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Photographic Techniques for Monitoring Resource Change at Backcountry Sites

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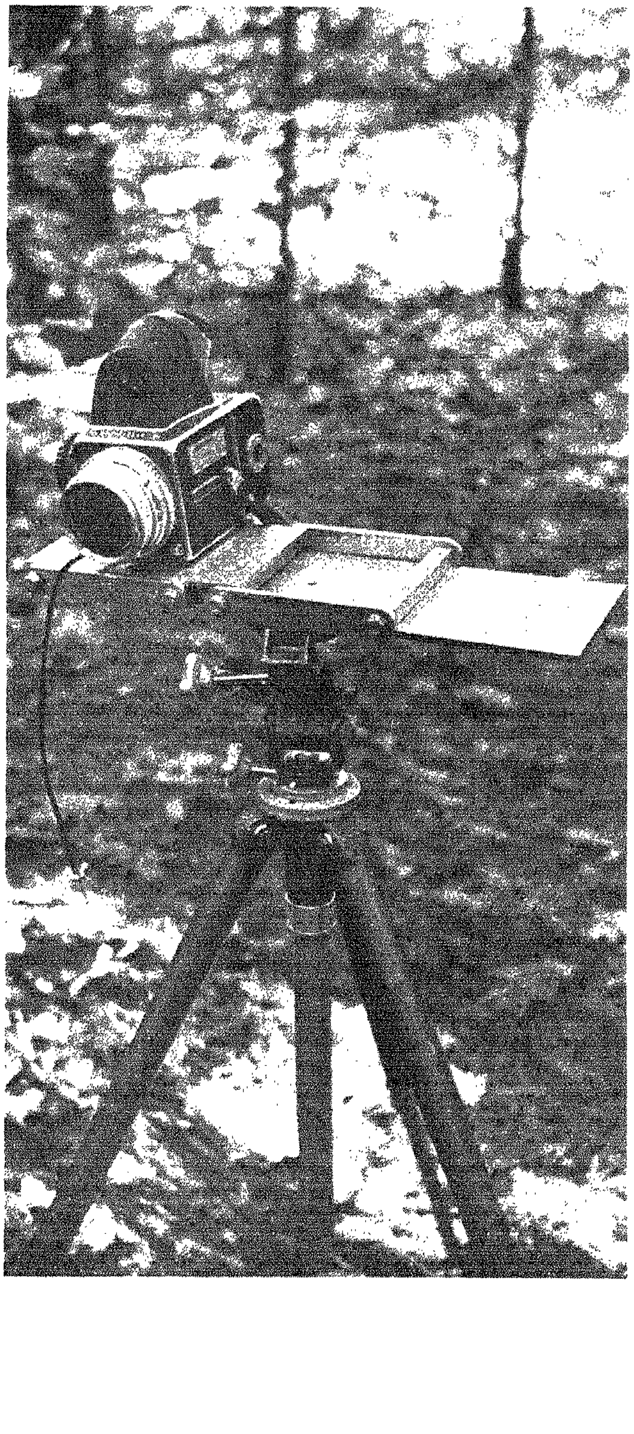

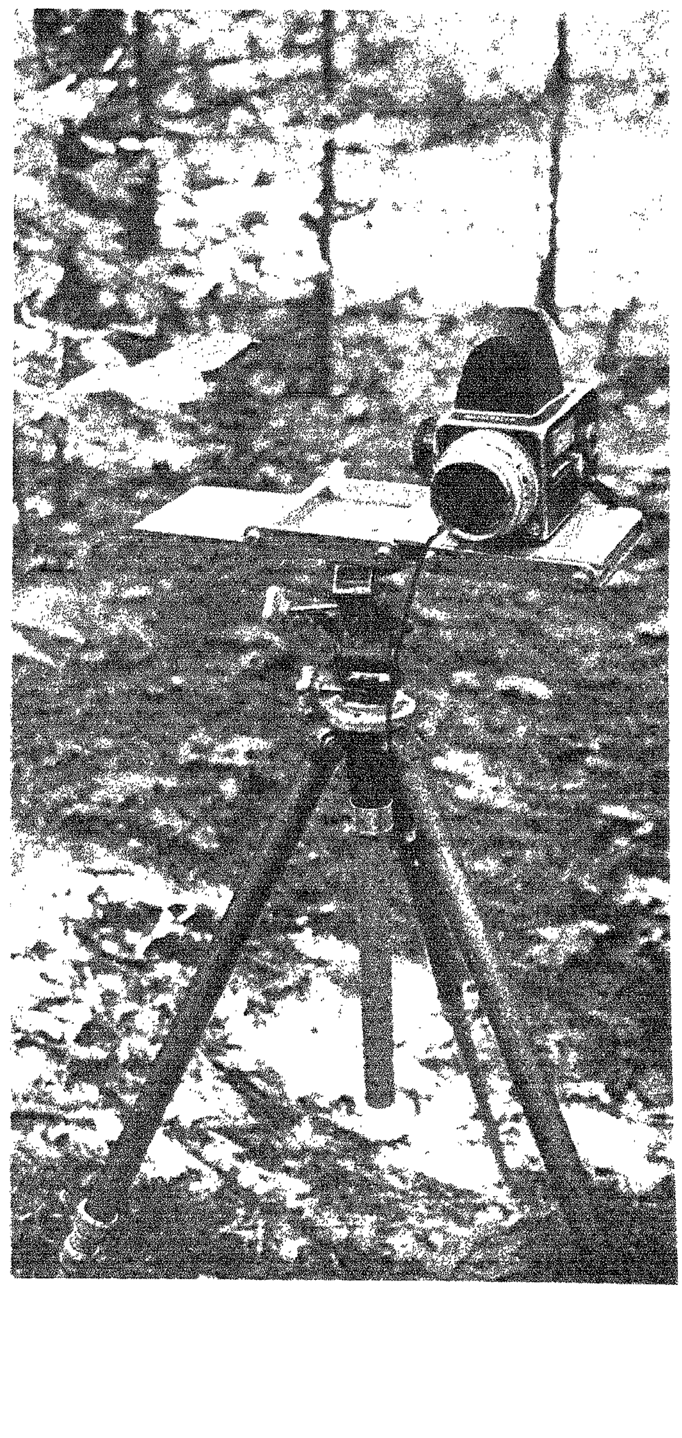

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Abstract

Resource change can be monitored by photographic methods. The question resource managers must ask is whether and how a photographic monitoring program fits with: (1) existing monitoring programs; (2) data requirements; (3) available equipment and funds; (4) personnel deployment; and (5) visitor education or personnel training needs.

The microsite techniques described in this report are generally the more expensive, requiring more time or specialized equipment in the field or lab than the macrosite techniques. The data obtained are detailed and, in some cases, quantifiable enough for research purposes. Quadrat photography could supplant a field quadrat analysis program. Trail mosaics could provide excellent vegetation records to accompany trail profiles obtained from nonphotographic trail transect monitoring programs. Stereo (or mono) photographic trail transects, although generally more expensive than field measured transects, are reasonable substitutes where it is essential that data be verifiable.

