United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-503
May 2001

Ground-Based Photographic Monitoring

Frederick C. Hall

Author

Frederick C. Hall is senior plant ecologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Natural Resources, P.O. Box 3623, Portland, Oregon 97208-3623. Paper prepared in cooperation with the Pacific Northwest Region.

Abstract

Hall, Frederick C. 2001 Ground-based photographic monitoring. Gen. Tech. Rep. PNW-GTR-503. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 340 p.

Land management professionals (foresters, wildlife biologists, range managers, and land managers such as ranchers and forest land owners) often have need to evaluate their management activities. Photographic monitoring is a fast, simple, and effective way to determine if changes made to an area have been successful. Ground-based photo monitoring means using photographs taken at a specific site to monitor conditions or change. It may be divided into two systems: (1) comparison photos, whereby a photograph is used to compare a known condition with field conditions to estimate some parameter of the field condition; and (2) repeat photographs, whereby several pictures are taken of the same tract of ground over time to detect change. Comparison systems deal with fuel loading, herbage utilization, and public reaction to scenery. Repeat photography is discussed in relation to landscape, remote, and site-specific systems. Critical attributes of repeat photography are (1) maps to find the sampling location and of the photo monitoring layout; (2) documentation of the monitoring system to include purpose, camera and film, weather, season, sampling technique, and equipment; and (3) precise replication of photographs. Five appendices include (A) detailed instructions for photo sampling, (B) blank forms for field use, (C) specifications and photographs of recommended equipment, (D) filing system alternatives, and (E) suggestions for taking photographs and analyzing change over time.

Keywords: Monitoring, photographs, landscapes, transects, animal sampling, riparian, succession, forests, rangeland.

Preface

This document started as an update of my 1976 publication on photo monitoring to appraise rangeland trends. The update was stimulated by a desire to document 40 years of experience in rephotography. This included about 150 ecology sample plots rephotographed at 5- to 10-year intervals, 25 years of herbage production, 25 years of riparian change photographed three times per season, and up to 40 years of rephotography of about 80 other situations, including wildfires, prescribed fires, tussock moth and spruce budworm damage, mountain pine beetle effects on lodgepole and ponderosa pine, fenceline contrasts between good and poor range condition, logging, revegetation, research studies and various landscape views. There is a great breadth of ground-based photographic monitoring in the literature. One aspect I found was use of photographs to estimate various existing conditions of vegetation and soil, such as comparison photo monitoring following Maxwell and Ward's (1976a) guides to estimate fuel loading, fire intensity, rate of spread, and resistance to control. Another was use of remotely controlled cameras to monitor presence of animals as illustrated by Kristan and others' (1996) video monitoring of osprey nest activities. And finally, repeat landscape photography of pictures taken at the dawn of cameras and exploration of the west, as exemplified by Progulske and Sowel's (1974) rephotography of Colonel Custer's exploration of the Black Hills in 1874—100 years of change. It is hoped that the information gained by personal experience and literature review will provide some guidelines for successful ground-based photo monitoring.

Fred Hall

Contents

Introduction

Ground-based photographic monitoring is designed for use by land managers, such as foresters, wildlife biologists, range managers, ranchers, and forest land owners. It is a way to document management activities and evaluate changes. For many people, photographs are faster and easier to interpret than measurements, and measurements, if needed, can be made from the photographs.

The system uses cameras at ground level rather than aerial photography or other aboveground sensing. It includes several applications using either still picture or video media. For example, fuel loading conditions found in the field can be compared with photographs of known fuel characteristics to estimate tonnage per acre, flame length, rate of spread, and control problems; this is known as *comparison photo-graphy*. Or, cameras can be remotely controlled to document animal activities, which is *remote photography*. Camera locations also may be established and the same scene rephotographed periodically for *repeat photography*. Photographs produce a unique kind of monitoring not duplicated by measurement or inventory systems, although photography is subject to requirements that limit its application and use.

I begin with definitions and concepts, then discuss items common to all photography, followed by comparison photo monitoring, remote photography, repeat photography, and end with relocation of photo monitoring sites.

Definitions

Discussion of ground-based photo monitoring should start with a few definitions:

Monitoring is detecting change or condition of various topics. In this paper, it includes detecting change in riparian shrub cover, healing of disturbed soil, identifying presence of animals, documenting air quality, or estimating condition of some item such as fuel loading or percentage of utilization of herbage.

Photography refers to photographs or video or digital images, color or black and white, taken or used at the site, as opposed to aerial photograph interpretation and Landsat image analysis. The concept of ground-based photo monitoring therefore means using photographs taken on the ground to evaluate change or condition of various items.

Camera format specifies a focal length of the lens and ultimate image size. Some common formats are 50-mm lens on a 35-mm camera, 70-mm lens on a 2- by 2-in camera, or a 128-mm lens on a 4- by 5-in camera. All are comparable insofar as what part of the landscape is included in the final image. Formats may differ for the same camera. A zoom lens on a 35-mm camera can change from 35-mm focal length wide angle to 110-mm telephoto. Most photographs in this publication were taken with a 35-mm camera and a 50-mm lens.

Three terms are used to identify types of photography:

Landscape photographs are of distant scenes or of a broad, general area often more than 10 ha.

General photographs document a topic being monitored and commonly cover 0.25 to 10 ha. They may be used alone or in conjunction with closeup photographs.

Closeup photographs are made of a specific topic on a small tract of ground often from a few decimeters to 10 by 10 m. They have no horizon reference, and the locations from where the photographs are taken therefore must be marked with stakes or fenceposts.

Finally, three terms are important in photographic sampling systems:

Witness site is an easily identified reference used to locate the monitoring area. It provides compass direction and distance to the camera locations.

Camera location is a permanently marked location for the camera.

Photo point is the direction of the photograph from the camera location. It is marked permanently by a steel stake or fencepost and commonly involves a size control board located in the center of the photograph. More than one photo point may be taken from a single camera location, and more than one camera location may photograph a single photo point.

Comparison and Repeat Photography

Comparison—In comparison photo monitoring, existing conditions are compared with conditions shown in a set of photographs. For example, Maxwell and Ward (1976a) produced a color photograph field guide for estimating logging fuel loading in tons per acre by size class with estimates of fire intensity, rate of spread, flame length, and resistance to control. Kinney and Clary (1994) developed a guide for estimating the percentage of utilization of riparian grasses and sedges by using photographs of various stubble heights. And Magill (1990) evaluated public concern over logging by having people rate a set of color landscape photographs taken at different camera focal lengths to simulate various distances from the scene.

Repeat—Repeat photography is characterized by taking multiple photographs of the same landscape, tract of ground, or activity, such as animal presence. It's particularly useful in three situations:

1. Landscape photography, where change is documented for landscape-sized areas over time. Some classic examples are Progulske and Sowel's (1974) documentation of Colonel Custer's exploration of the Black Hills wherein they rephotographed pictures taken in 1874. Another is panoramic photography using special camera equipment to take 360-degree views of landscapes, as Arnst (1985) shows for the Cascade Range of the Pacific Northwest.

2. Remotely operated cameras used to monitor animal behavior such as that of nesting ospreys (Kristan and others 1996), evaluate air quality (Fox and others 1987), or document animal distribution (Kinney and Clary 1998).

3. Site-specific repeat photography identifies specific topics on selected tracts of ground to document change or lack of change in vegetation and soil. Gary and Currie (1977) show a 40-year record of plant and soil recovery on an abused watershed in Colorado, and Smith and Arno (1999) document 88 years of change in managed ponderosa pine forests through 14 camera locations.

Clearly, photo monitoring is not a simple, routine procedure, but rather a multifaceted concept covering various purposes or objectives. To discuss this topic, the paper is organized into seven main parts: items common to all photo monitoring, comparison photos where current conditions are compared to a series of photographs and their condition rated, repeat photography of landscapes, photo monitoring by remotely operated cameras, site-specific repeat photography, and lessons in relocation of repeat photography.

The appendices cover many items in detail: Appendix A gives the methodology for monitoring change in vegetation and soil, appendix B contains blank forms for both office and field ready to copy, appendix C has plans for construction of meter boards and plot frames, appendix D discusses filing systems for photo monitoring, and appendix E illustrates photographic tips.

Common Items

Common to all photographic monitoring are (1) determining specific objectives, (2) using a repeatable technique, (3) choosing appropriate camera and film, and (4) developing a filing system.

Select Specific Monitoring Objectives

The first and most important item in any monitoring project is to have specific objectives. Questions answerable by photography must be asked before any kind of monitoring can be developed and installed. Consider a five-part query to develop these objectives: why to monitor, where to locate the sampling, what specific topic to evaluate, when to do the photography, and how to accomplish the photography (Borman 1995; Nader and others 1995; U.S. Department of the Interior, Bureau of Land Management 1996).

Why—Why to monitor asks for definition of the question needing an answer. Implementation monitoring asks if what was done was what was indicated, effectiveness asks whether the treatment did what was wanted, and validation asks if the treatment met the objectives. *Why* sets the stage for all other questions.

Where—Where to monitor depends upon the *why*. Where will the selected representative tracts, animal activity areas, treatment sites, or particular kinds of treatments be located? Will number, size, and location of activities such as fire, logging, revegetation, livestock grazing or flood affect the selected site(s)? Ask where the best location is that will answer the questions. Critical documents are a map to locate the site and a site map to document all camera locations and photo points.

What—Which items on the selected tract—vegetation, soil, streambanks, animals, air quality—will be monitored to support the *why*? Ask what the critical few items are that must be documented. What is expected to change? What will the picture demonstrate? Why should I take this picture (Johnson 1991)? The *what* dictates sampling layout.

When—When to monitor supports the *why* and *what* questions. Does monitoring encompass one year or multiple years? One season or more? Specific dates and time(s) of day? All are important in both animal and site monitoring. Scheduling includes time before treatment as well as after and frequency after initial treatment. Unplanned disturbances, such as fire or flood, pose special problems. A monitoring protocol may have to be developed on the spot to determine when and where during the event to establish photo points and to define a followup schedule.

How—How to monitor is determined by *what*, *why*, and *when*. It encompasses detailed protocols for photographic procedures used to obtain qualitative data (estimates) or quantitative data (measured in the field or measured on photographs). (Appendix B contains detailed instructions for both systems.) An example might be dealing with effects of livestock grazing on a riparian area: (1) Are streambanks being broken down? (2) Are riparian shrubs able to grow in both height and crown spread? (3) Is there enough herbage remaining after grazing to trap sediments from flooding? (4) Is herbaceous vegetation stable, improving, or deteriorating? Answering these questions will require selection of a sampling location and establishment of photo points and camera locations sufficent to gather adequate data. Try to select camera locations that will photograph more than one photo point. The time or times of year to take photos then must be specified, such as just prior to animal use of the area, just after they leave, or fall vegetation conditions. Will this riparian site be monitored for high spring runoff, late season low flows, or during floods? Monitoring of stream flows probably requires different scheduling from monitoring of animal use.

Repeatable Photo Technique

A second common item in photo monitoring is a repeatable technique that can be used by various people to attain similar results. For a technique to be repeatable, it must be simple, thoroughly documented, and illustrated. The following items are key elements in a well-documented and -illustrated technique:

1. A map locating the photo monitoring site and one or more maps of the photo monitoring layout for the site.

2. Camera locations and photo points permanently marked with steel fenceposts or iron stakes. Iron stakes should be flush with the ground to prevent tire and foot (hoof) damage. They are difficult to relocate but can be found with a metal detector. Positions of camera location and photo points are critical (Rogers and others 1983). The need for a constant distance between camera and photo point for all repeat photography is demonstrated under “Camera Format,” below.

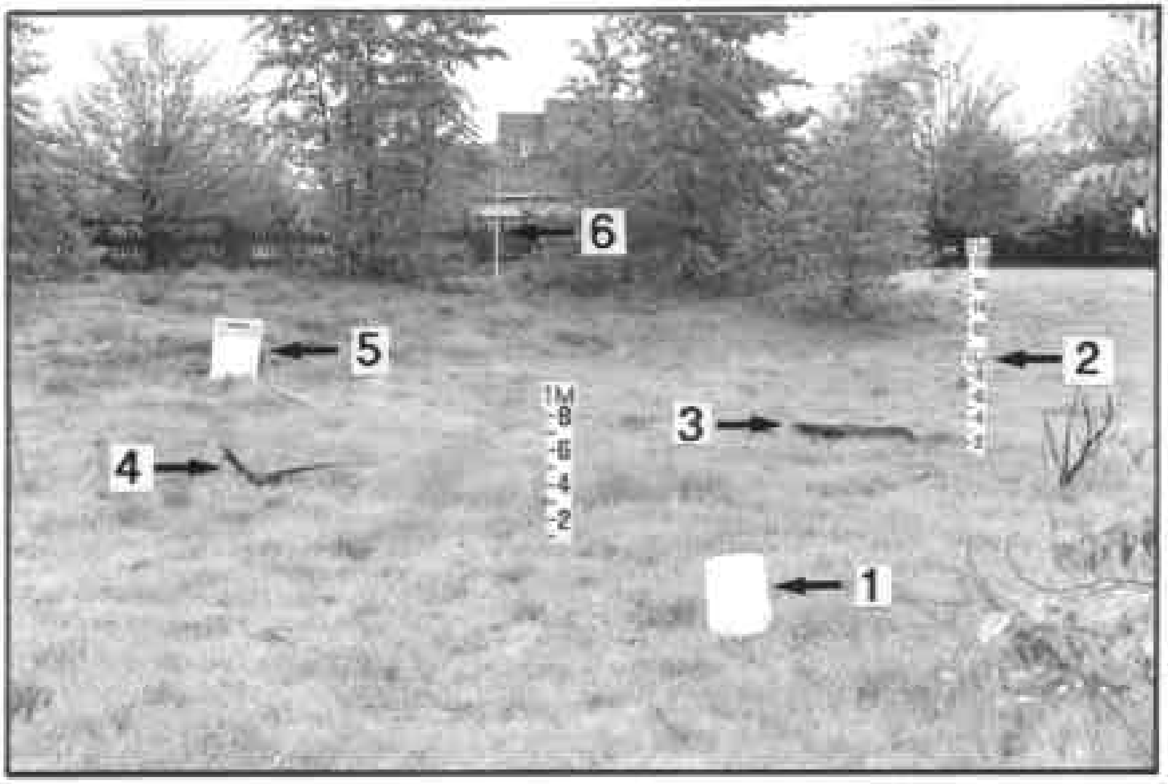


Figure 1—Landscape used to test effects of camera format (focal length), distance from camera to photo point (meter board), and camera position on size and location of items. Camera format is 35-mm using three focal lengths (lenses): 35-mm wide angle, 50-mm standard, and 70-mm telephoto. Distances are 7, 10, and 14 m. Camera positions are eye level (1.8 m), breast height (1.4 m), and offset right by 4 dm. Numbered items are outlined and compared: (1) bucket between camera and meter board, (2) double meter boards, (3) log on the ground, (4) root wad, (5) cart 15 m from the meter board, and (6) lamp pole 50 m from the meter board. Four situations will be evaluated: (**A**) varying the distance from camera to meter board but using the same focal length camera (figs. 2 and 3); (**B**) varying both distance and focal length such that the meter board is the same size in all pictures (figs. 4 and 5); (**C**) varying the camera focal length at a given distance (figs. 6 and 7), and (**D**) varying camera position over the camera location fencepost (figs. 8, 9, and 10).

3. Precise description, by time of day, weather, and season, of when landscape or general and closeup scenes are to be photographed—all are directly related to the objectives for monitoring; for example, before 10 a.m. and after 3 p.m. if back-lighted vegetation is needed (app. E), visibility of 25 or more miles for repeat landscape photography, high overcast to avoid shadows in forest photography (app. E), bird monitoring in spring, livestock grazing at mid or late season, or documenting high and low stream flows in spring and late summer. Special instructions, such as key landscape items to identify in landscape photography, also are needed.

4. A description of how to photograph and show camera locations and photo points on the site map. A size control board (fig. 1; app. C), such as a meter board, is needed for general photos and appropriate plot frames for closeup photos (app. C).

5. Suitable forms and field instructions for accomplishing the monitoring (apps. A and B).

6. An equipment list including a specified camera and film, field forms to be used in each photograph, any needed measuring or calculating equipment, and fence-posts and equipment to permanently mark photo locations. Specify whether a tripod is required and why.

7. Specific, detailed diagrams and instructions for installing and maintaining photographic equipment. This is particularly important with remotely operated camera systems to assure their proper functioning.

8. A comprehensive filing system (app. D; Johnson 1991, Nader and others 1995) with a container for each study to hold all information: monitoring objectives, site descriptions, maps, color slides, and black-and-white pictures with their negatives or digital memory cards with a copy of the images. All color slides, black-and-white pictures plus their negatives, and digital images and their memory cards need to be labeled immediately after processing. A note on the outside of the file of the last monitoring date is helpful.

Cameras and Film

The purpose of photo monitoring is to document change in a landscape or topic over time. Measuring change requires photographs of good to excellent resolution and color, both of which are influenced by camera and film.

Two kinds of cameras are available: film and digital. Each has specified formats, such as a film camera with 35-mm film with a 50-mm lens, which is similar to a digital camera with a 13-mm lens. Some photographers suggest that changing from one kind of camera format to another poses serious problems in matching photographs. This is not insurmountable, however, as discussed under “Camera Format,” below. Another concern is quality of image. Switching from one brand of color film to another tends to change tones, particularly green and blue. And changing from film to digital usually influences image resolution and color.

Film and digital camera characteristics—Both types of cameras come in two configurations: (1) viewfinder and (2) view-through-the-lens or single lens reflex (SLR). Many digital cameras use SLR principles with a liquid crystal display (LCD). An LCD is a miniature (about 25 by 37 mm) computer monitor screen that displays the image as seen through the lens (Kodak 1999b). Viewfinders show an image that is parallel with the lens and have an outlined box in the viewer to show what the image will cover when a picture is taken at close range (parallax correction). The image will always appear sharp. With SLR systems, the image is viewed exactly as it will appear: there is no parallax correction and the image will appear fuzzy when out of focus, but SLR cameras are more expensive.

Both film and digital cameras provide for a strobe flash system. Less expensive cameras often have built-in flash that fires straight ahead and is effective within 2 m for direct light and within 6 m for fill-in. More expensive cameras provide a “hot shoe” for attaching a more powerful and adjustable flash system. Additional flash systems add cost to the camera. Some cameras provide both an internal flash and a hot shoe.

Zoom lenses have become popular, particularly with the point-and-shoot automatic 35-mm cameras. They also seem to be common on many digital cameras. These lenses have two main attributes: they add flexibility to the camera and they tend to be less sharp than a fixed lens. Zoom lenses may pose problems in photo monitoring because of the need to set a precise focal length to reproduce the original image coverage. For an SLR lens, this isn't too difficult because the lens will have focal lengths marked. But a point-and-shoot 35-mm camera will zoom from 35-mm focal length to 100 mm or greater, a threefold difference in photo coverage, with no indication of the precise focal length used. The equivalent in digital cameras would be 9.2 mm to 28 mm. See "Camera Format" for details.

Lens quality and speed vary. Lens speed is given in f-stops. The "f" indicates how large a hole is open to admit light into the camera. Small f-stops admit much light and large f-stops admit little: for example, at f-3.5, two times more light is admitted than at f-5.6, and f-5.6 admits twice the light of f-8. Depth of field also increases with an increase in f-stop. A slow lens of moderate sharpness is often characterized by f-stops of 3.5 to 4.8 and fast lenses of good sharpness by f-stops of 1.2 to 2.4. A film camera with an f-3.5 lens that's wide open and shooting at 1/60 of a second will create an underexposed image if the light meter says f-2.4 is needed, but a camera with an f-1.2 lens can easily capture the image. Faster lenses are more expensive. The processing unit in the camera computer usually provides digital camera speed; faster speed costs more.

Resolution (sharpness of the image) in film cameras is a function first of lens quality and second of film speed, which translates to graininess in the final picture. The difference in cost for films between ISO 100 and 400 is minimal, but good lenses do cost more. In digital cameras, resolution is determined by maximum dpi (dots per inch) of the camera. As of January 2000, most digital cameras started at about 0.7 megapixels, suitable for 4- by 6-in snapshots, and go up to 3.6, appropriate for 11- by 14-in pictures. Do not use less than a 2-megapixel camera. Good quality optical lenses also enhance resolution. Most digital cameras offer a choice of three to five resolution levels. For example a 1.3-megapixel camera might offer its best resolution at 1280 by 1020, midresolution at 900 by 700, and lowest at 600 by 400. Finer resolution results in fewer images on a digital storage card and slower processing. Quality also is influenced by the kind of compression, if any, used to store the image, and compression influences how many images may be placed in a memory card.

Film and digital concepts—One might consider the digital camera a special purpose computer designed to take photographs (Kodak 1999b). Digital images are captured on an electronic storage, or memory, card that must be processed to produce an image. The camera can alter an image with different settings. Images are made up of dots called pixels, each composed of three colors: red, green, and blue. Intensity of each color can be adjusted. Film and digital storage cards are discussed shortly.

A camera using slide film exposes an image on film—*period*. Once the exposure is made, there is no recourse with correction. There is some recourse with black-and-white and color negative film by changing print exposure time, selection of paper, and dodging or burning items to be enhanced.

With digital cameras, the image is only one link in the chain to a photograph (Kodak 1999a): This chain is (1) the camera with its dpi or pixel resolution, lens quality that captures the image, and the camera's ability to modify pixel characteristics; (2) CPU (the computer) that processes the image with its ability to make major changes in the pixels and thus the image; (3) monitor with its color projection of the image on the screen, which is used as a basis for changing the image characteristics; and (4) the output device that either prints the image (printer) or projects it (projector). The camera, CPU, and output device affect the resolution (dpi), color quality, and contrast. Matching the camera resolution with that of the CPU and output device attains best image quality. They are **not** all the same.

Film speed, the amount of light required to expose the film, is characterized by an ISO rating. Film resolution (graininess of an image) also is a product of film speed: faster film has more grain. Common ISO ratings are 100 for slow speed and fine-grain film (for example 1/60th second at f-5.6); ISO 200, which can be shot at twice the shutter speed (1/120th second at f-5.6) and has medium graininess; and ISO 400, which can be shot at four times the shutter speed (1/250th second at f-5.6) but is rather coarse grained.

Digital camera equivalents are approximately 1640 by 1400 dpi for ISO 400 (2.4-megapixel camera), 1960 by 1600 dpi for ISO 200 (3.2-megapixel camera), and 2280 by 1800 dpi for ISO 100 (4.1-megapixel camera). To determine the camera rating, multiply the two pixel numbers: 1280*1020 = 1.3 megapixels.

Output (pictures) differs between film and digital cameras. The prints are similar because they are all images printed on paper. Prints from color and black-and-white film and from digital images all share the same result: a picture one can hold in their hand or mount on a monitoring form.

Slides made from film and digital images share few common traits, however. A film image is determined at exposure and can be shown in presentations through a slide projector. A digital image cannot. Generally, the digital image first must be downloaded from the camera and placed into memory of a laptop computer. Then the laptop must be connected to a digital projector for presentation. Recently, cameras have been programmed for download directly to a projector; however, this projects only slides in the camera. It does not provide for a presentation using title, data, and instructional slides. Here are some things to consider when projecting digital images for a presentation (Kodak 1999a):

1. Know the native resolution (dpi) of the laptop and the camera. Select the resolution that will support "high color" (16 bit) color depth (1280 by 1024 dpi; a 1.3-megapixel camera) or higher. Settings of the laptop computer above or below the camera settings will result in reduced image quality.

2. Match the resolution of the laptop with the resolution of the digital projector. If the laptop uses 1280 by 1020 dpi and the projector only 800 by 600, image quality will be at the projector resolution.

3. Understand that colors on the computer monitor used to modify image characteristics are not the same as those projected. The projector gives the more accurate color.

Film—Film is another consideration in photo monitoring, particularly the use of color slide film compared to negative films when prints are the desired outcome. Prints can be modified many ways by using different kinds of printing paper, exposure timing, dodging, burning, and different filters to make good comparison pictures. An advantage of black and white film is its long life. Most color films or prints tend to fade over the years, even if they are kept in dark, cool, dry locations.

Tones in color film differ according to the chemicals used in manufacturing and processing the film: Kodachrome has warmer, more vivid colors then Elite Chrome (Ektachrome), yet Elite Chrome (Ektachrome) tends to produce a truer reproduction of the greens and browns in a natural landscape.[1] Repeat photography done with different brands of film therefore produce some significant differences in appearance of vegetation conditions in the scene, whether real or not (Magill 1989). The photo monitoring protocol should prescribe the brand of film, speed of film, and light (weather) conditions for the project.

Film processing will influence how well photos can be compared. Most film is sent to a commercial processor where either slides are produced or pictures are printed at a standard size, such as 3½ by 5 or 4 by 6 in. Quality of processing differs. Do not cheapen your product by cutting costs and quality at the final step (Johnson 1991).

Weather should be related to film. How does current weather compare to conditions of previous photographs (Magill 1989, Maxwell and Ward 1980a)? A dense, heavy cloud layer will produce different colors and tones compared to a high, thin overcast, which in turn will be different from full sunlight that causes deep shadows. Maxwell and Ward (1980a) suggest overcast skies to reduce shadows and taking at least three different exposures to bracket light conditions for comparable colors between photos. Weather conditions of original photographs should be duplicated.

Digital storage cards—Digital cameras do not use film, but rather electronic storage cards (Kodak 1999a). Storage cards are not developed but are processed by computer. Any or all images can be erased and the card reused. The color quality, contrast, and depth can be manipulated. Either all images or selected ones can be copied from one card to another, greatly facilitating storage and retrieval of images. Different brands of cameras use different storage cards. Storage cards also come in several sizes and makes.

---

[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or services.

Storage cards vary in their megabyte (MB) capacity, which directly limits the number of images that can be stored. A general conversion from number of pixels in an image to number of images per storage card is a 1-to-1.2 ratio: a 1-megapixel photo requires about 1.2-MB of storage card capacity. For example, an image at 1280 by 1024 pixels (1.3-megapixels) would require an entire 2-MB card, or 24 photos could be placed on a 32-MB card. The same 32 MB card would hold 66 photos at 800 by 600 pixels (0.48-megapixel).

Digital storage cards can be reused. The deleted images, of course, are lost.

Processing of storage cards is quite different from film, with two alternatives: commercial or home processing. Commercial means the storage card is sent to a digital processing laboratory for prints similar to film. Home processing requires use of a CPU, with a download system from the camera, and a printer. For best image quality, the dpi of the camera and computer should be compatible, and the dpi of the computer and printer also should be compatible. Image quality is sacrificed if either the computer or printer cannot process the dpi of the camera, or image quality may be sacrificed by color rendition of the printer.

Digital images may be stored in three ways: (1) in the memory card used with the camera, (2) transferred to a compact disk (CD) and the memory card reused, or (3) transferred to a computer hard drive with essential information in its file and the memory card reused. If stored in a computer, assure that instructions for locating the folder or file are placed in the photo monitoring filing system.

Color prints are similar in cost between film and digital systems; however, slides made from digital memory cards tend to cost more. The use of two steps, from card to negative and from negative to slide, tends to reduce quality of the image.

Camera Format

Camera format is the combination of camera body image size and focal length of a lens. Format concepts apply to both film and digital cameras. Exact duplication of camera format is not of critical concern (Rogers and others 1983) when evaluating change in the subject photographed. Images may be enlarged or reduced to a constant area of coverage, printed, and compared.

When using slide film, however, images taken with different camera formats will project differently on the screen. This is a major concern discussed by Magill (1989) in his analysis of change in campgrounds. He projected slides onto a screen with a grid and adjusted size of the image according to specified criteria prior to analysis.

Some examples of common film camera formats that cover about the same area of a landscape are (1) 1- by 1.5-in image size (35-mm camera) using a 50-mm focal length lens, (2) 2- by 2-in (50- by 50-mm) image size using a 70-mm lens, or (3) a 4- by 5-in (100- by 125-mm) image using 128-mm lens. All are equivalent to a digital camera at 13-mm focal length. The advent of good quality zoom lenses permits a great variety of camera formats having both desirable and undesirable features.

A desirable feature is increased flexibility in choosing photograph formats without the need to change lenses. Undesirable features include higher f-stops and no constant focal length when rephotographing monitoring sequences.

The effects of camera format and distance from camera to subject are shown and discussed in figures 1 through 7. Camera position concerns are illustrated in figures 8 through 10. Change in emphasis on a topic by distance is discussed in “Camera Techniques,” below.

Figure 1 shows a testing landscape where six objects are positioned, photographed, and outlined to compare size and location of the objects with change in distance, focal length, and camera position. Three lenses were used with a 35-mm camera body: (1) 35-mm wide angle, (2) 50-mm as a standard for comparison, and (3) 70-mm telephoto; these are equivalent to digital cameras of 9, 13, and 18 mm. They were used in conjunction with three distances from camera to meter board: (1) 7 m, (2) 10 m as a standard for comparison, and (3) 14 m. The effect of camera position was evaluated at 10 m with a 50-mm lens. The standard for comparison was 1.4 m above the ground (breast height) centered over the camera location fencepost. Camera position was moved upward 4 dm to 1.8 m (eye level) and sideways 4 dm.

The first evaluation (fig. 2) is a standard camera format of 50-mm lens on a 35-mm camera positioned 7, 10, and 14 m from a meter board. All photographs in figure 2 are clearly different. Outlines of objects, adjusted in size to the meter board at 10 m are shown in figure 3. All objects are different in both size and location.

Next, both camera format and distance to meter board were adjusted. The objective was to photograph the meter board at a constant size where the 35-mm lens at 7 m gave the same size meter board as 50-mm at 10 m and 70-mm at 14 m (fig. 4). Notice the difference in backgrounds. Comparison of object outlines in figure 5 shows that all objects are different in both size and location, almost identical with figure 3.

Finally, focal lengths (35, 50, and 70-mm) were changed at a fixed distance, 10 m (figs. 6 and 7). Figure 6 appears to show very different scenes insofar as what is included within each photo. But when the images are adjusted to size of the meter board at 50 mm shown in figure 7, each object is almost exactly the same size and location. This effect is what Rogers and others (1983) discuss. Figures 2 through 7 clearly indicate that distance from camera to meter board is critical; whereas focal length is not.

Text continues on page 20.

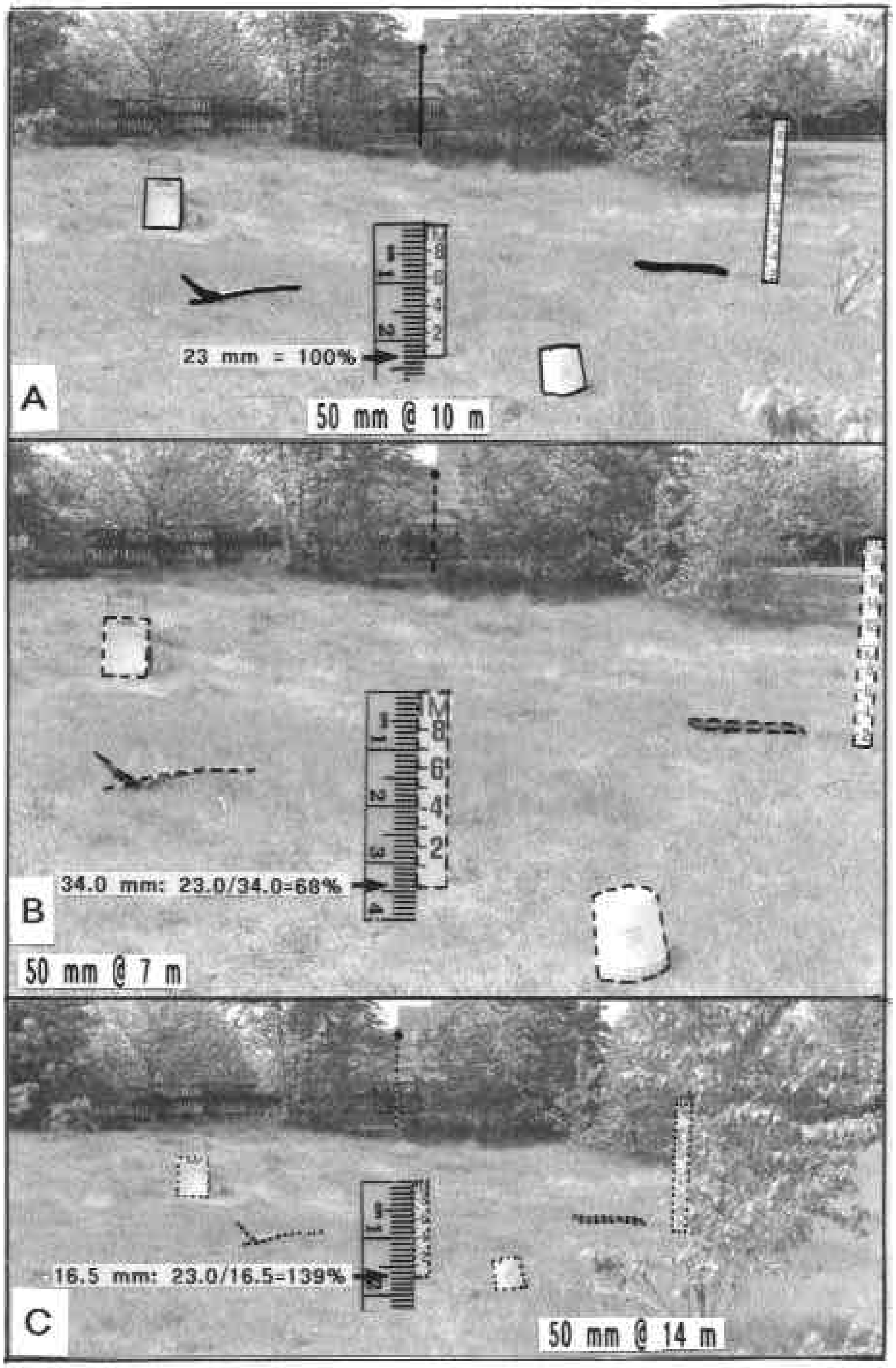


Figure 2—Effect of distance from camera to meter board on location and size of outlined objects when using the same camera format. Camera format is a 50-mm length lens on a 35-mm camera at 7, 10, and 14 m from the meter board. Objects were outlined on clear plastic overlay sheets as follows: 10 m in a solid line, 7 m in dashes, and 14 m in dots. Each outline was adjusted in size to match the meter board at 10 m as follows: measure in millimeters from the top of the board to bottom; this measurement is divided into the measure for 10 m for a percentage of change; then enlarge or reduce the overlay by that percentage. (**A**) The 10-m board was 23.0 mm and 100 percent; (**B**) the 7-m board was 34.0 mm reduced to 68 percent, and (**C**) the 14-m board was 16.5 mm enlarged to 139 percent. Figure 3 compares the adjusted outlines.

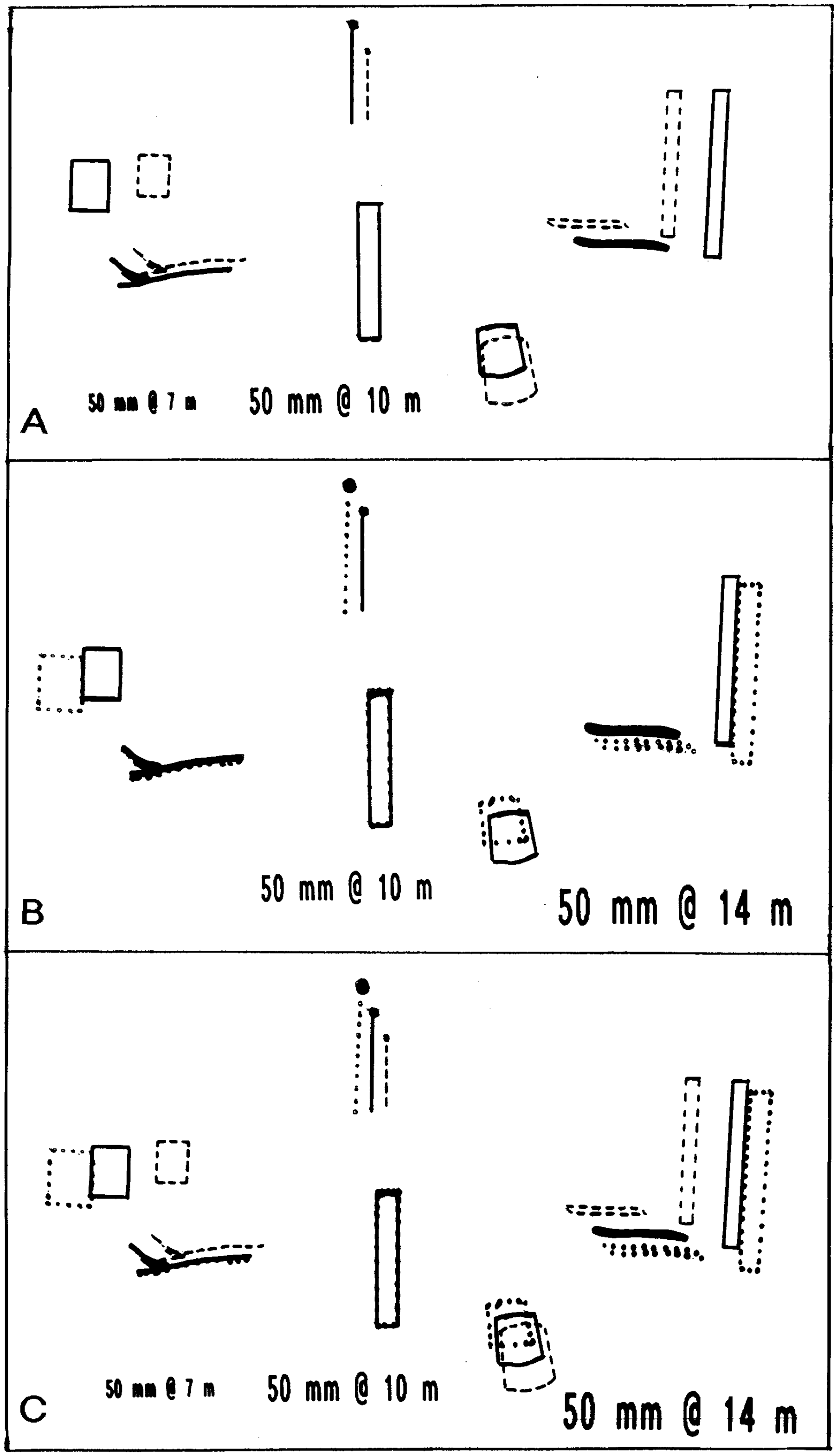


Figure 3—Overlays of object outlines from figure 2 adjusted in size to 10 m. The 10-m outline is solid, 7 m is dashes, and 14 m is dots. (**A**) Overlays of 7 m and 10 m shows objects of different size and location. (**B**) The 10-m and 14-m overlays also show different sizes and locations. (**C**) All three overlaid show that all objects are different in both size and location. Distance from camera to meter board is critical if objects in photographs are to be compared.

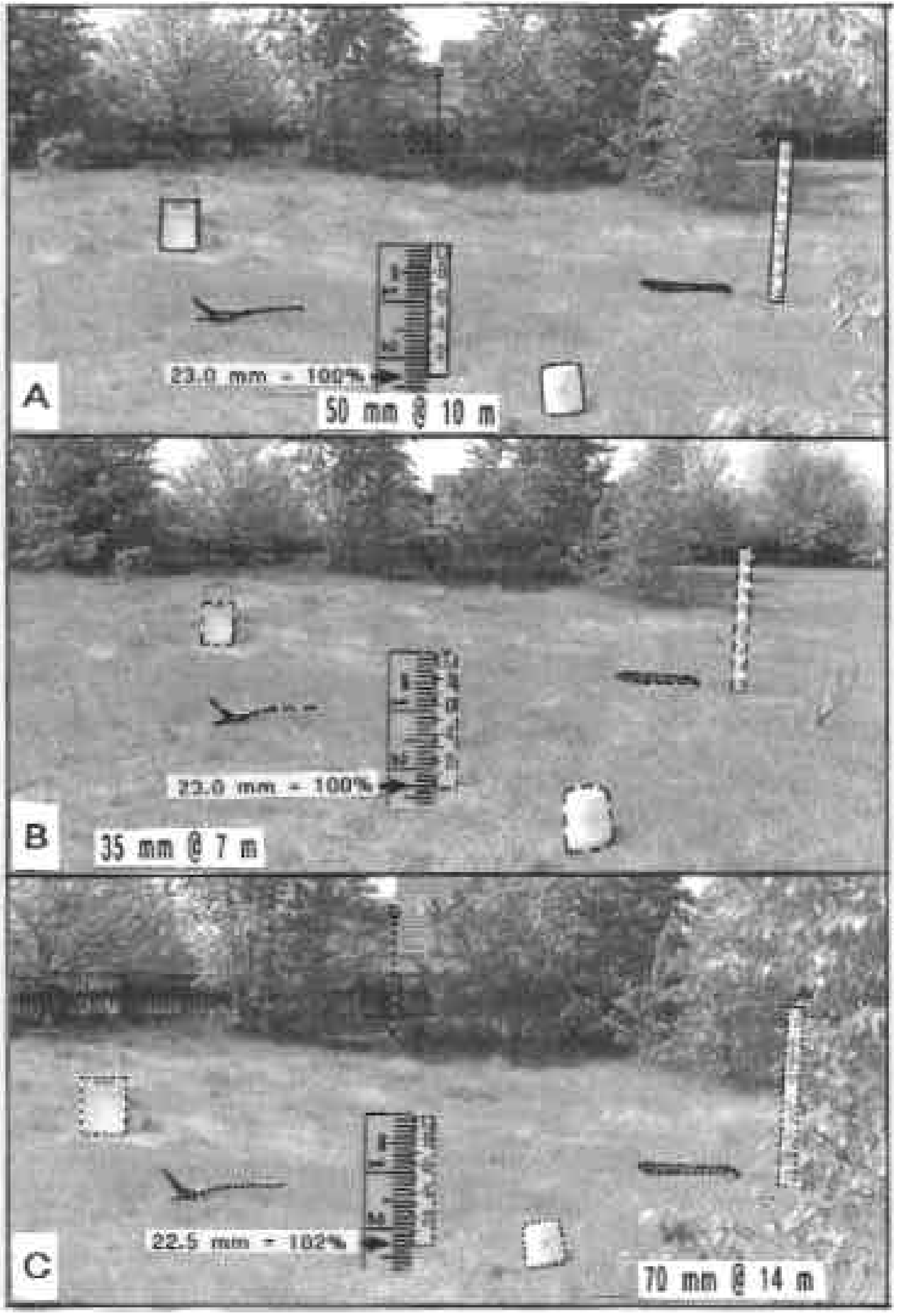


Figure 4—Both focal length and distance to meter board are adjusted to make the meter board the same size in each photograph: (**A**) 50-mm at 10 m, (**B**) 35-mm at 7 m, and (**C**) 70-mm at 14 m. Meter boards are measured to show similarity, and outlines were adjusted by the percentages shown. Objects are outlined on clear plastic overlays as follows: 50-mm with a solid line, 35-mm in dashes, and 70-mm in dots. Notice how the backgrounds change with a constant size meter board. Figure 5 compares the object outlines.

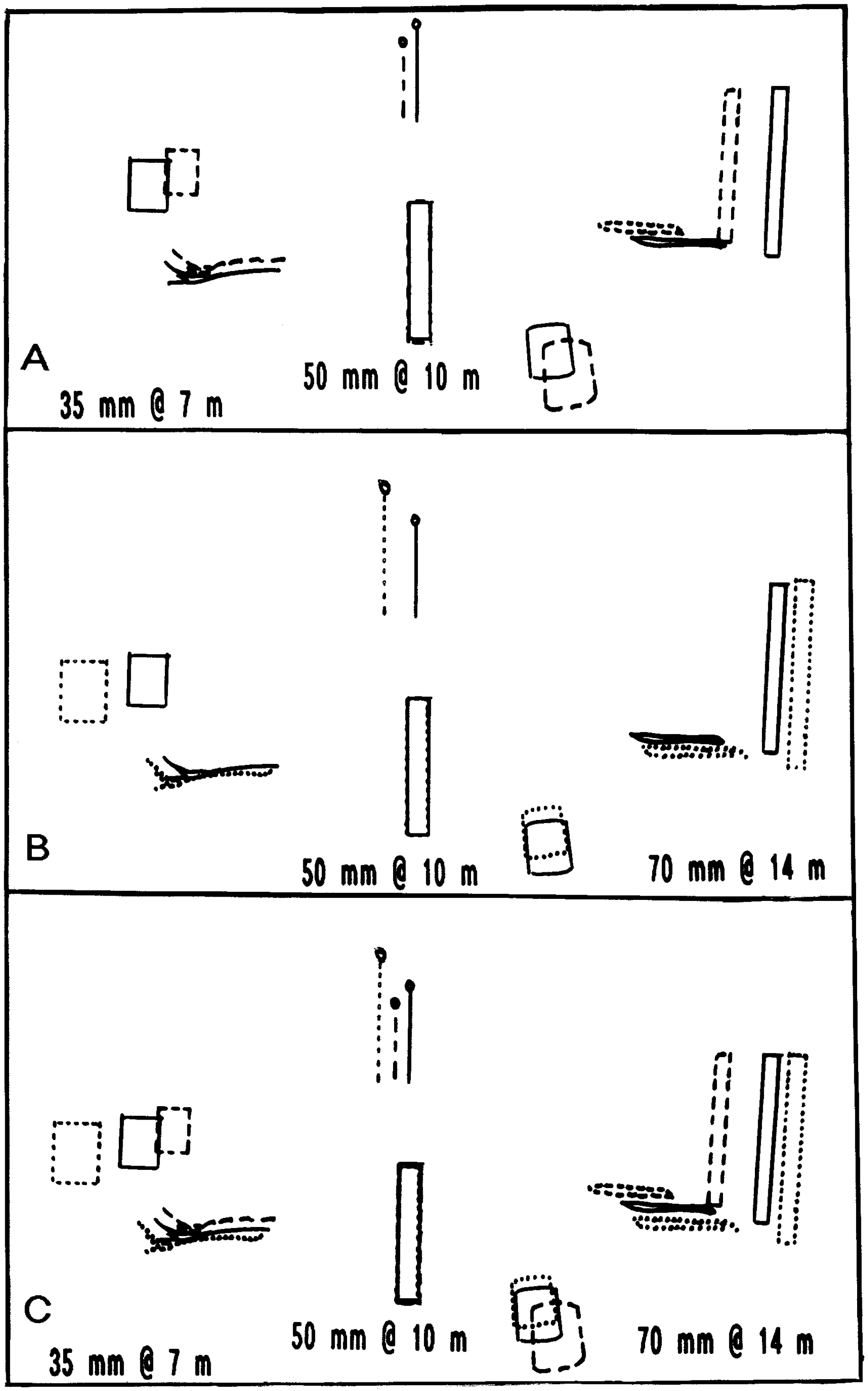


Figure 5—Object outlines from figure 4 overlaid to evaluate effects of camera focal length and distance from camera to meter board on size and location of objects. Photos were taken to keep the meter board at the same size. (**A**) The overlays for 35-mm at 7 m and for 50-mm at 10 m show different sizes and locations of items. A similar situation occurs with **B**. (**C**) All three overlaid shows a striking similarity to figure 3 because distance from camera to meter board is critical and focal length is not, as will be shown in figures 6 and 7.

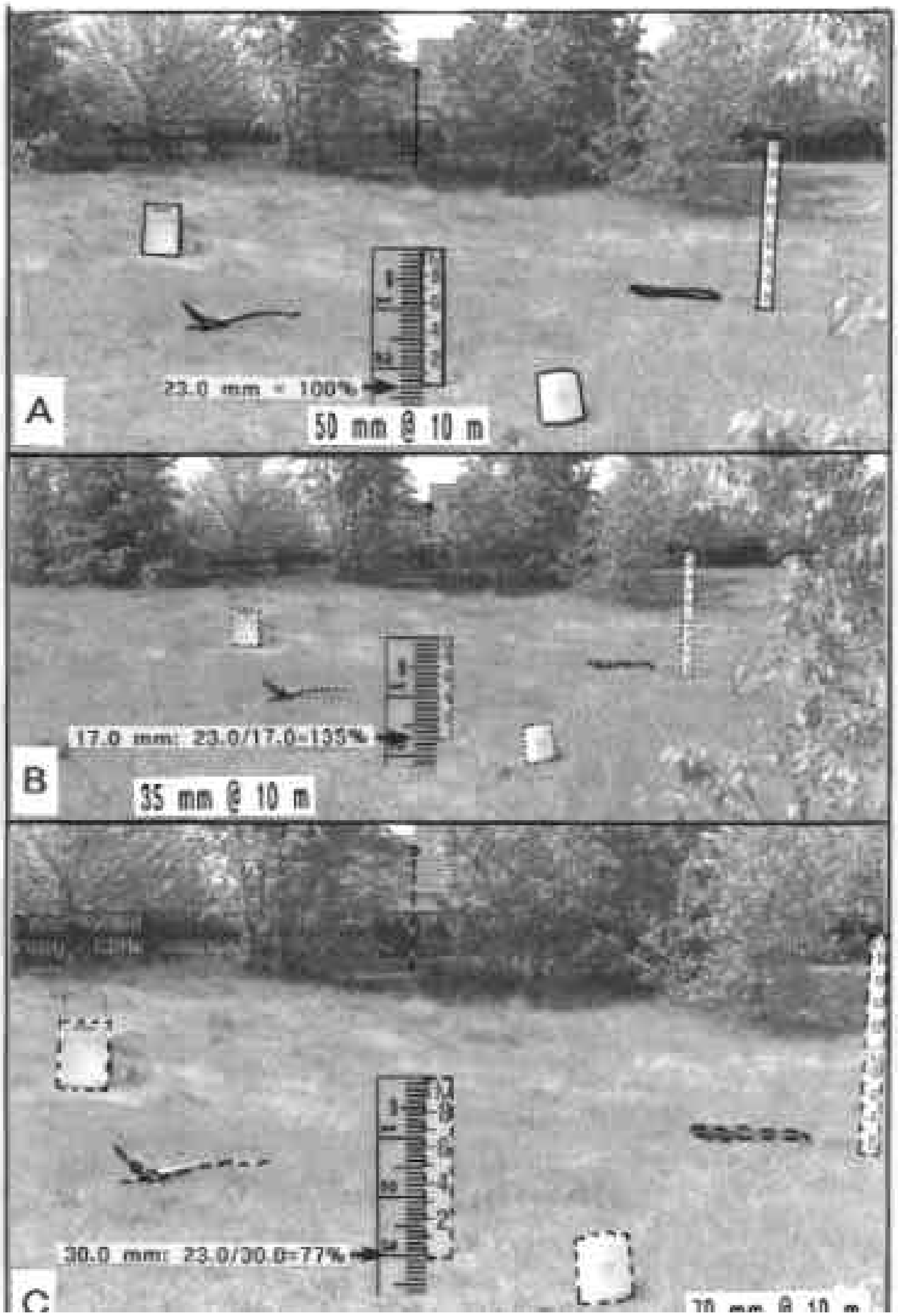


Figure 6—Effects of change in camera focal length of 35-mm, 50-mm, and 70-mm, at 10-m distance from camera to meter board using 50-mm at 10 m for comparison. Objects in each photograph were outlined on clear plastic overlays and were adjusted in size to the 50-mm at 10 m from the meter board as follows: (**A**) 50-mm was measured at 23.0 mm for 100 percent, solid outline; (**B**) 35-mm focal length was 17.0 mm, enlarged to 135 percent, outlined in dots; and (**C**) 70-mm was 30.0 mm, reduced to 77 percent, outlined in dashes. They are compared in figure 7.

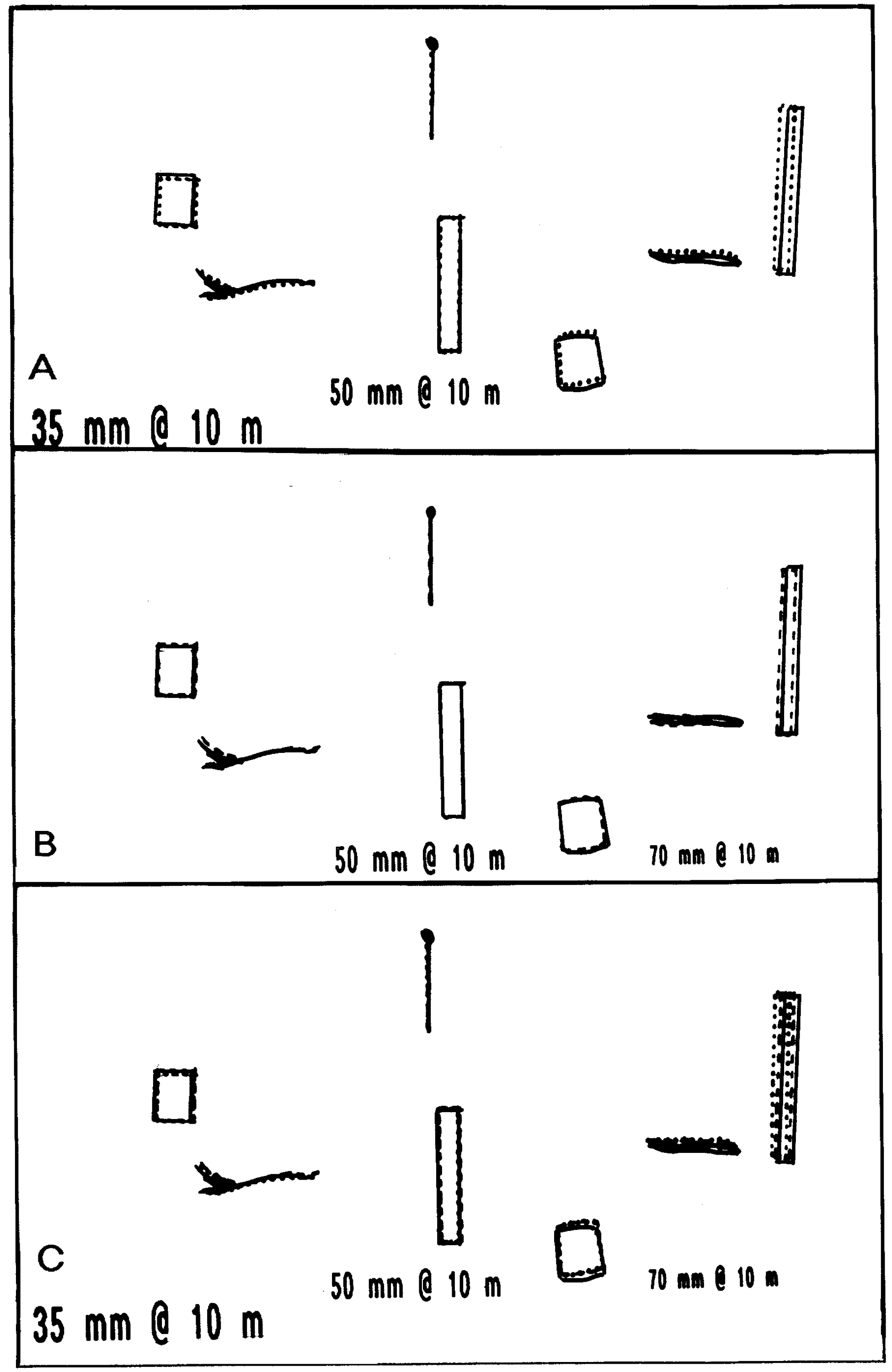


Figure 7—Object outlines for three camera focal lengths taken at 10 m from the meter board shown in figure 6. (**A**) Overlaying 35-mm and 50-mm shows almost no difference in object size or location. (**B**) Similarly, overlaying 50-mm and 70-mm shows little difference. (**C**) When all three are overlaid, there is almost no difference in object size or location. Camera focal length may differ without affecting analysis of photographic items when images are adjusted to a common size. A major disadvantage of using various focal lengths is the loss of background coverage in each photograph (shown in fig. 6, B and C). Comparison with figures 3 and 5 clearly demonstrates that distance from camera to meter board must remain the same.

Open to view page 18.

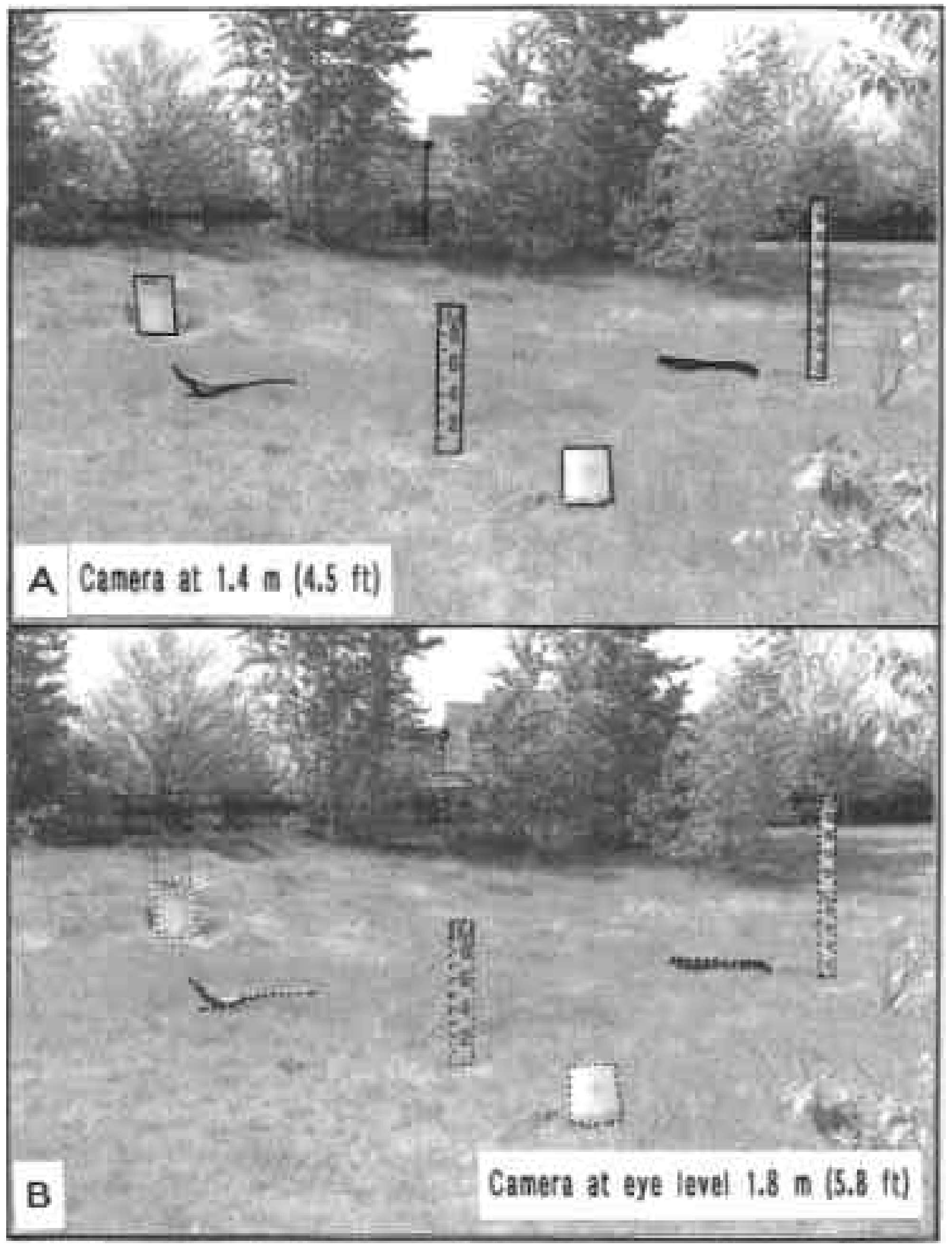


Figure 8—Effects of camera height aboveground on size and location of outlined objects. (**A**) Height of 1.4 m (4.5 ft, breast height) outlined in solid lines, is compared with (**B**) eye level of 1.8 m (5.8 ft) outlined in dots. The difference of 4 dm (16 in) is shown in figure 10A.

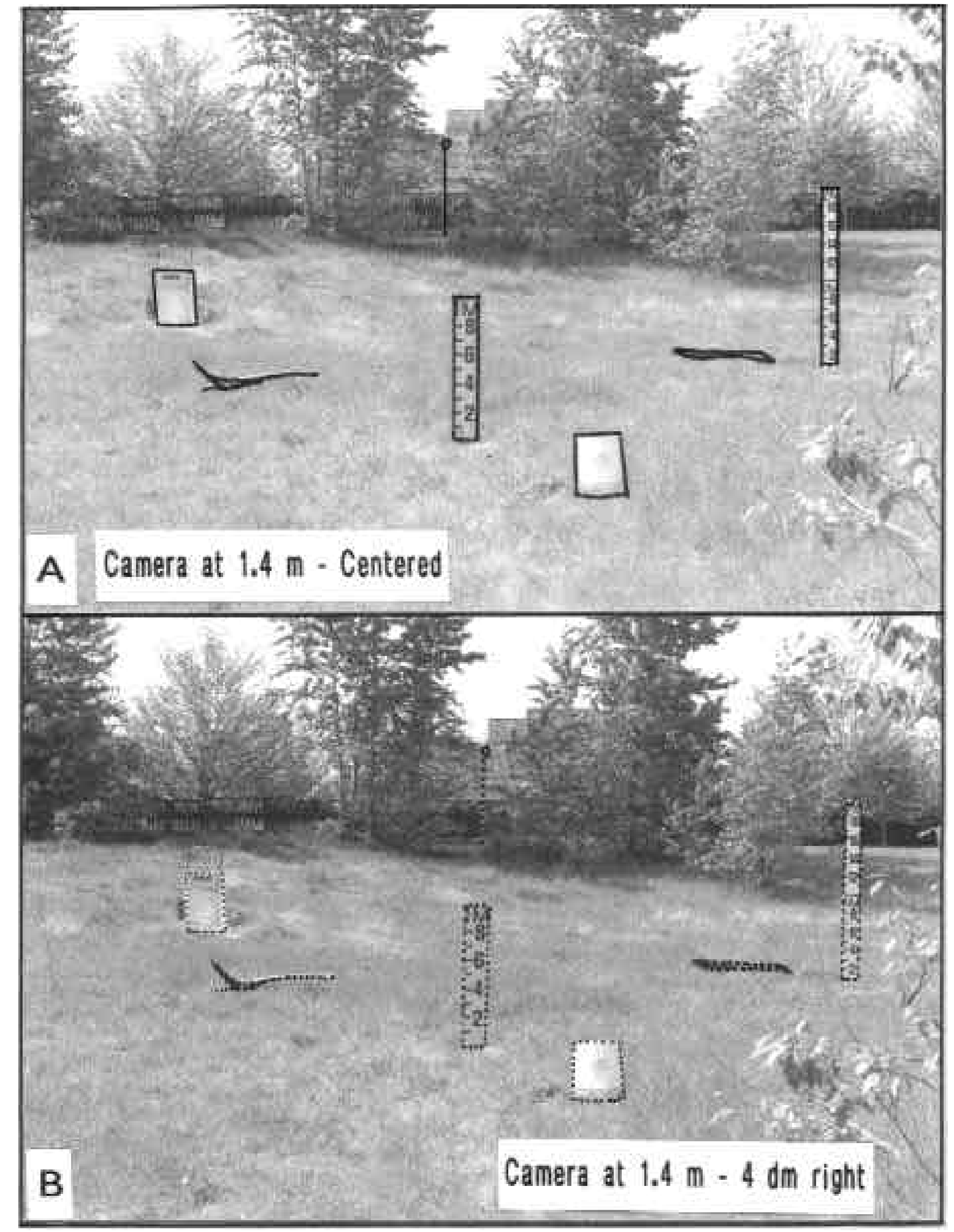


Figure 9—Effects of horizontal offset of the camera 4 dm (16 in) from center. (**A**) Center position is outlined in solid lines and (**B**) camera position to the right is outlined in dots. Difference in object size and location is shown in figure 10B.

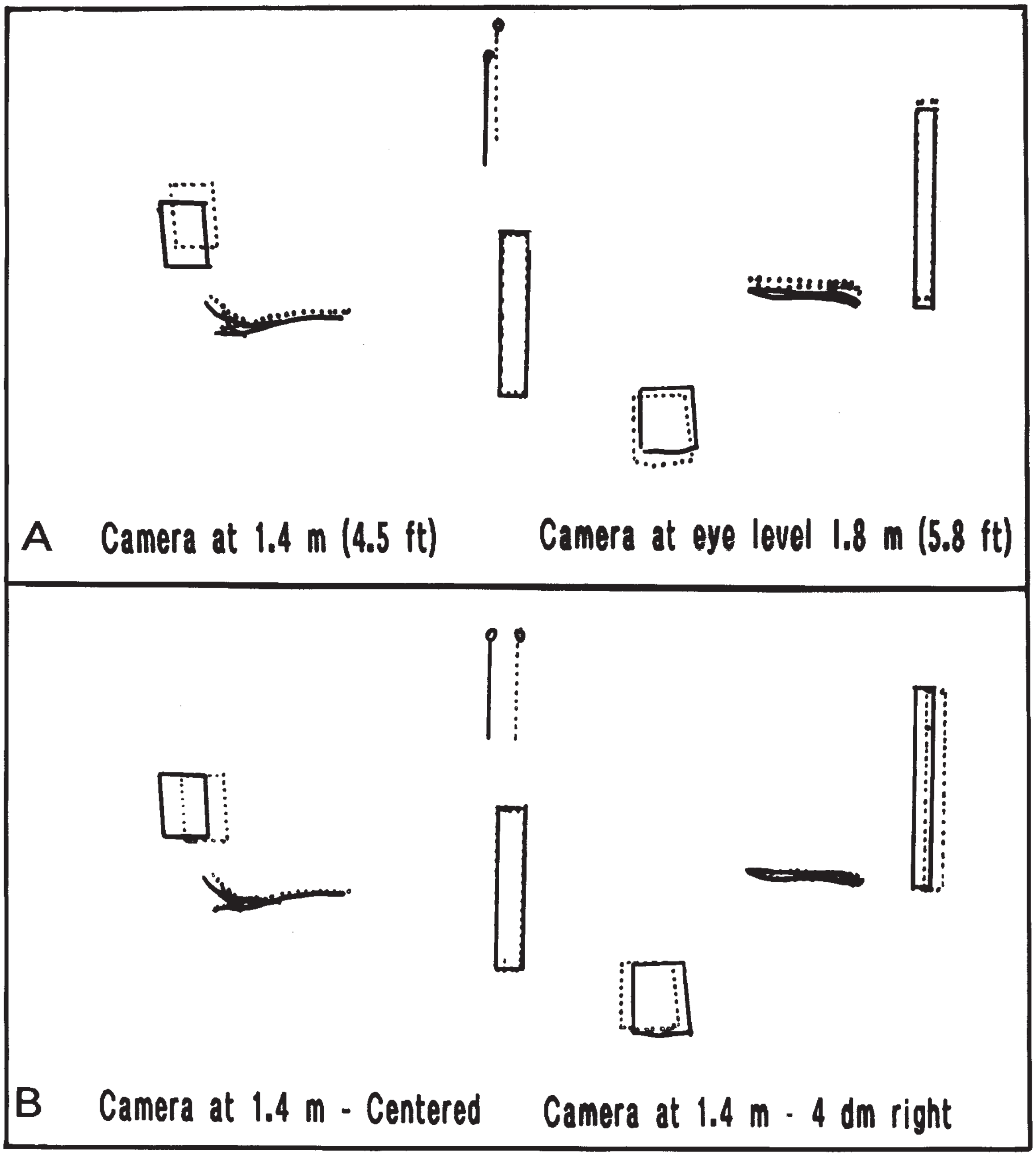


Figure 10—Effects of altering camera position by 4 dm (16 in) vertically and horizontally on size and location of outlined objects in figures 8 and 9. The reference position is 1.4 m (4.5 ft) centered over the camera location fencepost and outlined in solid lines. (**A**) Vertical movement of camera position, outlined in dots, to 1.8 m results in no change in object size but significant change in location on the photograph. (**B**) Horizontal movement of 4 dm (16 in) to the right, outlined in dots, results in no change in object size but significant change in position with the shift in a different direction from A. Position of the camera over the camera location fencepost affects location of objects but not size of objects.

Effects of camera position on object size and location are illustrated in figures 8 through 10. The photographs in figures 8 and 9 do not look different because 4-dm movement of the camera is difficult to detect. Figure 10, however, illustrates how much movement of objects occurs with only 4 dm (16 in) of change in camera position up or sideways. Although there is substantial change in object position, there is no change in size because the distance from camera to meter board was the same. Camera position is critical if location of objects is an objective of photographic monitoring; it is not critical if change in size of object is the objective.

Few restrictions and many opportunities exist in camera selection. The objective of photo monitoring suggests the appropriate style of camera and economics dictate the sophistication.

Filing System

A filing system must be developed for repeat photography. Place each photo study in a folder complete with purposes for the monitoring, site descriptions, notes, maps, color slides, and black-and-white prints with negatives or digital memory cards with prints (Johnson 1991, Nader and others 1995). The purpose of the file is to contain everything that other people will need for rephotography. Appendix D covers filing systems in detail.

Special note—It cannot be overemphasized to label and date all slides, black-and-white and color photographs, and the negatives as they are processed. Date and study location should be recorded on slides and negatives or digital memory cards by use of photo identification forms placed in the picture view at time of photography. Too often, negatives cannot be positively identified with their prints or date of photograph. I have found this a particular problem with negatives over 5 years old that document gradual change in conditions.

With these common characteristics in mind, two kinds of photo monitoring will be discussed: comparison photos and repeat photos.

Comparison Photo Montoring

Comparison photo monitoring means comparing on-the-ground circumstances to a set of photographs depicting various known conditions and assigning a value or rating to the field situation. This deals primarily with effectiveness monitoring and asking the question, "Did we do what we said we would?" Three examples are illustrated: (1) appraisal of fuel loading, (2) estimation of herbage utilization, and (3) monitoring of public concern.

Forest Residue Estimation

An example of comparison photo monitoring is appraisal of fuel loading (fig. 11). Maxwell and Ward produced photo series for quantifying forest residues in the coastal Douglas-fir—hemlock type (*Pseudotsuga menziesii* (Mirb.) Franco-*Tsuga heterophylla* (Raf. Sarg.) (1976a), ponderosa pine type (*Pinus ponderosa* P. & C. Lawson) (1976b), Sierra mixed conifer type (*Abies* spp.) (1979), and natural forest residues in several Pacific Northwest forest types (1980b). Other examples are Koski and Fischer (1979) using photo series for appraising thinning slash in northern Idaho, Wade and others' (1993) photo series for estimating posthurricane residue in southern pine, and Ottmar and others' (1990) sophisticated stereophoto series for quantifying forest residues in the Willamette National Forest in Oregon.

Maxwell and Ward (1980a) and Fischer (1981) present detailed instructions for developing photo series for forest residues. Their procedures were very similar except that Fischer placed the size control marker 20 ft (6 m) from the camera and Maxwell and Ward placed it 30 ft (9 m). Color was preferred by both to enhance recognition of dry and green fuel. The procedure of Maxwell and Ward follows:

1. Find very high and very low fuel loadings in the proposed forest type and size class, and then intermediate loadings. A forest type is the dominant tree species, and size class is the diameter at breast height (dbh) of the stand; for example, Douglas-fir pole size 5 to 9 in (12 to 22 cm) dbh. Their publications showed three to five different fuel loadings per forest type and size class.

2. Select slightly concave topography so that residue within 180 ft (54.5 m), a desired sampling distance, is visible.

3. Take photographs on overcast days because bright sunlight streaming through canopies creates sharp contrasts (see app. E).

4. Use a quality 35-mm camera with 50-mm lens.

5. Take the photograph in landscape format (long dimension of the photo will be horizontal.)

6. Use a reasonably fast, fine-grained color film (for example, Kodachrome 64).

1-DF-4-PC

DATA SHEET   Residue descriptive code 1-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.1	61
1.1-3.0	2.3	143
3.1-9.0	2.3	174
9.1-20.0	1.0	65
20.1+	0	0
Total	6.7	443

OTHER MEASUREMENTS

Average residue depth	(feet)	0.1
Ground area covered by residue 1/4-inch diameter and larger	(percent)	40
Average duff and litter depth	(inches)	0.7
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	79
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	21

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	51
Net volume cruised (M fbm/acre)	39
Average stems/acre cut	52
Average d.b.h. of stems cut (inches)	27
Stand age (years)	300
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	LL

REMARKS

Figure 11—Fuel loading comparison photograph from Maxwell and Ward (1976a, p. 32), originally produced in color. Conditions in the field are compared to a series of photographs to estimate fuel loading. This is one of a nine-report series showing residue after commercial thinning in Douglas-fir—western hemlock, size class 9 to 20 in dbh. The data table lists fuel loading weight and volume by size class, residue depth, percentage of ground cover by residue, average duff and litter depth, sound residue larger than 3.1 in by species, rotted residue larger than 3.1 in, harvest and precommercial thinning data, and the USDAForest Service fuel rating.

7. Shoot between f-8 and f-16 for a long depth of field.

8. Always use a tripod because low light under tree canopies may require exposures below $1/30^{th}$ of a second.

9. Use the standard national field system marker placed 30 ft (9 m) from the camera; it is a pole 6 ft (1.8 m) tall with a 1-ft^2 (3 by 3 dm) marker at the top and alternate foot distances painted black and white (fig. 11).

10. Take a minimum of three exposures so that all fuel loadings from different locations can be presented in the same color mode.

11. To sample fuel loading, establish five base lines radiating from the camera and equidistant apart, with five sample points on each line in view of the camera. Sample the down material from each of the 25 sample points.

12. Sample standing live and dead material from six sample points distributed over the 25 fuel loading points.

13. Compute down fuels, standing fuel (live and dead trees, shrubs, grasses, and forbs) by size class, anticipated rate of spread, and flame length under selected moisture content and wind speed.

Maxwell and Ward's format shows a color picture of fuel loading with all data contained in that picture as computed by their instructions (fig. 11). The product is a pocket-sized booklet, about 5 by 9 in (12 by 22 cm), listing the forest type, such as west-side Douglas-fir or east-side pine associated, size class of the forest type, and within each forest type and size class, three to five fuel loadings.

To use their system, a person goes to the field, identifies the forest type and size class, then turns to appropriate photographs in the booklet and compares the fuel loading at the site with pictures in the booklet. The fuel loading is then estimated by comparing the existing conditions to those described for the photograph most nearly approximating field conditions. Jensen and others (1999) applied the concept for estimating fuel loading to a fire hazard to do a watershed analysis for the parks department of British Columbia.

Herbage Utilization

Another comparison photo monitoring system deals with utilization of grasses and forbs by livestock. Schmutz (1971) and Schmutz and others (1963) pioneered a series of photographs for grasses in the Southwest. Kinney and Clary (1994) developed a series depicting various kinds of utilization on riparian graminoids (fig. 12). On a single page, the latter depict six degrees of utilization: 0, 10, 30, 50, 70, and 90 percent. To use their guide, the species in question must be identified, its stubble height determined, and the height compared to photographs in the guide to estimate the percentage of utilization.

Kinney and Clary's procedure for developing a guide is rather simple and straightforward, as follows:

1. A height-weight curve was developed for each species to be photographed. A height-weight curve is the relation of the percentage of total height of the plant with seed heads to percentage of utilization. For example, a plant 5 dm tall might have 10 percent of its weight in the top 20 percent of its height (fig. 12). Thus, a plant 80 percent as tall as an ungrazed plant would represent 10-percent utilization.

2. A plant with seed heads of the desired species is selected, vegetation removed from around that individual, and a black backdrop placed behind the plant (fig. 12).

3. The plant is photographed in its full stature. Then it is clipped at heights that represent 10, 30, 50, 70, and 90 percent utilization. At each clipping, the plant is rephotographed.

4. These six photographs are then assembled onto a single page and accompanied with a height-weight graph showing the relation between plant height and percentage of utilization (fig. 12).

Guenther (1998), working in annual grass rangeland in California, developed a photo-monitoring guide dealing with residual dry matter. He used a Robel pole[2] (Robel and others 1970) photographed from 10 and 20 ft. Eight photographs depict increments of annual grass biomass from over 1,000 lb/acre to less than 125 lb/acre. The Robel pole is supplemented with a 0.96-ft^2 hoop placed at its base with four golf balls to help appraise grass density.

His procedure is to place the pole and take a photograph. Then the vegetation is clipped within the 0.96-ft^2 hoop to document the herbage production.

---

[2] The Robel pole is discussed in appendix A.

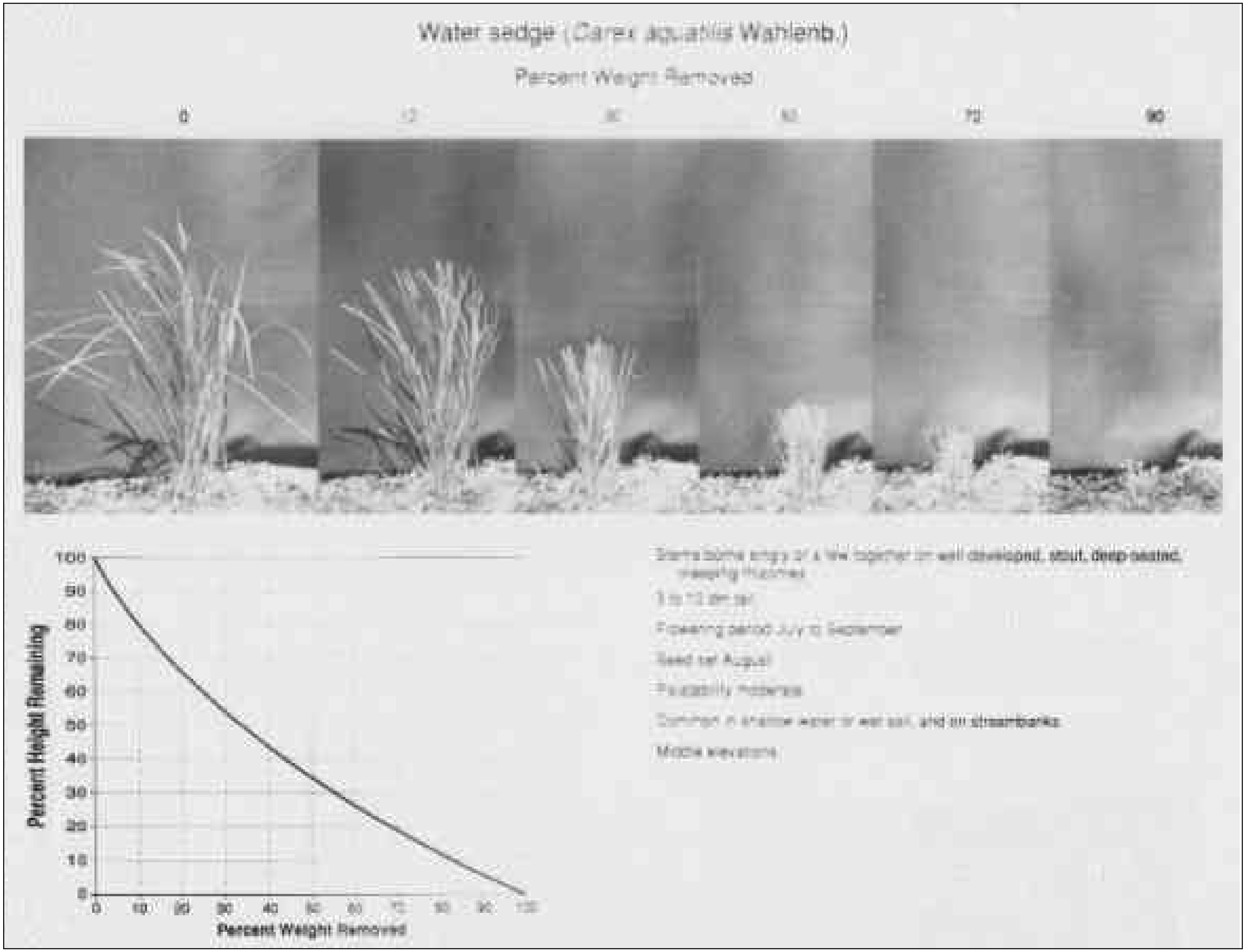


Figure 12—Sedge utilization comparison from Kinney and Cleary (1994, p. 7) for water sedge. Stubble height is shown for six levels of utilization. The photograph is compared to sedge utilization found in the field to appraise the amount of use.

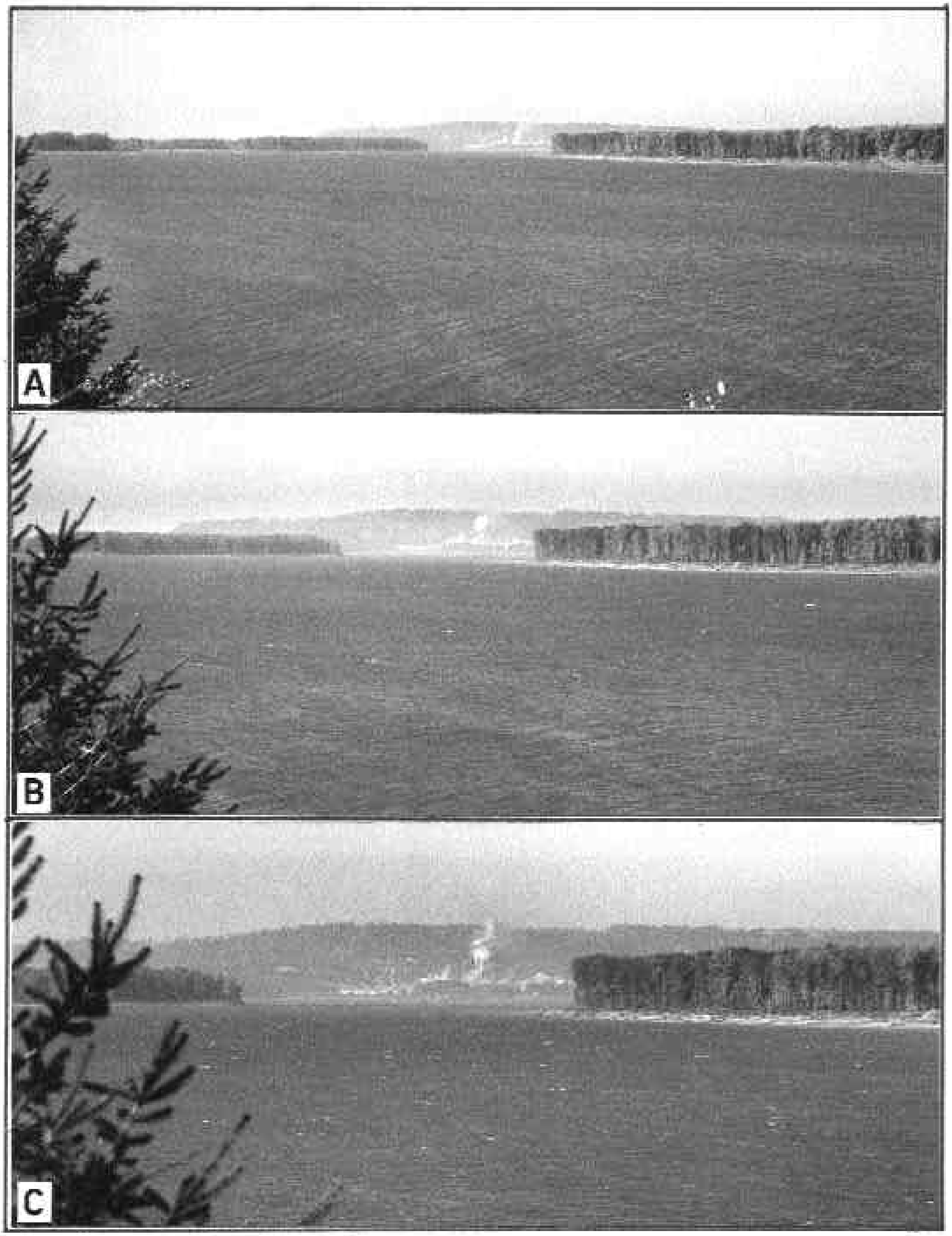


Figure 13—Comparison photographs of smoke from a pulpwood mill along the Columbia River taken from a turnout on Interstate 84: (**A**) 35-mm focal length simulating 20 mi distant, (**B**) 70-mm simulating 10 mi distant, and (**C**) 140-mm simulating 5 mi distant. Similar sets of photographs were used by Magill (1990), Benson (1983), and Ribe (1999) to appraise viewer's reactions to landscape scenes.

Monitoring Public Concern

Monitoring of public concern for landscape quality also uses a comparison photographic technique as discussed by Benson (1983), Magill (1990), and Ribe (1999). Their objectives were to test public awareness and concern for various landscape items, particularly effects of logging. Magill (1990) used a set of three to five photographs of the same landscape viewed at different distances (fig. 13). These were shown to people and their reaction or concern about the view documented. He tried to develop a threshold definition of various landscape features. The technique was as follows:

1. A landscape feature was selected as viewed from a suitable vantage point, such as a road or viewpoint.

2. This landscape was photographed with a 35-mm camera using color film and a zoom lens. Pictures were taken at 50, 70, 100, and 150 mm (fig. 13). This was done to simulate different distances from the landscape object, for example, 4.8, 3.2, 2.1, and 1.6 mi for each focal length, respectively.

3. No effort was made to select good visibility or particular weather conditions (fig. 13).

Benson (1983) discusses scenic beauty estimation and visual quality objective analysis through methods similar to those of Magill (1990). He also uses comparison photos to rate elk habitat characteristics and recreational impacts as part of forest planning. Ribe (1999) used photographs to test public response to 15-percent retention of green trees in clearcuts as a research method for appraising acceptance of alternatives in the Northwest Forest Plan.

Repeat Photography

As the name implies, repeat photography means retaking photographs from the same spot and of the same subject several times. To be effective, most repeat photography requires precise replacement of the camera and composition of the subject, be it a sample plot, view of a particular subject such as a streambank, or rephotographing a distant landscape.

Repeat photography is used for many purposes and, thus, can take on many different forms. It may be landscape rephotography covering 50 to more than 100 years of change (Skovlin and Thomas 1995); documenting animal activity at a specific site, such as ospreys (*Pandion baliaetus*) rearing young (Kristen and others 1996) or livestock distribution in a meadow (Kinney and Clary 1998); assessing air quality (Fox and others 1987); sampling change in vegetation using both general and closeup views (Hall 1976, Nader and others 1995); and appraising effects of management such as livestock utilization or logging (Gary and Currie 1977, Kay 1999, Kay and others 1999, Smith and Arno 1999). Hart and Laycock (1996) and Rogers and others (1984) present bibliographies on repeat photography. In this paper, a riparian setting, Pole Camp in eastern Oregon, will be used to illustrate various aspects of repeat photography.

Three things must be done for repeat photography to be successful: (1) map the site and the system layout, (2) document the system, and (3) permanently mark camera locations and photo points.

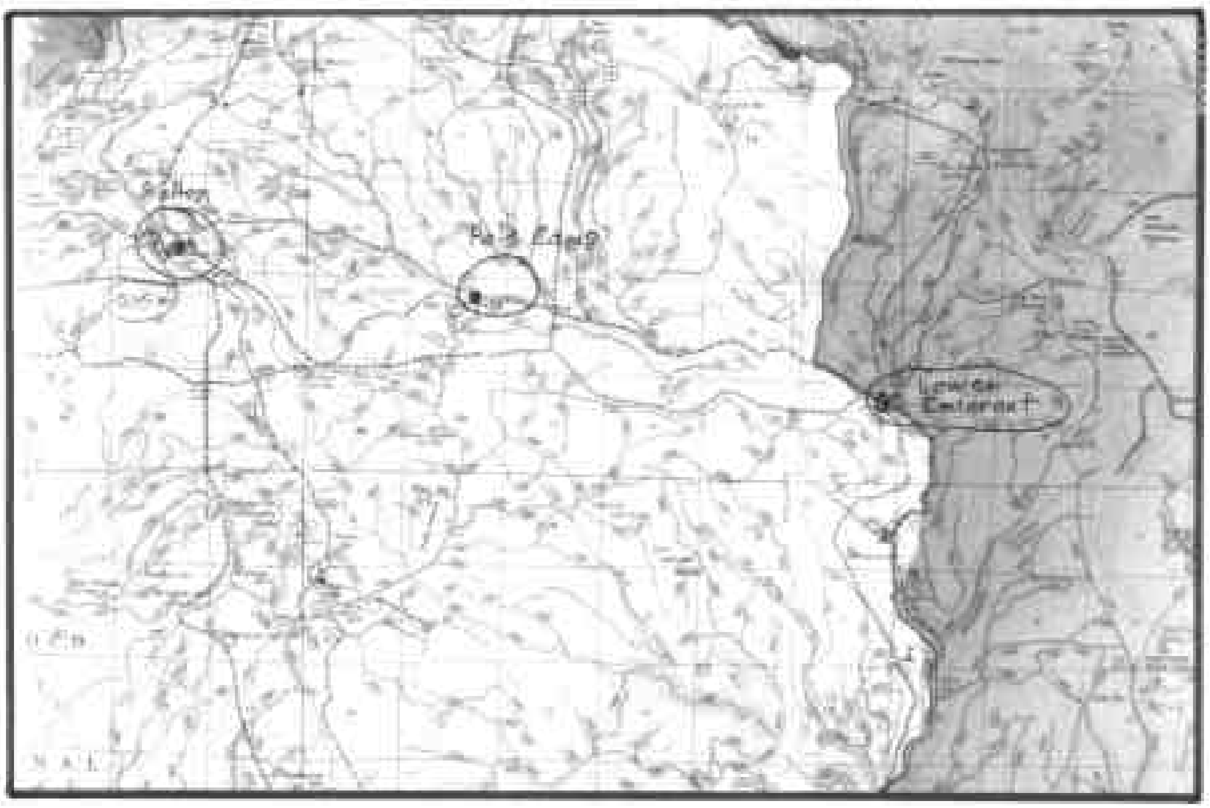


Figure 14—USDAForest Service Ranger District map showing locations of the Button Meadow, Pole Camp, and Lower Emigrant riparian study sites in northeastern Oregon. Road numbers, mileage from road junctions, and directions to the witness sites (a tree or fencepost with an orange tag identifying the monitoring area) are given in the study writeup.

Maps of Location and Monitoring Layout

Maps are essential for relocating and rephotographing topics as discussed by Bauer and Burton (1993), Borman (1995), Governor's Watershed Enhancement Board (1993), Hall (1976), Nader and others (1995), National Park Service (1992), USDA Forest Service (1982), and USDI Bureau of Land Management (1996). Two maps are important:

1. Map of the monitoring site location so that those other than the installers can find it. Figure 14, a USDA Forest Service ranger district map, identifies the road on which the site is located. Establish a witness marker along the road by placing an orange tag on a tree or fencepost. Inscribe on the tag the identity of the monitoring site.

2. A map of the photo monitoring system layout so that others can duplicate the original photography (fig. 15). From the witness marker identified on the general map, record directions and measured distances to each camera location and photo point (fig. 15). Measure on the ground; do not attempt conversion to horizontal distance.

The emphasis on *others* (other people) refers to a problem discovered by many (Borman 1995; Gruel 1980, 1983; Johnson 1984; Magill 1989; Nader and others 1995; Parker and Harris 1959; Phillips and Shantz 1963; Progulske and Sowel 1974; Puchbauer and Carrol 1993; Reppert and Francis 1973; Strickler and Hall 1980; USDA Forest Service 1982; USDI Bureau of Land Management 1996).

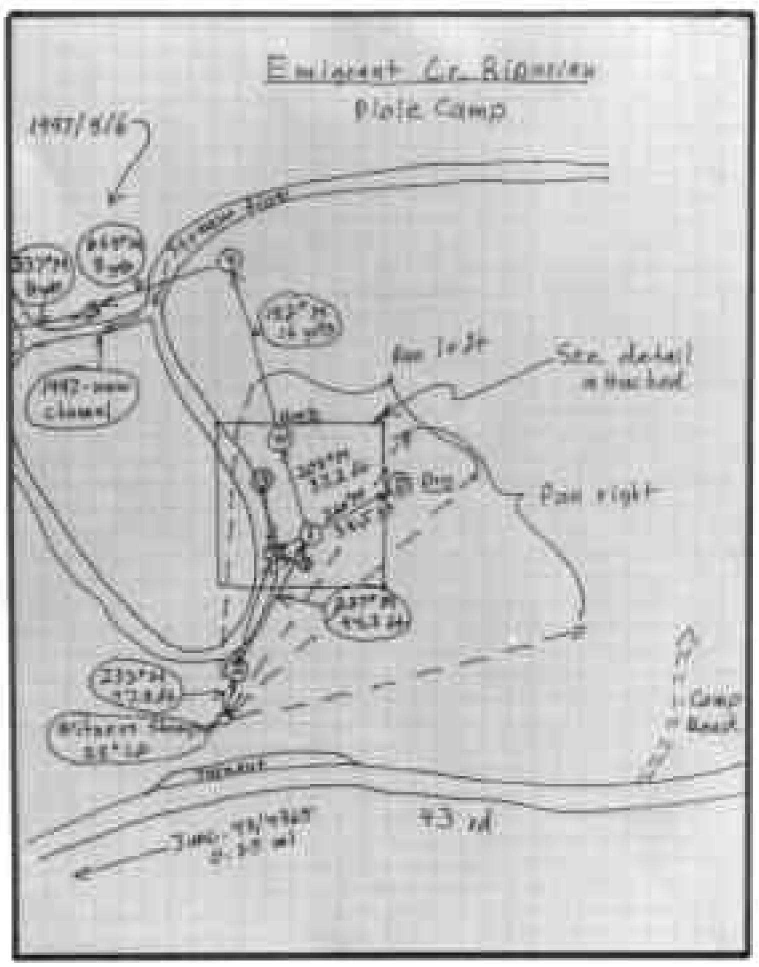


Figure 15—Study layout of the Pole Camp riparian site. Notice that all compass headings are shown as magnetic (M) to reduce confusion with the 21-degree deviation from true north in the Pacific Northwest. When distance is shown with a decimal point, it indicates a measured rather than a paced distance. Notice the two photo points from camera location 1—dry and wet. The boxed map is shown later in figure 27, which details location of the instream photo point.

