

Streblus heterophyllus
Syzygium maire PL
Ulex europaeus *
Veronica persica *
Veronica serpyllifolia *
Vitex lucens

Monocots 37 (29+ 8)

Acianthus sinclairii
Astelia grandis PL
Astelia hastata
Astelia trinervia
Carex banksiana
Carex dissita
Carex divulsa *
Carex lambertiana
Carex lessoniana
Carex ochrosaccus
Carex uncinata
Cordyline australis
Cordyline pumilio
Cyperus eragrostis *
Dactylis glomerata *

Digitalis purpurea *
Earina mucronata
Freycinetia banksii
Gahnia pauciflora
Gahnia xanthocarpa
Holcus lanatus *
Isolepis reticularis
Juncus effusus var. *effusus* *
Juncus planifolius
Lemna disperma
Microlaena stipoides
Oplismenus hirtellus subsp. *imbecillis*
Phormium tenax
Pterostylis brumalis
Pterostylis trullifolia
Rhopalostylis sapida
Ripogonum scandens
Schoenus maschalinus
Schoenus tendo
Tetraria capillaris
Tradescantia fluminensis *
Zantedeschia aethiopica *

Recolonisation of plants following fires on two of Auckland's volcanic cones

Ben Goodwin

In late 2019, fires occurred on three of Auckland's volcanic cones (maunga). The first two affected Maungawhau (Mount Eden) and Maungarei (Mount Wellington) on Guy Fawkes night (5 November), and were caused by fireworks. The third, and largest, occurred some weeks later (11 December) on the Māngere cone, and appears to have been caused by arson. I visited the sites at Māngere and Maungarei on seven occasions each, during 2019–2020, to observe the recolonisation of plants within the burnt areas. I also made a single, brief trip to each site in March 2021, to determine slightly longer-term changes. Unfortunately, the fire on Maungawhau (Mount Eden) occurred within the crater, which is not publicly accessible for cultural reasons.

Auckland's volcanic cones have a long history of fires. Naturalists and commentators from the mid-

nineteenth century describe landscapes and plants (e.g. *Pteridium esculentum*, *Coriaria arborea* and 'brushwood') typical of areas modified by fire. Pioneer missionary John Gare Butler ascended Maungarei in 1820 with Ngati Paoa chief Te Hinaki and noted: "...the grass and fern growing upon burnt earth and calcined cinders..." (Butler 1927: p. 97). Ernst Dieffenbach, in 1841, noted that the crater of Maungakiekie was "...overgrown inside with brushwood..." (Dieffenbach 1843: p. 459). William Colenso, in 1842 commented on the landscape in the vicinity of Penrose and Otahuhu: "the eye wanders over a succession of low volcanic hills bearing nothing but the monotonous brown fern, with here and there a shrub of *Coriaria*..." (Colenso 1846: p. 117). John Logan Campbell, regarding Ōhinerangi (Mount Hobson) in the 1840s, describes his ascent to the summit: "It was pretty stiff scrambling over the

top of high fern; for sometimes, when unable to creep through it, we had to trample over it as best we could" (Campbell 1881: p. 62); and regarding Maungauika (North Head) in the 1850s, geologist Ferdinand von Hochstetter noted that: "Manuka bushes and ferns cover the slopes of the hill" (von Hochstetter & Sauter 1867: p. 251).

Fires have also occurred on Rangitoto Island, with notable examples in 1887 and 1913 (Butler 2001). These Rangitoto fires appear to have affected the lava fields, although the plant communities on the cone could be fire-induced (Wilcox 2007); certainly, many fire-adapted plants occur there today (e.g. *Pteridium esculentum*, *Kunzea robusta*, *Leptospermum scoparium*, *Pomaderris amoena*). On Maungawhau, a hiatus in grazing during the 1930s led to overgrown pastures, which often caught fire during the long dry summers of the 1940s (Mount Eden Borough Council 1989); and during the same era, fires were also known to occur on the remaining cone of Te Tātua a Mataaho (Three Kings) (Reidy 2007). More recently, in November 2016 a large, deliberately-lit fire, swept through 13.2 ha of grassland on Motukorea (Brown's Island) ("*Woman stranded on uninhabited Browns Island lit fires*" N.Z. Herald 2016). In January 2020 a fire occurred on the eastern flank of Ōtāhuhu (Mount Richmond) ("*Fire on Auckland's Mt Richmond*" N.Z. Herald 2020); and in April 2020, a second fire occurred on Maungarei, just to the west of the earlier burnt area (Lilith Fisher, pers. comm., 2020).

