

References

- Cameron, E.K. 2000: Lucy May Cranwell, MA, DSc, DSc (Hon.), FLS (Lond.), FRSNZ, 1907-2000. *New Zealand Journal of Botany* 38: 527–535.
- Cranwell, L.M.; von Post, L. 1936: Post-Pleistocene pollen diagrams from the Southern Hemisphere: I, New Zealand. *Geografiska Annaler* 18: 308–347.
- Cranwell, L.M. 1936: The plant life of the Coromandel Ranges, pp. 31–37 in T.W. Rhodes (ed.), *Coromandel County Diamond Jubilee 1876–1936*. [copy in Auckland Libraries].
- Cranwell, L.M. 1941: Pollen grains of the New Zealand conifers. *New Zealand Journal of Science and Technology* 22: 1–17.
- Cranwell, L.M. 1953a: An outline of New Zealand peat deposits. *Reports of the Seventh Pacific Science Congress, Botany* 5: 186–208.
- Cranwell, L.M. 1953b: New Zealand Pollen Studies - The Monocotyledons. *Bulletin of the Auckland Institute and Museum* No. 3.
- Erdtman, G. 1924: Studies in micro-paleontology. Pt IV. Peat from the Chatham Islands and the Otago District, New Zealand. *Geologiska Foreningens i Stockholm Forhandlingar* 46: 679–81.
- Garrat, G.A. 1924: Some New Zealand woods. *New Zealand State Forest Professional Paper* No. 1. Government Printer, Wellington.
- Grange, L.I. 1939: Soils and agriculture of part of Waipa Country. *DSIR Bulletin* 76. Government Printer, Wellington. [Soils by L.I. Grange, N.H. Taylor, and C.F. Sutherland, Pedologists, Soil Survey Division, DSIR; J.K. Dixon & L. Hodgson, Soil Chemists, Cawthron Institute; F.T. Seelye, Mineral and Soil Analyst, DSIR. Climate by E. Kidson, Director, Meteorological Office, DSIR. Native Vegetation by Lucy M. Cranwell, Auckland War Memorial Museum. Agriculture by P.W. Smallfield, Fields Superintendent, Department of Agriculture].
- Grange, L.I. 1937: DSIR Soil Survey Division, Report by Director. *Appendices to the Journals of the House of Representatives* for 1937. Session 1, H–34. Government Printer, Wellington.
- Holzapfel, A. 2002: Early Waikato botanists. Pp. 29–31 in *Botany of the Waikato*. B. Clarkson, M. Merrett & T. Downs (Eds.). Waikato Botanical Society, Hamilton.
- Kirk, T. 1889: *Forest flora of New Zealand*. Government Printer, Wellington.
- Lundqvist, J. 1991: Carl Calzon Caldenius—geologist, geotechnician, predecessor of IGCP. *Boreas* 20: 183–89.
<https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1502-3885.1991.tb00306.x>
- McGlone, M.S.; Nelson, C.S.; Todd, A.J. 1984: Vegetation history and environmental significance of pre-peat and surficial peat deposits at Ohinewai, Lower Waikato lowland. *Journal of the Royal Society of New Zealand* 14: 233–244.
- Moore, L.B. 1986: Inaugural Lucy M. Cranwell Lecture: Cranwell botany in the Auckland years. *Auckland Botanical Society Newsletter* 41: 20–35.
- Orwin, J. 1974: Annotated bibliography on the ecology of New Zealand indigenous forest and scrub 1929-1970. *New Zealand Journal of Botany* 12: 45–113.
- Pearson, H.V. 1934: Map of Rukuhia Swamp [showing soil types and vegetation]. 43 by 25 ½ inches. Scale 20 chains to 1 inch. Unpublished map in Library, Auckland War Memorial Museum.
- Taylor, N.H.; Sutherland, C.F. 1938: North Auckland Soil Survey, Progress Report. *Appendices to the Journals of the House of Representatives* for 1938. Session 1, H–34. Government Printer, Wellington.
- Wardle, P. 1981: *The vegetation of New Zealand*. Cambridge University Press.
- Williams, P.A. 1981: Bibliography and subject index for *Leptospermum ericoides* and *L. scoparium* (Myrtaceae) in New Zealand, 1889-1980. *New Zealand Journal of Botany* 19: 305–310.
-

Forty-six years of lichen quadrat monitoring at Kawerua, Northland, New Zealand

Bruce W. Hayward

Introduction

Lichenometry (the use of lichens to date surfaces) has primarily been used in alpine and subalpine environments to date glacial moraines, landslides and other landform surfaces (e.g., Burrows & Orwin 1971, Gellatly 1982, Bull 2018). The slow growth rates of some crustose lichens also have the potential for dating other rock surfaces in geomorphology and archaeology. In the coastal zone these could include the dating of tsunami and storm gravel deposits, growth of boulder barriers and beaches, earthquake uplift events, coastal landslides and anthropogenic structures (e.g., Oliveira et al. 2020).

Lichenometry relies on information on the growth rates of lichen thalli, particularly crustose ones. This

is used to estimate the age of the largest thalli on the surface of interest. Photographic monitoring of the growth of lichen thalli provides the most accurate estimates of growth rates. The disadvantage of this method is that it takes years to get accurate growth rates for the slow-growing lichens. Another method for obtaining maximum growth has been to measure the size of the largest thalli on surfaces of known age, such as grave stones or landslides (e.g., Bull & Brandon 1998, Oliviera et al. 2020).