Compass deviation is one item of particular importance in laying out the site map and relocating sites for repeat photography. In the Pacific Northwest, deviation is about 21 degrees east. The problem is, What does this mean? Does one add or subtract 21 degrees from the magnetic compass heading? Most people traveling by water, air, or land use magnetic headings for their direction; land survey, on the other hand, uses true direction. When providing direction on any map, specify true or magnetic. Notice in figure 15 that direction is listed first and distance second to provide easily followed instructions: You have to know what direction you are going before you can start moving.

Documentation of the Photo System

Each repeat-photography monitoring system must be documented in writing (in other words, a protocol for operation is created). It should include the following items:

1. The original size and focal length of camera such as a 35-mm camera with 50-mm lens or a 2- by 2-in (50- by 50-mm) square format camera with 70-mm lens.

2. The film to be used: speed and type of film such as Kodachrome 64 versus Elite Chrome (Ektachrome) 200, color or black and white negative film. Using both may require two different cameras or one camera with two backs. Digital cameras do not use film.

3. Definition of methods for repeatability of photographs. Specify how to aim the camera to repeat the field of view; for example, “site on the 1M of a meter board.” The field of view must be held constant so changes in the subject matter, such as stream stability, vegetation change, or management activities, can be clearly documented.

4. Time of day, season of year, air quality for landscape rephotography, and lighting conditions, such as overcast sky to reduce shadows or backlighting to highlight vegetation (app. E).

5. A list of all equipment required.

6. Instructions for using mechanical or electronic aids for rephotography.

Permanent Marking

Witness sites, camera locations, and photo points or transects must be permanently marked for efficient photo monitoring. Steel stakes or fenceposts can be used. Each has advantages and disadvantages:

1. Steel stakes are difficult to find if vegetation overtops them.

2. Steel stakes protruding above the ground may be stepped on by animals or people, or run over by vehicles causing foot or tire damage. Stakes can be driven flush with the ground but then will require a metal detector to be relocated (White’s Electronics, Inc. 1996).

3. Fenceposts are clearly visible and thus subject to theft.

4. Cheap fenceposts made of stamped steel are useful and durable (including against theft) when purchased in 5-ft (1.5-m) lengths and pounded 2 ft (0.6 m) into the ground. The 3 ft (0.8 m) above the ground is easily seen, and the flimsy construction deters theft because the stamped steel posts are as difficult to remove as strong T-bar posts.

5. Any fencepost aboveground is subject to destruction by equipment when an area is disturbed. When disturbance monitoring is contemplated, stakes driven flush with the ground are appropriate. Most inexpensive metal detectors will locate a 3/8-in (1-cm) diameter steel stake driven flush with the ground within a radius of 12 in (3 dm) (White’s Electronics, Inc. 1996).

With this background, three kinds of repeat photography will be discussed: (1) landscape photography, (2) remote photo monitoring, and (3) site-specific monitoring.

Landscape Photography

Repeat landscape photography seems to have been devised by Professor S. Finsterwalder, who photographed and mapped glacial changes in the eastern Alps starting in 1888 (Hattersley-Smith 1966). In the United States, after the Civil War, photographers were invited to participate in exploring the Western United States. Some of these historical landscape pictures have been rephotographed 100 or more years later; for example, Progulske and Sowel (1974) rephotographed the area of Colonel Custer’s 1874 exploration of the Black Hills to show changes in 100 years,

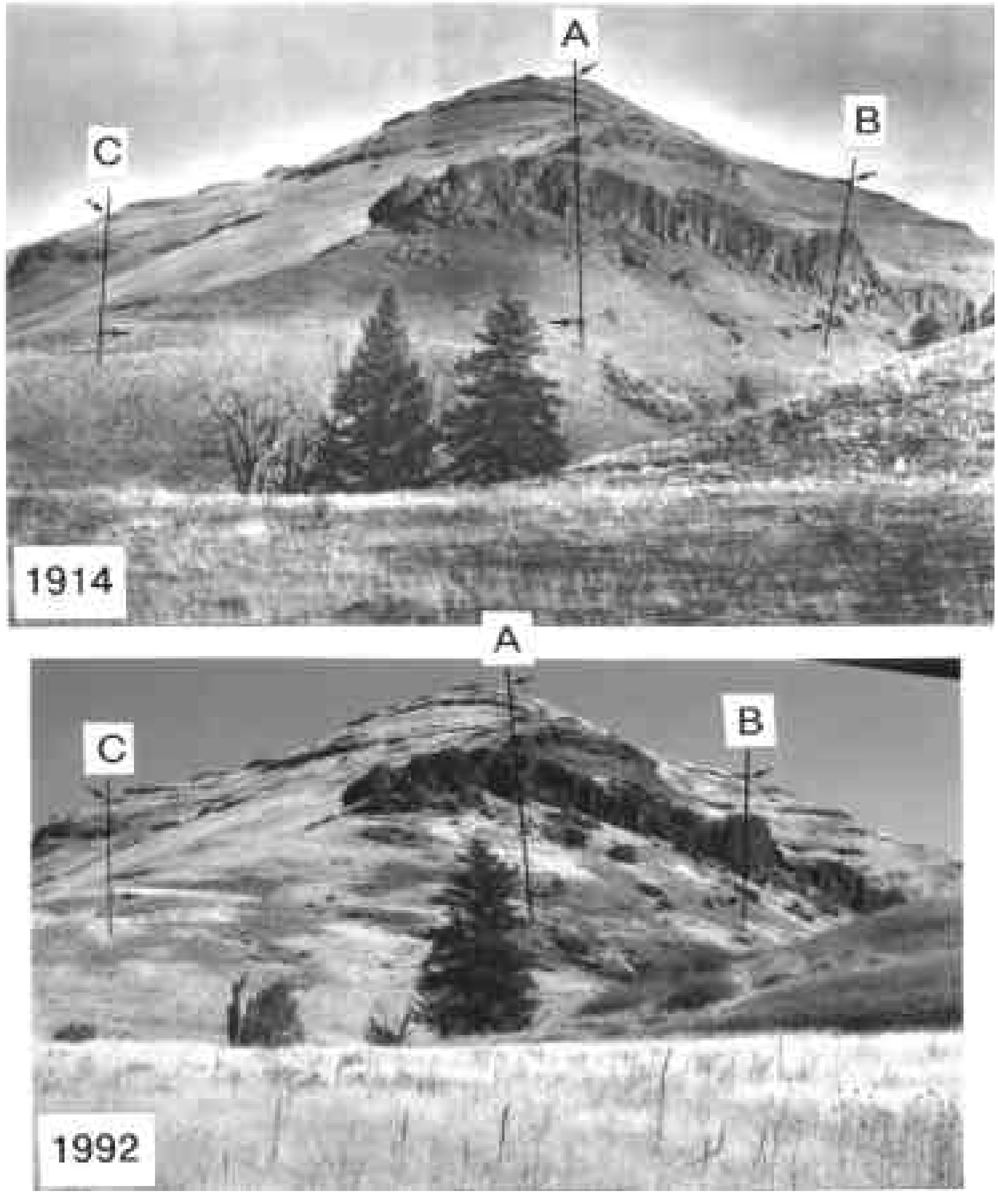


Figure 16—Relocation of historical photographs showing a view (1992) by Skovlin and Thomas (1995, p. 22-23) of Branson Creek, Wallowa County, Oregon, originally photographed in 1914 (top picture). The letter "A" identifies centerline orientation. Once the photographer was centered as on the original photograph, objects on the edges of the picture, such as "B" and "C", were chosen to refine location of the original camera. The photographer has to move forward or back until the angles of "B" and "C" are similar to the original photograph. Slight differences in orientation lines between 1914 and 1992 suggest the camera in 1992 was a few yards left of the original location. The usefulness of black-and-white photographs is illustrated here by triangulation lines placed directly on the picture.

and Skovlin and Thomas (1995) illustrated changes over 70 to 90 years in eastern Oregon (fig. 16). Landscape photography of small areas (10 to 100 ha) is discussed later and will be shown in figures 26 and 38. Appendix E illustrates some photographic techniques.

Johnson (1984), whose purpose was to evaluate change in sagebrush (*Artemisia* spp.) over 100 years or more, retook pictures taken by William H. Jackson during the 1860s to 1870s as part of the Hayden Expedition in Wyoming. Johnson concluded that sagebrush is highly site-specific, some changes have occurred but they differ among sites, and there has been no major shift in sagebrush distribution, although densities have changed. He felt the landscape today is a fair representation of the 1870s.

Phillips and Shantz (1963), who compared photographs taken by Dr. Shantz 50 to 60 years previously, report on another historical photo series of vegetation changes in the northern Great Plains. Dr. Shantz also photographed in eastern Colorado in 1904. Many of the locations for his pictures were rephotographed in 1986 after 82 years (McGinnies and others 1991).

Branson (1985), Gary and Currie (1977), Gruell (1980, 1983), Johnson (1987), Puchbauer and Carroll (1993), Rogers (1982), and Veblen and Lorenz (1991) discuss additional landscape rephotography.

Purpose

Purposes other than historical documentation have prompted long-term retaking of landscape photographs. Long-term, in this context, refers to retaking photographs taken by another person, usually more than 20 years previously. Some have evaluated effects of livestock grazing and change in western rangelands (Branson 1985; Chaney and others 1991; Johnson 1984, 1987; McGinnies and others 1991; Phillips and Shantz 1963, Skovlin and Thomas 1995).

Changes in rangeland vegetation from 1902 to 1988 were documented by Medina (1996) in his history of the Santa Rita Experimental Range in southern Arizona. Fifty years of secondary succession under sheep grazing in green fescue (*Festuca viridula* Vasey) grasslands were rephotographed in the Wallowa Mountains (Reid and others 1991), and effects of revegetation in green fescue grasslands depleted by sheep grazing in the Wallowa Mountains were shown by Strickler and Hall (1980). They documented Dr. Arthur Samson's pioneer range work in rehabilitation, which helped to formulate the first textbook on range management.

Other uses for long-term landscape photography have been to appraise the historical effects of fire on wildlife habitat in the Bridger-Teton National Forest, Wyoming (Gruell 1980, 1983); forest health concerns in the Boise National Forest, Idaho (Puchbauer and Carroll 1993), which used photography from as early as 1870; changes in wildlife habitat in north Yellowstone (Houston 1982); causes for mule deer (*Odocoileus hemionus* Zimm) population eruptions in the intermountain West (Gruell 1986); long-term successional changes in Blue Mountain ecosystems (Skovlin and Thomas 1995) as it affects forest health, range condition, and wildlife habitat; and to illustrate change in research natural areas (Herring and Greene 1997).

Considerations in long-term repeat landscape photography include three important factors:

1. Relocating photographs done 50 to 100 years previously.

2. Duplicating photographs taken by cameras that are no longer manufactured or available.

3. Dealing with photographic conditions such as season, weather, light, and air quality.

Relocation

Most authors say that finding the camera location was their most difficult problem. Without precise camera relocation, duplicating the scene photographed by original cameras and duplicating weather conditions were unimportant (Gruell 1980, 1983; Hart and Laycock 1996; Johnson 1984; Phillips and Shantz 1963; Progulske and Sowel 1974; Puchbauer and Carroll 1993; Skovlin and Thomas 1995).

Johnson (1984) notes that each: “...photosite was relocated over a 12 year period through time-consuming search in the field aided by knowledge of the countryside and comparison of expedition maps and reports with modern references.” He was referring to the Hayden Expedition. He also says that: “...the exact photo point was relocated by detailed inspection of photo features” (see fig. 16 and app. E).

A summary follows of comments by authors who have had to relocate landscape photography camera locations after 50 or more intervening years:

1. Study the travel log books, trail routes, and other descriptions of travel, not overlooking the slow rate of movement by horses and wagons, to locate a geographical area in which the old photograph might have been taken (Progulske and Sowel 1974).

2. Show the old photographs and descriptions to local residents for their ideas about location. In many cases, original photographers did not know local names of buttes; however, shape of the buttes and landforms are clues current residents can use to suggest camera locations (Progulske and Sowel 1974). If no travel logs are available, study of historic travel routes and railroads can provide clues as to where the photographers traveled and where they might have photographed (Phillips and Shantz 1963).

3. Identify unique landscape features such as hills, drainage ways, and their interrelationships. Phillips (in Phillips and Shantz 1963) comments that Dr. Shantz always seemed to find a prominent landmark to include in his photos, even on the Great Plains, which greatly aided in relocation. Many of Shantz’s photos were taken from the first railroads into an area where he would take photographs from a siding, town, or coaling station that could be readily relocated.

4. Orient the camera location by lining up near and distant objects in a triangulation system (fig. 16). For example, Progulske and Sowel (1974) point out that mountain profiles, abundance of rocks, thickness of soil, escarpments, and stream configuration were used. A search then can be made for rocks or dead trees, which lead to the target camera location. As Puchbauer and Carroll (1993) note, objects in the original photo often are overlooked during first examination; they suggest using a hand lens to locate subtle objects, such as old monarch trees (or their remains), on black-and-white photos.[3]

---

[3] In my experience, black-and-white prints are superior to color slides in relocation because prints can be easily examined by hand lens, and triangulation lines, shown in fig. 16, may be placed directly on the photograph.

5. Problems with relocation:

   A. Historic travel routes, roads, or railroads may have been obliterated by modern activities, thereby making identification of camera locations difficult.

   B. Intervention by other objects is one of the most common problems encountered. These objects can be trees, buildings, or other obstructions to the view from the original camera location.

   C. No clear, identifiable landscape feature by which to locate even the general area of a photograph.

Considerations

Camera—The original cameras and films cannot be duplicated by equipment available today in nearly all cases of photography before 1930. Duplication of the original scene, therefore, requires matching negative size with focal length to replicate the original photographs as nearly as possible. For example a 4- by 5-in press camera with 128-mm lens is roughly similar to a 35-mm camera with 50-mm lens. Most authors of historic landscape rephotography comment on this situation and recommend solutions. Rogers and others (1983) deal specifically with this problem and demonstrate that camera format is not critical; camera location and distance to featured objects are the critical factors. They discuss adjustment of print size to original prints and some problems with loss of items on the periphery of photographs; for example, some detail is lost when using a 35-mm camera format (a 2-to-3 ratio) to duplicate a 4- by 5-in format (a 2-to-2.5 ratio).

Film—Film, of course, also is different; one would hardly expect to use a wet plate glass negative in today's world. And even if an early camera is still in working condition, compatible films no longer are made.

Season and weather—The season and weather (lighting conditions, time of day, and air quality) are a third important consideration in long-term landscape rephotography. Many authors note that not all the original photographs could be used because of poor quality due to air conditions, deterioration, processing, or inadequate photographic technique. When a photo site was found, Johnson (1984) points out that “subsequently, one or more visits were made to the site to duplicate as closely as possible the light, time of day, and date of originals.”

These problems and conditions lead to rejection of many photographed landscapes as subjects for rephotography (Gruell 1980, 1983; Johnson 1984; Phillips and Shantz 1963; Progulske and Sowel 1974; Puchbauer and Carroll 1993; Skovlin and Thomas 1995).

Panoramic cameras—Panoramic cameras also have been used in landscape photography (Arnst 1985, Hanemann 1989). Hanemann describes the Osborn photo-recording transit, which is a unique camera once built in Portland, Oregon. The lens rotates through an arc of 120 degrees and focuses through a narrow slit onto a negative held in a semicircular position. This camera was used to rephotograph some of the scenes taken by Arnst (1985) in the Cascade Range of Oregon.

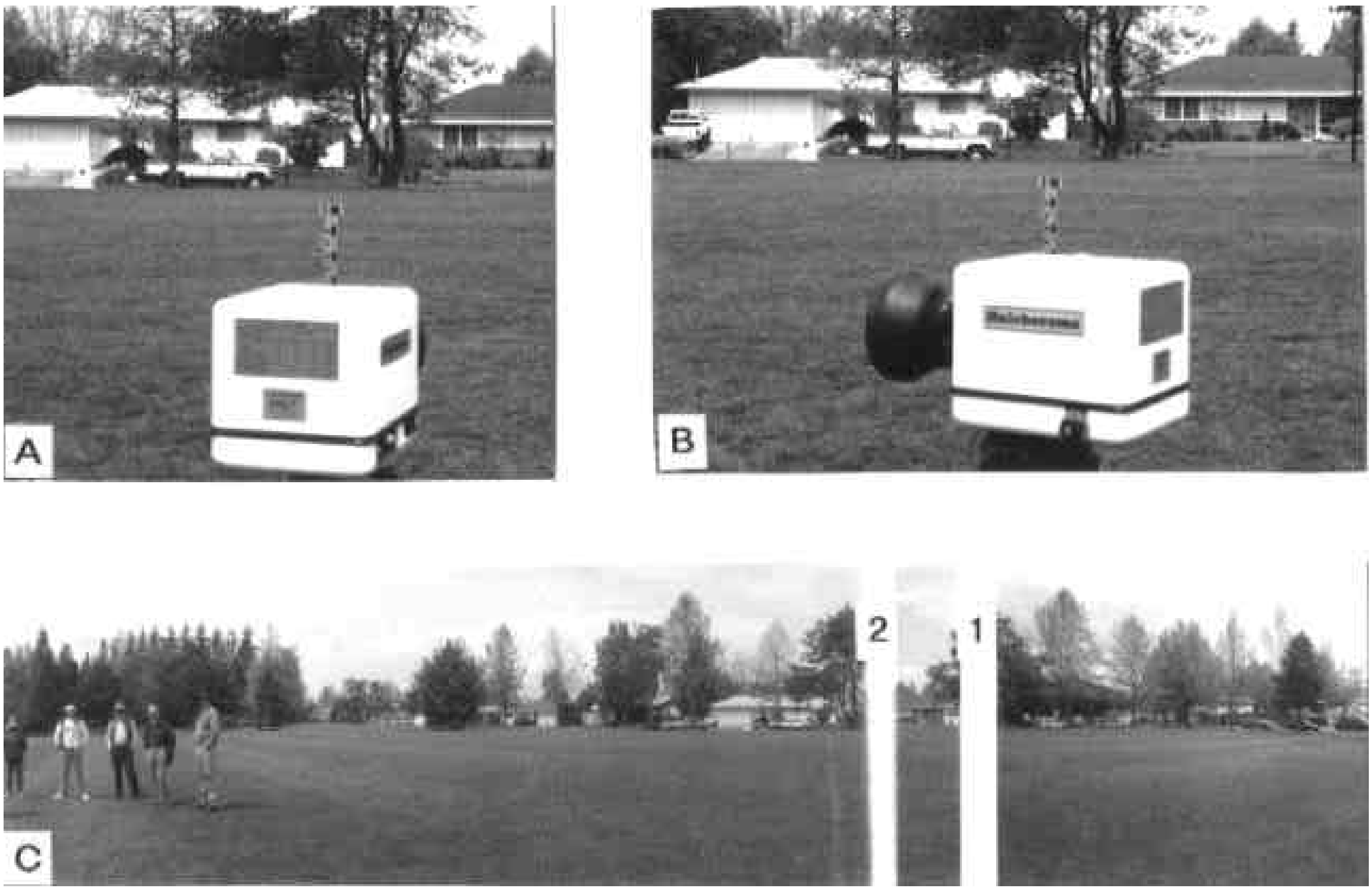


Figure 17—Panoramic photography using the rotating Hulcherama® Model 120 camera. The camera has no shutter. Instead, light is admitted through a vertical slit shown by the solid white bar (1) on the right in C. Amount of light is governed by a lens f-stop and by speed of camera rotation. (**A**) The camera begins its 360-degree rotation with the white line in C, then (**B**) continues past 360 degrees a few degrees to overlap the image. (**C**) Once started, the camera must continue to rotate at a specified speed. Should it be stopped, a fuzzy white strip will occur as shown by the white line (2) left of line (1) in C. A meter board has been used as a reference for the start of the rotation.

Today, panoramic cameras are built such that the camera itself rotates on a 360-degree arc while the film moves at the same rate of speed. The image passes through the lens and is constrained by a thin slit. The film rotates past the thin slit. An example is the Hulcherama® model 120 camera (Hulcher, n.d.; fig. 17).

Panoramic cameras have a singularly important requirement: they must be very accurately leveled so that rotation of the camera will photograph a constant horizon and this photograph can be retaken at a later date. Modern cameras can use both color and black-and-white film, commonly in 120 size, 12-exposure rolls. Exposure is determined by f-stop, slit width, and speed of camera rotation (Hulcher, n.d.).

Figure 18 illustrates problems using the meter board to orient general photographs instead of keeping a panoramic camera level. Camera location 1 at Pole Camp was chosen as the center of a 360-degree panoramic view of the area. Camera format was a 50-mm lens on a 35-mm camera body. The meter board was placed 10 m from the camera. For each successive photo, it was moved 8 m in a 10-m radius around the camera. On a flat flood plain, a meter board could be used to focus and orient the camera. However, camera orientation on the meter board in the stream of figure 18B lowered the view 1.3 m at the board, thereby causing displacement of the photos. Arrows point to a rock at top and a shrub in the center for orientation. An ideal panoramic view would have the camera level in all views to show changes in topography; thus the meter board would be lower in figure 18B and unusable for photo orientation.

Jensen and others (1999) used a camera rotated on a tripod similar to figure 17. In a test of observer variability, they found that 72 percent of the repeat photographs did not attain 20 percent overlap with originals. The causes were swapping cameras during rotation (to change film), thus causing misalignment of the view; inconsistent placement of the photo identification card, which should be placed at the same distance and location in the photo; and significant inconsistencies in exposure, which rendered some photos unacceptable for comparison because sun angle changed during 360 degrees of view.

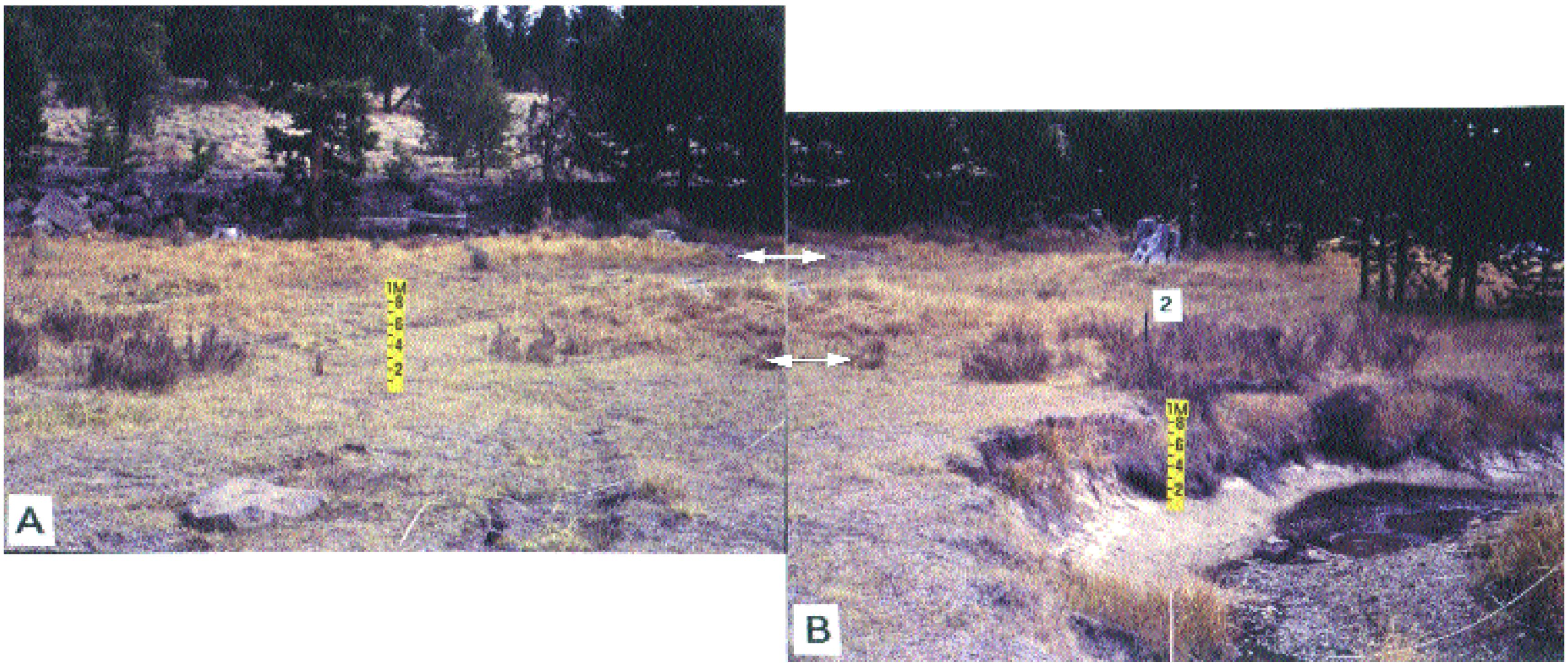


Figure 18—Two photographs of a 360-degree panoramic view of Pole Camp from camera location 1. The camera was focused on the “1M” of the meter board, similar to topic photographs, as a means for exact reorientation of subsequent pictures. As a result, view **B** is significantly displaced because the meter board is about 1.3 m lower than in view **A**. Overlap items are shown at arrows that cross from A to B. The number (2) identifies camera location 2. Above the (2) is the lodgepole pine witness stump. Figure 15 is a map of this site.

Figure 19—Mechanically triggered camera system used by Bull and others (1992) to monitor presence of marten (*Martes americana* Turton). Bait (arrow, lower right) was suspended on the tree to the right under a cover as one modification for winter operation. Camera was a 110 size with flashcube.

Remote Photo Monitoring

Remote photo monitoring uses unattended camera or video systems. Repeat photos are taken of a specific view, which may be a landscape (Fox and others 1987) or a specific activity such as a nest of ospreys (*Pandion haliaetus* Linn.) (Kristen and others 1996). Zielinski and Kucera (1995) deal with photo detection of animal presence in detail (fig. 19). Because remote photo monitoring is a topic unto itself, only a few examples will be presented.

Time-lapse systems have been described by Bryant,[4] [5] Bull and Meslow (1988), Fox and others (1987), Kinney and Clary (1998), Kristen and others (1996), and Temple (1972). They all used timing systems to trigger the camera at specified intervals ranging from fractions of a second to several hours. Movie cameras, 35-mm cameras, and video cameras were used. Bull and Meslow (1988) monitored pileated woodpecker (*Dryocopus pileatus* Linn.) chick feeding with a super 8-mm camera set to expose a frame every 8 to 12 seconds (Temple 1972).

Bryant (see footnote 4) used a time-lapse super 8-mm movie camera (Temple 1972) to monitor winter ice floods on Meadow Creek in eastern Oregon. The location was a research study site testing various livestock grazing effects on riparian ecosystems. The 45-minute flood lasted about 4 minutes at standard speed in a movie projector. Super 8-mm movie cameras have been replaced by camcorders.

---

[4] Personal communication. 1990. Larry D. Bryant,wildlife biologist, on Meadow Creek flood. USDAForest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, OR 97850-3368.

[5] Personal communication. 1990. Larry D. Bryant, wildlife biologist, on remote video camera. USDAForest Service, Pacific Northwest Research Station,1401 Gekeler Lane, La Grande, OR 97850-3368.

In another study (see footnote 5), Bryant used time-lapse remote video to document livestock use of riparian areas. He found that video “film” is less expensive than camera film, instant viewing and transmission were advantages, and cost of camcorders and deterioration of video film were disadvantages.

Kinney and Clary (1998) monitored livestock distribution patterns over several grazing seasons in meadows through repeat 35-mm camera photography. The camera took a picture every 20 minutes during daylight hours during a 15- to 20-day grazing period on three meadows over 2 to 4 years. Dry graminoid locations were preferred even though forage production was not the highest. They emphasized several things: The sun must be behind the camera for all exposures. The camera must be set to expose for the desired kind of vegetation; for example, on grass and not on the surrounding evergreen forest. And, animals are curious and often affect the camera location by pushing on it, which modifies the camera aim or destroys the installation.

Fox and others (1987) discussed monitoring of air quality with a 35-mm camera. Their equipment was a 35-mm camera body with a 135-mm lens, automatic winder, automatic exposure designed to be on only during the exposure (not continuously), an ultraviolet filter, a data back capable of imprinting the date and time, and a battery-powered programmable timer capable of triggering the camera at least three times per day in a housing for the complete system capable of standing alone and operating in temperatures from –34 to +54 °C while being unattended for at least 10 days. Their criteria state that the site must contain at least one horizon-visibility target with as many of these characteristics as possible: (1) large, (2) identifiable on a topographic map, (3) dark vegetation (such as conifers), (4) 32 to 80 km in distance, (5) two or three targets at various distances, (6) camera and target at about the same elevation, (7) target centered in the camera viewfinder, (8) site path not affected by local sources of air pollution, (9) target as free of snow in winter as possible for contrast, (10) exceptionally bright or dark foreground objects avoided, and (11) camera oriented to avoid sun on the lens for pictures taken any time during the day. They provide a diagram and a system for evaluating film by using microdensitometric analysis of color slides.

Kristen and others (1996) monitored osprey nest activity over a season by using a video camera set to expose one frame every six-tenths to one second. The images were then transmitted by a directional antenna to a receiving station up to 8 km distant and viewed on a monitor. The lapse in time could be adjusted at the monitor receiving station. A deep cycle battery supplemented by a solar panel supplied the power to the system.

Figure 20—Pole Camp “wet” sample location showing three dates of the same year. June 15 is before scheduled grazing, August 1 is at change in rotation pastures, and October 1 is after grazing. This pasture was rested from June 15 to August 1. October 1 illustrates the degree of livestock use of Kentucky bluegrass at the meter board, aquatic sedge behind the board, and willows in the distance.

CONTINUE

Site-Specific Repeat Photography

Site-specific means that a camera location and photo point or transect are permanently marked to document a specific topic on a limited tract of ground (not a landscape view) (Jensen and others 1999, Smith and Arno 1999). Directions and measured distances from witness site to camera locations and from camera to photo points or transects are required for precise relocation. For example, figure 20 is Pole Camp photo point "wet" (the wet meadow view). Topics were animal affects on willow shrubs (*Salix* spp.) and herbaceous stubble height remaining after grazing along the stream and adjacent meadow. A different kind of topic, planned disturbance and plant community development, is illustrated in figure 21.

Site-specific repeat photography may be divided into two kinds: topic and transect systems.

Topic Photographs

Topic photographs are shown in figures 20, 21, 22, and 23, where specific topics were monitored. This system uses a general photograph and may be supplemented by closeup photos of the meter board, a single plot frame (fig. 24), or overhead tree cover (fig. 25). Cole (1993) points out some limitations of topic photography when documenting damage to soils and vegetation from wilderness recreation. He indicates that measuring change from the photographs was difficult.

Transect identification using topic photography is used in the three-step method (Parker 1954, Parker and Harris 1959). In this method, Reppert and Francis (1973) could appraise species identification and their change in density and could verify correct replacement of the transect.

In British Columbia, Jensen and others (1999) applied topic photography to monitor recreational impacts, fuel loading, riparian vegetation and stream channels, disturbance recovery, and quantitative measurements of change in soil and vegetation. In an appraisal of observer variability, they found that a topic photopoint system could attain 80 to 100 percent overlap 95 times out of 100 (95-percent probability).

French and Mitchell (1983) used the single-topic approach to photograph change in shrubby vegetation in southern Idaho over 21 years. Pond (1971) evaluated an increase in chaparral (*Quercus* spp., *Ceanothus* spp., *Rhus* spp., *Arctostaphylos* spp.) for 47 years in an enclosure erected in 1920. Sharp and others (1990) show 40 years of change in a shadscale (*Atriplex confertifolia* (Torr. and Frem.) S. Wats.) stand in Idaho and correlate it with growing conditions to appraise effects of local weather on species dominance. In another study, Sharp and others (1992) document crested wheatgrass (*Agropyron desertorum* (Fisch. Ex Link) J. A. Schultes) production over 35 years and correlate it with growing conditions. Medina (1996) photo documented vegetation changes in the Santa Rita Experimental Range in southern Arizona at five locations: Burroweed (*Haplopappus tenuisectus*) increased and decreased with precipitation; jumping cholla (*Opuntia fulgida*) was absent in 1902, increased by the 1940s, then decreased; velvet mesquite (*Prosopis juliflora*) increased dramatically on mesic uplands but not on clayey, stony soils; and Lehman lovegrass (*Eragrostis lehmanniana*) increased and displaced many native species.

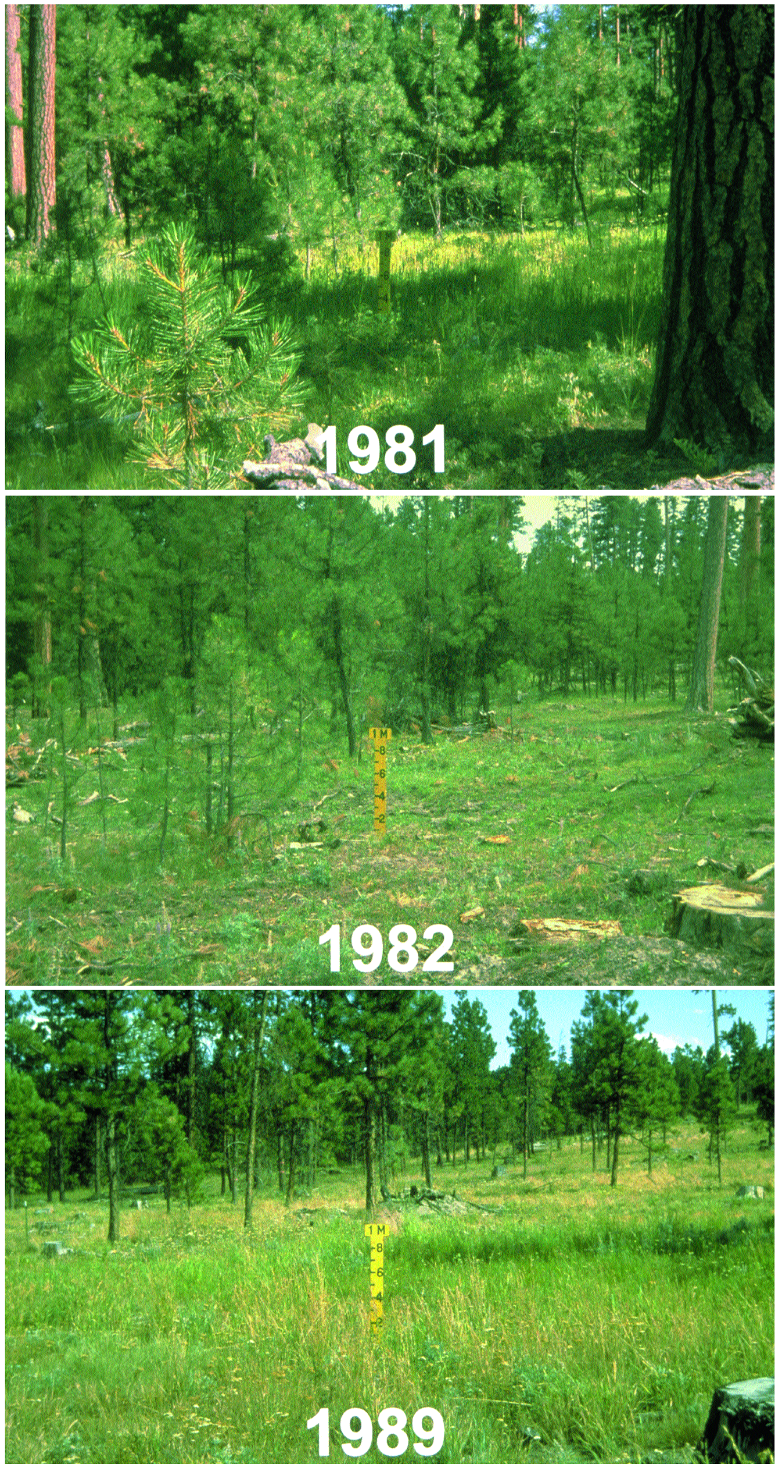


Figure 21—Aponderosa pine stand with pinegrass ground vegetation showing conditions after logging: undisturbed in 1981, after the first partial overstory removal in 1982, and in 1998 after the second overstory removal and precommercial thinning. These views, with their dramatic differences, emphasize the need for permanent marking of both camera locations and photo points. Exact reorientation of the picture uses the “1M” of the meter board as the photographic center (see fig. 29). All photographs were taken the first week of August.

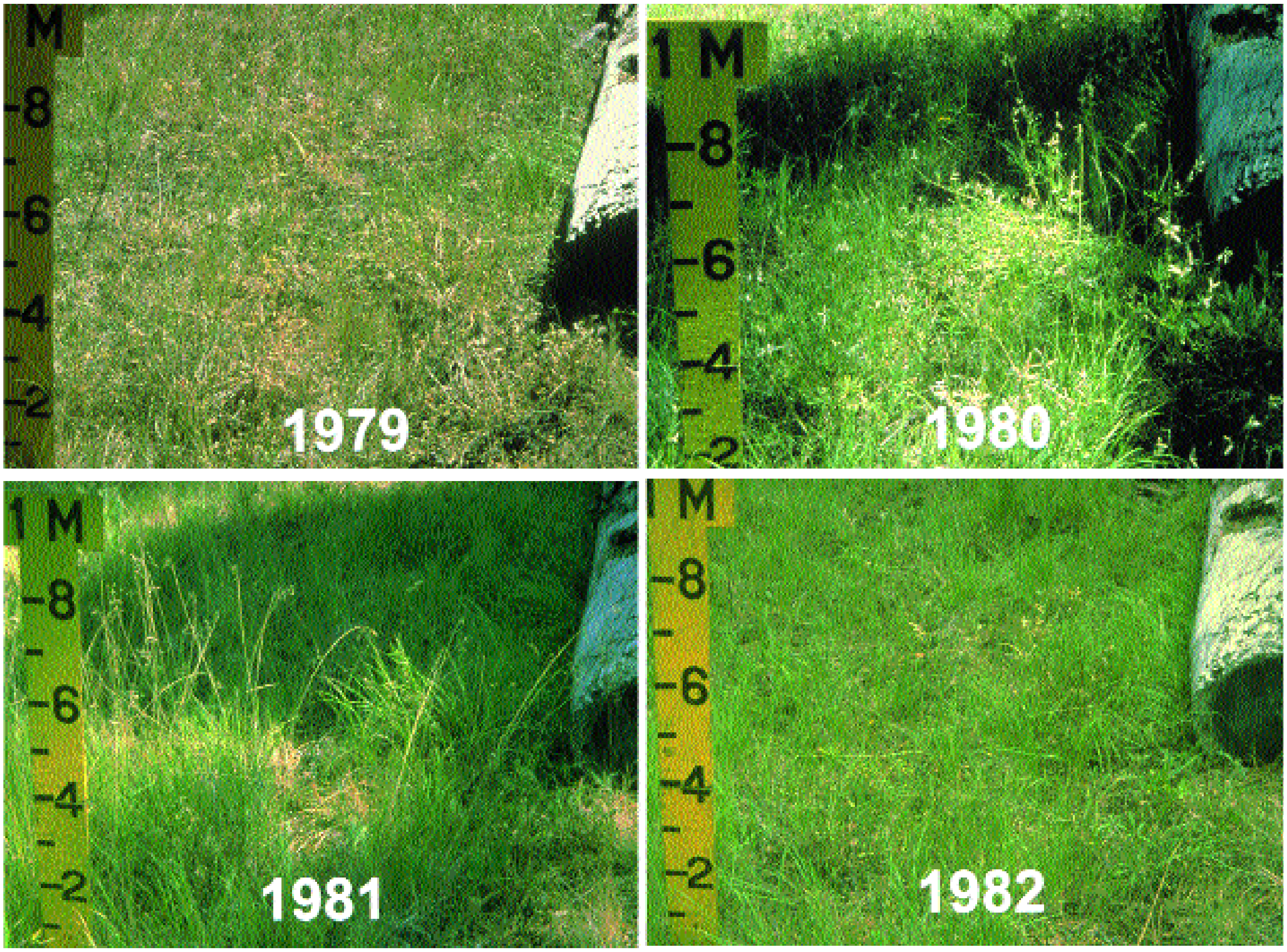


Figure 22—Photo monitoring each year at the same date (August 1) to document herbage production in a ponderosa pine stand with pinegrass. In 1979, drought occurred, which resulted in elk sedge (*Carex geyeri* Boott) dominance and only 400 lb of total herbage per acre. In 1980, lupine (*Lupinus caudatus* Kellog) was clearly important and pinegrass dominated over elk sedge with total herbage of 700 lb/acre. In 1981, Wheeler's bluegrass (*Poa nervosa* (Hook.) Vasey) was important, lupine was nearly absent, and pinegrass was common with total herbage of 750 lb, and in 1982, pinegrass was again clearly dominant without much bluegrass or lupine with total herbage about 600 lb/acre. Notice the lack of shadows under overcast skies in 1979 and 1982 compared to full sun in 1980 and 1981.

Effects on vegetation, soil, and streambanks from adjustment in livestock management are shown by Anderson and others (1990), Chaney and others (1991), Elmore and Beschta (1987), and Skovlin (1991). In Elk Creek, Oregon, a pair of repeat topic photographs was used to show riparian improvement (USDA Forest Service 1993).

Gary and Curry (1977) document changes in soil condition and erosion with a 40-year photographic record of plant recovery on an abused ponderosa pine watershed in Colorado. Skovlin (1991) shows changes in soil and vegetation on a forest zone bunchgrass type with a series of 1939, 1949, and 1989 photos that follow a shift in cattle grazing from season-long to deferred rotation.

Fire effects were followed by Lyon (1984), who presents 21 years of postfire change at the Sleeping Child burn, and Stickney (1986), who presents a similar series of photographs on succession for the first decade after the Sundance fire, both in northern Idaho. In another case, Lyon (1971) documented vegetation development

Figure 23—Streambank monitoring at the Pole Camp study site. In 1981 the camera location was 3 dm from the bank at a bend in the stream. An ice flood during early spring 1982 eroded the bend of the stream, increased its meander, and destroyed the camera location. In 1982, the camera was relocated 1.3 m to the left and 1 m back from the original location. The result was (1) apparent movement of the right bank, (2) the hole indicated by an arrow shows that only a portion of the bank fell into the stream, and (3) the angle between a rock in the stream bed and the camera to meter board was changed from 44 degrees to 39 degrees demonstrating the camera relocation. This kind of change in camera location or photo point should be avoided.

Figure 24—A1-m^2 plot frame marked at 2-dm intervals. Plot frames are quite useful in sparse vegetation such as the Crooked River National Grassland. The decimeter marks may be used to grid the plot frame (similar to fig. 28, below) to appraise vegetation change. However, riparian areas or other dense vegetation make plot frames questionable for photography, as suggested by figure 34.

after prescribed burning of Douglas-fir in south-central Idaho for 7 years; preburn and postburn vegetation was sampled, and photo points were established and recorded annually for the 7 years. His publication shows prefire vegetation and conditions 1, 3, and 7 years after burning. Blaisdell (1953) documented effects of prescribed burning on big sagebrush-wheatgrass. He shows one general two-photo series and a closeup six-photo series of before, immediately after, and 1, 2, 6, and 12 years after the burn. Johnson (1998) shows 5 years of response to fire by grassland and forest in eastern Oregon. The National Park Service (1992) provides detailed guides for documenting fire effects on vegetation.

Fire suppression effects in ponderosa pine stands are documented by Biswell (1963), Gruell and others (1982), and Weaver (1957, 1959). Smith and Arno (1999) provide repeat photos at 13 locations for an 88-year period. Gruell and others (1982) show 10 sets of repeat photographs of changes in ponderosa pine stands after logging and fire suppression. Shinn (1980) illustrates effects of fire suppression on western juniper (*Juniperus occidentalis* Hook.) sites.

Documentation of logging effects is shown in figure 21. In 1978, conditions were an undisturbed ponderosa pine overstory with pinegrass ground vegetation (*Calamagrostic rubescens* Buckl.) in the southern Blue Mountains of Oregon. The site was entered twice for selection cutting. The 1982 photo shows stand conditions after the first selection cut, and the 1988 one shows conditions after the second selection cut and precommercial thinning. Edgerton (1983) illustrates effects of logging on bitterbrush (*Purshia tridentata* (Pursh.) DC.) under lodgepole pine (*Pinus contorta* Doug. ex Laud.).

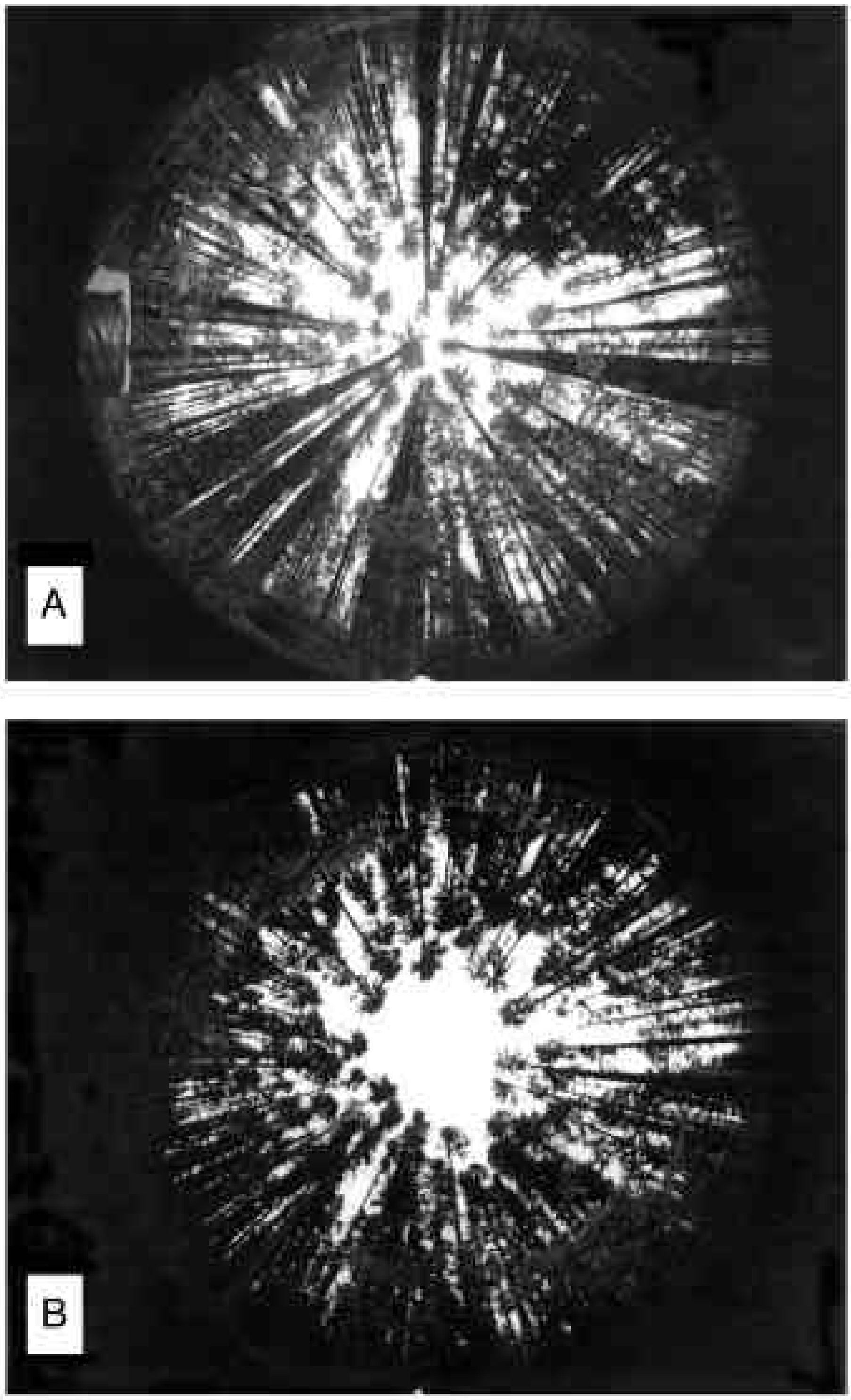


Figure 25—Photographs taken with a fisheye lens document change in forest canopy in a study of gap creation and effects on ground vegetation in 50-m-tall Douglas-fir (Easter and Spies 1993): (**A**) Canopy conditions before gap creation, and (**B**) canopy conditions after gap creation. Photographs cover a 180-degree vertical angle.

Another use of topic photo monitoring was documentation of harvester ant (*Pogonomyrmex owyheei* Cole) colonies over 9 years in southern Idaho (Porter and Jorgenson 1988).

In forested settings, tree cover often influences ground vegetation. Brown (1962) photographed tree canopy cover over a 180-degree arc using a special camera system. More recently, Chan and others (1986) applied electronic scanning and computer techniques to analysis of fisheye photographs under 50-m-tall Douglas-fir. Figure 25 illustrates use of fisheye photographs to monitor change in forest canopy following treatment to create small gaps (Easter and Spies 1993).

Topic photography does not have a fixed protocol similar to transect systems. Any topic that can be photographed is suitable; this is a very flexible concept.

Transect Photographs

Transect photo monitoring is a specialized activity dealt with in appendix A. Briefly, a general view of the transect is supplemented by closeup photographs taken of sample plots systematically along a line (fig. 25). Discussions are available in Bonham (1989), French and Mitchell (1983), Hall (1976), Lyon (1971), Nader and others (1995), National Park Service (1992), Owens and others (1985), Pierce and Eddleman (1970, 1973), Pond (1971), Ratliff and Westfall (1973), USDI Bureau of Land Management (1996), Wein and Rencz (1976), Wells (1971), and Wimbush and others (1967).

Winkworth and others (1962) supplemented their study of five measurement methods with systematic quadrant photographs taken from a stepladder. The photos gave an excellent representation of bunchgrass canopy coverage but were difficult to measure. Measurement required a simplification of the grass canopy outline, which introduced observer variability.

Transect photo monitoring may be summarized as follows:

1. Lay out the system and document it on a sitemap with directions and measured distances to camera locations and transect start and end (fig. 15).

2. Use the specified camera and focal length. Some recommend a 35-mm camera with a 28-mm lens. The 28-mm focal length will permit photographing a 1-m^2 plot with the camera held at eye level. Others recommend a 35-mm camera with 50-mm lens for small plots and oblique angles for larger plots (fig. 24).

3. Take two general photographs of the transect, one from each end, that include the photo identification form.

4. Use the required plot frame, such as 0.5 by 0.5 m or 1 by 1 m, placed at specified distances along the transect with a photo identification form (fig. 24).

5. To photograph and prevent shadows, stand on the north side of the plot frame, with toes touching the plot frame; make sure the photo identification form is visible.

6. Record data and information required by the system.

Figure 26—Landscape view of the Pole Camp riparian study flood plain. One problem with these landscape views is the lack of a fixed photo orientation spot, such as the meter board used in topic photographs (figs. 1, 20, 21, 23, and 28). Rephotographing the scene requires techniques similar to those shown in figure 17.

Pole Camp

Examples of site-specific repeat photography will use Pole Camp, a riparian meadow within a forested setting north of Burns, Oregon (fig. 26). In 1975 the cattle grazing system in Emigrant Creek watershed was changed from season-long use to a three-pasture, rest-rotation system wherein one pasture is spring grazed, a second is fall grazed, and a third is rested. This grazing is rotated over the following two years so that no pasture is used during the same time each year of a 3-year cycle. The purpose was to reduce livestock impacts on the riparian area and its stream. Monitoring was designed to appraise effectiveness of changed grazing. The five questions—why, where, what, when, and how—were addressed as follows.

Monitoring questions—*Why* to monitor dealt with the effectiveness of rest-rotation cattle grazing in improving riparian ecosystem function.

Where to monitor was determined by identifying critical or key livestock grazing areas. Pole Camp is one of three locations selected (figs. 14 and 26). Figure 14 is a road map locating the three areas, and figure 15 shows the Pole Camp monitoring layout.

What to monitor dealt with selecting specific sites at Pole Camp to record streambank stability (fig. 23), riparian shrub (*Salix* spp.) growth in height and crown width (fig. 20), herbaceous stubble height tall enough to trap sediments (fig. 20C), and herbaceous plant community stability, deterioration, or improvement (fig. 20).

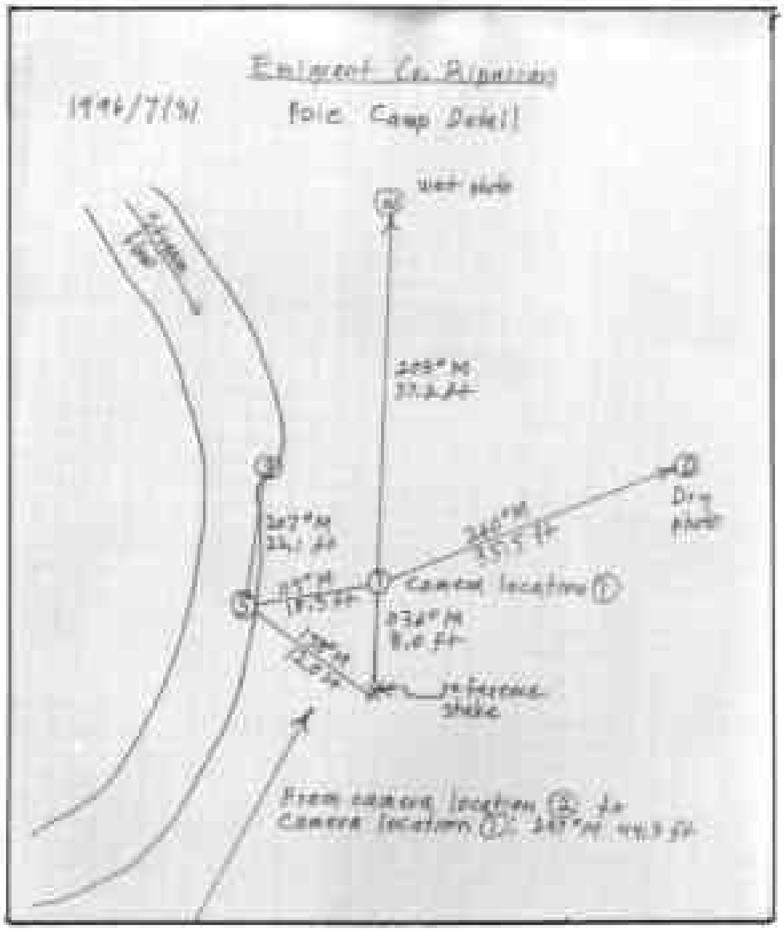


Figure 27—Triangulation location of the meter board (shown in figure 23) to document streambank erosion at Pole Camp. This map is the boxed area shown in figure 15. Any photo point or camera location in a tenuous spot should be referenced by two or more locator stakes.

When to monitor for livestock impacts was dictated by the grazing system, which required three monitoring times during the season: June 15 just before cattle grazing, August 1 as pastures were rotated, and October 1 after the grazing season ended (fig. 20). Pole Camp was used two years out of three: spring one year, fall another, and no use the third year.

How to monitor required developing a system of landscape, general, and closeup photos. A meter board in general photos is used for two closeup photos, one on each side of the board. A meter board generally was not used in the landscape pictures (fig. 26). An integral part of *how* was a map of the sampling layout (fig. 15) and any specific instructions, such as location of the instream meter board (fig. 23) shown in figure 27.

Exact Relocation

Exact relocation of photographs is one essential ingredient in site-specific photo monitoring (fig. 20). This is required if any comparison analysis of photographs is contemplated (Magill 1989, Rogers and others 1983; fig. 28 and app. A). Analysis entails comparing or overlaying photographs so change in the subject matter, usually vegetation, can be analyzed. Analysis may be through the use of grids as shown in figure 28 (Magill 1989 and app. A) or by use of digitizing (Cunningham and others 1996).

Exact realignment of general photographs is greatly facilitated by use of a target as shown in figures 20, 21, 28, 29, and 30. A meter board is recommended to mark the topic of interest, which usually is located in the center of the photograph. Place the meter board at a distance such that it will be 25 to 33 percent of the height of the photograph. Using a 35-mm camera with 50-mm lens, 10 m from the camera will produce 25-percent meter board height (fig. 2) and 7 m will produce 33 percent (fig. 2). This 7 m also will produce a 25-percent meter board height with a 35-mm camera lens (fig.4). Both the camera location and the meter board (photo point) are then permanently marked with fenceposts or steel stakes. The meter board is designed such that the numbers and letters can be read easily from a color slide or black-and-white photograph. Details of meter board construction are in appendix C.

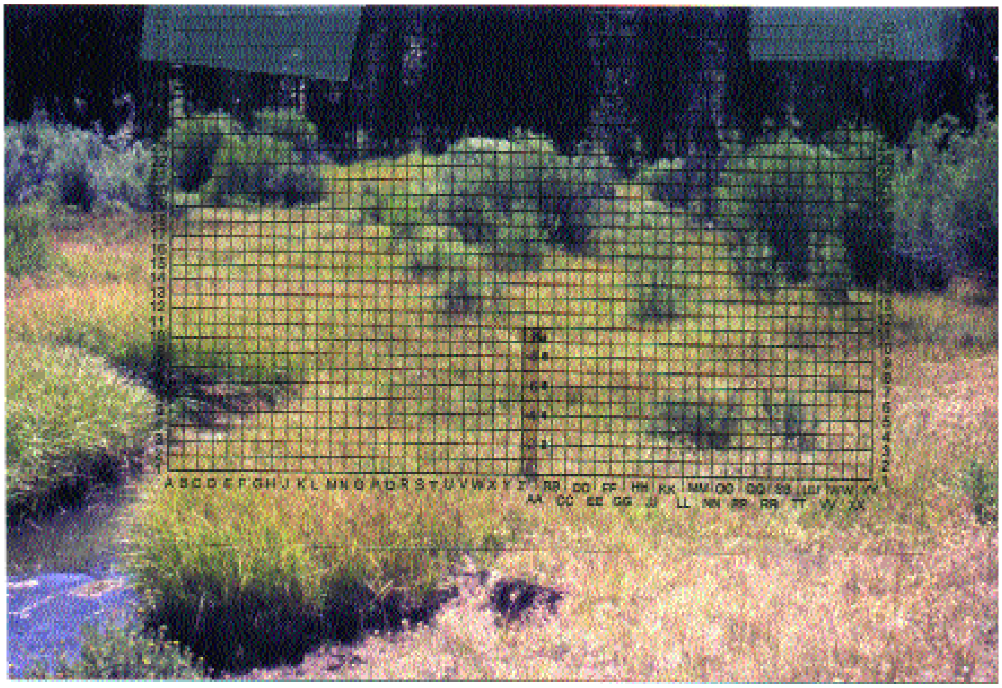
A successfully used alternative employs a target board 0.5 m wide and 2.5 m tall set 10 m from the camera. The board is painted black and white alternately every 0.5 m (Van Horn and Van Horn 1996). It was designed to document riparian rehabilitation efforts in herb and shrub vegetation.

Camera Techniques

General photographs—Consistent rephotography requires a reference point to orient subsequent views. The objective is to have the view remain constant while items within the view change. A meter board serves this purpose. Figure 29 illustrates three repeat photographs of a ponderosa pine-elk sedge community that was selectively cut; figure 29A illustrates how the camera focus ring is placed over the “1M.” This accomplishes two things: (1) it provides a common orientation point for the first and subsequent photographs, and (2) it provides a locus for focusing the camera for maximum depth of field. When the meter board is placed at the topic of interest, the topic should be in sharp focus. Figure 30 illustrates effects of various camera orientations.

The meter board also provides a size control for indexing a grid. A grid can be overlaid on the photograph as suggested by Magill (1989), depicted in figure 28, and discussed in appendix A. Grid analysis entails outlining each topic of interest and counting the number of grid intersects within the outline. Figure 30D shows sloppy installation of the meter board because the board is not vertical. Vertical orientation is essential if grid analysis is contemplated. Appendix C has construction plans for a meter board that include attaching a line or pocket level to the top so that the board can be oriented vertically.

Text continues on page 54.



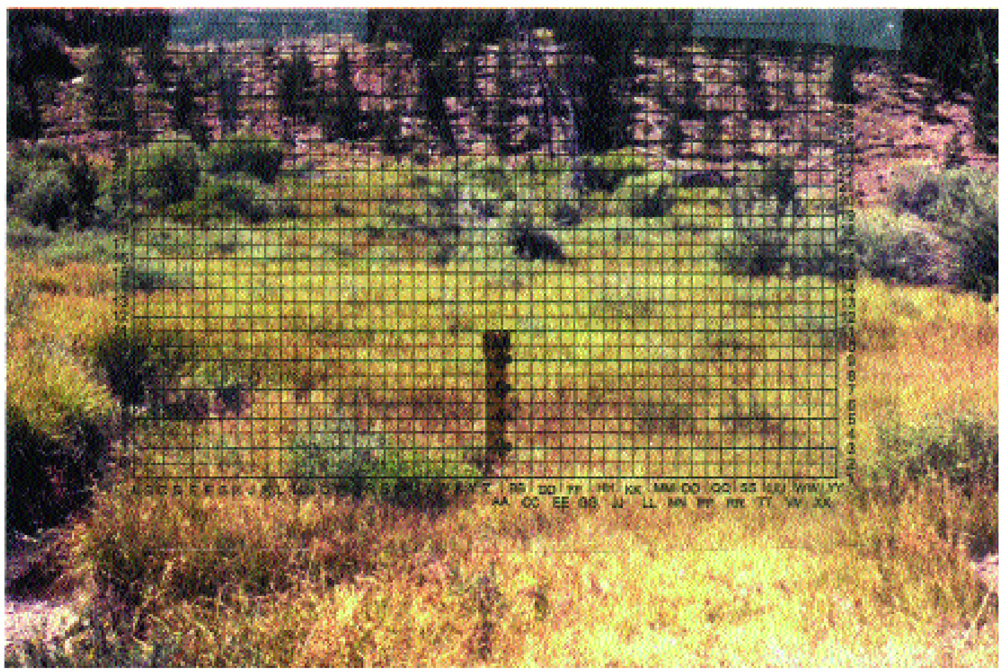


Figure 28—Grid intersect system used to outline and follow items with intersecting grid lines. This is Pole Camp wet (fig. 20) showing change in willow shrub profile area from 1981 to 1997 following 12 years of beaver (*Castor canadensis* Kuhl) utilization and high water tables caused by dams. In 1981, grid intersect U-13 identifies a young willow missing in 1997. Intersect RR-24 is at the top of a tall willow in 1981. The top is missing in 1997 owing to beaver cutting large stems for dam construction. Appendix Adiscusses grid analysis of photographs.

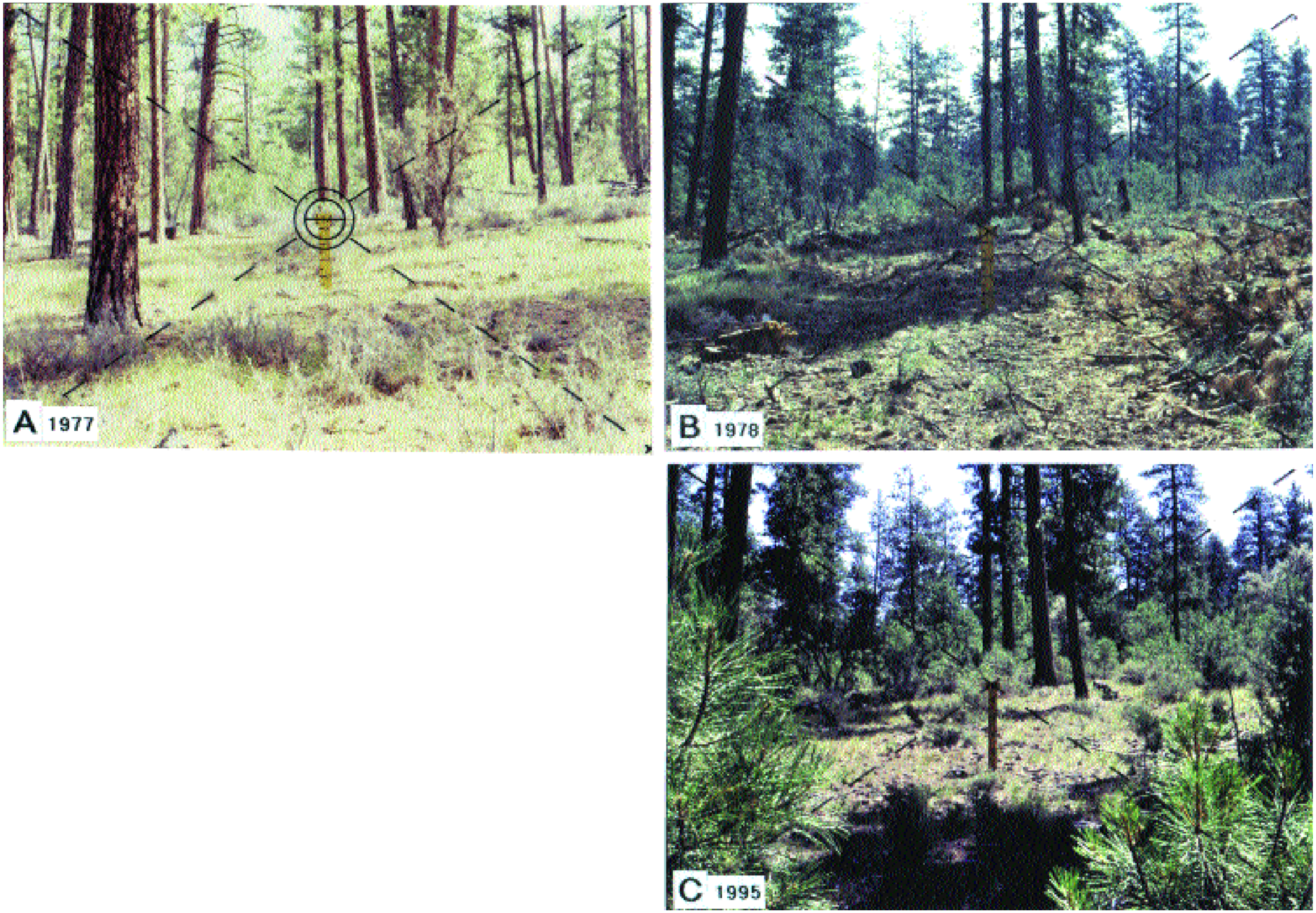


Figure 29—The meter board is used to aim the camera for consistent repeat photography. (**A**) Placement of the camera focus ring on the "1M", which puts the "1M" in the center of the picture (dashed lines). This orientation produces exact replication of repeat photographs as shown in B and C. The camera is focused on the "1M" placing it at the optimum sharpness for depth of field. With an f-stop of 8, everything in the picture will be in focus. This series is part of a study following logging effects on ground vegetation and stand structure (figs. 50 and 51): (**A**) 1977 just prior to a selection cut; (**B**) the summer after the cut and showing a two-turn skid trail crossing the meter board location; and (**C**) is 1995, 18 years later. Notice the color difference in A. The slide film was Anscrochrome compared to Ektachrome in B and C.

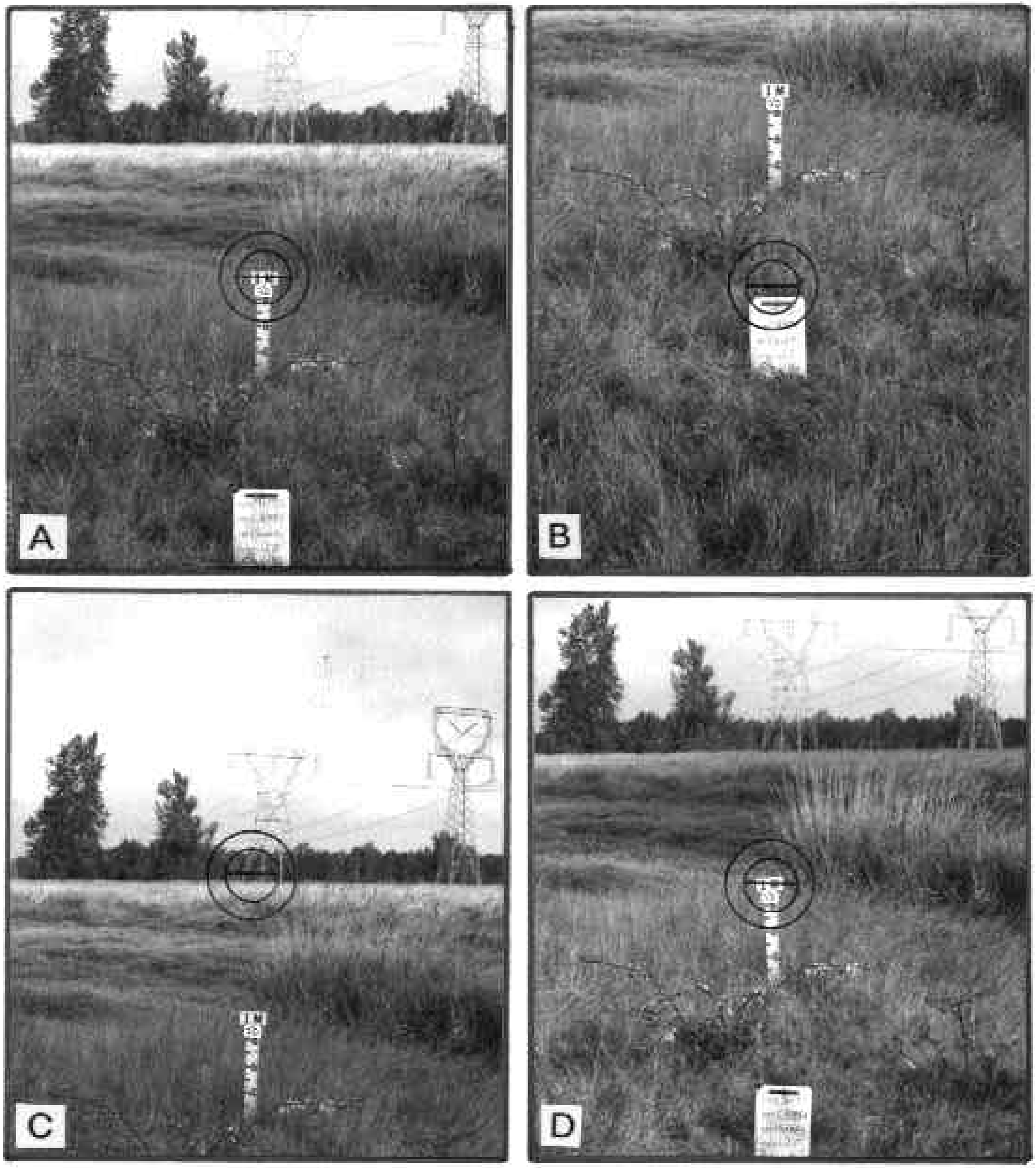


Figure 30—Photograph orientation using the camera focus system shown in **A** and placing it exactly on the “1M” of the meter board. (**B**) The focus is on the photograph identification sheet showing a maximum of ground vegetation. (**C**) The focus is on the distant horizon. (**D**) The meter board has not been set vertically, simply sloppy work. The tag on the meter board showing “2D” means this is photo point D at camera location 2. Five photo points are taken at this camera location. Notice the fadeout of the photo identification paper in B due to the light color. This will not happen with the medium blue shown in appendix C.

Use of double meter boards for identifying a topic of interest is illustrated in figure 31. The area is Lower Emigrant, one of three study areas on Emigrant Creek (fig. 14). When shrubs or other items exceed about 2 m in height, the double boards aid in following changes. Appendix C has plans for this double meter board, which folds in the center to provide a choice of either a 1-m or 2-m board.

Topic emphasis—Figure 32 illustrates four degrees of topic emphasis. A general topic, such as figure 21, may be represented by a 50-mm lens with meter board set at 14 m, a more limited topic is identified by the board set at 10 m, a closer view with the board set at 7 m, and a confined topic set at 5 m. The 5-m distance is recommended for shrub transect sampling discussed below.

Use of a 35-mm lens is illustrated in figure 33, a sagebrush-bunchgrass community. The meter board was placed 5, 7, and 10 m from the camera. The size of the meter board at these distances closely approximates a 50-mm lens at 7, 10, and 14 m, respectively.

Closeup photographs—Closeup photography is strongly recommended for topic monitoring locations. It is an integral part of transect systems. A view of ground conditions is taken with the meter board as a photo point locator and size control system. Figure 34 is a pair of closeup views from figure 20, Aug. ’76, showing characteristics of the wet meadow at Pole Camp. Accompany each photograph with notes on the vegetation.

Some people might prefer a square target on the ground (fig. 24). In sparse vegetation this is satisfactory, but it may not be a suitable system in riparian areas such as that in figure 35. Figure 35A was taken 1 month after cows were removed, and figure 35B shows the same area 3 months later. The 4-dm-tall vegetation would completely obscure any kind of plot frame laid on the ground.

Figure 35 also illustrates the importance of standing 2 m away from the meter board and placing the “1M” of the meter board in the upper corners of photographs. In figure 35A, the bottom of the meter board can be determined whereas in figure 35B it cannot be seen. The entire meter board must fit in the frame if analysis of the images is to be possible. In figure 35C, the “1M” of the meter board is down almost 2 dm from the top of the frame; the bottom of the meter board, therefore is 2 dm below the bottom of the photograph, which makes accurate comparison between figures 35A and 35C difficult.

This concept of precise relocation of photo images can best be illustrated by use of lap dissolve 35-mm projection equipment. The objective is to hold the meter board absolutely still on the screen and show the vegetation change as each photograph is dissolved onto another.

Text continues on page 60.

CONTINUE

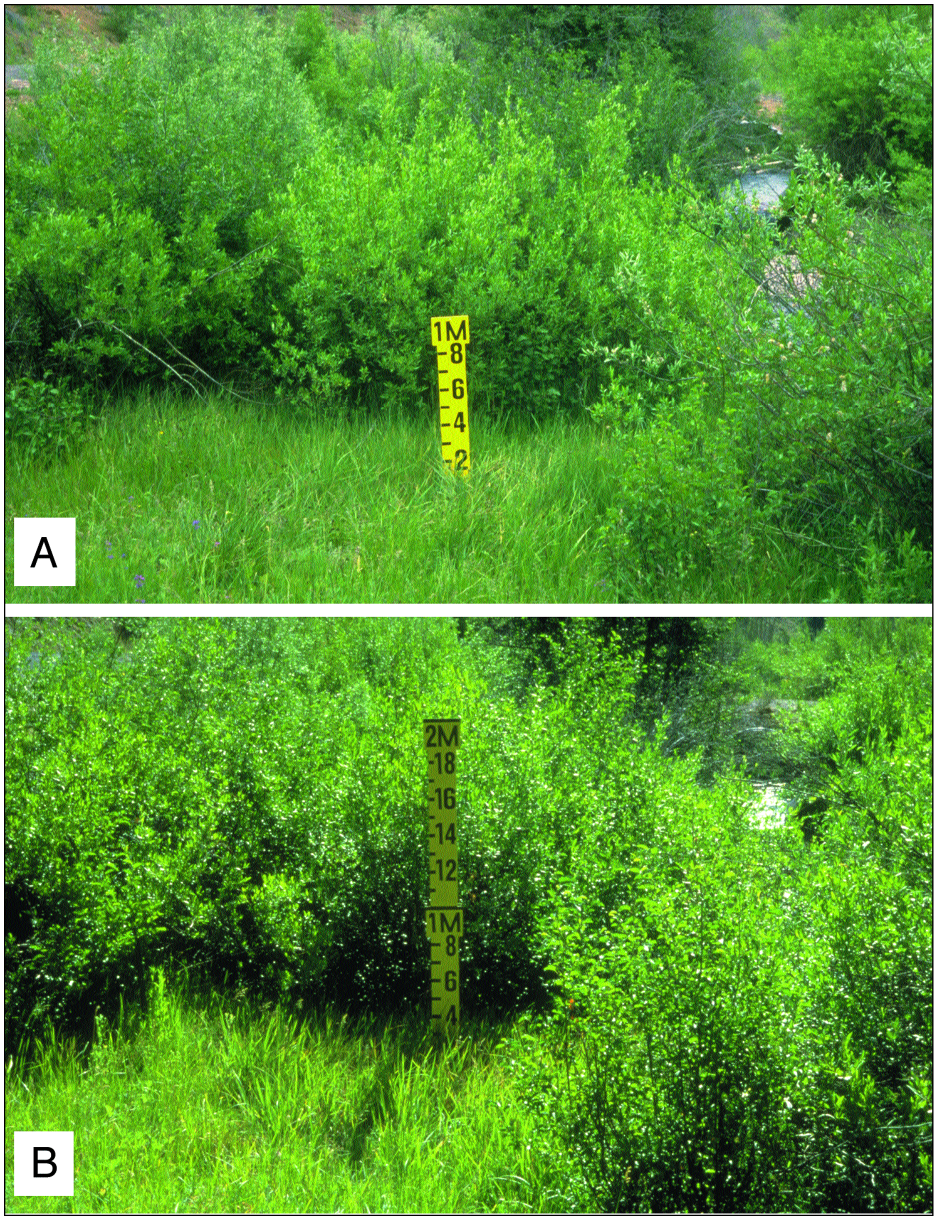


Figure 31—Use of double meter boards for topic identification (in this case, impacts on willows from grazing livestock) and monitoring: (**A**) a single meter board's effectiveness in appraising shrub impacts, and (**B**) a better system for documenting shrub reaction to grazing. The camera is focused on the “1M” for consistent photo orientation.

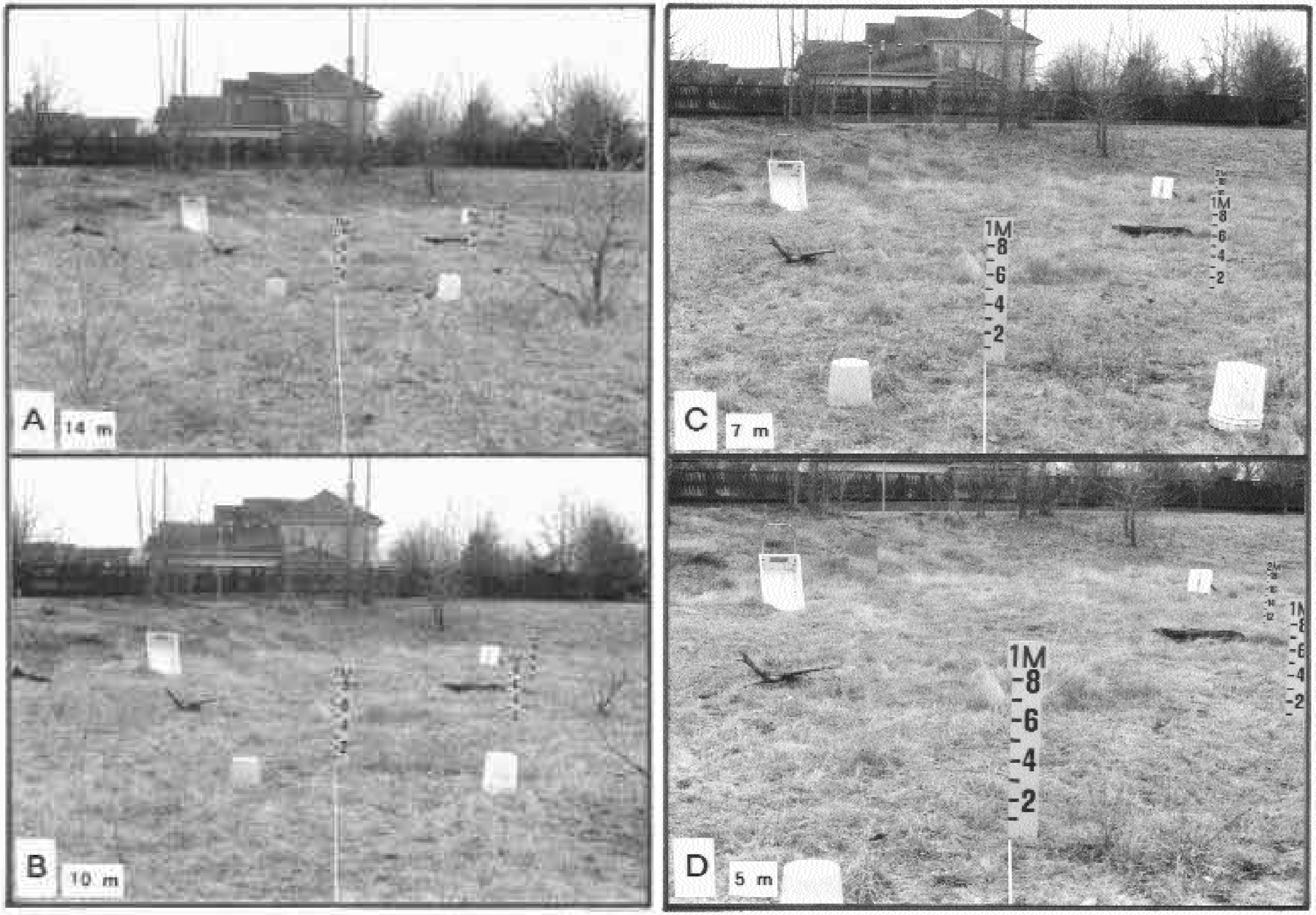


Figure 32—Emphasis on topic identification is shown by distance from camera to meter board using a 50-mm lens on a 35-mm camera: (**A**) 14 m from the camera illustrating a close landscape view, (**B**) 10 m from the camera (a distance I have used as a standard), (**C**) 7 m from the camera emphasizing a rather specific topic, and (**D**) 5 m from the camera (a distance recommended for individual shrub analysis). Size and nature of the topic being monitored determine distance from camera to photo point. This scene is a testing layout where distances from the camera to meter board were evaluated, camera focal lengths were tested, and combinations of focal length and distance were compared (figs. 1-10).

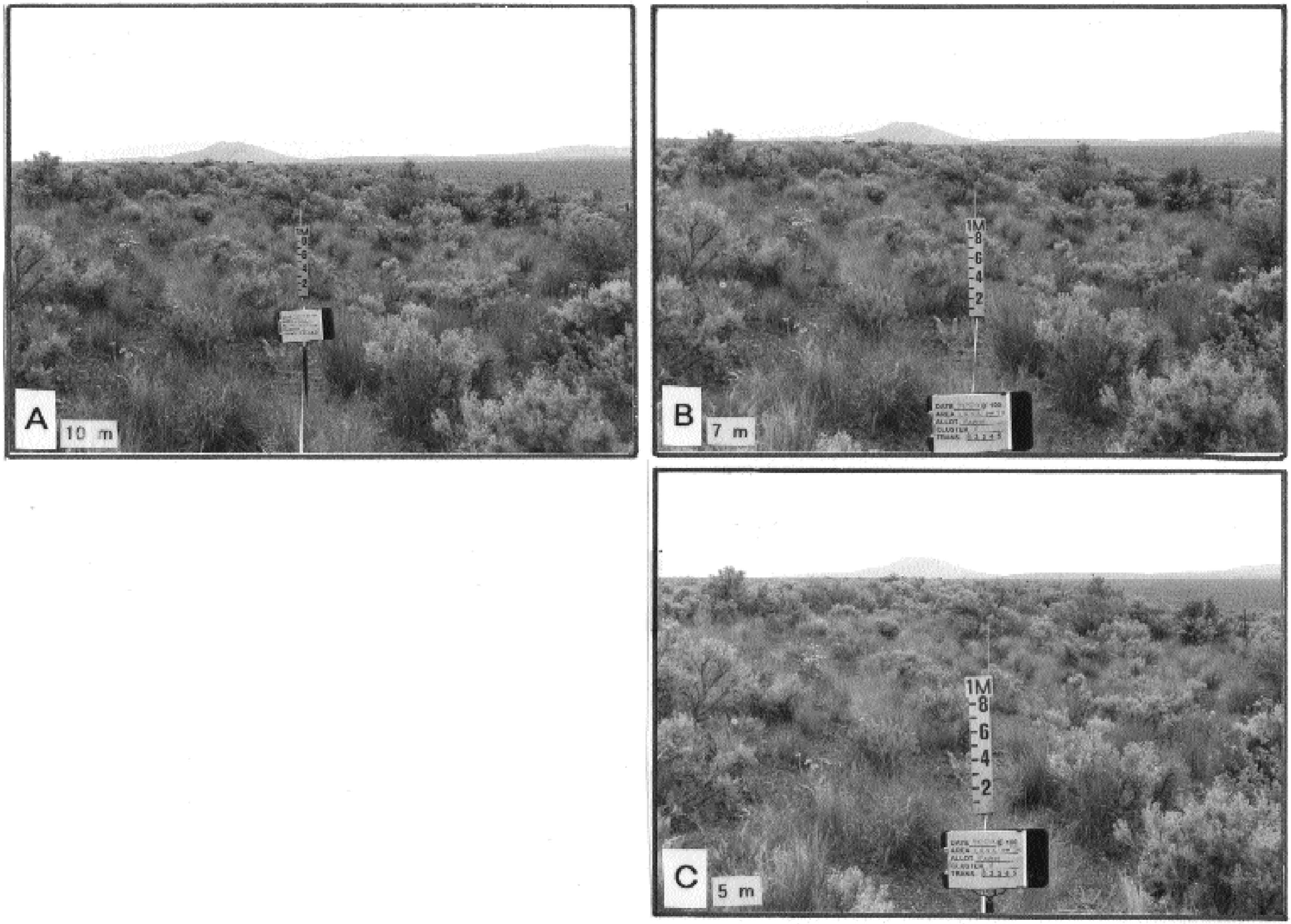


Figure 33—Evaluation of a 35-mm lens on a 35-mm camera for placement of a meter board to emphasize a topic. This is a transect in the Crooked River National Grassland in eastern Oregon. (**A**) Placement of the meter board 10 m from the camera. It is essentially the same as the 14-m distance with a 50-mm lens (fig. 32A). (**B**) A distance of 7 m, essentially similar to 10 m and using a 50-mm lens (fig. 32B). (**C**) Distance of 5 m, equivalent to 7 m with a 50-mm lens (fig. 32C). Comparison between figure 32 and this figure suggest advantages of pocket-size, quality 35-mm focal length cameras.

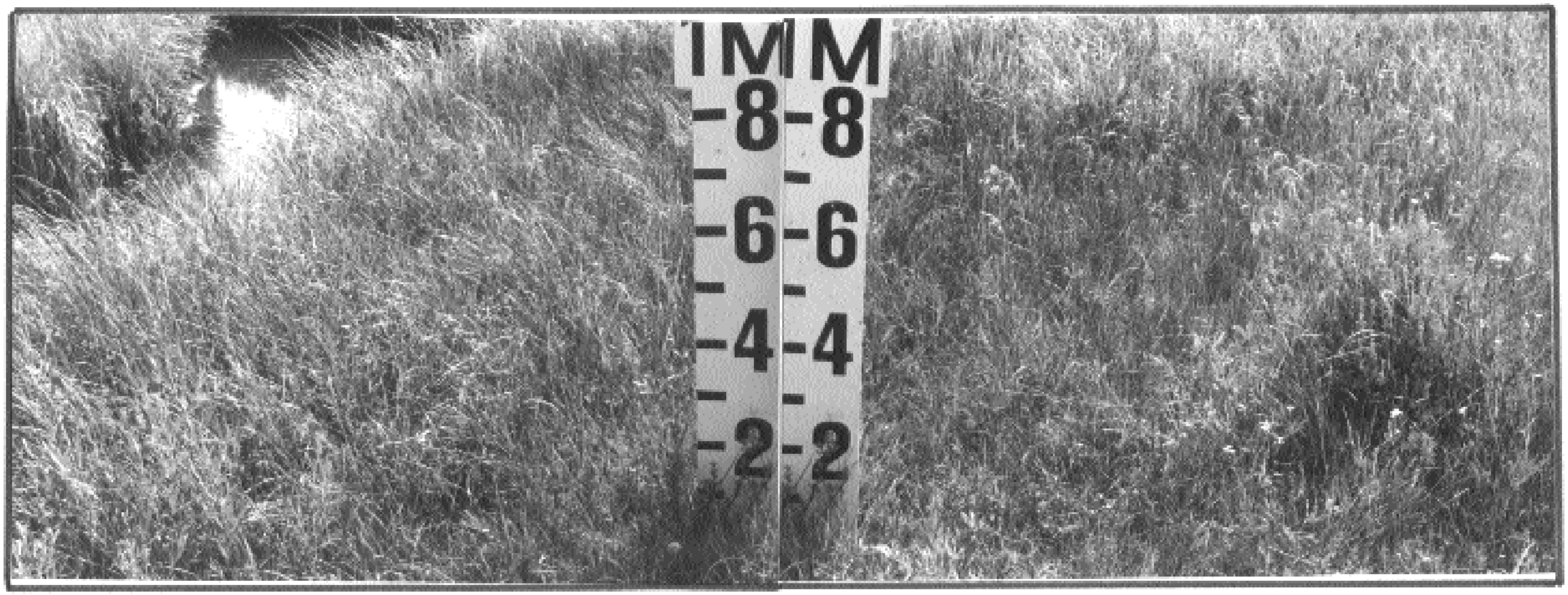


Figure 34—Technique for documenting ground vegetation using the meter board. Take one picture to the left and one to the right, keeping the meter board at the edge of the photograph. Stand 2 m from the board. Tilt the camera slightly off horizontal to make the meter board parallel with the side of the photograph. Place the “1M” top of the board in the upper corner of the view. The 2-m distance, using a 50-mm lens on a 35-mm camera, will assure that the bottom of the board is in the lower corner of the picture. When mounting the pictures, I overlap the meter boards so only one is showing. Set the camera to 3 m, which will put vegetation in focus from the bottom of the meter board to a distance of at least 2 m beyond the board. These are closeup views of figure 20, Aug. ’76.

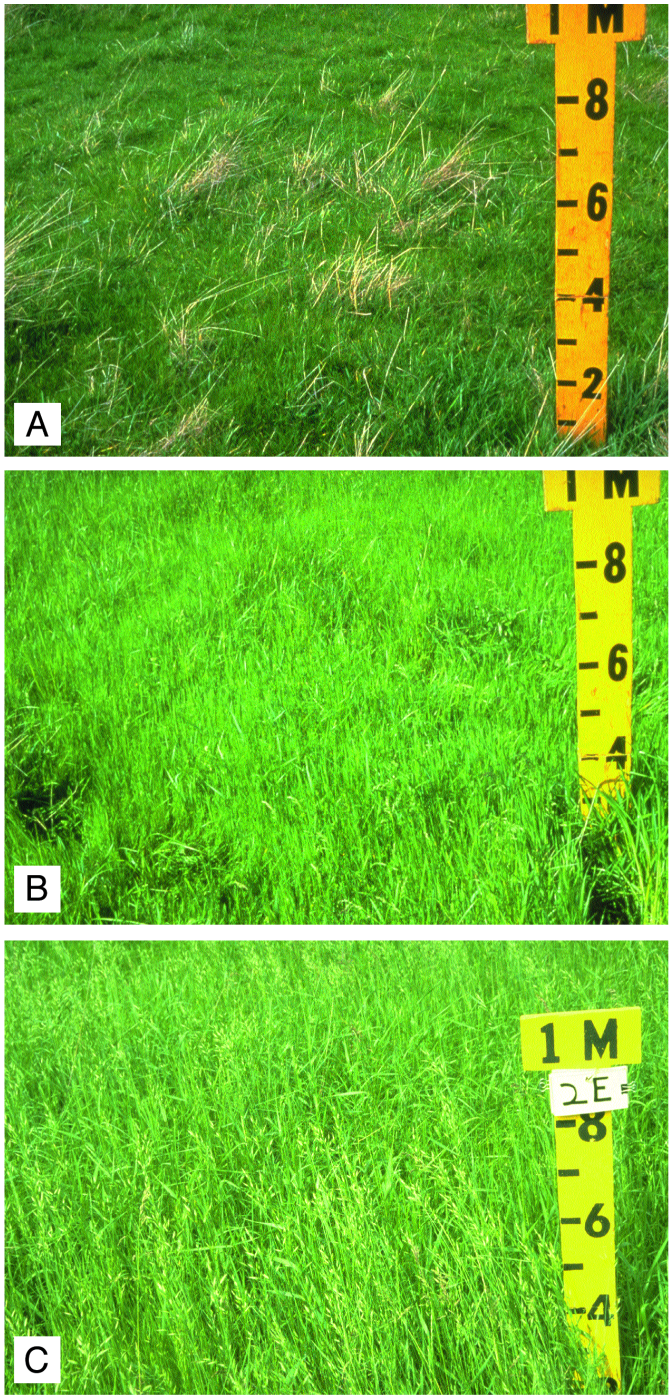


Figure 35—Riparian vegetation sampling on the Sandy Delta, south bank of the Columbia River, east of Portland, Oregon. Aplot frame would be appropriate in photograph **A** with the 1-dm stubble height, which also permits visual estimation of the bottom of the meter board. The plot frame would not be visible in **B** or **C**. Exact reorientation of the photograph is essential: (1) The "1M" must be in the top corner of the view, (2) the bottom of the board must be in the lower corner, (3) the photograph must be taken from 2 m with a 50-mm lens on a 35-mm camera, and (4) the camera must be tilted slightly off horizontal to make the board parallel with the side of the view frame. In B, just 3 months later, grass is over 4 dm tall and effectively hiding the bottom of the meter board and any plot frame that might have been used. Problems with tall vegetation and exact photograph reorientation are shown in C, where the "1M" was not placed in the top corner of the view frame. Instead it is about 2 dm below the corner meaning the bottom of the board is about 2 dm below the bottom of the picture, an unacceptable rephotograph.