Māngere

The fire at Māngere on 11 Dec 2019 occurred within the northern crater, burning most of the western half of it, from near the crater floor right up towards the tihi (summit) above (Fig. 1). In January 2019, after what had evidently been some time since any useful grazing had occurred (cattle last seen by me in May

2017), the internal slopes of the northern crater of Māngere had become swathed in dense, thigh-high rank grassland, dominated by kikuyu (*Cenchrus clandestinus*) and interspersed with *Dactylis glomerata*, *Lolium perenne* and *Plantago lanceolata*. The higher slopes toward the tihi are more exposed and drought-prone. There was less kikuyu at this elevation, and *Microlaena stipoides* and *Rytidosperma racemosum*, were present, along with various other grasses and exotic herbs. Regrettably, I did not record all species in these grasslands in 2019, but focused mainly on the natives, which were: *Microlaena stipoides*, *Acaena novae-zelandiae*, *Dichondra repens* and *Haloragis erecta*. In February 2019, Anthony Wright and I investigated the plants within the northern crater. We observed that amongst the thick kikuyu on the crater's internal slopes, the bases of large boulders offered habitat for *Doodia australis*, *Pellaea calidrupium* and, in one case, *Psilotum nudum*.

For this fire study, I first visited the site on the 23 December 2019, almost two weeks after the burn had occurred. The fire was almost totally restricted to tall, overgrown pasture growing on the fine-grained scoria slopes. The most severe damage occurred where the grass was tallest, the slopes steepest and the substrate most fine-grained. In this situation all of the surface vegetation was destroyed, leaving only bare scoria with a thin covering of ashes. The crater floor, which is mainly filled with larger scoria rubble and blocks, was largely unaffected. Likewise, the comparatively sparse vegetation on the higher slopes, toward the tihi burnt less severely. On flat sections, such as the old stock-paths which step their way up the slope, the fire damage was less severe and left some browned stems of kikuyu. Even only two weeks post-fire, kikuyu was observed to be regenerating vigorously, with shoots from underground stems pushing through



Fig. 1. Māngere Burn Site. 23 Dec 2019. All images by B.L. Goodwin.



Fig. 2. Maungarei Burn site, 49 days after the fire. Photo: 23 Dec 2020.

the bare scoria across the entire site. There were a very few unidentifiable dicotyledon seedlings and no monocotyledons germinating at this point.

By February, about two months after the fire, kikuyu had developed to cover 80-90% of the site,, with a relatively sparse sward of 10-30 cm in height on sloping ground, and a denser sward of up to 60 cm in height on flatter sections. Seedlings and young plants of about a dozen dicotyledons (see Appendix for detail) were becoming established across the remaining bare patches of scoria and areas where kikuyu remained thin. There was a general lack of monocotyledons establishing in this way, though *Rhytidosperma racemosum* was locally common. *Doodia australis*, *Plantago lanceolata*, *Carex divulsa* and *Paspalum dilatatum*, were observed regenerating from their partially-burnt bases.

There was little change to the species composition throughout the remainder of summer and autumn (possibly attributed to the very low rainfall during the period). By June, some six months after the fire, the diversity of exotic herbs was again increasing, and some indigenous species (e.g. *Senecio hispidulus* and *Microlaena stipoides*) were establishing. In late winter, 9 months after the fire, the legumes (Fabaceae) had become prominent, with the establishment of *Medicago arabica* and *Trifolium repens*, and an increase in the abundance of *Vicia disperma*. In November, after nearly 12 months post-fire, the burn site had a rich suite of plants, especially exotic herbs. Kikuyu had remained relatively low in height (generally below 30 cm) and though it covered most of the site, it was not so dense as to exclude other plants. Thicker and nearly-pure swathes of kikuyu, up to 90 cm in height, were present on the lower slopes only. Diversity of grasses was increasing, with *Anthoxanthum odoratum*, *Dactylis glomerata*, *Holcus lanatus* and *Lolium perenne* all establishing. *Rhytidosperma racemosum* was common on the higher slopes. The legume family continued its increase in diversity and abundance with the appearance of *Lotus suaveolens* and *Trifolium pratense*, and the continued increase in *Vicia disperma*, which was forming large tangled masses covering several square metres.

