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A MANUAL FOR THE PRODUCTION OF PHOTOGRAPHIC STANDARDS FOR USE IN HERBAGE YIELD AND COVER ESTIMATES

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A Manual for the Production of Photographic Standards for use in Herbage Yield and Cover Estimates

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1 Introduction

The large areas covered by central Australian pastoral leases, the geographical spread and variety of plant communities and limitations on human and financial resources means that the development of quick and efficient rangeland assessment techniques is necessary. While remote sensing technology has been increasingly used in rangeland studies, the most common form of physical assessment of the ground vegetation layer is still quadrat based. Quadrat based measurement in rangelands typically deals with the herbage layer of the plant community. The use of photographic standards (photostandards) to assist in the estimate of yield (Friedel and Bastin 1988) and cover can increase the accuracy and improve the efficiency of quadrat based assessment in a rangeland plant community.

Estimating the yields and cover levels of herbage species are important components of rangeland assessment. A comprehensive set of photostandards has applications in assessing plant response to rainfall, seasonal conditions, the impact of grazing animals and the effects of feral animals such as rabbits on the herbage layer of the plant community.

1.1 Comparative Yield

The use of photostandards as a comparative yield estimate was developed by Friedel and Bastin (1988) and was a modification of the Comparative Yield method (Haydock and Shaw 1975) for estimating the dry matter yield of pastures. In the original Comparative Yield method, pasture yield is estimated by comparison with preselected reference quadrats which are harvested to determine plant yields. In the modified method of Friedel and Bastin (1988) a set of reference photographs (photostandards) replaced these preselected reference quadrats.

Photostandards have been used extensively by the Northern Territory Department of Primary Industry and Fisheries (NT DPIF) and other rangeland related agencies to estimate plant dry matter yield in central Australian rangelands. The Queensland Department of Primary Industries (QDPI) have also used photostandards to estimate pasture yield on Mitchell grasslands (Phelps and Bates 1994).

1.2 Cover Estimates

Within a rangeland plant community the degree of tree and shrub cover, the level of herbage cover and the amount of litter can all be expressed as measures of plant cover. Quadrat based assessment deals primarily with the herbaceous plant layer, and the types of cover found in this layer including litter, basal and aerial plant cover can be measured using a variety of methods.

The measurement of litter cover is important in rangelands condition assessment as an indicator of soil fertility and because of it's role in reducing the effects of raindrop impact on surface soil structure and slowing wind and water erosion processes. In the CSIRO Rangeland Soil Condition Assessment Manual (Tongway 1994), litter cover is described in six classes ranging from cover class 1 (cover level "Nil", <1%) to cover class 6 (cover "very extensive", 100% but several cm thick). Other factors including a decomposition value and the origin of the litter are also included. The degree of cover is estimated against several reference photographs. Although plant litter cover is an important feature of rangeland ecology, the procedure described here for the production of photostandards deals with standing plant material and the degree of litter cover is not measured.

Basal cover of the herbage layer has been used as a measure of plant cover in Australian rangelands (Friedel and Shaw 1987, Friedel *et al.* 1996) and has most commonly been measured by a wheel point method (eg. Friedel and Shaw 1987, Griffin 1989, Arzani and King 1994). The use of a step point method has also been used to assess plant basal cover (Cunningham 1975). While basal cover has an advantage over aerial cover, it's insensitivity to grazing, even on relatively well vegetated rangeland areas recorded levels of basal cover can be very low. These low levels then increases the required sample size to unrealistic levels (Friedel and Shaw 1987). Consequently basal cover was not used as an indicator of plant cover for this procedure.

Aerial plant cover, defined as the proportion of the ground occupied by perpendicular projection of the aerial parts of plants under consideration (Grieg-Smith 1983) is the most widely measured form of cover in the herbage layer. Griffin (1989) listed the different techniques that have been developed to measure aerial cover. These include the use of a frame point quadrat, point intercepts along a line, point intercepts using a cross hair sighting tube, a step point method and a wheelpoint apparatus. The wheel point apparatus has emerged as the most widely used method of assessing aerial cover (Griffin 1989).

