JOURNAL OF HYDROLOGY (N.Z.) Vol. 12, No. 2, 1973

MASS MOVEMENTS IN THE UPPER POHANGINA CATCHMENT, RUAHINE RANGE

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ABSTRACT

Photographic evidence is presented which records firstly the frequency of mass movements in the upper Pohangina catchment, southern Ruahine Range, during the early establishment of mammals, and secondly the frequency after mammals had caused a substantial loss of the forest cover. In 1946 the erosion surface exposed by mass movements was 1.7 percent of the total catchment area. In 1963 the area was 2.7 percent, an increase of 60 percent in 17 years. An attempt is made to define the extent to which the increased erosion and mammal effects are interrelated.

INTRODUCTION

The amount of erosion that has occurred since deer and opossums colonized high-country catchments has led to concern that their activities upset the equilibrium of natural geomorphic processes. It is argued that the change in forest conditions induced by mammals (Zotov, 1949; Holloway, 1950; McKelvey, 1959; and many others) creates a greater likelihood of erosion than in the former undisturbed forest. Such reasoning is in theory well founded, yet difficult to verify in practice as it requires a thorough understanding of the natural erosion processes for an area before any erosion induced or accelerated by mammals can be identified. The photographic evidence presented in this paper records firstly the frequency of mass movements in the upper Pohangina catchment, southern Ruahine Range, during the early establishment of mammals, and secondly the frequency of mass movements after mammals had caused substantial changes in the composition and density of the forests.

PHYSICAL FEATURES AND THE VEGETATION

All the natural characteristics of the Pohangina catchment (Fig. 1) predispose the area to severe erosion, particularly in the form of mass movements. Approximately 80 percent of the land has

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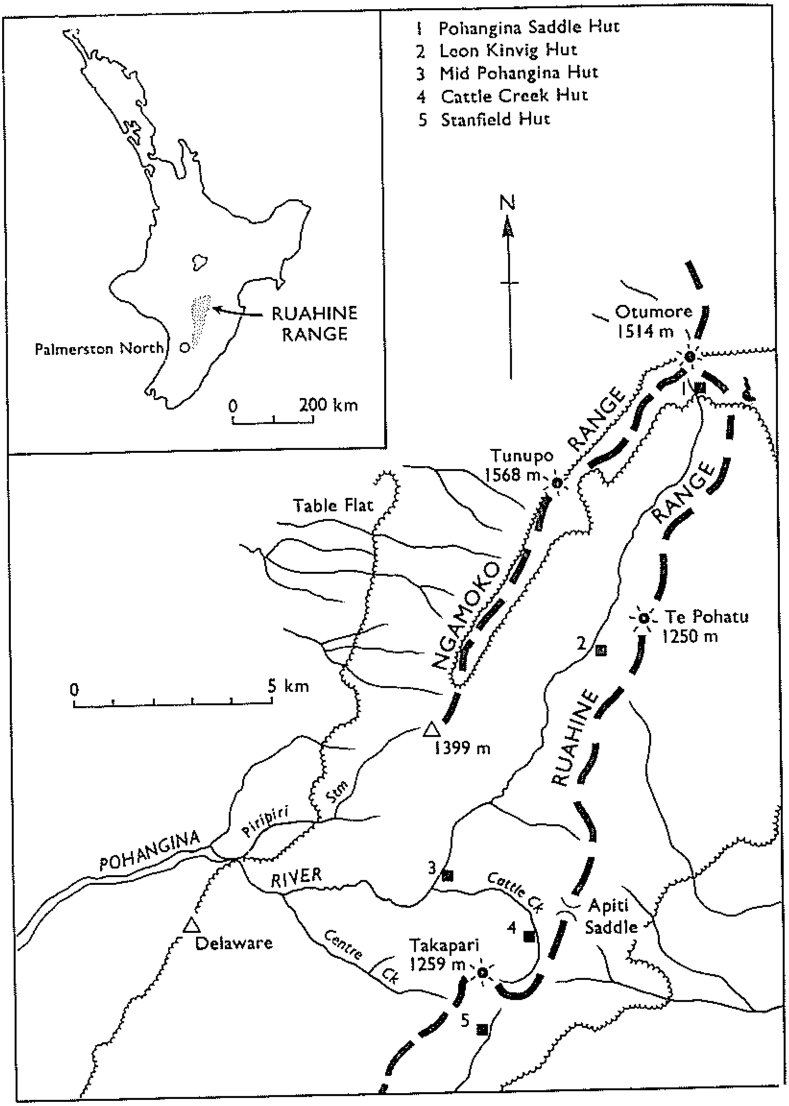

