

Supporting Information

1a—Indicator scores by country expressed as percentage of the total possible score.

Country seed system percentage scores							
	Argentina	Chile	Colombia	Costa Rica	Guatemala	Mexico	Peru
Selection and innovation							
1 - Different sources of information are used to identify native species	33%	67%	33%	50%	50%	67%	17%
2 - Research into the effect of climate change is used to inform selection of species	22%	33%	33%	33%	33%	78%	33%
3 - Information on species genetic diversity is used to identify goal-oriented planting material	57%	48%	33%	33%	24%	81%	43%
4 - Suitable information is readily available to inform stakeholders	33%	33%	33%	33%	44%	44%	0%
Seed harvesting and production							
5 - Seed sources that cover the priority native species have been identified and are protected	42%	33%	50%	33%	42%	67%	33%
6 - Improved material is available for priority species used in productive restoration	33%	17%	33%	50%	33%	17%	33%
7 - Nurseries are able to produce the priority species	50%	50%	50%	33%	50%	67%	33%
Market access, supply and demand							
8 - There is demand for priority native species of suitable provenance	33%	33%	17%	50%	67%	67%	17%
9 - There is a network of suppliers able to meet the demand for priority native species	33%	17%	33%	33%	50%	50%	17%
Quality control							
10 - Measures exist to comply with seed sourcing and harvesting standards	67%	0%	50%	100%	67%	100%	0%
11 - Measures exist to comply with seed quality standards	83%	17%	50%	100%	67%	100%	17%
12 - Quality control measures function as an integrated system	67%	0%	33%	100%	100%	100%	0%
Enabling environment							
13 - The seed system is underpinned by appropriate legislation and regulations	27%	13%	27%	27%	53%	80%	7%
14 - There is appropriate capacity building in order to support a seed system	40%	40%	27%	80%	40%	60%	0%
15 - There is sufficient financial support for key research needed for seed systems	33%	33%	33%	33%	33%	67%	33%

1b – Indicator point scores per question by country

	#	Indicator	Question	Argentina	Chile	Colombia	Costa Rica	Guatemala	Mexico	Peru
Selection and innovation	1	Different sources of information are used to identify native species useful for restoration in a variety of ecosystems	Are lists of priority native species for restoration available for key ecosystems?	1	2	1	2	1	3	1
			Are threatened species included in the priority lists for restoration?	1	2	1	1	2	1	0
	2	Research into the effect of climate change on native species across different ecosystems is used to inform selection of species and seed sourcing for restoration	Is there research on the effect of climate change on key ecosystem distribution?	1	1	3	3	2	3	3
			Is there research on the effect of climate change on priority native species distribution?	1	1	0	0	1	2	0
			Is there research on the effect of climate change used to inform planting decisions for restoration?	0	1	0	0	0	2	0
	3	Information on species genetic diversity is used to identify goal-oriented planting material	Are there provenance trials across the country for the priority species?	2	2	1	1	1	2	1
			Is data being collected from these trials?	3	3	1	3	1	3	3
			Is the data being used to inform seed source choice for restoration?	0	0	1	1	0	2	0
			Is there research on species population genetics?	2	2	2	1	1	2	2
			Is there research on defining eco-geographical zones for priority species?	3	2	1	0	1	3	2
			Is this information used to define seed transfer zones?	1	0	0	0	0	3	0
			Are there research initiatives developing improved material for those priority species used in restoration for productive purposes?	1	1	1	1	1	2	1

4	Suitable information is readily available to inform stakeholders in their restoration choices	Is suitable information readily available to stakeholders that helps in species choice for restoration?	1	1	2	1	2	2	0		
		Is suitable information readily available on how to identify the most suitable seed source?	1	1	1	1	1	1	0		
		Is suitable information readily available on the difference between wild and selected material?	1	1	0	1	1	1	0		
Harvesting and production	5	Seed sources that cover the geographical range of the priority native species have been identified and are protected effectively	Have seed sources been identified for the priority species?	1	2	2	1	2	2	1	
		Have seed sources been identified for key ecosystems?	1	0	2	1	0	2	1		
		Do seed sources cover the species range?	2	1	2	1	1	2	1		
		Are seed sources protected effectively?	1	1	0	1	2	2	1		
	6	Improved material is available for those priority species used in restoration for productive purposes	Is there improved material available for those priority species used in restoration for productive purposes?	1	1	1	1	1	1	1	
			Is improved material available for the key ecosystems?	1	0	1	2	1	0	1	
	7	Nurseries are able to produce the priority species adapted to each ecosystem	Are all the priority species being produced?	2	2	2	1	1	2	1	
			Are they being produced across each key ecosystem?	1	1	1	1	2	2	1	
	Supply and demand	8	There is demand for priority native species of suitable provenance for restoration across targeted ecosystems	Is there demand for priority native species?	2	1	1	2	3	2	1
				Do people request suitable provenance?	0	1	0	1	1	2	0
		9	There is a network of suppliers able to meet the demand for priority native species of suitable	Is there a network of suppliers?	2	0	1	1	3	2	1
				Can the network meet demand (access and quantity) for natives with suitable provenance?	0	1	1	1	0	1	0

		provenance across targeted ecosystems								
Quality control	10	Measures exist to comply with seed sourcing and harvesting standards	Does certification cover seed sourcing (population size, sampling method)?	2	0	1	3	2	3	0
			Does certification cover Harvesting (material type, permission to collect)?	2	0	2	3	2	3	0
	11	Measures exist to comply with seed quality standards	Does certification cover production (phytosanitary conditions, control of origin)?	2	1	2	3	2	3	1
			Does certification cover improved seeds?	3	0	1	3	2	3	0
12	Quality control measures function as an integrated system	Do these components function as a system?	2	0	1	3	3	3	0	
Enabling environment	13	The seed system is underpinned by appropriate legislation and regulations applied to native species and implemented	Are adequate regulations being implemented that support the use of material suitable for climate change?	0	0	0	0	0	0	0
			Are adequate regulations being implemented to define seed transfer zones?	0	0	0	0	0	3	0
			Are adequate regulations being implemented to protect seed sources?	0	0	0	0	3	3	0
			Are adequate regulations being implemented that provide incentives for the use of native species?	2	1	2	2	3	3	0
			Are adequate regulations being implemented for a certification system for native species?	2	1	2	2	2	3	1
	14	There is appropriate capacity to support a seed system	Is there sufficient capacity building for decision makers?	1	1	0	2	1	1	0
			Is there sufficient capacity building for technicians?	1	1	1	3	1	2	0
Is there sufficient capacity building for communities?			1	1	1	2	1	2	0	

15	There is sufficient financial support for key research needed for seed systems	Is there sufficient capacity building for the general public?	1	1	1	2	1	2	0
		Is there sufficient capacity building for students?	2	2	1	3	2	2	0
		Is there sufficient financial support for baseline information on priority native species & key ecosystems and climate change?	1	1	1	2	1	2	1
		Is there sufficient financial support for seed source identification?	1	1	1	0	1	2	1
		Is there sufficient financial support for research on material production?	1	1	1	1	1	2	1

Supporting information 2 – Case studies of the state of seed systems from seven countries in Latin America

The information used to create these summaries comes from conversations and questionnaires filled out by the experts presented in Spanish in the accompanying document¹. This is supplemented by the references given in the footnotes in this section. Thus, it does not necessarily represent the opinions of the authors of this report.