Macrosite techniques are less likely to provide research data, but are very useful for qualitative assessments. Panoramas can be produced in the course of normal inventory routines to provide supplemental information. They are more effective, however, if obtained through a carefully planned program of photographing each site at nearly exact 5-year intervals, but the logistics might be prohibitive. The monoscopic perspective grid technique can provide some measurable data, but it has limited applicability, and cannot be relied on for comprehensive surveys of site conditions.

The principal advantage of any photographic monitoring system is the visual record it provides. The viability of these techniques will, therefore, always depend on how much value is attached to: (1) the impact of pictoral display of resource change versus written description; (2) the convenience of laboratory or office (rather than field) data analysis; (3) the reproducibility of raw data; and (4) the reduction of subjectivity by personnel.

Acknowledgements

Materials for this report were drawn from many unpublished sources; consequently, the literature citations do not adequately reflect all of the contributors. The following persons and organizations deserve commendation: Anne Whitney and Jane McBride for the design and application of the quadropod technique; Laurence Van Meter for the development of the trail mosaic technique; Steve Rice, Harry Peet, and the Green Mountain Club for information gleaned from an ongoing 6-year photographic campsite monitoring program; Robert Vinton for the development of the perspective grid technique; Harriet Plumley for the coordination of this report; and Raymond Leonard for the encouragement and counsel of the staff of the Northeastern Forest Experiment Station's Backcountry Recreation Research Project in their search for better ways to monitor recreation resources.

Foreword

This report has been prepared under the auspices of the USDA Forest Service and the Appalachian Trail Conference to bring together assorted information on photographic techniques for monitoring resource change at wildland recreation sites. For the most part, the techniques were originally devised to gather research data, but some are practical enough to be useful management tools as well.

Introduction

Reasons for Resource Monitoring

A well-conceived resource monitoring program is essential to sound management planning. Research data and site inventories collected over time provide vital information about what, where, why, and how fast changes are occurring in the physical, biological, and aesthetic conditions of the resource. For wildland recreation managers, such information affects decisions concerning: (1) where to develop and how to assign priorities to maintenance programs; (2) what levels of funding are necessary to protect or improve the resource; (3) which plant species or ground conditions are the most fragile and should be monitored the most closely; (4) where visitor use patterns or types of use should be changed to reduce resource deterioration; and (5) how effective certain management programs have been (e.g. campsite reclamation). A good monitoring program, therefore, provides a record of changes in conditions of the resource, and documents the effects of certain management policies and actions.

Resource Monitoring Systems

Collecting information on wildland recreation conditions is expensive because access is limited and the resources extensive. To be cost-effective, monitoring programs must be systematic. The system must be designed to achieve a specific set of objectives; produce detailed and replicable records by easy-to-use methods; and permit ready retrieval of those records for comparisons of sites over time (Hendee et al. 1978).

Two exemplary systems currently in use to inventory and monitor backcountry campsites are Code-a-site (Hendee et al. 1976), used by the U.S. Forest Service, and the Human Impact Inventory (Moorhead and Schreiner 1976) used by the National Park Service. Both systems require field personnel to assess conditions at individual campsites. The information is recorded on cards which have "needle sorting" holes along the margin. The cards are preprinted with the desired information organized into categories around the perimeter. The needle-sorting process permits quick and easy comparisons between campsites for inventory purposes. Cards for individual sites can also be compared over time to monitor changes.

Currently used methods of monitoring trail (as opposed to campsite) conditions are less sophisticated in information storage and retrieval. Some backcountry managers and researchers collect data systematically by running a calibrated wheel along the trail and reporting conditions at standard intervals from a specified starting point (Leonard and Whitney 1977).

The Role of Photography

Photography can also be used systematically to provide a permanent record of site conditions for comparisons over time. A photographic monitoring system should enhance (not necessarily replace) the nonphotographic systems previously discussed. A visual record of campsites and trail locations can be advantageous for a number of reasons.

Photography can reduce subjectivity in recording site conditions. With campsite inventory systems, the accuracy and reliability of the information obtained depend on the strength of the criteria set forth in the coding instructions (Hendee et al. 1976), how closely the individual collecting the information follows the criteria in making his or her judgment, and the training and experience the observer has had. Photographs can be used to establish codebook criteria by providing characteristic examples of the different conditions that require classification. In addition, photographs can provide a means of validating field assessments by allowing more than one qualified observer to view the conditions of the area at a single point in time. These attributes are particularly important when personnel changes increase the variability of subjective bias.

Photography can, in some cases, reduce field costs. Where visual assessments are the primary source of information, less experienced field personnel can easily be trained to take representative photographs so that professional staff can perform the necessary analyses at their convenience in the office or laboratory.

Photography can be used as an educational tool. New personnel can be shown the past and present conditions of the resource quickly. The successes or failures of preventive maintenance, rehabilitation, or site hardening programs can be documented by photographic records. Interpretive programs designed to educate visitors on the impacts of their use of the resource, or the reasons behind certain regulations, can benefit from photographs obtained from monitoring programs.

Photographic monitoring techniques can give management information useful for decision making, but their use should be considered in the context of the types of data required and how field personnel are normally deployed. Photography cannot meet all data requirements; for example, many quantitative assessments such as soil analyses cannot be obtained from photographs. On the other hand, photographs are excellent for evaluating aesthetic conditions (Buhyoff and Leuschner 1978), and ecological trends (Gruell 1980). Photographic techniques for monitoring require more attention to timing than some nonphotographic techniques, since duplicating a photograph at the same time of day and near the same day of the year is often a requisite for usable results. This may be more difficult for field personnel to do in the course of normal routines than using Code-a-site or similar inventory/monitoring systems.

Photopoint Photography

The techniques detailed in this report require a referenced and relocatable camera position from which photographs can be taken periodically for comparison. When done properly, "photopoint" photography provides more accurate and useful qualitative data than simple "snapshot" photography. In addition, some degree of quantifiable information can often be obtained without sophisticated photogrammetric techniques or equipment. Since establishing a photopoint is part of the field methodology for many of the techniques to follow, the procedure is set forth here.

Field procedure. The first step in establishing a photopoint is to analyze the subject area carefully. Select a camera position that provides the most advantageous perspective (with the available equipment) of the expected change. Photographers on successive photo missions may feel compelled to move the camera point slightly to achieve what they feel is a better coverage of the subject. This might result in a loss of information, which could be avoided by properly anticipating what coverage will be necessary as changes occur over time. Documenting the reason for the camera placement when it is not immediately evident may avoid costly changes.

Once a location for the photopoint has been determined, a physical marker is required. Permanent landmarks such as boulders or other large objects should be taken advantage of when possible (Magill and Twiss 1965). Where landmarks such as these are not available, some kind of stake should be driven flush with the ground. Size, weight, and durability are limiting factors. Wood is light, but may deteriorate faster than desired. Objects as small as nails can be used with magnets attached to permit relocation with a compass or metal detector. Frost heaving can be a problem for small markers such as nails; large spikes may be more appropriate where the ground freezes. Any marker should be as inconspicuous as possible to avoid vandalism.

