Challenges to implementation of high-throughput genotyping technologies for DNA forensics in the timber market

Stephen Cavers

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NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

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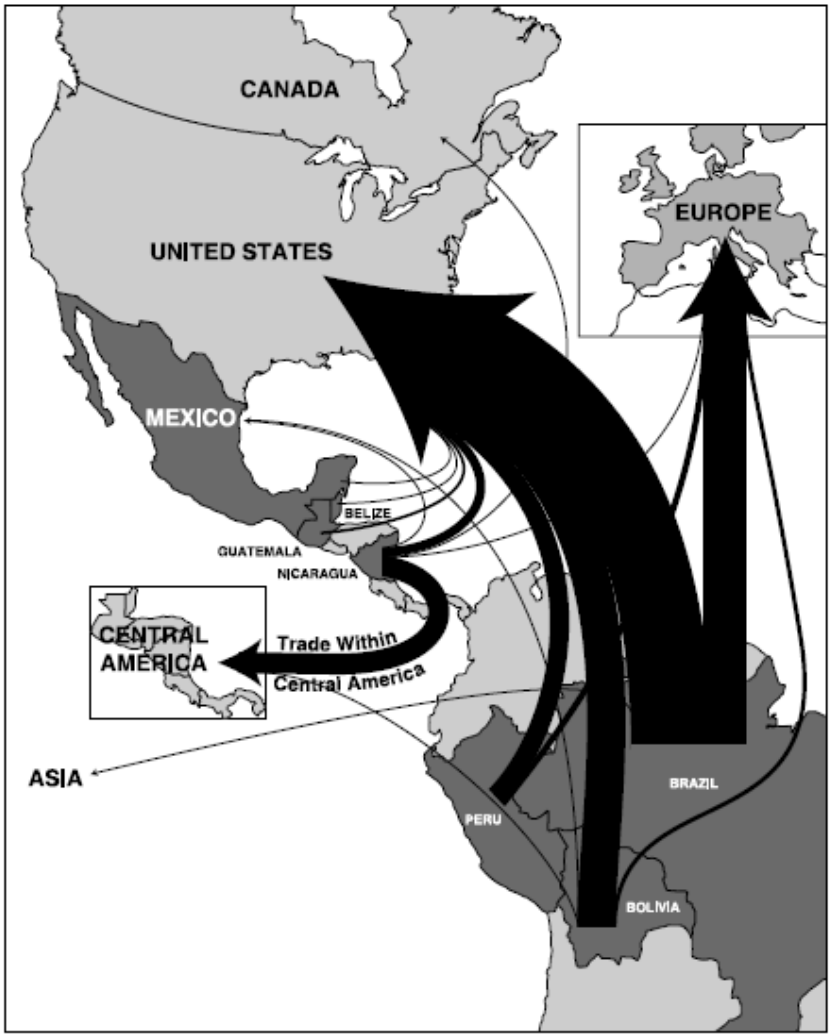
State of play

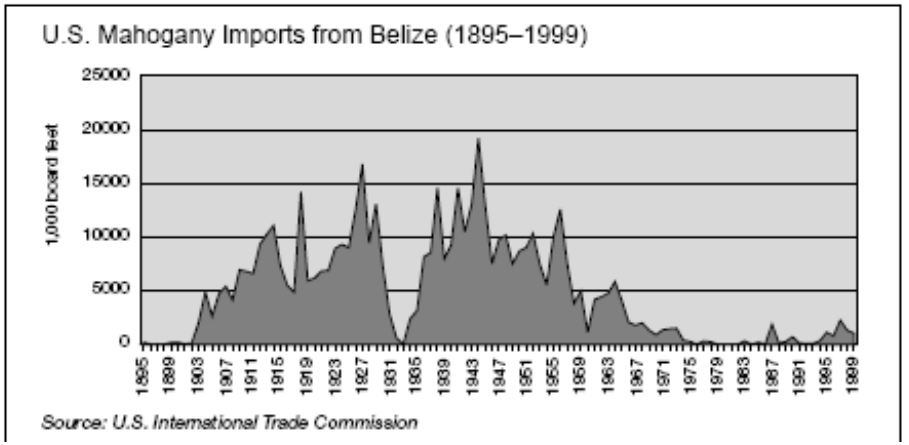
- Focus on tropical timbers – likely most uncontrolled extraction
- Genomic technologies ready to deliver
- Regulations in place with major consumer markets
- Agreements taking shape between consumer-producer

- But, time pressure is high

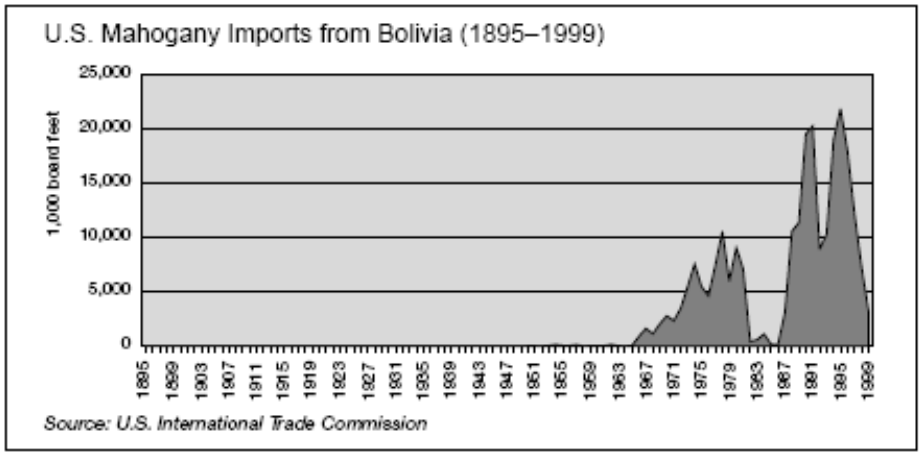
Mahogany resource exhaustion 20th C



Source: World Conservation Monitoring Centre (WCMC)



Source: U.S. International Trade Commission



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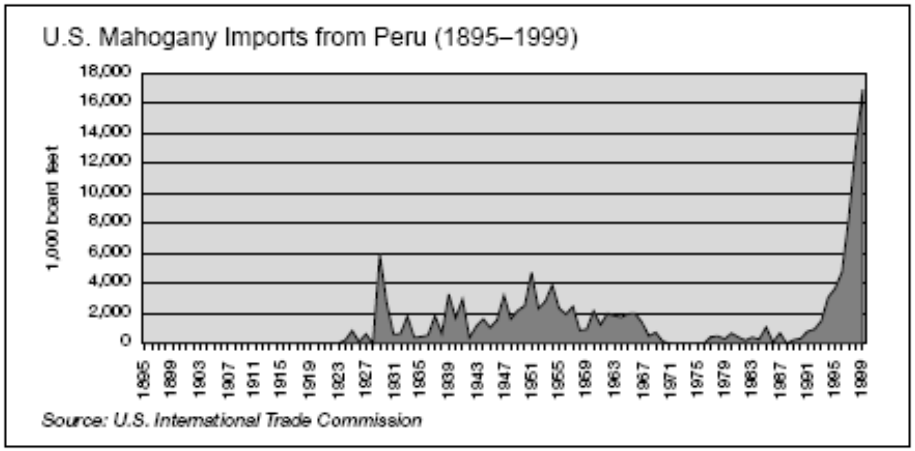