Photo Point Location

Photo point identifies the topic to be monitored (fig. 23); thus, it determines the camera location. One important factor is relocation of the meter board to orient later rephotography. In figure 27, the meter board was placed 10.3 ft from permanently marked camera location 1. The direction from the camera location to meter board was 115 degrees magnetic. The meter board location was marked with a fencepost, which severe flooding could remove; distance and direction to the meter board from a permanent location therefore are essential. The most foolproof method is a triangulation system using two permanent markers (fig. 27). The direction and distance from each marker are recorded. This triangulation method can replace the meter board within a decimeter of its original location. A diagram of the monitoring system should be part of the site map (fig. 15).

Camera Location

Selection of a camera location is determined by position of the topic (photo point) to be monitored. Consider how the distance from the camera to the meter board will influence topic emphasis (figs. 32 and 33). Both distance and photo point position are used to locate the camera for best documentation. Consider locating the camera where it will serve more than one photo point. This accomplishes three things: (1) efficiency is increased by using several photo points from a camera location, (2) the photo monitoring system is easier to relocate when one camera location will also locate two or more photo points, and (3) more information is obtained from the specific site being monitored.

Figure 35 shows “2E” on a meter board, meaning the fifth photo point at camera location 2. Using more than one photo point means careful location of the camera because it must be placed in a position to adequately depict several conditions specified in the monitoring objectives (appendix D). If a distance of about 10 m from camera to photo point is used, orient the camera location using a 10-m radius to encompass as many topics of interest as possible. The same distance from camera to photo point need not be the same for every photo point; for example, 8 m to photo point A, 10 m to B, and 12 m to C. However, the same distance to each photo point must be used for all subsequent photos: 8 m to A, 10 m to B, and 12 m to C.

Vegetation close to the camera location is another important consideration. Most authors who have rephotographed landscapes report vegetation grew up between the camera location and photo point, which obscured the view and rendered the rephotograph worthless. In many cases, the camera was moved to an unobstructed view (fig. 36).

Figure 26 illustrates a limited landscape photograph. The primary difference between this and a general site-specific view is the lack of a meter board for centering the camera view. Often, landscape views of an area must be reoriented in a manner similar to long-distance landscapes (fig. 16).

The need to map and stake both camera location and photo point is illustrated in figure 21. Treatment of the ponderosa pine-pinegrass community was so dramatic that relocation of photography without a map and permanent markings would be nearly impossible. Here stakes driven flush with the ground were relocated by use of a metal detector. Following treatment, fenceposts were placed at the stakes for easy relocation.

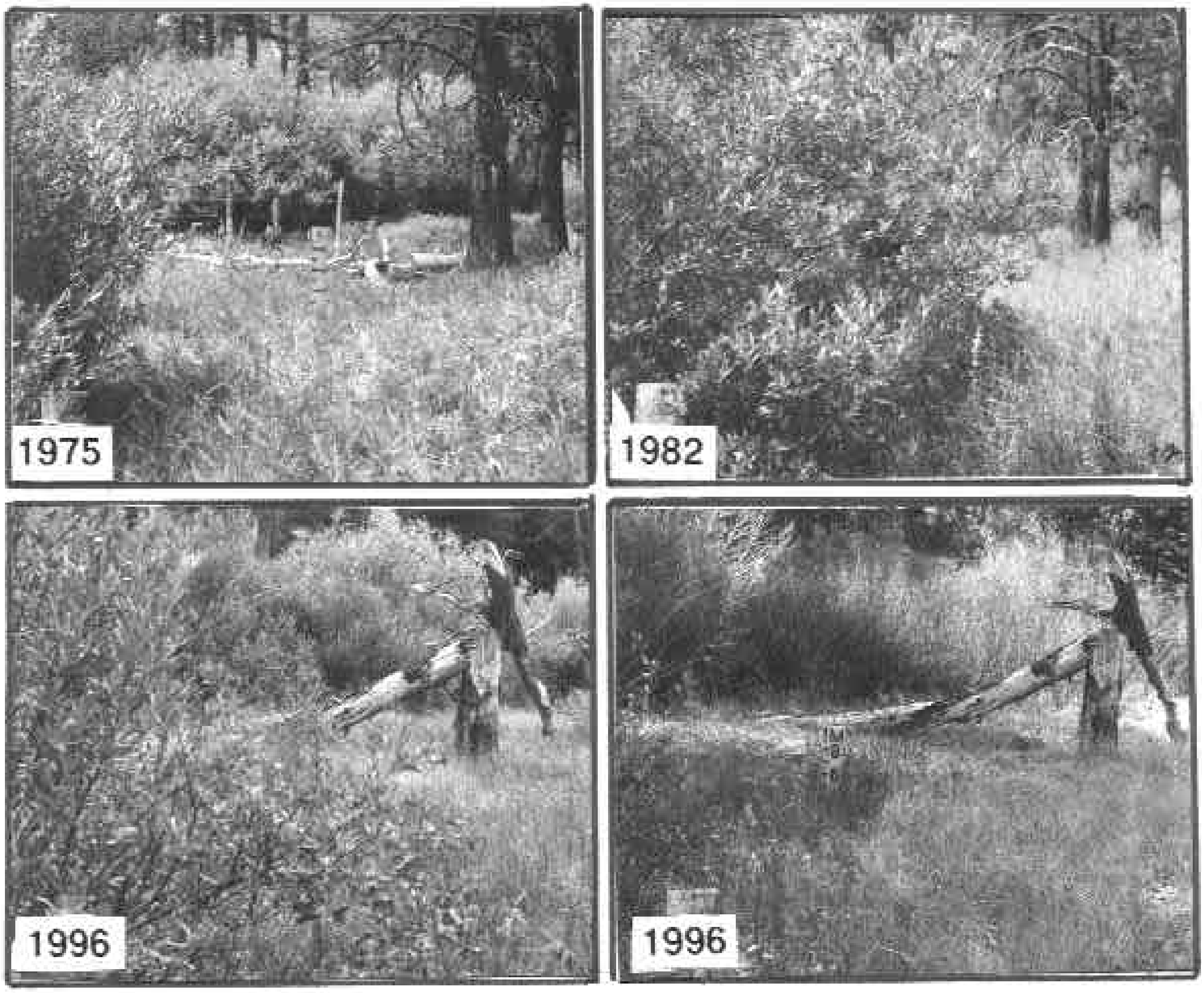


Figure 36—Effect of intervening vegetation between the camera and photo point. In 1975, the meter board was in full view at the start of the study to appraise effects of livestock on willow growth. By 1982, willows had grown between the camera and meter board requiring a change in the camera location. It was moved 1 m to the right. By 1996, willows had again obstructed the view so the camera location was moved 3 more meters to the right, a total of 4 m. This was a very poor camera location. Avoid locations where woody vegetation will obstruct the view and render future photographs difficult to interpret.

Riparian Areas

Riparian areas pose some particular problems in regard to camera location and photo points. Figure 23 documents streambank stability at Pole Camp. Figure 23A was the original camera location and photo point; however, the camera location was placed 2 dm from the bank. A winter ice episode eroded the bank, increased stream sinuosity, and destroyed the camera location. The camera had to be moved 1.2 m to the left and 1 m back from its original location. This resulted in a different view, as shown in figure 23B, which suggests that the streambank had moved 0.7 to 0.9 m to the right. But it had not moved to the right; the apparent movement was caused by a change in camera location—a situation to avoid.

Riparian areas provide other challenges, particularly after floods. Deposition of silt is a valuable topic to document. Consider, when installing photo monitoring, pounding the fenceposts down to exactly the height of the meter board. When silt is deposited, the height of the meter board above the fencepost will be a measure of silt deposition.

Floods have other influences. Fenceposts may be torn out, thereby eliminating the photo point or camera location. Thus, documentation of fencepost position is essential (Governor's Watershed Enhancement Board 1993). Figure 27 illustrates a triangulation method for replacing washed out fenceposts.

Relocation of Repeat Photography

Finding existing camera locations and photo points, whether landscape or site-specific, is sometimes difficult. Following are some suggestions for relocation.

Idiosyncrasies With Compass Directions

In the Pacific Northwest, there is a 21-degree deviation from magnetic north. This can result in problems of two kinds:

1. The compass heading written on the map or layout instructions should be labeled as either true or magnetic. If it is a true heading, was the 21-degree deviation added or subtracted from the magnetic heading?

2. When searching for the camera location or photo point, be prepared to try four different headings.

   A. Follow the heading and distance given. If the camera or photo point cannot be relocated, then . . .

   B. Subtract 21 degrees from the recorded heading and look. If the locations still are not found, then . . .

   C. Add 21 degrees to the given heading and follow that direction. If the camera location or photo point still has not been determined, presume that direction from the witness site to the camera location or photo point is reversed. In other words, a heading was taken from the photo point back to the camera location or camera location back to the witness site and recorded. Therefore . . .

   D. Add 180 degrees to the compass heading and proceed with (A) through (C), above. This system has produced results for me 95 percent of the time.

Field Book for Rephotography

A photo-monitoring field book is recommended for carrying the original and some intervening photographs into the field. If different people did previous photographs, you may discover some disorientation of subsequent views. For that reason, a copy of the original photograph is very important. Rephotograph the original and not the misoriented intervening photographs.

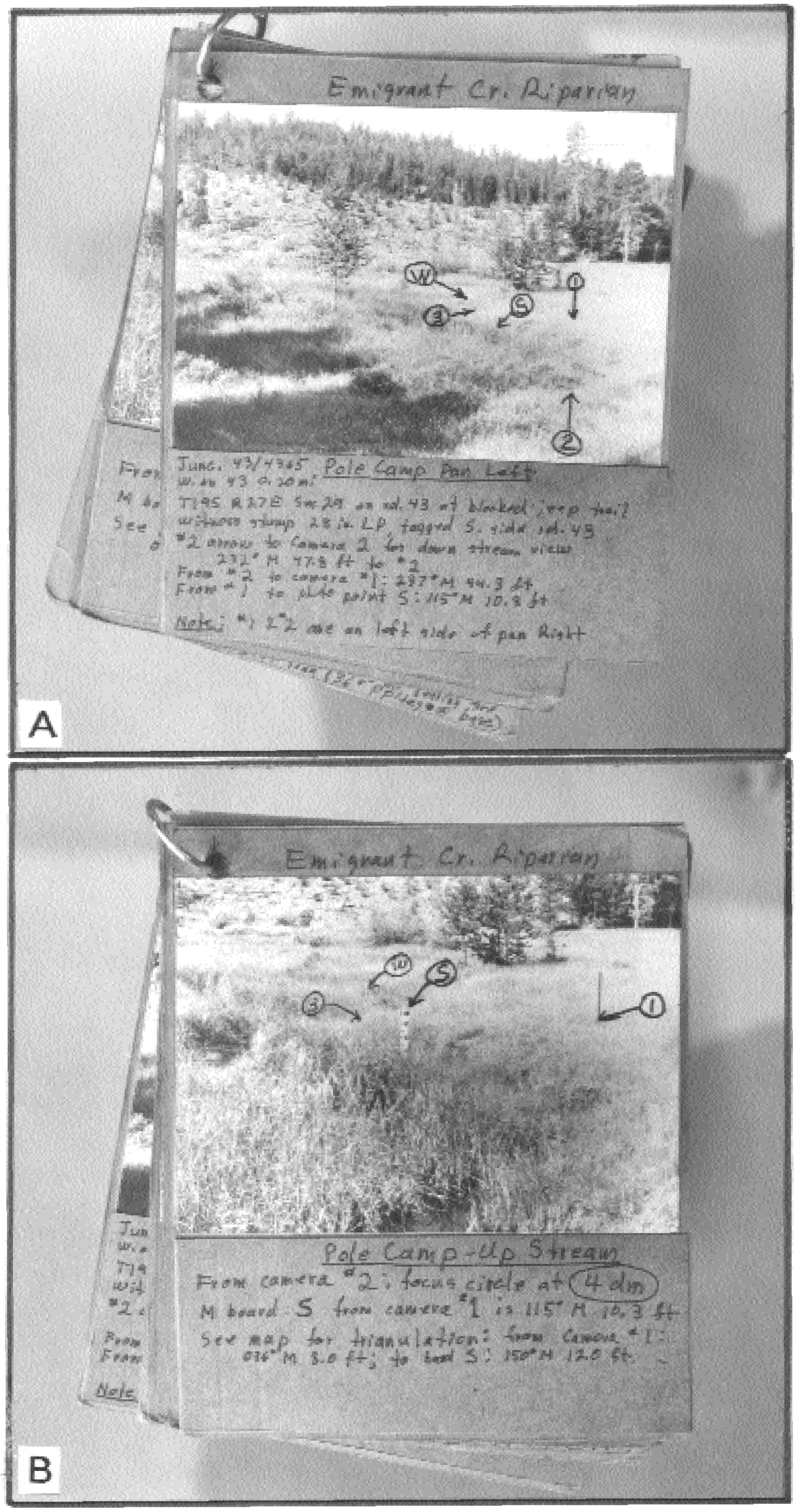


Figure 37—The author’s system for finding camera locations and photo points. It is a pocket-sized set of photographs and directions mounted on cardboard (file separator thickness). (**A**) A left landscape view of the sampling area at Pole Camp; the right view is figure 26. A also locates camera locations 1 and 2. Camera location 1 has two photo points: D is Pole Camp dry and W is Pole Camp wet (fig. 20). (**B**) The upstream photo point taken from camera location 2 to S and illustrated in figure 23. Maps of this area are shown in figures 14, 15, and 27.

A system I devised is shown in figure 37 for the Pole Camp example. Figure 37A is a landscape view of the Pole Camp flood plain with camera locations and some photo points identified. It locates the left of two flood-plain scenes; the right is shown in figure 26. Both are mapped in figure 15. Figure 37B is a general view from camera location 2 to photo point S on the streambank, the scene in figure 23.

The pocket-size booklet has a picture of each camera location and photo point complete with directions from the witness site to camera location and orientation of the photo point. Cheap 5-ft fenceposts driven 2 ft into the ground are used to mark both camera locations and photo points.

Once at the area, review the photographs for changes in vegetation. Next, note the number of years since the last photograph, particularly if it was taken more than 3 years previously. The purpose is to evaluate changes in the vegetation that might make previous photographs difficult to interpret (figs. 21, 23, 36, and 38; app. E).

If camera locations and photo points are not marked, align items in the photographs as depicted in figures 16 and 38 and appendix E. Start in the center of the photograph to orient the direction of the picture as shown by line 1 (fig. 38). Then, orient items on the sides of the picture, shown by arrows 2 and 3, to triangulate the camera location. Move forward or back along the line to establish the distances shown at 2 and 3. This is the camera location and photo point direction. Mark them with fenceposts and add a meter board (photo point) location.

Multiple-Camera System

When both color and black-and-white photographs are to be taken, consider the camera system shown in figure 39. One camera is for black-and-white, the other for color. The cameras are the same make and model to simplify adjustment for lighting and distance. Appendix C has construction details.

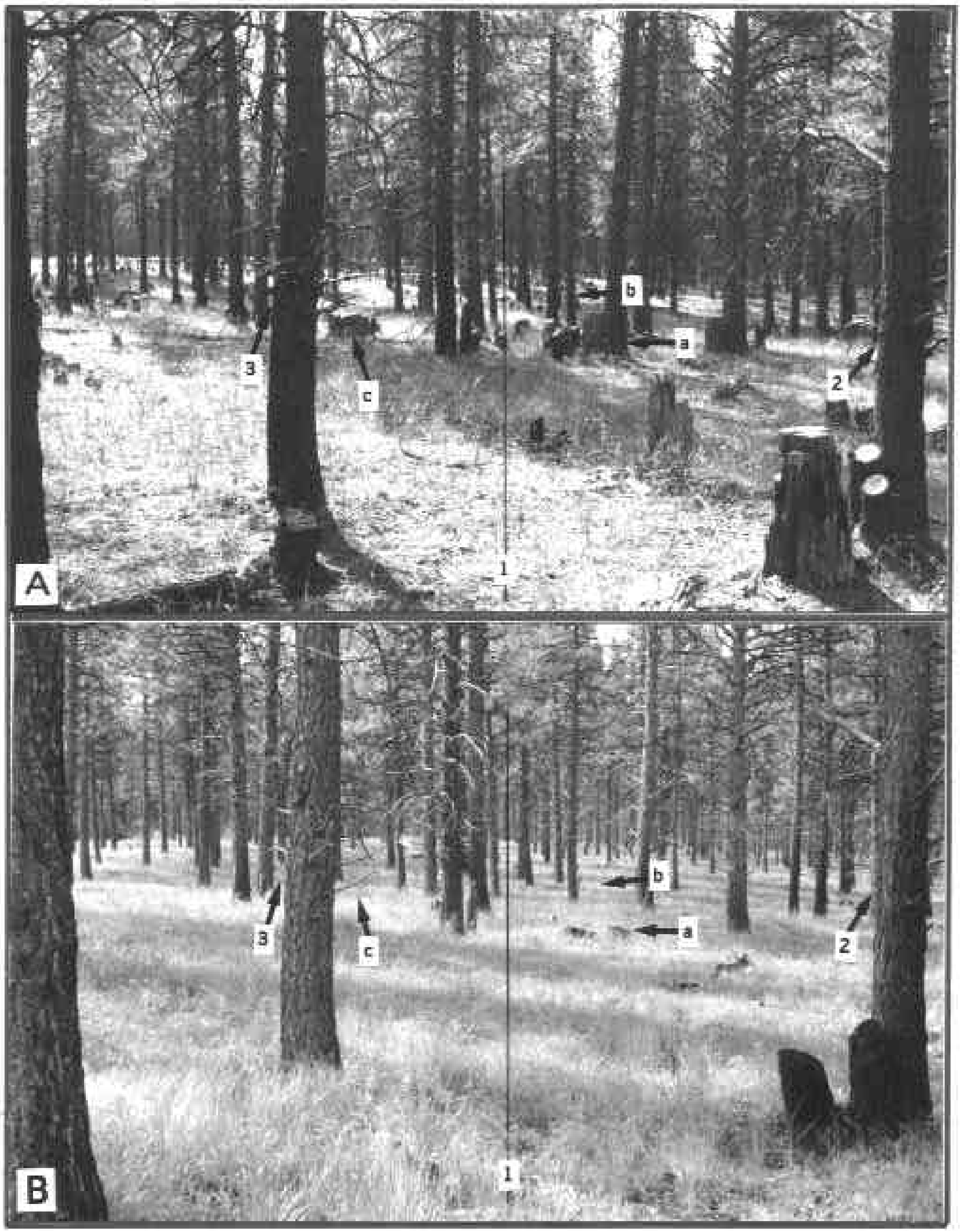


Figure 38—Photograph reorientation uses a black-and-white photo on which a triangulation system is diagramed. A center line (1) is established on the original photograph (**A**) for direction. The center line is identified by position of trees in the background and framing the picture with trees in the foreground. Then positions of items 2 and 3 at the sides of the picture are used to triangulate the camera location. Looking to the right, note the position of trees at arrow 2 while also looking left for tree positions at arrow 3. (**B**) Move forward and backward along the center line until items at arrows 2 and 3 are lined up. Try to include some unusual object in the photograph, such as the pair of stumps in the lower right corner. Photograph A is a pre-underburn condition, and B is postburn and salvage of killed trees. In B, note missing trees at arrows a and b, and a burned-out stump at arrow c.

Figure 39—Asystem for combining color and black-and-white photography. Both cameras are connected by strap aluminum 1/8 inch thick and 1 inch wide bent into a U-shape with holes drilled for mounting screws to connect the cameras. The cameras operate independently. Please consider using identical cameras so all setting controls are adjusted in the same way, greatly avoiding mistakes.

Review

Ground-based photo monitoring may be divided into two systems: (1) comparison photos whereby a photograph is used to compare a known condition (shown in the photo) with field conditions to estimate some parameter of the field condition, and (2) repeat photographs where several photos are taken of the same tract of ground over a period of time. Comparison systems can evaluate fuel loading and herbage utilization and monitor public reaction to scenery. Repeat photography was categorized into landscape, remote, and site-specific systems. Critical attributes of repeat photography are (1) maps to find the sampling location and of the photo monitoring layout; (2) documentation of the monitoring system to include camera and film, weather, season, sampling technique, and equipment; and (3) precise replication of photographs.

Literature Cited

Anderson, E.W.; Franzen, D.L.; Melland, J.E. 1990. R_X grazing to benefit watershed-wildlife-livestock. Rangelands. 12: 105-111.

Arnst, Albert. 1985. We climbed the highest mountains. Portland, OR: Fernhopper Press. 22 p.

Bauer, Stephen, B.; Burton, Timothy A. 1993. Monitoring protocols to evaluate water quality effects of grazing management on western rangeland streams. I: Establishing permanent photo points. EPA 910/R-93-017. Seattle, WA: U.S. Environmental Protection Agency, Region 10: 145-149.

Benson, Robert E. 1983. Using photos to extend resource inventory data. In: Bell, John F.; Atterbury, Toby, eds. 1983. Renewable resource inventories for monitoring changes and trends. Proceedings: international conference; 1983 August 15-19; Corvallis, OR. Corvallis, OR: Oregon State University, College of Forestry: 349-352.

Biswell, H.H. 1963. Research in wildland fire ecology in California. In: Proceedings: Tall Timbers: fire ecology conference, 1963 [dates unknown]; [location unknown]. Tallahassee, FL: Tall Timbers Research Station: 63-97.

Blaisdell, James P. 1953. Ecological effects of planned burning of sagebrush-grass range on the upper Snake River plains. Tech. Bull. 1075. Washington, DC: U.S. Department of Agriculture. 39 p.

Bonham, Charles D. 1989. Measurements for terrestrial vegetation. New York City: John Wiley & Sons.

Borman, Michael M. 1995. Photo monitoring. The Grazier. Corvallis, OR: Oregon State Extension Service. 282(May): 2-6.

Branson, Farrel A. 1985. Vegetation changes on western rangelands. Range Monograph 2. Denver, CO: Society for Range Management. 76 p.

Brown, Harry E. 1962. The canopy camera. Sta. Pap. 72. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 22 p.

Bull, Evelyn L.; Holthausen, Richard S.; Bright, Larry R. 1992. Comparison of 3 techniques to monitor marten. Wildlife Society Bulletin. 20: 406-410.

Bull, Evelyn L.; Meslow, E. Charles. 1988. Breeding biology of the pileated woodpecker—management implications. Res. Note PNW-RN-474. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 8 p.

Chan, S.S.; McCreight, R.W.; Walstad, J.D.; Spies, T.A. 1986. Evaluating forest vegetation with computerized analysis of fisheye photographs. Forest Science. 32(4): 1085-1091.

Chaney, E.; Elmore, W.; Platts, W.S. 1991. Livestock grazing on western riparian areas. Washington, DC: U.S. Government Printing Office.

Cole, David N. 1993. Campsites in three western wildernesses: proliferation and change in condition over 12 to 16 years. Res. Pap. INT-463. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 15 p.

Cunningham, David J.; Anderson, William H.; Anthony, R. Michael. 1996. An image-processing program for automated counting. Wildlife Society Bulletin. 24(2): 345-346.

Easter, M.J.; Spies, T.A. 1993. Using hemispherical photography for estimating photosynthetic photon flux density under canopies and in gaps in Douglas-fir forests of the Pacific Northwest. Canadian Journal of Forest Research. 24: 2050-2058.

Edgerton, P.J. 1983. Response of bitterbrush understory of a central Oregon lodge-pole pine forest to logging disturbance. In: Tiedemann, A.R.; Johnson, K.L., eds. Research and management of bitterbrush and cliffrose in western North America. Gen. Tech. Rep. INT-152. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 99-106.

Elmore, W.; Beschta, R.L. 1987. Riparian areas: perceptions in management. Rangelands. 9: 260-266.

Fischer, William C. 1981. Photo guides for appraising downed woody fuels in Montana forests: how they were made. Res. Note INT-299. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 12 p.

Fox, Douglas G.; Bernabo, J. Christopher; Hood, Betsy. 1987. Guidelines for measuring the physical, chemical, and biological conditions of wilderness ecosystems. Gen. Tech. Rep. RM-146. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 48 p.

French, Norman R.; Mitchell, John E. 1983. Long-term vegetation changes in permanent quadrants at the Idaho National Engineering Laboratory site. Bull. 36. Moscow, ID: University of Idaho, College of Forestry, Wildlife and Range Sciences. 42 p.

Gary, Howard L.; Currie, Pat O. 1977. The Front Range pine type: a 40-year photographic record of plant recovery on an abused watershed. Gen. Tech. Rep. RM-46. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 17 p.

Governor's Watershed Enhancement Board. 1993. Photo plots [Leaflet]. Salem, OR: State of Oregon. 16 p.

Gruell, George E. 1980. Fire's influence on wildlife habitat on the Bridger-Teton National Forest, Wyoming. Volume I: Photographic record and analysis. Res. Pap. INT-235. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 207 p.

Gruell, George E. 1983. Fire and vegetative trends in the northern Rockies: interpretations from 1871-1982 photographs. Gen. Tech. Rep. INT-158. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 117 p.

Gruell, George E. 1986. Post-1900 mule deer eruptions in the Intermountain West: principle causes and influences. Gen. Tech. Rep. INT-206. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 37 p.

Gruell, George E.; Schmidt, Wyman C.; Arno, Steven F.; Reich, William J. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana: implication for resource management. Gen. Tech. Rep. INT-130. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 42 p.

Guenther, Keith. 1998. Residual dry matter (RDM) monitoring photo guide. Clyde, CA: Wildland Solutions [234 Park Street, 94520]. 16 p.

Hall, Frederick C. 1976. Range trend sampling by photographs. R-6 Regional Guide 2-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 50 p.

Hanemann, Mike. 1989. The Osborne photo recording transit. International Association of Panoramic Photographers: 6(1): 6-7, 9.

Hart, Richard H.; Laycock, William A. 1996. Repeat photography on range and forest lands in the Western United States. Journal of Range Management. 49: 60-67.

Hattersley-Smith, G. 1966. The symposium on glacier mapping. Canadian Journal of Earth Sciences. 3(6): 737-743.

Hedgecoe, John. 1994. John Hedgecoe's landscape photography. New York City: Sterling Publishing Co. 224 p.

Herring, Margaret; Greene, Sarah, eds. 1997. Natural Areas Report. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 9(1): 1-8.

Houston, D.B. 1982. The northern Yellowstone elk: ecology and management. New York City: MacMillan Publishing Co. 474 p.

Hulcher, Charles A. [N.d.]. Instruction manual for Hulcherama model 120 panoramic camera. Hampton, VA: Charles A. Hulcher Co., Inc. 4 p.

Jensen, D.; Smith, W.; Bodman, M. [and others] 1999. Application of photopoint monitoring for the CRD Parks and Water Departments. [City unknown], BC: [Publisher unknown]. 114 p. Illustrated. [Water Department, Capital Regional District; Parks Department, Capital Regional District; Environmental Youth Team Program, Ministry of Environment, Lands and Parks].

Johnson, C. 1991. A photo point system: Eco-Area 3. Baker City, OR: U.S. Department of Agriculture, Forest Service, Wallowa-Whitman National Forest. 6 p.

Johnson, Charles Grier, Jr. 1998. Vegetation response after wildfires in National Forests of northeastern Oregon. R6-NR-ECOL-TP-O6-98. Portland, OR. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 157 p.

Johnson, Kendall L. 1984. Sagebrush over time: a photographic study of rangeland change. In: Proceedings: symposium on the biology of *Artemesia* and *Chrysothamnus*; 1984 July 9-13; [location of meeting unknown]. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 223-252.

Johnson, K.L. 1987. Rangeland through time: a photographic study of vegetation change in Wyoming, 1870-1986. Misc. Publ. 50. Laramie, WY: University of Wyoming, Agriculture Experiment Station. 188 p.

Kay, Charles E. 1999. Repeat photography and long-term vegetation change on the U.S. Sheep Experiment Station and other rangelands in the Centennial Mountains. Dubois, ID: Agricultural Research Service; final report to the U.S. Sheep Experiment Station. 281 p.

Kay, Charles E.; White, Cliff A.; Pengelly, Ian R.; Patton, Brian. 1999. Long-term ecosystem states and processes in Banff National Park and the central Canadian Rockies. Occas. Pap. 9. [Place of publication unknown]: Parks Canada, National Parks.

Kinney, John W.; Clary, Warren P. 1994. A photographic utilization guide for key riparian graminoids. Gen. Tech. Rep. INT-GTR-308. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 13 p.

Kinney, John W., Clary, Warren P. 1998. Time-lapse photography to monitor riparian meadow use. Res. Note RMRS-RN-5. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 5 p.

Kodak. 1999a. Digital learning center. http://www.kodak.com/US/en/digital/dlc/. (March 2000).

Kodak. 1999b. Learn about digital cameras. http://www.kodak.com/US/en /digital/cameras. (March 2000).

Koski, Wayne H.; Fischer, William C. 1979. Photo series for appraising thinning slash in north Idaho. Gen. Tech. Rep. INT-46. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 49 p.

Kristan, Deborah M.; Golightly, Richard T., Jr.; Tomkiewicz, Stanley M., Jr. 1996. A solar-powered transmitting video camera for monitoring raptor nests. Wildlife Society Bulletin. 24(2): 284-290.

Lyon, L. Jack. 1971. Vegetal development following prescribed burning of Douglas-fir in southcentral Idaho. Res. Pap. INT-105. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 30 p.

Lyon, L. Jack. 1984. The Sleeping Child burn: 21 years of postfire change. Res. Pap. INT-330. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 17 p.

Magill, Arthur W. 1989. Monitoring environment change with color slides. Gen. Tech. Rep. PSW-117. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 55 p.

Magill, Arthur W. 1990. Assessing public concern for landscape quality: a potential model to identify visual thresholds. Res. Pap. PSW-203. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 48 p.

Maxwell, Wayne G.; Ward, Franklin R. 1976a. Photo series for quantifying forest residues in the: coastal Douglas-fir-hemlock type; coastal Douglas-fir-hardwood type. Gen. Tech. Rep. PNW-51. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 103 p.

Maxwell, Wayne G.; Ward, Franklin R. 1976b. Photo series for quantifying forest residues in the: ponderosa pine type; ponderosa pine and associated species type; lodgepole pine type. Gen. Tech. Rep. PNW-52. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 73 p.

Maxwell, Wayne G.; Ward, Franklin R. 1979. Photo series for quantifying forest residues in the: Sierra mixed conifer type; Sierra true fir type. Gen. Tech. Rep. PNW-54. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 79 p.

Maxwell, Wayne G.; Ward, Franklin R. 1980a. Guidelines for developing or supplementing natural photo series. Res. Note PNW-358. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p.

Maxwell, Wayne G.; Ward, Franklin R. 1980b. Photo series for quantifying natural forest residues in common vegetation types of the Pacific Northwest. Gen. Tech. Rep. PNW-105. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 229 p.

McGinnies, W.J.; Shantz, H.L.; McGinnies, W.G. 1991. Changes in vegetation and land use in eastern Colorado: a photographic study, 1904-1986. ARS-85. Fort Collins, CO. U.S. Department of Agriculture, Agriculture Research Service. 165 p.

Medina, Alvin L. 1996. The Santa Rita Experimental Range: annotated bibliography (1903-1988). Gen. Tech. Rep. RM-GTR-276. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 67 p.

Nader, Glenn; DeLasaux, Mike; Delms, Rick [and others]. 1995. “How to” monitor rangelands. Handb. Level-1. Alturas, CA: University of California, Cooperative Extension Service, Modoc County. 44 p.

National Park Service. 1992. National Park Service Western Region fire monitoring handbook. Appendix D: Guidelines for establishing photopoints. San Francisco, CA: National Park Service.

Ottmar, Roger D.; Hardy, Colin C.; Vihnanek, Robert E. 1990. Stereo photo series for quantifying forest residues in the Douglas-fir-hemlock types of the Willamette National Forest. Gen. Tech. Rep. PNW-GTR-258. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 63 p.

Owens, M.K.; Gardiner, H.G.; Norton, B.E. 1985. A photographic technique for repeated mapping of rangeland plant populations in permanent plots. Journal of Range Management. 38: 231-232.

Parker, K.W. 1954. A method for measuring trend in range condition on National Forest ranges with supplemental instructions for measurement and observation of vigor, composition, and browse [Internal publication]. Washington, DC: U.S. Department of Agriculture, Forest Service. 37 p.

Parker, K.W.; Harris, R.W. 1959. The three-step method for measuring condition and trend of forest ranges: a resumé of its history, development, and use. In: Techniques and methods of measuring understory vegetation: Proceedings of a symposium; 1958 October; Tifton, GA. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 55-69.

Phillips, Walter S.; Shantz, Homer L. 1963. Photographic documentation: vegetational changes in northern Great Plains. Rep. 214. Tucson, AZ: The University of Arizona, College of Agriculture, Agriculture Experiment Station. 185 p.

Pierce, W.R.; Eddleman, L.E. 1973. A test of stereophotographic sampling in grasslands. Journal of Range Management. 26: 148-150.

Pierce, William R.; Eddleman, Lee E. 1970. A field stereophotographic technique for range vegetation analysis. Journal of Range Management. 23: 218-220.

Pond, Floyd W. 1971. Chaparral 47 years later. Res. Pap. RM-69. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 11 p.

Porter, S.D.; Jorgenson, C.D. 1988. Longevity of harvester ant colonies in southern Idaho. Journal of Range Management. 41: 104-107.

Progulske, Donald R.; Sowel, Richard H. 1974. Yellow ore, yellow hair, yellow pine: a photographic study of a century of forest ecology. Bull. 616. Brookings, SD: South Dakota State University, Agricultural Experiment Station. 169 p.

Puchbauer, Truman C.; Carroll, Franklin C. 1993. Snapshot in time: repeat photography on the Boise National Forest 1870-1992. Boise, ID: U.S. Department of Agriculture, Forest Service, Boise National Forest. 239 p.

Ratliff, Raymond D.; Westfall, Stanley E. 1973. A simple stereophotographic technique for analyzing small plots. Journal or Range Management. 26(2): 147-148.

Reid, Elbert H.; Johnson, Charles G., Jr.; Hall, Wade B. 1991. Green fescue grassland: 50 years of secondary succession under sheep grazing. R6-F16-SO-0591. Baker City, OR: U.S. Department of Agriculture, Forest Service, Wallowa-Whitman National Forest. 37 p.

Reppert, Jack N.; Francis, Richard E. 1973. Interpretation of trend in range conditions from 3-step data. Res. Pap. RM-103. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

Ribe, R. 1999. Regeneration harvest versus clearcuts: public views of the acceptability and aesthetics of Northwest Forest Plan harvests. Northwest Science. 73: 102-117.

Robel, R.J.; Briggs, J.N.; Dayton, A.D.; Hulbert, L.C. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management: 23: 295-297.

Rogers, G.F. 1982. Then and now: a photographic history of vegetation change in the central Great Basin Desert. Salt Lake City, UT: University of Utah Press. 152 p.

Rogers, G.F.; Malde, H.E.; Turner, R.M. 1984. Bibliography of repeat photography for evaluation of landscape change. Salt Lake City, UT: University of Utah Press. 179 p.

Rogers, Garry F.; Turner, Raymond M.; Malde, Harold E. 1983. Using matched photographs to monitor resource change. In: Bell, John F; Atterbury, Toby, eds. Renewable resource inventories for monitoring changes and trend: Proceedings of an international conference; 1983 August 15-19; Corvallis, OR. Corvallis, OR: College of Forestry, Oregon State University: 90-92.

Schmutz, Ervin M. 1971. Estimation of range use with grazed-class photo guides. Bull. A-73. Tucson, AZ: University of Arizona, Agricultural Experiment Station and Cooperative Extension Service. 16 p.

Schmutz, Ervin M.; Holt, Gary A.; Michaels, Charles C. 1963. Grazed-class method of estimating forage utilization. Journal of Range Management. 16: 54-60.

Sharp, Lee E.; Sanders, Ken; Rimbey, Neil. 1990. Forty years of change in a shadescale stand in Idaho. Rangelands. 12: 313-328.

Sharp, Lee A.; Sanders, Ken; Rimbey, Neil. 1992. Variability of crested wheat-grass production over 35 years. Rangelands. 14: 153-168.

Shinn, Dean A. 1980. Historical perspectives on range burning in the inland Pacific Northwest. Journal of Range Management. 33: 415-423.

Skovlin, Jon M. 1991. Fifty years of research progress: a historical document on the Starkey Experimental Forest and Range. Gen. Tech. Rep. PNW-GTR-266. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 58 p.

Skovlin, Jon M.; Thomas, Jack Ward. 1995. Interpreting long-term trends in Blue Mountain ecosystems from repeat photography. Res. Pap. PNW-GTR-315. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 102 p.

Smith, Helen Y.; Arno, Steven F., eds. 1999. Eighty-eight years of change in a managed ponderosa pine forest. Gen. Tech. Rep. RMRS-GTR-23. Ogden, UT: U.S. Department of Agriculture, Rocky Mountain Research Station. 55 p. + 14 foldout photopoint pages, 1 poster.

Stickney, Peter F. 1986. First decade plant succession following the Sundance forest fire, northern Idaho. Gen. Tech. Rep. INT-197. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 26 p.

Strickler, Gerald S.; Hall, Wade B. 1980. The Standley allotment: a history of range recovery. Res. Pap. PNW-278. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 35 p.

Temple, Stanley A. 1972. A portable time-lapse camera for recording wildlife activity. Wildlife Society Bulletin. 36(3): 944-947.

U.S. Department of Agriculture, Forest Service. 1982. Recording the changes: field guide to establishing and maintaining permanent camera point systems. R6-10095-1982. Portland, OR: Pacific Northwest Region. 13 p.

U.S. Department of Agriculture, Forest Service. 1993. Riparian revival: the story of Elk Creek [Leaflet]. Enterprise, OR: Wallowa-Whitman National Forest, Wallowa Valley Ranger District. 4 p.

U.S. Department of the Interior, Bureau of Land Management. 1996. Sampling vegetation attributes: interagency technical reference. BLM/RS/ST-96/002+1730. Denver, CO: Denver Service Center. 164 p.

Van Horn, Mia; Van Horn, Kent. 1996. Quantitative photomonitoring for restoration projects. Restoration and Management Notes. 14: 30-34.

Veblen, T.T.; Lorenz, D.C. 1991. The Colorado Front Range: a century of ecological change. Salt Lake City: University of Utah Press.

Wade, Dale D.; Forbus, James K.; Saveland, James M. 1993. Photo series for estimating post-hurricane residues and fire behavior in southern pine. Gen. Tech. Rep. SE-82. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 19 p.

Weaver, Herald. 1957. Effects of prescribed burning in ponderosa pine. Journal of Forestry. 55: 133-138.

Weaver, Herald. 1959. Ecological changes in the ponderosa pine forest of the Warm Springs Indian Reservation in Oregon. Journal of Forestry. 57: 15-20.

Wein, R.W.; Rencz, A.N. 1976. Plant cover and standing crop sampling procedures for the Canadian High Arctic. Arctic Alpine Research. 8: 139-150.

Wells, K.F. 1971. Measuring vegetation changes on fixed quadrats by vertical ground stereophotography. Journal of Range Management. 24: 233-239.

White's Electronics, Inc. 1996. Classic II SL™. Sweet Home, OR: White's Electronics, Inc. [1011 Pleasant Valley Road, 97368].

Wimbush, D.J.; Barrow, M.D.; Costin, A.B. 1967. Color stereo-photography for the measurement of vegetation. Ecology. 48: 150-152.

Winkworth, R.E.; Perry, R.A.; Rossetti, C.O. 1962. A comparison of methods of estimating plant cover in an arid grassland community. Journal of Range Management. 15: 194-196.

Zielinski, William J.; Kucera, Thomas E. 1995. American otter, fisher, lynx, and wolverine: survey methods for their detection. Gen. Tech. Rep. PSW-GTR-157. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 163 p., enclosure.

This page is intentionally left blank.

CONTINUE

Appendix A: Methodology for Photo Monitoring of Change in Vegetation or Soil

Contents

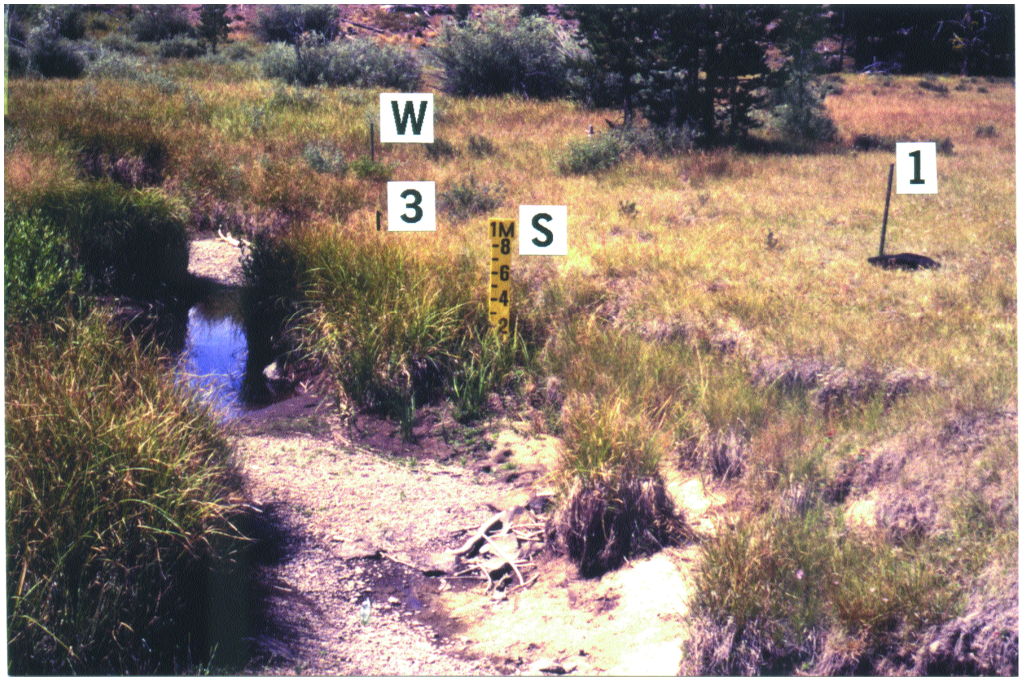


Figure 40—Ageneral photograph taken in 1997 with the topic of streambank stability. It is part of a riparian study on Emigrant Creek, Snow Mountain District, Ochoco National Forest, near Burns, Oregon. The site is Pole Camp, a place livestock find highly attractive. The location of Pole Camp is shown on the map in figure 41. This streambank photo point is taken up stream from camera location 2 shown on the map in figure 42. Fencepost 1 is camera location 1, fencepost 3 is camera location 3 looking downstream at photo point S, S is photo point streambank, and fencepost W is photo point wet meadow. Other views of this streambank are shown in figures 23 and 49.

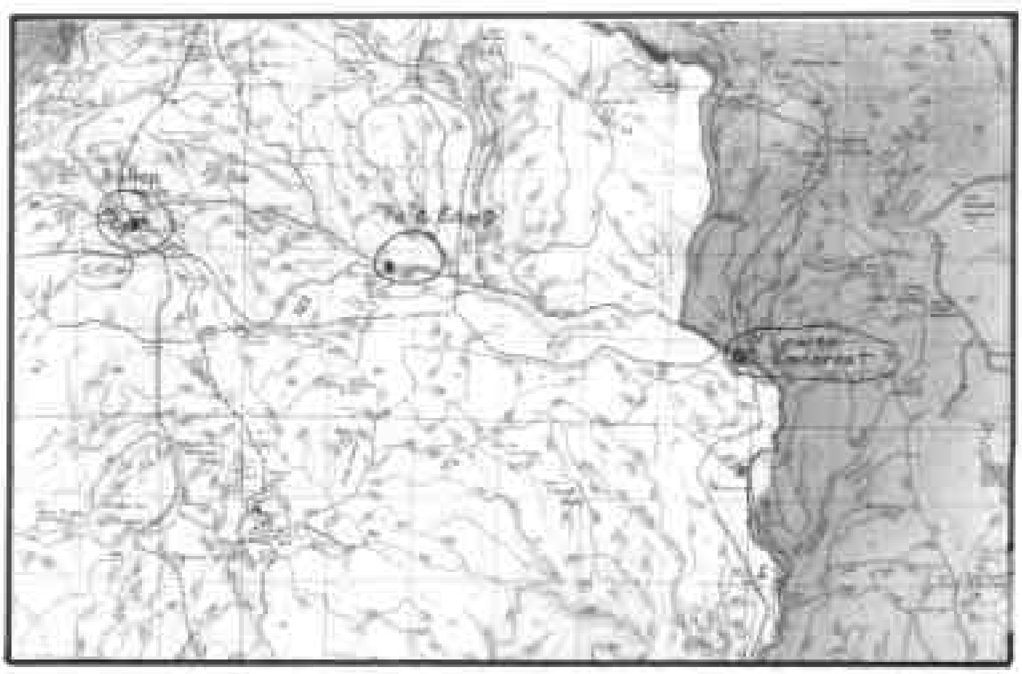


Figure 41—Local map showing location of the Emigrant Creek riparian study, Snow Mountain District, Ochoco National Forest, near Burns, Oregon. Three study areas are shown: Button Meadow at the head of Crowfoot Creek, Pole Camp shown in figures 20, 23, 26, 40, 44 and 49, and Lower Emigrant. This is one of two essential maps designed so people other than those installing the monitoring system can find the sampling sites. The other map is shown in figure 42.

Introduction

This appendix contains instructions on how to apply various photographic sampling methods designed to document changes in vegetation or soil on specific tracts of ground. It does not deal with general landscape photography or remotely operated cameras.

Nine photographic methods are discussed:

1. General photography where a scene is followed over time.
2. Topic photography dealing with a selected item, such as a streambank (fig. 40) or logging disturbance (fig. 21).
3. Grid analysis of photographs to document change in the selected topic or item.
4. Shrub sampling to record change in shrub profile area, usually accomplished by use of grid analysis.
5. Transect photography, in three dimensions, of square-foot plots.
6. Transect photo sampling of nested frequency plots.
7. Transect sampling of meter square (or 3-ft square) plots photographed at an oblique angle.
8. Photo documentation of tree canopy cover.
9. Photo records of herbage utilization using the Robel pole system.

All nine methods have several features in common, which are detailed in the following sections.

Selection of an Area

Selection of a monitoring area requires professional expertise liberally dosed with artistic finesse. The **purpose** for photographic monitoring is the most critical factor: Where in the landscape is the topic of concern, and once at the area, what kind of change should be documented? In some cases, *where* is straightforward; for example, documenting impacts of logging requires going to an area being logged (fig. 21) and documenting effects of beavers on a stream requires finding beaver dams. On the other hand, documenting impacts of livestock grazing requires understanding livestock distribution plus knowing the location of areas sensitive to grazing and the most critical season of use (figs. 20 and 40).

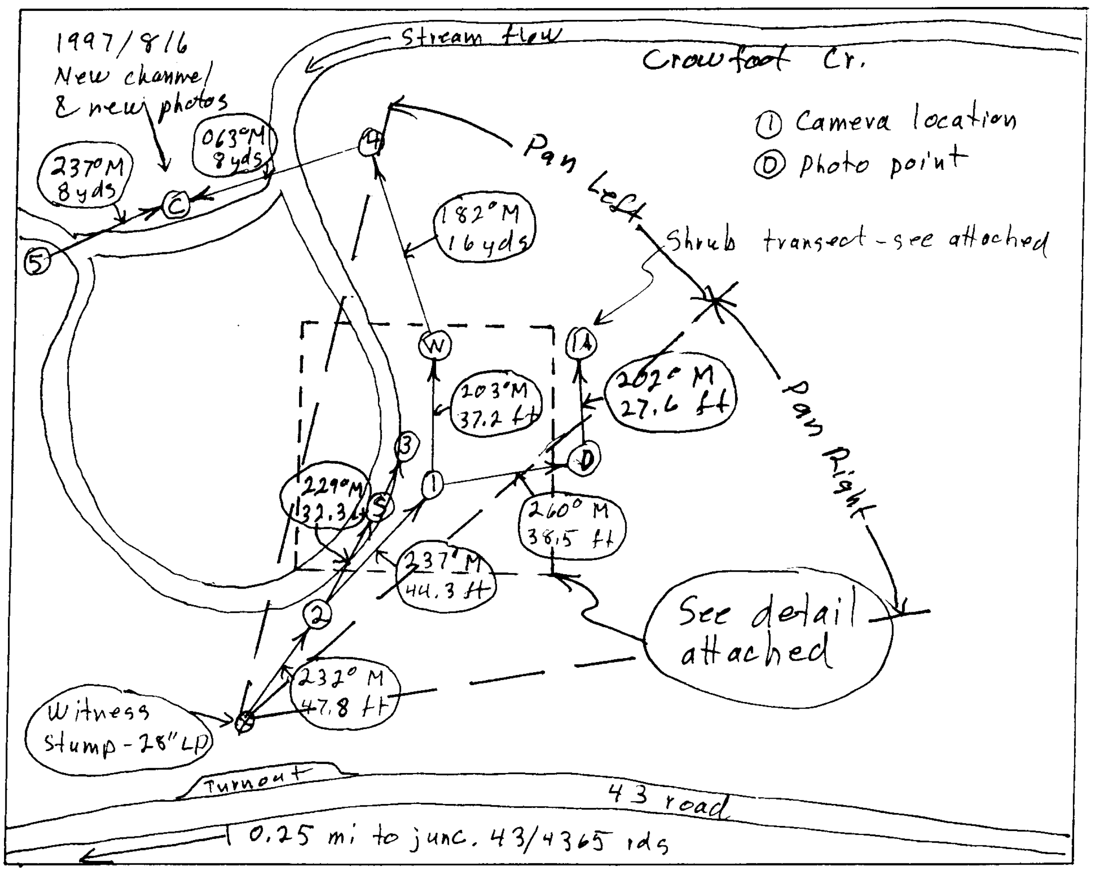
Once in an area, determine specifically what is to be documented for change. In figure 40 at Pole Camp, for example, the purpose was to document effects of livestock grazing on a riparian area. Pole Camp was selected because livestock preferred it. Specific objectives were to evaluate grazing effects on streambanks, willow shrub utilization, and differences in use between grass and sedge sites (Kentucky bluegrass by the fencepost on the right [1]) and sedge (at the fencepost in the background [W]). The topic in figure 40 is streambank stability.

Another example is the ponderosa pine stand shown in figure 21. In this case, the purpose for photo sampling was to document effects of a two-stage overstory removal and subsequent precommercial thinning on stand structure and ground vegetation. The site was selected based on the sale area. Stand conditions of open pine and clumped reproduction across an opening were chosen for the photo point. The opening was selected to avoid tree crown encroachment between the camera location and photo point and to appraise logging effects on livestock forage. It was photographed before and after each entry (fig. 21).

PHOTOGRAPHIC SITE DESCRIPTION AND LOCATION

Date 1974/10/5 Area Snow Mtn. Dist.
Unit Pole Camp Observer: F. C. Hall
No. of Camera locations: ~~3~~ 5 No. of Photo points: ~~3~~ 4
Plant community Dry & wet meadow; willows
Location: T.19S R.27E Sec. 29 SW of NE
Location description S of rd 43; 0.25 mi W of junc. 43 & 4365 rds off of turnout at E end of meadow
Photo purpose: Document effects of change from season-long cattle use to 3-pasture rest-rotation.
Discussion: Three photo points established in Oct 1974 documented dry meadow (D), wet meadow with willows (W) and a fallen block of sod at the stream edge (S). (1997) Flood of 2/96 washed out beaver dams & created a new channel. Shrub sampling initiated 6/97.

MAP



Use back of sheet for additional details.

Figure 42—Filing system form “Photographic Site Description and Location” showing the monitoring layout for Pole Camp. Note in the lower left corner a reference to the junction of roads 43 and 4365 at 0.25 mi. Immediately opposite the road turnout is a 28-in-diameter lodgepole pine stump. An aluminum tag, orange for visibility, is attached to the stump with directions and distances to camera locations: a witness site. An additional map, noted by the square labeled “See detail attached,” is shown in figure 27. It documents triangulation of the streambank photo point. Another note, “Shrub transect - see attached,” installed in 1997, is shown in figures 64 and 65.

When to Photograph

When to photograph usually is determined by the activity being monitored. Pole Camp is part of a study evaluating effects of cattle grazing on a riparian area. Figure 20 includes photographs taken three times per year corresponding to livestock activity: June 15 before grazing, August 1 as cattle change pastures, and October 1 after animals leave the allotment. This three-season monitoring is repeated every year.

The ponderosa pine stand (fig. 21) illustrates a very different monitoring schedule. Photography was planned for the first week in August so that vegetation development would be consistent. Photographs were taken just before logging and in each of the two growing seasons afterward to document rapid changes in ground vegetation. Then a 5-year rephotographing cycle was established to follow slower changes in both stand structure and ground vegetation. The routine was repeated with the second logging and the precommercial thinning.

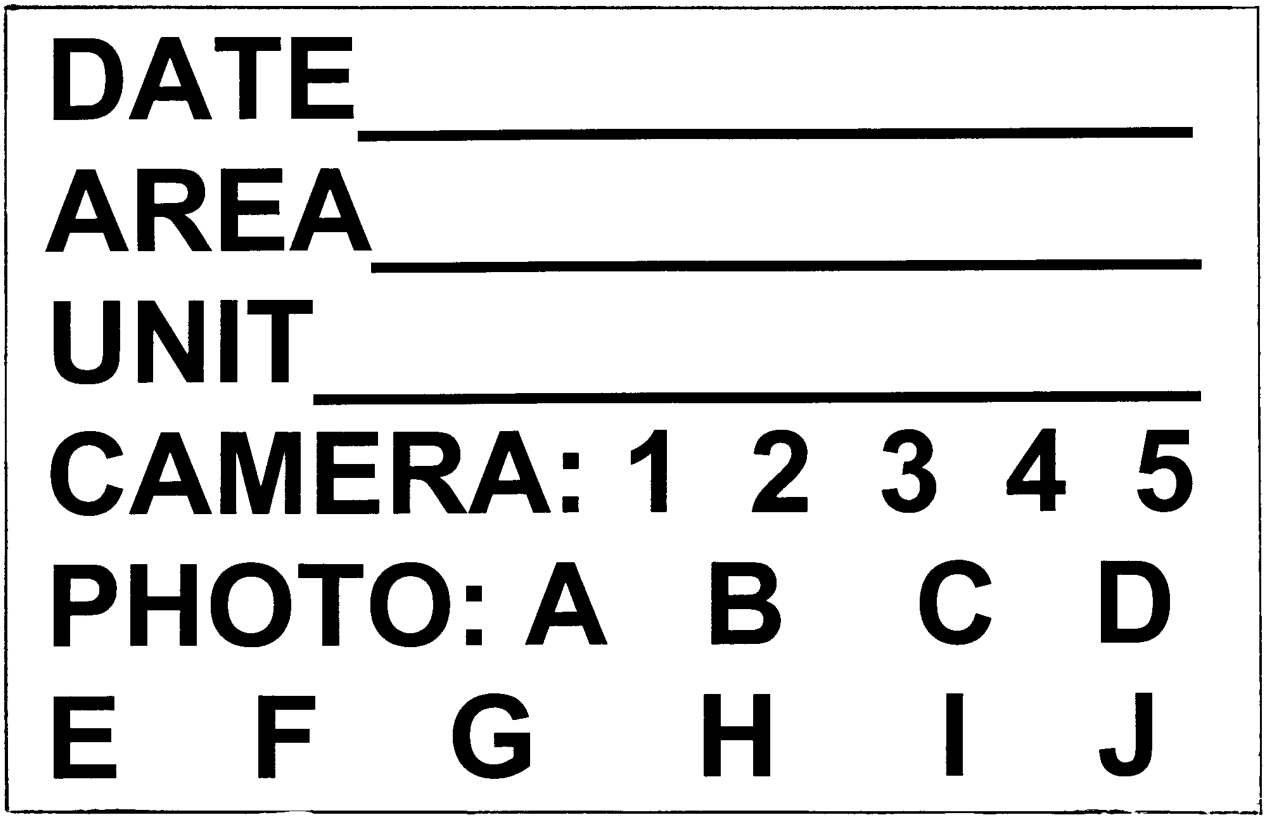
If vegetation is a primary topic, consider establishing a fixed date for rephotography. An established date has several advantages: (1) It offers an opportunity to evaluate seasonal differences in plant phenological development, (2) it provides a consistent reference for comparing change over several years, and (3) it establishes a consistent time interval over which change is documented.

Maps to Locate the Monitoring System

When the photo monitoring system has been established, prepare maps to locate the area and document the sampling layout. Assume that the person installing the monitoring program will **not** be the one to find and rephotograph the area. Provide maps and instructions accordingly. A local map showing roads and site locations is illustrated in figure 41 for Pole Camp, one of three locations for the Emigrant Creek riparian study.

After establishing the sampling system, establish a witness site or tree which marks the area. Identify it with a permanent marker, such as an orange aluminum tag, and determine direction and distance to camera locations or transects. Inscribe these on the identification tag. Next create a map of the camera locations and photo points or transects with directions and measured distances by using the filing system form "Photographic Site Description and Location" (fig. 42) found in appendix B. Note whether the direction is taken in magnetic or true degrees by indicating either "M" or "T." A 21-degree deviation in the Pacific Northwest must be accounted for. Measure distances between witness site, camera location, and photo points on the ground. Do not convert to horizontal distance.

Fenceposts or stakes—Monitoring, by definition, means repeated observation. Therefore, all camera locations, transects, and photo points must be permanently marked. The recommended method is with stamped metal fenceposts (fig. 40). These cost about $2.25 each for a 5-ft size in 2000. Stamped metal has several advantages over strong T-bar posts: the former are flimsy and will bend if driven into by a vehicle or run over by an animal; they will bend flat and remain in the ground to mark the spot; they resist theft because they are just as difficult to pull out as a good fencepost but not worth the trouble; and they are easy to carry and pound. But the primary advantage of flimsy fenceposts is their visibility, as shown in figure 40. If visibility is not desired, steel stakes are a choice but require a metal detector to relocate.



DATE ______________

AREA ______________

UNIT ______________

CAMERA: 1 2 3 4 5

PHOTO: A B C D

E F G H I J

Figure 43—An example of a photograph identification card to be placed in the camera view (fig. 44). This has been reduced to 60 percent. Appendix B has blank forms for reproduction onto dark blue paper. The best paper colors are Hammermill Brite Hue Blue® or Georgia Pacific Papers Hots Blue®. Light colored paper, common in the office environment, fades out under direct sun and should not be used.

Steel stakes often have been used and may be necessary in shallow soils or in areas that will be disturbed. If disturbance or shallow soils prevent use of fenceposts, the stakes should be driven flush with the ground. If left a few inches aboveground, stakes will damage tires, hooves, or feet and are often difficult to find. When driven flush with the ground, they require a metal detector for location (White's Electronics, Inc. 1996). Even then, the stakes must be of some mass for detection with a simple, $250 machine. Angle iron should be 1 in on the angle and at least 8 in long. Cement reinforcing bar should be at least three-eights of an inch in diameter and at least 8 in long.

One overriding consideration in photo monitoring is the requirement that the **same distance** be observed between the camera location and photo point for all subsequent photography of that sample. Any analysis of change depicted in the photographs can be done **only** when the distance remains the same. Therefore, always **measure** distance from camera location to photo point. A fixed distance for all photo monitoring is not required; this may differ from one photo point to another. Camera format also may change, such as first pictures with a 50-mm lens and next pictures with a 35-mm lens, but distance must remain the same. It can remain the same only if permanently marked.

Identification of Photographs

Identify each photograph by site name, photograph number, and date. Figure 43 is an example of a form for use in general or topic photographs (fig. 44). (Forms are in appendix B.) The critical factor is identification of **negatives** for color or black-and-white

CAMERA LOCATION AND PHOTO POINTS

Date 1997/6/17 Camera Location Witness Stump
Area Snow Mtn. Dist. Number of Photo points: 2
Unit Pole Camp Observer F.C. Hall
Comments From rd junc. 43/4365, on rd 43 for 0.25 mi W. to turnout on S. side road; witness stump 22" LP 20 yds. S
slope 1 Aspect W Slope position bottom

Photo point A —
Compass bearing: 237° M
Distance: —
Flood plain, left view of Pole Camp study site.
Mt. pine beetle killed LP stand in background
1, 2, 3 are camera locations; S & W are photo points

Photo point B: —
Compass bearing: 270° M
Distance: —
Flood plain, right view of Pole Camp study site.
1 & 2 are camera locations, D is dry meadow photo point.

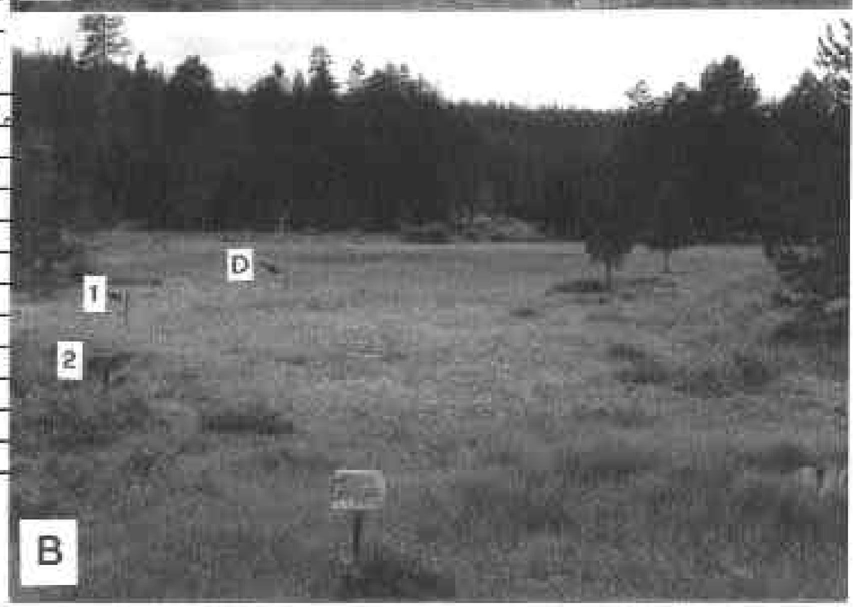


Figure 44—Filing system form "Camera Location and Photo Points" showing general photographs of Pole Camp taken from the witness stump: (**A**) left landscape and (**B**) right landscape noted in figure 42. Note repeat of fenceposts 1 and 2 in both pictures. Fenceposts identify camera locations 1, 2, and 3 and photo points D for the dry meadow, W for the wet meadow, and S for the streambank. Photo identification cards similar to figure 43, a form from appendix B, are at the bottom of each picture. The purpose of these photographs is twofold: (1) to illustrate the general sampling area and (2) to show location of the photo monitoring layout. Used in conjunction with the map in figure 42, someone other than the original sampling crew should be able to find and rephotograph this site.

pictures or digital images. Slides have borders to write on, but there is no similar space on negatives. Placing a photo identification card in each view as it is photographed assures a permanent record on the negative. Negative identification has been one my biggest problems!

Paper color is the next consideration. Plain white or light colors, common in the office environment, are not suitable because they are too light and will fade when photographed outdoors in full sunlight (fig. 30). The recommended paper color is either Hammermill Brite Hue Blue® or Georgia Pacific Papers Hots Blue® (app. B). Tests have shown these darker blue hues are superior to other vibrant colors such as green and yellow.

Description of the Topic

Describe what is in the scene to be photographed (fig. 44). This might include plant species, ground conditions, disturbances, or any other pertinent item. Appendix B contains forms with provision for recording these notes. For example, the filing system form, “Camera Location and Photo Points,” is shown in figure 44 with two views of Pole Camp. Figures 46 to 48 (shown below), using the same form, illustrate mountain pine beetle effects on lodgepole pine over 13 years. And figure 50 (also shown below) is the “Photo Points and Close Photos” form for a general view and two closeup photographs of a ponderosa pine-elk sedge plant community in undisturbed condition. Recording of the percentage of cover for various items is recommended for good photo descriptions.

Filing System

Photo monitoring requires a way to file slides, prints, and negatives. My system is organized around each study with an expandable file used to contain everything (app. D).

The expandable files are placed in a file cabinet dedicated to sampling and organized first by geographic location and then by date for next photography. By filing studies geographically, generally around overnight facilities, travel planning is greatly facilitated. Noting the next photography date on each file helps with seasonal planning (app. D).

General Photography

General photographs document a scene rather than a specific topic or conditions along a sampling transect (discussed below). They are similar to landscape pictures in that they do not require a size control board (meter board) on which to focus the camera and to orient subsequent photographs. They usually cover an area of 2 to 20 acres and distance of 50 to 200 yards (figs. 26 and 44).

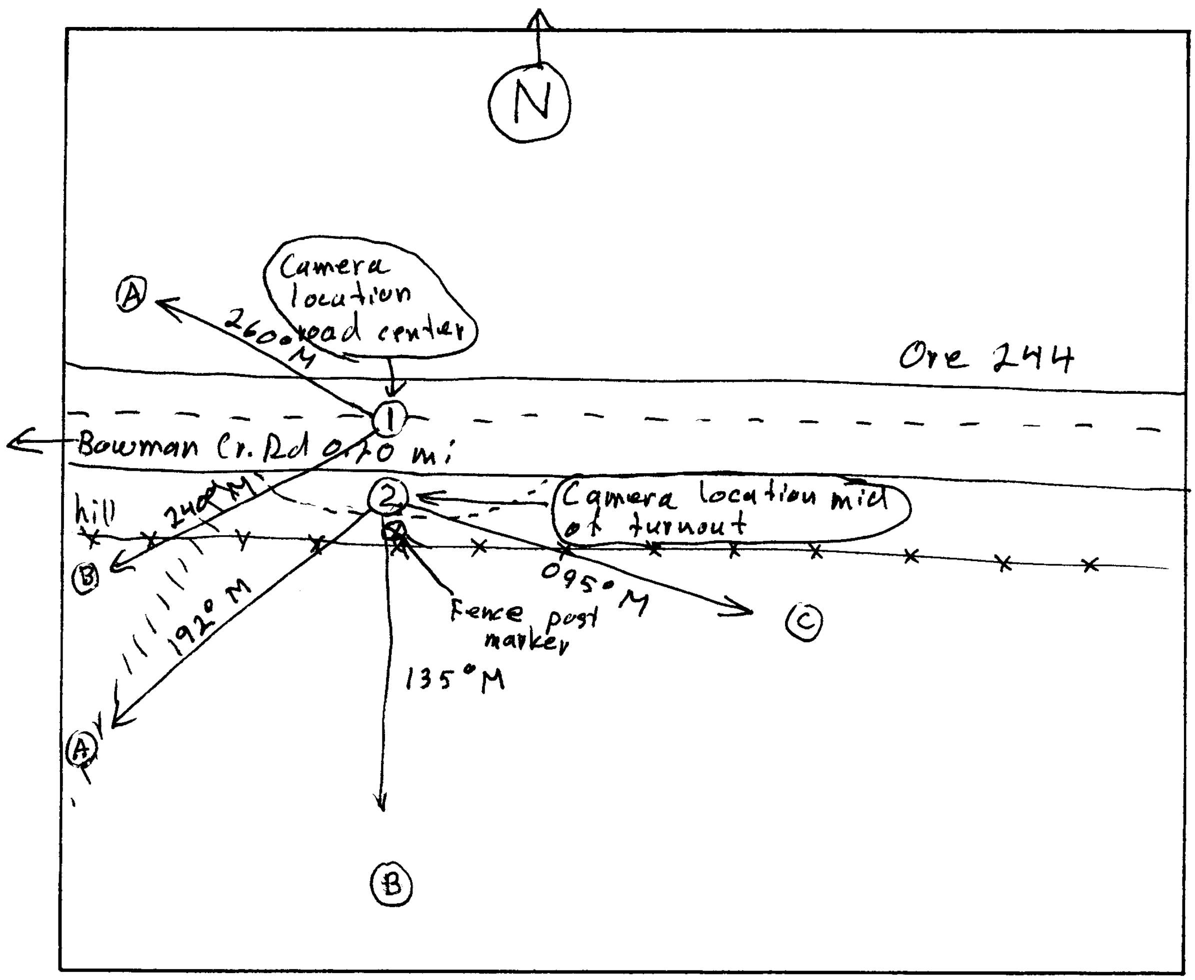
Concept

In many cases, general photographs document a scene in which a meter board cannot be placed where the camera can be focused on the “1M” of the board for distance and photo orientation (fig. 18). One use of a general photograph is shown in figure 26 depicting the setting of Pole Camp. Figure 44 is filing system form, “Camera Location and Photo Points,” containing this and a second view of Pole Camp wherein the fenceposts marking camera locations and photo points may be identified. Another use is illustrated in figures 45 to 48 documenting effects of mountain pine beetle attack on lodgepole pine.

PHOTOGRAPHIC SITE DESCRIPTION AND LOCATION

Date Aug 1976 Area Camas Cr. Meadows
Unit Ukiah District Observer: F. C. Hall
Number of photo points 5 Plant community: lodgepole pine
Location: T. 4S R 33E Sec. 35 SW of SW
Location description On Ore. hiway 244 between mile posts 15 & 16; 0.20 mi. east of junc with Bowman Cr. Rd.
Photo purpose: Document effects of Mt. pine beetle attack on bottomland climax lodgepole pine
Discussion Some betles noticed in 1975; this year major kill (70%) of dominant lodgepole - needles red. Follow for each year for 3 yrs, then about 5 yr. intervals.

MAP



Use back of sheet for additional details.

Figure 45—Filing system form “Photographic Site Description and Location” with map to locate camera locations and photo points documenting affects of mountain pine beetle on lodgepole pine. Two camera locations are shown. Figures 46 to 48 are from camera location 1 showing photo points 1Aand 1B.

Equipment

The following equipment needs to be taken to the photography site:

1. Camera or cameras for different film or digital camera
2. Photograph identification form "Camera-Photo" (see index to app. B; the form itself is not labeled)
3. Clipboard and holder for the photo identification sheets (app. C)
4. Previous photographs for orientation of the camera
5. Filing system form "Camera Location and Photo Points" (app. B)
6. Fenceposts and angle steel stakes, sufficient for the number of camera locations desired, with pounder
7. A tripod to use for camera orientation while viewing the photographs

Technique

Select a scene that will meet your monitoring objectives. Describe it by using the filing system form, "Camera Location and Photo Points," and include plant species, ground cover items, disturbance, or whatever the topic of the photograph is. Photograph the scene.

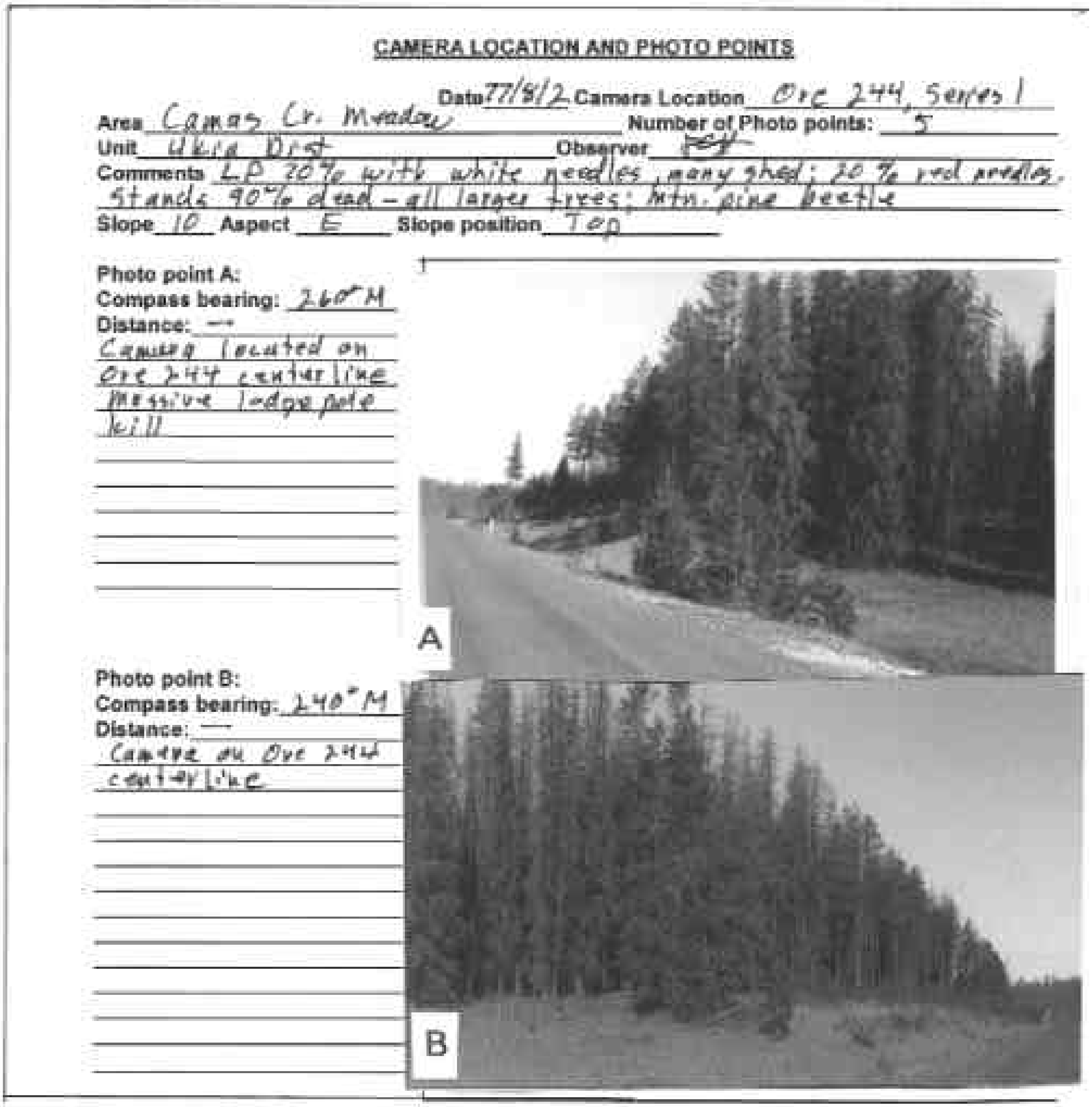
Make maps of the location and layout of the scene on the filing system form, "Photographic Site Description and Location" (app. B; fig. 45).

Reorientation—Reorientation of subsequent pictures is a major concern if a meter board was not used originally to mark and establish photo orientation. Key items of each view have to be identified. For example, in figure 44, the tall tree in the right background of picture (A) is the same tree in the left background of picture (B). Panoramic views such as figure 44 always should have about 10 percent overlap between photographs.

Systems used for landscape photo reorientation, (see fig. 16) are of major help. On a black-and-white copy of the scene, mark reorientation items as shown in figures 16 and 38. With the camera mounted on a tripod, compare the picture in hand with the scene through the camera. Orient the camera accordingly.

Figure 37 illustrates a method for rephotographing general views. It shows 3- by 5-in photographs mounted on 5- by 5-in cardboard. Instructions are given under each picture for its location and orientation. These fit into a vest pocket for use in the field. Figure 44A is a recent picture of figure 37A.

Example—Figures 45 to 48 illustrate general photography to document effects of mountain pine beetle on lodgepole pine along Oregon highway 244 in the Blue Mountains of eastern Oregon. Figure 45 is filing system form "Photographic Site Description and Location" mapping two camera locations. Camera location 1 has two photo points (figs. 46 to 48) and camera location 2 has three photo points. Monitoring started in 1976 when beetles first attacked the stands.


CAMERA LOCATION AND PHOTO POINTS

Date 77/8/2 Camera Location Orc 244, Series 1

Area Camas Cr. Meadow Number of Photo points: 5

Unit Ukia Dist Observer [illegible]

Comments LP 70% with white needles, many shed; 30% red needles. Stands 90% dead - all larger trees; Mtn. pine beetle

Slope 10 Aspect E Slope position Top

Photo point A:
Compass bearing: 260° M
Distance: →
Camera located on Orc 244 centerline Massive lodgepole kill

Photo point B:
Compass bearing: 240° M
Distance: —
Camera on Orc 244 centerline

Figure 46—Filing system form "Camera Location and Photo Points" documenting stand conditions in 1977, 1 year after a mountain pine beetle (*Dendroctonus ponderosae*) attack on lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.). Trees killed the first year have lost their needles. Compare to figures 47 and 48. Photo orientation used the road center line but cut off tops of the trees in both **A** and **B**.

Figures 46 to 48 use filing system form "Camera Location and Photo Points" to document beetle effects over 14 years. Figure 46 depicts effects in the second year of beetle attack when trees killed the first year started to drop their needles. Figure 47 is the third year after attack and shows massive standing fuel in A and salvage in B. Figure 48, taken 14 years after initial attack and 13 growing seasons after figure 46, illustrates tree fall in A and growth of natural regeneration in B.

CAMERA LOCATION AND PHOTO POINTS

Date 78/8/17 Camera Location Ore 244, Series 1
Area Camas Cr. Meadow Number of Photo points: 5
Unit Ukiah Dist. Observer [illegible]
Comments Lodgepole needles gray & shed; few green trees are mostly less than 3" dbh.
Slope 10 Aspect S Slope position Top

Photo point A:
Compass bearing: 260°M
Distance: —
90% of dominant & codominant trees with gray or shed needles

Photo point B:
Compass bearing: 240°M
Distance: —
Salvage logged winter of '77-78. Screen of dead trees retained

Figure 47—Stand conditions in 1978, 2 years after beetle attack in 1976. Photo point A shows 90 percent kill and massive standing dead fuel. Photo point B was salvaged in winter 1977-78. These photos were properly oriented to show tree tops and road center line.

Lack of a meter board on which to orient the camera is evident in figures 46 to 48. Treetops are cut off in figure 46, they are visible in figure 47, and again cut off in figure 48. It is important to precisely reorient repeat photos.

Text continues on page 92.

CAMERA LOCATION AND PHOTO POINTS

Date 91/8/5 Camera Location Ore 244 series 1

Area Camas Cr. Meadow Number of Photo points: 5

Unit Ukiah Dist Observer [illegible]

Comments Lodgepole regeneration growing well

Slope 10 Aspect 5 Slope position Top

Photo point A:
Compass bearing: 26°M
Distance: —
70% of lodgepole down by 5th year after beetle kill

Photo point B:
Compass bearing: 240°M
Distance: —
70% of trees in screen down after 5 yrs; salvaged area well stocked (not planted) and growing well

Figure 48—Stand conditions in 1991, 14 years after beetle attack and 13 growing seasons since figure 46. Photo point A shows most dominant trees are down, thereby creating severe burn conditions at ground level. Photo point B illustrates natural regeneration height growth. Compare photo orientation with figure 47, which is optimum; here, B has the tree tops cut off and about a 1/2 inch more pavement at the bottom. Orientation of repeat general photography requires skill and a set of orientation pictures similar to figure 37.

Topic Photography

Topic photography narrows the subject from a general view to a specific item of interest. It adds a meter board, or other size control object, to identify the photographic topic (figs. 40 and 49).

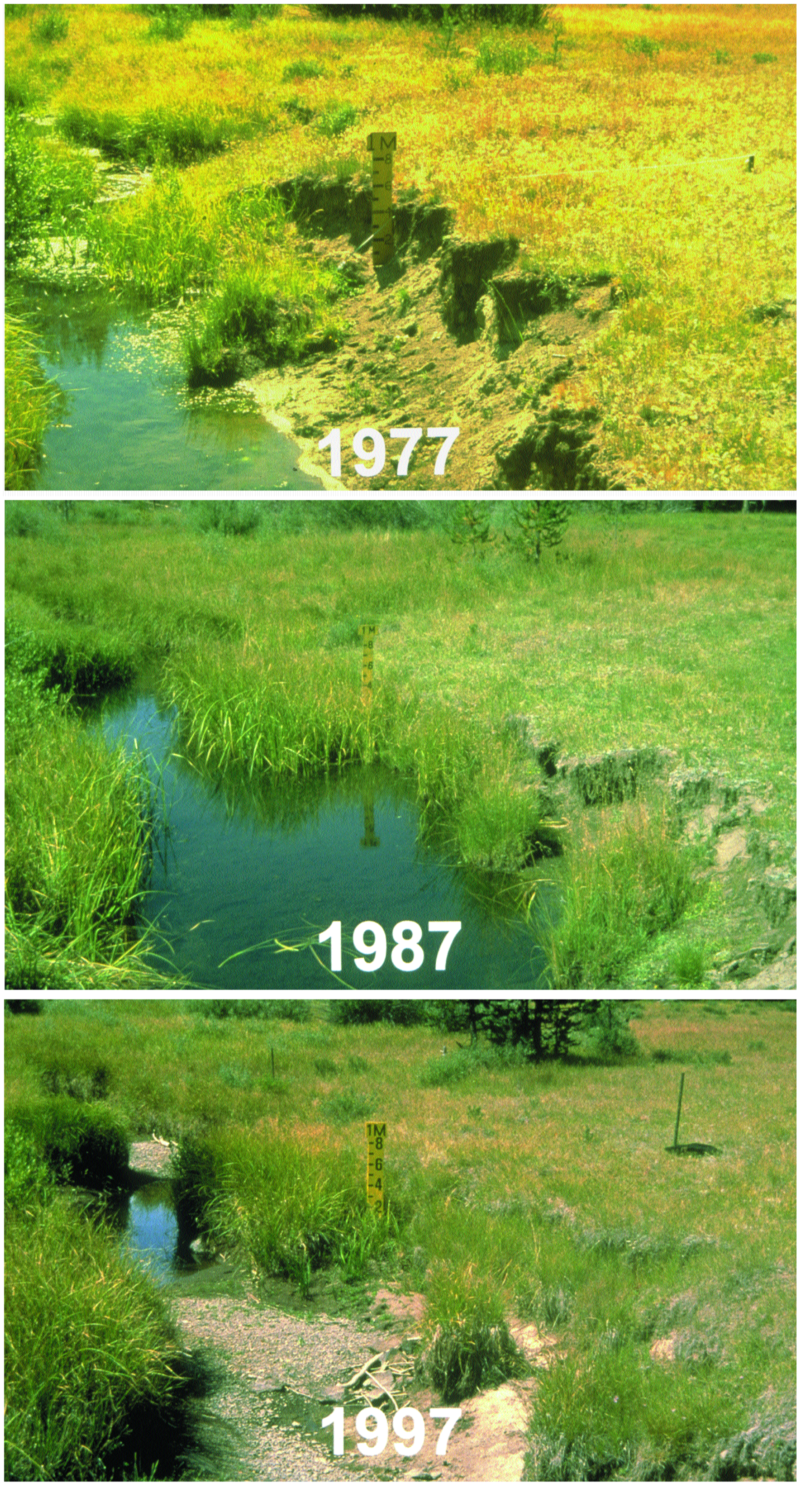


Figure 49—Topic photographs of streambank stability at Pole Camp. The specific topic of interest was fate of the fallen block of sod shown in 1977. Its fate might resolve the question of how fast the streambank will erode under change in livestock management from season-long use to three-pasture rest and rotation. By 1987, beavers had moved into the area raising the stream level, which converted Kentucky bluegrass on the fallen block to aquatic sedge. By 1997 the stream was dry because a flood in February 1996 washed out the beaver dams, cut a new channel, and drained late summer flows from this part of the stream. The block of sod is still present after 20 years of livestock grazing. See figure 23 for effects of a winter ice flood on the original camera location.

PHOTO POINTS AND CLOSE PHOTOS

Date 77/6/6 Camera Plot 226 (669)

Area Snow Mtn. Dist.
Unit Green Butte
Photo point: A
Observer F. C. Hall
Remarks 15 yr retake of ecology plot just prior to partial cut. Good range condition; benchmark for range condition guides, see plot 226 (669) for data.

Photo point A:
Left of meter board
Species/cover:
CAGE 60 %
PONE 15 %
CARO 5 %

Comments: Very good range condition; tight sod.

Photo point A:
Right of meter board
Species/cover:
CAGE 50 %
PONE 25 %
CARO 8 %
FRVI 2 %

Comments: Very good condition

Figure 50—Filing system form "Photo Points and Close Photos" documenting effects of selection logging in a ponderosa pine/elk sedge community (fig. 29). This area had not been previously logged and had only sporadic sheep use because water was 1.5 mi distant. The general view is followed by pictures to the left and right of the meter board. The concept is to show both a general view and a pair of closeups to document change. Figure 29 illustrates what happened in this view after logging and 18 years later. Figure 51 illustrates the same series to the left of the meter board. Species are CAGE (*Carex geyeri* Boott, elk sedge), PONE (*Poa nervosa* (Hook) Vassey, Wheeler bluegrass), CARO (*Carex rossii* Boott, Ross' sedge), and FRVI (*Fragaria virginiana* Duchesne, strawberry).

Concept

A meter board, or other size control board, is placed at the topic to (1) identify the item to be monitored for change; (2) establish a camera orientation reference point for subsequent photography; (3) set up a constant sized reference by which change may be documented, for example by grid analysis; and (4) provide a point to focus the camera for optimum depth of field.

Figures 40 and 49 illustrate identification of a very specific topic, streambank stability. Figure 50 deals with a general view limited to area around the meter board, the topic being effects of logging and precommercial thinning on stand structure and ground vegetation. The purpose of topic monitoring is the primary factor in selecting a monitoring layout.

Effects of camera focal length and distance from camera to meter board to emphasize the topic are discussed in figures 31 to 33. When the distance from camera location to topic is the same (figs. 6 and 7), the 70-mm and 35-mm pictures can be enlarged or reduced to the same size meter board as in the 50-mm photograph (fig. 7). When cropped, all pictures will be the same. This can be done with prints from negatives or digital images; it cannot be done with slides. Try to use the same focal length for all subsequent photographs.

Equipment

The following equipment is required for topic photography:

1. Camera or cameras with both color and black-and-white film, or digital camera
2. Form “Camera-Photo,” from appendix B for photograph identification, printed on medium blue paper
3. Forms from appendix B for site identification: “Photographic Site Description and Location,” and photo points: “Camera Location and Photo Points”
4. Meter board (app. C)
5. Clipboard and holder for the photo identification sheets (app. C)
6. Fenceposts and steel stakes, sufficient for the number of camera locations and photo points desired, with pounder
7. Compass and 100-ft tape for measuring distance
8. Metal detector for locating stakes

Technique

Several steps are necessary to establish topic photo monitoring. Pole Camp (fig. 44) will be used as an example.

Define the topics of interest—At Pole Camp, primary topics of interest were effects of livestock grazing on streambank stability, differential utilization of dry and wet meadows, and impacts on willow shrubs. Next, the desired coverage of the monitoring area must be defined. How many streambank sites are desired? How many dry and wet meadows and where? How many shrubs should be monitored and where are they located? Note in figure 44A the distribution of willow shrubs and in figure 44B, the pattern of dry to moist to wet meadow.

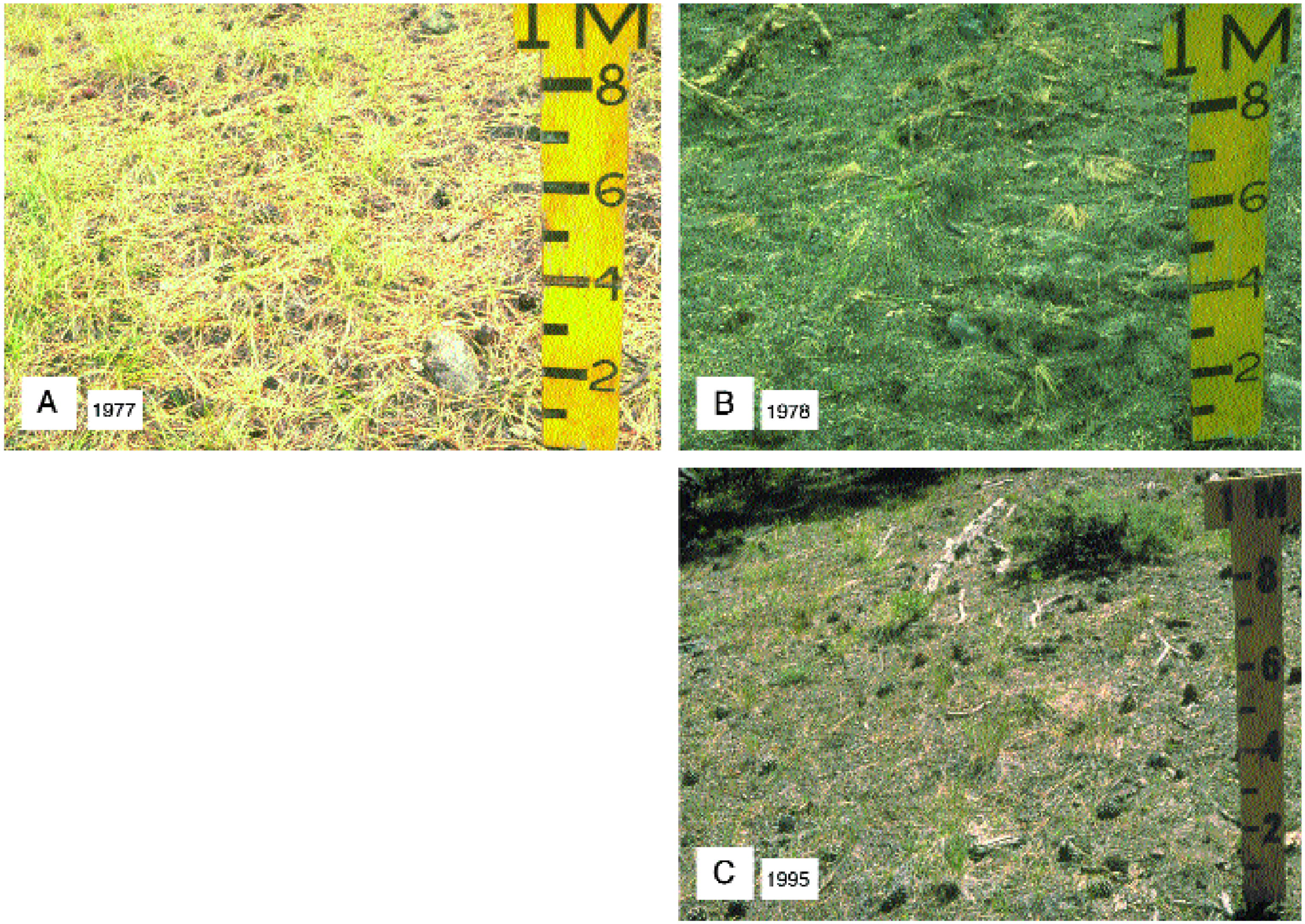


Figure 51—The ponderosa pine logging depicted in figures 29 and 50. (**A**) Prelogging with elk sedge clearly dominant, (**B**) tracts and destruction of the elk sedge, and (**C**) 18 years later, still with very little elk sedge, only some squirreltail grass, and a browsed bitterbrush.

PHOTO POINTS WITH OVERHEAD VIEWS

Date 96/8/5 Camera Wide Thin #3

Area Prairie City Dist Number of Photo points: 1

Unit Cold Cr. Observer F. C. Hall

Comments 25 yrs since pct; clearcut about 1950

Slope 5 Aspect W Slope position mid Topography undulating

Photo Point A

Compass bearing: 178° M

Distance 32.0 ft

Photo comments:

No cow use, trees now growing at 2.2" per dec.

Overhead of Photo Point A

Photo comments:

Ponderosa pine in fairly good vigor. 100 ft line transect showed 47% cover

Figure 52—Filing system form "Photo Points with Overhead Views" documenting current tree canopy cover in a stand precommercially thinned 25 years previously. The form is in appendix B. Remember to make notes on what is in each photo.

Closeup photos—In many cases, details might be desired that are not accommodated by a meter board 7 to 10 m distant. Closeup photos, one on each side of the meter board, are recommended (fig. 34). After the general photo is taken, walk up to the meter board and photograph it on each side. With a 50-mm lens, stand 2 m away or with a 35-mm lens, stand 1.5 m away. Figure 34 illustrates the result with a 50-mm lens. The critical element is to always place the top of the meter board all the way up in a corner of the view (fig. 35). Details on the ground are shown in about a 1.5- by 1.5-m area on each side of the meter board (fig. 34). The concept is a general photo and two closeup photos to document change (fig. 50).

Figure 50 illustrates use of filing system form “Photo Points and Close Photos” (app. B) for mounting and filing topic photographs. It is the 1977 view of ponderosa pine shown in figure 29. Figure 51 has close views of general conditions, shown in figure 29 for prelogging, that were taken 1 year later and 18 years later.

Multiple photo points—Coverage could be either multiple photo points from the same camera location or multiple camera locations focusing on the same photo point. Figure 42 maps two photo points (D and W) from camera location 1 and two camera locations (2 and 3) focusing on one photo point (S). Figure 44 shows these camera locations and photo points. Advantages are twofold: First, relocation tends to be easier because only one point must be located that will serve two or more views, and second, one point showing several views tends to tie the sampling area together.

Overhead canopy—Overhead canopy pictures may be useful when documenting changes in tree canopy cover (fig. 52). A word of **caution**: camera focal length **must be the same** for all subsequent pictures because there is no size control board by which to adjust different photos taken at different focal lengths to the same size. Directions for overhead photography are contained in the “Tree Cover Sampling” section, later in this appendix.

Distance from camera to photo point—Distance between camera location and photo point is critical for any repeat photography from the camera location: It **must** remain the same. Exact replication of distance for all rephotography is the reason camera locations and photo points must be permanently marked in the field and their distances measured. I have found the best system is with flimsy fenceposts. The same distance is not required, however, for other photo monitoring. Figure 42 shows different distances of photo points from camera location 1.

An investigator may elect to do all three kinds of photography: topic view, closeups on each side of the meter board, and an overhead view for maximum documentation of treatment effects.

