TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE Portland, Oregon SOIL CONSERVATION SERVICE

AGRONOMY NO. 51 April 1985

EROSION BRIDGE

Attached is Bulletin No. 23, "Range Improvement Studies", developed by the State of California, Department of Forestry. It demonstrates how to set up and use the 3-F Erosion Bridge.

We are using the Erosion Bridge in Oregon to identify sheet erosion. It has an advantage of being able to follow variabilities of surface elevations over a period of time. It will be of most use on sites that can be set up and measured over several years.

The length of the bridge can be lengthened or shortened. Oversized slots (see figure 6) can be placed at variable positions along the bridge to allow for a variability of widths. For instance, if a slot is made at approximately 37 inches, the bridge can be used for 36 inch spacing, etc.

Precautions In Using The Erosion Bridge

1. Work with landowners and get their concurrence before placing rods in the soil.

2. Mark the rods well by painting them with a highly visible color such as orange and flag where practical.

3. Erosion bridge sites, set up in cropland where they would hamper equipment, must be removed when the landuser requires it.

4. Always read the erosion bridge from the downhill side. No walking, clipping, etc., should be done on the site directly upslope from the bridge in such a way as to alter the water flow or erodibility of the area.

5. Keep traffic to a minimum immediately around the site as well as above the site.

6. Know the exact length and size of measuring rod(s) in case its lost and needs to be replaced.

7. Protect the carpenters level when carrying it in a vehicle as the bubbles are easily broken. Should they break another level can be used on the erosion bridge.

8. Set each erosion bridge site to a permanent benchmark nearby. Soils shrink and swell from wetting and drying as well as from freezing and thawing. Rods set to a benchmark can be rechecked to see that they have not moved vertically.

9. We are using 5/8 inch rebar because of its relatively low cost. (Note 5/8 inch or larger rods are more desirable).

10. Remove the rods from the soil by augering a hole alongside. Then work the rod sideways to free it. A pipe wrench can also be used to make a handle to help pull them up.

11. Measurements should be made in the fall after the soil has been wet and settled and in the spring after freezing and thawing is completed for situations where over-the-winter measurements are desired.

Measurements for irrigation erosion should be made just before an irrigation and right after the irrigation.

12. Erosion bridge sites should be placed away from natural concentrated flow areas. A sufficient number of sites should be located in a field or Conservation Treatment Unit (CTU) to represent the varied conditions that may be present. When a rill occurs in the erosion bridge area, do not read the pins that fall in the rill area--use an average of the other pins. Rills are measured by use of other methods that consider the volume of eroded area and bulk density of the soil.

13. Occasionally the bubble on the level should be checked by reversing it on the pins. Note if the bubble is in the same position. If not, it should be repaired or replaced.

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No. 23 September 1978

THE 3-F EROSION BRIDGE--A NEW TOOL FOR MEASURING SOIL EROSION

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The California Department of Forestry, through its range management and watershed protection programs, is frequently required to evaluate soil erosion on watersheds following fire or other vegetative disturbances. Past methods used to obtain these data were inexact and produced results of questionable validity.

The 3-F erosion bridge was developed to provide more accurate data. The tool is: (1) inexpensive; (2) easily constructed; (3) simple and reliable; (4) easily and conveniently carried in the field; (5) quickly read; and (6) effective in yielding valid data.

Fig. 1. Measuring soil erosion with the 3-F erosion bridge.

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THE TOOL

The bridge is a slightly modified 48-inch aluminum masonry level positioned between two fixed support pins. This provides several permanent reference points from which erosion can be measured without disturbing the soil at the point of measurement. Vertical and horizontal level bubbles assure installation accuracy and are used to determine whether the pins have been disturbed between measurements.

The bridge and accessories necessary for its operation are described as follows:

- 3-F erosion bridge--48-inch aluminum masonry level machined to provide 10 vertical measuring holes, a slot on one end and a hole on the other for support. (See figures 3-6.)
- Two steel support pins, each 5/8 inch in diameter, 4 feet in length, sharpened to a point at one end and chamfered 1/8 inch or more at the other.
- Sledge hammer.
- Metal soil-surface-level rod, 3/16 inch in diameter, 2 feet long.
- Clipboard and appropriate forms.
- Calibrated measuring tape.

