

Expansion of the Redwood Seed Collection Programme.

PROGRAMME COMPLETION REPORT TO THE SMALL & MEDIUM
ENTERPRISE COMMITTEE, FOREST GROWERS LEVY TRUST BOARD.

29 June 2023

Project Objective

To investigate seed production in various coast redwood (*Sequoia sempervirens*) stands, where possible of known genetic origin, and collect seed to meet the recent significant increased demand for redwood tree-stocks.

Background

Clonal redwood tree-stocks take up to two years to produce and the increased demand for establishing redwood has to be met, in the short term at least, from seedling production. Most redwood seedlings in recent years have been grown from seed imported from California. This can have several disadvantages:

- Most regular imports to NZ are from Zone 97, in the southern part of the range, where some stands seem to produce seed more frequently. However, this seed is considered less suitable for New Zealand conditions than seed from the northern part of the range, due both to latitudinal differences and to evolutionary differences. Terpene analysis indicates that the southern population was founded by a colonizing population different from those that founded the northern and central populations. (A copy of the Seed Zone map for Northern and Central California is presented as **Appendix One**.)
- Seed production from natural Californian stands is very infrequent. Pickable redwood cone crops in the northern part of the range occur on a frequency of about every seven to eight years and in the central and southern parts of the range, cone crops occur less frequently and, when they do occur, far fewer cones seem to be produced (J Rydelius, *pers.com*.)
- There is increased local demand for scarce seed, especially in the northern part of the natural range, as Californian foresters convert stands of other species, such as Douglas fir, to coast redwood, for increased economic returns; and due to redwood being planted beyond its natural range further north in southern Oregon.
- Seedlings from imported seed are prone to 'damping off' and botrytis fungal diseases as they are not adapted to New Zealand pathogens. Nurseries report recoveries as low as 50% from imported seed compared to negligible losses from NZ sourced seed. However, the current season has been so wet and humid that even NZ landrace seedlings are contracting Botrytis.
- There is often not the same level of quality selection applied to seed collection in California.

New Zealand seed collection records indicate that large volumes of seed were imported into New Zealand in the late 1920's. These are supported by annual reports of The Pacific Lumber Company (TPL) that record a total of 2,048 pounds of redwood seeds was sold to

New Zealand between 1924 to 1927 (J Rydelius, *pers.com.*) These collections were made on TPL lands in the vicinity of Arcata, Humboldt County, and any remaining stands established from this seed represent a valuable genetic resource for New Zealand. Similar records show that large volumes of redwood seed were also imported through agents in San Francisco during the late 1920's for planting at Golden Downs in the South Island.

A coast redwood "provenance trial" was established in 1981 in Rotoehu Forest with seedlings from eight seedlots provided by Bill Libby, Emeritus Professor of Forestry, UCLA, Berkeley, plus one seedlot from the 1901 Whakarewarewa (Whaka) Forest stand. Three seedlots were from Humboldt County (northern zone), including control-pollinated seed from the Simpson Timber Company; one seedlot from Mendocino County (middle range), although from one mother tree only; and four seedlots from the southern range. Earlier assessment of the trial (Vincent & Low 2001) indicated that the Whaka seedlot appeared to be in-bred, suggesting that the seed source of the Whaka stand was likely to have come from just one, or few, parent trees. Thinning of the Rotoehu stand in about 2003 aimed to favour well performed trees in order to produce a potential source of outcrossed, inter-provenance "hybrid" seed. Thinning favoured trees from the northern zone (about 69%).

In the early days of Soper Wheeler's operations in New Zealand, various seed collections were brought into New Zealand, originating from the northern part of the natural range, plus from the Simpson Timber Company's (STC) Anderson Seed Orchard. This seed orchard is located in the northern Sacramento Valley some 150 miles east of the natural range of redwoods in California, in order to promote cone production and isolate it from other redwood pollen. The ramets in that orchard were from among the first 20 to 30 "plus" trees selected from young growth redwood forests belonging to STC and other forest owners located in Humboldt and Del Norte Counties. Seed from the Anderson Seed Orchard has been used to grow seedlings that have been established in stands owned by The New Zealand Redwood Company and also for clients of NZ Forestry Limited during the early 2000's.

Occasionally, seed imported by ProSeed has come from locations that offer a valuable genetic resource for New Zealand breeding programs. An example are the stands located on Collins' property adjacent to Lake Ohakuri in the Central North Island, established in 1998 from seed collected from Mad River, Humboldt County.

Robert Appleton, of Appleton's Tree Nursery, Wakefield, has arranged seed collections from suitable locations in California.

The Sequoia Action Group (SAG) of the New Zealand Farm Forestry Association (NZFFA) carried out a limited seed collection operation in autumn 2022, using experienced qualified arborists. The 2022 operation targeted trees of superior growth and form in four North Island stands. We now have wood quality information from NIR analysis of core samples

taken from ‘plus’ trees in these stands and seed collection can now focus on these trees to provide an additional level of tree improvement.