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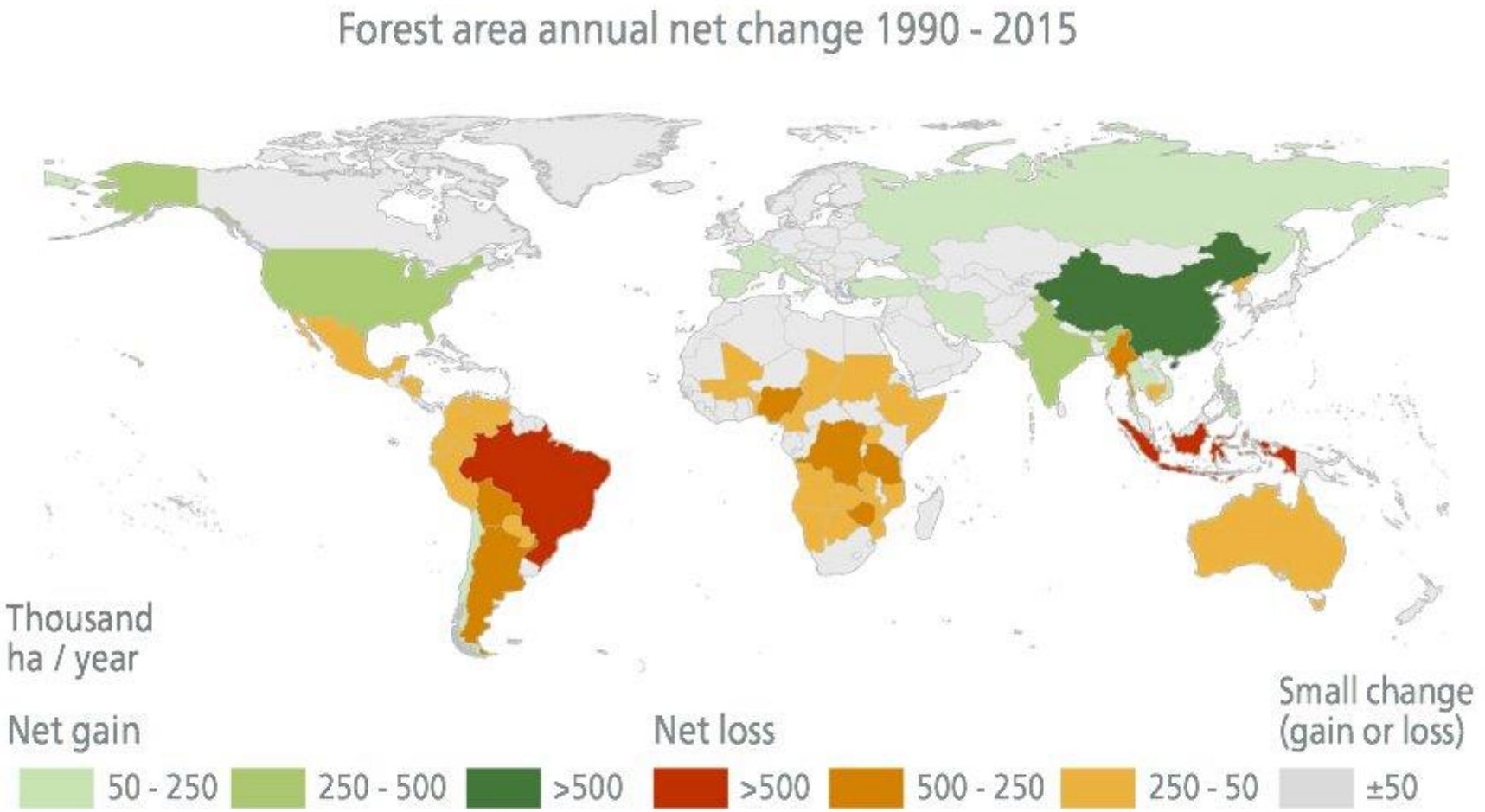
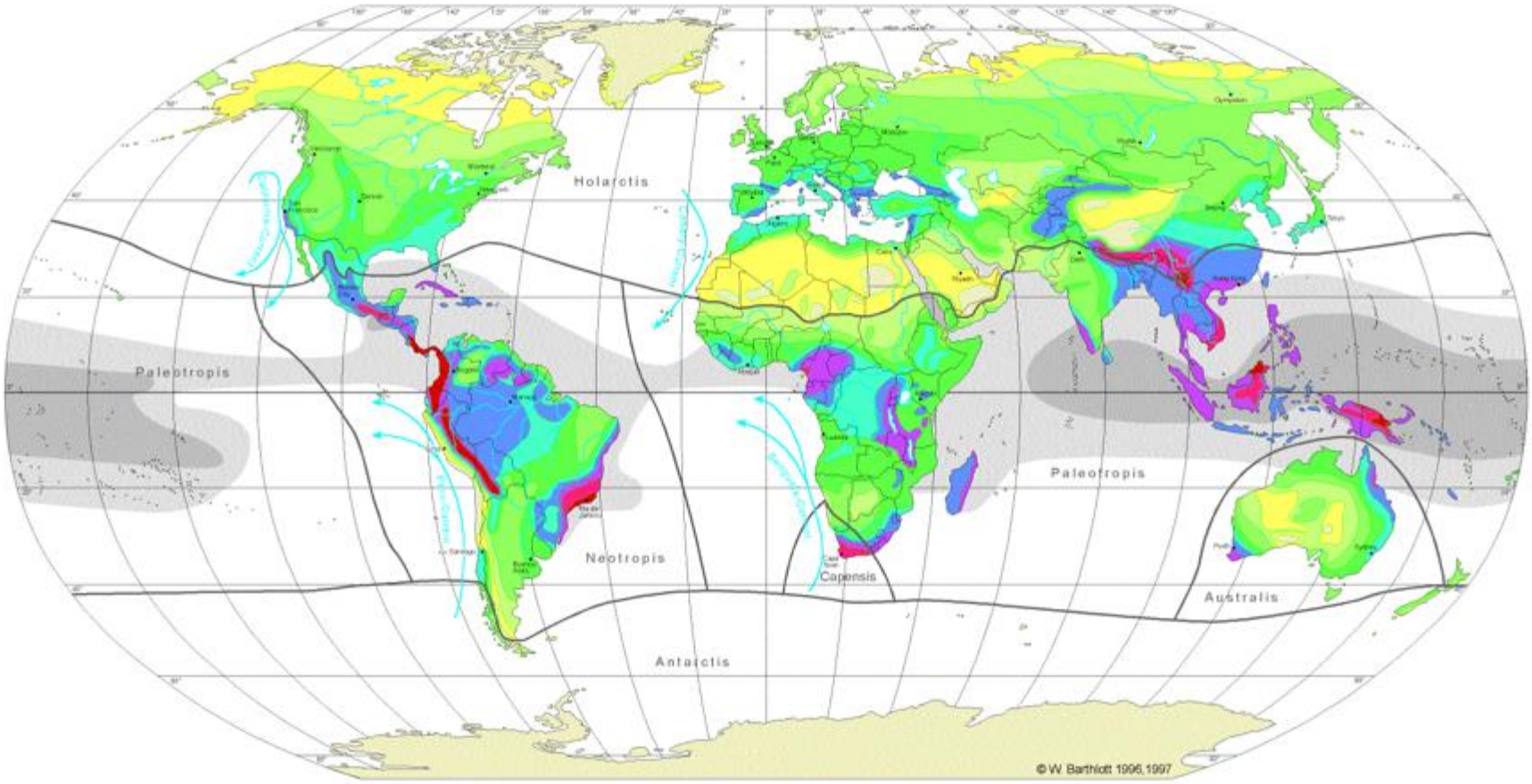

Forest area annual net change 1990 - 2015
Thousand ha / year
Net gain
50 - 250
250 - 500
>500
Net loss
>500
500 - 250
250 - 50
Small change (gain or loss)
±50
↑ Net forest increases
have been mostly in the temperate and boreal zones.
↓ The largest forest loss
has occurred in the tropics, particularly in Africa and South America.

FAO 2015

GLOBAL BIODIVERSITY: SPECIES NUMBERS OF VASCULAR PLANTS



Robinson Projection
Standard Parallels 38°N und 38°S
Scale 1: 130000000

Diversity Zones (DZ): Number of species per 10.000km²

- DZ 1 (<100)
- DZ 2 (100 - 200)
- DZ 3 (200 - 500)
- DZ 4 (500 - 1000)
- DZ 5 (1000 - 1500)
- DZ 6 (1500 - 2000)
- DZ 7 (2000 - 3000)
- DZ 8 (3000 - 4000)
- DZ 9 (4000 - 5000)
- DZ 10 (≥5000)

Capensis floristic regions

sea surface temperature

- >29°C
- >27°C

cold currents

W. Barthlott, N. Biedinger, G. Braun
F. Feig, G.Kier, W. Lauer & J. Mutke 1997
modified after
W. Barthlott, W. Lauer & A. Placke1996
Department of Botany and Geography
University of Bonn
German Aerospace Research Establishment, Cologne

