## 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

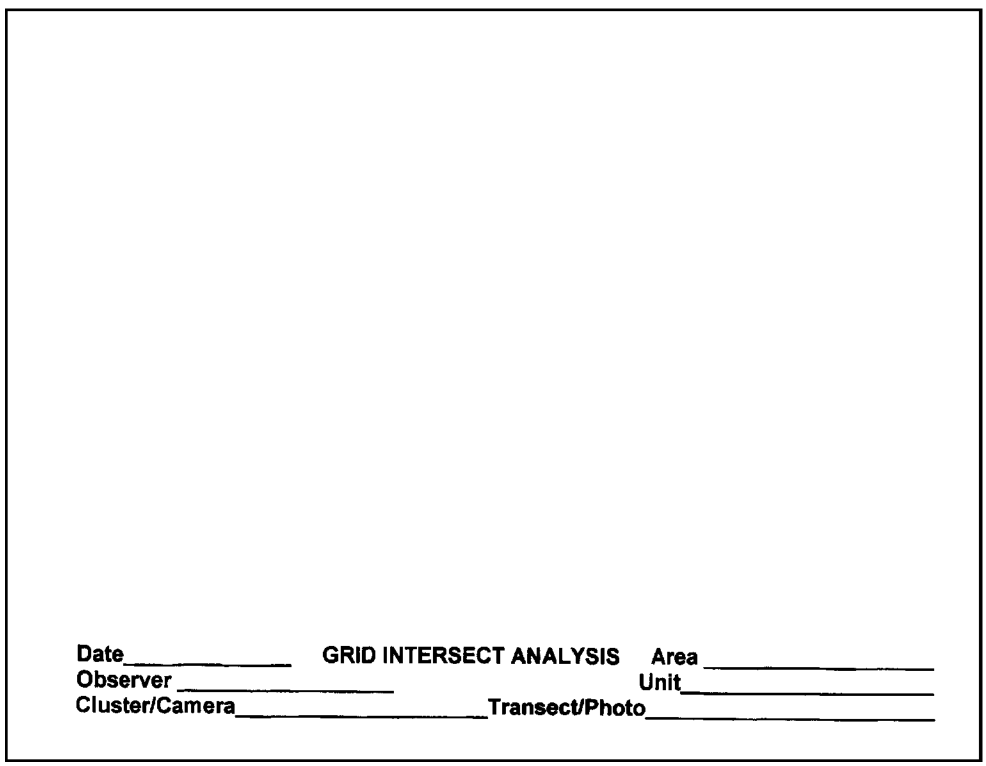
Requirements for photography suitable for grid analysis include the following:

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.

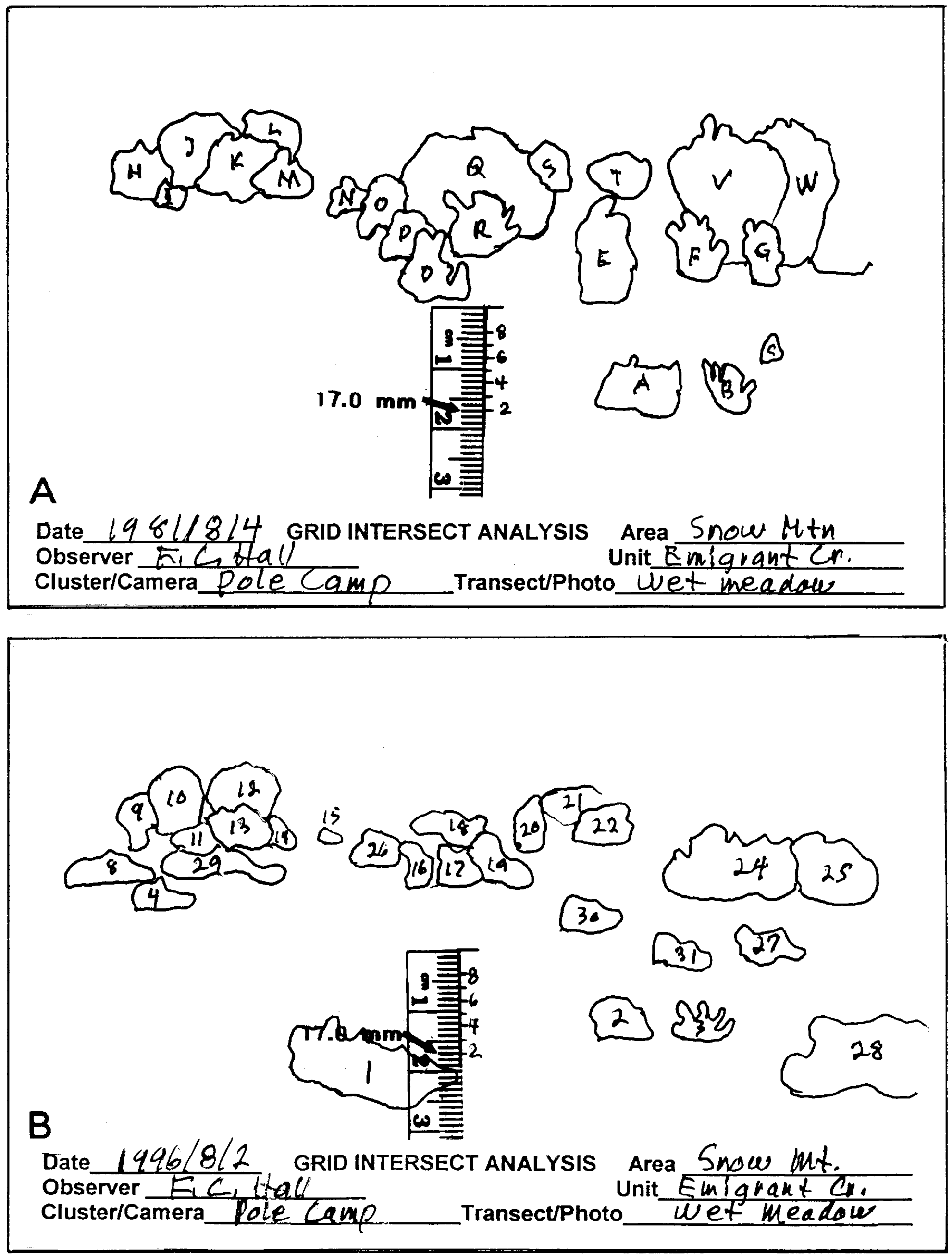



Figure 56—Measurement of meter boards for size adjustment of analysis grids: (**A**) 1981 and (**B**) 1996. Measure from the top down to the lowest visible decimeter mark to the nearest 0.5 mm, in these photos the 2-dm mark. Both measurements are 17.0 mm, which indicates the same distance from camera 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.

