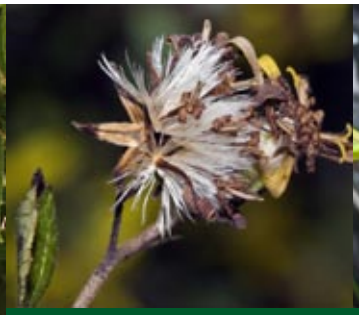
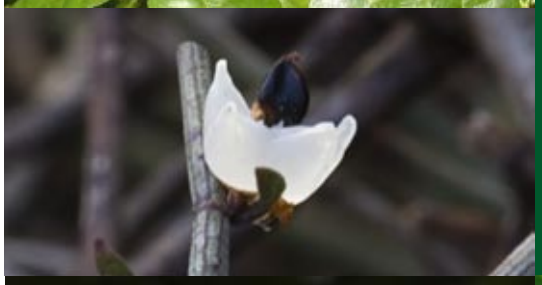



PROPOSAL FOR A SEED BANK FOR NEW ZEALAND'S THREATENED SEED PLANTS





Prepared by Phil Knightbridge
for the
New Zealand Plant
Conservation Network

June 2006

PROPOSAL FOR A SEED BANK FOR NEW ZEALAND'S THREATENED SEED PLANTS

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Cover photos (clockwise from bottom left): *Astelia chathamica* (Geoff Walls); *Acaena pallida*, *Corokia macrocarpa*, *Muehlenbeckia ephedroides* (Jeremy Rolfe); *Streblus banksii* (John Smith-Dodsworth); *Brachyglottis sciadophila* (Jeremy Rolfe); *Carex dolomitica*, *Myrsine argentea* (Simon Walls).

Main image: *Pittosporum dallii* (Simon Walls).

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BOXES

SUMMARY

I*n situ* conservation is the best way to conserve biodiversity and should remain the prime focus of threatened plant work.

E*x* situ conservation can contribute to securing species from extinction. A seed bank should be established for New Zealand's threatened seed plants with the primary objective of insuring against species extinctions.

Establishment of a seed bank for New Zealand's threatened plants would implement objective 4.1 c) of the New Zealand Biodiversity Strategy (for seed plants) and target 8 of the Global Strategy for Plant Conservation.

The Margot Forde Germplasm Centre is the obvious site for the development of a seed bank for New Zealand's threatened seed plants. The cost of adding native species to the existing seed bank would be relatively low (around $15K per year) and the facility already has relatively secure long-term funding.

In addition an access and benefit sharing agreement with the Millennium Seed Bank Project should be considered. This would both act as a back up in case of loss of material and provide a source of scientific information about seed banking wild species.

Once a threatened plant seed bank is established the need for a designated person to undertake collections should be assessed.

BACKGROUND

Throughout the world it is generally recognised that some form of *ex-situ* conservation is needed to insure against loss of species (e.g., Given 1994; Smith 2006). Principle 8 of The New Zealand Biodiversity Strategy (NZBS; Anon 2000) recognises this for New Zealand in stating that:

> *"Biodiversity is best conserved in situ by conserving ecosystems and ecological processes to maintain species in their natural habitats. Ex situ measures will be important to support the conservation of some species."*

About 9% of New Zealand's approximately 2300 vascular plant taxa (species and subspecies) are threatened with extinction, with a further 21% regarded as at risk (de Lange *et al* 2004). At present there are insufficient resources to secure all of these taxa from extinction in their natural habitats. In addition large-scale environmental change, such as that predicted to occur with global warming, could lead to many currently at risk or even non-threatened taxa becoming threatened with extinction in the future.

New Zealand's seed plants comprise the bulk (about 92%) of New Zealand's vascular plant taxa. Seed bearing plants are well suited to *ex situ* conservation in the form of long-term seed storage, commonly referred to as seed banking. Seed banking takes advantage of the fact that plants produce seed in quantity and the natural ability of many seeds to remain dormant in order to survive periods where environmental conditions are not suitable for germination.

The value of seed banking is well recognised by New Zealand's agricultural sector. Indeed New Zealand's Biodiversity Strategy notes that the long-term funding secured for the Margot Forde Germplasm Centre, which maintains collections of grassland plants, *"can be likened to the premium paid on the insurance policy for a sustainable grassland industry for New Zealand."* The same argument can surely be applied to the conservation of New Zealand's threatened seed plants.