Analysis of Change

The meter board is used as a constant size reference point for analyzing changes. The recommended system is grid analysis, discussed next. A clear plastic form with site identification information is taped to the photo and topics of interest outlined. Then an analysis grid is adjusted to exactly match the size of the meter board in the outline and is printed on white paper. The outline form is taped to the grid, and grid intersects on and within the outlines are counted and recorded. Amount of change between photos can then be determined.

CONTINUE

Photo Grid Analysis

Changes in vegetation, soil, fuel loading, streambanks, or other photographed items can be monitored by outlining the items on a clear plastic sheet that is then placed over grid lines. The method involves counting grid intersects falling on and within the outline and recording them. They are then compared to outlines of previous photographs of the same topic to estimate change. Each plastic sheet with its outlines becomes a database and must be identified. Outlines may be laid on top of each other and compared between photographs to visually assess changes.

Concept

The concept of grid analysis is based on a fixed geometric relation between camera and meter board to compare photographs. The basic requirement is a constant distance between camera and meter board (photo point) for the initial and all subsequent photographs. Different distances may be used for other photo points from the same camera location and at other camera locations depending on the topic of interest (figs. 49 and 50). An established camera height is desirable but not essential unless the grid is used to track change in position of items over time. Use of the same camera format, such as 50-mm lens on a 35-mm camera body, is recommended but is not required. Grids are designed to encompass a view limited to 13 to 15 degrees both horizontally and vertically. Views exceeding 15 degrees suffer from parallax caused by light refraction at the edges of a lens. Heavy lines surrounding the grid emphasize this limit.

A photograph of the topic (fig. 53, for example) is enlarged to 8 by 12 in for easy viewing. A clear plastic sheet, with information on date, site location, and topic, is attached to the photograph (figs. 54 and 55). The meter board in the photo is marked and the objects of interest outlined. Then a master analysis grid is adjusted for size by using the meter board on the outlined plastic sheet. For adequate precision in grid size adjustment, the meter board must occupy at least 25 percent of the height of the photograph; 35 to 50 percent is better. Adjustment in grid size requires measurement of the outlined clear plastic meter board (fig. 56), measurement of the meter board on a master grid (fig. 57), and reducing the size of the master to match the outline. Each individual picture must be measured for grid adjustment. Grids are reduced with a copy machine, printed on white paper, taped under the outlined clear plastic sheet, and grid intersects counted that fall on or within each outline (fig. 58).

Requirements

Requirements for photography suitable for grid analysis include the following:

1. Camera location and photo point (meter board) permanently marked so that exact relocation is possible. Consider use of cheap (stamped metal) fenceposts driven 2 to 3 ft into the ground for both camera location and photo point.

2. A size control board, such as a meter board, placed a prescribed distance from the camera for each photo point. The distance selected may be from 5 to 20 m depending on the meter board selected, a single meter board 1 m tall (figs. 49 and 50) or a double board 2 m tall (fig. 31). Distance for other locations may be selected according to the topic identified by the meter board. Make sure the visible part of the meter board occupies at least 25 percent of the picture height.

Text continues on page 103.

Figure 53—A1981 view of the Pole Camp wet photo point to be used as an illustration of grid analysis. This photograph will be compared to one from 1996. The first step is to attach a clear plastic outline form (fig. 54). Fill in the required site information and outline the shrubs (fig. 55).

Date_______________ **GRID INTERSECT ANALYSIS** **Area** ______________________
Observer ____________________ **Unit**_________________________
Cluster/Camera________________________ **Transect/Photo**___________________________

Figure 54—Form used to identify photographic outlines. Reproduce the form on clear plastic overhead projection sheets. This form has been reduced to 85 percent of its size in appendix C. The full-sized form is suitable for color photographs of 8 by 12 in. Use of the clear plastic overlay is illustrated in figure 55.

Figure 55—Photographs to be evaluated by grid analysis: (**A**) 1981 (fig. 53), and (**B**) 15 years later in 1996. Clear plastic overlays (fig. 54) have been taped to each photo. Each overlay is a data sheet so it must have all information entered to identify the outlines. First the meter board is outlined on its left side and top. Then each visible decimeter line on the meter board has been marked and the decimeter number written on the overlay. Finally, each shrub has been carefully outlined and given either a letter or number identification. The next step is size adjustment of the analysis grid.

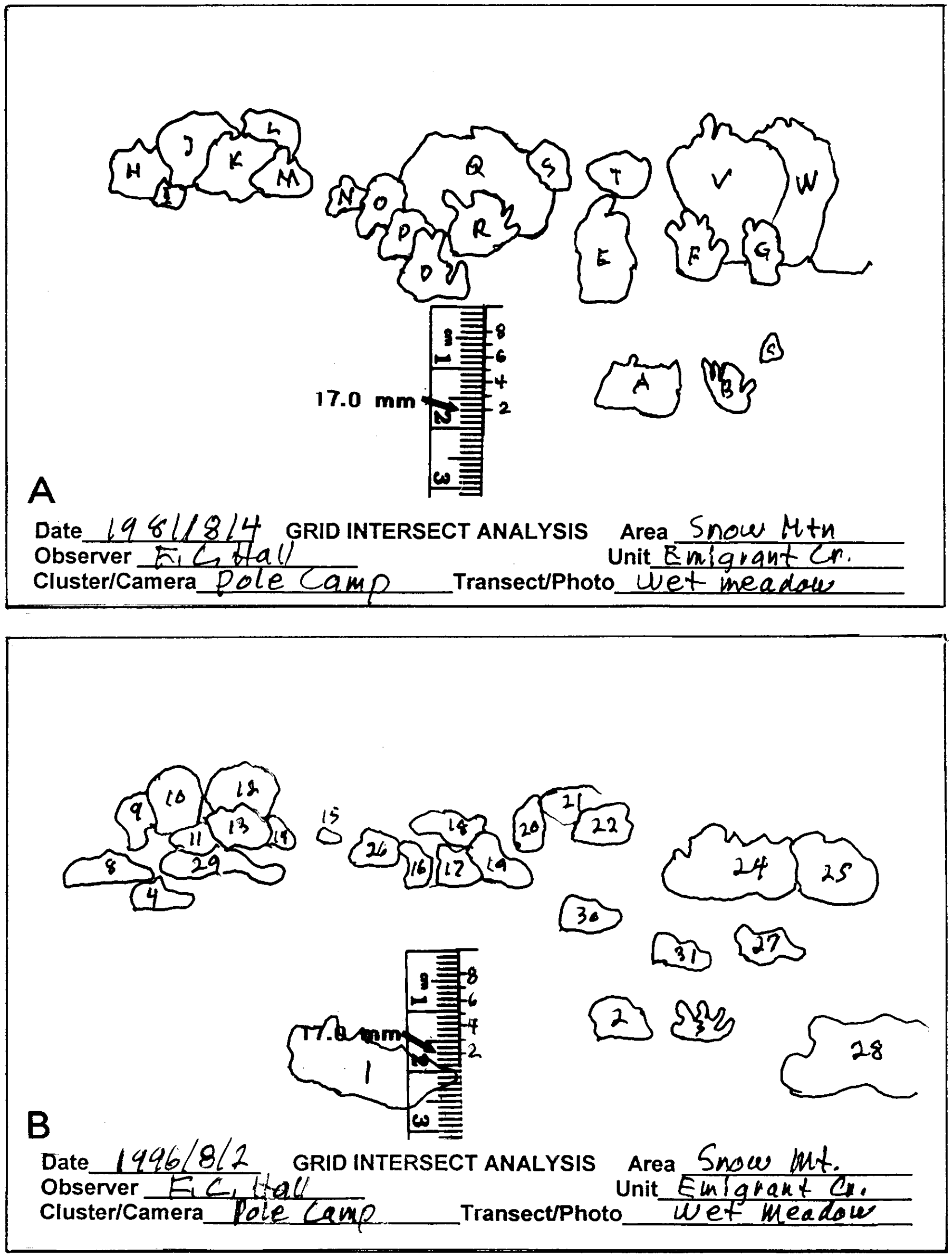


Figure 56—Measurement of meter boards for size adjustment of analysis grids: (**A**) 1981 and (**B**) 1996. Measure from the top down to the lowest visible decimeter mark to the nearest 0.5 mm, in these photos the 2-dm mark. Both measurements are 17.0 mm, which indicates the same distance from camera to board in both and consistent enlargement of the photos. The analysis grid (fig. 57) will have to be reduced in size to exactly match size of the meter boards in these outlines. An exact match is required for consistency in measurement between photographs.

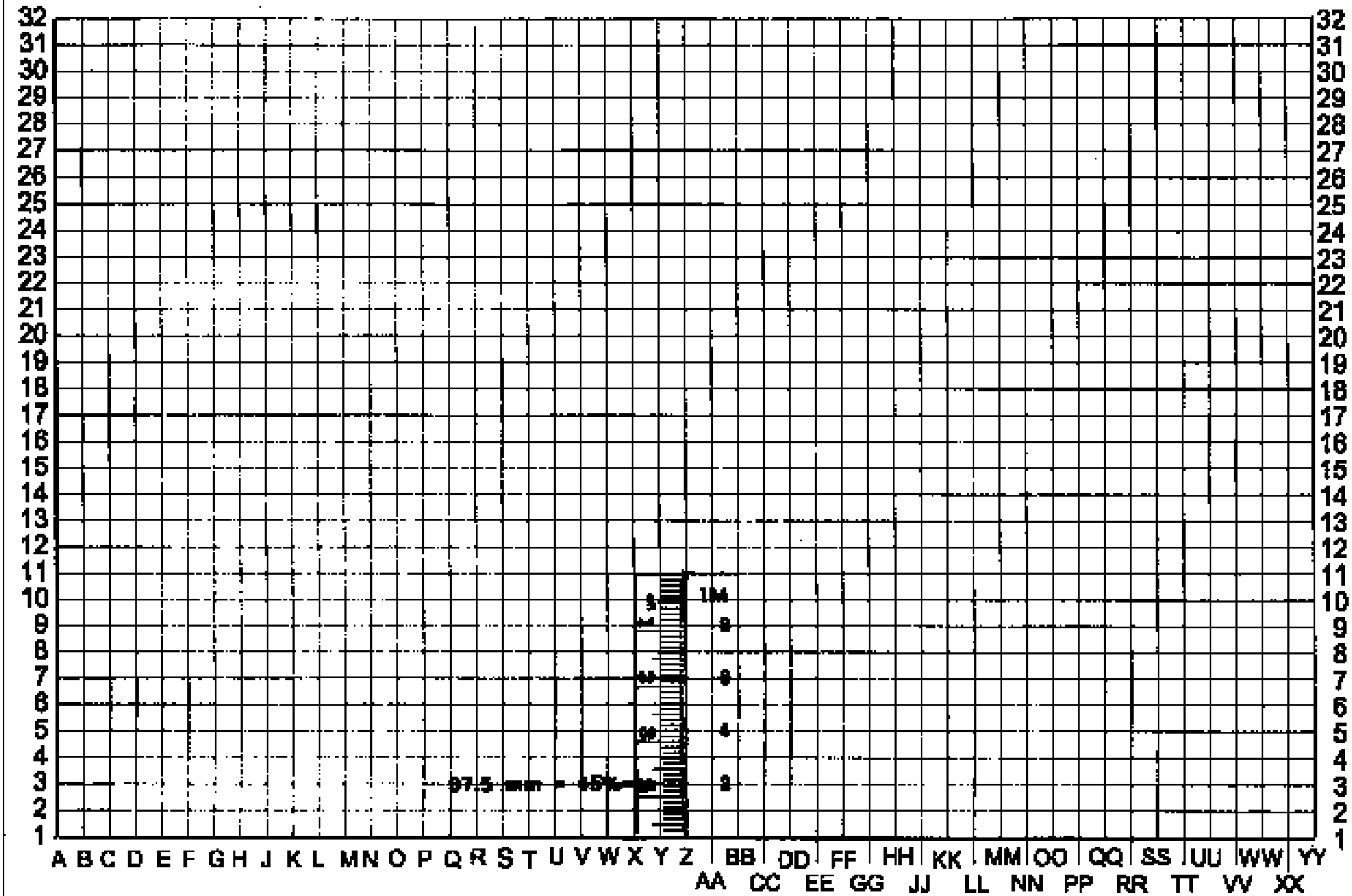


Figure 57—The master analysis grid found in appendix C. Measure from the top of the meter board to the 2-dm mark used in the outlines. This measurement is 37.5 mm. Divide 17.0 mm from the outlines by 37.5 for a reduction to 45 percent of the grid. Print the grid on white paper at 45 percent of its original size. The outline is laid over the reduced grid to check on alignment of meter board marks. Minor adjustments in grid size are made so that marks of the overlay and grid meter boards match exactly (fig. 58).

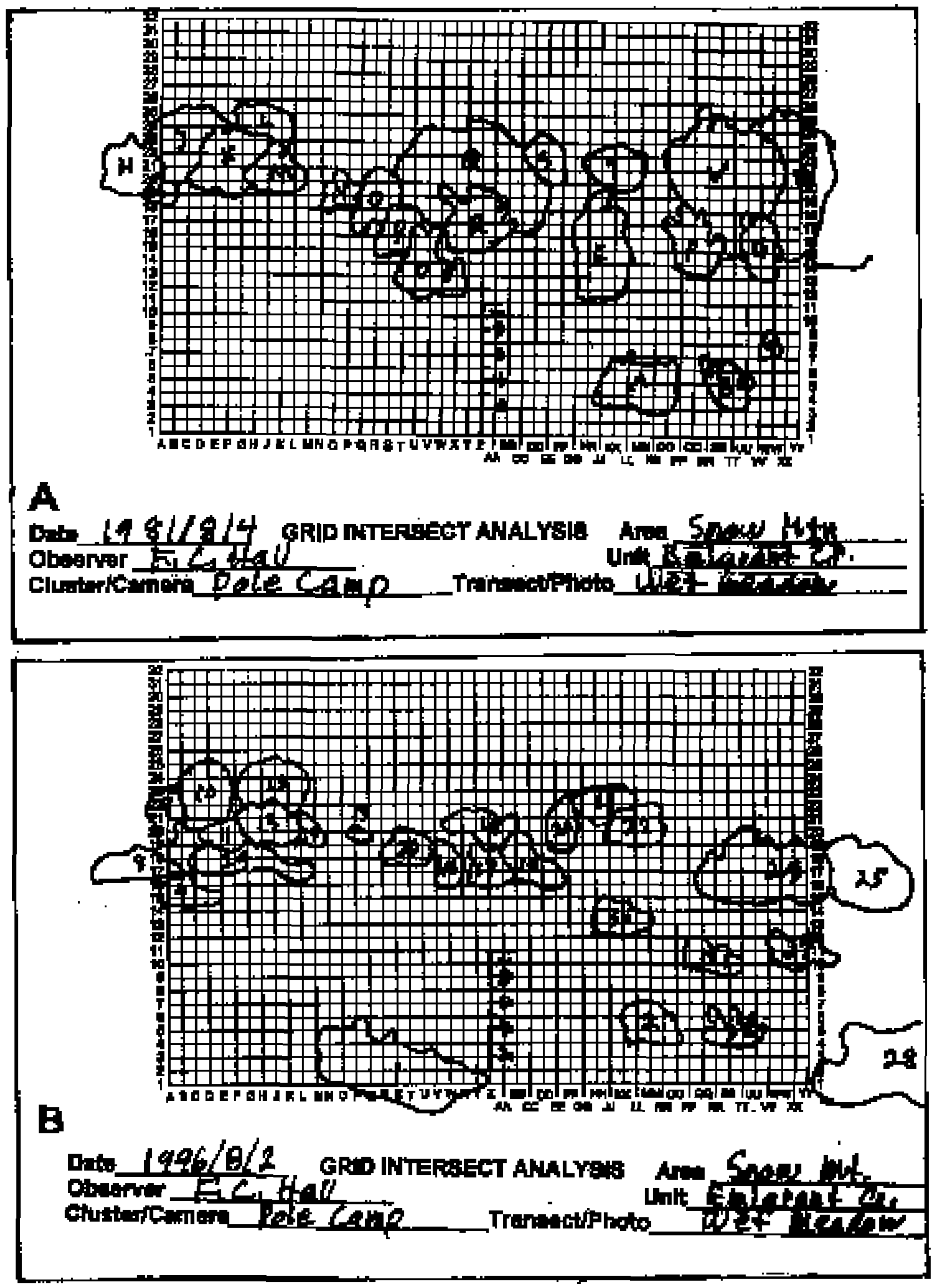


Figure 58—Outline overlays placed on analysis grids: (**A**) 1981 and (**B**) 1996. The next step is to count grid intersects within each outline. When an outline crosses a grid intersect, such as the two intersects between shrubs 17 and 19, AA/18 and AA/19 in photo B, count the intersects for the shrub in front (shrub 17). Also count intersects along the grid edge, such as the five intersects in shrub 24 on line YY, photo B.

1999/2/19

PHOTO GRID SUMMARY

Date 1999/10/22 Observer F. C. Hall
Area Snow Mtn Unit Emigrant Cr.
Cluster/Camera Pole Camp Transect/Photo Wet Meadow

Item #	Date 1981	Item #	Date 1996	Item #	Date
A	21	1	44		
B	12	2	15		
C	4	3	12		
D	19	4	8		
E	30	5	—		
F	17	6	—		
G	15	7	—		
H	1	8	2		
I	4	9	6		
J	19	10	17		
K	22	11	6		
L	9	12	15		
M	11	13	14		
N	6	14	4		
O	11	15	2		
P	13	16	8		
Q	63	17	10		
R	21	18	12		
S	7	19	13		
T	14	20	8		
~~U~~		21	11		
V	59	22	12		
W	26	~~23~~	—		
		24	43		
	404	~~25~~	—		
		26	9		
		27	10		
		~~28~~	—		
		29	16		
		30	10		
		31	11		
			318		
	404		318		

Figure 59—The filing system form “Photo Grid Summary” where number of grid intersects by outline are recorded. In figure 58A, shrub A had 21 intersects; 21 is entered for shrub A under 1981. The primary purpose for identifying each outline is to aid in recording the number of intersects. Notice that three more shrubs were identified in 1996 than in 1981, even though only 64 percent as many intersects were recorded.

Suggestion: When grid analysis is contemplated, clip vegetation away from the front of the meter board to expose the bottom decimeter line. This will provide for maximum precision in grid adjustment.

Photographed with a 50-mm lens on a 35-mm camera, a single meter board set at 10 m is 25 percent of the photo height (fig. 2A), at 7 m it is 36 percent (fig. 2B). A double meter board, 2 m tall (fig. 31), will be 25 percent of photo height at 20 m. The meter board is used to orient the photograph and adjust size of an analysis grid.

3. Orient the camera view on the meter board. Place the camera focus ring on the "1M" and focus (figs. 29 and 30). This accomplishes two things: (1) it provides for reorientation of all subsequent photographs, and (2) it provides for a sharp image at the topic marked by the meter board and an optimum depth of field.

The following items are required for grid analysis:

1. Photographs of the monitoring situation. Figure 53 is the wet meadow photo point at Pole Camp taken in 1981. It will be compared to a photo taken in 1996 to appraise change in shrub profile area. Print all photographs to be compared at the same size, preferably about 8 by 12 in, and in color for best differentiation of items to analyze.

2. "Grid Analysis Outline" (app. B) printed on clear plastic sheets used for overhead projection (for example, 3M® or Labelon® Overhead Transparency Film). Film is specifically designed for use with various printers (inkjet, plain paper, or laser). These sheets are imprinted with site information from the form in figure 54 and are used for drawing outlines around topics of interest.

3. The "Analysis Grid" form, shown in figure 57 (app. B). The grid must be adjusted in size to precisely fit each picture and outlined meter board (figs. 55 to 58). Instructions are given in the section, "Grid Adjustment," below.

4. "Grid Summary" form (fig. 59 and app. B).

5. Permanent markers for drawing on clear plastic (for example, Sanfords Sharpie® Ultra Fine Point Permanent Marker). Three colors are recommended when encountering overlapping outlines, as in figure 60, to aid in differentiating items. Colors suggested are black, red, and blue.

6. Good quality hand lens to help identify the periphery of items being outlined—in this case, shrub profiles.

7. A copy machine that will produce clear plastic overhead projection copies and can adjust size of the master grid to fit the photographs. Many copy machines can reduce to about 50 percent or enlarge to 200 percent. Be sure to use a copy machine that does not stretch the copy in either direction. Grids, adjusted for size and printed on white paper, are taped under each outline for analysis.

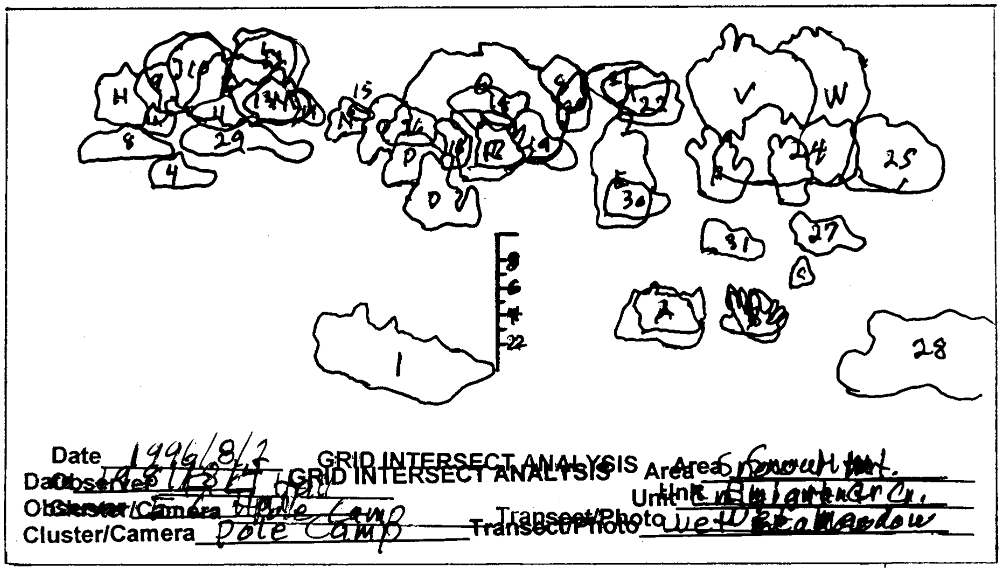


Figure 60—Outlines from 1981 (letters) and 1996 (numbers) overlaid for comparison of change in shrub profile. Note major changes in shrubs Q, V, and W, and a new shrub shown as 1. The dramatic reduction in shrub height of Q, V, and W from 1981 to 1996 was caused by beavers cutting the largest stems for dam construction.

Technique

Technique for grid analysis requires outlining the meter board and selected objects on the plastic overlay, “Grid Analysis Outline” form (app. B). The overlay has site information at the bottom because it becomes a permanent record of conditions on the date of each photograph (fig. 54).

Outlines on the overlay are interpreted by use of a grid that must be adjusted in size to exactly match divisions on the overlay meter board (figs. 56 and 58) in each photograph. The recommended procedure follows.

Outlining—Determine what is to be interpreted. In this example, change in willow profile area is the topic so all other items—grasses, sedges, forests and water—are not outlined. Decide whether individual shrubs will be evaluated or all shrubs lumped together. In this case, combined shrubs will be evaluated. Proceed as follows:

1. Fill out all information on the clear plastic overlay, because it becomes the permanent data record and must be identified (fig. 54). Date is the **photography** date, not when the outline was made.

2. Attach the plastic overlay to the photo at only one edge, such as the top, so that it may be lifted for close inspection of the photograph and then replaced exactly (fig. 55).

3. Using a straight edge, mark the left side of the meter board and its top on the overlay (fig. 55). Next, mark each decimeter division on the meter board and identify even-numbered decimeter marks by their number, such as 2, 4, 6, and 8 (fig. 55).

4. Starting in front, work systematically from left to right, outlining each shrub and labeling it with a letter or number (fig. 55). The primary purpose for identifying each shrub (or any outline) is administrative to assure that grid intersects inside an outline are not repeated or missed if interruptions occur during recording.

   At times, identifying change in specific shrubs might be desirable. If so, each shrub identified in the initial photo will have to be identified in all subsequent photos and the letter or number used initially will have to remain exclusive to the shrub or to the location where the shrub used to be. This is best accomplished by shrub profile monitoring, discussed in the next section. Any new shrubs will require their own exclusive new identification.

5. When outlining, pay particular attention to the periphery of the shrub by following as carefully as possible the foliage outline. Do not make a general line around the outside of the shrub. Mark directly on the foliage, not outside of it. Check outlines by lifting the overlay to check on foliage and inspect with the hand lens.

6. Work back into the photograph. The letter inside the front shrub outline identifies the overlapping shrub (figs. 55 and 56). Using different colored marking pens may enhance overlapping outlines. Intersects often will occur under an outline. Count them for the shrub in front only (do not count the intersect twice).

Grid adjustment—Outline interpretation requires use of an analysis grid (fig. 57), whereby each grid intersection on or inside the outline is counted and recorded. The grid must be adjusted in size based on the meter board outlined on each overlay. Proceed as follows:

1. Measure height of the meter board as it appears on the overlay to the nearest 0.5 mm. If the bottom line on the board is not visible, measure to the lowest visible decimeter mark. In figure 56, it is 2 dm and measures 17.0 mm from top to 2 dm. Similar measurements between the 1981 and 1996 photographs indicate that distance from camera to meter board was the same and that both pictures were enlarged identically.

2. Next, measure height of the meter board on the master analysis grid. In figure 57, it is 37.5 mm from the top to the 2-dm grid line (second from the bottom).

3. Determine the percentage of change required for the master analysis grid: 17.0/37.5 = 45 percent. On a copy machine, reduce the grid to 45 percent and print on plain paper. Overlay the outline on the grid to determine any additional size adjustment (fig. 58). This usually requires two or three trials.

4. Place the clear plastic overlay on the grid and assure that grid divisions exactly match those on the overlay meter board. Orient the overlay on the grid by using the left side of the meter board outline (fig. 58). Adjust the grid as necessary. When both overlay and grid meter board marks match exactly, tape the overlay to the grid.

Note borders on the grid. These mark the maximum 12- to 15-percent angle useful for grid analysis. Do not count intersects on outlines outside the grid.

5. On the filing system form, “Photo Grid Summary” (fig. 59), complete the required information and enter the year of the **photograph** in the “Date” column. This is the same date as on the plastic outline. List shrubs by letter or number in the “Item #” column. The form provides for recording intersects for three photographs. Note that items, shrubs in this case, are not required to have the same identification. Here, shrubs from 1981 are letters and those from 1997 are numbers because exact relocation of shrubs was not possible.

6. Starting in front and working from left to right, count the number of grid intersects on or within each outline. An intersect is where a horizontal and vertical grid line intersect. When the outline covers an intersect, count it for the shrub. Many times, the outline will separate two shrubs. Count the outline intersects for the shrub in front. Do **not** count the intersect twice. See figure 58A: intersect W-20 is on the outline for shrub “R” with shrub “Q” behind it. Record the intersect only for shrub “R.” This is why outlining **on** rather than outside of shrub foliage is important. Do not try to count intersects for the shrub behind when they cannot be seen; for example, in figure 58A, intersects of shrub “Q” behind shrub “R” should not be counted. Count intersects on the edge of the grid but not beyond the grid even though the shrub or outline might extend beyond the grid, such as shrub W in 58A along the YY line. The grid defines the area of analysis, not the photo coverage.

7. Record the intersects for each shrub beside its letter or number (fig. 59). Recording by shrub letter or number will simplify record keeping. Disturbances or the need to stop can occur at any time, and a record is needed of shrubs already recorded and where to begin again. When finished, sum all the intersects (fig. 59): 1981 had 404 and 1996 had 318 intersects. Ask yourself if these are significantly different. The next section deals with analysis of change.

Note: Each picture is produced by enlargement of a negative. Seldom are two enlargements made at exactly the same scale even though the negatives might be precisely sized. Therefore, grids must be sized **independently** for each photograph (figs. 56 and 58).

Figure 58 compares outlines from 1981 and 1996. Visually, there is a difference in shrub profile area. These outlines are overlaid in figure 60 as one way to interpret change.

Analysis of Change

This section deals with analysis of change considering grid precision and observer variability. The grid monitoring system provides an opportunity to overcome both problems, which are primarily differences among observers. Let each observer do grid analysis on all photographs and interpret the results. The same personal idiosyncrasies will be applied in object outlining, grid sizing and placement, and interpretation of grid intersects, greatly reducing between-observer differences that affect interpretation of change.

Table 1—Effect of distance from camera to meter board on grid coverage at 10, 20, 30, and 60 m

Distance, camera to meter board	Ratio	Angle	Grid size at distance from camera of: 10 m	20 m	30 m	60 m
Meters		*Percent*	-----------	*Decimeters*		-----------
5	1:50	2.0	2.0	4.0	6.0	12.0
7	1:70	1.4	1.4	2.8	4.2	8.4
10	1:100	1.0	1.0	2.0	3.0	6.0

Correct grid sizing and differences among observers influence analysis of change. Area within successive grid outlines may be digitized and compared. The data are entirely dependent, however, upon exact duplication of meter board outline size.

Grid precision—Percentage of photo height represented by the meter board is an important factor in precise fit of grids. The minimum is 25 percent and the optimum is 35 to 50 percent. A 35-percent meter board is 1.3 times more precise than a 25-percent board for grid adjustment.

Using a single meter board at 10 m (fig. 53), which is 25 percent of photo height, just a 0.5-mm difference in measurement at the meter board (17.0 vs. 17.5 mm; fig. 56) results in a 2.9-percent change in grid height. Grids 2.9 percent different in height also are 2.9 percent wider which results in a 5.9-percent difference in outline area. This same percentage applies to the number of intersects that may be within an outline.

A meter board occupying 33 percent of photo height would measure 22.5 mm in figure 56. A 0.5-mm difference here is only a 2.2-percent change in grid size. The 2.2 and 2.9 percent represent errors in measurement precision.

Distance from camera to meter board also affects precision of measurement on items beyond the meter board. Table 1 illustrates the effects of three distances between camera and meter board and how they affect grid precision at various distances from the camera. Because grids are adjusted to size at the meter board location, each grid is 1 by 1 dm at that location but this will change as distances increase.

A grid sized to a meter board 5 m from the camera measures 2 dm between grid lines at 10 m from the camera. This is two times greater than a grid sized at 10 m from the camera. At 30 m from the camera, a grid sized to a board 5 m from the camera will cover an area 6 by 6 dm. When sized to a meter board set 10 m from the camera, it will cover an area only 3 by 3 dm, one-half the dimensions and one-quarter of the area—a significant improvement in precision. Monitoring objectives help determine the optimum distance from camera to meter board as grid size adjustment and outline precision are balanced.

Observer variability—“Perfect” outlines are influenced by differences among observers.

1. Size adjustment of grids is influenced by observer skill. With a meter board at 25 percent of photo height, a 0.5-mm measurement difference of the meter board can mean as much as 2.9-percent difference in grid dimensions and 5.9-percent difference in area. Meter boards closer to 33 percent of photo height and larger photographs help to reduce this error. I recommend 8- by 12-in color photographs. A meter board at 33 percent of photo height would measure about 55 mm. A 0.5-mm measurement discrepancy would be only a 0.9-percent precision error.

2. The grid must be oriented exactly along the left side of the meter board as viewed (the observer’s left side) and precisely at the top and bottom or lowest clear decimeter mark. Orienting precision is subject to observer skill.

3. Interpretation of what constitutes the periphery of an object profile (shrub in this case) is subject to observer variability. Choices have to be made about where to place an outline and how precise it will be, particularly for overlapping shrubs. An intersect is counted if the outline crosses it. The desirability of the topic being outlined tends to influence a person's willingness to include or exclude marginal parts. Outlining on clear plastic without grid lines tends to reduce observer bias.

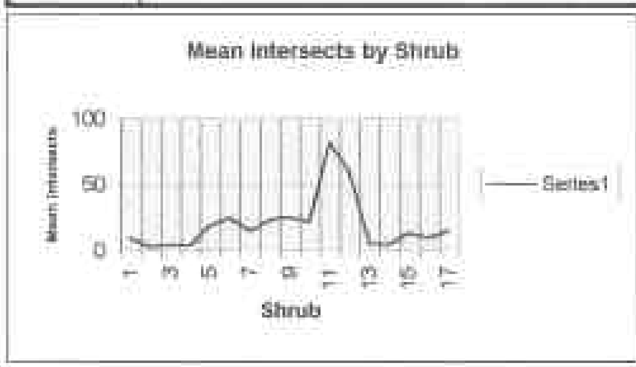
A test was made in January 1998 of observer variability in outlining the shrub profile area shown in figure 53. Results of the seven observers are in figure 61. A 6- by 9-in color print with properly sized grid was provided. Observers placed the grid, outlined shrubs, and summarized intersects within each outline. Variation between observers was measured by the 5-percent confidence interval (CI). The CI also was calculated as a percentage of the mean: CI divided by the mean, then multiplied by 100 equals the CI% for each shrub, total of all shrub intersects, and an average CI. Low CI%, such as 5 percent (shrub H), is interpreted as low observer variability, and a change of more than 5 percent in intersects probably is a significant difference. High CI%, such as 25 percent (shrub B), means high observer variability and more than a 25-percent change is required to be significant.

Percentage of confidence intervals ranged from 4.2 percent (shrub L) to 54.4 percent (shrub D) (fig. 61). The average CI% among the observers was 15.4 percent, suggesting that a change of more than 15 percent in intersects is required. However, the CI% for total intersects of all shrubs combined was only 5.7 percent indicating good concurrence among observers.

The number of intersects in an outline seems to influence the CI%. A graph at the bottom of figure 61 show higher CI% with lower intersects per shrub.

Differences in shrub profile area are rather clear in figure 58. Profile area in 1996 was 79 percent of that in 1981 (fig. 59). The reader may wish to test this observer variability; count the shrub profile intersects in figure 58 and compare to the data in figures 59 and 61.

Shrub	FCH	CE	DE	SE	MR	CQ	MN	Mean	Std.Dev.	5% CI	CI%Mean
A	10	9	12	8	13	8	7	9.571429	2.22539	0.8242813	8.611894322
B	4	3	5	2	4	3	2	3.285714	1.1126973	0.8242813	25.08682259
C	6	5	6	5	5	4	3	4.857143	1.069045	0.7919439	16.30472673
D	3	3	7	2	10	4	1	4.285714	3.1471832	2.3314196	54.39979127
E	22	13	26	22	23	17	15	19.71429	4.7509398	3.5194755	17.85241217
F	28	24	28	25	32	21	19	25.28571	4.4614753	3.3050415	13.07078572
G	17	12	18	14	19	15	11	15.14286	3.0237158	2.2399555	14.79215911
H	24	23	26	22	26	24	22	23.85714	1.6761634	1.2416946	5.204707832
J	30	23	26	24	30	25	21	25.57143	3.4086724	2.5251297	9.874808968
K	23	24	28	13	34	13	21	22.28571	7.6095178	5.6370976	25.29466952
L	86	81	79	91	82	81	77	82.42857	4.6853368	3.4708772	4.210769515
M	65	58	59	72	43	68	56	60.14286	9.5118973	7.0463722	11.71605833
N	6	6	5	6	6	6	5	5.714286	0.48795	0.3614713	6.325747193
O	7	4	5	4	6	5	5	5.142857	1.069045	0.7919439	15.39890858
P	14	14	14	12	16	13	13	13.71429	1.2535663	0.9286365	6.771307827
Q	9	12	11	11	7	14	9	10.42857	2.2990681	1.7031397	16.33147648
R	17	16	20	14	18	9	15	15.57143	3.5050983	2.5965616	16.67516637
S	24	23	22	16	22	24	21	21.71429	2.75162	2.0383881	9.387313837
TOTAL	395	353	397	363	396	354	323	368.7143	28.347335	20.999583	5.695353784
								MEAN	3.2249101	2.3432062	15.4060848



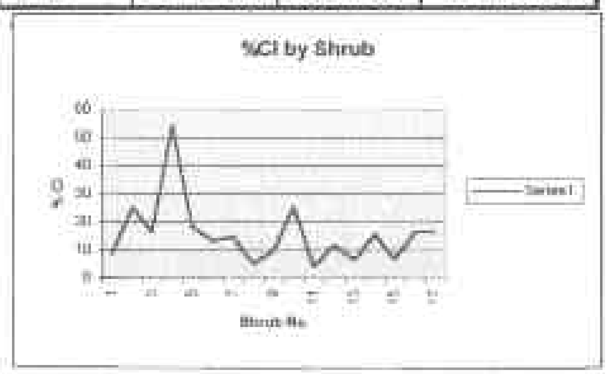


Figure 61—Summary of seven observers determining grid intersects on 18 shrubs from the same photograph. Variability among observers is characterized by the 5-percent confidence interval (5%CI) and is expressed by dividing the 5%CI by the mean intersects by shrub and multiplying by 100 (CI%Mean). The mean and CI%Mean are graphed by shrub.

Because CI% was rather high for individual shrubs, another observer variability test was conducted in winter 1999. Eight observers were provided with two photographs, one from 1975 and another from 1995, and asked to count total intersects of shrub profile. The CI% for 1975 was 7.5 percent and that for 1995 was 11.6 percent (fig. 62). The 1995 photo was more difficult to interpret.

The graph in figure 62 illustrates the mean, 5-percent confidence interval, and observer variability by year. Using the largest CI%, 11.6 percent, the averages are significantly different at the 0.5-percent level. Given a maximum of 12-percent observer variability here and 15 percent for total individual shrubs, a value greater than 12 percent of the average intersects is proposed as being significant at the 5-percent level of confidence for observer variability; for example, a mean of 384 intersects must change by more than 46 to say that the change was real and not due to observer variability at the 5-percent level of confidence (384*0.12 = 46.1). This may be expressed as 384±46 so that intersects greater than 430 or less than 338 may be considered a real change.

Outline Analysis - 2 photos, 99/3

Photo	FH1	FH2	EC	DR	DF	MN	SE	CQ	Mean	Std.Dev.	Cof.Var.	Max.	Min.	Range	% Range	5%CI	CI%mean
1975	376	364	394	473	386	330	359	393	384.38	41.59305	10.82096	394	330	64	0.1665041	28.8219	7.49839184
1995	201	241	255	232	208	152	263	196	218.5	36.53961	16.72293	263	152	111	0.5080092	25.3202	11.5881706

Figure 62—Outline analysis test for variability among eight observers in estimating shrub profile intersect. Photographs from 1975 and 1995 taken at the Pole Camp wet meadow photo point were compared. Series 1 is 1975 and series 2 is 1995. The 5-percent confidence interval for 1995, 12 percent of the mean, was used to determine a significant change in shrub profile.

25-year regression Pole Wet

Year	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	Mean
Area	378	401	422	379	394	392	353	436	407	393	365	363	229	247	247	227	249	228	262	214	254	267	330	380	412	329.2

****************** *********** Beavers********************** ****** ******

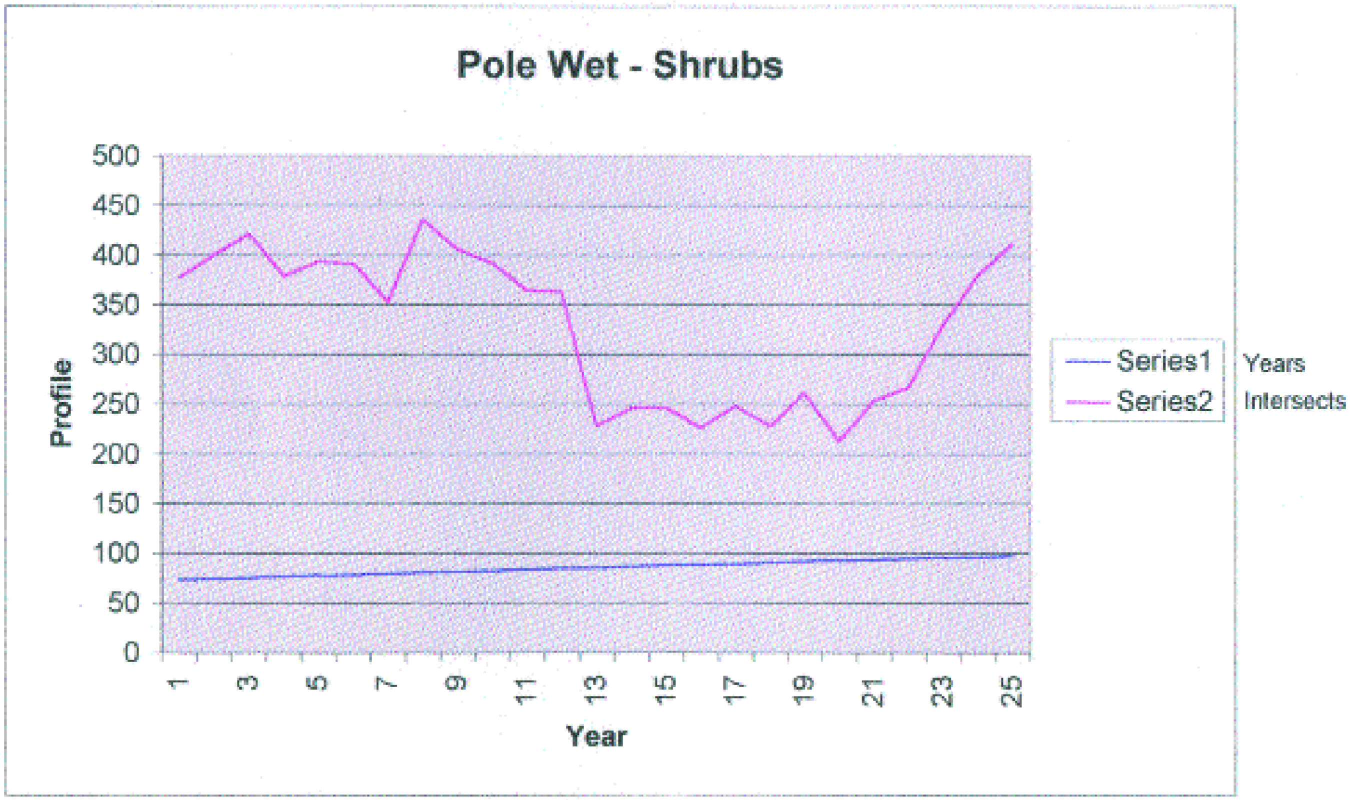


Figure 63— Regression of outline intersects from 1975 through 1997 for shrub profile changes at the Pole Camp wet meadow photo point. Intersects are total inside the grid area. Series 1 are the dates by year and series 2 are the intersects.

Studies, such as at Pole Camp where photographs are taken every year, are amenable to regression analysis of grid intersects. If the same person does the outlines, observer variability is greatly reduced. Figure 63 illustrates regression on shrub profile intersects at Pole Camp from 1975 to 1997 as determined from yearly photographs. Regression for the entire data set showed a decline of -0.63; however, when data were selected for the time of beaver activity in the area, 1983 to 1994, the regression was at -0.90, highly significant. Trendlines such as these seem very useful.

Grid Location of Items

Documenting change in position of items on a photograph requires precise photography. Three kinds of precision are required: (1) Distance between camera location and meter board must be the same for all repeat photos, (2) height of camera above the ground must be the same for all repeat photos, and (3) sizing and orientation of the grid must be precise.

Height of camera above the ground or orientation over the camera-location fencepost will change position but not size of objects. Figures 8 to 10 illustrate this relation by using the photo test view. Figure 10 overlays two sets of object outlines illustrating effect of camera position on location of objects and thus on the overlay grids. Reasons for this are shown in table 1.

Grid sizing and placement on the outline overlay, discussed previously, also are critical in detecting change in position.

None of these precision variables consider observer interpretation. They suggest that attempts to use photographs for monitoring change in position of objects seems questionable. If documentation of position change is desired, place the meter board in close proximity to the topic of interest, such as a streambank (figs. 23, 40, and 49), and measure from the meter board to the object of interest.

Shrub Profile Photo Monitoring

Change in shrub profile area can refer to either shrub utilization or shrub growth. It may be documented by repeat photography that uses grid analysis and horizontal camera orientation. Permanent camera locations and photo points, marked by either steel fenceposts or stakes, are required. Season of photography is a key factor in documenting change and causes of change in shrub profiles owing to shifts in leaf density.

Concept

Documenting change in shrub profile area involves photographing a shrub on two sides with the camera location moved 90 degrees for the different views. This photographs all profiles of a shrub. Camera locations and photo points must be marked with steel fenceposts or stakes to assure the same distance from camera to meter board for all future photographs. The same distance need not be used, however, for other camera locations. Adjust distance to suit the topic being photographed. Tall shrubs, where double meter boards are used (fig. 31), require a much greater distance than short shrubs.

The primary objective in monitoring change in shrub profile area or shape is to document utilization (reduction in area) or growth (increase in area). Thus, season of photography is of critical concern. If effects of animal browsing are the topics of interest, then photography both before and after utilization may be necessary. This requires selecting two seasons to photograph, such as just before livestock grazing and immediately after. If livestock graze at different seasons in the same pasture over several years (as with rest-rotation systems), as many as four dates may be required to document grazing effects over the period. Other dates, established by local knowledge, probably would be required with wildlife.

If growth in shrub profile area were the topic of interest, then photography after termination of growth would be desirable. Dryland shrubs usually have a definite termination of growth, called determinate shrubs. Some riparian shrubs, such as many willows, continue to grow until environmental conditions (for example, frost) cause a termination in growth. These are known as indeterminate shrubs. For these, the season to photograph must be based on the phenological development of the shrub species under consideration.

Once photographs have been taken, use the "Photo Grid Analysis" procedure (previous section) to document and estimate change in shrub profile area and shape.

Requirements

All basic photo monitoring requirements must be met for relocating the monitoring area and maintaining the same distance from camera to meter board:

1. Establish a monitoring objective when selecting an area and shrub species to evaluate. Determine a photography date or dates.

2. Make a map to find the monitoring area (fig. 64) and a map of the transect layout (fig. 65). The transect layout must include direction and distance from the witness site to the first shrub photo point and then its two camera locations, and from there, the direction and distance to the next shrub photo point and its camera locations. All shrub photo points must be tied together for ease in future location. The transect layout need not, probably will not, be a straight line (fig. 65).

3. Placement of the meter board is of critical interest because it will be used to document changes in shrub profile. There are three concerns: (1) Placing the meter board far enough to the side of the shrub to allow the shrub to grow in crown diameter (figs. 66 through 69)—consider a distance that is half the current shrub crown diameter (fig. 66); (2) placing the bottom of the meter board far enough toward the camera to assure the lowest line of the grid will be **below** the bottom of the shrub if it grows—consider placing the 2-dm line opposite the current bottom of the shrub (figs. 67 through 69); and (3) placing the board in one location and moving the camera for a 90-degree change in view (figs. 66 and 67).

4. Select a camera-to-photo-point distance that will permit the shrub to grow in both height and diameter. Consider a distance where the current shrub is about 50 percent of the camera view height and 70 percent of the camera view width (fig. 67, B and C).

Text continues on page 118.

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. Nested Freq. 1 sq.m. Robel Pole Shrub Form ____________

Date 1997/6/17
Area Snow Mtn.
Allot. Pole Camp
Cluster No. 1
Transects: 1 2 3 4 5
Plant community SAGE/CAAQ

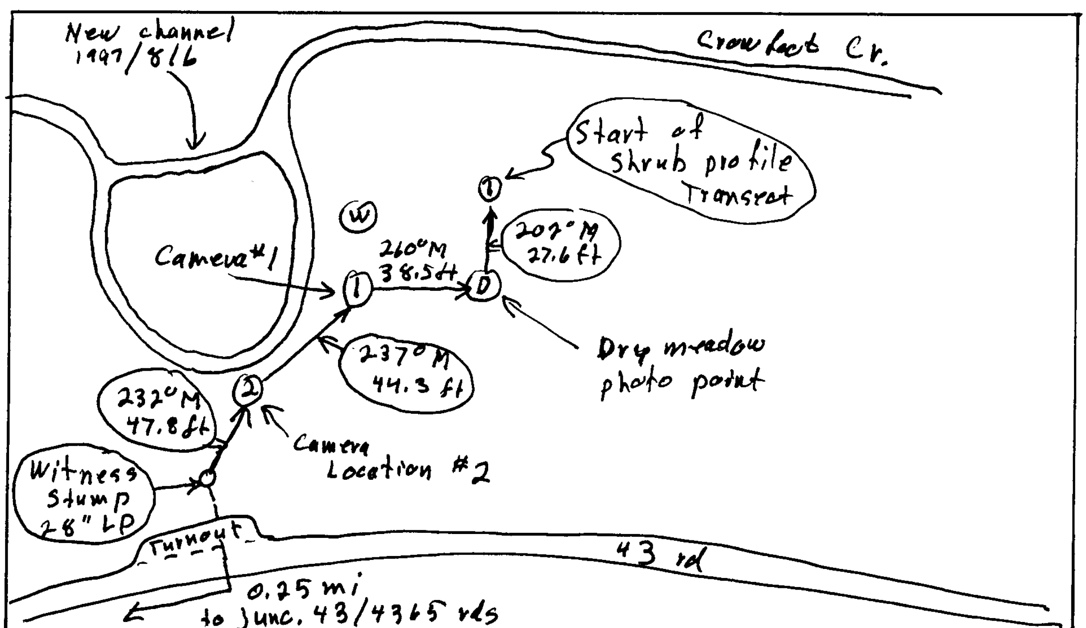
Grazing system:
Type rest/rot. Date 1977
Type ______________ Date_____
Type ______________ Date_____

Kind of animal: cattle sheep horses goats deer elk ________________

Location: T. 19S R. 27E
Sec. 29; SW of NE
Description: Open meadow betwee 43 rd and Crowsfoot Cr.; 0.25 mi W. junc. 43/4365 rds

Site Data: Elev. 5200 % slope 1
Slope aspect: ~~N NE E SE S SW W NW~~
Slope position: top up 1/3 mid low 1/3 bottom
Micro topography: convex flat concave
Macro topography: flat undulating rolling steep rough broken
Geology:
Deposition: wind stream lake colluvial residual ________________
Material: limestone mudstone sandstone granite serpentine diorite basalt andesite rhyolite tuffacious cinders pumice ash
Soil:
Restrictive layer: absent clay pan bedrock cemented ____________
Surface compaction: none moderate severe
Soil profile stone: absent gravel stony
Soil texture: sandy loamy silty clayey ashy
Other notes: 1998/8: fence across old access trail to meadow

MAP



See attached page for details

Figure 64—The filing system form “Sampling Site Description and Location” identifies the Pole Camp shrub profile monitoring system. The first line of the form provides for circling one of several monitoring systems; here, “Shrub Form” has been circled. Information on the area is entered, and a map is drawn to locate the monitoring system. This shrub profile transect is one of several photo monitoring installations at Pole Camp. Figure 42 diagrams four other camera locations and four photo points. A note at the bottom of this map says an attached page has details. The page is shown in figure 65.

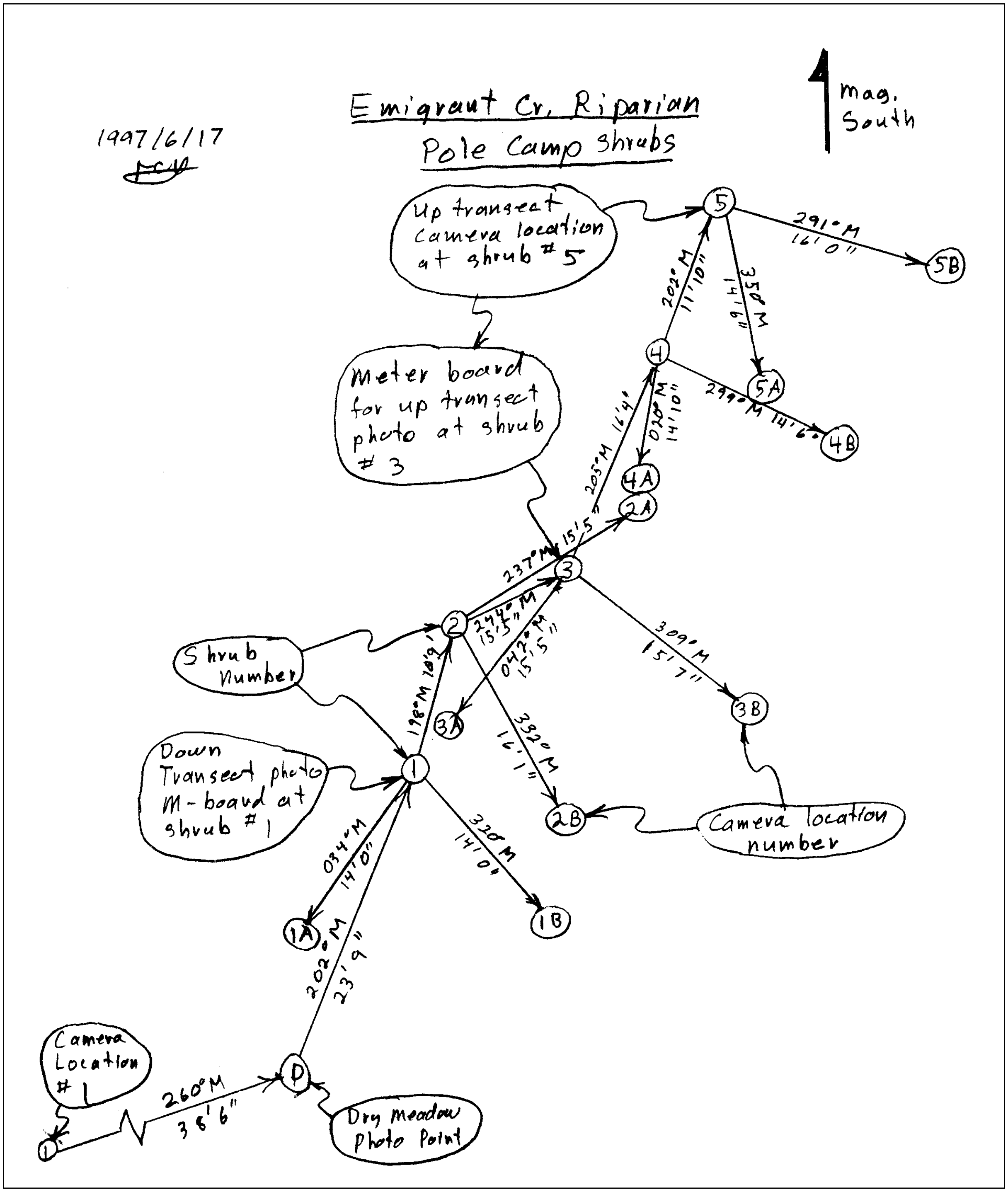


Figure 65—Details on the Pole Camp shrub profile transect. Instructions begin at camera location 1 for Pole Camp monitoring. The dry meadow photo point has been used as a camera location for a view down the transect (fig. 64). Direction in magnetic degrees and distance are shown for the five shrubs and the 10 camera locations.

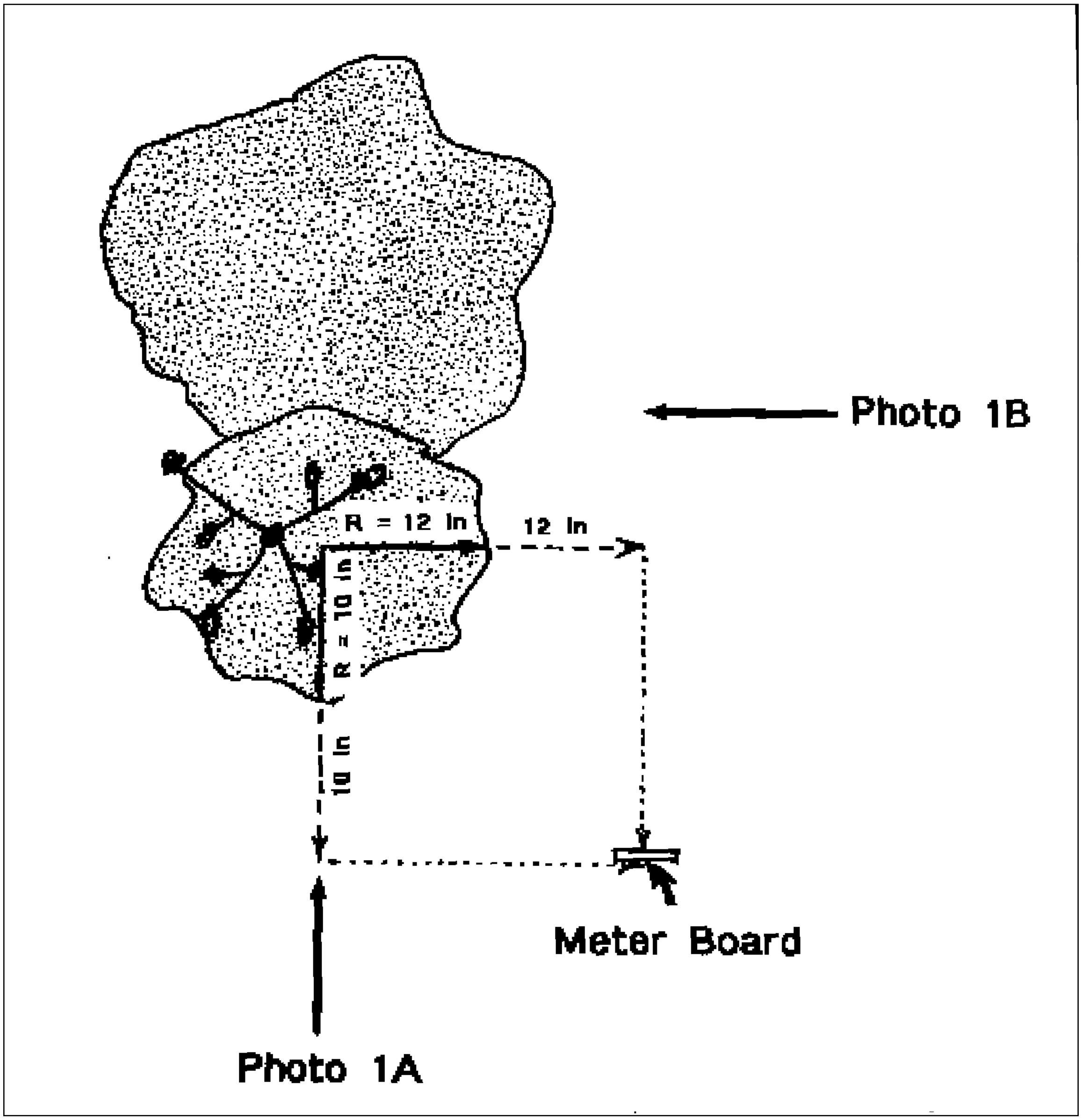


Figure 66—System for location of a meter board when photographing shrub profiles. Figure 67 shows the views from photo 1Aand photo 1B. Locate the board as follows: Measure the shrub radius in two directions at 90 degrees to correspond to the direction of photographs (12 in and 10 in). Move out from the shrub the same distances (12 in and 10 in) and locate the meter board at the intersection of the distances. This will place the meter board far enough to the side and front of the shrub so that the shrub can grow and still be analyzed with a grid.

SHRUB PHOTO TRANSECT

Date 97/6/17 Cluster 1 Transect 1 2 3 4 5

Area Snow Mt. Dist
Allot. Pole Camp
Investigator: [illegible]

Season of use late
Grazing system: Rest-rotation-3 pasture
Animals Cow/Calf

Direction 207° M
Distance 23' 9"

Shrub 1A
Direction 214° M
Distance 14' 0"
Comments SALIX GEYERIANA Browsed 2 yr ago. CAREX SIMULATA, POA PRATENSIS & POTENTILLA FLABELLIFOLIA suggest a dryish moist meadow

Shrub 1B
Direction 140° M
Distance 14' 4"
Comments SALIX GEYERIANA Browsed 2 yrs ago; 2 shrubs

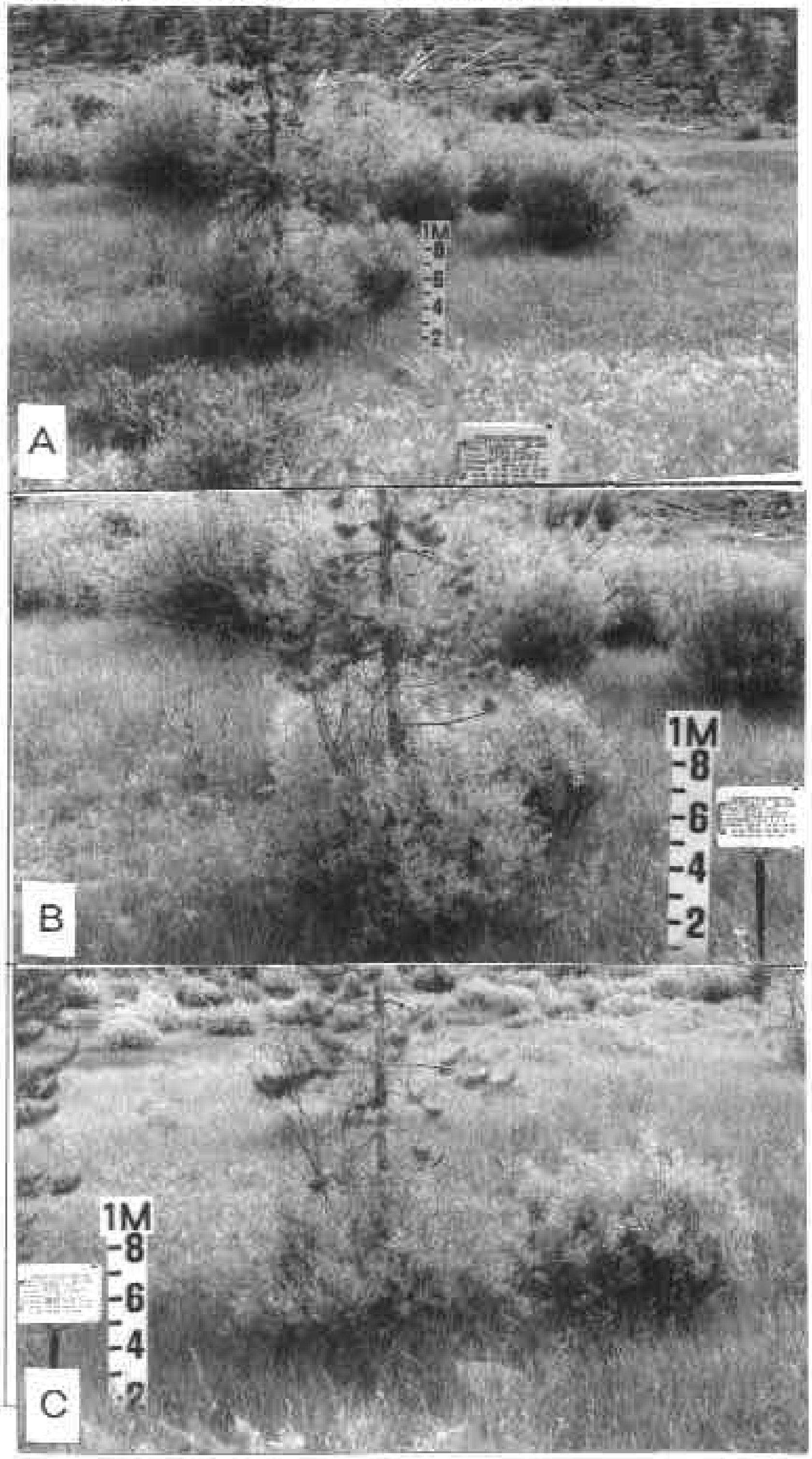


Figure 67—The filing system form “Shrub Photo Transect” (app. C) showing Pole Camp willow transect 1 and both views of shrub number 1. The top photograph (**A**) was taken down the transect and **B** and **C** are of shrub number 1. Notes on the vegetation and item photographed are made opposite each photograph. The form provides for two views each of 10 shrubs with views down the transect from each end.

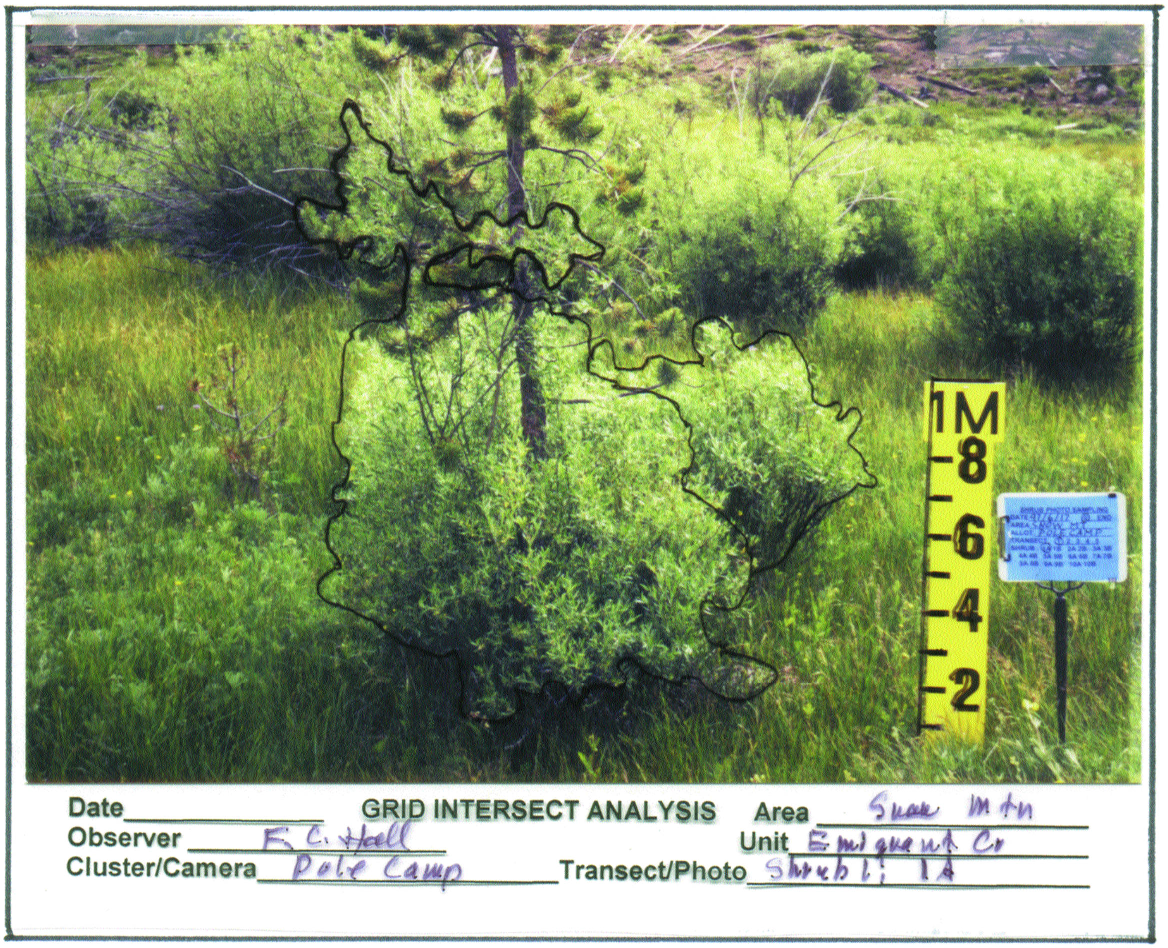


Figure 68—Grid analysis of shrub 1, view A, on the Pole Camp shrub profile transect. The outline form has been placed on the photo, information filled in, and the meter board marked. Outline as carefully as possible the shrub profiles. Do the same for photo B of shrub number 1 (fig. 69).

5. Try to select a single shrub or several shrubs separated from other shrubs in the camera view. If shrubs grow in profile area, their outer crown periphery may become difficult to separate from adjacent shrubs. Color photographs greatly aid in shrub-profile delineation.

6. Aim the camera so that the meter board is in the extreme left or right of the view (figs. 67 through 69). The shrub grid analysis overlay shows the meter board at the sides. Next, orient the camera so that the bottom of the meter board is just **above** the bottom of the camera view (figs. 67 through 69). Thus, a maximum amount of photo is allocated to current and future profile area of the shrub.

   Notice in figures 67 through 69 the relation between placement of the meter board bottom about 2 dm below the bottom of the shrub and orientation of the camera at the bottom of the meter board. The objective is to document change in shrub profile both upward and outward.

   When tall shrubs require double meter boards, such as in figure 31, the boards may be placed centered in front and the 2-m board grid (board in the center) used for analysis.

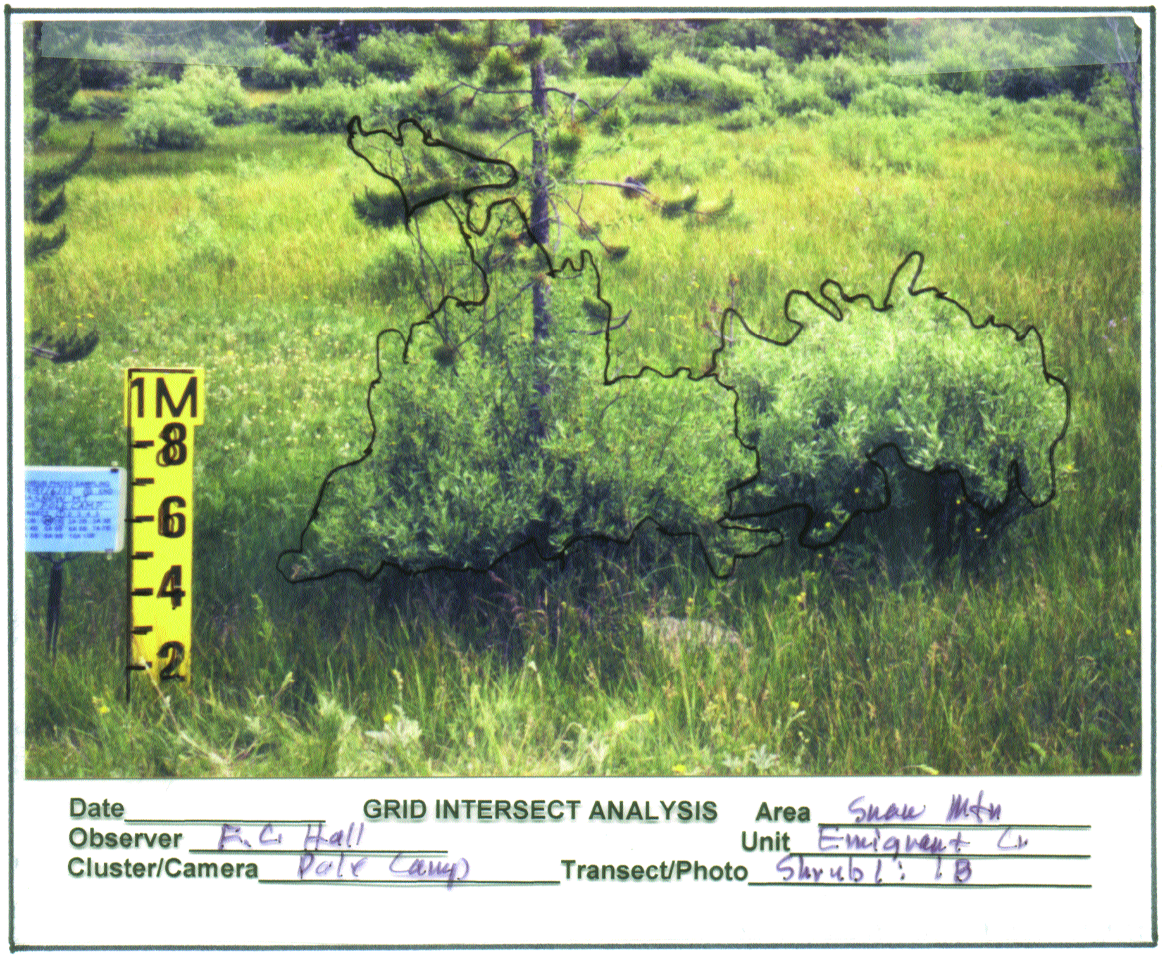


Figure 69—Outlines of view B, shrub 1, on the Pole Camp shrub profile transect. When two shrubs are present, separate their outlines as shown. Information on the bottom of the clear plastic overlay must be filled in for each photo. Remember to outline and mark the meter board.

7. Fill out and place the photo identification card, "Shrub Photo Sampling," next to the meter board (figs. 67 through 69). This is essential for labeling each slide, negative, or digital image.

8. Focus the camera on the meter board to assure greatest depth of field for the shrub. Then swing the camera either left or right to place the meter board at the side.

Equipment

The following equipment is required for shrub profile sampling:

1. Camera or cameras with both color and black-and-white film or digital camera
2. Forms from appendix B for photo and transect identification: "Shrub Photo Sampling" printed on medium blue paper, data and photo-mounting form "Shrub Photo Transect" printed on medium yellow paper, the "Grid Analysis Outline" printed on clear plastic, and "Analysis Grid-Shrub Analysis" adjusted in size and printed on white paper
3. Meter board (app. C)
4. Clipboard and holder for the photo identification sheets (app. C)

5. Fenceposts and steel stakes sufficient for the number of transects desired: 1 fencepost and 2 steel stakes per shrub; for a 10-shrub transect, 10 fenceposts and 20 stakes required; include a pounder
6. Compass and 100-ft tape
7. Metal detector for finding camera locations

Technique

The technique for shrub profile monitoring combines a transect system with principles discussed under "Photo Grid Analysis," above. A primary objective is to monitor **change** in shrub profile area and not to measure canopy cover of shrubs or shrub profile area per acre. Shrubs therefore are objectively selected for photography. The following technique emphasizes this selectivity.

1. Locate the area of consideration. Walk the area to select shrubs to be monitored. In many cases, shrub distribution does not lend itself to straight line transects, particularly in riparian areas with winding streams. Ask, "Why am I concerned with change in shrub profile area?" Is it to appraise utilization, assess vigor, or document increase in profile area? Is the location of shrubs important, such as shade along streams?

2. Mark each shrub to be photographed with steel fenceposts or a combination of posts and stakes: a fencepost to mark the meter board and two more posts or stakes to mark camera locations that view the shrub at 90 degrees (two different sides). Whenever possible, select a single meter board position that will accommodate the two camera locations (figs. 66 through 69). Measure distances from the photo point to camera locations.

3. After marking all the desired shrubs, diagram the transect layout (fig. 65). Take a direction and measured distance from the witness mark to the first shrub meter-board position. Diagram the two camera locations with direction and measured distance from the meter board. Then take direction and measured distance from the first shrub meter board to the second, documenting direction and distance of the camera locations. Continue to the end of the transect. Remember to indicate magnetic or true north.

4. When ready to photograph, fill out the filing system form, "Shrub Photo Sampling," for photograph identification (app. B) as shown in figure 67.

5. Take a general picture of the transect by setting the meter board at shrub 1 (fig. 67A). Stand 7 to 10 m from the board and place the "Shrub Photo Sampling" form in view (fig. 67A). Stake the camera location and add to the sampling layout diagram. Reference it to the witness location.

6. For each shrub, place the photo identification form,"Shrub Photo Sampling," next to the meter board (fig. 67, B and C). The form has a shrub number and letter for 10 shrubs. Match the shrub number and letter on the form with the transect diagram and circle it (in fig. 67B, 1A is circled).

7. Photograph the shrub. Then move to the second camera location, turn the meter board and the photo identification form to face the camera, cross out the last shrub view on the form, and circle the current one. In figure 67C, 1A is crossed out and 1B is circled.

8. Make notes of what is in the view (fig. 67). Identify the shrub, list herbaceous vegetation, and note anything of interest, such as browsing and by what.

9. Then move to the next shrub and repeat the process until completed.

10. Mount the photographs as shown in figure 67. The filing system form, "Shrub Photo Transect," is designed for 3- by 4½-in photos.

11. Conduct grid analysis of the pictures as discussed next.

Shrub Profile Grid Analysis

A complete review of the "Photo Grid Analysis" section, above, is necessary to do this evaluation. Only highlights specific to shrub-grid interpretation are presented here.

Print the photographs to be analyzed, in color, at 8 by 12 in. From appendix B, select the "Grid Analysis Outline" form (fig. 54) and duplicate on clear plastic. Fill out all information at the bottom of the outline form. The completed outline becomes a data file and must be identified. Tape the outline form to the photograph along one edge or top so that the outline can be lifted for close inspection of the photo and then replaced exactly (figs. 68 and 69).

Outline the shrub or group of shrubs in the photo. Do not try to guess the outline of a shrub hidden behind another. Outline, only what can be seen. Be as precise as possible.

Next, adjust the grid (with meter boards at each side) for shrub analysis (app. B) to exactly match the outline meter boards as discussed in "Photo Grid Analysis" (figs. 56 and 57). Tape the outline form to the grid (fig. 70).

Count intersects within each outline including intersects falling under an outline line (figs. 58 and 67), and enter on the filing system form, "Photo Grid Summary" (fig. 71). Please refer to the section "Photo Grid Analysis," and within it "Analysis of Change, Observer Variability," for a discussion of what constitutes a significant change in shrub profile area.

Test your own observation skills. Count grid intersects in figure 70 and compare to the results shown in figure 71. Expect a difference of three to six grid intersects.

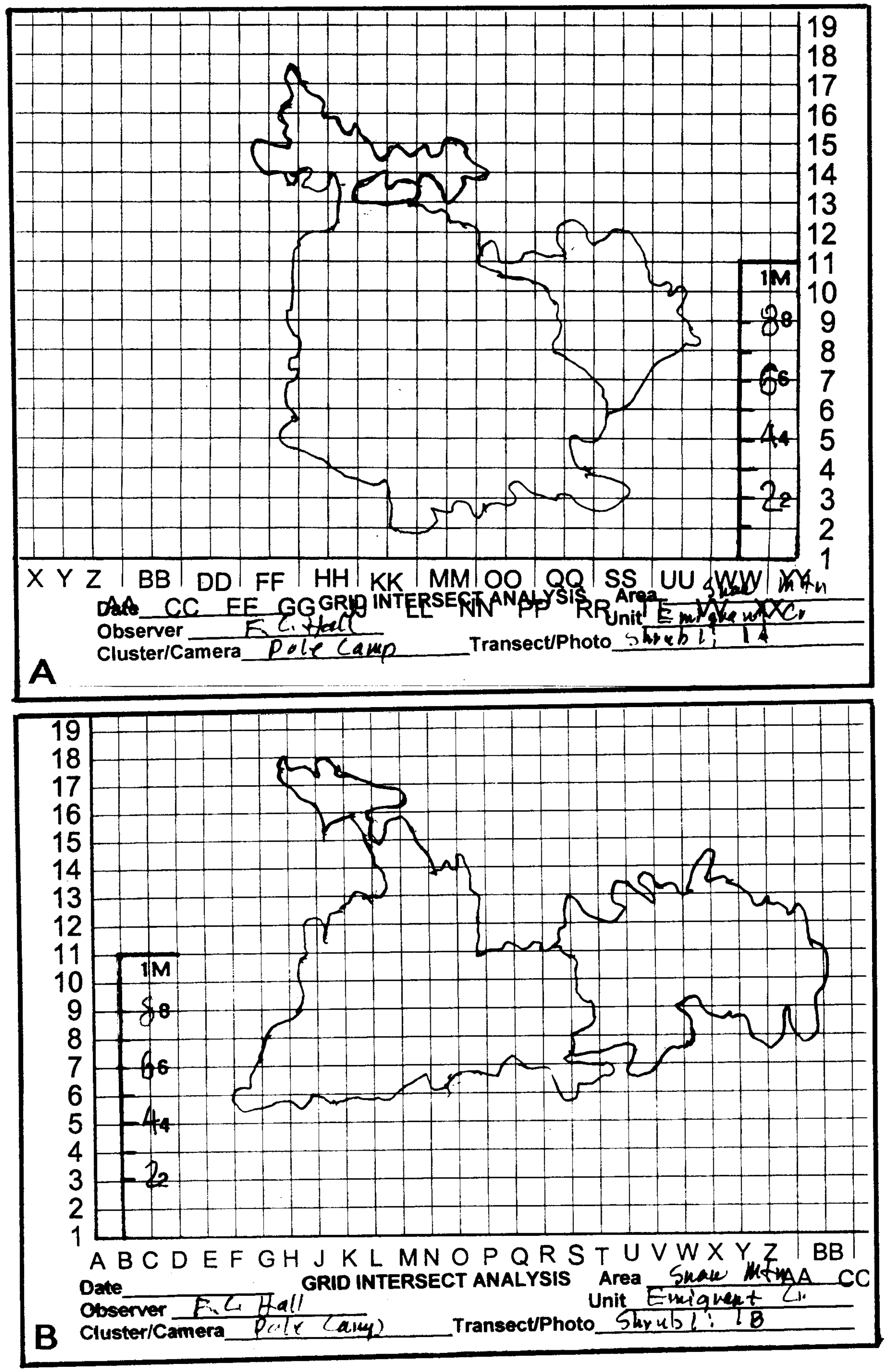


Figure 70—Grid outlines for shrub 1, views A and B on the Pole Camp shrub profile transect. Grids have been adjusted for size by the outlined meter board. Outlines are then taped to the grid. Count the grid intersects and record on the filing system form “Photo Grid Summary” (fig. 71).

1999/2/19

PHOTO GRID SUMMARY

Date 1998/8/4 Observer F. C. H.
Area Snow Mtn Unit Emigrant Cr.
Cluster/Camera Pole Camp Transect/Photo Shrub transect

Item #	Date 1998/8/4	Item #	Date	Item #	Date
1A	131				
1B	129				
2A	162				
2B	188				
3A	119				
3B	127				
4A	131				
4B	138				
5A	152				
5B	141				

Figure 71—Filing system form “Photo Grid Summary” for the Pole Camp transect. Future data on these shrubs may be compared for change as discussed in the “Photo Grid Analysis” section.

CONTINUE

Transect Photo Sampling

The historical purpose for transect sampling was to document change in vegetation and soil caused by livestock grazing, commonly called range trend analysis (Parker 1954, Parker and Harris 1959). The Parker three-step method (Parker 1954) was designed for this purpose. It used a 0.75-in diameter loop dropped at each foot along a 100-ft line. The system was supplemented by photographs taken of the transect from the 0- and 100-ft ends with additional closeup pictures of a 3- by 3-ft square at each end.

By 1970, the system had been installed at 16,500 locations and reviewed by the Rocky Mountain Forest and Range Experiment Station (Reppert and Francis 1973). The findings suggested that photographs are the most valuable part of the system. Photos (1) documented transects across two or more sites, (2) helped to evaluate species identification, and (3) were used to validate interpretation of measured data through a four-step process.

Based on these findings, Hall (1976) developed a photo monitoring method, which has been updated for presentation here.

Five kinds of photo transects will be discussed and illustrated: (1) 1-ft^2 frequency photographed with a stereo attachment on the camera (or photographed without the stereo), (2) nested frequency using four plot sizes in a 0.5- by 0.5-m frame, (3) 1-m^2 plot frame photographed at an angle, (4) vertical photographs of tree canopy cover, and (5) measurement of herbaceous stubble height using the Robel pole system. All five may be applied on top of any three-step transect or they may be installed in new areas for any documentation of ground vegetation and soil surface monitoring. The following factors apply to any transect system.

Locating a Sample Area

The introduction to this appendix discussed selection of an area and when to photograph. Probably the most important of these suggestions was to **define a purpose** for monitoring. In addition, several other elements might be considered: livestock grazing, wildlife distribution, and planned and unplanned disturbance because the investigator must be guided by factors not under their control. Transect photo monitoring is not limited to livestock effects analysis.

Livestock considerations—The three-step sampling system (Parker 1954) was designed to evaluate livestock grazing impacts on vegetation and soil. Instructions called for one to three transects. The objective was to attain 60 or more hits on vegetation with a 0.75-in loop. If more than 60 hits were not recorded on the first transect, then a second or third transect was installed until either 60 hits were obtained or three transects were established. Each set of transects was called a cluster. Nested frequency, also an appraisal tool for livestock impacts, requires five transects.

Location of transects has three primary requirements:

1. The site under each transect must be homogeneous. If an entire cluster of two to five transects is to represent a single site, vegetation and soil surface conditions under each of the transects must be homogeneous and similar to each other.

2. The kind of site selected should be one sensitive to livestock use. For example, in a complex meadow where dry meadow around the edge grades into moist meadow, which finally grades into wet meadow, the most desirable sampling location would be in the dry meadow because it is most sensitive to livestock use.

3. Locate the sample in an area best representing current livestock utilization.

These three criteria generally will satisfy the objectives of monitoring management effectiveness by photographic documentation of conditions; evaluation of sensitive areas which, when indicating an upward trend, imply that less sensitive areas are in a faster upward trend (or are in better condition); and distributing sampling locations on a least-cost or cost-effective basis.

The most difficult aspect of sample location deals with suitable representation of current livestock activity. Samples on a range area (allotment) grazed season long may not be adequately located or sufficient in number for the same area under rest-rotation grazing. Furthermore, locating a transect may be difficult in an allotment that has had a major change in management—for instance, from season long to rest-rotation—until livestock distribution over an entire grazing sequence has been evaluated. Selection of a site sensitive to livestock use in a unit under spring grazing might be quite different from that selected in the same unit under fall grazing.

Locating a sampling site requires a great deal of professional expertise liberally mixed with artistic finesse. Investigators must understand seasonal and topographic effects on livestock distribution, seasonal effects on plant community, and soil sensitivity to grazing, and they must have a critical eye for site homogeneity.

Wildlife considerations—Locating transects or clusters suitable for monitoring impacts of wildlife, including big game, on vegetation and soil requires knowledge of animal distribution and most critical season of use. Wild animals may be year-round residents or may be moved by snow or other weather conditions. The investigator must determine which season is most critical and where the animals are at that season for both transect or cluster location and season of sampling.

Planned disturbance—Planned disturbance sampling is where a treatment is prescribed and the area is sampled before and after implementation. Figure 21, a logged and precommercially thinned ponderosa pine stand, is an example of planned disturbance sampling. Two important factors to consider are (1) where to locate the sampling transects so they best represent effects of the treatment, and (2) use of camera location and photo point stakes pounded flush with the ground to resist mechanical displacement. These require use of a metal detector to relocate (White's Electronics, Inc. 1996). Use maps with directions and measured distances to aid in relocating stakes.

Fenceposts, flimsy or strong, used in any kind of disturbance other than prescribed fire, tend to do two things: (1) they bias operators of equipment to stay away from the posts, and (2) they may be removed completely from their location making exact replacement of camera locations and photo points nearly impossible. Prescribed fire sampling, however, might well use fenceposts, particularly for photo point locations. Pound the fenceposts down to the exact height of the meter board. Then photograph the fire as it passes the fencepost to document fire intensity, flame length, and burn aftermath. Coordination with the fire boss on transect layout and direction given topography and fire behavior might be advisable.

Unplanned disturbance—Unplanned disturbance, such as fire, blowdown, or flood, generally preclude predisturbance transect or cluster installation. Care should be taken to select areas where change is most critical or where postdisturbance activity, such as salvage logging, most likely would occur. If activity is probable, consider use of steel stakes driven flush with the ground and a metal detector to find them

Maps—Each cluster should have two maps: one to find the monitoring area (fig. 72), and another of the cluster layout (fig. 73). A blank form for “Sampling Site Description and Location” is in appendix B.

To use the “Sampling Site Description and Location” form shown in figure 73, circle the type of sample in the (top line), in this case “1 sq. ft.” Most items are self-explanatory such as entering the date installed, the name of the area, and the allotment. Grazing system should be entered, such as season long, enclosure, deferred-rotation, elk fall range, deer fawning area, etc., and the date when initiated or season of use. Circle the kind (or kinds) of animals using the sample area.

Describe location with both standard survey nomenclature and a description of where the sample is located in relation to land, vegetation, or road features. Describe it as if you were telling someone how to find it. Then diagram the sample layout in the map space (fig. 73). Note, location of identifiable features, compass headings as either true (T) or magnetic (M), measured distances, transect location and orientation, and the 0- and 100-ft ends. With transects laid end to end, continue the sample layout map on the back of the form (fig. 74).

The front side of the form is for a site description (fig. 73). Enter elevation and percentage of slope. Then circle the item best describing aspect, slope position, micro (within one acre) and macro (within one section) topography, kind of soil deposition, soil parent material, and kind of restriction to rooting depth (if there is a restriction within 5 ft of the soil surface). Enter depth to restriction and rooting depth. Circle items describing soil compaction, soil stone, and texture. A space is provided for comments not otherwise addressed.

Note: A single site description presumes all transects are on the same site. If they are not on the same site, fill out a new form for each different site.

Choice of film—Choice of film is a concern. Photo trend sampling is designed to measure change in vegetation and soil over time. Photographs taken 5, 10, or 15 years earlier are compared to current photographs. Film therefore must be selected that will retain its sharpness and clarity for a long time. Black and white film should be the first choice, but it can be supplemented by color film.

Text continues on page130.

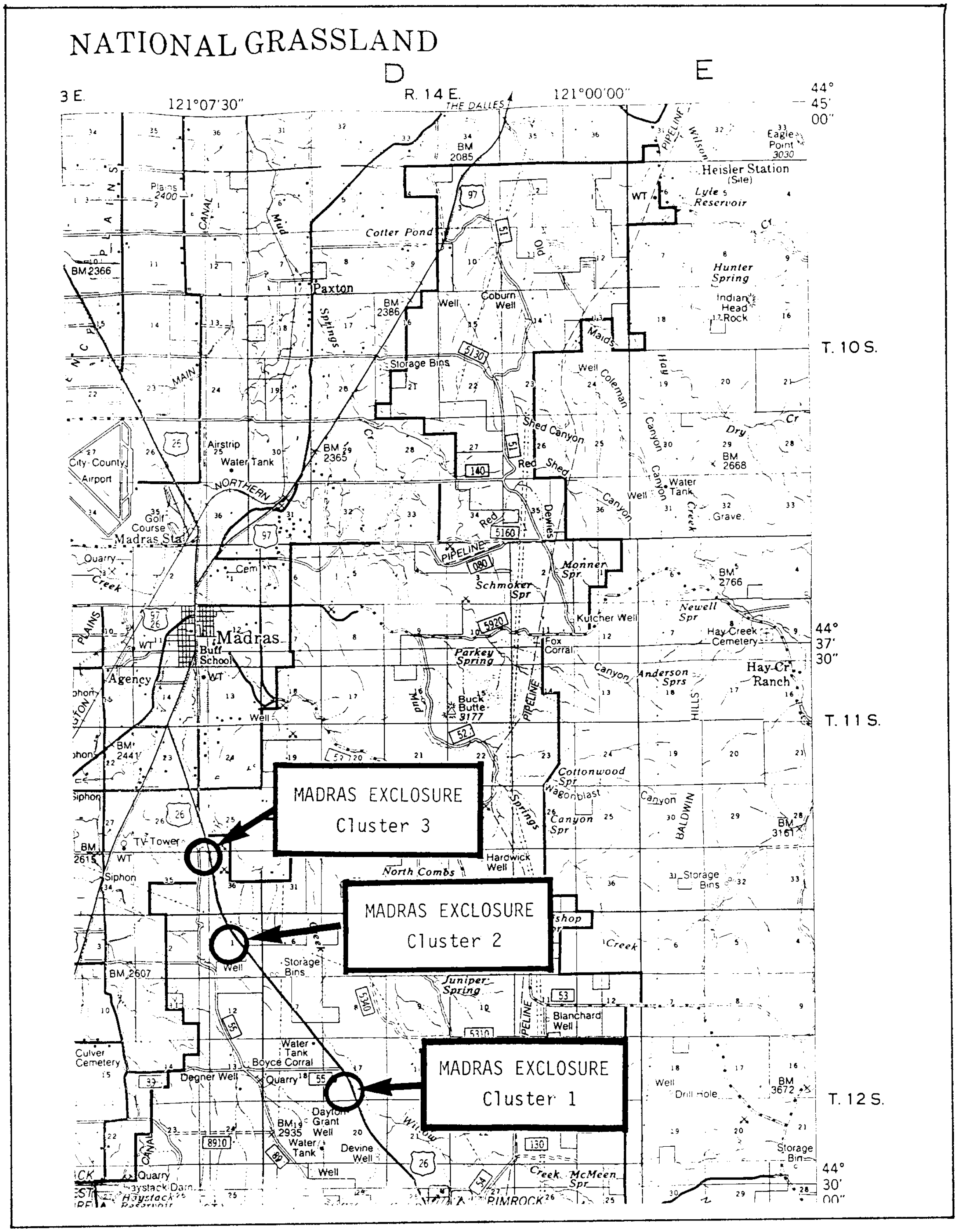


Figure 72—Ranger District map locating the Madras Exclosure and three range trend sampling clusters having three transects each in the Crooked River National Grassland. Cluster number 3, transect 1, will be used to illustrate photo sampling of square-foot frequency, nested frequency, and square-meter systems.

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. Nested Freq. 1 sq.m. Robel Pole Shrub Form ______

Date 1997/3/22 **Site Data: Elev.** 2775 **% slope** 8

Area Crooked River N.G. **Slope aspect:** N NE E SE S SW W NW

Allot. Madras **Slope position:** top up 1/3 mid low 1/3 bottom

Cluster No. 3 **Micro topography:** convex flat concave

Transects: 1 2 3 4 5 **Macro topography:** flat undulating rolling steep rough broken

Plant community ARTR/AGSP/POSA3

Geology:

Deposition: wind stream lake colluvial residual

Grazing system:

Type Exclosure **Date** 1954

Type ______ **Date** ______

Type ______ **Date** ______

Material: limestone mudstone sandstone granite serpentine diorite basalt andesite rhyolite tuffacious cinders pumice ash

Kind of animal: cattle sheep horses goats deer elk jack rabbits

Soil:

Restrictive layer: absent clay pan bedrock cemented ______

Location: T. 11S **R.** 13E **Sec.** 36 NW of NW

Surface compaction: none moderate severe

Soil profile stone: absent gravel stony

Soil texture: sandy loamy silty clayey ashy

Description: US hiway 26 at Crooked River N.G. sign; 2.1 mi from junct. US97 & US 26 S. of Madras.