Referencing the photopoint is the next step. Two nearby permanent objects can be used as references, but three are better. Trees are good references and may be marked with numbered aluminum tags. (Note: Tags are not appropriate in designated wilderness.) Identification tag numbers should be recorded along with the bearing and distance from each tree to the photopoint. Sketch maps should be made showing the azimuth from the reference object to the photopoint, the dbh and species of witness trees and the general object area in relation to trailheads, shelters, access roads, etc. (Figure 1). An altimeter reading and slope aspect indication should also help locate the photopoint on topographic maps. A photograph of the area and camera setup is also useful for relocation.

If different cameras are used for successive photos from the same point, they should at least be of the same format and use the same length lens. Film of the same type, speed, and spectral sensitivity should be used when possible. A change from black and white to color film can be made with less loss of information if a set of black and white

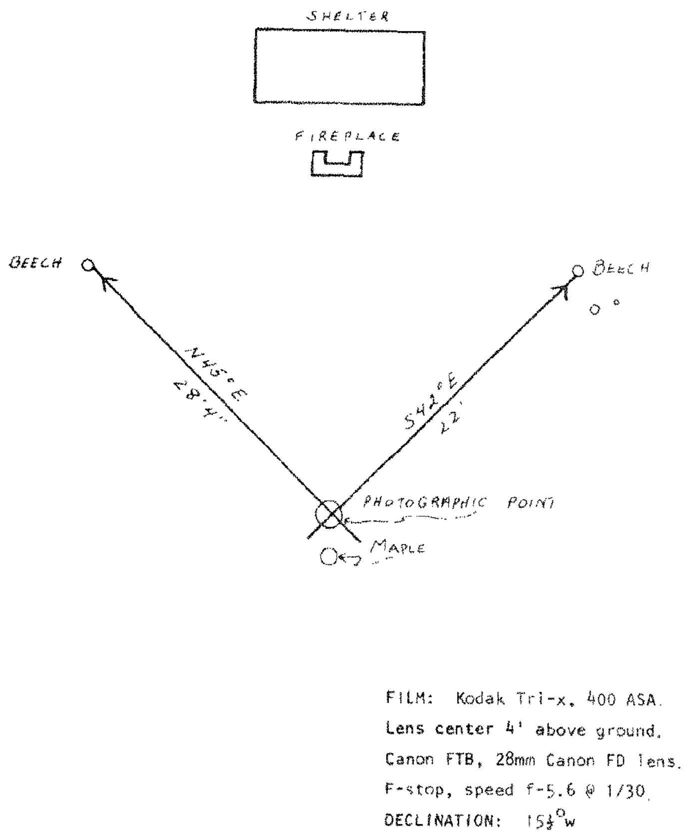

Figure 1.—Sketch map showing the location of a photopoint.

prints are also made from the color negatives or slides for the first year of comparison. The time of day should be duplicated as closely as possible to avoid shadows in different positions. The photos should also be taken during the same time of year (the size of the "window" of duplication days will vary according to the needs of the study). Carrying copies of the original photos in the field can facilitate accurate reproduction.

Quadrat Photography

The quadrat photography technique described here was developed at the Northeastern Forest Experiment Station in Durham, New Hampshire, for use in controlled experiments to study the impacts of trampling and group camping activities on certain designated areas. Photographs of quadrats were analyzed to determine the effects of such impacts on surface soil and forest litter conditions, vegetation survival, and species composition.

Equipment. The principal piece of equipment is a quadropod whose four legs attach to a 1 by ½ meter quadrat frame. The whole unit can be disassembled to be moved. The quadropod keeps the film plane a specified distance from and parallel to the ground. The rectangular shape of the quadrat makes a 35 mm camera most practical. A lens of 35 mm focal length is necessary to include the full quadrat in the frame with the quadrat size and camera-to-subject distance prescribed for this particular quadropod (Figure 2).

Other equipment includes an electronic flash unit, some opaque cloth and color film. A flash unit with sufficient power to provide full even coverage of the quadrat should be aimed directly at the ground plane to provide uniform lighting with minimal shadow. On bright, sunny days, the cloth should be used to shade the quadrat to keep the lighting uniform. Color film is preferable to black and white for differentiating between such things as live seedlings and forest litter. Color infrared may provide even greater differentiation in some instances. Slides are preferable to prints because they can more easily and inexpensively be enlarged by projection. If color slides are used, some sort of rear projection device is valuable. The Kodak Ektagraphic Series of tabletop rear projectors provide useful image sizes (from 35 mm slides) and a smooth hard viewing surface on which delineations can be drawn on acetate overlays.[1]

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service for any product or service to the exclusion of others that may be suitable.

Figure 2.—Quadropod.

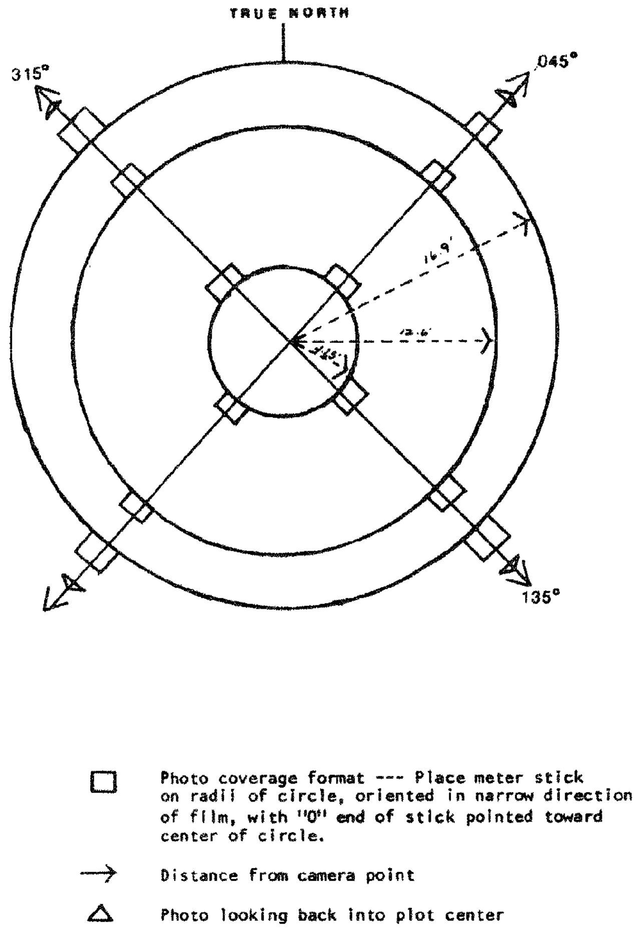

Figure 3.—Sketch of quadrat plots located along radii from a center point.

