Ground-Based Photo Monitoring

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Abstract.—Ground-based photo monitoring is repeat photography using ground-based cameras to document change in vegetation or soil. Assume those installing the photo location will not be the ones re-photographing it. This requires a protocol that includes: (1) a map to locate the monitoring area, (2) another map diagramming the photographic layout, (3) type and make of film such as Kodak Elite-2®, ASA 200, (4) specific instructions for doing the photography, (5) instructions for when to re-photograph. Use a meter board to identify the topic of interest, to orient current and repeat photographs by focusing on the "1M" of the board, to ensure maximum depth of field by focusing on the "1M," and to provide a measured reference for grid analysis of change.

BASIC CONSIDERATIONS

Methods of photo monitoring have several things in common. Selection of a monitoring area must be based on the purpose of photographic sampling (similar to measurement sampling). The area must be located on one map and the sampling layout shown on a second map with directions and distances. When to photograph is usually determined by the activity being monitored. Camera locations and photo points must be permanently located with fence posts or steel stakes ensuring the same distance from camera to photo point. And, all pictures should be taken with a photo identification paper in view to permanently identify slides and negatives.

Area Selection

Selection of a monitoring area requires a great deal of professional expertise liberally mixed with artistic finesse. The **purpose** of photographic monitoring is the most critical factor to consider. It appears as two kinds of questions: where in the landscape is the topic of concern, and once on the area, what kind of change do I want to document? In some cases, "where" is straightforward. For example, documentation of logging impacts locates the area being logged (fig. 1), just as effects of beavers on a stream locate by the beaver activity. On the other hand, documentation of livestock grazing impacts requires understanding livestock distribution plus knowing the location of areas sensitive to grazing and the season of use that is most critical.

Once in an area, the real decisions must be made. Determine specifically what is to be documented for change (fig. 1). For example, the purpose of the photo monitoring was to document effects of a two-stage overstory removal and subsequent pre-commercial thinning on stand structure and ground vegetation. The camera location was selected within 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.

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When to Photograph

When to photograph is usually determined by the activity being monitored. Figure 1 illustrates a monitoring schedule dictated by logging activity. Photographs were planned for the first week in August to keep vegetation development consistent. They were taken just before logging and in each of the two seasons after cutting to document rapid changes in ground vegetation. Then, a 5-year re-photograph cycle was established to follow slower changes in both stand structure and ground vegetation. The routine was repeated with the second logging and a pre-commercial thinning.

If vegetation is a primary topic, consider establishing a fixed date for re-photography. An established date has two advantages. First, it offers an opportunity to evaluate yearly differences in plant phenological development. Second, it provides a consistent reference for comparing change over several years.

Maps to Locate the Monitoring System

After establishing the photo monitoring system, prepare maps to locate the area and to document the photographic layout. Assume the person installing the monitoring program will **not** be the one to find and re-photograph the area. Provide maps and instructions accordingly. Show on a local map the monitoring area locations.

Figure 1.—*Photo monitoring change in a ponderosa pine/pinegrass community after two cutting entries. Two photos for each year are shown. Left is the general photo identifying the topic for monitoring and right is half of a close-up using the meter board as a reference. All photographs were taken the first week in August. (A) Before the first entry with native pinegrass. (B) The second growing season after the first partial overstory removal showing seeded domestic grass species. (C) The second growing season after the final overstory removal and before pre-commercial thinning. The opened stand and palatability of domestic grass species resulted in livestock grazing to a 3-in. stubble height. In (A), the camera focus ring is centered on the "1M" of the meter board to orient the photograph and ensure sharp focus at the topic.*

Select a witness post or tree to mark 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, map the camera locations and photo points or transects with directions and distances. Note whether the direction is taken in magnetic or true degrees by indicating either "M" or "T." A 21-degree east declination in the Pacific Northwest must be accounted for.

Monitoring, by definition, means repeated observation. Therefore, all camera locations, transects, and photo points must be permanently marked. The recommended method is stamped metal fence posts. At 1998 prices, these cost about $2.25 each for a 5-foot size. Stamped metal has several advantages over strong "T bar" posts: they 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 fence post but are not worth the trouble, and they are easy to carry and pound.

Steel stakes often have been used and may be required on shallow soils. However, they have several disadvantages compared to flimsy fence posts: they will damage tires, hooves, or feet; they are often difficult to find; they are subject to theft; and if driven flush with the ground, they require a metal detector for location.

Same Distance Between Camera and Meter Board

One critical consideration in photo monitoring is the requirement for the **same distance** between the camera location and photo point for all subsequent photography on that sample. Any analysis of change depicted in the photographs can **only** be done when the distance remains the same. A standard distance for all photo monitoring is not required. Distance may vary from one camera location to another. Camera format may also change, such as first pictures with a 50-mm lens and next pictures with a 35-mm lens, but distance must remain the same.

