Genetic principles for improving restoration success –*Thematic study on ecosystem restoration for FAO*

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Why are genetic considerations important for restoration success?

Genetic diversity is the foundation for:

Survival of planted trees on the restoration site

- Origin of seed must match site conditions to ensure adaptedness

Good growth, reproduction and resilience over tree generations

- Seed source forests must be large and genetically diverse enough to avoid inbreeding and to contain genetic material for natural selection
- Good seed collection practices must be observed to capture the genetic diversity of the seed sources

Example: importance of adaptedness for survival

Juglans nigra (Black walnut)

- Broad distribution in the US
- A provenance trial in 7 locations, 15-25 provenances planted at each location
- Survival after 22 years was much higher for local than for the other provenances (71% vs. 0% at some sites)

Bresnan et al. 1994

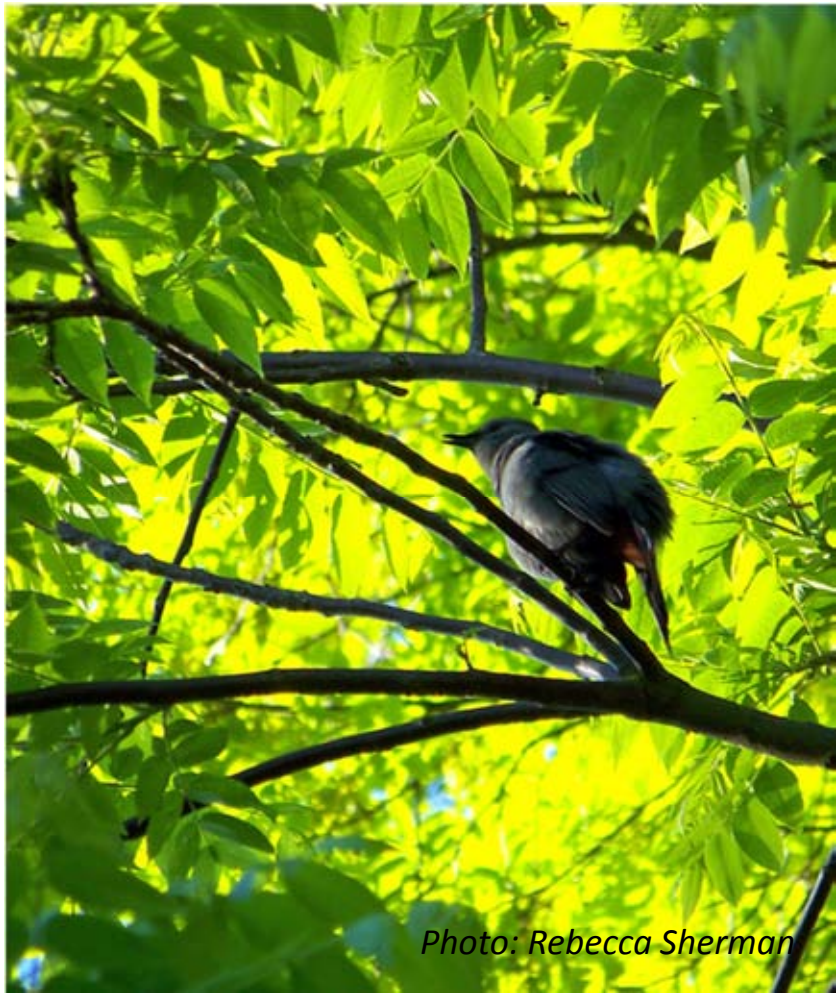

Photo: Rebecca Sherman

Example: Effects of inbreeding on growth

Pseudotsuga menziesii
(Douglas-fir)

- Comparison of selfed and outcrossed offspring 33 years after seedling establishment
- Survival of selfed trees was only 39% of the outcrossed trees
- DBH of selfed trees was only 59% of the outcrossed trees (for surviving trees)