Field procedure. To use this microsite technique effectively, establish a systematic series of quadrat plots over a larger area. For trail monitoring, determine plot locations along the trail at specified intervals after a randomly selected starting point. Use two stakes driven flush with the ground to locate two corners of the quadrat frame. For localized areas such as campsites, establish a series of transects across the area by tagging surrounding trees and running string between them. (String used for establishing transect lines should be stable enough not to stretch and sag when pulled taut.) Establish sample plots at intervals along each transect. Another method for campsites is to work from an established center point. Determine azimuths at right angles to each other (e.g. 45, 135, and 315°) and establish quadrat plots at specified distances from the center point along each azimuth (Figure 3).

When the quadropod with attached quadrat is in place, remove all overhanging leaves and branches that obstruct the view of plants inside the quadrat. Set the camera for the appropriate exposure and focusing distance. With the electronic flash and sun screen, the camera shutter and aperture settings should not change.

Take documentary photographs of the entire study area to aid in relocating it. In addition, an oblique (sidelong) photo of each quadrat may be useful. While no measurements can be made from these, they may aid in determining species composition.

Lab procedure. Enlarge prints or slides (using a Kodak Ektagraphic or similar device) to a convenient size. Cover the print or viewing surface (such as that provided by the Ektagraph) with acetate or other transparent material. Outline objects on the acetate with a grease pencil (Figure 4). Trace the delineations from the acetate to graph paper for areal measurements (Figure 5).

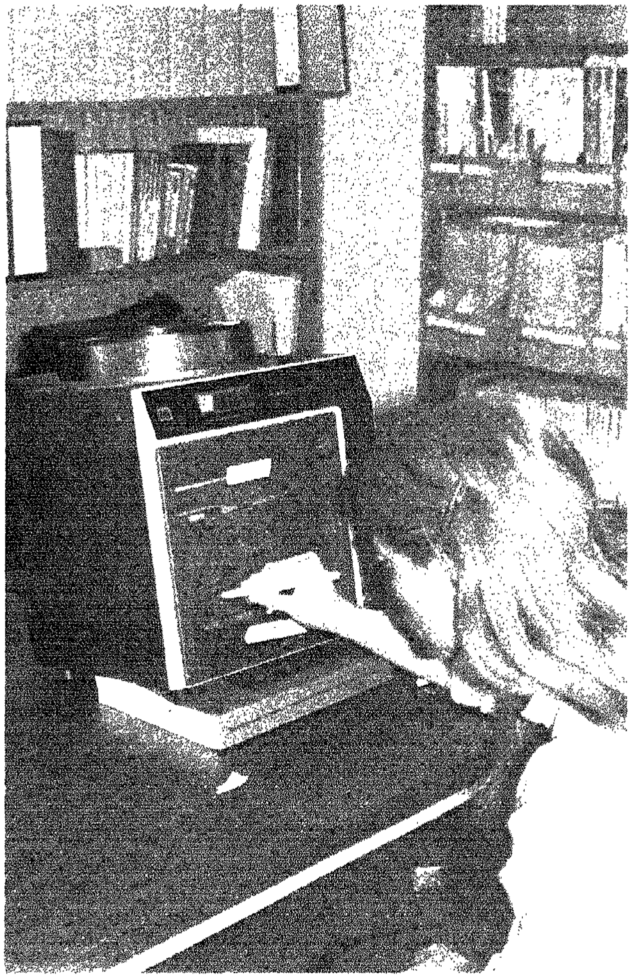

Figure 4.—Tracing the ground cover delineations onto acetate from the enlarged slide.

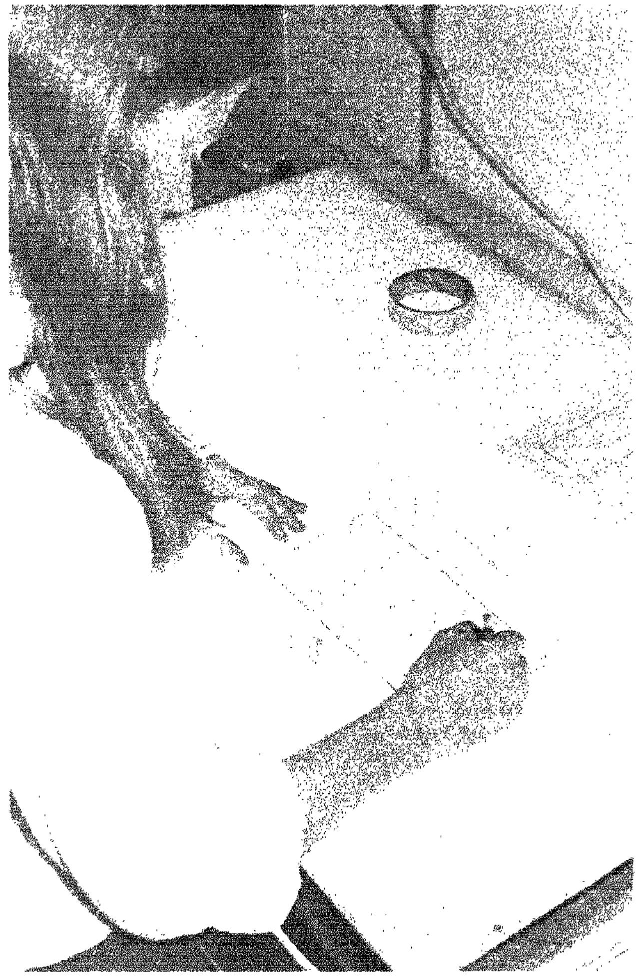

Figure 5.—Tracing the ground cover delineations onto graph paper.

Depending on the objectives of the study, a number of analyses can be performed. Individual plants or groups of plants of the same genus or species can be counted and measured. Areas of disturbed ground cover, including litter layers, can be outlined and rated by severity of disturbance. Areas of exposed mineral soil can be marked and measured. Plant survival and changes in conditions of the forest floor can then be determined. Comparisons may be made between whole quadrats or between subdivisions within each quadrat.

Discussion. The principal advantage of quadrat photography is the shift in time and expense from the field to the lab. Professional research analysts need not perform their task in the field, where such things as weather conditions might affect the reliability of the analyses. Photographs also provide records of raw data that can be used for different analyses later.

Vegetation height is a critical limiting factor for this type of photographic monitoring. High vegetation affects focusing, flash exposure, and visibility of the area beneath it.

For resource managers seeking a quick assessment of site conditions, the cost of establishing a series of plots for each site and analyzing the data as described here may be prohibitive.

Quadrat photography has been used primarily as a research tool in studies of such things as human impact on wildlands (by the Backcountry Project, NEFES), range vegetation (Ratliff and Westfall 1973; Pierce and Eddleman 1979; Wells 1971), and vegetation succession (Tueller et al. 1972; McKendrick 1976). The Ratliff and Westfall monitoring technique is worth elaborating on because it is rapid and uses lightweight equipment. Their camera support is a bipod fabricated from 1/2-inch electrical conduit with 1-foot-square quadrat frames (Figure 6). The quadrat frames are fitted with upright posts; the bipod can be slipped over them. With extra frames, one quadrat is set up while another is being photographed. The system uses the Honeywell Pentax stereoadapter, a device that splits the image and provides stereo viewing of the quadrat on a single commercially printed photo (Figure 7).

