Measuring Vegetation Changes on Fixed Quadrats by Vertical Ground Stereophotography¹

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Highlight

A photographic technique for recording changes in vegetation on small fixed quadrats has been modified and improved. Two 35 mm cameras fired simultaneously are used instead of one to take stereophotographs. Transparencies are viewed directly by transmitted light under a zoom stereoscope and plant cover measured by point counts made on the photographs with the aid of a counter connected to an electrically operated stage. Assessment of species composition and herbage weight is also possible from the photographs which themselves form a permanent record of vegetation on the quadrats.

Until recently photography in vegetation studies has been used mainly for purposes of illustration. Most ground³ photography shows plants more or less in profile, although verti-

FIG. 1. 35 mm cameras mounted for vertical ground stereophotography. Note dual shutter release mechanism. The frame is made of drilled $\frac{1}{4}$ inch aluminum plate for lightness with strength.

cal and oblique photographs have sometimes been taken. Winkworth et al. (1962), comparing methods for estimating plant cover in an arid grassland community, noted that photographs taken from the top of a stepladder gave excellent projectional representation of the ground flora. However, when they attempted to estimate cover from the photographs planimetrically, they found themselves having to simplify plant outlines quite arbitrarily, so abandoned the idea.

In 1967, Wimbush et al. described a technique for using vertical color stereophotography to record changes in alpine flora under grazed and ungrazed conditions. Pairs of photographs taken with a single camera mounted on a four-foot high stand were analysed to provide data on species composition and ground cover on quadrats just under one square meter in area. A method which has been developed for measuring changes in rangeland vegetation in western New South Wales, although based on that of Wimbush et al., is sufficiently different, particularly in the approach to analysis of photographs, to warrant separate description.

Taking Stereophotos

Vertical stereophotographs can be taken with a single camera as long as the camera is moved between photographs a distance roughly equal to the separation of a man's eyes. While such photography may be quite satisfactory in some circumstances, there are a number of reasons why the use of a stereocamera or twin cameras fired simultaneously is to be preferred: stereo-pairs so obtained are unaffected by fluctuations in light conditions or movement of plant parts owing to wind and time needed for photographing is reduced.

As suitable stereocameras were not available in Australia two identical 35-mm cameras fitted with 25 mm f4 wide angle lenses were mounted as illustrated in Figure 1. Four one inch diameter 16 gauge aluminum legs fit onto the frame to support the cameras some 132 cm above the ground: with lens centers approximately 15 cm apart this allows stereophotography of a quadrat $1 \times 1\frac{1}{2}$ meters. Fig. 2 shows the equipment being used to photograph a quadrat in scrub infested rangeland in northwestern New South

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³ The term "ground photography" is used to save confusion with aerial photography, the type of photography commonly associated with vertical stereophotographs.

FIG. 2. Photographing a quadrat in northwestern New South Wales.

Wales. Details such as quadrat number, date of photography etc. are recorded in chinagraph pencil on the white plastic card.

Viewing the Photographs

The simplest way of viewing stereophotographs is with a pocket stereoscope over a light table; however this does not allow examination in sufficient detail for full interpretation and analysis. The method of Wimbush et al. of projecting images from below a glass-topped table on to tracing paper, while permitting adequate enlargement, has the disadvantage that image sharpness is lost. This drawback is inherent in any projection technique. A good way to view a single transparency with facility for enlarging portions of it to the limit set by the grain size of the film is by means of a dissecting microscope fitted with a zoom or interchangeable lens system and using transmitted light. This allows features of the vegetation and ground surface to be seen in considerable detail though not in three dimensions.

Recently an instrument has become available which, in similar manner to the dissecting microscope, allows magnification of transparencies viewed directly by transmitted light but, in addition, permits pairs of photographs to be viewed stereoscopically. This is the zoom stereoscope described by Sims

and Benson (1967). Used in conjunction with a moveable stage on which transparencies are held, this is an ideal unit for studying stereophotographs.

Retrieving data

Information which can be obtained from photographs includes:

1. Species composition
 - (a) Occurrence
 - (b) Abundance
2. Percent cover
 - (a) Individual species
 - (b) Groups of species
 - (c) Total
3. Herbage weight
 - (a) Broad subdivision, say, into grasses and herbs
 - (b) Total.

Species Composition

Identification of species from photographs alone may not always be possible; it is therefore advisable to make a collection of plants which are flowering in the area whenever there is opportunity. Once plants are positively identified, it is generally easy to recognize them again in color photographs, particularly when they are seen in three dimensions. When counting individual plants it is helpful to superimpose a grid of fine threads or lines etched on glass or clear plastic over one of the transparencies.