Photostandards have also been used for the visual estimate of aerial plant cover. The QDPI used vertical photographs of cereal crop stubble at 10% cover increments as standards from which farmers estimated the level of stubble cover (Molloy 1988). In rangeland monitoring an estimate of percentage cover was included as part of the GRASS Check procedure (Forge 1994). In GRASS Check the percentage ground cover was compared against regular black and white square check patterns representing cover levels of 5%, 15%, 30%, 50% and 90%.

1.3 The Project

The set of photostandards used extensively by the NT DPIF in central Australia were limited in the range of yields and types of plant communities covered. The photostandards were also unsuitable for estimating aerial plant cover in the herbage layer as no truly vertical photographs were included in the original procedure.

A project was undertaken to develop a standardised method of producing photostandards for yield and aerial cover measurement. This manual details the equipment and standard method used by the NT DPI&F in central Australia to produce photostandards of a consistent quality for yield and cover estimates of pasture and forb species.

2 Method

2.1 Personnel

Two people are required for the field component of the photostandard procedure. Two operators are also required for estimating the level of cover from the developed photostandards.

2.2 Species Selection

Pasture and forb communities or associations which are routinely encountered in field work and for which yield and cover estimates are often required, should be selected for inclusion in an initial photostandard set. Once the species has been selected a range of standards covering different yields, levels of cover and growth stages should be photographed to account for all situations that may be encountered in the field. Within species, a range of growth stage from immature to mature should be included to show progressive changes in dry matter yield and cover levels.

A standardised procedure allows additions to be made to the photostandard master set as the need for new standards arises. If new species are encountered or specific photostandards required for certain projects photostandards should be prepared and included according to this standard procedure.

2.3 Site Selection

Once a species has been selected for inclusion as a photostandard then a site containing that species is required. For ease of production, the photostandard site should have the following attributes:

(a) good vehicle access
(b) flat topography
- to ensure the quadrat sits flat and avoids distorting the vertical photograph
(c) representative sample of the target species with a range of yields and cover levels

2.4 Materials

The equipment required both in the field and laboratory to complete a photostandard is listed in Appendix 1. Some of the equipment required for the vertical photograph will have to be constructed specifically. Specifications to be used in the construction of this equipment are set out in Appendix 2. Aspects of estimating plant cover from the developed photostandards are described in Appendix 3.

2.5 Photography

A photostandard that allows plant yield and cover to be estimated will require vertical and oblique photographs of a quadrat.

2.5.1 Quadrat Placement

Place the quadrat so that the subject plant/plants are centred inside the quadrat. The height stick should be visible in the back left of the quadrat with the base level with the soil surface. Ensure that the edge of the quadrat has not over laid any plants. If individual plants are covered by the edge of the quadrat then gently remove these plants from the quadrat. As litter is not being assessed remove anything that is not standing dry matter from the quadrat.

2.5.2 Photostandard Identification - Film and Photo Set Numbers

Before beginning each photostandard, a photograph should be taken that identifies a film number, a photo set number, the main species present, location and date of that photostandard. This information can be displayed on a blackboard. This information should also be recorded in a field notebook. The film number and photo set number are essential for identification of the photostandard throughout the production procedure.

A photo set is the set of all photographs associated with a particular quadrat. The photo set and film number are convenient and temporary numbers allocated by the operators, when the photographs are taken. They are used to identify the photograph with notes and measurements made in the field and laboratory. When the photos and data are later incorporated into a master set of accepted photostandards, permanent photostandard numbers are allocated.

2.5.3 Shadow

Uneven shadowing within the quadrat can reduce the accuracy of both cover and yield estimates. Therefore, remove any effects that shadow may cause by placing the quadrat in shade for both the vertical and oblique photograph. This is most readily achieved using a large beach umbrella held by the second person.

