Scaling Global Seed Banking

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The United Nations Decade on Ecosystem Restoration 2021-2030 offers the largest global opportunity to conduct land restoration projects the world has ever known. Efforts to undertake natural carbon sequestration projects through afforestation, reforestation, and natural revegetation are happening at an increasingly larger scale each year. In addition to conducting projects for carbon sequestration, there is growing understanding of how biodiversity improves the resiliency of ecosystems.

In 2022, the United Nations published its *Sustainable Development Goals Report* that included 17 goals to achieve “peace and prosperity for people and the planet.” Goal 15 enumerates several targets relating to the conservation and restoration of terrestrial ecosystems, and proposes that by 2020 the world's communities “promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally” [1].

There is also growing awareness that, in addition to global warming, massive biodiversity loss is happening at an alarming rate. At the Conference of the Parties (COP 15), Dec. 2022, representatives from 188 governments gathered to address biodiversity loss, restore ecosystems, and protect indigenous rights, which includes restoration of 30 per cent of terrestrial and marine ecosystems by 2030 at the latest [2]. These sustainability commitments are driving the development of projects worldwide, each one bringing the planet one step closer to achieving these goals. When restoration project managers plan ecosystem health into a project, they begin by defining objectives that will provide long term benefits to the land and to people of

the region. “Greater biodiversity in ecosystems, species, and individuals leads to greater stability [and to sites] adapted to a wide variety of conditions that are more likely to be able to weather disturbances, disease, and climate change” [3].

Botanic Gardens Conservation International’s publication *State of the World's Trees* [4] outlines the threats to the world’s native tree species, and concludes that one in every 3 trees today is at risk of extinction. This is a call to action. It is imperative that we collect the seeds from standing mother trees today, while they are still living. We also need to build relationships between people and trees so they are not valued only as wood.

Starting from the Seeds

Everything starts with the seed. The process for restoration of ecosystems consists of steps that, when built upon, create a holistic approach to landscape scale restoration. Seed is required to conduct any Afforestation, Reforestation and Revegetation project (ARR). Projects have traditionally relied on purchasing seed seedlings from nurseries. In some cases, information about the source of the seed, mother tree information, number of individuals collected from, region, and other important information is not known. This information is critical to the development of genetically diverse and resilient ecosystems. In many cases seed is collected from single, reliable, individual trees, resulting in a lack of genetic variation that creates

less robust stands that are susceptible to insect predation and disease. It is therefore necessary, even when collecting seeds for a single species, that restored ecosystems are grown from seeds collected from as many individual founders as possible.

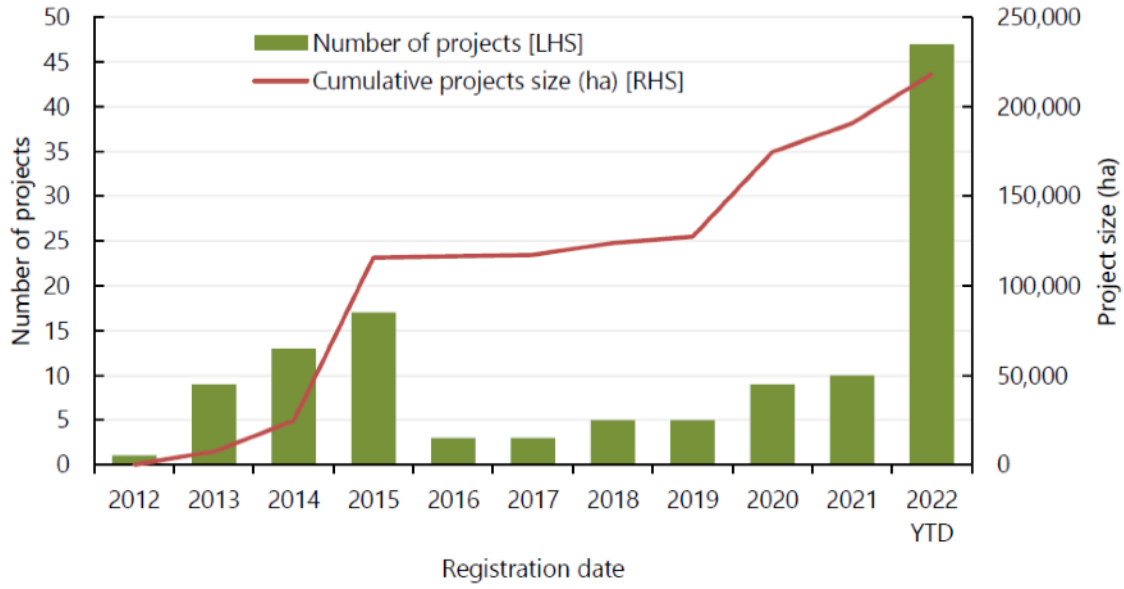
Forest species all over the world are at risk today. Seed is likely to be increasingly rare and expensive due to pollination disruption as extreme climate events continue to happen at an accelerated rate, and as projects attempt to scale for carbon credits. Weather patterns are changing and we cannot be sure about what seed will be available in the near future. This will limit seed production [5]. These kinds of events ultimately lead to extinction, both of plants and pollinators.

