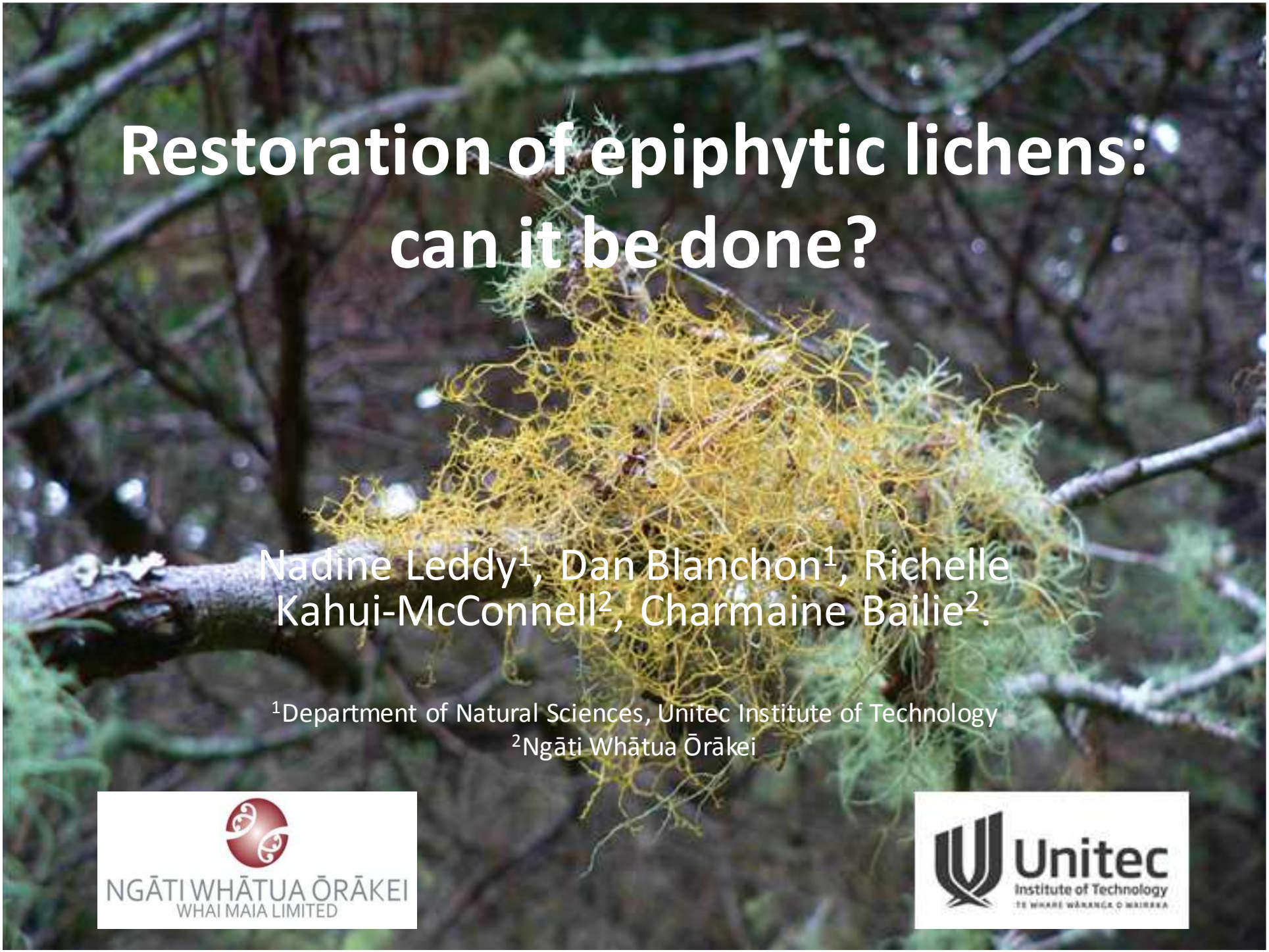

Restoration of epiphytic lichens: can it be done?

Nadine Leddy[1], Dan Blanchon[1], Richelle Kahui-McConnell[2], Charmaine Bailie[2].

[1]Department of Natural Sciences, Unitec Institute of Technology
[2]Ngāti Whātua Ōrākei

NGĀTI WHĀTUA ŌRĀKEI
WHAI MAIA LIMITED

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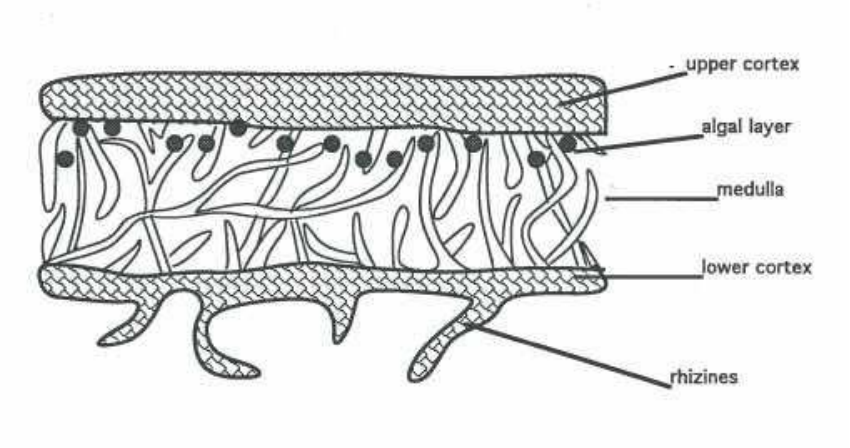
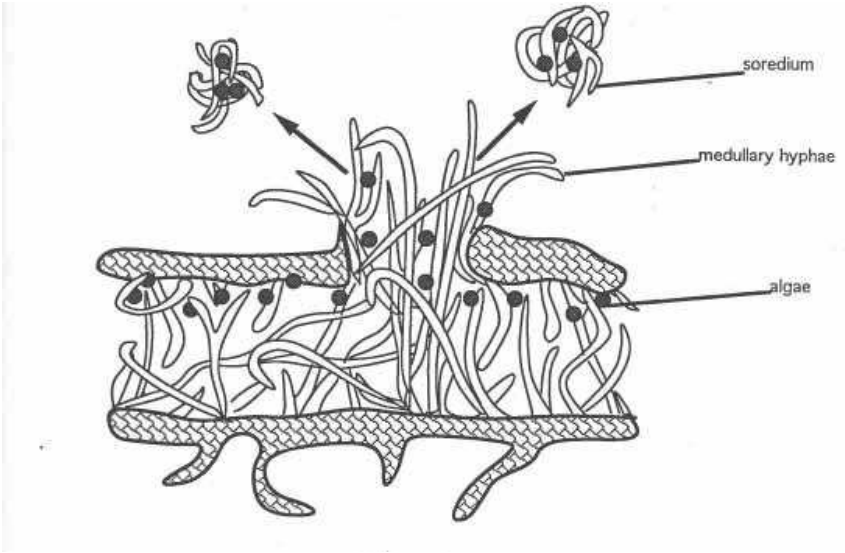
What are lichens?