A brief visit to the site in March 2021, about 15 months after the fire, revealed little change. The mixed grassland, still generally below 30 cm in height, continued to be dominated by kikuyu, but featured good quantities of pasture grasses and assorted herbs. Kikuyu continued to be most vigorous on the lower slopes, where tall, dense and nearly monospecific swathes had formed. Higher on the slopes, the large populations of *Vicia disperma* had collapsed and were replaced by localised tall kikuyu, which presumably benefited from the shelter

and/or increased nitrogen provided by the *Vicia*. *Ulex europaeus* was becoming common on the higher slopes and young *Cheilanthes distans*, having apparently established by spores, were occasional on the now-exposed boulders.

Maungarei

The fire at Maungarei occurred high on the south-western flank, burning around 0.2 ha of ungrazed pasture (Fig. 2). In contrast to Māngere, I had no previous notes on the pastures at Maungarei. The description of the site prior to the fire has therefore been based on the unburnt slopes surrounding the burn site, which are of the same elevation and a similar aspect. Assuming that the adjoining grassland was homogeneous with the burn site, it would have been dominated by *Arrhenatherum elatius* and kikuyu; with *Carex divulsa* frequent; and some *Anthoxanthum odoratum*, *Holcus lanatus* and *Microlaena stipoides*. *Leucanthemum vulgare* and *Plantago lanceolata* were also important components. The sward on these north-western slopes was dense, but relatively low, usually to around 40 cm in height. Like Māngere, the pastures of Maungarei were also ungrazed (stock removed ca. Sept 2017).

In December 2019, 49 days after the fire (the first opportunity I had to inspect the site), kikuyu had rapidly resprouted from underground stems and had expanded to cover about 80% of the site with a sward height of 10-20 cm. The remaining approximately 20% that was free of kikuyu was mostly-bare scoria. *Carex divulsa* and *Plantago lanceolata* were occasional and also in a relatively advanced stage of regeneration, with plants resprouting from their partially-burnt bases. Some plants of *Carex divulsa* were already in flower. Exotic herbs were represented by about half-a-dozen species (see Appendix for detail) and monocotyledons, aside from kikuyu and *Carex divulsa*, were not observed.

As at Māngere, there was little change to the flora of the burn site throughout summer and autumn. Notable exceptions were increases in *Medicago lupulina* and *Lotus pedunculatus* and the rapid establishment of *Microlaena stipoides*, all of which were growing on the remaining areas of bare scoria or where kikuyu was thinnest. *Arrhenatherum elatius* also began gradually establishing within swathes of kikuyu. In June (7 months post-fire) the diversity of exotic herbs was again increasing and this trend continued throughout the winter. By November, some 13 months after the fire had occurred, kikuyu cover was about 90%, but sward height was mostly below 40 cm. This cover was also not dense enough to exclude a good diversity of herbs, including several native

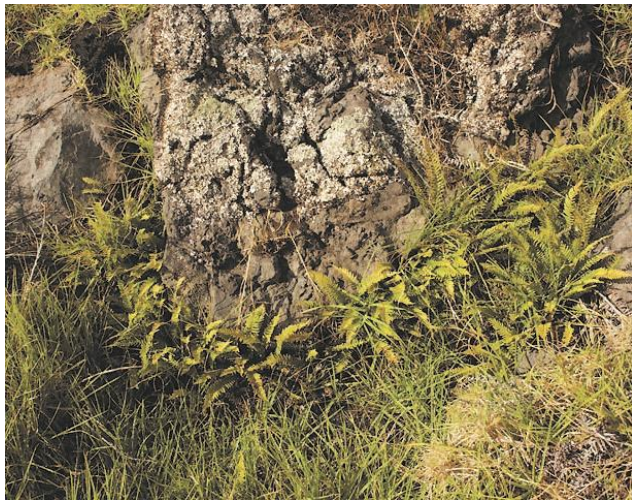


Fig. 3. Regrowth of *Doodia australis* on Māngere. Photo: 8 Mar 2020.

species, and some other exotic grasses. Likewise, from a brief visit in March 2021, 16 months post-fire, the only notable change in the intervening 3 months had been a continued expansion of *Microlaena stipoides*.

