MT TARAWERA: 2. RATES OF CHANGE IN THE VEGETATION AND FLORA OF THE HIGH DOMES

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SUMMARY: The flora and vegetation of the four high domes of Mt Tarawera; Ruawahia, Tarawera, Wahanga and Plateau. are described, and successional rates and trends determined at some sites by comparing 1964 and present-day photographs and records. Although below the regional tree limit, the dome tops are dominated by scattered low shrubs, herbs, grasses, mosses and lichens. With increasing distance from the 1886 eruption craters vegetation complexity and rates of succession increase. Plateau dome vegetation is successionally the most advanced. In the last 18 years tutu *(Coriaria arborea)* has spread from adjoining valleys on to the dome crests and is now invading the remaining dome top vegetation. The flora of the high domes has increased since 1964 and a high proportion of the additional species are adventives. Adventive conifers are becoming increasingly abundant on the dome tops and may modify the natural succession which is to kamahi *(Weinmannia racemosa)-broadleaf (Griselinia littoralis)* forest.

KEYWORDS: Volcanic areas; vegetation; flora; plant establishment; plant succession; tutu; *Coriaria arborea*; Coriariaceae; Mt. Tarawera.

INTRODUCTION

This i*s* a detailed study of the flora and vegetation of the high domes (above 900 m) of Mt. Tarawera, where primary succession was initiated by an eruption in 1886. Successional trends and rates of change are outlined by comparing results with those of Burke (1964). Background information on the volcanic history and earlier vegetation records are provided in the first paper of the series (Timmins, 1983).

METHODS

Vegetation data were collected at 50 sites during 1979-1980 using a point intercept method. Thirty-five sites were located at 50 m intervals across Plateau dome and a further 15 selected to represent the range of vegetation types present on the other dome tops. At each site a rectangular quadrat (1.25 m^2) was laid out and the species or substrate that intercepted each of 180 equidistant points recorded. Two vegetation layers were recognised; a ground layer (0-15 cm high) and a shrub layer (higher than 15 cm). Aspect, slope, type of substrate, drainage characteristics and other relevant information were also noted.

Sampling focused on Plateau dome for two reasons: the dome had been intensively studied by Burke (1964), and much of the dome top vegetation was about to be destroyed by the construction of an airstrip.(opened December, 1980).

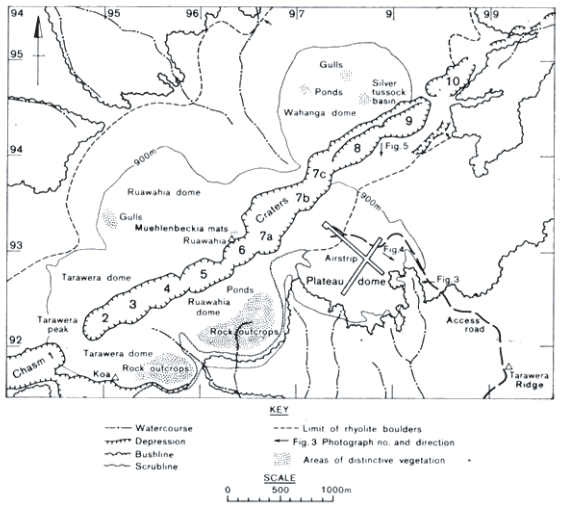

FIGURE 1. *Dome tops of Mt Tarawera. The study area is delimited by the 900 m contour. Source: NZMS2. N77/7.*

In addition, the vegetation of 18 successionally significant areas was described. These areas included three sites on Plateau dome photographed by Burke (1964), and rephotographed in 1982 to determine

TABLE 1. *Summary of spatial trends apparent in Plateau dome vegetation.*

	Close to crater	Away from crater
Vegetation cover	variable, generally low	variable, higher at dome edges
Racomitrium cover	high	low
Shrub cover	scattered	scattered, becoming continuous at dome edges
Species diversity	low	high
Non-vascular plant cover	high	low
Vascular plant cover	low	high
Substrate	boulders, ash & lapilli	ash & lapilli

the rate and extent of vegetation change over the previous 18 years (Fig. 1). Numerous reconnaissance trips were also made between 1979 and 1982 over the dome tops to determine the extent of the flora, and the abundance and distribution of individual plant taxa.

Further information on methods is provided in Dickinson (1980).

RESULTS

Plateau dome vegetation

At sites sampled on Plateau dome, ground layer vegetation covered 44% of the area and over half of this was contributed by four species: *Racomitrium (Racomitrium lanuginosum)* contributed 14% and *Raoulia glabra, R. albo-sericea* and *Rytidosperma viride* 5 %, 3 % and 3 % respectively. The remaining 19% of vegetation cover comprised a variety of herbs, shrubs, grasses, rushes, sedges, ferns, lycopods, orchids, mosses and lichens. In the shrub layer, total cover was only 8 %, of which just over one-third (3%) was monoao *(Dracophyllum subulatum).*

Although total vegetation cover was low there were patches of vegetation, with cover up to 100%, scattered over the otherwise sparsely vegetated substrate. These ranged from *Racomitrium* mats of low species diversity on the boulder-strewn substrate within 500 m of the crater to coalesced grass/herb-lichen mats of high species diversity on the ash and lapilli substrate beyond. Shrubs were usually scattered throughout, with monoao, the leading dominant, in the vicinity of the crater and tutu *(Coriaria arborea)* dominant near the dome edges. Non-vascular species *(Racomitrium* in particular) dominated the vegetation cover close to the crater. A change to vascular species dominance occurred at approximately 300 m from the crater.