This paper seeks to confirm the need for a long-term seed storage facility for New Zealand's threatened seed plants and identify options for the development of this facility.

SEED BANKING PROCEDURES

Of the 9000 plant species worldwide whose seed storage characteristics are known, over 90% are thought to have desiccation tolerant ('orthodox') seeds. Many of these are expected to remain viable in storage for at least 200 years. Species that can't have moisture content reduced to a level suitable for seed banking have so-called 'recalcitrant' seed (Hong et al 1996). The unknown proportion of New Zealand's seed plants with recalcitrant seeds would not be able to be seed banked and living collections would be the obvious *ex situ* conservation option for these taxa. There is a substantial literature on seed banking (e.g., Linington 2003), and the basic procedures are summarised in Box 1.

THE NEED FOR A SEED BANK FOR NEW ZEALAND'S THREATENED SEED PLANTS

One hundred and twenty of New Zealand's described seed plant taxa are listed as acutely threatened (de Lange *et al* 2004). A further 94 are chronically threatened and 496 are at risk. There are likely to be more threatened seed plant taxa within the approximately 200 vascular plants that require their taxonomic status to be clarified. I*n situ* conservation programmes are underway for some but not all taxa. Given this, *ex situ conservation* for New Zealand's threatened seed plants clearly has a role to play to insure against loss of both species and genetic diversity within these species (Box 2).

E*x situ* conservation programmes to date include maintaining threatened plant populations in living collections in Botanic Gardens or more novel sites such as traffic islands. However a workshop at the New Zealand Plant Conservation Network's 2005 meeting noted that the contribution of *ex situ* conservation efforts is hampered by the lack of documentation on which species are grown where. Another problem with living collections of plants is the potential for closely related species to hybridise (see Box 2). A seed bank for New Zealand's threatened plant taxa would be a long term and relatively low cost option for insurance against species loss which avoids the risk of hybridisation.

Box 1: Basic seed bank procedures

1. **Targeting and collecting** (for more detail see Royal Botanic Gardens Kew 2006)

   Select which species to target e.g. focus on threatened species.

   Aim to collect no more than 20% of the ripe seed from up to 50 individuals

2. **Seed cleaning**

   Separate seed from the fruit it is borne in. Cleaning is necessary to reduce bulk and disease risk.

3. **Drying**

   To maximise seed longevity, most seed banks dry seeds using fairly cool conditions. To do this, the air within the drying facility or room must be chemically dried. Moisture is thus pulled out of the seed into the 'moisture-hungry' air (15-18°C and 10-15% relative humidity).

4. **Viability testing**

   Once banked, a sub-sample is tested for viability. This takes the form of a germination test because ultimately the collections will need to be grown out. Leaving aside seeds that are empty (allowance can be made for empty seeds by X-raying seeds prior to drying to determine the proportion that are empty), those that don't germinate within the sub-sample are either dead or dormant. Distinguishing between the two involves use and interpretation of the vital stain Tetrazolium. By this stage in the banking procedure, the seeds will have experienced drying and freezing. Thus if the sub-sample germinates, it can be certain that the species involved produces seeds that are capable of long-term storage.

5. **Packing and storage**

   Dry seed is packaged into airtight containers and transferred to cold rooms (-18°C or cooler with 3-7% moisture content).

6. **Maintenance and distribution for use**

   It is recommended that, sub-samples are removed from storage at regular intervals e.g. 10 years to re-test germination. A database is necessary to track what seed is stored and where. Depending on what collecting agreements permit, samples are made available in small samples for specified conservation and research programmes. 'Rejuvenation' of stored seed may be achieved by new collections from the wild or by growing plants from seed banked seed and harvesting seed they produce.

Box 2: Examples of how a seed bank could help insure against the loss of New Zealand's threatened seed plants

A*triplex hollowayi* is New Zealand's only endemic annual strand plant. It was once found on the strand line of eastern North Island beaches but is now restricted to Northland beaches. Like many annuals its populations are naturally prone to large yearly fluctuations. The causes of decline are believed to include changes of beach profiles due to land development, over-collecting by botanists, sand mining, competition from introduced strand plants, and browsing and/or mechanical damage from animals. Intensive management had increased the wild population from 2 plants in 1990 to a high of 1338 plants in 2004. In 2005 there were 627 plants. Most plants are found at just two sites, with a few at a recent naturally established third site. Despite this success, the few sites this species is found at in combination with the potential for large population fluctuations, makes this species highly vulnerable to extinction. Some insurance against extinction is provided by storing seed locally on a short term basis, but moisture and temperature are not controlled and seed longevity is unknown.