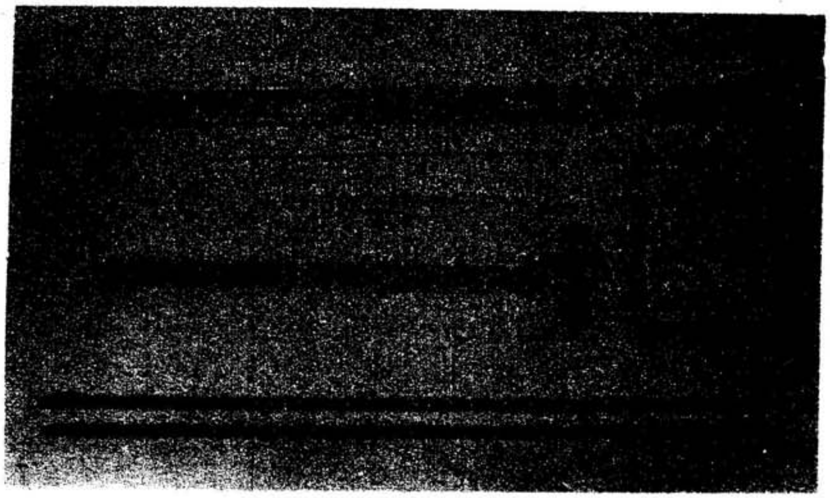

Fig. 2. 3-F erosion bridge and accessories.

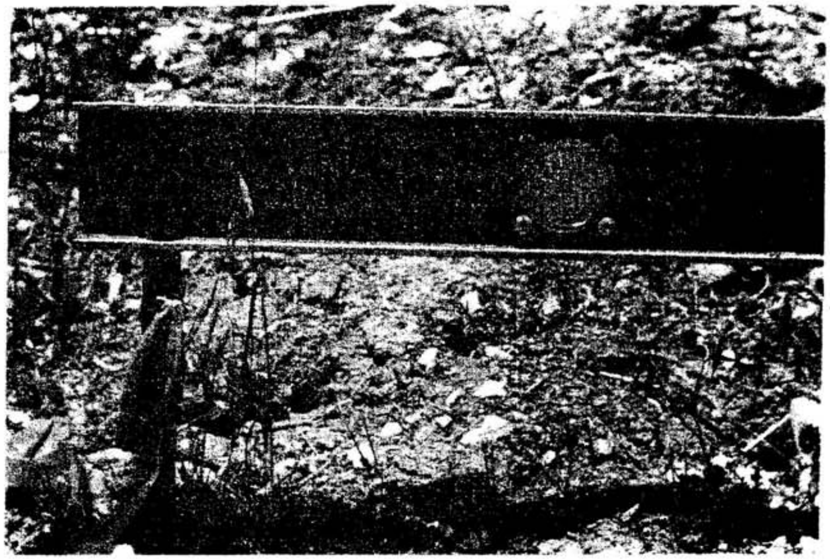

Fig. 3. 3-F erosion bridge in place; note level bubble.

ESTABLISHMENT AND OPERATION

After selecting an appropriate site, one support pin is plumbed using the vertical bubble in the level, and then driven approximately six to eight inches into the soil. It is then replumbed and driven to a depth of approximately three feet, replumbing as necessary to keep the pin plumb.

After the pin is in place, the bridge is used to measure the point at which the second pin is to be driven (approximately 45 inches from the first pin). The second pin is then driven into the soil in the same manner as the first. When the second pin is approximately the same height as the first, the level is positioned on top of the pins to check if they are level. Adjustments in height are made by removing the level and driving the tallest pin.

The tool is ready for operation when the pins are level and the level is positioned on the pins to form the bridge. Measurements are made at ten points along the bridge and readings are recorded on an erosion measurement form.

At each of the ten points, there are two vertically aligned holes through which the surface level rod slides. The rod is lowered gently to the soil surface.

It is important that no downward pressure be placed on the rod and that it is not dropped into position. The weight of the rod compresses the loose soil and ash and thereby reduces the possibility of mistakenly measuring compaction or settling as erosion.