FIG. 1 — Locality map.

slopes steeper than 30°*. Annual rainfalls range between 2000 and 3800 mm, and daily rainfall can exceed 250 mm. During stormy periods the area often suffers gale-force westerly winds.

Rocks underlying the upper catchment are highly shattered Jurassic dark-grey argillites alternating with sandstones (Ruahine Greywacke Group). The soils derived from this parent material are typical skeletal soils having indistinct profiles at mid and low slopes with variable proportions of angular rocks up to 20 cm^2 size throughout. The soil contains little clay or silt fraction. On upper slopes, the soil profile is often differentiated into a peaty surface layer of 10 to 50 cm depth overlying a columnar subsoil. There may be a gley layer in the subsoil near the boundary with the underlying basement rock.

TABLE 1 — Area of bare surface exposed by mass movements in the upper Pohangina catchment in 1946 and 1963.

Vegetation type	*Total area (ha)*	*Area of erosion surface (ha)*	
		1946	*1963*
Alpine grassland	361	1.4	1.8
Leatherwood scrubland	1901	44.1	25.1
Rata/kamahi forest	1192	17.2	40.4
Red beech forest	2942	57.8	115.7
Podocarp forest	1146	9.3	23.1
Total:	7542	129.8	206.1

Vegetation in the upper Pohangina comprises alpine grasslands, subalpine scrublands, cedar, rata/kamahi, red beech, and podocarp forests. The extent of each vegetation type is given in Table 1. The alpine grasslands, principally *Chionochloa pallens*, cover the Ngamoko Range above 1200 m. Between 900 and 1200 m, leatherwood (*Olearia colensoi*) forms an extensive belt of dense scrubland. In the lower part of this zone, *Senecio elaeagnifolius* and pink pine (*Dacrydium biforme*) are sub-dominants. At the timberline there is a narrow remnant zone of cedar forest. Its composition is highly variable, with cedar (*Libocedrus bidwillii*), *Senecio elaeagnifolius*, broadleaf (*Griselinia littoralis*), fuchsia (*Fuchsia excorticata*), pink pine and *Myrsine divaricata* occurring together in many different communities depending on local site factors. Rata/kamahi forest (*Metrosideros robusta, Weinmannia racemosa*) formerly covered all the slopes, between 450 and 900 m, south of the Pohangina River - Cattle Creek confluence, and red beech forest (*Nothofagus fusca*) occurs in the same altitudinal range north of the confluence. Below 450 m, the forest consists of emergent rimu

* Field data from Forest Research Institute survey, 1970.

(*Dacrydium cupressinum*), miro (*Podocarpus ferrugineus*), and rata, with a secondary tier of mahoe (*Melicytus ramiflorus*), kamahi, and rangiora (*Brachyglottis repanda*).

ESTABLISHMENT OF MAMMALS

A striking feature of the Pohangina catchment is the unhealthy appearance of the forest. There are extensive areas where the original forest canopy has died and collapsed. The impacts of mammals and to a lesser extent fires have been the major causal factors of this forest mortality.