Effects on indigenous plants

Displacement by aggressive exotic grasses, especially kikuyu, is currently one of the main threats to existing indigenous plant communities on the volcanic cones of Auckland. The density and height of ungrazed pasture has a strong effect on the diversity and abundance of native plants able to exist amongst it. Overall, the fires at Maungarei and Māngere had a positive effect on the indigenous flora. The immediate and nearly complete removal of exotic grasses provided a reprieve for existing populations of native plants within the burnt area, and opened up habitat for the establishment of others.

Of those native plants which were previously recorded from the burn sites, all had returned within 12 months of the fire, either by resprouting from unburnt parts, or by recolonising via seed or spores. The two exceptions to this were *Psilotum nudum* and *Haloragis erecta*, both of which were destroyed by the fire and did not recover or recolonise within the study period.

Of the ferns *Adiantum hispidulum*, *Cheilanthes distans*, *Doodia australis* and *Pellaea calidrupium*, all had populations within the burn sites and all were burnt (mostly right down to the rhizome) during the fire. *Adiantum hispidulum* and *Doodia australis* (Fig. 3) had both rapidly regenerated from their burnt rhizomes and were well advanced in growth by 2 months post-fire. *Cheilanthes distans* and *Pellaea calidrupium* (Fig. 4) were slower to recover and took



Fig. 4. Regrowth of *Pellaea calidrupium* on Māngere. Photo: 1 Jun 2020.

around 6 months to begin producing new fronds. As well as re-sprouting from burnt rhizomes, *Cheilanthes distans* also appears to have established by spores, with young plants observed at Māngere about 15 months post-fire. In June 2020, I took a cursory look at the site of a second fire on Maungarei which had occurred just to the west of the original site about two months previously. At this site *Asplenium oblongifolium* and *Pteris tremula* had been burnt down to the rhizomes, but both were regenerating well, with several new fronds on each plant.

Of the native dicotyledons previously recorded from the burn sites, all initially appeared to have been destroyed by the fire. However at Māngere, *Acaena novae-zelandiae* and *Dichondra repens* were observed again within two months of the fire, at which time they were also joined by *Oxalis exilis*. Other indigenous herbs took longer to colonise, with *Senecio hispidulus* being present at six and ten months post-fire, on Māngere and Maungarei respectively. *Geranium homeanum* was present on Māngere after 12 months and *Epilobium cinereum*, *Epilobium hirtigerum*, *Pseudognaphalium leuteoalbum* and *Senecio esleri* were all present at Maungarei after 13 months. *Muehlenbeckia complexa* was an interesting coloniser of the Maungarei burn site, where two young plants were noted three months post-fire; one of these expanded to form a sizable, though sparse, patch across the area over the following few months. The source of these plants is not clear as the species does not appear to occur elsewhere on the Maungarei cone, and the most recent record of it in the general area seems to be Wright's 1973 record (AK 134552) from the adjacent (now quarried) Mount Wellington lava field. Another vine present at Maungarei is a possible hybrid bindweed (which

appears to be *Calystegia soldanella* x *C. tuguriorum* which spread on to the burn site from bordering, unburnt grassland.

Of the Monocotyledons, *Microlaena stipoides* had re-colonised the Maungarei site and become common by three months post-fire, and continued to expand throughout the study period. However, on Māngere, it took longer to appear (six months) and remained sparse. *Carex inversa* was present (though rare) at Māngere by 12 months post-fire.

Conclusion

Prior to this study I had wondered if controlled burns could be used to manage the aggressive, exotic grassland on Auckland's volcanic cones, perhaps even inducing the native plant communities reminiscent of those reported in the nineteenth century. Though this study did not demonstrate dramatic recovery of long-lost plant assemblages, it did show a largely positive effect on the indigenous flora of both Māngere and Maungarei. Only two of the nine indigenous species that were previously

recorded from the burn sites were apparently lost directly as a result of the fire and did not recover or return to the site within the study period. Furthermore, an additional 10 indigenous species were able to colonise the sites, and five of these had not previously been observed by me on their respective cones, in fieldwork undertaken from ca. 2016 (Ben Goodwin unpublished data). The lasting reduction in kikuyu biomass has allowed for a more generally diverse, dynamic and interesting plant community. Between the two sites, over 90 species were recorded during the study, which is significantly more than what occurs in the unburnt areas of adjacent grassland. How long this diversity will continue to persist is yet to be determined. Experimenting with controlled, repeated burns would be worthwhile, to assess if indigenous species would be further encouraged and kikuyu progressively reduced.

A list of all species recorded from the sites and the approximate time when they were first observed is given in the Appendix.