Argentina

Selection and innovation

Argentina has recorded 719 native tree species. Since 2005 there has been an increasing amount of research on restoration and in 2012 a restoration network for Argentina was established that comprises 7 nodes across the country representing priority ecosystems, each run by a different group of stakeholders (universities, NGOs, private companies, government)². In addition, INTA (Instituto Nacional de Tecnología Agropecuaria) has a program for the revegetation of arid areas including germination trials and mass production of 35 species. There are many examples of post-fire restoration with natives as well as over 100 forestry research projects that include native species, restoration and biodiversity in plantations. There has also been extensive work to develop germination protocols for native species. CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) provides long-term funding for research into forestry and related issues.

Since its creation INTA has been promoting improved seed for exotic species. In 1993 a research program was created within this institution to improve the quality of genetic material for native forest species with high commercial value which has received support through more than 20 national and international projects. The program includes 16 native tree species from the genera *Nothofagus*, *Austrocedrus*, *Prosopis*, *Cedrela*, *Cordia*, *Handroanthus* and *Araucaria*. These have been well studied and there is some research on a handful of other tree species. This program continues today³.

The country has clear ecogeographical zoning at the ecosystem level. Provenance regions for seed sourcing zones have been established for *Austrocedrus chilensis*, and are being defined for 4 species of *Nothofagus*. Genetic characterization is available for *Araucaria augustifolia* (CR), *Austrocedrus chilensis*, four *Prosopis* species, 6 *Nothofagus* species, 3 *Cedrela* species, *Cordia trichotoma* and *Bulnesia sarmientoi*⁴.

The Unidad para el Cambio Rural is the executing agency for many sustainable forestry projects and is also the national authority for climate change, including the Green Climate Fund. In 2017 AFoA (Asociación Forestal Argentina) and INTA signed an agreement to work together to improve forest production under climate change. This includes developing improved varieties for climate change adaptation as well as the need to consider the trade-off between diversity and trait selection with respect to climate change, pest and disease resilience.

¹ Alcazar, C. et al (2017) Levantamiento de línea base y escenarios potenciales de sistemas de producción y suministro de semillas forestales como apoyo a los objetivos de restauración de los países de América Latina asociados a la Iniciativa 20x20. 244pp Bioversity International, Rome

² Zuleta, G et al (2015) Establishing the ecological restoration network in Argentina: from Rio1992 to SIACRO2015 *Restoration Ecology* 23(2):95-103

³ <http://forestindustria.magyp.gob.ar/archivos/biblioteca-forestal/domesticacion-y-mejoramiento-de-especies-forestales.pdf>

⁴ <http://www.fao.org/3/content/8d7d3d11-4150-4fd5-a71a-c1306eaea4da/i3825e1.pdf>

While plantation forestry is dominated by exotics, provenance and progeny trials have been established by the different projects developed since 1993 in the context of INTA's native species program. This is most advanced for two *Nothofagus* species in Patagonia and two *Prosopis* species in the Chaco. INTA and AfoA produce bulletins and literature for the general public about forest genetic resources and advances in the field.

Harvesting and production

There is little information about the distribution of seed sources for native species. Seed sources that do not fall into the protected area network do not receive any additional protection. However, there is a new Global Environmental Facility funded project that aims to conserve 10 priority native tree species in productive landscapes.

INTA coordinates the national Genebank Network (RBG). Each bank is responsible for a set of species, and there is a duplicate collection where everything is held. The network includes two banks for native species: seeds of *Cedrela* species in Jujuy and of native forest species in the Chaco. There are also seed banks run by universities and institutes that interact with the RBG. This includes, the national *Prosopis* gene bank of the National University of Cordoba which was created in 1985 and is one of the oldest for tree species. Improved seed is registered and controlled by INASE (Instituto Nacional de Semillas) for several *Nothofagus*, *Prosopis* and *Cedrela* species as well as *Araucaria angustifolia*.

A list of native plant nurseries is available on the Red Naturaleza website⁵ and they appear to exist in all provinces, especially in those with established forestry. Nurseries are owned by many different stakeholders, public, private and NGOs, and include some large government-run nurseries in Chubut (40 native species for arid zones with capacity to produce 50,000 seedlings per year), Cordoba (more than 55 native tree species), NOA (more than 10 native tree species), and a new nursery being established in Misiones to produce 500,000 certified native tree seedlings as part of a program on sustainable and competitive forestry. Improved seed is produced for several *Nothofagus* species.

Supply and demand

The law Presupuestos Mínimos de Protección Ambiental de los Bosques Nativos⁶ has resulted in an increased demand for native tree species. This law includes the provision of incentives for enrichment planting, restoring and protecting native forest, by provision of non-reimbursable funds to small and medium landowners according to an approved management plan. The funding is provided annually with no time limit and comes from a tax on the export of timber and agricultural produce. The funds are only available to regions that have carried out a native forest mapping exercise. In addition, stakeholders receive an additional 10% in economic support for using improved material. The GEF/World Bank program for forestry production and conservation for Mesopotamia, Delta de Rio Parana, NOA, Patagonia and Chaqueña also provides funds to help small and medium producers in sustainable forest management including the use of natives, improvement of nurseries and development of non-forest products.

At least 26 native tree species are available at a commercial scale, and several of the government nurseries produce 50,000-500,000 plants annually. The availability of improved seeds of some native species has resulted in an increased demand. INTA actively promotes endangered species for restoration, including nine tree species.

Quality control

INASE is responsible for the national legislation on seeds and manages a seed register, including improved varieties, seed certification and seed sources. Anyone who wishes to commercialize seeds or produce plants must register in the Registro Nacional del Comercio y Fiscalización de semillas (RNCyFS).

⁵ <http://www.rednaturaleza.com.ar/novedades/532-guia-de-viveros-de-plantas-aut-ctonas-nativas>

⁶ <http://www.derecho.uba.ar/academica/derecho-abierto/archivos/Ley-26331.pdf>

Over 500 entities are registered, although most are related to exotic species⁷. SENASA (Servicio Nacional de Sanidad y Calidad Agroalimentaria) is responsible for registration and certification of nurseries for phytosanitary reasons. There is also a voluntary certification system for selected and improved seed of five *Prosopis* species (*P. alba*, *P. chilensis*, *P. hassleri*, *P. nigra* and *P. flexuosa*) can be certified at present. This is a very strict certification system, and seed that passes the requirements can be sold in a container sealed with an official hologram. Both CIEFAP (Centro de Investigación e Investigación y extensión forestal Andino Patagónico) and INASE can officially analyze seed samples.

INTA works closely with scientists in the production of training materials on all aspects of forestry and sustainable land use. A new training center is being established in Misiones through which regional governments can apply for funding to provide technical assistance and monitor projects. However, to date the divulgation of materials has been more efficient in the central region of the country.

Chile

Selection and innovation

Chile has recorded 156 native tree species, and there is a wealth of ecological information available for many of these species. In particular, commercially important timber species have been well studied, as have species important for honey production, adaptive capacity and tolerance to shade and drought. In addition, 30 desert species have been identified as useful for restoration by INFOR (Instituto Forestal) in collaboration with local communities⁸. The Red Chilena de Restauración Ecológica was founded in 2014 and there is an active research community in restoration⁹. CONAF (Corporación Nacional Forestal) established a Programa Nacional de Restauración Ecológica which is in the process of being institutionalized. One of its aims is to generate nuclei of restoration areas across the country that can also act as foci for research and awareness raising. Agreements have already been made between CONAF, INFOR and INIA (Instituto de Investigaciones Agrarias) to this end. There is also a Plan Nacional de Restauración de Paisajes 2020-2030 that is undergoing public consultation.