Spatial differences in cover and composition of the vegetation sampled on Plateau dome are summarised in Table 1.

Vegetation of other areas

On Wahanga, Ruawahia and Tarawera domes total vegetation cover was less than on Plateau dome. Typically, stunted shrubs of monoao, *Gaultheria* spp., mingimingi *(Leucopogon fasciculatus)* and *Olearia* spp. were scattered over single plants or sporadic clumps of the herbfield species also found on Plateau dome. A few areas, however, supported distinctive vegetation (Fig. 1).

Two southern black-backed gull *(Larus dominican us)* colonies have established on Ruawahia and Wahanga domes since 1964 (W. D. Burke, pers. comm.) and a thick carpet of vegetation dominated by the adventive, sweet vernal *(Anthoxanthum odoratum)* now covers the ground at these sites. Average ground layer vegetation cover was 67% compared to 44% on Plateau dome, while litter covered 31 % of the ground in contrast to 7 % on Plateau dome. As well, there were higher proportions of vascular plants (93% compared to 51 %) and adventive plants (65% compared to 6%) there than on Plateau dome.

The presence of semi-permanent ponds on south Ruawahia dome has allowed semi-aquatic species such as *Myriophyllum propinquum, Limosella lineata* and *Glossosflgma submersum* to establish. Surrounding each pond there was a narrow zone of vegetation in which *Racomitrium* provided almost complete cover. To the south-west of the ponds were numerous rocky outcrops which supported more shrubs, especially tutu, than the surrounding ash and lapiIIi filled basins. Many of these shrubs, for example karamu *(Coprosma robusta),* kamahi *(Weinmannia racemosa)* and broadleaf *(Griselinia littoralis),* are components of the forest on the dome sides.

A basin on Wahanga dome had numerous clumps of silver tussock *(Poa laevis)* growing amongst *Racomitrium* mounds. On the slopes above the basin some of the largest *Pinus radiata* trees seen on the dome tops were noted. The tallest individual (over 9 m)

was cored and aged at approximately 30 yrs (M. R. Boase pers. comm.).

On the unstable ash and lapilli slopes in the vicinity of Ruawahia trig were two grass/herb-lichen ring growths averaging 4.5 m2 and dominated by *Muehlenbeckia (Muehlenbeckia axillaris).* These ring growths were discrete circular patches whose initial formation was dependent on the germination and radial growth of the creeping *Muehlenbeckia* (Burke, 1964). Here a tight continuous pad, up to 4 cm thick, had been built up by the establishment of the mosses *Bryum laevigatum* and *Campylopus clavatus* on the ash and lapilli stabilised by the *Muehlenbeckia* roots and stems. On top of the pad a few individuals of *Rytidosperma viride, Raoulia glabra, R. albo-sericea, Racomitrium* and other species were perched. Outside these rings the ash and lapilli were only sparsely vegetated (12 % cover) and *Muehlenbeckia* formed an insignificant component.

Flora

One hundred and ninety-seven plant taxa were noted on the dome tops of Mt. Tarawera during the study (Appendix 2). Of the 165 vascular plant taxa listed there are 116 indigenes and 49 adventives. Life forms with the greatest numbers of taxa present were shrubs and herbs while the numerically most important family was Compositae with 27 taxa in all. Tree species were poorly represented even though the dome tops are below the regional tree limit. Only four indigenous tree species grow on the dome tops at present; kamahi, broadleaf, fivefinger *(Pseudopanax arboreus)* and *P. colensoi*. Four other species, quintinia *(Quintinia serrata),* putaputaweta *(Carpodetus serratus),* Hall's totara *(Podocarpus hallii)* and toatoa *(Phyllocladus glaucus),* were found almost to the crest of the dome sides and there were seven adventive tree species growing about 900 m, six conifers and one willow *(Salix* sp.).

Many of the plants listed were in low numbers or very local. For example, *Metrosideros fulgens* was seen on only one rocky outcrop, *Helichrysum* sp. "*alpinum*" was confined to a few rocky outcrops to the south of Ruawahia trig, *Cassinia vauvilliersii* confined to the slopes east of Koa trig, one clump of *Scleranthus uniflorus* grew near the western edge of Ruawahia dome and a single plant of *Coprosma foetidissima* was recorded on a rocky outcrop south-east of Ruawahia trig. During the period of the study (i.e., 1979-1982) two adventive species, *Calluna vulgaris* and *Ornithopus perpusillus,* arrived on the dome tops and others, especially ragwort *(Senecio jacobaea)* and Yorkshire fog *(Holcus lanatus)* have become more abundant.