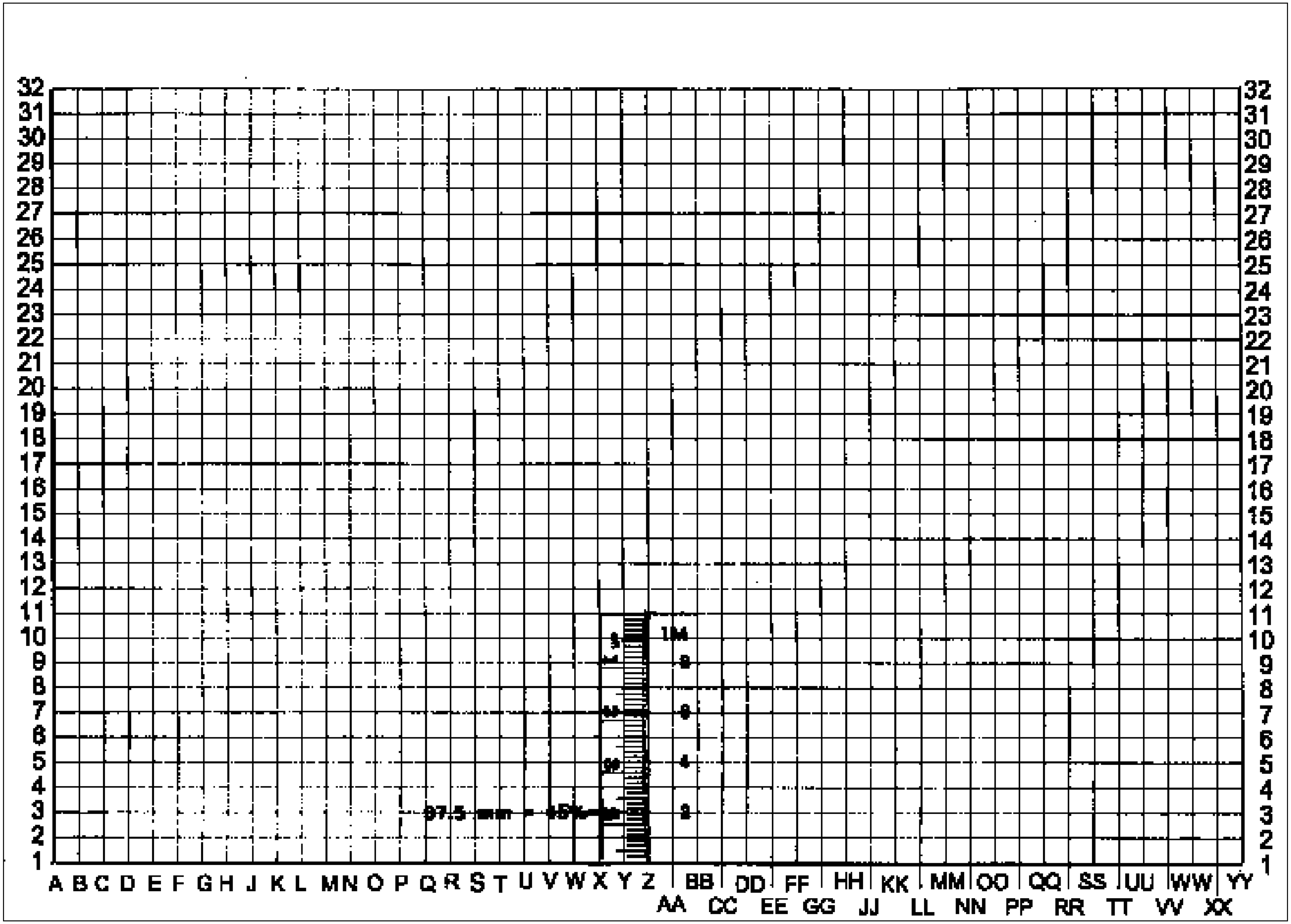



Figure 57—The master analysis grid found in appendix C. Measure from the top of the meter board to the 2-dm mark used in the outlines. This measurement is 37.5 mm. Divide 17.0 mm from the outlines by 37.5 for a reduction to 45 percent of the grid. Print the grid on white paper at 45 percent of its original 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).