While backcountry recreation managers may not be as concerned about empirical data as researchers are, they could certainly use quadrat photography for illustrative purposes. They may use the technique to document, in detail, trail widening problems, campsite deterioration due to human impact, or improvements due to rehabilitation programs.

Figure 6.—Bipod with 1-square-foot quadrat frame.

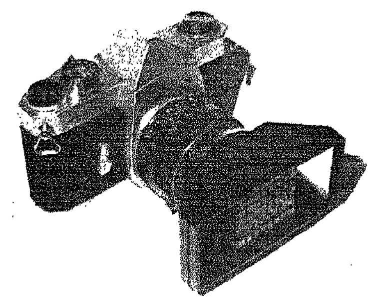

Figure 7.—Camera fitted with a stereoadapter.

Trail Mosaics

This is another form of vertical ground photography (i.e., with the camera pointing straight down) devised at the NEFES Backcountry Project to monitor vegetation changes and trail widening. A series of photographs are taken across a trail transect and pieced together to form a strip representation of the area beneath the transect.

Equipment. Trail mosaics require a camera and flash system with a tripod. The tripod's center post must be reversible so that the camera can be mounted between the legs of the tripod, or the head must tilt forward. Because the subject is close to the camera, a single-focal-length macro lens would be useful, but it is not essential. One, or preferably two, electronic flashes and a cloth sun screen are necessary for uniform lighting. At such close range a ringlight would simplify the setup and provide the most even, shadowless light.

Color negative or slide film is appropriate for this technique. Commercially developed color prints from negatives are a convenient size for this type of display. Slides are more practical if, in addition to a mosaic, some quantitative grid analysis is desired.

Several items are required to establish the transect and photograph it properly. Two fiberglass metric tape measures, string, two nails, tree tags, a plumb bob, and a hammer are necessary to set up the transect. A compass and clinometer are useful, and a small spirit level is necessary to adjust the camera position properly.

Field procedure. The procedure for establishing and measuring trail transects is described in detail by Leonard and Whitney (1977), so only a brief treatment is presented here. A transect is established by stretching a fiberglass tape measure and a string between two trees that permit a roughly perpendicular crossing of the trail. The tape measure is required to determine intervals for trail profile measurements and camera positions across the transect. The string can be drawn tighter than the tape measure, so it is used as the actual baseline for vertical profile measurements and camera height.

If a trail profile is desired, use a second tape measure with plumb bob attached to take vertical measurements at 10-cm intervals across the transect. Record the distance from the trail surface to the string at each measuring point. Position the camera at intervals along the transect that permit an overlap of about 25 percent between film frames. Record each camera position along the horizontal tape. To facilitate accurate camera alignment at a particular horizontal tape reading, mark the center of the camera bottom. To assure that the resulting photographs will piece together properly, the edge of the film in the camera must be parallel to the string at each repositioning.

Make all exposures with electronic flash to assure uniform lighting. At the close range prescribed, one flash may be difficult to position to avoid shadows and provide even lighting across the whole frame. A ringlight or two flashes rigged at about 60° angles ensure the best lighting for this technique.

Lab procedure. Trim and piece the prints together edge to edge to form a mosaic of the trail transect. If the transect was measured, mount the profile on the same display board with the mosaic to provide a graphic and qualitative representation. Analyze the transect profile to determine soil loss and changes in trail width. Use the photographs to illustrate changes in the mineral soil/litter ratio, plant survival, and vegetative occurrences (Figure 8).

Discussion. Information regarding vegetation types, amount of litter and bare soil, etc., is a necessary adjunct to trail profiles. The best record is perhaps supplied by trail mosaic photographs, which can be verified and analyzed in varying degrees of detail in the comfort and convenience of the office or laboratory.

However, too much relief in the ground surface or vegetation height can cause difficulties. Beside the problems of focusing, uneven flash illumination, and hidden vegetation, piecing the photos together is more difficult where the relief is too great.

The time required to set up the camera for an entire mosaic may also be prohibitive. This could be reduced somewhat by photographing only the right and left trail edges where the most changes normally occur, but some information and a degree of effectiveness of the strip mosaic representation is lost in doing so.

Trail mosaics can be effective supplements to other systematic trail sampling procedures for documentary or analytic purposes. Information obtained from trail transect monitoring can be used by researchers to determine relationships between site conditions, trail use, and trail degradation. Managers may be able to use such information to aid in the design and location of new trails, and the reconstruction of old trails (Leonard and Whitney 1977).

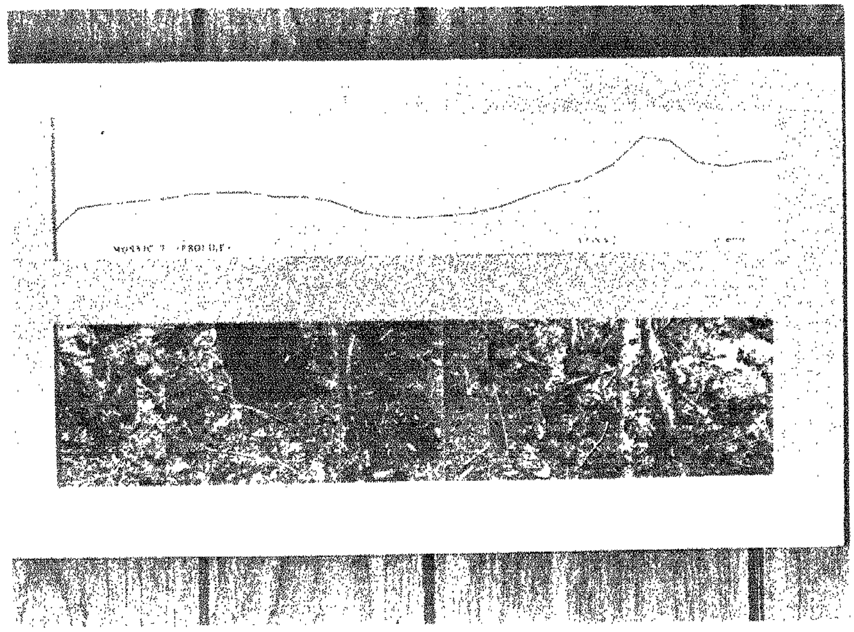

Figure 8.—Trail profile and accompanying mosaic.

Stereo Trail Transects

Drawing on methods introduced by Walker (1968), Rinehart et al. (1978) devised a technique for analyzing soil loss at selected trail transects to determine rates and patterns of trail entrenchment.

Equipment. This single-camera stereo system is based on the use of the Hardy flip-flop attached to a tripod (Figure 9). This stereoboard can be used with a 35 mm or a 2$^1/_4$ inch camera equipped with a normal lens for minimum distortion. A 2$^1/_4$ inch camera is superior to stereo viewing of contact prints and gives better image quality. An electronic flash may be helpful, but is not essential. Black and white film is recommended, since no advantage is gained from the use of color film.

Items necessary to establish the transect are: two tent stakes, two survey pins (or suitable substitutes for these items), a tape measure or string, and a white target card.