Figure 2 illustrates the effect of changing distance on location and size of objects in the picture. The view is a test landscape where objects have been placed at various distances from the camera. A 50-mm camera lens on a 35-mm body was used at distances of 7 and 10 m from the meter board. Clear plastic was placed on each photograph and the objects outlined: solid lines for 10 m and dashed lines for 7 m. Then, the 7 m outline was reduced in size to exactly match the size of the meter board at 10 m and the two outlines overlaid (C in fig. 2). Clearly, the size and location of objects are different. The reason is change in geometrical relationships between the camera and meter board. Angles from 7 m are different from those at 10 m.

Changing camera focal length, from 50 to 35 mm, will still produce very similar pictures. At 7 m, the 50-mm lens is shown in figure 2(A) while a 35-mm lens at the same distance would produce a photograph similar to figure 2(B). However, if both focal lengths are taken from the same distance and outlines adjusted in size to the meter board, both location and size of objects are will be the same. They are the same because the geometrical angles between camera and meter board are the same. A 35-mm lens simply has a wider view of the landscape.

Photograph Identification

Each photograph should be identified by site name, photograph number, and date. The critical factor is identification of **negatives** for color or for black and white pictures. Slides can be written on. However, there is no room to identify negatives. Placing a photo identification card in each picture view ensures a permanent record on the negative. This has been one my biggest problems—negative identification. The only identification for negatives of figure 1 is their envelope!

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

Cameras and Film

A wide variety of cameras and film are available and suitable for use. For example, a 27-exposure disposable camera using 35-mm color film with a 35-mm focal length lens is available for about $15. It is compact enough to fit in a shirt pocket. Processing for two 4- by 6-inch prints is about $14 for a total of $29. The other end of cost might be a fine zoom lens for $800 on a sophisticated 35-mm camera body costing $800 capable of 36 exposures using any 35-mm film. Purpose and longevity of the photo monitoring program are major factors in camera and film selection.

Cameras

Over the past 40 years, I used a pair of good quality 35-mm reflex cameras and 50-mm lenses (about $800 each at 1998 prices). One had color and the other had black and white film. Today, I use a nice quality weatherproof 35-mm camera with 35-mm lens, flash, and date-back, capable of 36 exposures, and compact enough to fit in a shirt pocket.

Several things might be considered in selecting cameras. (1) Is photo monitoring the primary purpose of the

Figure 2.—*Photographic test landscape used to evaluate camera to photo point distance and camera focal length. (A) A photo taken with a 50-mm lens on a 35-mm camera body 7 m from the meter board. (B) The same camera 10 m from the meter board. Objects in each photo were outlined on a clear plastic overlay: solid lines for 10 m and dashed lines for 7 m. Then the plastic outline for 7 m was reduced to exactly match the size of the meter board at 10 m. Finally, in (C), both outlines were overlaid to show difference in both object size and location. Differences are caused by change in geometric angles between the camera and meter board as distance changes.*

camera? If it is, then a pocket-size 35-mm focal length is most convenient. Seriously consider a disposable camera for about $15. (2) Do you contemplate other uses? Will a simple, wide angle lens camera suffice? Is a flash necessary for poor light conditions or indoor use? Then, a simple wide angle camera in the $150 bracket might be a choice. (3) Do you want a variety of focal lengths? Zoom lens cameras come in many forms and prices. Some under $200 are available, but their lenses require nearly full sunlight or flash, which tends to limit their usefulness for photo monitoring, particularly in low-light forested conditions. Good quality zoom or interchangeable lens cameras start at about $500.

Film

Three choices are available in film: (1) color slides, (2) color prints, or (3) black and white. I have always used color slide film in one camera and black and white in the other. Color slides are used for oral presentations and black and white for publishing. Both cameras are connected to an aluminum strap 1 inch wide and bent into a "U" so both can be handled with one hand.

I use both color and black and white because color film, slide or print, will fade with time and black and white will not. Once an exposure has been made on slide film, little can be done to enhance the image. Negative films, for either color or black and white, offer an opportunity to modify images when making prints. Different print paper may be used, time of exposure can be adjusted, and overexposed or underexposed parts may be "dodged" to enhance the image.

All film comes in various degrees of graininess. This is usually identified by the film speed; the higher the speed, the grainier the film. For example, ASA 64 is a very fine grain film whereas ASA 800 is quite grainy. ASA 800 color film is used in disposable cameras without flash.

Color film varies in color tones between brands from a single manufacturer, such as Kodak's Kodachrome® compared to Ektachrome Elite®, and between manufacturers such as Fuji and Kodak. Film developing may produce different tones from the same kind of film. Color prints can vary from the same negative depending upon how the prints were made. Time of exposure and kind of paper are critical. Do not cheapen your photography by cut-rate processing.