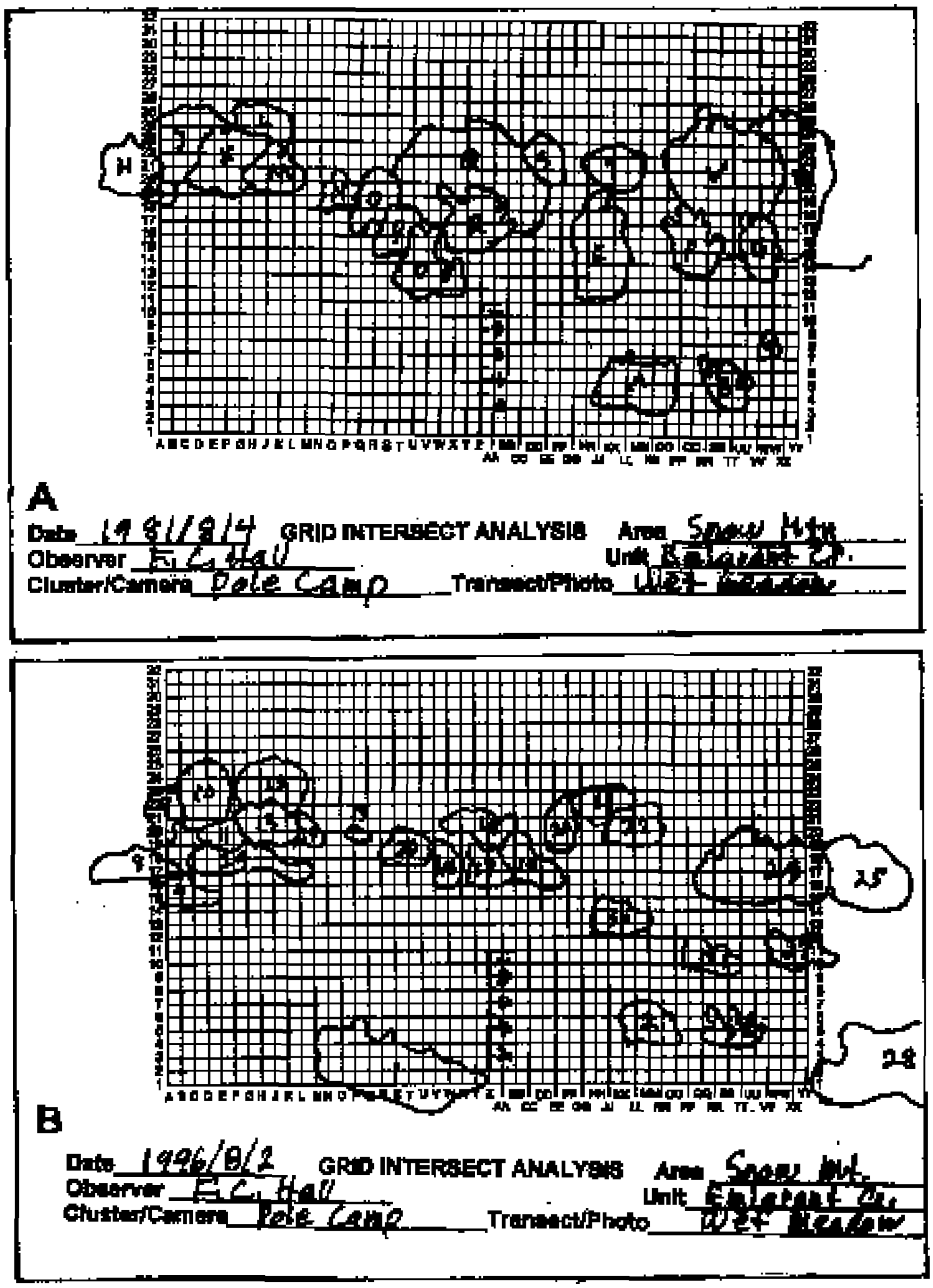



Figure 58—Outline overlays placed on analysis grids: (**A**) 1981 and (**B**) 1996. The next step is to count grid intersects within each outline. When an outline crosses a grid intersect, such as the two intersects between shrubs 17 and 19, AA/18 and AA/19 in photo B, count the intersects for the shrub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

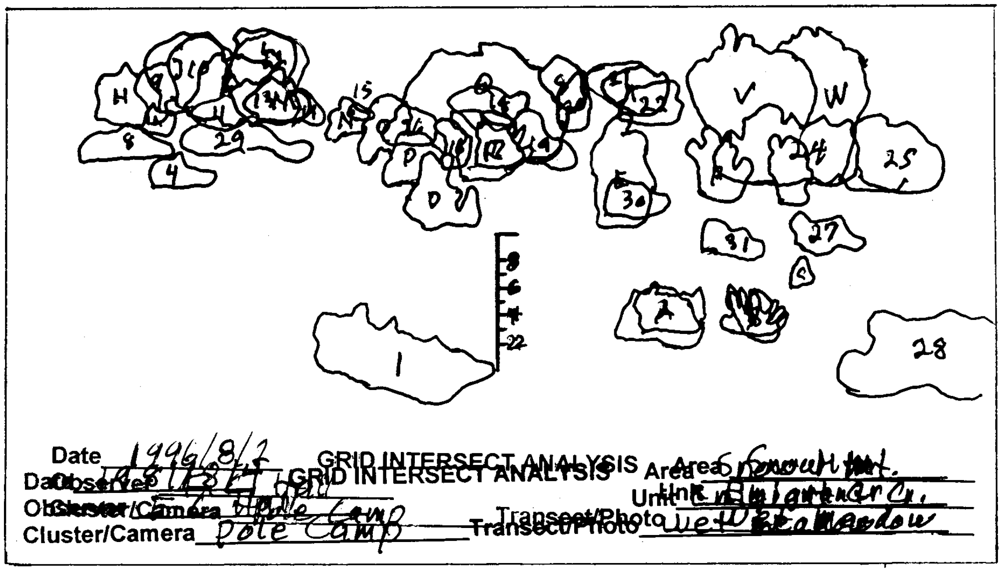



Figure 60—Outlines from 1981 (letters) and 1996 (numbers) overlaid for comparison of change in shrub profile. Note major changes in shrubs Q, V, and W, and a new shrub shown as 1. The dramatic reduction in shrub height of Q, V, and W from 1981 to 1996 was caused by beavers cutting the largest stems for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

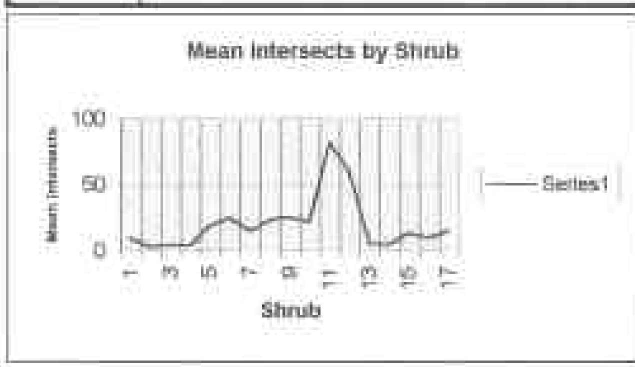
A test was made in January 1998 of observer variability in outlining the shrub profile area shown in figure 53. Results of the seven observers are in figure 61. A 6- by 9-in color print with properly sized grid was provided. Observers placed the grid, outlined shrubs, and summarized intersects within 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 | 2.3314198 | 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 | 9.874806968 |
| K | 23 | 24 | 28 | 13 | 34 | 13 | 21 | 22.28571 | 7.6095178 | 5.6370978 | 25.29466952 |
| L | 86 | 81 | 79 | 91 | 82 | 81 | 77 | 82.42857 | 4.6853368 | 3.4708772 | 4.210769515 |
| M | 65 | 58 | 59 | 72 | 43 | 66 | 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 | 2.5965816 | 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 |



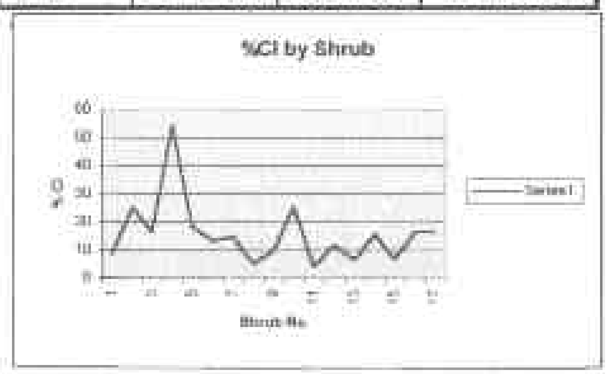




Figure 61—Summary of seven observers determining grid intersects on 18 shrubs from the same photograph. Variability among observers is characterized by the 5-percent confidence interval (5%CI) and is expressed by dividing the 5%CI by the mean intersects by shrub and multiplying by 100 (CI%Mean). The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