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Appendix. Species recorded from burn sites on Māngere and Maungarei during Dec 2019–Mar 2021. Based on the following trips:

Māngere: 2019: December (x2). 2020: February, March, June, August, November. 2021: March.

Maungarei: 2019: December. 2020: February (x2), March, June, August, November. 2021: March.

*= exotic

	Māngere	Maungarei	Notes
Pteridophytes			
<i>Adiantum hispidulum</i>	+		Single plant observed regenerating from partially burnt rhizome, 2 months post-fire. Grew well throughout 2020.
<i>Cheilanthes distans</i>	+		First observed 6 months post-fire. Single, small population, regenerating from partially burnt rhizomes. Young plants observed establishing on exposed rock within 15 months.
<i>Doodia australis</i>	+		Several colonies observed vigorously regenerating from partially burnt rhizomes, 2 months post-fire. Grew well throughout 2020.
<i>Pellaea calidrupium</i>	+		Small colonies partially burnt during fire. Not observed regenerating until 6 months post-fire. Grew well throughout 2020.
<i>Psilotum nudum</i>	+		Single plant, severely damaged during fire. Base of shoots remained green for 9 months post-fire, but plant did not recover.
Dicotyledons			
<i>Acaena novae-zealandiae</i>	+		Recovered sparsely (presumably from unburnt stems) within 2 months post-fire.
<i>Lysimachia arvensis</i> *	+	+	Māngere: First observed as seedlings 12 days post-fire, well established by 2 months post-fire and gradually increased throughout 2020. Maungarei: First observed 2 months post-fire, remained occasional throughout 2020 but increased to become common after 13 months post-fire
<i>Araujia sericifera</i> *		+	First observed as young plants 3 months post-fire, persisted throughout 2020 but struggled and grew little.
<i>Calystegia</i> sp. (<i>Calystegia</i> <i>?soldanella</i> x <i>C. tuguriorum</i>)		+	Observed vegetatively spreading into burn site from adjoining pasture, 7 months post-fire. Expanded to become locally common by 13 months post-fire.
<i>Centaureum erythraea</i> *	+		First observed 2 months post-fire. Sparse for the remainder of 2020.
<i>Cerastium glomeratum</i> *	+		First observed 6 months post-fire, at which time it was sparse. Sparse for the remainder of 2020 but was not observed 12 months post-fire.
<i>Chrysanthemoides monilifera</i> *		+	First observed as seedlings, 2 months post-fire. Rare throughout 2020.
<i>Conium maculatum</i> *	+		First observed 12 months post-fire, at which time it was locally common on the higher parts of the burn site.
<i>Crepis capillaris</i> *	+	+	Māngere: First observed 2 months post-fire. Remained occasional throughout 2020. Maungarei: First observed 13 months post-fire, at which time it was sparse.
<i>Daucus carota</i> *	+		First observed 2 months post-fire. Remained sparse throughout 2020.
<i>Dichondra repens</i>	+		First observed 2 months post-fire. Plants were present, and had expanded a little, by 9 months post-fire, but could not be located after this time.
<i>Echium plantagineum</i> *	+		First observed 12 months post-fire, at which time it was rare.
<i>Epilobium ciliatum</i> *		+	Observed on one occasion, 7 months post-fire, at which time it was sparse.
<i>Epilobium cinereum</i>		+	First observed 13 months post-fire, at which time it was sparse.
<i>Epilobium hirtigerum</i>		+	First observed 13 months post-fire, at which time it was sparse.
<i>Erigeron karvinskianus</i> *		+	Single plant observed in one occasion, 4 months post-fire
<i>Erigeron sumatrensis</i> *	+		First observed 3 months post-fire, at which time it was sparse. Was not observed 9 months post-fire, but was present again, though still sparse after 12 months.

