addition to a source of water for washing, drinking, and swimming, riparian camps offer higher aesthetics than non-riparian campsites. These are some reasons for their popularity. However, these activities can be detrimental to the water, and campsites located near riparian areas increase the probability for sediment discharge into the water.

TABLE 16

COMPARISON OF DISTANCES OF CAMPSITE TO WATER AND PRIMARY TRAIL, AND CAMPSITE DENSITY TO THEIR RESPECTIVE STANDARDS

Campsite Number[a]	Distance to Water	Distance to Primary Trail	Number of Campsites per Mile
	----------- feet	----------	- - Camps/Mile - -
1	2000.00[b]	20.20[e]	0.93[f]
2	4150.00[b]	23.60[e]	2.17[g]
3	4200.00[b]	251.30[d]	2.17[g]
4	4000.00[b]	28.60[e]	0.49[f]
5	21.00[c]	31.00[e]	0.62[f]
6	35.20[c]	21.50[e]	1.84[g]
7	451.09[b]	19.60[e]	0.99[f]
8	25.50[c]	23.00[e]	0.70[f]
9	41.30[c]	29.50[e]	0.74[f]

TABLE 16 (Continued)

Campsite Number[a]	Distance to Water	Distance to Primary Trail	Number of Campsites per Mile
	---------- feet ----------		- - Camps/Mile - -
10	157.10[b]	31.80[e]	3.40[g]
11	76.50[c]	27.00[e]	2.95[g]
12	27.20[c]	37.50[e]	1.03[g]
13	34.30[c]	11.50[e]	0.89[f]
14	9.80[c]	9.50[e]	1.99[g]
15	54.00[c]	7.80[e]	9.47[g]
16	71.00[c]	13.20[e]	2.81[g]
17	15.20[c]	8.50[e]	0.71[f]

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] Does not exceed standard for "Distance to Water" of 100 feet[2].
[c] Exceeds standard for "Distance to Water" of 100 feet[2].
[d] Does not exceed standard for "Distance to Primary Trail" of 100 feet[2].
[e] Exceed standard for "Distance to Primary Trail" of 100 feet[2].
[f] Does not exceed standard for "Number of Campsites per Mile" of 1 camp per mile.
[g] Exceeds standard for "Number of Campsites per Mile" of 1 camp per mile.

The distance of the campsite to the primary trail was an indicator for level of solitude. The standard for this indicator was 100 feet. The average distance of the campsite to the trail (ONRT) was 35.00 feet (Table 16, page 73). The range was 7.80 feet to 251.30 feet. All campsites exceeded this parameter except campsite three. In fact, the method to measure this parameter was the distance from the center of the campsite to the edge of the trail. Often, the edge of the campsite was touching the edge of the trail, and in one case, Road Camp, was in the middle of the trail.

In comparison to the Great Smoky Mountains National Park (GSMNP), the UKRW had similar traits of campsite distance to trail. Marion and Leung (1996) reported that nearly 60% of illegal campsites located in the GSMNP were less than 25 feet from the trail. Likewise, 59% of all UKRW campsites were located within 25 feet from the trail, and 94% were located less than 100 feet from the trail. In these cases, without designated campsite regulations, visitors tended to camp nearer to trails.

Campsite density was also a concern of the planners for wilderness character of the UKRW. Campsite density was recorded as the number of campsites per mile. The standard for this indicator was 1 camp/mile. The overall average of campsite density was 0.73 camps per mile. However, the individual campsite density ranged from 0.49 camps per mile to 9.47 camps per mile (Table 16, page 73). Campsites two, three, six, ten, twelve, fourteen, fifteen, and sixteen had density ratings of greater than one camp/mile.

In campsite density comparisons between the UKRW area as a whole to other wilderness areas, the UKRW exhibited fewer campsites per unit area. Cole (1993b) reported that in three wilderness areas he studied over a fifteen year period, the number of campsites increased. He stated that high-use lakes increased from 0.91 camps/ha to 2.13 camps/ha, and on low-use lakes the campsite density increased from 0.52 camps/ha to 1.73 camps/ha. He also reported that the campsite density of trail corridors only increased from 0.20 camps/ha to 0.27 camps/ha (Cole 1993b). For the entire area, the UKRW had a campsite density of only 0.004 camps/ha. This density was a lower density than Cole(1993b) found in his study area around lakes. In comparison to other south-central wildernesses, the UKRW had a campsite density of 0.38 campsites/km^2 which was a lower density than Caney Creek, Upper Buffalo, Hercules Glades and Garden of the Gods Wildernesses (McEwen *et al.* 1996). However, when only considering the ONRT corridor area (Opportunity Class Three, Figure 4., page 42) the campsite density was 0.25 campsites/ha (25.2 camps/km^2). This corridor (O. C. 3) was the primary area visited within the UKRW (Kuzmic 1993). This density was similar to Cole's (1993b) trail corridor density, and considerably higher than the four wilderness areas in McEwen and other (1996) study area.

Impact Rating Systems Analysis

There were two impact rating methods used in this analysis. Condition Class assessments were made using Frissell's condition class categories (Table 1, page 27), and Campground Impact Index Ratings (Appendix E). These rating systems used different methods to classify the level of impact in evidence at each site.

The average campground index rating for all sites was 1.93, ranging from 1.11 on campsite ten to 3.00 on campsite eight (Table 17, page 77) Campsite eight exhibited the highest impact rating possible, as it was classified as 3.00. Campsites five, six and sixteen were also well above 2.00, which indicated high impact levels.

The condition class assessment average was 2.82, ranging from condition class 1 on campsite seven, to condition class 5 on campsite sixteen (Table 17, page 77). Through this method, campsites eight, thirteen, and sixteen had a condition class of four or greater.

Individual Campsite Results

Each campsite had unique environmental conditions and unique trends of use. Additionally, each campsite had interrelated complexities that affected the differences in impact variables and the perceived level of impact. Consequently, a description of each campsite's measured impact parameters and use trends were recorded.

Pashubbe Point

Pashubbe Point camp, campsite one, was located in a mixed hardwood stand with deep lush grass vegetation covering most of the campsite area (Appendix A, G, and I). The campsite had a vegetation cover of 70.82%, which ranged from 10 to 100%, and was significantly lower than its control which had a vegetation coverage of 88.90% (Table 9, page 59). Likewise, the percent bare ground was significantly lower as the camp was 12.96% bare and the control was only 0.15% bare (Table 10, page 61) This site's average soil compaction

TABLE 17

COMPARISON OF CAMPSITE INDEX RATING AND CONDITION CLASS OF INDIVIDUAL CAMPSITES.

Campsite Number[a]	Index Rating[b]	Condition Class[c]
	---------------- Number ----------------	
1	1.55	3
2	2.00	3
3	1.44	2
4	1.78	3
5	2.56	3
6	2.56	3
7	1.55	1
8	3.00	4
9	1.78	3
10	1.11	2
11	1.44	2
12	1.55	2
13	1.78	4
14	1.89	3
15	1.33	3
16	2.67	5
17	1.89	2

[a] For individual campsite name and location see Table 6 (page 43) and/or Appendix A.
[b] For definition of "Campsite Index Rating," see Appendix E.
[c] For definition of "Condition Class," see Table 1, page 27.

was 1.90 kg/cm^2, and the control had an average of 0.84 kg/cm^2 (Table 11, page 63). Soil compaction affected both the instantaneous infiltration rate, and the saturated infiltration rate. These two infiltration rates were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66). Soil compaction was evident in soil penetrometer readings and both types of infiltration rates, as they were different from the control. This campsite also had four trees within its boundaries, and three trees exhibited damaged (Table 14, page 68).

Pashubbe Point's campsite area was 810.94 ft^2, while its barren core area was 21.88 ft^2 (Table 15, page 70). Measured distance from the campsite's center to the primary trail was 20.20 feet, while the distance from the campsite to water was more than 2000 feet. Campsite density was 0.93 camps/mile (Table 16, page 73), and this campsite had an index rating of 1.55 with a condition class rating of 3 (Table 17, page 77).

Implications of high vegetation cover and low bare ground area were that this site had a high tolerance of impact, either in impact resistance or resilience. Due to highly tolerant grasses, this campsite had the ability to recover from trampling after use. Further, total campsite area in comparison to barren core area indicated campsite impact tolerance. Campsite distance to trail was the only indicator exceeded.

Campsite area was minimally impacted through use, although it was the nearest campsite to Pashubbe Trailhead, it was reported to have about 40 camper-nights a year (Kuzmic 1993). Under this use level, the grass on the site were able to regenerate itself, removing some indication of impact.

Wilton Mountain

Wilton Mountain, campsite two, was located in a mixed hardwood stand, on a forested ridgetop (Appendix A, G, and I). The campsite had a vegetation cover of 24.92%, which ranged from 0 to 80%, which was significantly lower than its control vegetation coverage of 29.15% (Table 9, page 59). The percent bare ground exposure was also significantly higher from the control as the camp was 22.20% bare and the control was 3.76% bare (Table 10, page 61). The soil was also compacted through use, as the campsite had a soil penetrometer reading 1.92 kg/cm^2. and the control had 1.04 kg/cm^2 (Table 11, page 63). Soil compaction was also evident in both the instantaneous infiltration rate, and the saturated infiltration rates. These two variables were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66).

Wilton Mountain's campsite area was 1514.96 ft^2, which included a satellite area. The camp's barren core area was 93.75 ft^2, and the total number of trees damaged was three (Table 15, page 70). Measured distances from the campsite's center to the primary trail was 23.60 feet, while the distance from the campsite to water was more than 4150 feet. The measured campsite density was 2.17 camps/mile, due to the location of Wilton Point, just 256 feet away with only partial screening (Table 16, page 73). This campsite had an index rating of 2.00 with a condition class rating of 3 (Table 17, page 77), which indicated moderate levels of impact.

The indicators measured that did exceed their standard were campsite distance to trail and campsite density. The campsite was highly impacted through use and with 112 camper-nights per year, it was one of the highest used campsites within the area (Kuzmic 1993).

As noted above, campsite percent vegetation coverage was close to control averages. Likewise, the control's bare ground area was also the highest among all campsites. The area surrounding the campsite was rocky and had sparse vegetation.

The combination of high use levels and indications of low impact tolerance may point to the need for initiation of remedial steps to limit impact levels.

Wilton's Point

This campsite was listed as campsite three (Appendix A, G, and I). This site's dominant species stand was mixed hardwood, with a forest ridgetop vegetation type. This campsite was barely discernible, and only by campfire ring evidence and a small barren core was it designated as one.

The campsite area had an average vegetation cover of 62.24%, which ranged from 30 to 100%, and was significantly higher than its control (Table 9, page 59). The percent bare ground exposure was also significantly different from the control, as the camp was 6.33% bare and the control had no bare ground (Table 10, page 61). The soil was also compacted through use, as evident in both soil penetrometer readings and instantaneous infiltration rates (Table 11 and 12, pages 63 and 64). However, the saturated infiltration rate was also lower on the campsite than control with 1.43 cm/min and 1.61 cm/min respectively, but this was not significantly different (Table 13, pages 66). Wilton Point had no trees within the boundary of the campsite.

Wilton Point's campsite area was 804.69 ft^2, with a barren core area was 4.68 ft^2, this was the second smallest barren core area among all campsites (Table 15, page 70). Measured distance from the campsite's center to the primary trail was 251.30 feet, while the distance from the campsite to water was more than 4200 feet. The measured campsite density for this camp was 2.17 camps per mile, due to the location of Wilton Mountain campsite 256 feet away (Table 16, page 73). Campsite index rating was 1.44 and condition class assessment was 2 (Table 17, page 77), which indicated low levels of impact.

This campsite was the only campsite that was further that 100 feet from the primary trail and the only standard exceeded by this campsite was campsite density.

Both Wilton Mountain and Wilton's Point were located on the same ridge. These campsites were positioned in a rocky area with shallow soils. Instantaneous infiltration rates on the controls were among the lowest among all seventeen campsites. Noticeable impact has occurred rapidly on these two areas and remedial prescriptions may be necessary to maintain impact.

Mile 38

Mile 38 campsite, campsite four, was located just over a mile east of the Wilton Mountain campsite and about a mile and a half from Kiamichi River Trailhead (Appendix A, G, and I) This campsite was located in a shortleaf pine (*Pinus echinata*) dominant stand, on a forest/forbs/ shrubs vegetation type.

The campsite had an average vegetation cover of 13.70%, which was significantly lower than its control (Table 9, page 59). Percent bare ground exposure was also significantly different from the control, as the campsite bare ground average was 0.22% and the control had no bare ground (Table 10, page 61). The soil was also compacted through use, as the campsite had a soil penetrometer reading of 1.49 kg/cm^2, and the control had an average reading of 1.00 kg/cm^2 (Table 11, page 63). There was also a difference in the infiltration rates between the campsite and control. The instantaneous infiltration rate was 1.39 cm/min on the campsite with 2.22 cm/min on the control (Table 12, page 64). The saturated infiltration rate was also lower on the campsite than control (Table 13, page 66). Eight trees were within the campsite's boundary, which had no damage (Table 14, page 68).

Mile 38's campsite area was 929.69 ft^2, with a barren core area of 31.25 ft^2 (Table 15, page 70). Measured distances from the campsites center to the primary trail was 28.60 feet, while the distance from the campsite to water was more than 4000 feet. The measured campsite density for this camp was 0.49 camps/mile (Table 16, page 73), and this campsite had an index rating of 1.78 with a condition class rating of 3 which indicated a moderate level of impact (Table 17, page 77). The only indicator exceeded was campsite distance to trail, with a distance of 28.60 feet.

Despite a low vegetation cover of only 13.70%, the bare ground area was still less than 1%. Campsite area had a thick duff layer which consisted primarily of pine needles. Although percent bare ground exposure was significantly different from its control, it was the lowest average among all campsites, due to this duff layer. Due to its low use levels of only eight camper-nights per year (Kuzmic 1993) and the carpeting influence of the pine needles, this camp seemed to maintain its natural condition.

Kiamichi River Trailhead

Kiamichi River Trailhead (KRT), campsite five, was located about a quarter mile from the Kiamichi River Trailhead entrance portal (Appendix A, G, and I). KRT was located in a shortleaf pine dominated stand, on a forest/forbs/shrub vegetation type, in a riparian area. This site was easily discernible due to a large rock fire ring, and a large area with minimal vegetation.

The campsite area had a average vegetation cover of only 6.00%, which ranged from 0 to 60%, which differed significantly from its control (Table 9, page 59). This camp had the lowest vegetation coverage among all seventeen campsites. The percent bare ground exposure on the campsite was 37.70% which was also significantly different from the control which had a average of 0.20% (Table 10, page 61). Due to the Shortleaf pine dominance this site had a thick layer of duff covering the ground. The soil was also compacted through use, as the campsite had a soil penetrometer reading 1.87 kg/cm^2, and the control had a measurement of 1.20 kg/cm^2 (Table 11, page 63). There was a difference in the infiltration rates between the campsite and control. The campsite instantaneous infiltration rate was 1.96 cm/min on the campsite with 2.63 cm/min on the control (Table 12, page 64). The saturated infiltration rates were also lower on the campsite than control with 1.85 cm/min and 2.07 cm/min respectively (Table 13, pages 66). KRT campsite had ten trees within the boundary of the campsite, and three of the ten had been damaged (Table 14, page 68).

KRT's campsite area was 1207.81 ft^2, with a barren core area of 793.16 ft^2. This was the third largest barren core area among all campsites (Table 15, page 70). Measured distances from the campsite's center to the primary trail was 31.00 feet, while the distance from the campsite to water was 21.00 feet. The measured campsite density for this camp was 0.62 camps per mile (Table 16, page 73). This campsite had an index rating of 2.56 with a condition class rating of 3 which implicating moderate to high level of impact (Table 17, page 77). This campsite exceeded three of the five standards, which included barren core area, campsite distance to water, and campsite distance to trail.

Due to its proximity to the trailhead and river, this site was popular among many visitors. Kuzmic (1993) found that this site had the second highest level use among all campsites present in 1993 with 152 camper-nights per year.

Pine Mountain

This campsite (campsite 6) was located 148 feet east of Kiamichi River Trailhead camp (Appendix A, G, and I). This campsite was located in a mixed hardwood dominated stand, on a forest /forbs/shrub vegetation type, in a riparian area. This site was easily discernible as a campsite, due to the high level of impact and a distinguishable fire ring.

The campsite area had an average vegetation cover of only 12.02%, which ranged from 0 to 50%. This differed significantly from its control that had a average vegetation coverage of 75.00% (Table 9, page 59). The percent bare ground exposure on the campsite was 34.42% which was significantly different from the control which had a average of 0.19% (Table 10, page 61). Soil compaction was evident both in penetrometer differences, and both types of infiltration rates (Table 11, 12, and 13, pages 63, 64, and 66). Both the instantaneous and saturated infiltration rates were lower on the campsite than on the control. Pine Mountain had ten trees within the boundary of the campsite, and four of the ten had been damaged.

Campsite six had a campsite area of 1104.69 ft^2, with a barren core area of 587.50 ft^2, this was the fourth largest barren core area among all campsites (Table 15, page 70). Measured distances from the campsite's center to the primary trail was 21.50 feet, while the distance from the campsite to water was 35.20 feet. The measured campsite density for this camp was 1.84 camps/mile (Table 16, page 73). The standards exceeded were barren core area, campsite's distance to water, campsite's distance to trail, and number of camps per mile. This campsite exceeded four of the five indicators measured. This camp was close to the Kiamichi River Trailhead Camp, and due its proximity to the trailhead and river, it has become a popular site. This campsite had an index rating of 2.56 with a condition class rating of 3 which implicated moderate to high level of impact (Table 17, page 77).

River Sign

Campsite seven, River Sign campsite was located between Pine Mountain and Big

River camps, at the head of an old road that has a sign pointing to the Kiamichi River (Appendix A, G. and I). This campsite was located in a shortleaf pine dominated stand, on a forest/lush grass vegetation type, in a non-riparian area. This camp was identified in Kuzmic's study in 1993, yet through a preliminary investigation, this site had recovered and it was omitted from the original campsite population. However, as data collection initiated, the researcher found that the site had been impacted again and it was added to the campsite population.

The campsite area had a average vegetation cover of 92.77%, which ranged from 60 to 100% which was significantly higher than its control with an average vegetation coverage of 77.59% (Table 9, page 59).The campsite percent bare ground exposure was only 0.89%, but this was significantly higher than its control which had a average of 0.17% (Table 10, page 61). Soil was compacted through use, as the campsite had a soil penetrometer reading 1.33 kg/cm^2, and the control had 0.91 kg/cm^2 (Table 11, page 63). This result was the smallest difference of the campsite average from the control of 0.42 kg/cm^2. Infiltration rates were also evident between the campsite and control. The instantaneous infiltration rate was 1.92 cm/min on the campsite with 3.03 cm/min on the control. The saturated infiltration rate was also lower on the campsite than control, however this parameter was not significantly different (Table 12 and 13, pages 64 and 66). Campsite seven had one tree with minor damage (Table 14, page 68).

The River Sign camp had a total campsite area of 1182.81 ft^2, with a barren core area of only 1.56 ft^2 centered around the fire ring. This was the smallest barren core area among all campsites (Table 15, page 70). Measured campsite distance to the primary trail was 19.60 feet, while the campsite distance to water was 451.09 feet. The measured campsite density was 0.99 camps per mile (Table 16, page 73), and index rating was 1.55 with a condition class rating of 1 (Table 17, page 77). The only standard this campsite exceeded was the campsite's distance to primary trail.

This camp had the highest vegetation coverage among all seventeen campsites, in fact the campsite average was significantly higher than its control. The campsite was located on an open area, and it had a thick coverage of grasses and forbs. The surrounding area was a dense stand of pine and hardwoods, and the best control site was located in the adjacent stand of trees. The use level reported for this site was 85 camper-nights per year (Kuzmic 1993). However, due to the conditions of the campsite, it was hypothesized that the level of use had decreased since Kuzmic's study. The location of this site was also moderately tolerant to Impact due low level of measured impact.

Big River

Campsite eight was called "Big River" campsite (Appendix A, G, and I). Big River camp was located about a one and one-half miles from the Kiamichi River Trailhead. This campsite also was located in a mixed hardwood dominated stand, on a forest/forbs/shrub vegetation type, and in a riparian area because it was only 23.00 feet from the river. Due to the high level of impact, a distinguishable seven foot diameter fire ring, and many satellite sites, this campsite was easily discernible as a campsite.

The campsite area had the third lowest average vegetation cover of only 9.48%, which ranged from 0 to 50%, and differed significantly from its control with an average vegetation coverage of 54.14% (Table 9, page 59). The percent bare ground exposure on the campsite was 77.50% which was also significantly different from its control (Table 10, page 61). The soil was severely compacted through use, as the campsite had a soil penetrometer reading 3.48 kg/cm^2, and the control had 1.35 kg/cm^2 (Table 11, page 63). This was the second highest penetrometer rate among the campsites. Additionally, high soil compaction was evident in the differences in the infiltration rates. The campsite's instantaneous infiltration rate was 0.09 cm/min, which was the lowest instantaneous rate among all campsites, and the control had an average instantaneous rate of 1.45 cm/min (Table 12, page 64). The saturated infiltration rate was also the lowest among the campsites with an average of 0.17 cm/min, which was significantly lower than the control (Table 13, page 66). Within campsite eight's boundary there were twenty-one trees, and eleven had some degree of damage (Table 14, page 68).

This camp was the largest campsite with a total campsite area of 2395.31 ft^2, which included many satellite sites. This camp's barren core area was 1184.38 ft^2, which was second largest among all campsites (Table 15, page 70). Measured campsite distance to trail was 25.50 feet, while the campsite's distance to water was 23.00 feet. This site had a campsite density rating of 0.70 camps per mile (Table 16, page 73). This campsite had an index rating of 3.00 with a condition class rating of 4, implicating a very high level of impact, as 3.00 was the highest impact rating possible through that indexing system (Table 17, page 77).

This campsite exceeded four of the five indicators measured. The standards exceeded were barren core area, campsite distance to water, campsite distance to trail, and number of damaged trees on the site.

Due to its proximity to the river, this site was popular among many visitors. In fact, Kuzmic (1993) reported that this campsite as the highest used campsite within the area with 201 camper-nights per year. This campsite was a favorite campsite among large groups, therefore, there were many satellite sites created and the measured variables were severe. This site was extremely impacted in every variable measured and remedial prescriptions are needed.

Mile 42

Mile 42 campsite, campsite nine, was very close to a Kiamichi River tributary (Appendix A, G, and I). Mile 42 camp was located over a mile east along the trail from campsite eight, and almost a mile west of Valley camp (camp 10). This campsite was located in a shortleaf pine dominated stand, on a forest/lush grass vegetation type. Due to its proximity to water it was also considered a riparian site.

The campsite area had an average vegetation cover of only 37.75%, which ranged from 0 to 90%, and was significantly different from its control (Table 9, page 59). This campsite's control had the second highest vegetation cover of 99.25%. The percent bare ground exposure on the campsite was 37.13% which was also significantly different from the control which had a average of 0.00% (Table 10, page 61). The soil was also compacted through use, as the campsite had an average soil penetrometer reading 2.19 kg/cm^2, with a control reading of 1.18 kg/cm^2 (Table 11, page 63). There were also differences in the both types of infiltration rates between the campsite and control (Table 12 and 13, pages 64 and 66). Camp nine had one tree within the boundary of the campsite, and no tree damage (Table 14, page 68).

Total campsite area for this camp was 471.88 ft^2. This camp also had a barren core area of 109.38 ft^2 (Table 15, page 70). Campsite distance to the primary trail was 29.50 feet, while campsite distance to water source was 41.30 feet (Table 16, page 73). The calculated campsite density was 0.74 camps per mile (Table 16, page 73). This campsite had an index rating of 1.78 with a condition class rating of 3 which implicated moderate levels of impact (Table 17, page 77). The use level for this campsite was unknown. The standards exceeded by this campsite were campsite distances to trail and water source.

Valley

Valley camp was numbered as campsite ten (Appendix A, G, and I). Valley camp was located just east from campsite nine , and just over 80 feet from Mile 43 camp with only a partial screening separating the two camps. This campsite was located in a mixed hardwood dominated stand, on a forest/lush grass vegetation type. It was not classified as a riparian site. This site's only identifiable campsite trait was the presence of a fire ring.

The campsite area had an average vegetation cover of 78.00%, which ranged from 50 to 100%. The campsite area was significantly different from its control, which had the highest average vegetation coverage of 99.71% (Table 9, page 59). The campsite displayed a percent bare ground exposure of only 4.29% which was also significantly different from the control which had a average of 0.00% (Table 10, page 61). The soil was also compacted through use, as the average difference of campsite and control was 0.69 kg/cm^2 (Table 11, page 63). Additionally, both types of infiltration rates were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66). Valley camp had no trees within the boundary of the campsite.

Valley's total campsite area was 426.56 ft^2, with a barren core area of only 10.94 ft^2 (Table 15, page 70). The distance from the campsite to water was 157.10 feet. The only indicators exceeded by this campsite were campsite distance to the ONRT and campsite density. The measured distance from the campsite to trail was 31.80 feet, while the campsite density was 3.40 (Table 16, page 73). This campsite's parameters indicated a low level of impact as the camps index rating was 1.11, and condition class rating was 2 (Table 17, page 77). Kuzmic (1993) reported the level of use for the campsite at 27 camper-night per year, which also indicated a low use level.

Mile 43

As stated above, campsite eleven, or Mile 43 camp was partially screened from Valley camp as they were separated by only 80 feet (Appendix A, G and I). Mile 43 camp was located in a mixed hardwood dominated stand, on a forest/lush grass vegetation type. It was classified as a riparian site. This campsite was also difficult to discern as a campsite as the only identifiable campsite trait was the presence of a fire ring.

The campsite area had an average vegetation cover of 74.46%, which was different from its control (Table 9, page 59). The campsite had a percent bare ground exposure of only 2.02% which was also significantly different from its control (Table 10, page 61). The soil was also compacted through use, as the average difference of campsite soil compaction and control was 0.72 kg/cm^2 (Table 11, page 63). Additionally, both types of infiltration rates were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66). Camp 11 had no trees within the campsite's boundary.

This camp's total campsite area was 381.25 ft^2, which was the smallest camp found. The barren core area was only 4.69 ft^2, which was also one of the smallest (Table 15, page 70). The indicators exceeded by this campsite were campsite distance to the ONRT, distance to water source, and campsite density (Table 16, page 73). This campsite had an index rating of 1.44 with a condition class rating of 2 which implicated low levels of impact (Table 17, page 77).

Use levels for this campsite are unknown, however, low levels of use were indicated by the low amount of impact on the site.

Island

Island camp was numbered as campsite twelve (Appendix A, G, and I). Island camp was located about one half miles east of Mile 43 camp, and just over a half a mile from Road camp. This campsite was located in a mixed hardwood dominated stand, on a forest/lush grass vegetation type. Campsite twelve was named "Island camp " due to its location between a primary tributary and an intermittent stream leading to the Kiamichi River. Due to this location it was classed as a riparian site. This had recovered since use, however, due to developments, like rock chairs, racks, and fire ring, it was identified as a campsite.

The campsite area had an average vegetation cover of 70.91%, which ranged from 10 to 100%, and was significantly different from its control (Table 9, page 59). The average difference of bare ground exposure was only 2.95% which was also significantly different from the control (Table 10, page 61). The soil was also compacted through use, as the average difference of campsite and control was 0.66 kg/cm^2 (Table 11, page 63). Additionally, instantaneous and saturated infiltration rates were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66). Camp twelve had eight trees within the campsite boundary, and two trees exhibited some tree damage (Table 14, page 68).

Camp twelve's total campsite area was 623.48 ft^2, with a barren core area of only 15.63 ft^2 (Table 15, page 70). The distance from the campsite to water was only 27.20 feet, and the distance to the trail was 37.50 feet. This exceeded their standards (Table 16, page 73). The campsite density was 1.03 camps per mile, and this just barely exceeded the standard of one camp per mile. This campsite had an index rating of 1.55 with a condition class rating of 2 which implicated low to moderate levels of impact (Table 17, page 77). This camp was initiated after Kuzmic's study, therefore, no level of use data were known.

Road

Campsite thirteen was called "Road Camp" (Appendix A, G, and I). This camp was located in the trail on the eastern side of the wilderness area. Lower Beech Grove camp was the closest campsite at a calculated distance of 2200 feet. This campsite was located in a shortleaf pine dominated stand, on a forest/forbs/shrubs vegetation type. It was classified as a riparian site. This campsite was easily identifiable by impact and a fire ring.

The campsite area had an average vegetation cover significantly lower than its control. The control area had the second lowest vegetation cover across all campsites with an average of 43.19% (Table 9, page 59). The campsite had a percent bare ground exposure of 49.89% which was also significantly different from the control which had a average of 0.00% (Table 10, page 61). The soil was also compacted, as the average difference of campsite and control was 1.27 kg/cm^2 (Table 11, page 63). Additionally, both types of infiltration rates were significantly lower on the campsite than on the control (Table 12 and 13, pages 64 and 66). Camp thirteen had no trees within the campsite's boundary.

Road's total campsite area was 685.94 ft^2, with a barren core area of 159.38 ft^2 (Table 15, page 70). The indicators exceeded by this campsite were campsite distance to the ONRT and camp distance to water (Table 16, page 73). This campsite had an index rating of 1.78 with a condition class rating of 4 which indicated moderate to high levels of impact (Table 17, page 77).

This campsite was situated in a poor area. The location of the campsite was centered in an old road area next to the trail. The control area also had low averages of vegetation, which indicated a potential problem with impact tolerance.

Lower Beech Grove

Lower Beech Grove (campsite 14) was a camp located on a bluff overlooking a stream that flows into the Kiamichi River (Appendix A, G, and I). The closest camp was only 142 feet away. Lower Beech Grove camp was located in an American beech dominated stand, on a forest/ forbs/shrubs vegetation type. It was classified as a riparian site. This campsite was easily identifiable by a large devegetated core area and presence of a fire ring.

The campsite area had an average vegetation cover significantly lower than its control (Table 9, page 59). The campsite had a percent bare ground exposure of 48.74% which was also significantly different from the control (Table 10, page 61). The soil was also compacted through use, as the average difference of campsite and control was 1.49 kg/cm^2 (Table 11, page 63). Instantaneous infiltration rates were significantly lower on the campsite than on the control with measurements of 1.69 cm/min on the campsite and 4.17 cm/min on the control (Table 12, page 64). This was the largest difference among all campsites. Additionally, the saturated infiltration rates were different, as the average difference was 2.02 cm/min (Table 13, page 66). This was also the greatest difference among campsites. Lower Beech Grove camp had one of two trees within the boundary exhibiting tree damage (Table 14, page 68).

Camp fourteen's total campsite area was 464.75 ft^2, with a barren core area of 175.00 ft^2 (Table 15, page 70). The distance of the campsite to the trail was 9.80 feet, while the distance of the campsite to water was 9.50 feet (Table 16, page 73). The campsite density for this campsite was 1.99 camps per mile. The standards exceeded were campsite distance to trail, campsite distance to water, and campsite density. This campsite had an index rating of 1.89 with a condition class rating of 3 which indicated a moderate level of impact (Table 17, page 77). The reported use level for this campsite was 42 camper-nights per year (Kuzmic 1993), which also was an indication of moderate levels of use.

New

New camp (campsite 15) was a camp located just 142 feet north of Lower Beech Grove camp and about seven hundred feet south of Upper Beech Grove camp (Appendix A, G, and I). This camp was located in an American beech dominated stand, on a forest/lush grass vegetation type. It was classified as a riparian site.

This camp was created just prior to data collection, and was representative of the rapid speed by which campsites in this area deteriorate. Each camp was individually tested for significant change between data collection periods. This camp was the only camp that had significant change between each collection period on each impact variable. These trends exhibit Cole's idea of rapidly occurring impact on campsites with low impact tolerances (Cole 1993a).

On the first collection period, the area appeared the same as the surrounding area. The only evidence of use was a line of rocks used as a fire screen and a trampled area where a tent had been up. The campsite area was only 192.3 ft^2 with no bare ground area. The average difference of vegetation cover was 0.14%, and there were minor differences between soil compaction, and infiltration rates.

The second measurement identified greater impact differences. The campsite had been used, and a fire ring and barren core area had been established. The campsite area had doubled in size from 192.3 ft^2 to 405.6 ft^2. The bare ground area comprised 3.89% of the campsite, and the average difference of vegetation cover increased to 0.20%, and there were minor differences between soil compaction and infiltration rates.

The last measurement indicated an established site with the presence of a fire ring and a large area of trampled vegetation. The campsite area had increased to 550.53 ft^2 with a barren core area of 35.76 ft^2. The vegetation cover had decreased sharply and the differences of bare ground exposed, soil compaction, and infiltration rates had increased. The site went from condition class one to a condition class three in a three month period. The index rating changed from a 1.00 to a 1.33. This was indicative of the rate of impact, and this trend is similar to Figure 2, page 20. However, due to season variability, some caution is needed when evaluating these trends. If measurements were taken in a different season or across a whole year, some variabilty could be found.

The campsite area had an average vegetation cover significantly lower than its control with an average difference of 54.33% (Table 9, page 59). The campsite had a percent bare ground exposure of 13.00% which was also significantly different from the control (Table 10, page 61). Soil compaction was also evident in both soil penetrometer readings and infiltration rates (Table 11, 12 and 13). Although little use occurred over the data collection periods, the campsite had been severely impacted as shown by differences of instantaneous infiltration rates (Table 12, page 64). The average difference instantaneous infiltration rates was 1.20 cm/min. This difference was higher than many other impacted sites that had existed during Kuzmic's 1993 study. This suggested that this site had low resistance of impact. Additionally, the difference of saturated infiltration rates was also higher than on many other campsites (Table 13, page 66). Camp 15 had no trees within the campsite boundary.

This camp's total campsite area was 382.81 ft^2, with a barren core area of 17.18 ft^2 (Table 15, page 70). The distance of the campsite to the trail was 7.80 feet, while the distance of the campsite to water was 54.00 feet (Table 16, page 73). The campsite density for this campsite was 9.47 camps per mile. The standards exceeded were distance from the camp to trail, distance of the camp to water, and campsite density. This campsite had an index rating of 1.22 with a condition class rating of 3 which indicated moderate levels of use and impact (Table 17, page 77).

Upper Beech Grove

Upper Beech Grove, campsite sixteen, was located only 1.07 miles from State-Line Trailhead (Appendix A, G, and I). This campsite was located in an American beech dominated stand, on a forest/ridgetop vegetation type, and in a riparian area. Due to the high level of impact, a distinguishable six foot diameter fire ring, and a large barren core area, this campsite was easily discernible as a campsite.

The campsite area had the second lowest average vegetation cover of only 6.79%, which ranged from 0 to 50%, and differed significantly from its control with an average vegetation coverage of 96.88% (Table 9, page 59). The percent bare ground exposure on the campsite was 77 71% which was also significantly different from its control (Table 10, page 61). The soil was severely compacted through use, as the campsite had an average soil penetrometer reading 3.54 kg/cm^2, and the control had 0.98 kg/cm^2, a difference of 2.56 kg/cm^2 (Table 11, page 63). This was the highest penetrometer difference among campsites. Additionally, high soil compaction was evident in the differences in the infiltration rates. The instantaneous infiltration rate was 0.55 cm/min on the campsite with 2.38 cm/min on the control. This was the second lowest instantaneous infiltration rate among the campsites (Table 12, page 64). The saturated infiltration rate was also the second lowest among the campsites with an average of 0.43 cm/min, which was significantly lower than the control (Table 13, page 66). Campsite sixteen had five trees within the boundary of the campsite, and all five were damaged to some degree. Most trees exhibited severe root exposure as soil has eroded from the site (Table 14, page 68).

This camp was the second largest campsite with a total campsite area of 1678.13 ft^2. The barren core area of this campsite was 1600.00 ft^2, which was the largest among all campsites (Table 15, page 70). Measured distances from the campsite's center to the primary trail was 13.20 feet, while the distance from the campsite to water was 71.00 feet. The measured campsite density for this camp was 2.81 camps per mile (Table 16, page 73). This campsite exceeded all five standards measured. Upper Beech Grove had an index rating of 2.67 with a condition class rating of 5, due to the erosion of the campsite, implicating very high level of impact and use (Table 17, page 77).

Due to its proximity to the river and trailhead, and the unique traits of the American beech stand, this site was popular among many visitors. Due to the high level of impact and moderate level of use, 55 camper-nights per year, this camp had trends of low tolerance (Kuzmic 1993). This site was extremely impacted in every variable measured. This site had American beech trees with severely exposed root systems, and a very large barren core area. Remedial prescriptions are needed.

Rehabilitated

This camp was the first camp west of State-Line trailhead (Appendix A, G, and I). It was located about three quarters mile from the trailhead. This campsite was located in a mixed hardwood dominated stand, on a forest/forbs/shrub vegetation type, and In a riparian area. It was designated as a campsite due to impact present on the campsite and a fire ring.

The campsite area had an average vegetation cover of 17.43%, which differed significantly from its control with an average vegetation coverage of 96.71% (Table 9, page 59). The percent bare ground exposure on the campsite was 53.14% which was also significantly different from its control (Table 10, page 61). Soil compaction was evident in both penetrometer readings and infiltration rates. This camp was tied for the third highest difference in penetrometer readings wlth 1.49 kg/cm^2 (Table 11, page 63). The instantaneous infiltration rate and saturated infiltration rate was also significantly different lower than the control (Table 12 and 13, pages 64 and 66). Campsite seventeen had seven trees within its boundary, and three had been damaged (Table 14, page 68).

Total campsite area was 497.28 ft^2, with a barren core area of 267.28 ft^2 (Table 15, page 70). Measured distances from the campsite's center to the ONRT was 15.20 feet, while campsite distance to water was only 8.50 feet (Table 16, page 73). This campsite's density was 0.71 camps per mile. This camp exceeded the standards of campsite distance to trail and to water. This campsite had an index rating of 1.89, with a condition class rating of 2 which implicated low to moderate impact levels (Table 17, page 77). No use levels were known.

Impact Trends Among Groups of Campsites

Due to varying conditions of vegetation type, soil type, soil depth, aspect, geologic type, and water availability, no two sites were exactly alike. Due to these differences, campsite comparisons across the area are of limited use, since dissimilarities were expected. Therefore, when grouping the parameters for analysis, each impact parameter was assessed as the difference of the campsite from its control. This analysis accounted for differences on a site by site basis. An assumption was made that controls were indicative of campsites in the absence of recreational use, and through the measured difference, the differences of site were accounted for when grouping campsites for analysis. Trends could be analyzed in comparison of these differences by inclusion of a site's influencing factors, and thereby adjusting for the differences as noted above.

Riparian and Non-riparian Campsite Comparisons

Hypotheses were made that there was no difference in impact variables between riparian campsites and non-riparian campsites (Table 2, page 36). Greater use levels were expected on riparian campsites due to campers need for water, and unique recreational opportunities provided. Riparian areas attracted visitors as a source for swimming, sunbathing, fishing, or pleasant scenery. In addition to different use patterns, riparian areas also had different ecological conditions. For these reasons campsite conditions were compared across the two zones to evaluate whether these impact variables were influenced to a significant level.

The total campsite area of the two zones was compared and there was no significant difference found. While riparian campsites had a campsite area average of 899.39 ft^2, non-riparian campsites had an average of 944.94 ft^2 (Table 18, page 97).

However, when comparing the average barren core area among sites in the two zones, there was a significant difference. Riparian campsites had an average barren core area of 446.69 ft^2, which was much larger than the average barren core area of the non-riparian campsites of 23.84 ft^2 (Table 18, page 97). This indicated that the level of impact for campsites located nearer to riparian areas was higher. These differences were significant across the two zones and the differences of tolerance and use influenced this trend.