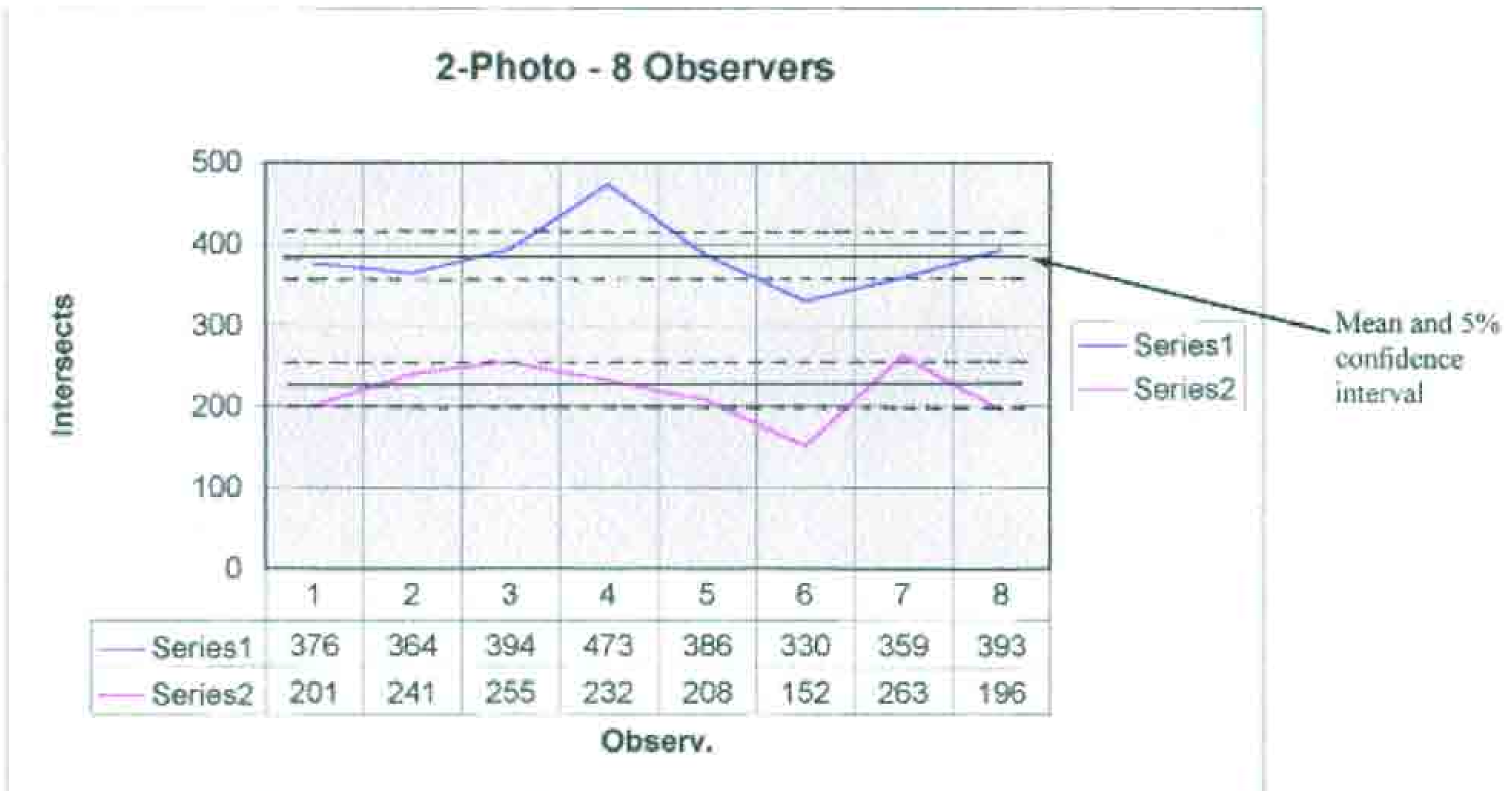



Figure 62—Outline analysis test for variability among eight observers in estimating shrub profile intersect. Photographs from 1975 and 1995 taken at the Pole Camp wet meadow photo point were compared. Series 1 is 1975 and series 2 is 1995. The 5-percent confidence interval for 1995, 12 percent of the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

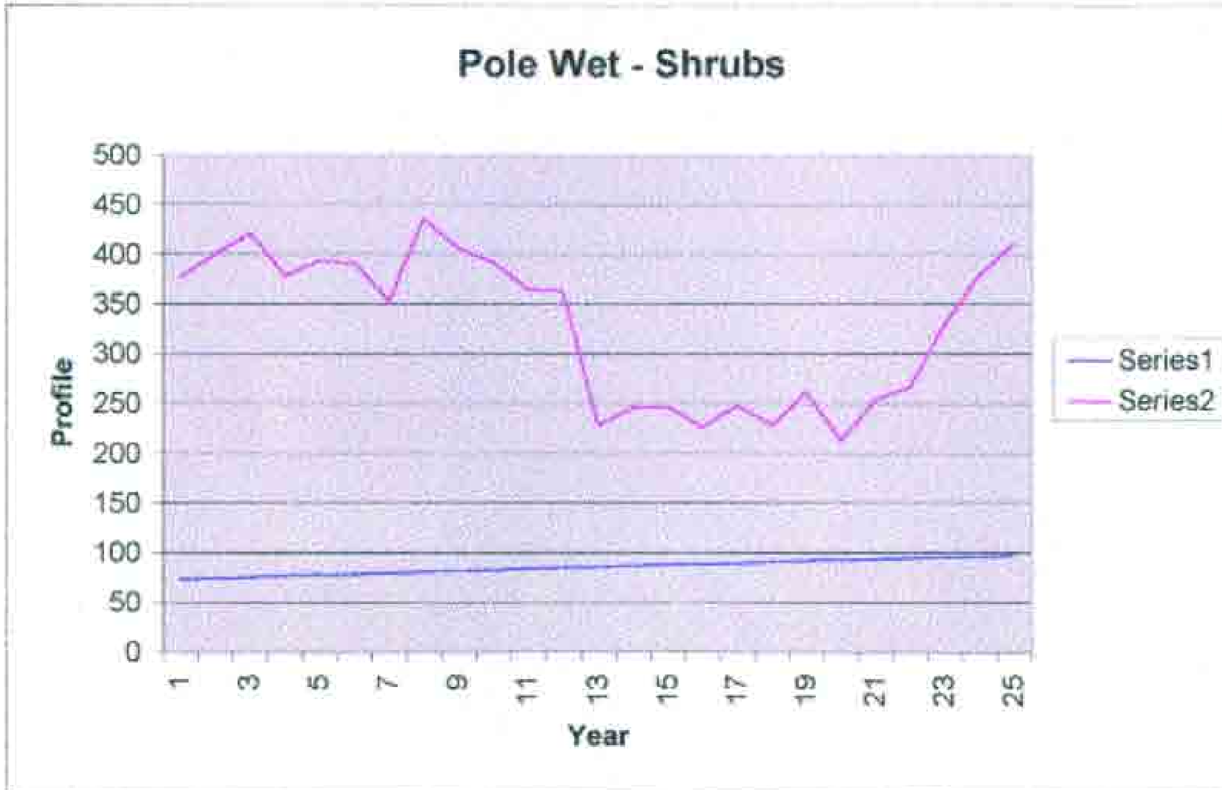



Figure 63— Regression of outline intersects from 1975 through 1997 for shrub profile changes at the Pole Camp wet meadow photo point. Intersects are total inside the grid area. Series 1 are the dates by year and series 2 are the intersects.