A methodology has been developed to define ecoregions for biodiversity¹⁰ and it has been applied as a pilot in the Araucanía region. A map for seed sourcing zones has been developed by INFOR for five native species in the south (4 *Nothofagus* species and *Drimys winteri*)¹¹. Additionally, a restoration project in the central semi-arid ecosystem led by the Pontificia Universidad Católica de Chile selects seeds from mother trees growing in areas of the native range that experience severe and regular droughts.

INFOR has a research program to monitor the impact of climate change on forest trials of different provenances. There is also a strategy for germplasm collection to enable the survival of forest species over more than 20 generations, and 15 species likely to be at risk from climate change have been identified. Detailed studies have been carried out on the impact of climate change on *Nothofagus alpina* and *N. obliqua*, as well as the distribution of southern beech forest¹². There is also a plan for adaptation to climate change for the forestry and agriculture sectors, but this has yet to be approved¹³.

⁷ https://www.inase.gov.ar/index.php?option=com_content&view=article&id=317&Itemid=182

⁸ <http://biblioteca.infor.cl/DataFiles/30804.pdf>

⁹ <http://www.restauremoschile.cl/wp-content/uploads/2017/01/Chile-Forestal-N%C2%B0383.pdf>

¹⁰ <http://biblioteca.infor.cl/DataFiles/30636.pdf>

¹¹ <http://biblioteca.infor.cl/DataFiles/26532.pdf>

¹² <http://biblioteca.infor.cl/DataFiles/26809-2.pdf>

¹³ http://www.conaf.cl/cms/editorweb/ENCCRV/ENCCRV-3a_Edicion-17mayo2017.pdf

INFOR has more than 30 years of experience with trials on 206 species (mostly exotic but a few native conifers and broadleaved trees) that extend across the country¹⁴. This includes 350 trials with *Nothofagus* and several with *Laurelia* (although this is in comparison to >1200 trials for *Pinus* and *Eucalyptus*). In collaboration with universities and forestry companies there is an active program for *Nothofagus alpina* with 4 provenance trials representing 125 families from 7 regions. The private company, Arauco, has carried out trials with different species including *Aristotelia chilensis* (maqui) and the endemic and endangered *Gomortega keule*.

Eight conifer and 85 broadleaved species have been characterized using genetic markers. This includes 10 *Nothofagus* species from Chile and Argentina. A detailed methodology has been developed for the collection of germplasm for future genetic diversity studies.

Harvesting and production

Harvesting of native species is not regulated and the origin of most seeds available in nurseries is unknown. A network of seed production areas was established by INFOR, CONAF and Universidad Austral de Chile, but has not been updated since 2000¹⁵. However, there is increasing awareness that this must be addressed.

CONAF has a program for the protection and recovery of all threatened forest species, as not all of the populations of tree species fall within the protected area network which was for the conservation of distinct ecosystems. CONAF is the administrative authority in Chile for CITES while INFOR is the scientific authority¹⁶. There is also some *ex situ* conservation through a network of 542 hectares of conservation orchards that include 12 native species. There is a national plan for the conservation of forest genetic resources, but this has yet to be made law¹⁷.

As a result of years of working with *Eucalyptus* and *Pinus*, the forestry sector has a high level of understanding about the importance of using improved varieties even if few species are being promoted. The Cooperativa de Mejoramiento Genético works with a network of medium and large enterprises to develop selected material of mainly exotic and a few native species, to optimize site-based productivity levels. CONAF has one success story with *Nothofagus alpina* for which first and second-generation clonal orchards have been established. Additionally, CONAF in close collaboration with INFOR developed seed orchards for *Laureliopsis semprevirens*, *Nothofagus obliqua*, *N. dombeyi*, *N. pumilio*. They are planning to include *Persea lingue* in these trials and in 2017 initiated a joint project for the *ex situ* conservation of *Araucaria araucana* through assisted migration, with the support of SIMEF (Sistema Integrado de Monitoreo de Ecosistemas Forestales) and GEF. Many of the trials are located on private lands of APROBOSQUE (Asociación Gremial de Propietarios de Bosques Nativos).

A very few species are regularly used and most native plant production is from small nurseries, owned by societies, small and medium landowners, local and national government, private enterprises and academic institutions. There are two seed banks that store and distribute seeds of species with high demand, or commercial interest and of conservation concern. These are part of the network of germplasm banks. Of the 161 registered nurseries producing native species in 2017, 10 had material available from known seed sources of 31 species. A total of 185 native species were available (including trees, grasses and perennials). Some nurseries had more than 40 species in stock¹⁸.

¹⁴ <http://biblioteca.infor.cl/DataFiles/30804.pdf>

¹⁵Castillo J.C & G Moreno (2000) Semillas Forestales del Bosque Nativo Chileno, Santiago, Chile pp248

¹⁶ <http://www.fao.org/3/contents/8d7d3d11-4150-4fd5-a71a-c1306eaea4da/i3825e12.pdf>

¹⁷ <http://biblioteca.infor.cl/DataFiles/30804.pdf>

¹⁸ <http://www.sag.gob.cl/ambitos-de-accion/viveros-y-depositos-de-plantas/84/registros>

Supply and demand

Chile has 3,044 million hectares of planted forests (representing 17.2% of the total forest cover) and it is estimated that 270 million exotic seedlings are produced annually, for the reforestation of harvested stands. To date only 0.5% of plantations use natives for which 2-3 million native forest seedlings are produced every year¹⁹. Demand for natives comes mostly from research institutes, protected areas in need of reforestation after fire, and restoration activities carried out by large timber and mining companies as compensation obligations for land use change.

While the old forest law promoted exotic plantations, the new law includes the use of native species²⁰. There is also a Fondo de Investigacion del Bosque Nativo with the aim of financing scientific research, training and monitoring related to native forest. There is an advisory board composed of the main institutions involved in forest management and a roundtable on native forests which promotes the need to increase the competitiveness of native species in the forestry sector.

The registered nurseries had a total of over 12 million plants available in 2017. Many of the nurseries produce for their own use and donation as well as for sale. However, one of the major factors restricting the use of natives is a lack of availability of selected and improved material. At present, improved seed is only commercially available for *Nothofagus alpina* and is obtained from CONAF's orchard at Huillilemu.

Quality control

Most seed used in forest nurseries is collected from the wild; only large nurseries can guarantee origin and quality of the seed as it tends to come from established seed orchards. While SAG (Servicio AgrícolaAgrícola y Ganadero) controls the quality of seed for export, regulations to control quality of material for use in-country do not exist or are voluntary as in the case of *Nothofagus alpina* and some exotics. INFOR produced a regulatory framework for the certification of forest seed in 2012 but it is yet to be approved²¹. SAG and CONAF are both responsible for forest nursery certification. Universities, CONAF and INFOR have many training programs, events and materials about the use of tree genetic resources, including the need to consider resilience to climate change, and a regular bulletin; Chile Forestal.