In addition to differences in barren core area, there were also differences in vegetation cover and bare ground exposure (Table 19, page 97). Riparian campsites were more impacted in both vegetation cover and bare ground exposure. The average vegetation cover for riparian camps was 30.78%, which was lower than the average cover on non-riparian campsites of 57.08%. Additionally, the average bare ground exposed on the non-riparian camps was 7.82%, which was significantly lower than the average of riparian camps of 38.84% (Table 19, page 97).

TABLE 18

RELATIONSHIP OF CAMPSITE AREA AND BARREN CORE AREA BETWEEN CAMPSITES IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Campsite Location	Campsite Area			Barren Core Area		
	Mean	Range	F-value	Mean	Range	F-value
	squared feet					
Riparian Camps	899.39	381-2395	1.50[b]	446.69	5-1600	23.84[c]
Non-Riparian Camps	944.94	427-1515		27.34	2-94	

[a] Riparian campsites were defined as campsites 100 or less feet from any water source, (n=11) Non-Riparian campsites were campsites farther than 100 feet from any water source, (n=6). All tests were done using the Kruskall-Wallis test.
[b] Difference was not significant, $p = 0.2273$.
[c] Significant difference, $p < 0.0001$.

TABLE 19

RELATIONSHIP OF VEGETATION COVER AND BARE GROUND AREA BETWEEN CAMPSITES IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Campsite Location	Vegetation Cover			Bare Ground		
	Mean	Range	F-value	Mean	Range	F-value
	percent					
Riparian Camps	30.78	6-74	15.06[b]	38.84	2-78	21.90[c]
Non-Riparian Camps	57.08	14-92		7.82	0-22	

[a] Riparian campsites were defined as campsites 100 or less feet from any water source, (n=11). Non-Riparian campsites were campsites farther than 100 feet from any water source, (n=6). All tests were done using the Kruskall-Wallis test.
[b] Significant difference, $p < 0.0003$; Hypothesis 2 rejected for vegetation cover.
[c] Significant difference, $p < 0.0001$; Hypothesis 2 rejected for bare ground exposure.

There was no difference in the campsite tree damage among the two zones. Tree damage seemed independent from impacts caused on these campsites (Table 20, page 98).

The soil compaction between riparian and non-riparian campsites was significantly different. Riparian campsites had a higher average resistance to soil penetration than non-riparian campsites (Table 20). The average penetrometer reading for riparian campsite controls was 1.02 kg/cm^2, while the non-riparian control's average was 0.93 kg/cm^2. The physical factors that affect soil compaction are soil type, amount of organic matter, and soil moisture (Hammitt and Cole 1987). The differences in location, as evident in the average difference among the campsites and the controls, affected the level of soil compaction.

Instantaneous infiltration rates between campsites of the two zones were not significantly different, however, there was a difference in saturated infiltration rates (Table 21, page 99). Riparian campsites had an average saturated infiltration rate of 1.26 cm/min which was significantly higher than the average found on non-riparian campsites. Riparian sites exhibited higher levels of impact, due to lower averages among the sites. Again, these campsite conditions could be a result of higher use levels and/or lower tolerance to impact.

TABLE 20

RELATIONSHIP OF DAMAGED TREES AND SOIL COMPACTION BETWEEN CAMPSITES IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Campsite Location	Damaged Trees			Soil Compaction		
	Mean	Range	F-value	Mean	Range	F-value
	---- percent ---			-------- kg/cm^2 ---		
Riparian Camps	34	0-100	0.28[b]	2.30	1.59-3.54	21.90[c]
Non-Riparian Camps	36	0-100		1.67	1.33-1.92	

[a] Riparian campsites were defined as campsites 100 or less feet from any water source, (n=11). Non-Riparian campsites were campsites farther than 100 feet from any water source, (n=6). All tests were done using the Kruskall-Wallis test.

[b] Difference not significant, $p = 0.60$.

[c] Significant difference, $p < 0.0014$; Hypothesis 2 rejected for soil compaction.

TABLE 21

RELATIONSHIP OF INSTANTANEOUS INFILTRATION RATES AND SATURATED INFILTRATION RATES BETWEEN CAMPSITES IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Campsite Location	Instantaneous Infiltration Rates			Saturated Infiltration Rates		
	Mean	Range	F-value	Mean	Range	F-value
	cm/min					
Riparian Camps	1.56	0.09-2.50	2.16^b	1.26	0.17-2.19	9.43^c
Non-Riparian Camps	1.47	1.25-1.92		1.44	1.27-1.80	

[a] Riparian campsites were defined as campsites 100 or less feet from any water source, (n=11). Non-Riparian campsites were campsites farther than 100 feet from any water source, (n=6). All tests were done using the Kruskall-Wallis test.
[b] Difference not significant, $p = 0.15$.
[c] Significant difference, $p < 0.004$; Hypothesis 2 rejected for saturated infiltration rates.

Lastly, the differences of level of impact were evident in both the index rating and the condition class assessed to each campsite among the two zones. Riparian campsites displayed an average index rating of 2.20, while the average index rating of the non-riparian campsites was 1.57 (Table 22, page 100). The average condition class assessed to the riparian campsites was 3.09, while the average for non-riparian campsites was 2.33. Both of these impact rating methods suggested that riparian campsites had moderate to high levels of impact, while non-riparian campsites had low to moderate impact levels.

In conclusion, riparian campsites exhibited higher levels of impact than non-riparian sites in barren core area, vegetation cover, bare ground exposure, soil compaction, and saturated infiltration rates. The barren core area of riparian campsites were influenced by the lower levels of vegetation cover and higher percentages of bare ground area. Both of these campsite variables influenced the barren core area. Soil compaction, as evident in soil penetration and soil permeability also influenced the decrease in vegetation cover and increase of bare ground exposure (Hammitt and Cole 1987).

TABLE 22

RELATIONSHIP OF CAMPSITE INDEX RATING AND CONDITION CLASS BETWEEN CAMPSITES IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Campsite Location	Campsite Index Rating			Condition Class Assessment		
	Mean	Range	F-value	Mean	Range	F-value
	------------------- rating ----------------------					
Riparian Camps	2.20	1.44-3.00	8.54[b]	3.09	2-5	7.15[c]
Non-Riparian Camps	1.57	1.11-2.00		2.33	1-3	

[a] Riparian campsites were defined as campsites 100 or less feet from any water source, (n=11). Non-Riparian campsites were campsites farther than 100 feet from any water source, (n=6). All tests were done using the Kruskall-Wallis test.
[b] Significant difference, $p < 0.0054$.
[c] Significant difference, $p < 0.0103$.

Implications were that the measured campsite conditions were affected both by level of use, and campsite ecological conditions. Riparian campsites tended to be more susceptible to soil compaction as indicated by the differences found. These differences communicated characteristics of ecological conditions which affected the tolerance of the site in combination with a degree of use levels. These indications reinforced a need to locate campsites further than one hundred feet from a riparian area, and leads management to focus on remedial prescriptions for these areas.

Differences Among Three Vegetation Types

The campsite conditions found among the various vegetation types were also analyzed (Table 2, page 36). Of the five possible vegetation types, only three were definable as vegetation types for campsites in this area. Each campsite was grouped into the most appropriate class for further comparisons. Regardless of the environmental conditions (or ecological characteristics) and/or level of use, it was assumed that sites located in various vegetation types displayed similar impact trends and/or levels of use.

The campsite area was significantly different across campsites in the three vegetation types (Table 23). Campsites located in forest/ridgetop and forest/forbs/shrub areas had similar campsite areas, while campsites located in forest/lush grass tended to have smaller campsite areas. Due to large variability, and small sample size, campsite barren core area was not significantly different across the three vegetation types.

The mean vegetation cover across campsites among the various vegetation types was different (Table 24, page 102). Forest/lush grass campsites were similar to forest/ridgetop campsites which had a mean vegetation coverage of 68.43% and 31.32% respectively. Forest/lush grass sites were not similar to forest/forbs/shrubs sites, however, forest/ridgetop and forest/forbs/shrub camps were similar in average vegetation cover. There were also differences between bare ground exposure (Table 24, page 102). Campsites in forest lush grass vegetation type had the smallest average bare ground percentage of 10.46%. Camps in the other two vegetation types had similar mean bare ground percent of 33 08% on forest ridgetop camps and 43.09% on forest/forbs/shrub camps.

TABLE 23

RELATIONSHIP OF CAMPSITE AREA AND BARREN CORE AREA BETWEEN CAMPSITES IN THREE VEGETATION TYPES[a]

Campsite Location	Campsite Area			Barren Core Area		
	Mean	Range	F-value	Mean	Range	F-value
	- - - - - - - - squared feet - - - - - - - -					
Forest/Lush Grass	611.39 a[b]	381-1183	11.59[c]	25.89 a	2-109	1.84[d]
Forest/Ridgetop	1332.59 b	805-1678		566.14 a	5-1600	
Forest/Forb/Shrub	1040.78 b	465-2395		456.85 a	31-1184	

[a] Campsite vegetation type was identified as Forest/Lush Grass (n=7), Forest/Ridgetop (n=3), and Forest/Forbs/Shrubs (n=7). All analyses were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Significant difference, $p < 0.0001$.
[d] Difference not significant, $p < 0.1766$.

TABLE 24

RELATIONSHIP OF VEGETATION COVER AND BARE GROUND AREA BETWEEN CAMPSITES IN THREE VEGETATION TYPES[a]

Campsite Location	Vegetation Cover			Bare Ground		
	Mean	Range	F-value	Mean	Range	F-value
	------------------ percent ------------------					
Forest/Lush Grass	68.43 a[b]	38-93	9.26^c	10.46 a	01-37	10.02^d
Forest/Ridgetop	31.32 ab	07-62		33.08 b	07-71	
Forest/Forb/Shrub	15.44 b	06-25		43.09 b	00-78	

[a] Campsite vegetation type was identified as Forest/Lush Grass (n=7), Forest/Ridgetop (n=3), and Forest/Forbs/Shrubs (n=7). All analyses were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Significant difference, $p < 0.0004$; Hypothesis 3 rejected for vegetation cover.
[d] Significant difference, $p < 0.0002$; Hypothesis 3 rejected for bare ground exposure.

Again the number and percent tree damage that occurred on campsites located in various vegetation types was not significantly different (Table 25, page 103).

Soil compaction differences were apparent among the three vegetation types (Table 26, page 103). Again, forest/lush grass camps which had a soil compaction of 1.72 kg/cm^2, was significantly lower than soil compaction found on campsites in the other two vegetation types. The soil compaction for forest/ridgetop camps and forest/forbs/shrubs camps were higher than forest/lush grass camps type but not significantly different from each other

However, there were no instantaneous infiltration rate differences nor saturated infiltration rates differences found between campsites in various vegetation types (Table 26, page 103). Although the averages among the three vegetation types seemed different, they were not, due to high variability.

Level of impact, as measured by impact index rating and condition class were also significantly different among campsites in the three vegetation types. Forest/lush grass camps

TABLE 25

RELATIONSHIP OF DAMAGED TREES AND SOIL COMPACTION BETWEEN CAMPSITES IN THREE VEGETATION TYPES[a]

Campsite Location	Damaged Tree			Soil Compaction		
	Mean	Range	F-value	Mean	Range	F-value
	------ percent ---			----- kg/cm^2 -----		
Forest/Lush Grass	29 a[b]	00-100	1.09[c]	1.72 a	1.33-2.19	6.00[d]
Forest/Ridgetop	48 a	00-100		2.41 b	1.77-3.54	
Forest/Forb/Shrub	31 a	00-52		2.30 b	1.49-3.48	

[a] Campsite vegetation type was identified as Forest/Lush Grass (n=7), Forest/Ridgetop (n=3), and Forest/Forbs/Shrubs (n=7). All analyses were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Difference not significant, $p = 0.3443$.
[d] Significant difference, $p < 0.0048$; Hypothesis 3 rejected for soil compaction.

TABLE 26

RELATIONSHIP OF INSTANTANEOUS INFILTRATION RATES AND SATURATED INFILTRATION RATES BETWEEN CAMPSITES IN THREE VEGETATION TYPES[a]

Campsite Location	Instantaneous Infiltration Rate			Saturated Infiltration Rate		
	Mean	Range	F-value	Mean	Range	F-value
	-------------------- cm/min --------------------					
Forest/Lush Grass	0.56 a[b]	0.40-0.80	1.06[c]	3.12 a	2.28-3.68	1.15[d]
Forest/Ridgetop	1.10 a	0.75-1.81		6.31 a	3.49-11.51	
Forest/Forb/Shrub	2.12 a	0.51-11.04		7.57 a	2.71-28.88	

[a] Campsite vegetation type was identified as Forest/Lush Grass (n=7), Forest/Ridgetop (n=3), and Forest/Forbs/Shrubs (n=7). All analyses were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Difference not significant, $p = 0.3585$.
[d] Difference not significant, $p = 0.3267$.

had the lowest average impact rating of 1.44 and a condition class of 2.29 (Table 27). Camps in forest/ridgetop had an average of 2.04 with a condition class average of 3.33. This was similar to sites in forest/forbs/shrub type which had an average impact index rating of 2.21 and an average condition class of 3.14. Both rating methods indicated that campsites in forest/lush grass types had low to moderate levels of impacts, while campsites in forest/ridgetop and forest/forbs/shrub vegetation types displayed moderate to high levels of impact.

The impact trends varied across vegetation types. Use levels were an unknown parameter, however, due to differences in impact levels, inferences were made that either vegetation type preferences for campsite location was different, or impact tolerance was different between vegetation types due to ecological conditions. Generally, forest/lush grass campsites had smaller campsite areas, and lower evidence of impact as indicated by vegetation coverage, bare ground exposure, and soil compaction.

TABLE 27

RELATIONSHIP OF CAMPSITE INDEX RATING AND CONDITION CLASS BETWEEN CAMPSITES IN THREE VEGETATION TYPES[a]

Campsite Location	Campsite Index Rating				Condition Class			
	Mean		Range	F-value	Mean		Range	F-value
	rating							
Forest/Lush Grass	1.44	a[b]	1.11-1.78	22.24^{c}	2.29	a	1-3	7.08^{d}
Forest/Ridgetop	2.04	b	1.44-2.67		3.33	b	2-5	
Forest/Forb/Shrub	2.21	b	1.78-3.00		3.14	b	2-4	

[a] Campsite vegetation type was identified as Forest/Lush Grass (n=7), Forest/Ridgetop (n=3), and Forest/Forbs/Shrubs (n=7). All analyses were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Significant difference, $p < 0.0001$.
[d] Significant difference, $p < 0.0021$.

Additionally, both the impact index rating and the condition class averages were lowest on sites in forest/lush grass vegetation type. This trends could be the effect of higher tolerances to impact, lower use levels, or combination of the two.

The differences between camps in forest/ridgetop and forest/forbs/shrubs were not as obvious, as parameters measured among campsites in these two vegetation classes were not significantly different.

The differences between camps in the three vegetation types can be attributed to soil depth, vegetation types, soil moisture, canopy closure, and level of use. Forest/lush grass camps had tendencies that could be attributed to the tolerance of vegetation, specifically the tolerance of grasses. Grasses are more tolerant to impact, as they exhibit higher resistance and resilience to impact (Cole 1982). This, in combination with the amount of sunlight reaching the mineral soil, likely resulted in high germination rates and more tolerant sites.

Campsites in forest/forbs/shrubs vegetation was prominent in the amount of impact those areas exhibited. Due to closed canopies, and the low tolerance of impact on forbs and shrubs, these areas exhibited lower tolerance to impact (Cole 1982).

Marion and Cole (1996) reported differences in the rate by which grassland areas and forb dominated areas were impacted. In their study, they reported that the soil penetration and relative vegetation cover changed across the two areas at different rates. They found that soil compaction increased faster on forb dominated sites. After extensive use, the forb dominated sites had much lower vegetation cover percentages than the open grassland sites. In fact, the open grassland had little change over the period of their study (Marion and Cole 1996).

Differences Among Dominant Species

The factors of the campsite that influence the dominant species type also influence the amount of impact. After the dominant species was recorded on each campsite, the dominant species was grouped into one of the following categories; mixed hardwoods, shortleaf pine, and American beech. The ecological conditions of the site influenced the presence of the species and the combination of the ecological conditions and species type influence the perceivable level of impact, and use.

Among the campsites with various dominant species, there was no difference in campsite area and barren core area (Table 28). The average vegetation cover was significantly lower on the cove species campsites than on any other sites (Table 29, page 107). The average vegetation cover for these campsites was 28.85%, while the shortleaf pine and mixed hardwood campsites had 40.14% and 43.40% vegetation coverages respectively. Average bare ground exposure and tree damages were similar among the various stands (Table 29 and 30, pages 107).

TABLE 28

RELATIONSHIP OF CAMPSITE AREA AND BARREN CORE AREA BETWEEN CAMPSITES IN THREE FOREST TYPES[a]

Dominant Stand	Campsite Area				Barren Core Area			
	Mean		Range	F-value	Mean		Range	F-value
	---------- squared feet ----------							
Mixed Hardwoods	948.89	a[b]	381-2395	0.72[c]	222.20	a	5-1184	1.67[d]
Pine	887.11	a	471-1208		265.87	a	2-793	
Cove Species	841.90	a	382-1678		597.39	a	17-1600	

[a] After the campsite's dominant species was recorded, campsites were grouped into three classes of dominant stands, which included mixed hardwood (n=11), shortleaf pine (n=4), and American beech (n=3). All tests were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Difference not significant, $p = 0.4916$.
[d] Difference not significant, $p = 0.1987$.

Soil penetrometer readings were significantly different among campsites in the various timber stands. Cove species campsites had higher soil compaction averages than both the pine and mixed hardwood campsites (Table 30, page 107). Campsites in pine dominant stands and mixed hardwood stands had similar responses of 1.91 kg/cm^2 and 2.01 kg/cm^2 respectively.

TABLE 29

RELATIONSHIP OF VEGETATION COVER AND BARE GROUND AREA BETWEEN CAMPSITES IN THREE FOREST TYPES[a]

Dominant Stand	Vegetation Cover			Bare Ground		
	Mean	Range	F-value	Mean	Range	F-value
	percent					
Mixed Hardwood	43.40 a[b]	09-78	4.59[c]	21.60 a	00-78	2.71[d]
Pine	40.14 a	06-93		31.40 a	01-50	
Cove Species	28.85 b	07-54		44.15 a	13-70	

[a] After the campsite's dominant species was recorded, campsites were grouped into three classes of dominant stands, which included mixed hardwood (n=11), shortleaf pine (n=4), and American beech (n=3). All tests were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Significant difference, p = 0.0152; Hypothesis 4 rejected for vegetation coverage.
[d] Difference not significant, p = 0.0772.

TABLE 30

RELATIONSHIP OF DAMAGED TREES AND SOIL COMPACTION BETWEEN CAMPSITES IN THREE FOREST TYPES[a]

Dominant Stand	Damaged Trees			Soil Compaction		
	Mean	Range	F-value	Mean	Range	F-value
	percent			kg/cm^2		
Mixed Hardwood	28 a[b]	00-75	0.11[c]	2.01 a	1.49-3.48	3.34[d]
Pine	30 a	00-100		1.91 a	1.33-2.23	
Cove Species	50 a	00-100		2.55 b	1.74-3.54	

[a] After the campsite's dominant species was recorded, campsites were grouped into three classes of dominant stands, which included mixed hardwood (n=11), shortleaf pine (n=4), and American beech (n=3). All tests were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Difference not significant, p = 0.8988.
[d] Significant difference, p = 0.0443; Hypothesis 4 rejected for soil compaction.

The instantaneous infiltration rates were similar across campsites in the various dominant stands. However, there were significant differences found in saturated infiltration rate analyses (Table 31). Saturated infiltration rates were significantly lower on the cove specie camps in comparison to camps on the other two stands. Mixed hardwood and pine campsites were not significantly different.

The impact rating among the campsites in various dominant stand types was significantly different between areas (Table 32, page 109). The average impact rating among campsites in cove species dominant stands was 2.26, which was similar to the campsites in pine stands which had an average of 1.91. Mixed hardwood stand camps had an average impact rating of 1.83 which was lower than both the pine and cove camps averages.

TABLE 31

RELATIONSHIP OF INSTANTANEOUS INFILTRATION RATES AND SATURATED INFILTRATION RATES BETWEEN CAMPSITES IN THREE FOREST TYPES[a]

Dominant Stand	Instantaneous Infiltration Rates Mean		Instantaneous Infiltration Rates Range	Instantaneous Infiltration Rates F-value	Saturated Infiltration Rates Mean		Saturated Infiltration Rates Range	Saturated Infiltration Rates F-value
	cm/min							
Mixed Hardwood	1.46	a[b]	0.09-2.50	0.69[c]	1.34	a	0.17-2.19	7.03[d]
Pine	1.67	a	1.32-1.96		1.58	a	1.19-1.85	
Cove Species	1.58	a	0.55-2.50		1.04	b	0.43-1.49	

[a] After the campsite's dominant species was recorded, campsites were grouped into three classes of dominant stands, which included mixed hardwood (n=11), shortleaf pine (n=4), and American beech (n=3). All tests were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Difference not significant, p = 0.5072.
[d] Significant difference, p = 0.0026; Hypothesis 4 rejected for saturated infiltration rates.

The condition class average for cove species campsites was 3.67 which indicated a higher impact rating than the rating of mixed hardwood stand campsites. Pine stand campsites were not significantly different from campsites in mixed hardwood stands or cove species stands.

Cove species sites had an impact index rating that indicated moderate to high levels of impact, while shortleaf pine sites and mixed hardwood sites displayed low to moderate levels of impact.

The cove species or American beech was deemed a unique species of the area. Due to this species unique characteristics, sites located in areas with this dominant species tended to have higher levels of impact. American beech is a species often found on moist sites. This species has a shallow root system and usually is not found on sites where the loamy top soil dries out quickly (Harlow *et al.* 1991). Due to the characteristics of this species, this cove area is one of the only places this species grows naturally in Oklahoma.

TABLE 32

RELATIONSHIP OF CAMPSITE INDEX RATING AND CONDITION CLASS BETWEEN CAMPSITES IN THREE FOREST TYPES[a]

Dominant Stand	Campsite Impact Index			Condition Class		
	Mean	Range	F-value	Mean	Range	F-value
	---------- rating ----------					
Mixed Hardwood	1.83 a[b]	1.11-3.00	7.03[c]	2.60 a	2-4	6.03[d]
Pine	1.91 b	1.55-2.56		2.75 ab	1-4	
Cove Species	2.26 b	1.89-2.67		3.67 b	3-5	

[a] After the campsite's dominant species was recorded, campsites were grouped into three classes of dominant stands, which included mixed hardwood (n=11), shortleaf pine (n=4), and American beech (n=3). All tests were done using the Kruskall-Wallis test.
[b] Any two means followed by the same letter, were not significantly different.
[c] Significant difference, p = 0.0026.
[d] Significant difference, p = 0.0186.

These differences implied that the optimal conditions for American beech posed greatest potential for impact as a result of recreational uses. The loamy soil, as well as the high soil moisture, created the worst environment for recreation. In addition to poor site characteristics, these sites were popular among UKRW visitors (Kuzmic 1993). Implications were made that the combination of these two characteristics produced high levels of impact on these sites.

The campsite that had significant change over the data collection periods was campsite fifteen and it was located in an American beech stand. The rate of change was remarkably fast as this campsite went from barely recognizable to a moderately impacted campsite within a three month period. This was characteristic of this stand type, as implications were made to this site's low level of tolerance to impact.

There were a few differences between the shortleaf pine sites and the mixed hardwood sites. Mixed hardwood sites seemed to have the highest tolerance to impact across the three types of stands, which was also evident in impact index ratings.

Analysis of Correlation

Some tests were done to evaluate the possible correlation of campsite impact variables to distance from trailhead (Table 2, page 36). The objectives of campsite hypothesis five were to determine if the campsite impact variables were correlated to campsite distance to the nearest trailhead, and if so, to determine the degree if this correlation. Spearman's rank correlation test was used and there were significant correlations. A negative correlation of -0.57 indicated a significant relationship of vegetation coverage and distance to the trailhead ($p < 0.01$). As campsite distance from the nearest trailhead increased, the percent vegetation cover decreased.

Additionally, soil compaction and distance to trailhead was found to have a negative correlation of -0.61 which was also significant at this same level ($p < 0.01$) (Figure 6, page 111)

This variable also indicated that as the campsite was farther from a trailhead, impact levels decreased as higher soil compaction readings were found on campsites closer to the trailheads. The remaining impact variables were tested and there was no significant correlation found. In the two cases that were significant, the level of the impact variables were less severe the further the campsites were from the trailhead.

The objectives of campsite hypothesis six were to determine if the campsite impact variables were correlated to the impact index rating system, and to determine the degree of this correlation if it was revealed. Spearman's rank correlation test was used and there were significant correlations found. The variables that were significant were vegetation cover ($r = -0.58$) and bare ground exposure ($r = 0.68$). Figure 7 (page 112) illustrates the relationship of bare ground exposure and impact index rating. The remaining impact variables were tested and there was no significant correlation found.

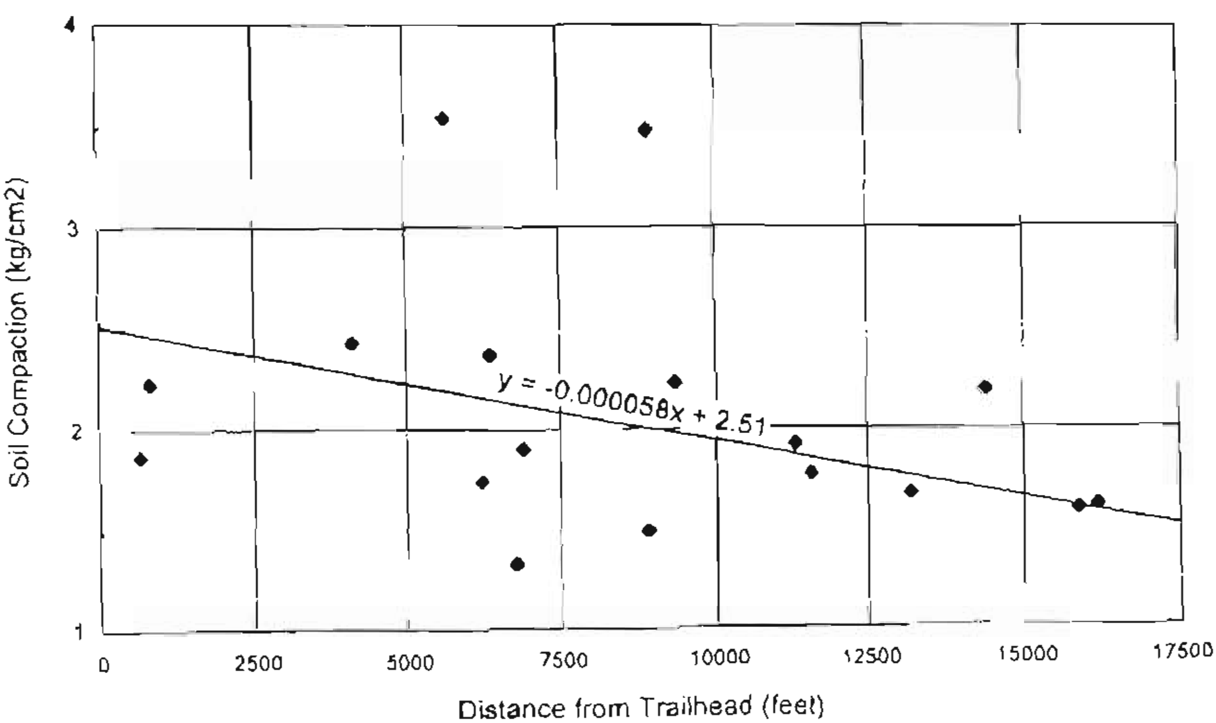


Figure 6. Correlation of Soil Compaction (kg/cm^2) and Distance to Nearest Trailhead (feet).

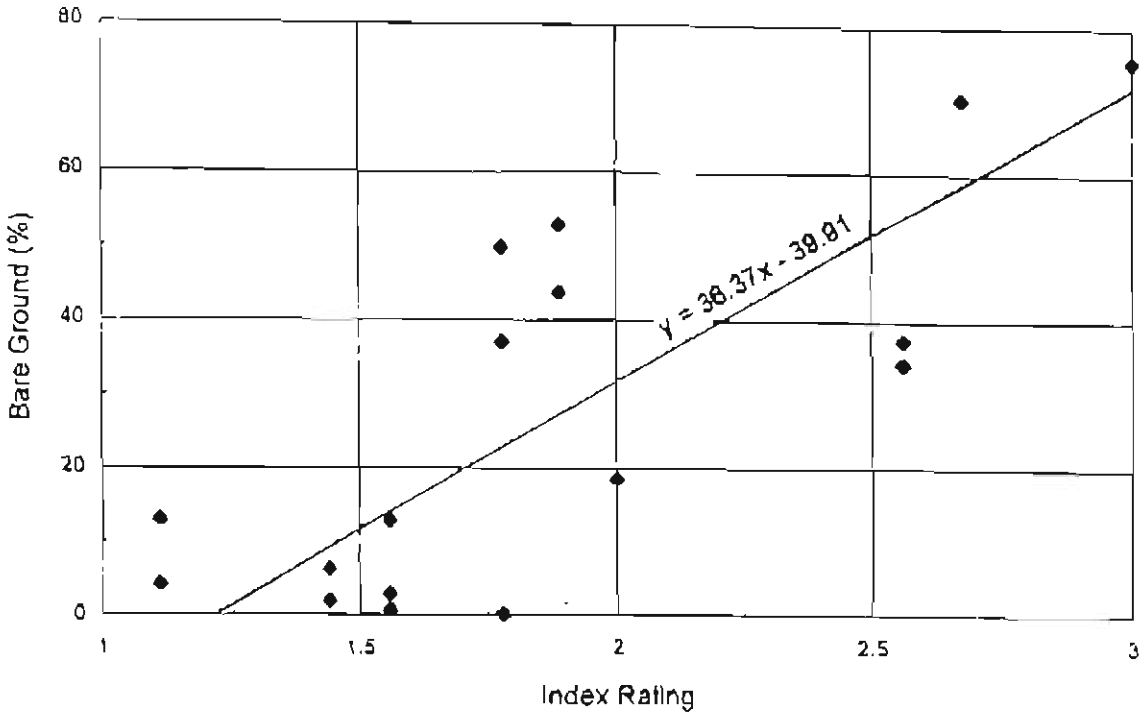


Figure 7. Correlation of Bare Ground Exposure (%) to Impact Index Rating.

Campsite Impact Summary

In summary of the findings there were significant levels of impact found among all campsites within the UKRW. Low to moderate impact levels were the norm across the wilderness area, though a few sites exhibited more severe conditions. Campsite conditions as a whole were at acceptable levels.

In comparison of the current campsite conditions to the LAC standards, there were some campsites that exceeded the standards. The barren core area indicator was exceeded by campsites five, six, eight, sixteen, and seventeen. However, the median barren core area was only 31.25 ft^2, which represented the small barren core area found among most camps. The indicator of number of trees damaged was only exceeded by campsites six, eight, and sixteen. The standard of 100 feet for campsite distance to the nearest water source was exceeded by all campsites east of Kiamichi River Trailhead except campsites seven and ten. The distance of campsite to ONRT was the indicator that was exceeded at all campsites, excluding campsite three. Finally, campsite density was exceeded by campsites two, three, six, ten, twelve, fourteen, fifteen, and sixteen.

Overall, the campsites most impacted were two, five, six, eight, and sixteen. These campsites routinely had the most severe classification of impact measured. These camps received the highest level of use (Kuzmic 1993) among all campsites within the study area. This, implied that the combination of ecological conditions for low impact tolerance and high use levels, created the high level of impact documented on these sites.

General Impact Trends

Some general trends were found across all campsites. Level of use was documented through Kuzmic's 1993 study and compared to levels of impact found on the campsites. Generally, as level of use increased the level of impact increased. According to known use levels, Big River, Wilton Mountain, and Kiamichi River Trailhead had the highest level of use. These three campsites had some of the lowest vegetation coverage found within the area.

Additionally, level of use was the only factor that influenced the level of tree damage of the campsites. Campsites six, eight and sixteen had high to moderate use levels, and each of these campsites had four or more damaged trees. Campsite sixteen had trees with severe root exposure.

In addition to level of use, there were some comparisons of site tolerance to impact. Campsites sixteen and fourteen were severely impacted and they had moderate levels of use (Kuzmic 1993). Additionally, campsites one, four, seven, and Pine Grove camp (not included in this study due to complete recovery) had moderate levels of use (Kuzmic 1993), and exhibited low levels of impact. This demonstrated campsite tolerance to impact as the campsite's resistance and resilience played an important factor, influencing the measured level of impact, due to their ability to sustain and recover from impact.

Further, soil compaction influenced the vegetation cover, bare ground exposure, and barren core area. This parameter was measured as soil penetration and soil permeability Both level of use and soil conditions affected this variable.

Riparian and Non-riparian Trends

There were significant differences between riparian and non-riparian campsites. These differences were barren core area, vegetation cover, bare ground exposure, and soil compaction. Each of these variables were related, but more significantly was the relationship of these variables to soil compaction. There were significant differences found in both soil compaction measurement and saturated infiltration rates between campsites in the two areas. Each test resulted in a more severe measurement on riparian campsites.

The impact implication was that soil conditions of most riparian campsites were more impact susceptible. In addition to the soil conditions, there were higher use levels on these areas. The combination of these two factors probably were the resulting factor of severity of impact. This reinforced the need to relocate campsites further from a water source due to impact conditions. Campsites located nearer to water sources have a an increased potential for deteriorating water conditions due to sediment run-off and water pollution from litter and waste.

Vegetation Type Trends

Forest/lush grass camps had smaller campsite areas and bare ground areas, lower soil compaction levels, impact index ratings, and condition class rating than campsites in other vegetation types. Camps in forest/lush grass types had similar vegetation coverage as camps in forest/ridgetops, but higher coverage than camps in forest/forbs/shrub vegetation type.

By the differences of smaller campsite areas, lower differences of vegetation coverage, bare ground exposure, and soil compaction, there were two principal factors indicated. First, the smaller campsite areas suggested lower use levels. Studies have shown that as use increases campsites exhibit increases in campsite area, vegetation loss, bare ground area, soil compaction, and tree damage (Cole and Hall 1992, Cole 1993).

Second, the tolerance of vegetation types, specifically grasses, influenced the rapid recovery of campsite condition as was indicated by the high levels of vegetation cover, lower bare ground area. Many studies have found grasses more tolerant to impact than forbs, shrubs, and other species (Cole 1983, Cole 1986, Cole and Hall 1992). The differences in soil compaction also indicated either more tolerant soil types or lower use levels.

Additionally, Marion and Cole (1996) found that forest/lush grass vegetation types were much more tolerant to impact due to, not only the vegetation species on the site, but the lack of canopy closure, and other environmental factors.

Therefore, due to low use levels, highly tolerant vegetation, and optimal conditions for impact tolerance, forest/lush grass campsite's vegetation type tended to provide campsites with lower levels of measured impact.

Dominant Stand Trends

The dominant species was divided into three "dominant stand" types which included: mixed hardwood, shortleaf pine (*Pinus echinata*), and a cove species which was American beech (*Fagus grandifolia*). There were some significant differences among the three stands. Campsite area and barren core area was similar across each stand measured. Bare ground exposure and damaged tree percentages were all similar. However, the average vegetation cover, soil compaction readings, and saturated infiltration rates for campsites with the cove species dominant was significantly different than those measurements on campsites in the other two stands. In each case, cove species camps were impacted more severely than the mixed hardwood and pine stand campsites. This trend was also evident in impact index ratings and condition class measurements, as American beech sites were more impacted than campsites in the other two stand types.

American beech are shallow rooted trees found on wet loamy soils that do not drain rapidly(Harlow *et al.* 1991). These conditions, in conjunction with the high use levels of the sites tended to result in increased impact levels, and severely deteriorated campsite conditions. The condition of these sites need immediate remediation prescriptions. Upper Beech Grove camp had trees with severely exposed root systems and the largest barren core area of 1600.00 ft^2. This site specifically needs some remedial action.

General Trail Impact Analyses

Trail transects were established at one mile intervals along the Ouachita National Recreation Trail (ONRT). In addition to mile trail transects, there were four transects that were added as trouble area transects. These transects were located in areas that were perceived by UKRW managers as locations where trail impact problems were evident (Table 7, page 44).

Prior knowledge of trail conditions were unknown, hence the level of change or trail deterioration was indeterminable. Data were collected at each transect in three replications over three collection period. The trail width, trail tread depth, number of treads, and trail profile were measured and averages were recorded (Table 33 and 34, pages 117 and 118).

The average width of trail was 2.73 feet. The widest trail was located at Mile 40 Transect which was in an old road and had an average of 7.10 feet, while the narrowest trail was located at Mile 36 Transect, which was located on a ridgetop and had an average width of 1.70 feet (Appendix B and H).

The average depth of trail was 0.40 feet, or 4.8 inches. The deepest trail was located at the Mile 38 Transect which had an average of 1.26 feet, and the shallowest trail at Trouble Transect Two (transect ten) with an average of 0.10 feet. The average number of treads was 1.31, with transects seven, nine, and eleven having more than one tread.

Table 34, lists the slope and trail profile area of each transect. The average slope for the trails at the transects was 6.45%. The steepest slope was found at trail transect location five, which also had the deepest trail tread. There were two transects that had almost no slope with percentages of 1.0%.

Comparisons to past trail profile conditions were impossible to derive as this study established base-line data. Some general trends were drawn, however, and this measurement

TABLE 33

COMPARISON OF TRAIL WIDTH, DEPTH, AND NUMBER OF TREADS AMONG THE SIXTEEN TRAIL TRANSECTS

Transect Number[a]	Trail Width[b]	Trail Depth	Number of Treads
	- - - - - - - - - feet	- - - - - - - - - -	- - Number - -
1	2.40	0.44	1
2	2.40	1.10	1
3	1.70	0.18	1
4	2.05	0.34	1
5	2.20	1.26	1
6	2.20	0.33	1
7	7.10	0.22	3
8	2.30	0.33	1
9	2.80	-0.08	2
10	2.70	0.10	1
11	4.30	0.39	3
12	2.60	0.09	1
13	1.90	0.50	1
14	2.73	0.69	1
15	2.10	0.21	1
16	2.10	0.38	1

[a] For individual transect type and location see Table 7 (page 44) and/or Appendix B.
[b] For definition of individual trail variable see table 5 page 40 or definition in glossary.

will be more relevant for comparisons in future studies. The range for trail profile was 9.68 ft^2 on trail transect seven, while the smallest trail profile was 3.34 ft^2 on transect three.

TABLE 34

COMPARISON OF SLOPE OF TRAIL AND TRAIL PROFILE
AMONG THE SIXTEEN TRAIL TRANSECTS

Transect Number[a]	Slope of Trail[b]	Trail Profile
	- - percent - -	squared feet
1	10.0	6.43
2	15.5	7.17
3	2.0	3.34
4	6.0	4.85
5	24.0	8.66
6	8.5	5.72
7	1.0	9.68
8	4.0	4.97
9	1.0	4.71
10	2.0	5.31
11	6.0	6.99
12	2.0	4.05
13	13.0	5.45
14	6.0	5.65
15	3.0	4.70
16	3.5	5.12

[a] For individual transect type and location see Table 7 (page 44) and/or Appendix B.
[b] For definition of individual trail variable see table 5 page 40 or definition in glossary.

Individual Trail Transect Results

Each trail transect location had unique environmental and geological conditions. Additionally, each transect had interrelated complexities that affected the differences in impact variables and the measurable level of impact. Consequently, a description of each trail transect impact parameters were recorded.