With the rod resting on the soil, a reading is made by placing the measuring tape on top of the bridge and adjacent to the rod; the distance to the top of the rod is read and recorded. As subsequent remeasurements are made, soil movement at each of the ten points can be calculated by comparing the current reading with preceding ones. If the current reading is less, a loss of soil or erosion at that point is indicated; a higher reading indicates soil deposition at that point.

To find the average soil movement at a 3-F erosion bridge station, the calculated differences at all points are algebraically added and the total divided by ten.

DISCUSSION

While use of the bridge is relatively easy, some problems can be expected if proper equipment and techniques are not used.

Field testing of various diameters and lengths of support pins showed that the 5/8 inch by 4 foot size was the minimum satisfactory size. Thinner or shorter pins, although lighter to carry, proved unsatisfactory because they were easily moved out of position due to soil expansion or animal disturbances.

Mushrooming of the ends of the support pins can be a problem unless they are chamfered more than 1/8 inch or a driving collar is used.

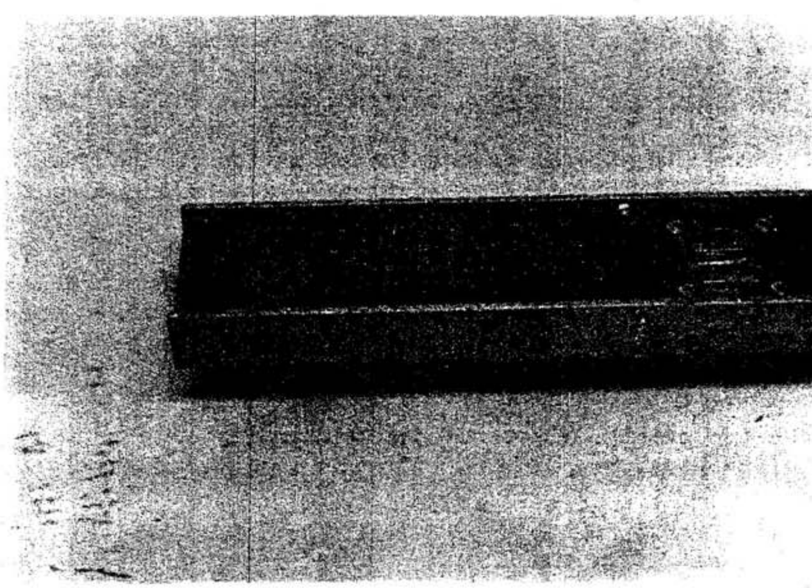

Fig. 4. Underside of 3-F erosion bridge showing hole for 5/8 inch support pin and 3/16 inch alignment holes for metal rod.

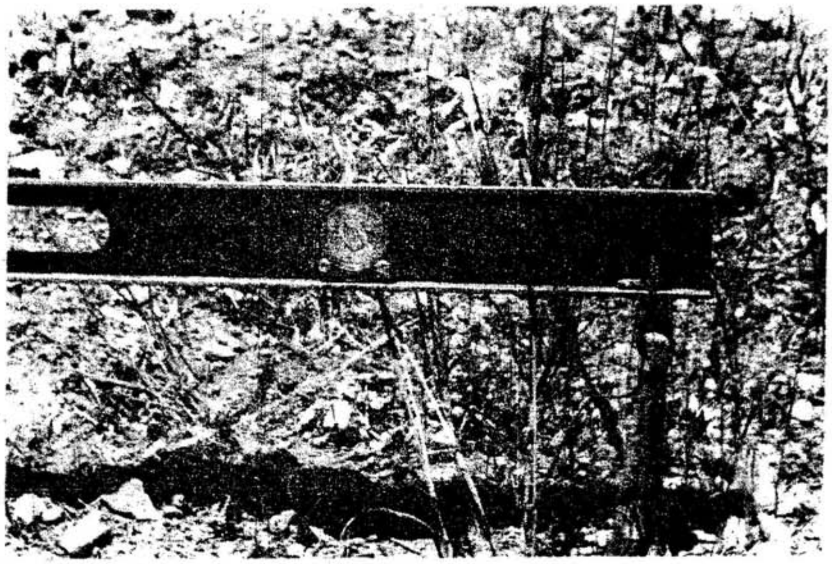

Fig. 5. 3-F erosion bridge in place.