2.5.4 The Oblique Photograph

The oblique photograph should be taken from a height of 180 cm (eye level of the operator), 1.5 m from the centre front edge of the quadrat with the camera focal length set at 50 mm and focused on the middle of the quadrat. To obtain the best results the aperture and speed should be set for the prevailing light conditions. However the aperture setting should not be less than *f*3.5 or the speed setting greater than 1/250s. A diagram of the procedure can be seen in Figure 1

2.5.5 The Vertical Photograph

The vertical photograph should be taken vertically above the centre of the quadrat at a height of 180 cm with a camera focal length of 35 mm. A pneumatic automatic shutter release with extension cord can be used to take the photograph. A small step ladder may be necessary to allow the operator to focus the camera from above. A height marker is not necessary for the vertical photograph, the graduations on the quadrat will give an indication of scale. To obtain the best results the aperture and speed should be set for the prevailing light conditions. However as for the oblique photograph, the aperture setting should not be less than *f*3.5 or the speed setting greater than 1/250s. Figure 3 in Appendix 2 gives an indication of the vertical photostandard structure and procedure.

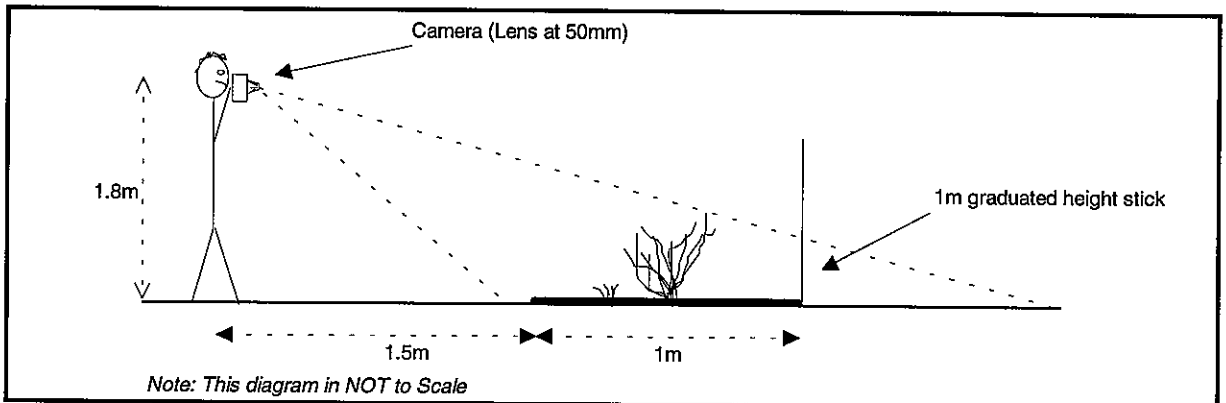


Figure 1 : The Oblique Photostandard Procedure

2.5.6 Print Size

The film should be developed and standard 15 cm x 10 cm (6"x 4") prints produced. This size print is the most common available, appropriate for use in the measure of plant cover and suitable for inclusion in field sets.

2.6 Plant Dry Matter Weight

2.6.1 Field

Clip all standing green and dry plant matter within the quadrat and bag by their individual species. Clearly label the appropriate bags, field weigh the samples and record the wet field weight beside the film and photo set number in the field notebook. Any fallen or detached plant matter is considered litter and for our purpose was not collected.

2.6.2 Laboratory

In the laboratory, oven dry the samples to a constant weight (usually 12 hours at 50°C). Weigh the samples recording the dry weights in the field notebook. The dry matter yield of each species, the total quadrat dry matter yield and moisture contents of individual species can then be calculated from dry weights.

A knowledge of the moisture contents of individual species at different stages of growth gives increased accuracy to estimates of dry weights for that species made in field exercises where oven dry weights are not available.

2.7 Aerial Plant Cover

The aerial plant cover within each quadrat should be measured and expressed as a percentage of the total area within the quadrat. Two operators each use a 64 point overlayed dot grid over the vertical photograph of each photostandard (standard 15 cm x 10 cm prints) to measure the percentage aerial cover. The method of construction of a the dot grid is set out in Appendix 1. The rationale behind the selection of the dot grid, choice of photograph size and number of operators is described in Appendix 3.