Colombia

Selection and innovation

Colombia has recorded 5776 native tree species. There are many small to medium-scale restoration projects using native species including work with over 100 species to promote biodiversity in the coffee sector²², and trials with more than 40 species led by NGOs, the private sector, universities and botanic gardens in different parts of the country. Many universities and research institutions (including Grupo de Restauracion Ecologica (GREUNAL) at Universidad Nacional de Colombia, SINCHI and the Humboldt Institute) carry out research on species functional traits and restoration of different ecosystems. There are detailed manuals produced by researchers from universities and the Ministry of Environment that look holistically at restoration, and include species selection.^{23,24} Effective protocols have been developed for profitable, socially inclusive and ecologically friendly restoration of gold mine spoils using exotic and native

¹⁹ <http://www.conaf.cl/nuestros-bosques/plantaciones-forestales/>

²⁰ <https://www.leychile.cl/Navegar?idNorma=274894&idVersion=2008-07-30>

²¹ <http://biblioteca.infor.cl/DataFiles/30636.pdf>

²² <http://www.co.undp.org/content/colombia/es/home/presscenter/articles/2014/08/22/biodiversidad-en-los-paisajes-cafeteros.html>

²³ <http://observatorioirs.org/web/wp-content/uploads/2015/11/restauracion-ecologica.pdf>

²⁴ <http://www.humboldt.org.co/es/estado-de-los-recursos-naturales/item/562-restauracion-paramos>

species²⁵. There is also a national network for experts working in ecological restoration (Red Colombiana de Restauración Ecológica REDCRE) and a National Restoration Roundtable (Mesa Nacional Asesora de Restauración). INSEFOR (Investigación en Semillas de Especies Forestales Nativas) has information on native species of potential commercial value. This program finished in 2004 but generated much important information including basic data on more than 49 native species²⁶. Information generated by these restoration projects is available via manuals produced by the different stakeholders, many of which are online²⁷. There is also an online decision support tool D4R for tropical dry forest species selection²⁸.

IDEAM (Instituto de Hidrología, Meteorología y Estudios Ambientales) has carried out modelling to predict the effect of climate change on the distribution of ecosystems at a country level, and the results are corroborated by an academic-led study²⁹. There are also two detailed regional studies for montane forest and dry forest species. Detailed mapping of vegetation exists and there is genetic characterization of about 30 native tree species but this information has not yet been used to characterize ecogeographical zones for seed transfer.

Under the INSEFOR program, CONIF (Cooperación Nacional de Investigación y Fomento Forestal) set up 19 field trials for *Cordia alliodora* in 1999 and 6 for *Tabebuia rosea* in 2001 as well as single trials for a further 3 coastal and 3 montane species. These were carried out in partnership with the private sector through COMFORE (Cooperativa Colombiana de Mejoramiento Forestal), a group of private sector forestry companies who wish to have access to selected material for plantations. Research findings are presented in an infrequent technical series available online.

Harvesting and production

Harvesting for restoration projects is mostly carried out without regulation and involves a large selection of stakeholders, including indigenous groups and local communities. However, a more formal system was developed under the INSEFOR project where 109 seed source sites were identified for 29 native tree species selected as priorities for forestry and restoration³⁰. This information was stored in a national register but is no longer accessible. Six sites were selected as pilot projects (for *Alnus jorullensis*, *Cariniana pyriformis*, *Cordia alliodora*, *Genipa americana* and two sites for *Tabebuia rosea*), and in 2003 41 individuals of *Tabebuia rosea*, 45 of *Cordia alliodora* and 30 of *Alnus acuminata* were identified under INSEFOR as superior trees and used to create seed orchards. Clonal gardens were developed for *Tabebuia rosea* and *Cordia alliodora*.

Almost 70% of the sites proposed as seed sources were on private land and although INSEFOR suggested conservation measures for these areas, they were not implemented. Thus, aside from existing regulation restricting land use change, there are no specific conservation measures that protect seed sources.

A national seedbank was created in 1999 for forest species and managed by CONIF. The facility has not been used for a while, although there are plans to revitalize it in collaboration with Instituto Humboldt. The distribution of nurseries across the country is not well understood, but a wide variety of stakeholders are involved in nursery production, including private companies, community groups, women's groups, NGOs, regional and national government³¹. There are several large private nurseries that have more than 50 native species in stock (e.g. Germinato, El Semillero), and there is even one company (Geoambiente) that has

²⁵ <http://www.fao.org/3/a-i3938e.pdf>

²⁶ <http://bibliotecadigital.agronet.gov.co/bitstream/11348/6703/2/016.pdf>

²⁷ http://www.ciencias.unal.edu.co/unciencias/data-file/user_46/file/Guia%20Metodologica.pdf

²⁸ <http://www.restool.org/>

²⁹ <http://revistas.udistrital.edu.co/ojs/index.php/colfor/article/view/4719>

³⁰ <http://documentacion.ideam.gov.co/openbiblio/bvirtual/005027/SEMILLASforestales.pdf>

³¹ <https://www.ica.gov.co/getattachment/Areas/Agricola/Servicios/Certificacion-de-Semillas/VIVEROS-REGISTRADOS.xlsx.aspx?lang=es-CO>

been dedicated to the production of native tree species for over 20 years producing over 4.5 million plants per year. This company also offers services of land preparation and planting. However, in general projects that require natives for restoration tend to set up their own transitory nurseries.

Supply and demand

Demand for natives comes from the obligation that they be used in compensation measures for biodiversity loss from development projects (e.g. hydroelectric projects and mines) which by law should focus on native species; for biodiversity-friendly coffee, for REDD+ certification and for ecosystem service protection (from companies such as Coca-Cola and FEMSA). Colombia has set a goal to reach 122,000 hectares of commercial forestry plantation³². Although the focus is exotic species there is demand for a few commercially important native tree species including *Bombacopsis quinata*, *Cordia alliodora*, *Ochroma pyramidale*, *Tabebuia rosea* and *Alnus acuminata*. The Certificado de Incentivos Forestal (CIF) provides up to 50% cost recovery for the establishment and maintenance of new plantations >1ha in size for both exotics and natives³³. However, there has been little uptake in use of natives.

The Regional Autonomous Corporations are responsible for implementing the national reforestation and restoration plan (Plan Nacional de Restauración) which can include incentives programs for the use of natives. For example, CORPOAMAZONIA provides incentives for forest restoration on land of 8-50ha in Caqueta and Putumayo when plants from a list of 73 native species are used.

The demand for material is met from transitory nurseries as well as some of the larger registered nurseries that can produce seed from licensed suppliers. Most improved seed is imported from CATIE or produced directly by private companies (e.g. *Pachira quinata*). However, this may change in the future as one of the objectives of COMFORE is to develop a network of nurseries producing improved planting material.

Quality control

The Instituto Colombiano Agropecuario (ICA)³⁴ is responsible for the legislation on forest seeds and seedlings for production and commercialization, and regulates material quality from the source to nursery. The registration process includes specification of seed sources as well as legal permission from the land owner for collection. There are additional criteria for the identification of improved material. Although there is a need for capacity building about how to adhere to the regulation, there are about 80 suppliers of forest seeds and plants registered through ICA. Seed quality must reach certain international standards, and purity and germination success have set minimum levels for each commercially valuable species. The origin of plant material is not included in quality control. Plant nurseries must register with ICA every 5 years. At present there are 82 forest tree nurseries registered.