In this note I provide results of photographic monitoring of lichens in six quadrats on maritime rocks in Northland over a 46-year period. This is certainly by far the longest lichen monitoring project in New Zealand and one of the few and possibly longest on maritime rocks anywhere in the world.

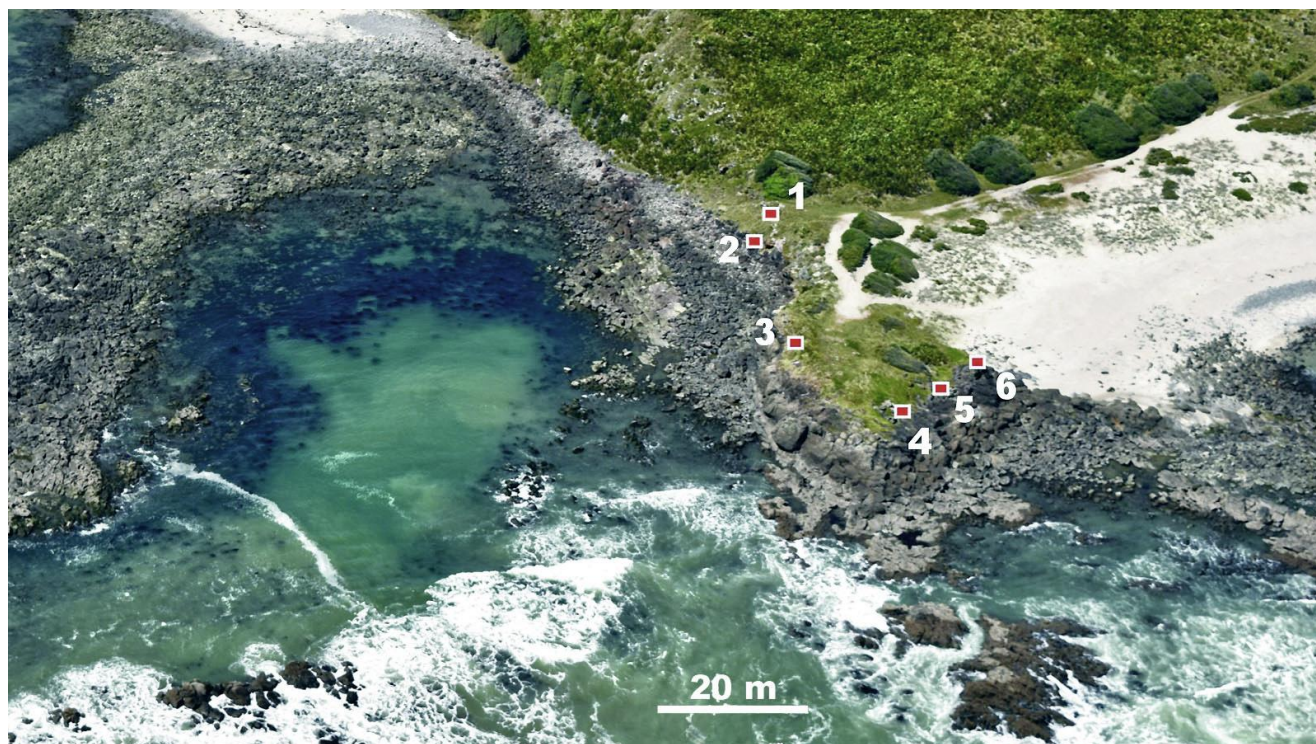


Fig. 1. Oblique aerial photo from the west of Kawerua Point, Northland, showing the location of the six lichen quadrats (numbered). Photo: B.W. Hayward, Nov 2015.

The next longest I have found in the literature was by Sancho et al. (2007) who recorded growth rates of crustose lichens in Antarctica based on earlier photographs taken 42 and 25 years previously.

History

In 1976 the late Roger Grace established six permanent lichen quadrats in the sea spray zone on maritime basalt rocks at Kawerua (Fig. 1; 35°38'18"S 173°26'26"E), adjacent to the former Auckland University Field Club Scientific Station on the remote west coast of Northland, New Zealand (Grace & Hayward 1978). The stated aim was to monitor their long-term growth rates in a pristine maritime environment away from the effects of any anthropogenic pollution, which is known to impact certain foliose species (e.g., Daly 1970). The idea was also to establish the growth rates of different species and to investigate the effects of different substrate aspects on their growth.

This is the fourth note recording results from forty-six years of photographic monitoring of these lichen quadrats. The first documented their location and

methods used to establish the quadrats and growth results over the first 18 months (Grace & Hayward 1978). The second and third notes recorded changes over the first 5 and 21 years (Hayward & Grace 1982, 1999). The vegetation and lichen flora of the study area on Kawerua Point were documented by Hayward & Hayward (1974) and the taxonomy and total lichen flora subsequently upgraded by Hayward & Hayward (1991).

Methods

Each quadrat is rectangular (0.5 x 0.3m) and covers an area of 0.15 m². The corners of each quadrat were permanently marked with drilled holes (Grace & Hayward 1978). Each quadrat was photographed at the time of establishment and has been rephotographed ten times since then (Table 1). Because of change of management and access difficulties, the quadrats were not visited between 1997 and 2019, but have been rephotographed twice in more recent years (2019, 2022). Early photography mostly used black and white film, but colour slides and more recently digital images have been used.

Table 1. Dates of lichen quadrat photographic monitoring at Kawerua, 1976-2022. Note that because of the remote location and more recent difficulty of access, times of photographic monitoring have not been able to be evenly spaced.

