Thar density and vegetation condition

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1. Introduction

The Himalayan thar control plan (DOC 1993) requires monitoring of thar densities and vegetation to test whether thar numbers in each area are consistent with an "ecologically acceptable vegetation and estate condition". Consequently 72 permanently marked, variable-area plots were established in five catchments between 1990 and 1994. Most of these were remeasured in 1996/97.

As part of its ongoing review and improvement process the Department of Conservation sought advice on the following question: Do the vegetation data collected to date, as part of the thar control plan, provide enough information on trend of vegetation condition to make an informed decision to change thar intervention densities?

There are three basic approaches by which knowledge of the relationship between vegetation condition and thar density might be ascertained:

1. Recording vegetation change in well-controlled manipulations of thar densities within finite experimental areas - such an approach necessitates small experimental areas which are likely to lead to unnatural foraging behaviour of animals in space.

2. Recording vegetation change inside and outside of exclosures in the manner of before-after control-impact (BACI) experimental designs - such an approach requires complete exclusion of animals from "con trol" areas and a knowledge of the actual animal use of open areas, allowing for the foraging behaviour of animals in space.

3. Recording of vegetation change in many places spread over a large area with varying animal density, in the form of a meta-analysis - again such an approach requires a knowledge of the actual animal use of sampled areas, allowing for the foraging behaviour of animals in space.

The first approach is problematic and impractical almost by definition. Of the two remaining approaches, the former is excluded as a possibility by the apparent absence of exclosures within the available data set (see Thomson et al. 1997a and 1997b). Thus the relationship between vegetation condition and thar density can only be assessed by the uncontrolled meta-analysis approach. This immediately imposes a number of restrictions on what can be gained from the data. These limitations will become apparent below.

2. Summary of the evidence

Thomson et al. (1997a and 1997b) provide analysis and comparison of data collected from three sets of permanent monitoring plots in three high-country catchments in Canterbury: the Hooker Valley, the North Branch of the Godley Valley, and Carneys Creek. The statistical analyses are essentially sound, even if one might quibble about independence v. pseudoreplication of binary data tested with χ^2 tests, or with the acceptance of standard levels of significance (e.g. $P<0.05$) in multiple univariate tests of response variates which are scarcely likely to be truly independent. The interpretation of the results can be summarised as:

- In the Hooker Valley, where thar density has not exceeded 1 beast/km^2, vegetation condition has improved.

- In the Godley Valley, where thar density has been as high as 10 beasts/km^2, vegetation condition has declined markedly.

- In Carneys Creek, where thar density has been around 8 beasts/km^2, vegetation condition has improved.

From the first two results, it might be concluded that the invention density (above which thar would cause a decline in vegetation falls between 1 /km^2 and 10 /km^2 (cf. the standard intervention density of 2.5 /km^2 in most of the management units). However, the Carneys Creek results confuse this by showing improved vegetation condition at an average thar density not dissimilar to that in the North Branch of the Godley Valley. Thus, as a meta-analysis of all three areas, it is not possible to identify a clear thar density inflection point between vegetation improvement and vegetation decline.

The absence of consistency within the meta-data, and the inability to come to any conclusions about intervention densities, arise from the limitations inherent in the design of the monitoring programme and their effect on interpretation of the statistical analyses. The problems fall under a number of headings.

2.1 PSEUDOREPLICATION AND CONFOUNDING

Since there are only single estimates of thar density per catchment area (as averaged over the monitoring period), the plots in each catchment area are effectively pseudoreplicates of thar impact. This means that there are really only three data points by which to determine the relationship of vegetation condition to thar density. This is further complicated by the possibility that vegetation response to different thar densities will then have a high likelihood of being confounded by the vegetation response to any or all other differences between the catchments examined. Some of these differences are obvious in the vegetation types present and the relative abundance of different species of tussock. Accepting trends as indicative of thar impacts can only be done by faith that the thar effect is of orders of magnitude greater than any other differences between catchments. Individual plots would more closely approximate true replicates if there were particular thar density estimates for the immediate vicinity of each plot. The only other alternative is to include data from many more catchments in the meta-analysis.

2.2 WITHIN-CATCHMENT VARIATION IN THAR DENSITY

Thomson et al. (1997a) point out that there is considerable variation in than use of the North Branch of the Godley Valley. One bluff system is estimated to experience 2x (1992) to 2.5x (1996) the catchment-average density of thar across the course of the year. It is unfortunate that all of the plots are spatially clustered on this particular bluff system. By contrast, thar use of Carneys Creek catchment is believed to be much more uniform (Forsyth 1997, in Thomson et al. 1997b) and thus the area of the plots probably experiences approximately the catch ment-average density of thar. Thus the conclusion that the Godley Valley and Carneys Creek show divergent trends in vegetation condition (declining and improving respectively) whilst experiencing essentially similar thar densities (see above) is undoubtedly inaccurate since the areas of the plots are probably experiencing very different thar densities.