<i>Euphorbia peplus</i> *	+	+	Māngere: First observed as seedlings/young plants 12 days post-fire, was well established within 2 months, was occasional throughout the remainder of 2020, increasing to frequent by 12 months post-fire. Maungarei: First observed 2 months post fire when it was locally common, gradually declined across 2020 and was not observed after 13 months post-fire.
<i>Foeniculum vulgare</i> *	+	+	Māngere: First observed 3 months post-fire. Sparse throughout the remainder of 2020. Maungarei: First observed 3 months post-fire. Expanded to become locally common at 4 months post-fire then declined throughout the remainder of 2020 and was not observed 13 months post-fire.
<i>Gamochaeta subfalcata</i> *		+	First observed 13 months post-fire, at which time it was rare.
<i>Geranium dissectum</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was occasional. Maungarei: First observed 12 months post-fire, at which time it was frequent.
<i>Geranium gardneri</i> *		+	First observed 13 months post-fire, at which time it was sparse.
<i>Geranium homeanum</i>	+		First observed 12 months post-fire, at which time it was sparse.
<i>Geranium molle</i> *	+	+	Māngere: First observed 2 months post-fire. Sparse throughout the remainder of 2020. Maungarei: First observed 7 months post-fire, at which time it was sparse. Gradually increasing to occasional by 13 months post-fire.
<i>Geranium purpureum</i> *		+	First observed 7 months post-fire, at which time it was sparse. Gradually increasing to become frequent by 13 months.
<i>Gomphocarpus</i> sp. *	+		First observed as young plants 7 months post-fire. Present throughout the remainder of 2020 but plants struggled and grew little.
<i>Haloragis erecta</i>	+		The few plants recorded from area previously were destroyed by fire. Not observed within burn site post-fire.
<i>Helminthotheca echioides</i> *	+	+	Māngere: First observed 2 months post-fire. Sparse for the remainder of 2020. Maungarei: First observed 13 months post-fire, at which time it was sparse.
<i>Lactuca serriola</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was sparse. Few plants noted at 12 months. Maungarei: First observed 13 months post-fire, at which time it was occasional.
<i>Leontodon saxatilis</i> *	+		First observed 2 months post-fire, at which time it was occasional. Had declined to sparse by 6 months post-fire and was rare by 12 months post-fire.
<i>Leucanthemum vulgare</i> *		+	First observed 2 months post-fire, not observed 3 months post-fire, but returned again 10 months post-fire (end of winter) and had expanded to become common by 13 months post-fire.
<i>Linum bienne</i> *	+		First observed 12 months post-fire, at which time it was locally common in the higher parts of the burn area.
<i>Linum trigynum</i> *	+		First observed 12 months post-fire, at which time there was one sparse patch in the higher part of the burn area.
<i>Lotus pedunculatus</i> *		+	First observed 2 months post-fire. Increased to become common by 3 months post-fire and then declined to just locally common by 13 months post-fire.
<i>Lotus suaveolens</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was locally common. Maungarei: First observed 13 months post-fire, at which time it was frequent.
<i>Medicago arabica</i> *	+		First observed 9 months post-fire, at which time it was occasional. Increased across 2020 to become frequent by 12 months post-fire.
<i>Medicago lupulina</i> *		+	First observed 2 months post-fire. Common throughout the remainder of 2020
<i>Mercurialis annua</i> *		+	First observed 3 months post-fire, at which time it was sparse. Gradually increased to become frequent by 13 months post-fire.
<i>Muehlenbeckia complexa</i>		+	Two young plants observed 3 months post-fire. One of these had expanded to sparsely cover 2-3 square meters by 7 months post-fire and was still present by 13 months post-fire.
<i>Modiola caroliniana</i> *	+	+	Māngere: First observed 2 months post-fire. Sparse, 6 months post-fire, apparently absent 9 months post-fire but observed again and had become occasional by 12 months post-fire. Maungarei: First observed 13 months post-fire at which time it was sparse.
<i>Orobanche minor</i> *		+	First observed 9 months post-fire. Rare throughout the remainder of 2020.
<i>Oxalis corniculata</i> *	+		Unidentified <i>Oxalis</i> first observed 2 months post-fire and was occasional throughout the remainder of 2020. Identification of <i>O. corniculata</i> not confirmed until 12 months post-fire, at which time it was frequent.
<i>Oxalis exilis</i>	+		Unidentified <i>Oxalis</i> first observed 2 months post-fire and were occasional throughout the remainder of 2020. Identification of <i>O. exilis</i> was confirmed at 2 months post-fire, but could not be confirmed again until 12 months post-fire, at which time it was sparse.