Other notes: Livestock excluded when hiway was fenced in 1954

MAP

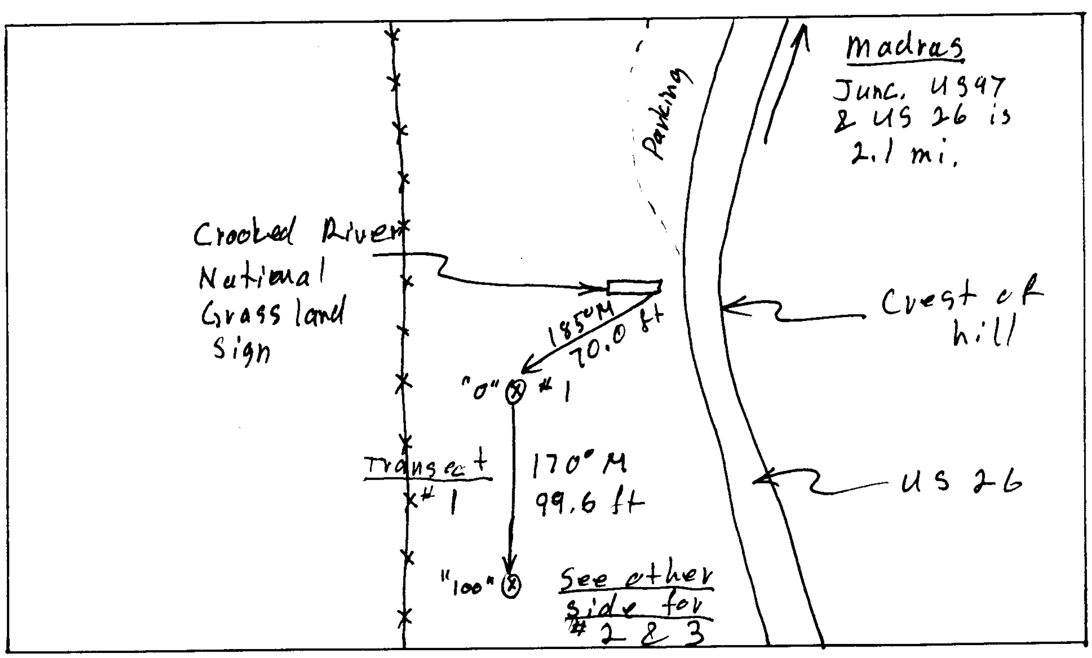


Figure 73—Filing system form “Sampling Site Description and Location” for finding the Madras Exclosure cluster 3. The first line lists a choice of sampling systems. Circle “1 sq. ft.” Fill in the required information as shown. After laying out the photo sampling system, plot it in the map space provided. If several transects require more space, use the form back (see fig. 74). Take direction and measured distance between the witness point (Crooked River National Grassland sign) and the first transect (185 degrees magnetic, 70.0 ft). Next take direction and measured distance to the 100-ft end of the tape (170 degrees magnetic, 99.6 ft). The 100-ft end-stake is at foot mark 99.6. See figure 74 for continuation of the map.

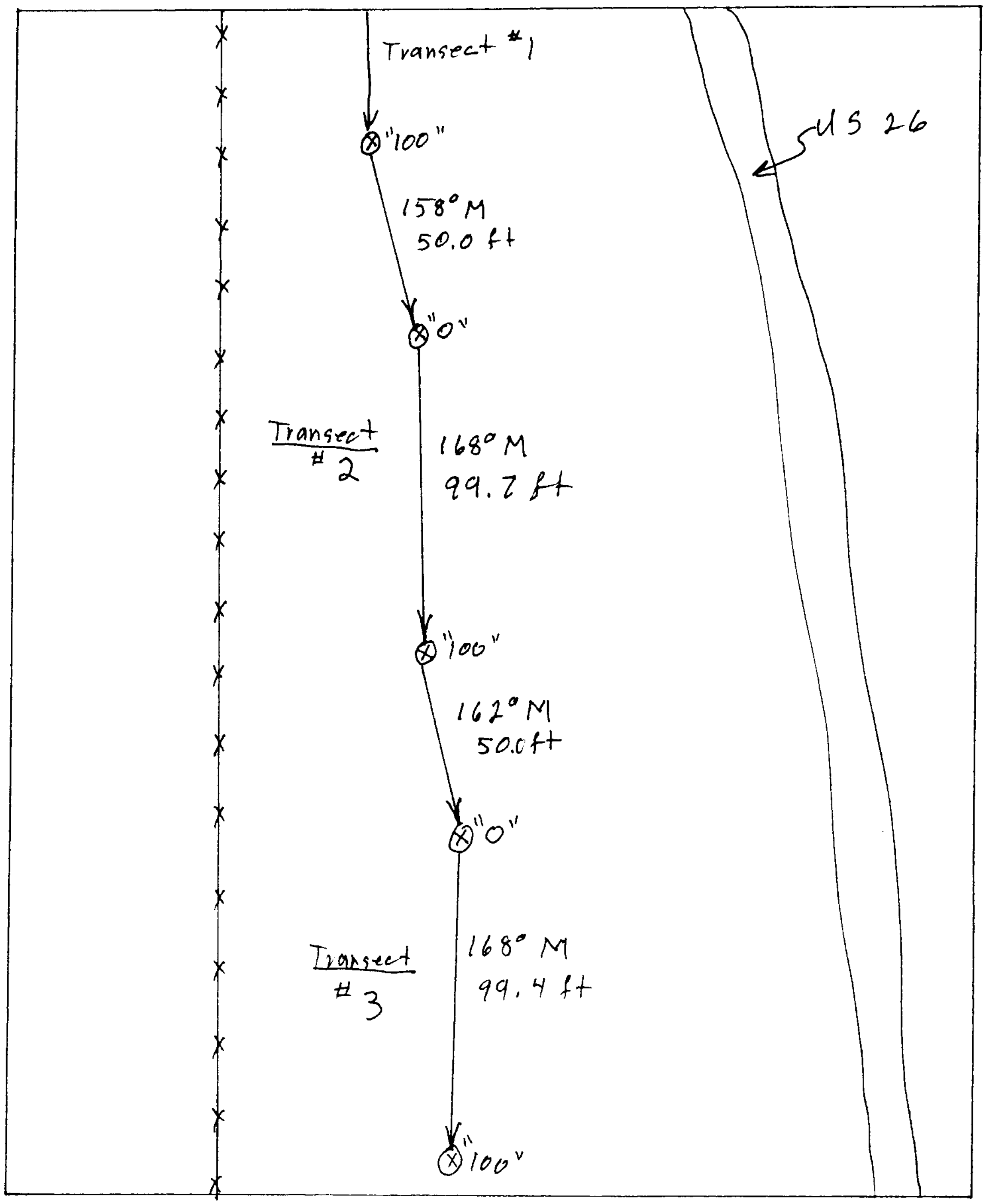


Figure 74—Map on back of figure 73 showing location of transects 2 and 3. When distances are measured, as shown here, use feet and tens of feet, for example, 50.0 ft between transect 1 at its 100-ft end and transect 2 at its 0-ft start. Then 99.7 ft between the 0-ft stake and the end stake located at foot mark 99.7 for transect 2. Continue for transect 3.

Film with an ISO rating of 100 or better should be used, particularly in forested conditions. A film of ISO 160 will have good contrast and fine grain. ISO ratings up through 400 may be considered. Higher ISO ratings mean smaller f-stops (higher f-number) and produce greater depth of field. Photos taken with films rated higher than ISO 400 will be grainy and nullify lens sharpness.

Digital cameras should have 2.1 megapixels or more. Graininess of images from cameras of 1.6 megapixels or less usually precludes accurate analysis of prints.

Season of year—Season of year for photography depends on objectives and past history. Reppert and Francis (1973) recommend repeat sampling within plus or minus 2 weeks of the original date. When placing the 1-ft^2, nested frequency, or 1-m^2 transects on top of existing three-step transects, date of sampling should be governed by the original readings. For newly established transects, date of installation should be governed by plant growth development (phenology) and season of critical concern. In general, a good time to sample is when plants are well into flowering or just completing their maximum seasonal growth.

Transect Installation

Document the direction and measured distance from a witness site to the 0-ft end of the first transect. Set a fencepost to mark the transect. Drive stakes to leave about 6 in aboveground onto which the 100-ft steel tape is clamped. Vice grips are very convenient. The 0-ft mark on the tape is aligned with the first angle iron stake and clamped in place. A mid-stake is located between foot marks 50 and 51, and the end-stake is located between the 99- and 100-ft marks and clamped in place. Make sure the zero end is labeled and that 0- and 100-ft ends are properly documented on the map (figs. 73 and 74). Mark both ends with fenceposts for easy relocation.

In disturbance sampling, presample the area with 6 in of stake aboveground for fastening the steel tape. After sampling, drive the stakes flush with the ground. For postsampling, plan on adding a stake nested inside the flush stake extending 6 in aboveground on which is clamped the 100-ft steel measuring tape. Relocation of the flush-pounded stakes will probably require a metal detector (White’s Electronics, Inc. 1996).

From the 0-ft stake, record direction (note true or magnetic) and measured distance to the 100-ft steel stake (figs. 73 and 74) for each transect. Tie the transects together for easy relocation by direction and measured distance from one to another (fig. 74). Always record location of both the 0- and 100-ft ends.

Every transect should have a photograph taken from both the 0- and 100-ft ends (figs. 75, top, and 77). Each photograph down the transect should be identified with the cluster-transect form (app. B). Place the identification form at 15 ft, a size control board at 33 ft, hold camera at eye level, and photograph the transect with the camera focus system on the size control board’s “1M” and the photo identification sheet at the bottom of the picture (fig. 75). Repeat this procedure at the 100-ft end of the tape by placing the identification sheet at foot mark 85 and the size control board at foot mark 67 (fig. 77).

Text continues on page134.

PHOTO TREND SAMPLE – 1 SQ.FOOT

Date 1997/3/22 Cluster 3 Transect 1 2 3 4 5

Area Crooked River N.G.

Allot. Madras

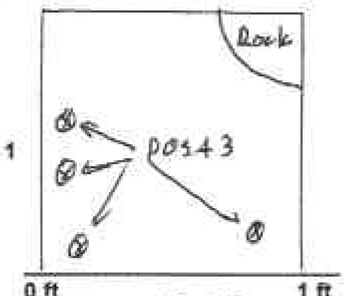
Investigator

Season of use none

% use —

Grazing system exclosure

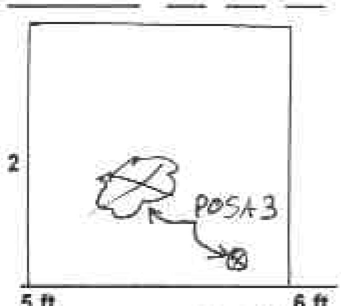
Remarks Hyway exclosure



Soil surface: B G R L C

Line intercept:

Species From To Feet



Soil surface: B G R L C

Line intercept:

Species From To Feet

Figure 75—Filing system form “Photo Trend Sample - 1 sq. ft.” illustrating its use (continued in figs. 76 and 77). Two additional forms are shown: transect identification (top picture) and plot identification (lower two pictures). Fill out required information on each form: CRNG (Crooked River National Grassland), Madras Exclosure, cluster 3, transect 1, date, and notes. Photograph the transect from the 0-ft (top picture) and the 100-ft ends (fig. 77). Then place the square-foot plot at the specified foot mark (plot 1 from 0 to 1 ft). Fill out the plot identification form, circle plot 1, and place in view. Soil surface items are B = bare ground, G = gravel, R = rock, L= litter, and C = cryptogamic crust. Circle each item occurring in the plot.

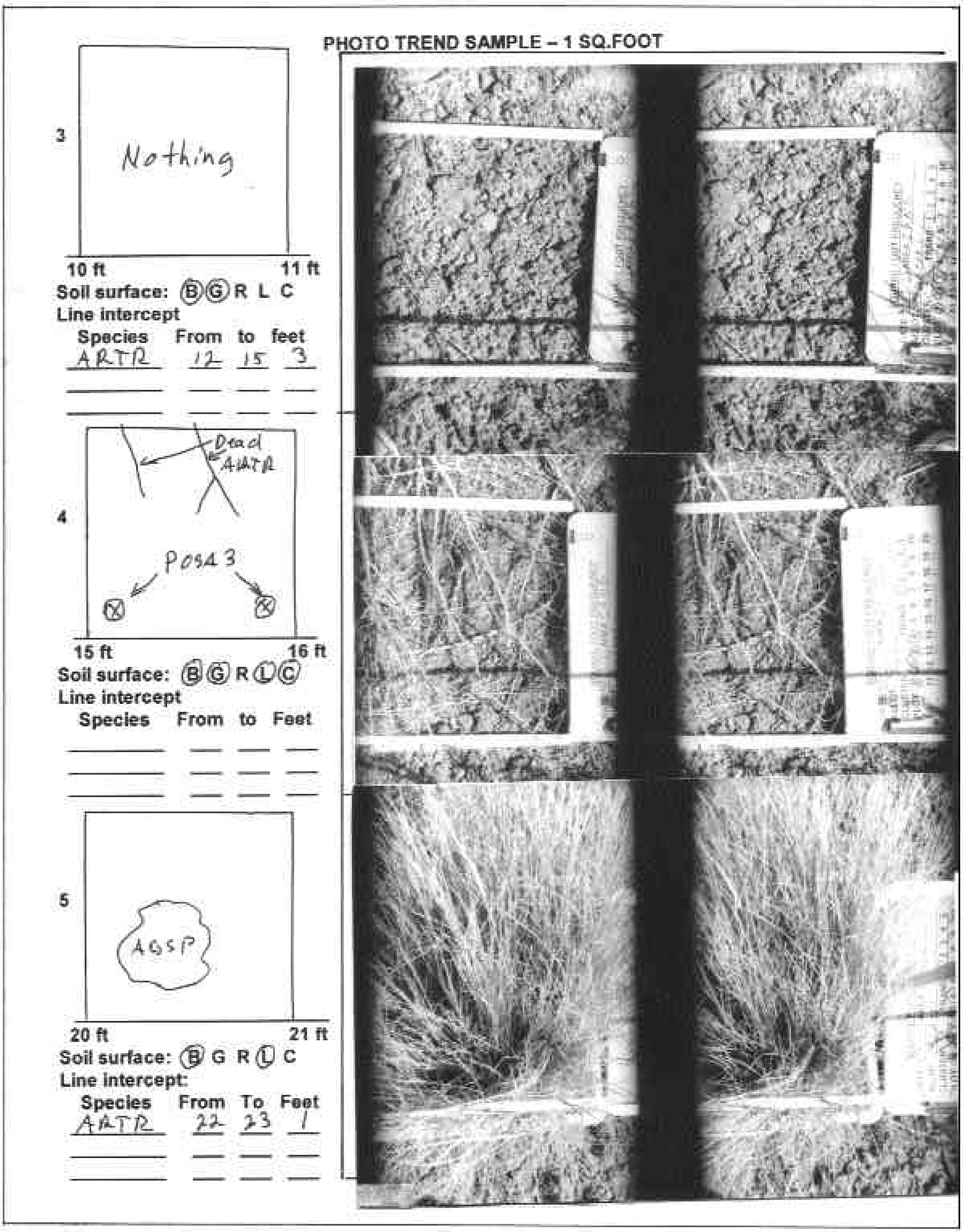


Figure 76—Second page of the "Photo Trend Sample - 1 sq. ft." form with provision for three more sample plots. Notice under plot 3 that ARTR (*Artemisia tridentata* Nutt., big sagebrush) intersected the tape between foot marks 12 and 15 for 3 ft of line intercept. Intersect is counted between the first foot mark from one plot to the next; in this case, from foot 10 to 15. ARTR also intercepted the line as shown under plot 5. Additional pages provide for all 20 ft^2 plots. Other species are AGSP (*Agropyron spicatum* vis. *Pseudoroegneria spicata* (Pursh) A. Love., bluebunch wheatgrass), and POSA3, (*Poa secunda* J. Presl., Sandberg's bluegrass).

PHOTO TREND SAMPLE – 1 SQ.FOOT

SUMMARY

Species	Frequ.	Interc.
POSA3	17	
AGSP	5	
LOMAT.	2	
PHLOX		
BASA		
SIHY	1	
STOC		
ARTR		6
PUTR		1
CHNA		

Bare soil	18
Gravel pavement	15
Rock	2
Litter	15
Cryptograms	8

Estimated Utilization

Species	% Use
—	—

ACTIVITIES

Logging —
Fire —
Revegetation —
Insects —
Wildlife deer, few pronghorn antelope
Other

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Apparent range condition Good
Apparent range trend Static

COMMENTS

Hyway exclosure

Figure 77—Last page of the form “Photo Trend Sample - 1 sq. ft.” with a view up the transect from the 100-ft end. This page is also the summary sheet where frequency of species and soil surface items are listed. Space is provided for observed utilization, activities, climate, condition, and comments. The sign in the upper right is the witness point for this cluster (fig. 73). Species are AGSP (*Agropyron spicatum* vis. *Pseudoroegneria spicata* (Pursh) A. Love, bluebunch wheatgrass), POSA3 (*Poa secunda* J. Presl, Sandberg’s bluegrass), SIHY (*Sitanion hystrix* (Nutt.) J.G. Sm., squirreltail), STOC (*Stipa occidentalis* Thurb. ex S. Wats., needlegrass), BISO (*Balsamorhiza sagittata* (Pursh) Nutt., arrowleaf balsamroot), LOMAT (*Lomatium* species), PHLOX (*Phlox* species), ARTR (*Artemisia tridentata* Nutt., big sagebrush, PUTR (*Purshia tridentata* (Pursh.) DC., bitterbrush), and CHNA (*Chrysothamnus nauseosus* (Pallas ex. Pursh) Britt.).

The cluster-transect identification form (app. B) is used for both the 0- and 100-ft ends of a transect. Print information in large letters similar in size to those on the form. This size can be read on the photographs (figs. 75 and 77). Circle “0” in upper right corner for the 0-ft end (fig. 75). After taking the picture, cross out the “0” and circle the “100” for the picture at the 100-ft end (fig. 77).

A size control board is required (specifications in app. C). The illustrations in figures 75 and 77 have a size control board marked with “1M” (indicating 1 m) and decimeters labeled as 2, 4, 6, and 8. Use of a size control board has several purposes: (1) depth of grass, height of shrubs, or other items can be estimated; (2) when the camera focus system is placed on the “1M,” pictures will be consistently oriented both horizontally and vertically for easy comparison; (3) focusing the camera on the “1M” assures sharp picture clarity and greatest depth of field at the meter board; and (4) grid analysis may be performed if desired.

General transect photographs from the 0- and 100-ft ends should be taken with the three-dimensional attachment (fig. 78) on 1-ft^2 transects (fig. 75 through 77) if available, otherwise with a 50-mm lens. For other sampling, use a 50- or 35-mm lens for nested frequency, 1-m^2, and canopy cover. A 50-mm lens should be used with Robel pole to adequately document pole divisions. In addition, a standard photograph (without 3-D) is highly recommended on 1-ft^2 transects to encompass a broader horizon of the plant community and, when color slides are produced, to use in slide talks dealing with range trend (fig. 77).

Transect data forms—Forms are provided in appendix B. The series of “Photo Trend Sample-...” forms double as both data forms and a filing system for the photographs. Another form identifies the cluster and transect photograph in letters large enough to be read on the negative. The plot identification form identifies each plot and labels it on the photo negative. Because these forms are used in the field, they should be printed on a paper color that is easy on the eyes and will not burn out in photography under direct sun. “Photo Trend Transect” forms should be printed on medium yellow paper, such as Champion Goldenrod© or Hammermill Copy Plus Goldenrod©, which have been found quite acceptable. Light yellow paper, common in the office environment, is less satisfactory. Transect and plot photograph identification forms will resist fading out under direct sun if printed on medium blue color paper. Tests have shown that Hammermill Brite Hue Blue© or Georgia Pacific Papers Hots Blue© are most useful.

One-Square-Foot Plot Transect

One-square-ft sampling employs a square-foot plot placed every 5 ft along a 100-ft transect for a total of 20 plots. It is designed to document changes in species, their density, and frequency as a means to estimate change in vegetation and soil surface conditions.

Concept

Each 1-ft^2 plot is photographed in stereo to provide a permanent, visual record of vegetation and soil surface conditions. At the same time, each plant species rooted in the plot is recorded and presence of bare soil, gravel (1/8- to 3/4-in diameter), rock, litter, and cryptogams are noted. At a later time, the same transect will be

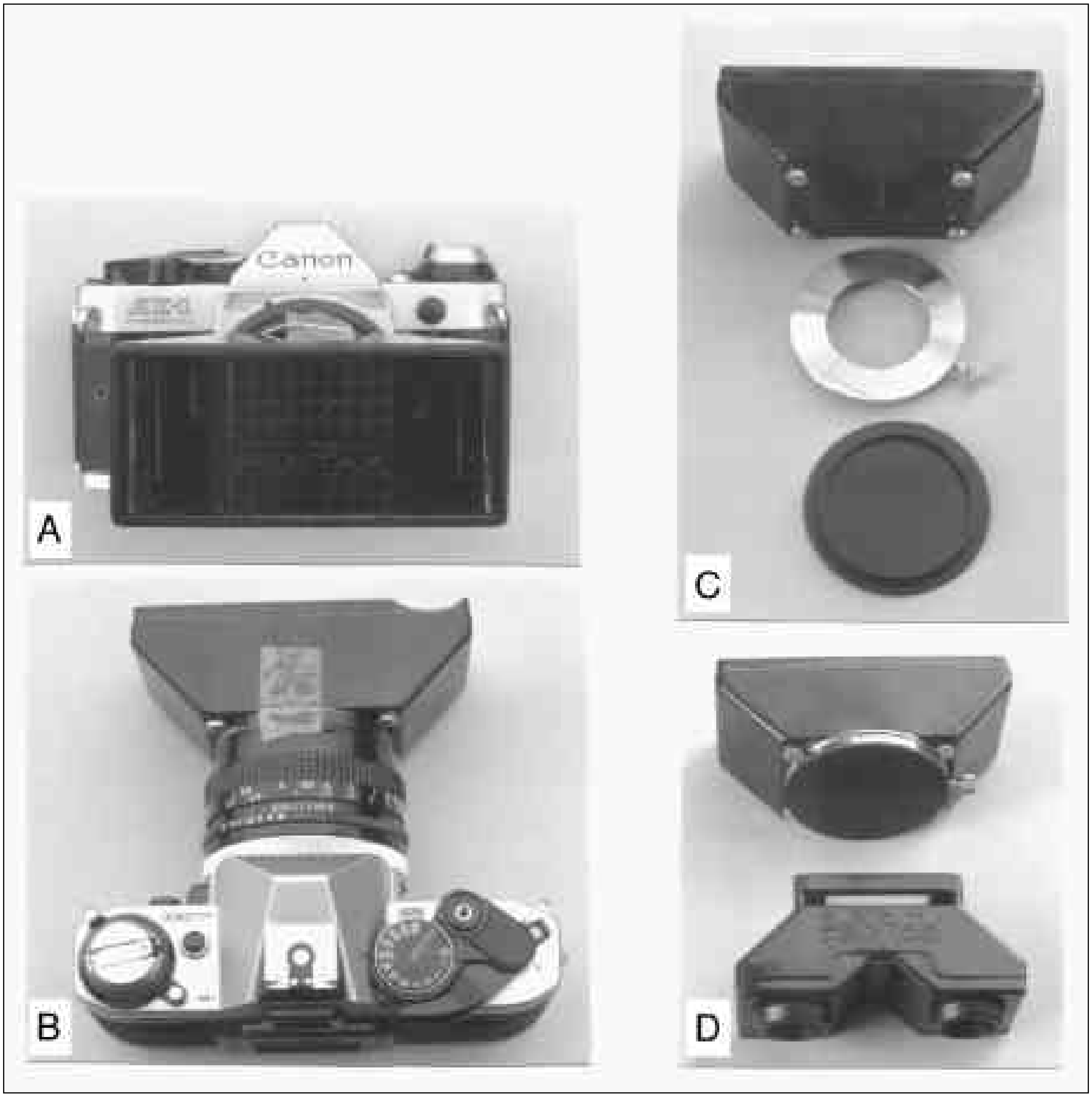


Figure 78—Camera using a 50-mm lens with stereo adapter mounted (**A** and **B**). This a Honeywell Pentax Stereo Adapter® with the connection plate removed because it will not fit on a Canon® camera. (**C**) The connection plate and its cover are shown removed. In B, the stereo system has been taped to the camera over a filter. It must be aligned horizontally with the camera (A). (**D**) The complete system includes the stereo adapter and slide viewer.

reread and rephotographed to provide a comparison set of pictures and data. Range trend is interpreted by comparing original and followup photos and data of each 1-ft^2 plot to appraise changes in species presence, density, basal area, frequency, shrub and tree line intercept, and soil surface characteristics.

Photographs are used to measure or estimate vegetation and soil parameters, aid in evaluating plant identification, facilitate illustration of range trend or lack of trend, and reduce observer variability in comparing transect readings taken at different times. Anybody can compare and measure the difference between photographs.

Stereo photographs greatly aid species identification and interpretation of vegetation and soil parameters. Try evaluation on one-half of a stereo pair—then view it with a stereoscope (fig. 75)!

Equipment

The following equipment is required for 1-ft^2 sampling:

1. Camera or cameras with color and black-and-white film and stereo adapter (fig. 78)
2. A 1-ft^2 plot frame (app. C)
3. Forms from appendix B: for photo identification "Cluster-Transect" and "Square Ft Frequency" printed on medium blue paper; and the data and photo-mounting form "Photo Trend Sample - 1 sq. ft." printed on medium yellow paper
4. Meter board (app. C)
5. Clipboard and holder for the photo identification forms (app. C)
6. Compass and a 100-ft steel tape with clamps or vice grips to clamp onto angle iron stakes
7. Fenceposts and angle iron stakes sufficient for the number of transects desired: two fenceposts and three angle iron stakes per transect and a pounder
8. Metal detector for locating transect stakes

Technique

Map the location of the transect cluster (fig. 72). Establish the transects and map them on the filing system form "Sampling Site Description and Location" (fig. 73). If slope exceeds 10 percent, orient transects on the contour so that uphill is left of the transects when viewed toward the 100-ft end. Placing plot frames and photographing uphill is easier than working downhill. Fill out information on the form and circle "1 sq. ft." on the top line. If transects fall in a line, continue the map on the back of the form (fig. 74).

A three-dimensional adapter for 35-mm cameras with 50-mm lenses is desirable for both general and 1-ft^2-plot photographs (fig. 78). Such adapters may not be available, however. If not, use a 50-mm lens in preference to a 35-mm for best detail resolution. Take general pictures from the 0-ft (fig. 75, top) and 100-ft ends (fig. 77) to show vegetation prior to trampling from placing and photographing the 1-ft^2 plot (figs. 75 and 76).

The filing system form, "Photo Trend Sample – 1 sq. ft." (app. B), is illustrated in figures 75 to 77. It should be printed on medium yellow paper such as Champion's or Hammermill's Goldenrod© to ease eyestrain. It is used to diagram plants and mount photographs of the 20 plots. Fill in date, area (Crooked River N.G.), allotment (Madras grazing unit), cluster number (3), transect number (1), and the investigator's name. "Season of use" means when during the previous 12 months the area was used, such as season long, spring, summer, fall, or winter. The "% use" is the average utilization at the time of sampling. "Grazing system" means the kind currently being used, such as season long, rest-rotation, or alternate year. Any comments may be made under "Remarks" (fig. 75) or "Comments" (fig. 77).

Transect photos are identified by the filing system form "Cluster-Transect" (figs. 75 and 77). It should be printed on medium blue paper. Fill in the date (97/3/22), circle either "0" or "100" (fig. 75 is 0, and fig. 77 is 100) to indicate which end of the transect is being photographed, area (CRNG), allotment (Madras), cluster number (3), and the transect number (1). For the downtransect photo, place the camera at the 0-ft stake, photo identification form at 15 ft, and the meter board at 33 ft; for uptransect photos, camera at 100 ft, photo identification form at 85 ft, and meter board at 67 ft.

Each square-foot plot and its photograph is labeled individually ("Square Foot Frequency") and positioned on the transect as noted on the form "Photo Trend Sample - 1 sq. ft." Place the 1-ft^2 plot at the first location, between 0 and 1 ft, with its identification card. Diagram the location of each plant species and label as shown in figures 75 and 76. Diagram basal area in bunchgrasses and area of rhizomatous or single-stemmed species when they occur within the square foot. The diagram is used for species identification and counting frequency, not for measurement of change. The stereo photograph is used to measure plant and soil change.

Under the plot diagram, circle soil surface items in the plot: "B" is bare ground (> 50 percent ground cover), "G" is gravel (> 50 percent ground cover of stones 1/8- to 3/4-in diameter), "R" is rock (> 3/4 in), "L" is litter (> 50 percent ground cover), and "C" is cryptogamic crust (> 50 percent ground cover).

Identify each square foot plot with the "Square Ft Frequency" form (app. B). It labels each 1-ft^2 plot and its photograph (figs. 75 and 76). One sheet is designed for use with all 20 plots on a transect. Try to print the necessary information in letters similar in size to those on the form. This will ensure readability in photographs. For plot 1, circle number 1, place form on ground next to the tape and adjacent to the square-foot plot. Place the plot frame at footmarks 1 and 2 as noted on the form. With a stereo adapter attached to the camera, hold the camera at eye level directly above the plot and expose for both the square-foot plot and the photo identification paper (fig. 75). For plot 2, cross out number 1 and circle number 2 (fig. 75). Place the plot frame at foot marks 5 and 6 as noted on the form. For plot 3, cross out number 2 and circle 3 (fig. 76) and place at foot marks 10 and 11. Repeat for all 20 plots. Use a new sheet for each transect.

Caution: Expose for both the photo identification paper and the plot. Generally, paper will reflect more light than vegetation and soil; the paper therefore should be slightly overexposed while soil and vegetation are slightly underexposed. Acceptable paper exposure is essential to read the printing in each plot photo. Medium blue paper, not office blue color, may be attained at most office supply stores.

In addition, from plot number 1, record shrub and tree (under 6 ft tall) canopy cover intercept by species above the transect tape between the start of one plot and the start of the next. Record beginning and ending foot marks and number of feet between intercepts. For example, in figure 76, plot 3 starting at 10 ft had a shrub intercept from 12 to 15 ft between it and plot 4, for a total of 3-ft crown intercept. Plot 5 starting at 20 ft had a shrub intercept from 22 to 23 ft between it and plot 6, for a total of 1 ft.

Another important source of supplemental information, particularly in the Pacific Northwest where many range types are forested, is the effect of tree cover. Cover must be sampled on all forested ranges. It is discussed as an additional transect sample in the "Tree Cover Sampling" section, below.

Summarize Data

After all 20 plots have been photographed and diagrammed, the transect is summarized on the last page of the “Photo Trend Sample - 1 sq. ft.” form (fig. 77). The left side documents frequency and line intercept by species as well as by soil surface items. List all species found on the transect. Sometimes a shrub or tree species will be rooted in a plot for frequency and also will be recorded for crown intercept. Record the shrub or tree species in both cases. For frequency, count the number of plots in which the species occurred and record. For intercept, total the number of feet for each species and record (fig. 77).

The same procedure is followed at the bottom of the species listing for bare ground, gravel pavement, rock, litter, and cryptogams. Determine the number of plots in which each of these items occurred (fig. 77). Bare soil occurred in 18 sample plots, gravel pavement in 15, rock in 2, litter in 15, and cryptogams in only 8 plots.

The rest of the “Photo Trend Sample - 1 sq. ft.” form is devoted to supplemental information (fig. 77). At the bottom left, record the two or three species sustaining the greatest utilization regardless of whether they are decreasers or not. The objective is to document how much utilization occurred for which species, not to estimate “proper use.”

On the lower right side of figure 77, briefly describe any activities that occurred since the last transect reading. Provision is made for logging disturbance, fire, revegetation, insects, wildlife effects, and other.

Evaluate recent climatic conditions (fig. 77). Circle whether temperature was hotter, about average, or colder for this growing season (when the sampling was done), last year, two years ago, three years ago, and four years ago. Do the same for precipitation falling between January 1 and July 1: Was it above average, about average, or below average? This information should be available from local weather stations. Precipitation in the mountains can differ considerably from local stations, and no attempt is made to quantify differences.

Estimate whether apparent range condition is good, fair, poor, or very poor. These are range management terms equivalent to ecological definitions of potential natural vegetation (PNV), late seral, mid seral and early seral. PNV is the stable, native plant community that will become established after succession following disturbance. In much of the Pacific Northwest, livestock forage rating guides can be used to determine range condition. For areas without livestock forage rating guides, estimate range condition to the best of your ability.

Next, estimate apparent range trend. If you have a strong feeling that range trend is down, say so; if you have a strong feeling the trend is up, say so; if you are not sure about trend, say that also.

Space is provided for other comments. Whenever possible, make these additional comments in the field while you are looking at the transect.

If the site is forested, add the “Tree Cover Sampling” transect to this file.

RANGE TREND REREADINGS

Circle the sampling system: 20 plots 1 sq,ft, 100 plots Nest. Frequ. 5 Plots 9 sq.ft.(1 sq. m)

Area Crooked R. N. G. Allotment Madras Cluster 3 Transect 1 2 3 4 5

Species	Averages by Year									
	1957	1982	1997							
Tree Crown Cover (in percent)										
TOTAL										
Shrub intercept (in feet)										
ARTR	5	6	6							
PUTR	—	—	1							
CHNA										
TOTAL	5	6	7							
Frequency: No. plots for 1 sq.ft. & 9 sq.ft. (1 sq. m); nested frequ. value										
POSA3	12	15	17							
AGSP	2	3	5							
LOMAT	6	3	2							
PHLOX	1									
BASA	1	1								
SIHY	1	1	1							
STOC	1									
ARTR										

Figure 79—The filing system form “Range Trend Rereadings” is printed front and back (fig. 80 shows the back). Provision is made for 10 rereadings of each transect. Fill in the top section to identify the cluster and transect. Then enter the year of each reading and copy data from the last page of the “Photo Trend Sample - 1 sq. ft.” form (fig.77).

RANGE TREND REREADINGS (Continued)

Elements	Averages by Year 1957	1982	1997						
Range Condition Guide/date									
Bunchgrass 1951	P								
4RTR 1983	F	F	G						
Decreasers:	2	3	5						
Palatable Increasers	14	16	18						
Unpalatable Increasers	7	3	2						
Invaders	—	—	—						
Vegetation - (root crown)	16	17	17						
Bare Soil	20	20	18						
Gravel (1/8 to ¾ inch)	16	14	15						
Rock (> ¾ inch)	2	2	2						
Litter	8	12	15						
Cryptogams	4	6	8						
% Utilization by species									
None	—	—	—						
Season of Use	—	—	—						
Climate									
Temp: Current	+	0	0						
Last year	0	0	0						
2 yrs. Ago	0	+	0						
3 yrs. Ago	0	0	—						
4 yrs. Ago	—	0	—						
Ppt.: Current	0	+	+						
Last year	0	+	+						
2 yrs. Ago	0	0	0						
3 yrs. Ago	—	0	0						
4 yrs. Ago	+	0	—						
Apparent range condition	F	F	G						
Apparent range trend	S	U	S						

Figure 80—Back of the "Range Trend Rereadings" form providing for data analysis by use of rating guides for livestock forage (range condition guides). The remaining transect summary data from figure 77 may also be added by date.

Range Trend Analysis

Data obtained by square-foot frequency are summarized for trend analysis in the filing system form “Range Trend Rereadings” (fig. 79). The form is designed for a series of up to 10 transect readings that may be compared side by side. The columns under “Averages by Year” require the year of reading to be entered at the top. The form in appendix B is printed front and back corresponding to figures 79 and 80.

Figure 79 is the front of the form. Circle which sampling system was used, “20 plots 1 sq. ft.” in this case. Enter the information on area, allotment, and cluster number and circle the transect number. Enter the date of reading at the top of the “Averages by Year” column. Figure 79 shows three hypothetical transect readings: 1957, 1982, and 1997. The data in figure 79 refer to the 1997 reading.

If tree cover was sampled (trees over 6 ft tall), enter the total number of feet of intersect by species and total. Then enter the total number of feet of intercept by shrub species and total. Shrub species intercept is summarized on the last page of the form “Photo Trend Sample - 1 sq. ft.” (fig. 77), a total of 7 ft.

The next data set (fig. 79) is for herbaceous species sampled by either 1-ft^2 or 1-m^2 or nested frequency. The data are summarized on the last page of the form “Photo Trend Sample - 1 sq. ft.” (fig. 77). Circle the sample plot used (“1 sq. ft.”). Enter the number of plots in which each species was rooted. Maximum number of plots for 1 ft^2 is 20 and 9 ft^2 or 1 m^2 has five plots. Nested frequency uses a different value. It is the total value of all five transects (100 plots) by species. See the “Nested Frequency Transect” section, below, for details.

Figure 80 shows the back of the form, which summarizes additional information and data. Enter data by date in the column “Averages by Year.” If a range condition guide (or livestock forage rating guide) is available, list it and its date. In this case, an old bunchgrass guide of 1951 was used for the 1957 reading, which rated P (poor condition). A 1983 guide for big sagebrush (ARTR, *Artemisia tridentata* Nutt.) was used to estimate range condition for all three years. The 1983 guide showed data for 1951 rated F (fair) condition instead of poor.

These range condition guides list species by their reaction to livestock grazing: *decreasers* decrease under heavy use; *palatable increasers* are less palatable and tend to increase with heavy use. However, if heavy use continues, these species also decrease. *Unpalatable increasers* are species that livestock do not like to eat, and they tend to increase. *Invaders* are species generally not found on rangeland in good condition.

Data are summarized by the above categories of plant species (fig. 80). Total the number of plots by species in each category and enter. For example, AGSP (*Agropyron spicatum* vis. *Pseudoroegneria spicata* (Pursh) A. Love, bluebunch wheatgrass) is the only decreaser, so its data are entered (5 plots). Palatable increasers are POSA3 (*Poa secunda* J. Presl, Sandberg’s bluegrass), SIHY (*Sitanion hystrix* (Nutt.) J.G. Sm., squirreltail), STOC (*Stipa occidentalis* Thurb. Ex S. Wats., needlegrass), and BASA (*Balsamorhiza sagittata* (Pursh) Nutt., arrowleaf balsamroot), so their data are summarized and entered in “palatable increasers” (18 plots). LOMAT (*Lomatium* species) and PHLOX (*Phlox* species) are considered unpalatable increasers and are entered as such (2 plots).

The next section of figure 80 deals with soil surface conditions. “Vegetation - (root crown)” is the number of plots in which a root crown of a bunchgrass is present. In 1997, 17 plots had a root crown and 3 had no vegetation rooted in them. Single stem plants, like many forbs, do not contribute directly to soil surface protection. This information is taken from the stereophotographs as is the frequency of bare ground, gravel, rock, litter, and cryptogams. The latter five items are summarized at the bottom left of the “Photo Trend Sample - 1 sq. ft.” form (fig. 77). The section on “% Utilization by species” provides space to enter stubble height or other means to estimate utilization by species as taken from the “Photo Trend Sample” form, lower left. In this exclosure, there was no utilization. If there was use, estimate the season of use, as spring (spr), summer (sum), fall (fall), or winter (wint).

Climate information is listed in the next section for the current and preceding three years, which has been summarized in the lower right of the form, “Photo Trend Sample - 1 sq. ft.” (fig. 77). Finally, copy the estimates of apparent range condition and trend from the “Photo Trend Sample.” Abbreviations are G = good, F = fair, P = poor, and VP = is very poor, a condition where decreasers are absent and livestock management is no longer a feasible means for attaining an upward trend to good condition. Trend abbreviations are U = upward trend, S = static or no trend, and D = downward trend.

Trend Interpretation

Interpretation of trend is accomplished by comparison of data in the columns. Data for 1997 were measured; those for 1982 and 1957 were constructed. A current, soundly developed livestock forage rating guide (range condition guide) is a major aid in trend interpretation. Statistical analysis is not possible on this kind of data. No trend, or stable status, is indicated by little change in either vegetation or soil surface data.

Upward trend, or successional change to good condition (potential natural vegetation: PNV), is generally indicated by increased decreasers, and often palatable increasers, accompanied by a decrease in unpalatable increasers. If earlier condition was below fair, there should be improvement of soil surface conditions, such as litter and cryptogamic crust, with less bare soil. Seldom will rock or gravel change in an upward trend. Consult the livestock forage rating guide (range condition guide) for data characterizing the PNC soil surface status

A downward trend, or successional change to poorer condition (earlier seral status), is characterized by reduction in decreasers, increase in palatable increasers initially in fair and good condition (late and PNV seral status), and then their decrease as seral status approaches very poor condition (early seral). Soil surface data also should change with decreases in vegetation, litter, and cryptogams and increases in bare soil and possibly gravel.

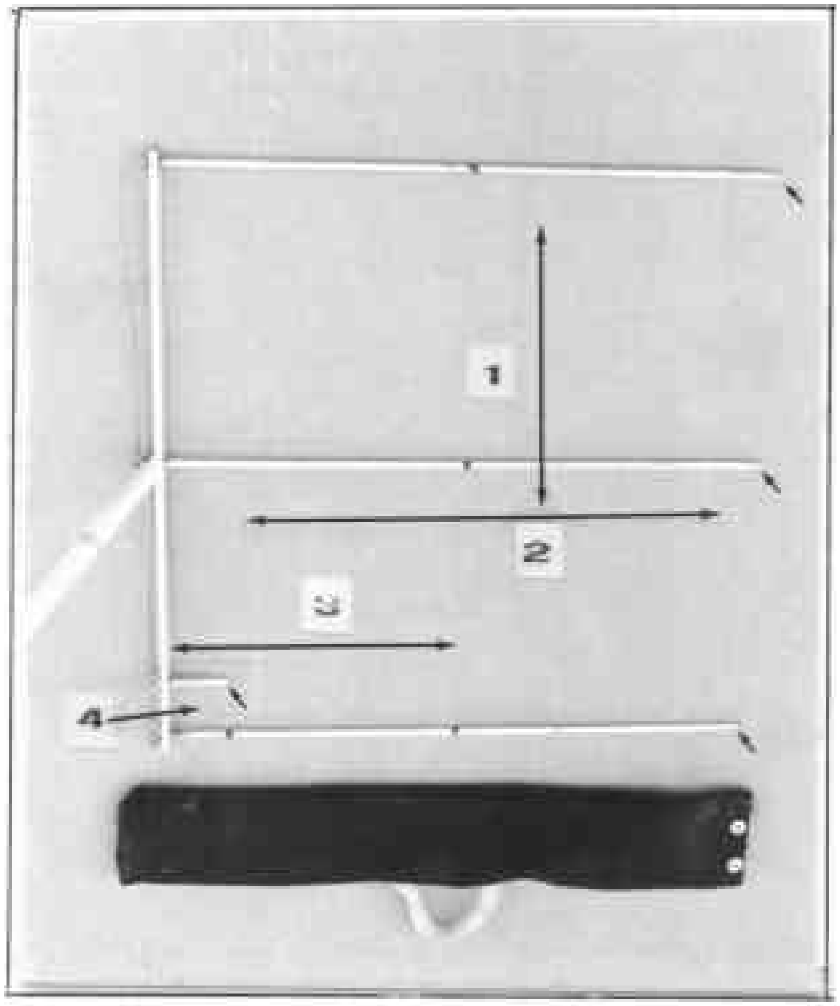


Figure 81—Nested frequency sampling frame with four plot sizes and its carrying case. Plot size 4 is 5 by 5 cm, size 3 is 25 by 25 cm, size 2 is 25 by 50 cm, and size 1 is 50 by 50 cm. Plant species rooted within each of the plot sizes are assigned the plot size value. The ends of each prong are sharpened for use as point samples of soil surface conditions (short arrows). The frame case has a strap for easy handling.

Poor and very poor condition classes (early and mid seral ecological status) pose two important questions: (1) Has vegetation passed a threshold whereby it may not be able to reattain its PNV composition and density of species? An example is a cheatgrass-dominated stand where decreasers are absent and only a few palatable increasers are present. Adjustment in livestock management is no longer feasible to attain an upward trend. (2) Has the soil been damaged sufficiently that it has passed a threshold and no longer can support the historic PNV community? Such threshold changes are indicated by erosion of the A-horizon, increase in gravel as a result of erosion, and severe compaction. A well-developed livestock forage rating guide contains parameters on PNV status of bare ground, gravel pavement, rock, and A-horizon characteristics that may be compared with current soil conditions. It should specify criteria when a soil threshold has been crossed.

Nested Frequency Transect

Nested frequency employs a sample frame with four nested plot sizes. It documents change in species frequency along five 100-ft transects of 20 plots each. Statistical analysis suggests significant change in frequency at the 80-percent level of probability.

Concept

Frequency is defined as the number of times a species occurs (is rooted) in a given number of plots and considers only whether species are present or absent. It is an objective and repeatable means of collecting data to evaluate change.

The nested frequency concept involves sampling vegetation with four various sized plots nested within a frame (fig. 81). The overall frame is 50 by 50 cm with smaller subplots of 25 by 50 cm (50 percent of the large plot area), 25 by 25 cm (25 percent of the large plot area), and 5 by 5 cm (1 percent of the large plot area). The assumption is made that a species rooted within the 5- by 5-cm subplot also occurs in the 25- by 25-cm subplot, the 25- by 50-cm subplot and in the 50- by 50-cm subplot. Similarly, a species rooted in the 25- by 25-cm subplot occurs in the larger subplots. Therefore, once a species is recorded in a subplot, it is **not** recorded if found in a larger subplot.

Samples are taken along five randomly selected transect lines confined to a single ecological type (range site). The data collected are a function of plot size, which is related to density and distribution of the vegetation. These data serve as a basis for determining trend and can be evaluated by applying statistical procedures. Statistical analysis requires use of 100 plot frames or 400 total plots. Twenty plot frames on each of five transects yield 100 plot frames.

Ground cover measurements are obtained by sampling soil surface items under pointed ends of four prongs of the nested frequency frame (fig. 81). Twenty sample frames on five transects will yield 400 sample points. Items recorded are vegetation (root crown), bare soil, gravel (1/8- to 3/4-in diameter), rock (>3/4-in), litter, and cryptogams.

When trees or shrubs occur on the transect, their canopy intercept above the transect is recorded.

It is recognized that the nested plot has apparent replication. A plant occurring in the 5- by 5-cm plot also occurs in the 25- by 25-cm plot, the 25- by 50-cm plot, and the 50- by 50-cm plot. As this is a question of statistical bias, two things overcome the possible sampling error. One is that each frame is not an independent sample; therefore, only one degree of freedom is used. Secondly, empirical analysis indicates that if a site is adequately sampled, in this case 400 nested plot samples (100 plot frames), the final result is highly similar whether all plots are randomly tested or if a nested plot (with apparent replication) is used.

Plants rooted within each of the four plots in the frame are recorded by plot size. The 5- by 5-cm plot is assigned the value of 4 (fig. 81), the 25- by 25-cm plot the value of 3, 25- by 50-cm plot a 2, and the 50- by 50-cm plot a 1. These values are then assigned by species and recorded on the filing system form, “Nested Frequency Transect Data” (fig. 86, discussed below).

Table 2—Table of random numbers

Row			Random Number		
1	23 25 75 48 59	01 83 72 59 93	76 24 97 08 96	95 32 03 67 44	05 54 55 50 43
2	10 53 74 35 08	90 61 18 37 44	10 96 22 12 43	14 87 16 03 50	32 40 43 63 23
3	50 05 10 03 22	11 54 38 08 34	38 97 67 49 51	94 05 17 58 53	78 80 59 01 94
4	32 42 87 16 95	97 31 26 17 18	99 75 53 08 79	94 25 12 58 41	54 88 21 05 13
5	11 74 26 93 81	44 33 93 08 72	32 79 73 31 18	22 64 70 68 50	43 36 12 88 59
6	11 01 64 56 23	93 00 90 04 99	43 64 07 40 36	93 80 62 04 78	38 26 80 44 91
7	55 75 11 89 32	38 47 55 25 71	49 54 01 31 81	08 42 98 41 87	69 53 82 96 61
8	77 73 80 95 27	36 76 87 26 33	37 94 82 15 69	41 95 96 86 70	45 27 48 38 80
9	07 09 25 23 92	24 62 71 26 07	06 55 84 53 44	67 33 84 53 20	43 31 00 10 81
10	44 86 38 03 07	52 55 51 61 48	89 74 29 46 47	61 57 00 63 60	06 17 36 37 75
11	63 14 89 51 23	35 01 74 59 93	31 35 28 37 99	10 77 91 89 41	31 57 97 64 48
12	62 58 48 69 19	57 04 88 65 26	27 79 59 36 82	90 52 95 65 46	35 06 53 22 54
13	09 24 34 42 00	68 72 10 71 37	30 72 97 57 56	09 29 82 76 50	97 95 63 50 18
14	40 89 48 83 29	52 23 08 25 21	22 53 26 15 87	93 73 25 95 70	43 78 19 88 85
15	56 67 16 68 26	95 99 64 45 69	72 62 11 12 25	00 92 26 82 64	35 66 65 94 34
16	71 68 75 18 67	61 02 07 44 18	45 37 12 07 94	95 91 73 78 66	99 53 61 93 78
17	97 83 98 54 74	33 05 59 17 18	45 47 35 41 44	22 03 42 30 00	89 16 09 71 92
18	22 23 29 06 37	35 05 54 54 89	88 43 81 63 61	25 96 68 82 20	62 87 17 92 65
19	02 82 35 28 62	84 91 95 48 83	81 44 33 17 19	05 04 95 48 06	74 69 00 75 67
20	65 01 71 65 45	11 32 25 49 31	42 36 23 42 86	08 62 49 76 67	42 24 52 32 45

Equipment

The following equipment is required for nested frequency sampling:

1. Camera or cameras with both color and black-and-white film, or digital camera
2. A nested frequency plot frame (app. C)
3. Forms from appendix B: “Cluster-Transect” for transect identification, and “Nested Frequency” for plot identification both printed on medium blue paper, and data and photo mounting form “Photo Trend Sample - Nested Frequency” and “Photo Trend Sample -Nested Frequency Summary” printed on medium yellow paper
4. Meter board (app. C)
5. Clipboard and support for holding the photo identification forms (app. C)
6. A compass and 100-ft steel tape with clamps or vice grips to clamp onto angle iron stakes
7. Fenceposts and angle iron stakes sufficient for the number of transects desired: 2 fenceposts and 3 angle iron stakes per transect and a pounder
8. Metal detector for locating transect stakes

Technique

Each of the five transects is defined as a randomly selected line along which data are collected. A minimum of five transects are established at five randomly selected compass directions radiating from a central point whenever site conditions are suitable.

Select compass headings in 10-degree increments between 0 and 35 from table 2. If site conditions require placement in a line, distances between transects should be randomly chosen. The example below illustrates transect placement around a central witness location by using the first five values in table 2 that are between 0 and 35 (from 0 degrees; that is, 360 degrees to 350 degrees). Chose numbers less than 36 (360 degrees) and add a “0” to the value for compass bearing. For example, in the first row, “23” would be a compass bearing of 230 degrees for transect 1. Transect 2 would be 250 degrees, transect 3 is 10 degrees, transect 4 is 240 degrees, and transect 5 is 80 degrees. Select a different row for each new cluster of five transects.

Placement of the transects requires a witness site with direction (indicate whether magnetic or true) and measured distance to the central marker for five radiating transects or to transect number 1 (fig. 82). For radiating transects, measure out 5 ft from the central marker (fencepost) and start the transect as discussed under “Transect Layout” in the “Transect Photo Sampling” section above. Record direction determined above (magnetic or true) and distance to the three angle iron stakes. If transects are in a line, record direction and measured distance between the 100- and 0-ft ends of each transect (fig. 74).

Diagram the transect layout on the filing system form (fig. 82), and fill out information on the form. Remember to circle “Nested Freq.” on the top line of the form. Note the transect numbers at their 0-ft ends.

Each transect photo is identified by the filing system form shown in figures 83 and 85. The photo identification form should be printed on medium blue paper for use in the photographs. Fill in the date (97/3/22), circle either “0” or “100” (fig. 83 is 0, fig. 85 is 100) to indicate which end of the transect is being photographed, note area (CRNG), allotment (Madras), and cluster number (3), and circle the transect number (1).

Place the nested frequency plot frame uphill on the left of the transect tape as viewed toward the 100-ft end. Locate the 5- by 5-cm plot against the tape, open end of the frame toward the 100-ft end. Figures 83 and 84 show, under the plot diagram, foot marks on the tape where each plot frame is placed. Print this form on medium yellow paper to reduce glare because it is used to record data.

Place the nested plot frame at the first location, between 0 and 1.6 ft. The form “Nested Frequency” (app. B) shown in figures 83 and 84 identifies each plot frame. It should be printed on medium blue paper to reduce overexposure in the Sun. For photo plot 1, circle number 1 and place on the ground at the open end of the plot. For plot 2, cross out number 1 and circle number 2 (fig. 83). Repeat for all 20 plots (fig. 84).

List all species in each frame and diagram their locations (figs. 83 and 84). A plant is considered rooted within the plot if any portion of the stem or root crown is contained therein. For mat-forming species, any portion of the crown extending into the plot will constitute presence of that plant.

Text continues on page 151.

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. **Nested Freq.** 1 sq.m. Robel Pole Shrub Form ________

Date 1997/3/22
Area Crooked River N.G.
Allot. Madras
Cluster No. 3
Transects: 1 2 3 4 5
Plant community ARTR/ AGSP/POSA

Grazing system:
Type Exclosure Date 1954
Type ________ Date ____
Type ________ Date ____

Kind of animal: cattle sheep horses goats deer elk jack rabbits

Location: T. 11S R. 13E
Sec. 36 NW of NW
Description: US hiway 20 at Crooked River N.G. sign; 2.1 mi from junct. US 97 & US 26 S. of Madras.

Site Data: Elev. 2775 % slope 8
Slope aspect: N NE E SE S SW W NW
Slope position: top up 1/3 mid low 1/3 bottom
Micro topography: convex flat concave
Macro topography: flat undulating rolling steep rough broken

Geology:
Deposition: wind stream lake colluvial residual
Material: limestone mudstone sandstone granite serpentine diorite basalt andesite rhyolite tuffacious cinders pumice ash

Soil:
Restrictive layer: absent clay pan bedrock cemented ________
Surface compaction: none moderate severe
Soil profile stone: absent gravel stony
Soil texture: sandy loamy silty clayey ashy
Other notes: Livestock excluded when hiway was fenced in 1954

MAP

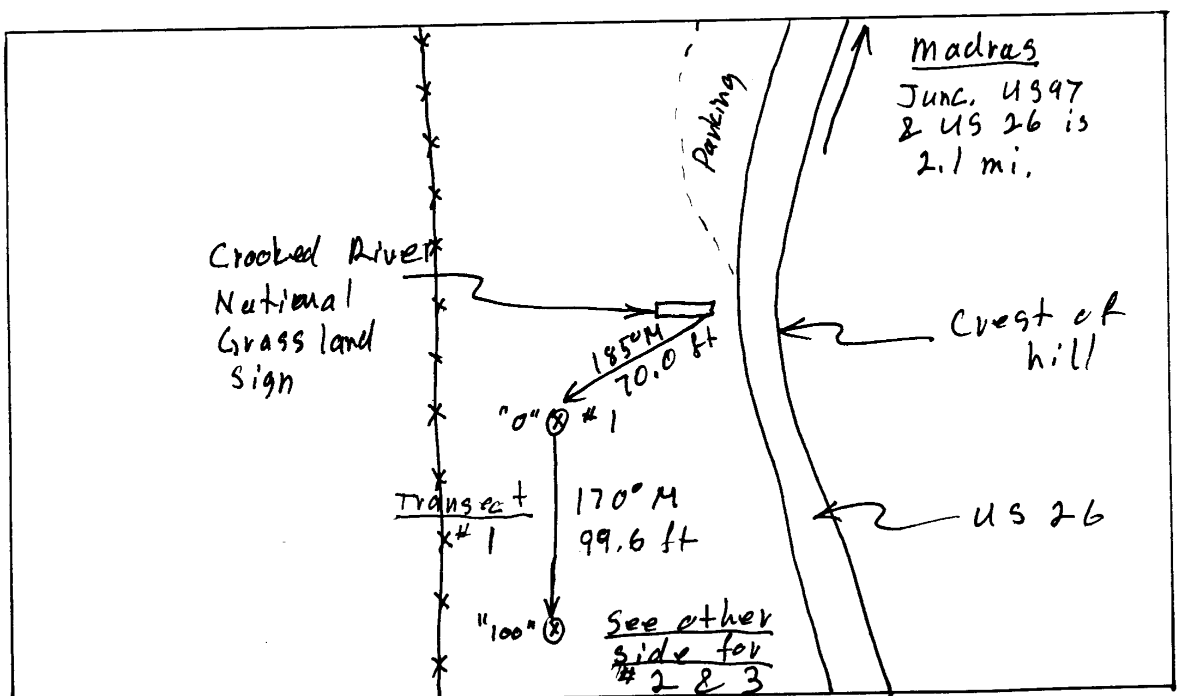


Figure 82—Filing system form “Sampling Site Description and Location” for this nested frequency discussion (same as fig. 73). First, circle “Nested Freq.” on the top line, then fill in the information requested, and diagram the transect layout. Figures 73 and 74 are the complete documentation.

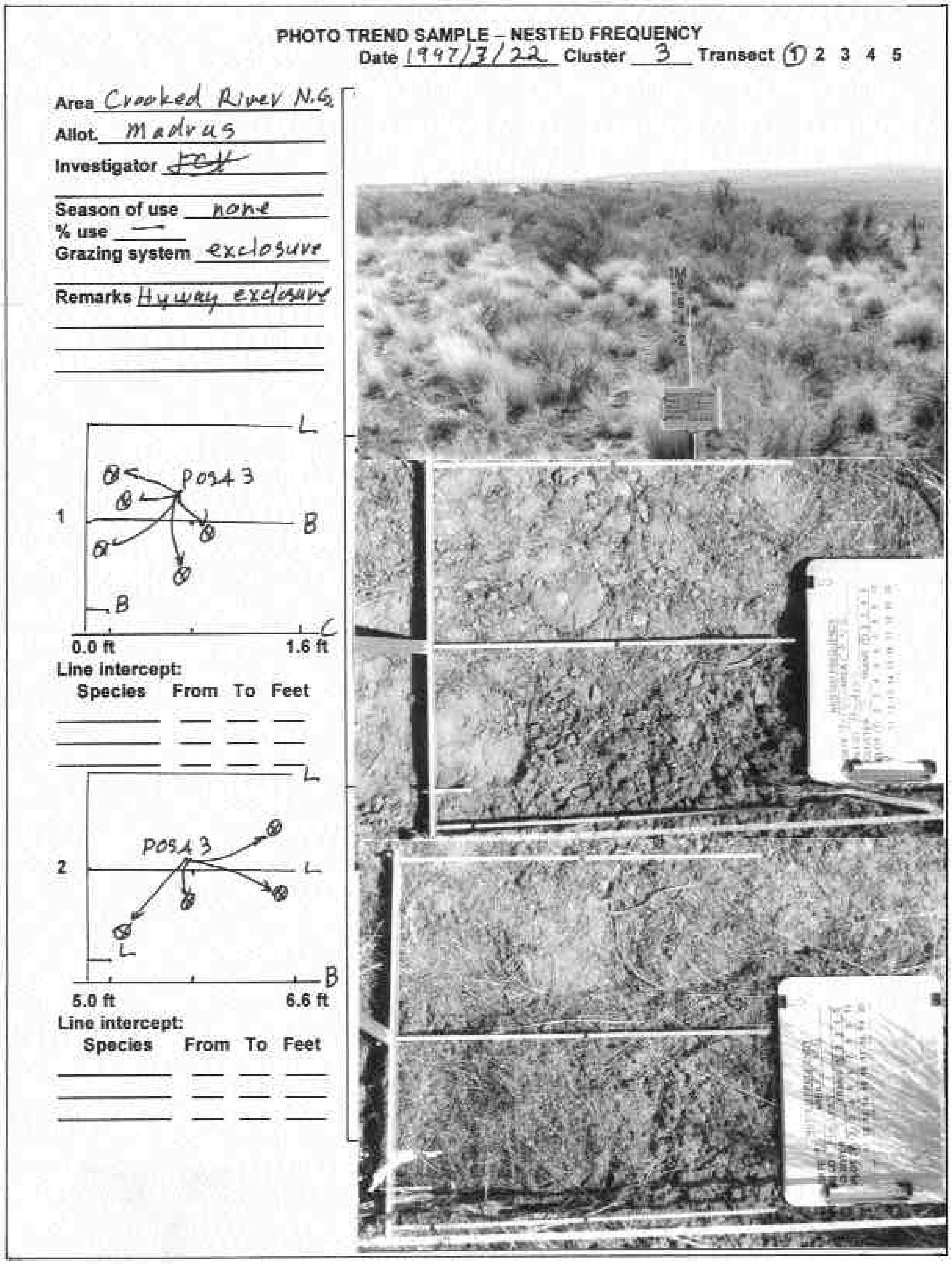


PHOTO TREND SAMPLE – NESTED FREQUENCY

Date 1997/3/22 Cluster 3 Transect 1 2 3 4 5

Area Crooked River N.G.

Allot. Madras

Investigator [illegible]

Season of use none

% use —

Grazing system exclosure

Remarks Hyway exclosure

Line intercept:

Species From To Feet

Line intercept:

Species From To Feet

Figure 83—Filing system form “Photo Trend Sample - Nested Frequency” illustrating its use. Two additional forms are required: transect identification (top picture) and plot identification (lower two pictures). Fill out required information on each form: CRNG (Crooked River National Grassland), Madras Exclosure, cluster 3, transect 1, date, and notes. Photograph the transect from the 0-ft (top picture) and the 100-ft ends (fig. 85). This is the same transect shown in figure 75. Notice the soil surface items at the end of each prong: B = bare ground, G = gravel, R = rock, L = litter, and C = cryptogamic crust.

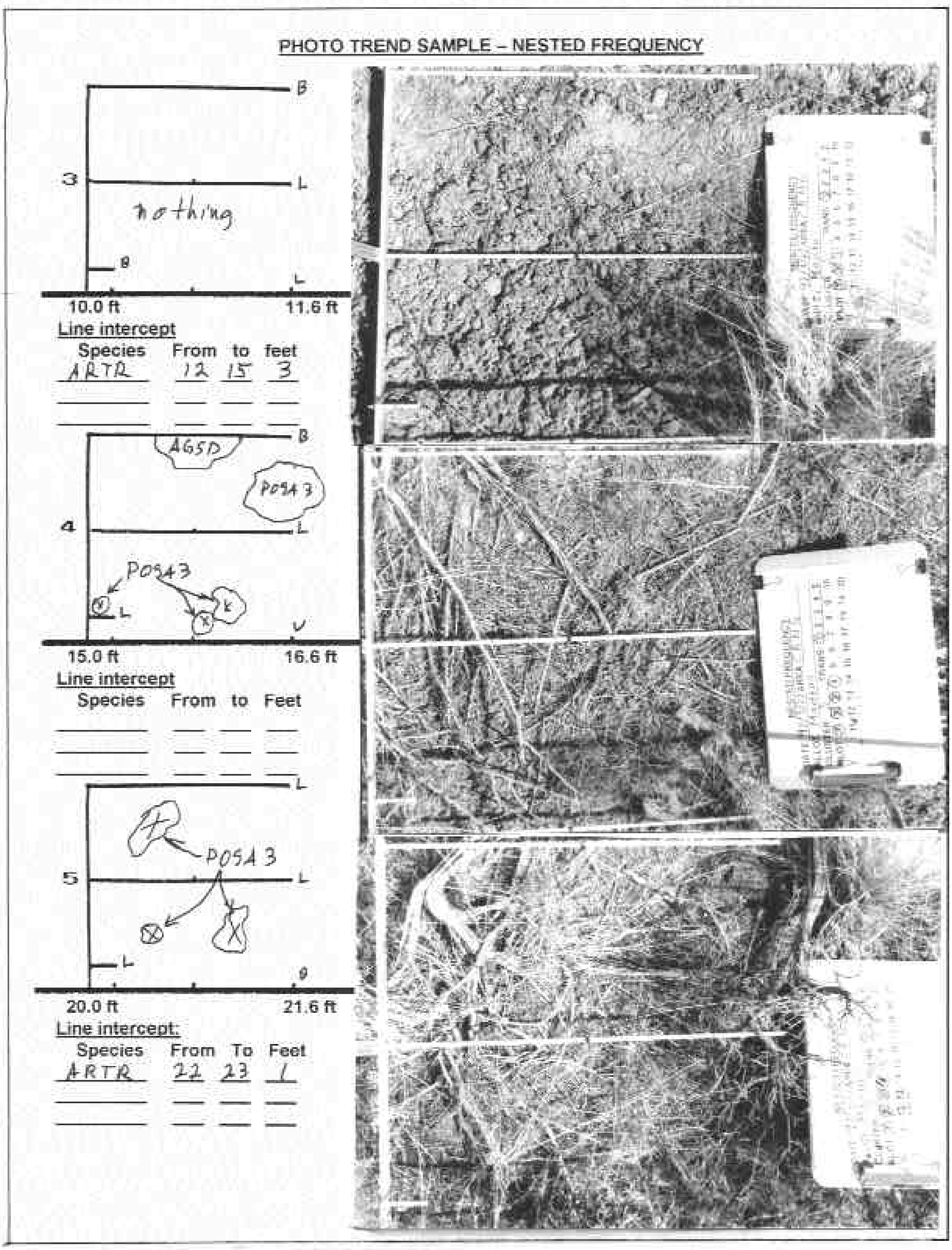


Figure 84—Nested frequency data sheet and photo-mounting form for plot frames 3 to 5. A space on the left is available for recording crown canopy intercept along the transect. Under plot frame 3, ARTR (*Artemisia tridentata* Nutt., big sagebrush) canopy intersected the transect at foot marks 12 to 15 for 3 ft of intercept. Record intercept between plot frames starting and ending with the beginning footmark for each plot. For plot frame 3, the intersect is from footmark 12 to 15. Plot 5 had ARTR intercept between footmarks 22 and 23 for 1 ft of intercept. Other species are AGSP (*Agropyron spicatum* vis. *Pseudoroegneria spicatum* (Pursh.) A. Love., bluebunch wheatgrass), and POSA3, (*Poa secunda* J. Presl., Sandberg's bluegrass).

PHOTO TREND SAMPLE – NESTED FREQUENCY

SUMMARY

NOTE: use the nested frequency data forms on the next two pages.

ACTIVITIES

Logging —
Fire —
Revegetation —
Insects —
Wildlife Deer, rabbits
Other Exclosure

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Apparent range condition Good
Apparent range trend Static

COMMENTS

Hiway exclosure

Estimated Utilization

Species	% Use
—	

Figure 85—Last page of the filing system form "Photo Trend Sample - Nested Frequency." Notice that data are not summarized on this form. Instead, they are summarized for each transect on the filing system form, "Nested Frequency Transect Data" (figs. 86 and 87), and all five transects are summarized on another form, "Nested Frequency Cluster Summary" (figs. 88 and 89). Fill in activities, climate, and comments as appropriate.

Next, record point sampling by noting what is under the pointed end of the four prongs (figs. 83 and 84). Use the following abbreviations: V = vegetation (plant root crown), B = bare soil, G = gravel (stones 1/8- to 3/4-in diameter), R = rock (> 3/4 in), L = litter, and C = cryptogams. These are point samples.

After photographing and diagramming a plot, determine shrub or tree (under 6 ft) intercept along the line from the start of one plot to start of the next. For example, figure 84 between plot numbers 3 and 4 (between foot marks 10.0 ft and 15.0 ft), ARTR (big sagebrush) intersected the line from foot marks 12 to 15 for 3 ft of intercept.

Proceed down the transect with photographs and diagrams of each plot frame. Complete the last page of the form “Photo Trend Sample - Nested Frequency” (fig. 85).

Another important source of supplemental information is the effect of tree cover. Cover should be sampled on all forested ranges. It is discussed below in the “Tree Cover Sampling” section.

Summarize Data

Transect summary—Using diagrams for each sample on the form, “Photo Trend Sample - Nested Frequency” (figs. 83 and 84), summarize them on the filing system form, “Nested Frequency Transect Data” (figs. 86 and 87). Fill in information at the top for unit, area, cluster, and transect. This form is printed front and back. The table lists “Sample Number” across the top. These correspond to the sample numbers shown on figures 83 and 84. Species are listed down the left side.

Using “Nested Frequency Transect Data” (fig. 86), start with sample 1 of the transect (fig. 83) and evaluate the smallest subplot (rated 4 in fig. 81), record species rooted within it, and assign the frequency value of 4 (no species in sample 1). Next record species rooted within the next largest subplot (rated 3 in fig. 81) and assign a frequency value of 3. POSA3 is recorded at 3. Continue with the next largest plot (25 by 50 cm) rating species a 2 (none in sample 1). Do **not** record a species rooted within a smaller plot. Finally, record species only in the whole plot frame (50 by 50 cm) with a 1 (none in sample 1).

Continue to record the frequency value in each sample by species (fig. 86). Total the value for each species on the right. These totals will be entered in the form, “Nested Frequency Cluster Summary” (figs. 88 and 89). The maximum total would be 80 if the same species occurred in every 5- by 5-cm plot rating 4. Species that do not fall in a plot of the frame are not given a value; that is, ARTR and BASA in figure 86.

Next summarize point sampling at the bottom of figure 86. Dot tally the occurrence of each of the six items from abbreviations at the ends of the four frame prongs (figs. 83 and 84). Sum the dot tallies in the “Totals” space. Next add the totals row for a grand total, which must equal 80 because there are 80 points in the 20 samples.

Text continues on page 158.

NESTED FREQUENCY TRANSECT DATA

Area: Crooked R. N. G. **Allotment:** Madras **Date:** 97/3/22

Investigator: FCH & GPH **Cluster:** 3 **Transect:** 1 2 3 4 5

Plant community: ARTR/AGSP/POSA3

Species	Sample Number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Value
POSA3	3	3	–	3	3	4	3	3	3	3	4	2	3	3	3	–	4	3	3	3	56
AGSP				1		1		3		1	2	4	1	3	3					1	19
ARTR																					
LOMAT							3			3											6
PHLOX									1												1
BASA																					
SIHY																		3			3

POINT SAMPLING

Ground cover	Veg.	Soil	Gravel	Rock	Litter	Crypt.	Total
Dot tally	–	⊠ ⊠	⊠ |:	··	⊠ ⊠	⊠ ⊠ ··	
Totals	–	20	15	2	20	23	80

NEXT SHEET FOR LINE INTERCEPT OF SHRUBS AND TREES

Figure 86—Filing system form "Nested Frequency Transect Data," where frequency values by species and point sampling on the plot frame prongs are recorded. Starting with plot frame 1 (sample number 1), list the frequency value for each species in the "Sample Number" column. POSA3 rated a "3" (fig. 83). Next, add up the 20 frequency values and enter in the "Total Value" column. POSA3 added to 56. Transfer these values to the "Nested Frequency Cluster Summary" form (fig. 88). Then, dot tally in "Point Sampling" the items at each of the four prong points. Plot 1 had one litter (L), two bare soil (B), and one cryptogam (C). Add the dot tallies in each column by item. The sum of these "Totals" tallies should be 80. The sum of each item is then transferred to the "Nested Frequency Cluster Summary (continued)" form (fig. 89).

NESTED FREQUENCY TRANSECT DATA (Continued)

Line intercept of trees and shrubs

Shrub species	Line Intercept								Total	Percent
ARTR	3	1	1	1					6	6
PUTR	1								1	0,5
								Totals	7	6.5

Tree species	Line Intercept								Total	Percent
								Totals		

Figure 87—Second page of the "Nested Frequency Transect Data (Continued)" form where line intersect data for shrubs and trees are summarized. ARTR added to 6 ft of line intercept for 6 percent canopy cover. Line intercept data are summarized in the "Nested Frequency Cluster Summary (Continued)" form (fig. 89).

NESTED FREQUENCY CLUSTER SUMMARY

Area: Crooked River N.G. **Allotment:** Madras **Date:** 97/3/22
Investigator: FCH & GPH **Cluster:** 3
Plant community: ARTR/AGSP/POSA3

Species	Transect Number 1	2	3	4	5	(To trend summary) Total Value
POSA3	56	43	68	49	58	274
AGSP	19	18	16	26	31	110
ARTR	—	1	3	—	1	5
LOMAT	6	12	2	—	9	29
PHLOX	1	4	—	3	—	8
BASA	—	—	1	—	1	2
SIHY	3	—	4	—	2	9
STOC		1			1	2

OVER FOR LINE INTERCEPT AND POINT SAMPLING

Figure 88—The filing system form "Nested Frequency Cluster Summary" where five transects of the nested frequency cluster are summarized. The frequency values for transect 1 (fig. 86) are entered in the "Transect Number" column 1. Add the frequency values by species and enter in the "Total Value" column. The maximum value is 400 if the same species occurred in all 5- by 5-cm plots rating a 4. These values are then transferred to the filing system form "Range Trend Rereadings" (fig. 90) according to date of the rereading. The data summarized above are shown for 1997.

NESTED FREQUENCY CLUSTER SUMMARY (Continued)

LINE INTERCEPT

Shrub species	Transect Number 1	2	3	4	5	(To trend summary) Total	Percent
ARTR	6	9	4	5	11	35	7
PUTR	1	1		1		3	–
CHNA			1			1	–
Tree Species							

POINT SAMPLING

Ground Item	Transect Number 1	2	3	4	5	(To trend summary) Total Hits	Percent
Vegetation (root crown)	–	2	–	1	3	6	2
Bare soil	20	34	4	36	16	110	28
Gravel (1/8 to ¾ in.)	15	12	21	7	16	71	18
Rock (> ¾ in.)	2	2	4	–	–	8	2
Litter	20	18	20	17	19	94	24
Cryptogams	23	12	31	19	26	111	28
Totals:	**80**	**80**	**80**	**80**	**80**	**400**	**100**

Figure 89—Back page of the "Nested Frequency Cluster Summary (Continued)" form where line intercept and point sampling data are entered for each of the five transects. For line intercept, enter the feet by transect. Total the feet by species; for example, ARTR (35) and enter. Then divide the total feet by 500 (500 ft of transects) for the percentage of cover (7 percent). Transfer the "Total" by species to the "Range Trend Rereadings" form (fig. 90). In "Point Sampling," enter each transect's data and sum in two directions. Data for each transect column must total 80. Add across rows for "Total Hits" by item. Determine percentage of occurrence of each item by dividing by 400, the total maximum number of hits possible. Add the "Total Hits" column to ensure it is 400. Transfer data in the "Total Hits" column by item to the "Range Trend Rereadings (Continued)" form (fig. 91).

RANGE TREND REREADINGS

Circle the sampling system: 20 plots 1 sq,ft, 100 plots Nest. Frequ. 5 Plots 9 sq.ft.(1 sq. m)

Area Crooked R. N. G. Allotment Madras Cluster 3 Transect 1 2 3 4 5

Species	1957	1982	1997							
	Averages by Year									
Tree Crown Cover (in percent)										
TOTAL										
Shrub intercept (in feet)										
ARTR	38	36	35							
PUTR	6	3	2							
CHNA										
TOTAL										
Frequency: No. plots for 1 sq.ft. & 9 sq.ft. (1 sq. m); nested frequ. value										
POSA3	261	288	274							
AGSP	58	92	114							
ARTR	4	5	5							
LOMAT	43	36	29							
PHLOX	7	10	8							
BASA	12	8	2							
SIHY	11	16	9							
STOC	15	8	2							

OVER FOR ADDITIONAL DATA

Figure 90—The filing system form “Range Trend Rereadings” where transect data are entered each time the cluster is read. Circle the sampling system on the first line (“100 plots Nest. Frequ.”). Enter the cluster identification information. Notice that “Transect 1 2 3 4 5” are all circled. Enter the line intercept for shrubs and trees from each “Nested Frequency Cluster Summary (Continued)” (fig. 89) by year. Circle “nested frequ. value” and enter the sum of frequency values by year from figure 88. These values, by species, will be tested for significant change by using table 3. See text for details.

RANGE TREND REREADINGS (Continued)

Elements	Averages by Year 1957	1982	1997						
Range Condition Guide/date	—	—							
none									
ARTA 1983	F	F	G						
Decreasers:	58	92	114						
Palatable Increasers	299	320	287						
Unpalatable Increasers	54	51	42						
Invaders	—	—	—						
Vegetation - (root crown)	3	4	6						
Bare Soil	139	121	110						
Gravel (1/8 to ¾ inch)	79	82	71						
Rock (> ¾ inch)	8	7	8						
Litter	81	88	94						
Cryptogams	90	98	111						
% Utilization by species									
none	—	—	—						
Season of Use	—	—	—						
Climate									
Temp: Current	+	0	0						
Last year	0	0	0						
2 yrs. Ago	0	+	0						
3 yrs. Ago	0	0	—						
4 yrs. Ago	—	—	0						
Ppt.: Current	0	+	+						
Last year	0	+	+						
2 yrs. Ago	0	0	0						
3 yrs. Ago	0	0	—						
4 yrs. Ago	—	—	0						
Apparent range condition	F	F	G						
Apparent range trend	Sat	Up	Sat						

Figure 91—Second page of the “Range Trend Rereadings (Continued)” form where data are interpreted for change in vegetation and soil surface characteristics. If a range condition guide (livestock forage rating guide) applies to the monitoring area, list it and its date. Then rate the condition of each rereading. Next list the frequency values for decreasers, palatable increasers, unpalatable increasers, and invaders. There is no maximum value because species are lumped together and may total more than 400. See text for details.

Table 3—Table of significant change for nested frequency[a]

Less than	Initial value	More than	Less than	Initial value	More than	Less than	Initial value	More than
17	25	31	137	155	171	257	280	301
21	30	37	142	160	176	261	285	307
25	35	43	147	165	181	266	290	312
30	40	48	151	170	176	271	295	317
35	45	55	156	175	192	276	300	322
39	50	59	161	180	197	281	305	327
43	55	65	166	185	202	285	310	333
48	60	70	170	190	208	290	315	338
53	65	75	175	195	213	295	320	343
57	70	81	180	200	218	300	325	348
62	75	86	185	205	223	307	330	353
67	80	91	189	210	229	309	335	359
71	85	97	194	215	234	314	340	364
76	90	102	199	220	239	319	345	369
81	95	107	204	225	244	324	350	374
85	100	113	209	230	249	329	355	379
90	105	118	213	235	255	334	360	384
95	110	123	218	240	360	339	365	389
99	115	129	223	245	265	343	370	395
104	120	134	228	250	270	348	375	*
109	125	139	233	255	275	353	380	*
113	130	145	237	260	281	358	385	*
118	135	150	242	265	286	363	390	*
123	140	155	247	270	291	368	395	*
128	145	160	252	275	296	372	400	*
132	150	166						

[a] Using 100 nested frequency plot frames, the table shows a significant change in frequency value at the 80-percent probability level. Enter the table at “Initial value” with the *previous* frequency value for the 5 transects(100 plot frames). Compare the *previous* value with the *current* value to determine whether a significant change has occurred. A change is significant if the *current* value is smaller than the “Less than” value or greater than the “More than” value.

Finally, if shrubs and trees were intercepted, record the number of feet of intercept on the form, “Nested Frequency Transect Data (Continued)” (fig. 87). Total the number of feet and determine the percentage cover. For ARTR, 6 ft of intercept in 100 ft of line is 6 percent. If a tree or shrub was not intersected, there will be no data for it.

Cluster summary—Once the transect has been summarized, transfer data to the filing system form, “Nested Frequency Cluster Summary” (fig. 88). Fill in the required information at the top. List species down the left side and enter their frequency values by transect. Add the species values for a “Total Value.” These total values are transferred to the “Range Trend Rereadings” summary to test for significant change in species (fig. 90). The maximum value possible would be 400 if the same species occurred in all 5- by 5-cm plots on all transects.

Next, transfer the line intercept data for each transect to the “Nested Frequency Cluster Summary (Continued)” form and total (fig. 89). A total of 35 ft of ARTR was intersected in 500 ft of transect for 7 percent cover. Transfer the intercept in feet to the “Range Trend Rereadings” form (fig. 91).

Finally, transfer the point sampling data by transect to the “Nested Frequency Cluster Summary (Continued)” form (fig. 89). These data must be added in two directions. Each transect column must add up to 80. Then add each item by row for their total hits. Add the “Total Hits” column, which must add to 400. Finally, determine the percentage of each item (hits/400). Transfer total hits to the form, “Range Trend Rereadings (Continued)” (fig. 91).

If the site is forested, tree canopy cover must be determined, a topic discussed in the “Tree Cover Sampling” section, below

Trend Interpretation

Interpretation of trend in species frequency values is facilitated by table 3, used in conjunction with the “Range Trend Rereadings” summary form (fig. 90). Interpretation is illustrated with measured data for 1997 and constructed data for 1957 and 1982. For example, AGSP, a decreaser, is a key species used to indicate trend. In 1982, its total frequency value was 92 and in 1997 it was 114. The previous value of 92 is located in table 3 in the “Initial value” column, falling between 90 and 95. Then the current value of 114 is compared to the values in the “More than” column opposite 90 and 95. These table values are 102 and 107. Because 114 exceeds the values, there is an 80 percent probability that a significant upward trend in AGSP frequency has occurred.

Downward trend is a reverse of this procedure. The 1982 total frequency value for POSA3 of 288 was the initial value and the value for 1997 of 274 is the current value (fig. 90). In table 3 in the “Initial value” column, find 288 and read 266 as the “Less than” value. The current value of 274 is not less than 266 and the downward change in POSA frequency therefore is not significant.

LOMAT, an unpalatable increaser, on the other hand, did show a significant decrease between 1957 and 1997. The initial value of 43 (fig. 90) is found in the “Initial value” column with a “Less than” value of about 33. The 1997 frequency value of 29 is less than 33, thereby suggesting an 80-percent significant probability of a reduction in frequency.

One could conclude that an increase in AGSP, a decreaser, and a decrease in LOMAT, an unpalatable increaser, indicate an upward trend in range condition. There is no statistical test for line intercept or point sampling data. Interpretation would suggest little change in ARTR cover. A decrease in bare soil and an increase in cryptogams, from 1957 to 1997 (fig. 91), suggested by table 3, would tend to support an upward trend interpretation.

In the upper left of the “Range Trend Rereadings (Continued)” (fig. 91) form under the “Elements” column, provision is made for use of range condition guides (livestock forage rating guides). List the guide name and date if one is applicable to the ecological type. The guides group plant species into four categories. Decreasers are species that are most palatable and decrease in frequency with heavy livestock use. Palatable increasers are species that are eaten but are less palatable than decreasers. They tend to increase in frequency or percentage of composition as decreasers decline. If heavy grazing continues, these species also decline. Unpalatable increasers are species that livestock do not care to eat but are present in good range condition (potential natural community ecological status). Invaders are those species that generally do not occur in good condition; they invade the site after serious heavy grazing.

Add the frequency values of those species falling into each category. For example, AGSP is the only decreaser so its frequency value for 1997 is 114. Palatable increasers are POSA3, BASA, SIHY, and STOC, whose frequency values (fig. 90) add up to 287 (274 + 2 + 9 + 2 = 287). Unpalatable increasers are ARTR, LOMAT, and PHLOX whose frequency values add up to 42. There is no statistical test for significant change in these items. They are presented to aid interpretation.

Nine-Square-Foot (1-Square-Meter) Plot Transect

Nine-square-foot transects are designed to enhance the three-step sampling system by increasing the number of ground view photographs from two to five. Reppert and Francis (1973), in their analysis of the three-step method, found photographs to be the most useful part of the method and could be used to test and validate the transect data.

Concept

The 9-ft^2 (1-m^2) plot system is derived directly from the three-step concept of a general transect photograph plus a photo of a 3-ft square at each end of the transect. This system adds three more 9-ft^2 (1-m^2) plots at the 25-, 50-, and 75-ft locations on the transect. Photographs are taken of the plot frame at an oblique angle from eye level. There are no plot measurements involved, but line intercept of woody species is provided. A grid may be imposed on the plot frame by physically connecting marks on the frame, but interpretation is difficult owing to the oblique angle.

The 9-ft^2 (1-m^2) plot is not a sample of frequency because five plots are too few and 9 ft^2 is too large. In many cases, two or more species will occur at 100-percent frequency. A person cannot determine whether plants were spaced at 2 ft 10 in in distance (which would mean 100-percent frequency) or at 10 in in distance (which also would result in 100-percent frequency). The difference between 10 in and 2 ft 10 in can be important in evaluating range trend. Five plots of 9-ft^2 do provide, however, a repeatable view of vegetation and soil surface conditions for comparison between photos taken over time, a subjective means for interpreting trend.

Equipment

The following equipment is required for 9-ft^2 (1-m^2) sampling:

1. Camera or cameras with both color and black-and-white film, or digital camera
2. A 9-ft^2 (1-m^2) plot frame (app. C)
3. Forms from appendix B are for transect identification, “Cluster – Transect,” and for plot identification “9 sq. feet - 1 sq. meter” printed on medium blue paper; and data and photo-mounting form, “Photo Trend Sample – 9 sq. ft. (1 sq. m),” printed on medium yellow paper
4. Meter board (app. C)

5. Clipboard and support for holding the photo identification forms (app. C)
6. Compass and a 100-ft steel tape with clamps or vice grips to clamp onto angle iron stakes
7. Fenceposts and angle iron stakes sufficient for the number of transects desired: 2 fence posts and 3 angle iron stakes per transect, and a pounder
8. Metal detector for locating transect stakes

Technique

Establish the transects and map them on the filing system form, "Sampling Site Description and Location" (fig. 92). Fill out information on the form and circle "1 sq. m" on the top line. If transects fall in a line, continue the map on the back of the form (fig. 74).

General photographs from the 0- and 100-ft ends of the tape are required (figs. 93 and 95). Remember to circle "0" for the front photo and cross it out and circle "100" for the end photo.

The 9-ft^2 (1-m^2) plot transect is different in several respects from the 1-ft^2 and nested frequency transects:

1. Plot photographs are taken from an oblique angle rather than overhead
2. The picture is taken down the transect line
3. The transect line bisects the center of the plot (figs. 93 and 94)
4. The photograph of the last plot is taken from a different direction. Photo plot 1 is taken with camera over the 0-ft stake and the plot at 3.5 to 6.5 ft, whereas the last plot at 96.5 to 93.5 ft is taken with the camera over the 100-ft end and aiming back down the transect to the plot

Place the plots, on center, down the transect. Figures 93 and 94 illustrate the foot marks on the transect where each plot is located. Place a 9-ft^2 (1-m^2) plot between the 3.5- and 6.5-ft marks (fig. 93). Roughly diagram the location of each species and label. Circle soil surface items listed under the plot diagram: B = bare soil (> 50 percent of ground cover), G = gravel (> 50 percent cover of stones 1/8 to 3/4 in), R = rock (> 3/4 in), L = litter (> 50 percent of ground cover), and C=cryptogams (> 50 percent of ground cover).

Fill in photo identification form "9 square feet-1 square meter," circle photo 1 and place at a far edge of the plot (fig. 93). Handhold the camera over the 0-ft stake (see note in fig. 93 under the photograph), make sure the photo identification sheet is visible, and take the photo.

Move to the next plot location at 25 ft (fig. 94). Determine canopy intercept along the line for trees less than 6 ft tall and shrubs from the start of plot 1 (0.0 ft) to the start of plot 2 (25.0 ft). A single species may have more than one intercept if more than one individual crosses the transect between 0 and 25 ft (fig. 93).

At plot 2, repeat diagrams. Camera location is at foot mark 21.5 (3.5 ft away from the plot) as shown in figure 94 under the photograph. On photo identification form, "9 square feet - 1 square meter," cross out "1," circle "2," and photograph.

Text continues on page 166.

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. Nested Freq. 1 sq.m. Robel Pole Shrub Form ______

Date 1997/3/22
Area Crooked River N. G.
Allot. Madras
Cluster No. 3
Transects: 1 2 3 4 5
Plant community ARTR/ AGSP/POSA

Grazing system:
Type Exclosure Date 1954
Type ______ Date ____
Type ______ Date ____

Kind of animal: cattle sheep horses goats deer elk jack rabbits

Location: T. 11S R. 13E
Sec. 36 NW of NW
Description: US hi'way 20 at Crooked River N. G. sign; 2.1 mi from junct. US 97 & US 26 S. of Madras.

Site Data: Elev. 2775 % slope 8
Slope aspect: N NE E SE S SW W NW
Slope position: top up 1/3 mid low 1/3 bottom
Micro topography: convex flat concave
Macro topography: flat undulating rolling steep rough broken

Geology:
Deposition: wind stream lake colluvial residual ______
Material: limestone mudstone sandstone granite serpentine diorite basalt andesite rhyolite tuffacious cinders pumice ash

Soil:
Restrictive layer: absent clay pan bedrock cemented ______
Surface compaction: none moderate severe
Soil profile stone: absent gravel stony
Soil texture: sandy loamy silty clayey ashy
Other notes: Livestock excluded when hi'way was fenced in 1954

MAP

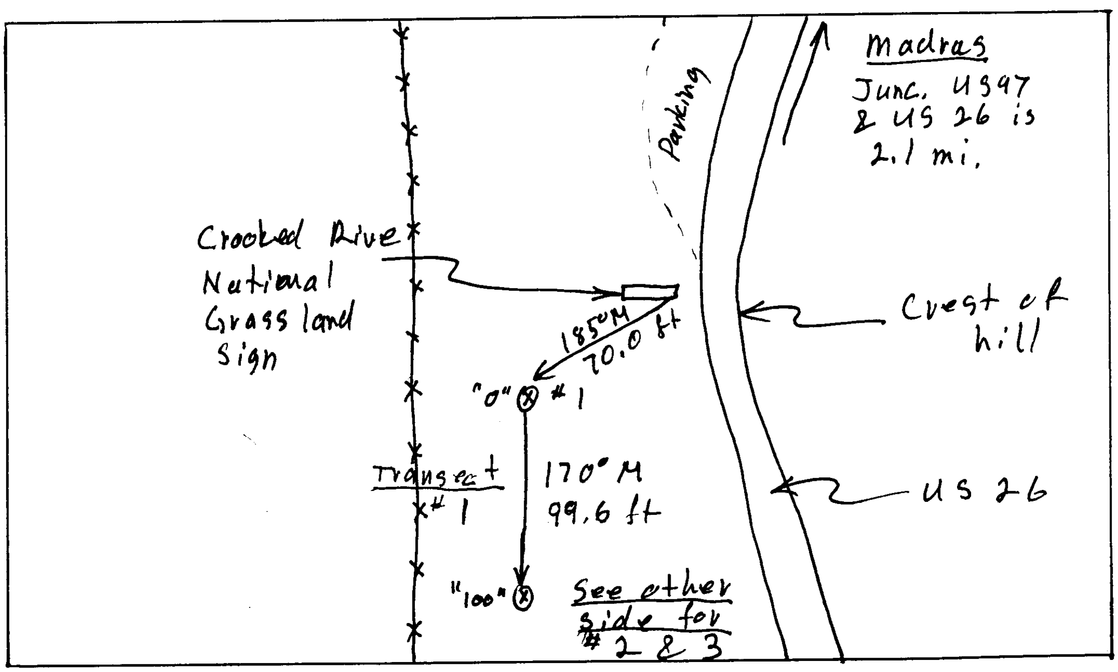
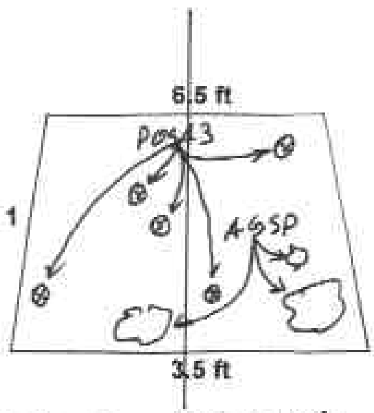


Figure 92—Filing system form "Sampling Site Description and Location" locating the 9-ft^2 (1-m^2) transect system. It is the same location used for 1-ft^2 and nested frequency sampling. Circle "1 sq. m." on the top line. Fill in the rest of the information. Map the transect layout. Transects had to run end to end so the map continues on the back of the form (see fig. 74).

PHOTO TREND SAMPLE – 9 sq.ft. (1 sq. m)
Date 1997/3/22 **Cluster** 3 **Transect** 1 2 3 4 5

Area Crooked River N. G.
Allot. Madras
Investigator [illegible]
Season of use none
% use —
Grazing system exclosure

Remarks Hyway exclosure



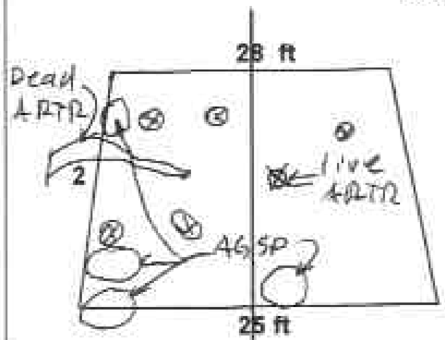
Soil surface: B G R L C
Line intercept:

Species	From	To	Feet
ARTR	12	15	3
ARTR	22	23	1

Camera at the 0 foot mark.

Figure 93—Filing system form "Photo Trend Sample - 9 sq. ft. (1 sq. m.)" illustrating its use. Two additional forms are required: transect identification (shown in the upper picture) and plot identification (lower picture). Fill out required information on each form: CRNG (Crooked River National Grassland), Madras Exclosure, cluster 3, transect 1, date, and notes. Photograph the transect from the 0-ft (upper picture) and the 100-ft ends (fig. 95). This is the same transect shown in figures 75 and 77. Soil surface items are B = bare ground, G = gravel, R = rock, L= litter, and C = cryptogamic crust. Circle each item occurring in the plot.