Funding assistance has enabled the Sequoia Action Group (SAG) to increase the quantity of seed collected from known stands and to identify other redwood stands throughout the Country that are producing cones, thereby increasing the availability of seed. Numerous stands were identified and inspected for the presence of cones using the experienced arborist crew used by SAG in 2022 and where cones were present, they were collected, with priority given to “plus” trees.

Cone collection was carried out in April 2023. Cones were then dried on racks to extract the seed, which was then cleaned using a range of sieves of various mesh sizes.

Results

The Rotoehu provenance trial has been inspected for cones for the past two years and no cones were evident. The Rotoehu site is regarded as a particularly benign site, not noted for cone production. Archive material collected from some of the Rotoehu trees were propagated as mature cuttings, or grafts and these clones have been relocated to the Amberley seed orchard. To date only a few cones have been produced but the quantities were too small to consider collecting.

No cone production has yet been observed on stands established in the early 2000’s from seed imported by the Soper-Wheeler Company; nor from the 1998 established stands at Lake Ohakuri, or from stands grown from seed imported by Robert Appleton.

Details of the older stands inspected, together with relevant comments and the weight of cones collected, are presented in **Table One**.

Three stands, one located in Hawkes Bay (Holt Arboretum), one at Manutahi, northern Tairāwhiti, and the 1922 established Taumarunui stands, were unable to be inspected due to access issues resulting from Cyclone Gabrielle.

Two 1935 established stands in the Wairarapa, located in areas administered by the Department of Conservation, were unable to be inspected due to a general lack of cooperation by DOC officials and the Iwi contact details required for access permission were received too late for cone collection to be considered. These stands were of particular interest as they were established from a genetically diverse large importation of seed from Pacific Lumber Company lands in Humboldt County, northern California.

Only seven of the fifteen stands inspected had trees that had produced cones. One stand (Rongoiti Gardens, Taihape) had produced cones in 2022, but no cones were evident in 2023. The Te Wera stand had spent cones from previous years evident in the litter,

indicating the likelihood of cones being present in the upper crown, but there was insufficient time to arrange collection by the experienced arborists. Other arborist companies in the Region were not interested in climbing 50-metre-high redwood trees!

Access to the Homebush property in Canterbury was too late to collect cones this year. Spent cones were present and a small quantity of seed was collected from sweepings for germination testing. The stand will be targeted for an earlier collection next year.

Table One: Collection Summary of Stands Inspected.

Site	Comments	Cones (kg)
Taihape Reserve	Present and abundant.	27.0
Rongoiti Gardens.	None present, although last year's cones present on some trees. Reinspect in 2024.	0.0
Redwood Park, Te Kuiti.	Present in average numbers.	5.3
Skyline, Rotorua.	Present in average numbers.	4.8
Hodgson, Glen Massey.	Abundant on younger poorly sited stand (wind exposed) but absent on older, better stand.	20.0
K Wright, Fleming Rd, Rotorua	Absent in old stand superior stand, present in younger stand - edge trees. Bulk grade only.	9.5
Carrington, Oropi, BoP.	Absent. Worth reinspecting when stand is older.	0.0
Tairua Forest, Whangamata	Outstanding trees, but cones absent.	0.0
Wairenga-o-kuri, East Coast	None present this year, although last year's cones present on a few trees.	0.0
Ross Estate, East Coast	Absent in young clonal stands. Genetics of older stand too poor to consider collection.	0.0
Te Puia, East Coast	Outstanding old trees, but cones absent.	0.0
Wharerata Forest	No sign of coning.	0.0
Weytman, Knapdale, Gisborne	Shelterbelt. Cones collected from two superior trees, being tested for viability separately.	2.0
Te Wera Forest, Taranaki	Some cones present, but no sufficiently skilled arborists available in time to collect them.	0.0
Homebush, Canterbury	Very old stand. Cones present, but largely blown. Target for bulk collection next year.	0.2
	TOTAL	68.8

Derived weight. Some shed seed collected from sweepings under trees.

The first four stands listed in Table One were the source of seed collected by the Sequoia Action Group in 2022 and were the source of seed collected by some SAG members over a decade ago. 'Plus' trees in these stands had been sampled by increment coring in 2022 to determine heartwood durability by NIR analysis. For the 2023 collection, those plus trees displaying low heartwood mass loss (high durability) provided seed classed as "Climbing Select Plus". Seed from plus trees that did not meet the durable heartwood standard, together with plus trees from other stands yet to be evaluated by NIR analysis, provided seed classed as "Climbing Select". Edge trees together with those stands with trees of generally poor form provided seed classed as "Bulk".

The quantity of seed extracted and cleaned is presented in **Table Two**. This represents an 18.2% seed weight to cone weight, a little higher than the 16.3% recovery in 2022.

Table Two: Seed Weight by Quality Rating.

Seed Quality	Quantity (kg.)
Bulk	4.1
Climbing Select	4.3
Climbing Select Plus	4.1
Total =	12.5

The seed will be allocated to various nurseries to be contract grown for the Sequoia Action Group to be marketed to various redwood growers.

A trial was carried out by SAG using a drone in Redwood Park, Te Kuiti, to attempt to identify those trees with cones present in the upper crown. This proved unsuccessful as the drone's camera lens was too wide angled to provide adequate definition. As a result, all tree inspections, and cone collection when cones were present, were carried out by suitably qualified arborists.