Mile 35

Mile 35 transect was the first transect located east of Pashubbe Trailhead. This transect was positioned in a pine dominated stand on a trail with a slope of 10.0% (Table 34, page 118). This trail transect location had an average trail width of 2.40 feet, and an average trail tread depth of 0.44 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 6.43 ft^2. This transect was located in a forest/ridgetop vegetation type, with an aspect of 137°. The location was just less than a mile from the trailhead (Appendices B and H), referenced to mile marker 35.

Trouble Transect One

This transect was located about 500 feet east of Mile 35 Transect and just over a half mile west of Pashubbe Point camp. It was designated as a trouble area by Ouachita National Forest managers, due to trail tread depth and trail slope. This transect was positioned in a pine dominated stand on a trail with a slope of 15.5%. This trail location had an average trail width of 2.40 feet, and an average trail tread depth of 1.10 feet (Table 33, page 117). This was the second deepest trail tread found among all trail transects. There was only one trail tread, and the trail profile was 7.17 ft^2 (Table 34, page 118). This transect was located in a forest/ridgetop vegetation type, with an aspect of 191°. The location was just over a mile from the trailhead (Appendices B and H).

Mile 36

Mile 36 transect was the third transect east of Pashubbe Trailhead. This transect was positioned on a trail in a pine/black oak dominated stand. This trail location had a slope of 2.0%, an average trail width of 1.70 feet, and an average trail tread depth of 0.18 feet (Tables 33 and 34, pages 117 and 118). There was only one trail tread, and the trail profile was 3.34 ft^2. This trail profile area was the smallest among all trail transects and it also had the narrowest trail bare ground area. This transect was located in a forest/ridgetop vegetation type, with an aspect of 312°. This transect was not referenced to a mile marker, but was located near a marked tree (Appendices B and H).

Mile 37

Mile 37 transect was the fourth transect, located about 1500 feet east of Wilton Mountain Campsite. This transect was positioned on the ONRT in a black oak dominated stand. Trail slope was 6.0% and the average trail width was 2.05 feet (Tables 33 and 34, page 117-118). The trail tread depth average was 0.34 feet. There was only one trail tread, and the trail profile was 4.85 ft^2. This transect was located in a forest/ridgetop vegetation type, with an aspect of 142°. There was no mile marker to reference this site (Appendices B and H).

Mile 38

Mile 38 transect was a transect located east of Mile 38 campsite. This transect was positioned near a trail switchback in an area that had a steep slope. The transect was located in a pine/hickory dominated stand and the trail slope average was 24.0% (Table 34, page 118). This was the steepest slope found on trail transects in the area. This trail transect had an average trail width of 2.20 feet, and exhibited the deepest average trail tread depth of 1.26 feet (Table 34, page 117). There was only one trail tread, and the trail profile was 8.66 ft^2. This transect was located in a forest/ridgetop vegetation type, over a mile and a quarter from Kiamichi River Trailhead (Appendix B and H).

Mile 39

Mile 39 transect was the first transect located west of Kiamichi River Trailhead. This transect was positioned in a pine dominated stand on a trail with a slope of 8.50%. This trail transect location had an average trail width of 2.20 feet, and an average trail tread depth of 0.33 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 5.72 ft^2 (Table 34, page 118). This transect was located in a forest/ridgetop vegetation type, with an aspect of 41°. The location was just less than half a mile from Kiamichi River Trailhead and although no mile marker was found, the 39 mile marker tree was found and referenced for this site. (Appendices B and H).

Mile 40

Mile 40 transect was the first transect located east of Kiamichi River Trailhead, and east of Pine Mountain campsite by about 1500 feet. This transect was positioned on an old road area and in a mixed hardwood dominated stand. The trail slope for this transect was 1.0%, and the trail tread depth was 0.22 feet (Tables 33 and 34, pages 117 and 118). Mile 40's trail width average was 7.10 feet, trail profile average was 9.68 ft^2, and there were three trail treads. This trail transect was the widest and had the largest trail profile area. It was also one of the few transects that had more than one trail tread. This transect was located in a forest/forbs/shrubs vegetation type (Appendices B and H).

Mile 41

Mile 41 transect was a transect located about 500 feet east of Big River campsite. This transect was positioned in a oak dominated stand on a trail with a slope of 4.0%. Trail transect average trail width was 2.30 feet, and the average trail tread depth was 0.33 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 4.97 ft^2 (Table 34, page 118). This transect was located in a forest/forbs/shrub vegetation type, in a riparian area. Trail transect location was referenced to mile marker 41 (Appendices B and H).

Mile 42

Mile 42 transect was located about 40 feet west of Mile 42 campsite, in an old road area. The trail area of this transect was dominated by mixed hardwood species, and trail slope was 1.0%. This trail transect location had an average trail width of 1.80 feet, and an average trail tread depth of -0.08 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 4.71 ft^2 (Table 34, page 118). This transect was located in a riparian vegetation type, as it was very near the river. No mile marker was found for location reference (Appendices B and H).

Mile 43

Mile 43 transect was a transect located between Mile 43 camp and Island camp (Appendix B and H). It was referenced to the mile 43 marker. This transect was positioned in a pine/oak dominated stand on a trail with a slope of 2.00% (Table 33, page 118). This trail transect location had an average trail width of 2.70 feet, and an average trail tread depth of 0.10 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 5.31 ft^2. This transect was located in a forest/lush grass vegetation type, near to the Kiamichi River, and it was classified as an old road transect.

Mile 44

Mile 44 transect was the first transect located east of Road campsite (Appendices B and H). This transect was located near and referenced to mile marker 44, and it was positioned in a pine/hickory dominated stand The trail had a slope of 6.0%, and the average trail tread depth was 0.39 feet (Tables 33 and 34, pages 117 and 118). This trail transect location had an average trail width of 4.30 feet, an average trail profile area of 6.99 ft^2, and there were three treads. This transect was located in a riparian vegetation type. It was also designated as being in an old road area.

Trouble Transect Two

This transect, Trouble Transect Two, was located 500 feet east of Upper Beech Grove campsite, and was referenced to an American beech tree with the initials JD and DD carved into it (Appendices B and H). This transect was positioned in an American beech dominated stand on a trail with a slope of 2.0% (Table 34, page 118). This trail transect location had an average trail width of 2.60 feet, and an average trail tread depth of 0.09 feet (Table 33, page 117). There was only one trail tread, and the trail profile was 4.05 ft^2. This transect was located in a forest/forbs/shrubs vegetation type.

Mile 45

Mile 45 transect was located east of Rehabilitated Campsite, on the trail leading away from the river. This transect was positioned in a black oak dominated stand on a trail with a slope of 13.0% (Table 34, page 118). This trail transect location had an average trail width of 1.90 feet, and an average trail tread depth of 0.50 feet (Tables 33, page 117). There was only one trail tread, and the trail profile was 5.45 ft^2. This transect was located in a forest/ridgetop vegetation type, with an aspect of 229°. The mile marker was not found in reference to this site (Appendices B and H).

Trouble Transect Three

This transect (transect fourteen) was located near the non-designated overlook, at a switchback along the ONRT. The placement of this trail transect was just less than a mile from Stateline Trailhead (Appendices B and H). This transect was positioned in a black oak/hickory dominated stand on forest ridgetop vegetation type. The trail had a slope of 6.00%, and a tread depth of 0.69 feet (Tables 33 and 34, pages 117 and 118). This trail transect location had an average trail width of 2.73 feet and an average trail profile area of 5.65 ft^2.

Trouble Transect Four

Trouble transect four was located about a half mile from Stateline Trailhead. This transect was positioned in a white oak dominated stand. The trail had a slope of 3.0% and a tread depth of 0.21 feet (Tables 33 and 34, pages 117 and 118). Trail width was 2.10 feet, and there was only one trail tread. The trail profile average for this transect was 4.70 ft^2. This transect was located in a forest/ridgetop vegetation type. Transect location was referenced to a large boulder and a white oak that resembled a scarecrow tree (Appendices B and H).

Trouble Transect Five

This was the nearest transect to Stateline Trailhead, as it was only three hundred yards from the wilderness portal (Appendices B and H). This transect was positioned in a hickory dominated stand, near the ridge of Rich Mountain. The trail had a slope of 3.50% and a trail depth of 0.38 feet (Tables 33 and 34, pages 117 and 118). This trail location had an average trail width of 2.10 feet, and an average profile area of 5.12 ft^2. This transect was located in a forest/ridgetop vegetation type.

Grouped Trail Impact Analyses

Riparian and Non-riparian Trail Comparisons

Trail transects were divided into riparian trail transects and non-riparian transects. Comparisons were made across transects in these two zones. There were six transects designated as riparian transects, and ten designated as non-riparian transects. The width of trail was similar across the two zones, as riparian trails had an average width of 3.63 feet, while non-riparian trails had an average of 2.18 feet (Table 35, page 125).

TABLE 35

RELATIONSHIP OF TRAIL WIDTH AND TRAIL DEPTH BETWEEN TRAIL TRANSECTS IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Trail Transect Location	Trail Width			Trail Depth		
	Mean	Range	F-value	Mean	Range	F-value
	feet					
Riparian Trails	3.63	2.30-7.10	1.04[b]	0.18	-0.08-0.39	4.21[c]
Non-Riparian Trails	2.18	1.70-2.73		0.54	0.81-1.26	

[a] Riparian trail transects were defined as transects 100 or less feet from any water source, (N=10). Non-Riparian trail transects were transects farther than 100 feet from any water source, (N=6). All tests were done using the Kruskall-Wallis test.
[b] Difference was not significant, $p = 0.3134$.
[c] Significant difference, $p < 0.0461$; Hypothesis 1 rejected for trail depth.

However, the depth of trail tread was not the same across zones. The average trail tread depth for riparian trails was 0.18 feet, which was not a deep as non-riparian trails with an average trail tread depth of 0.54 feet.

There was also a difference in the average number of trail treads across the two zones. The average number of treads for riparian transects was 1.83 treads, while the average for non-riparian trails was 1.00 treads (Table 36, page 126). The trail profile area was not significantly different between the two zones.

Old Road and Non-old Road Trail Comparisons

Trails located on old roads were compared to trails not located on old roads. The trail width was significantly different across trail transects on the two trail types. Old road trails had an average of 4.23 feet, which was wider than the average for non-old road trails of 2.22 feet (Table 37, page 126).

However, the trail depth between the two trail types were not significantly different across the two areas (Table 37, page 126). Further, the number of treads was also significant across the two areas. Old roads had an average of 2.25 treads, which was higher than the average for trails not in old roads (Table 38, page 127).

TABLE 36

RELATIONSHIP OF NUMBER OF TREADS AND TRAIL PROFILE BETWEEN TRAIL TRANSECTS IN RIPARIAN AND NON-RIPARIAN AREAS[a]

Trail Transect Location	Number of Treads			Trail Profile		
	Mean	Range	F-value	Mean	Range	F-value
	------ number ----			------- squared feet -----		
Riparian Trails	1.83	1-3	10.39[b]	5.95	4.05-9.68	3.98[c]
Non-Riparian Trails	1.00	1		5.71	3.34-7.17	

[a] Riparian trail transects were defined as transects 100 or less feet from any water source, (N=10). Non-Riparian trail transects were transects farther than 100 feet from any water source, (N=6). All tests were done using the Kruskall-Wallis test.
[b] Significant difference, $p < 0.0024$; Hypothesis 1 rejected for number of trail treads.
[c] Difference was not significant, $p = 0.0578$.

TABLE 37

RELATIONSHIP OF TRAIL WIDTH AND TRAIL DEPTH BETWEEN TRAIL TRANSECTS IN OLD ROADS AND NON-OLD ROAD AREAS[a]

Trail Transect Location	Trail Width			Trail Depth		
	Mean	Range	F-value	Mean	Range	F-value
	------------------- feet ---------------------					
Old Road Trails	4.23	2.80-7.10	31.19[b]	0.13	-0.08-0.39	0.89[c]
Non-Road Trails	2.22	1.70-2.73		0.49	0.09-1.26	

[a] All tests were done using the Kruskall-Wallis test.
[b] Significant difference, $p < 0.0001$; Hypothesis 2 rejected for trail width.
[c] Difference was not significant, $p = 0.3506$.

The trail profile area for the two different trail locations were different, as the old road transect had a larger profile area than non-old road transects (Table 38).

TABLE 38

RELATIONSHIP OF NUMBER OF TREADS AND TRAIL PROFILE BETWEEN TRAIL TRANSECTS IN OLD ROADS AND NON-OLD ROAD AREAS[a]

Trail Transect Location	Number of Treads			Trail Profile		
	Mean	Range	F-value	Mean	Range	F-value
	------ number ----			------- squared feet -----		
Old Road Trails	2.25	1-3	30.20[b]	6.67	4.71-9.68	8.33[c]
Non-old Road Trails	1.00	1		5.51	3.34-7.17	

[a] All tests were done using the Kruskall-Wallis test.
[b] Significant difference, $p < 0.0001$; Hypothesis 2 rejected for number of trail treads.
[c] Significant difference, $p < 0.006$; Hypothesis 2 rejected for trail profile.

Analysis of Correlation for Trail Transects

Analyses for correlation were made among each trail variable to the trail distance from the nearest trailhead (Hypothesis 3, Table 4, page 39).

The objectives of trail hypothesis three were to determine if the trail impact variables were correlated to the distance of the trail from the nearest trailhead. Spearman's rank correlation test was used and there were no significant relationships found. Due to the type of impact found within the area there was not a significant correlation of trail impact variables to the distance from the nearest trailhead. Due to reported day-use levels, there were many visitors that hiked the UKRW without camping, causing similar impacts along the trail (Kuzmic 1993).

The objectives of trail hypothesis four were to determine if the trail impact variables were correlated to the slope of the trail and to determine the degree if this correlation if it was revealed (Table 4, page 39). Spearman's rank correlation test was used and there was significant correlation found. The only variable that was significant was trail tread depth (r =

0.79). Figure 8 illustrates the relationship of this correlation. The relationship of trail depth to slope was positive, which indicated that as the trail slope increased, the trail tread depth increased. These findings were similar to many studies evaluating the correlation of trail depth to slope (Helgath 1975, Burde and Renfro 1986, Cole 1983, Cole 1991). The remaining impact variables were tested and there was no significant correlation found.

Impact Summary of Litter Found on the ONRT

During collection periods, the researcher continually inspected the trail for litter. The amount of litter encountered was low over the collection period. The average amount of litter found on the ONRT was about one piece per mile over the entire trail. Generally, the highest litter amounts were found on the campsites. However, the standard for litter on the trail was "0 pieces per mile" and as some pieces were found the standard was exceeded.

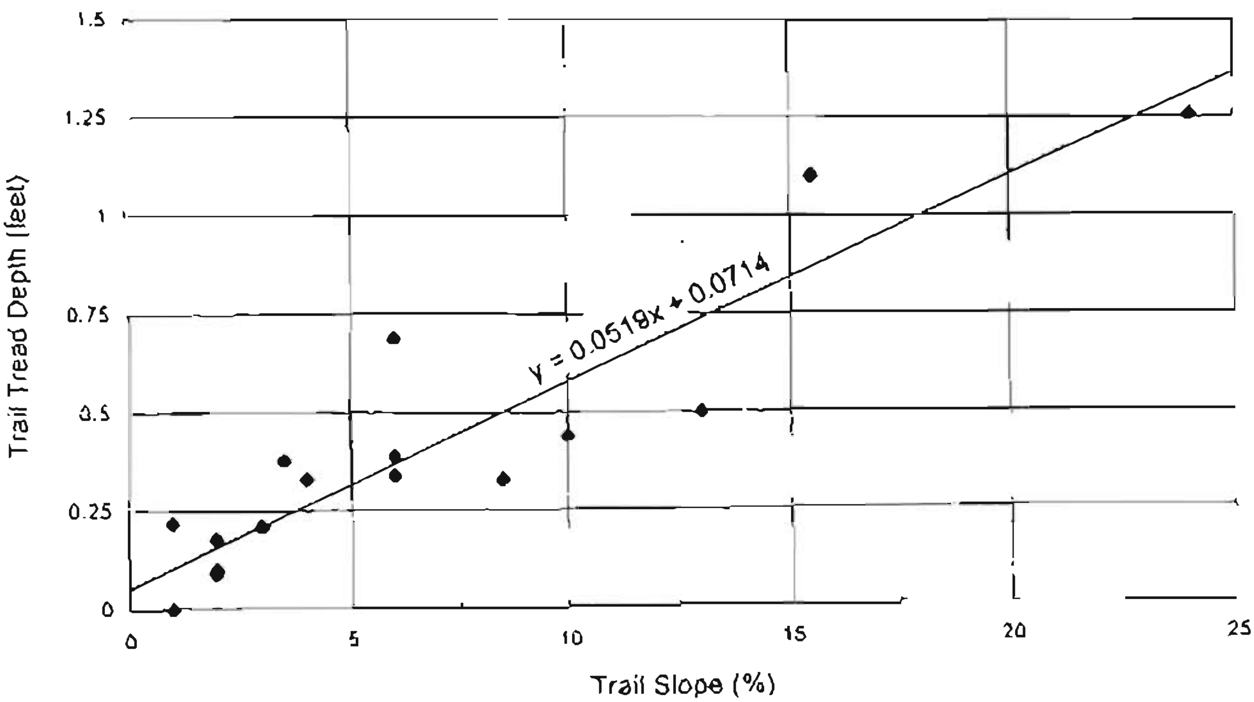


Figure 8. The Relationship of Trail Tread Depth to Trail Slope.

Impact Summary of Trail Transects

There were significant differences found on trails located in various areas. Trails located in riparian zones were similar to non-riparian in trail width and trail profile, but dissimilar in trail depth and number of trail trends (Tables 35 and 36, pages 125 and 126).

Trails located in riparian zones had an average slope of 2.67%, with four of the six locations having a slope of 1 to 2 %. Due to the relatively flat area, and proximity to water, these areas were located on wet slow draining soils which were puddle prone. When puddles formed, hikers tended to evade them by walking around, thus widening the trail. The lack of slope decreased trail erosion potential, therefore the soil depth for these areas were not as deep as trails in non-riparian areas.

However, the average slope for trails located in non-riparian areas was 8.85%. The relationship of trail depth to slope was positive ($r = 0.79$) (Figure 8, page 128). Therefore the trail depth in non-riparian areas was deeper than riparian areas.

Many have found that the slope of the trail was strongly related to the type of impact found on the site (Helgath 1975, Cole 1983, Burde and Renfro 1986, Cole 1991, Leung and Marion 1996). Cole (1983) found trends on trails in his study area, that slopes greater than 4.7% were severe by which it created optimal conditions for trail erosion thus resulting in increased trail depth. Additionally, the lack of slope caused trail widening by the puddling phenomenon. Areas with slope percentages of less than 1%, were prone to trail widening.

Trails located in old roads were also a problem within this area. This was one of the problems identified by the UKRW visitors (Kuzmic 1993). Trail width, number of treads, and trail profile were larger among old road trails than non-old road trails. The average width for old road trails was 4.23 feet, which was significantly larger than the average for non-old road trails of 2.22 feet. The number of treads were also greater in old roads than in non-old roads.

Quite likely, UKRW visitor may perceive the trail along old road as visually obtrusive since they had a wide corridor surrounded by trees on both sides and multiple trail treads.

There were ruts where vehicles had traveled in the past, and many times this was the location of the multiple trail treads. Most of the trails located in old road areas were flat, as the average slope for these areas was 2.50%.

As Leung and Marion (1996) stated, trails in some backcountry areas were placed in convenient locations of an old road or trail. At one time, these old roads were used to transport people from point A to point B, and selections of road placements were not in consideration of the optimal area to minimize impacts, but rather a straight line between travel points.

Trail placement needs reevaluation and consideration of optimal tolerance and use.

Trail Profile Bracket Evaluation

The trail profile bracket was light weight and easy to transport through the study area. The bracket was easily assembled and disassembled when measuring sites along the trail. The instrument was evaluated through a statistical comparison of difference between replication measurements and in each case no significant difference was found, therefore, the bracket exhibited a high degree of precision. The trail profile bracket is recommended for future studies.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of Objectives and Procedures

This study was designed to establish baseline data for initiation of Upper Kiamichi River Wilderness (UKRW) impact monitoring. Campsite measurements were documented and current campsite conditions were compared to specific standards. Trail transects were also established at one mile intervals along the Ouachita National Recreation Trail (ONRT), for future trail condition measurements and trail deterioration analysis. Statistical analyses were made to evaluate UKRW campsite and trail impact trends.

UKRW's indicators and standards were previously established and standards were Opportunity Class specific. The UKRW was divided into four Opportunity Classes by which varying impact levels were tolerated, and the primary study area was the corridor surrounding the ONRT, which is designated as Opportunity Class Three (O. C. 3).

Data were collected in three replications to eliminate potential measurement error, and these data collection periods were one week periods in May, June, and July

Campsite data collection consisted of permanent point system, completion of a rapid inventory form, impact rating assessments, with photographic records for added emphasis and future monitoring site relocation. Data included; campsite area, barren core area, vegetation cover, bare ground area, soil compaction, instantaneous and saturated infiltration rates, and tree damage. Two impact assessments used were Frissell's Condition Class definitions and classification system (Table 1, page 27), and an Impact Index Rating system (Appendix F) provided by the U. S. Forest Service. Impact Index Rating method considered nine variables and classed each variable on a scale of one to three, the average of these classes was the impact index rating. The Rapid Inventory form, provided by the U. S. Forest Service, was designed to collect campsite data which indicated use levels, use patterns, or ecological conditions. The form defined the parameters and descriptor categories used for this study (Appendix C).

In addition to analyzing campsite to control differences, three comparative subgroups were analyzed. These subgroups included riparian campsites to non-riparian campsites, campsite comparisons between three forest vegetation types, and campsite comparisons between three dominant tree species types. The vegetation types analyzed were forest/lush grass, forest/ridgetop, and forest/forbs/shrubs, and the dominant species types were grouped into mixed hardwood, shortleaf pine (*Pinus echinata)*, and American beech (*Fagus grandifolia)*. Additionally, campsite impact variables were analyzed for correlation to both the campsite distance to nearest trailhead and impact index rating.

In addition to trail transect establishment, trail transect data collection consisted of trail slope, trail width, area aspect, number of trail treads, and vegetation type. Trail profile brackets were used to measure trail profile area, and trail tread depth.

Two comparative pair analyses were made, including riparian trails to non-riparian trails and old road trails to non-old road trails. Each trail variable was also tested for correlation to trail transect distance to nearest the trailhead and trail slope.

There were a total of ten hypothesis tested (Table 2, page 37, and Table 4, page 39). Statistical tests used were Wilcoxen Signed Ranks Test, Kruskall-Wallis Test, and Spearman Rank Correlation. All test were done with S. A. S. (Statistical Analysis System), at a 0.05 significance level.

Summary of Campsite Findings

The campsite population consisted of seventeen campsite located in O. C. 3, at varying distances along the ONRT (Appendix A). The average campsite area was 915.31 ft^2, with a barren core average of 298.68 ft^2. Average campsite vegetation loss was 37.00%, as each campsite had a significant vegetation loss except campsite seven which had a significant vegetation gain. Average bare ground exposure across all campsites was 27.48%, which ranged from 77.50% on campsite eight to 0.22% on campsite four. Campsite soil compaction average was 2.08 kg/cm^2, while the average control soil compaction was 0.99 kg/cm^2. Number of trees damaged on campsites was 2.02 trees/site. Average instantaneous and saturated rates were 1.53 cm/min and 1.32 cm/min respectively, and on most campsites, both parameters were significantly lower than their controls.

The indicators measured, as defined by the UKRW Limits of Acceptable Change (LAC) plan, were barren core area, campsite's distance to nearest water source, campsite distance to the primary trail, number of trees damaged per campsite, and number of camps per mile.

The standard for O. C. 3, for barren core area was 200 ft^2. Five of seventeen campsites (Campsites five, six, eight, sixteen, and seventeen), or almost one-third of all campsites exceeded this standard.

O. C. 3 standard for distance of the nearest water source was 100 ft, and each campsite east of Kiamichi River Trailhead exceeded this standard, except campsites seven and ten. The average campsite distance to water source was 904.07 ft, while the average campsite distance to water source for campsites east of Kiamichi River Trailhead was 78.39 ft. This was considerable campsite location problem, as almost two-thirds of all campsites exceeded this indicator's standard. O. C. 3 standard for campsite distance to the primary trail was 100 ft, and every campsite exceeded this standard except campsite three. This was also a campsite location problem affecting privacy and solitude as 94% campsites exceeded this standard.

Number of damaged trees indicator had a standard of less than four per campsite, in this opportunity class. Campsites six, eight, and sixteen exceeded this standard. Additionally, campsites with campsite areas larger than 1000 ft^2 should be mentioned. Campsites two, five, six, seven, eight, and sixteen had a total campsite area larger than this proposed standard, and indicator.

Among the two impact rating systems, campsites five, six, eight, and sixteen had ratings that indicated moderate to high impact levels. Campsite eight was documented as having the most severe conditions with the Impact Index Rating method and campsite sixteen had the most severe Condition Class with an assessment score of "5." Campsites not listed above exhibited low and moderate impact indications.

In addition to individual campsite analyses, significant results were found in grouped campsite comparisons. Riparian and non-riparian campsites were compared to test for differences between these two zones. Campsites in these two areas had similar campsite areas and number of damaged trees. Riparian campsites had an average barren core area of 446.69 ft^2 which was significantly larger than non-riparian campsites with an average barren core area of 27.34 ft^2. The vegetation cover was also more severe on riparian campsites, as the average vegetation cover for riparian campsites was 30.78%, while the average vegetation cover for non-riparian campsites almost doubled with 57.08%. The bare ground exposure for riparian campsites, averaged 38.84% which was higher than the average for non-riparian campsites with an average of 7.82%. Additionally, soil compaction, and saturated infiltration rates were more severe on riparian campsites than on non-riparian campsites. In conclusion, riparian campsite impact levels were more pronounced than non-riparian campsites, due to significant differences in both the impact index rating and the condition class assessment.

There were three vegetation types identified within the UKRW's boundaries. These vegetation types were forest/lush grass, forest/ridgetop, and forest/forbs/shrubs. Campsites of these three vegetation types were compared to demonstrate differences between these areas. Campsites in these three areas had different campsite areas as forest/lush grass camps had an average campsite area of 611.39 ft^2, which was significantly smaller than campsite area averages of both forest/ridgetop campsites of 1332.59 ft^2 and forest/forbs/shrubs campsite of 1040.78 ft^2. Campsite barren core areas between three vegetation types were similar. Vegetation cover and bare ground exposure percentages were also different across the campsites areas. Forest/lush grass campsites had an average vegetation cover of 68.43%

which was higher than forest/forbs/shrubs campsite's average of 15.44%. Further, forest/ridgetop campsites had an average vegetation cover of 31.32% which was similar to campsites in the other two vegetation types. Bare ground exposure on forest/lush grass camps was 10.46% which was lower than the averages on campsites in the two other vegetation types. Additionally, soil compaction was more severe on forest/ridgetop and forest/forbs/shrubs camps than on forest/lush grass camps. The number of damaged trees, and both infiltration rates were similar across campsites in the three vegetation areas. The impact index rating and condition class assessment was also indicative of these findings as the averages found on forest/lush grass camps indicated low to moderate levels of impact, while impact levels were more pronounced on campsites in both forest/ridgetop and forest/forbs/shrubs.

The dominant species was recorded and then classed into dominant species classes. The dominant species classes were derived as three unique tree species types that required unique conditions. Campsite area and barren core area were similar across the three dominant species stands. Mixed hardwood stand campsites had an average vegetation cover of 43.40%, which was similar to pine stand campsites with an average of 40.14%. However, cove species campsite vegetation cover was 28.85%, which was significantly lower than averages on campsites in the other two stand types. The bare ground exposure percentage, tree damage, and instantaneous infiltration rates were similar across campsite in the three land types. However, there were significant differences in soil penetrometer reading and saturated infiltration rates. The average soil compaction for mixed hardwood stand and pine stand campsites was 2.01 kg/cm^2 and 1.91 kg/cm^2 respectively. These readings were significantly lower than 2.55 kg/cm^2 which was the average found on campsites in the cove species stand. These trends were also documented in saturated infiltration readings, as cove species stand campsites had averages lower than campsites in the other two stand types. The campsite impact index rating for cove species stand camps exhibited higher impact levels than other campsites. Furthermore, campsite condition class assessment for cove stand campsites were higher than mixed hardwood stand campsites, and pine stand sites had similar condition class assessments as both mixed hardwood sites and cove species sites.

Data were analyzed for correlation relationships. Each impact variable (Table 3, page 37) was compared to distance to trailhead. These tests investigated the correlation of level of impact to the distance of the trailhead. There were some correlations found in vegetation cover ($r = -0.57$) and soil compaction ($r = -0.61$, Figure 6, page 111). Both of these impact variables exhibited a negative correlation. This correlation implicated that campsites farther from a trailhead, had less impact than campsites closer to a trailhead.

Date were also analyzed for correlation of each impact variables to the impact index rating. There was a correlation found in vegetation cover ($r = -0.58$), and bare ground exposure ($r = 0.59$, Figure 7, page 112). This correlation implied that vegetation cover and bare ground exposure were good indicators of impact levels due to their relationship to the impact index rating.

Summary of Trail Findings

Litter analyses were made and the average amount of litter found on the ONRT was about one piece per mile. Generally, the highest litter amounts were found on the campsites. However, the standard for litter on the trail was "0 pieces per mile" and as some pieces were found, it was concluded that the standard had been exceeded.

Trail impact conditions were compared across riparian and non-riparian trail transects. Non-riparian trails were significantly deeper than riparian trails, and riparian trails tended to exhibit more trail treads than non-riparian trails. The trail width, and trail profile was similar across trail transects in the two zones.

Old road trail transects were compared to non-old road transect. Old road transects were wider, had more trail treads, and higher trail profiles, than non-old road trails. Trail tread depth was similar across the two trail transects areas.

Correlation analyses were made of each trail transect variable (Table 5, page 41) and distance to trailhead. There was no significance correlation found.

Additionally, correlation analyses were made for each trail transect variable to trail slope. Through this analysis, a strong correlation relationship of trail tread depth and trail slope was found (r = 0.77, Figure 8, page 128).

Conclusions of Campsite Conditions

Impact trends found on the UKRW's campsite were similar to impact trends documented by other wilderness impact studies. There were complex relationships found in site impact tolerances and inferences were made to use level. Various impact levels were documented and these differences could be due to ecological conditions and use levels. Implications were that due to ecological conditions and use levels, there were varying impact levels measured on UKRW campsites. These ecological conditions that could directly influence UKRW campsite's impact level are soil type, soil depth, soil texture, and soil moisture as well as vegetation tolerances. These factors influence a campsite's resistance and resilience, which in turn influence impact levels and visitor perception of impact.

The nodes and linkages phenomenon (Manning 1979) was a trend exhibited at the UKRW as inferred from the absence of trails leading away from the ONRT and no evidence campsites outside O. C. 3.

Several campsite conditions exceeded their standards, and the standard most often exceeded was campsite distance to ONRT. This likely influences the level of solitude and privacy perceived by campers. Most campsites had screening ratings of partial to none between campsites and trail, allowing passersby a direct view of campsite area and its inhabitants. This likely affects the perception of solitude and crowding of both the camper and hiker.

Additionally, campsite distance to water source was exceeded by eleven of seventeen campsites. Although visitors typically like to camp near a water source, this trend affects not only the physical campsite conditions, in respect to low impact tolerance due to poor campsite ecological conditions, but it may also affect the Kiamichi River water purity.

Individual impact problems were found on a few sites as some campsites had unacceptably large barren core areas. These areas were heavily impacted, as the barren core area was larger that the LAC standard for campsites (Table 16, page 70). The barren core area for these sites indicated high use levels, or poor tolerance to impact due to ecological conditions.

Another indicator that was exceeded by relatively few campsites, was number of damaged trees on the site. The standard is less than four and campsites six, eight, and sixteen had four or more damaged trees. The trees on campsites six and eight, exhibited conscious tree damage, as visitor had chopped down, bent over, carved in, and peeled bark from trees on these campsites. Campsite sixteen exhibited unconscious tree damage as the total impact on this site caused severe root exposure on the American beech trees of the campsite area.

The campsite density for the entire wilderness was low when compared to other wilderness areas. The density for the UKRW was 0.004 camps/ha, or 1.5 camps/1000 acres. The spacing of campsites along the ONRT, resulted in an average of 0.95 campsites per mile, however, there were some campsites less than 200 feet within one another. There were nine campsites that had a campsite density greater than the standard of 1 camp/mile. Seven of these campsites were influenced through the creation of three new campsites initiated since Kuzmic's 1993 study. The initiation of Wilton's Point, Island, and New campsites created some of the high levels of campsite density.

Increases in campsite numbers were also evident in other studies, as campsite density increases through time. This trend is a result of an over-crowding perception by visitors due to perceived impact, actual displacement due to occupancy of a nearby campsite, or through a preventive measure for campers to secure the wilderness perception they desire (Cole 1993).

In comparison of riparian to non-riparian campsites, inferences were made that significance differences in soil compaction and saturated infiltration rates were a result of lower tolerance to impact, due to poor soil conditions. These sites were more susceptible to impact, and higher use levels due to their unique position and recreational opportunities provided by these sites.

Forest/lush grass vegetation type campsites had a grass dominated understory vegetation, and due to lower impact levels measured, implications were that this vegetation type gave these sites higher impact tolerance. Grasses are more tolerant to impact than forbs and shrubs and after impact occurs, these grasses recover rapidly (Hendee *et al.* 1990, Cole and Hall 1992). Significant differences in soil compaction indicated more tolerant soil conditions to impact and/or lower use levels.

There were some significant differences found between the three dominant stand campsites measured. Campsite area, barren core area, bare ground exposure, and damaged tree percentages were all similar. However, the average vegetation cover, soil compaction readings, and saturated infiltration rates exhibited higher impact levels on campsites with cove species dominant than the two other dominant stand campsites. This trend was also evident in impact index ratings and condition class measurements, as American beech sites were more impacted than campsites in the other two stands.

There were relationships found that indicated the campsites proximity to trailhead was important. However, these relationships were weakly correlated, indicating that some visitors likely had favorite campsites in the UKRW's interior, or they wished to remove themselves to a more primitive area. Campsites close to the trailhead tended to exhibit higher levels of impact, like campsites five, six, eight, sixteen, and seventeen, and campsites further from the trailheads tended to exhibit lower impact levels, like campsites ten, eleven, and twelve (Appendix A).

Implications for Campsite Management

The most prominent UKRW campsite problem was campsite distance to the primary trail. Sixteen of seventeen campsites were less than 100 feet from the ONRT, and in many cases a campsite's edge touched the trail's edge. This is an indicator derived for the UKRW management and most campsites exceeded this standard. This may be a severe problem affecting the perception of solitude and privacy by visitors in the UKRW.

Secondly, eleven of twelve campsites were located nearer than 100 feet from a water source. This is also a severe campsite problem that may affect the Kiamichi River's water condition.

There were other standards exceeded by the UKRW campsites. Three campsites had more than four trees damaged, five campsites had barren core areas larger than 200 ft^2, and six campsites had campsite densities larger than 1 camp/mile. These were problems considered when remedial prescriptions were defined.

Many have argued for the most "light-handed" methods to manage wilderness. Often, the most appropriate and most light-handed management prescription is visitor education. By educating the visitor of good backcountry practices and opportunity expectations, visitors can leave the area as wild as possible, while gaining good experience through their visit.

Through "leave no trace" camping methods education, some impact problems could be reduced. "Leave no trace" camping methods suggest a 200 feet buffer between the camp and the nearest water source, and camping far from the trail (Hampton and Cole 1988). This would reduce future campsite creation within 100 feet of water sources. Many have also suggested camping well off of the trail to minimize the impact seen by passing hikers and to increase visitor solitude. Leave no Trace education should also include limiting tree damage and its importance.

"Pack-in, pack-out" education needs more emphasis to reduce the level of litter on the campsites, as well as programs to encourage small group camping. Large groups tend to cause higher levels of impact and leave more litter, over a very short time. Camping in large groups cause both physical campsite impacts and social impacts to visitors who pass by or hears them in the next valley.

Additional education should emphasis the importance of campsite location based on type of experience desired. If a camping excursion is all that is needed, campers should be encouraged to camp at an already existing campsite. This would minimize the impact caused to the area by using an already existent impacted campsite, instead of creating a new campsite. New campsites rapidly become high impact sites. Therefore to maintain impact levels within acceptable limits, previously impacted campsite use holds impact levels below a threshold (Cole 1993a).

If solitude and primitive conditions are expected, campers should be encouraged to get off the trail and hike into Opportunity Class One and get away. These campers need to know how to pick a campsite with potentially high tolerance to impact, and they should be discouraged from camping in the same location more than once a year.

Educational media such as signs and simple pamphlets describing the above conditions and benefits should be used by UKRW management. Although this may not be the optimal method for wilderness education (Doucette and Cole 1993), this is the most applicable due to low use levels (Kuzmic 1993) and management resources available.

Education should reduce the number of trees damaged, and new campsite creation in unacceptable areas, but education will not remove problem campsites. Management will have to close campsites to remove them. As stated previously, campsite distance to the trail and water source were two primary problems within this area, in addition to some campsites with barren core areas exceeding the standard. To alleviate these problems, closure of a few sites is recommended, specifically sites two, six, eight, and sixteen.

Although campsite closure is considered a more "heavy-handed" management prescription, some campsite closure are recommended. Campsite closure should be based on weighted measures that dictate attribute importance, as an management objective. Campsite closure would include; fire ring removal, firewood dispersal, posting signs of campsite closure, and in extreme cases, revegetation with native plant species

As UKRW managers maintain impact levels, and they attempt to meet the standards defined in their LAC plan, campsite closure will occur across the entire area. Currently, sixteen of seventeen campsites exceed at least one standard, and the indicator exceeded is campsite distance to trail. In determining which campsite to close, campsite conditions should be compared to set UKRW standards by this area's LAC plan. However, managers need to decide on what conditions need remediation first. Therefore, managers need to first evaluate campsite conditions individually, and then as a whole. Hence, managers would observe campsite impact levels, specifically barren core area and number of damaged trees, and then compare these indicators to campsite density and campsite distance to trail and water source. The worst conditions need immediate remediation, and then eventually minor impact conditions should be alleviated.

Campsites recommended for immediate closure were sites that exhibited severe impact levels and conditions that exceeded most of the standards. Campsite two should be closed, but campsite three should likely be retained as a future campsite area. Campsite six should be closed, and no other campsites should be established nearby due to severe campsite densities. Campsite eight was the largest campsite within the area, and this campsite exceeded four of five indicators measured. Therefore, campsite eight should be closed and, due to low campsite densities, a new campsite should be established in a more resistant location. Also, campsite sixteen exhibited high impact levels as each indicator measured was exceeded. This site should be closed, and due to high campsite densities, and initiation of another campsite, no other campsites should be established nearby. In the near future, campsites eleven and thirteen may also need further evaluation for possible closure, since are approaching threshold levels in the UKRW's LAC plan.

As an endeavor to maintain UKRW standards, eventually almost all campsites will need to be closed. A viable management scheme for new campsite establishment would include making new designated campsite areas, with an arrow on a small wooden sign directing campsite location. After one campsite is closed managers need to pick the optimal new campsite location. Through this study, American beech stand campsites were least tolerant to impact due to inferences made in campsite condition comparison. The second most impacted campsites were sites located nearer than 100 feet of the Kiamichi River. Campsite located in forest/lush grass vegetation types exhibited low impact levels and were perceived as being more tolerant due to the existence of the sites lush grass. As managers select an appropriate campsite location, they determine the optimal spot for tolerance due to ecological conditions, and best privacy and solitude conditions.

Again, education could communicate that recreational visitors could get off the ONRT to experience a more wild recreational opportunity and as they practice "leave no trace" camping methods they should cause little impact. This is considered the most important UKRW management message to recreational visitors.