PHOTO TREND SAMPLE – 9 SQ.FT. (1 SQ. M)

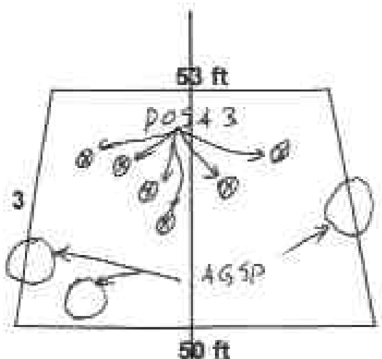


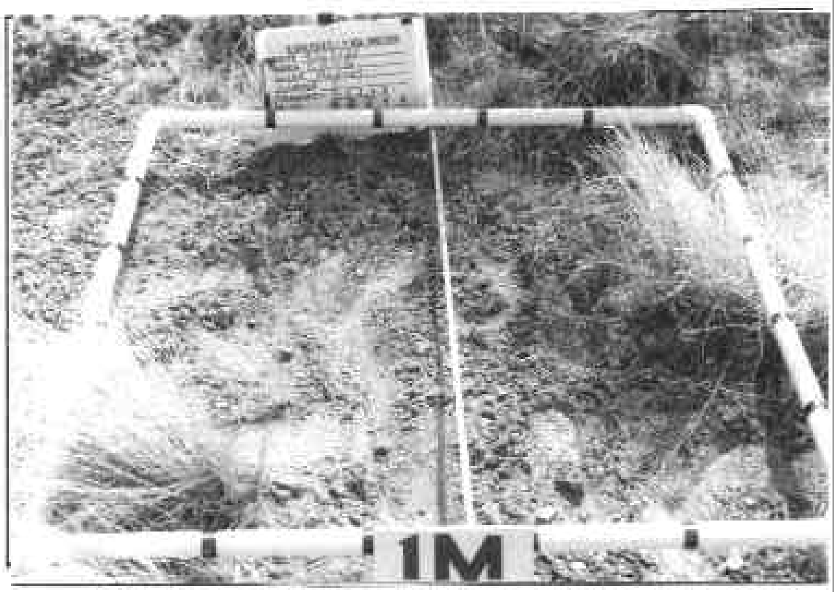
Soil surface: B G R L C

Line intercept:

Species	From	To	Feet
ARTR	27	28	1

Camera at the 21.5 foot mark.





Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Camera at the 46.5 foot mark.

Figure 94—Second page of the “Photo Trend Sample - 9 sq. ft. (1 sq. m.)” form locating plots 2 and 3. Plot location foot marks are shown on the left. Camera location foot mark is shown under the photograph. Remember to circle the soil surface items within the plot. Cross out the previous plot number and circle the current one.

PHOTO TREND SAMPLE – 9 sq.ft. (1 sq. m)

SUMMARY

Species	Frequ.	Interc.
POSA 3	5	
AGSP	4	
ARTR	1	6
LOMAT	2	
PHLOX	1	
BASA		
SIHY	2	
PUTR		1

Bare soil	5
Gravel pavement	3
Rock	2
Litter	5
Cryptogams	5

Estimated Utilization

Species	% Use

ACTIVITIES

Logging –
Fire –
Revegetation –
Insects –
Wildlife Deer, rabbits
Other

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Apparent range condition Good
Apparent range trend Static

COMMENTS

A hiway exclosure

Figure 95—Summary sheet of the “Photo Trend Sample - 9 sq. ft. (1 sq. m)” form with the 100-ft transect photograph. Frequency of occurrence by species is on the left. Under that is frequency of soil surface items. Fill out appropriate information on the right.

Do the same for plots 3 and 4.

Plot 5 is different. It is photographed in the opposite direction from the others, back down the transect (see number 4, above).

Summarize Data

After sampling, fill in the summary on the last page of form, “Photo Trend Sample - 9 sq. ft. (1 sq. m)” (fig. 95). It is the same summary sheet used with the 1-ft^2 plots, and the procedure is identical. If the site is forested, tree crown cover must be sampled as discussed below.

Trend Interpretation

Transfer summary data from the last page of the form, “Photo Trend Sample – 9 sq. ft. (1 sq. m)” (fig. 95) to the “Range Trend Rereadings” form (figs. 96 and 97). Fill out the form information and circle “5 plots 9 sq. ft. (1 sq. m)” on the top line. Enter the transect intercept data by date of rereading. Then enter the frequency data by date of rereading (fig. 96). Data were measured for 1997 and constructed for 1957 and 1982.

On the second page (fig. 97), summarize by date and frequency by decreaser, palatable increaser, unpalatable increaser, and invader. Do not add up the frequency ratings from the first page (fig. 96) because frequency of these large plots is not additive. Instead, return to the data forms (figs. 93 and 94) and count the number of plots by species. Often two species in a category, such as unpalatable increasers, will occur in the same plot. The total frequency for unpalatable increasers from figure 96 is 4 but the frequency for the category had a frequency of only 3 (LOMAT, PHLOX, ARTR).

Transfer the soil surface items. Vegetation is any plant root crown, so a frequency of 5 for a species would be a 5 for vegetation. Transfer utilization and climate information. Finally, transfer the estimated range condition and trend information.

Interpretation of change is based on professional judgment and interpretation of photos.

Tree Cover Sample

Tree cover has direct influences on ground vegetation by casting shade. Trend in density and composition of species is often as much influenced by this shade as by grazing or light disturbance. Any transect placed in a forest setting should have tree cover sampled.

Concept

Tree canopy cover significantly influences density and composition of ground vegetation (shrubs and herbs). The effect is so important that documentation of tree cover on forest land transects is strongly recommended. Tree canopies are photographed by using a camera leveling board to assure vertical orientation of the camera (fig. 98).

On a 100-ft transect used for square-foot, nested-frequency, or 9-ft^2 (1-m^2) sampling, photograph tree cover at the 0-, 25-, 50-, 75-, and 100-ft locations. Overhead photos also may be taken with topic photography utilizing a single overhead photo (fig. 52). At 40-percent canopy cover using a 50-mm lens, trees taller than 70 ft will

Text continues on page 169.

RANGE TREND REREADINGS

Circle the sampling system: 20 plots 1 sq,ft, 100 plots Nest. Frequ. 5 Plots 9 sq.ft.(1 sq. m)

Area Crooked R. N.G. Allotment Madras Cluster 3 Transect 1 2 3 4 5

Species	Averages by Year									
	1957	1982	1997							
Tree Crown Cover (in percent)										
TOTAL										
Shrub intercept (in feet)										
ARTR	5	6	6							
PUTR	–	–	1							
CHNA	–	–	–							
TOTAL										
Frequency: No. plots for 1 sq.ft. & 9 sq.ft. (1 sq. m); nested frequ. value										
POSA3	5	5	5							
AGSP	3	4	4							
LOMAT	3	2	2							
PHLOX	1	1	1							
BASA										
SIHY	2	2	2							
STOC	1									
ARTR	2	1	1							

OVER FOR ADDITIONAL DATA

Figure 96—The filing system form "Range Trend Rereadings" where the transect data are compared to previous readings. Fill in the required information and circle "5 plots 9 sq. ft. (1 sq. m)." Transfer information from figure 95 to this form.

RANGE TREND REREADINGS (Continued)

Elements	Averages by Year 1957	1982	1997
Range Condition Guide/date none	—	—	—
Decreasers:	3	4	4
Palatable Increasers	5	5	5
Unpalatable Increasers	4	3	3
Invaders	—	—	—
Vegetation - (root crown)	5	5	5
Bare Soil	4	3	5
Gravel (1/8 to ¾ inch)	5	5	3
Rock (> ¾ inch)	2	2	2
Litter	5	5	5
Cryptogams	4	5	5
% Utilization by species			
None - exclosure			
Season of Use			
Climate			
Temp: Current	+	0	0
Last year	0	0	0
2 yrs. Ago	0	+	0
3 yrs. Ago	0	0	—
4 yrs. Ago	—	0	—
Ppt.: Current	0	+	+
Last year	0	+	+
2 yrs. Ago	0	0	0
3 yrs. Ago	—	0	0
4 yrs. Ago	+	0	—
Apparent range condition	P	P	F
Apparent range trend	S	S	S

Figure 97—Second page of the “Range Trend Rereadings” form where previous information is compared. See text for details.

appear in adjacent pictures providing a continuous 100-ft transect of tree cover. If a 35-mm lens is used, trees over 50 ft tall will provide a continuous strip. Whatever focal length is used to begin, the **same focal length** must be used for subsequent photos. Long axis of the camera should be across the transect.

Equipment

The following equipment is required for sampling tree cover:

1. Camera or cameras with both color and black-and-white film, or digital camera
2. A camera leveling board (app. C)
3. Form from appendix B for data and photo mounting: "Photo Trend Sampling - Tree Cover"
4. Meter board (app. C) to set the leveling board and camera on
5. A compass and 100-ft steel tape with clamps or vice grips to clamp onto angle iron stakes used for ground vegetation sampling
6. Fenceposts and angle iron stakes sufficient for the number of transects desired: 2 fenceposts and 3 angle iron stakes per transect and pounder (these are on the equipment list for ground vegetation sampling system)
7. Metal detector for locating transect stakes

Technique

On the 100-ft transect used for square feet, nested frequency, or 9-ft^2 sampling, photograph tree cover at the 0-, 25-, 50-, 75-, and 100-ft marks. Position the meter board at each of the foot marks, place the camera leveling board on top of the meter board, and set the camera on the leveling board with the long axis perpendicular to the transect and the viewfinder toward the 0-ft mark (fig. 98).

Move the meter board sideways to level the camera board cross-transect. Then level the camera board down-transect, bend down to take your head out of the picture, and photograph (fig. 98).

Important criteria—There is neither a size control (meter board) nor photo identification sheet in these pictures. Four procedures, therefore, **must** be followed:

1. The same focal length lens must be used for all subsequent photographs so images can be compared. Note the effects of focal length in figures 6 and 7.

2. The camera must be the same height aboveground. Use the meter board for consistent heights. Figures 2 and 3 illustrate the effect of change in distance using the **same focal length** lens.

3. Make sure the camera is oriented perpendicular to the transect with the viewfinder toward the 0-ft mark (fig. 98). Remember this by viewing the transect through the camera, and then rotating it 90 degrees upward to view the canopy. This camera orientation helps with placement of photos on the form. There is no "right side up" on these photos. Their orientation can be determined only by the exposure numbers at the bottom of the film.

4. Write down the film exposure number and the cluster and transect data so that negatives can be identified and picture orientation determined.

Figure 98—Tree canopy cover photography system. Ameter board is placed crosswise (perpendicular) to the transect at foot marks 0, 25, 50, 75, and 100. Hold camera level board on top of the meter board and place the camera on the level board. First center the crosstransect level by moving the meter board sideways. Then tilt the camera level board so the down-transect-level is centered, move your head out of the camera view, and photograph.

Summarize Data

Attach crown cover photos to the filing system form, “Photo Trend Sampling - Tree Cover” (figs. 99 and 100). Fill out information on the top two lines. Roughly diagram canopy outlines and label by species for identification. Then proceed as follows to determine canopy cover on each photo (figs. 99 and 100):

1. Print on clear plastic five copies of the grid analysis outline form (fig. 54), one for each photo. Tape along one edge over a photo and enter information for the photo (fig. 101). Outline the tree canopies carefully and identify by letter or number.

2. Print (without size adjustment on white paper) a copy of the analysis grid for shrub analysis (grid with meter boards at each edge) from appendix B. Remove the outline overlay from the photo and tape onto the grid. Orient the outline overlay on the bottom line of the grid and next to the left meter board but one grid line to the right (fig. 101). The top and right edges of the outline probably will fall between grid lines.

3. Determine the total number of grid intersects on the picture. Remember to count the left and bottom grid lines to determine total number. In figure 101, there are 26 grid lines across and 17 up for a total of 442 intersects.

Text continues on page 174.

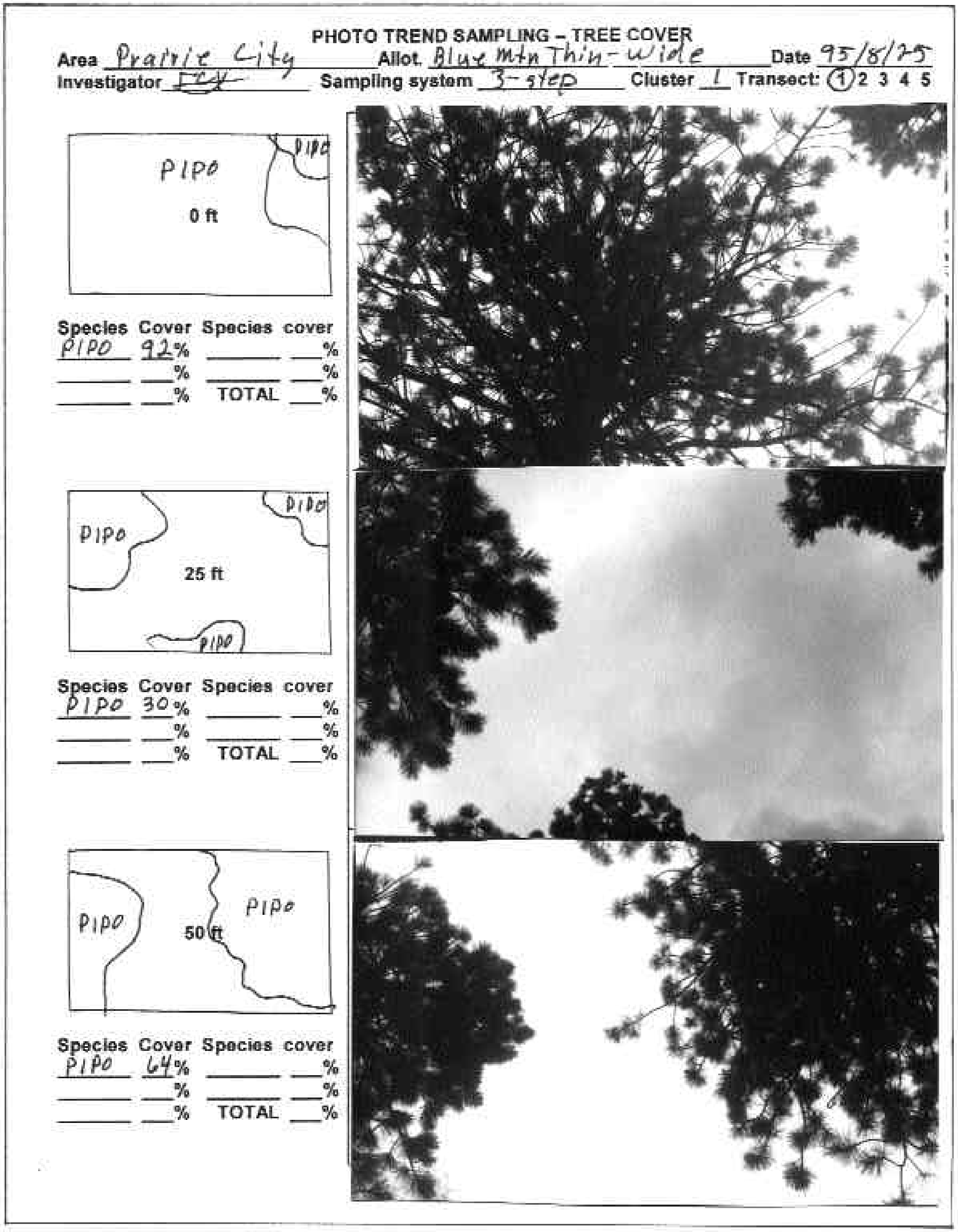


PHOTO TREND SAMPLING – TREE COVER

Area Prairie City Allot. Blue Mtn Thin-Wide Date 95/8/25

Investigator Fey Sampling system 3-step Cluster 1 Transect: 1 2 3 4 5

PIPO PIPO

0 ft

Species	Cover	Species	cover
PIPO	92%		%
	%		%
	%	TOTAL	%

PIPO PIPO PIPO

25 ft

Species	Cover	Species	cover
PIPO	30%		%
	%		%
	%	TOTAL	%

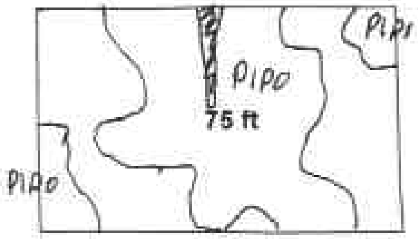
PIPO PIPO

50 ft

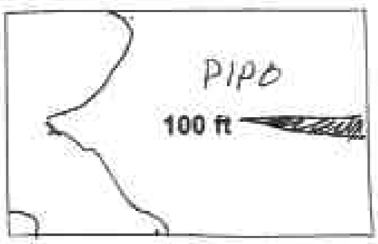
Species	Cover	Species	cover
PIPO	64%		%
	%		%
	%	TOTAL	%

Figure 99—Filing system form "Photo Trend Sampling - Tree Cover" used to mount tree canopy cover photos and to estimate cover. Percentage of cover is determined by dot or intersect grid analysis (illustrated in fig. 101). Diagrams of cover are used to identify species, not to determine the percentage of cover (PIPO: *Pinus ponderosa* P. & C. Lawson, ponderosa pine).

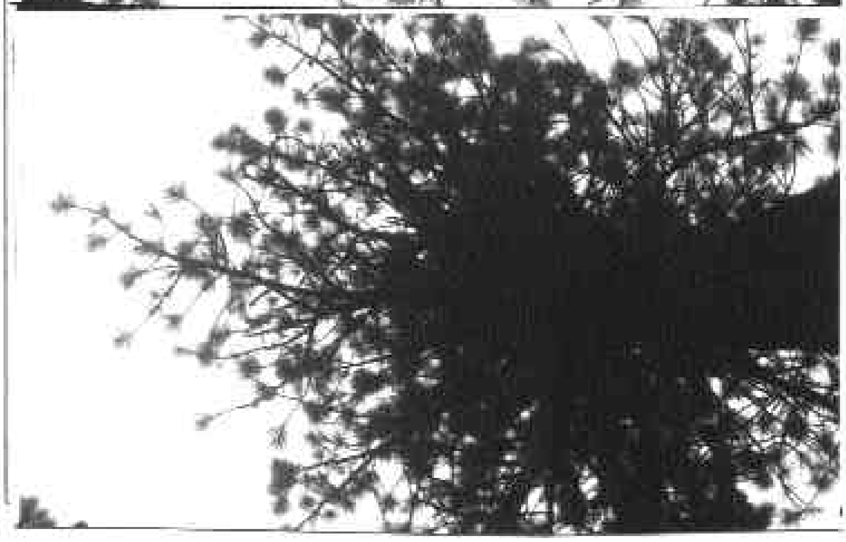
PHOTO TREND SAMPLING – TREE COVER



Species	Cover	Species	cover
PIPO	70 %		%
	%		%
	%	TOTAL	%



Species	Cover	Species	cover
PIPO	74 %		%
	%		%
	%	TOTAL	%



SUMMARY

Ave. Species	% cover
PIPO	66

SD = 22.67
SE = 10.18
CI_5 = 28.3

Figure 100—Second page of the “Photo Trend Sampling - Tree Cover” form with the cover summary. In this case, statistical analysis results were added: SD = standard deviation, SE = standard error, and CI_5 = the confidence interval at the 5-percent level of probability.

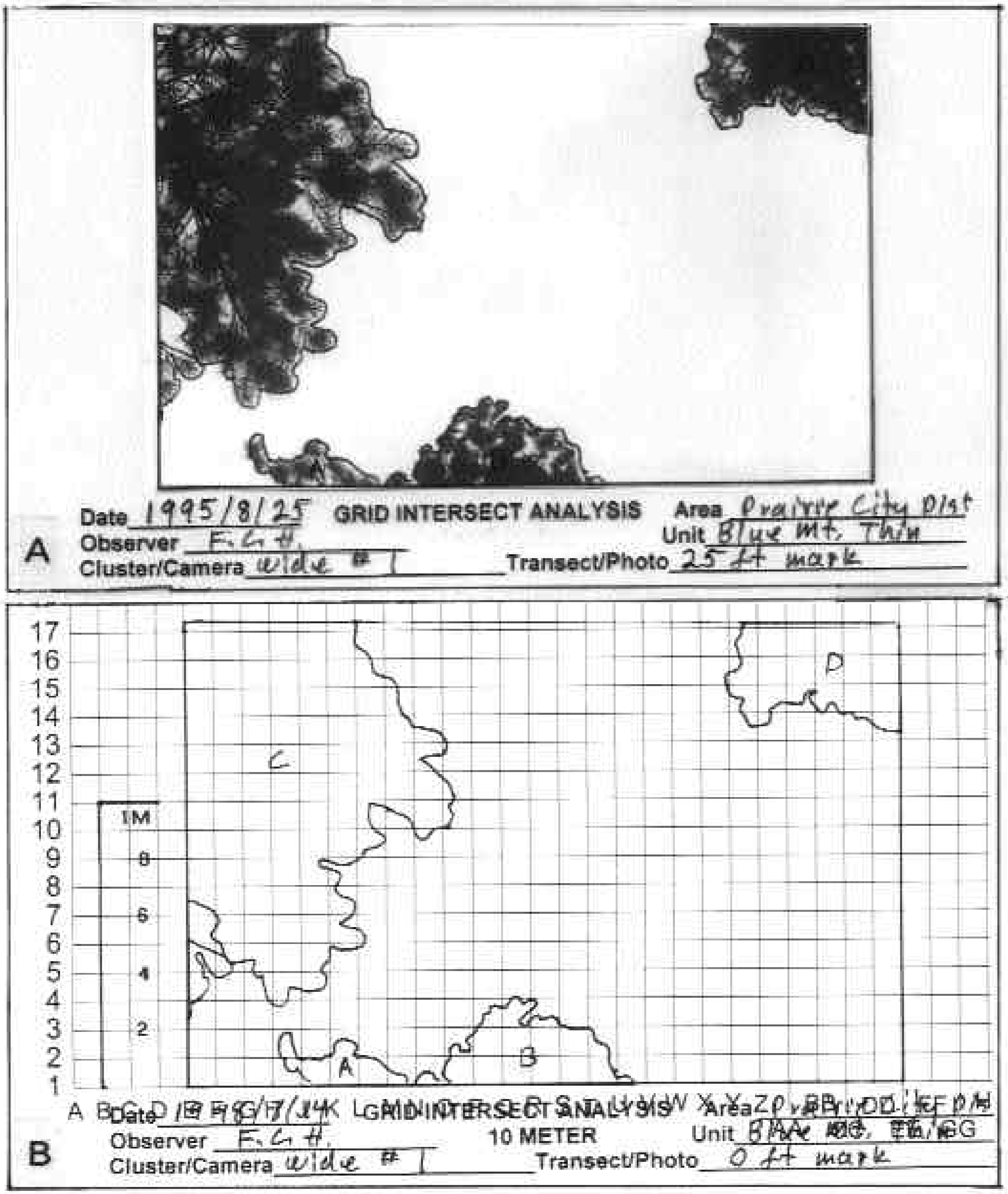


Figure 101—Determination of tree canopy cover using grid intersect. The grid intersect outline form printed on clear plastic is overlaid on photo **A** and tree canopies outlined, here for the 25-ft photo (fig. 99). Then in **B**, the outline is placed on the shrub analysis grid (with meter boards at each side) and printed on paper. Intersects within each tree canopy outline are counted (131) and divided by the total number of intersects within the photo (442, or 17 × 26) for 30-percent canopy cover.

4. Decide if tree canopy or open space will be counted. To ease counting, I prefer to count the item of least coverage: open space in the 0-ft picture of figure 99 and tree cover in the 25-ft picture (fig. 99). Count grid intersects on the left edge and bottom of the photograph. When counting open space, subtract the grid intersects from the total to determine canopy cover. In figure 101, the number of grid intersects falling on the tree canopy is 131. Percentage of cover is 131 ÷ 442 = 29.6, or 30-percent canopy cover.

5. For each photo, list canopy cover by species on the left of the filing system form, "Photo Trend Sampling Tree Cover," under the canopy diagram. Retain each outline as a permanent data form.

6. Add canopy cover for each photo, average, and enter in the summary shown in figure 100: a total of 330 divided by 5 is an average of 66-percent canopy cover.

Trend Interpretation

If there are five samples for statistical analysis of change, the mean of 66.0 will have a standard deviation of 22.7, a standard error of 10.2, and a confidence interval at the 0.05-percent probability level of 28.3 (fig. 100). The Student's T-test may be used to evaluate significant change in tree canopy cover between two data sets.

Usage Measured by Robel Pole

Stubble height of vegetation remaining after livestock grazing indicates animal preference for certain areas, may be used to adjust animal distribution, and suggests intensity of utilization. The Robel pole system documents this stubble height.

Concept

The basic concept is to measure stubble height, or ungrazed herbaceous height, by using a pole marked in inches and photographing it (a "visual observation") from a specific distance and height aboveground. Robel and others (1970) discuss the mathematics and test results. Guenther (1998) used the same concept to estimate annual grass herbage production in California. He uses two views: one from 20 ft and another from 10 ft. A 0.96-ft^2 hoop is placed at the base of the pole for visual reference.

The pole is 2.5 in in diameter and marked in alternate black bands by inches (fig. 102). A 4-m-long line is attached at 1-m height on the Robel pole and connected to the top of a 1-m-tall line pole (app. C). The Robel pole is set at the sample location (station) while the line is stretched and a photograph taken (visual observation) from the top of the line pole (fig. 103). Landscape orientation seems to be better than portrait for depicting utilization, because the former broadens the view at the Robel pole.

The location of the Robel pole is termed a "station" from which two visual observations are made: one in the direction of the transect and a second 180 degrees backwards to the start of the transect.

These consistently used measurements, 4-m distance and 1-m height of camera (4-to-1 ratio), provide repeatable angles for documenting stubble height (Robel and others 1970).

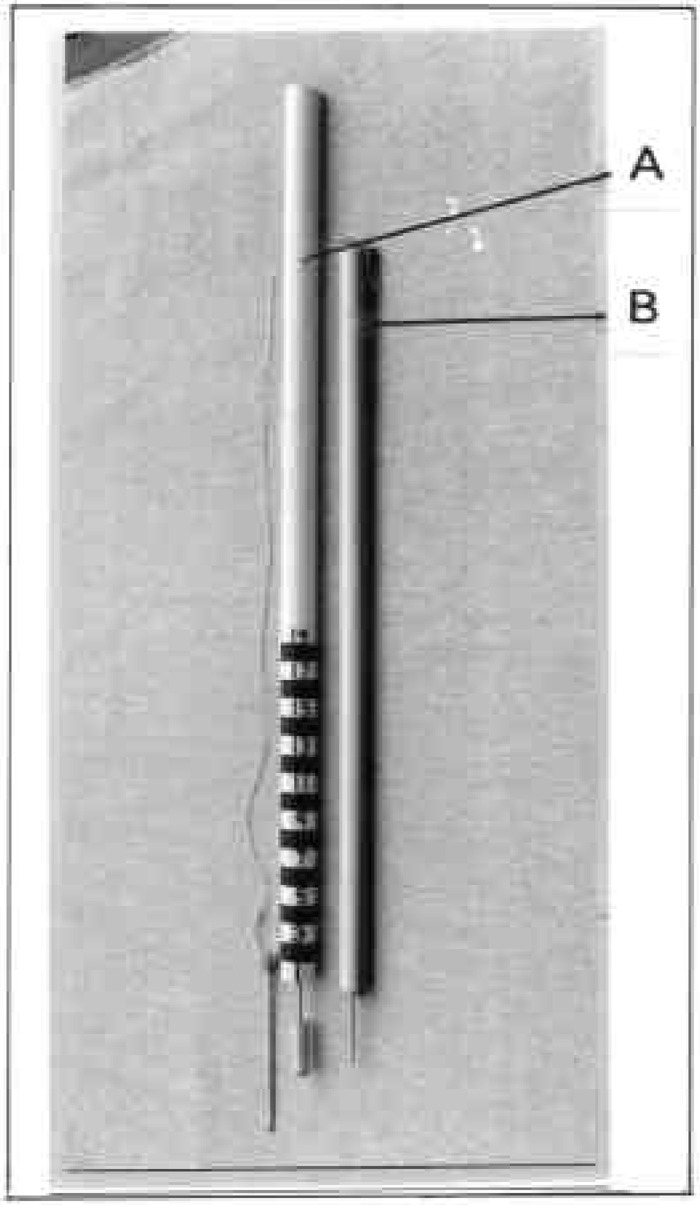


Figure 102—Robel pole has two main parts: the Robel (measuring) pole (**A**) and the camera height pole (**B**). The Robel pole is 2.5 in diameter and the camera height pole 1.5 in so the latter will fit inside the Robel pole. “A” points to an eye where a 4-m long line is attached. The line is shown wrapped around the camera height pole in B. A tent peg with 2 m of line may be used to hold the Robel pole when one person is sampling. See appendix D for details.

Transects generally are not permanently located with fenceposts and steel stakes. A fencepost marking a sampling station may significantly alter domestic livestock use owing to its physical presence. If permanent transects are desired, they should be located with fenceposts identifying the transect start and end. They may be set at visual observation camera locations with the station located by a steel stake driven flush with the ground. A metal detector is needed for relocation (White’s Electronics, Inc. 1996).

Equipment

The following equipment is required for Robel pole transect sampling:

1. Camera or cameras with both color and black-and-white film, or digital camera
2. Robel pole with its 4-m line and a line pole (fig. 102, app. C)

Figure 103—Technique for photographing the Robel pole. In this case, the camera is held in the “portrait” or vertical position. I prefer the “landscape” or horizontal camera orientation (see fig. 106) because it covers a broader area of ground at the Robel pole. Spikes on the bottom of the Robel pole and line pole (fig. 102) are 1/4-in steel rod 6 in long, which are capable of holding both poles upright.

3. Forms from appendix B for transect identification, “Cluster – Transect,” and station identification, “Utilization - Robel Pole,” both printed on medium blue paper, and data and photo-mounting form, “Utilization - Robel Pole Sampling,” printed on medium yellow paper
4. Meter board (app. C)
5. Clipboard and support for holding photo identification sheet (app.C)

Technique

Site selection is a function of animal use and management objectives. For this illustration, a moist meadow in forested rangeland was selected because it is the most palatable kind of vegetation in the area and because it is adjacent to a water hole. Provide the usual two maps: one to locate the sampling area (fig. 104) and another to map the sampling transect (fig. 105). Draw a map on the filing system form, “Sampling Site Description and Location” and fill in necessary information.

1. Determine the number of transects and number of visual observation stations per transect. Then determine the direction of each transect and the interval between stations. All are influenced by two factors: homogeneity of vegetation and uniformity of animal use. Record and map transects on the filing system form, “Sampling Site Description and Location” (fig. 105). The filing system form, “Utilization - Robel Pole Sampling,” provides for 25 stations and 50 observations (fig. 106).

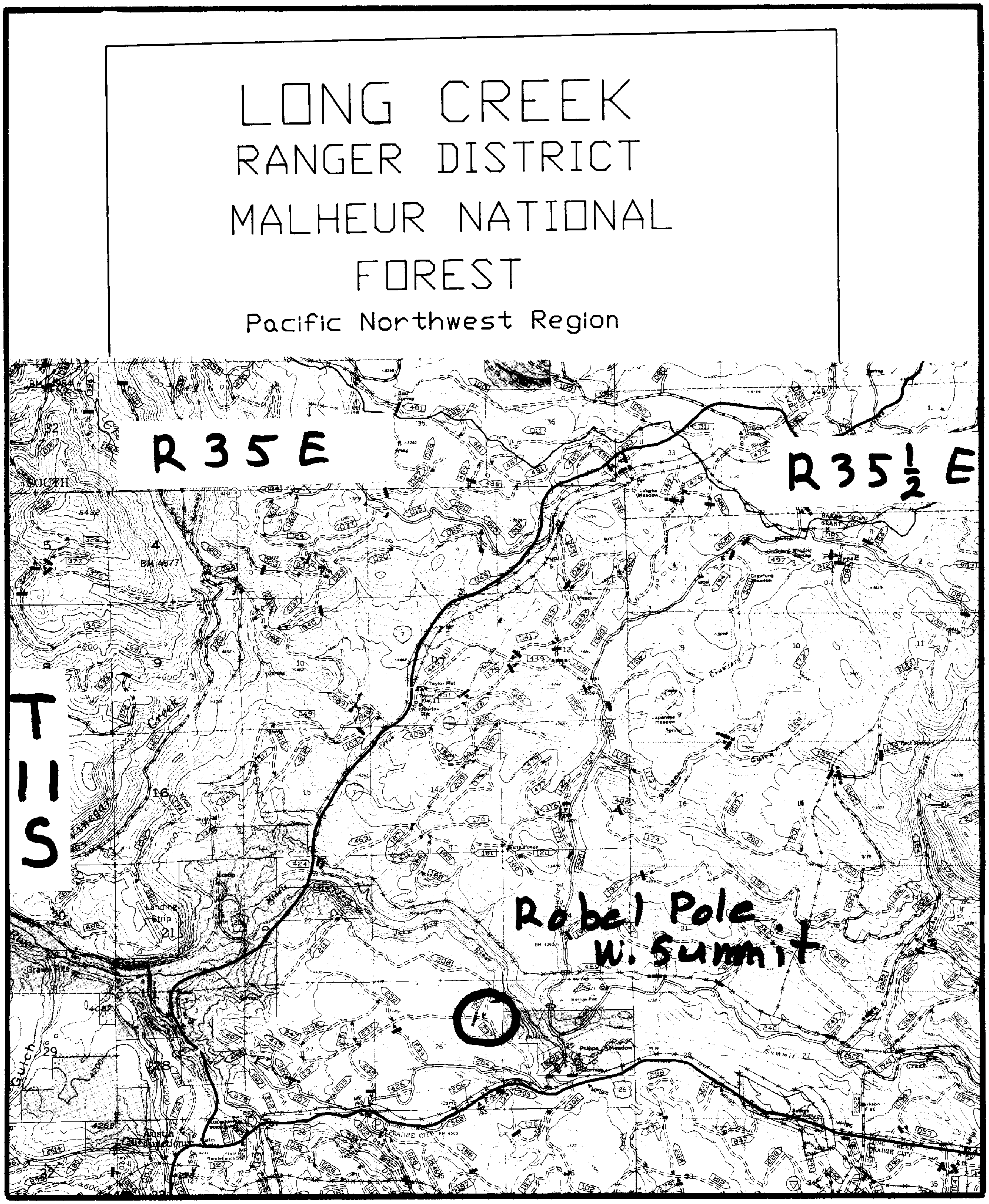


Figure 104—Ranger District map of the Robel pole utilization sampling site. It is on the West Summit Allotment at a road junction. Figure 105 shows the precise location.

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. Nested Freq. 1 sq.m. Robel Pole Shrub Form ____________

Date 1997/7/7

Area Long Cr. Dist.

Allot. West Summit

Cluster No. 1

Transects: 1 2 3 4 5

Plant community POPR meadow

Grazing system:
- Type RR Date_____
- Type __________ Date_____
- Type __________ Date_____

Kind of animal: cattle sheep horses goats deer elk ____________

Location: T. 11S R. 35E

Sec. 26 SE of NE

Description: Rd 237; 0.65 mi from junct rd 204; at water hole; PP at rd fork 24" DBH - tagged

Site Data: Elev. 4525 % slope 2%

Slope aspect: N NE E SE S SW W NW

Slope position: top up 1/3 mid low 1/3 bottom

Micro topography: convex flat concave

Macro topography: flat undulating rolling steep rough broken

Geology:

Deposition: wind stream lake colluvial residual ____________

Material: limestone mudstone sandstone granite serpentine diorite basalt andesite rhyolite tuffacious cinders pumice ash

Soil:

Restrictive layer: absent clay pan bedrock cemented ________

Surface compaction: none moderate severe

Soil profile stone: absent gravel stony

Soil texture: sandy loamy silty clayey ashy

Other notes: Stations at 8 yd intervals

MAP

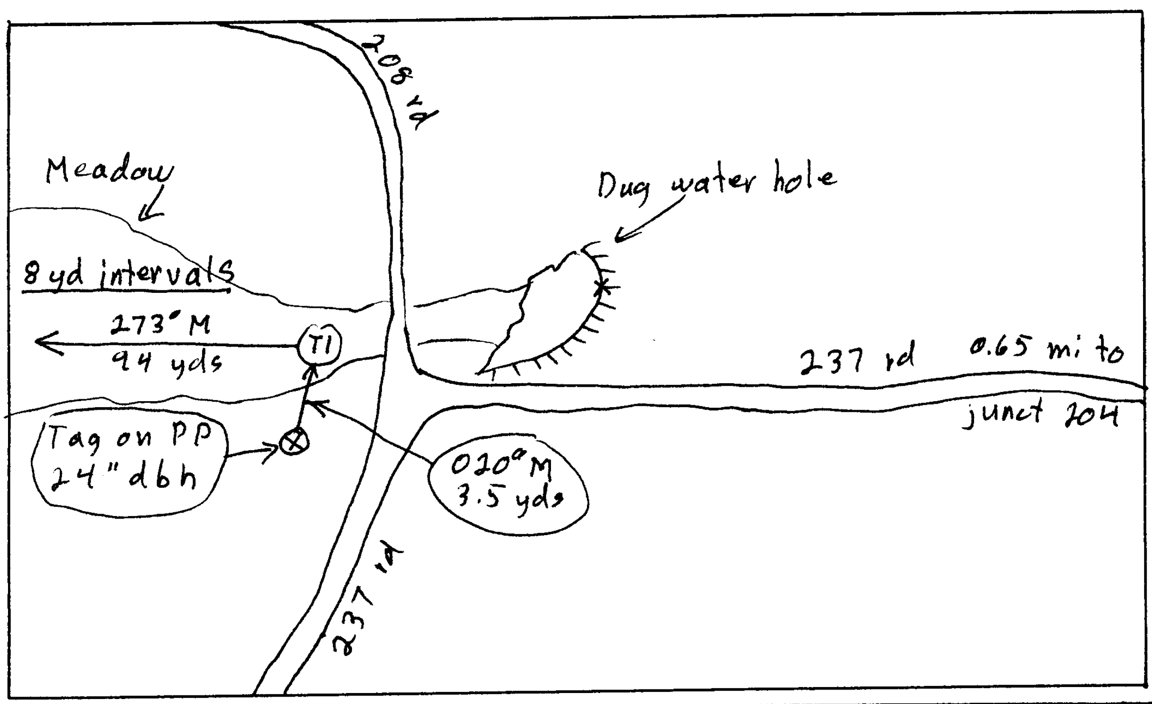


Figure 105—Filing system form "Sampling Site Description and Location" with information and transect location diagrammed. Remember to circle the sampling system, "Robel Pole," on the first line.

2. In this illustration, the meadow is small, oblong, and homogeneous. Only one transect is needed with 10 stations. The transect is oriented lengthwise and calls for a compass heading of 273 degrees magnetic and a total distance of 94 yd, which results in 8-yd intervals between stations (fig. 105).

3. Mark station 1 of the transect with the meter board. Place the camera location fencepost 10 m distant on the transect line. Fill out the transect photo identification form, circle the “0,” place it at 5 m, and photograph the transect (fig. 106 A).

4. At the first station, fill out the photo identification form, “Utilization - Robel Pole Sampling,” printed on medium blue paper; circle “1A,” and place next to the Robel pole at the station (fig. 106 B). Extend the line its full 4 m along the transect toward the fencepost that locates the transect. Set the line pole on the transect line, and photograph the Robel pole with the bottom of the pole in the center of the photo (fig. 106B). Focus on the pole to assure the sharpest image.

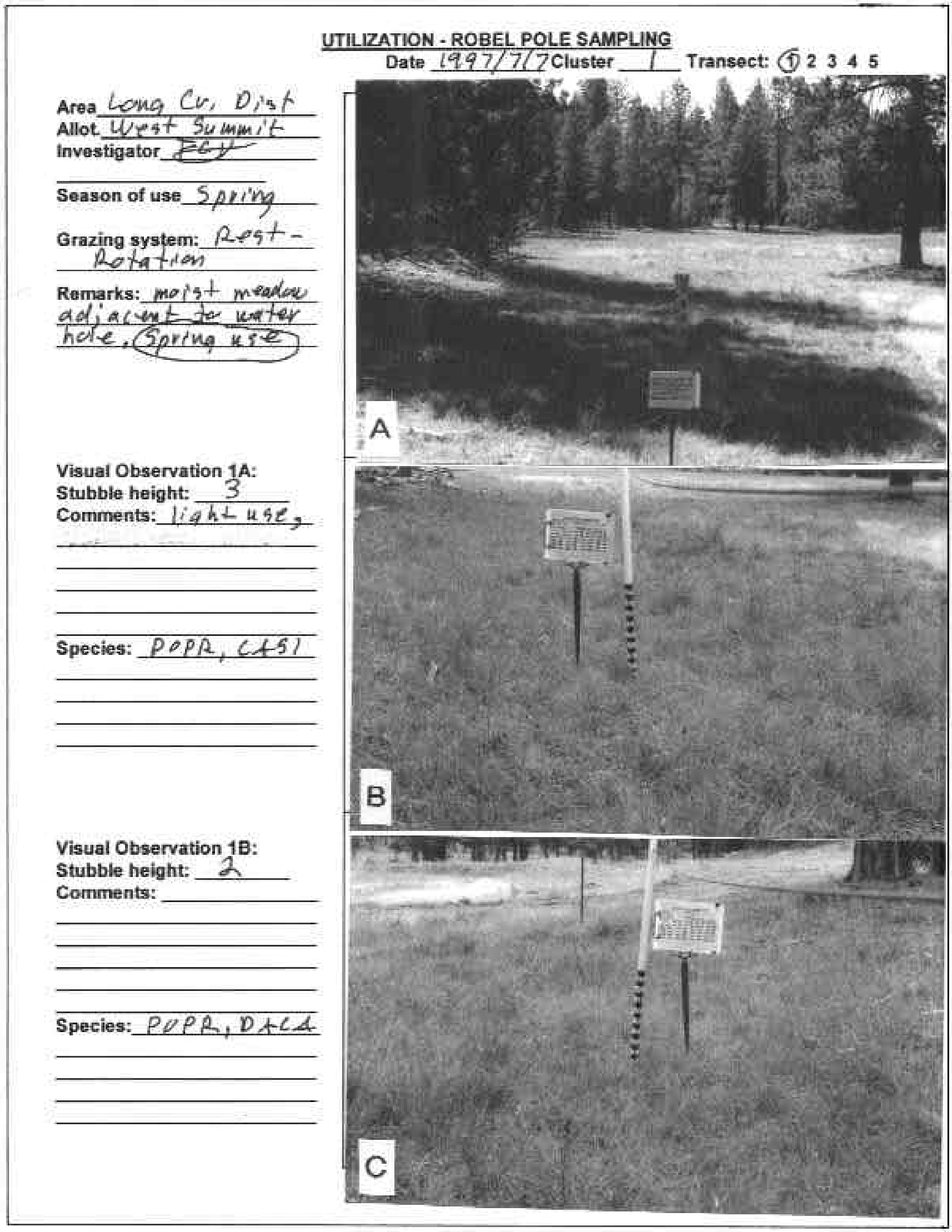
5. Using the filing system form, “Utilization - Robel Pole Sampling,” printed on medium yellow paper (fig. 106), fill in the first page. Then opposite “Visual Observation 1A” (station 1), record the stubble height, any comments, and the one to three species immediately in front of the pole that are being measured for stubble height. In this case, Kentucky bluegrass and analogue sedge are intermixed (fig. 106 B). Stubble is shown on the white “3” band with very little on the black “4” band. Record 3 for stubble height (3 in).

6. Next, move to the opposite side of station 1, 180 degrees, for visual observation 1B (fig. 106C). Pick up the line pole, turn the Robel pole and the photo identification paper around, cross out “1A” and circle “1B” on the identification paper, extend the line, and repeat the photography (fig. 106C). Record on the “Utilization - Robel Pole Sampling” form, in the “Visual Observation 1B” space, species being measured, the stubble height, and any comments. In this case, Kentucky bluegrass and California oatgrass are intermingled. Stubble is shown on the black “2” band and not on the white “3” band for a height of 2 in.

7. For the next station, determine direction and step off the required distance, in this case 8 yd. Forms in appendix B following the first page of “Utilization - Robel Pole Sampling” do not have visual observation (station) numbers, but a blank space instead (fig. 107). Print sufficient sheets for the number of stations. Then enter appropriate visual observation (station) numbers. Thus each station has its own page. Take photographs, data, and notes as discussed above (fig. 106).

8. Repeat for each station (figs. 107 and 108). At the end of the transect (fig. 108C), establish a fencepost 10 m beyond the last station. On the transect photo identification sheet, cross out the “0” and circle “100” to indicate the end of the transect. Photograph the transect looking toward the “0” end.

Text continues on page 184.



UTILIZATION - ROBEL POLE SAMPLING

Date 1997/7/7 Cluster 1 Transect: 1 2 3 4 5

Area Long Cr. Dist

Allot. West Summit

Investigator ECY

Season of use Spring

Grazing system: Rest-Rotation

Remarks: moist meadow adjacent to water hole. (Spring use)

Visual Observation 1A:

Stubble height: 3

Comments: light use,

Species: POPR, CASI

Visual Observation 1B:

Stubble height: 2

Comments:

Species: POPR, DACA

Figure 106—The filing system form "Utilization - Robel Pole Sampling" is used to mount pictures, record stubble height, and identify species at the Robel pole. Only those species immediately in front of the pole, whose stubble height is being photographed, are listed. (**A**) Looking down the transect with station 1 at the meter board. Both visual observations of station 1 are shown: (**B**) down the transect, and (**C**) 180 degrees reversed and looking up the transect. The fencepost marks the camera location and start of the transect. Species are POPR (*Poa pratensis* L., Kentucky bluegrass), CASI (*Carex simulata* Mackenzie, analogue sedge), and (DACA (*Danthonia californica* Boland, California oatgrass). Species in front of the Robel pole **must** be recorded. The line upper right in B and C is the 4-m-long line measuring distance from camera to pole.

UTILIZATION - ROBEL POLE SAMPLING

Visual Observation # 2 **A**
Stubble height: 2
Comments:
POPR lowest stubble
ht.

Species: POPR, CASI
Little use on JUBA

Visual Observation # 2 **B**
Stubble height: 4
Comments:
POPR lowest stubble
ht.

Species: POPR, CASI

Figure 107—Second page of form "Utilization - Robel Pole Sampling" illustrating documentation and photographs of station 2. On this form at the top, enter the station number in the blank at "Visual Observation # ___ A". Remember, on the photo identification form, to cross out "1B" and circle "2A" before photographing. Notes often are valuable in these situations.

UTILIZATION - ROBEL POLE SAMPLING

Visual Observation # 10 A
Stubble height: 4
Comments:

Species: DACA, JUBA

Visual Observation # 10 B
Stubble height: 3
Comments:

Species: CASI, JUBA

Photograph from end of transect

Comments: Cows removed at 3" stubble of DOPA. All other spp with taller stubble hts.

Figure 108—Last page of the form “Utilization - Robel Pole Sampling” with the last station, number 10 in **A** and **B**, and a transect view toward the 0-ft end (**C**). The camera is 10 m from the last station and the photo identification sheet is halfway between camera and meter board. JUBAis *Juncus balticus* Willd., baltic rush. Remember to cross out the “0” and circle “100.”

UTILIZATION - ROBEL POLE SUMMARY

Date 97/7/7 Examiner: [illegible]

Area Long Cr. Dist. Allotment West Summit

Cluster 1 Transect: 1 2 3 4 5 Sampling interval 8 yrd

Station	VO "A"	VO "B"	Species "A" (Front)	Species "B" (Back)
1	3	2	POPA, CASI	POPA, DACA
2	2	4	", "	", "
3	2	3	", DECE	", DECE
4	3	3	", "	", "
5	6	6	", "	", DACE
6	4	5	DECE, DACA	DECE, JUBA
7	3	3	DACA, DECE	", "
8	7	5	JUBA, DACA	DACA, DECE
9	3	4	DACA, JUBA	", JUBA
10	4	3	", "	CASI, "
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
Total	37	38		
Grand Total	75			
Average	3.75			

SD = 1.41
SE = 0.32
CI_5 = 0.66

Cluster Summary

Trans 1 3.75
Trans 2 ________
Trans 3 ________
Trans 4 ________
Trans 5 ________
AVE ________

Figure 109—Filing system form "Utilization - Robel Pole Summary" with location information, stubble heights, and species taken from the transect data and photo-mounting form. Add the stubble heights in each column (37 and 38), total the columns (75), and determine the average (75 ÷ 20 = 3.75). The average stubble height is 3.75 in. Variability in stubble height may be calculated by determining the standard deviation (SD), standard error (SE), and the confidence interval at the 5-percent confidence level (CI_5). These have been entered on the form. The stubble height is 3.75 ± 0.66 in, at the 5-percent confidence level.

Summarize Data

Add each of the stubble height columns: visual observation A ("VO A") is 37 and "B" is 38; then add the column totals: 37 + 38 = 75. Determine the average stubble height for 20 observations: 75 ÷ 20 = 3.75. In this example, the standard deviation (SD) was 1.41, standard error of the estimate (SE) was 0.32, and the 5-percent confidence interval (CL_5) was 0.66, which were recorded on the form. These data also may be used to determine significant differences among transects by using the Student's t-test. In this case, the stubble height was 3.75 in ± 0.66 in at the 5-percent probability level.

Literature Cited

Guenther, Keith. 1998. Residual dry matter (RDM) monitoring photo guide. Clyde, CA: Wildland Solutions [234 Park Street, 94520].

Hall, Frederick C. 1976. Range trend sampling by photographs. R6 Regional Guide 2-1. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 50 p.

Parker, K.W. 1954. A method for measuring trend in range condition on National Forest ranges with supplemental instructions for measurement and observation of vigor, composition, and browse. Admin. Publ. Washington, DC: U.S. Department of Agriculture, Forest Service. 37 p.

Parker, K.W.; Harris, R.W. 1959. The three-step method for measuring condition and trend of forest ranges: a resume of its history, development, and use. In: Techniques and methods of measuring understory vegetation: Proceedings of a symposium; 1958 October; Tifton, GA. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 55-69.

Reppert, Jack N.; Francis, Richard E. 1973. Interpretation of trend in range conditions from 3-step data. Res. Pap. RM-103. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

Robel, R.J.; Briggs; J.N.; Dayton, A.D.; Hulbert, L.C. 1970. Relationships between visual obstruction measurements and weight of grassland vegetation. Journal of Range Management. 23: 295-297.

White's Electronics, Inc. 1996. Classic II SL™. Sweet Home, OR: White's Electronics, Inc. [1011 Pleasant Valley Road, 97368].

Appendix B: Blank Forms for Photo Monitoring

This appendix contains forms for photo monitoring. To be of the most use, they need to be copied onto three paper colors or overhead projection clear plastic, depending on their use. Office forms are printed on standard white paper. Field forms are printed on either of two colors: blue paper to place in photographs to identify each photo or yellow paper to ease eye strain for field forms. Outline forms for grid analysis are printed on clear plastic. Grids and summary forms are printed on white paper. Paper colors I've found suitable for each form are shown in **bold**.

White paper is used for summary forms and for grids adjusted to size of the outline overlays.

Blue paper is Hammermill Brite Hue Blue® or Georgia Pacific Papers Hots Blue®, or equivalent, used in the actual photographs for identification. This shade of blue has proven to be least sensitive to changes in sunlight, from full sun to shade, and has the least tendency to "bleach out" in full sun.

Yellow paper is Champion Goldenrod® or Hammermill Copy Plus GOLDENROD®, or equivalent, to be used for field forms. It has proven to be the least annoying in direct sunlight for field recording data, maps, diagrams, and other descriptions.

Clear plastic sheets for printing outline overlays are 3M® or Labelon® Overhead Transparency Film. These films are specifically designed for different printers such as laser, inkjet, or plain paper.

These forms are printed here at 90 percent of their original size. To reproduce at full size on 8½- by 11-inch paper, set the copy machine for a 110-percent enlargement.

Page and figure numbers for examples of their use are given in the following list.

Paper and form	Page	Figure examples
Photograph identification forms, printed on **blue paper**:		
Cluster, transect	191	33, 66, 75, 83, 93, 106
Camera, photo	192-193	26, 43
Shrub photo sampling	194	67-68
Square-foot frequency	195	75-77
Nested frequency	196	83-85
9 square feet – 1 square meter	197	24, 93-95
Utilization, Robel pole	198-199	106-108
Sampling site description and location (map), printed on **yellow paper**	200	65, 73-74, 82, 92, 105
Photographic site description and location (map), printed on **yellow paper**:	201	26, 42, 45
Photo mounting and data forms, printed on **yellow paper**:		
Camera location and photo points	202-205	44, 46-48
Photo points and close photos	206-211	50
Photo points with overhead views	212-221	52
Grid analysis outline form, printed on **clear plastic**	233	54-56, 58, 60, 68-70, 101
Analysis grids—adjust size and print on **white paper**:		
1 meter	234	28, 57-58
2 meter	235	
Shrub analysis	236	70
Photo grid summary form, printed on **white paper**	237	59, 71
Transect sampling forms for photo mounting and data collection, printed on **yellow paper**:		
Shrub photo transect	222-231	65, 67-69
Photo trend sample - 1 sq. ft.	238-245	75-77
Photo trend sample - nested frequency—	246-253	83-85
Nested frequency transect data	254-255	86-87
Nested frequency cluster summary	256-258	88-89
Photo trend sample - 9 sq. ft. (1 sq. m)	259-262	93-95
Photo trend sampling - tree cover	263-266	99-100
Utilization - Robel pole sampling	267-299	106-108
Summary forms, printed on **white paper**:		
Photo grid summary	237	59
Range trend rereadings	265-266	79-80, 90-91, 96-97
Nested frequency transect data	255-256	86-87
Nested frequency cluster summary	256-258	88-89
Utilization - Robel pole summary	270	109

Paper color found best for photo identification forms is this color blue.

It is **Hammermill Brite Hue Blue®**

or **Georgia Pacific Papers Hots Blue®**

This page is intentionally left blank.

Paper color that is easy on the eyes and used for transect data collection as well as photo mounting is this color.

It is **Champion Goldenrod®**

or **Hammermill Copy Plus GOLDENROD®**

/

This page is intentionally left blank.

DATE ________ 0 100

AREA ________

ALLOT. ________

CLUSTER ________

TRANS. 1 2 3 4 5

DATE ____________________

AREA ____________________

UNIT ____________________

CAMERA: 1 2 3 4 5

PHOTO: A B C D

E F G H I J

DATE ____________________

AREA ____________________

UNIT ____________________

CAMERA: 6 7 8 9 10

PHOTO: A B C D

E F G H I J

SHRUB PHOTO SAMPLING

DATE ____________________ 0 END

AREA ____________________________________

ALLOT. ____________________________________

TRANSECT 1 2 3 4 5

SHRUB 1A 1B 2A 2B 3A 3B

4A 4B 5A 5B 6A 6B 7A 7B

8A 8B 9A 9B 10A 10B

SQUARE FOOT FREQUENCY

DATE __________ AREA ____________________

ALLOT. ________________________________

CLUSTER ________ TRANS: 1 2 3 4 5

PLOT	1	2	3	4	5	6	7	8	9	10
FEET	0 - 1	5 - 6	10 - 11	15 - 16	20 - 21	25 - 26	30 - 31	35 - 36	40 - 41	45 - 46
	11	12	13	14	15	16	17	18	19	20
FEET	50 - 51	55 - 56	60 - 61	65 - 66	70 - 71	75 - 76	80 - 81	85 - 86	90 - 91	95 - 96

NESTED FREQUENCY

DATE ____________ AREA ______________________

ALLOT. ______________________________________

CLUSTER __________ TRANS: 1 2 3 4 5

PLOT	1	2	3	4	5	6	7	8	9	10
FEET	0 - 1.6	5 - 6.6	10 - 11.6	15 - 16.6	20 - 21.6	25 - 26.6	30 - 31.6	35 - 36.6	40 - 41.6	45 - 46.6
	11	12	13	14	15	16	17	18	19	20
FEET	50.- 51.6	55 - 56.6.	60 - 61.6	65 - 66.6	70 - 71.6	75 - 76.6	80 - 81.6	85 - 86.6	90 - 91.6	95 - 96.6

9 SQ.FEET – 1 SQ. METER

DATE ____________________

AREA ____________________

ALLOT. ____________________

CLUSTER ____________________

TRANSECT: 1 2 3 4 5

PLOT:	1	2	3	4	5
FEET	3.5-6.5	25-28	50-53	75-78	96.5-93.5
METERS	1-2	7-8	15-16	22-23	29-28

UTILIZATION - ROBEL POLE

Date________________ Cluster_____

Area______________________________

Allot._____________________________

Transect: 1 2 3 4 5

1A	1B	2A	2B	3A	3B	4A	4B
5A	5B	6A	6B	7A	7B	8A	8B
9A	9B	10A	10B	11A	11B		
12A	12B	13A	13B	14A	14B		

UTILIZATION - ROBEL POLE

Date ____________________ Cluster _______

Area ______________________________________

Allot. _____________________________________

Transect: 1 2 3 4 5

15A 15B	16A 16B	17A 17B
18A 18B	19A 19B	20A 20B
21A 21B	22A 22B	23A 23B
24A 24B	25A 25B	

SAMPLING SITE DESCRIPTION AND LOCATION

Circle: 1 Sq.Ft. Nested Freq. 1 sq.m. Robel Pole Shrub Form ____________

Date ________________________
Area ________________________
Allot.________________________
Cluster No. _______
Transects: 1 2 3 4 5
Plant community _____________
____

Grazing system:
Type ______________Date_____
Type ______________Date_____
Type ______________Date_____

Kind of animal: cattle sheep
horses goats deer
elk _______________

Location: T._____ R._____
Sec.________________
Description:_________________
____
____
____

Site Data: Elev.____________ % slope________
Slope aspect: N NE E SE S SW W NW
Slope position: top up 1/3 mid low 1/3 bottom
Micro topography: convex flat concave
Macro topography: flat undulating rolling
steep rough broken

Geology:
Deposition: wind stream lake colluvial
residual____________________
Material: limestone mudstone sandstone
granite serpentine diorite
basalt andesite rhyolite
tuffacious cinders pumice ash

Soil:
Restrictive layer: absent clay pan bedrock
cemented _____________
Surface compaction: none moderate severe
Soil profile stone: absent gravel stony
Soil texture: sandy loamy silty clayey ashy
Other notes:_______________________________
____
____

MAP

PHOTOGRAPHIC SITE DESCRIPTION AND LOCATION

Date ____________________ **Area**____
Unit________________________________**Observer:**______________________________________
No. of Camera locations: ______________**No. of Photo points:**____ ____________________
Plant community____
Location: T._____ **R.**_____ **Sec.**____
Location description____
____
Photo purpose:____
____
Discussion:____
____
____
____

MAP

Use back of sheet for additional details.

CAMERA LOCATION AND PHOTO POINTS

Date____________ Camera Location____________________

Area______________________________________ Number of Photo points: ______________

Unit________________________________Observer________________________________

Comments ____

____

Slope_____ Aspect ________ Slope position______________

Photo point A:

Compass bearing: ___________

Distance:__________________

Photo Point A

Photo point B:

Compass bearing:___________

Distance:_________________

Photo Point B

CAMERA LOCATION AND PHOTO POINTS

Photo point C________________
Compass bearing:____________
Distance:____________________

Photo point C

Photo Point D: ________________
Compass bearing:____________
Distance:____________________

Photo point D

Photo Point E: ________________
Compass bearing :____________
Distance:____________________

Photo point E

CAMERA LOCATION AND PHOTO POINTS

Photo Point F: ____________
Compass bearing:__________
Distance:________________

Photo point F

Photo Point G: ___ ________
Compass bearing:__________
Distance:________________

Photo point G

Photo Point H: ____________
Compass Bearing:__________
Distance:________________

Photo point H

CAMERA LOCATION AND PHOTO POINTS

Photo Point I: ______________
Compass bearing:____________
Distance:__________________

Photo point I

Photo Point J: ______________
Compass bearing:____________
Distance:__________________

Photo point J

PHOTO POINTS AND CLOSE PHOTOS

Date __________ Camera ______________________________

Area ________________________ **Unit** ________________________ **Photo point: A** **Observer** ______________________ **Remarks** ______________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________	**General photograph of point A**
Photo point A: **Left of meter board** **Species/cover:** ______________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ **Comments:** _________________ ____________________________ ____________________________ ____________________________ ____________________________	**Close photo to left of meter board**
Photo point A: **Right of meter board** **Species/cover:** ______________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ ____________________________ **Comments:** _________________ ____________________________ ____________________________ ____________________________	**Close photo to right of meter board**

PHOTO POINTS AND CLOSE PHOTOS

Date____________________
Area____________________
Unit ____________________
Camera __________________
Photo point: B
Observer__________________
Remarks __________________

General photograph of point B

Photo point B
Left of meter board
Species/cover:______________

Comments:________________

Close photo to left of meter board

Photo point B
Right of meter board
Species/cover: ______________

Comments:________________

Close photo to right of meter board

PHOTO POINTS AND CLOSE PHOTOS

Date________________________
Area________________________
Unit ________________________
Camera _____________________
Photo point: C
Observer_____________________
Remarks ____________________

General photograph of point C

Photo point C
Left of meter board
Species/cover:________________

Comments:___________________

Close photo to left of meter board

Photo point C
Right of meter board
Species/cover: ________________

Comments:___________________

Close photo to right of meter board

PHOTO POINTS AND CLOSE PHOTOS

Date____________________
Area____________________
Unit ____________________
Camera __________________
Photo point: D
Observer__________________
Remarks __________________

General photograph of point D

Photo point D
Left of meter board
Species/cover:______________

Comments:________________

Close photo to left of meter board

Photo point D
Right of meter board
Species/cover: ______________

Comments:________________

Close photo to right of meter board

PHOTO POINTS AND CLOSE PHOTOS

Date____________________________
Area____________________________
Unit ____________________________
Camera __________________________
Photo point: E
Observer_________________________
Remarks _________________________
____
____
____
____
____

General photograph of point E

Photo point E
Left of meter board
Species/cover:_______________
____
____
____
____
____
____
____
Comments:__________________
____
____
____
____

Close photo to left of meter board

Photo point E
Right of meter board
Species/cover: _______________
____
____
____
____
____
____
Comments:__________________
____
____
____
____

Close photo to right of meter board

PHOTO POINTS AND CLOSE PHOTOS

Date________________________
Area________________________
Unit ________________________
Camera ______________________
Photo point: ____
Observer_____________________
Remarks _____________________

General photograph of point _____

Photo point _____
Left of meter board
Species/cover:________________

Comments:____________________

Close photo to left of meter board

Photo point _____
Right of meter board
Species/cover: ________________

Comments:____________________

Close photo to right of meter board

PHOTO POINTS WITH OVERHEAD VIEWS

Date_______ Camera ______________________________

Area______________________________________ Number of Photo points: ______________

Unit______________________________________Observer______________________________

Comments ____

____

Slope_____ Aspect ________ Slope position ______________ Topography _______________

Photo Point A

Compass bearing: ___________

Distance____________________

Photo comments:____________

____

____

____

____

____

____

____

Photo point A

Overhead of Photo Point A

Photo comments:____________

____

____

____

____

____

____

____

____

____

____

____

____

Overhead of photo point A

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point B
Compass bearing: ____________
Distance______________________
Photo comments:____________

Photo point B

Overhead of Photo Point B
Photo comments:____________

Overhead of Photo point B

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point C
Compass bearing: ____________
Distance ____________________
Photo comments: ____________

Photo point C

Overhead of Photo Point C
Photo comments: ____________

Overhead of Photo point C

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point D
Compass bearing: ____________
Distance ______________________
Photo comments: ____________

Photo point D

Overhead of Photo Point D
Photo comments: ____________

Overhead of Photo point D

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point E
Compass bearing: ____________
Distance______________________
Photo comments:______________

____
____
____
____
____
____
____

Photo point E

Overhead of Photo Point E
Photo comments:______________

____
____
____
____
____
____
____
____
____
____
____
____

Overhead of Photo point E

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point F
Compass bearing: ____________
Distance ______________________
Photo comments: ____________

Photo point F

Overhead of Photo Point F
Photo comments: ____________

Overhead of Photo point F

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point G
Compass bearing: ____________
Distance____________________
Photo comments:____________

____
____
____
____
____
____
____

Photo point G

Overhead of Photo Point G
Photo comments:____________

____
____
____
____
____
____
____
____
____
____
____
____

Overhead of Photo point G

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point H
Compass bearing: ____________
Distance ____________________
Photo comments: ____________

____
____
____
____
____
____
____

Photo point H

Overhead of Photo Point H
Photo comments: ____________

____
____
____
____
____
____
____
____
____
____
____
____

Overhead of Photo point H

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point I
Compass bearing: ____________
Distance ____________
Photo comments: ____________

Photo point I

Overhead of Photo Point I
Photo comments: ____________

Overhead of Photo point I

PHOTO POINTS WITH OVERHEAD VIEWS

Photo Point J
Compass bearing: ____________
Distance____________________
Photo comments:____________

Photo point J

Overhead of Photo Point J
Photo comments:____________

Overhead of Photo point J

SHRUB PHOTO TRANSECT

Date __________ Cluster ______ Transect 1 2 3 4 5

Area ____________________
Allot. ____________________
Investigator: ______________
____
Season of use____________
Grazing system: __________
____
Animals _________________
____

Direction_________________
Distance_________________

General photograph down the transect

Shrub 1A
Direction ________________
Distance ________________
Comments________________
____
____
____
____
____
____

Shrub 1A

Shrub 1B
Direction ________________
Distance ________________
Comments ______________
____
____
____
____
____
____

Shrub 1B

<u>**SHRUB PHOTO TRANSECT**</u>

Shrub 2A
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 2A

Shrub 2B
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 2B

SHRUB PHOTO TRANSECT

Shrub 3A
Direction ____________________
Distance ____________________
Comments____________________

Shrub 3A

Shrub 3B
Direction ____________________
Distance ____________________
Comments____________________

Shrub 3B

SHRUB PHOTO TRANSECT

Shrub 4A
Direction ____________________
Distance ____________________
Comments____________________

Shrub 4A

Shrub 4B
Direction ____________________
Distance ____________________
Comments____________________

Shrub 4B

SHRUB PHOTO TRANSECT

Shrub 5A
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 5A

Shrub 5B
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 5B

SHRUB PHOTO TRANSECT

Shrub 6A
Direction ____________________
Distance ____________________
Comments ____________________

Shrub 6A

Shrub 6B
Direction ____________________
Distance ____________________
Comments ____________________

Shrub 6B

SHRUB PHOTO TRANSECT

Shrub 7A
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 7A

Shrub 7B
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 7B

SHRUB PHOTO TRANSECT

Shrub 8A
Direction ____________________
Distance ____________________
Comments____________________

Shrub 8A

Shrub 8B
Direction ____________________
Distance ____________________
Comments____________________

Shrub 8B

SHRUB PHOTO TRANSECT

Shrub 9A
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 9A

Shrub 9B
Direction ____________________
Distance ____________________
Comments____________________
____
____
____
____
____
____

Shrub 9B

SHRUB PHOTO TRANSECT

Shrub 10A
Direction ____________________
Distance ____________________
Comments____________________

Shrub 10A

Shrub 10B
Direction ____________________
Distance ____________________
Comments____________________

Shrub 10B

Up transect photograph:
Direction ____________________
Distance ____________________
Comments: ____________________

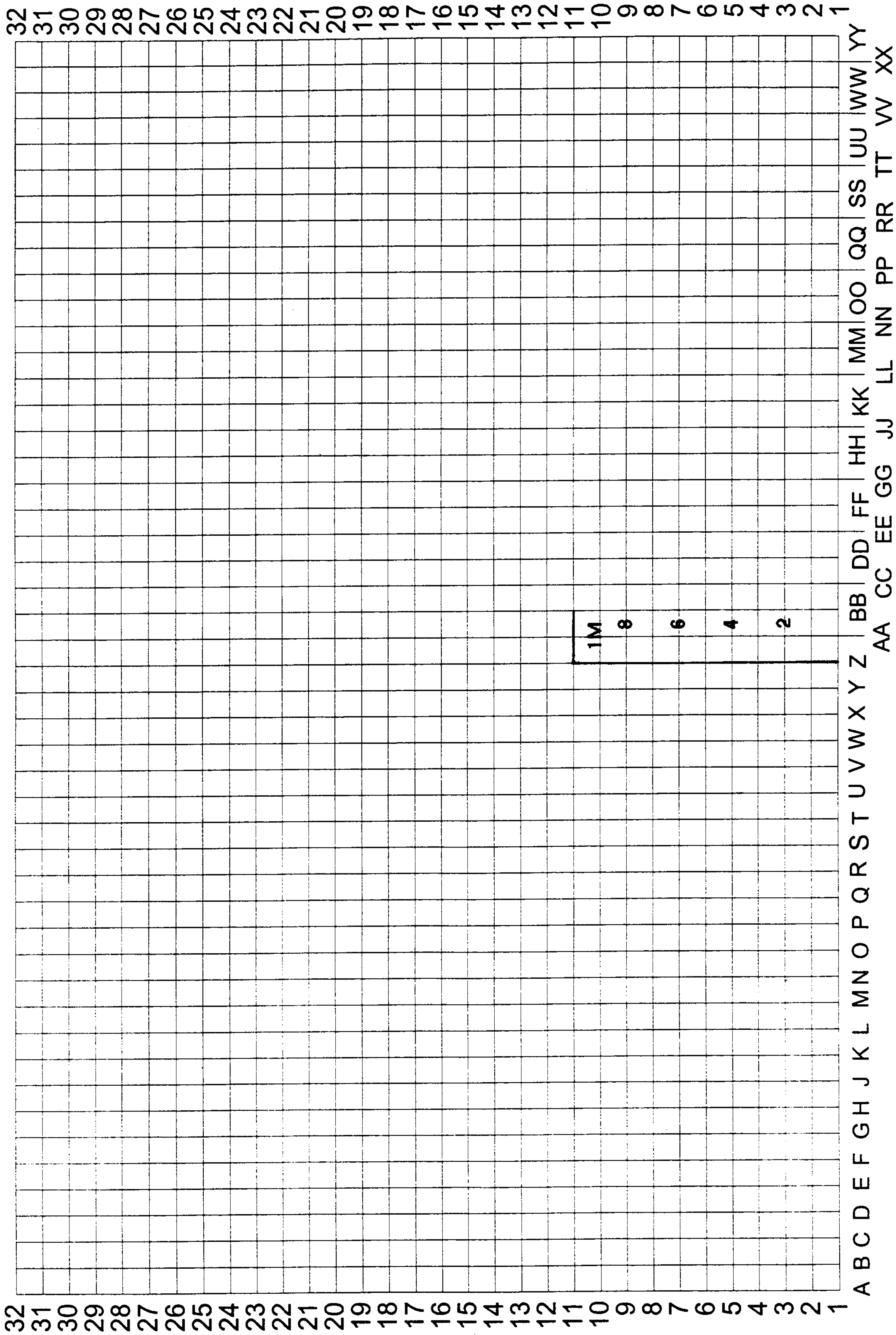
General photograph up the transect

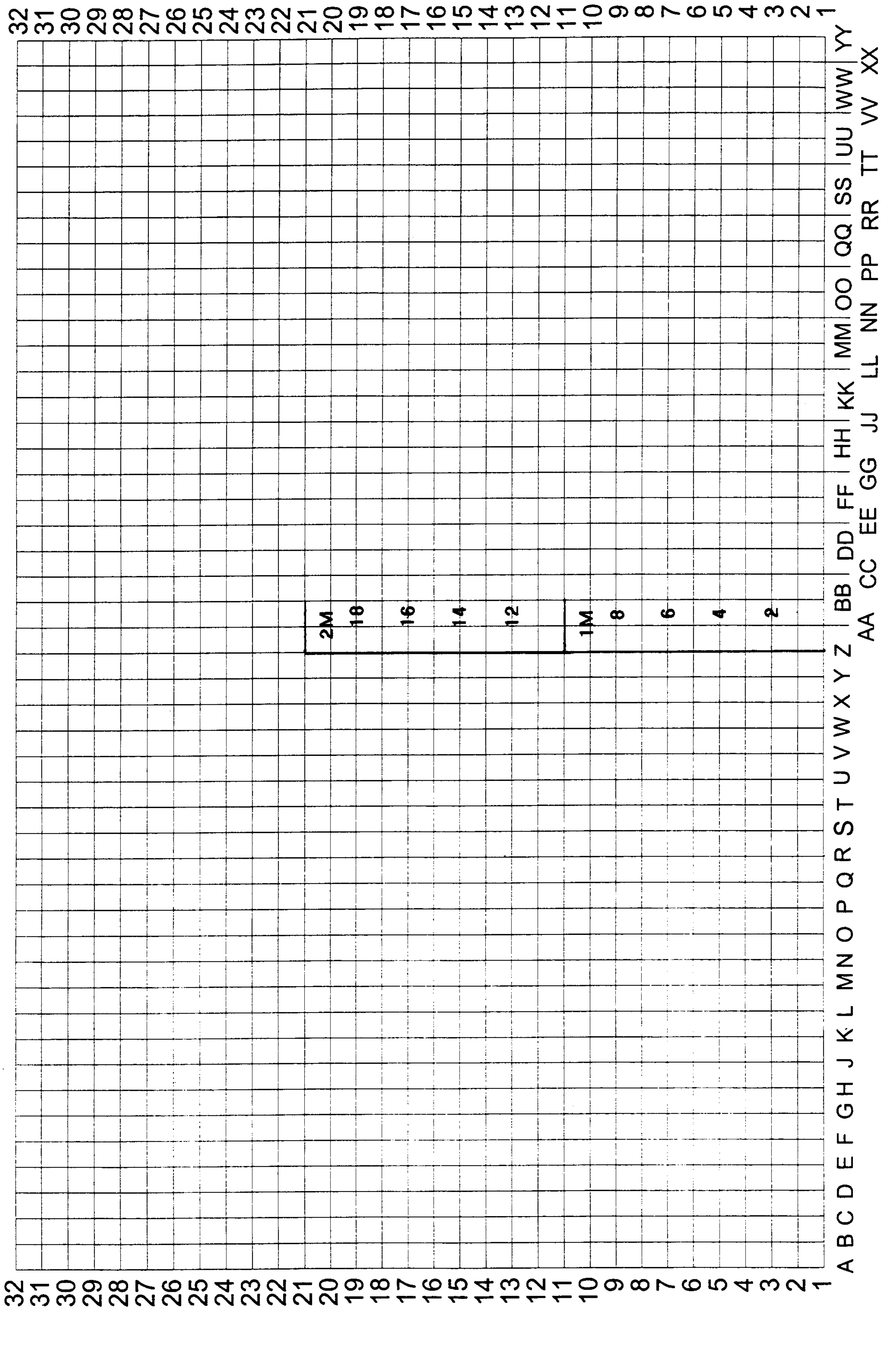
This page is intentionally left blank.

Date ______________ **GRID ANALYSIS OUTLINE** Area ____________________

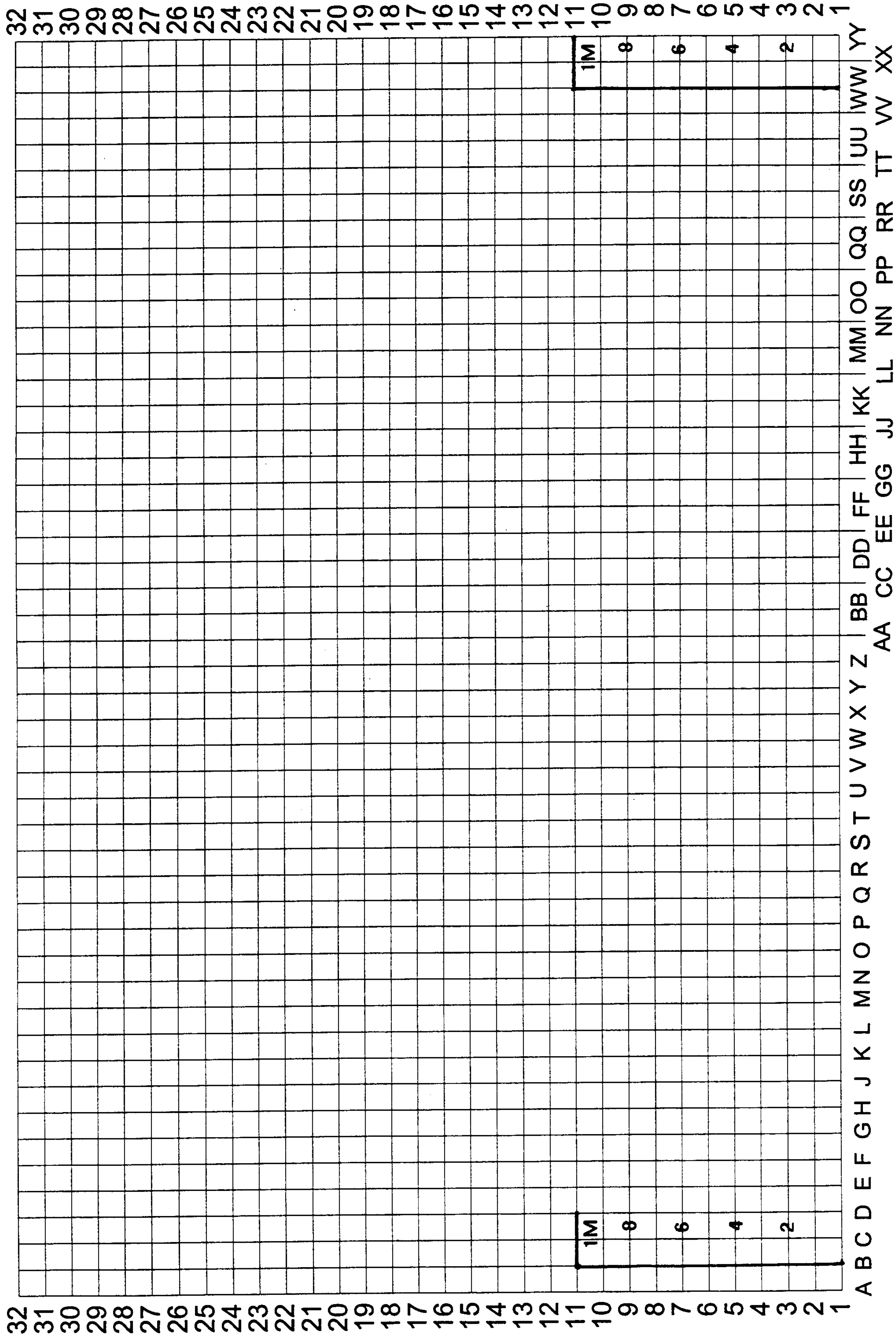
Observer ____________________________ Unit ______________________________________

Cluster/Transect ________________________ Transect/Photo _____________________


A B C D E F G H J K L M N O P Q R S T U V W X Y Z AA BB CC DD EE FF GG HH JJ KK LL MM NN OO PP QQ RR SS TT UU VV WW XX YY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
1M 8 6 4 2



A B C D E F G H J K L M N O P Q R S T U V W X Y Z AA BB CC DD EE FF GG HH JJ KK LL MM NN OO PP QQ RR SS TT UU VV WW XX YY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
2 4 6 8 1M 12 14 16 18 2M


A B C D E F G H J K L M N O P Q R S T U V W X Y Z AA BB CC DD EE FF GG HH JJ KK LL MM NN OO PP QQ RR SS TT UU VV WW XX YY
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
1M
8
6
4
2

1999/2/19

PHOTO GRID SUMMARY

Date________________ Observer________________________________

Area________________________________Unit________________

Cluster/Camera ______________________ Transect/Photo________________

Item #	Date	Item #	Date	Item #	Date

PHOTO TRENDSAMPLE – 1 SQ.FOOT

Date ___________Cluster _____ Transect 1 2 3 4 5

Area ______________________
Allot. ______________________
Investigator ________________
____
Season of use______________
% use ________
Grazing system_____________
____
Remarks __________________
____
____
____
____
____

1

0 ft 1 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

2

5 ft 6 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

General photograph down the 100 ft. (30 m)

tape from the <u>0 end</u>

Size control board at 33 ft (10 m)
Photo identification paper at 15 ft (5 m)

Photograph of plot 1

Photograph of plot 2

PHOTO TREND SAMPLE – 1 SQ.FOOT

3

10 ft 11 ft

Soil surface: B G R L C

Line intercept

Species	From	to	feet

Photograph of plot 3

4

15 ft 16 ft

Soil surface: B G R L C

Line intercept

Species	From	to	Feet

Photograph of plot 4

5

20 ft 21 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Photograph of plot 5

PHOTO TRENDS SAMPLE – 1 SQ.FOOT

6

25 ft 26 ft

Soil surface: B G R L C

Line intercept

Species	From	to	feet

Photograph of plot 6

7

30 ft 31 ft

Soil surface: B G R L C

Line intercept

Species	From	to	Feet

Photograph of plot 7

8

35 ft 36 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Photograph of plot 8

PHOTO TRENDSAMPLE – 1 SQ.FOOT

9

40 ft 41 ft

Soil surface: B G R L C

Line intercept

Species	From	to	feet

Photograph of plot 9

10

45 ft 46 ft

Soil surface: B G R L C

Line intercept

Species	From	to	Feet

Photograph of plot 10

11

50 ft 51 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Photograph of plot 11

PHOTO TREND SAMPLE – 1 SQ.FOOT

12

55 ft 56 ft

Soil surface: B G R L C

Line intercept

Species	From	to	feet

Photograph of plot 12

13

60 ft 61 ft

Soil surface: B G R L C

Line intercept

Species	From	to	Feet

Photograph of plot 13

14

65 ft 66 ft

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Photograph of plot 14

PHOTO TRENDS SAMPLE – 1 SQ.FOOT

15

70 ft 71 ft

Soil surface: B G R L C

Line intercept

Species From to feet

Photograph of plot 15

16

75 ft 71 ft

Soil surface: B G R L C

Line intercept

Species From to Feet

Photograph of plot 16

17

80 ft 81 ft

Soil surface: B G R L C

Line intercept:

Species From To Feet

Photograph of plot 17

PHOTO TREND SAMPLE – 1 SQ.FOOT

18

85 ft 86 ft

Soil surface: B G R L C

Line intercept

Species From to feet

______ __ __ __

______ __ __ __

______ __ __ __

Photograph of plot 18

19

90 ft 91 ft

Soil surface: B G R L C

Line intercept

Species From to Feet

______ __ __ __

______ __ __ __

______ __ __ __

Photograph of plot 19

20

95 ft 96 ft

Soil surface: B G R L C

Line intercept:

Species From To Feet

______ __ __ __

______ __ __ __

______ __ __ __

Photograph of plot 20

PHOTO TREND SAMPLE – 1 SQ.FOOT

SUMMARY

Species	Frequ.	Interc.

Bare soil

Gravel pavement

Rock

Litter

Cryptogams

Estimated Utilization

Species	% Use

General photograph up the 100 ft (30 m)

tape from the 100 (30m) end

Size control board at 67 ft (20 m)
Photo identification paper at 85 ft (26 m)

ACTIVITIES

Logging

Fire

Revegetation

Insects

Wildlife

Other

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Apparent range condition

Apparent range trend

COMMENTS

PHOTO TREND SAMPLE – NESTED FREQUENCY

Date ______________ Cluster ______ Transcect 1 2 3 4 5

Area ____________________

Allot. ____________________

Investigator ______________

____

Season of use ____________

% use _______

Grazing system ___________

____

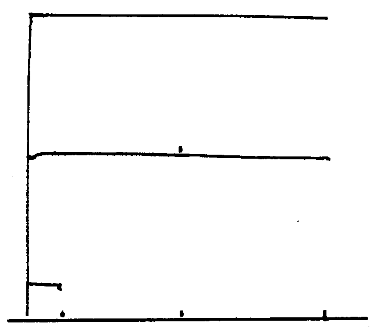
Remarks ______________

____

____

____

1

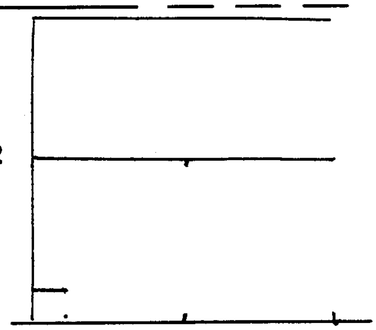


0.0 ft 1.6 ft

Line intercept:

Species	From	To	Feet

2



5.0 ft 6.6 ft

Line intercept:

Species	From	To	Feet

General photograph down the 100 ft. (30 m)

tape from the 0 end

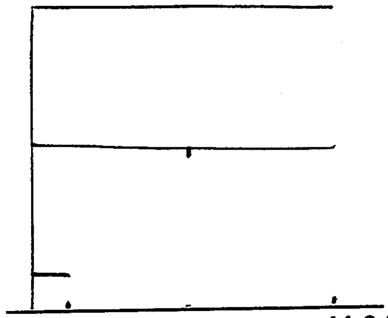
Size control board at 33 ft (10 m)
Photo identification paper at 15 ft. (5 m)

Photograph of plot 1

Photograph of plot 2

PHOTO TRENDSAMPLE – NESTED FREQUENCY

3



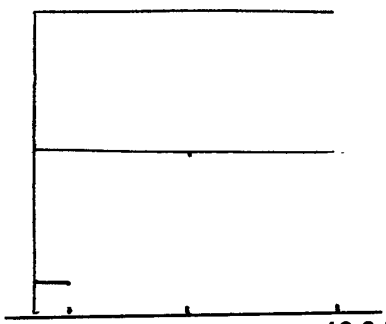
10.0 ft 11.6 ft

Line intercept

Species	From	to	feet

Photograph of plot 3

4



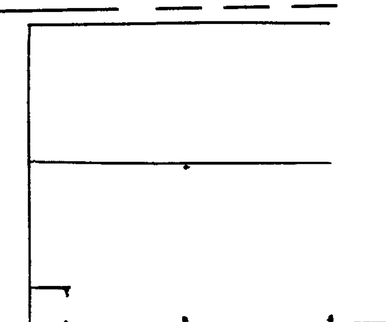
15.0 ft 16.6 ft

Line intercept

Species	From	to	Feet

Photograph of plot 4

5



20.0 ft 21.6 ft

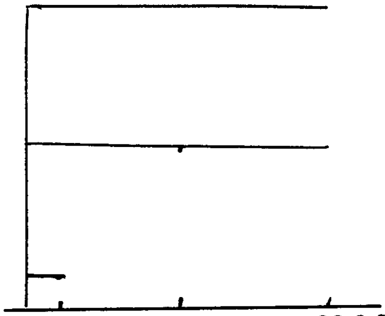
Line intercept:

Species	From	To	Feet

Photograph of plot 5

PHOTO TREND SAMPLE – NESTED FREQUENCY

6



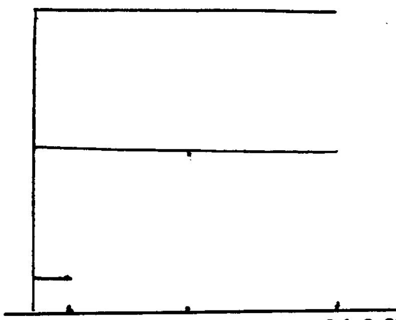
25.0 ft 26.6 ft

Line intercept

Species	From	to	feet

Photograph of plot 6

7



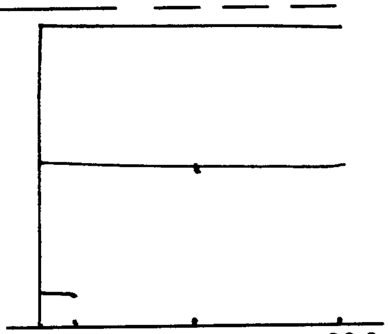
30.0 ft 31.6 ft

Line intercept

Species	From	to	Feet

Photograph of plot 7

8



35.0 ft 36.6 ft

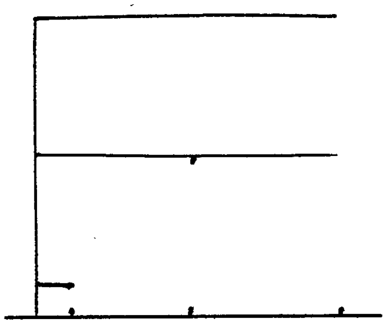
Line intercept:

Species	From	To	Feet

Photograph of plot 8

PHOTO TREND SAMPLE – NESTED FREQUENCY

9



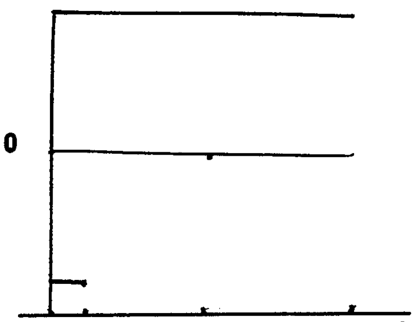
40.0 ft 41.6 ft

Line intercept

Species	From	to	feet

Photograph of plot 9

10



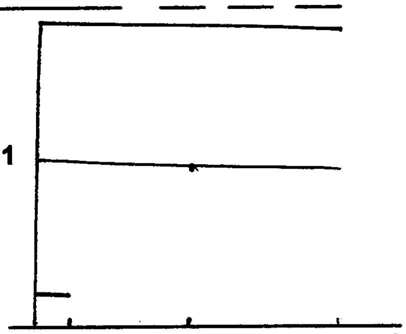
45.0 46.6 ft

Line intercept

Species	From	to	Feet

Photograph of plot 10

11



50.0 ft 51.6 ft

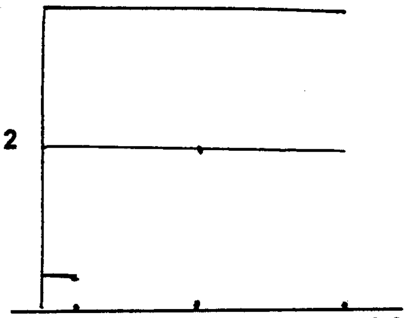
Line intercept:

Species	From	To	Feet

Photograph of plot 11

PHOTO TREND SAMPLE – NESTED FREQUENCY

12



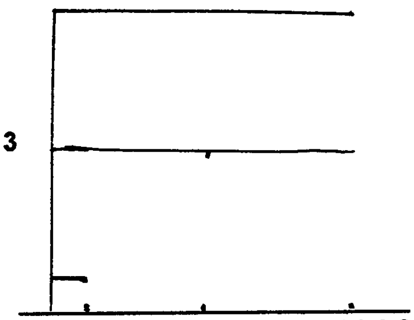
55.0 ft 56.6 ft

Line intercept

Species	From	to	feet

Photograph of plot 12

13



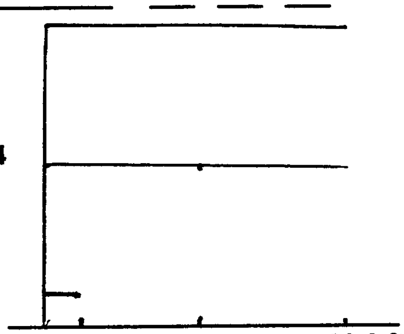
60.0 ft 61.6 ft

Line intercept

Species	From	to	Feet

Photograph of plot 13

14



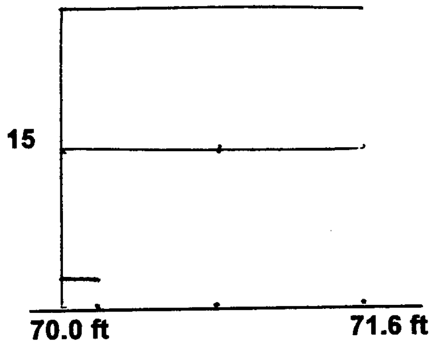
65.0 ft 66.6 ft

Line intercept:

Species	From	To	Feet

Photograph of plot 14

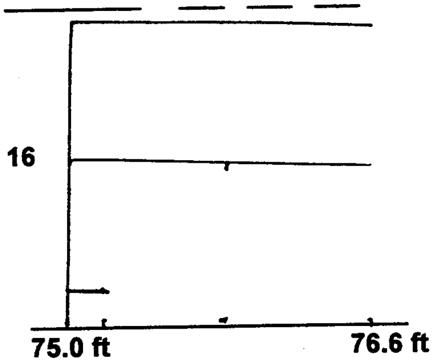
PHOTO TRENDS SAMPLE – NESTED FREQUENCY



Line intercept

Species	From	to	feet

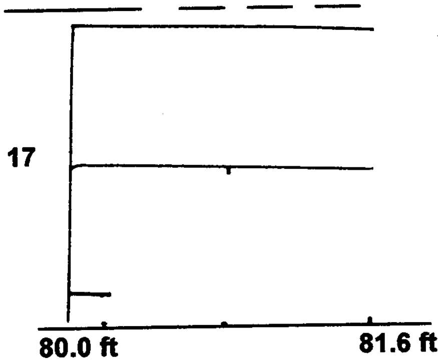
Photograph of plot 15



Line intercept

Species	From	to	Feet

Photograph of plot 16



Line intercept:

Species	From	To	Feet

Photograph of plot 17

PHOTO TRENDS SAMPLE – NESTED FREQUENCY

18

85.0 ft 86.6 ft

Line intercept

Species	From	to	feet

Photograph of plot 18

19

90.0 ft 91.6 ft

Line intercept

Species	From	to	Feet

Photograph of plot 19

20

95.0 ft 96.6 ft

Line intercept:

Species	From	To	Feet

Photograph of plot 20

PHOTO TREND SAMPLE – NESTED FREQUENCY SUMMARY

NOTE: use the nested frequency data forms on the next two pages.