Clearly there was a failure to recognise the spatial heterogeneity of the vegetation within catchments and the heterogeneity of thar impact through spatially varying browsing behaviour, etc. when the plots were first established. The average plot trend in vegetation could only be correlated validly with the catchment-average thar density if the vegetation plots were randomly distributed across the entire catchment. This is clearly not the case. There is a need for an estimate of thar density/use in the immediate vicinity of the clusters of plots. This might have to be achieved by regular dung counts in plots (using removal of dung during monitoring visits, to avoid future double counting).

The above higher estimates of thar use in the immediate vicinity of the Godley Valley plots might unwisely be used to conclude that the intervention level should fall somewhere between $8/km^2$ (Carneys Creek where vegetation is improving) and $18/km^2$ (Godley Valley where vegetation is declining). Any figure within this range is much higher than the current intervention density. However, this conclusion would be invalid because the thar cannot be managed at the scale of single bluff systems, but at the catchment scale, and because the behaviour of the thar is ultimately determined by catchment-scale patterns. Each catchment is a mosaic characterised by the set of vegetation types present, the relative areas and patch sizes of these vegetation types, and the neighbourhood relations of the patches. Thus animal behaviour is controlled by *relative* palatability and *relative* abundance (possibly in a multiplicative way), where *relative* is with respect to what is available in the catchment, and all mediated by neighbourhood relations as they determine sequential access to desirable food resources during wandering (see Senft et al. 1987). Such relativities will differ between catchments. These issues undoubtedly complicate the suggestion above that dung counts in plots might be useful, and so it may not be viable to use local estimates of thar density. Monitoring plots spread out across whole catchments may be the only solution.

2.3 REPRESENTATIVENESS OF VEGETATION TYPES

It is unclear whether the clusters of vegetation monitoring plots are indeed representative of the whole catchments. For example, there seems to be little explicit recognition of bluff tops, a probable favoured habitat of thar, except for the comment in Thomson et al. (1997b) that one plot was not remeasured in 1996 because it was dangerously steep. A thar might not think so.

2.4 TUSSOCK HEALTH AS AN INDICATOR

The main indicator in these analyses has been snow tussock "health". However, it might be questioned whether this is a sufficient indicator of "ecologically acceptable vegetation and estate condition" as stated in the Control Plan objectives (DOC 1993). Thomson et al. (1997a) argue for tussock, using evidence that 50% of the diet of thar is tussock. However, tussock will constitute far more than 50% of the vegetation biomass in many of these systems. Palatability (and likely browsing threat to a plant species) is more appropriately gauged by the ratio of representation in the vegetation biomass to representation in the diet of the browser. Thus quite rare plant species can be most palatable and most susceptible to browsing. Such species would be the best indicators of "vegetation condition" if condition is a measure of biodiversity of species, rather than maximum biomass (to which tussock is the main contributor in these communities). Clearly the definition of "acceptable vegetation condition" needs to be revisited and made more explicit. Acceptable thar densities for acceptable tussock condition (and watershed protection) are likely to be higher than acceptable thar densities for acceptable palatable herb condition (and biodiversity protection).

2.5 TIME LAGS

A final issue in interpretation of these data is the question of time lags. Snow tussocks are known to require at least three years to recover from defoliation (Mills et al. 1989), and the time varies between species of *Chionochloa* (Lionel Solly, unpubl. data). Some of the apparently contradictory responses of vegetation to essentially the same average thar density at the Godley Valley and Carneys Creek may be historical consequences of the patterns on thar population decline and subsequent recovery before and during the monitoring period. The extent to which this may be true would require study.

3. Conclusion

Given the apparently contradictory evidence in the meta-analysis of the data from three catchments, and the above-listed caveats deriving from the limitations of the design of the monitoring programme, it is not possible to come to any conclusion about the nature of the relationship between thar density and trend in vegetation condition, and therefore it is not possible to judge whether the current intervention levels are appropriate or should be changed.

The following actions should be investigated for future modification of the monitoring programme:

1. Define local thar densities at vegetation plots.
2. Record and analyse for rarer plant species.
3. Construct exclosures as "controls".

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