White et al. 2007

Photo: Charlie Hickay

Example: Effects of poor seed collection practices accumulate over generations

Acacia mangium

- Introduced to Sabah from Australia in 1967 in two small stands (34 and ca. 300 trees) where all trees had the same mother tree. This material formed the basis for more than 15 000 ha of plantations.
- A nursery trial showed reduction in average height by 44% from the first to the third generation (Sim 1984):

Generation	1st	2nd	3rd
Height (cm)	32.5	20.7	18.1

Limited attention to genetic considerations in restoration

Few experimental studies on genetic considerations in restoration projects but most of those reveal:

- Questionable matching of germplasm and site, e.g. mixing of seed from clearly distinct sources, or using inland seed sources for restoring forests in coastal areas
- Poor genetic quality of seed sources, reflected as low seed weight, poor germination and seedling survival
- Poor seed collection practices which had resulted in genetic bottlenecks, reflected as low seed weight and poor germination

Photo: Soumitra Dhali

Krishnan et al. 2013, Liu et al. 2008, Broadhurst et al. 2006, Li et al. 2012

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Experiences among restoration practitioners

A survey among 23 practitioners who have developed or advanced forest restoration methods

- Only half of the restoration methods incorporated guidelines or recommendations for seed collection
- *“it is very difficult to get people to collect seed from more than one tree”*
- Lack of knowledge about and seed for native tree species was considered a main constraint to the wider application of the various restoration methods
- More than half of the respondents indicated that the restoration methods do not consider effects of climate change.