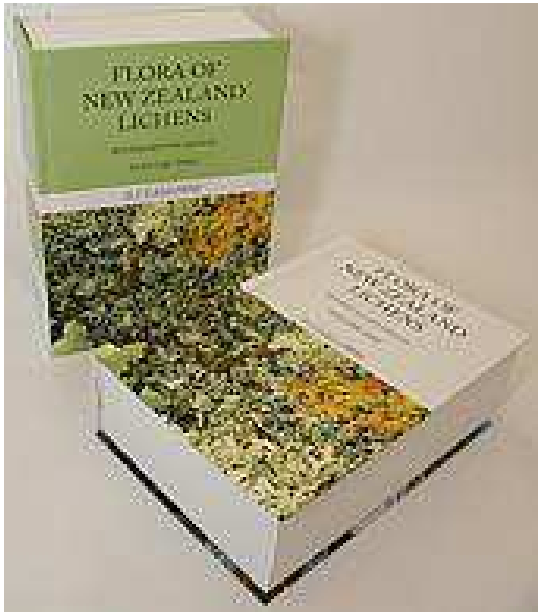
Ecological importance of lichens

Lichens have important ecological roles:

- Stabilizing soils
- Food and habitat for invertebrates
- Soil formation
- Water storage and cycling

Some lichens also fix nitrogen

Lichens in New Zealand



310 genera of lichen-forming fungi + 44 genera of lichenicolous fungi

1799 taxa, 10% of lichen species known worldwide

Important ecosystems for epiphytic lichens

Old mangroves

Important ecosystems for epiphytic lichens

Podocarp forest – particularly kahikatea and totara

Important ecosystems for epiphytic lichens

Pohutukawa (coastal) forest

Important ecosystems for epiphytic lichens

Pohutukawa (coastal) forest

Old kanuka forest

Specific substrate tree species are also important for lichens

Taraire/tawa Leaves

Totara leaves

A. Knight

Are any lichens threatened with extinction?

	Number of taxa
Total	1799
Extinct	0
Nationally Critical	4
Nationally Endangered	4
Nationally Vulnerable	3
Declining	4
Naturally Uncommon	173
Data Deficient	975
Not Threatened	636
Endemic	375

Threat classification of the NZ Lichen Flora (de Lange et al. 2012)

Why might lichens be threatened?

- The loss of lichens from urban and agricultural areas is a widespread phenomenon.

- Air-borne pollutants such as SO_2 and NO_2 from the burning of fossil fuels are the main causes. These and other pollutants cause a range of physiological and anatomical effects, including death of the lichen.

- Extensive research has been done on mapping and quantifying air-pollution related declines in lichen floras (e.g. Hawksworth & Rose 1970 onwards).

- In some areas of Europe, reduction in air pollution is allowing lichen floras to at least partially recover (e.g. Ranta (2001).

Habitat loss

Habitat loss is another key factor in the decline of some lichen species, mainly due to vegetation clearance for:

- Agriculture
- Forestry
- Urbanisation

Key issues – loss of particular species of tree substrates, loss of particular age or density of vegetation, change of microclimates, alteration of ecosystem processes.

Habitat restoration

- Despite the importance of lichens to ecological functioning (providing food and habitat for invertebrates and some lichens fixing atmospheric nitrogen), little effort is made to restore lichens – there is perhaps assumption they will return naturally.

- This does not usually seem to be entirely the case – usually a small assemblage of light-loving common species occur, but not the forest species.

- Why?