A decade ago, carbon sequestration projects were largely monoculture timber projects that did not provide many ecosystem services for the region. Recently, these projects have shifted to developing more ecologically complex projects that not only provide carbon sequestration benefits, but also many ecosystem services for the environment such as habitat for insects and animals, and building soil health. The high-value projects also include many co-benefits for societies including opportunities for sustainable business models and employment through non-timber forest products, equality between men and women, and climate justice. Crucially, these benefits also provide new ways for communities to relate to existing forests, as well as opportunities to relate to new forests on degraded lands.

This graph from Australia demonstrates a greater demand for quality seed as well as the need for a greater diversity of species availability due to the large increase in projects in 2022.

Project registration and size by year – Environmental Plantings (MAG, 2022)

Figure 10 Project registration and size[14] by year – Environmental Plantings



Forest Health:

When severe weather events such as drought occur, the pollinators may be able to access the plants but the plants are affected by physiological stress, thus their floral resources (flowers, nectar production, and pollen) are impacted [6].

Biodiversity is directly connected to carbon sequestration by links to forest health, resilience, and habitat creation. As we expand species diversity in projects, we are also building forest health. For example, it is especially important for communities to grow the high value hardwoods that are unique to the region, rather than limiting projects to the handful of common and genetically limited go-to species that are now found throughout the world, such as Eucalyptus, Pinus, Acacia, Swietenia, and Gmelina.

Monocultures cause the loss of soil productivity (increasing acidification), reduced fertility, breakdown of nutrient cycles, increased pests, and disease (due to high density), and negative effects on biodiversity [7]. Clear cutting causes dramatic alteration of the land and soil, and results in poor habitat for native birds due to uniform rows with no understory. A study of the Grains for Greens program in China showed that birds and bees (which reflect biodiversity) did not do well in monocultures. Furthermore, monocultures are far less effective at reducing runoff and soil erosion than are native forest structures [8].

Among the many non-timber forest products produced in forest restoration projects, some provide short-term economic benefits including honey, medicinal plants, seed markets, and weaving from natural materials. Additionally, there are numerous other values largely taken for granted, such as pollination services, improvements to air quality, and habitat creation.

Resilience: Ching Liu, et. al. showed that mixed species are more productive than monocultures, and by having varied growth rates and species height at maturity they allow for shelter and protection from frost, pests, and wind damage, while building soil humic material. Together, these effects make mixed-species forests more resilient [9].

Today, many reforestation projects are also reporting a shortage of understory species such as forbs and grasses [*personal communications*] In order to build healthy habitats, we need to maximize the diversity of appropriate species and functional groups.