The alignment and spacing of the support pins can be difficult unless care is used when driving them. The pins should be checked and plumbed frequently as they are driven. Rocky soils can present problems because the pins are deflected by the rocks and their proper spacing cannot be maintained. Sometimes the pins cannot be driven in far enough because they hit large rocks.

On soils with high coefficients of expansion (clogs), care should be taken to be sure pins have not moved between measurements. It is also important to make measurements when soil moisture content is about equal to that of the previous measurements.

It is important that the second pin be started exactly 45 inches from the first; otherwise the pins may have to be bent to accomodate the erosion bridge. Although a tolerance of ½ inch in either direction is allowed by the slot in the bridge, it is difficult to achieve these tolerances unless the pins are carefully driven.

Field testing has shown that a two-man team can establish an erosion station in approximately 15 minutes, with the actual measurements taking about two minutes. The accuracy of the measurements varies with the graduations on the measuring tape. A metric tape can be accurately read to 1 millimeter. A tape graduated in 0.01 foot can be accurately read to 0.005 foot.

SUMMARY AND CONCLUSIONS

The 3-F erosion bridge is an effective tool for obtaining meaningful soil erosion data on burned and denuded watersheds. It is a simple, inexpensive, reliable, and accurate instrument.

Field work has shown that the bridge can yield valid data for determining the relative magnitude of on-site, sheet-type soil movement and is especially useful when studying the effects of vegetative cover on the amount of soil movement after fire. To estimate total soil movement, the 3-F erosion bridge must be used in combination with other techniques for measuring gully and streambank erosion.

Although the data obtained is accurate for each point measured, care should be taken in how data is interpreted and the conclusions drawn from it.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the following California Department of Forestry employees: Patrick Fay, Equipment Maintenance Supervisor, and Brad Mailahn, Ecology Corpsman, for their guidance and assistance in modifying the erosion bridge; and to Harry Harp, Information Officer, for his photographic contributions.

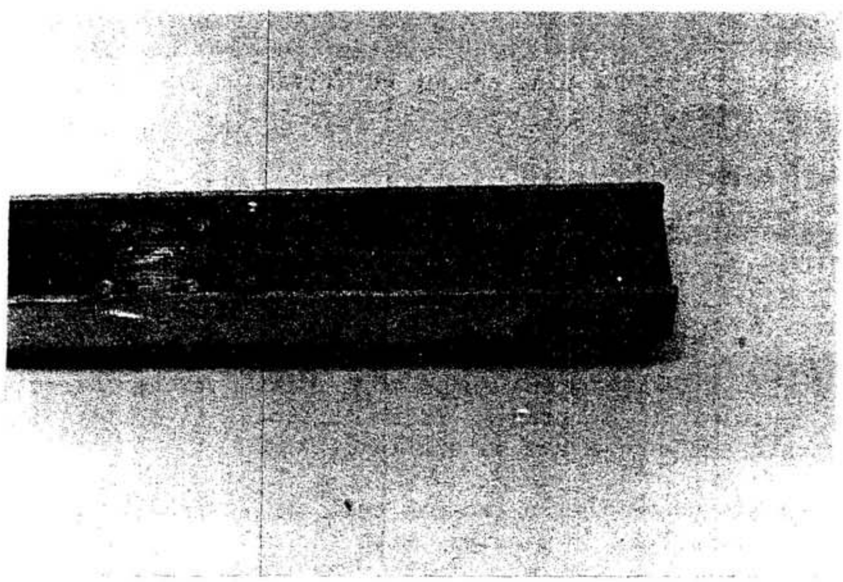

Fig. 6. Underside of 3-F erosion bridge showing oversized slot for 5/8 inch support pin. The slot allows about ½ inch tolerance in each direction for ease in placing level on the second support pin.