Costa Rica

Selection and innovation

Costa Rica has recorded 2606 native tree species. The functional traits of 199 Mesoamerican tree species used by farmers have been documented³⁵ and there is additional information on 25 dry forest species suitable for restoration as well as a study of 157 species in a watershed in the central highlands³⁶. INISEFOR (Instituto de investigación y servicios forestales de la Universidad Nacional de Costa Rica) has an active

³² <https://www.minagricultura.gov.co/noticias/Paginas/Minagricultura-actualiza-informaci%C3%B3n-estad%C3%ADstica-sobre-plantaciones-forestales-en-el-pa%C3%ADs.aspx>

³³ <https://www.finagro.com.co/productos-y-servicios/CIF>

³⁴ <https://vuf.minagricultura.gov.co/Documents/2.%20Normatividad%20registro%20y%20Movilizaci%C3%B3n%20ICA/3.%20Resoluci%C3%B3n%202457%20de%202010.pdf>

³⁵ <https://www.catie.ac.cr/catie-noticias/759-libro-arboles-de-centroamerica-ahora-en-version-digital.html>

³⁶ http://www.cpsg.org/sites/cbsg.org/files/documents/Rio_Torres_Plants_2015.pdf

research program on threatened timber species. There are over 200 publications from previous projects such as Madeleña (focused on multiple use trees) and Prosefor (focused on forest tree seeds) as well as active research programs at CATIE (Centro Agronómico Tropical de Investigación y Enseñanza). While much of this research is only available in books, some of the information can be found online³⁷. Funding for research on forestry has been reduced significantly recently and universities have had to develop business models in order to maintain facilities and research programs.

Scenarios for change in ecosystem distribution under climate change have been carried out for 2070-2100³⁸. The national biodiversity policy (2015-2030) mentions the need to safeguard biodiversity at the ecosystem, species and genetic level with actions that include habitat restoration in order to strengthen biodiversity's adaptation to climate change. Planning for adaptation and resilience involves strengthening connection between forest fragments and increasing forest cover, and does not address the genetic composition of the forest.

The distribution of different forest types has been mapped, and genetic characterization of 18 forest tree species has been carried out to determine population-level variation and help inform tree breeding programs. This information has not been used to define seed transfer zones

While forestry has focused to two exotics (*Tectona grandis* and *Gmelina arborea*), a project run by CATIE aimed at improving tree planting material (1977-1995) set up an extensive network of provenance trials across the country that included at least 8 native species. Provenance trials that are still actively managed include *Swietenia macrophylla*, *Cedrela odorata*, *Vochysia ferruginea* and *V. guatemalensis* and contain material collected across Latin America. The NGO-run Guanacaste conservation area has field trials of 26 species and 700 individuals³⁹. This information is used to guide choice of seed for plantation forestry.

Harvesting and production

While there is a national network of seed producers for the two commercially important exotic species that involves small and medium sized businesses, individuals and a cooperative of farmers, there is no network for native species. However, seed sources have been identified for *Bombacopsis quinata*, *Cupressus lusitanica*, *Vochysia guatemalensis* and *Terminalia ivorensis*. Apart from the well managed network of protected areas, and regulations protecting native species in general, there is no additional system for the protection of seed sources.

Superior seed trees for 25 species of native tree in the dry forest have been identified, in addition to the four species listed above. There is an extensive research program (GENFORES) led by the Instituto Tecnológico de Costa Rica that involves private companies and NGOs, focused on improving material for exotic plantations, as well as some natives. CATIE also carries out research on the same theme.

The Guanacaste conservation area has clonal gardens for 7 native species (including *Bombacopsis quinata*, *Swietenia humilis*, *Dalbergia retusa* and *Astronium graveolens*). Seed orchards exist (or have existed) for several exotic species as well as *Bombacopsis quinata*, *Cupressus lusitanica*, *Vochysia guatemalensis* and *Terminalia ivorensis* and improved seed is available for some of these species from CATIE's forest seed bank. This seed bank commercializes material from about 45 forest tree species of which approximately half are

³⁷http://repositorio.bibliotecaorton.catie.ac.cr/bitstream/handle/11554/2959/Manejo_de_semillas_de_100_especies.pdf?sequence=1

³⁸https://www.google.com.pe/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiG57asuNrWAhWkKpAKHU0iBfUQFggkMAA&url=http%3A%2F%2Fcambioclimaticocr.com%2Fmultimedia%2Frecursos%2Fmod-1%2FDocumentos%2Fvulnerabilidad_en_bosques.pdf&usg=AOvVaw1jjMF6ceGx5HdpszCZVnWP

³⁹ <https://www.acguanacaste.ac.cr/biodesarrollo/programa-de-restauracion-y-silvicultura/programa-de-restauracion-y-silvicultura>

native, but the main seed volumes produced are from two exotic species (*G. arborea* and *T. grandis*) for national use and for exportation to more than 15 countries⁴⁰.

There are 37 registered and certified nurseries of which 16 are found in the dry forest region of Guanacaste. These are run by universities, government, private NGOs and private companies. However, the species produced by each nursery is not available in the registry. ICE (Instituto Costarricense de Electricidad) has four large nurseries capable of producing 1 million plants per year of 100 native species used to mitigate the impact of large-scale renewable energy projects. There are also many private restoration initiatives which have established their own on-site nurseries.

Supply and demand

Because natural regeneration is vigorous, many restoration projects do not need to plant or sow seed. Active planting of natives for production forestry is also low as commercial forestry focuses on exotic species. However, the Forest Law states that at least 5% of plantation land must be covered with natives⁴¹. In addition, there are several initiatives that require the use of native species (e.g. REDD+). FONAFIFO (Fondo Nacional de Financiamiento Forestal) supports small and medium size producers in forest management, reforestation, nurseries, agroforestry, restoration etc. FONAFIFO also manages the payment for ecosystem services incentives program which includes a category for reforestation using threatened native species from a list of 19 species, as well the reforestation of areas for ecosystem service protection that prioritize natives⁴².

As part of CATIE's Prosefor project (active from 1993 to 2002) a regional seed network was set up to enable exchange of selected seed between countries in Central America and the Caribbean, including information on seed sources⁴³. This network does not exist anymore and apart from native seed available through the CATIE forest seed bank there is no centralized supply system for native species.

Quality control

A program for forest species seed certification (managed by ONS - Oficina Nacional de Semillas) was established in 1993 and regulates the production and commercialization of seeds and nursery plants⁴⁴. After registering a seed source, harvesting is only authorized following a site visit by technicians, with frequent visits throughout the harvesting period. ONS also carries out physical analyses of seeds (at CIGRAS in the University of Costa Rica) and if it meets minimum standards, authorizes its commercialization. Although this system is only used for exotics, it could be applied to any species. The Oficina Nacional de Semillas is also responsible for monitoring and certifying improved material at its source. Additionally, the Forest Law has very stringent planting strategies for plantation forestry to ensure that stands are not composed of monocultures.

CATIE has produced many manuals on the production of certified forest material and is a well-known actor both nationally and in the region for providing high quality post-graduate training.

Guatemala

Selection and innovation

Guatemala has 1812 native tree species recorded. Research to identify those species useful for restoration has not been carried out systematically, but the use of 555 has been established⁴⁵, and INAB

⁴⁰ <https://www.catie.ac.cr/attachments/article/93/BSF-Catalogo-2017.pdf>

⁴¹ https://www.cne.go.cr/cedo_dvd5/files/flash_content/pdf/spa/doc387/doc387-contenido.pdf

⁴² <http://www.fonafifo.go.cr/>

⁴³ <http://orton.catie.ac.cr/repdoc/A0017s/A0017s55.pdf>

⁴⁴ http://ofinase.go.cr/wp-content/uploads/2017/09/ley_semillas6289.pdf

⁴⁵ [http://186.151.231.170/inab/images/descargas/especies/Guia%20de%20Especies%202.6\(Previa\).xlsx](http://186.151.231.170/inab/images/descargas/especies/Guia%20de%20Especies%202.6(Previa).xlsx)

(Instituto Nacional de Bosques) has identified priority species for commercial forestry⁴⁶. This includes two species with an established market and a further 31 species with commercial potential. Five of these species are threatened with extinction and are prioritized for use restoration and reforestation projects. In addition, 22 native species have been identified for use in agroforestry in semi-arid areas. Information on trees for firewood is available to the general public⁴⁷. IUCN has developed a database containing 100 species of trees and shrubs suitable for restoration in Central America, including Guatemala⁴⁸.