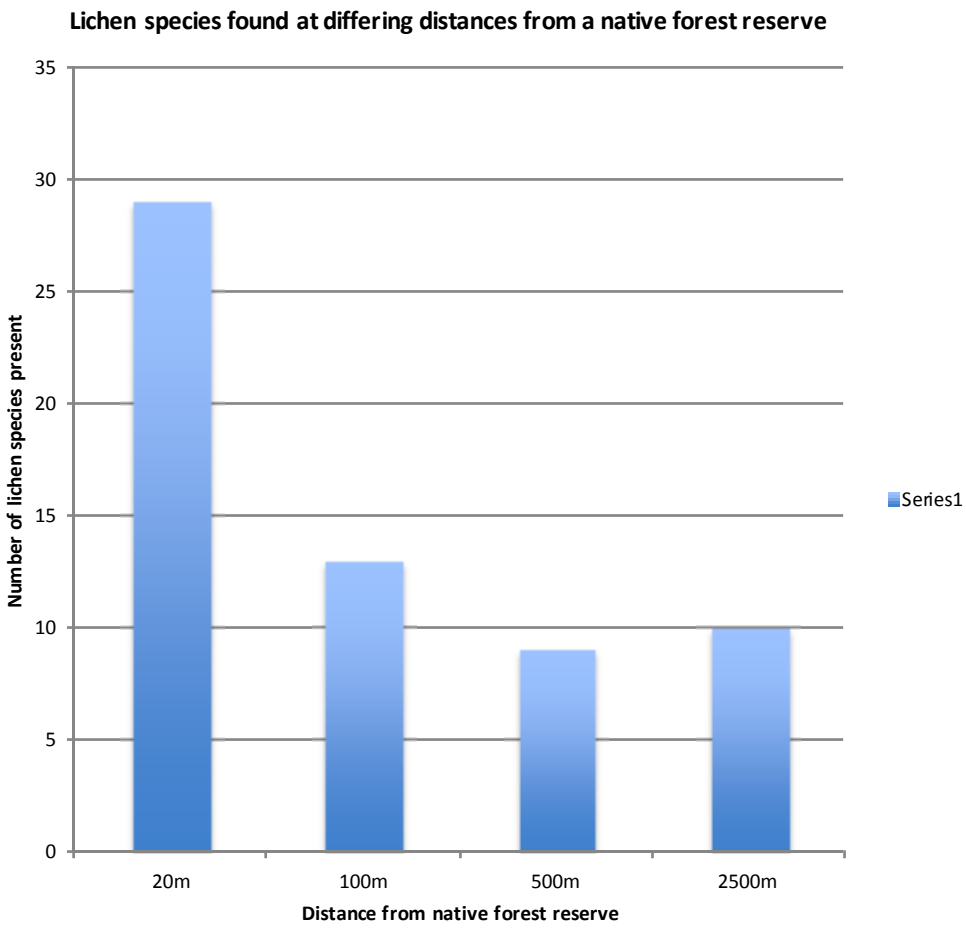
Possible reasons

The apparent inability of some lichen species to colonise restoration plantings could be explained by a number of factors:

- Air pollution
- Lack of appropriate substrate tree species (or rock type)
- Substrate quality (e.g. age of tree)
- Lack of propagule dispersal
- Lack of appropriate microclimate

Distance from lichen propagule source does seem to have an effect

- A study of 12 year old plots of planted native tree species at varying distances from native bush fragments found that the highest number of lichen species were found in the plot closest to the native forest (20m).
- Sites 500m and 2500m from the native forest only had common edge lichen species (i.e. what you find on urban street trees).



How do you restore lichens? What does the literature say?

- Biggest challenge - facilitating attachment of propagules upon host substrates (Brooker et al. 2011).
- Early research (Scheidegger 1995; Scheidegger et al. 1995) used gauze discs as an artificial dispersal method:
  - Propagules applied directly to gauze discs
  - 95% propagule loss from displacement within first two months
  - Identified first two months as a vital period for hyphae development

- Recent studies (Kon & Ohmura 2010; Pangpet et al. 2009; Liden 2009) modified methods to include adhesive substances to address displacement issues:
  - Enhanced immobilization/fixation
  - Included habitat requirements and reference ecosystems
  - Resulted in higher survival and vitality rates

The project

Aim:

To identify appropriate methods for lichen translocation, and apply a pilot study to translocate lichens into the Whenua Rangatira ecological restoration site , Orakei, Auckland.

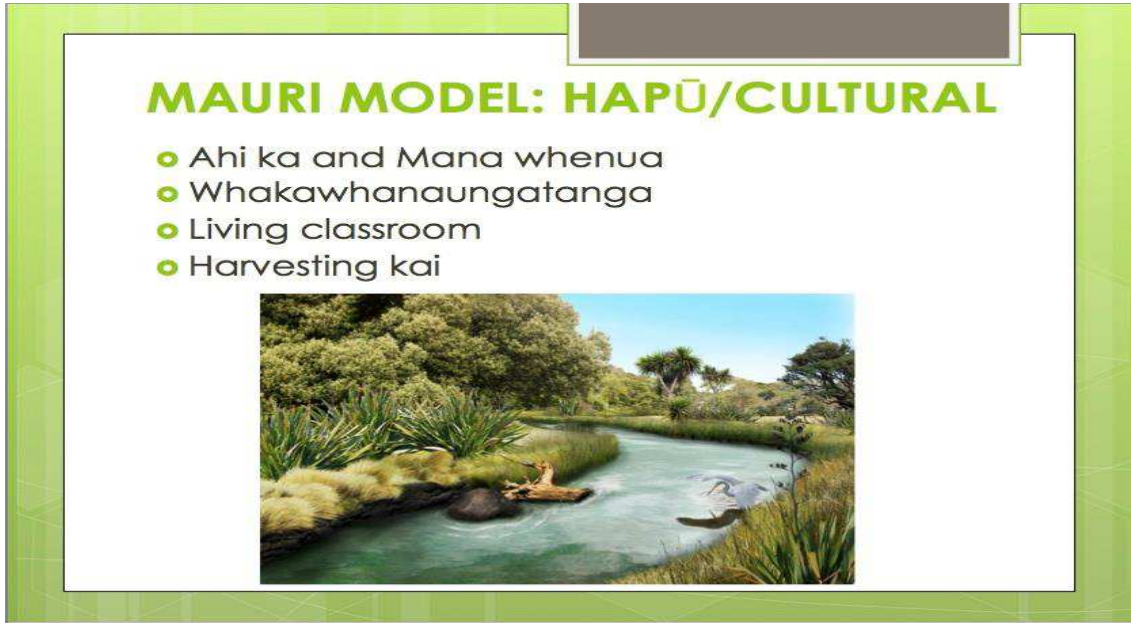
Objectives:

- Identify potential lichen propagule types and translocation methods - literature review
- Obtain baseline data – species list and planted zone habitat conditions at the restoration site
- Select reference ecosystems and target lichen species to translocate into Whenua Rangatira ecological restoration site.

