Science Saving Rainforests: restoring genetic diversity to 60 tree species of the critically endangered Big Scrub rainforest

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The Science Saving Rainforests (SSR) Program is a large landscape-scale multi-species restoration project that aims to address the lack of genetic diversity in the remaining patches of Critically Endangered *Lowland Rainforest of Subtropical Australia* (LRSA) (EPBC Act 1999), with a particular focus on the small isolated remnants of the Big Scrub Rainforest in North-eastern New South Wales (NNSW). Long term outcomes from the SSR Program will include the production of genetically-diverse planting stock for 60 LSRA tree species for use in restoration projects that will increase adaptive potential and resilience to future threats such as predicted climate change conditions, new pests and emerging diseases. This novel project was launched in 2017 by Big Scrub Rainforest Conservancy (BSRC), in partnership with the Research Centre for Ecosystem Resilience (ReCER) team at the Botanic Gardens of Sydney (BGS), Dr Robert Kooyman, Firewheel Rainforest Nursery and Big Scrub Foundation.

The Big Scrub, a rainforest under threat

The Big Scrub Rainforest was once the largest 75,000 ha contiguous expanse of Lowland Subtropical Rainforest located between the modern-day towns of Ballina, Byron Bay and Lismore. Tragically, the cedar getters of the mid-1800s commenced the demise of the Big Scrub as they extensively logged Red Cedar (*Toona ciliata*) from the pristine rainforest. This, coupled with new settlers moving to the area in the mid- to late-1800s, who were required by government regulation to clear the rainforest to obtain freehold title, reduced the Big Scrub to ~1% of its former glory, resulting in c. 80 small isolated remnant rainforest patches across a now heavily fragmented landscape.

Fast forward to the early 21st Century, the remaining Gondwana-descended Big Scrub rainforest remnants host an incredibly rich biodiversity, supporting more than 400 plant species (including 38 threatened flora species) and a broad variety of animals (including 61 threatened fauna species). For some plant species in the Big Scrub remnants, only a small handful of scattered individuals persist, significantly reducing the long-term capacity for successful cross pollination and reproduction as well as increasing the likelihood of inbreeding and the associated deleterious impacts of inbreeding depression. Without our help, the magnificent Big Scrub rainforest, with lineages dating back more than 200 million years, will quietly slip away.

Genetic rescue to the rescue!

To restore genetic diversity to the 60 rainforest tree and woody plant species that are included in the SSR Program (*i.e.*, 30 key structural species which make up the canopy and other key structural components of the rainforest ecosystem plus 30 threatened species), we are using the latest genome science to inform us of the individual trees or populations from which to collect propagule material that will capture 90% of a species' genetic diversity in the NNSW genetic neighbourhood. Propagated material will be ultimately planted in a Living Seedbank Plantation to facilitate within species cross pollination and produce genetically-diverse seedstock which will be used in future lowland rainforest restoration projects. This genetic rescue approach will reunite local gene pools that were previously connected up until c. 150-200 years ago, assisting gene flow within species across the landscape and helping improve species' reproductive fitness and adaptive potential. The multi-species strategy used in the SSR Program enhances the long-term outlook for the overall LSRA ecological community (including c. 700 ha of replanted rainforest) and for the many threatened flora and fauna that rely on it.

Methodology

Briefly, to date, more than 12,000 leaf samples have been collected by Dr Robert Kooyman and associates across the entire distribution range for 56 of the project's 60 rainforest plant species. In some cases, this has entailed collecting leaf samples from Far North Queensland populations through to southern New South Wales. DNA is then extracted and sequenced and genomic data analysed by BGS to better understand genetic variation within each species and to identify local genetic regional neighbourhoods.

Guidelines are subsequently provided by BGS to BSRC advising where to best collect propagule material from that will capture a minimum of 90% of the common allelic diversity within the local NNSW genetic neighbourhood

for each of the 60 species. Guidelines are also provided on where to collect a small amount of propagule material from Lowland Subtropical Rainforest within a more northerly Big Scrub-future-climate-matched area (year 2070).

Wherever possible, propagule material will be collected and cuttings produced by Firewheel Rainforest Nursery. However, for species unable to be struck via cuttings, young wildings or seed will be collected. Propagated material will be planted into our Living Seedbank Plantation with seed produced from each species to be propagated for use in future restoration projects to help restore the Big Scrub Rainforest. The project's innovative methodology can be applied to other degraded ecosystems across the global context.

Initial results

Results have recently been received by BSRC for 23 key structural species with further results from BGS expected in the coming months. For each species, results provided indicate: the local NNSW genetic neighbourhood; smaller sub-regions from which to collect propagule material; the number of trees from which to collect in each sub-region; key areas of high genetic diversity; populations to avoid where relatively high levels of kinship or clones have been detected; and future-climate-matched areas.