Conclusions and Implications for Trail Management

Through future monitoring, trail location in old roads could be evaluated to gauge trail deterioration differences between old road and non-old road. By moving the trail, great cost as well as increased impact would be incurred (Echelbeger and Plumley, 1986). Therefore, moving the trail is not recommended.

Certain trail segments need maintaining and trail hardening. Some locations, where trails are located on steep slopes need water bars or logs placed across them as steps to slow the movement of water down. These trail locations include areas adjacent to transects two, five, six, and fourteen.

Minimum trail impact education programs need to be initiated to encourage hiking within the trail's bare ground area and to discourage littering.

Recommendations for Further Study

1.) Establishment of a routine monitoring program is needed. Since the UKRW use level is low compared to other areas, a suggestion would be a yearly campsite condition monitoring using the impact index rating system. Additionally, once every five years a more precise measurement method should be used, such as a study like this one. This method provides more accurate data to analyze campsite condition.

2.) Annual trail monitoring program initiation by measuring trail transects once every year, and evaluate the ONRT for litter levels and trail deterioration.

3.) Investigate the impact trends between riparian and non-riparian campsites. Determine causal effects and reasons for differences.

4.) Determine the factors that caused the differences between American beech stand campsites and the other campsites.

5.) Initiate a study to evaluate the reason that people typically camp near the trail and water source.

6.) Examine how visitors perception has changed through management implementation.

7.) Investigate UKRW visitor perception of the area's environmental condition.

8.) Initiate environmental studies to evaluate the long term differences caused through factors other than on-site recreation.

9.) Examine impacts resulting from campsites being established close to a water source.

10.) Examine differences in impact between close canopy campsites and campsites with no canopy closure.

11.) Document campsite condition, like vegetation cover, bare ground exposure, infiltration rates, soil compaction, vegetation species, soil pH, and soil nutrients, as new designated campsites are created. Compare conditions prior to Initial use, to future conditions after use. Evaluations could be made seasonally and annually.

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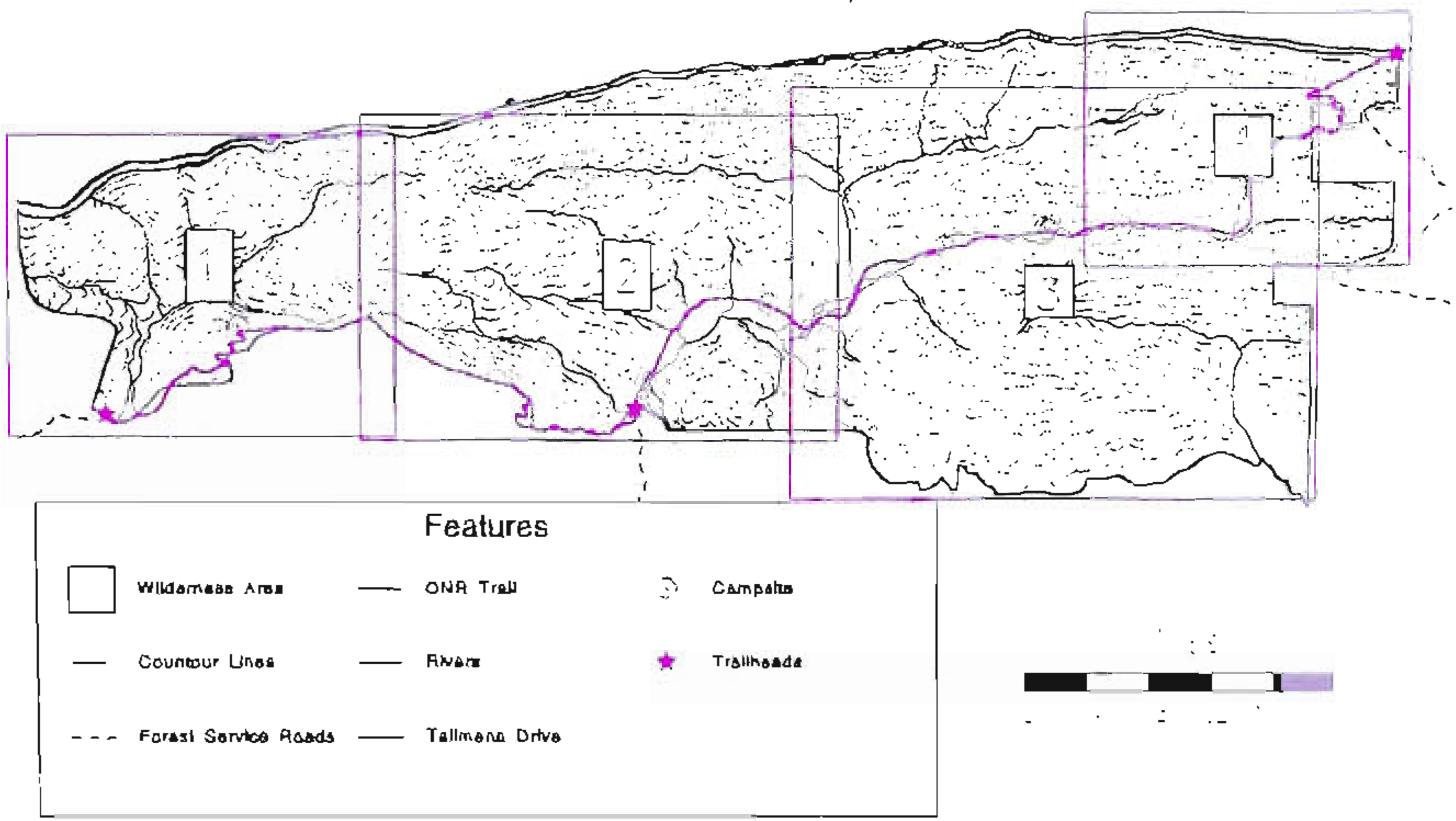
APPENDICES

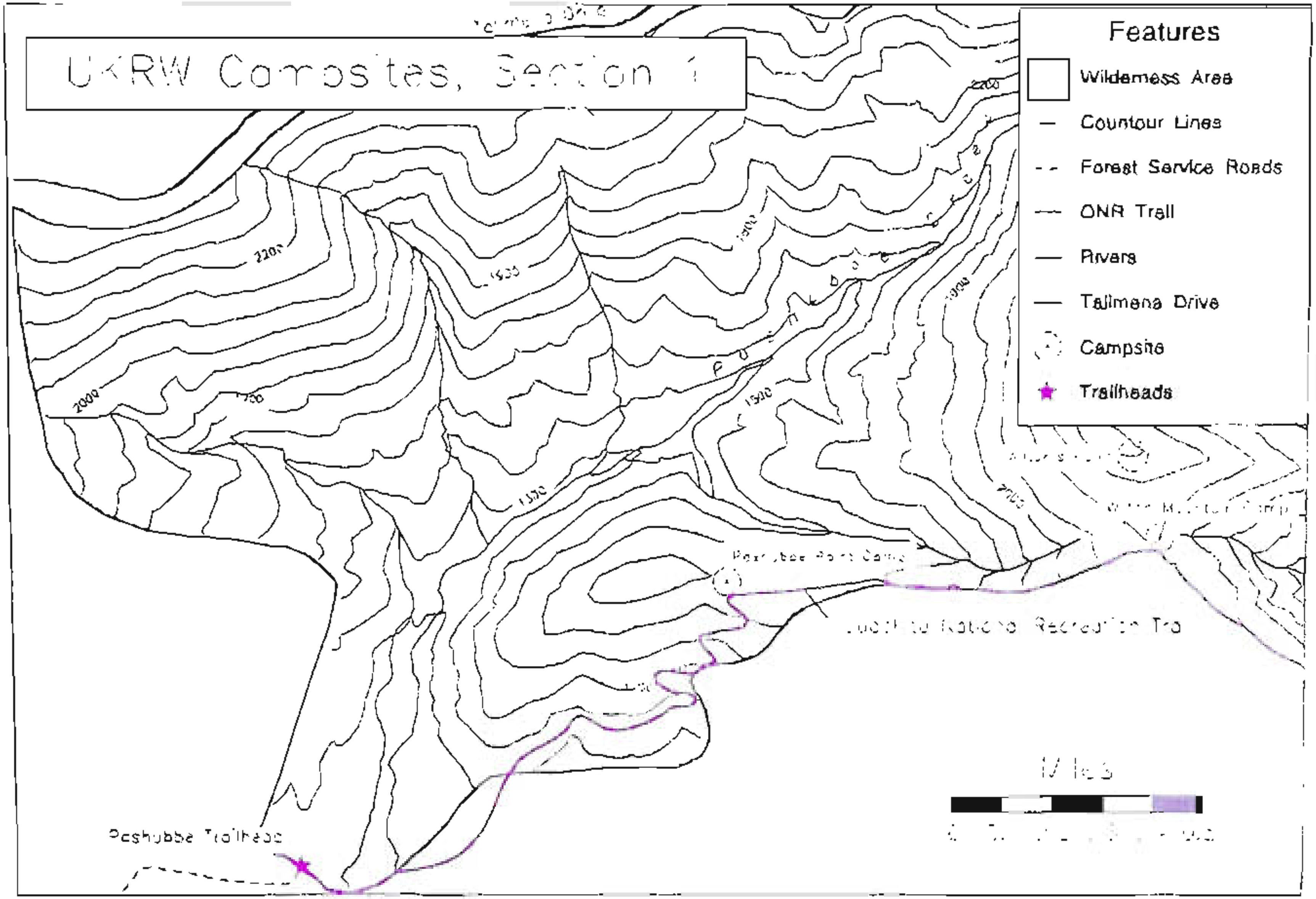
APPENDIX A

MAP INDEX FOR CAMPSITE LOCATION

UKPW Campsite Locations

Section Descriptions





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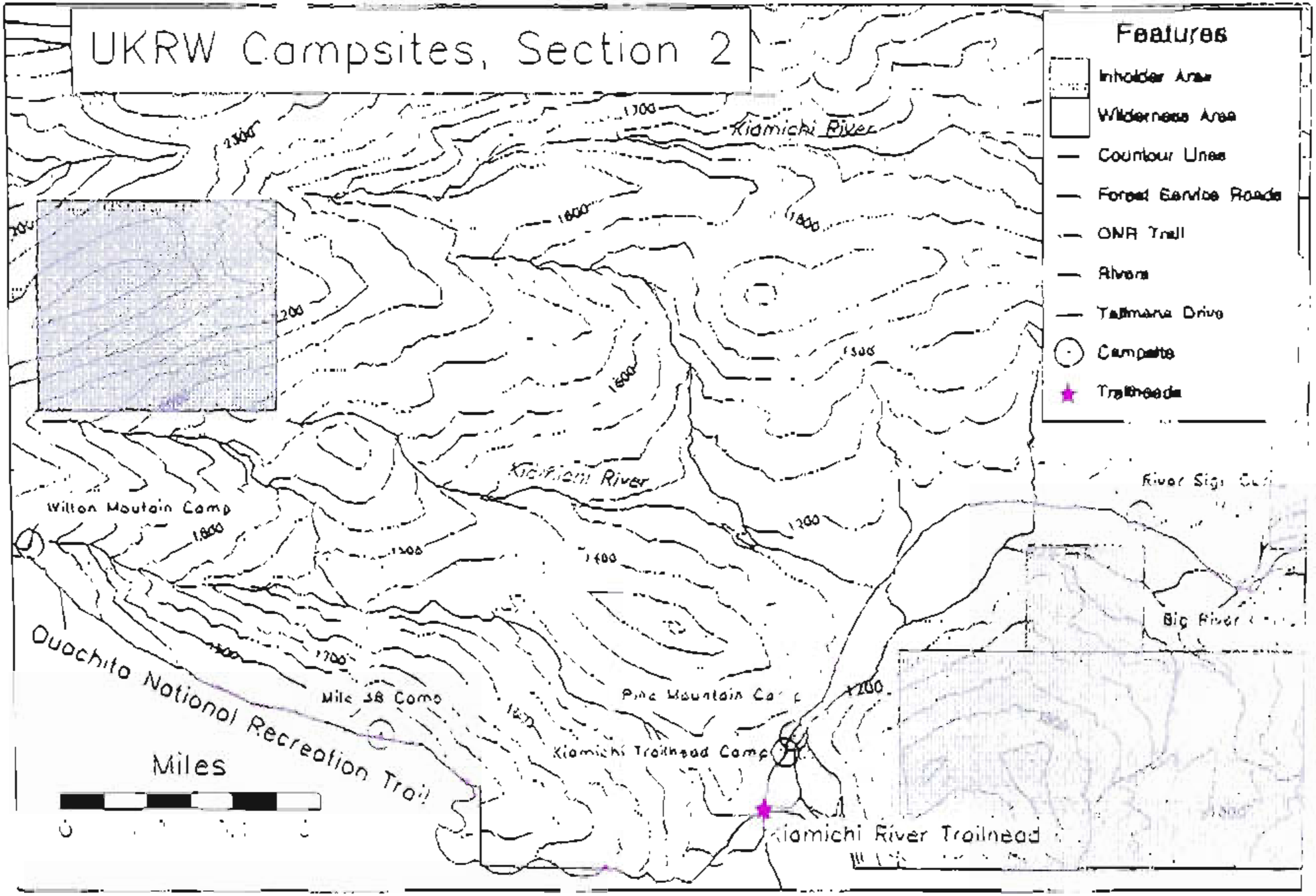
Forest Service Roads
ONR Trail
Rivers
Talimena Drive
Campsite
Trailheads



UKRW Campsites, Section 2
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Kiamichi River
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Pine Mountain Ca
Kiamichi Trailhead Camp
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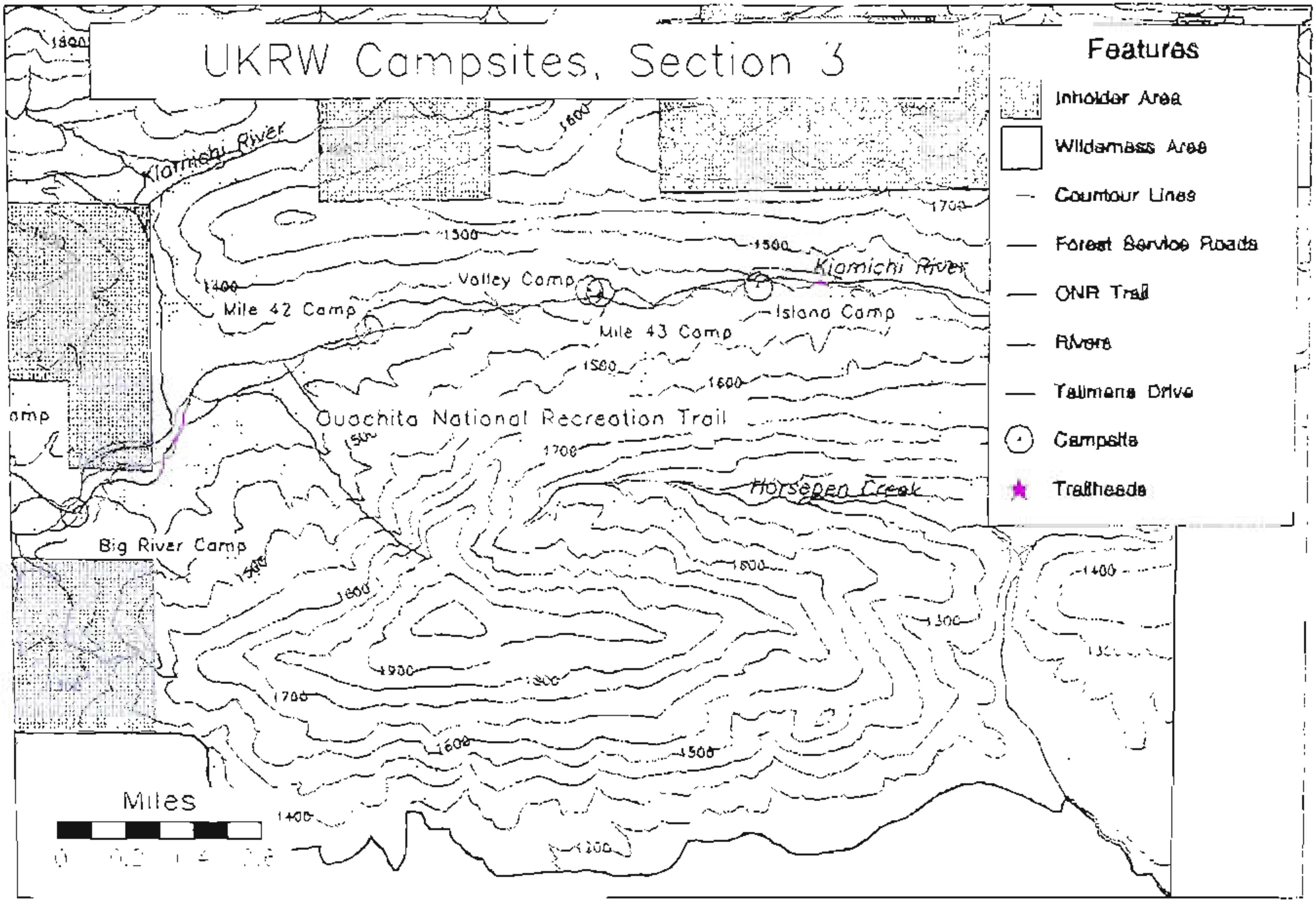
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Forest Service Roads
ONR Trail
Rivers
Talimena Drive
Campsite
Trailheads
Kiamichi River
Valley Camp
Mile 42 Camp
Mile 43 Camp
Island Camp
Ouachita National Recreation Trail
Horsepen Creek
Big River Camp
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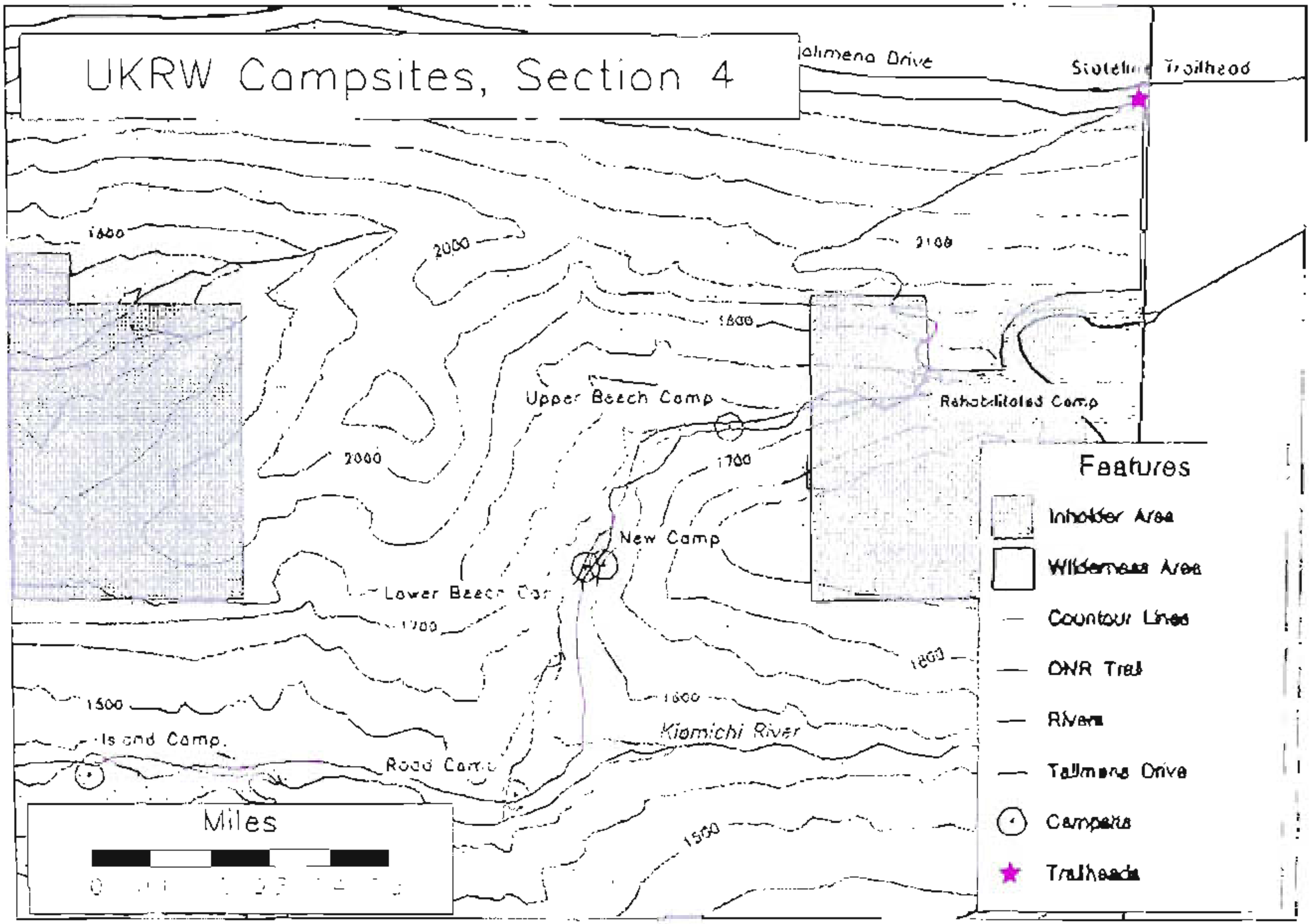
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Rehabilitated Camp
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New Camp
Lower Beech Ca
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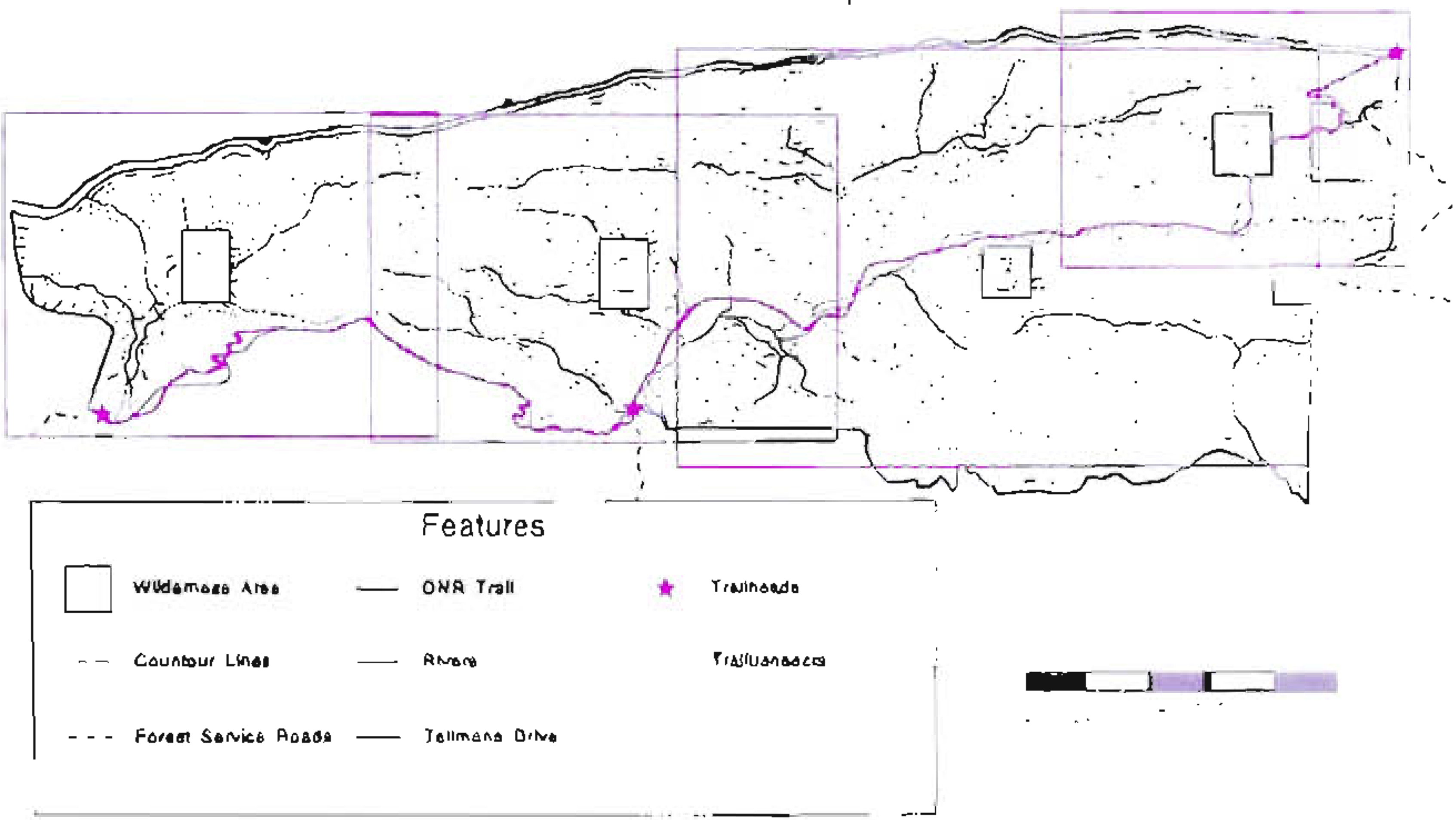
Kiamichi River
Is and Camp
Road Cam
1500
Miles
Features
Inholder Area
Wilderness Area
Countour Lines
ONR Trail
Rivers
Tallmena Drive
Campsites
Trailheads

APPENDIX B

MAP INDEX FOR TRAIL TRANSECTS LOCATION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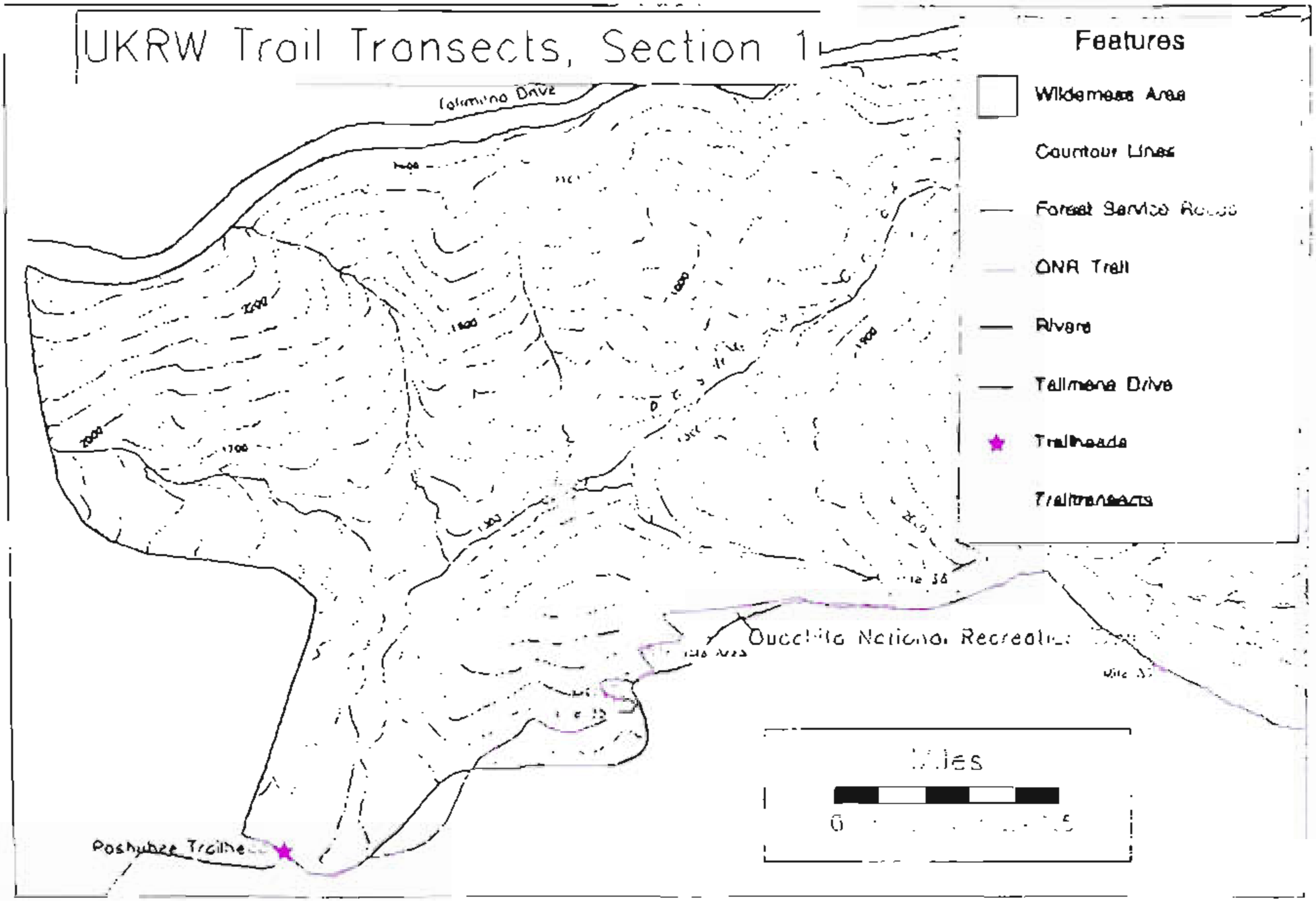

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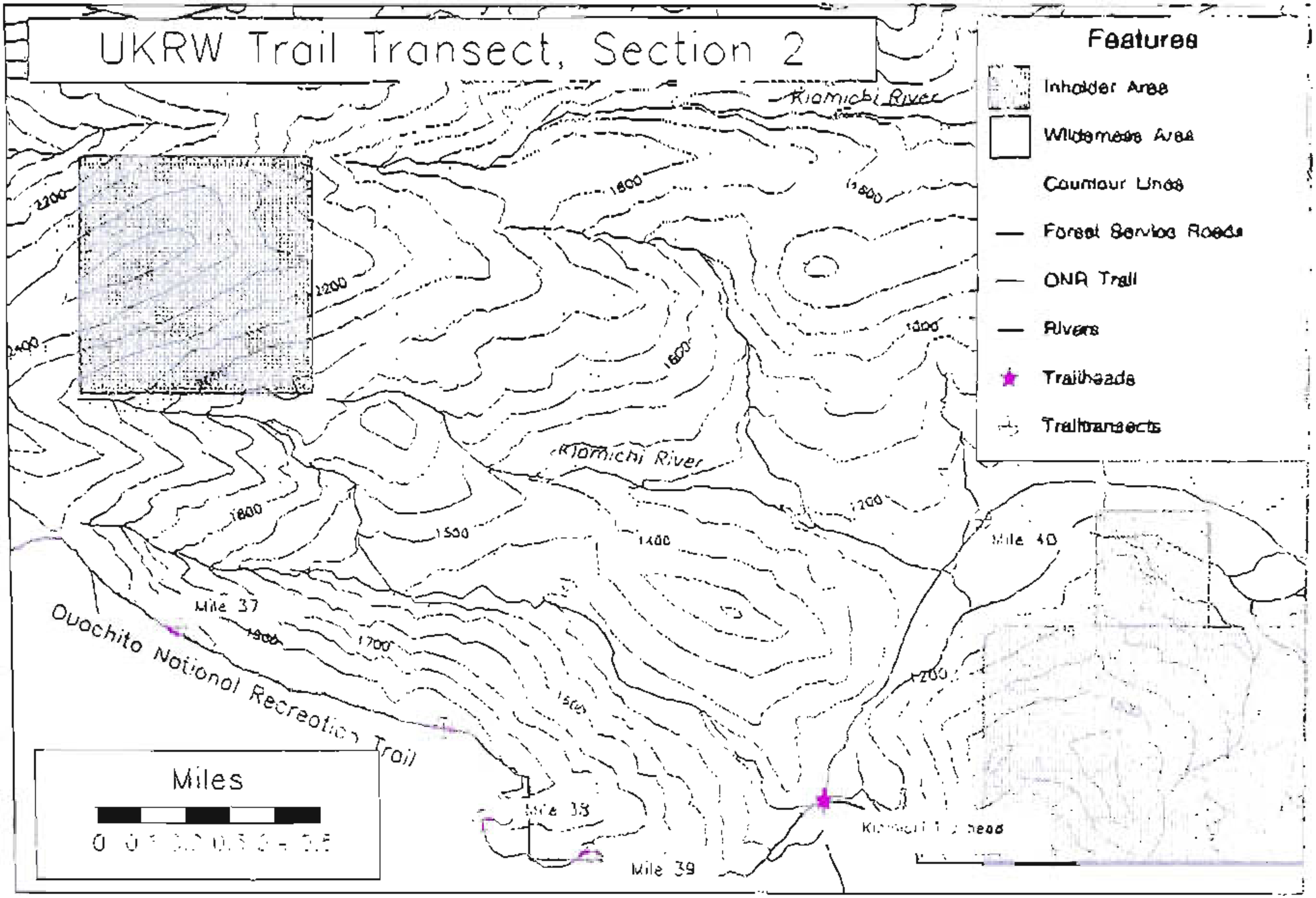
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Kiamichi River
Ouachita National Recreation Trail
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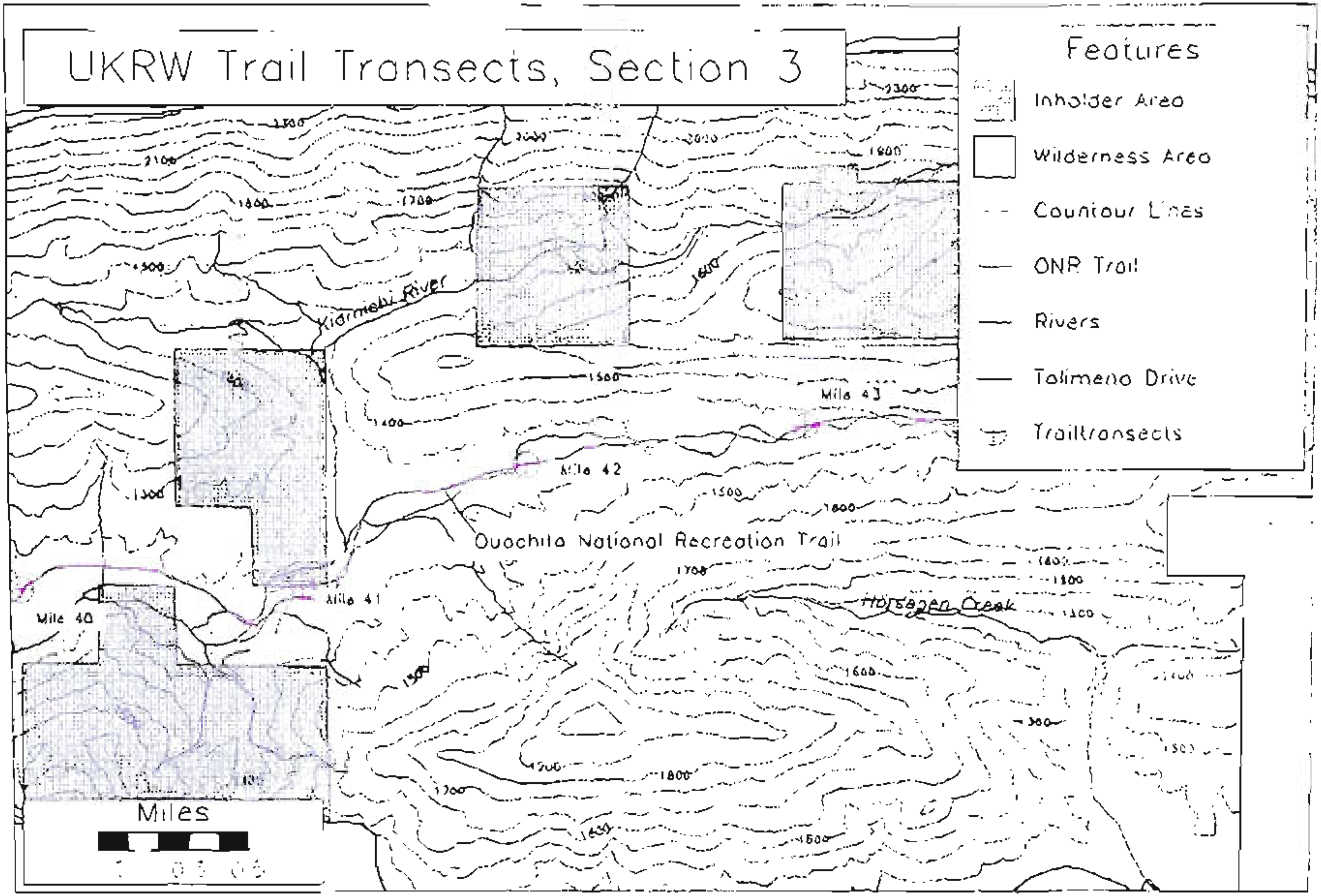
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Features
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Wilderness Area
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Trailtransects
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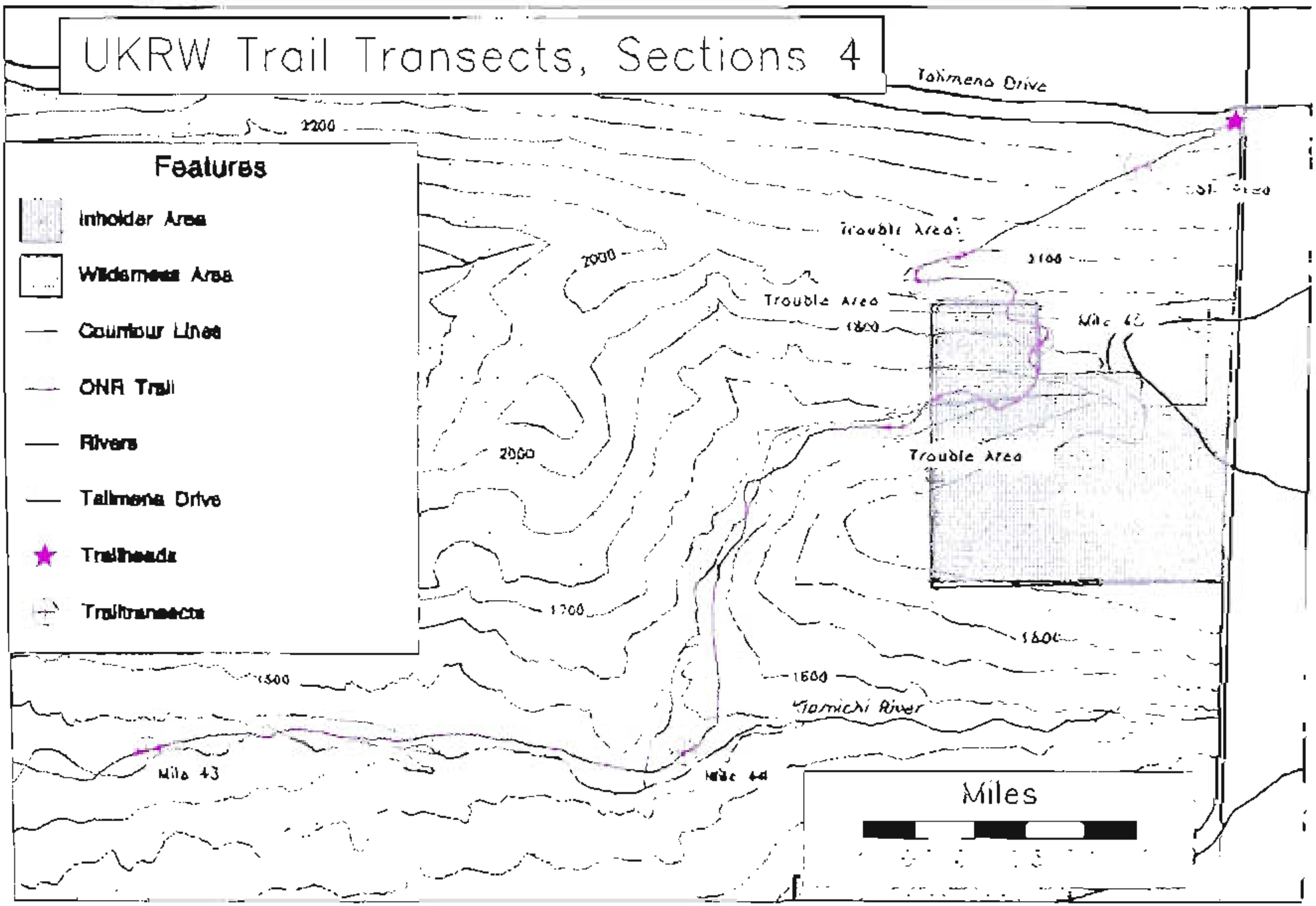
Horsepen Creek
Mile 40
Mile 41
Mile 42
Mile 43
Miles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Wilderness Area
Countour Lines
ONR Trail
Rivers
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Mile 43
Mile 44
Miles

APPENDIX C

PROCEDURES FOR DATA COLLECTION AND DATA COLLECTION FORMS FOR CAMPSITES

PROCEDURES FOR DATA COLLECTION AND DATA COLLECTION FORMS FOR CAMPSITES

1.) Site Name and Number. Campsite name and number were recorded.

