SLOPE ASPECT AND TUNNEL EROSION IN THE LOESS OF BANKS PENINSULA, NEW ZEALAND

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ABSTRACT

The relationship between slope aspect and tunnel erosion on Banks Peninsula has been previously noted but not measured. For a sample area of Banks Peninsula the ratio of the number of tunnelled slopes to the total number of slopes potentially subject to tunnelling was determined for each aspect class of 22½°. This ratio represents the relative likelihood that a slope in a particular aspect class will be affected by tunnelling. The results, presented in the form of a rose diagram, show that slopes facing west to north-west are most likely, and slopes facing south-east to south-south-west least likely, to be affected by tunnelling.

INTRODUCTION

A relationship between slope aspect and tunnel erosion in loess on the Port Hills of Banks Peninsula (Fig. 1) has been noted, but not measured, by Hosking (1962). He observed that generally the most serious and frequent tunnelling occurs on the west-north-west facing slopes, but noted that a comparison of different aspects was difficult for this area because there were few south-east or east facing slopes. It was observed (Hughes, 1970) that the relationship between slope aspect and tunnelling appeared to exist throughout Banks Peninsula, and a method was devised to measure this.

METHOD

A sample area, as shown in Fig. 1, was chosen for intensive study. About 75 percent of all tunnel-affected slopes on the peninsula occurred in this area.

From maps and aerial photographs, every slope affected by tunnelling was identified (377) and its aspect, width (length along the contour) and the severity of tunnelling were recorded. Slopes were classed as being seriously, moderately or slightly affected on the basis of density of tunnelling and degree of collapse. Subsequent field checks confirmed these observations but revealed that minor

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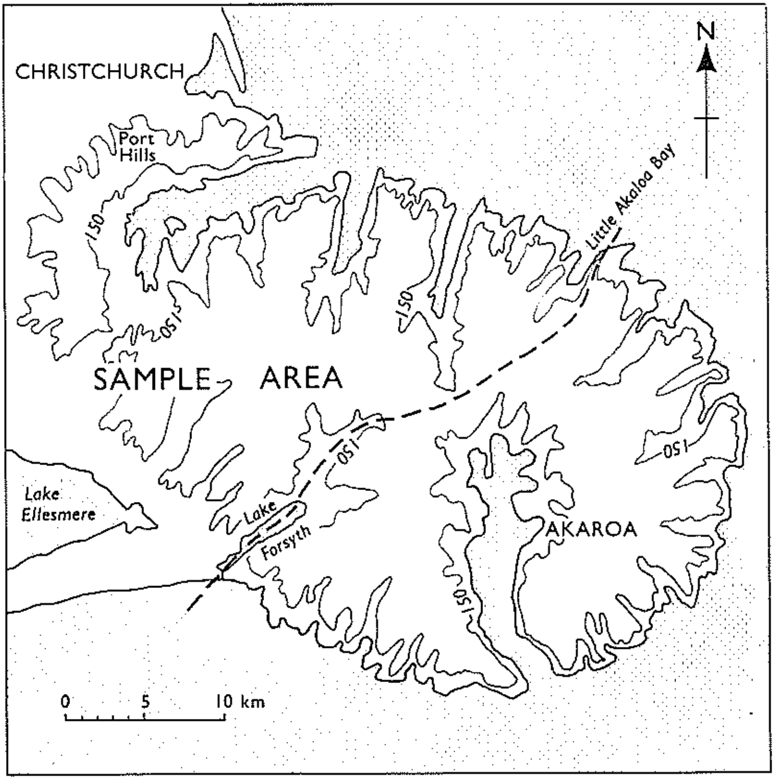

FIG. 1 — Banks Peninsula, showing location of the study area. (Contour shown: 150 m.)

tunnelling was often not visible on the aerial photographs (scale approximately 1:30 000).

Each occurrence was weighted for severity of tunnelling and width of slope affected. Slightly, moderately and seriously affected slopes were rated 1, 2, and 3 respectively. Each 200 metres of affected slope width was rated as one. For example, a slightly affected slope 1 kilometre wide would be rated as 5 (1×5), whereas a seriously affected slope 600 metres wide would be rated as 9 (3×3). The weighted occurrences of tunnelling for each aspect class of $22\frac{1}{2}°$ were then summed.

It was observed in the field and from the photographs that tunnelling seldom occurred at altitudes higher than 150 metres (500 feet) above sea level. Below this elevation the thickest deposits of loess occur, and the soil and vegetation conditions most favour the initiation of tunnels (Hughes, 1970). Not all slopes where these optimum conditions for tunnelling obtain are subject to this form of erosion; all slopes in this category were, however, considered to be potentially subject to tunnelling. The number of such potentially erodible slopes in each aspect class varied considerably. For this reason the aspect of every width of slope, whether affected by tunnelling or not, below an altitude of 150 metres and more than 1 kilometre wide that could be determined from topographic maps (scale 1:63 360) was noted. Three hundred and thirty-five such slopes were identified, and these were weighted for slope width and summed for every $22\frac{1}{2}°$ aspect class as above.

