The importance of leaf area determinations in the plant sciences has stimulated the use of a great variety of techniques for measurement of leaf area (Marshall, 1968). Light interception techniques have been used most extensively for fast yet accurate determinations of leaf area. A large number of such photoelectric planimeters have been devised (Marshall, 1968).

Most photoelectric planimeters follow the same basic design. Leaves are held in a horizontal position on a stage and illuminated from above with a diffuse light source. The amount of light intercepted by these leaves is measured by a photoelectric sensor located below the stage. The components of such a devise are housed in a light-proof enclosure. Since most planimeters have been designed to accommodate large leaves, a large evenly-illuminated stage is paramount. To achieve this, it has been necessary to use substantial distances between the light source, the stage and the sensor (Donovan et al., 1958); collimating and condensing lenses (Miller et al., 1956; Davis et al., 1966); or an optical cone (Kramer, 1937). These modifications have resulted in extremely large and complex planimeters which are often expensive and limited to laboratory use. Small portable photoelectric planimeters have been devised, but these have not been refined to the point where errors can be reduced to an acceptable level (Voisey and Kloek, 1964).

Desert range species are particularly suited for use in a small stage photoelectric planimeter. A large number of these small leaves can be conveniently placed on a rather small stage and most species have leaves which are completely opaque. We describe here a small stage, inexpensive, portable and precise photoelectric planimeter, which is particularly suited for western range species.

**Methods and Materials**

Construct a small light-tight housing (30 x 30 x 60 cm) of a suitable material such as 6 mm (¼ inch) plywood with a small access door (Fig. 1). Paint the inside of this housing with a mat black paint and provide the access door with a rubber light-tight seal. A small 29 watt a-c bulb provides an excellent source of illumination if line power is available. A small 6 or 12 d-c automotive bulb could also be employed when line current is not available. Mount this lamp on a small plate and use a series of bolts with wing nuts or a similar mounting scheme to adjust the height of the plate. Because of the low amount of heat produced by such a bulb, no ventilation is required in the housing as is usually needed in most other photoelectric planimeters (Davis et al., 1966; Kramer, 1937; Miller et al., 1956). The illumination sensor used in this particular planimeter is a 4.9 cm (1.9 inches) diam. photovoltaic cell (Model HR-1247, Centralab Instruments Co., El Monte, California). This output from this photovoltaic cell is measured with a microammeter. The stage is located immediately above the light sensor and consists of a piece of normal window glass painted with black paint except for a 4.9 cm diam. area immediately above the photocell. Spread the leaves on this 4.9 cm diam. stage and cover the leaves with a piece of frosted glass to hold the leaves flat and to insure an even illumination field. If necessary, a series of screen filters can be placed between the stage and the lamp to reduce and defuse the light. This photoelectric planimeter can be constructed for less than $100.

**Highlight**

A small and inexpensive photoelectric planimeter is described. This planimeter is particularly suited for the precise determination of leaf area for many western range species.

The assistence of Mr. Lee Camp in the construction and testing of the planimeter is gratefully acknowledged.
Results and Discussion

Since the height of the light bulb above the stage is variable, adjust the instrument to indicate a full scale microammeter reading when no leaves are on the stage. Check this before and after each leaf sample is read. This will compensate for any changes in bulb output or sensitivity of the photoelectric sensor caused by changes in temperature. Place the leaves on the stage and cover with the frosted glass for a photocell reading.

We calibrated this planimeter with small pieces of opaque paper of known area. A linear regression from these data possesses a coefficient of determination, $r^2$, of 0.987. The regression equation and the 95% probability confidence bands for this regression are plotted in Figure 2. These confidence bands suggest the limits of error for prediction of leaf area based on the regression relationship. The area of a leaf sample which yields approximately 90% of full scale reading on the microammeter can be predicted within $\pm 7 \text{mm}^2$ or $\pm 2\%$ with 95% probability. For small leaves, this represents a high degree of accuracy.

This portable planimeter has been used extensively for determination of leaf area for a number of cold desert range shrubs such as shadscale (Atriplex confertifolium), and winterfat (Eurotia lanata). In addition, the instrument has been used successfully for leaf area determination of forage samples from fistulated sheep.

This small-stage planimeter is ideally suited for field or laboratory measurements of small leaves such as from desert range plants. For larger leaves, especially those which are not completely opaque, a large stage air-flow planimeter would appear preferable (Jenkins, 1959; Mayland, 1969).

Highlight

Seeds of winterfat (Eurotia lanata) were planted at four depths in three soils held at five moisture levels. Emergence was best from the $\frac{1}{16}$-inch depth, and when soil moisture was nearer field capacity than saturation.

Winterfat (Eurotia lanata (Pursh) Moq.) is a desirable shrub for revegetating semiarid ranges. Results of direct seeding of winterfat in New Mexico, however, have been erratic. One reason for lack of success has been unfavorable weather following seeding.

Another reason may have been that the seeds were covered too deeply. Recently it was found that, in wet soil at least, establishment of winterfat seedlings is best when seeds are planted on the surface (Springfield, 1970). Wilson (1931) also observed that winterfat fruits would germinate on the soil surface if there were several days of wet weather. Other investigators have reported better results from shallow than from deep planting (Hilton, 1941; Riedl et al., 1964; Statler, 1967).

Objectives of this study were to determine the effects of depth of seeding, soil texture, and soil moisture level on seedling emergence.