Seven hybrids are listed in Appendix 2. All three

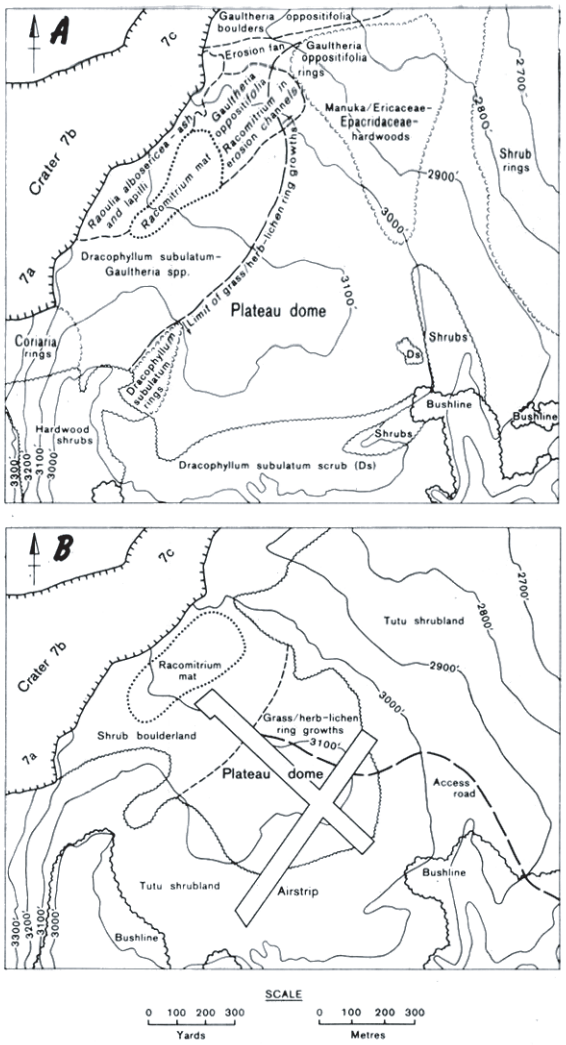

FIGURE 2. *Plateau dome vegetation: A-in* 1964 *(from Burke* (1964)); *B—in* 1982.

Gaultheria species present on the dome tops commonly hybridize, resulting in a complex swarm of crosses and backcrosses. Several putative hybrids of *Raoulia albo-sericea* and *R. glabra* were noted near the craters. As well, three individuals of the putative intergeneric hybrid between *Celmisia gracilenta* and *Olearia arborescens* were found near the Ruawahia summit. This appears to be the first record of an intergeneric hybrid involving these species.

Rates of vegetation change

(i) Plateau dome

Considerable change in the vegetation of Plateau

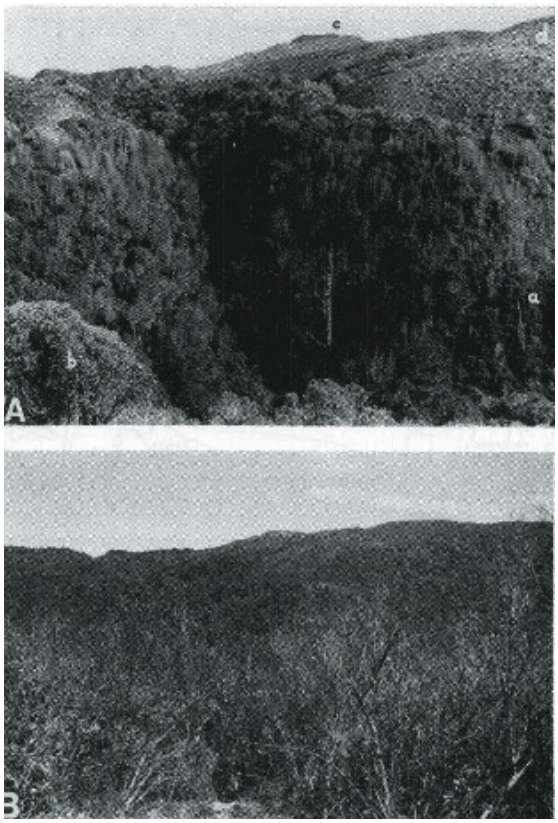

FIGURE 3. *Bus/dine on the south-east edge of Plateau dome: A-in 1964 (c = ridge opposite Ruawahia trig); B-in 1982.*

dome has taken place between 1964 and 1982 (Figs. 2A, B). The most significant has been the spread of tutu from the valleys, up the dome sides and on to the eastern edges of the top. In general, the cover of tutu followed topography; greatest in the valleys, decreasing up the ridge sides and lowest on the dome tops. Several vegetation types mapped by Burke (1964) have been overwhelmed by tutu (Fig. 2B) and scattered tutu shrubs have also established elsewhere.

The bushline (see Timmins, 1983) has extended up the valley sides where shrub-sized individuals of kamahi, broadleaf, *Olearia furfuracea* and karamu have established beyond the zones marked by Burke (1964).

On the top of Plateau dome, vegetation cover in "all sites studied has increased but the changes have been less marked. Grass/herb-lichen ring growths have grown and coalesced to form, in places, irregular herbfield mats with high cover. Between these growths and Crater 7 (Fig. 1) the shrub cover has increased and the *Racomitrium* mat adjacent to the crater has doubled in area.