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 ______

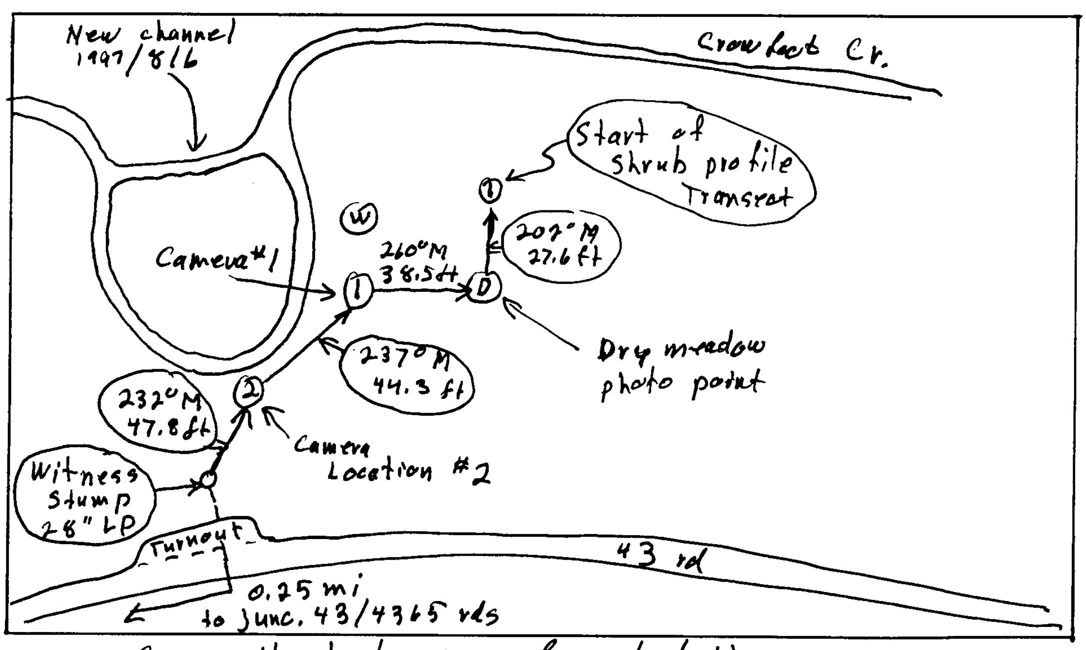
Location: T. 19S R. 27E
Sec. 29; SW of NE
Description: Open meadow between 43 rd and Crowsfoot Cr.; 0.25 mi W. junc. 43/4365 rds

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.

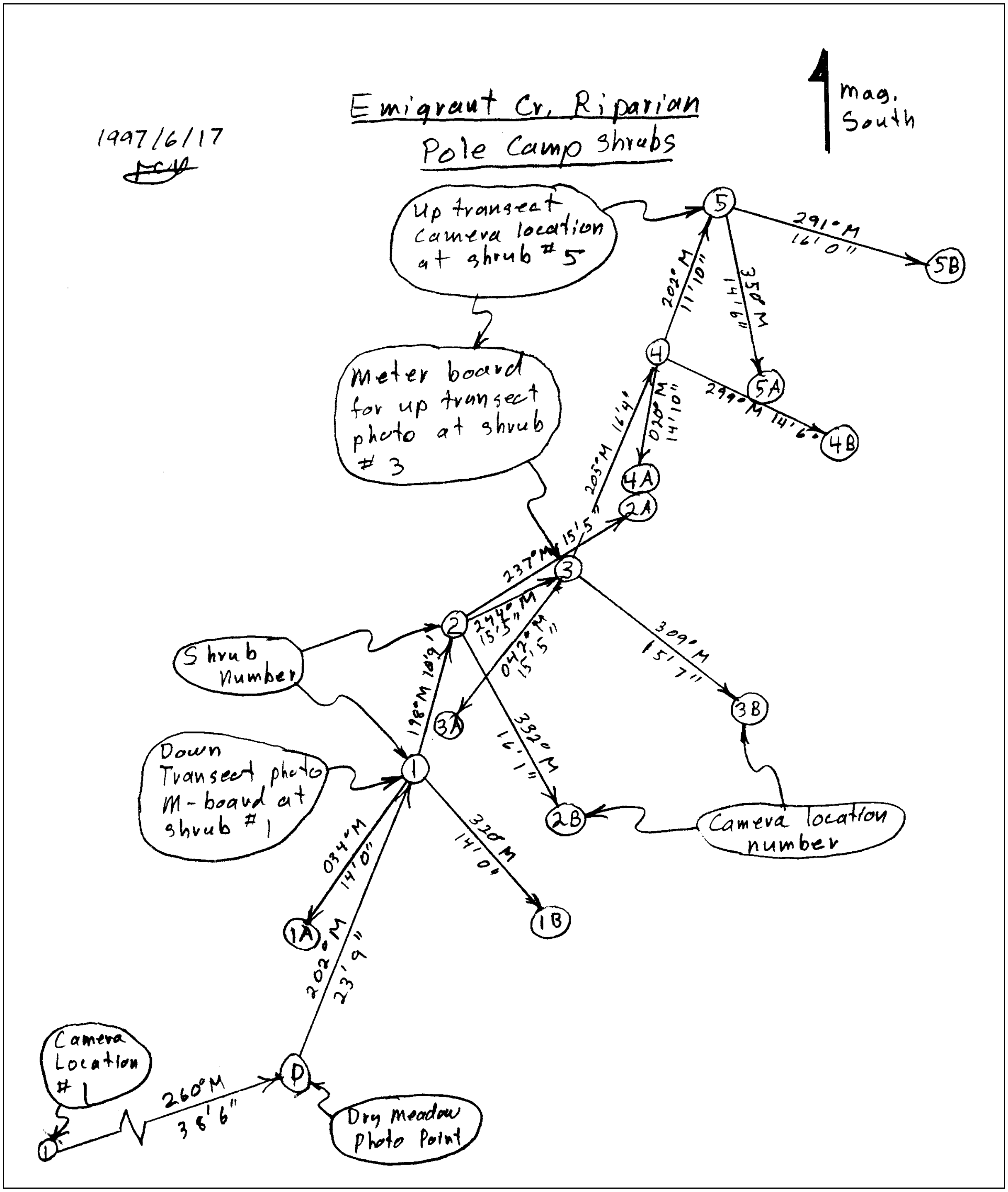



Figure 65—Details on the Pole Camp shrub profile transect. Instructions begin at camera location 1 for Pole Camp monitoring. The dry meadow photo point has been used as a camera location for a view down the transect (fig. 64). Direction in magnetic degrees and distance are shown for the five shrubs and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