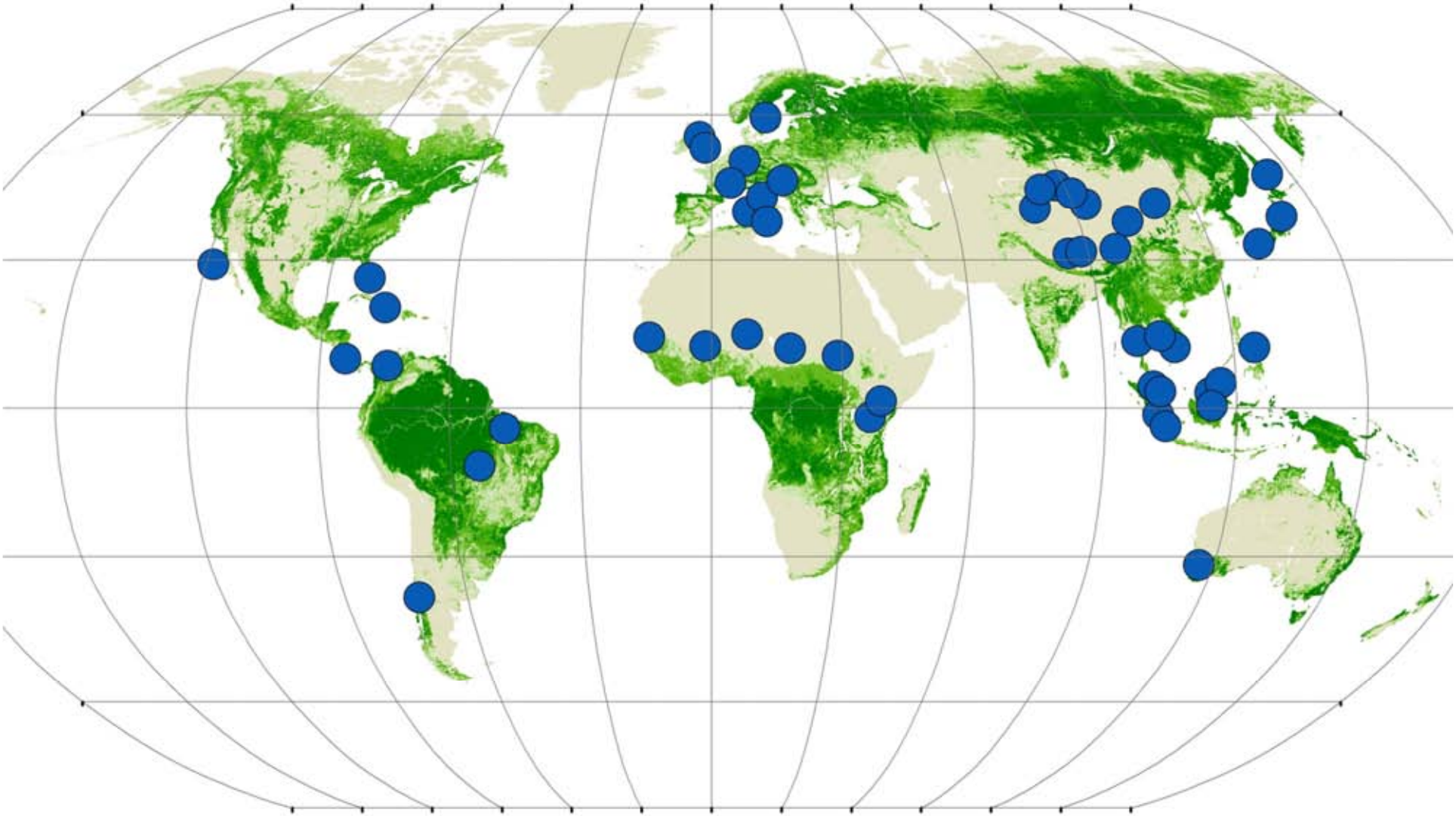
Bozzano et al. 2014

Thematic Study on ecosystem restoration

Thematic study: Genetic considerations in ecosystem restoration using native tree species

- Commissioned by FAO for the first global report on the State of the World's Forest Genetic Resources
- Reviews on overarching issues:
  - Seed provenance, Propagation methods, Fragmentation, Gene flow, Collection of propagation material in the absence of genetic knowledge etc.
- Descriptions and case studies of restoration methods
- Survey among restoration researchers and practitioners about common approaches
- Analysis of genetic considerations in restoration practice
- Recommendations for policy, practice and research

Case study locations



Recommendations – policy and capacity strengthening

Recommendations for policy and incentives

- Create demand for good quality seed of native tree species through political commitment and supportive regulatory frameworks
- Commission development of seed zones for sourcing and transferring seed, and mechanisms for their implementation
- Create financing mechanisms that support the use of native tree species and good quality seed
- Support planning of restoration efforts in the landscape context

Preparing seed for direct seeding.
Photo: Luciana Akemi Deluci

Recommendations for capacity strengthening and knowledge management

- Adjust existing guidelines for seed collection to the restoration context, and to the changing climate conditions
- Provide training and support to restoration practitioners, local nurseries and seed collectors about seed collection and propagation techniques for native tree species
- Strengthen mechanisms for sharing information on native tree species, their propagation, management and conservation.
- Advocate for a more holistic view in evaluating restoration success

National focal points for Forest Genetic Resources

- Asia Pacific Forest Genetic Resources Programme, APFORGEN, www.apforgen.org
  - Main objectives: strengthen FGR national programmes, enhance regional networking and collaboration, collaborative research
  - 14 member countries
- National focal points for the State of the World's Forest Genetic Resources Process (2009-2014), FAO
  - Recent country reports on the FGR status and priorities, building on stakeholder consultations

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Thank you

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Web resources – species information and restoration methods

- **The Agroforestree database** by ICRAF
  - information on propagation and distribution of hundreds of tree species
  - http://www.worldagroforestry.org/resources/databases/agroforestree
- **The Tropical Restoration Information Clearinghouse** (TRIC) by Environmental Leadership and Training Initiative, Yale University
  - annotated literature lists relevant to restoration, including grey literature; information on dozens of restoration projects
  - http://reforestation.elti.org/
- **Rain Forest Restoration Initiative** by ELTI
  - Publications, manuals; list of nurseries for native species
  - http://www.rainforestation.ph
- **Forest Restoration Research Unit** of Chiang Mai University,
  - Practical restoration manuals
  - http://www.forru.org/
- **The Seed Information Database** by Royal Botanic Gardens, Kew,
  - optimal germination protocols, seed storage behaviour etc. on more than 11 000 tree and shrub species (July 2012)
  - http://data.kew.org/sid/