(ii) Photograph pairs

Figure 3A, photographed in 1964, shows part of the kamahi forest on the south-east edge of Plateau dome. At the bushline the vegetation consisted of shrubs and shrub-sized trees, predominantly kamahi, with some *Olearia furfuracea* (b), *Gaultheria* spp. and broadleaf. Above this and towards the top of the dome edge, scattered shrubs grew above a ground cover of grass/herb-lichen ring growths (d). The two trunks protruding above the forest canopy (one in the centre of the picture and the smaller labelled 'a') are Hall's totara which were killed in the 1886 eruption (Burke, 1964). In the November, 1982 view from the same location (Fig. 3B) the 1964 bushline is still discernible even though it has become obscured by the spread of shrubs, particularly tutu (up to 4 m high) on to the ridge crests. The tutu is unseasonably leafless as a result of particularly severe winter frosts. Also beyond the 1964 bushline, but restricted to the ridge sides, are individuals (up to 6 m) of kamahi, broadleaf, karamu and *Olearia furfuracea,* and patches of manuka *(Leptospermum scoparium* up to 4 m). Below bushline the forest canopy comprises mainly kamahi (up to 12 m in the valleys) with minor amounts of broadleaf, quintinia, Hall's totara, puta-putaweta and scattered emergent toatoa.

Figure 4A was taken in 1964 from within a patch of monoao (c) (up to 0.6 m high) on the south-east edge of Plateau dome looking over the forested Tarawera ridge dome (d). The bush line (b) is again obvious on the side of the ridge in the immediate background. Above this, scattered shrubs occur on the ridge sides but give way to grass/herb-lichen rings towards the ridge top (a). Figure 4B, taken in 1982, shows that a thick shrub cover dominated by tutu has established on the ridge sides and crests, overtopping and obscuring the monoao (foreground) and the grass / herb-lichen rings (background). Tutu (up to 2 m) and monoao, mingimingi and *Gaultheria* spp. (mostly less than 1 m) form a canopy of about 50 % cover on the ridge tops. Shrub height and cover increases down the ridge side until near the valley bottom there is a tall shrubland of tutu, manuka, *Olearia furfuracea* and karamu. This grades into a kamahi forest similar to that shown in Figure 2B.

Figure 5A was taken in 1964 from the south-east rim of Crater 8 (Fig. 1) looking south towards the top of Plateau dome. Ring growths of *Gaultheria oppositifolia* (dark rings) and manuka occur at the base and sides of the slope while lighter-toned grass/herb-lichen rings are present on the ridge crest. On

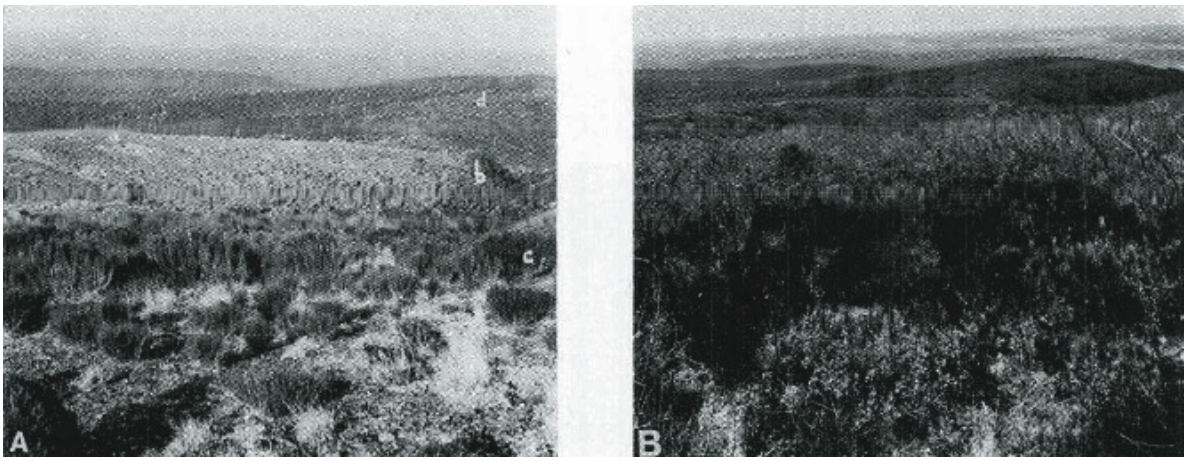

FIGURE 4. *Monoao patch on southeast crest of Plateau dome: A-in* 1964; *B-in* 1982.