2.7.2 Estimating Aerial Plant Cover

The vertical print of each photostandard is used in the estimate of cover. The dot grid should be overlayed on the quadrat in the photostandard and clipped in place to ensure it does not move during the procedure. Using the criteria listed below, the number of dots that have a positive contact with or overlay a piece of standing plant material should be counted as a strike.

(a) Count as a positive strike any dot that intercepts any piece of standing dry matter, including the visible basal system of the plant.

(b) If doubt exists over a positive strike then estimate if 50% or greater of the area of the dot intercepts the plant piece. If so COUNT as a strike.
If less than 50% intercepts then DISCOUNT as a strike.

(c) If doubt exists whether a piece of plant material is litter or standing matter, inspect the area surrounding the dot in the context of the rest of the quadrat.
If doubt still remains DISCOUNT as a the strike.

(d) Any plant material classified as litter is not considered and should not be counted.

The total number of strikes can be used to calculate the percentage cover from the equation below.

Percentage Plant Cover (%) = (Number of "strikes" / Total number of dots) x 100

The percentage aerial plant cover is recorded on the photostandard.

2.8 Photostandard Master Set, Field Sets and Negative Storage

2.8.1 The Master Set

Following the development of the photographs and the completion of plant dry matter yields and cover estimates, it is important to correctly label and store the original photographs in a master set containing all the photostandards produced. The front of each original print should be labelled with the information listed below. An easy and neat way to do this is to use computer generated labels. The label should be attached so as not to cover any of the quadrat shown in the photostandard.

* Photostandard number
* Film number
* Negative number
* Plant species and their corresponding dry matter yield (g/m^2)
* Total aerial plant cover for the quadrat (%)

The master set should be arranged so photostandards are numbered sequentially, (eg:Photostandard 1,2,3.....). As new photostandards are produced they should be added to the existing master set and given the next photostandard number. It is important to note that the photo set number is discarded and a completely new photostandard number is now generated. The original film number is also changed and the photostandard is instead allocated the next film number available in the master set. This system of numbering allows greater flexibility. As new photostandards are produced they can be added to the master set and any potential gaps in photostandard numbers that may arise through the rejection of a standard during production is eliminated.

The original prints in the master set should never be taken into the field.

2.8.2 Negative Storage

The original negatives should be labelled, catalogued and placed within a fire proof safe for storage. All negatives should be labelled with the photostandard number, film number, and negative number. A complete index giving these details should be listed in the front of the negative album to ensure quick and easy access to the required photostandard.

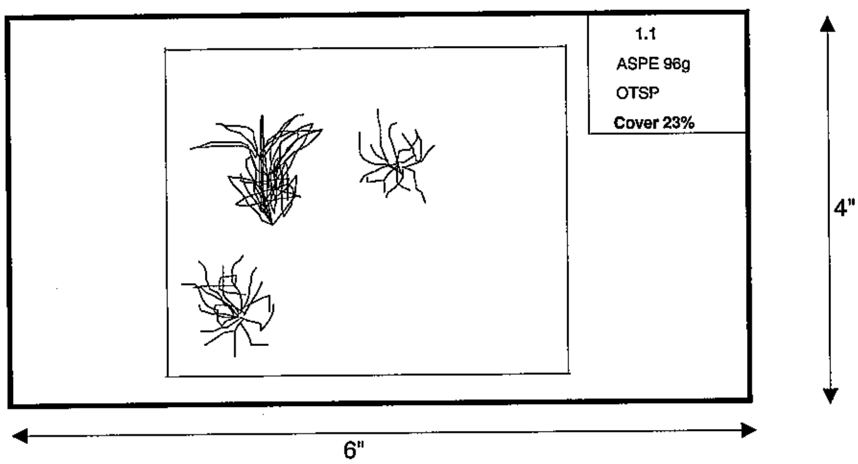
2.8.3 Construction of Field Sets

The construction of field sets depends on the needs of the field operator. Standard sets may be developed for routine field work with specialised sets developed as the need arises. All prints required for field albums can be selected from the master set and the corresponding negative used to produce a field copy. The photographs used in field albums should be labelled on the front for ease of use in the field. A summary of the information that should be included is listed below.

