SOME UNUSUAL PROBLEMS IN SAMPLE PLOT DESIGN

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Summary

Sample plots are being established along selected sampling lines throughout the high mountain protection forests of New Zealand for the purpose of measuring changes in the vegetation, particularly those consequent on the presence of introduced animals and affecting the soil conservation and water regulation values of the forests. The present condition of the forests must be recorded as thoroughly and accurately as possible but physical factors, examples of which are given, impose severe limitations on plot design. The design adopted, a 1/10th acre cruciform belt transect with internal circular milacre sub-plots, is essentially a compromise. Items recorded on each plot are briefly listed.

Introduction

Last year, in the pages of this Journal, proposals for survey of the watershed protection forests of New Zealand were briefly outlined (Holloway 1956). Inter alia, the need for the establishment in the forests of each watershed of a series of permanent reference and observation points, transects, charted quadrats, camera stations and the like, was stressed. These must be established before there can be measurement of the changes that are in progress consequent on the introduction into the forests of grazing and browsing animals. They must be established before there can be accurate assessment of the real effects of varied animal control operations. Their design and establishment has, therefore, been a major survey objective during the past year, the first year of protection forest survey. An account of this work, all of which has been carried out in the forests of the Waimakariri River watershed, Canterbury, may be of general interest by reason of the number of novel problems that have had to be faced.

The Sampling Pattern

From the start it was certain that random or grid sampling techniques could not profitably be employed. The terrain is, in general, far too difficult. Between pre-selected points such as those that might be chosen on a pin-prick basis, or by super-imposition of a regular grid, there is commonly no direct travel route that is at all practicable. Two points, a mile or so apart on the map, may be several days apart in time. Sampling must, therefore, be selective with establishment of plots at points, or along lines, considered representative of some
significant portion of the forest under study. Fortunately, in the present case, the adoption of this procedure involves no extra field work since the required preliminary reconnaissance surveys are to be made irrespective of the nature of the sampling pattern employed.

In practice, line selection is simpler than point selection. On completion of reconnaissance survey of an area of forest, the mountain slope (or slopes where there is variety in the forest) most typical of the whole is selected for sampling. Directly up this slope, commencing from some point chosen solely for its ease of identification on air or ground photographs, a line is run from the valley floor or lowermost forest margin right through to the uppermost limits of vegetation. Plots are established along this line at fixed altitudinal intervals, an interval of 500 ft. having been employed to date. One line to every 10,000-12,000 acres of forest and related land has been run in the Waimakariri where there is considerable uniformity in the composition, though not in the condition of the forest.

Plot Design—Basic Requirements

The plots must be designed, as already indicated, to measure all changes in progress consequent on the introduction of grazing and browsing animals into the forest. They must permit ready evaluation of the true effects of varied animal control operations. We must seek, in other words, a measure of total change in total plant population and a measure of the effect of such changes on the site. This requirement is far broader than is usual in sample plot work. Most sample plots are designed to answer but one or a few simple questions about one or a few species only. The items to be recorded are normally simple things, stem diameters, total heights, numbers of stems per unit area, and so on, all items susceptible of simple numerical expression. In the present case, however, there is no such simplicity. The questions to be answered are neither few nor simple. Many items cannot readily be expressed numerically. The composition, structure, density and health of the vegetation at the sampling points must be recorded as completely, accurately and concisely as possible. The condition of the forest floor and of the forest soil, patterns of animal use, and any other items of possible significance in the broad field of watershed management, must be noted.

The plot record must cover all these points. In addition, as in all sample plot work, plot techniques must be standardised and reduced to a drill which will ensure direct comparability between the records compiled by different sets of observers. It has not been easy to design a plot that will come near to providing all the information required. It has not been easy to reduce the work to a drill. The design adopted (described below) is not ideal from any point of view. Suggestions for its improvement would be most warmly welcomed. All that is asked is that due attention be paid, in offering suggestions, to the physical factors of time and place that severely limit all choice in design.
Limiting Factors in Plot Design