<i>Parentucellia viscosa</i> *		+	First observed 13 months post-fire at which time it was frequent.
<i>Pericallis × hybrida</i> *		+	First observed 7 months post-fire, at which time it was frequent. Had declined to occasional by 13 months post-fire.
<i>Physalis peruviana</i> *		+	First observed 13 months post-fire, at which time it was rare.
<i>Phytolacca octrandra</i> *	+		First observed 2 months post-fire. Remained rare, struggled and grew little throughout 2020.
<i>Plantago lanceolata</i> *	+	+	Māngerei: Seedlings and young plants first observed 2 months post-fire, at which time they were common. Older plants also observed regenerating from partially burnt rhizomes at this time. Frequent throughout remainder of 2020. Maungarei: Seedlings and young plants first observed 2 months post-fire, at which time they were common. Older plants also observed regenerating from partially burnt rhizomes at this time. Frequent throughout remainder of 2020.
<i>Pseudognaphalium luteoalbum</i>		+	First observed 13 months post-fire, at which time it was sparse.
<i>Ranunculus parviflorus</i> *	+		Only observed once, 6 months post-fire (winter) at which time it was locally common.
<i>Rumex acetosella</i> *	+		First observed 6 months post-fire and was localised for the remainder of 2020.
<i>Senecio esleri</i>		+	First observed 13 months post-fire and was sparse for the remainder of 2020.
<i>Senecio hispidulus</i>	+	+	Māngerei: First observed 6 months post-fire and was sparse for the remainder of 2020. Maungarei: First observed 10 months post-fire. Sparse for the remainder of 2020 but became frequent, 13 months post-fire.
<i>Senecio skirrhodon</i> *	+	+	Māngerei: First observed 9 months post-fire and was sparse for the remainder of 2020. Maungarei: First observed 6 months post-fire and was occasional for the remainder of 2020.
<i>Senecio vulgaris</i> *		+	Few plants observed on one occasion, 10 months post-fire.
<i>Sherardia arvensis</i> *	+		First observed 9 months post-fire at which time it was sparse, gradually increased to occasional by 12 months post-fire
<i>Silene gallica</i> *	+	+	Māngerei: First observed 12 months post-fire, at which time it was occasional in the higher parts of the burn area. Maungarei: First observed 13 months post-fire, at which time it was frequent.
<i>Solanum chenopodioides</i> *		+	First observed 7 months post-fire, at which time it was sparse. Gradually increased to become frequent by 13 months post-fire.
<i>Solanum linnaeanum</i> *		+	First observed 3 months post-fire. Occasional for the remainder of 2020.
<i>Solanum nigrum</i> *	+	+	Māngerei: Unidentified <i>Solanum</i> seedlings/young plants first observed 2 months post-fire. Identification of <i>S. nigrum</i> not confirmed until 6 months post-fire. Struggling plants sparse for the remainder of 2020. Maungarei: Unidentified <i>Solanum</i> seedlings/young plants first observed 2 months post-fire. Identification of <i>S. nigrum</i> not confirmed until 7 months post-fire. Struggling plants generally sparse until 13 months post-fire, at which time they were frequent.
<i>Sonchus asper</i> *	+	+	Māngerei: First observed 6 months post-fire. Sparse for the remainder of 2020. Maungarei: First observed 7 months post-fire. Sparse for the remainder of 2020
<i>Sonchus oleraceus</i> *	+	+	Māngerei: First observed 2 months post-fire. Occasional for the remainder of 2020. Maungarei: First observed 2 months post-fire. Sparse for the remainder of 2020
<i>Taraxacum officinale</i> *	+	+	Māngerei: First observed 6 months post-fire. Sparse for the remainder of 2020. Maungarei: first observed 7 months post-fire. Rare for the remainder of 2020.
<i>Tolpis barbata</i> *	+		First observed 12 months post-fire, at which time it was sparse.
<i>Trifolium pratense</i> *	+		First observed 12 months post-fire, at which time it was rare.
<i>Trifolium repens</i> *	+	+	Māngerei: First seen 9 mths post-fire, at which time it was occasional. Gradually expanded to become frequent by 12 mths post-fire. Maungarei: First seen 10 mths post-fire, at which time it was occasional. Gradually expanded to become common by 13 mths post-fire.
<i>Ulex europeaus</i> *	+		First observed as a single plant, resprouting from partially burnt base 2 mths post-fire. Seedlings also noted at this point. Rare for the remainder of 2020, but seedlings locally common 12 mths post-fire. Seedlings developed into low plants (ca. 50cm) 15 mths post-fire.
<i>Verbascum thapsus</i> *		+	First observed 7 months post-fire. Rare throughout the remainder of 2020.
<i>Verbascum virgatum</i> *		+	First observed 4 months post-fire. Sparse for the remainder of 2020.
<i>Vicia disperma</i> *	+		First observed 2 months post-fire, at which time it was sparse. Increased to become frequent by 9 months post-fire and was locally abundant and forming thick interlaced tangles over several square meters, 12 months post-fire. The populations had collapsed by 15 months post-fire.