TABLE 2. *Species recorded in and around the Ruawahia* Muehlenbeckia *mats.*

	Mat		Outside Mat	
	Burke (1964)	This study	Burke (1964)	This study
Bryum laevigatum	+	+	+	
Campylopus clavatus	+	+	+	+
Ceratodon purpureus		+		
Polytrichum juniperinum		+		+
Racomitrium lanuginosum	+	+		+
Leucopogon fraseri	+	+		
Muehlenbeckia axillaris	+	+		
Pimelea prostrata	+	+	+	+
Deyeuxia avenoides		+	+	+
Dichelachne crinita		+		+
Hierochloe redolens	+	+		
Rytidosperma gracile		+		+
R. viride	+	+	+	+
Luzula picta	+	+	+	
Celmisia gracilenta	+	+	+	+
Raoulia albo-sericea	+	+	+	+
R. glabra	+	+	+	+
Hypochoeris radicata	+	+	+	+
Sagina procumbens		+		
Total	13	19	10	12

the slopes are runnels in the ash and lapilli and near the crater they are lined with *Racomitrium*. The area, rephotographed in 1982, shows that there has been a great influx of shrubs particularly in the valleys and on the ridge sides where total cover is up to 100% in places. Very few shrubs, however, have advanced on to the Plateau dome ridge crest or the crater slope in the foreground. The dominant species is again tutu but significant numbers of toetoe *(Cortaderia fulvida)* are also present, as well as a few emergent *Pinus radiata* and *P. contorta*. The runnels in the ash and lapilli are still discernible in Fig. 5B,

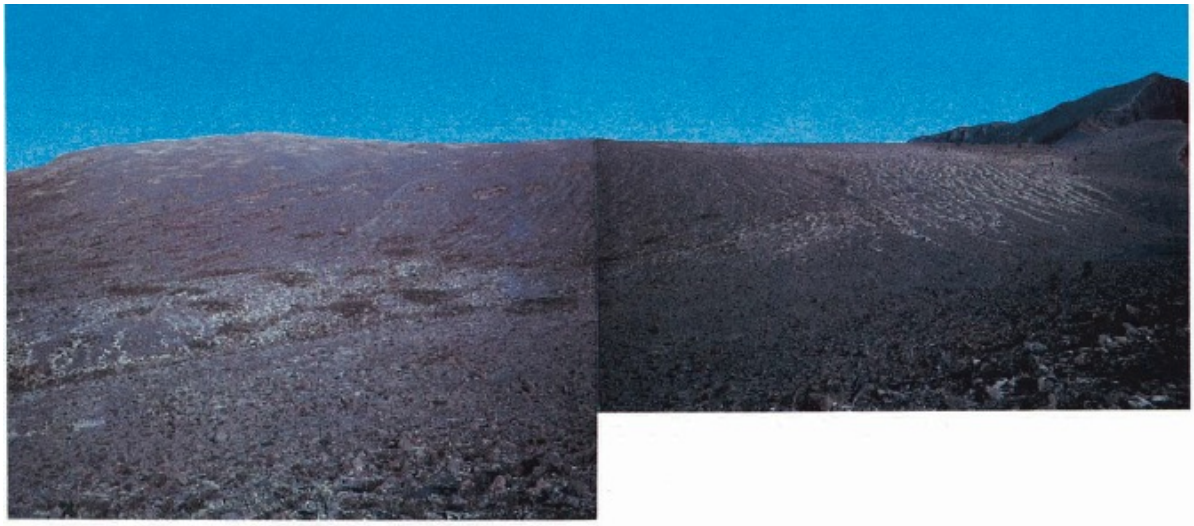

FIGURE 5A

FIGURE 5B

FIGURE 5. *Plateau dome from edge of crater 8: A—in 1964; B—in 1982.*

as shrub cover is more complete in the runnel bottoms than on the sides.

Rates of floristic change

(i) Ruawahia *Muehlenbeckia* mats

The *Muehlenbeckia* mats described by Burke (1964) (Fig. 1) have increased in area (from an average of 2.5 m^2 to 4.5 m^2) and support additional species (13 in 1964, 19 in 1979). Little change has occurred in the vegetation on the unstable ash and lapilli in close proximity to the mats (Table 2).

(ii) Crater 7

From Burke's (1964) description of the vegetation in the crater, little change appears to have occurred over the last 15 years. There are still (1982) large areas where plants are absent or present as only scattered individuals. The most significant development since 1964 has been the spread of shrubs, particularly tutu, on the south-facing, shaded rhyolite cliffs.

A list of plants recorded in Crater 7 is presented in Appendix 1. The total vascular taxa has increased from 63 in 1964 to 74 in 1979 with 28 taxa being added and 17, formerly present, not recorded. The total adventive taxa has increased from 10 to 20 with 14 taxa being added and four, formerly present, not recorded.

INTERPRETATION

Present patterns and possible explanations

(i) Vegetation

The present (1982) vegetation pattern on the dome tops of Mt Tarawera is related to the distance from the eruptive centres or craters. Near the craters, the vegetation is characteristically patchy and low growing, and most of the few species present are non-vascular. With increasing distance from the craters there is an increase in vegetation height, cover, species numbers and a change to vascular species dominance. These trends are modified by a number of factors.

Vegetation is less advanced on Wahanga, Tarawera and Ruawahia domes, which are at least 60 m higher than Plateau dome. Vegetation is also noticeably less advanced on the north-western flanks, which were more completely devastated by the 1886 eruption, and which are more isolated from a seed source (Timmins, 1983).