Whenua Rangatira ecological restoration site

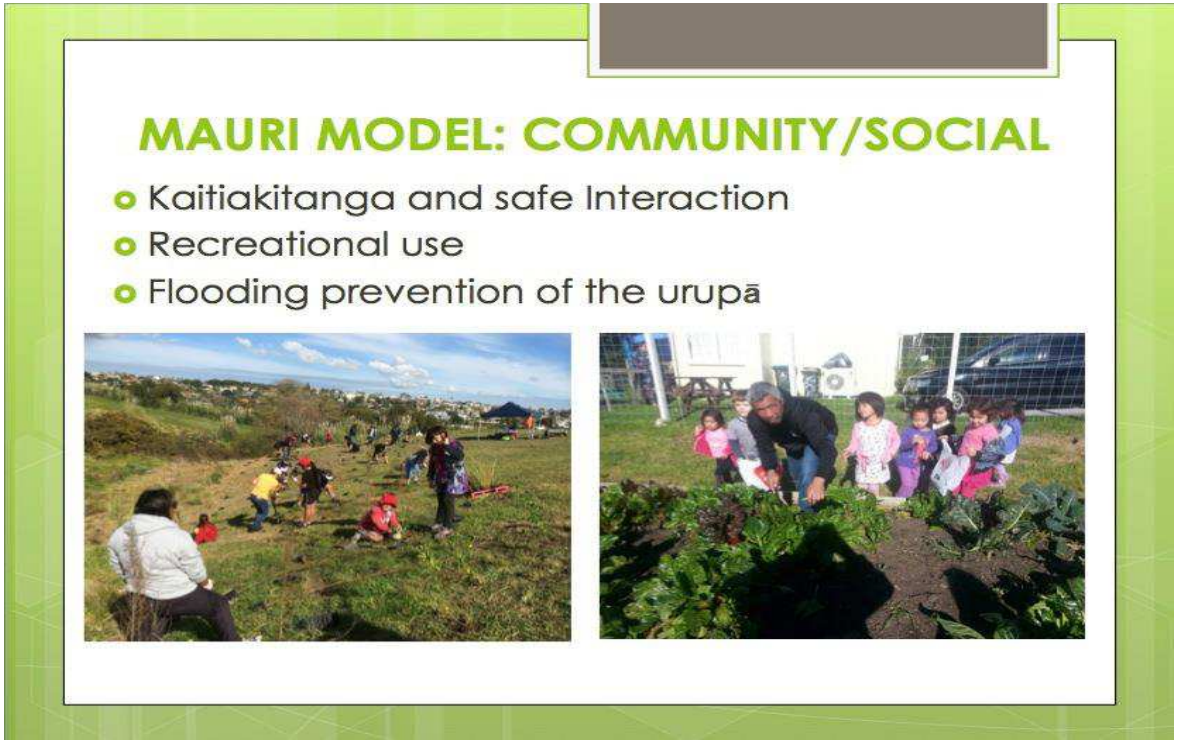
- Resource use and management was originally maintained by Ngāti Whātua
- Majority of land was lost during European occupancy and transferred to individual title instead of communal ownership
- Affected land practises – High level of degradation e.g. urbanisation, burning, livestock grazing, loss of biodiversity of plant and animal species
- Affected Health of Ngāti Whātua people – Disconnection to the land, lost sense of ancestral lineage, loss of knowledge in resource management

Whenua Rangatira ecological restoration site



- Mauri – Life force in all living things and its capacity to support life
- Unique concept that includes people as a vital component to a healthy ecosystem
- Ko Te Pukaki – Project responsible for the restoration of Whenua Rangatira site:
  - Follows the Mauri model for ecological restoration, including organic processes
  - Connects people to the environment through participation, education and training
  - Holistic culture-scape management approach to restoration
  - Knowledge from tūpuna – plant species needed for food, medicine, resources e.g weaving.

Whenua Rangatira ecological restoration site

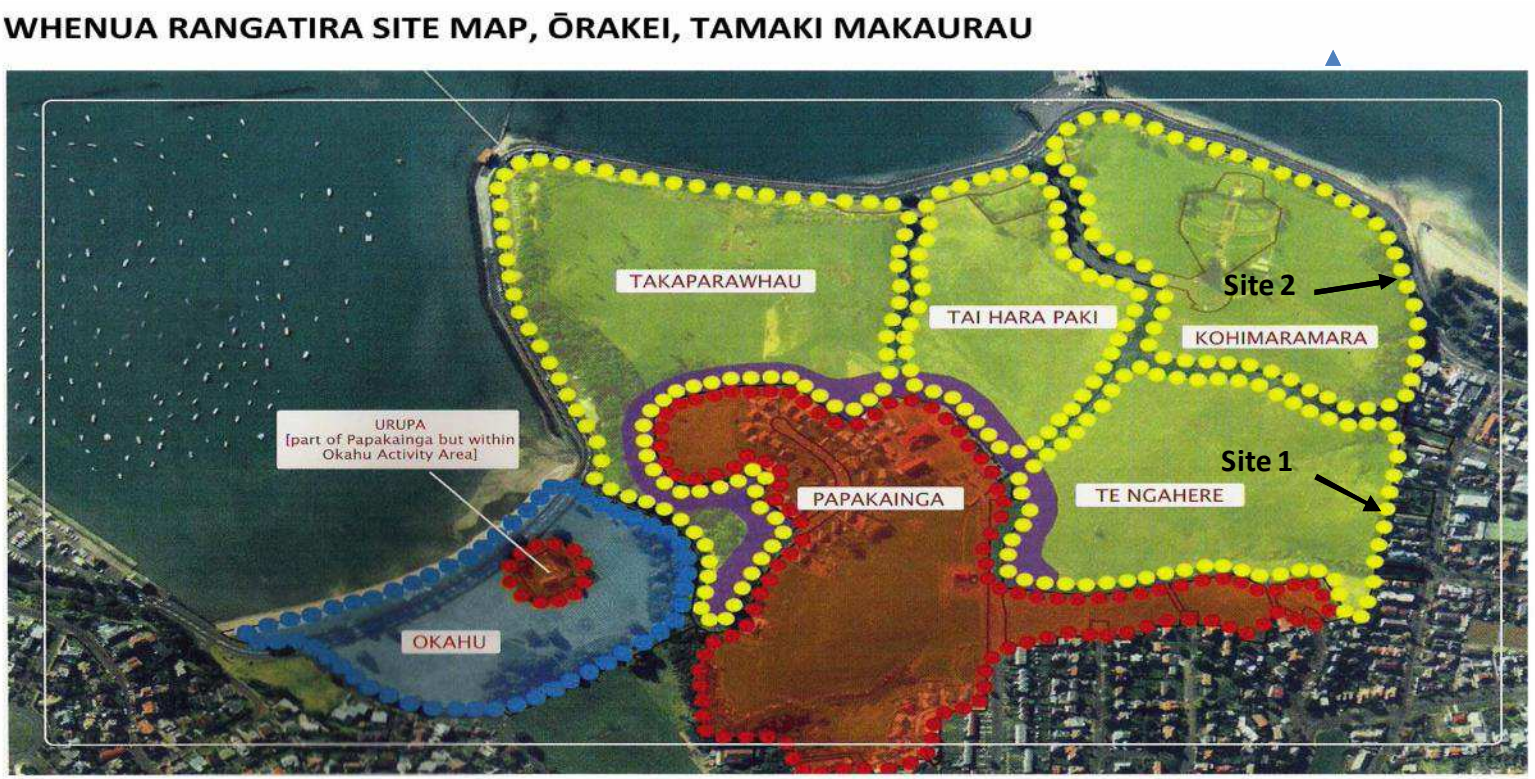


Ecological restoration plan achievements:

- People reconnected through community planting days, social events and education
- Over 200,000 trees planted, that whakapapa (eco-sourced) from an onsite nursery
- Planting zones established, ranging from 2-15 years, and is ongoing
- Biodiversity focus is including more research to address missing ecosystem components
- Lichen translocation research is one method to reintroduce missing species that once may have been there

Translocation target sites

Selected sites concentrated on the oldest planted zones with established continuity of suitable tree substrates to support lichen survival



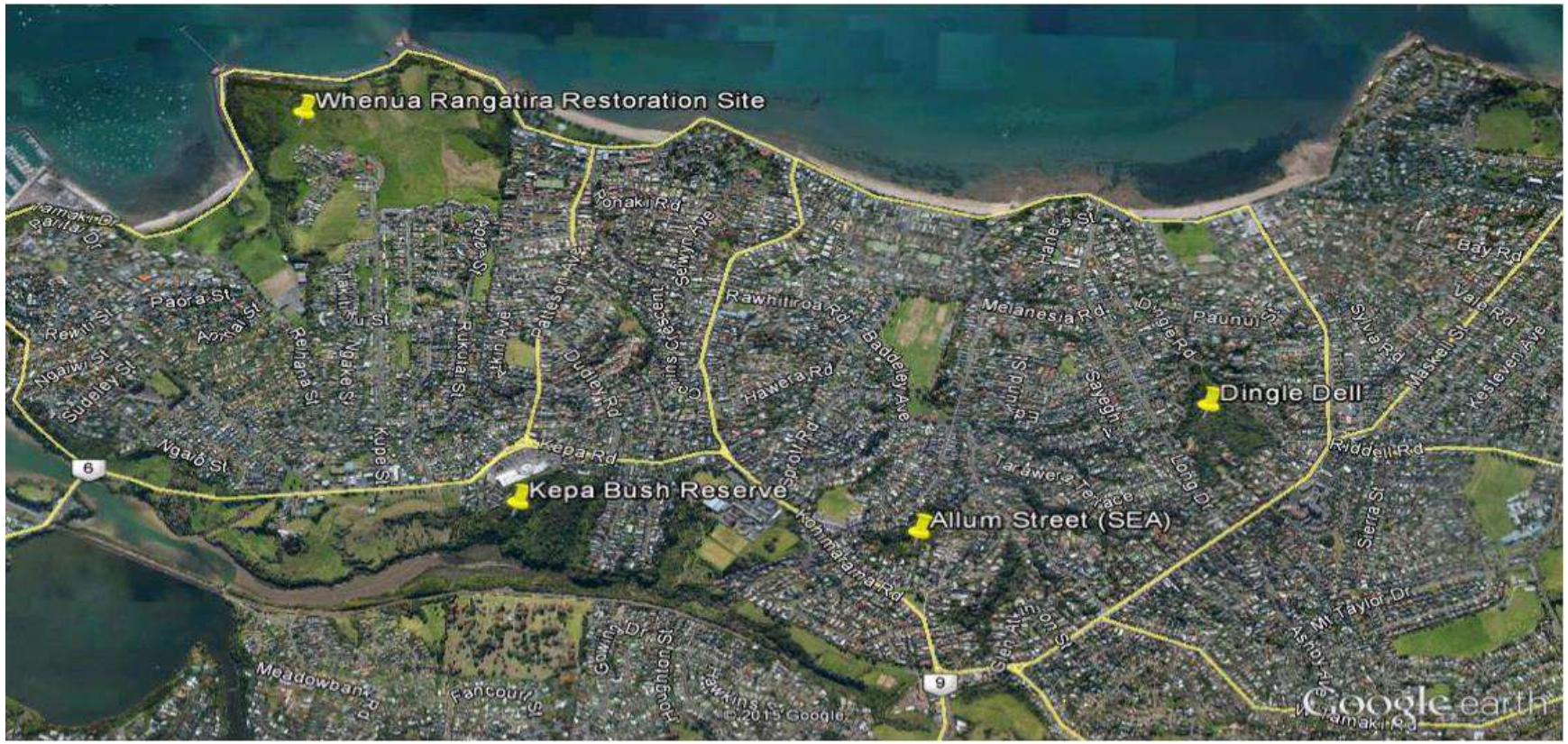
Translocation Site 1 – Te Ngahere

- lower gully bordering a waterway
- Conditions - moist, shaded with plenty of light gaps

Translocation Site 2 – Kohimaramara

- Cliffside zone in a drier area
- Exposed to coastal conditions
- Less light gaps

Reference ecosystem sites



- Geographical proximity
- Reference conditions closely matched the conditions of the restoration site
- Included topography, remnant existing native vegetation and soil types.
- Possible reference ecosystems for target lichen species collection