General photograph up the 100 ft (30 m) tape from the 100 ft (30m) end

Size control board at 67 ft (20 m)
Photo identification paper at 85 ft (26 m)

ACTIVITIES

Logging________________________
Fire________________________
Revegetation________________________
Insects________________________
Wildlife________________________
Other ________________________
____
____

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Apparent range condition________________________
Apparent range trend ________________________

COMMENTS

Estimated Utilization

Species	% Use

NESTED FREQUENCY TRANSECT DATA

Area:____________________**Allotment:**______________________**Date:**________
Investigator:____________________**Cluster:**_____ **Transect:** *1 2 3 4 5*
Plant community:____

Species	Sample Number																				Total Value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

POINT SAMPLING

Ground cover	Veg.	Soil	Gravel	Rock	Litter	Crypt.	Total
Dot tally							
Totals							80

NEXT SHEET FOR LINE INTERCEPT OF SHRUBS AND TREES

NESTED FREQUENCY TRANSECT DATA (Continued)

Line intercept of trees and shrubs

Shrub species	Line Intercept								Total	Percent
								Totals		

Tree species	Line Intercept								Total	Percent
								Totals		

NESTED FREQUENCY CLUSTER SUMMARY

Area: ______________________ Allotment: ___________________________ Date: __________

Investigator: ______________________________________ Cluster: _________

Plant community: ____

Species	Transect Number 1	2	3	4	5	(To trend summary) Total Value

OVER FOR LINE INTERCEPT AND POINT SAMPLING

NESTED FREQUENCY CLUSTER SUMMARY (Continued)

LINE INTERCEPT

Shrub species	Transect Number 1	2	3	4	5	(To trend summary) Total	Percent
Tree Species							

POINT SAMPLING

Ground Item	Transect Number 1	2	3	4	5	(To trend summary) Total Hits	Percent
Vegetation (root crown)							
Bare soil							
Gravel (1/8 to ¾ in.)							
Rock (> ¾ in.)							
Litter							
Cryptogams							
Totals:	80	80	80	80	80	400	100

Table 5. Significant change table for nested frequency.

Using 100 nested frequency plot frames, the table below shows a significant change in frequency value at the 80% probability level. Enter the table at "Initial value' with the *previous* frequency value for the 5 transects (100 plot frames). Compare the *previous* value with the *current* value to determine if a significant change has occurred. A change is significant if the *current* value is smaller than the "Less than" value or greater than the "More than" value.

Less than	Initial value	More than
17	25	31
21	30	37
25	35	43
30	40	48
35	45	55
39	50	59
43	55	65
48	60	70
53	65	75
57	70	81
62	75	86
67	80	91
71	85	97
76	90	102
81	95	107
85	100	113
90	105	118
95	110	123
99	115	129
104	120	134
109	125	139
113	130	145
118	135	150
123	140	155
128	145	160
132	150	166

Less than	Initial value	More than
137	155	171
142	160	176
147	165	181
151	170	176
156	175	192
161	180	197
166	185	202
170	190	208
175	195	213
180	200	218
185	205	223
189	210	229
194	215	234
219	220	239
204	225	244
209	230	249
213	235	255
218	240	360
223	245	265
228	250	270
233	255	275
237	260	281
242	265	286
247	270	291
252	275	296

Less than	Initial value	More than
257	280	301
261	285	307
266	290	312
271	295	317
276	300	322
281	305	327
285	310	333
290	315	338
295	320	343
300	325	348
307	330	353
309	335	359
314	340	364
319	345	369
324	350	374
329	355	379
334	360	384
339	365	389
343	370	395
348	375	*
353	380	*
358	385	*
363	390	*
368	395	*
372	400	*

PHOTO TRENDS SAMPLE – 9 sq.ft. (1 sq. m)

Date ______________ Cluster ______ Transect 1 2 3 4 5

Area ______________________

Allot. ______________________

Investigator _______________

Season of use _____________

% use ________

Grazing system ____________

____

Remarks __________________

____

____

____

____

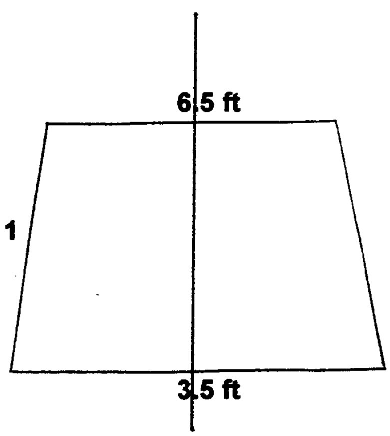
____

General photograph down the 100 ft. (30 m)

tape from the <u>0 end</u>

Size control board at 33 ft (10 m)

Photo identification paper at 15 ft (5 m)



Photograph of plot 1

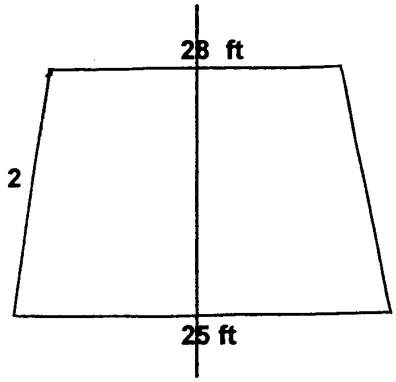
Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Camera at the 0 foot mark.

PHOTO TREND SAMPLE – 9 SQ.FT. (1 SQ. M)



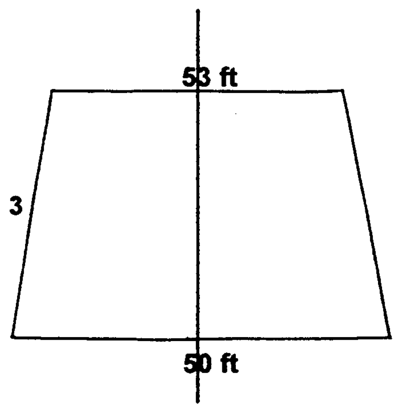
Photograph of plot 2

Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Camera at the 21.5 foot mark.



Photograph of plot 3

Soil surface: B G R L C

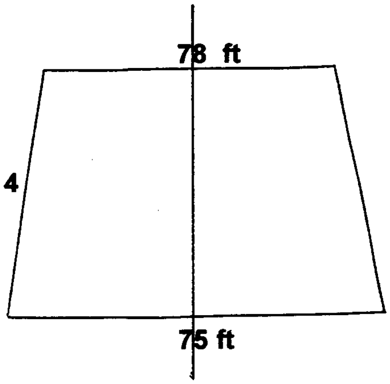
Line intercept:

Species	From	To	Feet

Camera at the 46.5 foot mark.

PHOTO TRENDSAMPLE – 9 SQ.FT. (1 SQ. M)

4



Soil surface: B G R L C

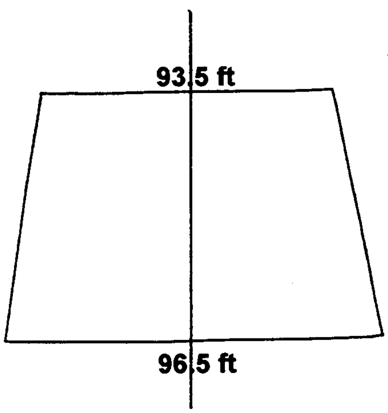
Line intercept:

Species	From	To	Feet

Photograph of plot 4

Camera at the 71.5 foot mark

5



Soil surface: B G R L C

Line intercept:

Species	From	To	Feet

Photograph of plot 5

STOP: Change camera direction - photo from the 100 ft end

Camera at the 100 foot mark.

PHOTO TRENDS SAMPLE – 9 sq.ft. (1 sq. m)
SUMMARY

Species	Frequ.	Interc.

General photograph up the 100 ft (30 m)

tape from the 100 (30m) end

Size control board at 67 ft (20 m)
Photo identification paper at 85 ft (26 m)

ACTIVITIES

Logging____
Fire____
Revegetation____
Insects____
Wildlife____
Other____

CLIMATE compared to Average

	This Yr.	Last Yr.	Two Yrs.	Three Yrs	Four Yrs.
Temp	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -
Ppt.	+ 0 -	+ 0 -	+ 0 -	+ 0 -	+ 0 -

Bare soil ____
Gravel pavement ____
condition____
Rock ____
trend____
Litter ____
Cryptogams ____

Apparent range

Apparent range

COMMENTS

Estimated Utilization

Species	% Use

PHOTO TREND SAMPLING – TREE COVER

Area ____________________________Allot. ___________________ _________________Date ____________

Investigator_______________ Sampling system _______________ Cluster ___ Transect: 1 2 3 4 5

0 ft

Species	Cover	Species	cover
________	___%	________	___%
________	___%	________	___%
________	___%	TOTAL	___%

Vertical photo of tree cover above 0 foot mark

25 ft

Species	Cover	Species	cover
________	___%	________	___%
________	___%	________	___%
________	___%	TOTAL	___%

Vertical photo of tree cover above 25 foot mark

50 ft

Species	Cover	Species	cover
________	___%	________	___%
________	___%	________	___%
________	___%	TOTAL	___%

Vertical photo of tree cover above 50 foot mark

PHOTO TREE SAMPLING – TREE COVER

75 ft

Vertical photo of tree cover above 75 foot mark

Species	Cover	Species	cover
_______	___%	_______	___%
_______	___%	_______	___%
_______	___%	TOTAL	___%

100 ft

Vertical photo of tree cover above 100 foot mark

Species	Cover	Species	cover
_______	___%	_______	___%
_______	___%	_______	___%
_______	___%	TOTAL	___%

SUMMARY

Species	Ave. % cover
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____
_________	_____

RANGE TREND REREADINGS

Circle the sampling system: 20 plots 1 sq,ft, 100 plots Nest. Frequ. 5 Plots 9 sq.ft.(1 sq. m)

Area____________________Allotment____________________Cluster_____Transect *1 2 3 4 5*

Species	Averages by Year									
Tree Crown Cover (in percent)										
TOTAL										
Shrub intercept (in feet)										
TOTAL										
Frequency: No. plots for 1 sq.ft. & 9 sq.ft. (1 sq. m); nested frequ. value										

OVER FOR ADDITIONAL DATA

RANGE TREND REREADINGS (Continued)

Elements	Averages by Year									
Range Condition Guide/date										
Decreasers:										
Palatable Increasers										
Unpalatable Increasers										
Invaders										
Vegetation - (root crown)										
Bare Soil										
Gravel (1/8 to ¾ inch)										
Rock (> ¾ inch)										
Litter										
Cryptogams										
% Utilization by species										
Season of Use										
Climate										
Temp: Current										
Last year										
2 yrs. Ago										
3 yrs. Ago										
4 yrs. Ago										
Ppt.: Current										
Last year										
2 yrs. Ago										
3 yrs. Ago										
4 yrs. Ago										
Apparent range condition										
Apparent range trend										

UTILIZATION - ROBEL POLE SAMPLING

Date ___________ Cluster ______ Transect: 1 2 3 4 5

Area____________________

Allot.____________________

Investigator______________

____

Season of use_____________

Grazing system:___________

____

Remarks:________________

____

____

General photograph down the transect from the start

Size control board at 33 ft (10 m)
Photo identification paper at 15 ft (5 m)

Visual Observation 1A:

Stubble height: _________

Comments:_______________

____

____

____

____

____

Species: ________________

____

____

____

____

Photograph of observation 1A forward on contour

Visual Observation 1B:

Stubble height: _________

Comments: ______________

____

____

____

____

____

Species:_________________

____

____

____

____

Photograph of observation 1B backward on contour

UTILIZATION - ROBEL POLE SAMPLING

Visual Observation #_____A
Stubble height: __________
Comments: ________________
____
____
____
____
____
Species: __________________
____
____
____
____

Photograph of observation ____ A forward on contour

Visual Observation # _____B
Stubble height: __________
Comments: ________________
____
____
____
____
____
Species: __________________
____
____
____
____

Photograph of observation ____ B backward on contour

UTILIZATION - ROBEL POLE SAMPLING

Visual Observation #_____A **Stubble height: _________** **Comments: _______________** ________________________ ________________________ ________________________ ________________________ ________________________ **Species: _________________** ________________________ ________________________ ________________________ ________________________	**Photograph of observation ____ A forward on contour**
Visual Observation # _____B **Stubble height: _________** **Comments: _______________** ________________________ ________________________ ________________________ ________________________ ________________________ **Species: _________________** ________________________ ________________________ ________________________ ________________________	**Photograph of observation ____ B backward on contour**
Photograph from end of transect **Comments: _______________** ________________________ ________________________ ________________________ ________________________ ________________________ ________________________ ________________________ ________________________ ________________________	**General photograph up the transect from the end** **Six control board at 33 ft (10M)** **Photo identification paper at 15 ft (5 m)**

UTILIZATION - ROBEL POLE SUMMARY

Date ___________ Examiner: ______________________________
Area ______________________ Allotment ____________________________
Cluster ____ Transect: 1 2 3 4 5 Sampling interval ________

Station	VO "A"	VO "B"	Species "A" (Front)	Species "B" (Back)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
Total				
Grand Total				
Average				

Cluster Summary
Trans 1 ________
Trans 2 ________
Trans 3 ________
Trans 4 ________
Trans 5 ________
AVE ________

CONTINUE

Appendix C: Photo Monitoring Equipment

Contents

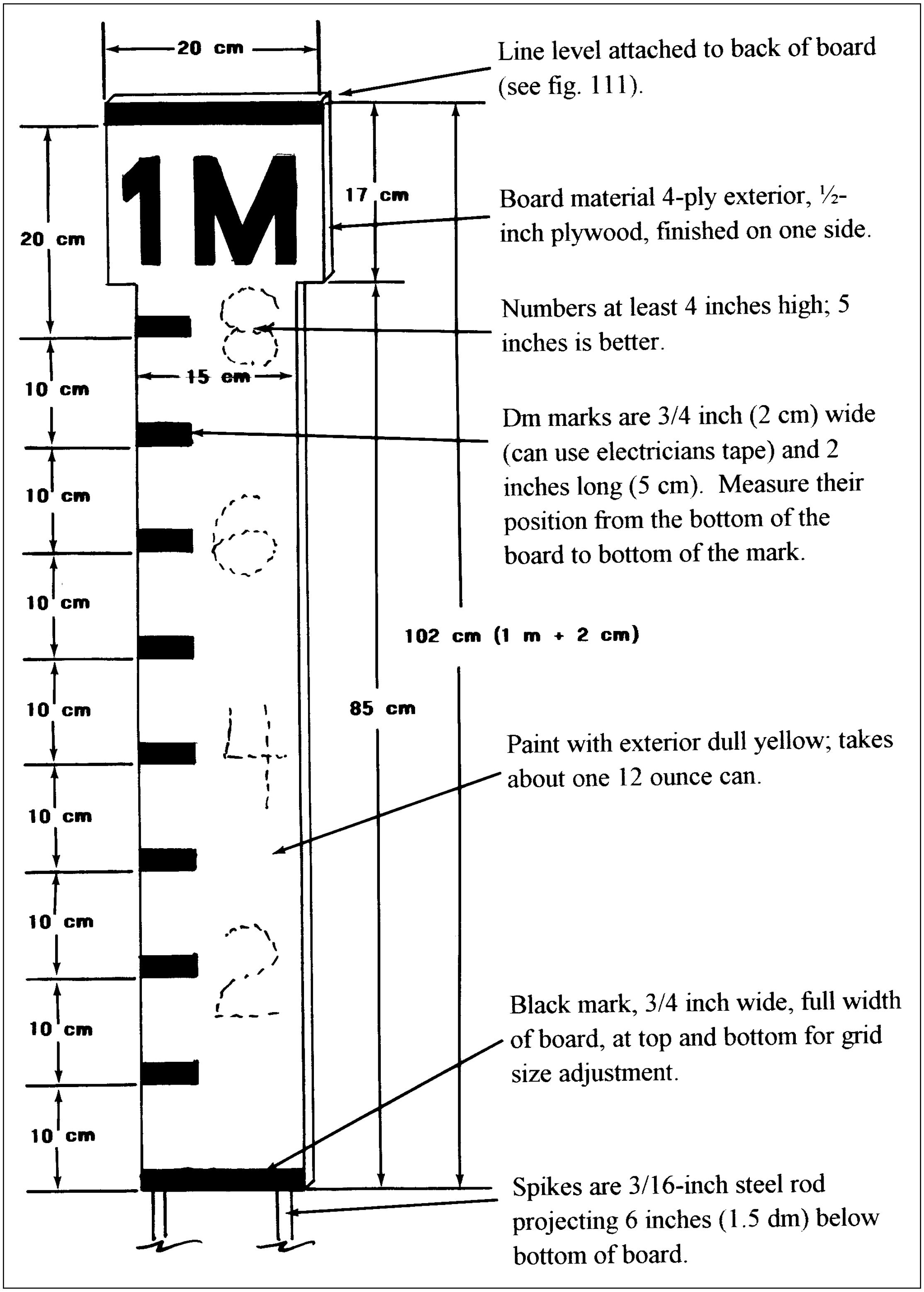


Figure 110—Construction details of a 1-m-tall meter board. The same measurements are used for the 1-m-tall folding board and for the 2-m folding board.

Meter Boards

Meter boards are used to mark photo points. They help in taking consistent repeat photographs if the camera is oriented on the “1M” of the board. Sharp exposure at the meter board is assured by focusing the camera on the “1M.” Meter boards also provide a size control in photographs that can be used to adjust the analysis grids when measuring the attributes shown in a photo. This section described how to construct meter boards.

One-Meter Board

Materials	Cost[1]
	Dollars
1 piece 1/2-in 4-ply exterior or marine plywood,	
finished on one side, 1 by 4 ft @ $20/sheet	3
1 steel rod 3/16-in diameter, 36 inches long	1
Numerals:	
1 packet adhesive-backed numerals,	
5-1/4 in tall, on a reflector, (need numbers 1, 2, 4, 6, 8)	4
(Alternative is 4-in nail-on numbers, 5 @ $2/numeral)	(20)
1 4- to 5-in-long line or pocket level	4
1 16-oz can dull yellow spray paint, exterior	4
Screws:	
2 #4 5/8-in line level screws	
9 #6 3/4-in spike plate screws	1
A few feet of black electricians tape	1
Total	18

Meter boards are constructed from 1/2-in, 4-ply plywood, at least exterior quality and preferably marine quality (waterproof glue). Waterproof glue is desirable when sampling riparian areas because the meter board often will be placed in water. (Dimensions and layout are shown in fig. 110). Cut out according to the measurements shown in figure 110.

Prime the front of the board before painting. Then apply two coats of dull, textured, yellow paint to reduce reflection from the sun. Yellow is used for visibility. If dull yellow paint is not available, do not sand or smooth the front of the board. Unsanded roughness causes the paint to be rough, thus reducing glare. Most of the 12-oz pressure can will be required for two coats.

[1] Prices given are approximate as of 2000.

The numerals 2, 4, 6, and 8 should be black and at least 4 in tall. For good readability in projected slides, 5 in is even better. All illustrations in this publication show 5-in numbers. There are many sources for these, including paste-on numbers, numbers on a card that must be cut out, and nail-on numbers. I use 5-1/4-in-tall numbers on a reflective card with adhesive back. Each number must be cut out and applied to the painted surface. The “M” in “1M” is made from electricians tape, or it may be painted on.

Black marks at each decimeter and bands at top and bottom may be applied in one of two ways: paint them on at 2 cm wide or use black electricians tape, which is 3/4 in wide (1.8 cm). The top, bottom, and decimeter marks are used to adjust grid size before grid analysis of items in the photographs. Location of the marks on the meter board therefore must be positioned precisely (fig. 110).

A line level is attached to the back of the board at the top (fig. 111). This allows the board to be oriented vertically, which is essential for grid analysis, and it makes pictures look good.

Steel spikes are attached to the bottom of the board (fig. 112) to hold it in the ground. Steel rod, 3/16-in diameter, works well because it is strong enough to hold the board upright and small enough in diameter to be pushed into rocky soil. Spikes should extend 6 in below the bottom of the board (fig. 112). Rods come in 36-in lengths. About 30 in is required. Bend the rod into a “U” shape to match the dotted outline in figure 112.

For convenience, a carrying handle may be attached to the edge of the board near the 5-dm position.

Two-Meter Folding Board

Two-meter boards are used when shrubs or other vegetation exceeds the height of a 1-m board (fig. 113). They are, very simply, two single-meter boards attached by hinges and a barrel bolt so that either the 1-m or 2-m length may be used.

Figure 111—Aline level is used to orient the board vertically. Obtain a 4- to-5-in-long line level and drill a hole in each end for a screw. Attach one end of the line level to the back of the meter board ½ in (1 cm) from the top. Then orient the board vertically by using a carpenters level along one side. Hold the board in position, adjust the line level to horizontal, and carefully screw in the other end.

Materials	**Cost** *(see footnote 1)*
	Dollars
2 pieces 1/2-in 4-ply exterior or marine plywood, finished on one side, 1 by 4 ft @ $20/sheet	6
1 steel rod 3/16-in diameter, 36 in long	1
Numerals:	
2 packets adhesive-backed numerals, 5¼ in tall, on a reflector, (need 2 each of 1, 2, 4, 6, 8)	8
1 4- to 5-in-long line or pocket level	4
2 16-oz cans dull yellow spray paint, exterior	8
2 strap hinges, 4-in size, heavy duty	5
1 barrel bolt, 5-in size, heavy duty	8
Screws:	
2 wood screws, #4 5/8-in line level screws	
9 #6 3/4-in spike plate screws	
1 #10 1/2-in sheet metal screw, for below the barrel bolt (sheet metal needed for hardness);	
2¾-in washers	
10 #10 1-in hinge wood screws	
8 #10 1/2-in barrel bolt wood screws	2
Several feet of black electricians tape	1
Total	43

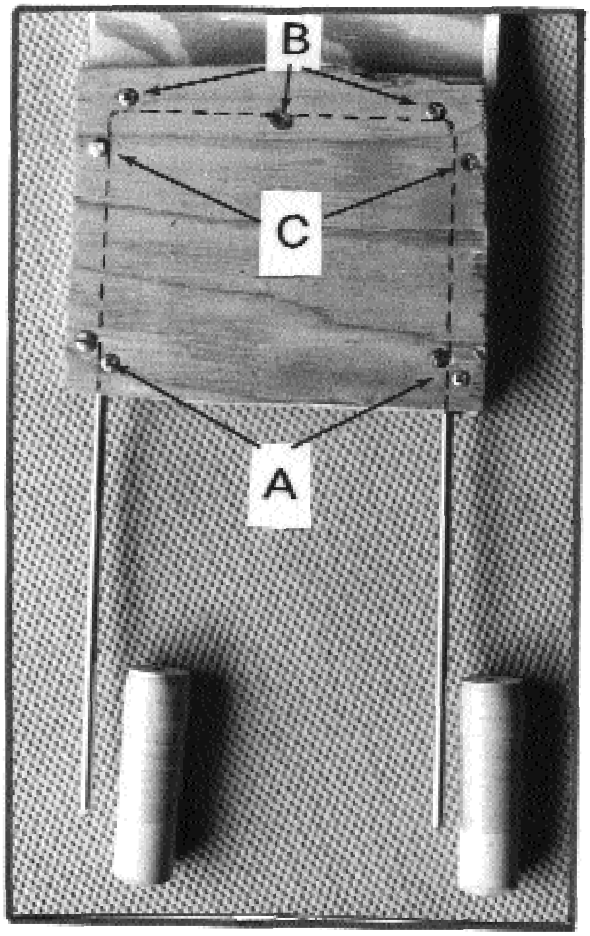


Figure 112—Spikes in the bottom of the board are pushed into the ground to hold the board upright. Use a 3/16-in diameter steel rod about 30 in long. Bend it into a U-shape as shown by the dotted line. It is placed under a plywood plate and held in place by nine screws. Leave about 6 in (1.5 dm) of rod below the board. Screws are positioned to hold the rod in place. (**A**) Insert a screw on each side of the rod at the bottom. (**B**) Insert three at the top to prevent upward and downward movement of the rod. (**C**) Place one at each side at top to prevent sideways movement. Drill out doweling to fit over the spikes for safety.

Figure 113—Use of a folding 2-m board to document height and growth of tall shrubs. This board is hinged in the middle and held upright by a barrel bolt. When folded together (fig. 109), it functions as a 1-m board. Here, the board has been unfolded to 2 m.

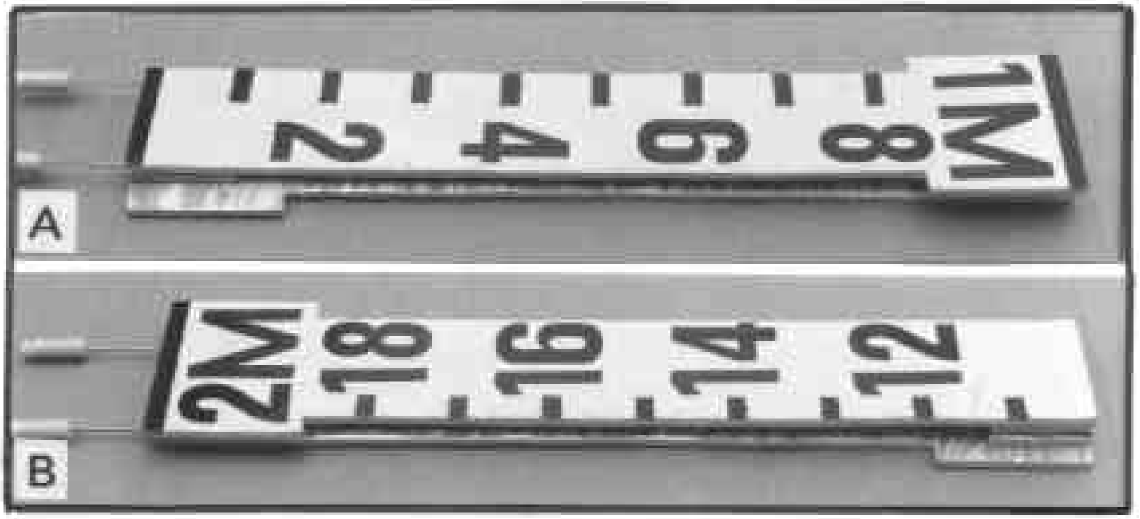


Figure 114—The 2-m board system. (**A**) Standard 1-m board with the top half folded underneath. (**B**) The folded board has been turned over to show the 2-m section.

Construct two 1-meter boards as discussed previously. On the first, construct with spikes at the bottom and numerals as shown. On the second, use “2M” at the top instead of “1M,” and add numeral “1” to each of the decimeter numbers as shown in figures 113 and 114. The numeral “1” can be made from electricians tape.

Figure 115 illustrates the hinge, barrel bolt, and position of the line level between the two halves of the meter board. Proceed as follows:

1. Refer to figure 115. Attach hinges (A) to plywood the same thickness as the barrel bolt and glued to both halves of the meter board. The 5-in bolt shown in figure 115 required 3/8-in plywood. These plywood blocks raise the meter board halves so that the barrel bolt will clear both its connecting strap (B) and the line level (D) when folded. Attach the hinge straps to the top board first. Then use a straight edge to align both halves in a straight line. Finally, attach the bottom straps to the bottom board while firmly holding both halves together.

2. Install the barrel bolt next. Position the barrel bolt at the very bottom of the upper meter board so the bolt drops down when the boards are erected. Place the barrel bolt strap (B) as close to the top of the bottom board as possible without the screws splitting the wood. The bolt should protrude about 3/8 in below the strap (figs. 115C and 116A). Insert a sheet metal screw and sufficient washers under the bolt end to hold it firmly against the strap to prevent flexing when the boards are unfolded (fig. 116B).

3. Position the line level on the bottom (1-meter) board where it can be seen from above when the boards are folded for 1-meter use, and from the back when unfolded for 2 meters (fig. 115D). The line level can be seen when the boards are folded by looking down through the strap holding the barrel bolt when it drops.

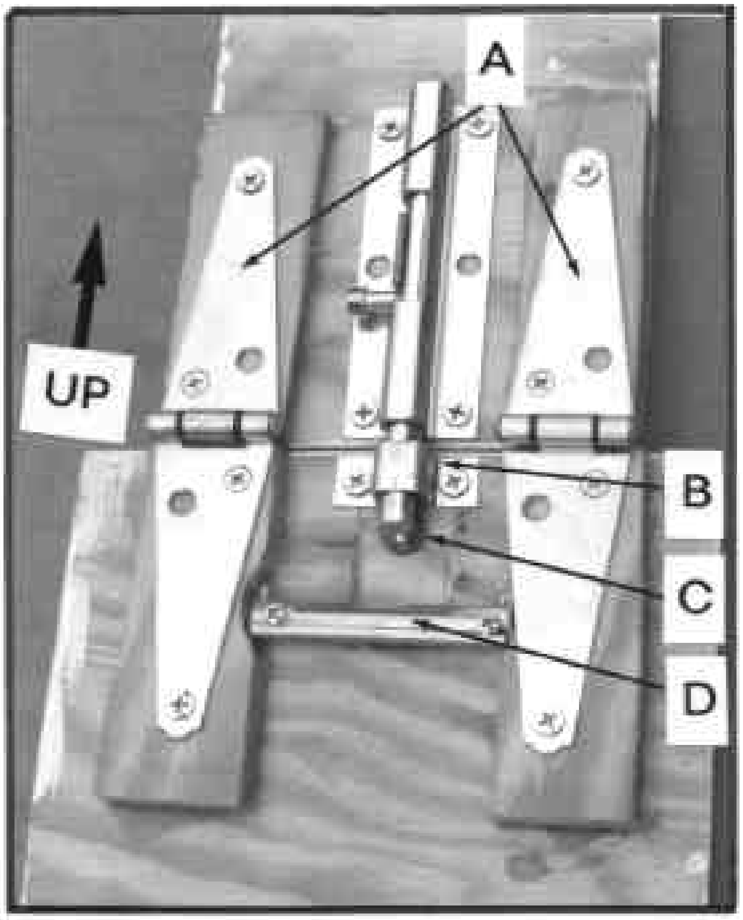


Figure 115—Hinges and a barrel bolt connect the halves of the 2-m board. (**A**) When installing hinges, attach to the top board first, carefully align the boards in a straight line, and then attach the lower straps of the hinges. (**B**) The barrel bolt should be oriented to fall down when the board is unfolded. Position the bolt and its strap at the edges of the board halves so that the bolt protrudes about 3/8 in below the strap. (**C**) Install an adjusting screw (fig. 116) to tighten the barrel bolt against its strap and stiffen the two boards when unfolded. (**D**) A line level is placed an inch below the barrel bolt on the lower board half such that it can be viewed from above when folded and from behind when unfolded, as shown.

Figure 116—Adjusting screw and washer used to remove play between the barrel bolt and its strap, which will stiffen the two halves when unfolded. (**A**) Measure the distance between the bolt and the board. (**B**) Insert a round-headed sheet metal screw with enough washers to make the bolt fit firmly under the flange. Sheet metal screws are preferred because of their hardness. Pound the flange down if necessary.

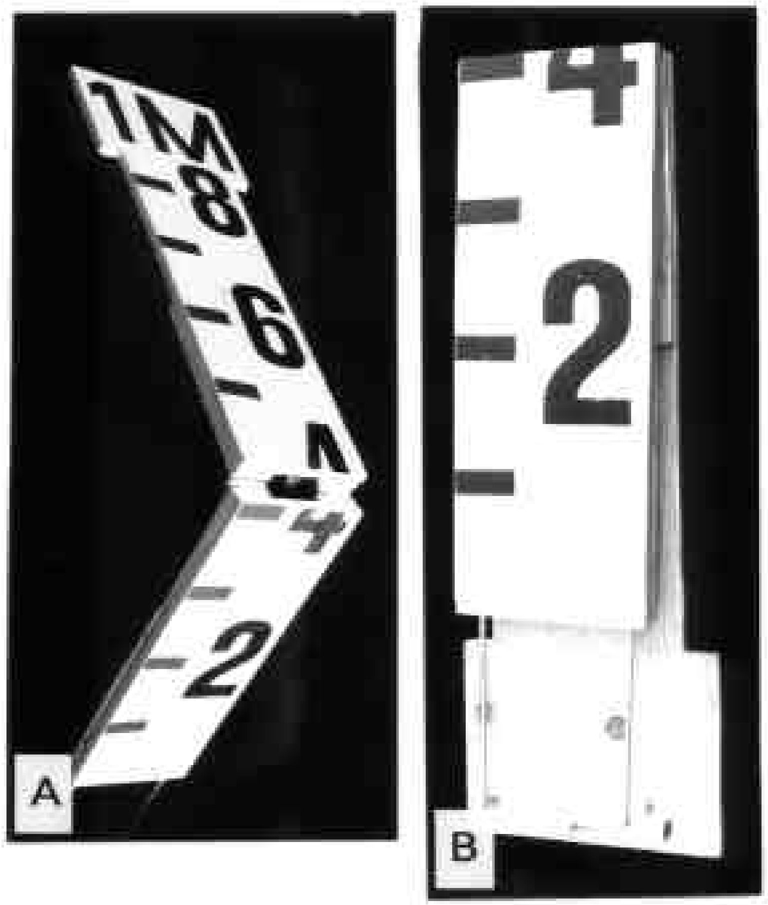


Figure 117—Folding 1-m board specifications. (**A**) Cut a standard 1-m board at 4 dm and install hinges and a barrel bolt. This offset is used to protect the spikes (**B**). Assemble the board before painting and application of decimeter marks to assure correct measurements.

One-Meter Folding Board

If field transportation of a meter board is a concern, the 1-meter board can be made to fold. The hinge system is described and shown in figures 115 and 116. Figure 117 illustrates dividing the board at 4 dm to provide protection for the spikes.

Photograph Identification-Sheet Holder

Each photograph taken in photo monitoring should be identified. Plot photographs are identified by a form attached to a clipboard and placed within view of the plot form. General and topic photos taken of the meter board are identified by a form attached to a clipboard and positioned between the camera and meter board. Making the clipboard and a post to hold it are described.

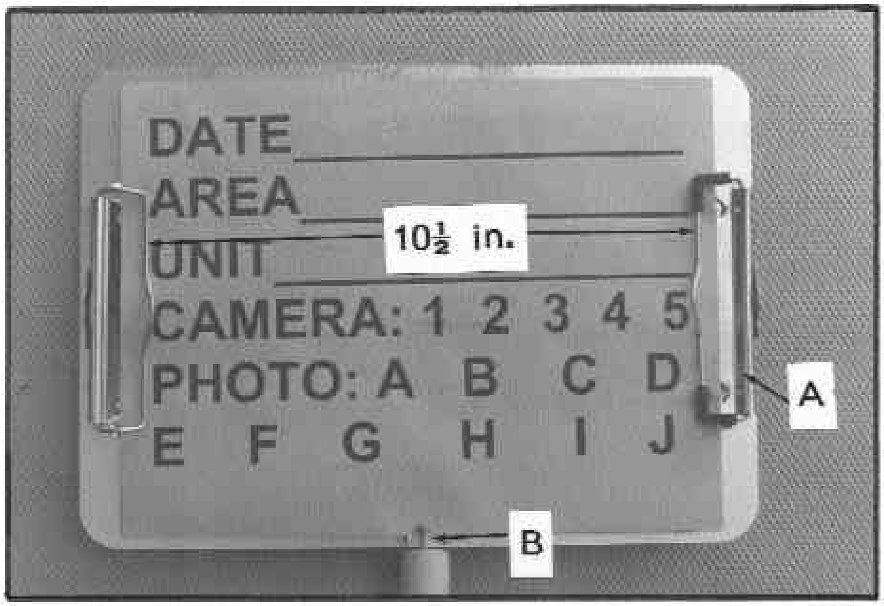


Figure 118—Clipboard for displaying photo identification forms. A second clip (**A**) is taken from another clipboard and either screwed or riveted to this clipboard. Distance between the clipboard clips should be 10½ in to do two things: (1) hold the sheet in windy conditions and (2) not cover essential information. The clipboard is placed on the ground for plot photos or on top of a clipboard post (see fig. 119) to be set in front of the camera. When placed on the post, a screw (**B**) is inserted into the wooden block holding the ¼-in rod behind the clipboard (see figs. 119 and 121) to prevent the clipboard from rotating in the wind.

The clipboard is shown in figure 118. It is a standard 12-in clipboard with the addition of a second clip removed from another clipboard and attached by rivets or screws as shown. The critical factor is to place the clips no closer than 10½ in to avoid covering any information on the identification paper. Two clips are required to prevent the identification sheet from blowing in the wind.

Materials *(see footnote 1)*	**Cost**
	Dollars
2 clipboards 12 in long @ $4.50/each; second clipboard for its clip	9
6 1/8-in diameter bolts or rivets to attach the second clipboard clip and straps for the clipboard post	1
2 1/4-in line guides or straps	1
Total	11

Remove the clip from the second clipboard and attach it to the first board with either two bolts or two rivets.

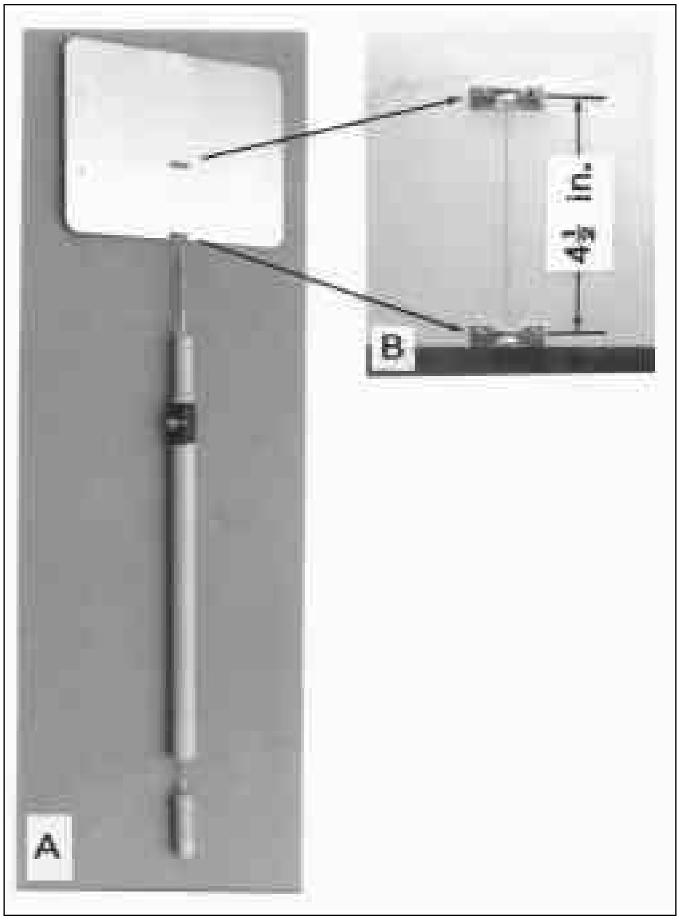


Figure 119—The clipboard post (**A**) in its compressed position ready to be inserted into the straps behind the clipboard. The ¼-in rod slides into two ¼-in straps on the clipboard. (**B**) These straps are positioned 4½ in apart and riveted (as shown) or bolted to the clip board with 1/8-in rivets or bolts.

Figure 119 shows the clipboard post in its compressed position. Two straps capable of having a 1/4-in diameter rod inserted are attached to the back of the clipboard in the middle, as shown. They are centered 6 in from each end and placed 4½ in apart so that the 5-in rod will engage each (fig. 119B).

The clipboard post is an adjusted pole, 1 in in diameter, with a spike on one end to push in the ground and a telescoping inside pole with a rod at the other end to which the clipboard is attached (fig. 119A). It is composed of telescoping plastic pipes each 18 in long (fig. 120A). It is 22 in long when compressed and 32 in long when extended (fig. 120B). An adjustable hose clamp is attached to the upper end of the larger pipe so that it may be compressed around the inside pipe to hold it in place (fig. 120).

Materials	**Cost** *(see footnote 1)*
	Dollars
1-in CL 200 PVC pipe @ $1/10 ft	1
3/4-in CL 200 PVC pipe @ $1/10 ft	1
1-in diameter hose clamp	1
1/4-in diameter, 36-inch steel rod; piece, cut two 7-in pieces`	1
Several feet of black electricians tape	4
Total	8

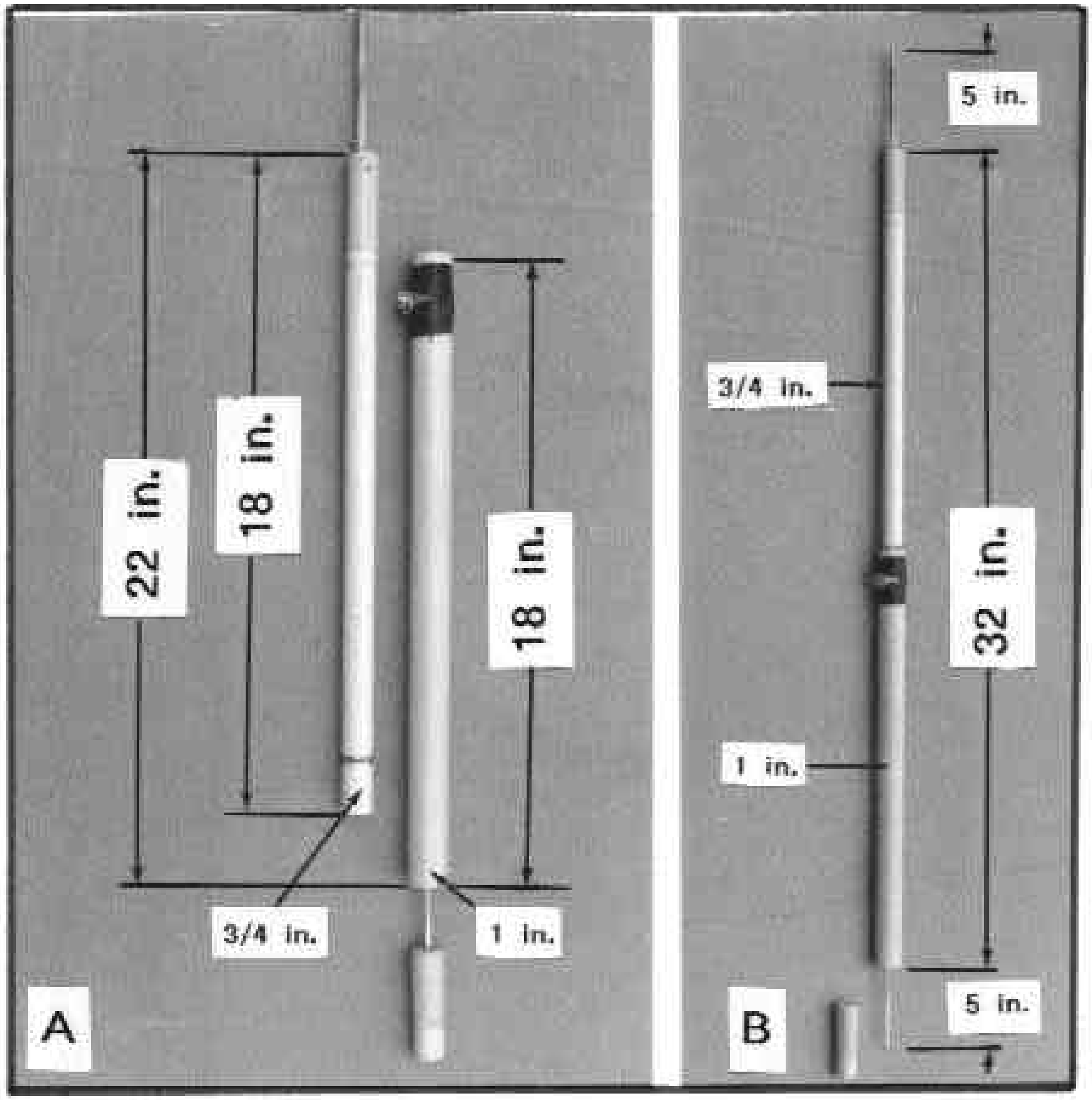


Figure 120—Details for constructing the clipboard post. (**A**) The 1-in PVC pipe CL200 and ¾-in PVC pipe CL200, which fits inside the 1-in pipe, are each 18 in long. When the ¾-in pipe is inserted into the 1-in pipe and compressed, they are 22 in long. (**B**) The 18-in inside pipe has been extended 14 of its 18 in, for 32 in. The ¼-in diameter spikes at the bottom and top both extend 5 in beyond the pipe and are imbedded into doweling inserted in the pipe.

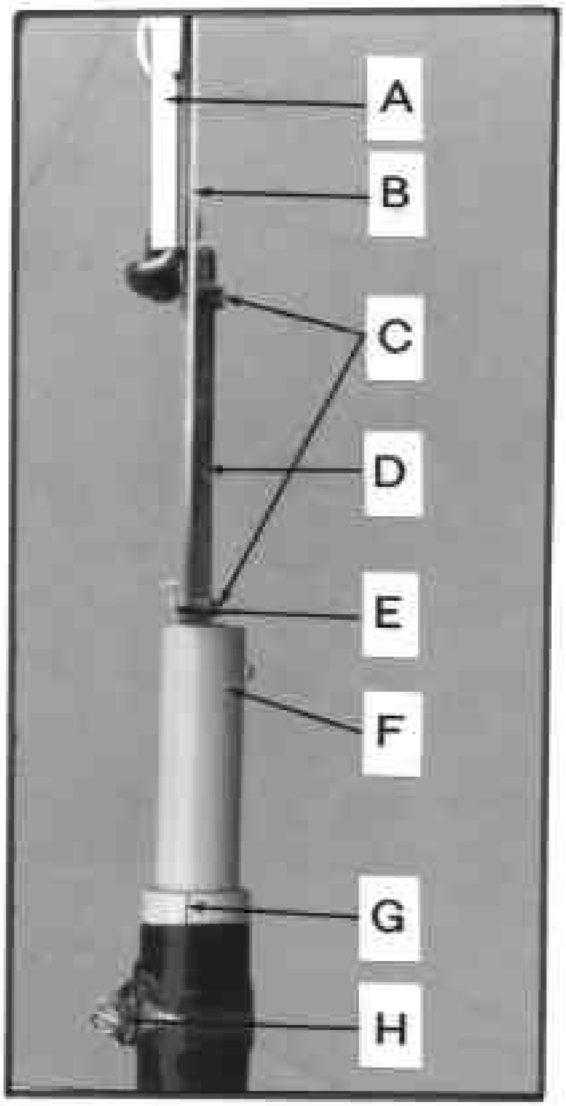


Figure 121—Details of how the clipboard is placed over the rod as viewed from the edge of the clipboard. (**A**) The clip of the clipboard. (**B**) The edge of the clipboard, in this case an aluminum board. (**C**) The ¼-in straps into which the ¼-in rod of the post is inserted. (**D**) The ¼-in rod of the post inserted into the clipboard straps. (**E**) A screw inserted into the wood doweling to hold the ¼-in rod, which prevents the clipboard from rotating in the wind (see fig. 118). (**F**) A piece of doweling fitted inside the ¾-in PVC pipe, which is drilled out for a ¼-in steel rod and held in place by a screw. (**G**) A sawcut 2 in into the 1-in PVC pipe so that the pipe can be compressed by the hose clamp (**H**) to hold the inside pipe at the desired height. At H, the hose clamp is secured with electricians tape.

The clipboard post is composed of two parts (fig. 121). One is 1-in CL 200 PVC pipe and the other is 3/4-in CL 200 PVC pipe, both 18 in long. The 3/4-in pipe fits inside the 1-in pipe with some slack. If pipe specifications other than these are used, be sure that one pipe will fit inside the other. When compressed, the clipboard holder is 22 in tall. When extended with 4 in of pipe inside, it is 32 in tall (fig. 120B).

To make the clipboard post adjustable, saw down 2 in into the end of the 1-in pipe (fig. 121G). Attach a 1-in hose clamp an inch below the top of the pipe and secure it with electricians tape (fig. 121H). Tighten the hose clamp so that the inside 3/4-in pipe can just be moved up and down to adjust height of the clipboard above vegetation or other obstructions.

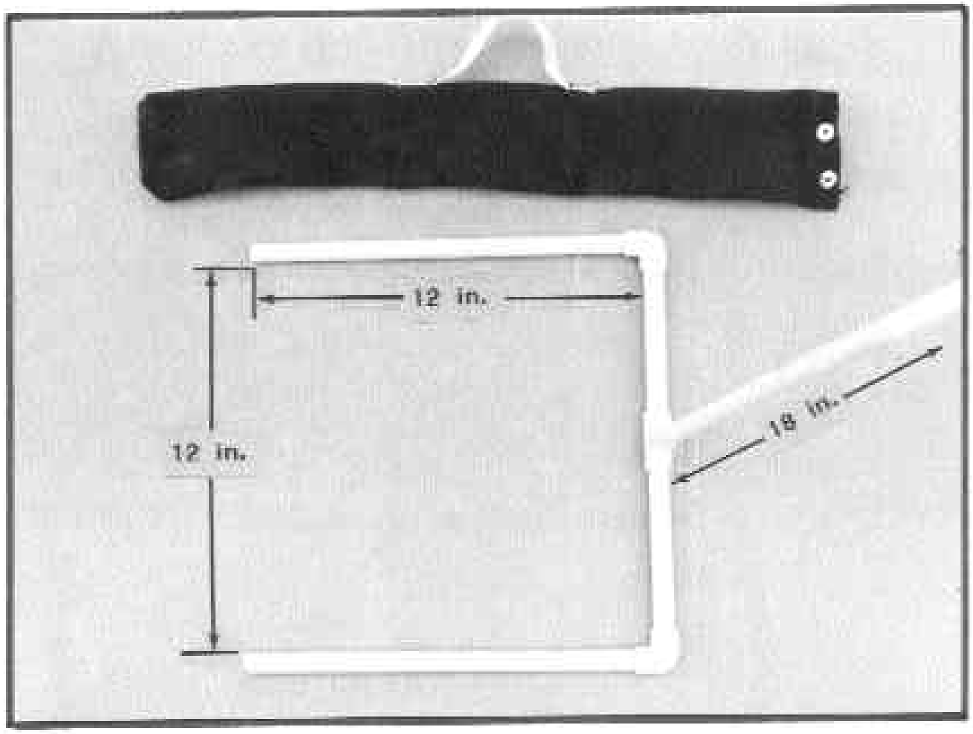


Figure 122—The 1-ft^2 sampling frame is made from ½-in PVC pipe. Inside measurement is 12 in square. The side opposite the handle is open to facilitate placement in shrubby vegetation. An 18-in-long handle facilitates placement of the frame.

One-Square-Foot Sampling Frame

The 1-ft^2 sampling frame is used with stereo photographic sampling. It is constructed from 1/2-in-diameter PVC pipe and measures 12 in square (fig. 122). An 18-in-long handle reduces effort when placing the frame.

Materials	**Cost** *(see footnote 1)*
	Dollars
1/2-in-diameter PVC pipe, 10 ft long @ $3/piece	3
2 90-degree, 1/2-in PVC elbows; 1 1/2-in PVC "T"	1
Total	4

Consider not cementing the elbows to the pipe so that the frame can be taken apart to transport. Figure 123 shows the frame disassembled with its carrying case. The case is made from canvas with a handle and two snaps at the open end.

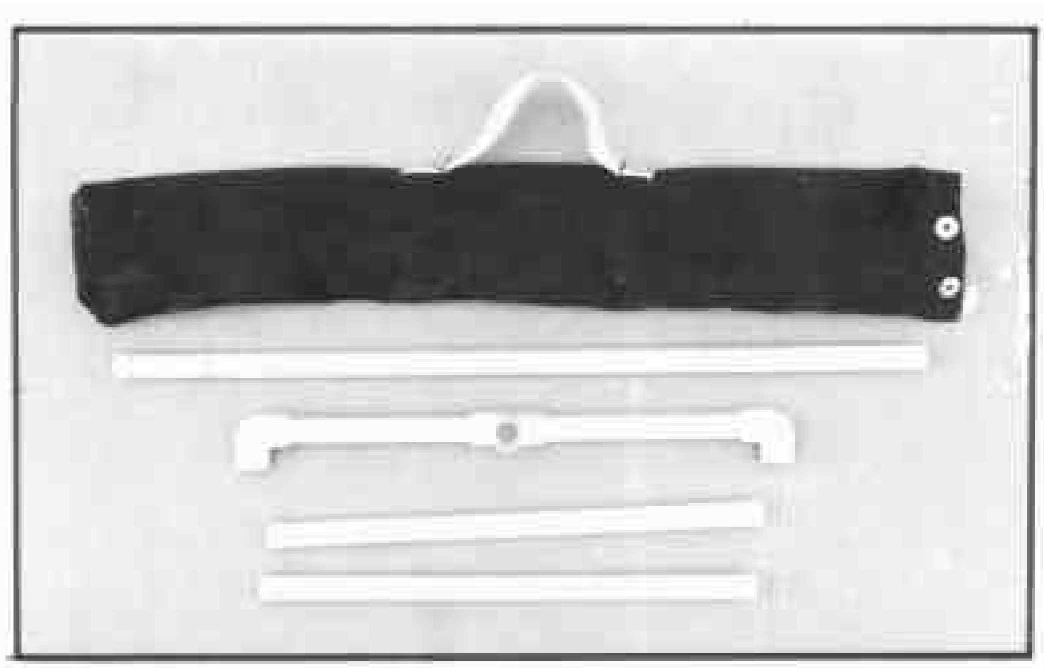


Figure 123—A1-ft^2 sampling frame disassembled with its carrying case. The case is made from canvas with a handle and two snaps at the open end.

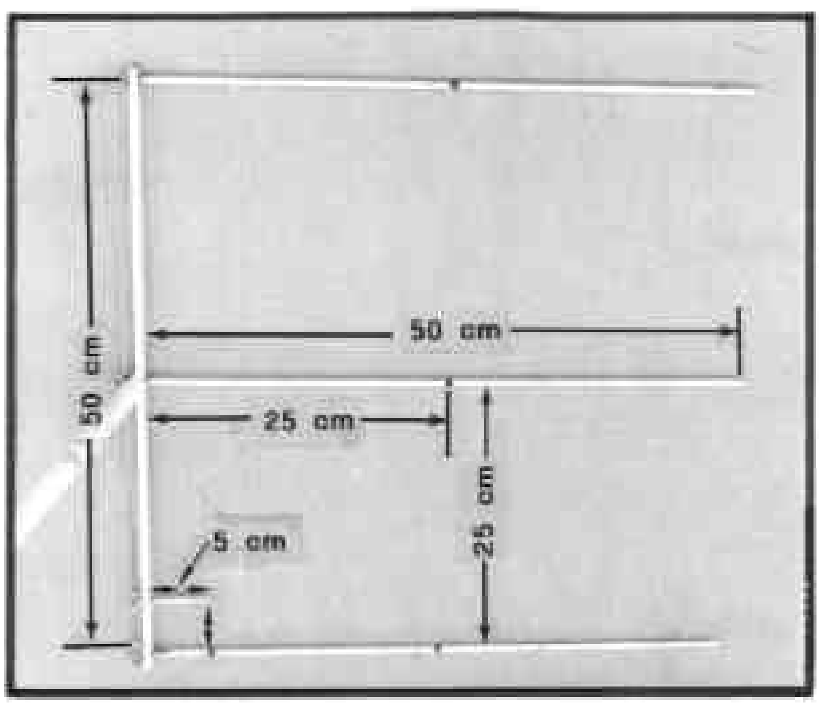


Figure 124—Nested frequency plot frame specifications. Measurements shown are inside dimensions. The four prongs must be cut 2 cm longer to provide for threading the ends and the aluminum back piece must be cut 2 cm longer to provide for ¼-in tapped drill holes for the edge prongs.

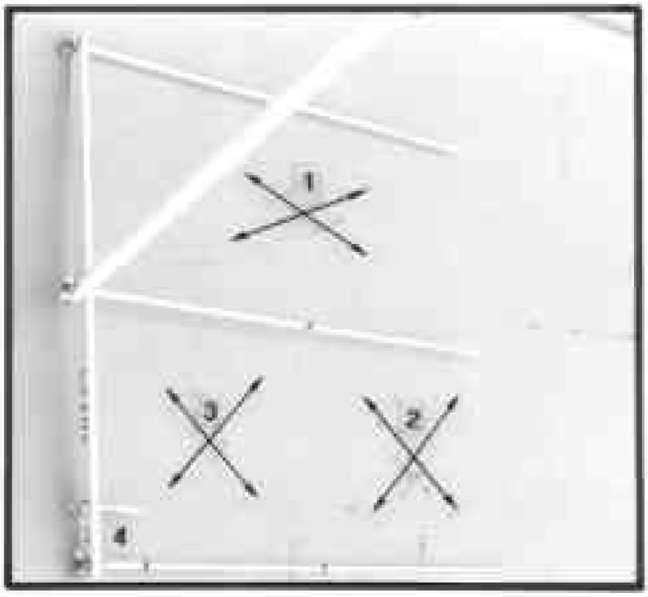


Figure 125—Plot locations in the nested frequency plot frame. The smallest is rated “4,” next largest a “3,” half the plot frame is rated “2,” and the rest a “1.” Plants rooted in each section are given the assigned rating, which is recorded by species.

Nested Frequency Sampling Frame

Nested frequency is a sampling system designed for low variability rates among observers; it is based on statistical analysis to detect change. A plot frame, 1/2-m square, with four sizes of nested plots is used (fig. 124). Species are recorded and given a value when rooted within any of the four subplots.

Values are assigned based on plot size (fig. 125). Species numerous enough to fall within the smallest subplot are rated highest to reflect their greater density. Species are recorded starting with the smallest subplot (4) and proceeding to larger subplots. Once a species is recorded, do not repeat its presence in a larger subplot.

Figure 124 specifies plot dimensions. Please note length requirements in the materials list below. The steel rods must be cut 2 cm longer so they can be threaded and screwed into the aluminum back piece. The aluminum back piece must be 2 cm longer than the dimensions shown in figure 124 to accommodate tapped holes for the outside rods.

Materials	**Cost** *(see footnote 1)*
	Dollars
1 tap and die set for 1/4-in steel rod	(borrowed)
3 1/4-in steel rods, 36 in long:	
3 pieces cut 52 cm long, threaded for 2 cm (effective length 50 cm)	
1 piece cut 7 cm long, threaded for 2 cm (effective length 5 cm)	3
1-in by 1/4-in aluminum bar stock cut 52 cm long @ $10/6 ft (drill and tap 4 holes, each 1/4-in diameter, at 1, 6, 26, 51 cm)	4
5 wing nuts for 1/4-in threaded steel rod	1
PVC pipe 1/2-in diameter SCH40 cut 50 cm long, @ $3/10 ft	1
Total	9

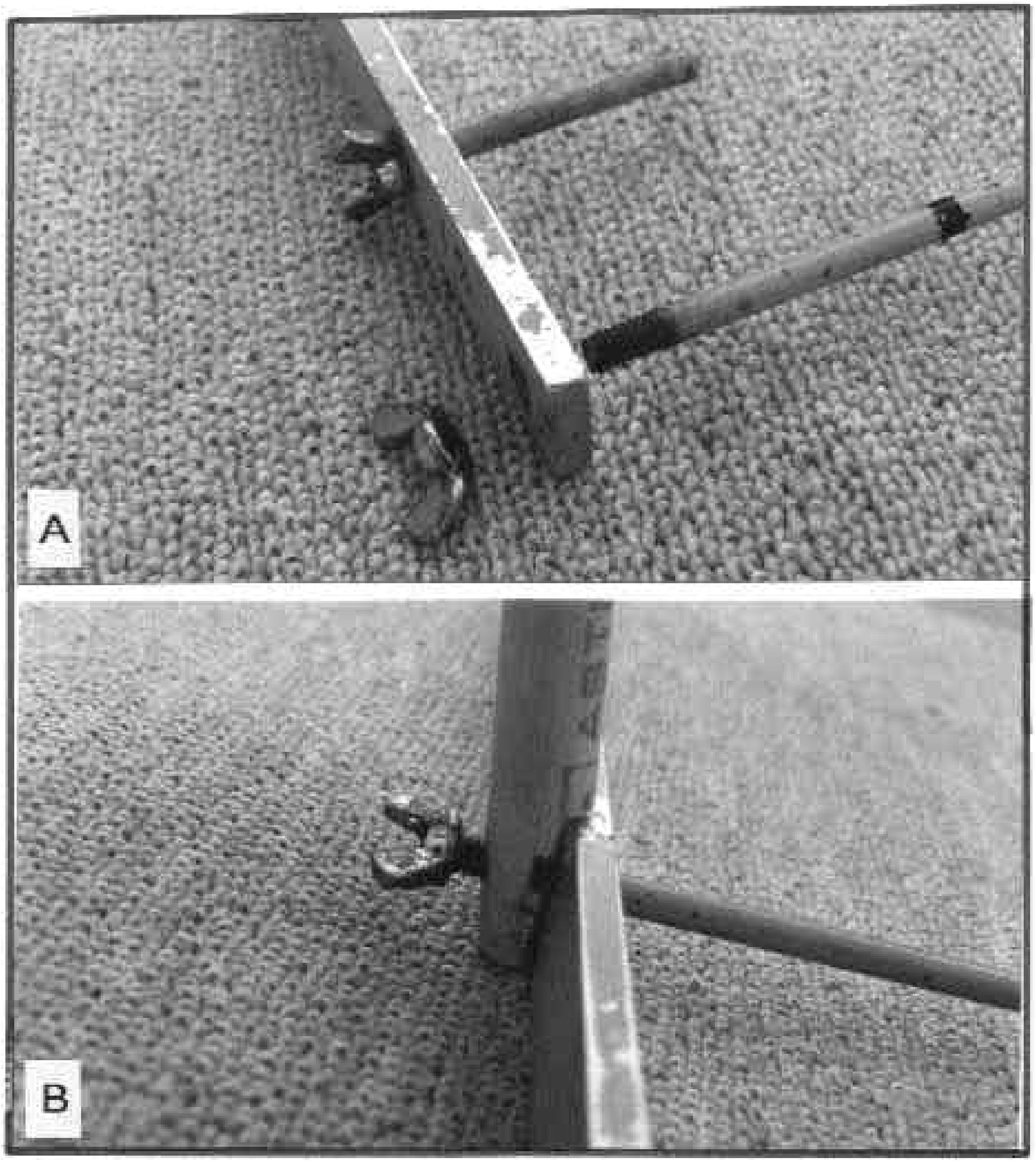


Figure 126—Method for attaching the nested frequency prongs to the 1-in by ¼-in aluminum back piece. (**A**) A 50-cm prong is shown threaded and ready to screw into the aluminum back piece. Next to it is the 5-cm-long prong attached. The 5-cm subplot is identified by the black mark on the 50-cm prong and the end of the 5-cm prong. (**B**) The center 50-cm prong is shown screwed into the aluminum back piece and through the 50-cm handle, with a wing nut ready to tighten the handle to the back piece.

Sharpen the ends of the four prongs to a 45-degree angle. These points are where ground cover items are recorded, such as bare ground, gravel, or rock.

Screw the threaded rods into the aluminum back piece (fig. 126A). Secure the rods with wing nuts. Be sure the measurements shown in figure 124 are met.

The 50-cm PVC handle is cut out and attached (fig. 126B). Cut one-third of the way through the pipe 1 in above its end to fit over the aluminum back piece. Then, from the bottom and starting in the center, cut at an angle to the upper cut. Finally, drill a 1/4-in hole to match the hole at 26 cm in the aluminum back piece (fig. 126B). Assemble as shown in figure 126B.

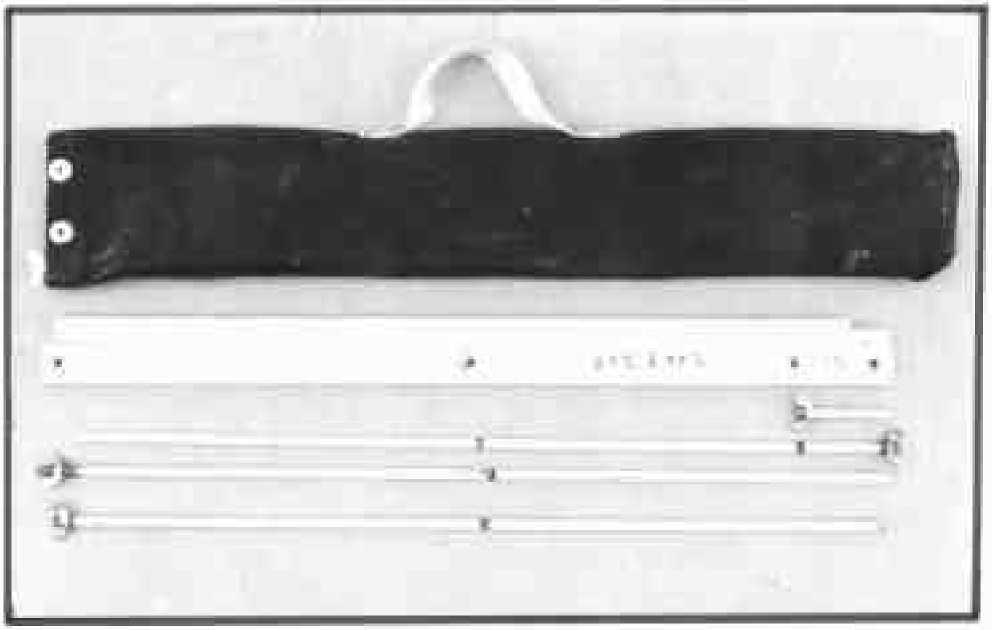


Figure 127—The disassembled nested frequency plot frame is shown with its carrying case. Notes on the aluminum back piece show percentage of the plot frame occupied by the 25- by 25-cm subplot (25 percent), 25- by 50-cm subplot (50 percent), and the 5- by 5-cm subplot (1 percent).

Paint the frame with dull yellow paint. When dry, paint the black marks at 5 and 25 cm on one prong and at 25 cm on the other prongs. These marks identify the various subplots sizes shown in figures 124 and 125.

The plot frame may be disassembled for carrying as shown in figure 127.

One-Square-Meter Sampling Frame

One-square-meter photo plot frames are designed to replace Parker's (1954) three-step method using a 3-ft by 3-ft plot frame. Both are used in photographs taken at an oblique angle. His plot frames were made from two 6-ft folding rulers, the joints of which could be used to draw a grid on a photograph. This 1-m^2 frame is marked off in 2-dm increments (fig. 128).

Materials	**Cost** *(see footnote 1)*
	Dollars
3/4-in SCH40 PVC pipe @ $2/10 ft, 2 required	4
90-degree 3/4-in PVC corners SCH40, 4 required	2
4 by 8 inch, 1/2-inch thick scrap plywood	(scrap)
2 screws #6, 1 in long	
Several feet of black electricians tape	4
Total	10

Cut the 3/4-in PVC pipe into four 1-m lengths (fig. 128A). Be precise because the pipes, when inserted into the elbows, fit at exactly the elbow corner. Do not glue the pipes to the elbows. The frame will be adequately stable with the pipes simply pushed into the elbows and then can be broken down for transport (fig. 128B).

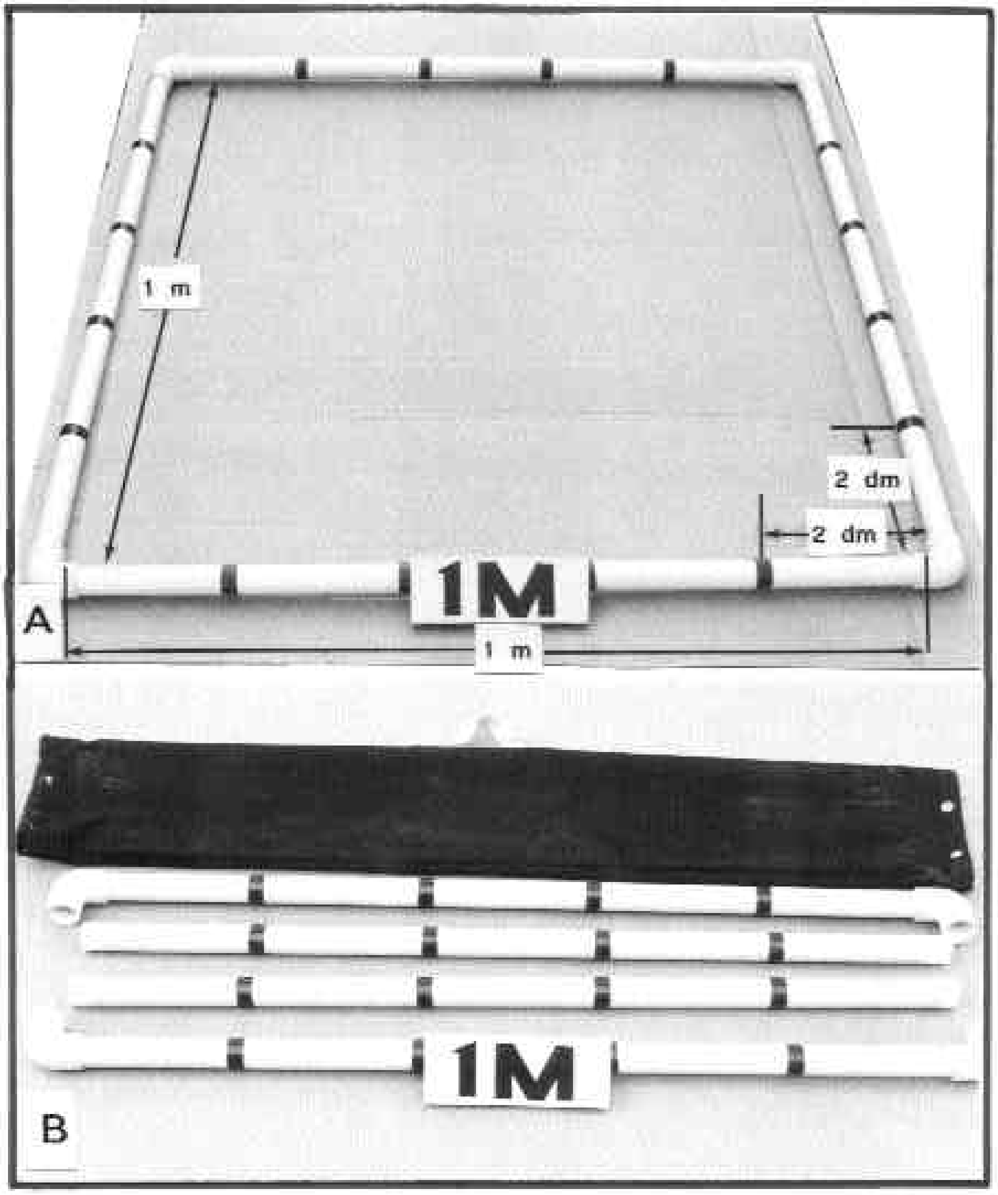


Figure 128—The 1-m^2 plot frame (**A**) is marked off in 2-dm increments. Inside measurements are 1-m per side. The ¾-in pipe may be measured precisely and inserted into the elbows because the elbows have a stop at the exact position of the elbow bend. Do not cement the elbows to the pipe because the plot frame can be disassembled for easy transport in its canvas carrying case (**B**).

Next, measure out 2 dm on all four pipes and circle the pipe at these locations with electricians tape to mark a 2-dm grid system (fig. 128).

In figure 128, a 1/2-in-thick piece of plywood measuring 4 by 8 in (1 by 2 dm) has been attached to identify the meter plot frame. The "1" and "M" are made with 3/4-in-wide electricians tape. The plywood is attached with two screws through the board and into the PVC pipe. I use the identification for slide talks to quickly identify the size of plot frame.

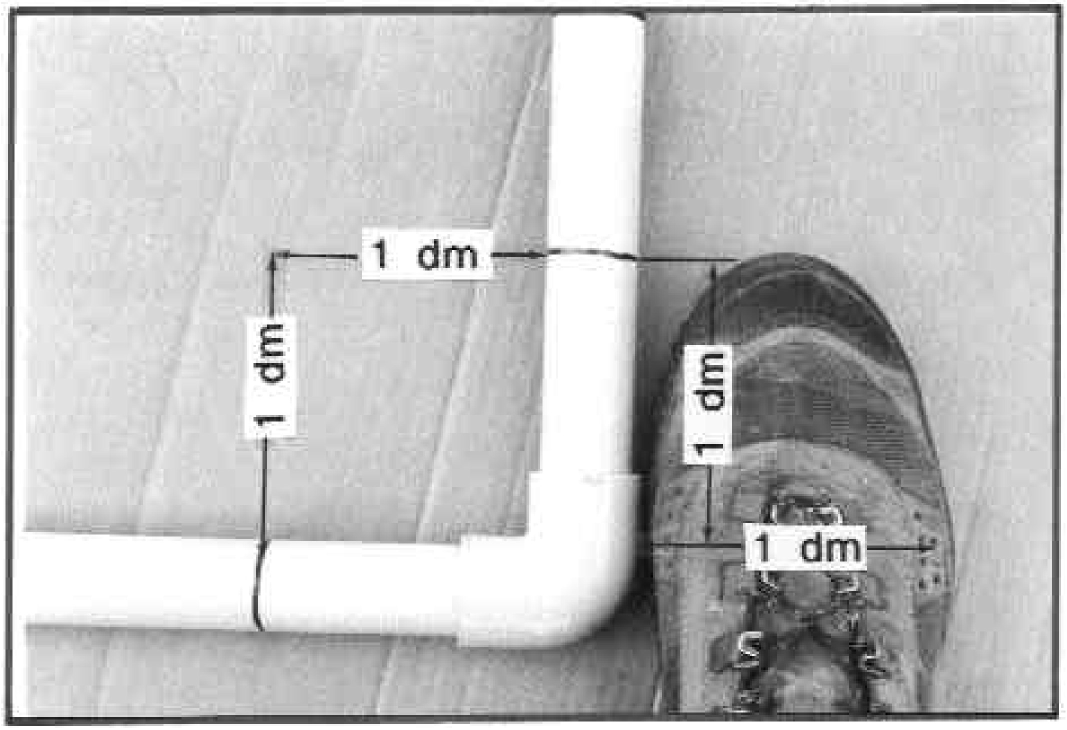


Figure 129—Amethod is shown for estimating small increments of cover. In a 1-m^2 plot frame, 1 dm^2 is 1 percent cover. This represents about the front one-third of my foot. Because a 1-m^2 plot is 3.4 feet on a side, each large step represents 1 percent cover so long as the cover is represented by each and every step. An area 2 by 2 dm is 4 percent cover, about 1.3 of my foot. I now have a measuring system for estimating cover of items I encounter while walking across an area.

Figure 129 reflects a system I have found useful in estimating cover of vegetation or soil surface items. An area 1 dm by 1 dm is 1 percent of a square-meter plot. A square-meter plot, being 3.4 ft on a side, is a little longer than the stride of a person about 6 ft tall. The front one-third of my foot is about 1 by 1 dm (fig. 129). Therefore, each time I take a long step, any vegetation that covers the front one-third of my foot is 1 percent of the cover. But the vegetation must approximate that area for *each and every step*. If it does not, then canopy cover of that item is less than 1 percent.

Each 2-dm area is 4-percent cover, a little more than one of my whole feet. Thus, when walking through an area, I have some reasonably firm idea of how to estimate cover of various items.

Robel Pole Sampling System

The Robel pole (Robel and others 1970) offers a way to document stubble height of herbaceous vegetation. They tested various systems for observing stubble height and settled on a pole marked in 1-in increments and set 4 m from an observation position 1 m high. Figure 130 shows specifications for making the Robel pole system.

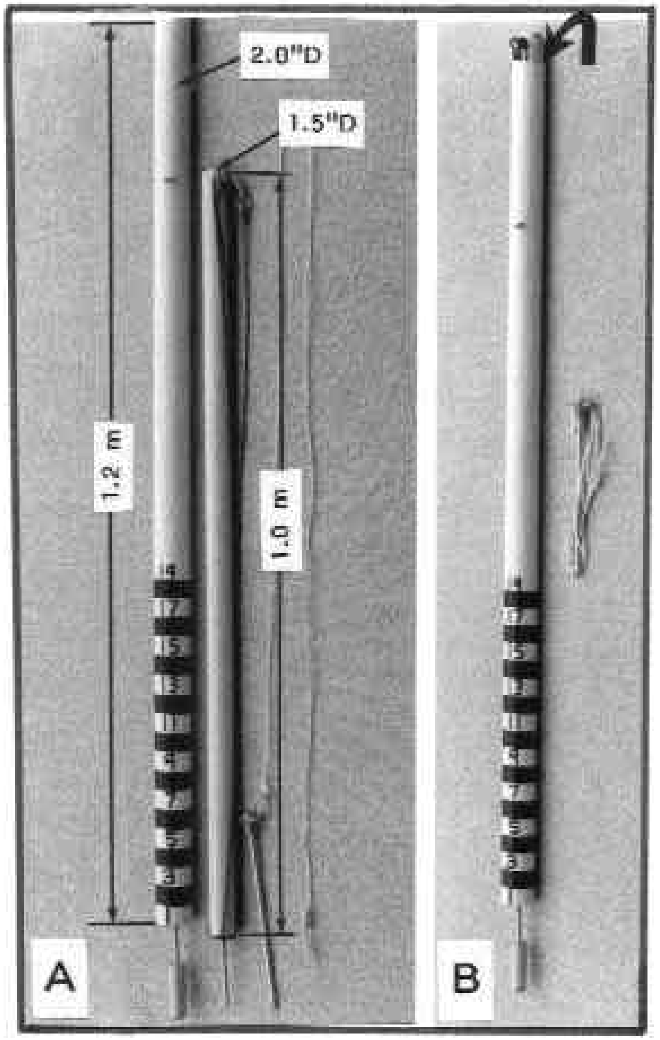


Figure 130—Robel pole specifications and criteria are shown. (**A**) A 2.0-in diameter PVC pipe is used for the Robel pole and 1½-in pipe for the camera height pole. These diameters permit the camera height pole to be inserted into the Robel pole (**B**) for carrying. A tent stake for supporting the Robel pole is carried in a person's pocket. In A, the Robel pole is 1.2 m tall with an eye at 1.0 m. The camera height pole is 1 m tall to which is fastened a 4-m measuring line. When working alone, use a tent stake with 2 m of line to hold the Robel pole vertically while pulling the 4-m line taunt.

Materials	**Cost** *(see footnote 1)*
	Dollars
2-in diameter CL200 PVC pipe @ $3/10 ft (cut 1 piece 1.2 m for the Robel pole)	3
1.5-in diameter CL200 PVC pipe @ $3/10 ft (cut 1 piece 1.0 m for the camera-height pole)	3
20 ft 1/8-in diameter nonstretch rope	1
1½-ft 1/4-in diameter steel rod (cut 2 pieces 8 in long)	1
2 #6 size eye screws; 1 6-in tent stake	2
1 snap with ring; several feet of black electricians tape	3
Total	13

The Robel pole system consists of two poles and a 4-m section of line attached between the poles. Figure 130 lists the specifications permitting the camera-height pole to be placed inside the Robel pole for carrying. Figure 131 illustrates construction and marking of the Robel pole and details.

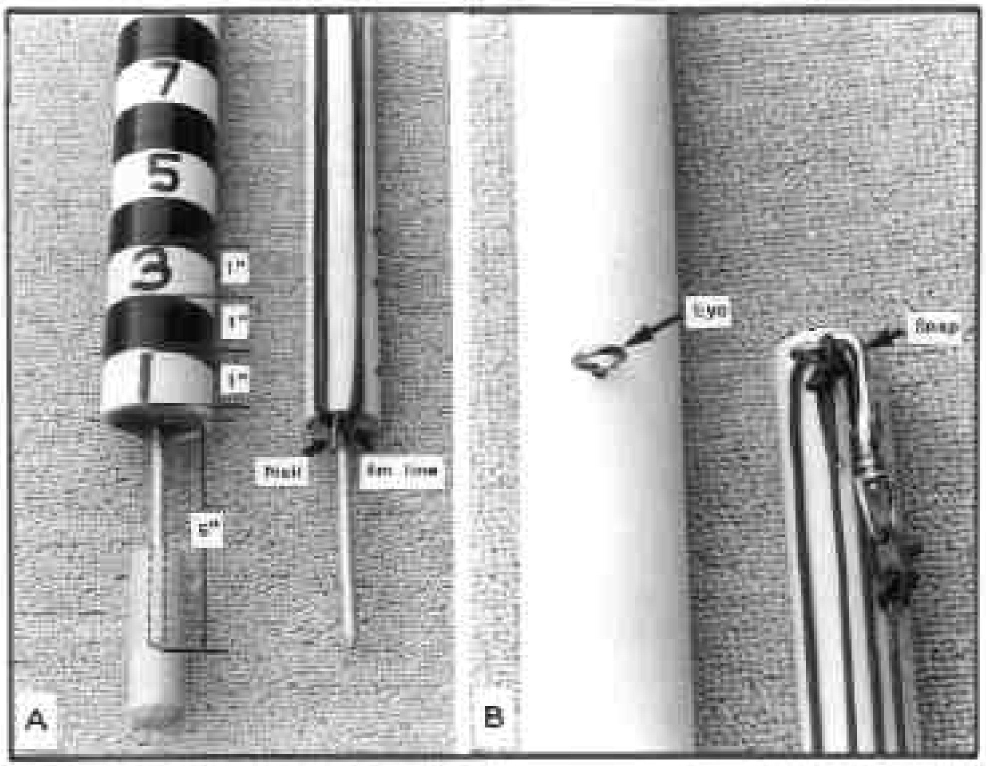


Figure 131—(**A**) The Robel pole is marked at 1-in increments with black electricians tape. Alternate inch increments are inscribed with permanent black markers for every odd-numbered inch. Steel rods ¼-in diameter extend 6 in below the Robel pole and the line pole. The Robel pole rod is protected by doweling drilled out for ¼-in steel rod. Steel rods are secured inside the PVC pipe by doweling. (**B**) An eye is attached to the Robel pole 1 m aboveground. After screwing in the eye, remove it and cut off the sharp end, then replace the eye. Cutting off the sharp end provides room for the camera height pole to be inserted into the Robel pole (fig. 130B). A 4-m line, secured by a nail, is wrapped around the camera height pole. It is snapped to the eye on the Robel pole to measure consistent distance between Robel pole and the camera. The camera height pole, 1 m tall, provides a consistent camera height when the camera is positioned at the top of the pole.

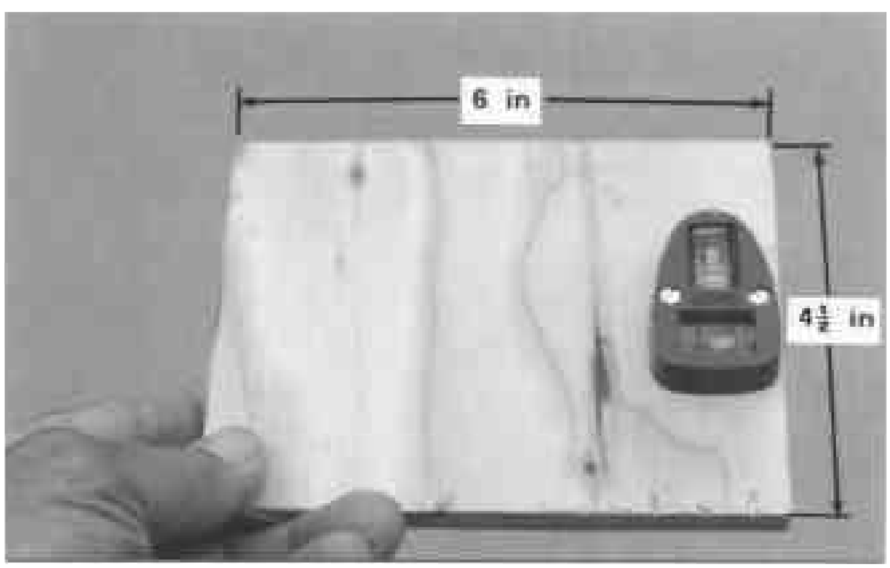


Figure 132—Aleveling board for taking overhead photos of tree canopy cover measures 4½ in by 6 in and has a two-way level attached. It is made from scrap ½-in plywood.

Figure 133—The camera leveling board is used to consistently rephotograph the tree canopy. Place the leveling board on top of the meter board for consistent height above the ground. Place the meter board at a right angle to the transect line. Move the meter board sideways to center the crosstransect bubble, then tilt the level board to center the downtransect bubble, and photograph.

Camera Leveling System

Photographs taken looking up at the tree canopy require a camera leveling system for consistent rephotography. The system described here uses the meter board top as one axis for consistently orienting the camera and a leveling board for the other axis (figs. 132 and 133).

Materials	**Cost** *(see footnote 1)*
	Dollars
1 2-way level or 2 line levels	4
4½- by 6-in, 1/2-in thick, scrap plywood	(scrap)
Total	4

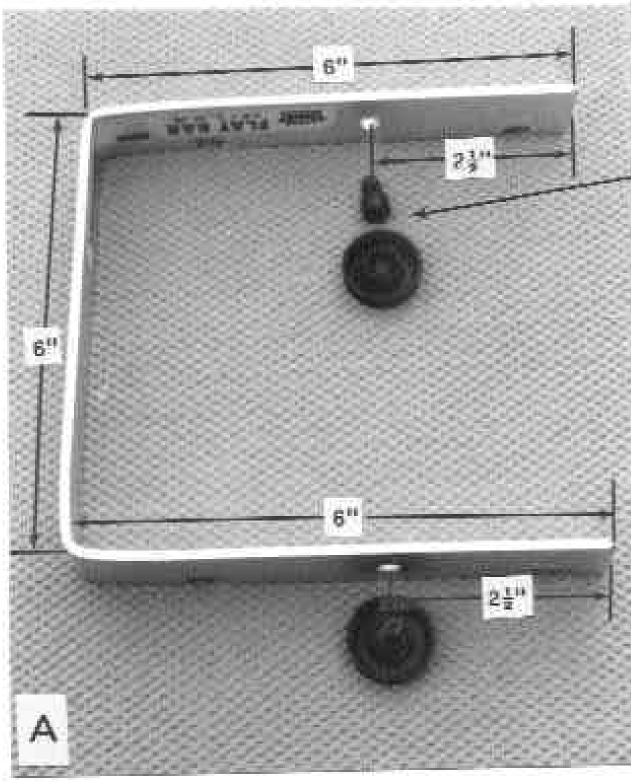
Figure 132 illustrates the camera leveling board's dimensions and placement of the two-way level. Figure 133 illustrates uses of the leveling board. Place it on the top edge of the meter board, move the meter board left or right to center on the cross-transect level, then tilt the board to center the down-transect level. Move your head out of the way and photograph.

Figure 134—Double camera bracket for use when photographing in both color and black and white. The bracket is made from 1- by 1/8-in stock aluminum bar with holes drilled to mount the cameras. Identical cameras are recommended to simplify camera adjustment. Figures 135 and 136 illustrate construction details.

Double-Camera Bracket

Two cameras usually are needed to photograph in both color and black and white. A bracket holding both cameras together provides for simple and effective manipulation of the cameras (fig. 134). Identical cameras simplify adjustment. When ready to photograph, simply shoot with the top camera, then the bottom, and advance the films.

Materials	**Cost** *(see footnote 1)*
	Dollars
1 6-ft piece aluminum bar stock, 1 in wide by 1/8 in thick (cut a piece 18 in long)	8
Instant thumb screws:	
2 1/4-in diameter standard 20 thread, 3/8-in shank screws	1
2 instant thumb screws	1
Total	10



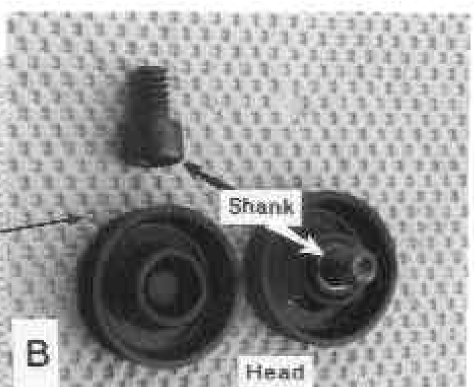


Figure 135—The double-camera bracket (**A**) with thumb screws to attach the cameras. Washers may be needed if thumb screw shanks are too long. (**B**) Thumb screws come in two parts: the shank and the head. The head must be forced onto the shank by using a vise (**C**).

The aluminum bar stock, cut to 18 in, is bent into equal 6-in segments to form a “U” (fig. 135A). Then, 1/4-in holes are drilled 2½ in from the ends (fig. 135A) to hold the cameras. Be sure the holes will place the cameras where the rewind buttons will be accessible (fig. 136B). Next, on the aluminum bar make two 1/4-in cuts, ½ in apart, into the aluminum toward the front of the camera and bend the 1/2-in piece upward to about a 30-degree angle (fig. 136A). Do not bend more than 30 degrees or the aluminum will break. These tabs will prevent the cameras from rotating on the bracket.

Assemble the thumb screws, which come in two parts — the shank and the thumb head (fig. 135B). Be sure the shank will fit the camera mounting socket. A 1/4-in diameter, 20-thread shank 3/8 in long will work. Press the head onto the shank as shown in figure 135C using a vise. Heavy pliers usually do not apply sufficient force to seat the thumb head.

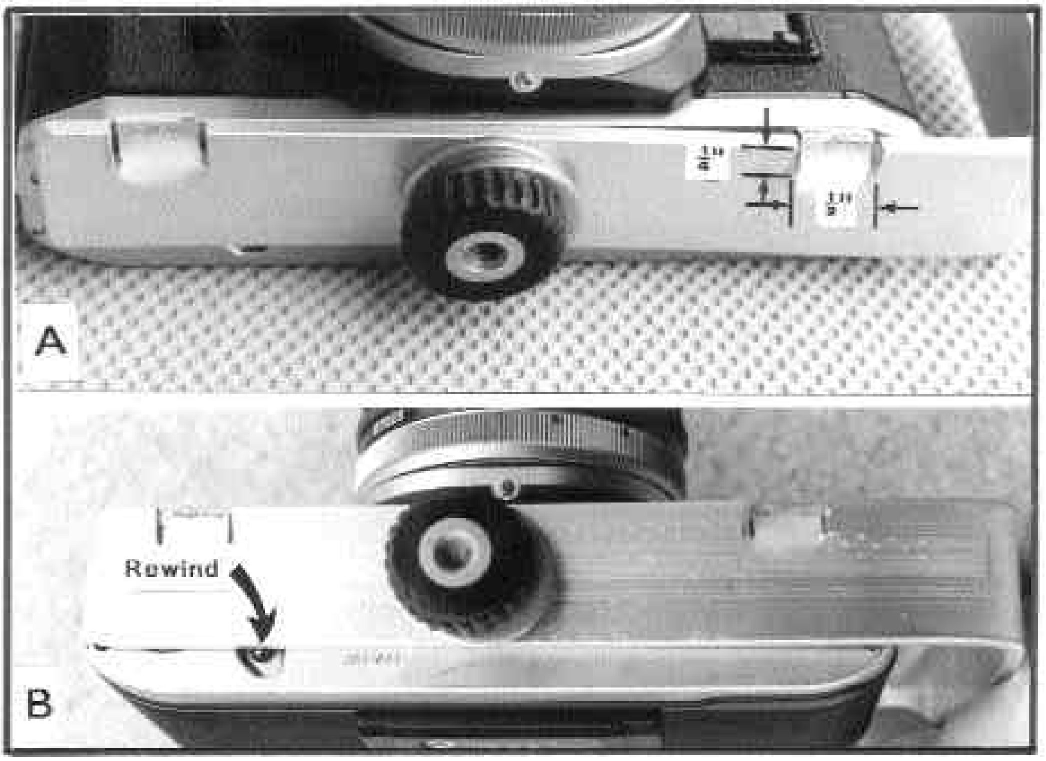


Figure 136—Two factors are important in attaching the camera to the bracket. (**A**) Make two ¼-in cuts into the front of the bracket, ½ in apart, and bend upward no more than 30 degrees to prevent rotation movement of the camera. (Bending them farther may break them off.) (**B**) Be sure the bracket clears the rewind button so that film may be changed while the camera is attached to the bracket.

Fenceposts

Flimsy fenceposts are available at builders supply outlets such as Home Depot©. They are listed as “light duty” stamped metal fenceposts. Measured across the top, the long axis is 1¼ in. Medium duty stamped fenceposts measure 2 in. Light duty posts may have to be ordered.

Identification Tags

Orange colored, aluminum tags suitable for installing on witness sites to identify a monitoring location may be obtained from:

Dixie Steel and Sign Co.
P.O. Box 54616
Atlanta, GA 30308
Phone: 404-875-8883
Fax: 404-872-5423

Obtain a tool-steel inscriber to inscribe directions and distances to camera locations and photo points directly on the tags. The tags are about 12 gauge thickness with black and orange paint.

Appendix D: Photo Monitoring Filing System

Contents

Introduction

The concept of photo monitoring implies repeat photography, which in turn suggests the need for a filing system where, over the years, one can regularly deposit their photographs and data. This appendix describes some attributes of filing systems I've found useful over the last 40 years.