1976	1978	1979	1981	1982	1986	1990	1993	1997	2019	2022
Oct 25	Jan 1	Jan 8	Jun 3	Jul 15	Jan 30	Jan 16	Jun 30	Jun 16	Mar 14	May 12

Quadrat changes 1976-2022

Quadrat 1 (Fig. 2)

This quadrat on a near-horizontal face was selected for its cover of the foliose lichens *Dufourea ligulata* (orange), *Xanthoparmelia australasica* (yellow-green) and *Xanthoparmelia pulla* (darker green). When established in 1976 there were approximately fifty healthy rosette-shaped thalli of *D. ligulata*, each 10–60 mm diameter. By 1979 the centres of some of the larger thalli were cracking up, fragmenting and beginning to erode and by 1981 virtually all had disappeared completely. *Dufourea ligulata* had recolonised by 1982 and had grown into healthy rosettes by 1986. Between 1986 and 1991, quadrat 1 was smothered by the spread of native *Muehlenbeckia complexa* vine that completely killed off all the lichens beneath and it remained this way through 1997.

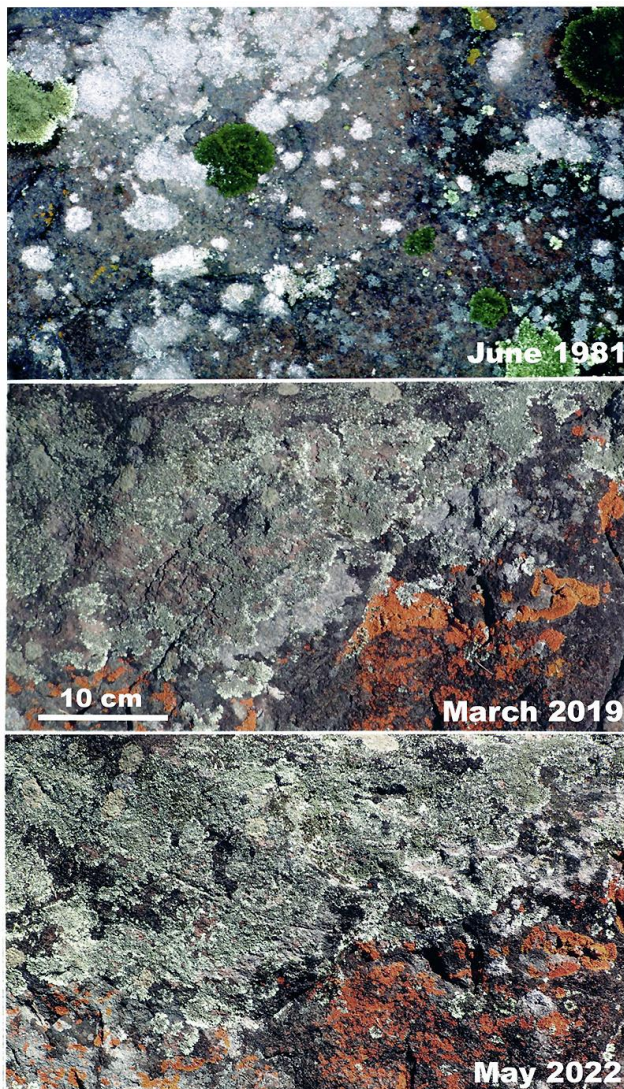


Fig. 2. Colour photos of quadrat 1 in 1981, 2019 and 2022. The near flat-lying quadrat was smothered by vegetation and all lichens lost for a period between 1981 and 2019. Lichens: orange = *Dufourea ligulata*; light green (1981) = *Xanthoparmelia australasica*; dark green (1981) = *Xanthoparmelia pulla*.

In 1976 there were two thalli of yellow-green foliose *Xanthoparmelia australasica* (each c.50 mm diameter) and two thalli of the foliose *Xanthoparmelia pulla* (30–50 mm diameter). These thalli showed healthy radial marginal growth from 1976 to 1986, doubling in diameter but with older central portions fragmenting and disappearing. In 2019, the vine cover had disappeared and the quadrat was once again covered in two species of foliose lichen (Fig. 2) – *D. ligulata* covering the lower right of the quadrat and *X. australasica* dominating the rest. Based on earlier growth rates, I estimate that these new foliose lichens had colonised the rock about 2008. Average annual growth rates for the margins of several *D. ligulata* and *X. australasica* thalli over the three-year period 2019–2022 were ~1.5 mm/yr, somewhat slower than in the 1980s (1.5–5 mm/yr). As noted previously the older central portions of many of these foliose thalli are already breaking up and disappearing and some thalli have completely disappeared in the last three years.

Areas of diffuse cover by a grey-white (infertile) crustose lichen grew slowly during the ten-year period 1976–1986, were unaffected by whatever caused the disappearance of *D. ligulata* and were periodically overgrown by faster-growing foliose thalli. In 2019 and 2022 there were also similar diffuse patches of crustose thalli but all differed from those of the 1980s.

Quadrat 2 (Fig. 3)

This quadrat is sited on a slightly overhanging rock face and monitors the growth of distinctive white circular thalli of an unidentified infertile crustose lichen. In 1976 there were c.30 thalli, each c.5–30 mm diameter, covering c.5% of the quadrat. By 1997 there were c.100 thalli, each c.5–50 mm diameter, covering c.20% of the quadrat and by 2022 c.40% of the quadrat was covered in crustose lichen. The dense cover of white thalli on the left side of the quadrat in 1997 had mostly broken up and disappeared by 2019. The younger outer margins of three of the 1997 thalli were still present in 2019 but had mostly disappeared by 2022. Some individual thalli on the right side of the quadrat that were tiny (5–12 mm diameter) in 1976 could still be identified in 2022 (24–40 mm diameter) having had average annual radial growth rates of their margins of 0.2–0.3 mm/y, comparable with those measured during the first 21 yrs of monitoring.