Field procedure. To establish the transect, drive the tent stakes flush with the ground on both sides of the trail so that a line between them is perpendicular to the treadway. Place the stakes about 2 feet beyond the trail edge to minimize accidental or malicious tampering and to allow for future trail widening. The stakes should be secure enough to resist movement so that they will be at a consistent height at each rephotographing. Record the distance between the stakes to aid in verifying photo scale calibrations and finding the second stake after the first has been found.

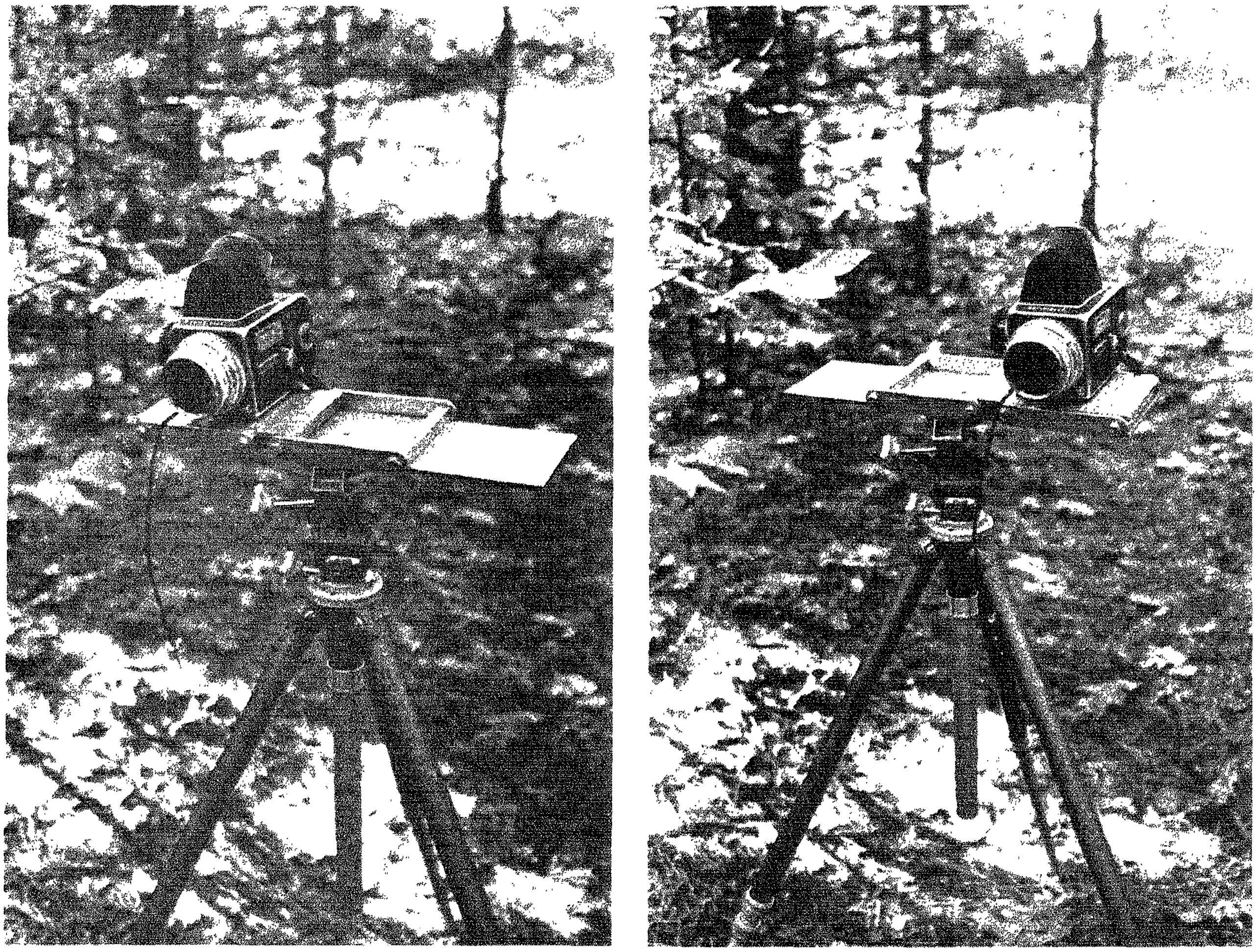

Figure 9.—Hardy flip-flop with a 2¼-inch camera.

Place the two surveying pins plumb (vertically) over the stakes to serve as references for the stereo plotting procedure. Stretch the tape measure between the two tent stakes, holding it directly on top of them. Write the transect number on the target card and place it on edge directly beneath and parallel to the transect line.

Set up the tripod 15 feet downhill from the transect. Mount the camera and stereoboard. Position the camera so that the center of the lens is approximately level with the center of the entrenchment area (Figure 10). Make sure the film plane is parallel to the transect line by using a compass to coordinate alignment of the transect and stereoboard. Level the stereoboard. Focus on the target card markings, and expose a pair of photos starting from the left side.

Some deviations from the foregoing camera positioning are permissible under certain circumstances. A standard camera-to-transect distance is advisable in order to keep the photo scale consistent for all transects; however, a greater distance may be required for complete coverage of some wide trails. In addition, a shorter distance may be necessary on steeper trails to keep the camera level. The camera may be tilted if absolutely necessary, but the angle must be recorded, from a clinometer, and accurately duplicated on subsequent photo missions. For hand-drawn cross-sections using simple stereo viewers, accurate positioning of the camera is very important. Minor aberrations are acceptable if more sophisticated stereo plotting devices are available.