Several species of mammals were introduced to the Ruahine Range. Red deer were liberated near the Pohangina Valley at Table Flat (1922) and Delaware (1922) (Elder, 1965; Logan and Harris, 1967). Elder (1965) considers that these liberations can have been little in advance of the spread of deer from earlier liberations in the northern Ruahines. The rise of deer numbers in the southern Ruahines is not well documented. Elder (1965) indicated that by 1940 deer were well established in the upper Pohangina and peak numbers occurred during the 1950s. However, there are conflicting reports of two stags being shot well south at Coppermine Creek in 1914, and of abundant deer tracks at Maharahara Trig by 1925 (Ruahine Forest Working Plan, 1964–69). Opossum liberations were made in the Pohangina Valley in 1893 (Pracy, 1966). There was a general movement up into rata/kamahi forest in the late 1940s, where numbers increased rapidly (Elder, 1965). The populations appear to have gradually declined in the Pohangina during the 1960s. Goats have been noted all along the western side of the Ruahines, although the only dated introduction was at Opawe in 1925 (Ruahine Forest Working Plan). They were present in the Pohangina catchment during the 1950s, but have since been eradicated. Elder (1965) implies that domestic cattle from Te Ohu Station may have been wintered within the upper Pohangina.

A Forest Research Institute survey of the upper Pohangina during 1970 found that the effects of mammals on the vegetation were varied. In the alpine grassland, modifications have been caused mainly by domestic stock rather than deer. Mammals have had insignificant influence on the leatherwood scrubland, apart from some tracking along ridges. However, just below the scrubland in cedar forest there have been considerable changes in the composition of species and a general opening up of the forest by deer. There are well defined tracks, and the understorey has been cleared of species most preferred by deer. In contrast, opossums have so far made little use of this upper forest.

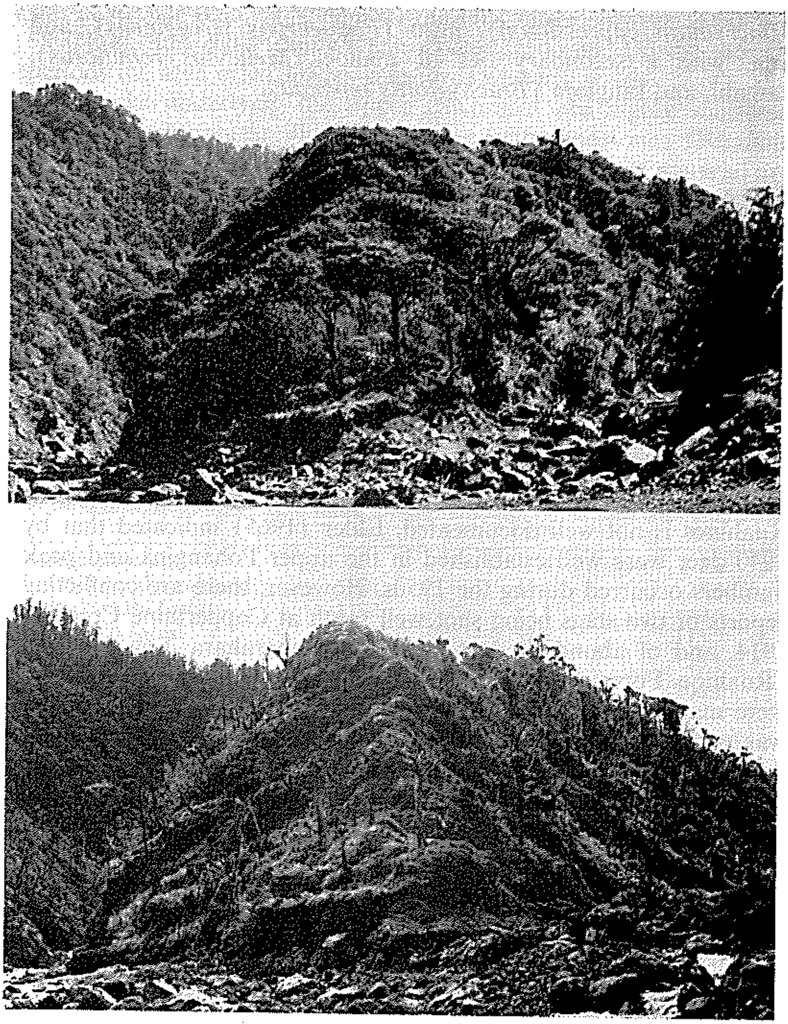

FIG. 2 — Repeat photographs of rata/kamahi forest in the upper Pohangina catchment showing the extent of the forest depletion. The upper photograph was taken in 1950 by Dr J. S. Findlay and the lower in 1971 by the author.