1. All work to be carried out at any one sampling point must be capable of completion in 1-1½ hours by a four-man party.

The strength of field parties is dictated partly by the need for a strong party in case of accidents and partly by the need to ensure party mobility. The field men operate in pairs, one man measuring, one man booking. A two-man party is not a safe party in difficult mountain country; a six-man party is a slow cumbersome party. The time limit on plot work is a matter of elementary logistics. All plots on one line must be completed in one day. If this cannot be done, field parties must either carry their camps up the mountain slopes with them or make a double trip up and down. During the past season plots were established on 21 lines covering just under 75,000 vertical feet of mountainside. Load carrying or double-tracking over such a distance must clearly be avoided. With the present design of plot a four-man party can complete a line of four to five plots, spending 1-1½ hours on each plot, in 12-13 hours. Where there are more than five plots on a line, the lowermost plot(s) can be completed the previous evening but the uppermost plots must, at all costs, be completed on the first ascent. Where rivers must be crossed en route to lines (averaging one line in five) the need for completion of the full line in one day is even greater. The river can normally be re-crossed the same evening but a crossing the next day, or for several days, may be impossible. Supply arrangements must be made accordingly. Each additional day spent on lines or on the wrong side of rivers means, in fact, two or more extra days in the field, profitless days spent packing food.

2. There is need for great economy in movement about each plot. There should be little need for the men booking to move far from plot centre and little need for the men measuring to move from the centre line.

All operations must be carried out on steep to very steep slopes. The average slope at plot centre for the 83 plots established during the past season was 34° (range 16°-42°) with many steeper pitches within the plots. In many parts of the country, e.g., the western slopes of the Southern Alps, average angles of slope will exceed even these figures. Movement about such slopes with tape, measuring rod and notebook is not easy. It can be very difficult where the scrub is dense or the forest is stunted. Square or circular plots of size from 1/10th acre upwards do not permit the necessary economy in movement. Belt transects, optimum width 25 links, have been found to be preferable.

3. All portions of a plot should be visible from plot centre. The limit of visibility is commonly about 200 links and may be much less in heavy scrub. The ends of a belt transect, 400 x 25 links, may fall across unclimbable bluffs. In one instance a cross-slope transect 200 x 25 links hung at either end across an impassable gorge. There is not
much point in commencing work on a plot that, for physical reasons, cannot be completed.

The Design Adopted

Acre plots (500 x 200 links), as heretofore employed in forest survey work, must obviously be abandoned for work in the mountain forests. Even 1/10th acre plots, circular or square, may be difficult to establish as already indicated. Line transects do not provide sufficient information and profile charts take too long to make. Belt transects 25 links wide have been found to be the easiest to measure but even these should not fall below 1/10th acre.

This seeming impasse has been overcome by designing a plot that is essentially a belt transect, 200 x 25 links running up and down slope from plot centre but with the addition of two wings, each 100 x 25 links, across slope (see Figure 1). No portion of the plot is more than 112.5 links from plot centre and the men booking are not, therefore, required to move about the plot. And no portion of the plot is more than 12.5 links from the centre line of each arm or plot section and the men measuring are not required to move off this centre line. The great disadvantage of the design is, of course, the considerable length of the plot perimeter (900 links) in relation to the total plot area (1/10th acre); but we can see no way of avoiding this. In partial recompense the true status of all marginal items (i.e., whether they are inside the plot or out) can quickly and accurately be determined by use of a 12.5 link measuring rod, a rod which is not too long to be handled with comfort.

This cruciform belt transect is the basic plot. On it all plants exceeding 12 inches total height are recorded by species and by two inch diameter classes—under one inch stems and dead stems being separately booked. No attempt is made to chart the vegetation but the records for each of the four sections are maintained separately and this provides some indication of species grouping and intra-plot distribution.

Other observations are made on 20 circular milacre plots spaced at 6 ft. intervals along the centre lines of the four sections of the principal plot (i.e., 5 milacre plots per section). On these milacres:

1. All plants under twelve inches total height, low growing species and the seedlings and juveniles of tall species, are recorded by species and frequency classes (solitary specimens—1, very abundant—5).