Cartography: M. Gref
Department of Geography
University of Bonn

Challenges

Diversity & the taxonomic gap

Legality & spatial structure gap

Implementation gap

Principal Objective: management of illegal trade

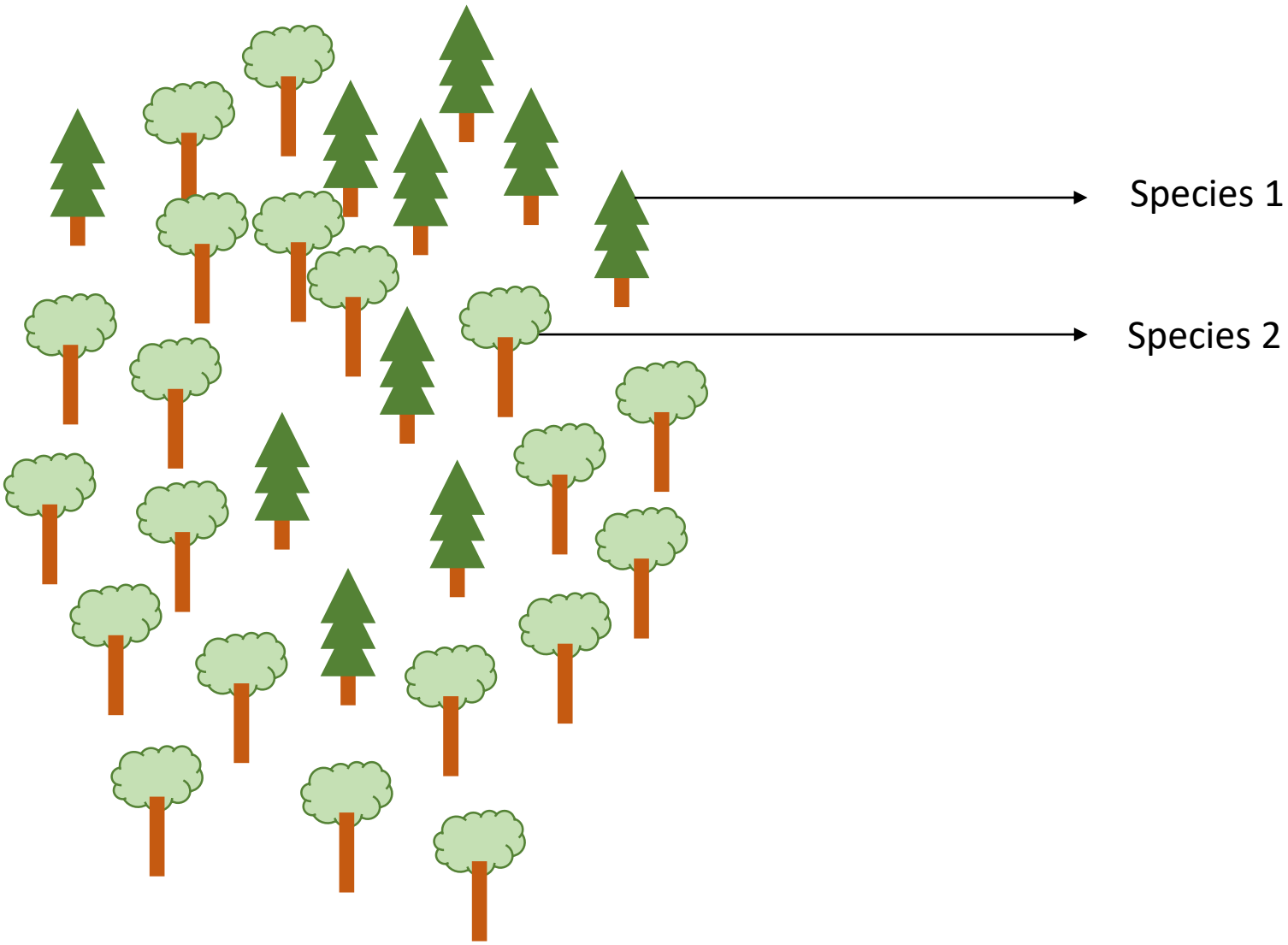
What constitutes illegality?

- Trade of species other than designated
- Sourcing of individuals outside legally designated zone
- [Sourcing of individuals within designated zone but outside limits]

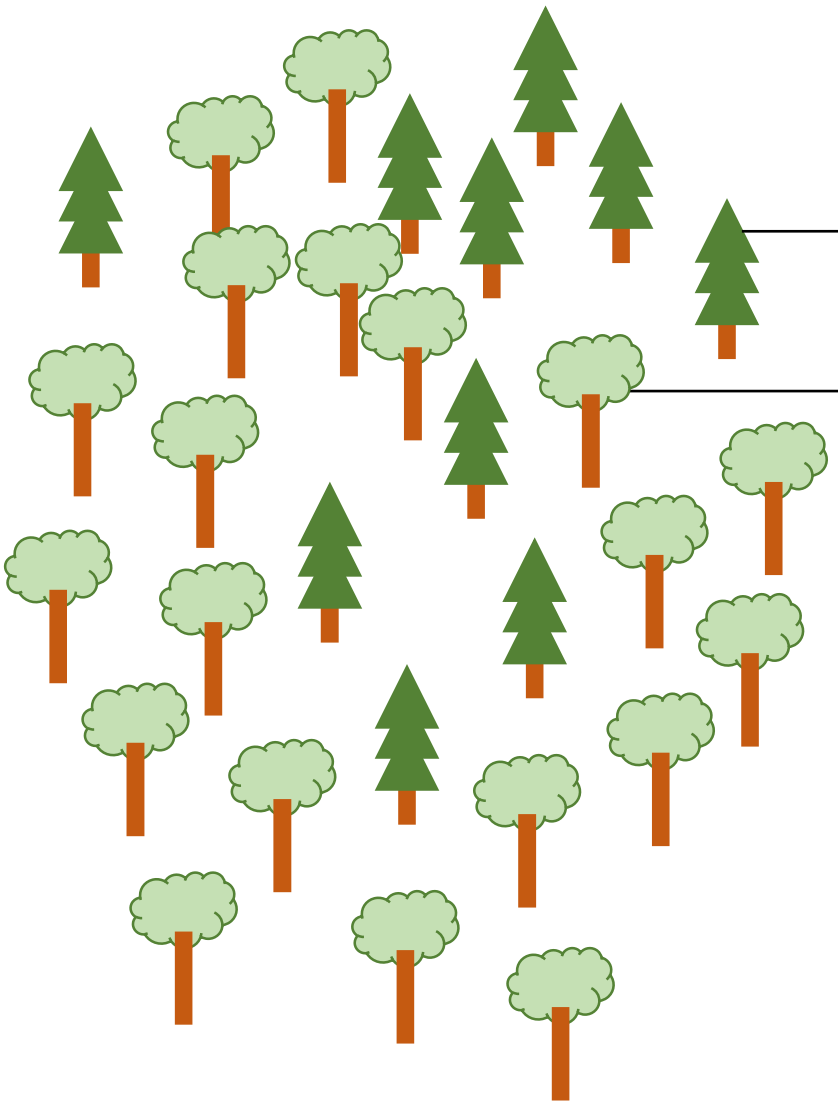
Objectives of DNA forensic methods:

- Species ID
- Tracing to origin

An ideal world

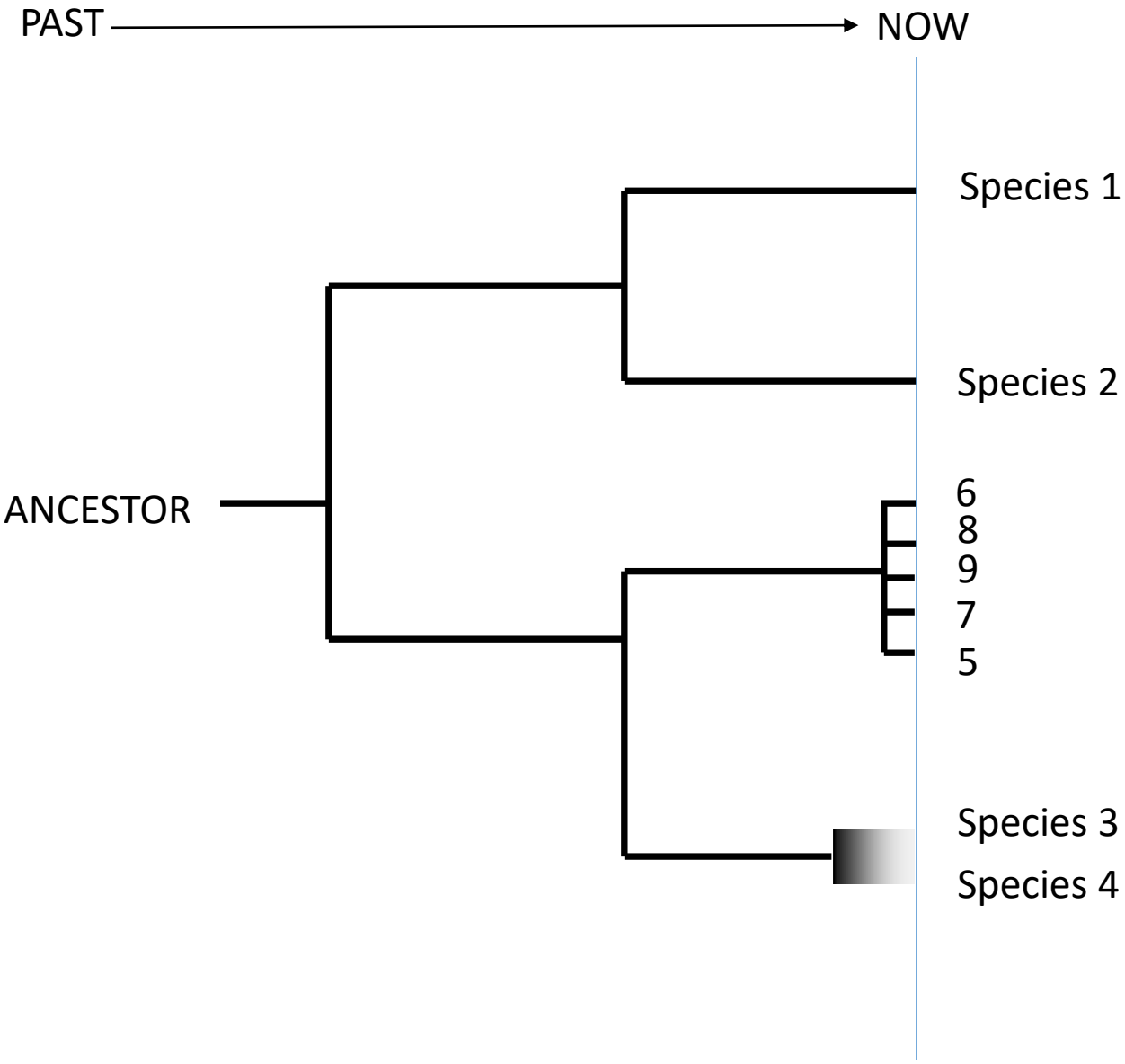


An ideal world



Species 1

Species 2


PAST
NOW
Species 1
Species 2
ANCESTOR
6
8
9
7
5
Species 3
Species 4

Challenges

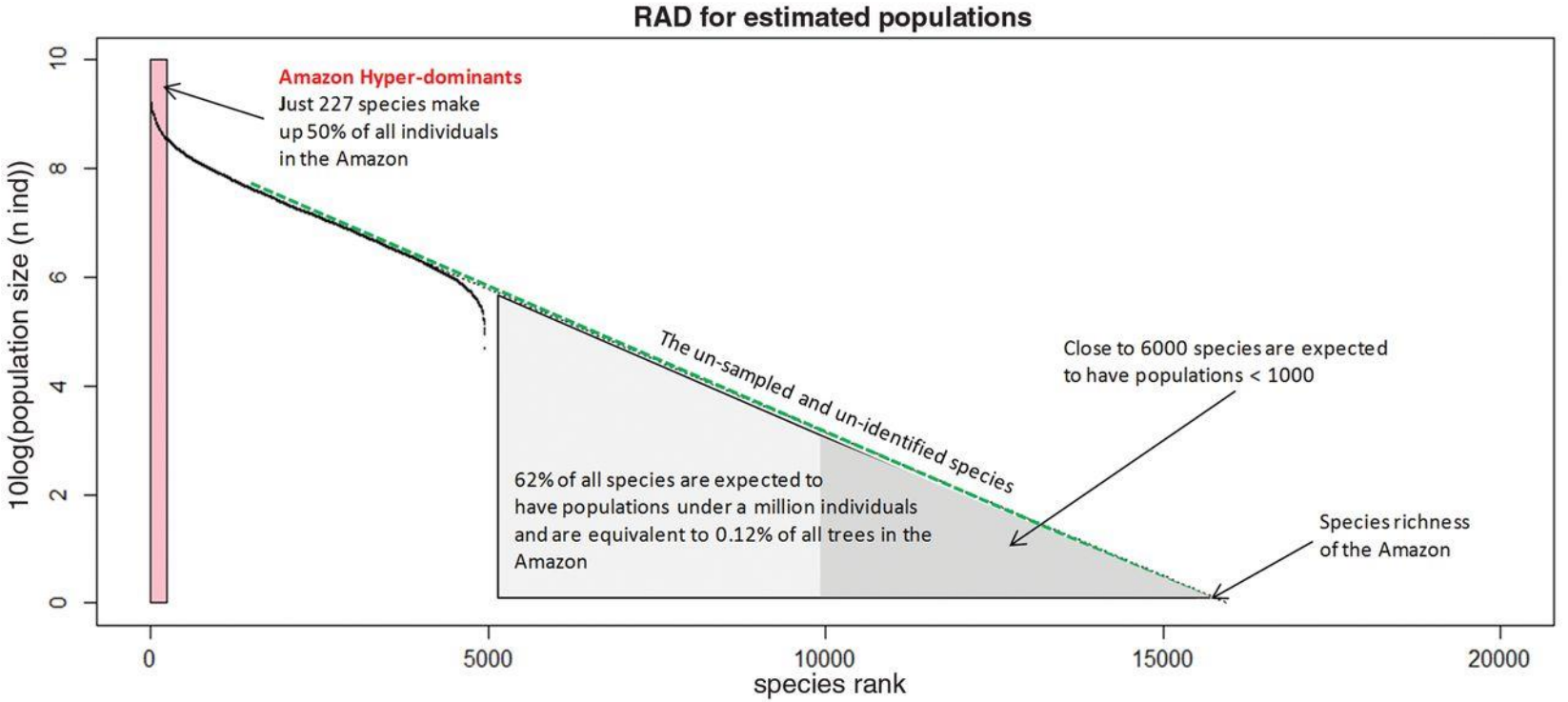
Diversity & the taxonomic gap

Legality & spatial structure gap

Implementation gap

Challenge: species diversity

- Number of tree species in tropics 35000-50000
- Number of Amazonian tree species estimated at 7-11000
- Ways to prioritise:



Hans ter Steege et al. Science 2013;342:1243092

Challenge: taxonomic gap

- New species still being described
- Last year - 2000 plant species, including;
-
  - 10 new species of Trichilia (Meliaceae)
  - 5 new species of *Dalbergia* from Gabon
  - new Brazilian genus

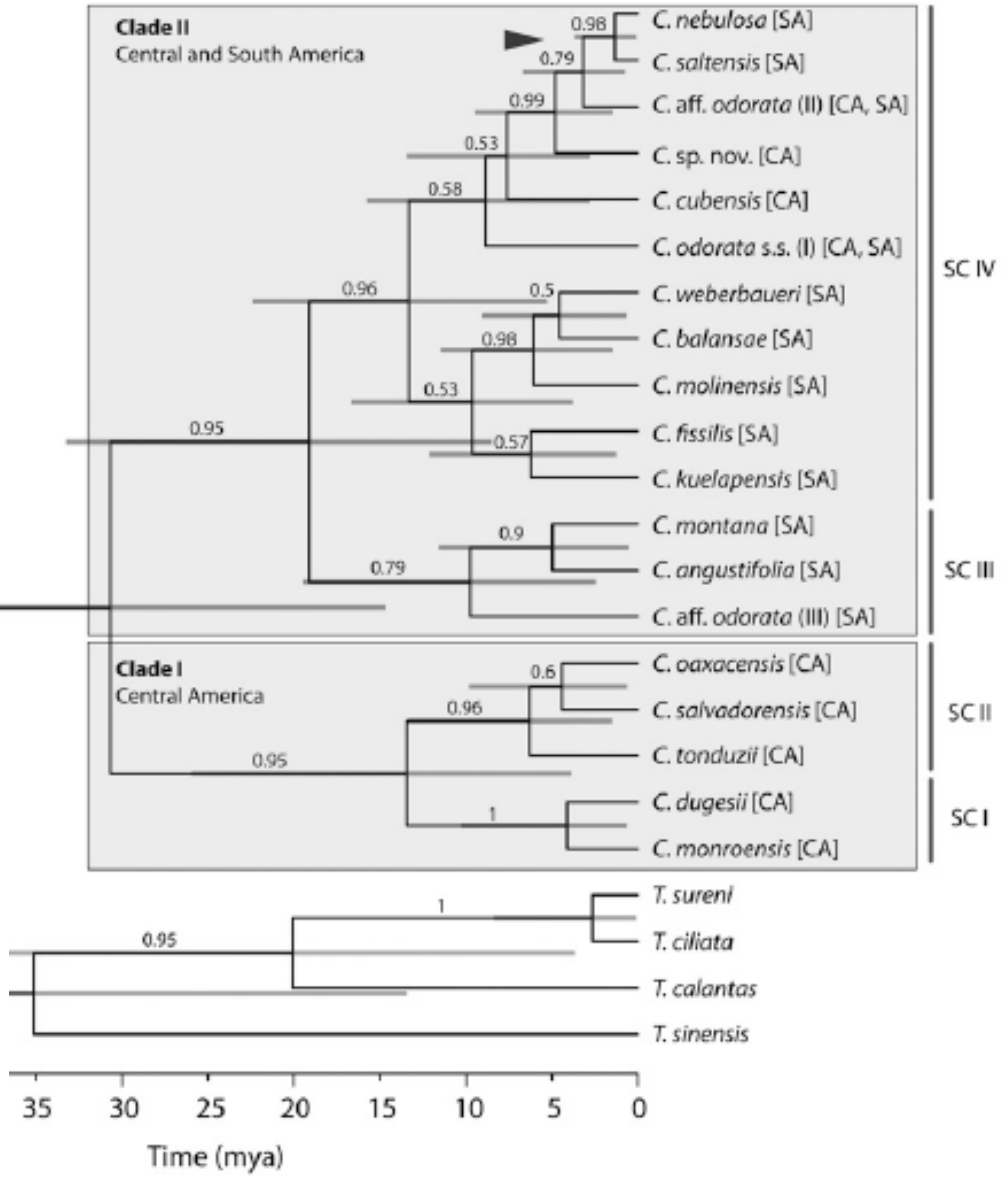
- Even well-known and traded species insufficiently characterised; *Caesalpinia echinata* reclassified