2.) Campsite Center Point Identification and References. The campsite central point was re-established through the use of reference points identified.

3.) Condition Class Assessment. Condition Class of site was assessed and recorded using the criteria listed previously in Table 1, page 27.

4.) Vegetation. The most prominent vegetation type on the site was recorded. This variable was divided into six categories:

1.) Forest/Ridgetop
2.) Forest/Forbs/Shrubs
3.) Forest/Lush Grass
4.) Old Homesite
5.) Grassland/Glade
6.) Riparian

5.) Dominant Species. The dominant species of the site was documented. Dominant species was the species that was most representative of the site.

6.) Landform. Landform group was comprised of six categories;

1.) North Slope
2.) Creek Bottom
3.) Shelter Bluff
4.) South Slope
5.) Ridgetop
6.) Terrace

7.) Trail Screening. Campsite screening from the trail was estimated and categorized.

1.) Complete
2.) Partial
3.) None

8.) Distance to Constructed Trail. Campsite distance to the ONRT was measured from the center of the campsite to the nearest edge of the ONRT.

9.) Distance to Closest Water Source. Campsite distance to the nearest water source was measured from the campsite's center to the nearest water source's edge.

10.) Type of Water. The source of water referred to in step 11 was documented.

1.) Creek
2.) Pond
3.) Spring
4.) Other ____________.

11.) Number of Trails. Number of trails connected to the campsite were counted.

12.) Distance to Closest Campsite. Campsite distance between campsites was measured if the campsite was within two hundred feet of the next campsite. Otherwise, this distance was calculated in the office.

13.) Campsite Screening. Screening between campsites was estimated and categorized into one of the following classes.

1.) Complete
2.) Partial
3.) None

14.) Maximum Party Size Accommodated. Party size accommodations was estimated and grouped into one of the folowing categories.

1.) 1-2
2.) 3-6
3.) 7-10
4.) 11-15
5.) More than 15

15.) Type of Use. Type of use that had occurred on the site was approximated, and data was grouped into one of the following categories;

1.) Hiker
2.) Horse
3.) Hunter-hiker
4.) Hunter-auto

16.) Facilities. The number of the following site developments were recorded; fire ring, primitive seat, constructed seat, table, shelf, counter, meat rack, hitchrail, or other.

17.) Closest Firewood Source. The distance to the nearest firewood source was determined.

1.) On-site
2.) 50 feet away
3.) 50-100 feet way
4.) More than 100 feet away.

18.) Impact Parameters.

A. Campsite Area and Barren Core Area. Sixteen transects were established, radiating from the central point to campsite edge. Each transect was rotated clockwise twenty-two and a half degrees (22.5°). A clothe tape was used to measure the distance from campsite center to the first sign of vegetation and to the campsite's edge. The edge of the campsite was determined by changes in vegetation height/disturbance, topography, organic litter amount and/or organic litter type (Marion 1991).

B. Site Photograph. Campsite photographs were taken. Multiple photos were taken of the campsite standing outside the campsite and looking in.

C. Undisturbed Islands and Satellite Areas. Undisturbed islands and satellite sites were measured for area analysis.

D. Percent Vegetation Ground Cover. Vegetation cover was measured as a percent coverage through placement of quadrants. Four transects for quadrant measurements were established. The azimuth for the first transect was randomly drawn before going to the field, and the remaining transects were rotated ninety degrees (90°) in a clockwise direction. Quadrates were placed along the transects at distances determined in Appendix D. The results were placed into one of five categories;

1.) 0-5%
2.) 6-25%
3.) 26-50%
4.) 51-75%
5.) 76-100%

E Soil Exposure. Soil Exposure was defined as a percentage of ground with little or no organic litter and/or vegetation cover. This parameter was measured in conjunction with the vegetation cover listed above. Each quadrate was analyzed for the percent soil exposure and results were placed into one of five categories;

1.) 0-5%
2.) 6-25%
3.) 26-50%
4.) 51-75%
5.) 76-100%

F. Soil Compaction. Soil compaction was measured with a pocket soil penetrometer. Measurements were taken at the lower right hand corner of each quadrate placement.

G. Water Infiltration Rates. Water infiltration rates were taken twice per site within 3.2 to 6.56 ft from the site's center along two transects. This positioning was pre-determined before data collection. Infiltration rates were measure with a double-ring Infiltrometer. The time elapsed for the infiltration of the first 0.39 inch (1 cm) of water was called the instantaneous rate, while the rate for the first two inches (5 cm) was called the saturation rate.

H. Number of Trees. Number of trees (trees are woody species taller than 155 in.) within the site boundary was counted and recorded for stem damage assessment and root damage assessment. Marion's (1991) tree damage rating was used as listed below.

1.) None/Slight: No or slight damage, only broken or cut lower branches, a nail, or minimal trunk scars.
2.) Moderate: Numerous small trunk scars and nails, or one moderate sized scar.
3.) Severe: Many large trunk scars, penetrating to inner wood, girdling of tree.

Marion's (1991) root damage rating was used as listed below.

1.) None/Slight: No or slight root exposure such as typical adjacent offsite areas.
2.) Moderate: Top half of major roots exposed from more than one foot from tree.
3.) Severe: Three-quarters or more of major roots exposed from one foot from tree, soil erosion obvious.

I. Cleanliness. The amount of litter/trash was evaluated. Litter or trash was defined as any human waste or non-natural substance that is left at the site. This included human and any non- native animal feces. Categories are listed below.

1.) No more than scattered charcoal from one fire ring. No other litter found.
2.) Remnants of more than one fire ring, some litter or manure. Some litter was considered a handful up to a two and a half gallon container of litter.
3.) Human waste much litter or manure. Much litter was more than a two and a half container of litter.

19.) Establish Control Plot. Control plot was established along a pre-determined azimuth and at a distance of three times the length of the nearest campsite transect. If a control plot was placed in an area uniquely different from the campsite, an alternative control plot was chosen.

A. Control Plot Center. Azimuth and distance from the campsites center point to the control plot center was recorded.

B. Perimeter for Control Plot. Pins with flagging were placed around the edge of the control site for number of trees and tree damage analysis on the control plot.

C. Vegetation Ground Cover of Control Site. Vegetation cover was assessed through methods described for campsite analysis. Quadrate transects were placed along the same azimuth and distances used in the campsite area. Results were placed into the same categories listed above.

D. Soil Exposure. This parameter was also measured in conjunction with the vegetation cover listed above, as the percent soil exposure was placed a category listed above.

E. Soil Compaction. Measurements were taken as on the campsite area.

F. Water Infiltration Rates. Water infiltration rates were taken twice in the control site position exactly as the same location as the campsite in relation to control plot center. Infiltration rates were measured in exactly the same methods used on the campsite.

20.) Calculations Done in the Office. Calculations were made for completion of impact parameters. The following was derived in the office.

A. Campsite Barren Core. Barren core area was calculated with computer software.

B. Total Campsite Area. Total campsite area was also calculated through computer software.

C. Sketch Map. From data taken in "Impact Parameters, 18a above, a campsite map was drawn. This map included azimuth and lengths of transects, barren core area, and total campsite area.

D. Distance to Closest Trailhead. The distance from the campsite to the closest trailhead was measured after returning from the field.

E. Number of Campsite Within Mile. Number of campsites per mile was calculated.

F. Campsite Index. Campsite index rating (Appendix E) was completed.

Wilderness Campsite Impact
Permanent Sampling Unit Form

Site Name ______________________ USGS Quadrangle ______________

Site Number ____________________ Township __________________

Wilderness _____________________ Section ___________________

Date __________________________ Coded by __________________

Campsite Center Point Identification

Locate three reference points and document azimuth to center point, distance, and description of the reference points with a map. Take three photos documenting location where taken and azimuth.

Wilderness Campsite Impact
Rapid Inventory Form

General Site Description

1. Site Number __________ Date ______________
2. USGS Quad. ___________
3. Township ___________ Section ___________
4. Condition Class ________
5. Vegetation: (Circle one)

   1. Forest/Ridgetop 2. Forest/Forbs/Shrubs
   3. Forest/ Lush Grass 4. Old Homestead
   5. Grassland/Glades 6. Riparian

8. Dominant Species ___________ ________________
9. Landform: (Circle one)

   1. North slope 2. Creek Bottom
   3. Shelter Bluff 4. South slope
   5. Ridgetop 6. Terrace

10. Distance to Constructed Trail* __________________
11. Screening: (Circle one)

    1. Complete 2. Partial 3. None

12. Number of Trails ____________
13. Distance to Water ___________
14. Type of Water: (Circle one)

    1. Creek 2. Pond
    3. Spring 4. Other _____

15. Distance to Closest Campsite ___________________
16. Screening: (Circle one)

    1. Complete 2. Partial 3. None

17. Maximum Party Size
    Acc: (Circle one)

    1. 1-2 2. 3-6
    3. 7-10 4. 11-15
    5. More than 15.

18. Type of Use: (Circle all that apply)

    1. Hiker 2. Horse
    3. Hunter-Hiker 4. Hunter- Auto

19. Closest Firewood: (Circle one)

    1. On Site 2. 50 Feet
    3. 50 - 100 Feet 4. More than 100 Feet

20. Facilities: Present ___________ Absent __________

    1. Fire ring ________________
    2. Primitive Seat ____________
    3. Constructed Seat ___________
    4. Table/Shelf/Counter ________
    5. Meat Rack _______________
    6. Hitchrail _________________
    7. Other ___________________

21. Photos Taken _______________

Distance (feet)

Azimuth	Barren Core	Campsite Area		Azimuth	Barren Core	Campsite Area
0.0°				180.0°		
22.5°				202.5°		
45.0°				225.0°		
67.5°				247.5°		
90.0°				270.0°		
112.5°				292.5°		
135.0°				315.0°		
157.5°				337.5°		

Barren Core Area ______________ + Satellite Area ______________ -

Island Area ______________ = Campsite Area ______________

Quadrant Azimuth, Length, and Number of Quadrates.

Quadrant	Transect Length	# of Quadrates		Quadrant	Transect Length	# of Quadrates
NE				SE		
SW				NW		

Number of Trees within the campsite area. ______________

Tree Number	Species[a]	Azimuth	Distance	Stem Dam.[b]	Root Dam.[b]

a Tree Species; Q. = Quercus, F. =Fagus, C. =Carya, P. =Pinus

b Damage rating, defined by U. S Forest Service

CAMPGROUND IMPACT INDEX

IMPACT RATING (Circle One Category)

Campsite:

	1	2	3	Calculation Impact Index (DO IN OFFICE)
VEGETATION LOSS	(No difference in coverage)	(Difference one coverage class)	(Difference two or more coverage classes)	
MINERAL SOIL INCREASE	(No difference in coverage)	(Difference one coverage class)	(Difference two or more coverage classes)	
TREE DAMAGE: No. of trees scarred or felled ____ trees	(No more than broken lower branches)	(1-8 scarred trees, or 1-3 badly scarred or felled)	(>8 scarred trees, or >3 badly scarred or felled)	
ROOT EXPOSURE: No. of trees with roots exposed ____ trees	(None)	(1-6 trees with roots exposed)	(>6 trees with roots exposed)	
DEVELOPMENT:	(None)	(1 fire ring with or without primitive log seat)	(>1 fire ring or other major development)	
CLEANLINESS: No. of fire scars ____ fire scars	(No more than scattered charcoal from 1 fire ring)	(Remnants of >1 fire ring, some litter or manure)	(Human waste, much litter or manure)	
SOCIAL TRAILS: No. of trails: ____ trails	(No more than 1 discernible trail)	(2-3 discernible, max. 1 well worn)	(>3 discernible or more than 1 well worn)	
CAMP AREA: Estimated Area: ________ ft^2	(<540 ft^2)	(540-1070 ft^2)	(>1070 ft^2)	
BARREN CORE CAMP AREA: Estimated Area: ________ ft^2	(<54 ft^2)	(54-540 ft^2)	(>540 ft^2)	

Impact Index : ________

Infiltration Rates.

Number	Azimuth	Distance	Instantaneous Infiltration	Saturated Infiltration
1				
2				

Litter Classification ________

Quadrate Measurements

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ________
Quadrant Number ________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Control Plot

Azimuth ____________ Distance ____________

Number of Trees within Control Area __________

Infiltration Rates.

Number	Azimuth	Distance	Instantaneous Infiltration	Saturated Infiltration
1				
2				

Quadrate Measurements

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover ________
Bare Mineral Soil ________
Soil Compaction ________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

Transect Number ____________
Quadrant Number ____________
Vegetation Cover __________
Bare Mineral Soil __________
Soil Compaction __________

APPENDIX D

QUADRANT PLACEMENT

Quadrate Placement

Quadrates were used to determine percent vegetation cover, percent bare mineral soil exposure, and soil penetrometer reading placement. Quadrate placement was pre-determined to eliminate measurement bias, and transect azmuth for quadrate placement were determined prior to data collection. Quadrate placement was dependent on the individual transect length, and the distance between quadrate placement varied in respect to distance from campsite center. This was done for the expressed purpose to avoid over measuring the campsite central core. See table below for placement.

TABLE 39

QUADRANT LOCATION ON THE QUADRANT LOCATION TRANSECT

Length of Transect (ft)	Number of Quadrants	Number and Placement (ft)
< 6.00	1.5	Randomly placed
6.01 - 7.00	2	1 - .25 ft from center 2 - 3.5 ft from center
7.01 - 8.00	2	1 - .5 ft from center 2 - 4.0 ft from center
8.01 - 9.00	2	1 - 1.0 ft from center 2 - 5.5 ft from center
9.01 - 10.00	3	1 - .25 ft from center 2 - 3.5 ft from center 3 - 7.0 ft from center
10.01 - 11.00	3	1 - .50 ft from center 2 - 4.0 ft from center 3 - 7.5 ft from center
11.01 - 12.00	3	1 - .50 ft from center 2 - 4.0 ft from center 3 - 8.0 ft from center
12.01 - 13.00	3	1 - .50 ft from center 2 - 4.5 ft from center 3 - 9.0 ft from center

TABLE 39 (Continued)

Length of Transect (ft)	Number of Quadrants	Number and Placement (ft)
13.01 - 14.00	4	1 - .25 ft from center 2 - 3.5 ft from center 3 - 7.0 ft from center 4 - 10.5 ft from center
14.01 - 15.00	4	1 - .25 ft from center 2 - 4.3 ft from center 3 - 7.9 ft from center 4 - 11.3 ft from center
15.01 - 16.00	4	1 - 50 ft from center 2 - 4.5 ft from center 3 - 8.3 ft from center 4 - 12.0 ft from center
16.01 - 17.00	4	1 - 1.0 ft from center 2 - 4.7 ft from center 3 - 8.3 ft from center 4 - 12.5 ft from center
17.01 - 18.00	4	1 - 1.0 ft from center 2 - 6.0 ft from center 3 - 9.5 ft from center 4 - 13.0 ft from center
18.01 - 19.00	5	1 - .50 ft from center 2 - 4.8 ft from center 3 - 8.1 ft from center 4 - 11.5 ft from center 5 - 14.9 ft from center
19.01 - 20.00	5	1 - 1.0 ft from center 2 - 4.8 ft from center 3 - 8.3 ft from center 4 - 11.5 ft from center 5 - 15.3 ft from center
20.01 - 21.00	5	1 - 1.0 ft from center 2 - 6.0 ft from center 3 - 9.5 ft from center 4 - 13.0 ft from center 5 - 17.0 ft from center

TABLE 39 (Continued)

Length of Transect (ft)	Number of Quadrants	Number and Placement (ft)
21.01 - 22.00	5	1 - 1.0 ft from center 2 - 6.0 ft from center 3 - 10.0 ft from center 4 - 14.5 ft from center 5 - 18.0 ft from center
22.01 - 23.00	5	1 - 1.0 ft from center 2 - 6.0 ft from center 3 - 11.0 ft from center 4 - 15.0 ft from center 5 - 18.5 ft from center
23.01 - 24.00	5	1 - 1.0 ft from center 2 - 6.0 ft from center 3 - 11.0 ft from center 4 - 16.5 ft from center 5 - 21.0 ft from center

APPENDIX E

CAMPSITE IMPACT INDEX RATING CALCULATION

CAMPSITE IMPACT INDEX RATING CALCULATION

This method used parameters collected from the site and the sites control to estimate overall campsite impact based on the index below. Campsites had a rating of 1-3, depending on the amount of impact.

1.) The average campsite vegetation cover percentage was compared to the control's average vegetation cover percentage. Coverage class differences were determined and recorded.

1 No difference in coverage class
2 One coverage class difference.
3 Two or more coverage class differences.

2.) The campsite's mean bare mineral soil percentage was compared to its control average percentage. Differences of percentage classes was determined and recorded.

1 No difference in coverage class.
2 One coverage class difference.
3 Two or more coverage class differences.

3.) Tree damage on the site was recorded.

1 No more than broken lower branches.
2 1-8 scarred, or 1-3 badly scarred or felled.
3 More than 8 scarred trees, or more than 3 badly scarred or felled.

4.) Tree root exposure on the site was recorded.

1 None.
2 1-6 trees with exposed roots.
3 More than six trees with exposed roots.

5.) The number of developments on the site was categorized and recorded.

1 None.
2 One fire ring with or without primitive log seat.
3 More than one fire ring or other major developments.

6.) The site's amount of litter was placed into a category

1 No more than scattered charcoal from one fire ring.
2 Remnants of more than one fire ring, some litter or manure.
3 Human waste, much litter or manure.

7.) The number of social trails of the site was recorded.

1 No more than one discernible trail.
2 Two to three discernible trails, or maximum of one well worn trail.
3 More than three trails, or more than one well worn trail.

8.) Campsite area was calculated and grouped into one of the following categories.

1 Less than 540 squared feet.
2 540 squared feet to 1070 squared feet.
3 More than 1070 squared feet.

9.) Barren core area was calculated and placed into one of the following categories.

1 Less than 54 squared feet.
2 54 squared feet to 540 squared feet.
3 More than 540 squared feet.

10.) The category listing of each impact paramter was added and then divided by nine to get the average rating of each parameter measured. No parameters were multiplied by a weighted nunber to emphasize to any single parameter as more important. The category average was the Campground Impact Index Rating for the site.

APPENDIX F

PROCEDURES FOR DATA COLLECTION AND DATA COLLECTION FORM FOR TRAIL TRANSECTS

PROCEDURES FOR DATA COLLECTION AND DATA COLLECTION FORM FOR TRAIL TRANSECTS

1.) Site Number. Trail transect number was recorded.

2.) Trail Transect Fixed Point Location and Identification. The position of the first endpoint for the trail transect was documented by three reference points. After the Initial endpoint was established the second fixed point was established. The fixed points were extended one foot past the determined edge of the trail and total distance was positioned to the nearest whole foot.

3.) Placement of Fixed Points for Measurement. After determining the fixed point placement, a 1/2 inch metal threaded pipe was tapped into the ground. The top of the pipe was level or just below the surface of the ground. The azimuth and distance from one fixed point to the other was recorded.

4.) Profile Bracket Construction. PVC connectors were attached to the fixed point receptacles. The profile bracket was built across the trail (Figure 3, page 32). Additional risers were placed for added support. Line levels were used to make sure the bracket was level. The entire bracket distance across the trail was recorded.

5.) Trail Profile Measurements. Measurements were taken from the top of the bracket to the ground (nearest tenth of an inch). Measurements were taken every six inches and a plumb bob was used to ensure the measurement of a perpendicular line from the top of the bracket.

8.) Width of Trail. Trail width included the distance from one side to the other of the zone obviously disturbed by trampling. This included both bare ground area and area with disturbed vegetation.

9.) Bare Ground Width. The bare ground width was the length from one edge of the trail to the other of the zone that was void of vegetation.

10.) Maximum Depth. The maximum depth of the trail was recorded. The height of the nearest riser was subtracted.

11.) Presence of Multiple Treads. The area was assessed for multiple treads of the pathway.

12.) Vegetation. The vegetation type was recorded on the site exactly as done on the campsite measurements.

1.) Forest/Ridgetop
2.) Forest/Forbs/Shrubs
3.) Forest/Lush Grass
4.) Old Homesite
5.) Grassland/Glade
6.) Riparian.

13.) Dominant Species. The dominant species for the site was recorded.

14.) Landform. The landform of the trail location was the most dominant factor evident in that location. Landform group was comprised of 6 categories:

1.) North Slope
2.) Creek Bottom
3.) Shelter Bluff
4.) South Slope
5.) Ridgetop
6.) Terrace.

15.) Trail Slope Measurements. A suunto clinometer was used to measure trail slope along the trail.

16.) Aspect. Aspect was measured with a compass.

17.) Calculate the Area of Profile. Trail profile area was calculated using the formula given in Figure 3, page 32.

DATA COLLECTION FORM FOR TRAIL TRANSECTS

1.) Transect Number. ______________ 2.) Type of Transect ________________

3) Trail transect fixed point location and identification and reference points.

4.) Trail profile measurements

V_1	______	V_2	______
V_3	______	V_4	______
V_5	______	V_6	______
V_7	______	V_8	______
V_9	______	V_{10}	______
V_{11}	______	V_{12}	______
V_{13}	______	V_{14}	______
V_{15}	______	V_{16}	______

5.) Width of trail profile bracket. ______

6.) Bare ground width ______

7.) Maximum depth ______

8.) Presence of multiple treads ______

9.) Vegetation type (Circle One).

1.) Forest/Ridgetop 2.) Forest/Forbs/Shrubs 3.) Forest/Lush Grass

4.) Old Homesite 5.) Grassland/Glade 6.) Riparian.

10.) Dominant species ______

11.) Landform (Circle One)..

1.) North Slope 2.) Creek Bottom 3.) Shelter Bluff

4.) South Slope 5.) Ridgetop 6.) Terrace.

12.) Slope measurements along the trail ______

13.) Aspect ______

15.) Area of trail profile ______

APPENDIX G

PHOTOGRAPHIC REPRESENTATION OF IMPACT ON INDIVIDUAL CAMPSITES

Figure 9. Pasnubbe Point Campsite, Facing East (above), and South (below).

Figure 10. Wilton Mountain Campsite, Facing North (above) and South (below).

Figure 11 Wilton's Point Campsite, Facing East (above) and North (below).

Figure 12. Mile 38 Campsite. Facing East (above) and South (below).

Figure 13. Kiamichi River Trailhead Campsite, Facing West (above) and South-west (below).

Figure 14. Pine Mountain Campsite, Facing North-east (above) and North (below).

Figure 15. River Sign Campsite, Facing South (above) and North (below).

Figure 16. Big River Campsite, Facing South-west (above) and North (below).

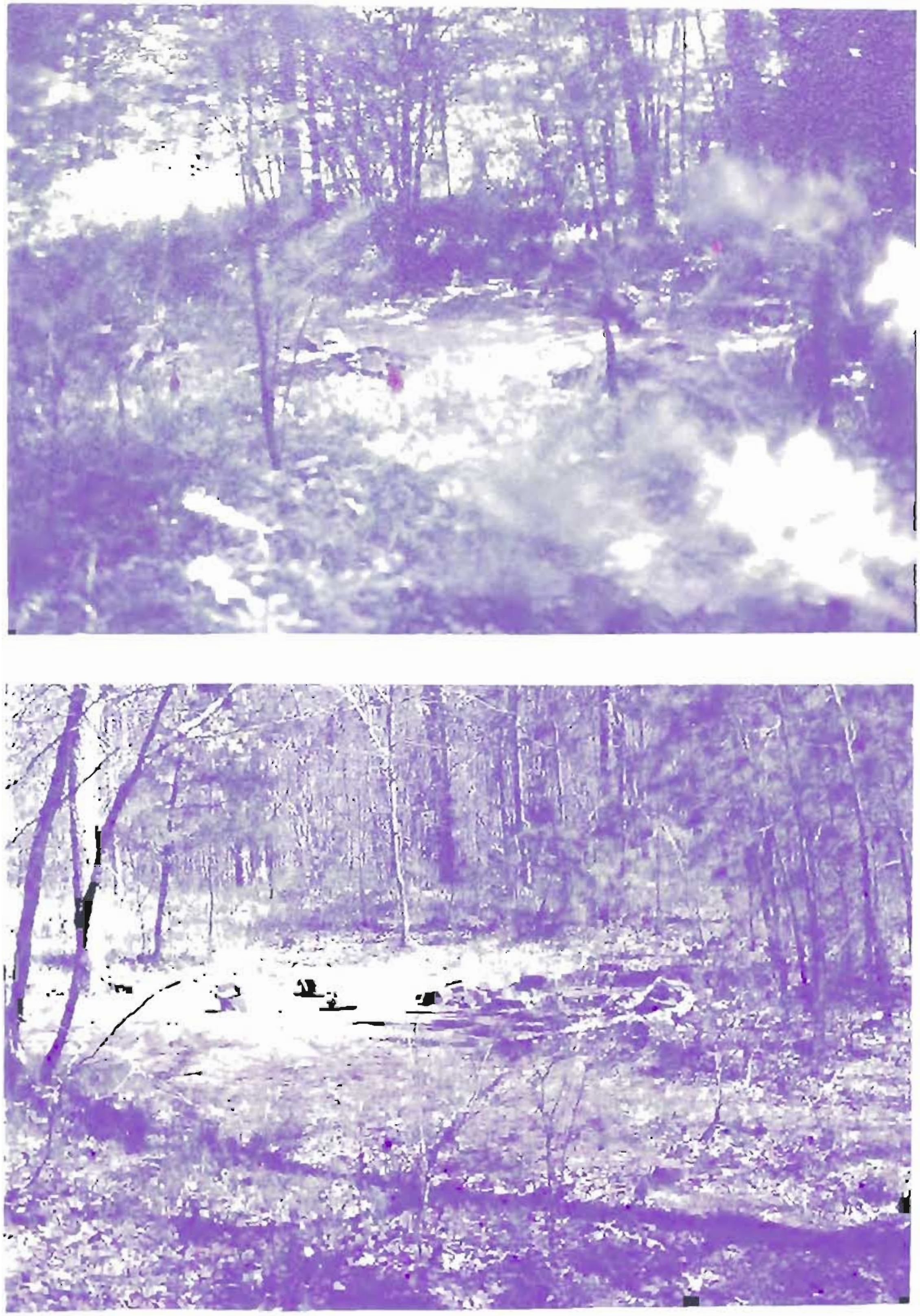
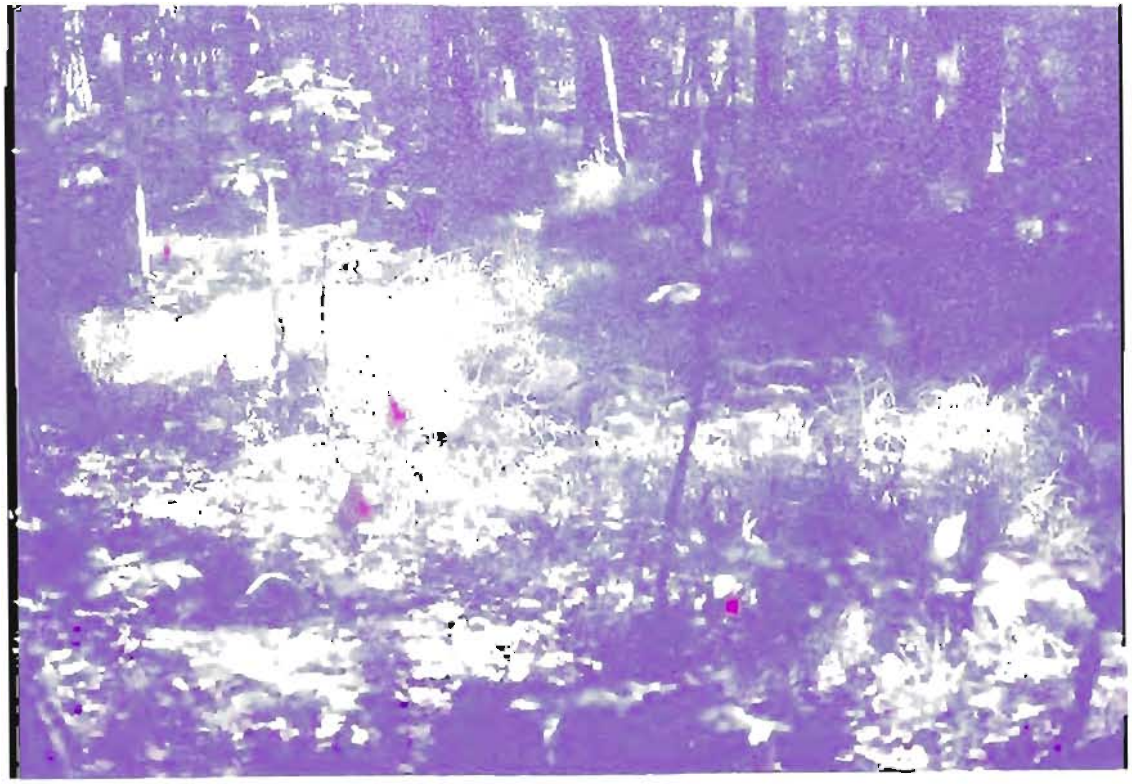


Figure 17. Mile 42 Campsite. Facing West (above) and North (below)



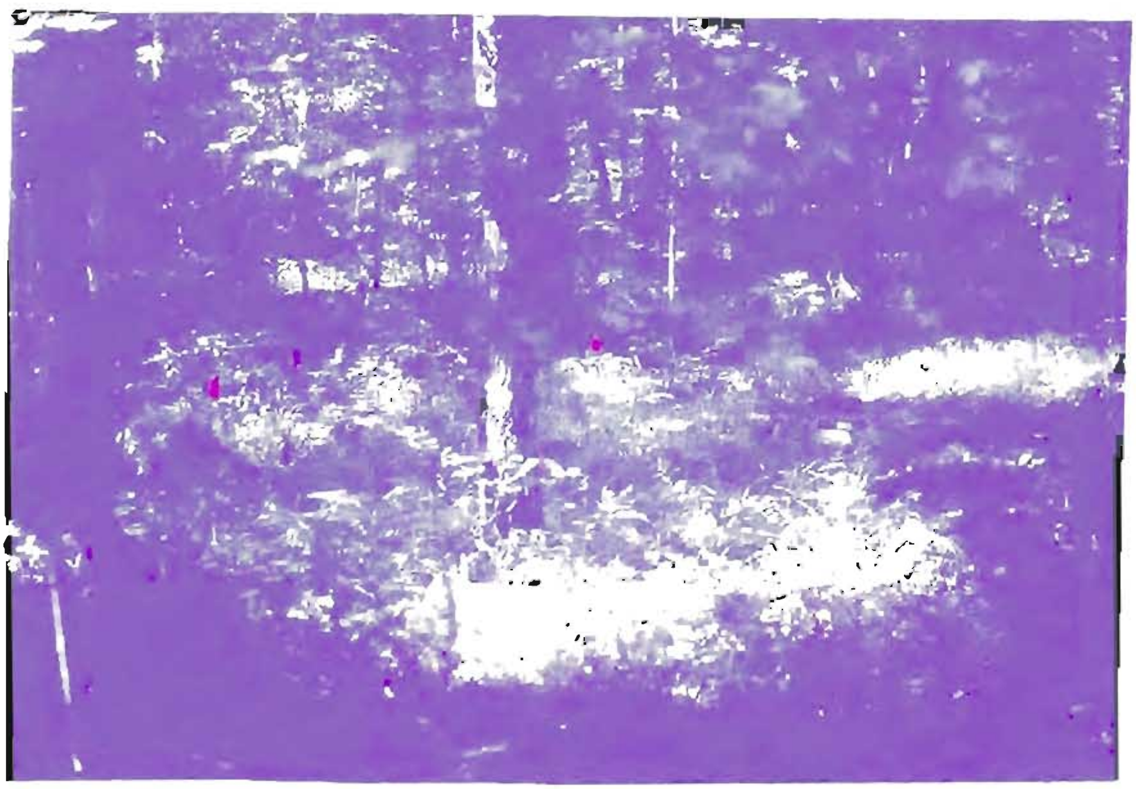


Figure 18. Valley Campsite, Facing East (above) and West (below).

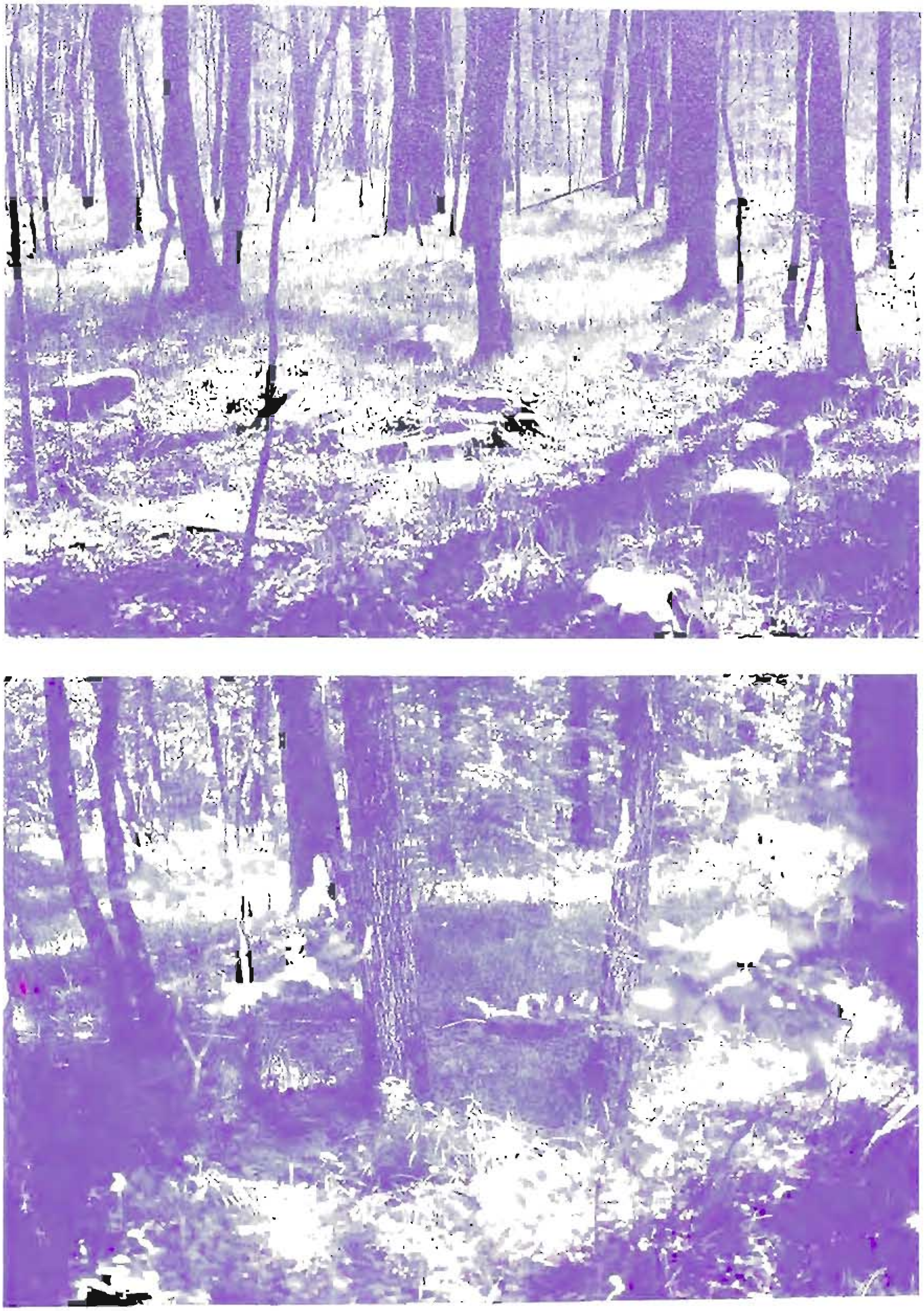


Figure 19. Mile 43 Campsite, Facing East (above) and North (below).

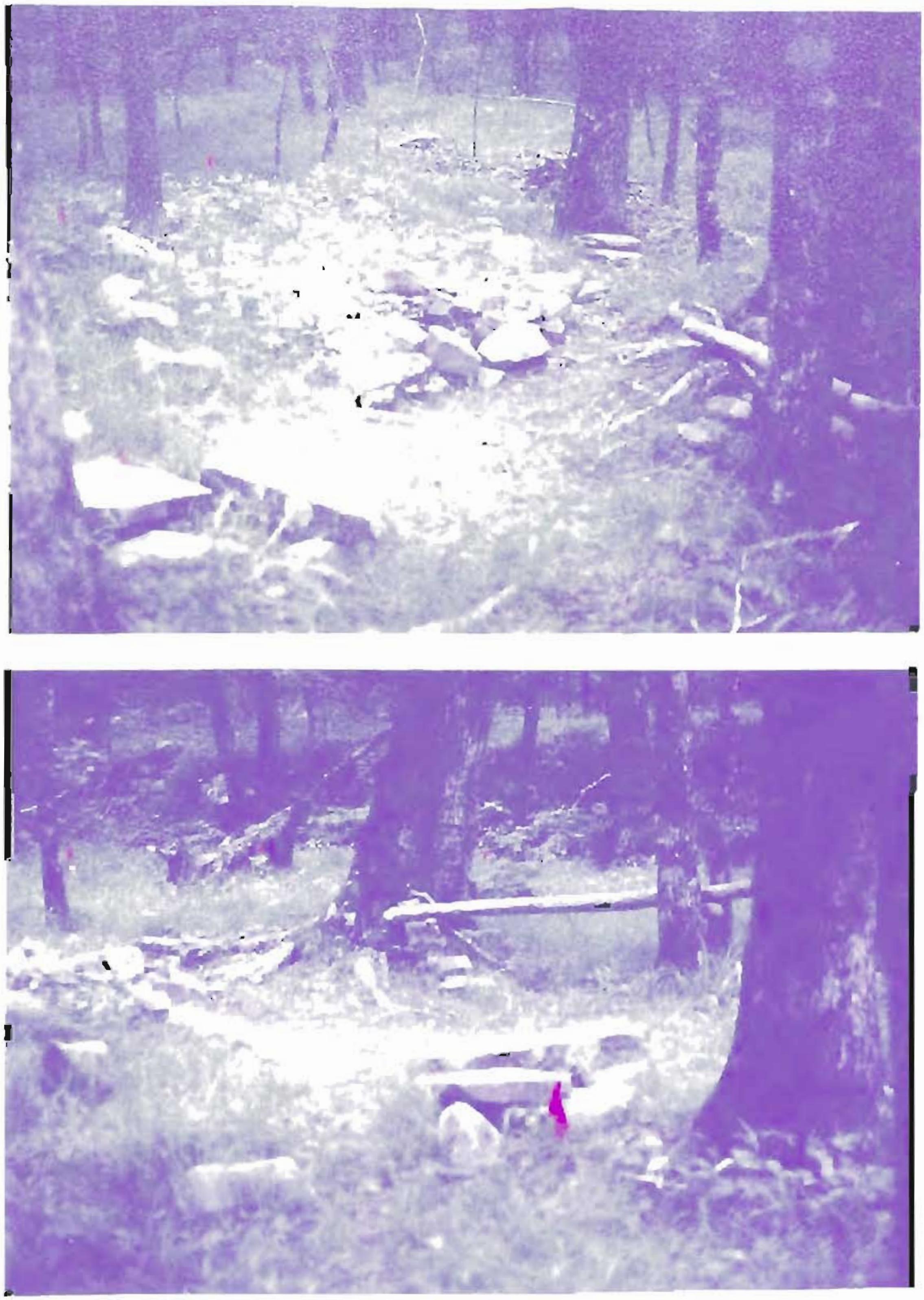


Figure 20 Island Campsite, Facing East (above) and South (below).