More recently, an evaluation of various drones and cameras has been conducted on redwood trees by the UAV team at Scion. The three drones that were used were a Mavic, a Phantom P4 and a Matrice M300, with cones observed in all cases. However, one of the issues in using drones in a stand is that it is often difficult to identify the correct tree that the drone is observing. Nevertheless, the use of the right type of drone will be more cost efficient than having arborists climb trees to determine whether cones are present in the stand or not, despite possible difficulties of identifying individual trees.

Discussion

The number of stands of mature trees producing cones was disappointing resulting in a lower than anticipated quantity of seed collected.

Collection was primarily focused on "plus" trees and often these trees either had no cones present, or in lower numbers than non-select trees. Hence a greater quantity of seed could have been collected by concentrating efforts in the available time on sub-dominant and edge trees, but at the expense of quality.

As a general observation, once redwood trees in New Zealand begin producing cones, they continue to produce them almost every year, but in varying quantities due to various undetermined edaphic and climatic factors. This seems to contrast with patterns in the natural range, where cone production is less frequent. The absence of cones in the Rongoiti

and Wairenga-o-kuri stands this year, when there was coning last year, suggests that 2023 was a poor year for cone production.

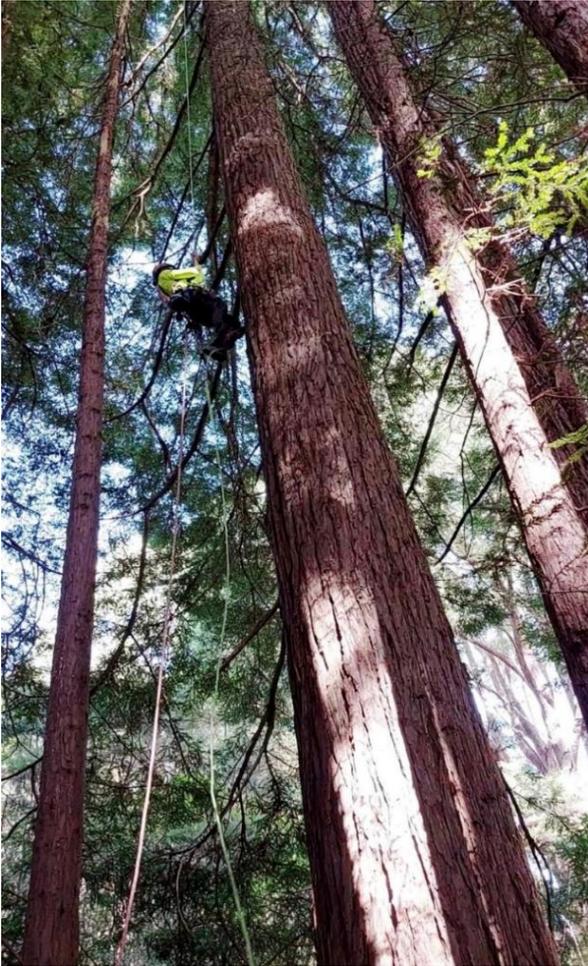


Figure One: Arborist in action in the Te Puia stand, Tairawhiti, established in the 1930's. There were no cones present.



Figure Two: 1934 Established stand at Opoutere, Tairua Forest. There were no cones present. Recent flooding through the stand had no impact on the stability of the stream banks due to the redwood roots.

The fact that cone production in seed orchards is promoted by placing trees under stress (e.g., locating orchards on dry sites and withholding water to induce stress), it is understandable that cone production will be absent, or at least minimal, in well-sited stands. The 42-year-old Rotoehu Provenance Trial is an example. However, it seems surprising that stands 80-to 100-year-old stands, such as at Te Kuiti and Taumaranui (not inspected this year), in areas regarded as highly suitable for redwood, produce cones whereas similarly aged stands in the Rotorua area (K Wright property and Fish & Game, Paradise Valley), at Tairua and on the East Coast (Te Puia) do not.

I am aware of anecdotal evidence that natural stands that are flooded periodically will produce abundant quantities of seed the following season. Jim Rydellius (*pers.com.*) has commented to me that he has observed such an event in an area of the Eel River, where sediment from flooding has starved the roots of oxygen. Perhaps the more frequent cone production in New Zealand is promoted by seasonally high soil moisture levels, which is uncommon in California where redwood grows in low rainfall climates and obtains most of its moisture through its foliage from summer fogs. If there is any substance to this hypothesis, then perhaps there will be prolific cone production next season in parts of New Zealand subject to recent high rainfall and flooding.

A handwritten signature in black ink, appearing to read 'R.H. Webster', written in a cursive style.

R.H. Webster B.Sc., B.For.Sc.(Hons), FNZIF
Chair, Sequoia Action Group, NZFFA.

29th June 2023.

Appendix One: Seed Zone Map of Northern California.

- Del Norte County —>
- Humboldt County —>
- Mendocino County —>
- Sonoma County —>
- Marin County —>
- SAN FRANCISCO —>
- San Manteo County —>
- Santa Cruz County —>
- Monterey County —>