Quadrat 3

This north-facing near-vertical rock face had a mix of foliose and crustose lichen thalli that were monitored between 1976 and 1997, but when revisited in 2019 the entire face was buried beneath a thick cover of the native *Muehlenbeckia* vine which had killed off all the lichens. The face is currently bare rock where the vine has been pulled back from over it.

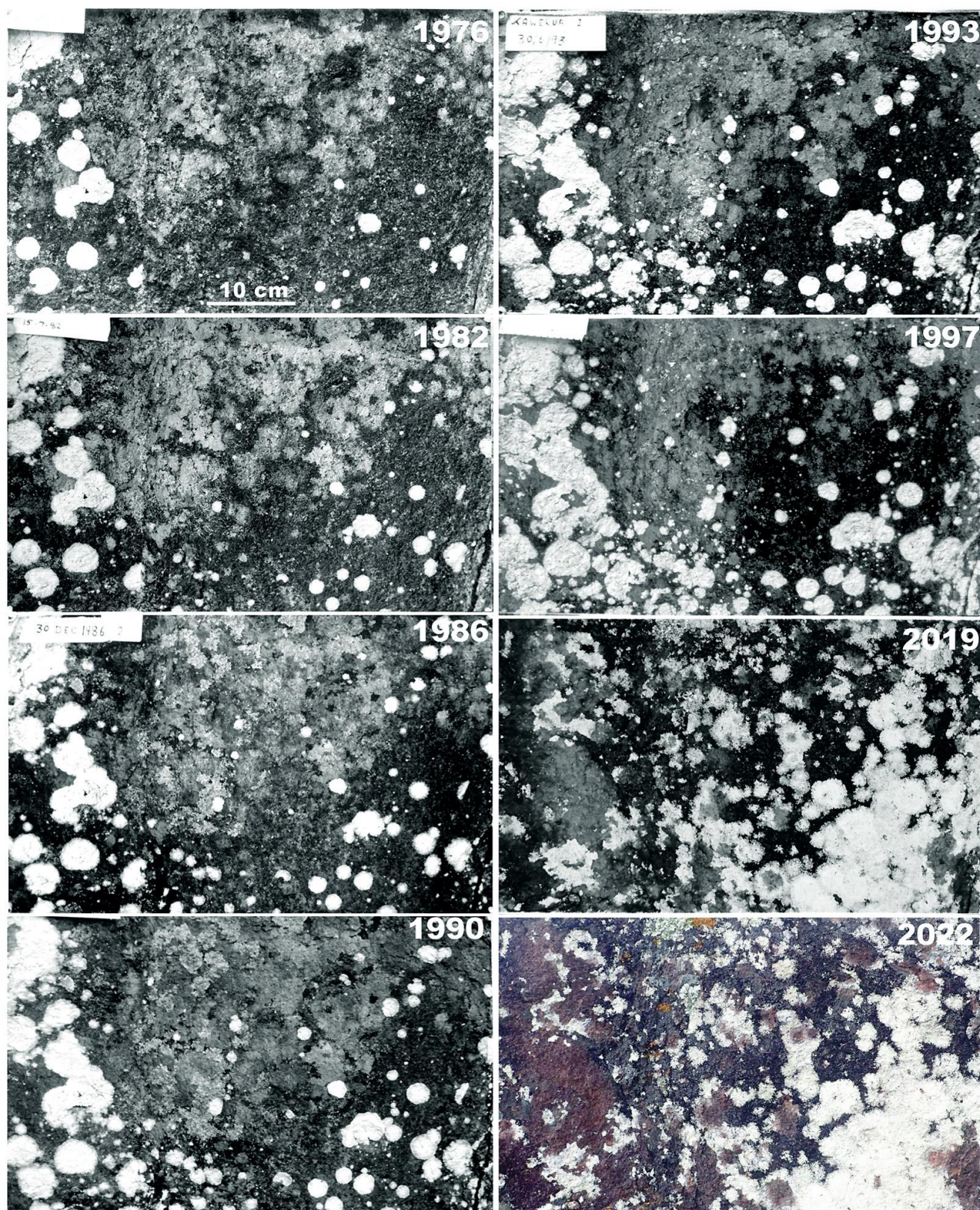


Fig. 3. Sequence of eight photos of Kawerua lichen quadrat 2, showing changes in the size of mostly infertile crustose lichens, 1976-2022.

Quadrat 4 (Fig. 4)

Early on, this flat-lying quadrat provided the best opportunity for monitoring the foliose *Xanthoparmelia australasica*. In 1976, numerous thalli (up to 100 mm across) covered c.20% of the quadrat, but by 1979 this had drastically declined to c.1%. Many thalli had disappeared and only a narrow peripheral rim remained of the others. The remaining narrow peripheral arcs of the original thalli grew outwards through 1982 and by 1990 once again covered c.15% of the quadrat. Thalli coverage decreased through 1993 to 1997, when only c.5% coverage of small fragments remained. In 2019 and 2022 no *X. australasica* was present in this quadrat at all. Part of the right side of the quadrat was colonised by small *Dufourea ligulata* thalli in the early 1980s. These reached their maximum coverage by 1990, after which there was a progressive decrease again through to 1997. In 2022, the percentage coverage by *D. ligulata* over the right side of the

quadrat remains about the same as in 1997 although no individual thallus can be recognised from 25 years earlier. During the 46 years of monitoring, areas of infertile light grey crustose thallus have grown slowly and changed shape as they periodically lost marginal and central portions. They now cover c.40% of the quadrat compared with c.30% in 1976.