Scenarios for the climate-driven change in forest cover have been carried out⁴⁹ and an inter-institutional group (GBByCCC) was set up in 2016 to discuss forests, biodiversity and climate change⁵⁰. This group focuses on REDD+ and the need to maintain forest cover, and does not consider the need to ensure resilience of forests through genetic diversity. However, for several commercially important species the potential distribution change under different climate scenarios has been modelled⁵¹.

There is a very broad life zone mapping for the country but it may not be detailed enough for an ecogeographical zoning to define seed transfer zones. Country-wide genetic studies have been carried out for two species (*Pinus ayacahuite* and *Abies guatemalensis*), with restricted studies on a further six native species. There is also private sector research which is not freely available.

There are no provenance trials in the country, but the University of North Carolina has a collection of five native *Pinus* species in the USA; each from one wild population and has carried out trials there through the CAMCORE program. There is also a network of permanent forestry plots for commercial species across the country that are regularly monitored, which include some native species. This information is available online⁵².

Improved seed has been developed for *Tabebuia donneli-smithi* through a private-public collaboration, with collection of seed from 50 superior trees. Working with Grupo DeGuate CAMCORE has provided material and technical support for the establishment of a clonal orchard and 2nd generation pilot plantations for at least two *Pinus* species⁵³. There is little public information available about improved varieties.

Harvesting and production

INAB allows landowners to register their land for various uses including the production of seed and germplasm. By 2015, 219 sites (1621ha) had been registered, belonging to municipalities, private companies, NGOs, private land owners, and communities. These lands produce seed of 37 species, most of which are native, and as the new PROBOSQUE incentives system will also provide funding for land registered for seed and germplasm production, the number of sites is expected to increase⁵⁴. At a local scale, seed trees were identified and marked in the Maya Biosphere reserve and the botanic garden and three arboreta have important collections of native species that could also be used as seed sources.

⁴⁶ <http://www.fao.org/3/contents/8d7d3d11-4150-4fd5-a71a->

⁴⁷ <http://186.151.231.170/inab/images/descargas/industriaycomercio/Guia%20Especies%20forestales%20para%20le%C3%B1aV8WEB.PDF>

⁴⁸ <http://www.especiesrestauracion-uicn.org/index.php>

⁴⁹ [http://www2.congreso.gob.pe/sicr/cendocbib/con4_uibd.nsf/42CD9BC51BBCC84005257C9E00514F51/\\$FILE/1_pdf_sam_37.pdf](http://www2.congreso.gob.pe/sicr/cendocbib/con4_uibd.nsf/42CD9BC51BBCC84005257C9E00514F51/$FILE/1_pdf_sam_37.pdf)

⁵⁰ http://www.marn.gob.gt/paginas/Grupo_de_Bosques_y_Cambio_Climtico_GBByCC

⁵¹ http://repositorio.bibliotecaorton.catie.ac.cr/bitstream/handle/11554/6367/Impacto_del_cambio_climatico_en_plantaciones_forestales_en_Centroamerica.pdf;jsessionid=17397BBE044E79E392699DB625F5CBF9?sequence=1

⁵² <http://ppm.inab.gob.gt/>

⁵³ http://186.151.231.167/Documentos/Boletines/Boletin_2016/mejoramiento-genetico-forestal.pdf

⁵⁴ http://186.151.231.167/Paginas%20web/Fuente_Semillera.aspx

The only orchards in the country are run by the private sector for seed production for a few commercially valuable species of native *Pinus*, as well as exotics. At present improved seed is imported from CATIE (Costa Rica) for exotics and CAMCORE for native *Pinus*.

There are 458 registered seed suppliers⁵⁵, including individuals, communities and businesses. A national seed bank (BANSEFOR) was created in 1978 to contribute to improving the genetic quality of forestry plantations, as well as the conservation of threatened species. 26 species are represented in the seed bank, with seed being available from 9 localities for *Pinus maximinoi*. The seedbank has been used to plant over 50,000ha with natives⁵⁶.

Nurseries for plant production appear to be distributed across the country. They are owned by a variety of stakeholder including community groups, businesses (Agrobosques -a community project by Cementos Progreso has two nurseries capable of producing 2 million plants annually for community-based restoration projects), and government (where nurseries in the Petén produce 12 native species). There are 47 registered nurseries.

The government agency CONAP (Consejo Nacional de Áreas Protegidas) has a plan to establish a network of protected areas to represent the country's ecosystems. It has also developed conservation areas for wild crop relatives. In addition, there are 147 private forest reserves. For trees outside of the protected area network, the only protection from land use change comes from the registration of private land as a seed source for which the landowner receives a monetary incentive via PROBOSQUE.

Supply and demand

Demand for native species is strongly influenced by the conditions associated with government incentives. There have been two incentive programs for reforestation (run by INAB in coordination with the Ministry of Public Finance): PINFOR (1997-2016) and PINPEP (from 2007). PINFOR provided direct payments for reforestation projects, management and protection of natural forest. Payments were available to municipalities, communities, land owners and social groups. The aim was to create nuclei of highly productive forest across the country using seed from certified seed sources⁵⁷. PINPEP is an incentives system for owners of small areas of forestry and agroforestry land (<15ha)⁵⁸. From 2010 projects receiving funding from PINFOR required the use of seed from selected sources (including BANSEFOR and registered seed sources) and focused on 10 species, 8 of which were native. However, this was only upheld for restoration projects using commercial species. Seventy-five percent of PINFOR-funded projects used *P. maximinoi* and *P. caribe*. A new incentives project, PROBOSQUE, began in 2017. This includes incentives for forest and watershed restoration (where the aim is to restore 200,000ha of native forest) as well as production and agroforestry. Fourteen species are promoted under this program for use in production plantations, including 12 natives. PROBOSQUE will also actively promote the use of threatened native species including four *Pinus* species using seed registered by BANSEFOR⁵⁹. There is also a significant external demand for *Pinus maximinoi* seed from other countries in the region.

The incentives program PINPEP supported reforestation of 3800ha over a ten-year period from 2007-2015, and while how much of the 200,000ha restoration goal under PROBOSQUE, or the 1.2million hectares pledged under Initiative 20x20, will require active planting has yet to be calculated, there is likely to be a need for scaling up material availability. It is assumed that many projects set up their own temporary nurseries as restoration occurs at a small scale. The largest restoration program at present relies on material

⁵⁵ http://186.151.231.167/Paginas%20web/Fuente_Semillera.aspx

⁵⁶ <http://186.151.231.167/Paginas%20web/Bansefor.aspx>

⁵⁷ <http://186.151.231.167/Paginas%20web/Pinfor.aspx>

⁵⁸ <http://186.151.231.170/inab/index.php/45-servicios-inab/120-pinpep>

⁵⁹ <http://www.fao.org/partnerships/forest-farm-facility/43818-0b956f693db9f38841a46a2e4887a29f8.pdf>

from Agrobosques (mentioned above) who transports material from their two centralized nurseries to the local communities.