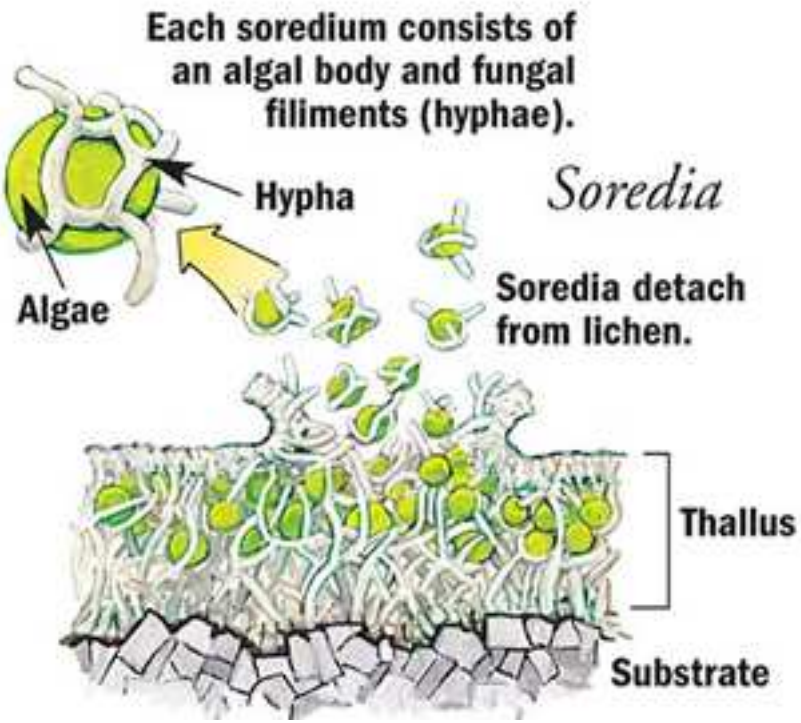
Short-listing lichen species for translocation

Crocodia aurata – lichen used in this study

- Lichen species lists compared from surveys of the restoration site and reference ecosystem sites
- Final selection based on species, absent from the restoration site, but present through the reference ecosystem sites
- 14 species were identified within all three reference ecosystems
- Selection narrowed down to corticolous (bark dependent) species, with vegetative reproductive propagules
- Available ecological information for species (Galloway, 1988)

Translocation methods – propagule type

- Asexual diaspore translocation selected for propagule type trial (to reduce negative effects on collection sites)
- Soredia propagules are clonal reproduction structures, that can be used to establish new populations (Scheidegger et al., 2009).
- Soredia scraped off the thallus of freshly fallen material collected within reference ecosystems
- Used thallus parts, while not part of the study, were attached to a pohutukawa tree and monitored



Translocation methods - attachment

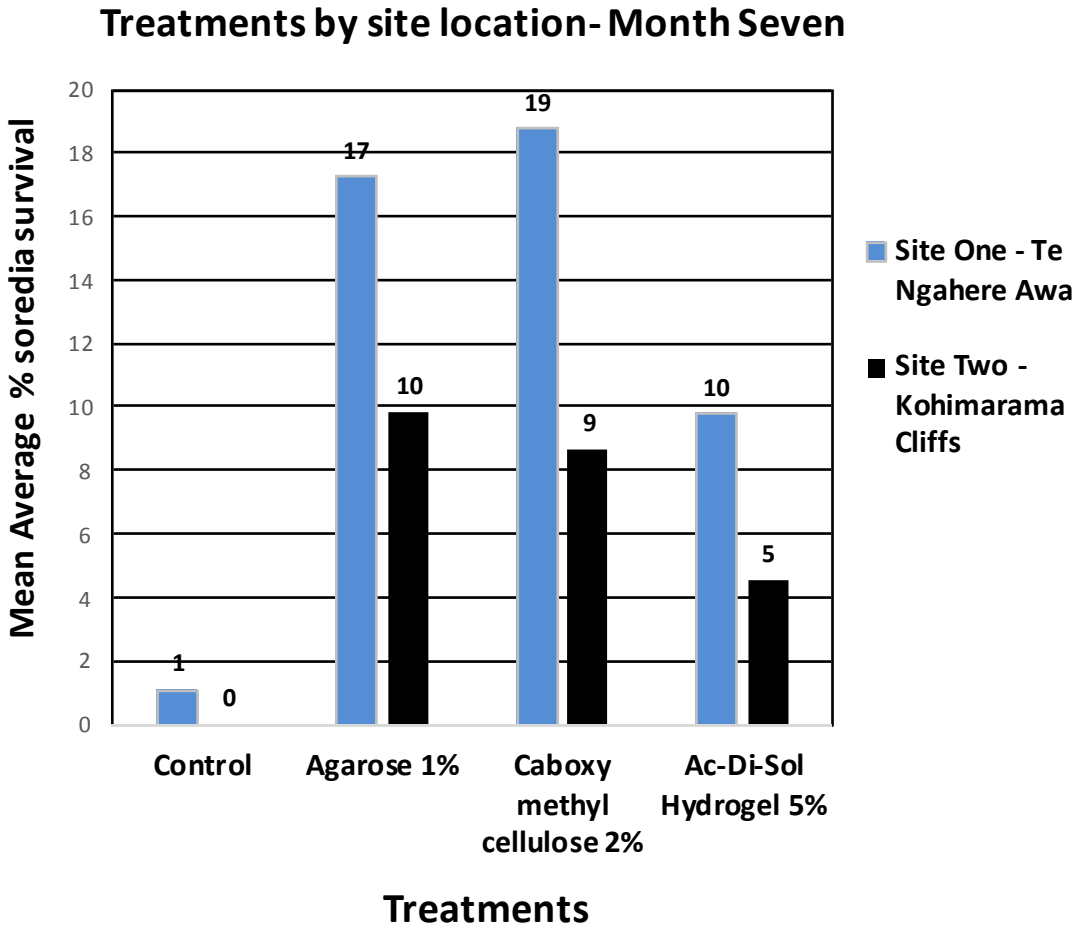
- Double sided 10x10mm surgical gauze squares used as an artificial dispersal method
- Soredia applied to three adhesive gel solutions:
  - Agarose 1%
  - Carboxy-methyl cellulose 2 %
  - Ac-Di-Sol Hydrogel 5%
- Polymer waterproof adhesive used to attach prepared gauze packets, by the corners
- 100 gauze packets placed over two site locations
- Gauze packets applied to North and South aspects of ten cabbage trees

Results – propagule loss

- Major loss of propagules, through displacement, occurred within the first two weeks of placement:
  - Rain washout
  - Lack of hyphae development