The former rata/kamahi forest canopy was killed by opossums during the 1950s (see Fig. 2), and has generally collapsed leaving only scattered trees of species not preferred by opossums: rimu, putaputaweta (*Carpodetus serratus*), lemonwood (*Pittosporum eugenioides*), and broadleaf. Beneath the remaining trees is a grassland/scrubland community dominated by pepperwood (*Pseudo-*

wintera colorata), tree ferns (*Dicksonia* and *Cyathea* spp.), hook grass (*Uncinia* spp.), bush rice grass (*Microlaena avenacea*), and water fern (*Histiopteris incisa*). Opossums have also had a serious effect on red beech forest by depleting the secondary canopy tier of kamahi, fuchsia, and pate (*Schefflera digitata*), especially on gully sites. Beneath the large red beech trees are dense communities of pepperwood, crown fern (*Blechnum discolor*), and tree ferns. A similar depletion of the secondary canopy tier has occurred in the low-altitude podocarp forest. Most of the rata/kamahi canopy was killed by opossums. There is now a dense understorey of tree ferns, rangiora and pepperwood. The effects of deer, goats, and domestic stock in podocarp and red beech forests have been mainly confined to changes in the understorey composition. Deer are limiting the advance growth of preferred tree species on open areas, especially in rata/kamahi forest.

NATURAL MORTALITY AND FIRES

There is some forest mortality which cannot be linked with mammals. There appears to be a natural down-slope movement of some forest communities; for example, the widespread mortality of cedar and pink pine at the upper timberline. Similar trends are shown by mountain totara (*Podocarpus hallii*) and red beech. The mortality is particularly noticeable at the upper limit of each species, and is often accompanied by a lack of effective regeneration. This down-slope retreat of vegetation communities has been described by Elder (1956).

Fire has also influenced the Pohangina vegetation. Esler (1963) has found evidence of pre-European fires in the southern Ruahine and northern Tararua Ranges. It is likely that the Pohangina catchment was affected to some extent. In early European times, the Pohangina Valley was a stock route linking Hawke's Bay and the Manawatu, and three major fires have been recorded (Elder, 1965). One, in 1915, ran up the Pohangina Valley and crossed Apiti Saddle, apparently as a series of spot fires. Two other fires, in the 1880s and 1945, spread over the Pohangina Saddle area. The remains of all three fires are evident today, but the area affected is relatively small.

MASS MOVEMENTS

Fig. 3A is an aerial photograph of an area in the Pohangina taken in 1946 (Survey 230) and Fig. 3B a repeat photograph of the same area taken in 1963 (Survey 1550). While the area shown constitutes only 8 percent of the catchment area, it illustrates the magnitude of forest and erosion changes in the total upper catchment (see Table 1). The area of bare surface exposed by massive

FIG. 3A — Vertical aerial photograph of approximately 600 ha in the Pohangina catchment taken in 1946. (Courtesy of the Department of Lands and Survey.)

erosion over the entire upper catchment was determined from the two photographic surveys under a Ziess N2 mirror stereoscope using a dot grid of 100 dots per square inch (15.5 dots/cm^2). Cedar forest could not be delineated on the aerial photographs and has therefore been included in the forest type which occurs immediately below it, that is, either rata/kamahi or red beech forest.

In 1946 the erosion surface exposed by mass movements was 1.7 percent of the catchment area. In 1963 the area was 2.7 percent, an increase of 60 percent in 17 years. The greatest increase in area of erosion surfaces had occurred in the forests, while the erosion area under scrubland declined and was little changed in the alpine grassland.