Quality control

Since 2010 seed certification has been the responsibility of BANSEFOR. Land owners wishing to register their land receive a technical field inspection to check the type of material and sampling strategy, determine seed quality, count the number of superior trees and assign a category to the forest. A management plan is also developed for the forest and a laboratory control of seed quality is carried out. Additionally, any commercial plantation must use seed from a certified source. Nurseries must register with INAB every 3 years, which should involve active inspection of the nursery. The privately-run Agrobosques nurseries are monitored by the State University of New Mexico. SIFGUA (Sistema de Información Forestal de Guatemala) manages data on registered seed sources, nurseries, imports and exports and plantations with information available online⁶⁰. INAB has lots of training material available and also gives training, especially to recipients of government grants.

Mexico

Selection and innovation

Mexico has recorded 3364 native tree species of which CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad) has information on 233 with 70 identified as potentially useful for restoration, across all ecosystems⁶¹. The focus of research on functional traits and germination has to date been on conifer species which are commercially valuable, and most of which are native, but there is user-friendly information on more than 143 species available on the CONAFOR (Comisión Nacional Forestal) website⁶².

The importance of considering climate change in reforestation planning is reflected in two technical documents produced by CONAFOR which look at both the change in forest zones and the need to use germplasm from other areas^{63,64}. Those natives likely to be highly impacted have been identified, and there are trials being carried out simulating altitudinal shifts of individuals in mountainous areas^{10,41}. Thirty-seven species including 17 conifer species have been selected for genetic characterization⁶⁵, but at present this has only been carried out for 8 native species (6 conifers and 2 broadleaved species). Using genetic and ecological information the country has been divided into ecogeographical zones, and these zones are used to guide forest germplasm movement as by law germplasm used in restoration must come from the same ecogeographical region⁶⁶.

Provenance trials are held at 21 locations across the country and include 58 species (many of which are native), and there is a detailed manual on best practices for setting up new trials⁶⁷. Ten species are represented in clonal orchards, clonal seed banks and seed orchards, some of which are on community

⁶⁰ <http://www.sifgua.org.gt/>

⁶¹ http://www.conabio.gob.mx/conocimiento/info_especies/arboles/doctos/inicio.pdf

⁶² <http://www.conafor.gob.mx/portal/index.php/temas-forestales/reforestacion/fichas-tecnicas>

⁶³ <http://www.conafor.gob.mx:8080/documentos/ver.aspx?grupo=19&articulo=3230>

⁶⁴ <http://www.conafor.gob.mx:8080/documentos/docs/19/6688Gu%C3%ADa%20T%C3%A9cnica%20para%20la%20Planificaci%C3%B3n%20de%20la%20Reforestaci%C3%B3n.pdf>

⁶⁵ https://coin.fao.org/coin-static/cms/media/11/13310714832850/informe_rgf.pdf

⁶⁶ <http://www.conafor.gob.mx:8080/documentos/docs/19/1290Manual%20para%20la%20identificaci%C3%B3n%20y%20establecimiento%20de%20Unidades%20productoras%20de%20Germoplasma%20Forestal.pdf>

⁶⁷ <http://www.conafor.gob.mx:8080/documentos/docs/19/1290Manual%20para%20la%20identificaci%C3%B3n%20y%20establecimiento%20de%20Unidades%20productoras%20de%20Germoplasma%20Forestal.pdf>

lands, and CONAFOR works actively with the regional governments to increase the production of improved material as well as raise awareness. There is also active research on recalcitrant seed preservation. CONAFOR produces *Innovación Forestal*, a technical magazine and coordinates national thematic networks for researchers on all aspects of forestry, biodiversity and climate change. There is also an independent network for ecological restoration (REPARA). Information on many aspects of forestry is coordinated centrally through the Sistema Nacional de Información Forestal (SNIF).

Harvesting and production

Seed collectors must apply for a permit to CONAFOR⁶⁸. In 2012 each state had production units for forest genetic resources, totaling 210 units (including 11 seed areas and 171 tree stands). A further 361 areas have been identified for the mass production of material⁶⁹. While there has been an increase in research on improved seed, so far none is available at a commercial scale.

Many *in-situ* seed sources are protected through national protected areas and management systems which include a system of 10,855 management areas for conservation (small areas for the conservation of important populations or individuals). This is in addition to the production units for forest genetic resources which include 28 threatened species, and the wild populations of 11 threatened tree species of commercial importance that have been identified specifically for further protection⁷⁰.

There are 37 seed banks for medium-term storage, and 17 temporary seed storage areas. These are mostly government-run and include native and exotic species for public reforestation projects. There are also 341 registered forestry nurseries, managed by communities, land owners, businesses, local governments, the military and CONAFOR⁷¹.

Supply and demand

Mexico established 242,000 hectares of planted forest between 2000 & 2012, representing 0.1% of forest cover, much of which uses commercially valuable native species⁷². There has been a big effort to increase the availability of germplasm for these species through the creation of production units and forest nurseries that are distributed across the whole country; in 2014 61% of projects funded by CONAFOR were within 100km of a nursery. Improved seed produced in Mexico is not yet available commercially.

Due to the problem of degraded lands and low success rate of many restoration programs⁷³ there is an increased interest in better project management and the use of a wider range of natives, led by the government. Areas requiring restoration have been mapped by CONAFOR⁷⁴ who has also developed guidelines on which species should be used for each ecosystem⁷⁵.

While the magnitude has not been quantified, it appears that much of the demand for native species comes from projects with funding from a government program (PRONAFOR) which funds and provides incentives for research, REDD+, commercial forestry, sustainable forest management, protection, payment for ecosystem services and restoration. This program builds on ProArbol that ran from 2007-2012. The funding is given to priority regions that change every year but there is an emphasis on providing support to

⁶⁸ <http://certificadoramexicana.com/documentos/NMX-AA-169-SCFI-2014.pdf>

⁶⁹ https://coin.fao.org/coin-static/cms/media/11/13310714832850/informe_rgf.pdf

⁷⁰ https://coin.fao.org/coin-static/cms/media/11/13310714832850/informe_rgf.pdf

⁷¹ <https://www.gob.mx/reforestacion/articulos/produccion-de-arboles-forestales-en-mexico>

⁷² http://www.dof.gob.mx/nota_detalle.php?codigo=5342498&fecha=28/04/2014

⁷³ <http://www.conafor.gob.mx:8080/biblioteca/ver.aspx?articulo=493>

⁷⁴ <http://www.cnf.gob.mx:8090/snif/portal/zonificacion#>

⁷⁵ <http://www.conafor.gob.mx:8080/documentos/docs/7/579Restauraci%C3%B3n%20de%20ecosistemas%20forestales.pdf>

communally owned lands which represent most of the country's forested area⁷⁶. Planting material for different ecosystems can be provided by CONAFOR (including improved material). In addition, state governments have their own incentives programs, resources are also available through REDD+ and the Forest Investment Program and new plantations should preferentially use native species that are of commercial value. In addition, compensation as part of the mitigation hierarchy for development projects requires the use of at least 3 species of natives suited to the ecosystem and that seed is collected near to the site to be restored⁷⁷.

Quality control

Seed collectors must apply for a permit from CONAFOR before collecting seed and provide information such as the source location, land ownership, permission to collect, species, type of material, type of seed source (e.g. seed orchard, clonal orchard, superior individuals or wild population), amount of material and population status⁷⁸. The quality of material from the production units for forest genetic resources is also under the responsibility of the forestry department, while for other material it is controlled by the Servicio Nacional de Inspección y Certificación de Semillas (SNICS) under the Ministry of Agriculture. The national network of forest genetic resources evaluates and registers superior individuals of commercially important species, and coordinates the creation of seed orchards from these individuals. Nurseries must meet minimum phytosanitary requirements for certification, and restoration projects must plant species of a given size and at a specified density.