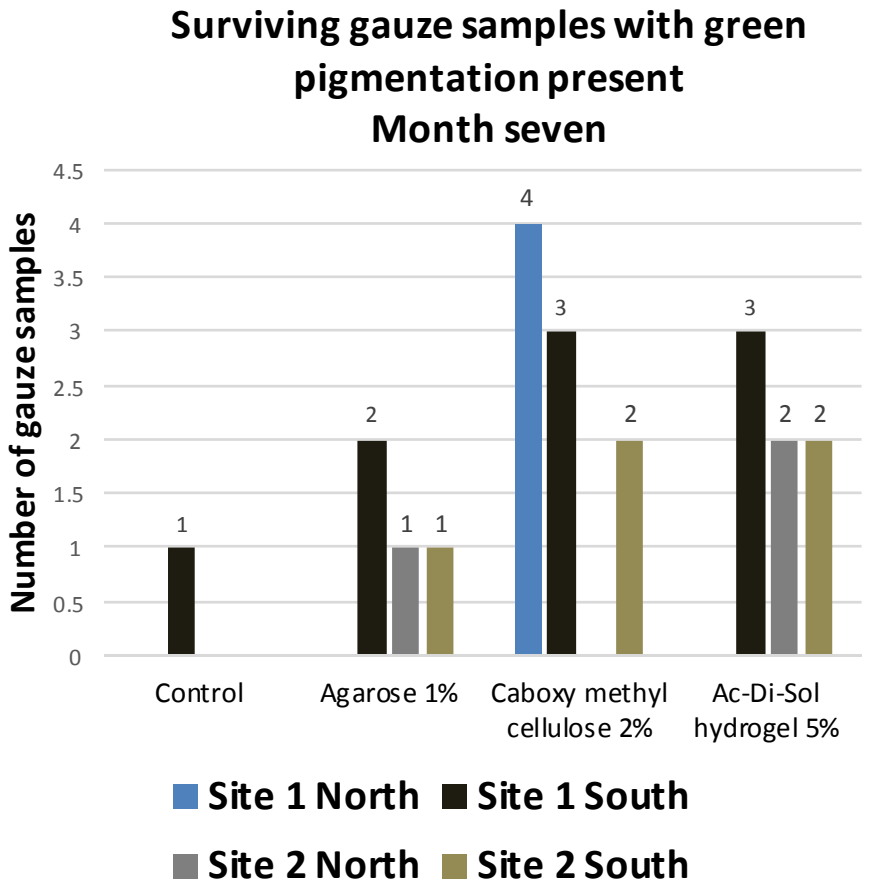
- Highest losses occurred within the controls (soredia only, no gel) :
  - Week 2 - 9% site 1, 11% site 2, remained
  - Month 7 - 1% site 1, Nil at site 2, remained

- Carboxy methyl cellulose 2% and Agarose 1% treatments had the highest propagule survival rate across both site locations



Results – propagule vitality

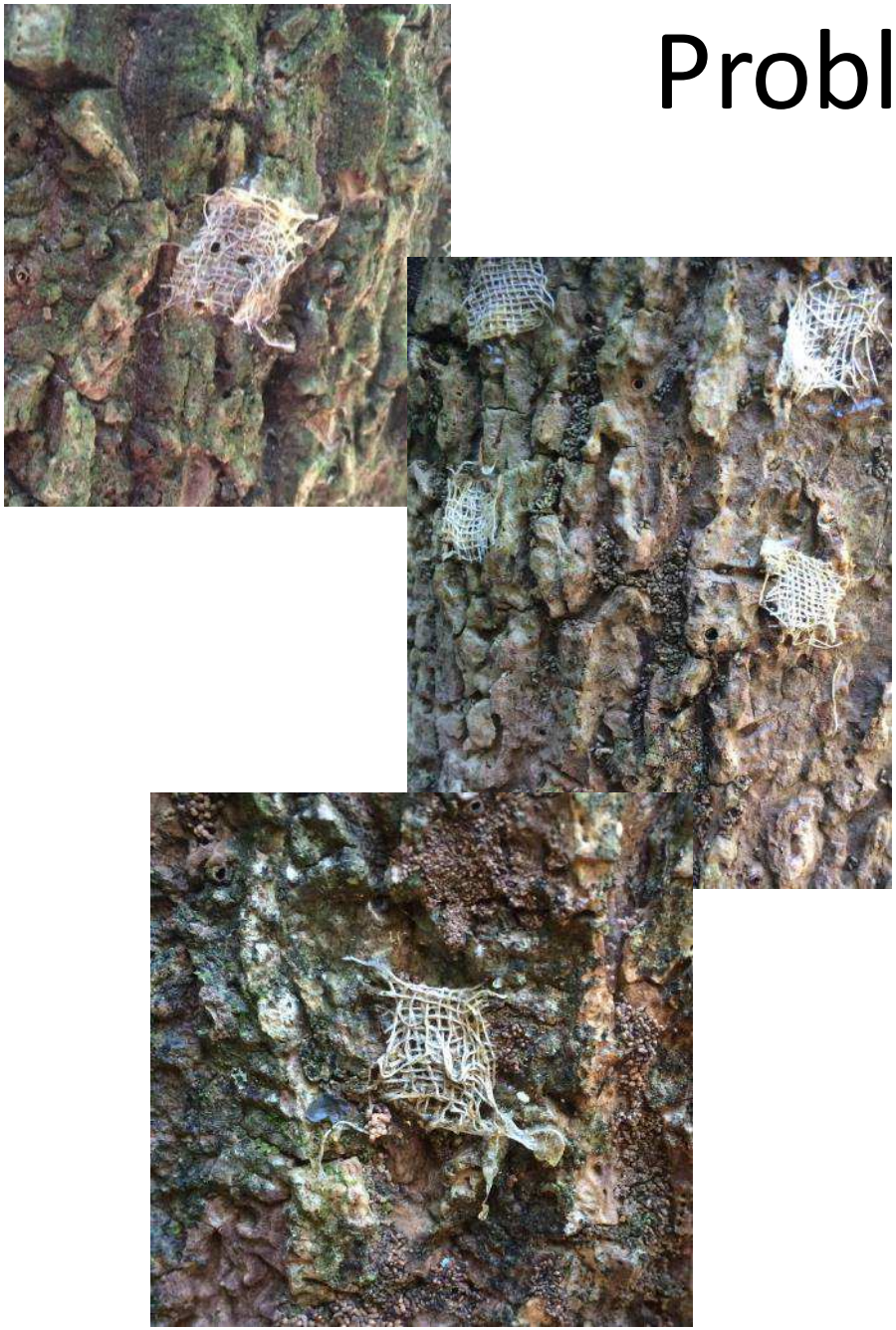
- Swelling of soredia occurred in the first month on the North aspect of site 1:
  - No controls (soredia only) swelled
- Surviving soredia displayed green pigmentation in the fourth month:
  - 13% of samples, mostly South aspect, site 1
- Green pigmentation in surviving soredia after seven months:
  - 26% of samples, mostly South aspect over both sites
  - Highest presence in Carboxy methyl cellulose 2% treatments