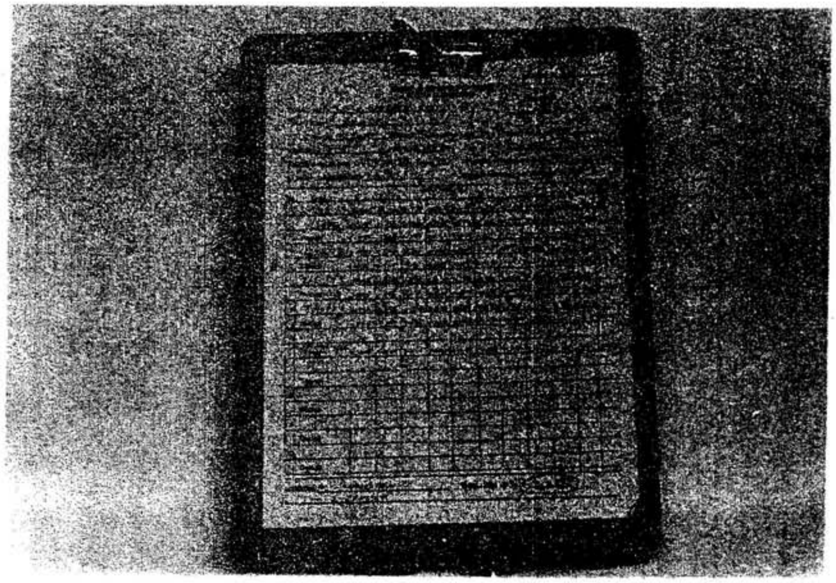

Fig. 7. Clipboard and sample recording form.

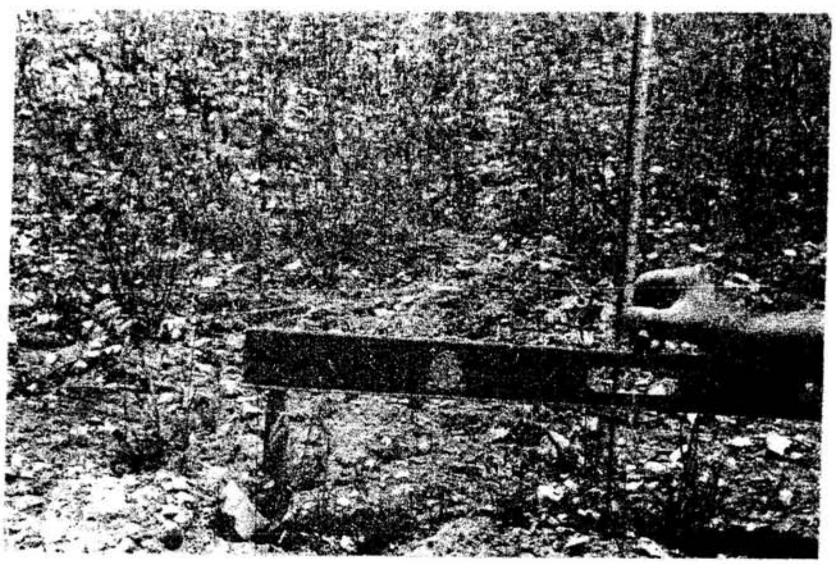

Fig. 8. Measuring soil erosion on point number 3.

APPENDIX C: Erosion Bridge Construction

Schematic diagrams (Figures C.1 and C.2) show features of the erosion bridge and measuring rod described in the paper by Ranger and Frank (1978).