The two main types of dome-top substrate, rhyolite boulders, and ash and lapilli, support quite different vegetation. In the vicinity of the craters, vegetation is better developed in bouldery areas where woody species such as kamahi, broadleaf, and *Coprosma* spp. commonly establish (e.g., rocky outcrops, floor of Crater 7). Boulder cracks and crevices trap wind-blown materials and plant litter and retain water for long periods, providing a more favourable microclimate for seeds to germinate and establish. The ash and lapilli substrate is generally unstable and water rapidly percolates through the upper layers. This is particularly marked in the craters where there are 'scree' slopes generally devoid of vegetation. On flatter sites, in drainage depressions and on south. facing slopes, water is retained more readily and there is a greater vegetation cover. In the few depressions where water remains ponded for several months, the species represented include several semi-aquatics which are common on the shores of the lakes surrounding Mt Tarawera.

(ii) Flora

The low numbers and local distributions of many taxa, common occurrence of hybrids, and dominance of shrubs and herbs are all features characteristic of a colonising flora. Most of the non-forest taxa presently dominating the dome tops have seeds suited to dispersal by wind or birds. These taxa are found in other areas within the Rotorua lakes district so they probably colonised following short-distance seed dispersal. With time, the dome-top flora can be expected to approach that of nearby forest-covered Makatiti Dome, the only other dome in the district over 900 m. On Makatiti, there were fewer herbs and grasses and more than twice the number of fern species than on Mt Tarawera, and trees were dominant. The podocarps, Hall's totara, rimu *(Dacrydium cupressinum)* and toatoa were present, but none was yet growing on the dome tops of Mt Tarawera.

Successional trends and rates of change

The rate of succession on the dome tops of Mt Tarawera is variable. Change has been most rapid in sites near the bushline. At these sites (an example is shown in Fig. 3), succession from a bare surface to grass/herb-lichen rings has taken approximately 70 years, and this has changed to tutu shrubland in the last 18 years. If this rate of change is maintained on sites presently dominated by grass-herb-lichen rings, at least 50% of Plateau dome will be covered in tutu shrubland before the year 2000. By then kamahi and broadleaf, already well established in several places on the dome tops, should be becoming prominent in tutu shrubland sites. Consequently the 'open tops' and low growing vegetation, which has characterised this dome over the last 50 years will be gone.

The rate of succession on sites on the other high domes al)d in the immediate vicinity of the crater is much slower. For example, the *Muehlenbeckia* mat vegetation that established within 50 years of the eruption has changed little since (Table 2) and there have been only small changes in the crater vegetation.

The typical succession has been modified at two sites following the establishment of gull colonies. As a result of guano enrichment and possible assisted seed dispersal, a grass-herbfield vegetation dominated by vascular adventive species has developed there.

Although the flora of the dome tops has undoubtedly increased since Burke (1964) studied the mountain, most of the new arrivals have been adventive species which have ecologically similar roles to the indigenous species already present. They have arrived indirectly as a result of animal, mainly human, activity on the dome tops. Adventive conifers have become increasingly abundant on the dome tops, most having established within the last 30 years. Over recent years several volunteer groups have felled trees and pulled out saplings and seedlings, which has partly checked their spread. But unless a concerted effort is made soon to remove the adventive conifers, they will continue to become more numerous and eventually dominate large areas of the dome tops.

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APPENDIX 1.

Plant List for Crater 7 (70, 7b, 7c) (Additions to Burke's (1964) checklist).*

	Crater 7a	Crater 7b	Crater 7c
INDIGENOUS PLANTS			
Non-vascular plants			
Algae			
Trentepoh/ia sp. *	+		+
Lichens			
Aspicilia sp. *		+	
Cladia aggregata		+	
C. retipora		+	+
*Cladonia delormis var. crenulata**			+
C. leptoclada		+	+
*Hypogymnia lugubris**		+	
*Parmotrema reticulatum**			+
*Rhizocarpon geographicum**	+		+
Stereocaulon corticatulum	+	+	+
S. implexum(?)	+	+	
*S. vesuvianum**		+	+
*Usnea rubescens**	+		+
U. sp.	+	+	+
Mosses			
*Breutelia pendula**		+	
Bryum laevigatum			+
Campylopus clavatus	+	+	+
*Polytrichadelphus magellanicus** I		+	+
*Polytrichum juniperinum**	+	+	+
Racomitrium lanuginosum	+	+	+
*R. ptychophyllum**	+	+	+
Vascular Plants			
Dicot. trees			
Griselinia littoralis	+	+	
Pseudopanax arboreus			+
Weinmannia racemosa		+	
Dicot. shrubs			
Coprosma robusta	+	+	+
Coriaria arborea	+		+
Dracophyllum strictum		+	+
D. subulatum		+	
Gaultheria antipoda			+
G. *oppositifolia*	+	+	
G. *paniculata*	+	+	+
Dicot. shrubs			
Hebe stricta var. *stricta*	+		
Leptospermum scoparium		+	+
Leucopogon fasciculatus	+	+	+
L. fraseri	+	+	+
Muehlenbeckia axillaris	+	+	+
Olearia arborescens		+	+
O. furfuracea	+		+
Pimelea prostrata	+	+	+
Psilopsids and Lycopods			
*Lycopodium australianum**		+	
L. fastigiatum		+	
L. scariosum		+	+
Ferns			
*Blechnum penna-marina**	+		+
B. vulcanicum	+	+	+
B. sp. (*B. capense* agg. common sp.)	+	+	+
*Dicksonia squarrosa**	+		+
*Histiopteris incisa**		+	
Hymenophyllum multifidum		+	+
*Paesia scaberula**	+		
*Polystichum vestitum**	+		+
Orchids			
*Thelymitra longifo/ia**		+	+
Grasses			
Cortaderia fulvida	+		+
*Deyeuxia avenoides**	+	+	+
Dichelachne crinita			+
Hierochloe redolens	+	+	+
*Lachnagrostis filiformis**		+	+
Rytidosperma gracile			+
R. viride	+	+	+
Sedges			
Morelotia affinis		+	+
Rushes			
Luzula picta	+	+	+
Composite herbs			
Celmisia gracilenta	+	+	+
Raoulia albo-sericea	+	+	+
Composite herbs			
Raoulia glabra	+	+	+
R. tenuicaulis	+		+
R. albosericea X *R. glabra**	+	+	+
Dicot. herbs			
Acaena anserinifolia		+	+
Epilobium brunnescens		+	
E. glabellum			+
E. melanocaulon	+		
E. microphyllum	+	+	+
*E. pubens**		+	+
Geranium potentil/oides var. *potentil/oides**			+
G. *sessililforum* var. *novae-zelandiae*		+	
Gunnera monoica (inc. G. *albocarpa* and G. *strigosa)**			+
*Nertera ciliata**		+	+
ADVENTIVE PLANTS			
Gymnosperm trees			
*Pinus contorta**		+	+
*P. radiata**	+		
Dicot. trees			
Salix sp. *	+		
Dicot. shrubs			
*Erica lusitanica**		+	+
Lupinus arboreus	+	+	+
Grasses			
Holcus lanatus	+	+	+
*Poa trivia/is**	+		
*Vulpia bromoides**		+	
Composite herbs			
*Chrysanthemum leucanthemum**			+
*Cirsium vulgare**	+		