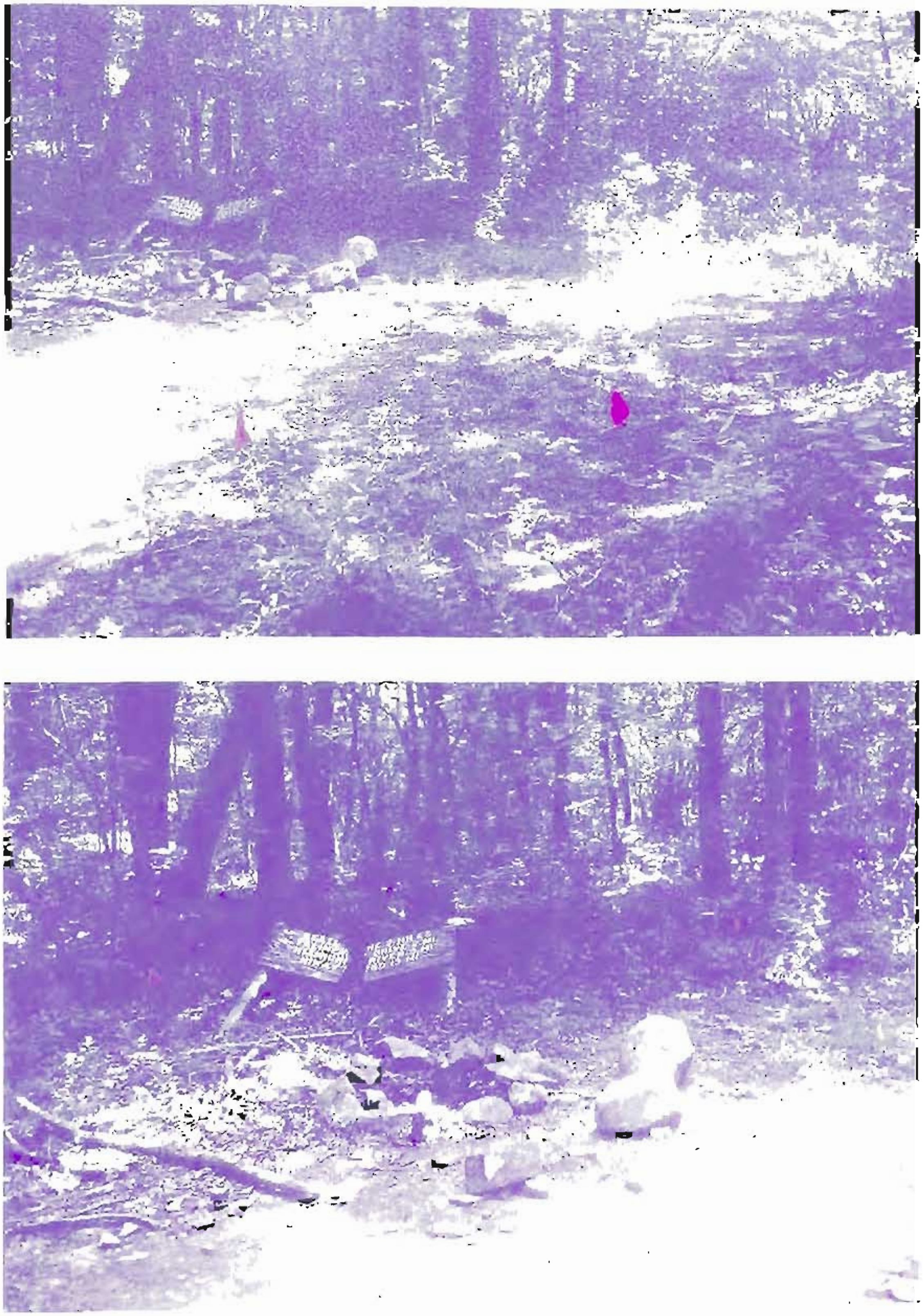
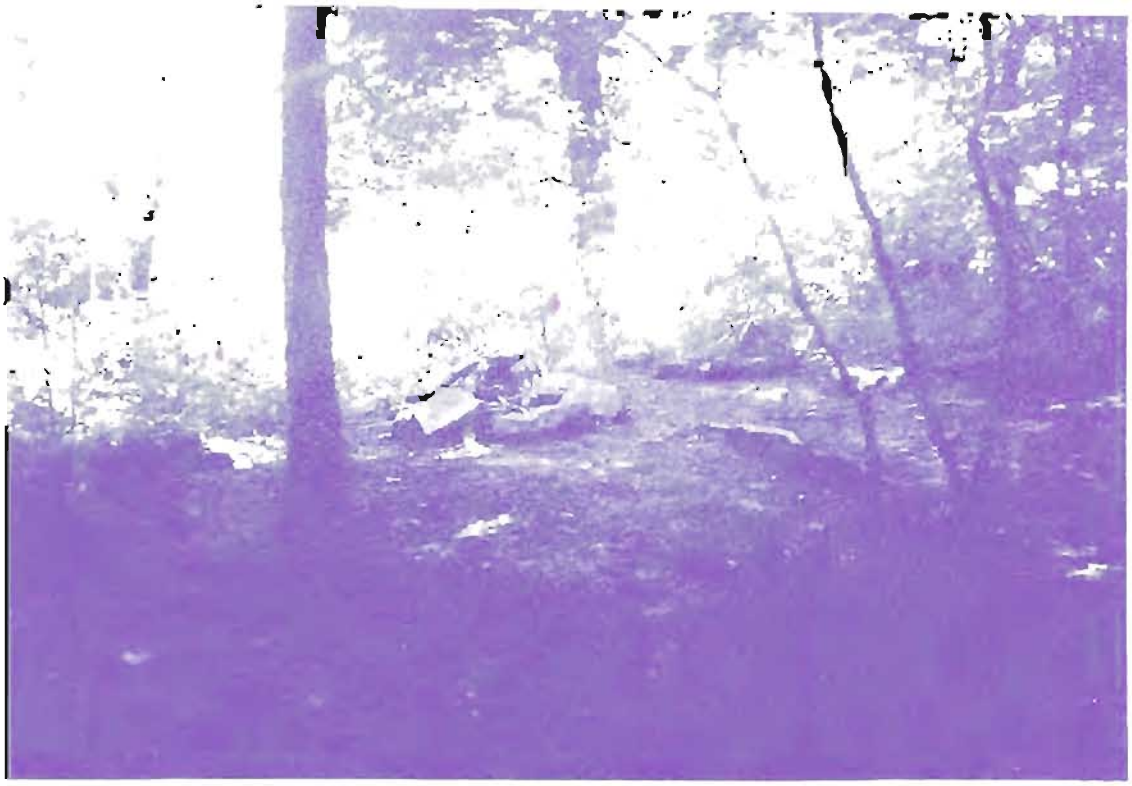


Figure 21. Road Campsite, Facing North-east (above) and North-east (below).



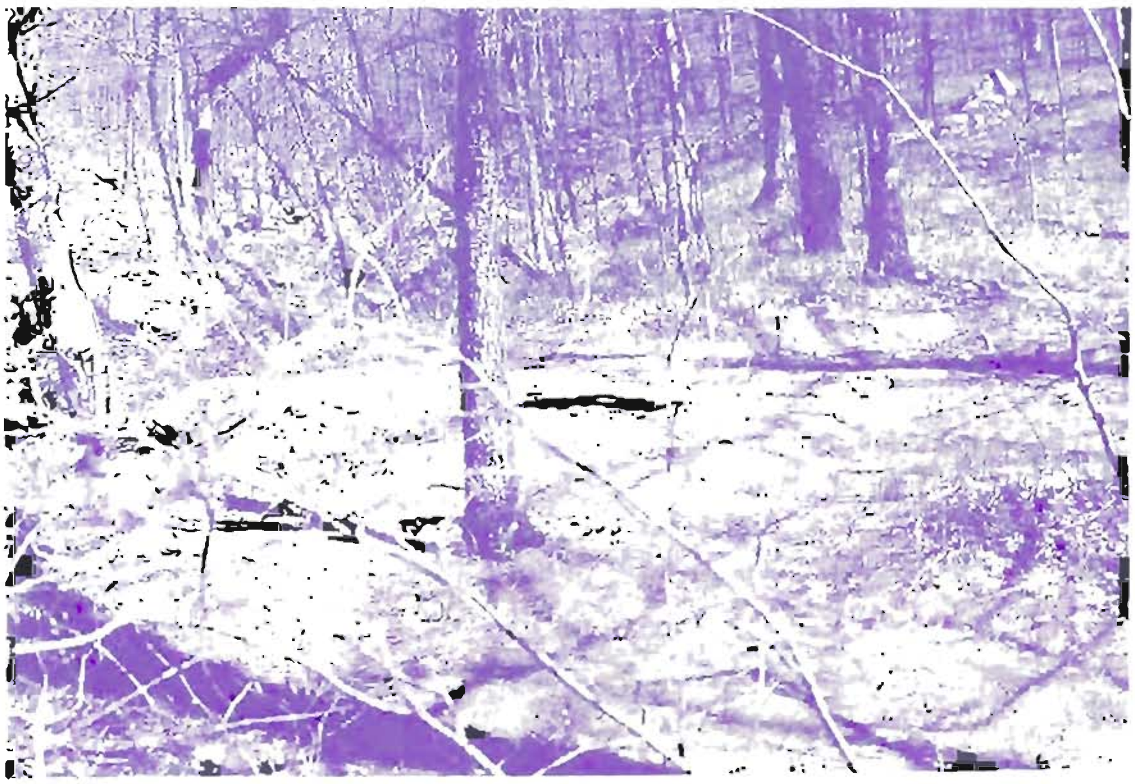


Figure 22. Lower Beech Grove Campsite. Facing North-east (above) and North (below).

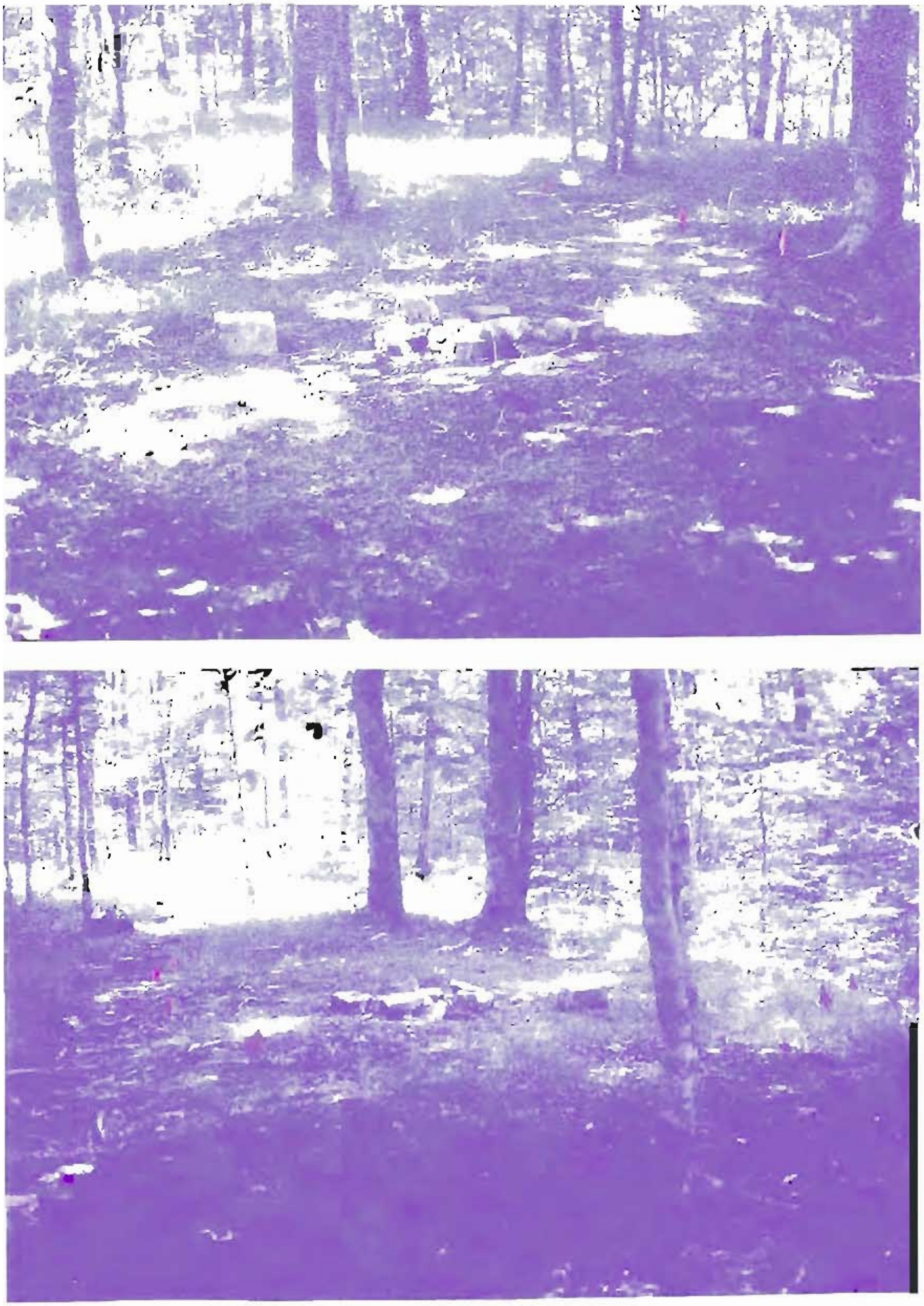


Figure 23. New Campsite, Facing South (above) and North (below).

Figure 24. Upper Beech Grove Campsite, Facing South-west (above) and North (below).

Figure 25. Rehabilitated Campsite. Facing South-west. Taken in April (above) and June (below).

APPENDIX H

PHOTOGRAPHS OF INDIVIDUAL TRAIL TRANSECTS

Figure 26. Mile 35, Facing West.

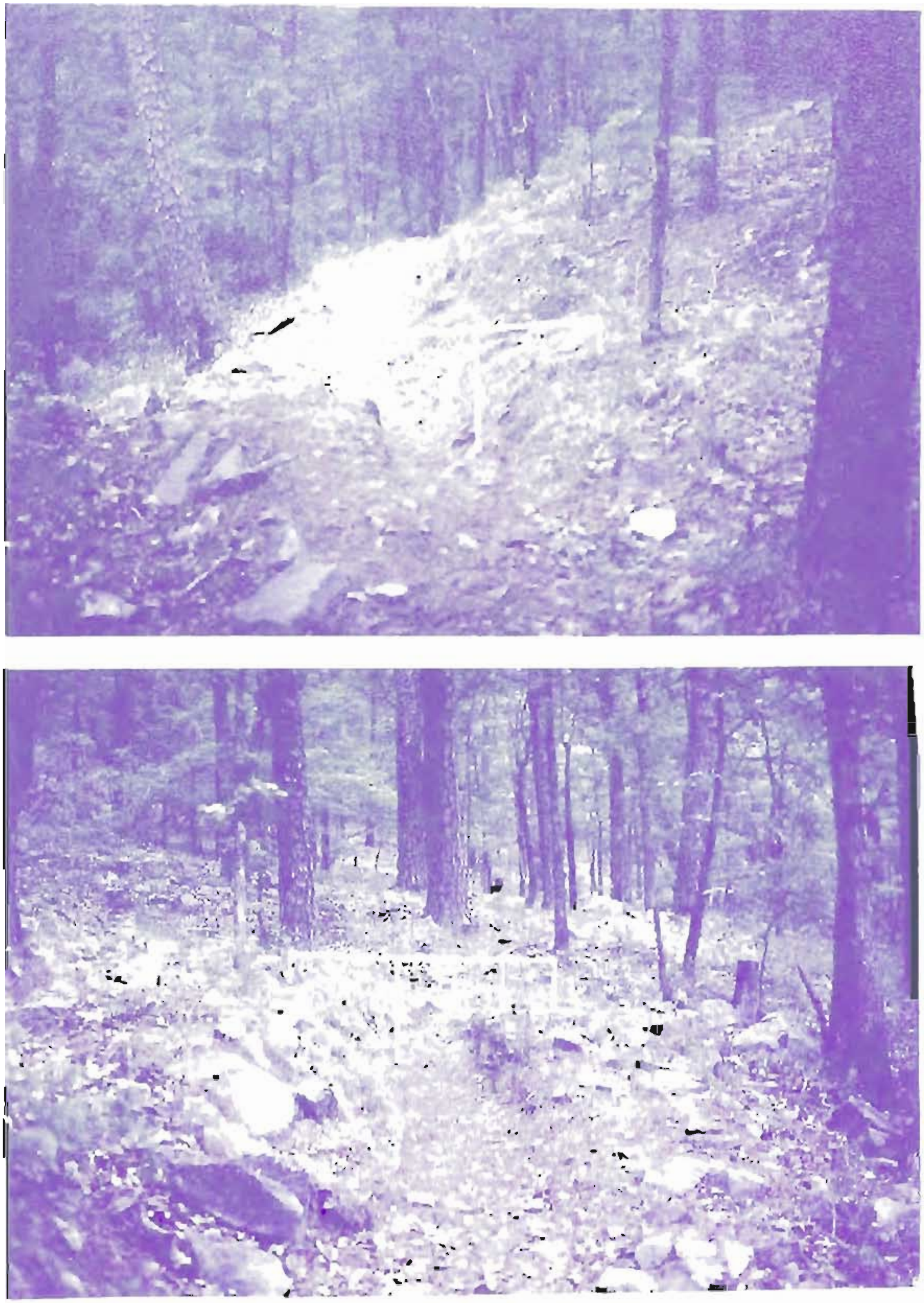


Figure 27. Trouble Area Transect (Transect Two), Facing West (above) and East (below).

Figure 28. Mile 36 Transect, Facing East (above) and West (below).

Figure 29 Mile 37 Transect, Facing East (above) and East (below)

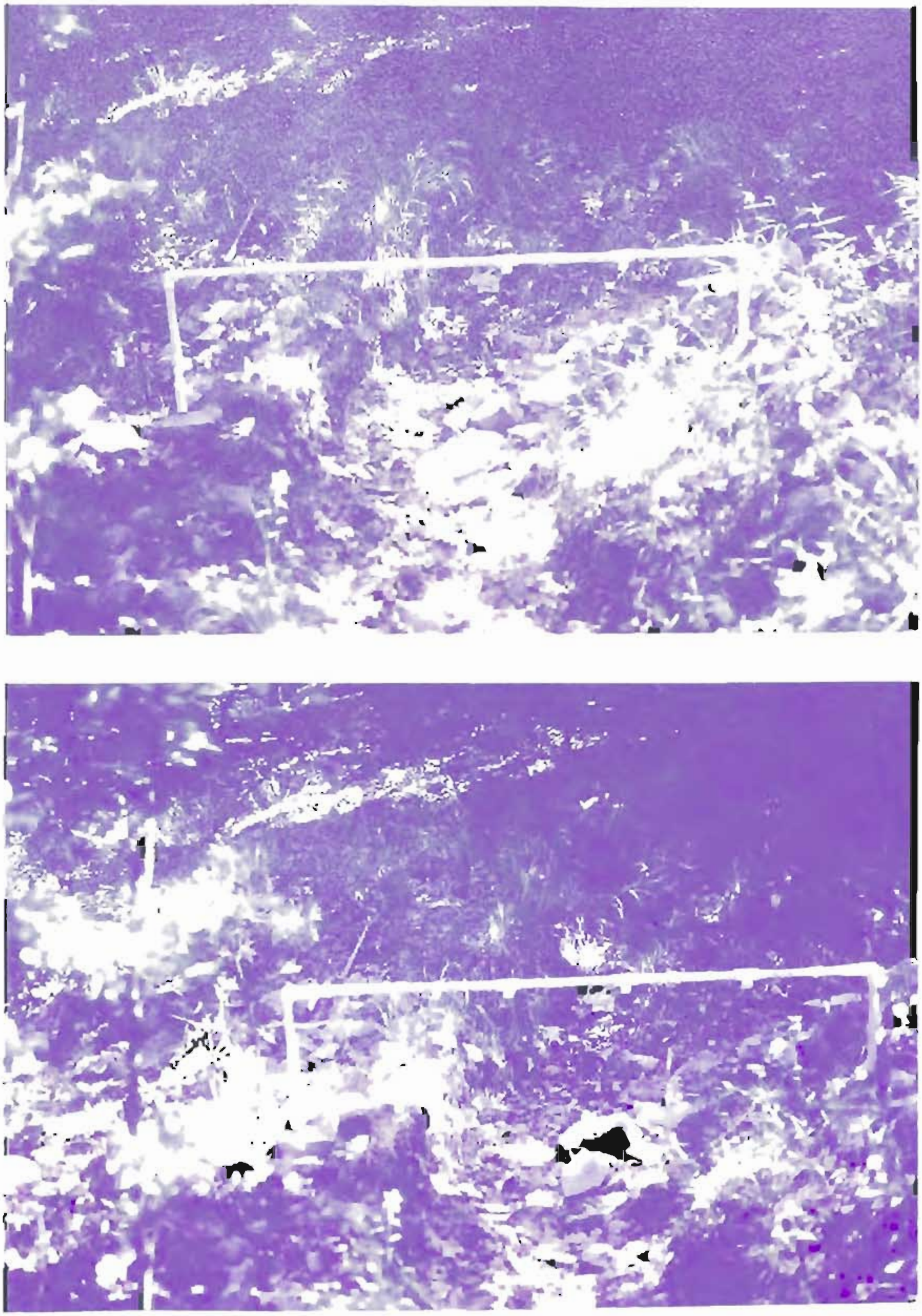


Figure 30. Mile 38 Transect, Facing West

Figure 31. Mile 39 Transect, Facing West.

Figure 32. Mile 40 Transect, Facing East (above) and West (below).

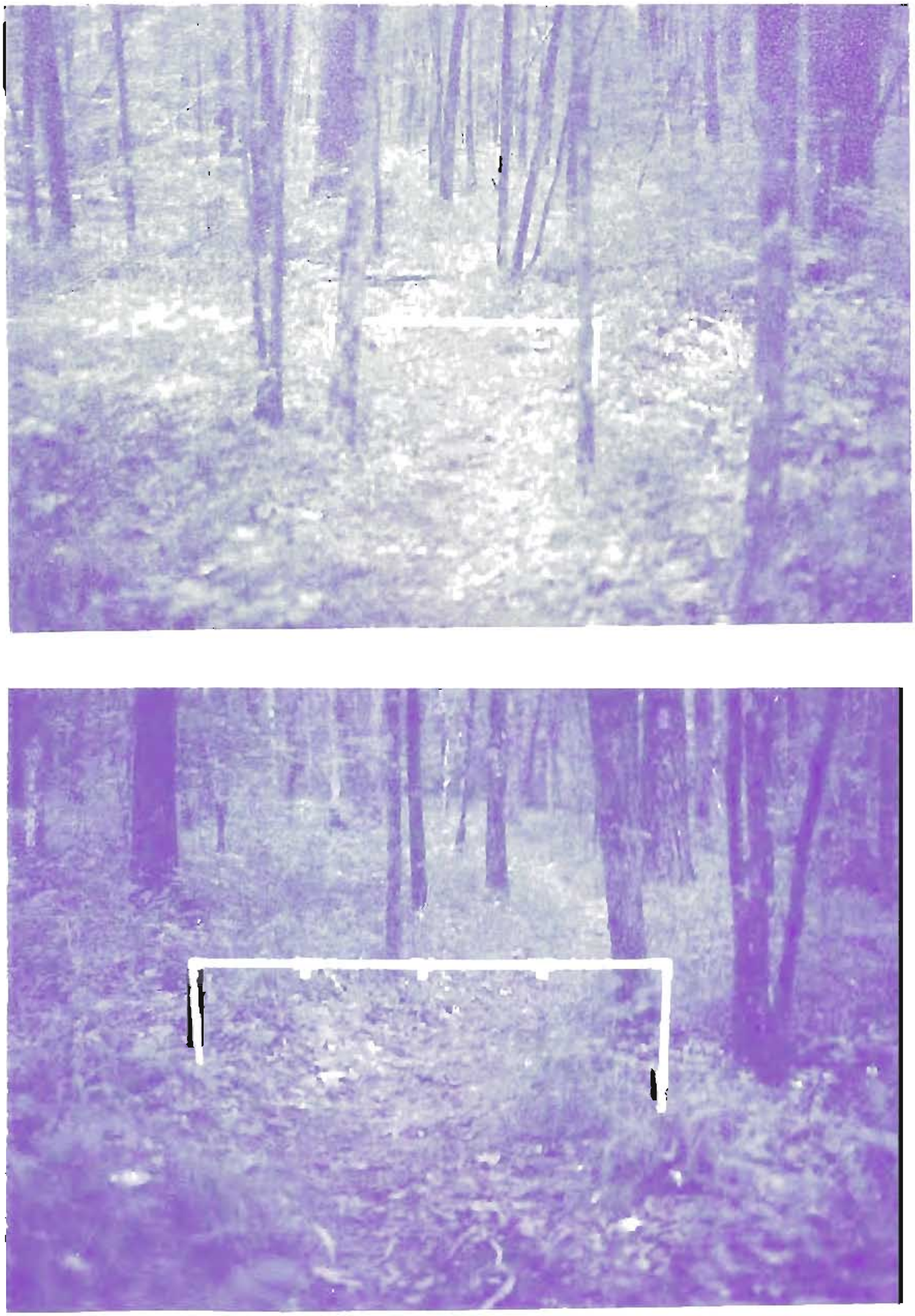
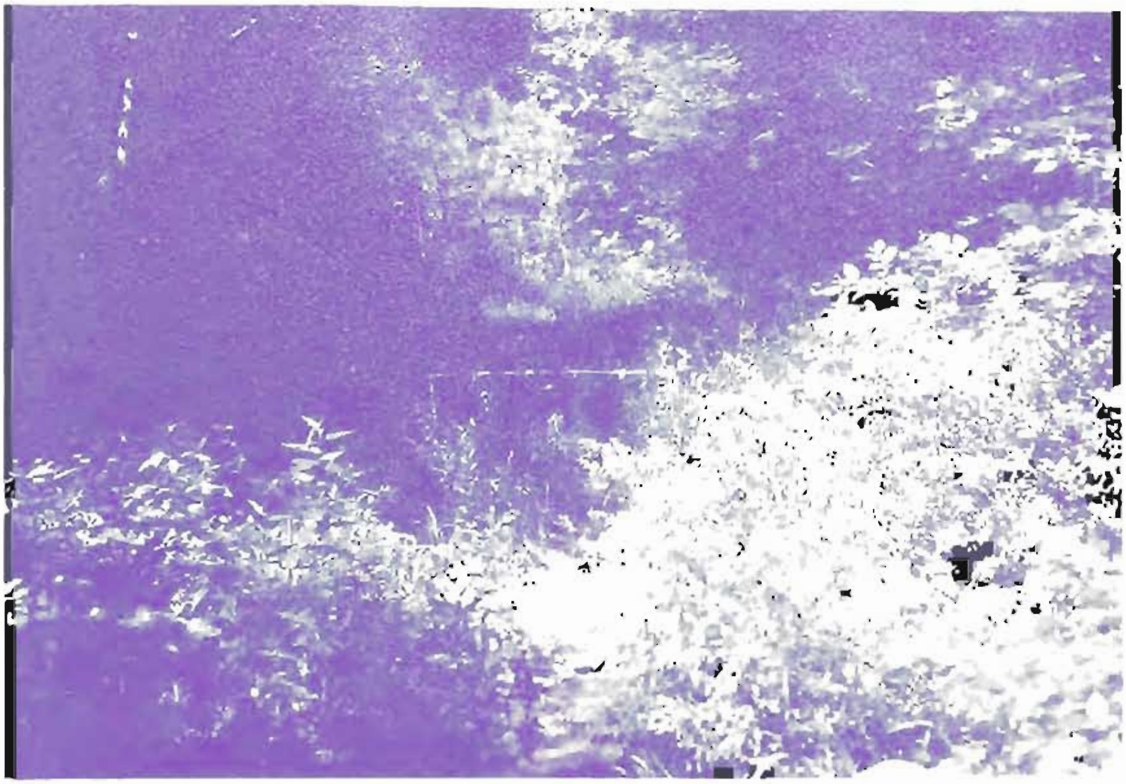


Figure 33. Mile 41 Transect, Facing East (above) and West (below).



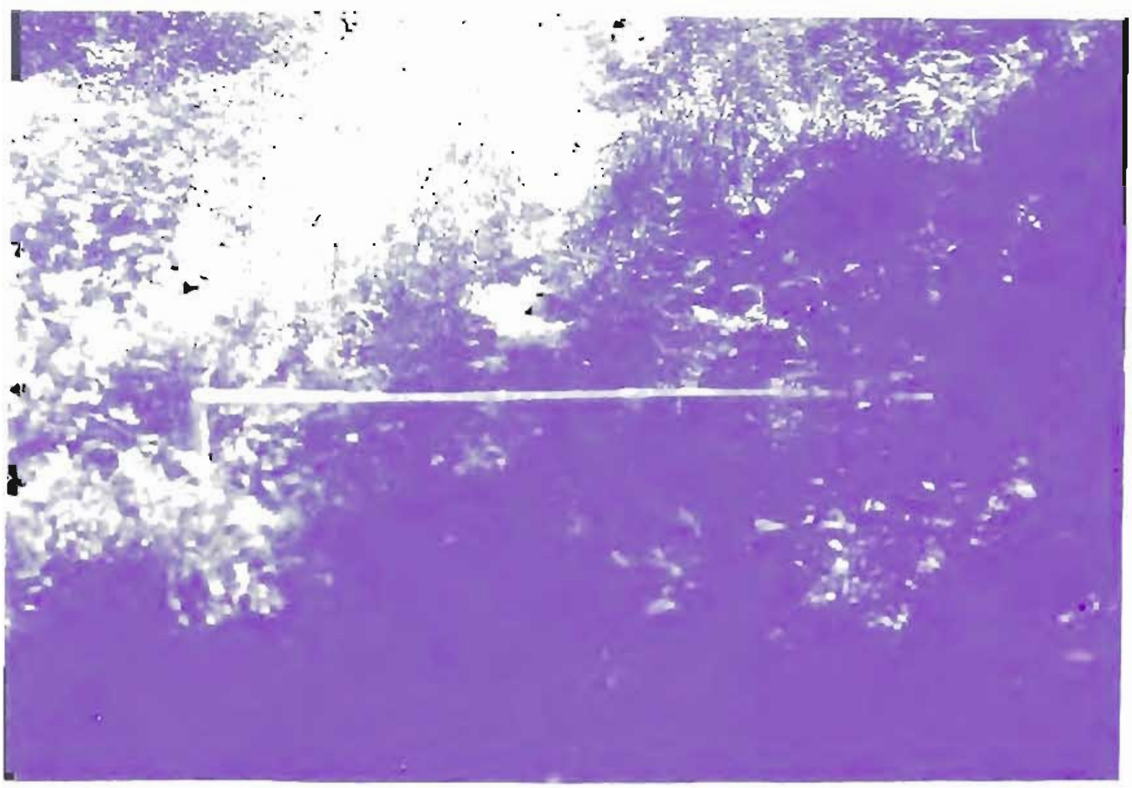


Figure 34. Mile 42 Transect, Facing East (above) and West (below).

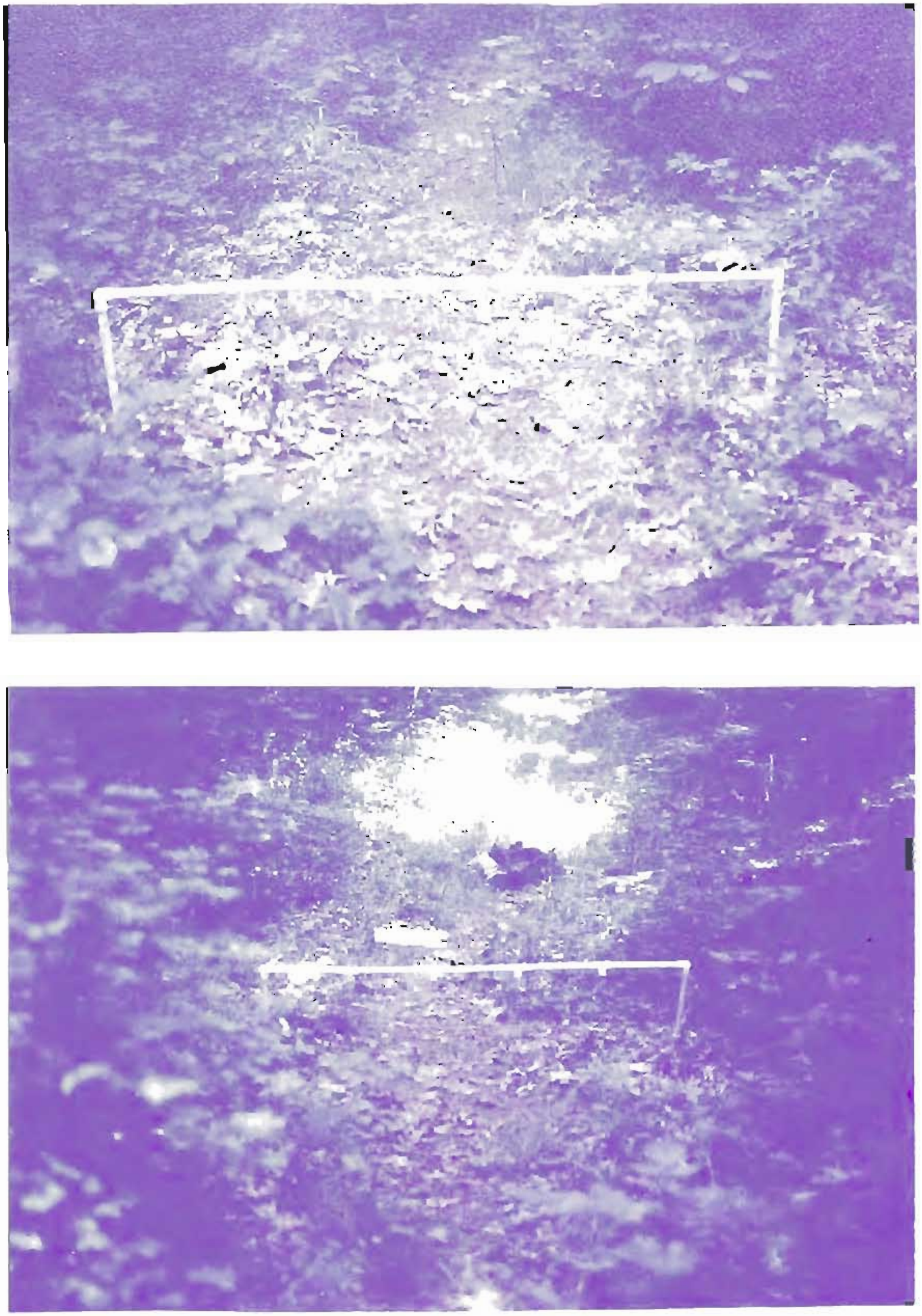


Figure 35. Mile 43 Transect, Facing East

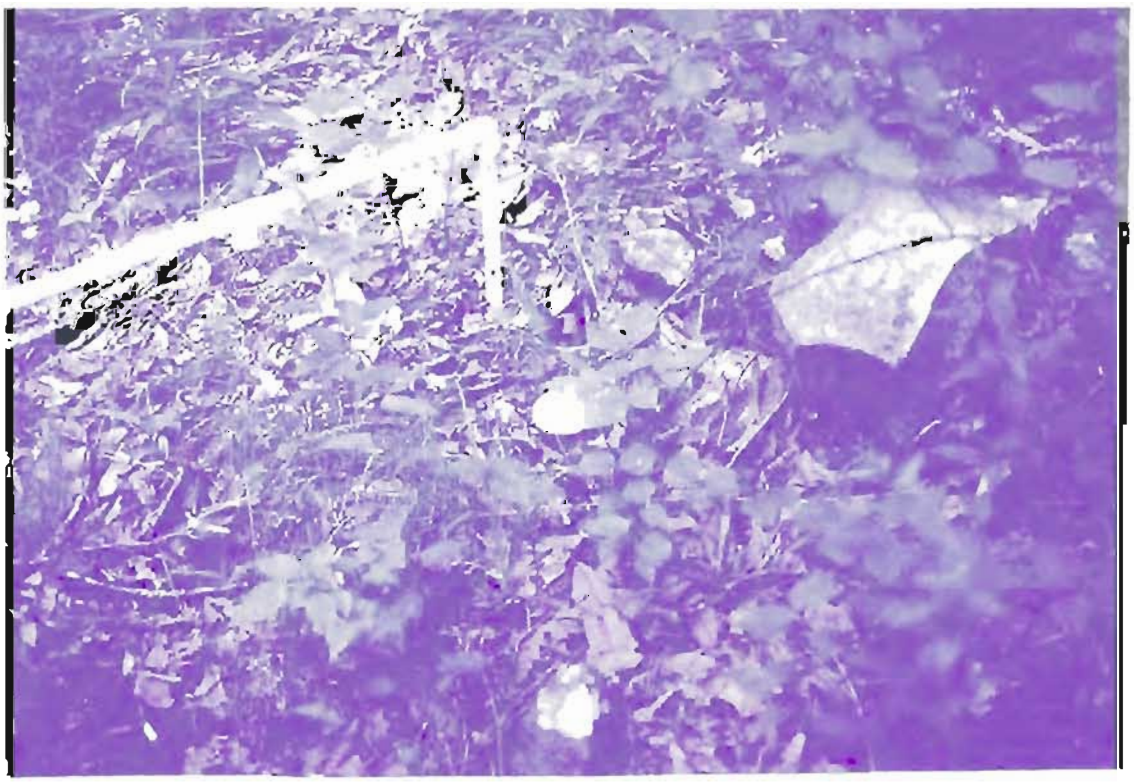


Figure 36 Mile 44 Transect, Facing North (above) and Mile Marker (below)

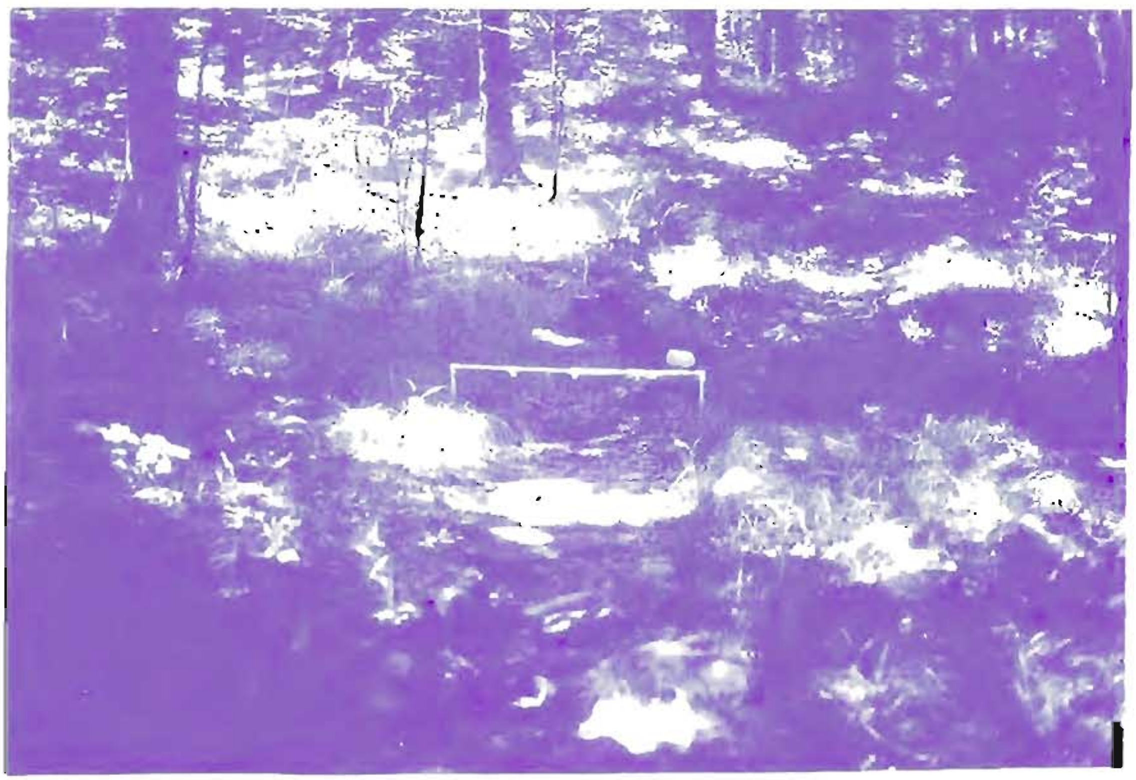


Figure 37. Trouble Transect 2 (Transect 12). Facing North (above) and West (below).