* Comparative Yield Standard
* Dry matter yields for all species in the photostandard (g/m^2)
* Aerial plant cover (%)

The Comparative Yield Standard was developed as part of the Centralian Range Assessment Program (Bastin 1989) and uses a 25 point scale from 0 to 7.0 (eg: 0,0.25,0.5,0.75,1, 2...7.0); where
0 = bare ground
Standard 1 = 100g/m^2 = 1000 kg/ha
Standard 2 = 200g/m^2 = 2000 kg/ha
Standard 7 = 700g/m^2 = 7000 kg/ha

It is used extensively by the NT DPI&F in central Australia during rangeland assessment. An example of the vertical photograph of a photostandard as it would appear in a field album with a label is shown in Figure 2.



Note: This diagram in NOT to Scale

Figure 2: Sample of Vertical Photostandard showing location of label

3 ACKNOWLEDGMENTS

Acknowledgment must be made of the assistance of Coral Allan in field and laboratory work. Thanks also to Christine Trefry for Figures 6 & 7 and to Mark Hearnden for the statistical analysis in Appendix 3.

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APPENDIX 1

(a) Field Equipment

* 35 mm SLR Camera with zoom lens, variable shutter speed and aperture settings
* Remote shutter release
* Colour print film of ISO 100 speed or greater
* Tape measure
* Height stick, painted black and white in 10 cm graduations to 100 cm
* 1m x 1m steel quadrat, constructed from 25 mm (1") angle iron, painted black and white in 10 cm graduations
* Vertical camera support arm - Refer Appendix 2
* Horizontal camera arm with clamp and camera attachment - Refer Appendix 2
* Small step ladder
* Large umbrella
* Field Notebook
* Pasture shears
* Paper sample bags
* Field balance
* Small 45 cm x 30 cm field black board and chalk

(b) Laboratory Equipment

* Laboratory balance with weight range 1kg x 0.1g
* Drying oven
* Laser printer labels
* Print and negative albums

(c) Construction of a 64 Point Dot Grid

The dimensions of a vertical quadrat viewed in a 15 cm x 10 cm (6"x4") photograph are approximately 8 cm x 8 cm. To minimise edge effects, the rows and columns of the square dot grid should start 0.5cm from the edge of the quadrat. This leaves a 7 cm x 7 cm area over the quadrat in the photostandard. By spacing the dots 1 cm apart, a 64 point dot grid is produced in 8 rows and 8 columns which covers this area.

The grid should be initially be drawn on A4 sized graph paper with 1mm x 1mm graduations and then photocopied onto A4 clear plastic overhead sheets to produce an overlay dot grid.

To make it easier to view the dots against the photostandard the dots may be copied in a range of colours such as cyan (light blue) for light coloured vegetation or white for greener vegetation.

APPENDIX 2

Construction of the Vertical Support Arm and Horizontal Camera Arm

(a) Vertical Support Arm

Weld a 20 mm long, 6 mm diameter (1/4") steel bolt to the base of a 2m length of 19 mm (3/4") RHS steel. Drill a hole large enough for the bolt halfway along one side of the quadrat. Ensure the hole is far enough away from the edge of the quadrat to allow a nut to be tightened from underneath. Insert the vertical arm through the hole and secure with a nut (Figure 4) to produce the right angled standing structure shown in Figure 3. Paint this vertical support arm black so that it is unobtrusive in the vertical photograph.