Quadrat 5 (Fig. 5)

This rock face is colonised by thalli of two infertile crustose lichens that have grown slowly with many individual thalli still identifiable after 46 years. The radial growth rates of these crustose thalli between 1997 and 2022 have been the same as for the preceding 21 years at 0.3–0.5 mm/yr. Most of the larger thalli in 1997 had disappeared by 2019 or only had a marginal arc remaining. A small elongate *D. ligulata* colonised along the edge of a crack in the bottom left of the quadrat in the early 1990s and was still present but no larger in 2022.

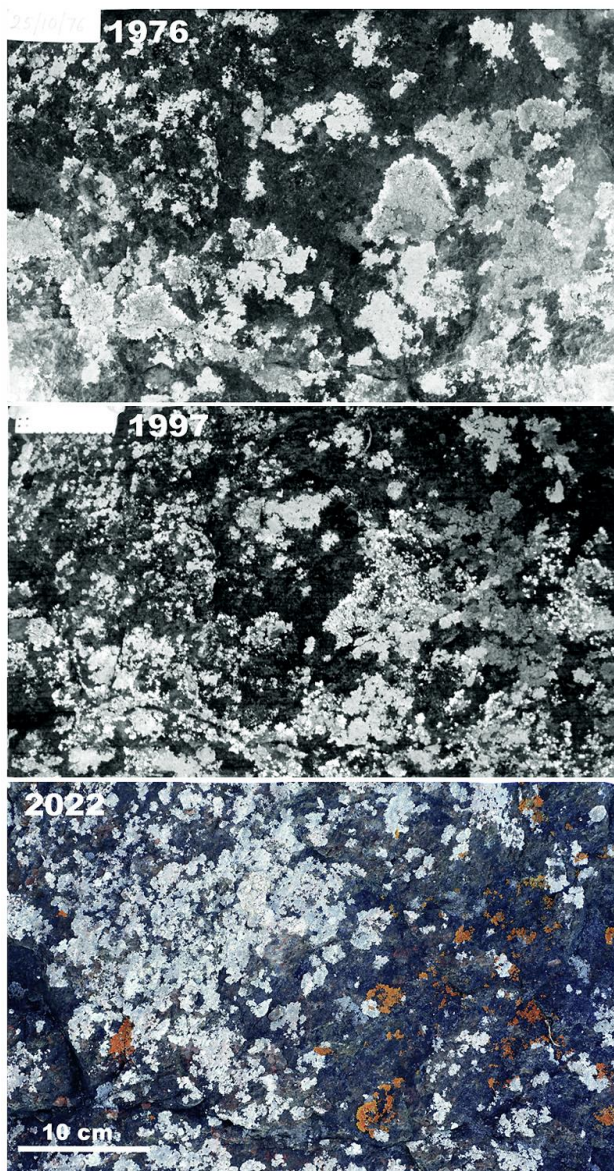


Fig. 4. Photos of quadrat 4 in 1976, 1997 and 2022 showing changes that have occurred over the 46 years of monitoring. Lichens: foliose large (1976) = *Xanthoparmelia australasica*; orange (2022) = *Dufourea ligulata*.

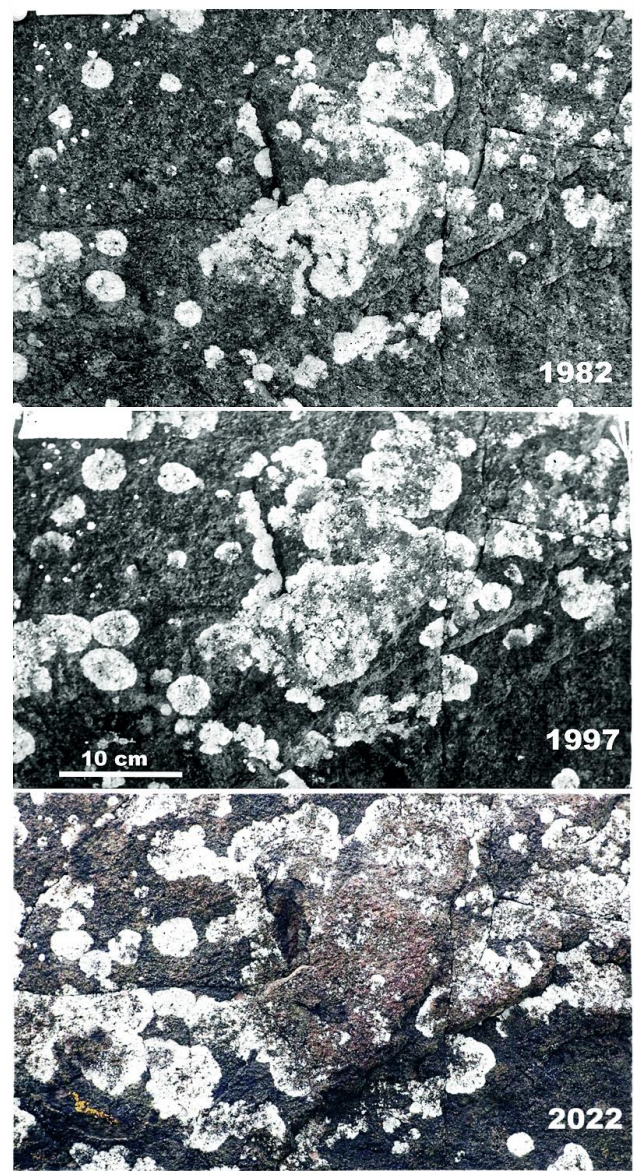


Fig. 5. Photos taken in 1982, 1997 and 2022, showing growth and loss of mostly infertile crustose thalli in Kawerua lichen quadrat 5, 1982–2022.