Habitat Creation:

Native forest restoration has been shown to be the most significant natural carbon sequestering system, and the rate of carbon accumulates with tree size and age [10]. In a native forest, the large trees sequester carbon and the understory species will also sequester carbon and provide food for animals and insects as well as leaf litter, which support the large trees. The ground covers keep the soil cooler and preserve soil carbon.

In an agroforestry system, native emergent trees or non-invasive, non-native hardwood trees comprise the over story and sequester carbon. The understory species consists of fruit and nut crops, hay, annual food crops, nitrogen fixers, and useful ground covers. These land use systems are positively impactful for native habitat and other ecosystem services.

Creating Jobs and Economic Models

New forestry projects also provide opportunities for new jobs. The forestry industry is currently changing and requires a new workforce to aid in creating these complex forest systems, and to protect them into the future. Verified carbon projects require 30-year commitments by the landowners and project implementers, thus there is a need to educate stakeholders about the importance of healthy forests in their communities. Rather than the traditional practice of clear-cutting forests to obtain an

economic benefit from them, there are other non-timber products that can be grown to support livelihoods and standing forests. Forest products such as berries, seeds, fungi, honey, small animal husbandry (eggs), nuts, medicinal plants, oils, plants for paper making, weaving materials, resins, etc. add value to the forest and economic value to communities living in and around those forests. There are added benefits such as shade which cools the ground, local rainfall or moisture increase, reduced runoff, and improved forage. These benefits are realized as the forest matures.

Scaling:

In order to grow new resilient ecosystems, it is important to start by assessing the availability of the resources needed to initiate projects. First, a species list is developed by studying reference sites, conducting research on land use history, and assessing the local soils. Then, seed is collected from as diverse a parent population as possible to ensure maximum genetic diversity. If the project does not have the capacity to collect seeds, it may purchase them from local seed companies or universities, or buy seedlings from nurseries. This poses a problem if seed availability is limited. Simply using the only seed currently available can cause land managers to reduce their species lists. Therefore, it is important to develop a specialized seed collecting workforce to increase the number of species available and improve the options for local projects. This will help provide jobs and create another value to the community that supports standing forests. With increasingly accurate GPS systems on available on phones, newly trained seed collectors can provide more transparency about where they are collecting seeds and how many mother trees they are collecting from. This encourages multiple founders, thus diversity within a species.

While many projects have the goal of up-scaling, there may not be enough seed available to do so [11]. In many places remnant native forests are small and fragile. Therefore “seed orchards” (planted groves of native species) can also be created to take the pressure off unsustainable harvests in native forests and allow seed collectors to amass seed more easily. Newly created forests will then become the seed sources of the future. A thoughtful approach to seed orchards should be taken to ensure balanced seed collection methods from all parent individuals in the orchard, so that individual plants are not selected for specific traits, as is done in agricultural seed orchard methodologies.

Saving for the Future:

Several institutions such as The Millennium Seed Bank and Botanic Gardens Conservation International have developed international standards for seed banking. The protocols and tools for drying and banking orthodox seeds are straightforward. They ensure the preservation of seeds beyond a year or two, which is the outcome when seeds are handled in poor conditions. If seeds are properly handled (cleaned, dried, and packed), many species can be banked for decades or longer.

Without proper seed banking facilities, many projects will collect large amounts of seeds and use what they can before the seeds become inviable, unnecessarily wasting precious seed resources. Simple methods for cleaning and drying seeds ensure that they can retain viability and be useful for years to come, providing a resource for the next generation of land managers who will inherit the projects and resources from the current stewards of the Earth.

Infrastructure:

Many seed banks today are focused on research and banking collections for long term emergency relief. Some have more specific missions of preserving seeds from only the rarest species in a given region. However, very few seed banks in the world are focused on amassing common native species for scaling restoration projects. There is a significant opportunity for seed networks and companies to develop these conservation tools and create seed cooperatives and seed markets. This opportunity can also be developed by botanical gardens, which in this era incorporate conservation into their garden strategies to strengthen their role in ex-situ conservation. Not only is this an important shift in the role of botanical gardens today, but it is recognized in the Global Strategy for Plant Conservation as a critical ex-situ conservation tool to safeguard ecosystems, species, and genetic diversity. This is specifically achieved with botanical gardens and seed banks.