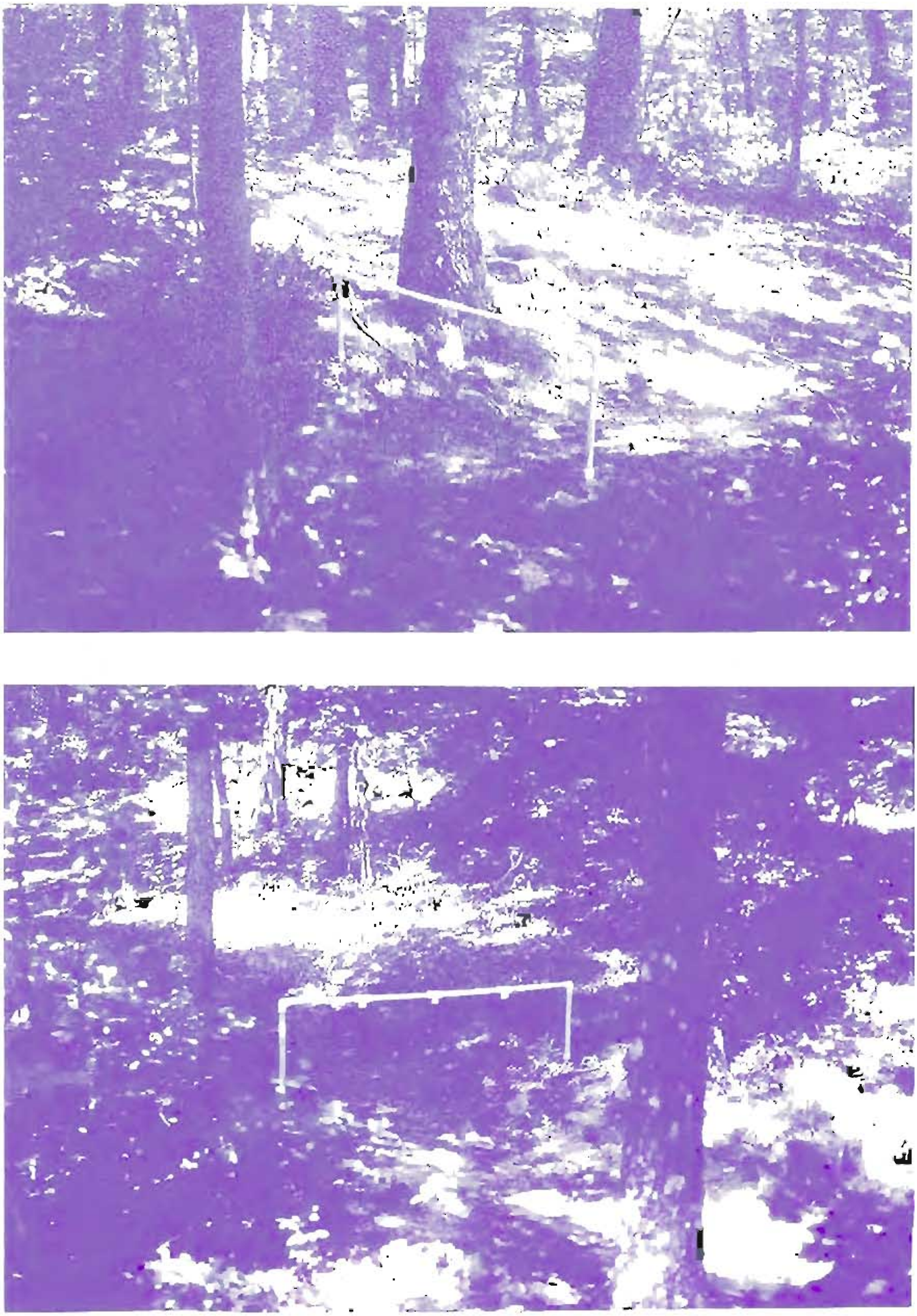


Figure 38. Mile 45 Transect, Facing South-east (above) and South-west (below).

Figure 39 Trouble Transect Three (Transect 14), Facing South

Figure 40. Trouble Transect Four (Trans. Fifteen). Facing East (above) and North-west (below).

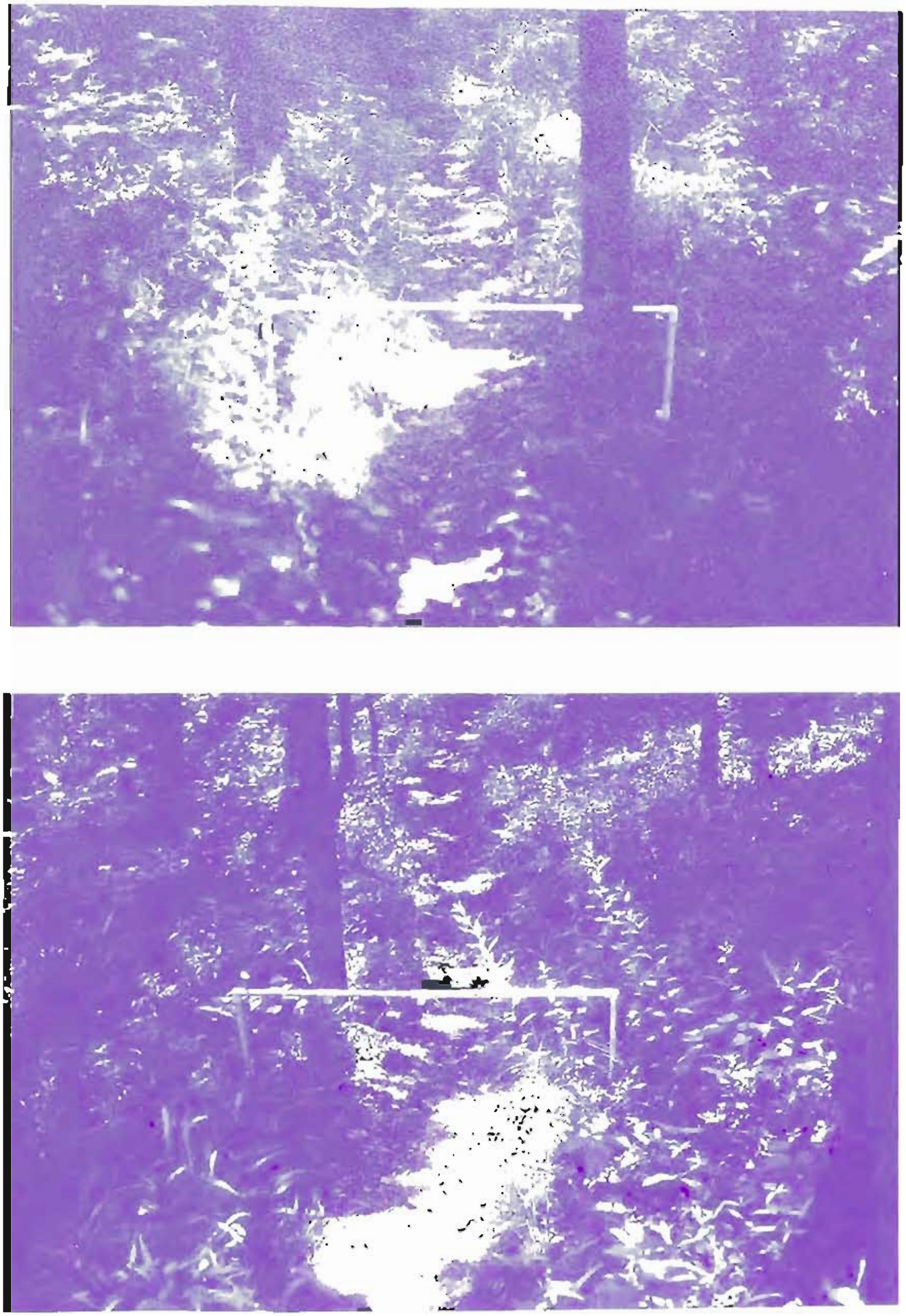
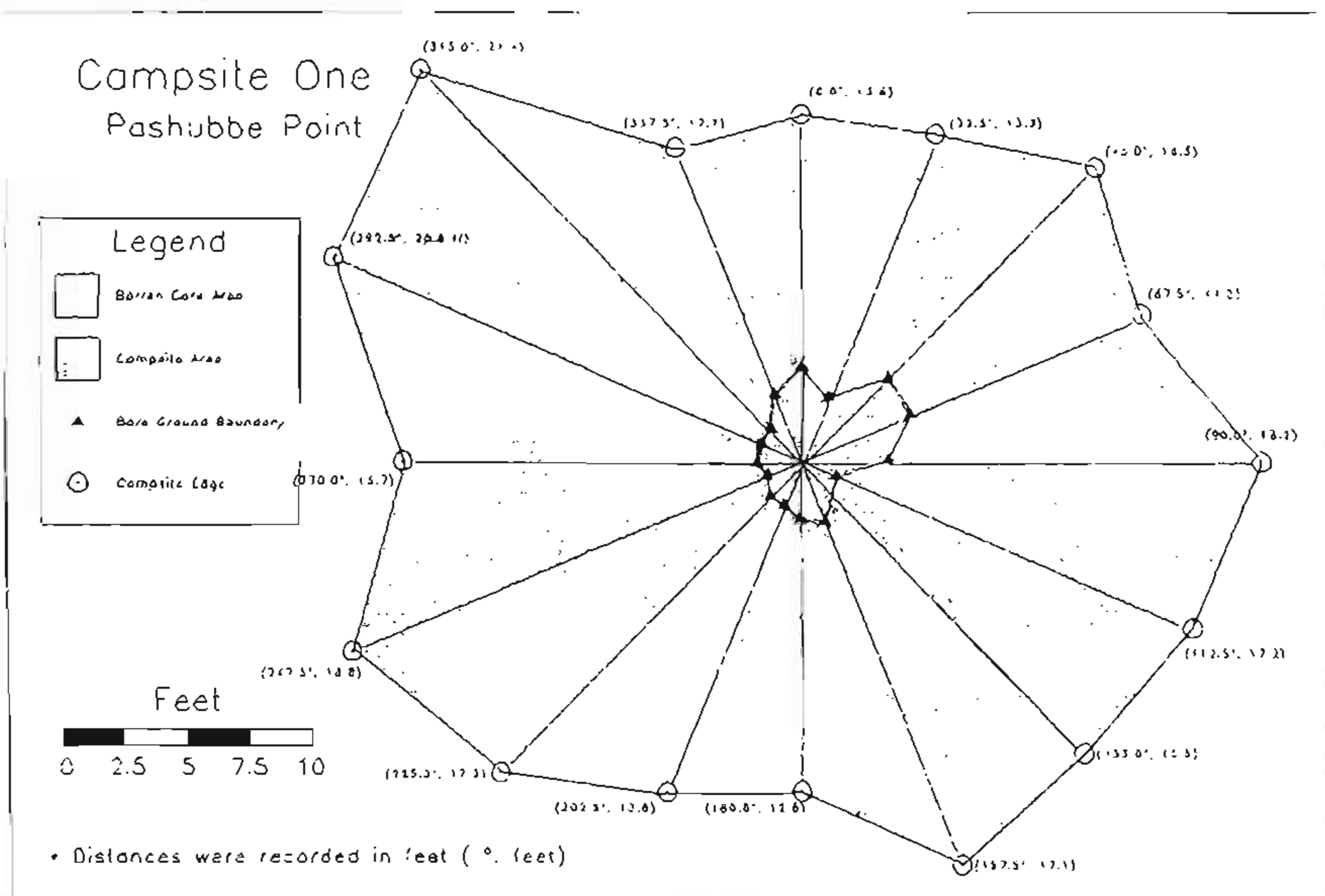


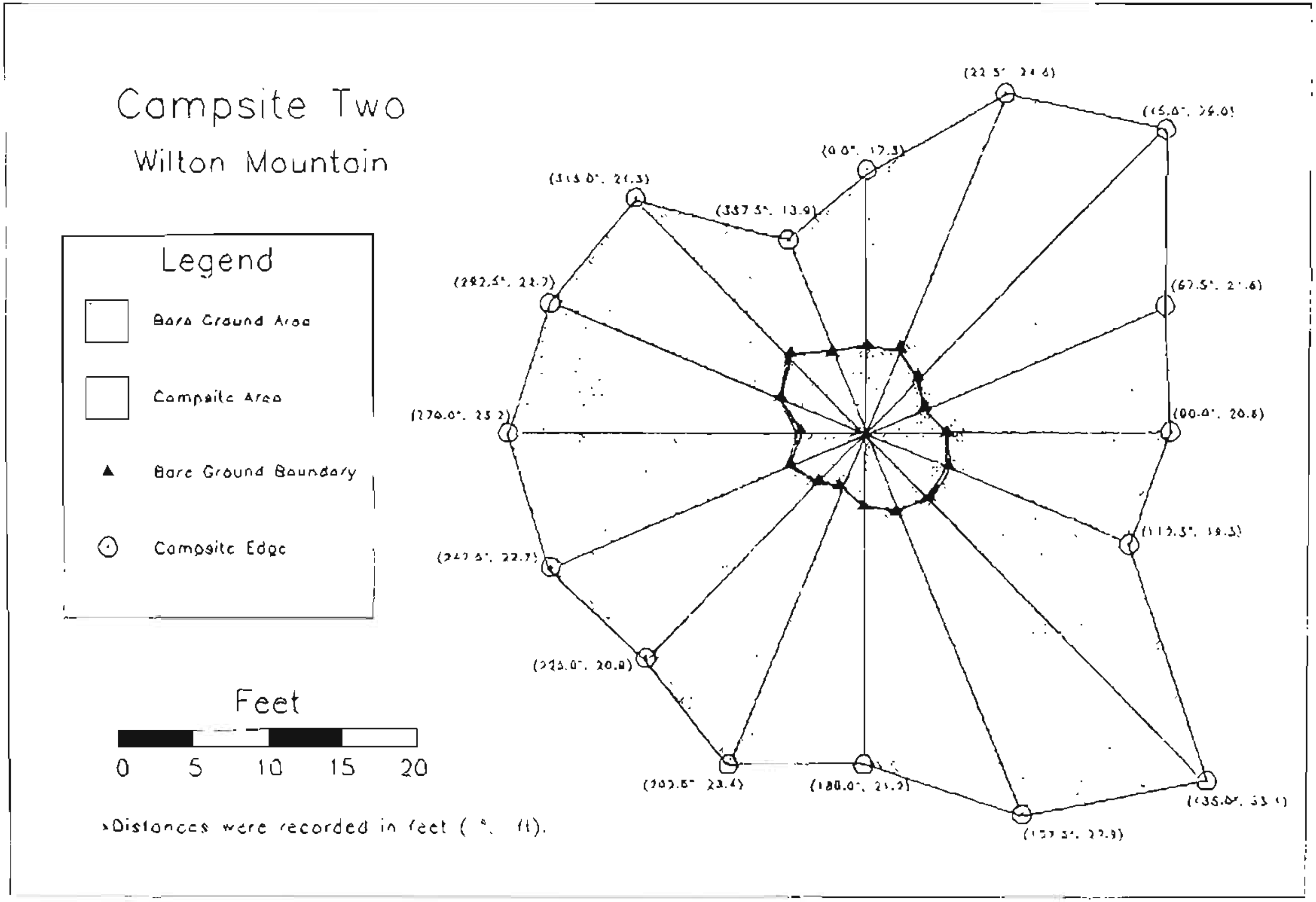
Figure 41. Trouble Transect Five (Transect Sixteen). Facing East (above) and West (below).

APPENDIX I

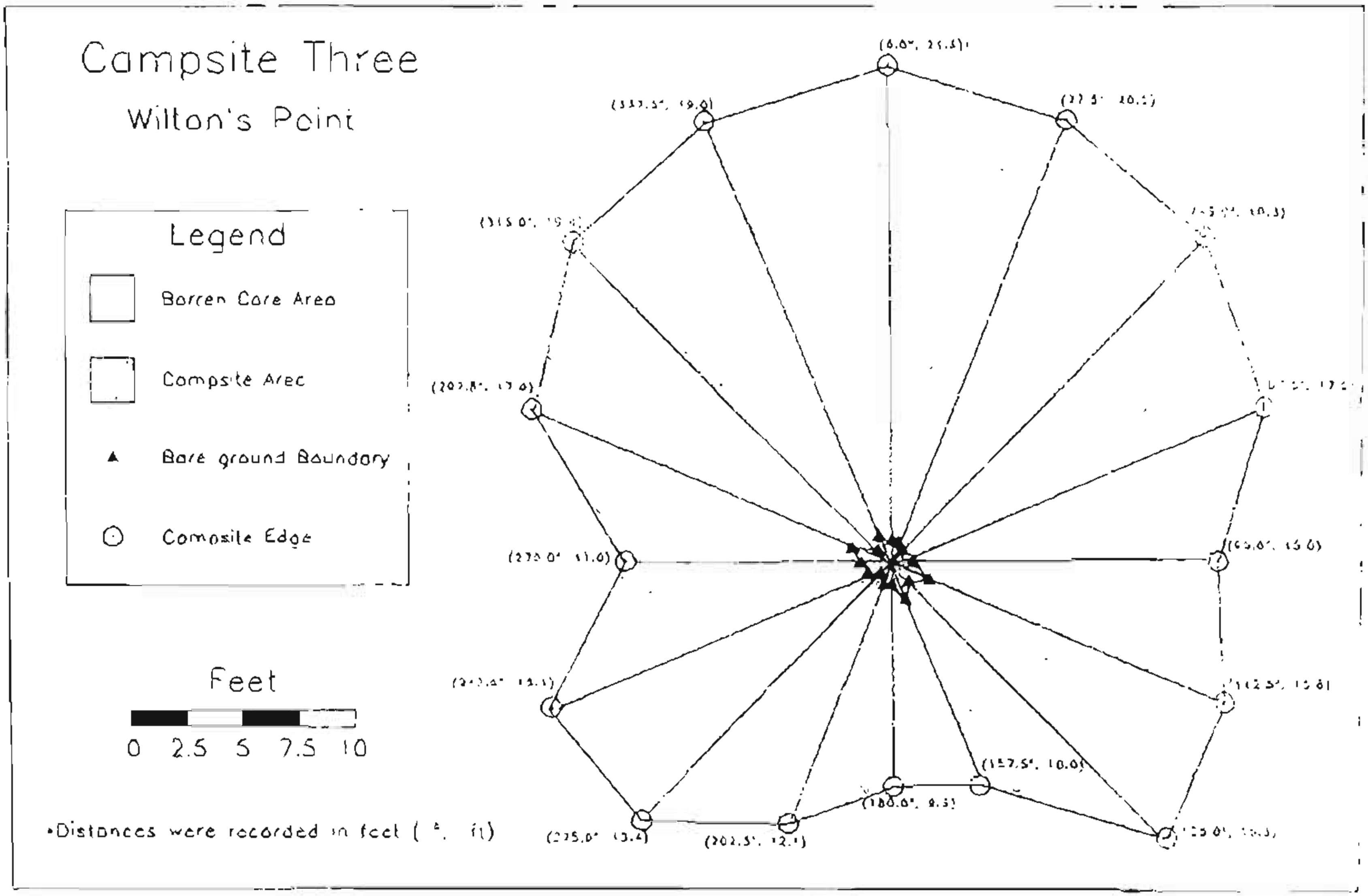
INDIVIDUAL CAMPSITE MAPS

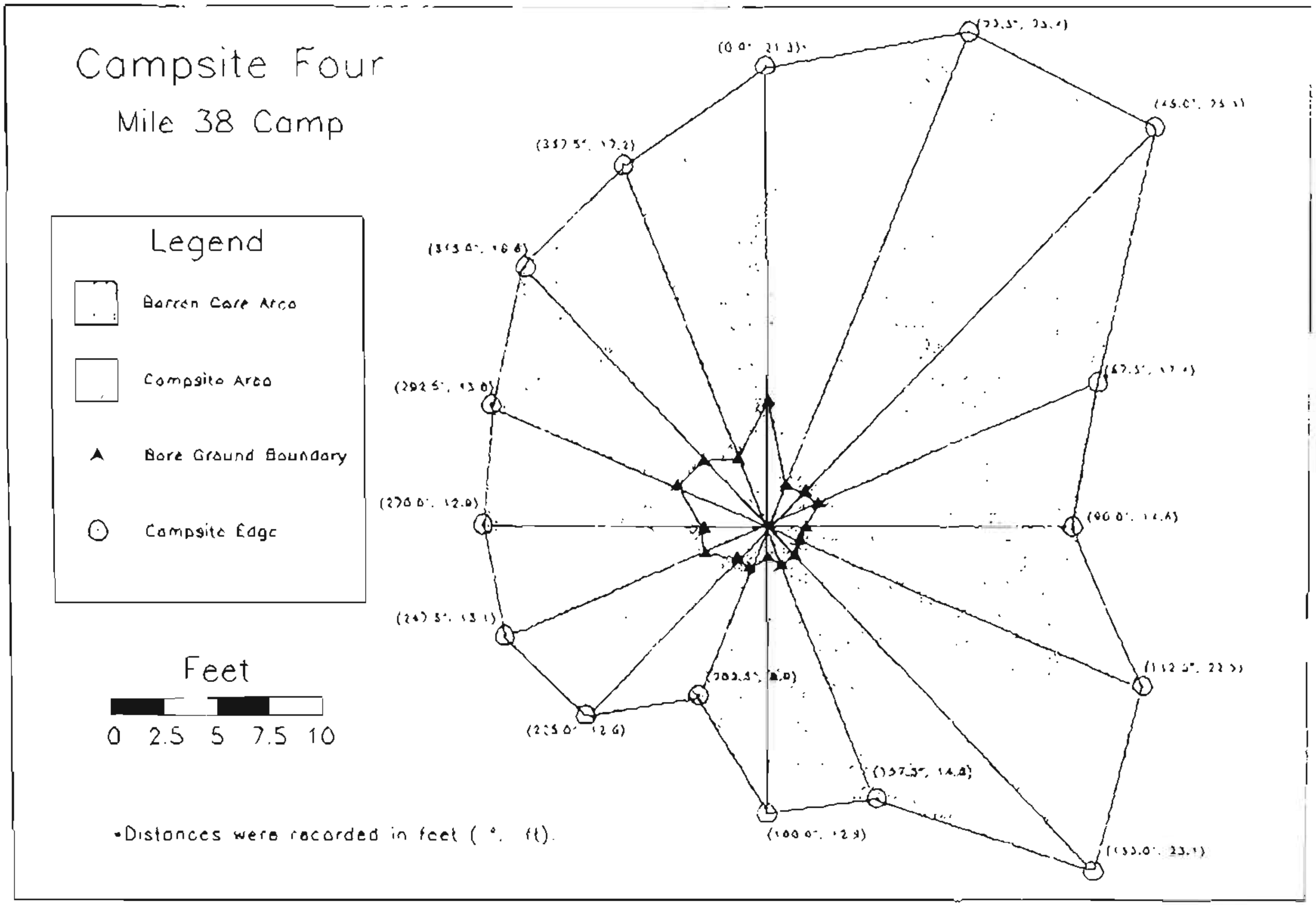


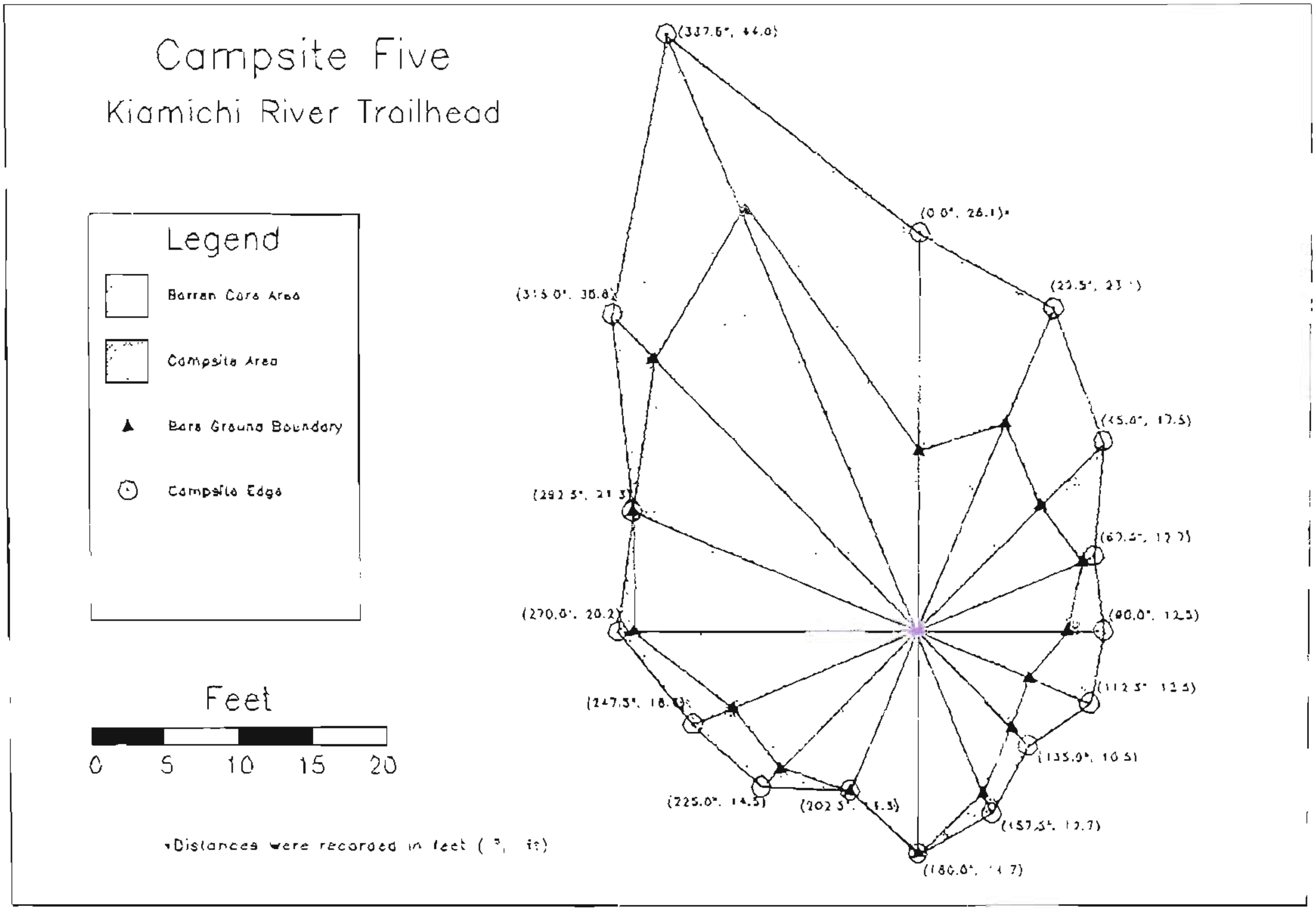
Campsite One
Pashubbe Point
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
* Distances were recorded in feet (°, feet)



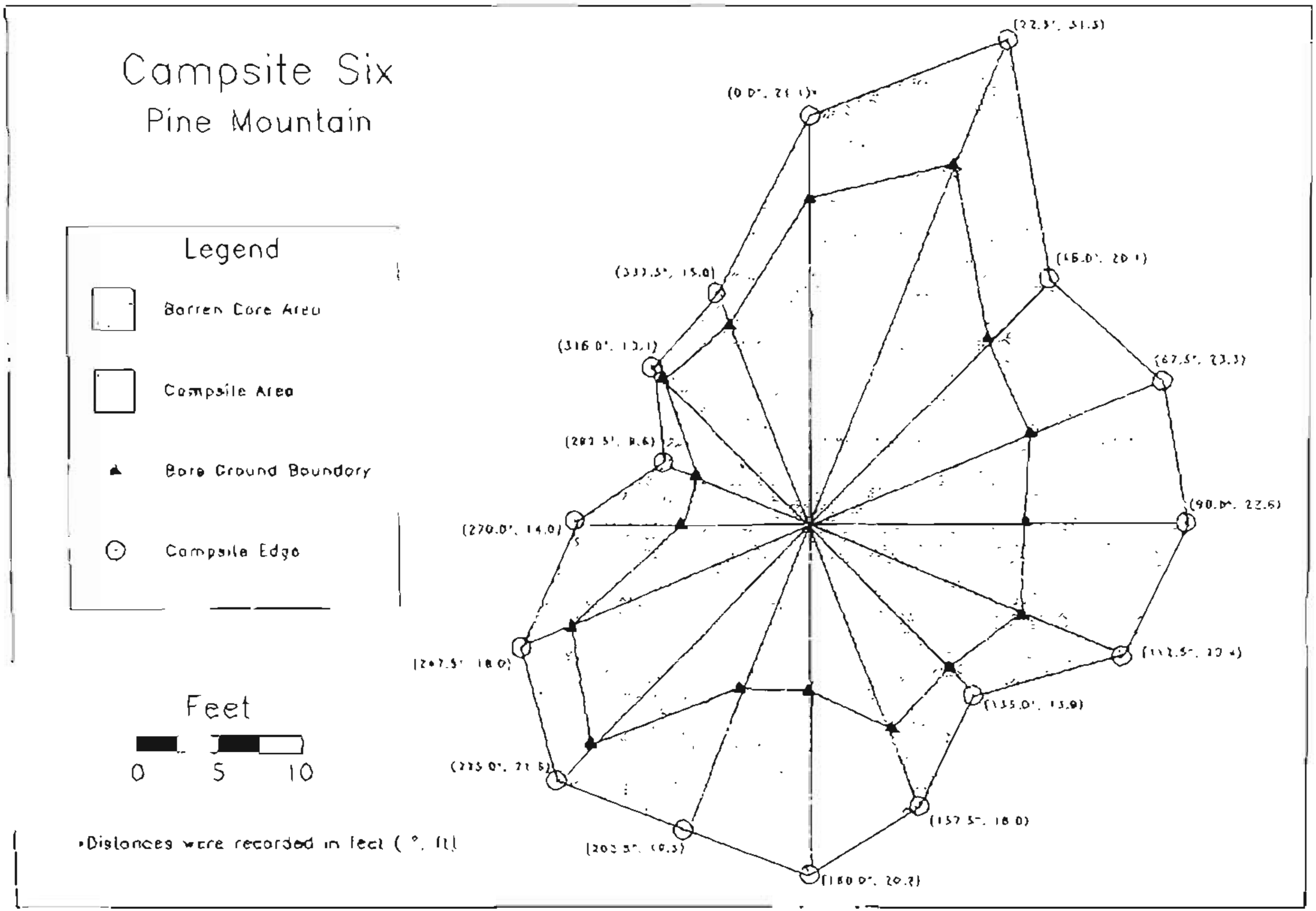
Campsite Two
Wilton Mountain
Legend
Bare Ground Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 5 10 15 20
(0.0°, 17.3)
(337.5°, 13.9)
(90.0°, 20.8)
*Distances were recorded in feet (°, ft).

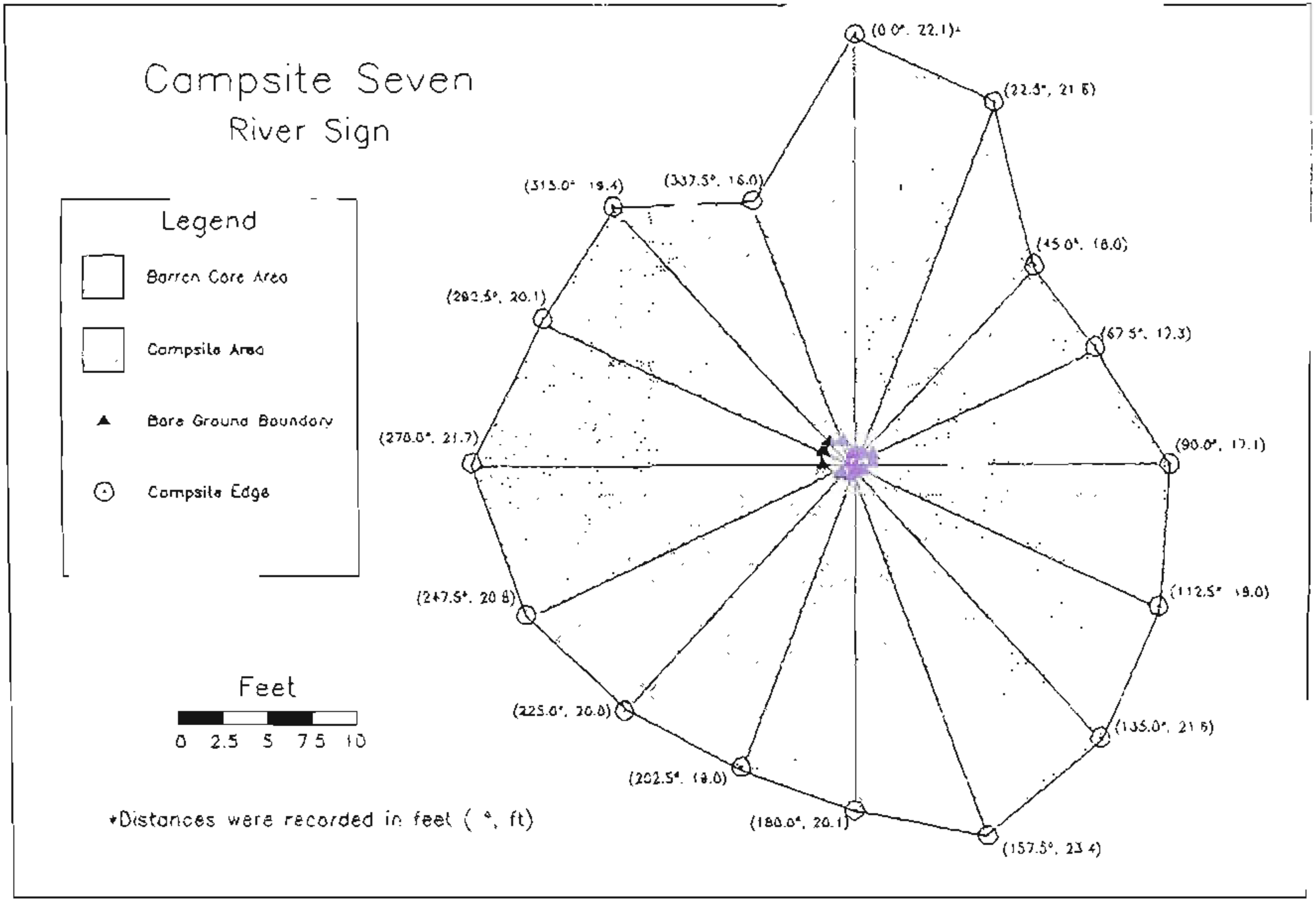

Campsite Three
Wilton's Point
Legend
Barren Core Area
Campsite Area
Bare ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
(157.5°, 10.0)
(180.0°, 8.5)
(202.5°, 12.1)
*Distances were recorded in feet (°, ft)

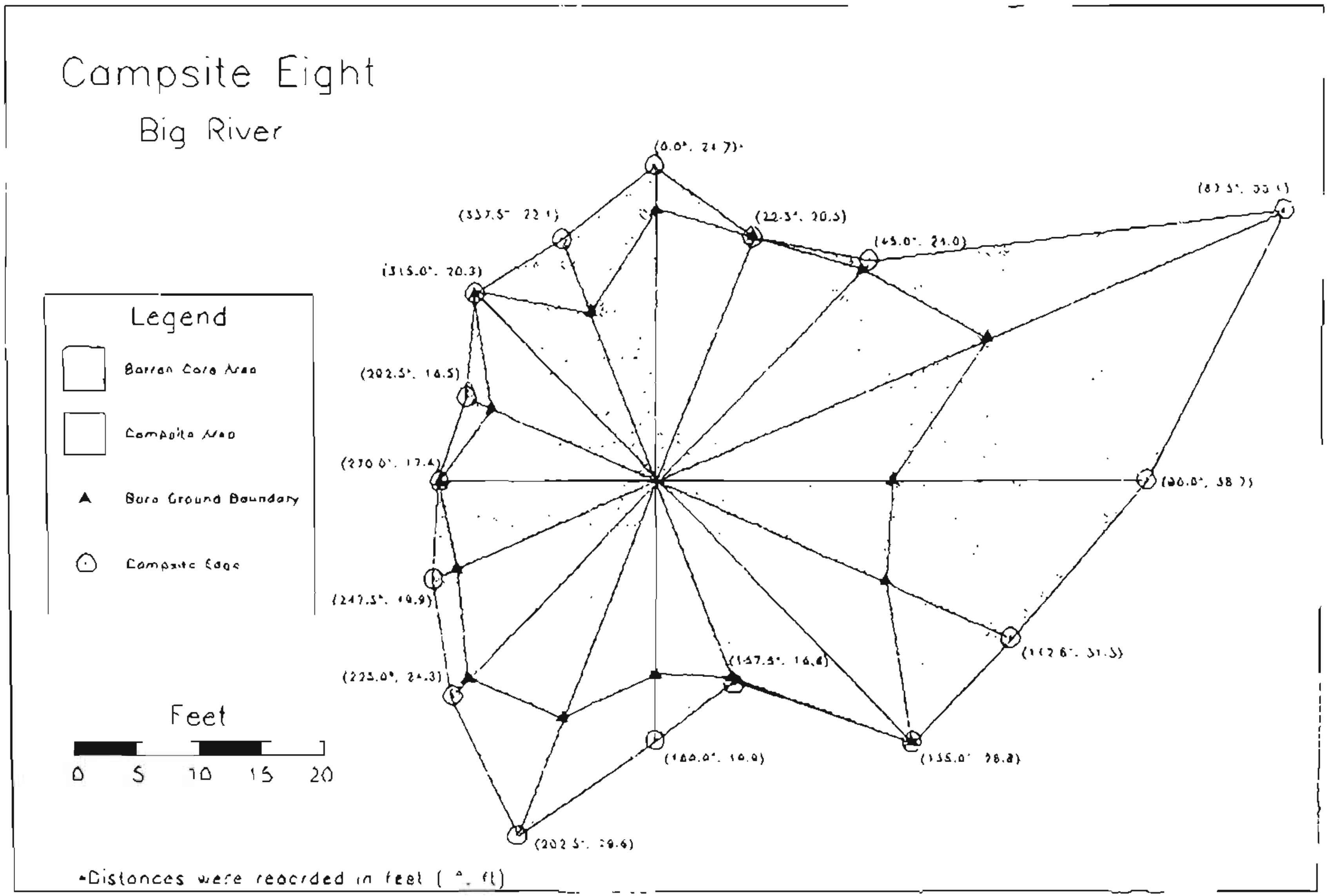

Campsite Four
Mile 38 Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
*Distances were recorded in feet (°, ft).