C*armichaelia prona*, once thought to be a distinct species of broom, was restricted to lake margins in the Castle Hill basin, Canterbury, but became extinct in the wild in the 1950s. Browsing by hares and livestock, and botanical collecting were the likely causes of its demise. In 1982 New Zealand botanist Andrew Purdie found one plant growing at the Edinburgh Royal Botanical Gardens. Andrew obtained seed from this plant and returned it to New Zealand where by varied and tortuous means material made its way to the Department of Conservation's Motukarara Nursery where plants were grown for reintroduction to the wild. Although this taxon is now regarded as part of the more widely distributed C*armichaelia juncea*, the story of this plant is an excellent example of how *ex situ* conservation can insure against species extinctions. Seven of New Zealand's native brooms are acutely threatened with extinction. The hard, impermeable seed coats of brooms and other legumes make them well suited to seed banking. Eleven C*armichaelia* species retained high seed viability for up to 24 years of storage in paper bags at room temperature (Gruner & Heenan 2001).

P*achycladon* aff. *fastigiata* (CHR 279206; Chalk Range) is a very rare undescribed cress taxon from Marlborough. It can be grown by seed and tissue culture but is hard to keep alive for an extended period. The taxon is so rare that it has only been seen fruiting once. It is believed fruiting is naturally irregular but when it does occur is in profusion. Thus seed banking of some of the abundant seed available in a good seeding year would be a good insurance against extinction in the wild.

There are a suite of threatened plants restricted to a limestone outcrop at Awahokomo, Waitaki Valley. These include the gentian G*entianella calcis* var. *calcis*, the cress P*achycladon exilis*, and the grass P*oa spania*. Ongoing threats at this site include rabbit browsing and habitat modification and competition with weeds such as H*ieracium pilosella*, stonecrop (S*edum acre*) and the grass cocksfoot (D*actylis glomerata*). A recovery plan for this site has identified seed banking as insurance against the very real possibility of extinctions in the wild.

The gentian G*entianella scopulorum* is restricted to coastal headlands at Charleston. In 2001 just 16 adult (flowering plants) were known. By 2006 this had been increased to 94 adult plants largely through planting of nursery raised seedlings. Gentians are difficult to maintain in cultivation and thus *ex situ* living plant collections are not a reliable insurance against extinction in the wild.

New Zealand has eight acutely threatened coastal cress taxa (described and undescribed). Nelson's Lepidium banksii is one of the most threatened. Intensive management over fifteen years has managed to increase the wild population from 14 to 321. However these wild populations are under constant threat from herbivory e.g., by caterpillars, competition with weeds and disease such as the white rust Albugo candida. In combination with periodic droughts these threats have the potential to decimate the wild population in any given year. Maintenance of more than one coastal cress species in any ex situ living plant collection is complicated by the ability of many of the species to hybridise. As cresses are typically prolific seeders, seed banking of seed collected during favourable years would be a useful insurance against extinction.

OPTIONS FOR A SEED BANK FOR NEW ZEALAND'S THREATENED SEED PLANTS

Objective

A clear reason for the development of a seed bank is necessary in relation to the overall strategic approach to threatened plant conservation. This is particularly important to guide decisions as to what to store and how (Department of Conservation and Land Management 1998). For example, the aim should not be to seed bank the entire flora.

For New Zealand it is suggested that the **primary objective** of a seed bank should be to **provide insurance against extinctions in the wild**. Thus priority should be given to seed banking those species that are most at risk of extinction. At a minimum this would include any of New Zealand's 53 nationally critical seed bearing plant taxa that exhibit orthodox seed storage behaviour.

Secondary objectives of a seed bank for New Zealand's threatened plants could be to store seed from good seed years for use in future restoration work and to facilitate research on seed storage behaviour. There has been relatively little research on the seed storage characteristics of New Zealand's native plants (Hill 2004).

Although education and advocacy are objectives of some seed banks, it is suggested that for New Zealand at least this would be better achieved by living *ex situ* collections such as those in Botanic Gardens as the plants themselves can be seen by the public.