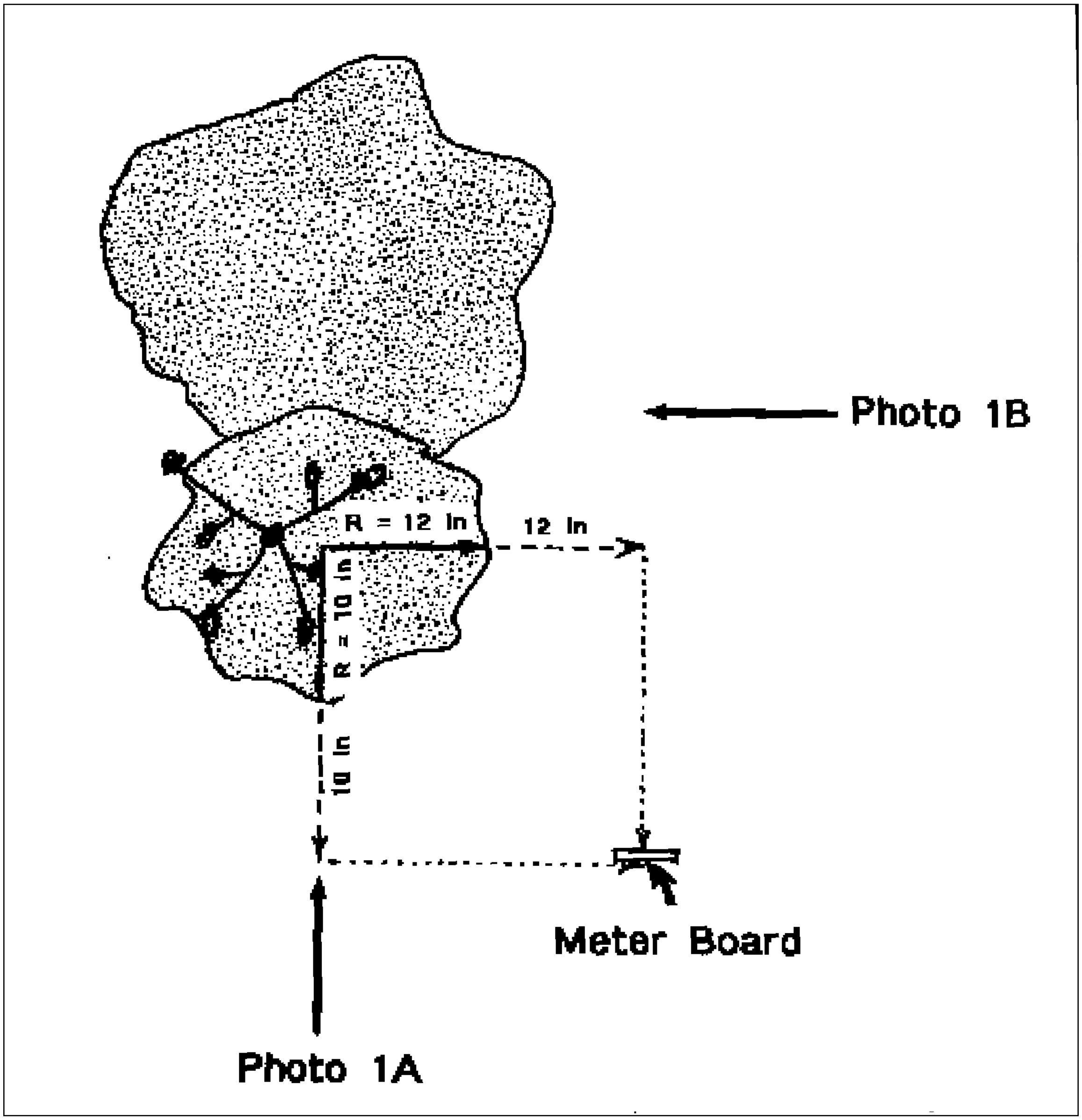



Figure 66—System for location of a meter board when photographing shrub profiles. Figure 67 shows the views from photo 1Aand photo 1B. Locate the board as follows: Measure the shrub radius in two directions at 90 degrees to correspond to the direction of photographs (12 in and 10 in). Move out from the 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.