In addition to the photographic analysis, the broad physical characteristics of mass movements were examined in nine randomly chosen subcatchments. These erosion surfaces had an average slope of 45° (range 25–65°), and were most frequent on north- and east-facing slopes. They were also most frequent between 800 and 1000 m altitude, which corresponds with the upper levels of the rata/

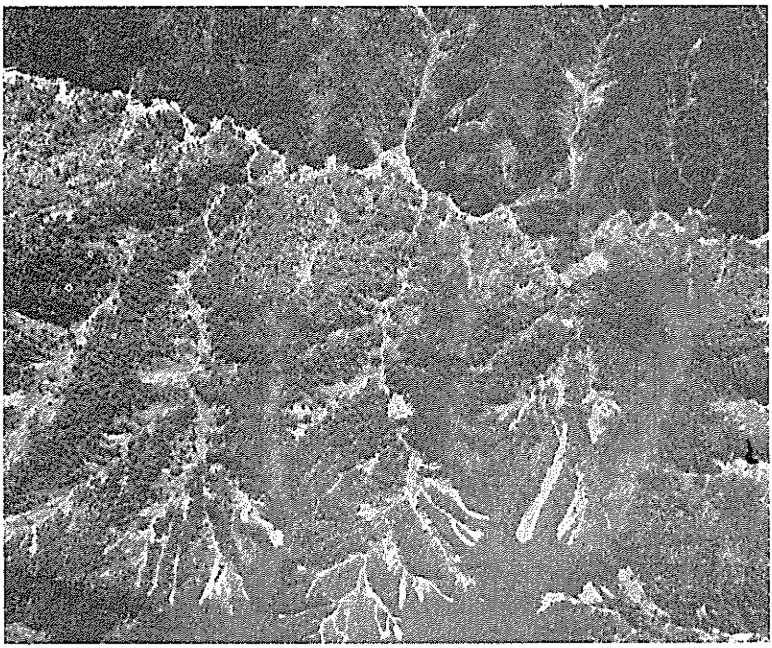

FIG. 3B — Vertical aerial photograph of the same area as in Fig. 3A taken in 1963. (Courtesy of the Department of Lands and Survey.)

kamahi, red beech, and cedar forest types. Widths ranged from 3 to 100 m, and lengths from 10 to 200 m. The average depth of movements was less than a metre.

For a particular site the physical factors which have a primary influence on the type of erosion appear to be the physiography and soil characteristics. On upper slopes a mass movement normally begins as a wet debris slide with a distinct shear plane of either hard rock or a less permeable soil layer. The initial movement occurs just below the tree root zone. As the material progresses downslope it becomes a wet debris flow enlarging by lateral corrasion and further tree collapses. Movement usually continues to the nearest stream channel. Mass movements on lower slopes may resemble wet debris slides but more often are slumps. They are deep-seated and have less recognizable shear planes. Movement is often initiated by flood flows in stream channels undercutting the loose deposits of rock and soil along the banks.

MAMMALS AND MASS MOVEMENTS

The results of the Forest Research Institute survey of the upper Pohangina show that since 1946 opossums have had a greater influence on forest structure and composition than any other cultural agent. Fire and ground-browsing mammals had some influence before 1946, so the frequency of mass movements visible on the 1946 photographs cannot be assumed to be entirely geological erosion. Between 1946 and 1963 there was an increase of 60 percent in the area of bare surfaces. An increase of this order suggests an acceleration in the erosion rate, yet it does not indicate whether or not it is mammal-induced.

The photographic evidence and a few established forest plots show a loss of between 50 and 90 percent in basal area of rata/kamahi forest as a result of tree mortality from opossum browsing. The species which died were, apart from rata, secondary canopy species such as kamahi, pate, wineberry (*Aristotelia serrata*), and fuchsia. Their death exposed the remaining physiognomic dominant species (mountain totara, miro, and rimu) to windthrow during storms. The collapse of large trees is commonly associated with a mass movement. There are also indications that the upper slopes are more prone to mass movements once the stumps and roots of the former forest trees begin to rot.