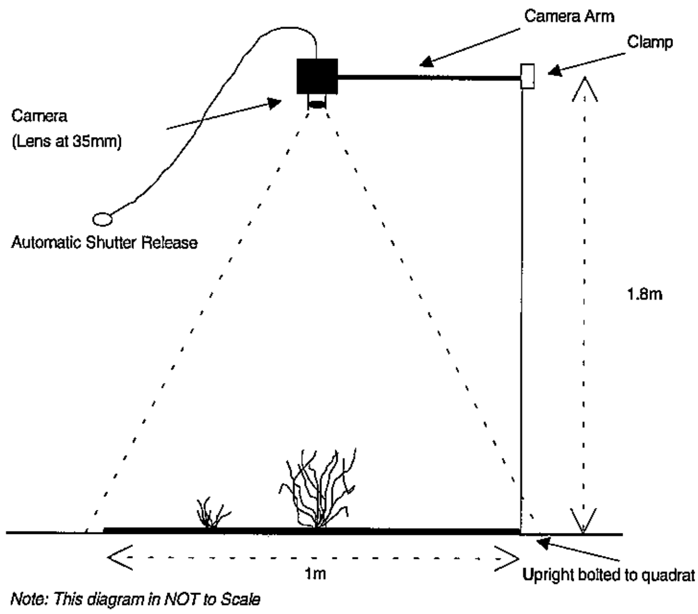


Figure 3: Vertical Photograph Structure

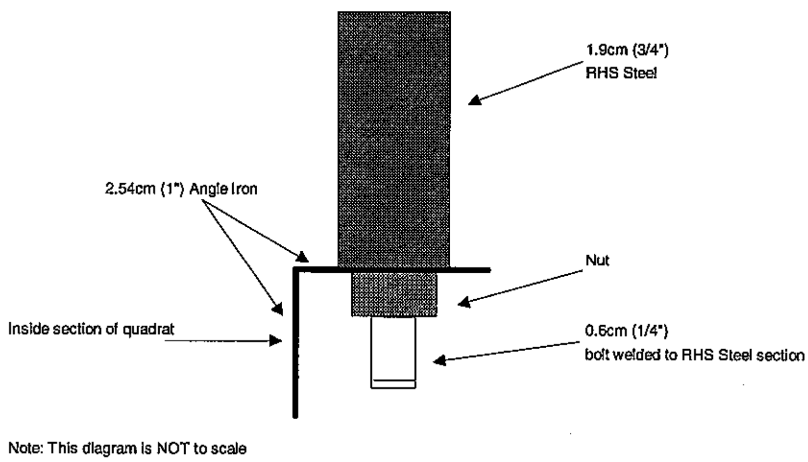


Figure 4 : Quadrat and Vertical Arm Join

APPENDIX 2

Construction of the Vertical Support Arm and Horizontal Camera Arm

(b) Horizontal Camera Arm

The horizontal camera arm is clamped to the vertical support arm at one end and attaches to the camera at the other to produce the structure in Figure 5. The horizontal camera arm is attached to the upright arm via a simple adjustable clamp (Figure 6). The other end of the camera arm is permanently bolted to a quick release camera tripod mount (Figure 7). When measuring the dimensions of the horizontal camera arm take into consideration the size of different tripod mounts and cameras. Adjust the length of the arm accordingly, to ensure the camera points directly at the centre of the quadrat.