- Also have species complexes, cryptic species, hybrids

Cedrela odorata

- 1981 - 1 widespread, variable species
- 2010: 17+ species, inc.
  - Complexes
  - Cryptic species
  - Hybrids

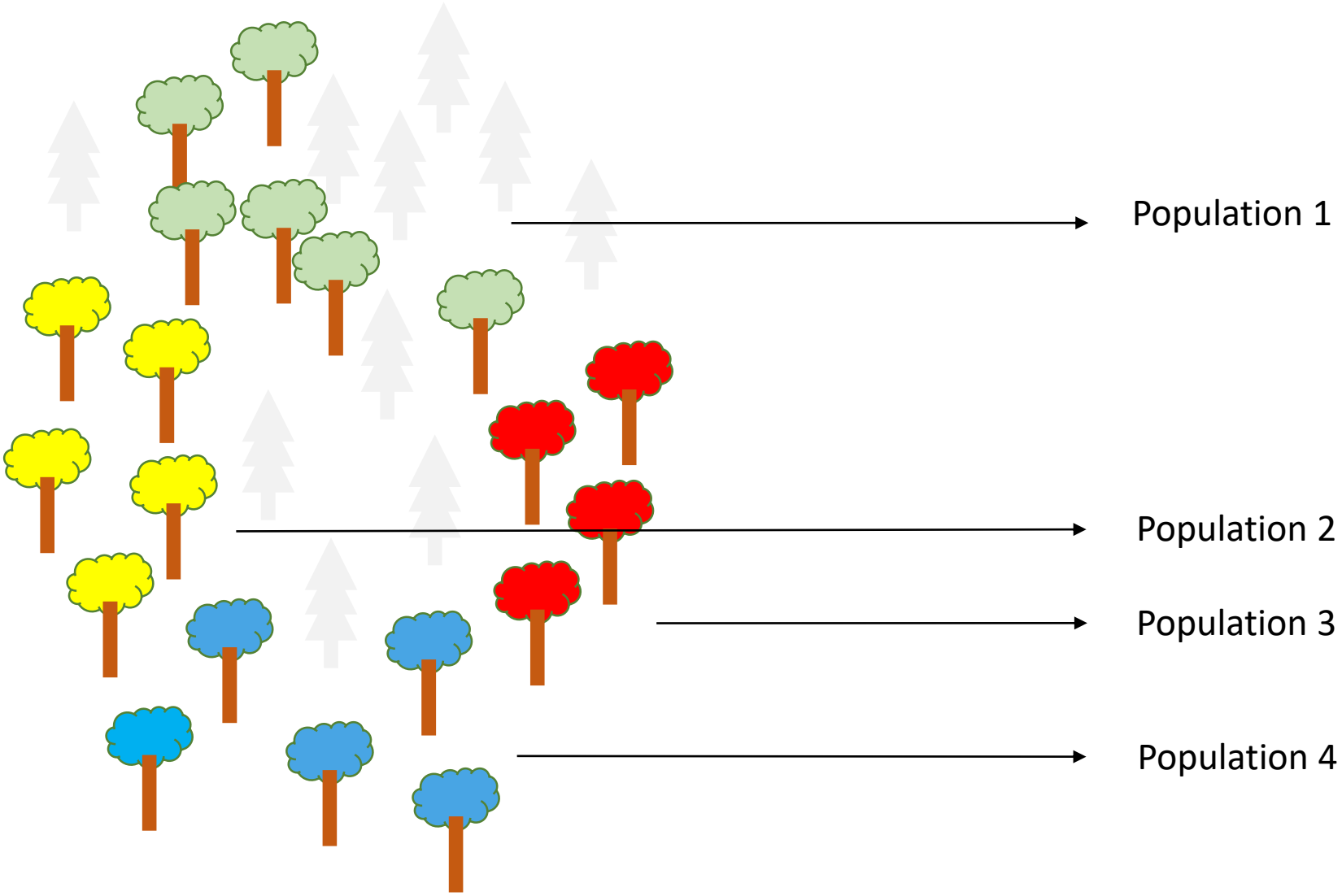
A. Leaf of *Cedrela* sp. (left), **B.** Flowers (middle), **C.** seeds (right), photographs taken by A. Muellner-Riehl



Solutions ?

- Support taxonomy but find ways to accelerate species descriptions
- Boost reference collections – accelerate by mandatory sample provision linked to authority to log?
- Adjust legal approach to deal with reality that species have ‘fuzzy edges’

An ideal world



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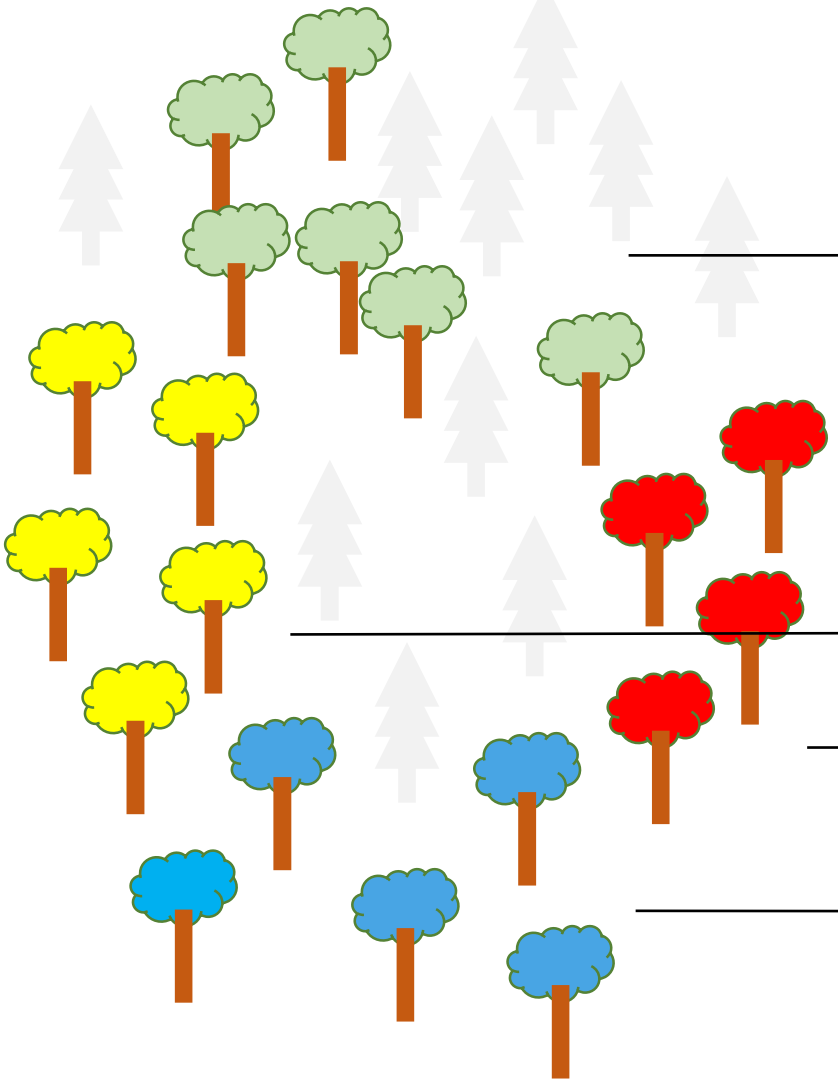