Peru

Selection and innovation

Peru has recorded 4439 native tree species. Individual research in dry, montane and high montane forest led by NGOs and universities has identified those species of most use for restoration, and there is substantial research on the use of natives for mine site remediation in the Amazon by the University of Florida. Functional traits of tree species are being compiled by ICRAF in the Amazon and Bioversity International in tropical dry forest.

There is a broad classification of ecosystem types but a more detailed zoning has yet to be agreed upon. There is genetic characterization for many of the main forestry species, including key species for restoration. However, SENASA (Servicio Nacional de Sanidad Agraria) has defined seed sourcing areas according to political regional boundaries; material from one region is not permitted to be used in another under the current phytosanitary legislation.

There is a national strategy for forests and climate change elaborated by the Ministry of Agriculture (MINAGRI) and the Ministry of Environment (MINAM) with the aim of ensuring increased carbon sequestration by increasing forest cover and increasing connectivity to help resilience⁷⁹. The Instituto Geofísico del Peru has predictive maps for expected changes in ecosystem distribution under climate change. The National Plan for Recovering Degraded Areas produced by SERFOR will also be an important initiative once approved.

There are more than 100 field trials in the coast, mountains and rainforest that focus on exotics but also a handful of natives of commercial importance - *Bertholletia excelsa*, *Amburana cearensis*, *Calycophyllum spruceanum*, *Dipteryx micrantha*, *Caesalpinia spinosa* and *Alnus acuminata*. There are trials in the tropical dry

⁷⁶ http://www.conafor.gob.mx/apoyos/index.php/inicio/app_apoyos#/detalle/2017/68

⁷⁷ <https://www.gob.mx/conafor/acciones-y-programas/apoyos-conafor>

⁷⁸ <http://certificadoramexicana.com/documentos/NMX-AA-169-SCFI-2014.pdf>

⁷⁹ <http://www.minam.gob.pe/wp-content/uploads/2016/07/ESTRATEGIA-NACIONAL-SOBRE-BOSQUES-Y-CAMBIO-CLIM%C3%81TICO-DECRETO-SUPREMO-007-2016-MINAM11.pdf>

forest with *Prosopis pallida*, *Capparis scabrida*, *Tabebuia guayacan*, and *Bursera graveolens*. INIA (Instituto Nacional de Innovación Agraria), IIAP (Instituto de Investigaciones de la Amazonía Peruana) and SERFOR (Servicio Forestal y de Fauna Silvestre) manage collections of native fruit tree species.

Harvesting and production

Harvesting is not regulated, and involves rural and indigenous communities, as well as the private sector. In Cajamarca AGRO RURAL (Programa de Desarrollo Productivo Agrario Rural) coordinates a network of seed collectors for montane species who they call upon when they need seed for a rural development project.

Seed stands have been identified for a few species including *Swietenia macrophylla* in Tahuamanu-Madre de Dios and Purus-Ucayali managed by NGOs. The private nursery BASFOR has stands in Ancash for *Alnus acuminata* (93 trees), *Buddleja incana* (75 trees) *Caesalpinia spinosa* (75 trees), *Cedrela lilo* (87 trees) *Polylepis racemosa* (50 trees) and *Prunus serotina* (78 trees)⁸⁰. There is no specific protection of seed sources outside of the protected area network although researchers have proposed strategies for this.

Seed orchards exist for several of the most commercially valuable tree species, run by a variety of NGOs, universities and the government. These include clonal seed orchards for *Bertholetia excelsa*, *Hevea brasiliensis*, *Guazuma crinita*, *Calycophyllum spruceanum* and *Bactris gasipaes*. Vegetative material is taken from planted stands of *Polylepis incana* and *Polylepis racemosa* managed by ADEFOR (Asociación Civil para la Investigación y Desarrollo Forestal), a group set up in 1979 with support from international funding⁸¹.

There is no official inventory of nurseries and while many private nurseries do produce natives, restoration projects often set up their own temporary facilities. Commercial species are produced by private companies including BASFOR which sells seeds of 14 natives of known provenance, and superior seed from 6 natives from seed stands. Another commercial nursery, SEMIFOR, produces seeds of at least 10 native Amazon tree species.

Supply and demand

The Forest Law clearly promotes the use of native species in restoration projects and other laws (such as those related to mine closure, or protected area management) also require their use. The compensation guidelines for development projects is also likely to insist on the use of native species. However, to date, the use of native species has been modest with a low diversity of species used (although there are some notable exceptions). Material of a limited number of species can be supplied by private nurseries who also have selected seed for some species, but it appears that demand is often reached through project-specific temporary nurseries. Most of the seed for plantation forestry is imported from Brazil, Colombia, Chile and Costa Rica. For natives it is available nationally for a handful of species including *Alnus acuminata*, *Caesalpinia spinosa* and *Prunus salicifolia* in the montane region, *Prosopis pallida* in the tropical dry forest, and for *Cedrelina catanaeformis*, *Amburana cearensis*, *Dypteryx micrantha*, *Bactris gasipaes*, *Calycophyllum spruceanum* and *Guazuma crinita* in the Amazon. For the last three species improved seed is available in sufficient quantity to meet demand. Cuellar et al (2019)⁸² carried out a detailed study to understand the market potential and current use of forest tree seeds, the stakeholders involved in seed network, and the potential of scaling, with increased emphasis on quality control.

There is some funding for commercially valuable species through government sources such as PNIA (Programa Nacional de Investigación Agraria); INNOVATE PERÚ and FINCYT del Consejo Nacional de Ciencia, Tecnología e Innovación Científica (CONCYTEC).

⁸⁰ e.g. <http://www.arborizaciones.pe/biblioteca-forestal/rodales-semilleros-establecidos/el-aliso>

⁸¹ <http://www.adefor.org/portal/index.php/adefor/logros>

⁸² Cuellar-Bautista JE, Ugarte-Guerra LJ & Vilcapoma Areche E (2019) Situación actual y características del mercado de semillas forestales a nivel de regiones de la costa, sierra y selva del Peru Revista Xilema 29(1): 25-35 <http://dx.doi.org/10.21704/x.v29i1.1347>

Quality control

There is a legal framework in place for all plant seeds (Ley General de Semillas), which includes the Reglamento de Semillas Forestales, covering registry of seed collectors, management of seed stands, seed collection strategy and seed production as well as seed quality⁸³. The Reglamento is currently under review by COSEFOR (Comité de Semillas Forestales), a committee composed of the main institutions involved in forestry; the revised version will also include specific regulations for species or groups of species, as this is a precondition for certification. The law will be upheld by regional seed committees.

Forest nurseries are obliged to register with SERFOR, but this is not enforced. However, commercial plantations must register with SERFOR and state where their planting material came from in order to be able to sell their timber. SENASA is responsible for controlling nursery phytosanitary conditions, although to date the focus is on agricultural nurseries. However, planting material is usually obtained from informal sources the quality of available planting material is not monitored officially, but is maintained by the trust between the nursery manager and the expectations of their regular customers.

⁸³ [http://www.inia.gob.pe/images/EnteRector/DOC_PEAS/Legislacion/RegalmentodeSemillasForestales\(08-2011\).pdf](http://www.inia.gob.pe/images/EnteRector/DOC_PEAS/Legislacion/RegalmentodeSemillasForestales(08-2011).pdf)