APPENDIX 1 (continued)

	Crater 7a	Crater 7b	Crater 7c
*Erigeron ftoribundus**	+	+	+
Hypochoeris radicata	+	+	+
*Mycelis muralis**			+
Senecio jacobaea	+	+	
Dicot. herbs			
Cerastium fontanum ssp. *triviale**			
*Epilobiurn ciliaturn**	+		
*Linum catharticum**		+	
*Rumex acetosella**	+		
Sagina procumbens		+	+
Trifolium dubium		+	

Total = 95 (21 non-vascular and 74 vascular)

APPENDIX 2:

List of all plants recorded during this study on dome tops and craters on Mt Tarawera (above 900 *m)*

Nomenclature follows Allan (1961), New Zealand Weed and Pest Control Society (1969), Moore and Edgar (1970), Allison and Child (1971, 1975), Martin and Child (1972), and Healy and Edgar (1980), except where authorities are cited.

INDIGENOUS PLANTS

Non-vascular plants

Algae
Trentepohlia sp.

Lichens
Aspicilia sp. Massal. *
Cladia aggregata
C. *retipora*
Cladonia capitellata
C. *deformis* var. *crenulata*
C. *leptoclada*
Hypogymnia lugubris
*Parmotrema reticulatum**
*Pseudocyphellaria delisea**
P. mougeotiana
P. sp
Rhizocarpon geographicum
Stereocaulon corticatulum
S. *implexum* (?)
S. *vesuvianum**
Usnea rubescens
U. sp.

Liverworts
Chandonanthus squarrosus
Jungermannia sp. *(indundata?)*

Mosses
Breutelia pendula
Bryum laevigatum
Campylopus clavatus
C. sp.
Ceratodon purpureus
Dendroligotrichum dendroides
Dicranaloma sp.
Hypnum cupressiforme
Polytrichadelphus magellanicus
Polytrichum juniperinum
Racomitrium lanuginosum+
R. ptychophyllum

Dicot. lianes
Metrosideros diffusa+
M. fulgens
Muehlenbeckia hybrid? *(M. axillaris* X *M. australis)+*

Psilopsids and Lycopods
Tmesipteris elongata Dang.
Lycopodium australianum+

Vascular plants

Dicot. trees
Griselinia littoralis
Pseudopanax arboreus (Murr.) Philipson
P. colensoi (Hook. C.) Philipson
Weinmannia racemosa

Dicot. shrubs
Brachyglottis repanda
Cassinia vauvilliersii+
Coprosma foetidissima+
C. *lucida*
C. *robusta*
C. sp. (unnamed) *(C. parvijfora* var. *dumosa* Cheeseman 1906, non C. *p.* var. *dumosa* sensu Allan 1961)+
C. *propinqua* X C. *robusta*
Coriaria arborea
Corokia buddleioides var. *linearis*
Cyathodes empetrifolia+
C. *juniperina*
Dracophyllum strictum
D. subulatum+
Gaultheria antipoda
G. oppositifolia+
G. paniculata
G. antipoda X *G. oppositifolia*
G. antipoda X *G. paniculata*
G. oppositifolia X *G. paniculata*
Hebe stricta var. *stricta*
Leptospermum ericoides
L. scoparium
Leucopogon fasciculatus A. Rich. +
L. fraseri A. Cunn. +
Muehlenbeckia axil/aris
Olearia arborescens
O. furfuracea
O. arborescens X *Celmisia gracilenta+*
Pimelea prostrata+
Pomaderris ericifolia Hook.