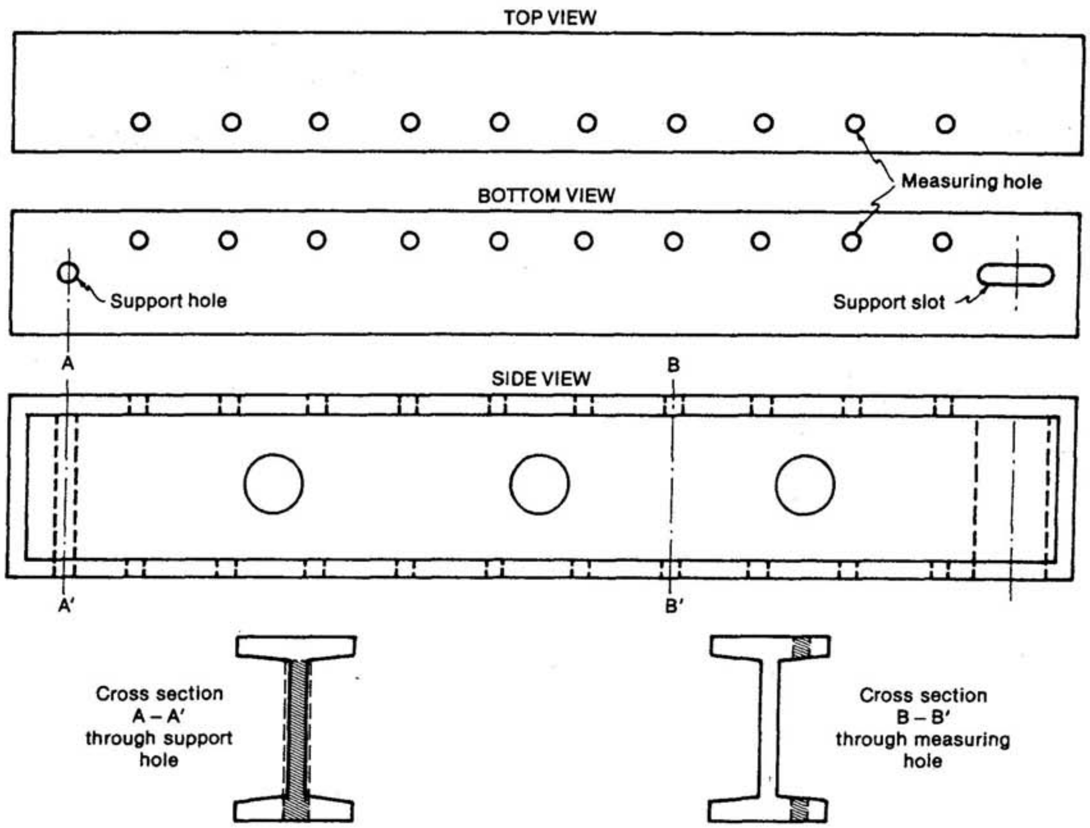

Figure C.1. Erosion bridge.

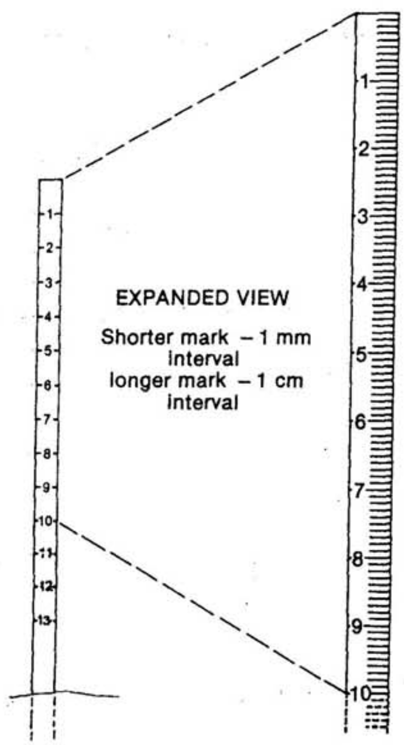

Figure C.2. Measuring rod.

APPENDIX D: Stratified Sampling

Suppose you have divided the project area into k different strata. For each individual stratum, apply the procedures developed in the text giving the following terms:

A_j = total size of the jth stratum (acres);

P_j = proportion of the area that is soil in the jth stratum;

ρ_j = bulk density of the soil in the jth stratum (g/cm^3);

$\bar{\bar{d}}_j$ = value of $\bar{\bar{d}}$ for the jth stratum (computed with n_j psu's);

$S^2(\bar{\bar{d}}_j)$ = variance of $\bar{\bar{d}}_j$;

where j = 1, 2, . . ., k. Note that the following must hold

$$A = \sum_{j=1}^{k} A_j = \text{total acres in the project area,}$$

and

$$n = \sum_{j=1}^{k} n_j = \text{total number of psu's taken on the project area.}$$