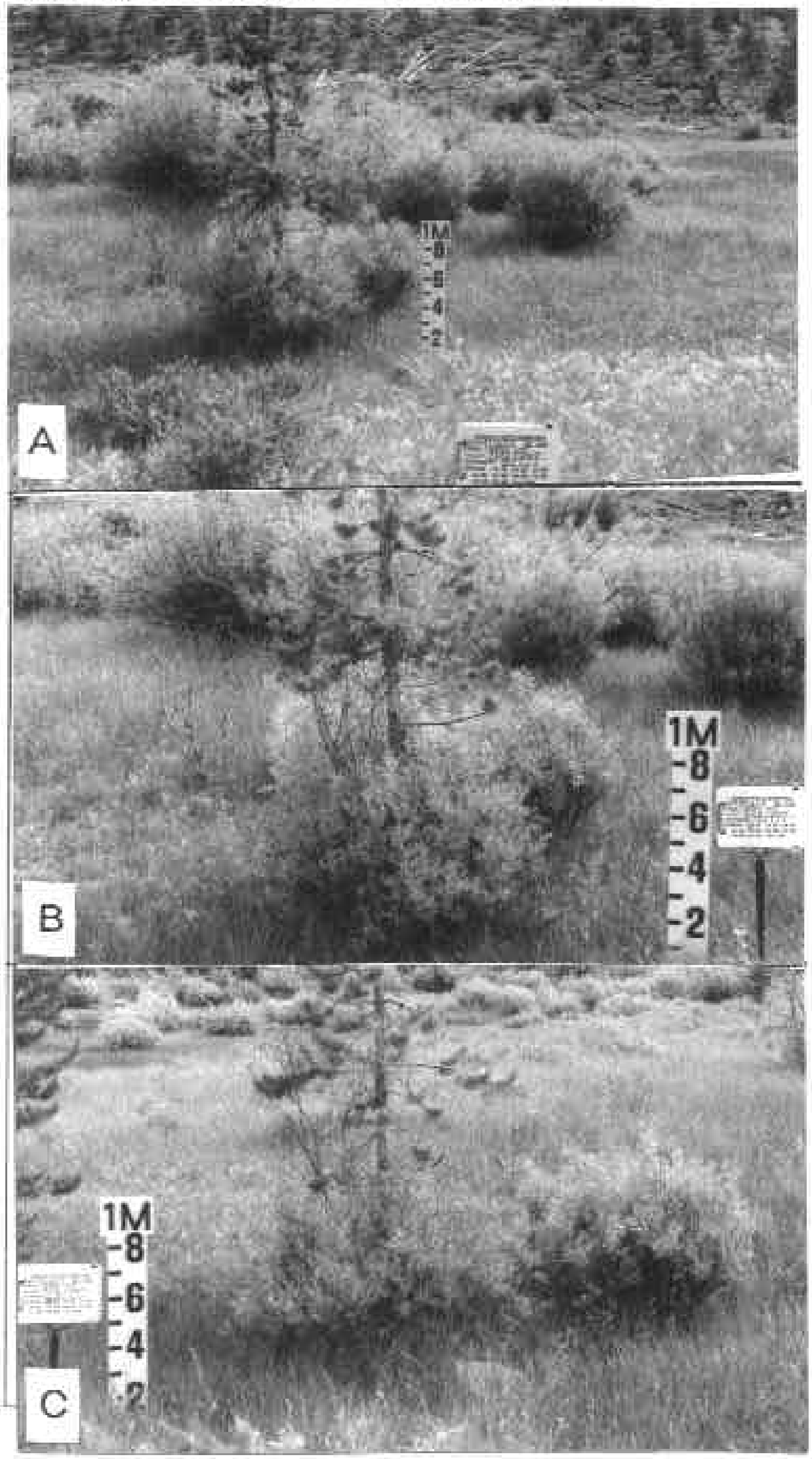
**SHRUB PHOTO TRANSECT**

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.

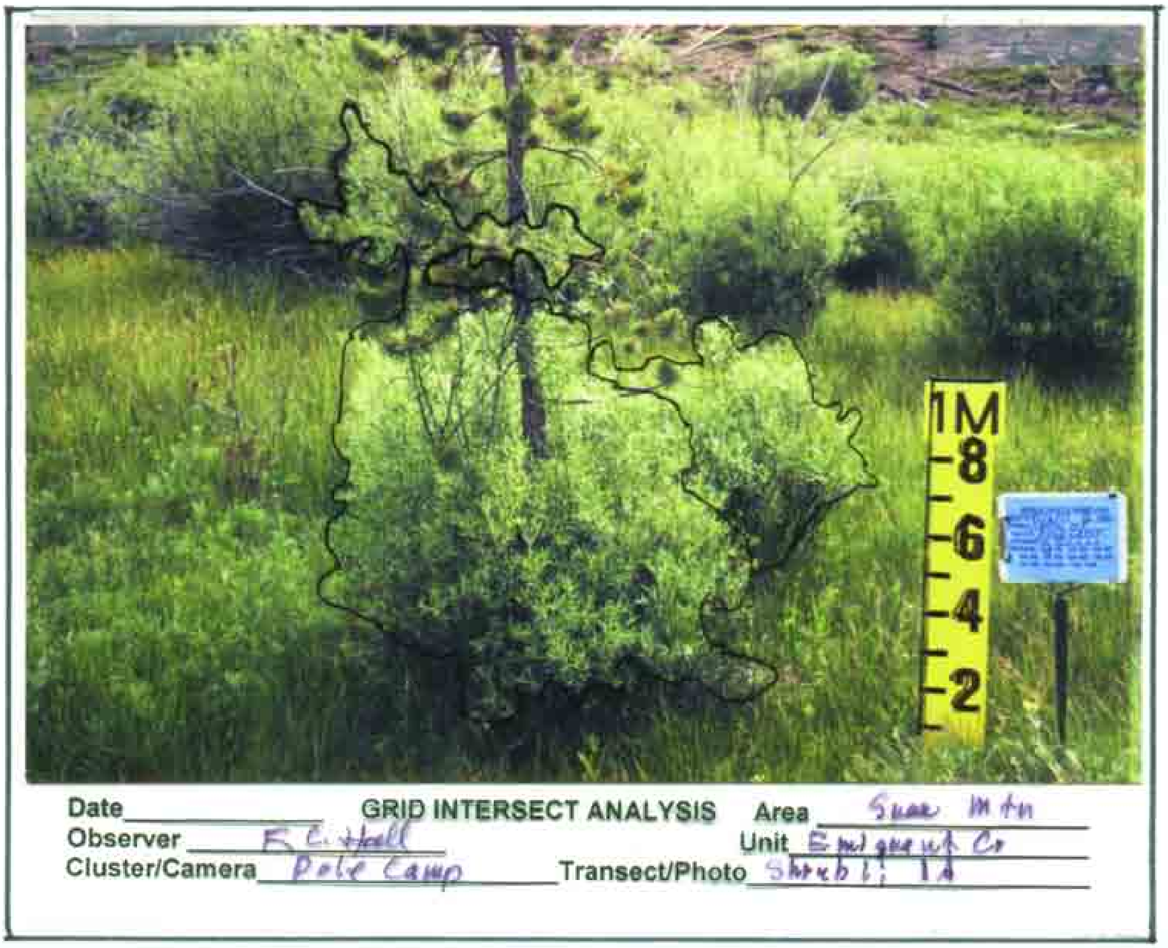



Figure 68—Grid analysis of shrub 1, view A, on the Pole Camp shrub profile transect. The outline form has been placed on the photo, information filled in, and the meter board marked. Outline as carefully as possible the shrub profiles. Do the same for photo B of shrub number 1 (fig. 69).

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.