Sedges
Gahnia pauciflora
Morelotia affinis+
Uncinia uncinata+

Rushes
Juncus gregiflorus
Luzula picta+

APPENDIX 2 (continued)

L. cernuum
L. jastigiatum+
L. scariosum+
1. vo/ubile+

Ferns
Asplenium flaccidum Forst. f. ssp. *flaccidum*
Blechnum penna-marina+
B. vulcanicum
B. sp. *(B. capense* agg. common sp. lower pinnae reduced in length)
Dicksonia squarrosa
Grammitis sp.
Histiopteris incisa
Hymenophyllum multifidum+
H. sanguinolentum
Ophioglossum coriaceum+
Paesia scaberula
Phymatosorus diversifolius (Willd.) Pic. Ser.
Polystichum vestitum
Pteridium esculentum (Forst. f) Nakai

Orchids
Aporostylis bifolia
Earina autumnalis
E. mucronata
Microtis unifolia+
Prasophllum colensoi
Pterostylis sp.
Thelymitra longifolia

Grasses
Cortaderia fulvida
Deyeuxia avenoides+
Dichelachne crinita
Hierochloe redolens (Vahl) Roemer et Schultes+
Lachnagrostis filiformis+
Poa anceps Forst. f.+
P. laevis
Rytidosperma gracile (Hook. f.) Connor et Edgar
R. viride (Zotov) Connor et Edgar+

Dicot. herbs (other than composites)
Nertera ciliata+
N. depressa
Pratia angulata
Ranunculus hirtus
Scleranthus uniflorus+*
Stellaria parviflora

ADVENTIVE PLANTS

Vascular plants

Gymnosperm trees
Larix decidua
Pinus contorta Dougl.
P. radiata
P. strobus L.

Monocot. herbs (other than orchids, grasses, sedges, rushes)
Astelia solandri

Composite herbs
Celmisia gracilenta+
Gnaphalium delicatum Drury*+
G. sp. *(G. luteo-album* agg.)
Helichrysum filicaule+
H. sp. (unnamed; aff. *H. bellidioides) ("H. alpinum"* of Cockayne, 1928)*+
Lagenifera pumila (Forst. f.) Cheesem. +
Raoulia albo-sericea Col. +
R. glabra+
R. tenuicaulis+
R. sp. (unnamed; aft'. *R. australis)+*
R. albo-sericea X *R. glabra*
Senecio minimus Poir.

Dicot. herbs (other than composites)
Acaena anserinifolia+
Epilobium alsinoides
E. billardierianum Ser. ssp. *cinereum* (A. Rich.) Raven et Engelhom
E. brunnescens (Cockayne) Raven et Engelhom+
E. glabellum+
E. melanocaulon+
E. microphyllum
E. nummulariifolium R. Cunn. ex A. Cunn.
E. pubens
E. tenuipes
Geranium microphyllum Hook. f.+
G. *potentilloides* L'Her. ex DC. var. *potentilloides*
G. *sessiliflorum* Cav. var. *novae-zelandiae* Carolin+
Glossostigma submersum+
Gonocarpus micranthus Thunb. ssp. *micranthus+*
Gunnera monoica (incl. G. *albocarpa* and G. *strigosa)*
Hypericum japonicum+
Limosella lineata+
Myriophyllum propinquum+*

Composite herbs
Chrysanthemum leucanthemum+
Cirsium arvense
C. *vulgare*
Crepis capillaris+
Erigeron floribundus+
Hypochoeris radicata
Leontodon taraxacoides+
Mycelis muralis+
Senecio jacobaea
Taraxacum officinale

Dicot. herbs (other than composites)
Achillea millefolium
Anagallis arvensis

APPENDIX 2 (continued)

P. sp. (2-needle)
Pseudotsuga menziesii

Dicot. trees
Salix sp.

Dicot. shrubs
Calluna vulgaris
Erica lusitanica
Hakea sericea Schrad.
Lupinus arboreus
Ulex europaeus

Grasses
Agrostis tenuis+
Aira caryophylla+
Anthoxanthum odoratum+
Holcus lanatus
Lolium perenne
Poa annua
P. trivialis+
Vulpia bromo ides

Rushes
Juncus articulatus+
J. effusus+
J. tenuis+

Centaurium erythraea+
Cerastium fontanum Baumg. ssp. *triviale* (Link) Jalas+
Daucus carota
Epilobium ciliatum
Geranium molle
Linum catharticum+
Lotus pedunculatus
Ornithopus perpusillus+
Parentucellia viscosa+
Prunella vulgaris+
Rumex acetosella+
Sagina procumbens+
Trifolium dubium
T. repens

Number of non-vascular plants:	32
Number of indigenous vascular plants (including 7 hybrids):	116
Number of adventive vascular plants	49

* Specimens lodged at NZCHR, Lincoln
\+ Specimens lodged at NZFRI, Rotorua