<i>Vicia hirsuta</i> *		+	First observed 13 months post-fire, at which time it was common.
<i>Vicia sativa</i> *		+	First observed 13 months post-fire, at which time it was sparse.
Monocotyledons			
<i>Agapanthus praecox</i> *	+		Single plant observed on one occasion 12 months post-fire.
<i>Anthoxanthum odoratum</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was frequent in the higher areas of the burn site. Maungarei: First observed 13 months post-fire, at which time it was sparse.
<i>Arrhenatherum elatius</i> *		+	First observed 3 months post-fire, at which time struggling plants were occasional. Gradually increased across 2020 to become frequent at 6 months post-fire and common 13 months post-fire.
<i>Asparagus asparagoides</i> *	+		First observed 3 months post-fire. Rare throughout the remainder of 2020.
<i>Briza minor</i> *	+		First observed 12 months post-fire, at which time it was sparse.
<i>Carex divulsa</i> *	+	+	Māngere: Observed regenerating from partially burnt roots, 2 months post-fire. Seedlings first observed 2 months post-fire. Occasional throughout remainder of 2020. Maungarei: Observed regenerating from partially burnt roots, 2 months post-fire. Seedlings first observed 3 months post-fire. Occasional throughout remainder of 2020.
<i>Carex inversa</i>	+		First observed 12 months post-fire, at which time it was rare.
<i>Cenchrus clandestinus</i> (syn. <i>Pennisetum clandestinum</i>) *	+	+	Māngere: Observed regenerating from subterranean root systems 12 days post-fire. Rapidly expanded to cover 80-90% of the total burn area with a sward 10-60 cm in height by 2 months post-fire. Growth then slowed, with only minimal increase in cover and sward height throughout the remainder of 2020. By 12 months post-burn, total cover was ~90% and sward height mostly below 30 cm, but up 90 cm in favorable areas. Maungarei: Observed regenerating from subterranean root systems 2 months post-fire, by which time it had expanded to cover ~80% of the total burn area with a sward height of 10-20cm in height. At 3 months post-fire, coverage was ~90% and sward height was 30 cm maximum. Growth then slowed, with only minimal increase in cover and sward height throughout the remainder of 2020. By 13 months post-burn, total cover remained ~90% and sward height was mostly below ~40 cm.
<i>Dactylis glomerata</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was frequent. Maungarei: First observed 10 months post-fire. Sparse throughout the remainder of 2020.
<i>Ehrharta erecta</i> *	+	+	Māngere: Few plants observed on one occasion, 6 months post fire. Maungarei: First observed 3 months post-fire, at which time it was occasional. Gradually declined to sparse at 7 months post-fire and was not observed 13 months post-fire.
<i>Holcus lanatus</i> *	+	+	Māngere: First observed 12 months post-fire, at which time it was sparse. Maungarei: First observed 10 months post-fire, at which time it was sparse. Increased to become frequent by 13 months post-fire.
<i>Lolium perenne</i> *	+		Unidentified <i>Lolium</i> sp. first observed 9 mths post-fire. <i>L. perenne</i> not confirmed until 12 mths post-fire, at which time it was sparse.
<i>Microlaena stipoides</i>	+	+	Māngere: First observed 6 months post-fire. Sparse throughout the remainder of 2020. Maungarei: First observed 3 months post-fire, at which time it was common. Had declined by 7 months post-fire to become sparse. Was common again 13 months post-fire.
<i>Paspalum dilatatum</i> *	+		Observed regenerating from partially burnt bases 2 months post-fire. Sparse throughout the remainder of 2020.
<i>Poa annua</i> *	+		Only observed 6 months post-fire (winter), at which time it was locally common.
<i>Rytidosperma racemosum</i> *	+		First observed 3 months post-fire, at which time it was frequent and locally common. Declined by 6 months post-fire, but was common again by 12 months post-fire.
<i>Sporobolus africanus</i> *	+		First observed 9 months post-fire, at which time it was sparse. Increased gradually over the remainder of 2020 to become occasional by 12 months post-fire.