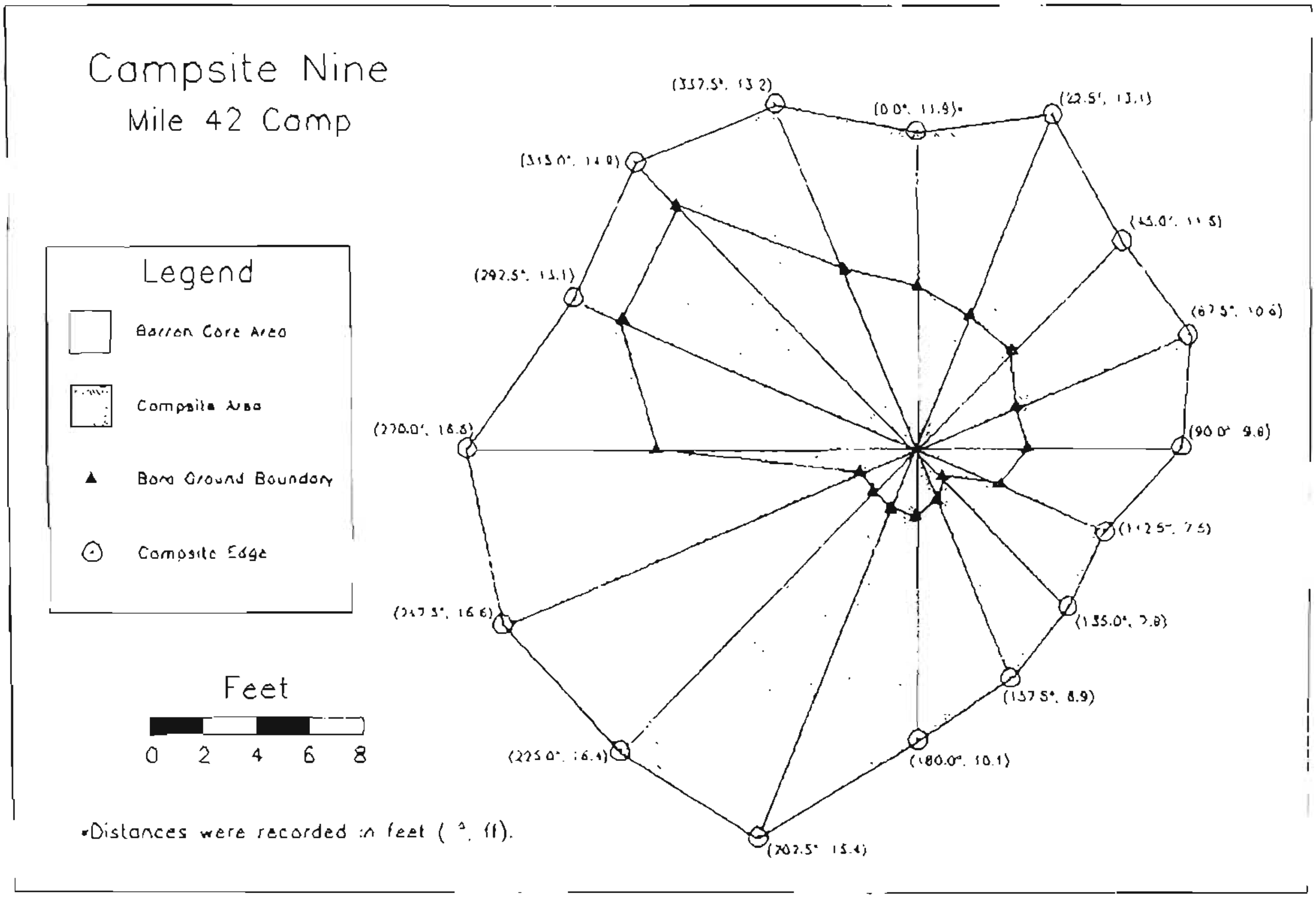


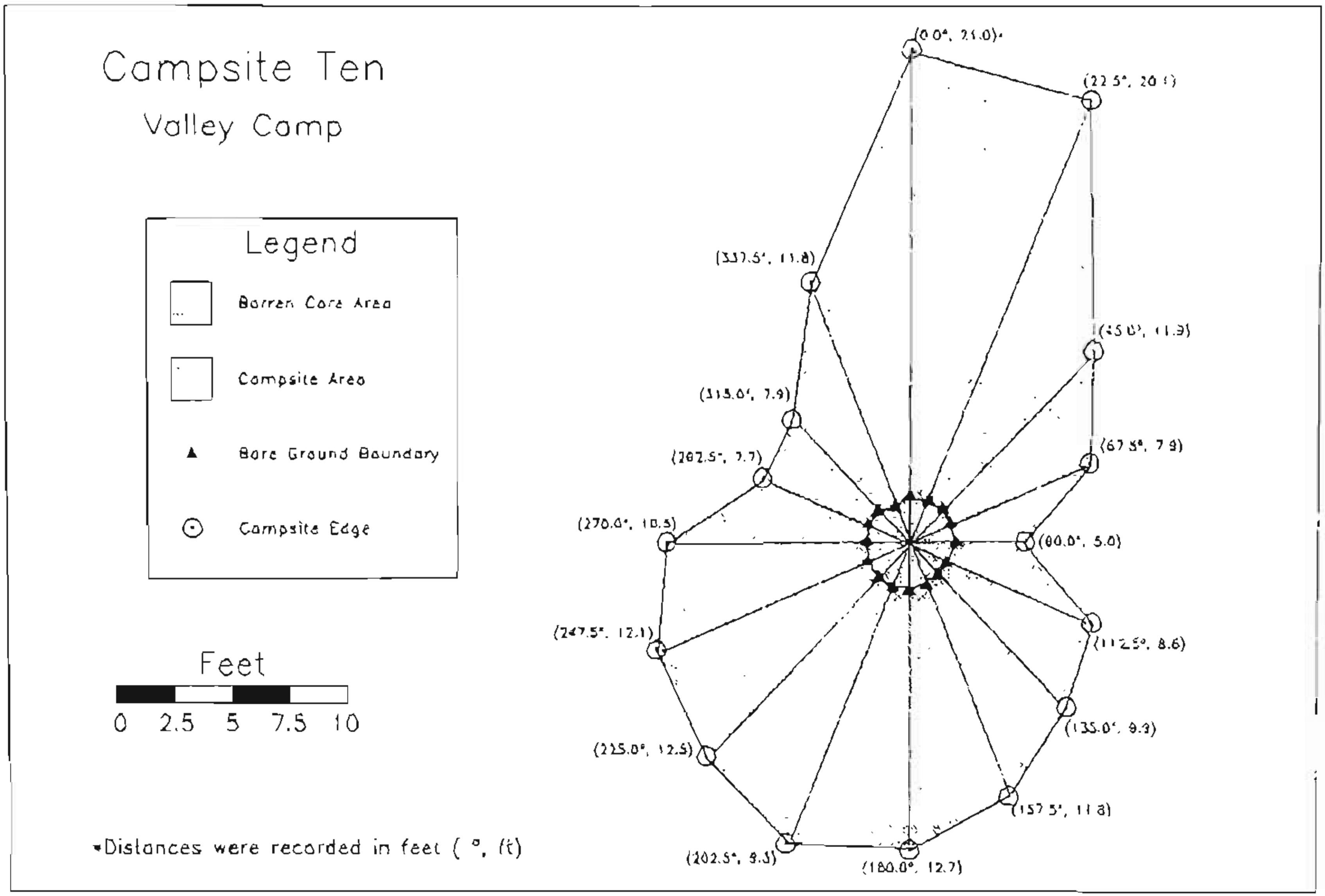
Campsite Five
Kiamichi River Trailhead
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 5 10 15 20
*Distances were recorded in feet
(337.5°, 44.0)
(0.0°, 26.1)*
(45.0°, 17.5)
(270.0°, 20.2)
(90.0°, 12.5)
(225.0°, 14.5)
(135.0°, 10.5)
(157.5°, 12.7)

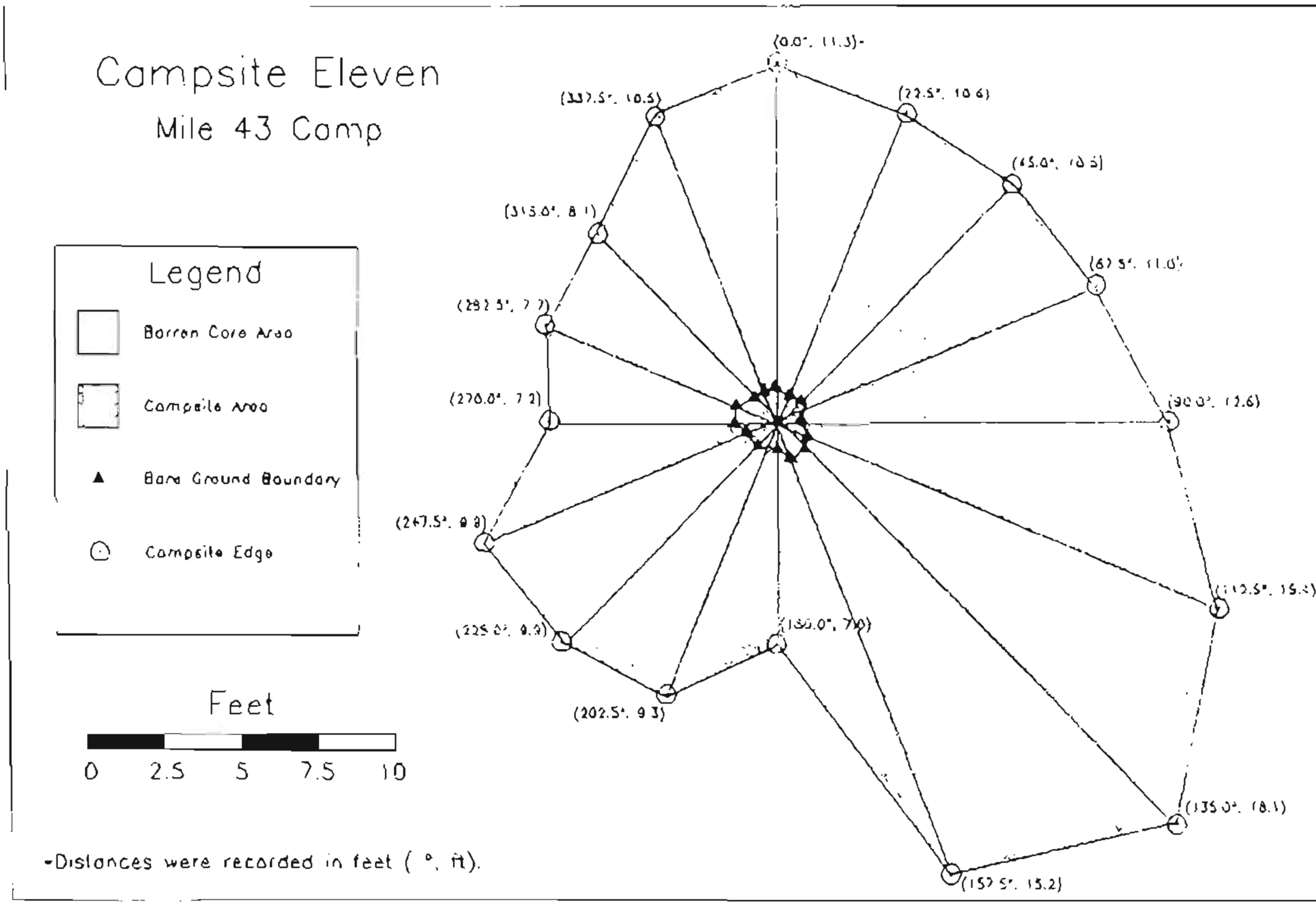

Campsite Six
Pine Mountain
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0
5
10
*Distances were recorded in feet (°, ft)
(22.5°, 31.5)
(45.0°, 20.1)
(67.5°, 23.3)
(90.0°, 22.6)
(135.0°, 13.9)
(157.5°, 18.0)
(180.0°, 20.3)
(247.5°, 18.0)
(270.0°, 14.0)
(316.0°, 13.1)
(337.5°, 15.0)

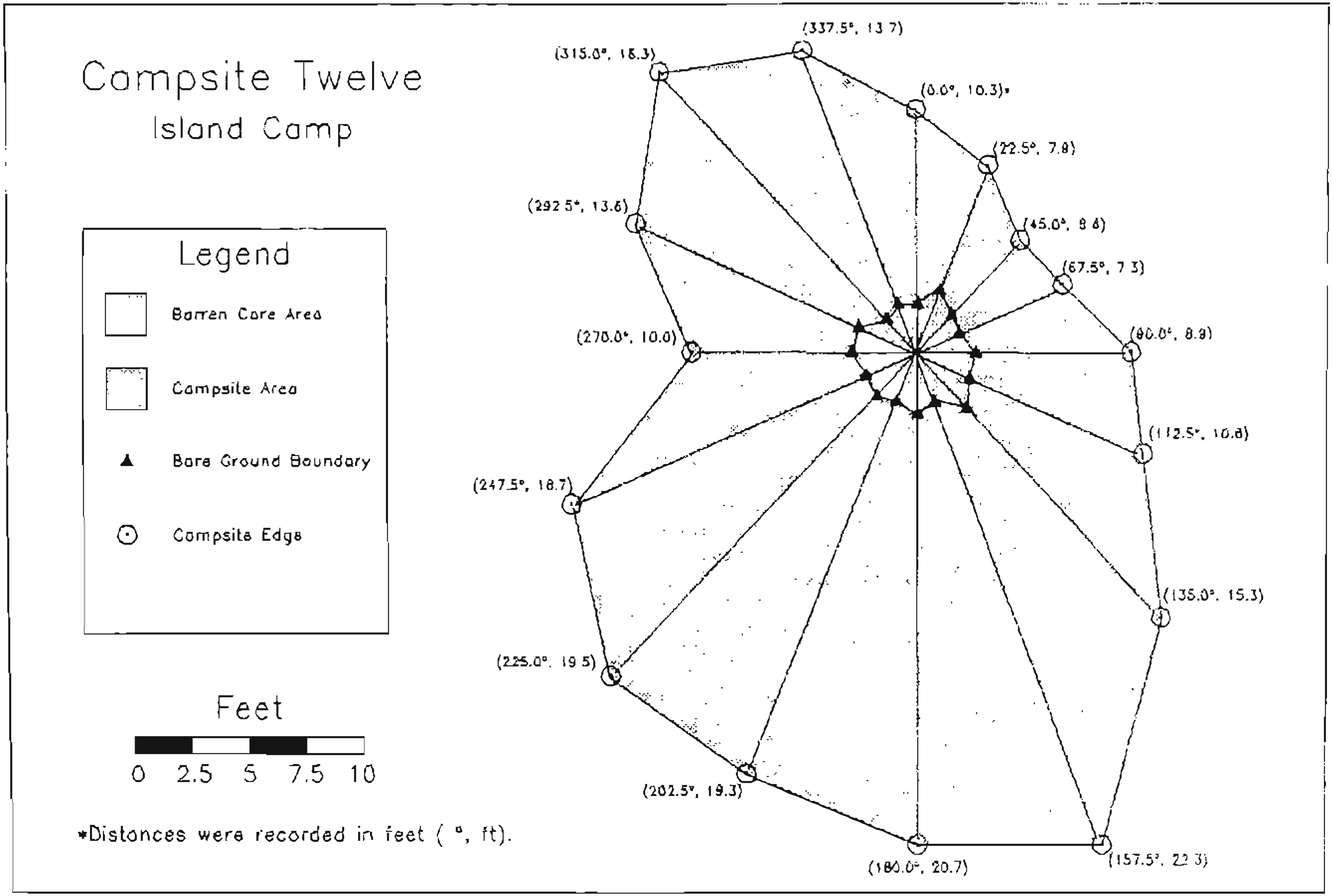

Campsite Seven
River Sign
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
*Distances were recorded in feet (°, ft)
(0.0°, 22.1)*
(22.5°, 21.6)
(45.0°, 18.0)
(67.5°, 17.3)
(90.0°, 17.1)
(112.5° 19.0)
(135.0°, 21.6)
(157.5°, 23.4)
(180.0°, 20.1)
(202.5°, 18.0)
(225.0°, 20.8)
(247.5°, 20.8)
(270.0°, 21.7)
(292.5°, 20.1)
(315.0° 19.4)
(337.5°, 16.0)

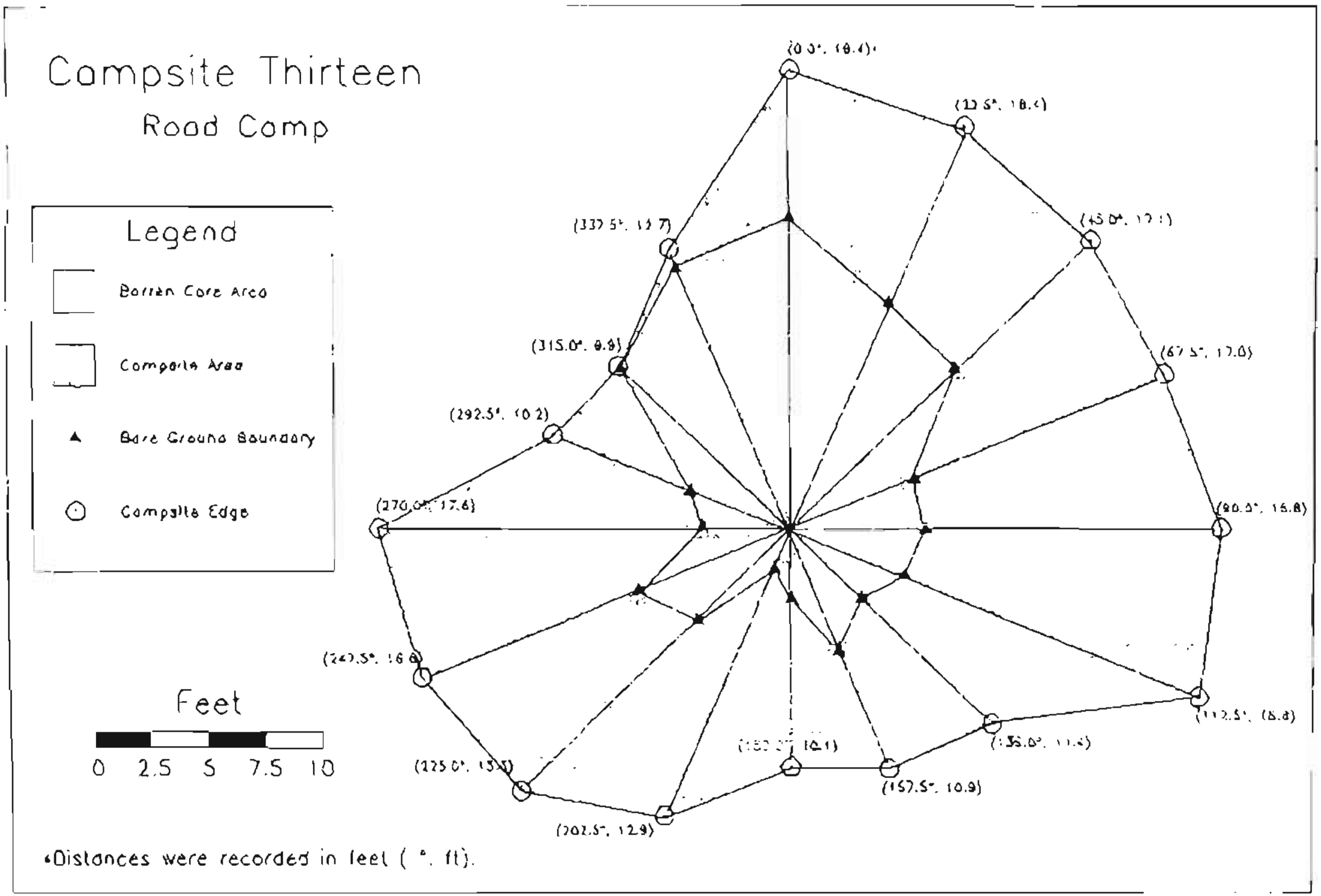

Campsite Eight
Big River
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 5 10 15 20
(0.0°, 24.7)*
(337.5°, 22.1)
(22.5°, 20.5)
(45.0°, 24.0)
(315.0°, 20.3)
(202.5°, 16.5)
(270.0°, 17.4)
(90.0°, 38.7)
(247.5°, 19.9)
(225.0°, 24.3)
(157.5°, 16.6)
(135.0°, 28.8)
(202.5°, 29.6)
*Distances were recorded in feet (°, ft)


Campsite Nine
Mile 42 Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2 4 6 8
*Distances were recorded in feet (°, ft).
(337.5°, 13.2)
(0.0°, 11.9)*
(22.5°, 13.1)
(315.0°, 14.8)
(45.0°, 11.5)
(292.5°, 13.1)
(67.5°, 10.6)
(270.0°, 18.8)
(90.0° 9.8)
(112.5°, 7.5)
(247.5°, 16.6)
(135.0°, 7.8)
(157.5°, 8.9)
(225.0°, 16.4)
(180.0°, 10.1)
(202.5° 15.4)

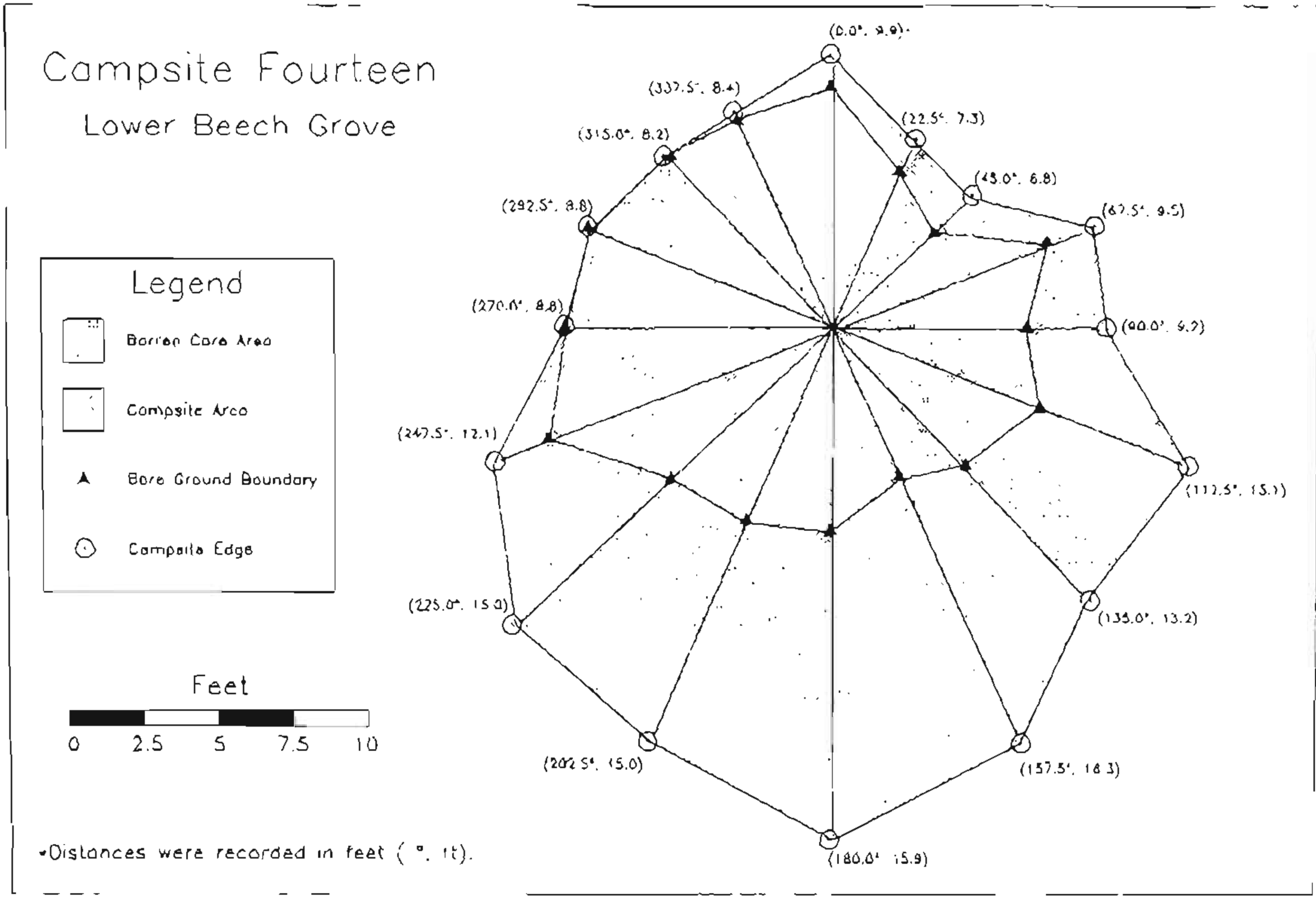

Campsite Ten
Valley Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
*Distances were recorded in feet (°, ft)
(0.0°, 21.0)*
(337.5°, 11.8)
(315.0°, 7.9)
(67.5°, 7.9)
(270.0°, 10.5)
(90.0°, 5.0)
(247.5°, 12.1)
(112.5°, 8.6)
(135.0°, 9.3)
(225.0°, 12.5)
(157.5°, 11.8)
(202.5°, 9.3)
(180.0°, 12.7)


Campsite Eleven
Mile 43 Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
-Distances were recorded in feet (°, ft).
(0.0°, 11.3)
(22.5°, 10.6)
(45.0°, 10.5)
(67.5°, 11.0)
(90.0°, 12.6)
(112.5°, 15.3)
(135.0°, 18.1)
(157.5°, 15.2)
(180.0°, 7.0)
(202.5°, 9.3)
(225.0°, 9.3)
(247.5°, 9.8)
(270.0°, 7.2)
(292.5°, 7.7)
(315.0°, 8.1)
(337.5°, 10.5)

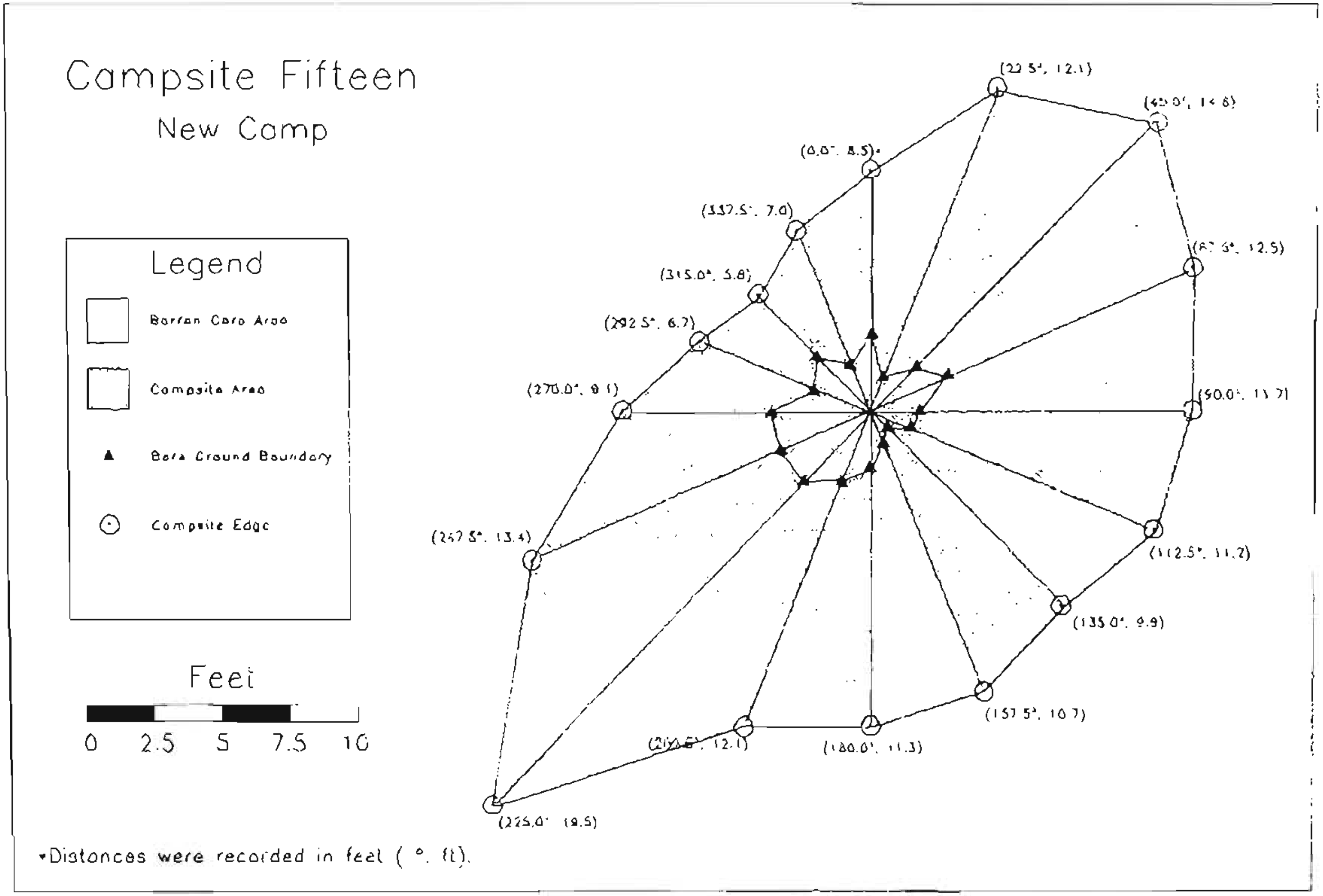

Campsite Twelve
Island Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
*Distances were recorded in feet (°, ft).
(337.5°, 13.7)
(315.0°, 18.3)
(0.0°, 10.3)*
(22.5°, 7.8)
(292.5°, 13.6)
(45.0°, 8.8)
(67.5°, 7.3)
(270.0°, 10.0)
(90.0°, 8.9)
(112.5°, 10.8)
(247.5°, 18.7)
(135.0°, 15.3)
(225.0°, 19.5)
(202.5°, 19.3)
(180.0°, 20.7)
(157.5°, 22.3)



Campsite Thirteen
Road Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
(67.5°, 17.0)
(90.0°, 16.8)
(157.5°, 10.9)
(202.5°, 12.9)
(225.0°, 15.5)
(247.5°, 16.6)
(270.0°, 17.6)
(292.5°, 10.2)
*Distances were recorded in feet (°, ft).



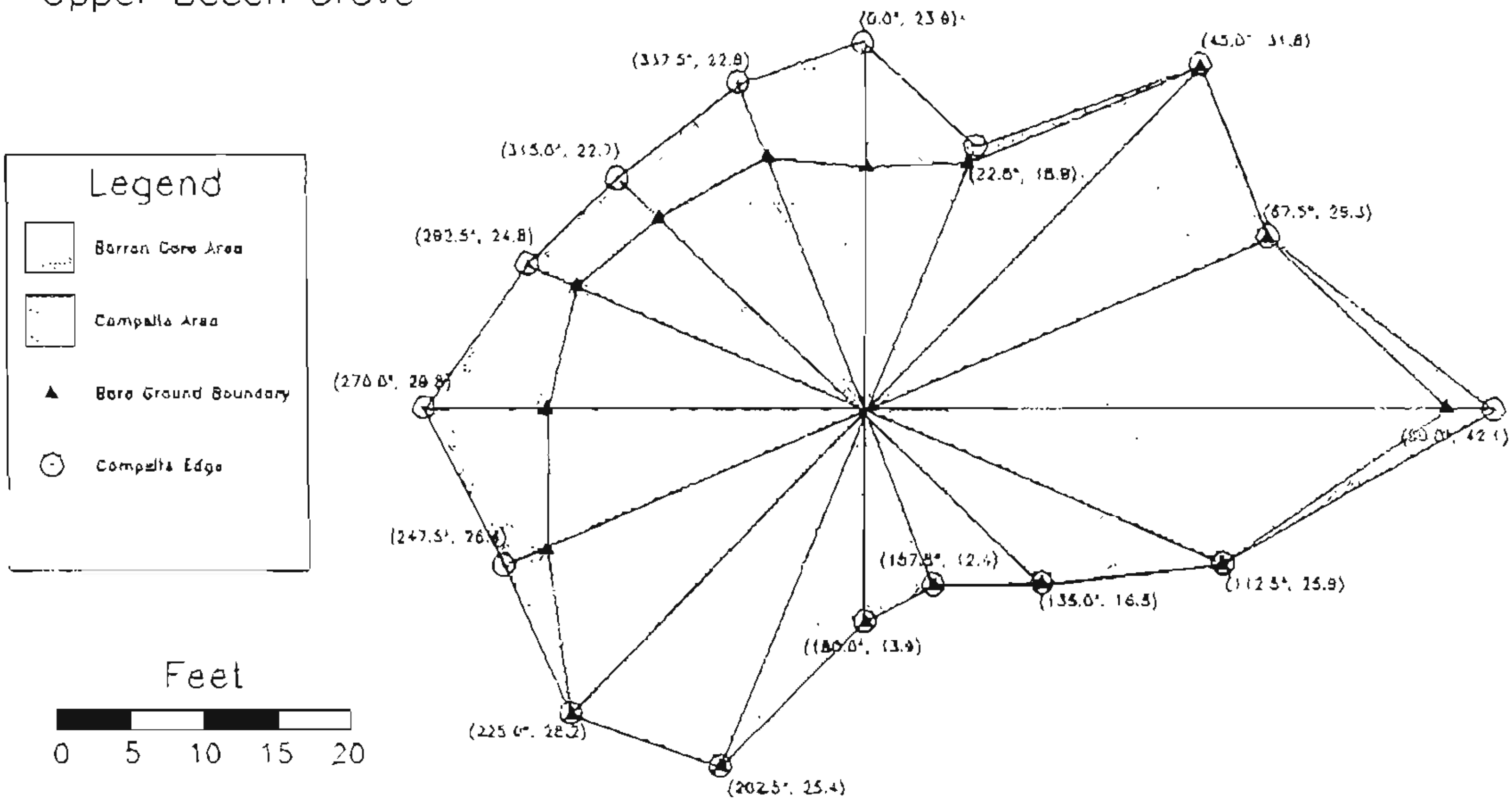
Campsite Fourteen
Lower Beech Grove
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
(0.0°, 9.9)*
(337.5°, 8.4)
(22.5°, 7.3)
(315.0°, 8.2)
(45.0°, 6.8)
(292.5°, 8.8)
(67.5°, 9.5)
(270.0°, 8.8)
(90.0°, 9.7)
(247.5°, 12.1)
(112.5°, 15.1)
(225.0°, 15.0)
(135.0°, 13.2)
(202.5°, 15.0)
(157.5°, 18.3)
(180.0°, 15.9)
*Distances were recorded in feet (°, ft).



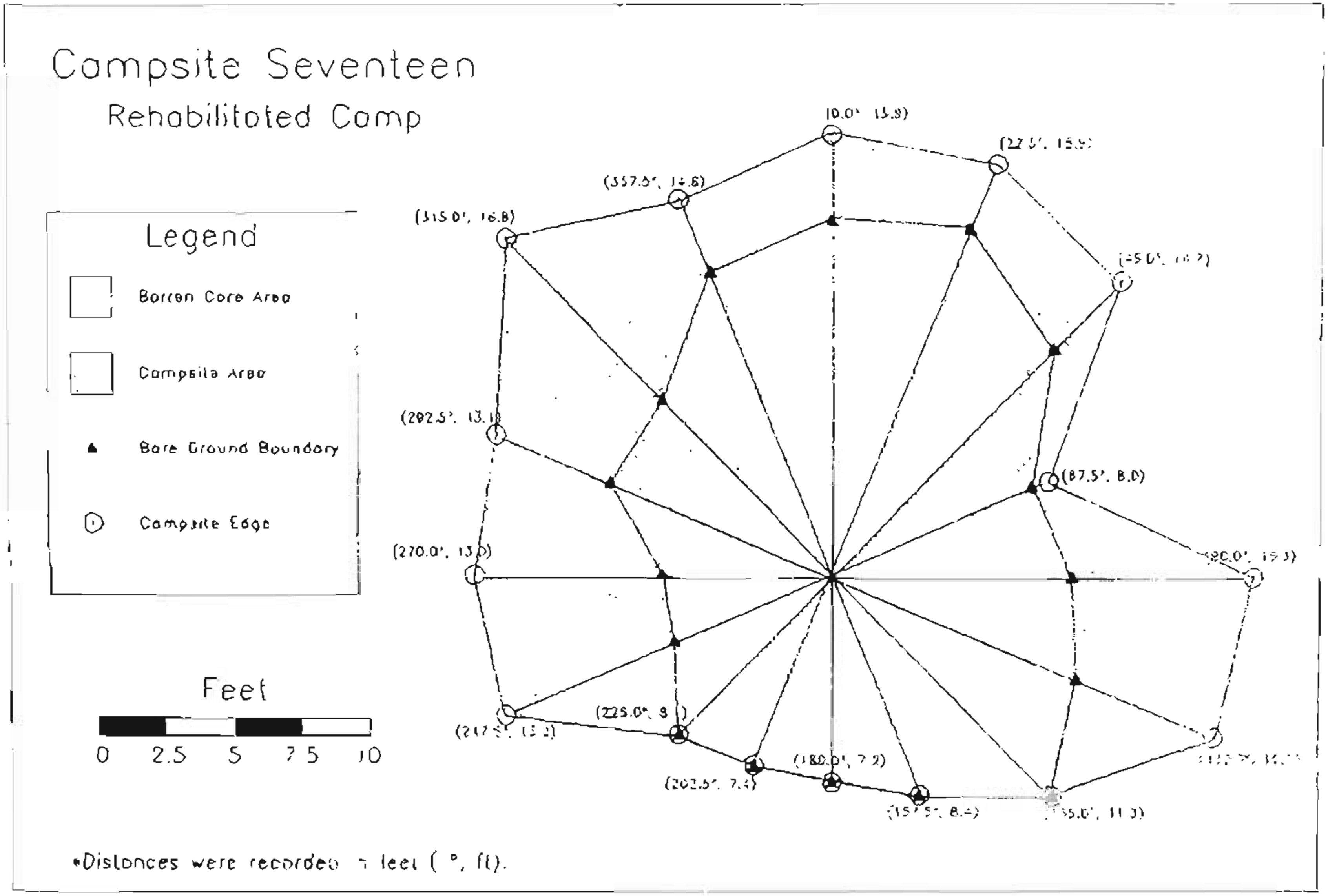
Campsite Fifteen
New Camp
Legend
Barren Core Area
Campsite Area
Bora Ground Boundary
Campsite Edge
Feet
0
2.5
5
7.5
10
(22.5°, 12.1)
(0.0°, 8.5)*
(337.5°, 7.0)
(315.0°, 5.8)
(292.5°, 6.7)
(247.5°, 13.4)
(112.5°, 11.2)
(135.0°, 9.9)
(157.5°, 10.7)
(180.0°, 11.3)
(225.0°, 19.5)
*Distances were recorded in feet (°, ft).

Campsite Sixteen

Upper Beech Grove



*Distances were recorded in feet (°, ft).


Campsite Seventeen
Rehabilitated Camp
Legend
Barren Core Area
Campsite Area
Bare Ground Boundary
Campsite Edge
Feet
0 2.5 5 7.5 10
(315.0°, 16.8)
(357.5°, 14.8)
(282.5°, 13.1)
(87.5°, 8.0)
(180.0°, 7.2)
(202.5°, 7.4)
*Distances were recorded in feet (°, ft).

VITA

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Master of Science

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