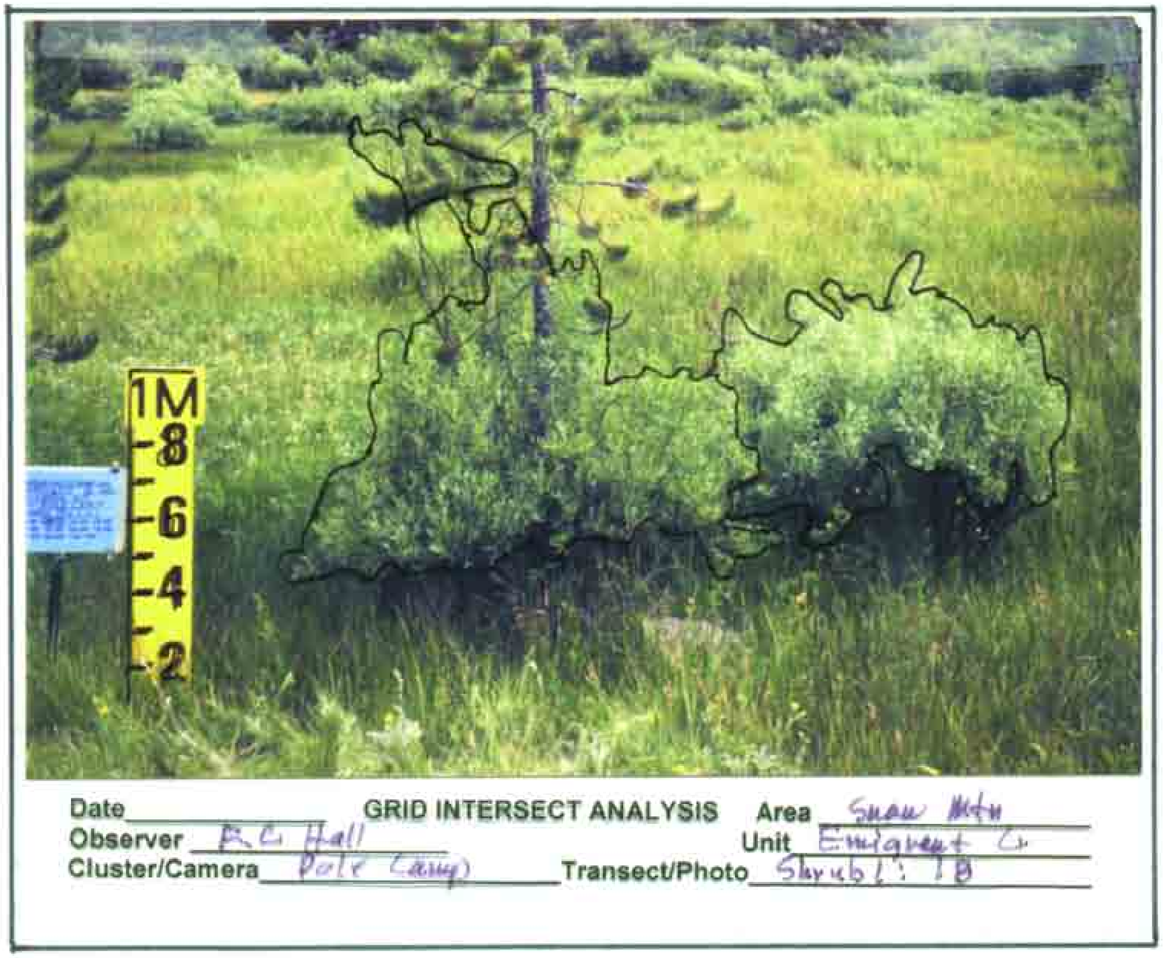



Figure 69—Outlines of view B, shrub 1, on the Pole Camp shrub profile transect. When two shrubs are present, separate their outlines as shown. Information on the bottom of the clear plastic overlay must be filled in for each photo. Remember to outline and mark the meter board.

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.

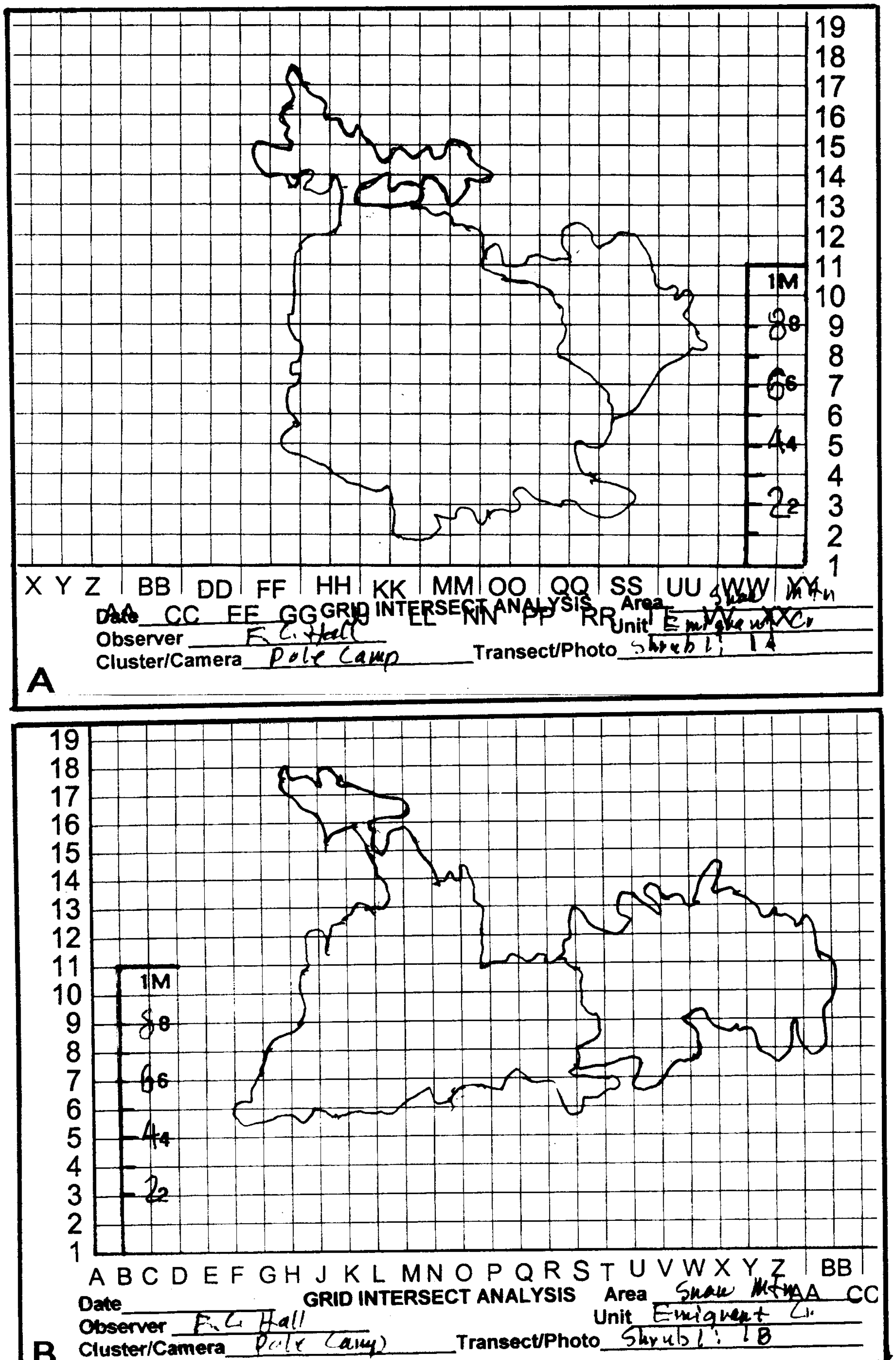



Figure 70—Grid outlines for shrub 1, views A and B on the Pole Camp shrub profile transect. Grids have been adjusted for size by the outlined meter board. Outlines are then taped to the grid. Count the grid intersects and record on the filing system form "Photo Grid Summary" (fig. 71).

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