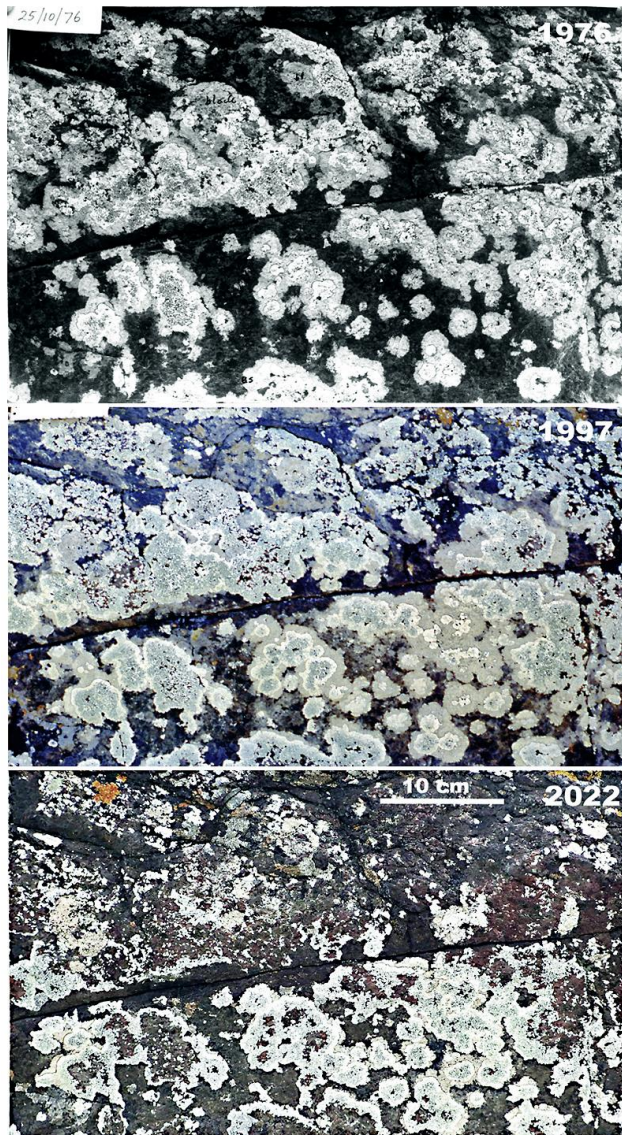


Fig. 6. Growth and loss of infertile crustose thalli in Kawerua lichen quadrat 6, 1976–2022.

Quadrat 6 (Fig. 6)

This vertical, south-facing quadrat was, in 1976, densely covered in an unidentified crustose species which appears to have a grey prothallus surrounding a central white-margined thallus. In the first 21 years of monitoring, all thalli exhibited slow, uninterrupted radial growth of 0.1–0.5 mm/yr. During this period almost all thalli remained entire with only minor signs of loss of the central older parts. Between 1997 and 2022, however, there was extensive fragmentation and loss of almost all thalli in the upper half of the quadrat and of the central portions of thalli in the lower half. Coverage reduced from c.80% in 1997 to c.40% in 2022, but where trackable individual thalli continued to grow at similar rates to previously (0.1–0.3 mm/yr).

Discussion

Growth rates

Some studies elsewhere have indicated that young thalli (<10 mm diameter) have faster growth rates than larger thalli or variable growth rate curves (Armstrong 2015), but this has not been able to be resolved in this small study, where similar radial growth rates of the thallus margins have been recorded in all thalli >10 mm diameter. Our Kawerua monitoring (Table 2) shows that foliose thalli grow considerably faster (0.5–7.0 mm/yr) than crustose thalli (0.1–1.0 mm/yr), similar to that found elsewhere in the world (Fletcher 1980).

Our monitoring of this limited number of thalli has shown no difference in the growth rate between small and larger thalli of *Xanthoparmelia australasica* and *Dufourea ligulata*. The fastest growth rates for both foliose and crustose thalli have been recorded

Table 2. Average annual radial growth rates (mm/year) measured for each species in each quadrat and averaged over the period that they were present.

Quadrat	1	2	3	4	5	6
Sloping towards	SW	W	N	S	SW	SE
At an angle of	15°	105°	55°	20°	55°	90°
<u>Foliose lichens</u>						
<i>Heterodermia speciosa</i>	-	-	-	1–1.5	-	-
<i>Xanthoparmelia pulla</i>	2.5–4	-	-	-	-	-
<i>Xanthoparmelia australasica</i>	1.5–5	-	0.7	1–1.5	-	-
<i>Dufourea ligulata</i>	3.5–4	0.5–7	1–2	0.5–1.5	1–2	-
<u>Infertile crustose lichens</u>						
Indet. spp.	0.5–1.0	0.2–0.5	0.2–0.3	0.1–0.3	0.3–0.5	0.1–0.5

in the quadrat nearest to horizontal (quadrat 1). The consistently lowest growth rates (for crustose thalli) have been recorded in quadrat 6, which is on a vertical rock surface facing south (perpetual shade). These differences in growth rates between quadrats (Table 2) are probably attributable to substrate aspect resulting in differences in rainfall received, moisture retention time and hours of direct sunlight.