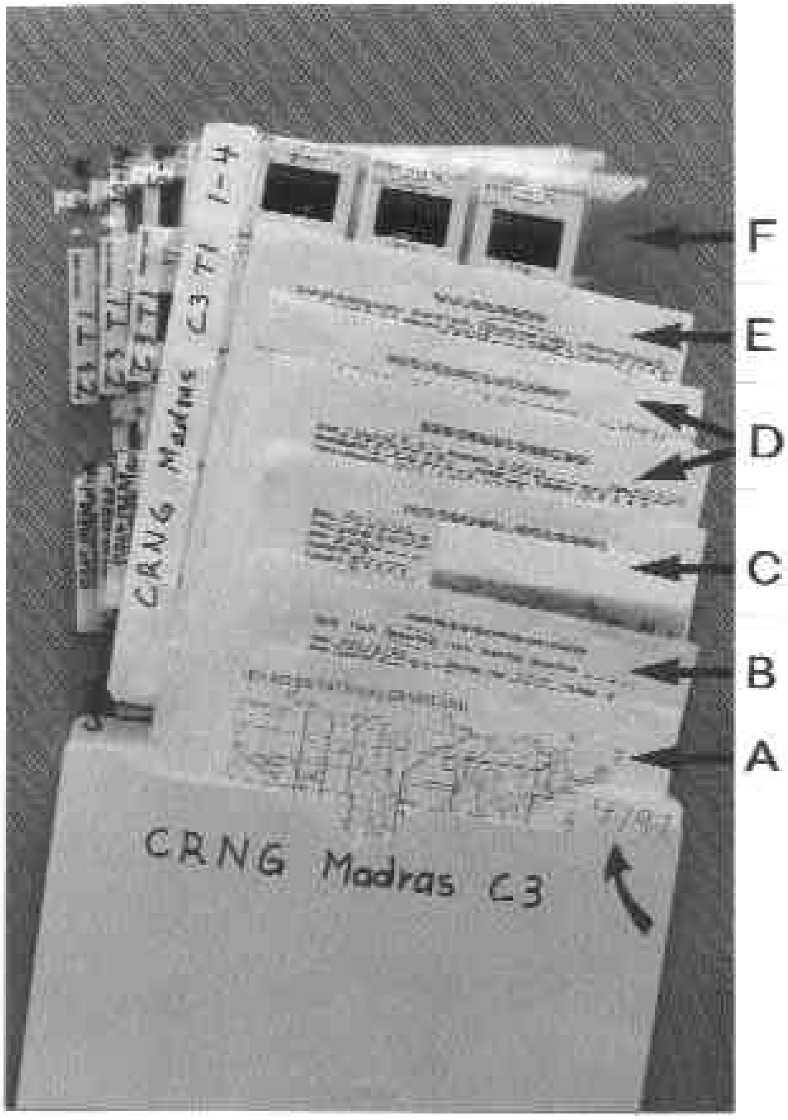


Figure 137—File folder contents for the Crooked River National Grassland trend cluster C3. I use several sizes of expanding folders: 2-fold shown here, 4-fold, and 8-fold to fit the file size. Each folder is labeled and the last date of sampling is attached to the upper right corner (arrow). All items pertaining to the sample location are included in the file: (**A**) general area map (fig. 72), (**B**) the form “Sampling Site Description and Location” for a plot layout map (fig. 82), (**C**) a form for attaching photographs and recording data shown here as the “Photo Trend Sample - Nested Frequency” (figs. 83-85), (**D**) data summary forms shown here as “Nested Frequency Transect Data” (figs. 86 and 87) and “Nested Frequency Cluster Summary” (figs. 88 and 89), (**E**) trend interpretation using “Range Trend Rereadings” (figs. 90 and 91), and (**F**) clear plastic holders for slides (fig. 139). Not shown are black-and-white negatives in their envelopes identified by date, cluster, and transect.

Office Filing System

Office organization of the filing system presumes that each monitoring location is completely contained in its own folder (fig. 137). Consider three alternatives for filing these folders: by (1) date of rephotography, (2) topic of the study, or (3) geographic location of the study.

Date of Photography

Date of photography may be season of year, such as Pole Camp in spring, summer, and fall (fig. 20); once each year at a specific date, such as herbage production (fig. 22); irregularly based on disturbance such as logging (figs. 29, 50, and 51); or at specified intervals, such as every 5 years—the three intervals between 1977 in figure 46 and 1991 in figure 48.

An advantage of organizing by date is having files immediately available each year according to their schedule. This means that topics of sampling and geographic locations are interspersed requiring search of all files. I place the date information on the upper right corner of the file rather than file by date.

Topic Being Monitored

The topic being monitored determines the purpose for monitoring and the kind of vegetation under consideration. Topics may be exclosures (fig. 137), livestock trend sampling (figs. 75, 83, and 92), sagebrush-grass (figs. 75, 83, and 92), logging effects (figs. 21, 50, and 51), herbage production (fig. 22), or livestock utilization (figs. 20 and 106-108).

Similar topics are filed together, such as logging with overstory removal (fig. 21) and a single light thinning (figs. 50 and 51) in ponderosa pine. All logging may be put together or all ponderosa pine may be located together. If logging is the topic, salvage of beetle-killed lodgepole pine (figs. 46-48) would be filed with it. Decisions must be made on organizing the files by topic, none of which will prove wholly satisfactory.

Geographic Location of the Study

Geographic location is determined by the closest available motel, access by major road, or distance to travel. My work from Portland, Oregon, covering two states, is organized by towns that gave good access and an acceptable motel. When going to an area on other work, I look in its geographic file to determine if any photo monitoring locations are due for sampling. What might be combined between current work activity and photo monitoring? Are there any monitoring sites in the neighborhood of the work area or on the route? Dates on the files are the first consideration. Is the work activity occurring about the same date as required for sampling? Consider organizing files by date and then by topic within a geographic file. Another approach is to allot several days for monitoring. Having files by location greatly facilitates travel planning and might save considerable time in visiting each site. Filing by location has been my choice for many years.

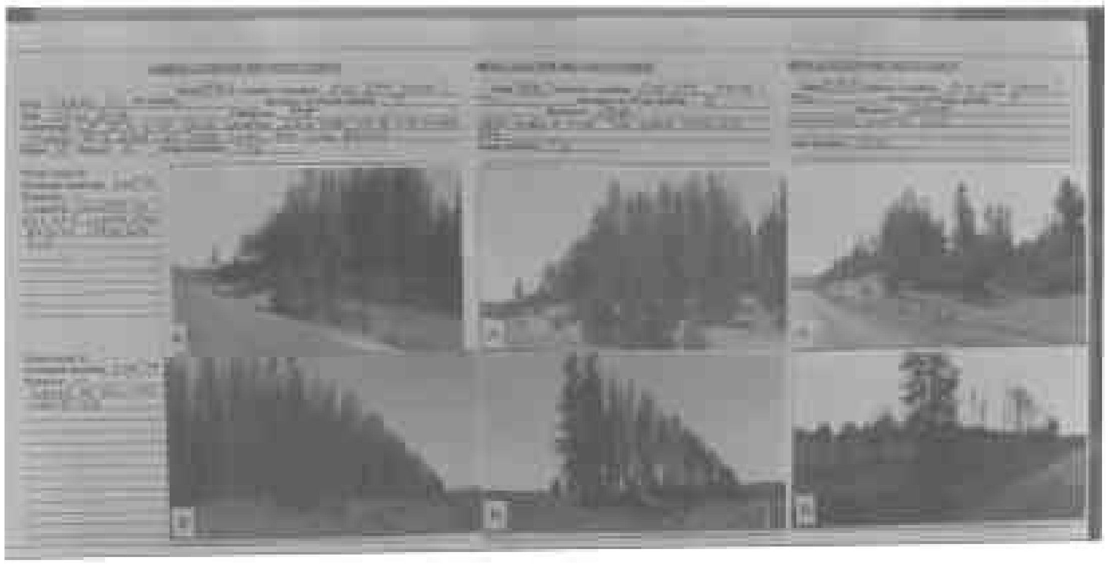


Figure 138—Three pages of filing system form “Camera Location and Photo Points” overlapped to compare changes between three dates. These are figures 46, 47, and 48 located by the map in figure 45. Essential information for making comparisons is in the upper right portion of the form: date and camera location. Overlay the forms so that photographs can be compared as shown. Camera orientation in close landscape photography can be a problem resulting from no meter board or permanent item on which to orient the camera. Compare photo B for 1977 and 1978 with B for 1991. The horizon is similar for the first two but quite different for 1991, a situation to be avoided. Also notice the variation in the road crest in the A photos.

File Contents

All information pertaining to a photo monitoring project should be placed in a single file. This may entail duplicate copies of some items, such as a request and authorization for a study, which might require filing in an office administration folder as well as in the project folder. Long-term investigation, like photo monitoring, is significantly enhanced when historical documents are included in the file.

Consider six kinds of items to include: (1) authorization, approval, or justification for the project; (2) maps to find the monitoring location—a general map noting the location and a site-specific map diagraming the sampling layout; (3) photo-mounting forms that also may be used to record data, such as transect sampling systems; (4) envelopes for negatives, either color or black-and-white, or both, digital memory cards, or compact discs (CDs); (5) summary forms when data are collected; and (6) plastic sheets for holding slides.

Authorization, Approval, or Justification

Document initiation of the photo monitoring project. This may entail copying instructions or policy from an organization, a written request to monitor and subsequent approval, or those parts of an environmental impact statement requiring monitoring of specific activities. If an environmental impact statement, or similar document, is required, include it. Assume that someone totally unfamiliar with your organization’s policy, protocol, or operational procedures may pick up the file and will have everything they need to understand and use the monitoring system. This has proven invaluable in monitoring projects older than 20 years because policy, protocol, and operational procedures change.

Maps

Two maps always should be included in the monitoring file (fig. 137): a general map showing how to find the monitoring site (fig. 72), and a detailed site map of the monitoring system (fig. 73). These maps should be in such detail that a person new to the area can find the monitoring location and do the rephotography.

Photo-Mounting Forms

Effective use of photographs in monitoring suggests that they should be mounted to facilitate comparison. The filing system forms in appendix B are organized so that photos are mounted on the right, underneath the date and camera location. Pages may be overlapped to compare any number of photos by date (fig. 138).

Two kinds of photo-mounting forms are provided: those for topic or landscape photography where measurements are not made (figs. 44, 45, 46-48, and 138), and those for transect sampling where measurements are recorded in the field (figs. 67-69, 75-77, 83-85, 93-95, 99-100, and 106-108). The form shown in figure 137 is a transect form (figs. 83-85). These forms have space for 3- by 5-inch photos.

Summary Forms

Summary forms are used with transect sampling to summarize and interpret the data. One important form is “Range Trend Rereadings,” used to compare data among years (figs. 79-80 and 90-91). It may be used with several of the sampling systems. Other forms are designed for a specific system, such as nested frequency (figs. 86-89; tables 2 and 3) or Robel pole utilization (fig. 109).

A different kind of summary form is used with grid analysis. It is a piece of clear plastic (fig. 54) labeled with sampling date, site name, and item, on which outlines of items (shrubs in this illustration) are drawn (figs. 55-56, 60, and 68-69). The outlined sheet is placed on a grid (figs. 58 and 70), which is adjusted in size to the outline, and the number of intersects within each outline are recorded on a summary form (figs. 59 and 71). The photograph, sized grid, outline sheet, and summary form are all filed.

Envelopes for Negatives

Negatives, color or black-and-white, should be kept in the monitoring file. I find that keeping them in the envelopes from processing is quite satisfactory; there is a compartment for the negatives and one for the pictures. I routinely have two prints made: one for mounting and another as a spare. The envelope is labeled with date of photography, monitoring location, and camera-photo point identification.

Each picture on the negative should be identified by a photo identification sheet placed within the camera’s view. After several sessions of rephotography, identifying which negative was taken in what year can be impossible. This becomes a serious threat to integrity of the project when prints are made simultaneously from several years of rephotography of the same photo point. How might the various negatives be returned to their proper envelope?

Digital images may be stored in the file by any of three methods: (1) memory cards with their containers, (2) transferred to a CD, or (3) stored on the hard drive of a computer with essential identifying information. Directions to find the computer filing system should be placed in the file.

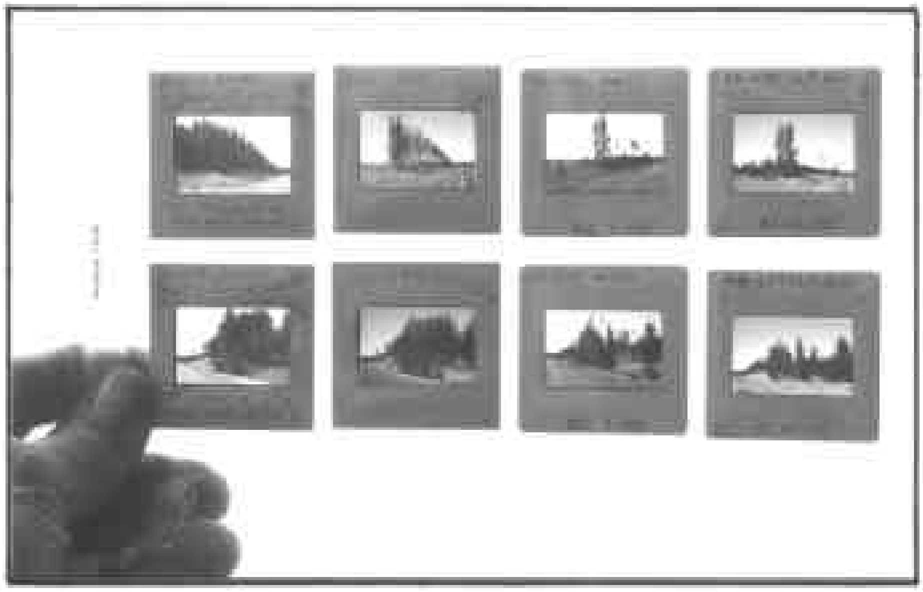


Figure 139—Slides filed in clear plastic sheets facilitate comparison among years. I use either of two systems: four columns by date using the slide holder in portrait view (shown here) or five columns by date using the slide holder in landscape view where five sets of slides are compared. Shown here are slides of figures 46 though 48 and 138. This system of four dated columns also was used in figure 137, where four sheets were required to hold slides for each date.

Slide Files

Slides may be filed in two kinds of holders: rigid opaque plastic or flexible clear plastic sheets. Rigid holders protect the slides on only one side, the other is open. Clear plastic have pockets (2 by 2 in) into which slides are placed (fig. 139). They are protected on both sides. A product **not** having PVC in its makeup will not damage the slide itself (for example, ClearView™). Some flexible pocket sheets will adhere to the slide and damage the emulsion. Slides do not fall out of rigid holders but they do tend to fall out of flexible pocket holders. Even so, my preference is for flexible pocket holders because they take only one-third the filing space of rigid ones.

Slides may be returned to you from processing in either paper or plastic mounts. Paper is less rigid and easier to write on but will hang up in projectors more often and is useless if ever dampened. Plastic requires felt-tip pens for effective writing such as Sanfords Sharpie® Ultra Fine Point Marker, the same one used for drawing outlines on clear plastic sheets. I specify "plastic mounts," "number only," and "do NOT date" when I have slide film processed.

All my slides are dated by when they were taken, not when processed. I use a "000" size date stamp with year, month, and day. A stamp significantly reduces time handling the slides. Each should be identified by a "photo identification" form within the view (figs. 26, 33, 67-68, 75, 83, 93, and 106). In addition, I label each slide for easy recognition and add any pertinent information (fig. 139).

Consider filing slides in columns by date (figs. 137 and 139). If there are five slides for a photo point, I file them in landscape orientation (horizontal) in the slide holder. This permits comparing five sets of slides from five different dates on one sheet. If there are four or less slides, I use columns in portrait (vertical) orientation (fig. 139) where four columns may be compared. Using a light table, one can view a number of photo points over considerable time. In figure 139, only photos A and B are shown covering a time span from 1977 to 1997.

Appendix E: Photo Techniques

Contents

Introduction

This appendix is devoted to several topics with much of the discussion occurring in the figure captions.

Hedgecoe (1994) introduces his treatise on landscape photography by discussing learning how to see. What the eye transmits to the brain is not what the camera records. The eye scans a topic for several seconds while the brain filters out the surroundings. Our eyes perceive fine detail over just a small area in the middle of the view. The camera records a fixed rectangular part of the scene with no overt identification of a topic. The view recorded has constrained edges, unlike the movement of eyes. A photograph, therefore, must be purposely oriented to record what the eye and brain see.

Johnson (1991) suggests asking several questions to help resolve eye and camera relations: Why am I taking this picture? What is the purpose of this picture? What will the picture demonstrate? What appeals to me in this scene? and What am I looking for? “Looking for,” the topic of interest, might occur in one of three planes: foreground, middle distance, and far distance. These are relative distances between the camera and the horizon. Close photography might have only 200 yards from the camera to the horizon or back of the scene (fig. 26), in contrast to 10 miles in a general landscape view (fig. 16). Composing the picture to focus on the topic is an important objective.

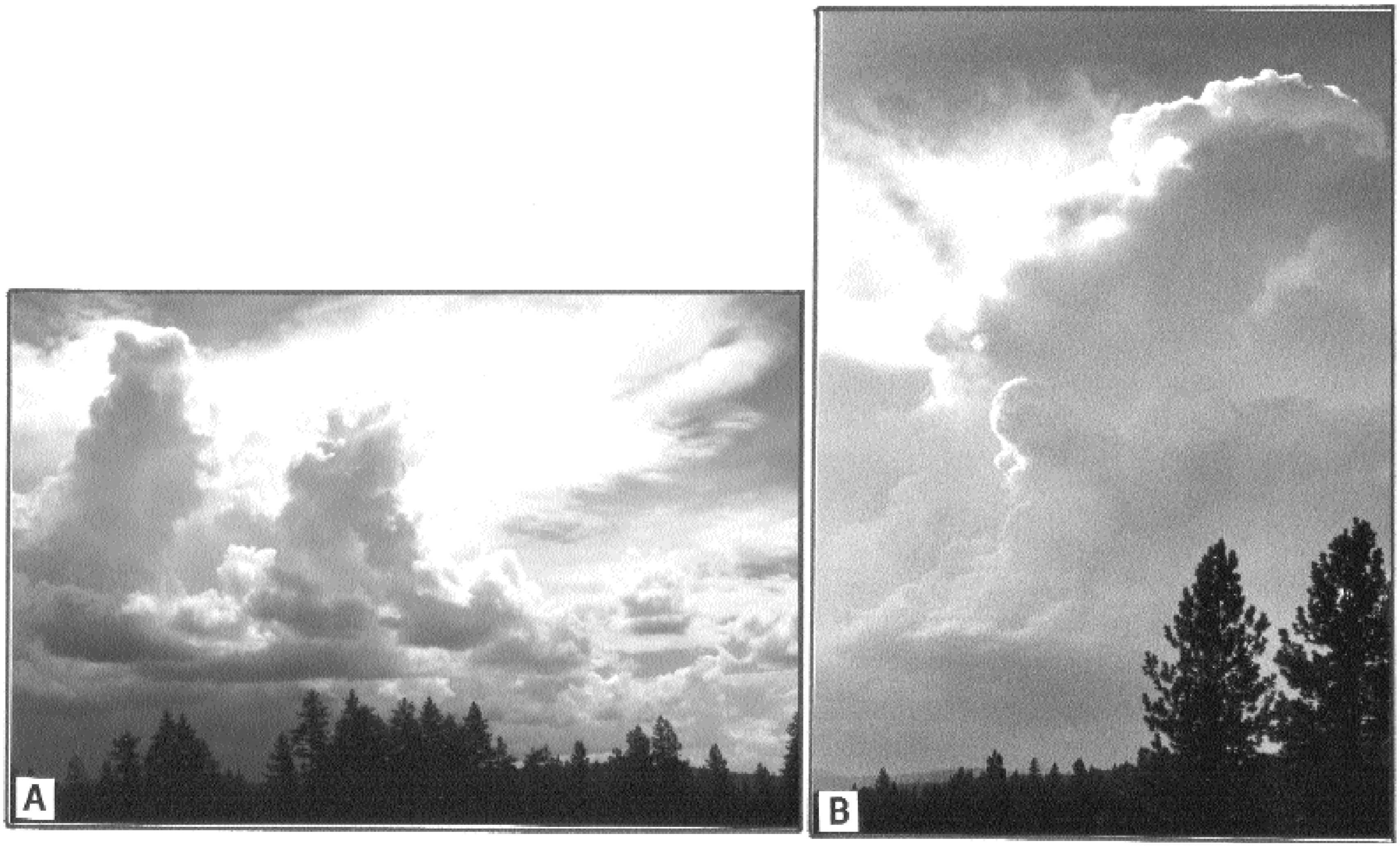


Figure 140—Comparison of (**A**) landscape and (**B**) portrait camera orientation. Hedgecoe (1994) considers landscape camera orientation as peaceful and stable and portrait orientation as active and unstable. Do you agree?

Composition of Photographs

Hedgecoe (1994) suggests that camera orientation helps to convey a message. Landscape (horizontal) orientation suggests peaceful and stable conditions, and portrait (vertical) orientation connotes active and unstable situations. Figure 140 compares these orientations.

Mobility of camera location is more valuable than a battery of lenses for photographic composition (Hedgecoe 1994). By moving around to view the topic, one can totally change the composition of the picture. Different foreground and background elements may be aligned, or detail close to the camera may be avoided or included. The point is to make the picture emphasize the chosen topic.

The next consideration is composition: First identify the topic of interest, and then position the camera to enhance the topic. Hedgecoe clearly discusses the "rule of thirds," which is based on the golden mean, a 1:1.62 ratio, about the dimensions of a 35-mm image, which seems to be the ratio most pleasing to people from western cultures (fig. 141). It suggests that about 33 percent is a valuable percentage to use for positioning the topic. In landscape photography, it is used to position the horizon: one-third sky to two-thirds land, or as shown in figure 135, one-third land and two-thirds sky. The next "third" is to frame the picture on at least one side with something. And the last "third" is to divide the land (or sky) into thirds by use of an angle. The angle may be a road, change in vegetation, crest of a hill, cloud formation (fig. 140), or other item. Perhaps the mnemonic "one-SAT" will help recall "one side, one angle, one-third."

Figure 142 begins a series illustrating this adage. Figure 143 is a broad view of the landscape used for illustration. Figure 144 is a common type of camera orientation, placing the horizon in the center of the picture. Lowering the camera, as in figure 145, illustrates a one-third horizon; in figure 146, the camera moves to the right to frame the scene. One angle is represented by the slope. Figure 147 is the actual scene taken near the Snake River in Oregon, showing the topic of terracing on the near slope resulting from livestock grazing and no terracing on gentler slopes.

Figure 148 illustrates the "thirds" concept but reverses one-third sky for one-third land to emphasize the topic of spring rain showers in the Great Basin. (In reality, only one-fourth is land.) In photo (B) the camera was repositioned to frame the picture with sagebrush and to include a fence for the "angle" and as a perspective on scale.

Pattern is use of contrasting objects such as a house in a field, row of trees, hills and a valley, or dramatic differences in vegetation as shown in figure 149. The topic was a meadow and its adjacent forest. Pattern also is illustrated in figure 150 but in a dramatically different way. Here pattern is related to texture of the siding compared to the roof and ground.

Text continues on page 313.

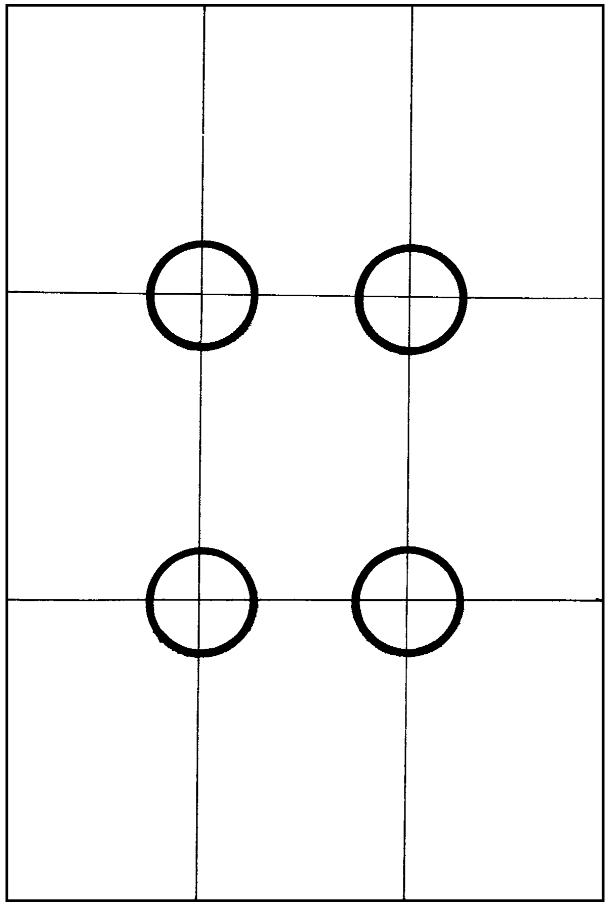


Figure 141—The “rule of thirds” depicted with a 35-mm image. Divide the image into thirds and use the intersection of the lines as a guide for topic location. In portrait photography, a person’s face or other item of interest is located at one of the circles. Landscape photography uses a modification as shown in figure 142.

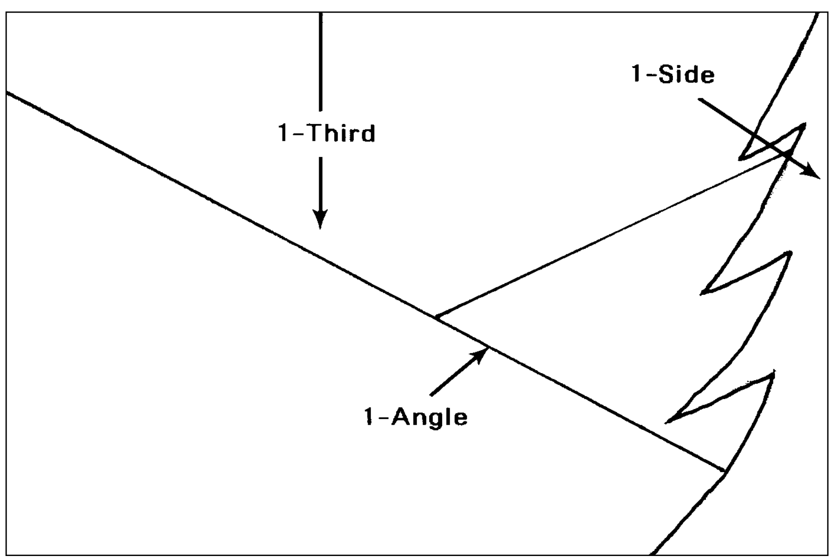


Figure 142—Figures 143 through 147 illustrate the concept of “thirds” (Hedgecoe 1994) or the concept of “one-third, one side, one angle” for placing the topic of interest in a photograph. “One-third” suggests that only one-third of the picture should be sky or land. In figure 142, only one-third is sky. “One side” suggests framing the picture in some way, here with a tree. “One angle” calls for some line in the picture at an angle. This diagram is expanded to a real landscape diagram in figure 143.

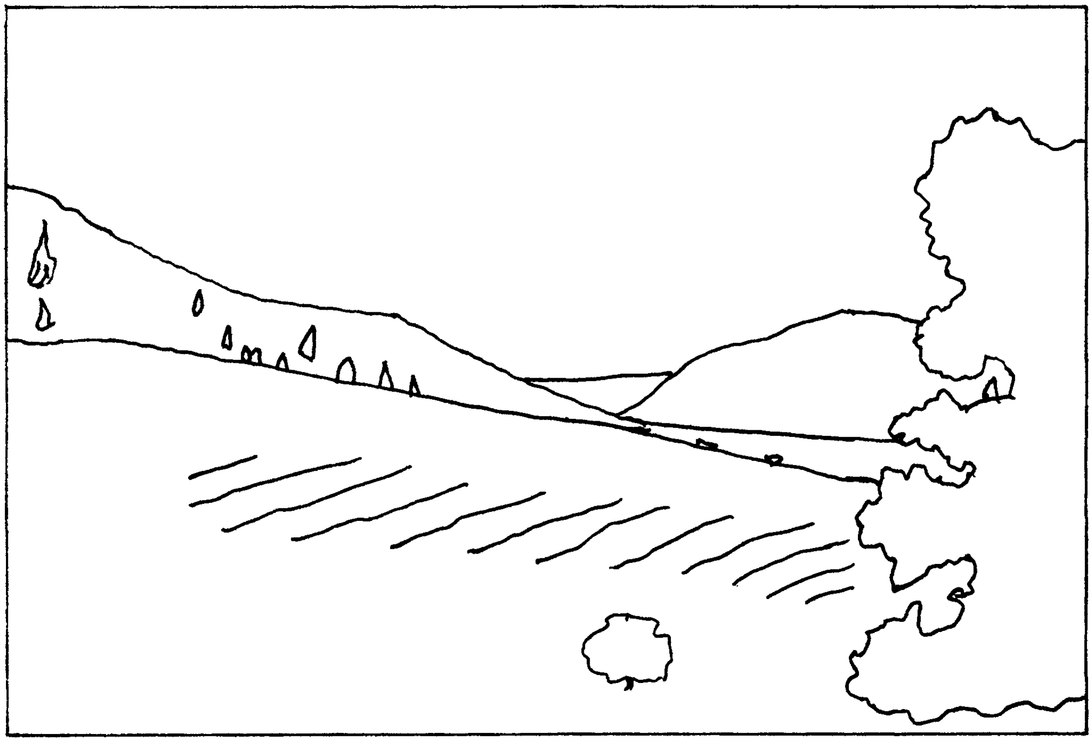


Figure 143—Abasic scene. Orientation of the camera will be further illustrated in figures 144 through 146.

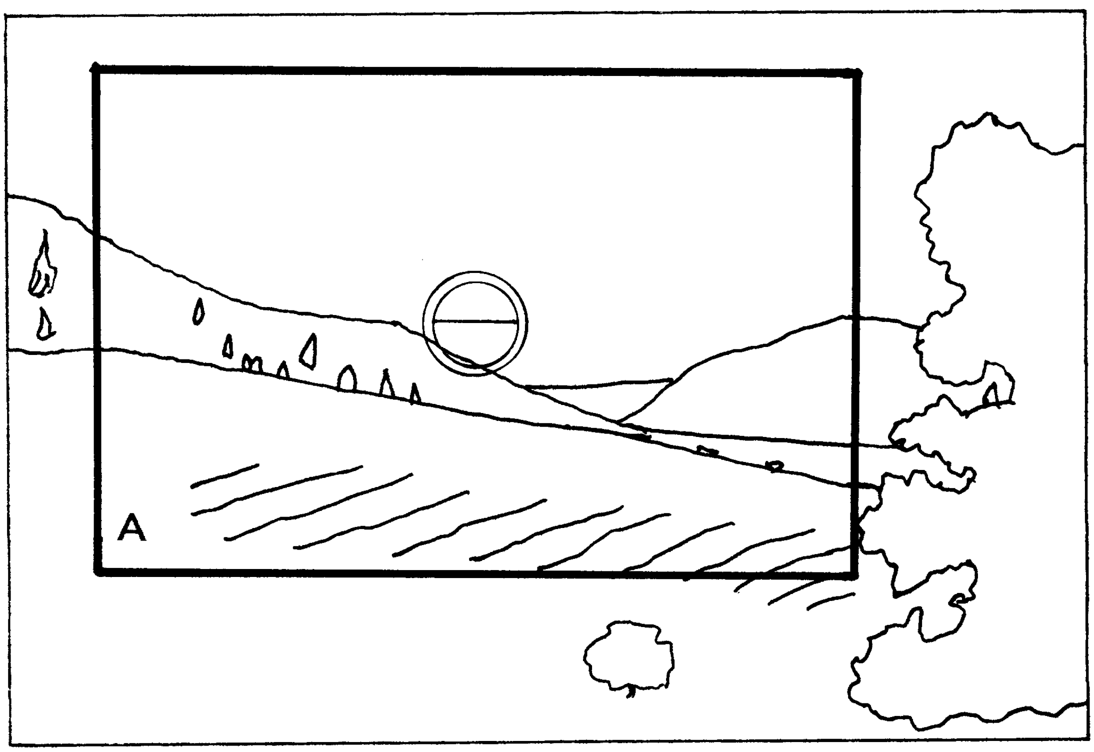


Figure 144—Here the camera focus has been placed on the horizon resulting in half sky and half land. Compare to figure 147A.

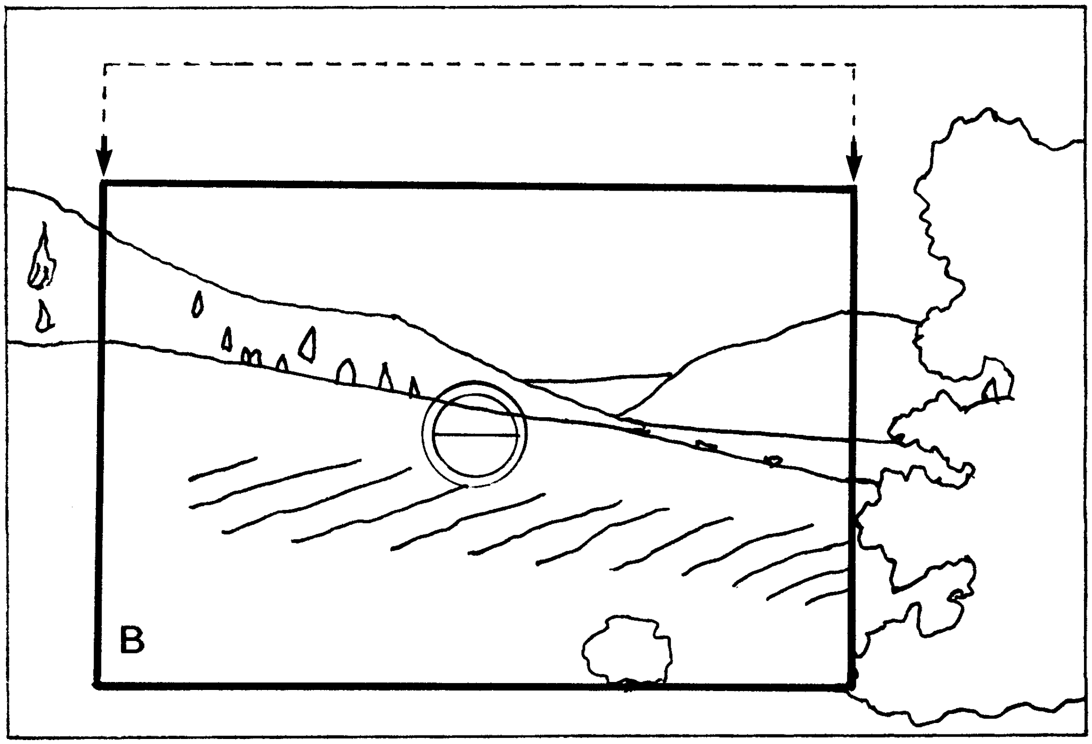


Figure 145—The camera has been lowered to one-third sky providing some focus on the foreground topic of a rippled slope. Compare to figure 147B.

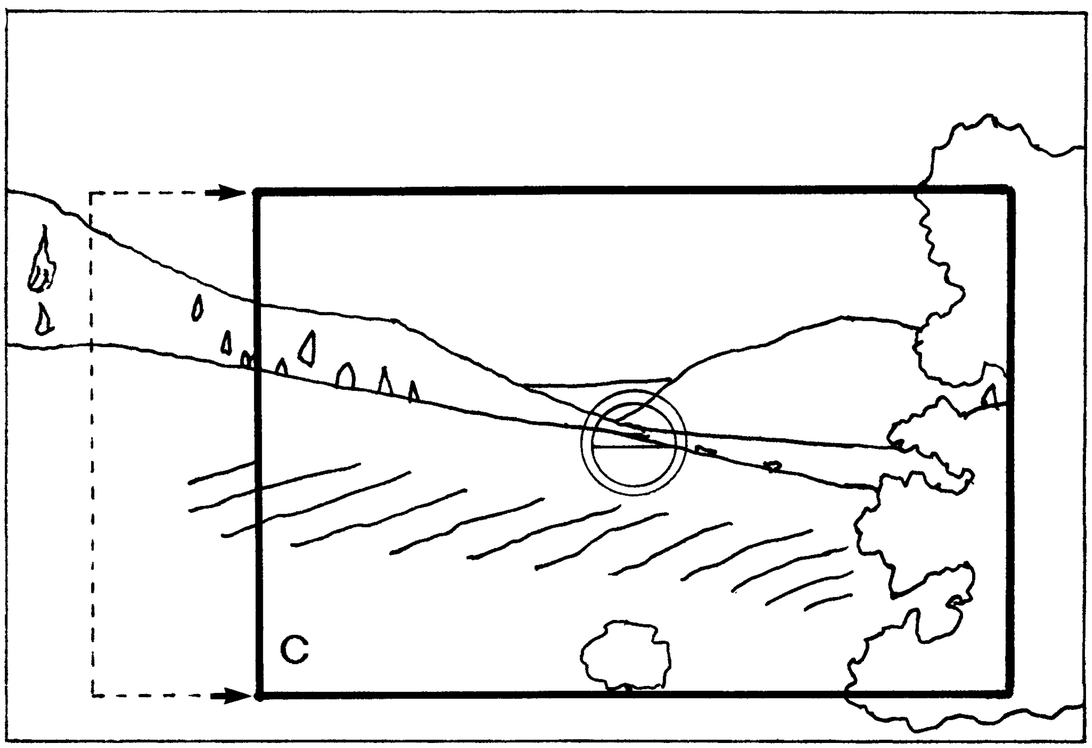


Figure 146—The camera was moved sideways to the right so that a tree would frame the picture. Here, four landscape photography concepts are illustrated: (1) one-third sky; (2) one-side framing; (3) one angle, the crest of the foreground slope; and (4) topic of the foreground rippled slope. The rippling (terracing) was caused by livestock use. These views are shown in figure 147.

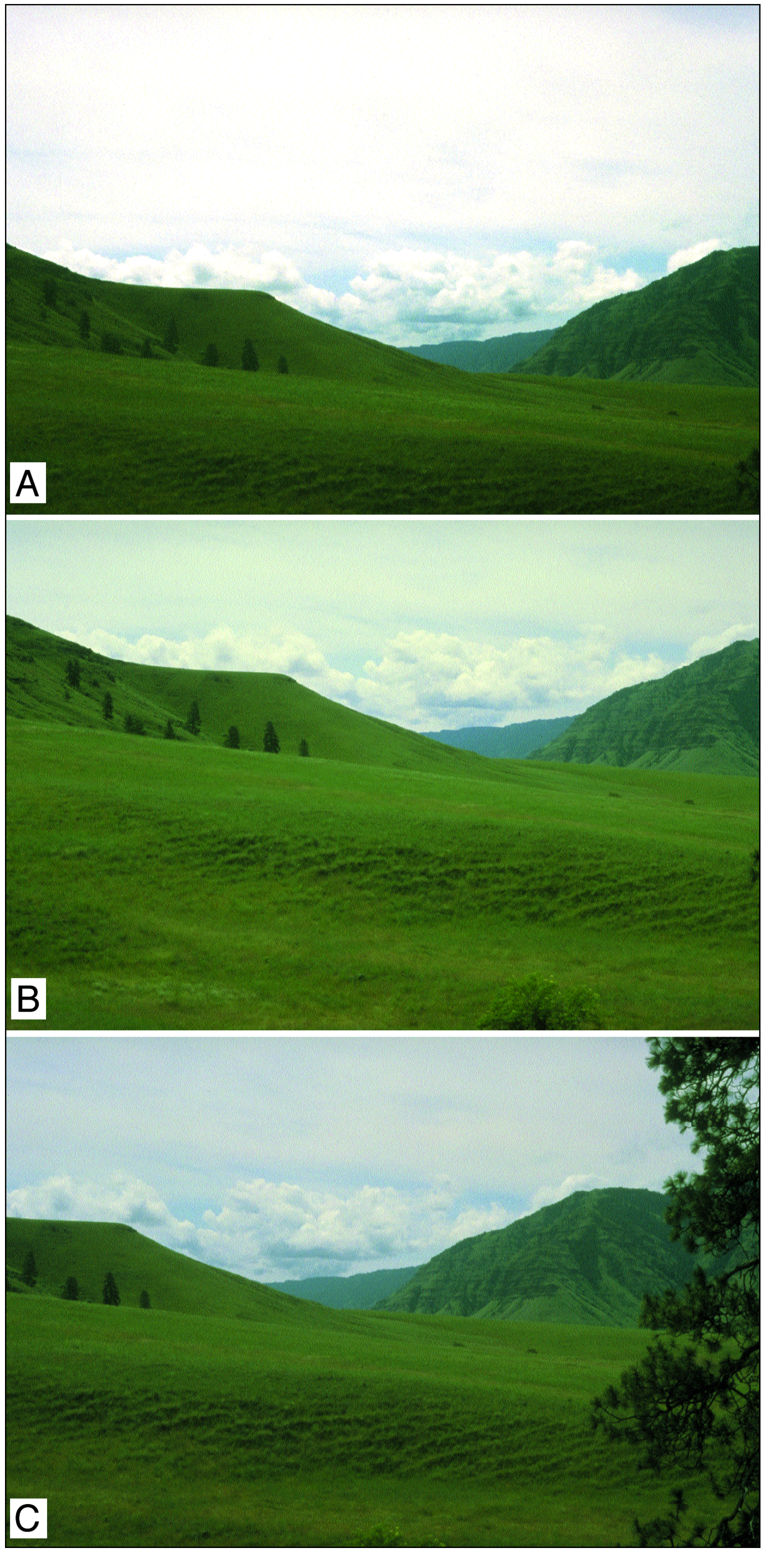


Figure 147—**A**, **B**, and **C** correspond to figures 144, 145, and 146, respectively. Exposure is an important consideration in landscape photography. In A, the land has been underexposed because the camera light meter was overly influenced by the bright sky. Expose for the topic of interest. If serious photography is contemplated, always take at least three exposures: one at what the meter says, one an f-stop less, and one an f-stop more.

Figure 148—Reversing the “one-third sky” rule is necessary when the topic is weather. (**A**) Land was reduced to about 25 percent to emphasize spring rain clouds over the Great Basin. (**B**) Moving the camera a few feet uphill provided framing with sagebrush and a fence line, which provides scale and an angle. Also see figure 140.

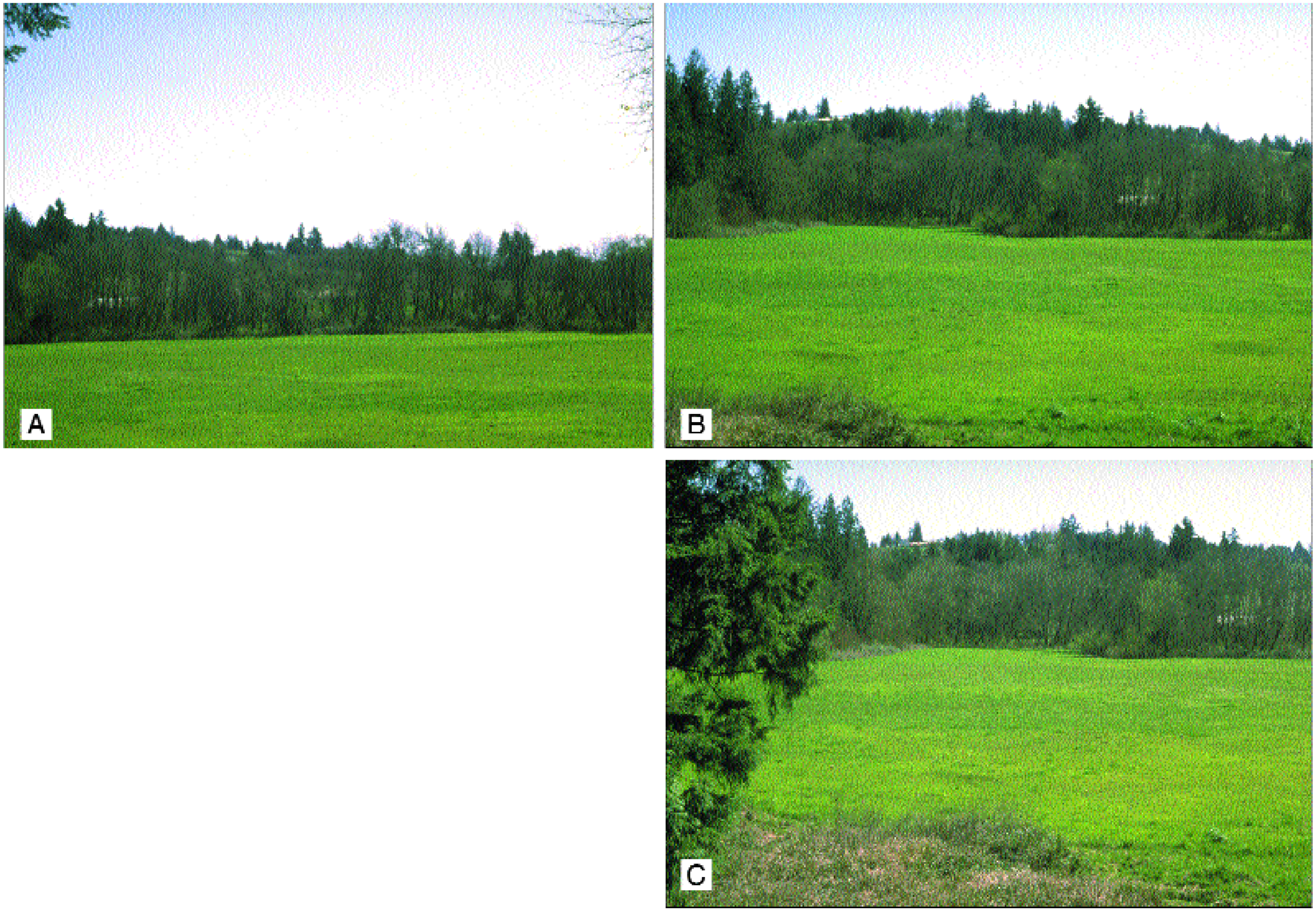


Figure 149—The topic here is a meadow. (**A**) The horizon halves the picture. (**B**) The camera was turned 20 degrees to the left and orientation lowered for one-third sky to show an extension of the meadow into the distance. This provided a break in the meadow edge and functions as an "angle." (**C**) The scene was framed by a tree. This figure also illustrates pattern by the forested hill and smooth pasture.

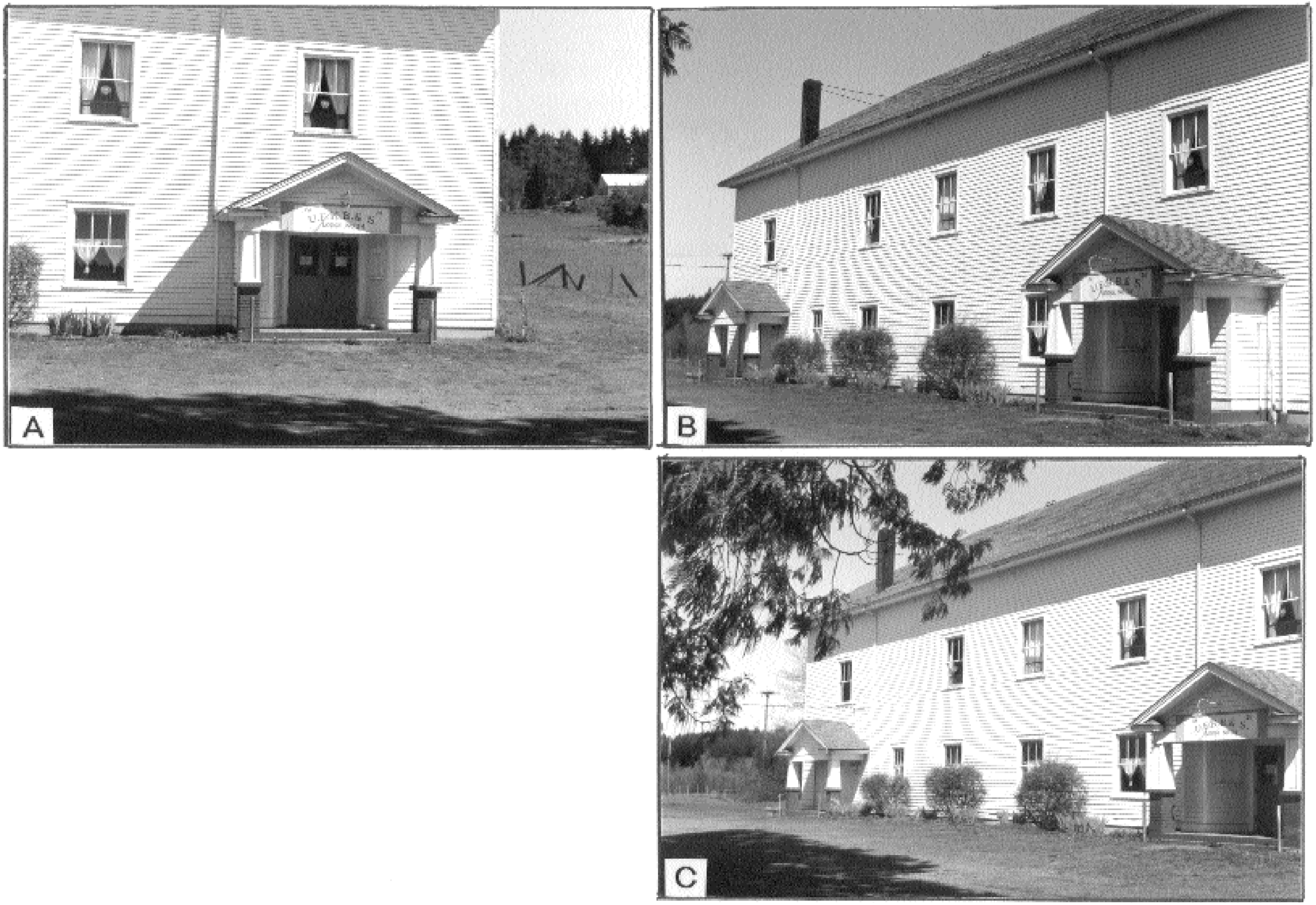


Figure 150—A totally different application to define the topic with one-third, one side, and one angle is shown with a structure. (**A**) A perfectly nice documentary of a country organizational building with one-third ground. (**B**) Adds a converging angle while preserving the name. (**C**) Simply frames the picture.

CONTINUE

Figure 151—Aframed landscape view is shown with the topic of a farmstead. Buildings are used to provide scale as is the fence. Backlight (sun shining towards the camera) creates a halo effect around each tree below the farm to give a three-dimensional effect.

Perspective or scale is provided by objects of known size; for example, the farm buildings in figure 151. In figure 148B, the fence line provided both an angle and a sense of perspective. Figure 149 could have been enhanced by an object in the meadow to indicate how wide it is.

Change in camera focal length is another method for dealing with composition and emphasizing a topic. Figure 152 compares two focal lengths and their effect on emphasis of ponderosa pine savanna. Figure 153 illustrates change in topic with change in focal length. The topic changes from an island in a river to a sweeping bend in the river with an island.

Composition may be summarized as follows: define a topic (What do I want to show?), apply the one-SAT concept (one side, one angle, one-third), use pattern to emphasize the topic, and provide perspective for the topic.

Light

Light is abused more often than used. It may be used to highlight objects, put a three-dimensional effect into a landscape, create unsolvable problems with shadows, and wreak havoc with a topic when sky and ground exposure are being reconciled. Abuse of light results from inattention to exposure and lack of time to photograph in suitable lighting conditions.

Sun may be used to enhance a three-dimensional effect in a two-dimensional photograph (figs. 151 and 154). Sun from behind the topic, particularly vegetation, tends to shine on the outside leaves while making a shadow in back. This forms a “halo” effect setting off individual plants and simulating a three-dimensional effect. Figure 155 illustrates the effect in grass, shrubs, and trees. Notice how the trees stand out as individuals in figure 151. The halo effect is summarized in the proverb of “photograph before 10 and after 3” when the Sun is low enough to create a good halo.

Text continues on page 319.

Figure 152—Effect of focal length is important in photograph composition and topic identification: (**A**) 50-mm lens on a 35-mm camera 10 m from the meter board emphasizing savanna ponderosa pine, and (**B**) 35-mm lens on the 35-mm camera from the same camera location but the meter board has been moved to 7 m making it the same size as in A. Scale of the grassland has been increased. Which picture more honestly illustrates forest savanna?

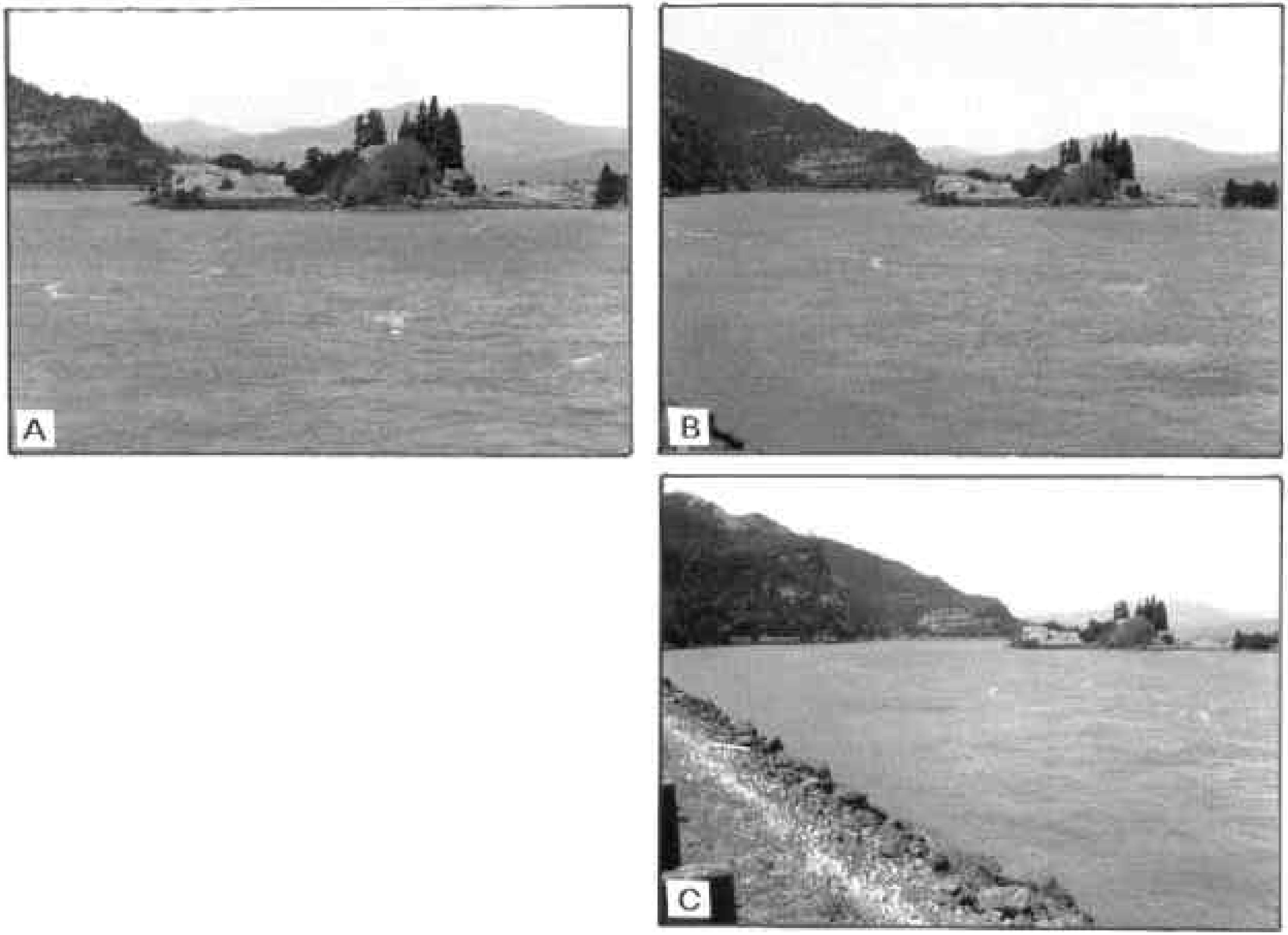


Figure 153— A second use of focal length is to change perspective in a photograph. The setting is an island in the Columbia River. Focal lengths were (**A**) 70-mm, (**B**) 50-mm, and (**C**) 35-mm on a 35-mm camera. In A, the island is the topic; in B, the island and river are both topics (which creates a dull photo); and in C, a sweeping curve of the river is the topic with the setting of an island.

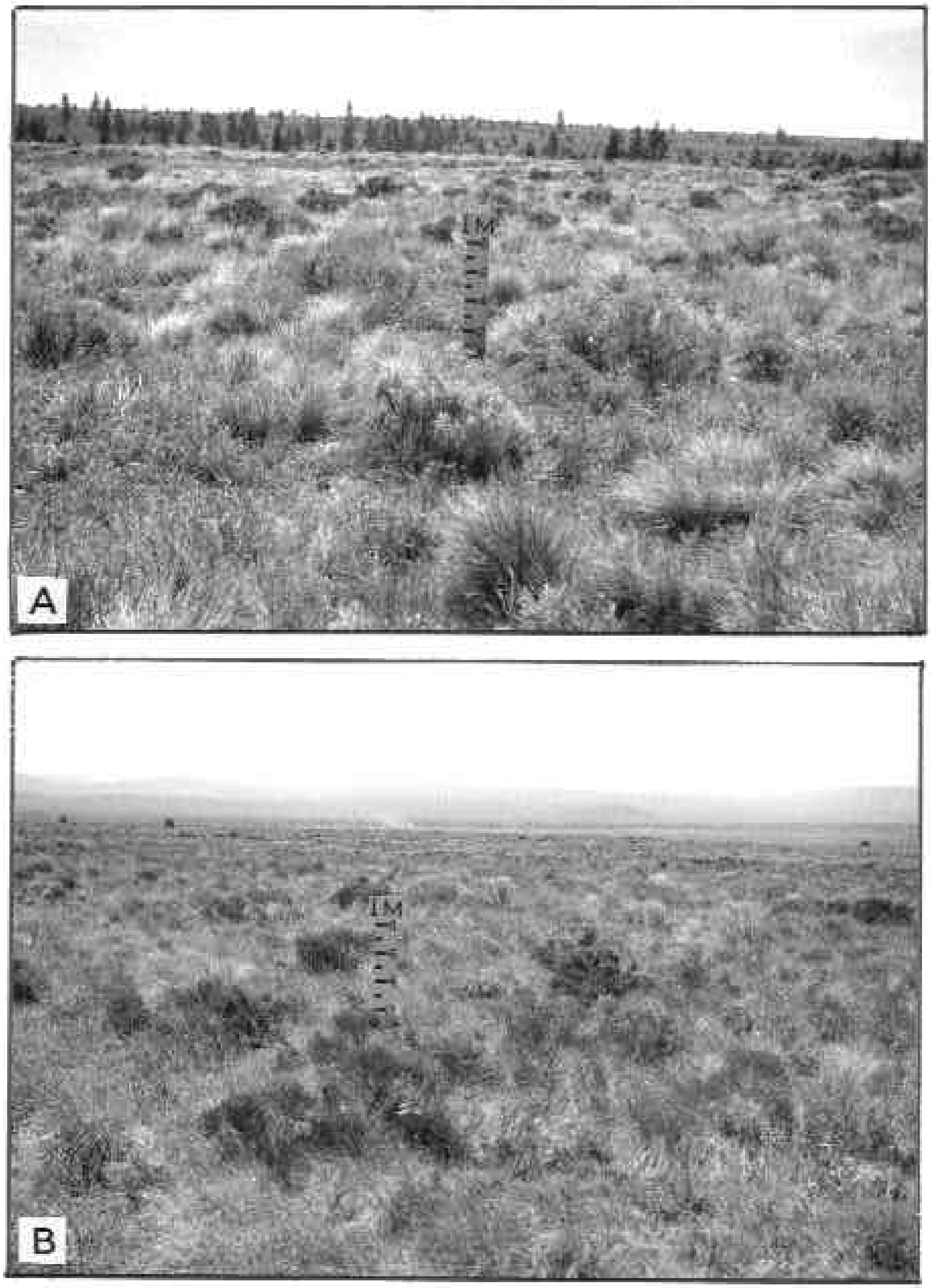


Figure 154—Light position affects emphasis on vegetation. (**A**) Photo taken into the Sun so that the subject is backlighted, which produces a “halo” around the edges and a shadow away from the Sun. The halo highlights vegetation and tends to give the picture a three-dimensional effect. An old adage says to photograph “before 10 and after 3" so that the Sun is low enough to enhance the halo effect. (**B**) The Sun is shining on the front of the vegetation (frontlight). Notice in B how the hills in the distance stand apart from each other owing to haze in the air.

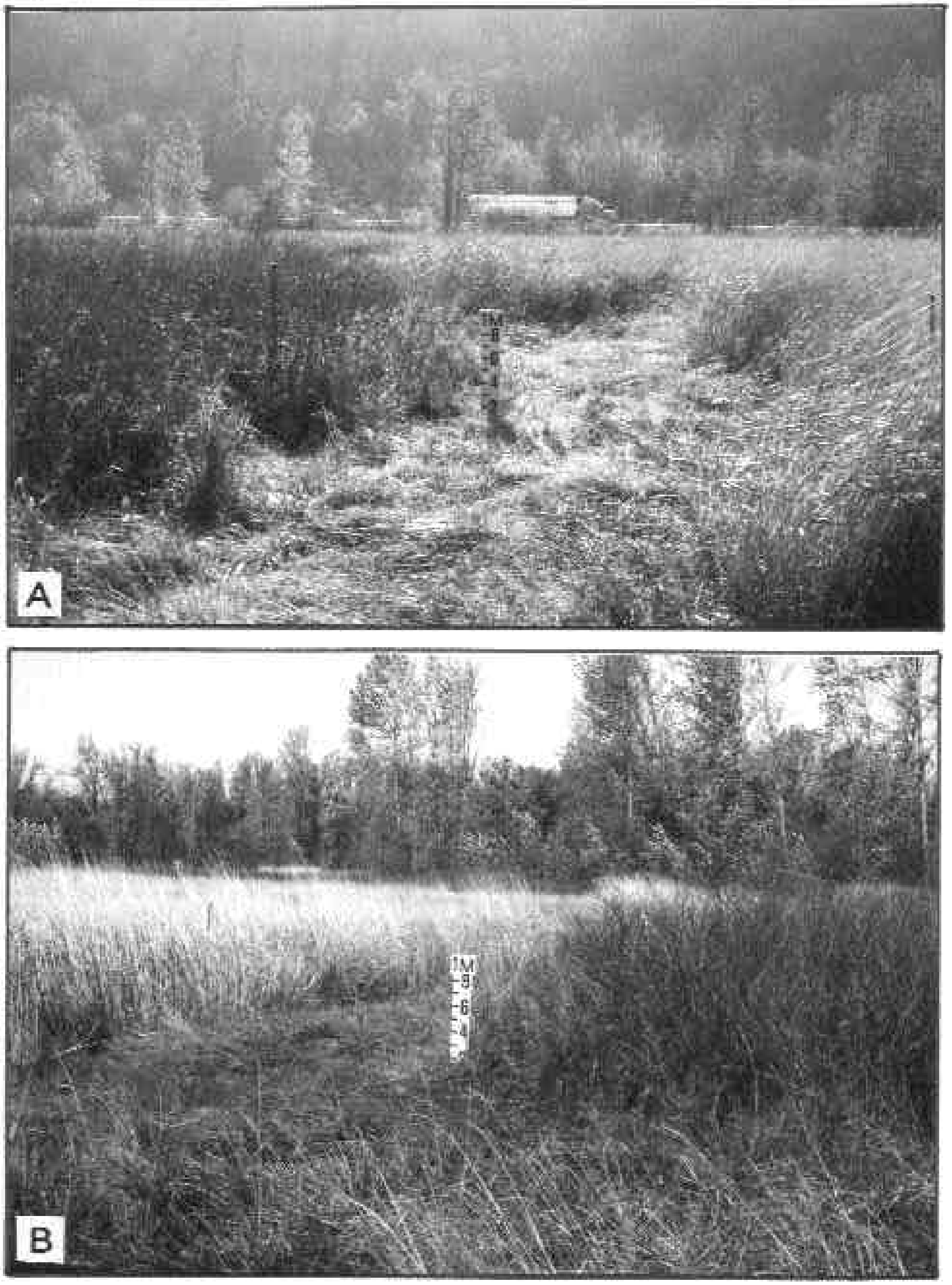


Figure 155—Asecond example of how backlight (**A**) versus frontlight (**B**) affects the highlighting of vegetation. The halo effect is well illustrated by the trees in A.

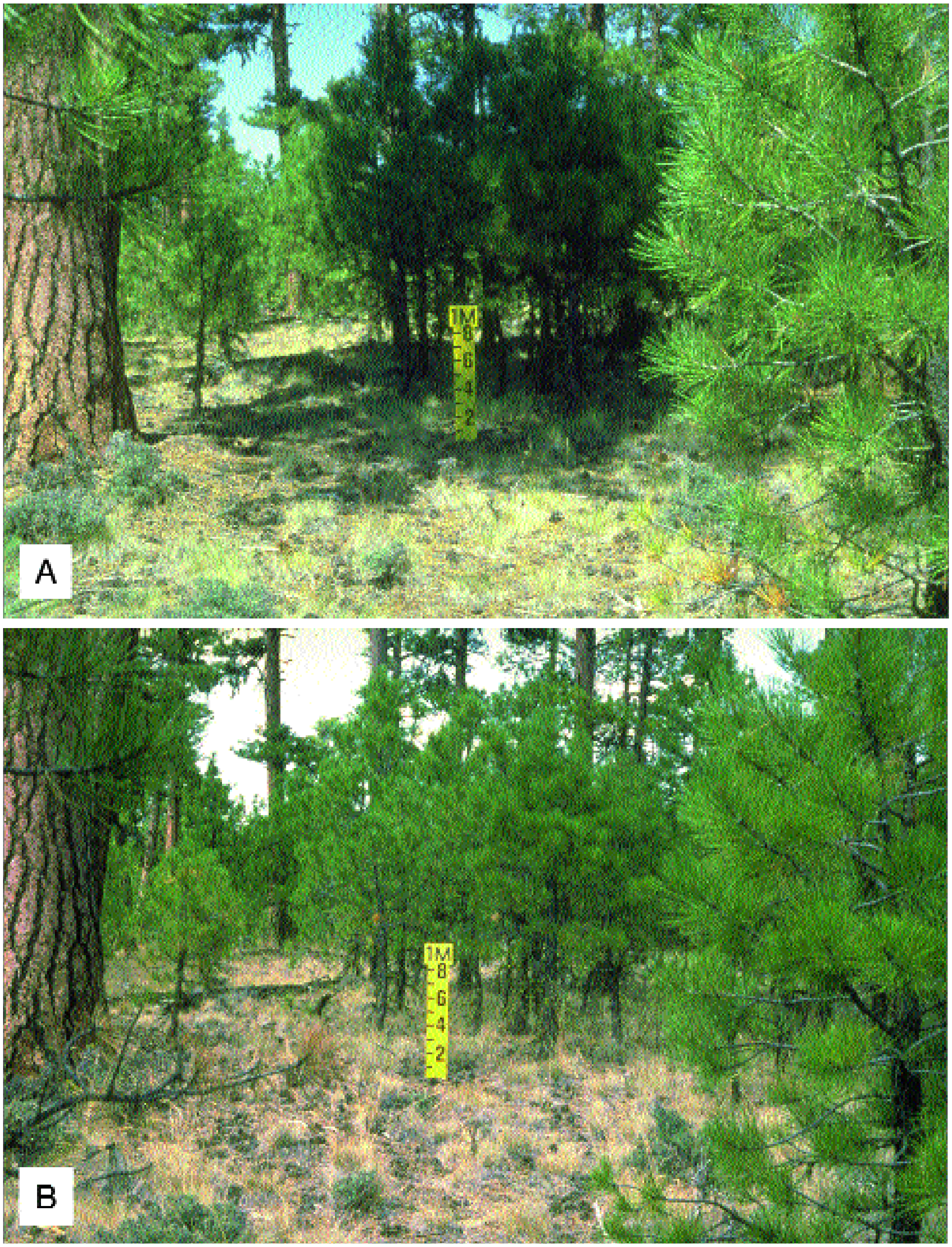


Figure 156—Overcast or full sunlight has major effects in shadow formation, a particularly serious consideration in forests. Overcast days (**B**) produce no shadows. Compare to full sunlight in **A**. With black-and-white film, the shadows may be "dodged" during the enlargement process to bring out much detail. Color film unfortunately has only about half the latitude of black-and-white film for shadows, so particular care must be taken when adjusting exposure. Slides cannot be dodged.

Sunlight compared to overcast skies has advantages and disadvantages. Overcast provides no three-dimensional effect and sunlight produces shadows. Figures 156 and 157 illustrate the disadvantages of shadows.

Camera exposure setting is a key to good use of light. Figure 147, A and B, illustrates the effects. In figure 147A, the exposure was overly influenced by the bright sky, which resulted in underexposure of the land. Determine the camera exposure for the brightest item close to the topic (sky or vegetation in full sunlight) and then for the topic or darkest item at the topic. Average the exposures. If you have any doubt, take three shots: one at the average, one an f-stop under, and one an f-stop over the average. Figures 156 and 157, however, illustrate a problem. The shadow is too dark and the sunlight on the vegetation too bright to be properly exposed, even with black-and-white film. Black-and-white film has about twice the latitude of color; color latitude is about one f-stop above and below average, and black-and-white film is about two f-stops.

Camera exposures in landscape photographs, particularly those showing areas more than 2 mi in the distance, should be set at a minimum of three f-stop settings: the light meter reading and one f-stop below and one above. When distance exceeds 2 mi, haze in the air influences the light meter to indicate less brightness than the land actually is reflecting, which causes overexposure of the land. In these cases, consider taking photos at both one and two f-stops additional exposure. Aerial photography suffers the same problem.

The effect of shadows and poor exposure in photographs may be partially corrected on prints (not slides) by dodging during enlarging. Dodging entails use of a cotton swab ½ to 2 in in diameter or a piece of light cardboard with a hole in it ½ to 2 in in diameter. Both should be very ragged around the edge to avoid creating a harsh edge in the finished print. During enlargement exposure, wave the swab above the overexposed area to cast a shadow and reduce the exposure time for that area. For underexposed areas, use the cardboard with the hole to shade most of the print and allow longer exposure to bring out details. Digital images may be enhanced by computer.

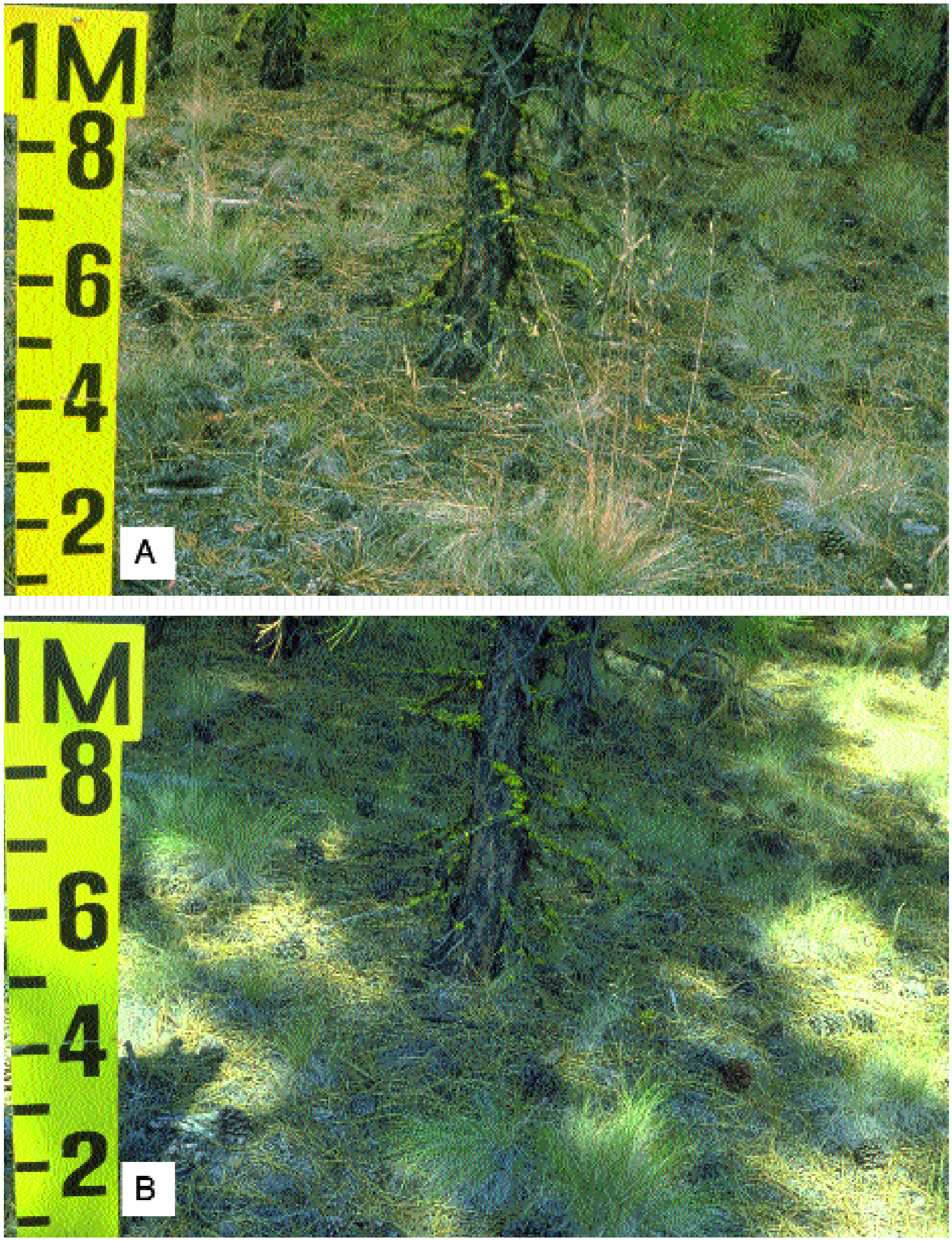


Figure 157—This example is taken at the same photo point as figure 156: (**A**) overcast and (**B**) a clear day with full sunlight.

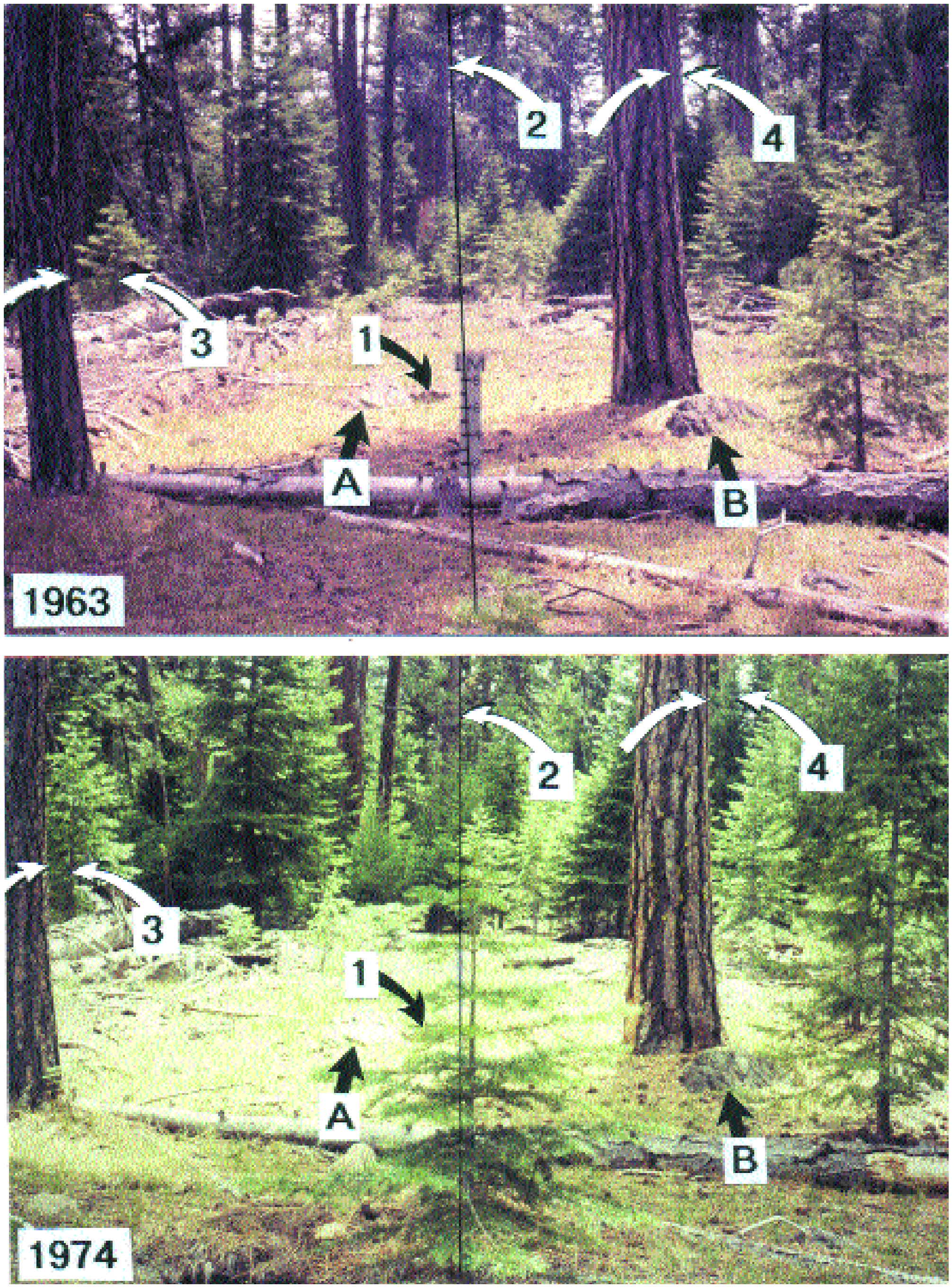


Figure 158—Relocation of photographs may be difficult when disturbance has occurred. In 1963, the centerline was established with a rock at 1 and the side of a large tree at 2. The arrows, A and B, indicate large rocks present in all photographs but not on the centerline; they help to locate the site and to validate the location. Left-side triangulation is identified by arrows at 3 showing the distance between a large tree and a small one. Right-side triangulation at 4 is identified by the side of a large foreground tree and one in the background. These triangulate the camera location. In 1974, the same items are shown without a meter board. Selection cutting occurred after 1974 with results shown in figure 159.

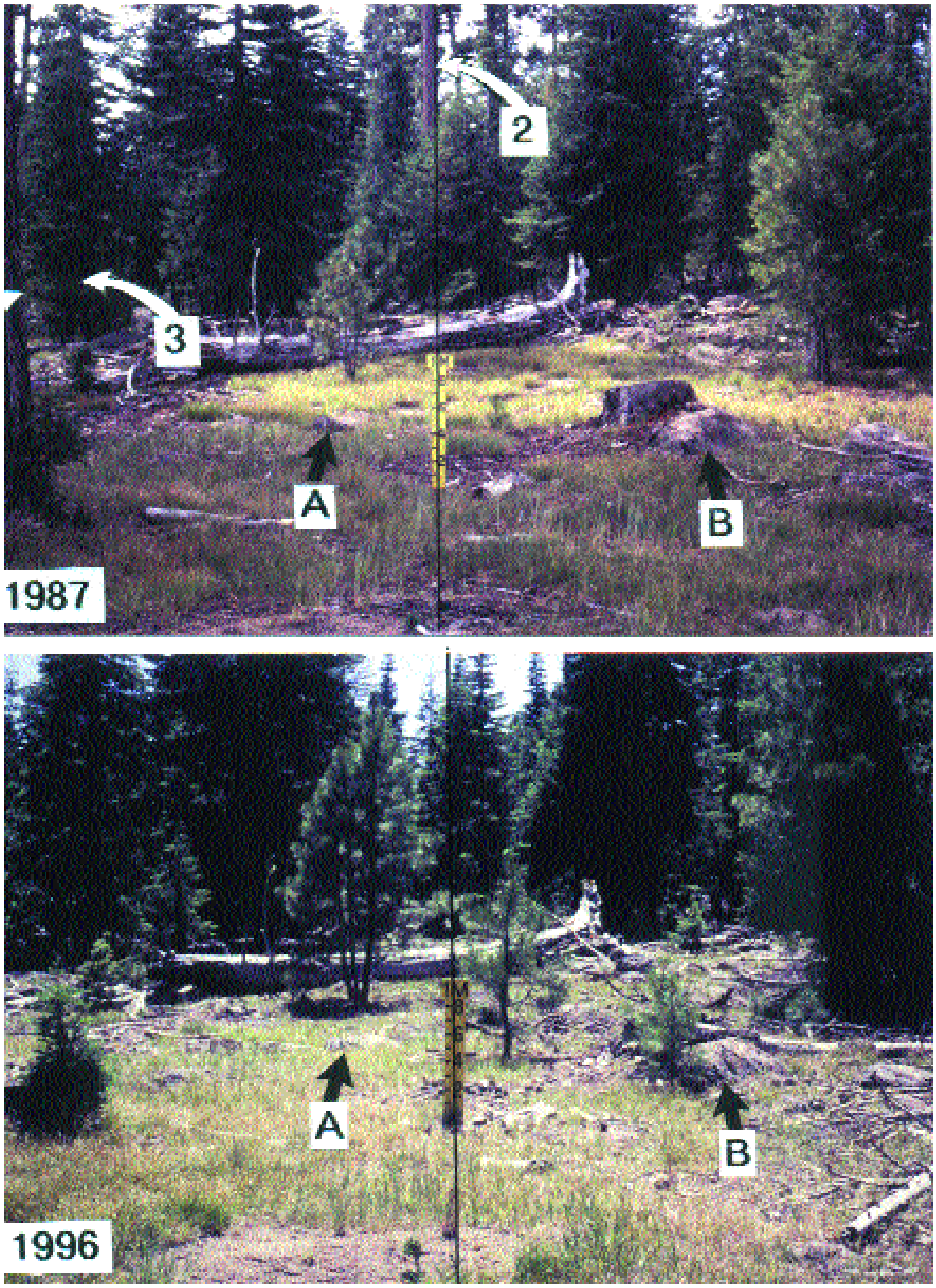


Figure 159—By 1987, selection cutting had removed the right foreground tree and the tree in the background located at 4 in figure 158, which eliminated the triangulation point. The rock at 1 was missing but the large tree in the background at 2 was present. Left-photo triangulation was still identified at 3. By 1996 after final overstory removal, all original vegetation orientation references were missing. Finding the location is facilitated by rocks at A and B, particularly B with its permanent location at the base of a tree. Precise relocation of both camera and photo points (meter board) were possible only from permanent steel stakes in the ground. Note soil hole spoils in the foreground. There has been no colonization of B or C horizon by native species in 33 years.

Relocation of Photographs

Figure 158 illustrates relocation of a camera location and photo point. The procedure is similar to that shown in figure 38. On the original photo (1963), draw a central line. A rock in the foreground and a tree in the background help establish the line. Remember, the meter board will not be in position when the site is next visited, so it cannot be used for the center line. Then establish reference points at the edges of the photograph to triangulate the camera location (fig. 158, 1963, points 3 and 4). For the1974 photo, walk forward and backward on the center line looking at the left and right sides of the picture, (3) and (4), for triangulation of the camera location. When these side identifications match numbers 3 and 4 in 1963, the camera location has been established. Note change in size of small trees between 1963 and 1974. These changes can be confusing in relocation.

Figure 159, 1987, is 13 years after figure 158 and after a first partial overstory removal. The foreground tree (item 4 in fig. 158) and the background tree are both missing so this triangulation point is no longer usable. On the left of the photo, triangulation point 3 is still available to aid location of the camera location. However, the rock at 1 has been removed and the down tree has shifted position making exact location of the center line difficult. By 1996, after the final overstory removal (fig. 159), all original reference points have been destroyed. Only rocks at arrows A and B remain. They verify that this is the same area, but do not relocate the camera location or photo point.

The moral to this story is to permanently locate, with steel stake or fencepost, both the camera location and the photo point. If disturbance such as this is anticipated, use steel stakes or ½-in-diameter rebar driven flush with the ground. Driving them flush with the ground will help prevent them from being ripped out by equipment. A metal detector will be needed to relocate the stakes.

Any kind of disturbance or vegetation growth can make relocation of photo monitoring points difficult if they are not marked by steel stakes or fenceposts. Figure 160 illustrates the effects of a wildfire where the camera location and photo point were permanently staked. The camera location could have been located approximately by aligning the meter board with a juniper in the background, the pair of junipers on the far right, and juniper branches on the left.

The advantages of using steel stakes are shown in figure 161. This kind of photo point cannot be exactly relocated by referring to general triangulation methods.

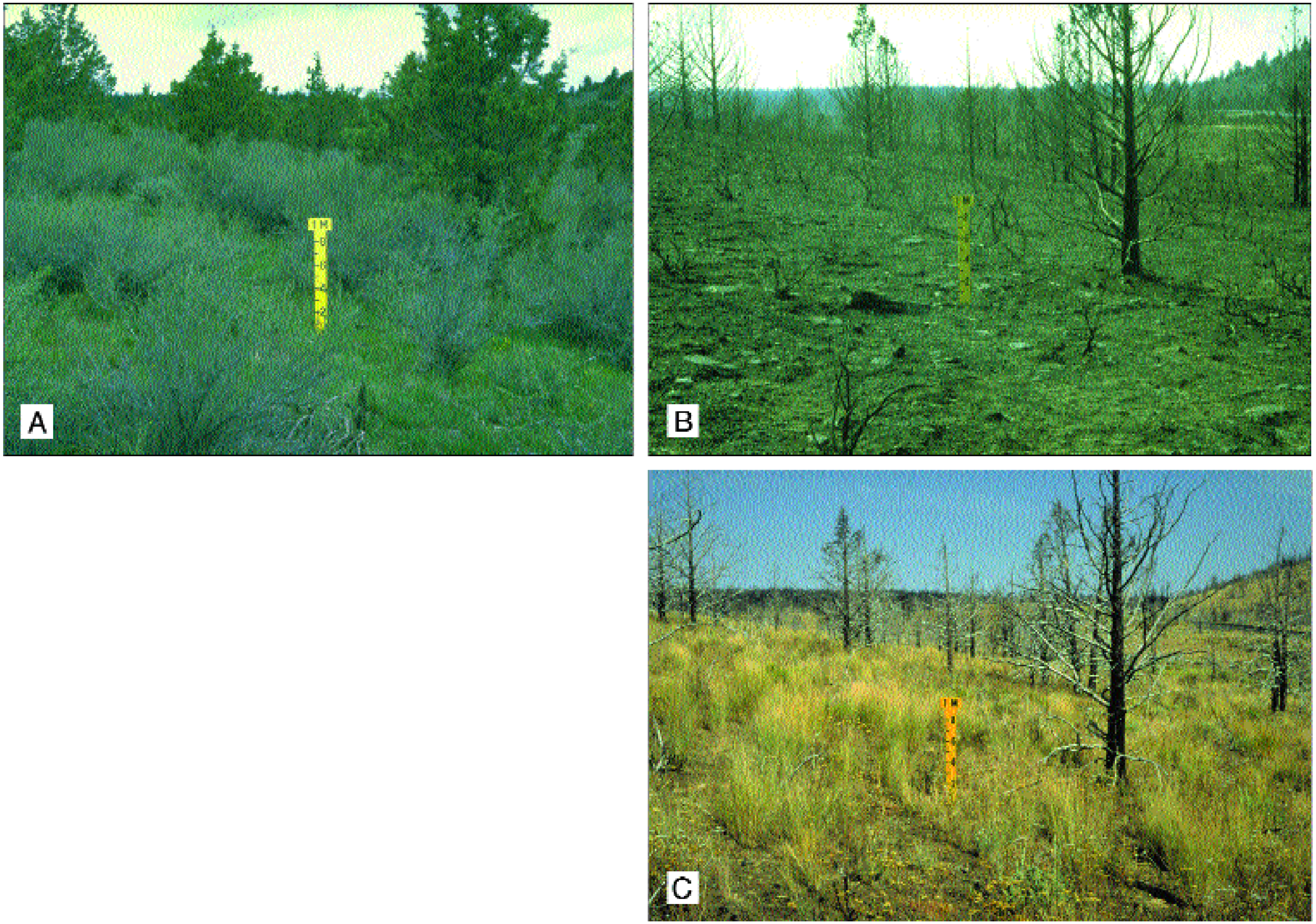


Figure 160—Rephotography of disturbed areas is illustrated. (**A**) The preburn vegetation. This sample plot was established as a data source for livestock forage rating guides. It was in the best vegetative condition for juniper/bitterbrush/Idaho fescue (*Juniperus occidentalis* Hook./*Purshia tridentata* (Pursh) DC./*Festuca idahoensis* Elmer). (**B**) Six years later the area burned by wildfire. (**C**) The area 4 years after the burn. Approximate relocation would be possible by noting the juniper directly above the meter board, the pair of junipers on the far right, and the branches of a juniper on the far left. Fortunately, the sample plot had been staked. Idaho fescue, killed by the fire, is being replaced by bluebunch wheat-grass (*Agropyron spicatum* vis. *Pseudoroegneria spicata* (Pursh) A. Love).

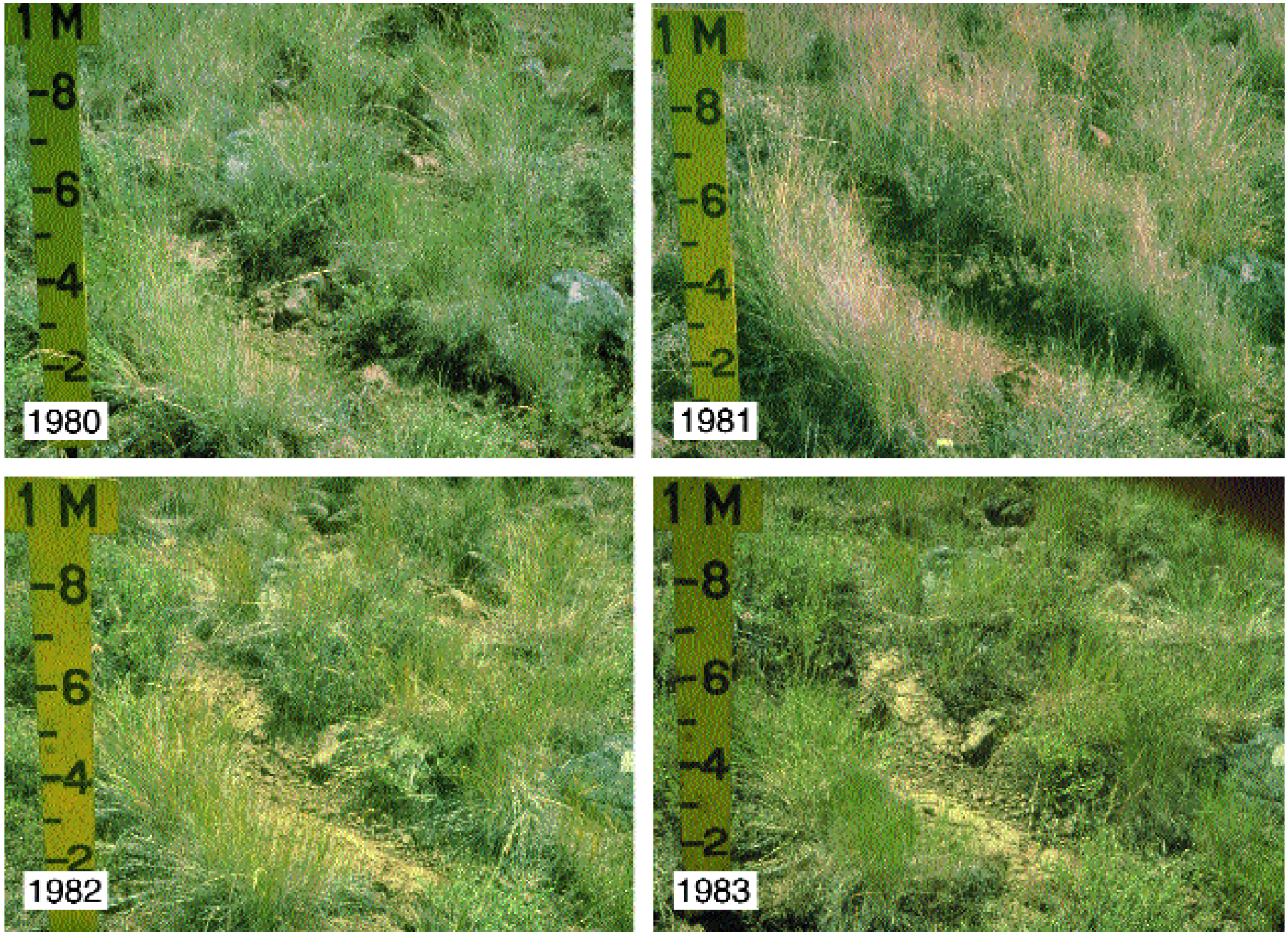


Figure 161—An example of photo monitoring of herbage production in a bluebunch wheatgrass community. Four years of a 25-year study are shown for the first week in August. Three things might be noted: (1) great variability in herbage production, particularly between 1981 and 1983; (2) tremendous difference in seed head production: some in 1980, abundant in 1981, none in 1982, and scattered in 1983; and (3) the difference in greenness of the grass.

Index

Regular = page where item is included in discussion
Bold = page where major discussion occurs
Italic = page with an illustration
Bold italic = page with an illustration and a major discussion

Metric and English Conversions

When you know:	Multiply by:	To find:
Millimeters (mm)	0.04	Inches
Centimeters (cm)	0.39	Inches
Decimeters (dm)	3.9	Inches
Inches (in)	2.54	Centimeters
Meters (m)	3.28	Feet
Feet (ft)	0.3	Meters
Square meters (m^2)	10.76	Square feet
Square feet (ft^2)	0.09	Square meters
Meters (m)	1.09	Yards
Kilometers (km)	0.62	Miles
Miles (mi)	1.61	Kilometers
Hectares (ha)	2.47	Acres
Acres	0.4	Hectares
Kilograms per hectare (kg/ha)	0.89	Pounds per acre
Pounds per acre (lb/acre)	1.12	Kilograms per hectare
Grams (g)	0.035	Ounces
Ounces (oz)	28.35	Grams
Celsius (°C)	(1.8 × °C) + 32	Fahrenheit
Fahrenheit (°F)	0.55(°F - 32)	Celsius

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	desmith@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, OR 97208-3890