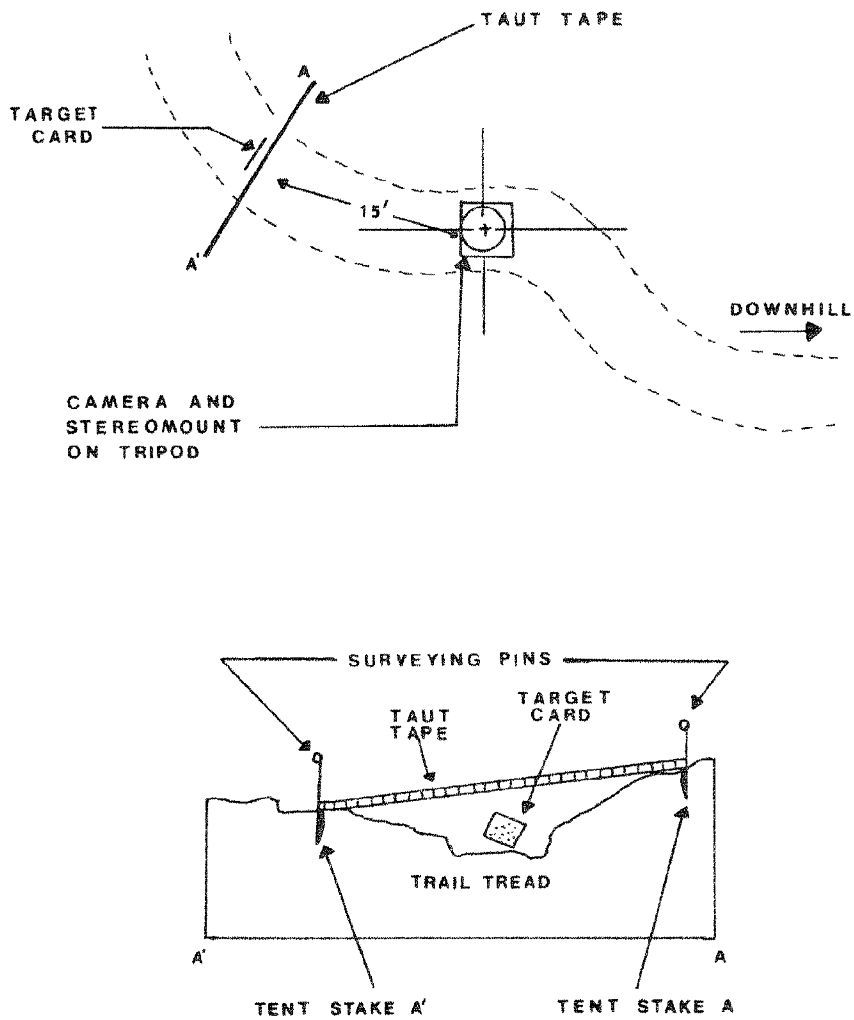

Figure 10.—A typical set-up for photographing a trail transect.

Lab procedure. Contact prints from 2¼ inch negatives are suitable for analysis, and either 2¼ inch or 35 mm negatives can be enlarged if the entire negative is printed, without cropping.

Determine the scale of the photo. First measure the size of the target card image with a pocket comparator to the nearest .01 cm. Calculate the representative fraction (RF) using the following formula:

$$RF = \frac{\text{target card width in photograph}}{\text{actual target card width}}$$

Make ground measurements by multiplying any photo measurements by the inverse of the RF.

Determine the area of the trail cross section. Cover the photo with acetate or similar transparent material. While viewing through a stereoscope, draw a line along the ground directly under the reference line from one survey pin to the other. Using a polar planimeter, measure the area between the reference line and ground line. Multiply this measurement by the square of the inverse RF to determine the actual cross sectional area. Subtract from previous measurements for that transect to determine the amount of net soil loss.

Discussion. This technique is a photographic alternative to on-site measurement. Rinehart et al. (1978) attributed several advantages to stereo trail transects including: (1) photos can reveal actual trail configuration better than points plotted on a graph from numerical measurements; (2) photo analysis can be performed any time to check for inconsistencies or questionable measurements (field measurements cannot be repeated); (3) photos can be more efficient in short season areas (the more time-consuming measurements are performed in the lab or office rather than in the field).

Disadvantages of stereophotographic transects are associated with the lab analysis. Vegetation in front of the transect may prevent the photo interpreter from plotting an accurate ground line. Although skilled photogrammetrists are needed to achieve the most accurate results from stereo photographs, less skilled personnel can obtain on-site measurements. Rinehart et al. (1978) found that ground measurements were also more consistent between observers than photo measurements, although the levels of error were acceptable in both tests.

The total cost of photographic transect monitoring is greater than that of on-site measurements. More expensive equipment is required, and more time is consumed in the lab analysis. An alternative to stereo monitoring which has been used at the NEFES Backcountry Project appears to reduce the cost differential somewhat: Instead of determining the ground line beneath the transect from stereo photos, the line is established on-site by using a nylon string. The string is stretched between the transect stakes and released slowly on one end. The inherent elasticity of the nylon causes the string to lie along the contours of the trail. Since the string establishes the lower base line, one photograph instead of two can be taken. Advantages of this method are: (1) there is no restriction on the size of the enlargement of the photo for analysis, and (2) there is no error due to faulty stereo viewing.

The typical objective of photographic trail transect monitoring has been to provide quantitative research data for statistical analysis to determine correlations between site conditions and use factors. Such information could be useful in management planning. Managers could also use the stereo or monoscopic photographs to display soil-loss problems for educational purposes.

Campsite Panoramas

Walker (1968) and Lucas (1975) have used site panoramas to provide overviews of large recreation sites. Photographs are taken with ordinary photo equipment and pieced together to form a panorama for qualitative assessments of change in the area.

Equipment. A camera (either a 2¼ or 35 mm) and a tripod are the basic necessities. Carry both a normal and a wide angle lens if they are available. Use the normal lens where camera placement is not restricted. Where space is limited, a wide angle lens with a field of view around 65° (35-mm lens for a 35-mm camera, or a 65-mm lens for a 2¼-inch camera) should provide ample coverage in most situations. Wider angle lenses are subject to less tolerable degrees of distortion, which makes piecing the photos together more difficult. A perspective-control lens would provide maximum coverage with minimal distortion, but it is not essential. A focusing screen with a grid is useful. Fast color negative film is best because of its excellent ground-cover differentiation, wide exposure latitude, and long contrast range.

The camera is leveled with a spirit level and its azimuth measured with a compass. A clinometer can be used for measuring the degree of forward tilt when necessary. A smooth plate mounted between the camera and tripod provides a convenient surface on which to place the level and compass. A plumb bob hung from the tripod center post aids in locating the camera directly over the photopoint (Figure 11).

Field procedure. Choose a photopoint that permits the most thorough representation of the area with consideration for future changes. If there is a structure (e.g., a hiker's lean-to) on the site, a view of the area to the front and

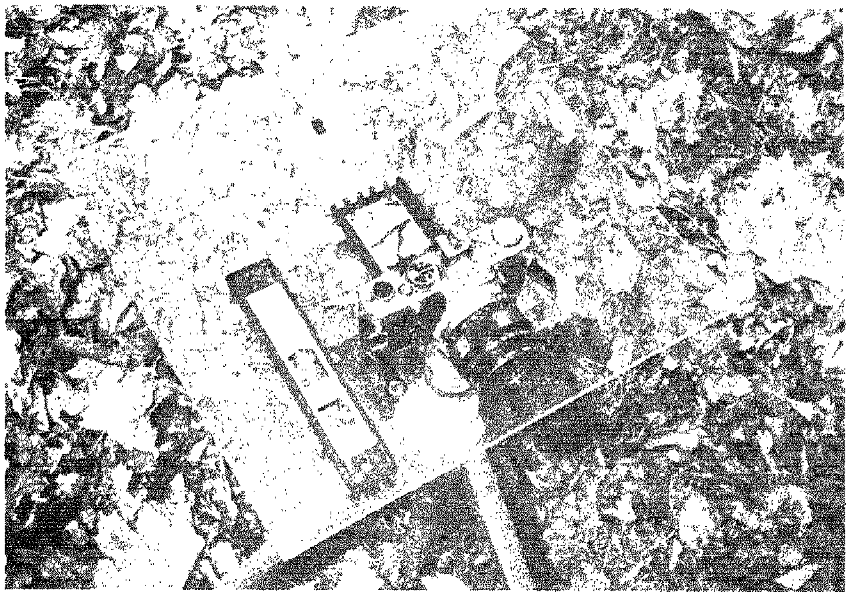

Figure 11.—Camera set-up for site panorama.

sides of the structure is most useful; this dictates a 140 to 180° panorama, taken from the center front of the structure. For sites without structures, 360° panoramas can be made from a central photopoint. The ground cover, shrub screening, and tree trunk conditions are what should be recorded.