2. Counts are made of all animal pellet groups (see Riney, 1957) distinguishing between species (hare, rabbit, sheep, opossum, pig, deer, chamois, etc.), and recognising two age groups (fresh, i.e., obviously dropped within the last seven days, and old).

3. The condition of the forest floor is described by estimating, to the nearest 10 per cent., the proportion of the area occupied by moss, litter, bared topsoil, exposed subsoil, rock, erosion pavement, running scree, etc.
Figure 1
Four photographs are taken (weather permitting) of each plot, these being taken from plot centre looking outward along the centre lines of the plot sections. A soil pit is dug at plot centre and the profile described. A general description is given of the vegetation on the plot and in the surrounding area and more detailed notes cover the condition of animal tracks (evidence of use or disuse), the extent of animal browsing and grazing (species browsed, left untouched, and degrees of use), insect damage, etc. Details of altitude, aspect and slope are, of course, recorded for all plots, and all forest traversed between plots is described, notable features being photographed where possible.

Grassland and Scrubland Plots

The scrubland and unoccupied alpine grasslands that lie above the timberline must be sampled equally with the forests. The plot design outlined above cannot be employed in the grasslands for the task of recording the plants that occur on the transect would take many times longer than is permissible. For the grasslands (and herbfields, etc.), therefore, the procedure is modified. The belt transect becomes a line transect, still arranged in cruciform fashion, and the plants located at every second link along the lines are recorded, all plants being noted, not only those exceeding twelve inches total height. The milacre plots are recorded as already described but again all plants growing thereon are noted, not only those under twelve inches in height. Details of vegetation composition, therefore, are recorded by two methods, providing a useful check.

From the scrublands, both belt and line transect techniques have been tested but neither technique works satisfactorily in dense scrub on very steep slopes. This scrub is commonly so dense and the slopes are so steep and broken that all movement through it is at snail’s pace. Tapes cannot be run out evenly and, at any point, the soil cover may be formed by the interlocking branches of a dozen woody species with semi-woody and herbaceous species beneath. But this scrub is, nevertheless, in process of modification by animals. Opossums delight in it. Chamois penetrate it freely and deer with not much greater effort. Hares locally abound. The stages of modification (or of recovery in the event of successful animal control) should be followed through. How this can best be done, however, is a matter still to be determined. Probably the straight sampling approach must be abandoned with all future effort directed toward study of the weak and sore spots in the scrubland zone; and this technique might well prove to be the best for the alpine grasslands also. It would not work well in the forest zone, however, and for forested lands selective sampling techniques will almost certainly be retained.

Conclusion

The work of establishment of the permanent reference and sampling points is not, of course, the whole task of the teams engaged in survey
of the high mountain protection forests. Hand-in-hand with this job, fairly thorough reconnaissance surveys are being made, photographic records of the condition of the watersheds are being compiled, and much detailed research is underway or planned. All approaches are designed to tie in together so that sample plot information can be checked against reconnaissance information, reconnaissance information against the photographic record, etc. But the sampling job is an important one and, when the samples are re-examined and re-measured, perhaps in five years, perhaps in ten, we should have some reliable information concerning the changes that are in progress. Perhaps in five years, perhaps in ten! This may seem too long. But if we look at it in the light of the labour involved it may seem that the forecast is over-optimistic. May we conclude by giving a few figures concerning the work done during the 1956/57 summer field-work season, in course of which 83 plots on 21 sampling lines were established by a single field party.

Total days in field ............................................ 79
Valley travelling (packwork on foot) ............. 22.5 days, 318 miles
Reconnaissance work ........................................... 14.5 days, 194 miles
Line-plot work .................................................. 25.5 days, 76 miles
Sum of altitude gains on reconnaissance ............... 54,000 ft.
Sum of altitude gains on line-plot work

(75,000 ft. of actual line) ........................... 116,000 ft.
Total mileage on foot .................................... 588 miles
Total altitude gains ......................................... 170,000 ft.

If progress seems slow, we ask that these figures be borne in mind. The Waimakariri watershed forests were easy ones to survey compared with many still to be done. We would repeat our remark that we would welcome suggestions for improvement in our sample plot design but believe that it will be understood that we seek suggestions for its simplification rather than for its elaboration.

References