Location and cost

There has been a range of suggested locations for a seed bank for New Zealand's threatened seed plants. For example the Auckland Regional Botanic Gardens have attempted unsuccessfully to secure funding for a low-tech seed bank and the Christchurch Botanic Gardens had been recently exploring options. The location and basic information on New Zealand's existing seed banks is given in Box 3. A list of key seed bank contacts is given in Appendix 1.

Tasmania has recently established a Seed Conservation Centre in a remodelled part of a building in the Royal Tasmanian Botanic Gardens. The goal is to seed bank 800 species with a focus on species that are endemic, threatened, typical of threatened ecosystems, of economic and ethnographic importance or of evolutionary significance. The cost of establishment two years ago was about Aus$180,000. Given this, a conservative estimate to establish an equivalent facility in New Zealand would be about $250,000. Annual running costs plus the cost of employing at least one full time staff member would be in the vicinity of $100,000.

Significant cost savings are likely if a seed bank for native plant conservation can be linked with an existing seed bank. The Margot Forde Germplasm Centre at AgResearch's Palmerston North campus appears to offer the ideal opportunity for this. There is currently adequate space to store seed from the up to 700 threatened or at risk seed plant taxa that may have orthodox seeds. A special low temperature/low humidity drying room (15°C; 10% relative humidity) is available if it is deemed necessary to dry seed before storage. (Most seed currently stored is left to dry slowly in the walk in seed cool store). If it was found necessary to store seed at very low temperatures some additional deep freezers may be required.

The main additional costs would be staff time to complete seed cleaning, dry seed if necessary, package seed for storage, enter the collection details into a database, conduct a germination test once seed is dried and cooled and provide feedback to seed collectors on which species

required further collections. Depending on the amount of seed collected in any given year these costs are estimated in the order of $15K per year. These costs do not include the cost of initial seed collection or the costs of replenishing seed stocks (which is likely to be best done by new collections from the wild rather than harvesting seed from individuals grown from seed banked seed (e.g., see Hamilton 1994)).

Seed collection could be undertaken by a dedicated person. Funding for such a position including time and overheads would likely be in the order of $100K per year. The alternative would be for collections to be undertaken as part of other planned work. Given that many threatened plant sites are in remote, difficult to access areas, this is likely to be more efficient in the long-term. It is suggested that the latter approach should be adopted initially, but be reviewed after the first year of seed bank establishment.

It is generally recommended that there is a back up collection of seeds in case of catastrophe at the primary facility. Options for this could be the existing Crop & Food's Lincoln facility or developing an access and benefit-sharing agreement with Kew Garden's Millennium Seed Bank (Box 4).

Box 3: Existing New Zealand seed banks

Margot Forde Germplasm Centre

Located at AgResearch's Palmerston North campus. This is one of the Foundation for Research Science & Technology's (FRST) recognised *nationally significant databases and collections* and it receives funding on this basis (although current annual funding of $500K is not adequate to cover costs). It is currently the national genebank of a wide range of grassland plants, including some collections of native grass species. 64,000 packets of seed are currently stored. Herbarium specimens are lodged with the Massey University herbarium (MPN). There is likely to be enough capacity within the existing facilities to cope with the seed banking of up to 700 threatened native seed plant species. This could be achieved with relatively little extra funding given the seed bank is already largely funded and no additional building is required. There is an on-line database of seed collections.

Crop & Food

Located at Crop & Food's Lincoln campus. This is largely used for wheat and barley seed storage, but some native species such as kakabeak have been stored in the past. There is some debate whether this collection is also one of FRST's recognised *nationally significant databases and collections* but at present the seed bank does not receive FRST funding. The charge for seed storage is on a m^3 basis and would be in the order of a few hundred dollars per year per m^3.

Private Companies

Companies selling seeds maintain seed banks for shorter term seed storage. These are not likely to be suitable for long-term seed storage for conservation purposes.

Box 4: The Millennium Seed Bank Project (MSBP)

The MSBP is an international plant conservation partnership, catalysed by the Royal Botanic Gardens, Kew (RBG Kew), in the UK. Bilateral research, training and capacity building relationships are supported world-wide in order to advance the conservation of wild plant species. By July 2005 the MSSB held nearly 24,000 collections of about 12,000 species.