Project progress and practical considerations

Living Seedbank Plantation – site selection, preparation and design

We have recently acquired, on a long-term lease, a site to host our Living Seedbank Plantation in the original Big Scrub footprint at the Macleans Ridges property of our sister organisation, Big Scrub Foundation (Figure 1). The site's rich Red Ferrosol soil is typical of the Big Scrub Rainforest and is located in an area that minimises bushfire and flood risk. Cover cropping has commenced at the site to improve soil fertility and structure and we are actively investigating ways to improve beneficial bacteria and mycorrhizal fungi at the site to ensure good nutrient transfer and cycling within the soil.

The planting layout for our Living Seedbank Plantation follows best practice genetic recovery design principles including: planting in species blocks; planting all trees of a particular species within c. 50-100 m of each other to facilitate successful cross pollination; and randomising the layout of individual trees within each species block. A schematic representation of a species block planting is provided in Figure 2. On average, each species block within the plantation site will house approximately 25–30 trees.

Propagule collections underway

Propagule collections are underway across NNSW (Figure 3). To ensure all propagule material can be traced back to its original wild-growing population, metadata is captured in the BGS ReCER App by our collection team and stored in a master database. Additionally, unique labelling is assigned to each propagule that will remain with it for its entire lifecycle.

Financial support welcomed

We have been fortunate to have secured financial support from the NSW Government, from our project partner, Big Scrub Foundation, and from private donors.

Figure 1. The Living Seedbank Plantation site for the Science Saving Rainforests Program at Macleans Ridges, located in the heart of Big Scrub country. Photo: Noel Outerbridge

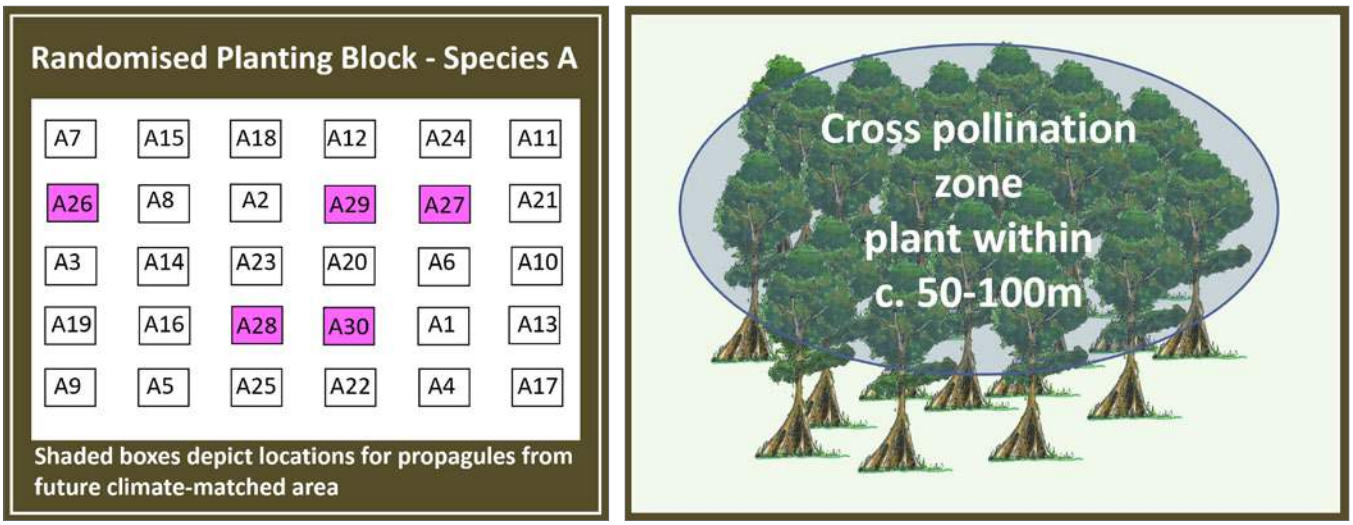

Figure 2. Best practice genetic recovery design principles are being followed in the Living Seedbank Plantation. This includes: planting in species blocks; randomising individual tree layout within each species block; and planting trees in each species block within c. 50-100 m of each other to maximise cross pollination.

However, the need to continue to raise funds remains for this world-first, internationally-significant long-term (50 + years) genetic recovery project that will help save from extinction the Critically Endangered Lowland Rainforest of the Big Scrub. More information on ways to support the Science Saving Rainforests Program can be found at: https://bigscrubrainforest.org/

Acknowledgements and conflicts of interest

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Figure 3. Propagule collections from wild tree populations have commenced. Photos: Renee Borrow