FIG. 3. Electrically operated stage unit set up beneath a zoom stereoscope (see text for description of the functions of knobs B and C). Portion of the counting unit can be seen at left.

Table 1. Estimates of ground cover (Number of "hits" and %) on two 1.5 square meter quadrats from point counts of color stereophotographs.

Quadrat Number	Grass		Herbs		Litter		Bare		Total count
	Hits	Percent	Hits	Percent	Hits	Percent	Hits	Percent	
1.	126	30	19	5	11	3	264	63	420
	121	30	21	5	4	1	254	64	400
	115	29	26	6	16	4	243	61	400
	83	28	17	6	9	3	184	63	293
	87	31	14	5	2	1	177	63	280
	88	31	14	5	6	2	172	62	280
	62	29	10	5	3	1	142	65	217
	56	26	9	4	2	1	147	69	214
	61	28	7	3	6	3	146	66	220
2.	77	18	17	4	6	1	327	77	427
	76	18	16	4	5	1	334	77	431
	71	17	18	4	6	1	325	78	420
	47	16	10	3	4	1	235	80	296
	48	17	9	3	3	1	220	79	280
	51	19	15	6	5	2	199	73	270
	37	16	9	4	3	1	183	79	232
	45	19	10	4	3	1	173	76	231
	43	19	6	3	1	—	181	78	231

Percent Cover

The method outlined below differs materially from that used by Wim-bush et al. for estimating cover from vertical ground stereophotographs. It employs a technique used for many years by geologists and soil scientists for mineral analysis of rocks and soils, and more recently by Heady and Torell (1959) for measuring composition of clipped and grazed forage samples. In principle it is identical with the point quadrat method of vegetation analysis (except that only first "hits" can be recorded), but in practice it is faster, more convenient and, because of the much greater number of points which can be assessed, more accurate.

The transparencies to be studied are fixed in position on a moveable stage beneath a zoom stereoscope and the stage adjusted so that cross hairs in one eyepiece are over one corner of the stereo-image. Alternatively, a single transparency can be so located beneath a binocular dissecting microscope. According to which species or class of vegetation (or bare earth) is directly beneath the cross hairs, a "hit" is recorded in an appropriate column in a notebook or by pushing a button on a bank of post office counters. The stage is then moved laterally a mea-

sured distance, bringing a new point on the picture beneath the cross hairs. This procedure is repeated until a traverse of the picture has been completed, when a new traverse position is selected. In this fashion the whole quadrat can be systematically surveyed.

Figure 3 is a close-up of an electrically-operated stage unit which can be used in conjunction with a point counter to move transparencies beneath the zoom stereoscope. While this piece of equipment is not essential to the method it is particularly convenient and automatically ensures that the stage is moved between counts. Each time a button on the counter is depressed the stage shifts to the left a measured distance, in this case 1.25 mm. At the end of a traverse the operator turns knob B to select a new traverse position and slides the stage to the right as far as it will go by means of knob C. Knob B is fitted with an indexing ratchet so that movement (by 1/3 mm steps) can be felt instead of having to be measured, allowing the operator to continue to view the picture before him. A micrometer stage from a microscope can be adapted to serve almost equally as well.

In Table 1 estimates of vegetation cover from thrice replicated counts of approximately 200, 300 and 400 points

per quadrat are compared for two quadrats. Results agree closely both within replications and between counting rates suggesting that, for this type of cover, counting more than 200 points is an unnecessary labor. A count of this number of points can be accomplished in 5 to 10 minutes. Where cover of individual species is required a considerably higher rate of counting might have to be used.⁴

In good seasons and on ungrazed sites it may be necessary to correct for over-estimation of plant cover: this type of error is inherent in photographic methods of assessment and increases as plants grow taller according to the relationship

$$\frac{\text{apparent cover}}{\text{true cover}} = \frac{H^2}{(H-h)^2}$$

where H is the height of the camera lens above the ground and h is the height of the plant.

Herbage Weight

Weight of herbage per unit area is a measure of pasture productivity and as such is essential to rangeland studies. Because clipping and weighing is a laborious and time-consuming job, most workers, if they have extensive areas to assess, estimate herbage weight by eye more or less after the method of Pechanec and Pickford (1937). Stereophotography can be employed for estimating herbage weight in this manner with the advantage that a "bank" of reference stereophotographs (photographs of vegetation which is afterwards clipped and weighed) can be used to assist in keeping estimates tolerably accurate. A pocket stereoscope and light table is all the equipment necessary for retrieving this kind of information from transparencies.

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⁴See R. Brewer's discussion of accuracy of grain counts on pages 46-50 of Brewer, 1964, but remember that it cannot be assumed that plants are randomly distributed.

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