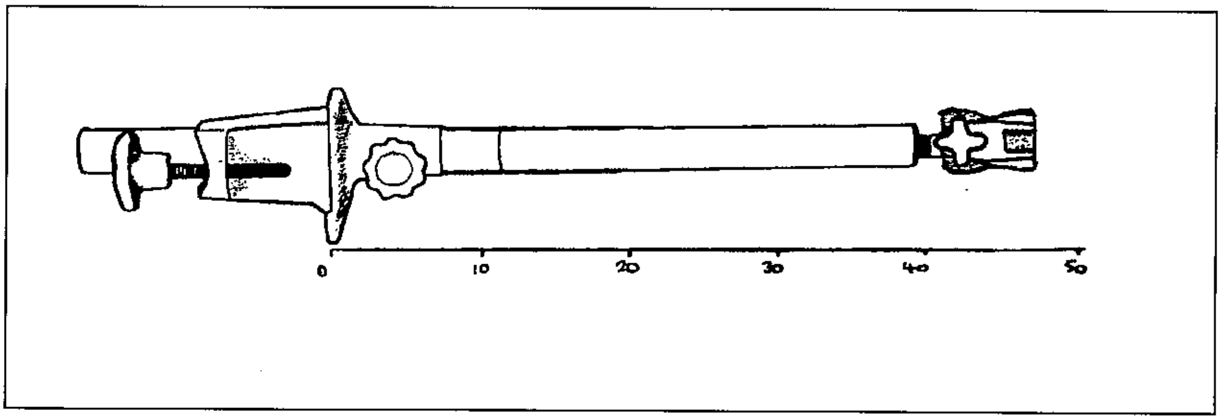


Figure 5 : Overview of Camera Arm

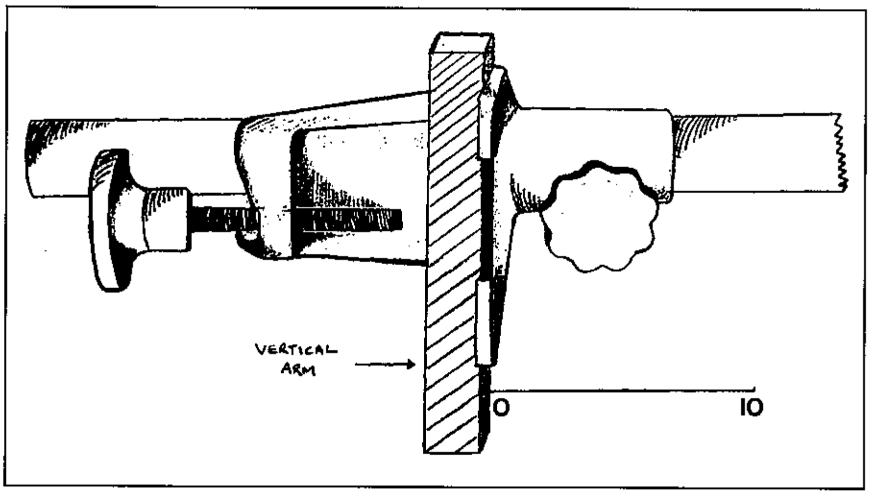


Figure 6 : Vertical Arm / Camera Arm join with Clamp

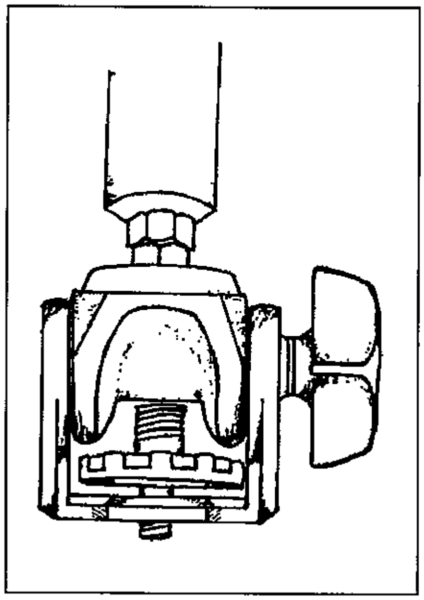


Figure 7: Quick release tripod mount on Camera Arm

APPENDIX 3

The Measurement of Aerial Plant Cover within a Quadrat viewed through a Vertical Photostandard.

The level of aerial plant cover within each photostandard was assessed using an overlay dot grid with cover expressed as a percentage of the total area within the quadrat. In order to assess what print size was suitable, the appropriate dot grid size (number of dots) and the number of operators required to give an acceptable estimate of cover, several small trials were designed.

Trial 1 - Print Size

In the first trial, seven inexperienced operators measured the percentage cover of three different photostandards, each represented by two different print sizes. The small print size was the standard 15 cm x 10 cm print and the large size was 30 cm x 20 cm. A 121 point dot grid was used in the exercise.

Table 1: Trial 1- Cover and Print Sizes

Operator	Estimated Levels of Cover (%)					
	Print 1		Print 2		Print 3	
	Large	Small	Large	Small	Large	Small
1	44	41	50	51	34	41
2	63	66	83	88	38	35
3	66	65	87	90	38	43
4	43	43	95	96	23	21
5	63	62	86	87	41	46
6	63	65	83	88	39	42
7	61	49	83	79	31	35
Average	**58**	**56**	**81**	**83**	**35**	**38**
Std Dev	**10**	**11**	**14**	**15**	**6**	**8**

The effect of print size was analysed using ANOVA where observations of cover were blocked on operators. The effect of different print size of the same photostandards on the estimate of cover was not significant ($F_{1,30} = 0.111$, $p = 0.7418$). Changing the print size of the photostandard did not significantly change the estimated level of cover.