Longevity By applying the recorded average growth rates to the size of the largest thalli in each quadrat it is possible to calculate the approximate age of the oldest lichens present. The largest foliose thallus (140 mm diameter *N. pulla* in quadrat 1) was c.21 years old before it disappeared after 1986. The oldest *X. australasica* (20 yrs, 56 mm diameter) and *D. ligulata* (27 yrs, 88 mm) were recorded in quadrat 3, before they were killed off by vine growth after 1997.

The oldest crustose thallus is in quadrat 6. It has grown from 34 mm diameter in 1976 to 44 mm in 2022 at a steady annual rate of radial growth of 0.1 mm/yr. Extending this growth rate back in time would make this lichen >200 yrs old. The oldest crustose thalli in quadrats 5 (50 mm diam) and 2 (64 mm) are c. 125 yrs old.

Disappearing lichens

These monitoring studies show that the centre of larger and older thalli (both foliose and crustose) often crack, crumble and erode away leaving ring-shaped thalli which may continue to grow outwards around the circumference until they themselves disappear. The cause of this cracking is ascribed to hygroscopic flexing (expansion and contraction during wetting and drying caused by weather) of the more firmly attached central portions of the thalli (Scott 1974).

Between 1976 and 1997 the three quadrats with the best developed foliose lichens showed a cyclic pattern of progressive increasing lichen coverage followed by a rapid disappearance. After the "die-back" the foliose thalli slowly grew back from the small remaining scraps that survived and from new colonists that established. During that 21-yr period two asynchronous "die-back" episodes were recorded. Unfortunately monitoring of these die-back cycles since 1997 has been interrupted by smothering of two of the quadrats by surrounding vegetation and the complete loss of foliose lichens in the third.

A second cause of loss of lichen thalli (including the younger marginal parts) is possibly from small grazing invertebrates (Fletcher 1980). At Kawerua the most likely culprits are the introduced European snail (*Helix aspersa*), slugs or insects. In another study, slugs have been shown to graze preferentially on certain lichen taxa because of their chemistry

(Lawrey 1980). This could account for our earlier observations in quadrat 1 where yellow *D. ligulata* thalli were most affected followed by yellow-green *X. australasica* and least affected were green-brown *X. pulla*.

In our studies, a further cause of lichen thallus loss appears to be the periodic flaking away of the surface 1–5 mm of weathered rock with consequent creation of small patches of fresh surfaces for colonisation (e.g., quadrat 1). This flaking may be a result of normal physical and chemical weathering or have been aided by the action of lichen metabolites.

Conclusions

Forty-six years of photographic monitoring of six permanent lichen quadrats on maritime basalt rocks at Kawerua, New Zealand, provide an insight into the dynamics of lichen ecosystems. They do not exhibit a straight-line progression from colonisation and succession through to a climax vegetation. Their foliose lichen cover, in particular, shows cyclical waxing and waning in response to a number of factors. These will make it particularly difficult to use maritime lichen survival or growth rates as unambiguous monitors of air pollution or for dating rock surfaces. Three quadrats, with an originally rich cover of foliose thalli, exhibited asynchronous cycles of progressive growth followed by dramatic "die-back" and later recovery. The "die-back" is attributed to a combination of hygroscopic flexing and fragmentation of the central portions of foliose thalli and episodes of heavy grazing by small invertebrates. Longer-term monitoring of crustose thalli suggests that they too have cycles of growth followed by thallus loss, but with cycle lengths >50 yrs.

The growth rates of foliose lichens on substrates with differing aspects are considerably different and need to be assessed carefully if foliose maritime lichens are to be used to date the age of rock surfaces. The slower-growing crustose thalli appear to be less variable in their growth rates and are likely to provide more reliable age assessments. Foliose lichens grew considerably faster (0.5–7.0 mm/yr radial increase) than crustose lichens (0.1–1.0 mm/yr), with foliose growth rates faster on flat-lying (quadrat 1) surfaces than those on more steeply inclined faces, probably a result of greater moisture retention on horizontal surfaces.

Acknowledgments

I thank the late Roger Grace for establishing and taking the first photographs of the lichen quadrats in 1976. Jill Kenny, Egon Eberle and Carol Gunn are thanked for their assistance during the more recent monitoring visits in 2019 and 2022 and Te Roroa are thanked for providing access in 2022. The manuscript has benefitted from comments by Dan Blanchon.