The MSBP currently works with over 40 partners in 17 countries, from the USA and South America to Africa, including all Australian states. These major partnerships are formalised through long-term Access and Benefit-sharing Agreements.

POLICY AND LEGISLATION RELEVANT TO SEED BANKS

There are a number of current policy documents that refer to *ex situ* conservation, or more specifically to seed banks (Box 5). In general these leave open the option of establishment of a seed bank for New Zealand's threatened plants.

The Native Plants Protection Act 1934 remains the only legislation dealing exclusively with conservation of native plant species. It poses no obstacles to the establishment of a native plant seed bank.

In 1991 a group of claimants lodged a claim to indigenous flora and fauna with the Waitangi Tribunal on behalf of a number of iwi. This is known as the WAI 262 claim after its Tribunal registration number. The scope of the claim includes the ownership and use of indigenous flora and fauna and their genetic resources, related knowledge and intellectual property rights, and their management and conservation. This claim is still in process. The New Zealand Biodiversity Strategy notes that the Strategy should not constrain the Crown's ability to provide a policy response to the claim. However, it was also noted that neither should the existence of the claim unreasonably fetter Crown policy development in the biodiversity area.

Issues such as access to genetic resources have been considered in the development of seed banks and have also been addressed in international agreements such as the Convention on Biological Diversity. For example the access and benefit sharing agreements developed by the Millennium Seed Bank recognise the sovereign rights of states over their own biological resources and the authority of national governments to determine access to genetic resources subject to national legislation. The interests of other stakeholders and rights holders, including indigenous and local communities and farmers, in biological resources and associated information are also acknowledged.

RISKS IN DEVELOPING A SEED BANK

The major risks in developing a seed bank are that it will divert resources from *in situ* conservation efforts and foster the belief that once the seeds are banked no further conservation effort is required to secure those species. This can be avoided by ensuring that the focus of a seed bank is an insurance policy against species extinction and that it is clear that it is a small part of an overall strategy for conserving plant biodiversity.

It needs to be recognised that *ex situ* collections such as seed banks are simply a sample of the genetic variation present in a species at the time the collection was made. The seed held in seed banks does not have the opportunity to evolve in response to changing selection pressures that may be acting on the wild populations (e.g. Hamilton 1994). If seed banking is to be an insurance against extinction in the wild, multiple collections over time will be required to maintain this insurance.

There is a low risk of a catastrophe at the seed bank resulting in the loss of stored material. This risk would be further reduced by the establishment of a back up collection at another facility.

Box 5: Relevant policy and strategies relating to seed banks

New Zealand Biodiversity Strategy

The most relevant desired outcomes for 2020 are from themes 1 and 4:

> *"No further human-induced extinctions have occurred. Populations of all indigenous species and subspecies are sustained in natural or semi-natural habitats, and their genetic diversity is maintained. Fewer threatened species require active recovery programmes and ex situ management."*
>
> *"In situ conservation of indigenous genetic resources is complemented by ex situ means, where necessary."*

A number of priority actions are suggested to achieve the conservation of New Zealand's genetic resources including Objective 4.1 c) for which DOC is identified as the key player:

> *"Identify significant areas of risk in managing genetic resources of New Zealand's indigenous species that are threatened or in decline (with reference to threatened species recovery programmes), and recommend how these risks can be reduced, for example through germplasm banks."*

Convention on Biological Diversity

New Zealand has ratified this convention. This Convention includes ex situ collections and the rules governing them. Policies on sovereign rights and benefit sharing such as those established by the Millennium Seed bank and the Margot Forde Germplasm Centre are based directly on the Convention.

Global Strategy for Plant Conservation

New Zealand has ratified this strategy which was presented at the Convention on Biological Diversity in April 2002. Target 8 of this strategy is that:

> *"60 per cent of threatened plant species in accessible ex situ collections, preferably in the country of origin, and 10 per cent of them included in recovery and restoration programmes;"*

Conservation General Policy

The proposal for a native plant seed bank is not inconsistent with any of the policies in this document.

ACKNOWLEDGEMENTS

This paper has benefited greatly from input from many people including Steve Benham, Warren Williams, Simon Moore, Janeen Collings, Shannel Courtney, John Barkla, John Sawyer, Tom Myers, Sam White and Nick Singers.

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APPENDIX 1: KEY SEED BANK CONTACTS

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