For each aspect class the number of tunnelled slopes was expressed as a percentage of the total number of slopes potentially subject to tunnelling (both weighted as above). The results are shown in Fig. 2. This ratio is a measure of the actual tunnelling that has occurred, for each aspect class, on all the slopes that are potentially subject to tunnel erosion.

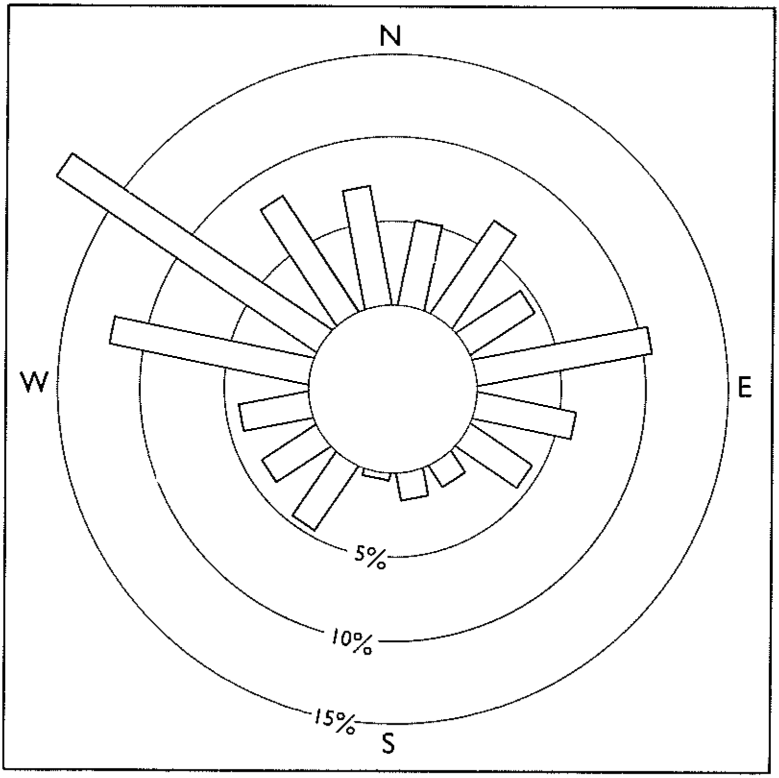

FIG. 2 — Aspects of slopes affected by tunnelling.

RESULTS

Slopes in the west to north quadrant, especially those facing west to north-west, are most severely tunnelled, and slopes in the east to south and south to west quadrants are least severely tunnelled.

A secondary mode occurs of east to east-north-east facing slopes, for which there is no apparent physical explanation. The number of slopes facing this direction, both affected and unaffected by tunnelling, is small compared with most of the other aspect classes.

DISCUSSION

The reasons for this relationship have been discussed more fully elsewhere (Cumberland, 1944; Gibbs, 1945; Hosking, 1962, 1967; Hughes, 1970).

In the summer, potential evapotranspiration exceeds rainfall and runoff from higher slopes, and drought conditions prevail on the slopes affected by tunnelling. The west to north facing slopes are most exposed to both the summer afternoon sun, when temperatures are highest, and the dominant hot dry north-west wind. Consequently, the soils on these slopes dry out to a greater extent than on other slopes, and this leads both to pasture deterioration – which has been greater in the past – and to the enlargement of fissures at depth in the loess. Depletion of the vegetation cover and trampling by stock lead to the breakdown of the natural structure of the topsoil. The consequent sealing of the soil surface by rain-splash and the baking effect of the sun decreases the infiltration capacity of the soil. The volume and velocity of runoff from such slopes is greater than from more densely vegetated slopes.

Once this increased runoff enters the highly erodible loess below a compacted layer in the soil its movement is facilitated by the enlarged fissure system. The result is a greater incidence of tunnelling on west to north-west facing slopes.

Owing to improved pasture management techniques introduced over the past few decades. conditions as severe as those outlined are no longer widespread. Field observations indicate that in most of the sample area there has been little apparent development of the tunnel systems since the first aerial photographic coverage of the area was made in 1941. By 1941 most of the tunnel systems of Banks Peninsula were in an advanced state of collapse and although new tunnels have been, and are still being initiated, it is likely that the soil loss since this time has been small compared with that before 1941. Thus it appears that most of the tunnel systems may be relict features corresponding to a period of maximum pasture deterioration before the 1940s (Hughes, 1970).

ACKNOWLEDGMENT

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