References

- Armstrong, R.A. 2015: Lichen growth and lichenometry. Pp. 213–227, In: Upreti, D.K.; Divakar, P.K.; Shukla, V.; Bajpal, R. (Eds.), *Recent advances in Lichenology*, Vol.1. Springer, New Delhi, India.
- Bull, W.B. 2018: Accurate surface exposure dating with lichens. *Quaternary Research* 90: 1–9.
- Bull, W.B.; Brandon, M.T. 1998: Lichen-dating of earthquake-generated regional rock fall event, Southern Alps, New Zealand. *Geological Society of America Bulletin* 110: 60–84.
- Burrows, C.J.; Orwin, J. 1971: Studies on some glacial moraines in New Zealand – 1. The establishment of lichen-growth curves in the Mount Cook area. *New Zealand Journal of Science* 14: 327–335.
- Daly, G.T. 1970: bryophyte and lichen indicators of air pollution in Christchurch, New Zealand. *Proceedings of the New Zealand Ecological Society* 17: 70–79.
- Fletcher, A. 1980: Marine and maritime lichens of rocky shores: their ecology, physiology and biological interactions. Pp. 789–842. In: Price, J.H.; Irvine, D.E.G.; Farnham, W.F. (Eds.), *The shore environment. Vol.2: Ecosystems*. Academic Press, London.
- Gellatly, A. 1982: Lichenometry as a relative-age dating method in Mount Cook National Park, New Zealand. *New Zealand Journal of Botany* 20: 343–353.
- Grace, R.V.; Hayward, G.C. 1978: Establishment and monitoring of permanent lichen quadrats at Kawerua, Northland, New Zealand. *Tane* 24: 173–183.
- Hayward, B.W.; Grace, R.V. 1982: Lichen growth and grazers - five years of monitoring lichen quadrats at Kawerua. *Tane* 28: 187–197.
- Hayward, B.W.; Grace, R.V. 1999: Transient and ancient lichens - twenty-one years of growth monitoring at Kawerua, Northland. *Tane* 37: 27–41.
- Hayward, B.W.; Hayward, G.C. 1974: Lichen flora of the Kawerua area. *Tane* 20: 124–139.
- Hayward, B.W.; Hayward G.C. 1991: Kawerua lichens - a revision. *Tane* 33: 9–20.
- Lawrey, J.D. 1980: Correlations between lichen secondary chemistry and grazing activity by *Pallifera varia*. *The Bryologist* 83: 328–334.
- Oliveira, M.A.; Llop, E.; Andrade, C.; Bramquinho, C.; Goble, R.; Queiroz, S.; Conceicao-Freitas, M.; Pinho, P. 2020: Estimating the age and mechanism of Boulder Transport Related with Extreme Waves Using Lichenometry. *Progress in Physical Geography* 44: 870–889.
- Sancho, L.G.; Green, T.G.A.; Pintado, A. 2007: Slowest to fastest: Extreme range in lichen growth rates supports their use as an indicator of climate change in Antarctica. *Flora* 202: 667–673.
- Scott, G.D. 1974: Evolutionary aspects of symbiosis. Pp. 581–598, In: Ahmadjian, V; Hale, M.E. (Eds.), *The Lichens*. Academic Press, London.

"Flora of Samoa", by W. Arthur (Art) Whistler

Reviewed by Rhys Gardner

With keys and descriptions and covering American Samoa and The Independent State of Samoa (formerly Western Samoa), this is the archipelago's first-ever traditional-style Flora (see footnote for publication details). The c. 250 Samoan pteridophytes have not been included, however, "just" the flowering plants: 543 native species (a third of them endemic) and 290 naturalized ones (including 49 possible Polynesian introductions). This still makes for a good-sized tome, and coincidentally, one nearly identical in appearance and heft (strong covers, 2 kg of glossy paper) to the other recent NTBG publication, Sykes' "Flora of the Cook Islands".

As well as being an inveterate traveller and collector, Art Whistler (Fig. 1) was a diligent pre-digital-age photographer, and here his images (nearly 700, at a guess, along with some taken by other botanists) are presented in 159 colour plates. More than two thirds of the flora is shown, from the newest weeds to the native rarities, with a good coverage of large groups like the orchids, *Cyrtandra*, *Elatostema*, *Eumachia* and its look-alike *Psychotria*, *Melicope* and *Syzygium*. I would have liked to have also seen, though, a few of the classical *US Exploring Expedition* and *Icones Plantarum* illustrations, or references to them.

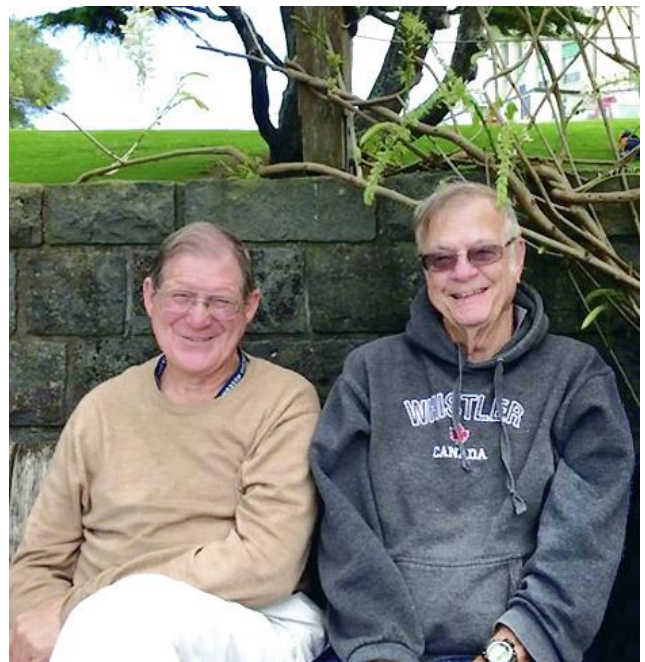


Fig. 1. Art Whistler (right) with Rhys Gardner, at the Magnolia Garden, Auckland Domain. Photo: Alice Campbell, 21 Oct 2019.

Art examined Pacific plant collections from all round the world, including those in the older European