Another process which appears to associate opossum influences with erosion in both rata/kamahi and red beech forest arises from the almost complete mortality of fuchsia, wineberry, and pate along the sides of small stream channels. Once the trees collapse, grasses, ferns, and herbaceous species form dense communities up to 50 metres above the stream channels. This induced vegetation appears less able to stabilize the accumulations of loose rock and soil along stream banks. The result is undercutting during peak flood flows and oversteepening of the lower slopes, which in turn precipitates slope failure. The changes of stream-channel vegetation also influence the transport of material from mass movements Previously the forest vegetation obstructed the erosion material in log jams, a process noted in the Hunua Range by Pain (1968). Where there are only ferns and grasses on stream banks, the material is able to flow largely unimpeded to the main river channel.

While mammal-induced tree mortality can be associated with erosion, the climatic history of the past few decades could account for at least some of the increased erosion. Grant (1965) suggests that a great deal of the erosion on the eastern side of the Ruahine Range results primarily from exceptional rainstorms. He has reliable information that many new erosion scars followed heavy storms in the 1930s, 1950s, and 1960s (Grant, 1969). Grant (1966) found from maximum daily rainfalls recorded at 16 stations in eastern Hawke's Bay, "that the period 1931–60 was stormier than the

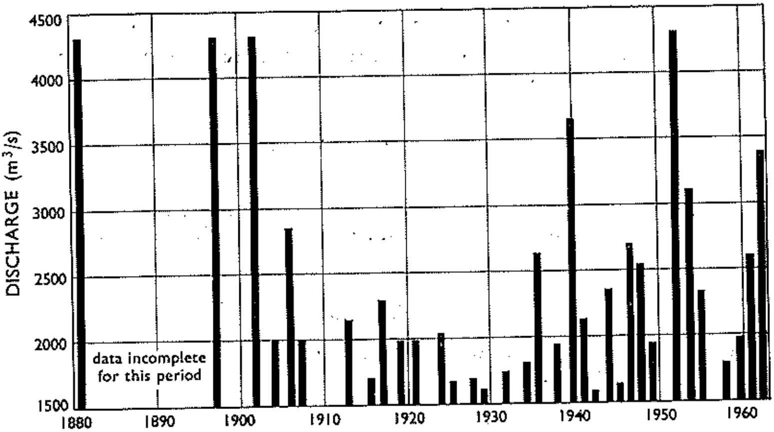

FIG. 4 — Flood levels of the Manawatu River above 1500 m^3/s at the Fitzherbert Bridge, Palmerston North.

preceding 30 years, and the indications are that this rather higher level of average regional storminess persists". The flood history of the Manawatu River (Fig. 4) suggests that Grant's findings are probably relevant for the Manawatu River catchment in general terms. There is a distinct rise in the frequency of large floods beginning around 1940. An exceptionally large flood (3620 m^3/s) occurred in 1940, and a hundred-year flood (4330 m^3/s) in 1953. The Manawatu River flood flows are probably not a complete record of storms for the upper Pohangina, as localized intense rainfalls can occur in mountain areas and be largely unnoticed downstream. Nonetheless, it could be argued that the increased frequency of mass movements is simply related to the greater number of storms occurring in the period being examined.

CONCLUSIONS

Undoubtedly the influence of mammals, particularly opossums, has had some part in causing erosion. Most of the increased frequency of erosion occurred in those vegetation types which suffered most from mammals, in particular the rata/kamahi and red beech forest. In addition the area of mass movements in the subalpine scrublands, which were least influenced by mammals, declined during the same period. The likely factor of increased storminess for the period concerned must logically be assumed to increase the possibility of mass movement. It is impossible to determine from the field evidence whether the forest damage induced by mammals simply coincided with the period of greater storminess, or whether the increased erosion has been the result of both influences combining to unbalance natural erosion rates and the protective capacity of the vegetative cover.

ACKNOWLEDGMENTS

The author is grateful to J. T. Holloway and J. Orwin of the Protection Forestry Division, Forest Research Institute, Rangiora, and to A. Cunningham of N.Z. Forest Service, Napier, for constructive criticism of the manuscript.

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