Population 1

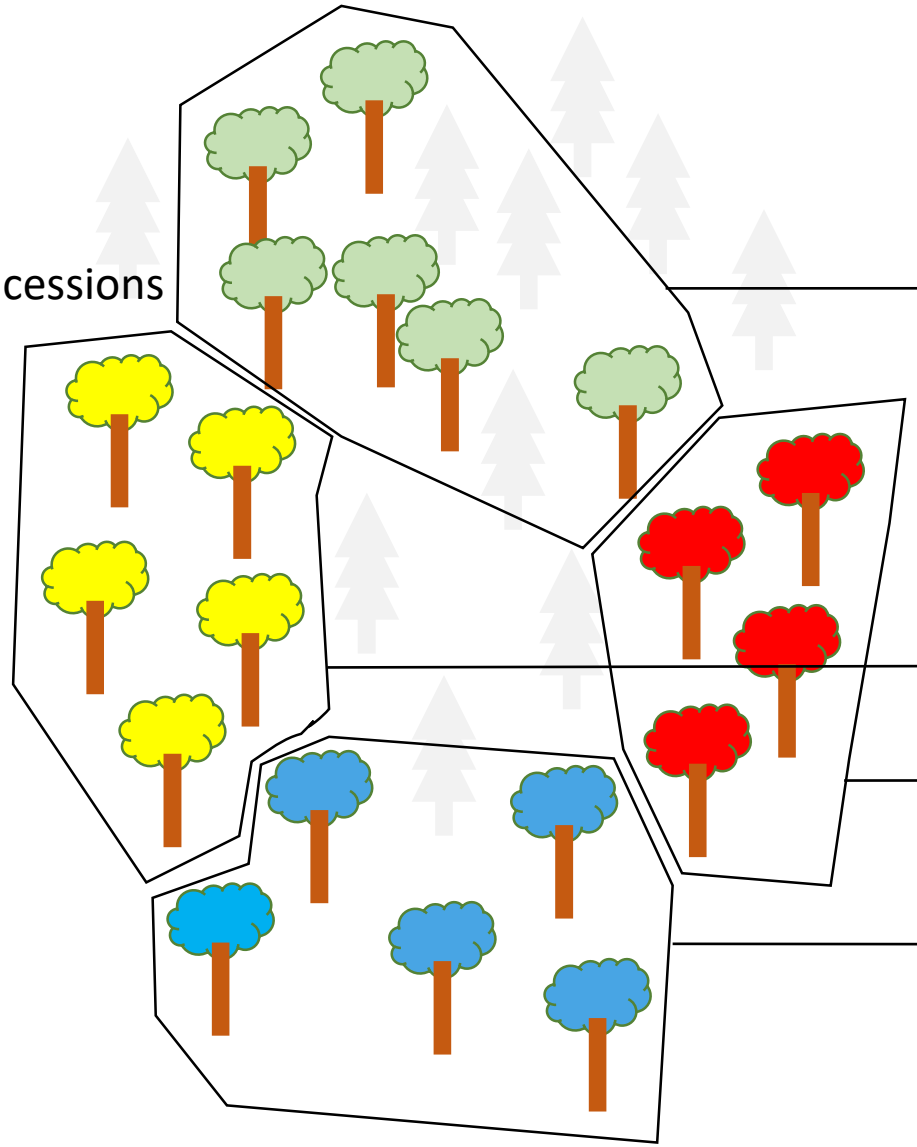
Population 2

Population 3

Population 4

An ideal world

Concessions



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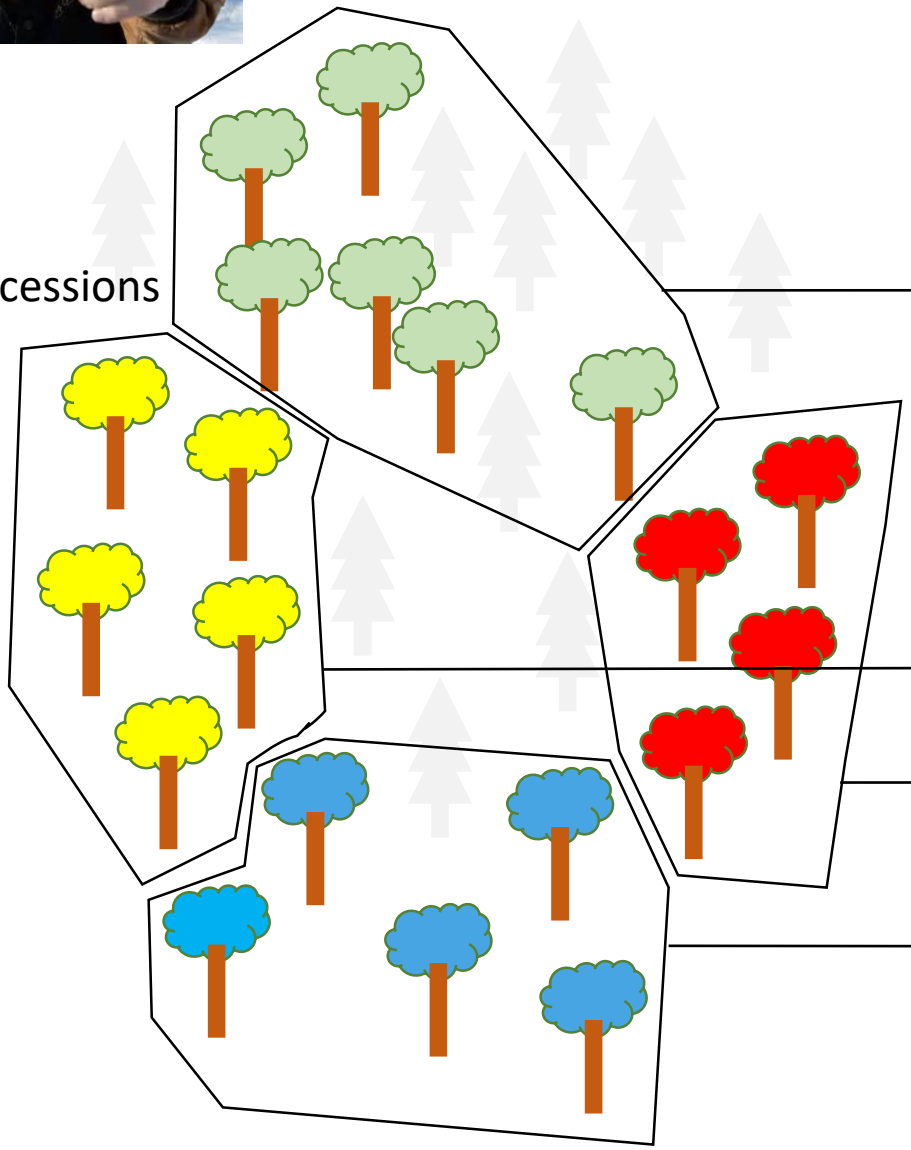
An ideal world

Concessions



Population 1

Population 2

Population 3

Population 4

Challenges

Diversity & the taxonomic gap

Legality & spatial structure gap

Implementation gap

Tropical tree ecology

- Species diverse forests
- Low density species
- Highly dispersive

Pollen - kilometers

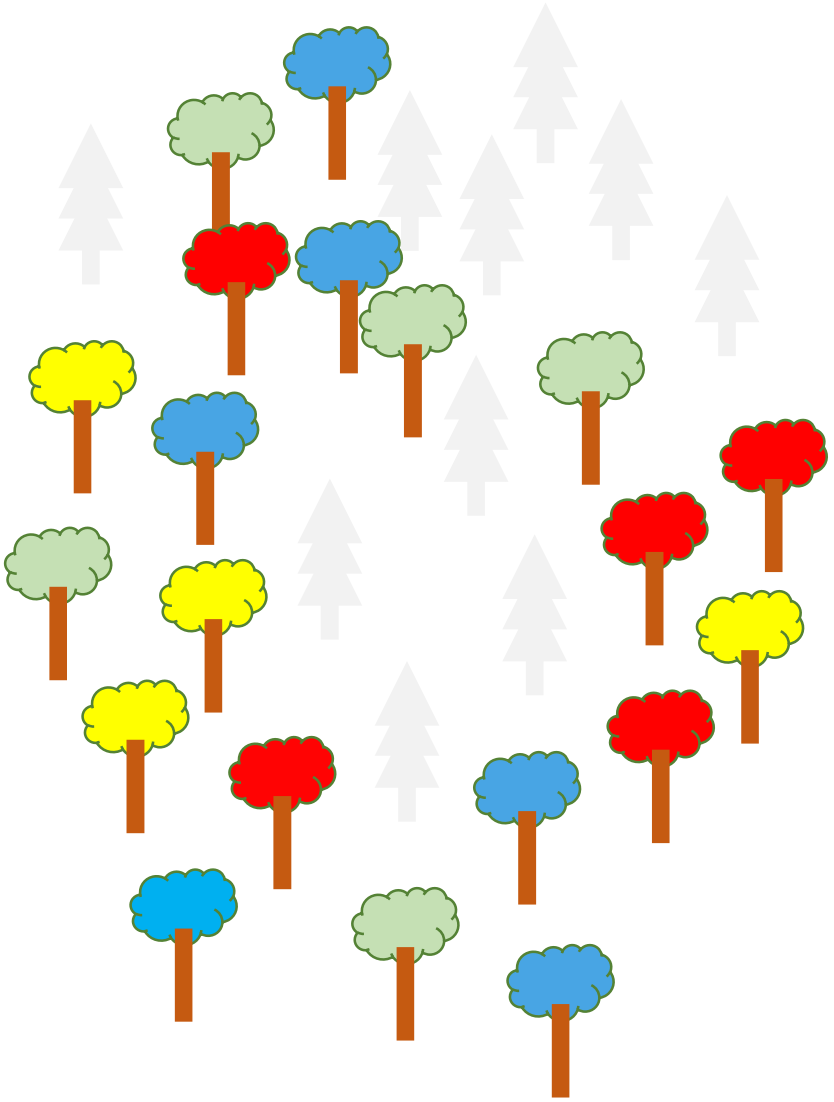
Seed - 100s meters

- Population structure

a function of dispersal ability (+ history, ecology, geography)