Camera height needs to be constant, and the camera ideally should be level throughout the rotation. If a level camera position cannot be maintained for every frame (and a Perspective Control lens is not available), the camera may have to be tilted forward. If this is done, the angle of tilt must be constant throughout the rotation. Record the usual photopoint information (camera, lens and film used, witness tree information, and sketch map), camera height, and degree of forward tilt (if any).

When the camera is positioned, take a series of photos from left to right. If the panorama covers 360°, use a target card positioned at true north about 10 to 20 feet from the photopoint or mark the beginning photo. Each photograph should overlap the preceding one by 25 to 30 percent to reduce the effect of lens distortion, which is most prominent at the frame edges. Record the azimuth of each camera sighting. To reduce differences in magnification between successive photos (which prevent good matchups when the photos are pieced together), Blaker (1976) suggests that you first measure and mark the desired overlap on both sides of the camera's ground glass (or use grid lines if available) so that the joining point of the photos will always be equidistant from the lens axis, and second, that you do not change the focus during the panorama series.

Lab procedure. The photographs are trimmed and pieced together from left to right. It is important to trim both adjoining photographs in the middle of the overlap area. This removes the portions of the images where the distortion is most evident. With a straightedge and razor blade, trim the left photo first, align it over the right photo and trim that one. Mount the photos on mounting board. On the back of the board, mount copies of the site data, photopoint reference maps, and any documentary photos taken at the site. Keep a file of the duplicates of all mounted photos and maps for use in the field during subsequent photo sessions.

Compare successively taken panoramas for changes in tree and shrub conditions and numbers, evidence of use (i.e. litter, shelter alterations, tree damage), and the amount of bare, compacted soil in the area.

Discussion. Photo distortion and match-up procedures make areal or other measurements from panoramas impractical. Any quantitative data from panoramas could only be in the form of numerical counts of such things as trees, fire rings, etc.

Weather conditions are a limiting factor in achieving usable results. A bright but hazy day provides the best lighting for this type of photography. Bright sunlight causes shadows and differences in exposure between frames, and you may have to shoot directly into the sun.

This technique for monitoring provides a broad overview of larger backcountry sites. Panoramas can provide direction for management, training tools for personnel, or visitor education material. They may also be used by researchers in combination with other data about the physical characteristics of the site and use levels to give a better understanding of their interrelationships, which can be beneficial for management planning.

Perspective Grid Photography

This technique was devised at the NEFES Backcountry Project. It uses a perspective grid to obtain quantitative information about ground cover changes from single photographs.

Equipment. Either camera format may be used, but a wide angle lens with an angle of view around 75° is important. A tripod, plumb bob and metered steel or woven metallic tape measure are also necessary. If a 35 mm camera with interchangeable focusing screens is available, a screen with center cross hairs would be useful to center the plot center in the frame and to adjust the side tilt of the camera.

Since some control must be exercised in the photo enlarging process, either in-house darkroom facilities or custom photo printing are important. The type of film to use depends on the capabilities of the darkroom. Black and white film would be the least restrictive. Grain may be a consideration in determining what speed film to use, since enlargements up to 11 by 14 inches are recommended.

Field procedure. This technique is accomplished in two phases. A perspective grid is first photographed for subsequent use with photos taken in the field. To establish the grid, lay out a 4- by 4- or 6- by 6-meter plot on an asphalt surface such as a parking lot. Draw in grid lines at ½-meter intervals with white chalk. Anchor the tape measure at the grid center and extend it along the corresponding grid line toward the camera point. Mark the tape where it intersects each grid line. Establish a suitable camera height (1.5 meters is recommended), and move the camera and tripod along the tape until the grid fills the viewing screen. Locate the camera point on the tape with a plumb bob.

In the field, choose a central point for the study area. Anchor the tape at that point with a visible stake (for the photographic session only—afterward mark the center point with an unobtrusive marker for later relocation). Extend the tape toward a suitable photopoint location and anchor it beyond the camera point marking on the tape. Position the tripod over the camera mark on the tape with a plumb bob. If the ground is undulating, pull the tape taut so that it is horizontal from the center point to the camera point, and measure the camera height from the taut tape instead of the ground level. Record the azimuth of the tape from center to camera position, and establish a photopoint on the ground under the camera.

Adjust the camera so that the plot center is in the center of the frame and the bottom of the frame is at right angles to the tape.

Lab procedure. The perspective grid image produced by the method described here has a width-to-height ratio of 5 to 2. To enlarge the grid to a workable size, print each half of the single negative on 11- by 14-inch photo paper. Piece the two halves together to form the final image. Trace the grid image on an acetate overlay. Add ½- or ¼-meter lines to the overlay to aid in ground cover delineations.

Enlarge the photograph of the field plot in the same way, producing a pieced-together print. Orient the perspective grid overlay on the plot photograph by matching the center stake and marked points on the tape with the appropriate grid lines.

Delineate borders of vegetation types (such as grass-like, herbaceous or woody) and mineral soil. Transfer the delineations from the perspective grid to a square grid (bird's-eye view) by examining points where the mapped borders cross the grid lines. Estimate the area of each type of ground cover or bare soil with a dot grid.

Discussion. Topography is the principal problem with this technique. The grid is photographed on a flat surface, whereas the field site is often undulating or sloping, causing altered perspective and greater distortion, and reducing the accuracy of measurements. The technique is better suited to field areas than to forests because tree trunks can obscure much of the ground cover in an oblique photograph. The largest area that can reasonably be represented is a 36-square-meter plot.

In the lab, there are several sources of error that are difficult to control. Piecing together the photos is one source. Transferring the delineations from the perspective grid to the square grid is a more serious source of error, especially when a mapped zone does not cross any grid lines.

As with panoramas, lighting can be critical to obtaining usable results. Even lighting is essential for accurate mapping. This may necessitate shooting only on slightly overcast days.

This monitoring technique has a certain limited applicability where less-than-perfect, but greater-than-rough estimates of ground cover changes are required at larger sites.

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Resource change can be monitored using photographic methods. Both microsite and macrosite techniques suitable for backcountry use are described and discussed in detail. The microsite techniques, including quadrat photography, trail mosaics and photographic trail transects, are generally the more expensive, requiring more time or specialized equipment in the field or lab than microsite techniques. The data obtained is detailed and quantifiable to a degree that may be acceptable for research purposes. Macrosite techniques, including panoramas and the monoscopic perspective grid technique, are less likely to provide research data, but are useful for qualitative assessments.

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Keywords: Microsite; macrosite, quadrat photography, trail mosaics; trail transects; panoramas; perspective grid

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