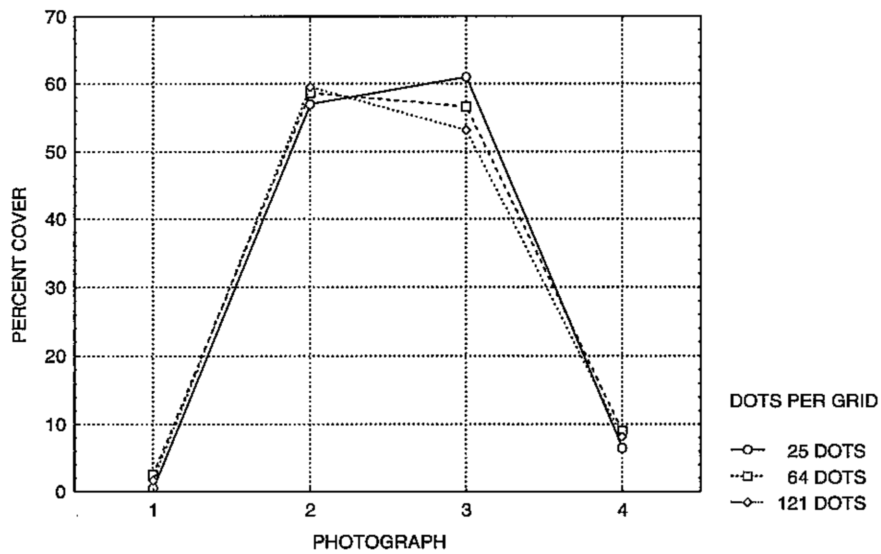
Trial 2 - Appropriate Dot Grid Size and Number of Operators

The second trial sought to determine the appropriate size of the dot grid (a small, medium or large number of dots) and the number of operators necessary to provide an estimate of cover from a photostandard within the 95% confidence interval.

The trial had 10 operators who estimated the level of cover in four different 10 cm x 15 cm photostandards with three different sized dot grids. The dot grids had 25, 64 and 121 dots. The combination of photostandards and dot grids meant each operator had 12 measures of cover to record. The order that each operator measured cover was randomised. The design of the trial was a randomised complete block, with the operators as blocks and the photostandards and the dot grids as fixed factors.

The effect of dot grid number on estimated percent cover for each of the photographs was analysed by ANOVA using individual operators as a blocking factor. Two operators who showed excessive variance in estimates were removed from the analysis. There was no significant effect for operator ($F_{7,77}$=1.88, p=0.0852) or dot grid number ($F_{2,77}$=0.53, P=0.5891). The effect of photograph was highly significant ($F_{3,77}$=1261.44, P<0.0001) as expected, as these were chosen to represent levels of high and low percent cover. The interaction effect of dot number and photograph was significant ($F_{6,77}$=2.79, p=0.0165) most likely due to the more variable estimates for photograph 3 (Figure 1) where plant litter was far more prevalent.

Figure 1. Interaction means for each dot grid and photograph.



Print Size, Dot Grid Size and Number of Operators

Trial 1 showed that different print sizes had no significant effect on estimates of cover. Therefore to minimise costs and improve efficiency, the standard 15 cm x 10 cm prints should be used for cover estimates.

From trial 2, the size of the dot grid was found not to have a significant effect on the estimate of cover, except in the photostandards where high litter cover was present. Therefore greater caution and extra care should be taken in assessing cover in those photographs where a high level of litter is present, to ensure only aerial plant cover is measured. For easier construction, a 64 point dot grid should be used for the assessment of cover.

Trial 2 also indicated that the procedure was repeatable regardless of user, after two operators who showed consistently high variation were removed from the analysis. Given this it may be prudent to train and calibrate inexperienced operators using a set of standard photographs with known levels of cover before measuring cover in photostandards To reduce the level of operator error, two operators should assess the covers levels within each photostandard and the average taken as the percentage cover for that photostandard.