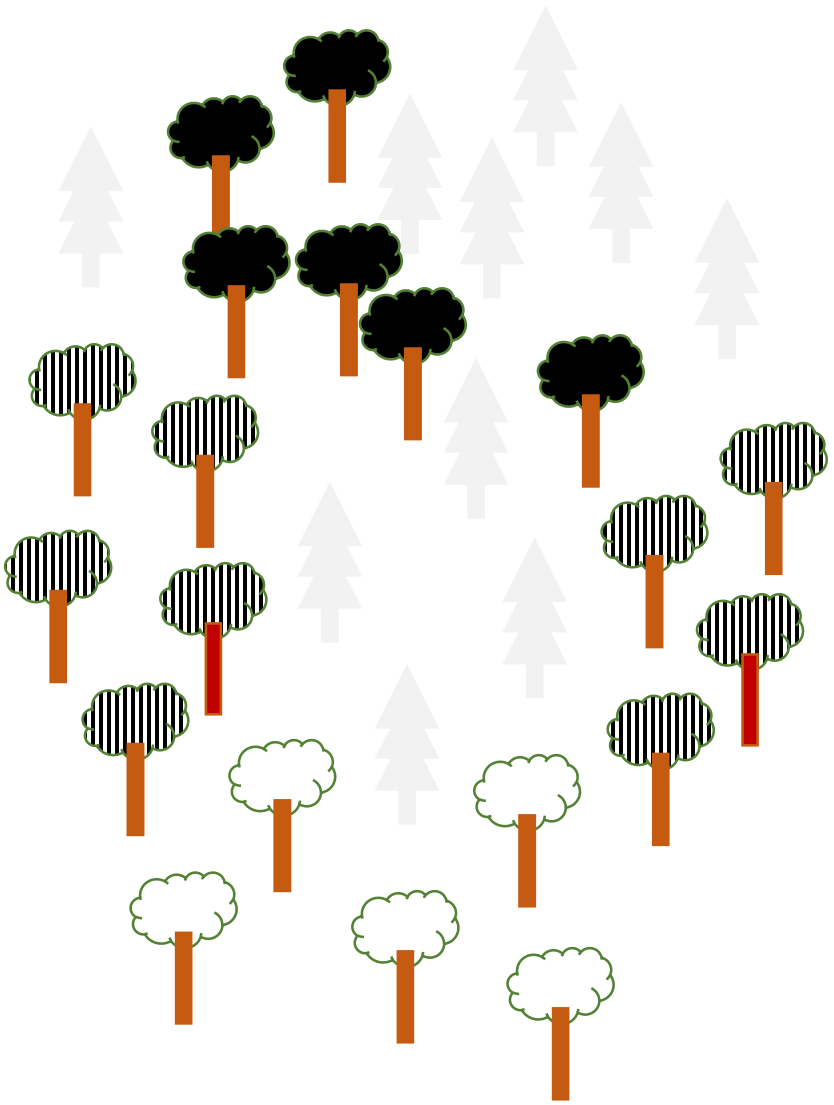
- ‘Populations’ may (likely) extend large distances