It is important for project planners, land managers, and restoration technicians to learn about their regional uniqueness in terms of botanical resources and ecosystems. As we move away from the few most often used fast growing species and move towards the rich biodiversity of a place, we secure resilience for the next generation.

To create successful projects, we can build the infrastructure that is needed for doing work at scale. This requires proper nursery facilities, seed banks, and water systems to support the field work. Seed is lost due to poor viability at germination, low vigour in the nursery, pests, and poor acclimatization. If the seed bank infrastructure creates optimum conditions, these factors can be reduced at each step of the restoration process. If there are more seeds collected than are needed in a

given year, they can be used in later planting seasons or sold. Proper seed banking infrastructure allows restoration projects more flexibility when facing long drought periods, fires, flooding, and pest damage.

Building relationships between people and trees:

New seed collectors and seed bank technicians will be increasingly important in the first stages of the restoration cycle. As teams learn their regional species and regularly monitor for ripe seeds, they will become increasingly efficient in gathering large quantities of fresh seed that can then be cleaned and stored for the near-term and for expanding restoration for years to come. This work will create the foundation for successful restoration projects. It will also connect people with their land and engender respect for the biota living on it. They will be the future experts on natural ecosystems.

There is no question that increasing seed supplies will benefit the quality of reforestation projects and the capacity to scale. In addition, seed networks and cooperatives can build a business case for non-timber forest products, thus adding value to ecosystem restoration and standing forests.

References

[1] UN General Assembly, *Transforming our world : the 2030 Agenda for Sustainable Development*, 21 October 2015, A/RES/70/1, available at: https://www.refworld.org/docid/57b6e3e44.html [accessed 7 November 2023]

[2] UNEP, UN Environment Program, available at: https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement

[3] Center for Biological Diversity, available at: https://www.biologicaldiversity.org/programs/biodiversity/elements_of_biodiversity/#:~:text=Greater%20biodiversity.

[4] Botanic Gardens Conservation International, State of the Worlds Trees, available at: https://www.bgci.org/resources/bgci-tools-and-resources/state-of-the-worlds-trees/

[5] Benjamin B. Phillips, Rosalind F. Shaw, Matthew J. Holland, Ellen L. Fry, Richard D. Bardgett, James M. Bullock, Juliet L. Osborne. Drought reduces floral resources for pollinators, available at: https://onlinelibrary.wiley.com/doi/epdf/10.1111/gcb.14130

[6] Jane Memmott, Paul G Craze, Nickolas M Waser, Mary V Price. Global warming and the disruption of plant-pollinator interactions available at: https://pubmed.ncbi.nlm.nih.gov/17594426/

[7] European Commission, available at: https://ec.europa.eu/research-and-innovation/en/horizon-magazine/rise-and-fall-monoculture-farming

[8] Fangyuan Hua, et. al, The Biodiversity and ecosystem service contributions and trade-offs of forest restoration approaches, available at: https://www.science.org/doi/full/10.1126/science.abl4649

[9]Ching Liu, et. al, Mixed-species versus monocultures in plantation forestry: Development, benefits, ecosystem services and perspectives for the future, available at: https://www.researchgate.net/publication/326677444_Mixedspecies_versus_monocultures_in_plantation_forestry_Development_benefits_ecosystem_services_and_perspectives_for_the_future

[10] Stephenson et al., 2014, Rate of tree carbon accumulation increases continuously with tree size, Nature 12914

[11] Jalonen R, Valette M, Boshier D, Duminil J, Thomas E. Forest and landscape restoration severely constrained by a lack of attention to the quantity and quality of tree seed: Insights from a global survey. Conservation Letters. 2018,11:e12424. available at: https://doi.org/10.1111/conl.12424