PHOTOGRAPHIC TECHNIQUE

Photographs identify a specific topic of interest (fig. 1). A meter board, or other size, control board, is placed at the topic for several reasons: It (1) identifies the item to be monitored, (2) establishes a camera orientation reference point for subsequent photography, (3) ensures greatest depth of field at the topic by focusing the camera on the "1M" of the board, and (4) establishes a constant-size reference by which change may be documented—with grid analysis, for example.

Photo Sampling Guidelines

Several steps might be considered when establishing photo monitoring. Figure 1 will be used as an example.

Define the topics of interest. The topics in figure 1 are effects of converting old-growth ponderosa pine/ pinegrass, *Pinus ponderosa* P.&C. Lawson/*Calamagrostis rubescens* Buckl., to a young forest, response of residual understory to thinning, and reaction of ground vegetation to overstory manipulation.

Next, define what coverage is desired in the monitoring area. How many camera locations and photo points are desired? What pre-cutting stand conditions are important?

In many cases, details might be desired that are not accommodated by a meter board 7 to 10 m distant. Close photos, one on each side of the meter board, are recommended. These are taken at 1.5 to 2 m distance and show details on-the-ground in approximately a 1.5- by 1.5-m area. The concept is a general photo and two close-up photos to document change (fig. 1).

Consider the advantages of multiple photo points from the same camera location or multiple camera locations focusing on the same photo point. Advantages are twofold. First, relocation tends to be easier because only one point must be located that will serve two or more views. Second, one point showing several views tends to tie the monitoring area together.

Distance From Camera to Photo Point

Exact replication of distance for all re-photos is the reason camera locations and photo points must be permanently marked in the field. My preferred system is with flimsy fence posts. However, establishment of a fixed distance for all photo monitoring is not required. Tailor the camera-photo point distance to the topic being monitored.

Topic Description

Describe the setting and topic to be photographed each time photos are taken. Figure 1 illustrates a general photo and one of two close-up pictures of ground conditions. Record activities within the general photo and plant species, bare ground, or other items and their estimated cover for the close-up pictures.

Camera Orientation and Focus

Consistent re-photography requires a reference point to orient subsequent views. A meter board serves this purpose. The objective is to have the meter board remain constant while items within the view change. Figure 1 illustrates three repeat photographs of a ponderosa pine/pinegrass community that was cut twice. Figure 1(A) illustrates how the camera focus ring is placed over the "1M." This accomplishes three things: (1) It provides a common orientation point for the first and subsequent photographs. (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 always be in sharp focus. And (3), it serves as a measurement reference for grid analysis of change.

Close-up pictures on either side of the meter board help monitor the topic under study. After taking the general photo, walk up to the meter board and photograph it on each side. With a 50-mm lens, stand 2 m (7 feet) away, or with a 35-mm lens, stand 1.5 m (5 feet) away. Figure 1 illustrates partial close-up photos using a 50-mm lens. The critical factor is to always place the top of the meter board all the way up in a corner of the view. When you stand 2 m away with a 50-mm lens, the bottom of the board will be at the bottom of the picture as shown.

GRID ANALYSIS

The meter board is also used as a size reference for analyzing changes. One system is grid analysis, illustrated in figure 3. A pair of photographs, preferably in color and enlarged to 6 by 9 inches, is selected on which to document change in some topic. In figure 3, the topic is riparian shrub profile area from 1981 to 1996.

A clear plastic grid is adjusted in size to exactly match the meter board measurements as follows. The meter board is measured on the photograph, such as 24 mm, and divided by the measurement on a grid master such as 30 mm for a reduction in size of the master to 80 percent. The reduced grid master is then printed on a clear plastic overhead transparency sheet and taped at one edge to the photograph. One-edge taping permits lifting the clear grid to closely inspect the photograph.

Next, topics of interest are outlined on the grid. When outlining, be careful to place the line precisely on the edge of the topic. Exact placement is required because an intersect under the line is counted. Intersects within each outline are counted and recorded for each photograph. Finally, the number of intersects are compared between photographs to estimate change. In figure 3, shrub profile intersects were 396 for 1981 and only 222 for 1996. Unpublished test results using seven observers indicate this is significant at $P = 0.01$. The outlines may also be compared as shown in figure 3(C).

SUMMARY

Ground-based photo monitoring is a rapid system for monitoring changes in ground conditions such as vegetation and soil. For best results, map the location so others can find and re-photograph, permanently mark each camera location and photo point so distance between the two does not change, and use a meter board or equivalent to mark the topic of concern, to orient later photographs, ensure sharp focus on the topic, and adjust analysis grids.

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Figure 3.—*Grid analysis of change in riparian shrub profile from 1981 to 1996. A master grid was reduced on a copy machine so the meter board profile on the grid exactly matched the meter board in the photo. This reduced grid was then copied onto clear transparency plastic and taped to the photograph. Each shrub under the grid was outlined. The two grids were then overlaid for comparison as shown in (C). These grids are permanent documentation of changes on the photographs so they must be labeled with the study and site identification.*