Possible positive results

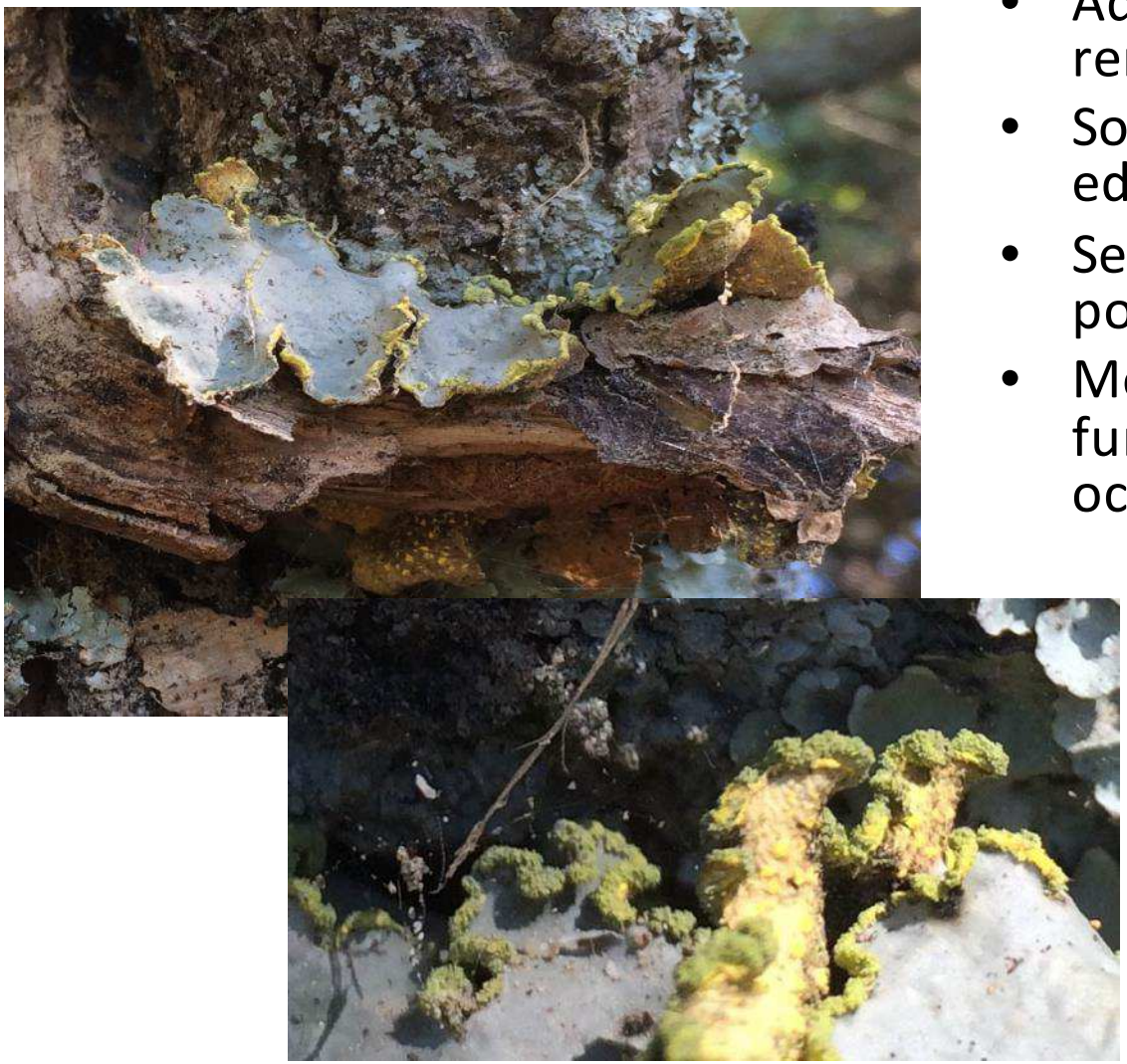
- *Crocodia aurata* lobe or invader species?
- Presence of small lobule appeared at six months on a Carboxy methyl cellulose sample at site 1
- To early to positively identify as *Crocodia aurata*
- Signs of marginal yellow pigmentation present, which is consistent with *Crocodia aurata*

Problems



- Invertebrate damage – direct predation from mites, weevils, snails.
- Invertebrate damage – indirect effects of wood-boring invertebrates
- Competition from other lichens and bryophytes

Results – whole thallus



- Adult thallus fragments remained healthy.
- Soredia regrew on scraped edges of thallus.
- Several thalli survive on the host pohutukawa tree at site 2
- Monitoring continues to see if further dispersal via soredia occurs.

Interim conclusions

- The use of surgical gauze packets was an effective artificial dispersal method for propagules between the reference ecosystems and the restoration site
- Adhesive gel solutions did increase the level of immobilisation and fixation of soredia, compared to the control
- Carboxy methyl cellulose 2% solution had the highest performance in propagule survival and vitality across both site conditions
- Whole thalli are faster than using soredia, but may not be suitable if source populations are rare.

Acknowledgments and references

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