(not) An ideal world



Genetic groups
Not geographic

(not) An ideal world

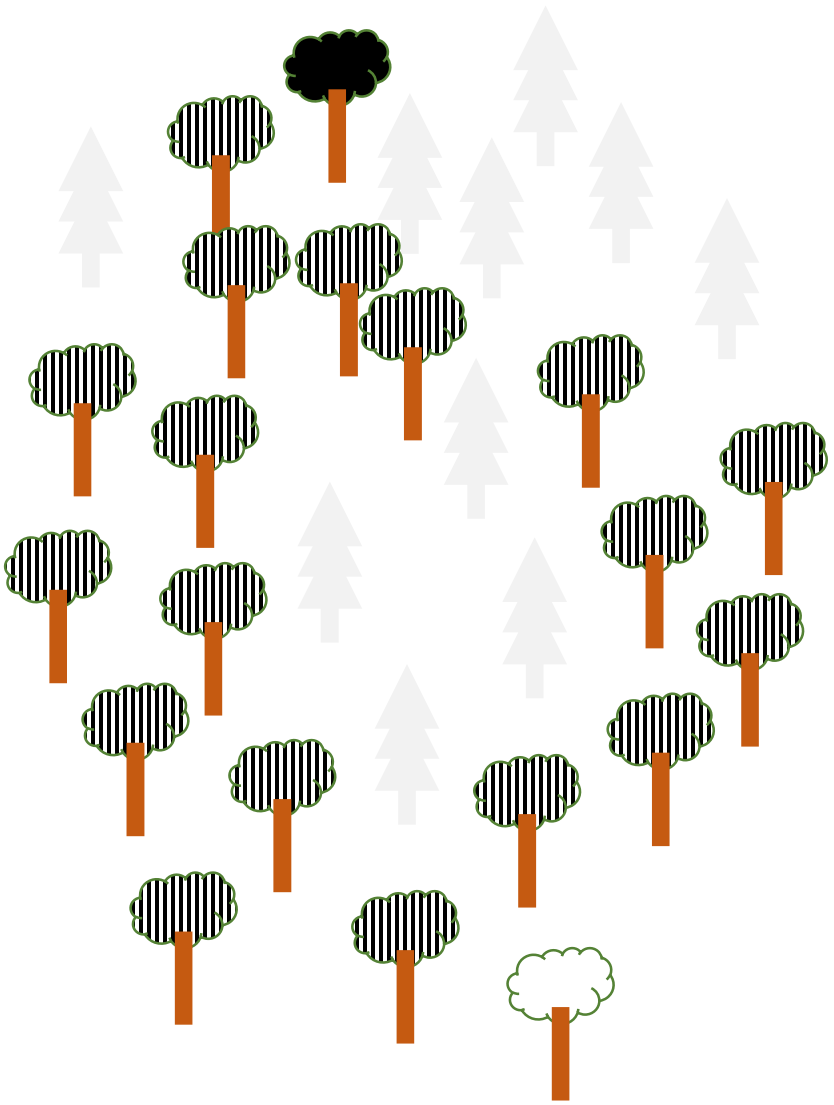


Population 1

Admixed individuals

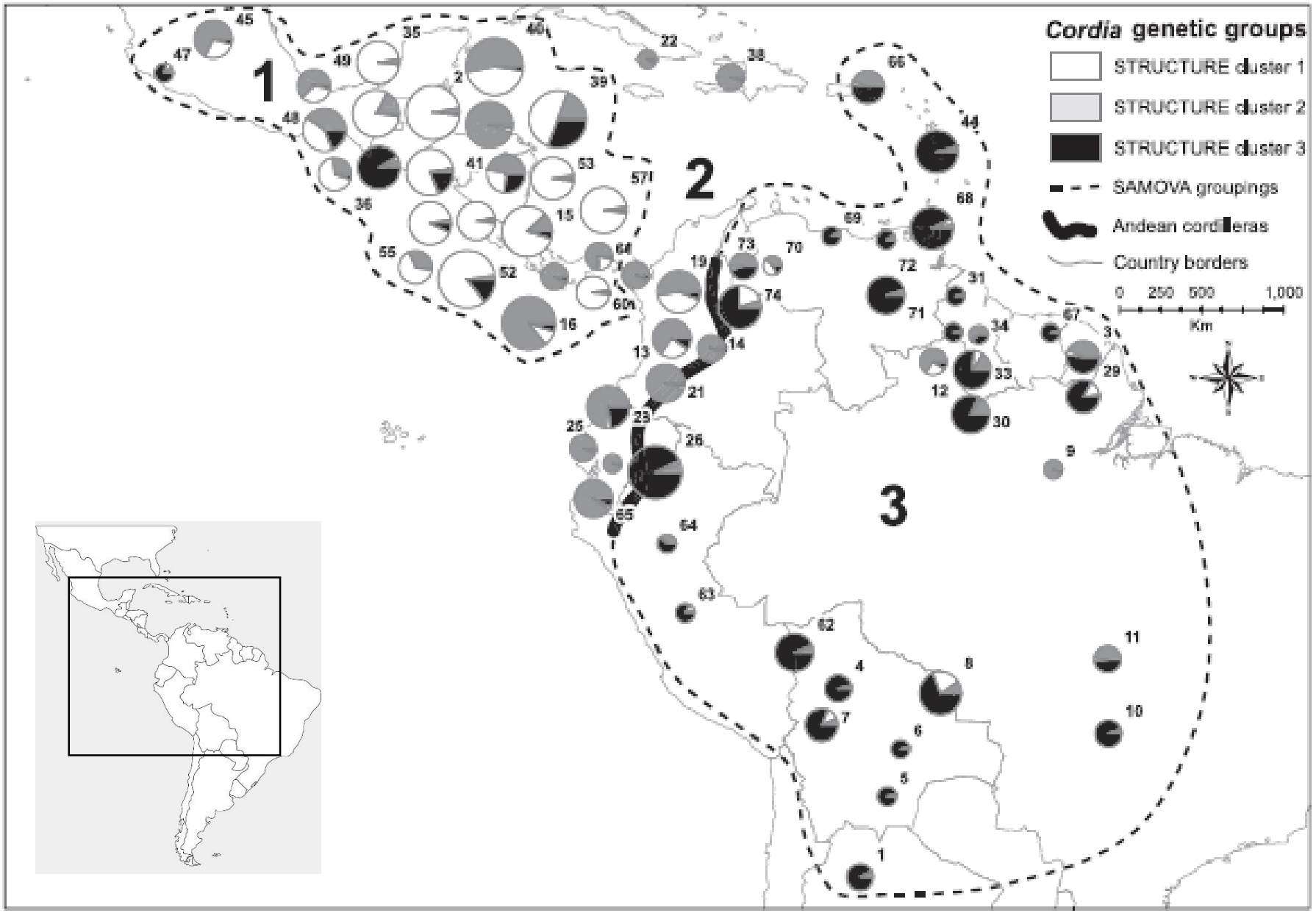
Population 2

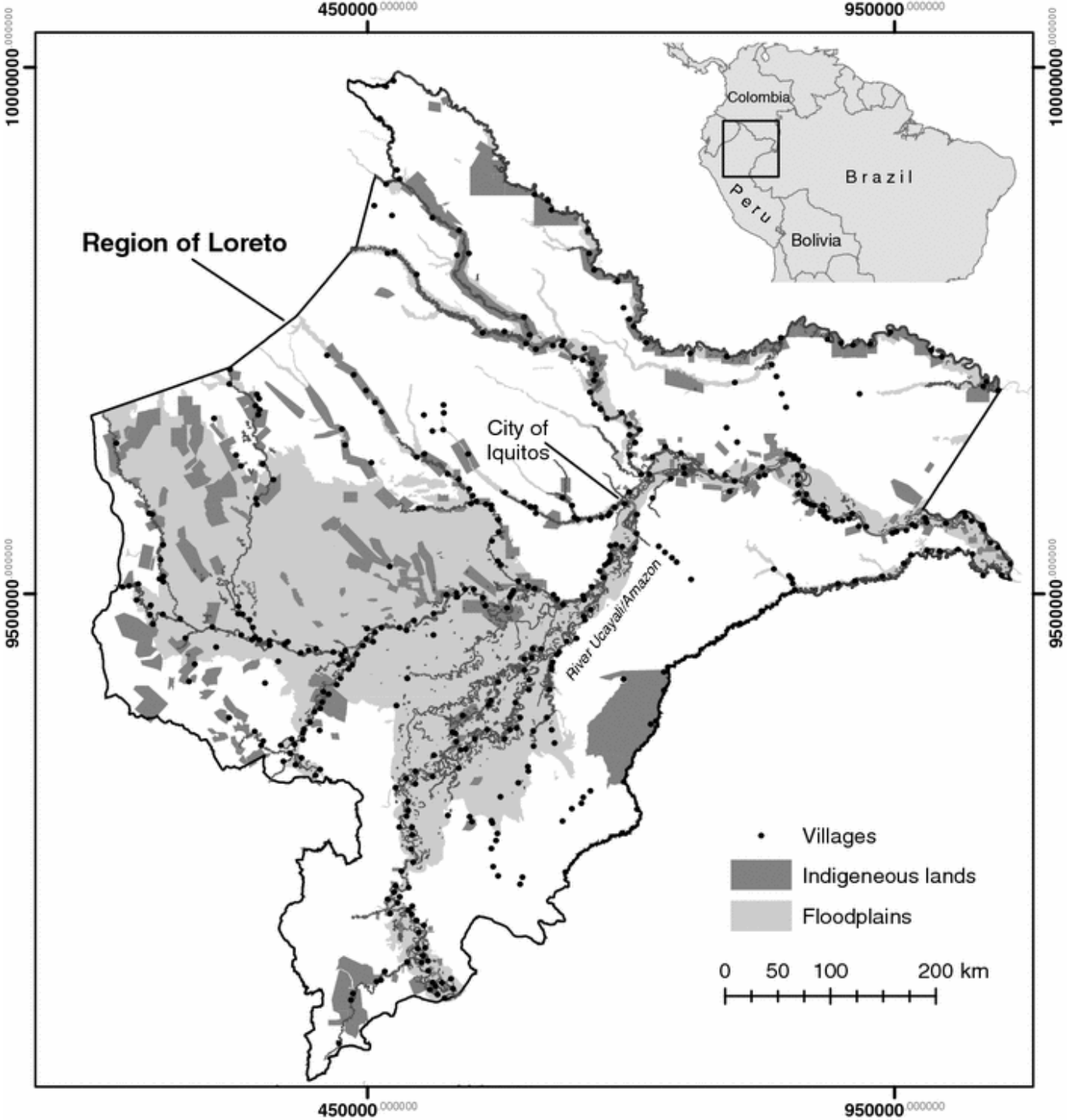
(not) An ideal world

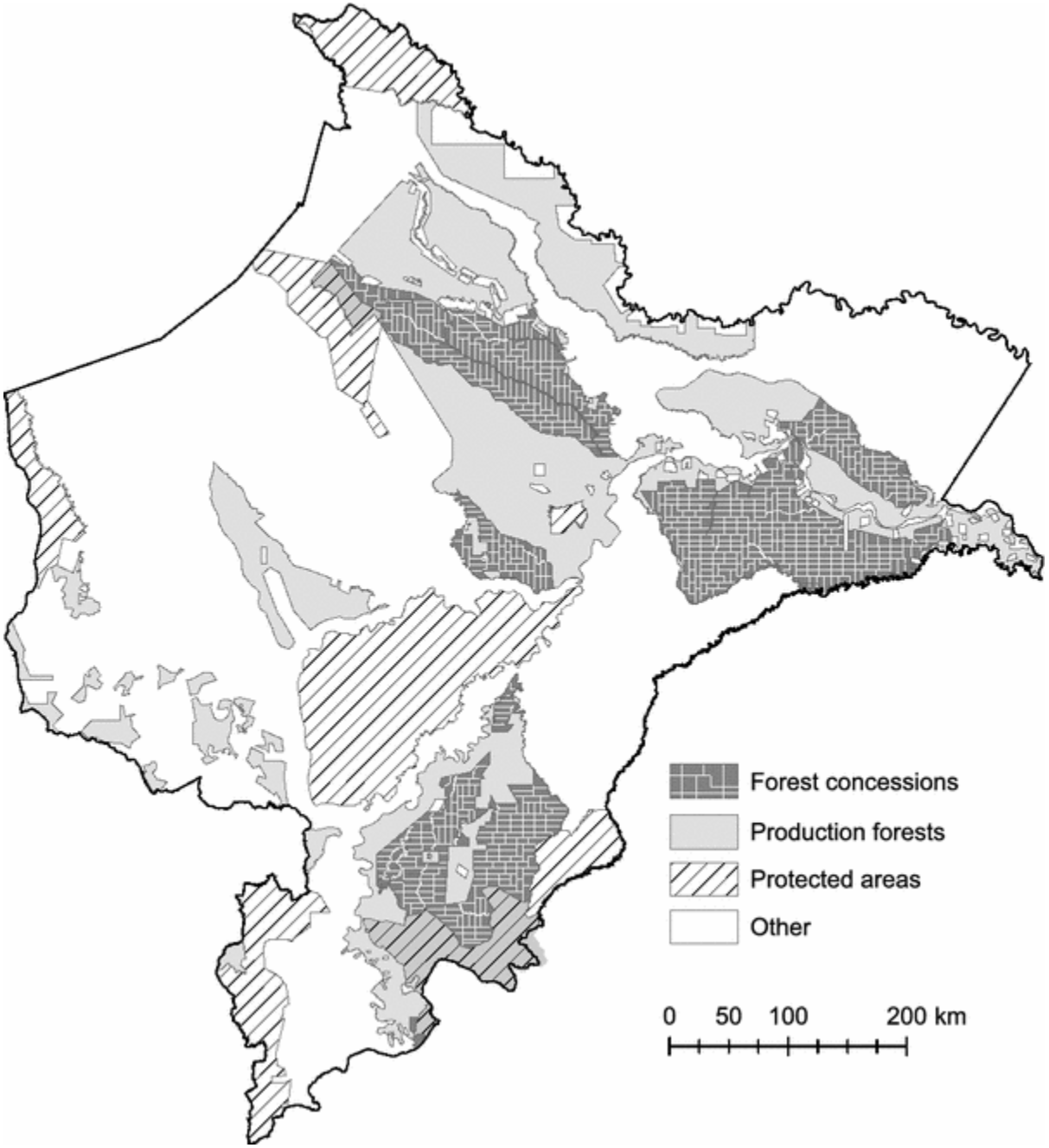


Population ?

Cordia alliodora

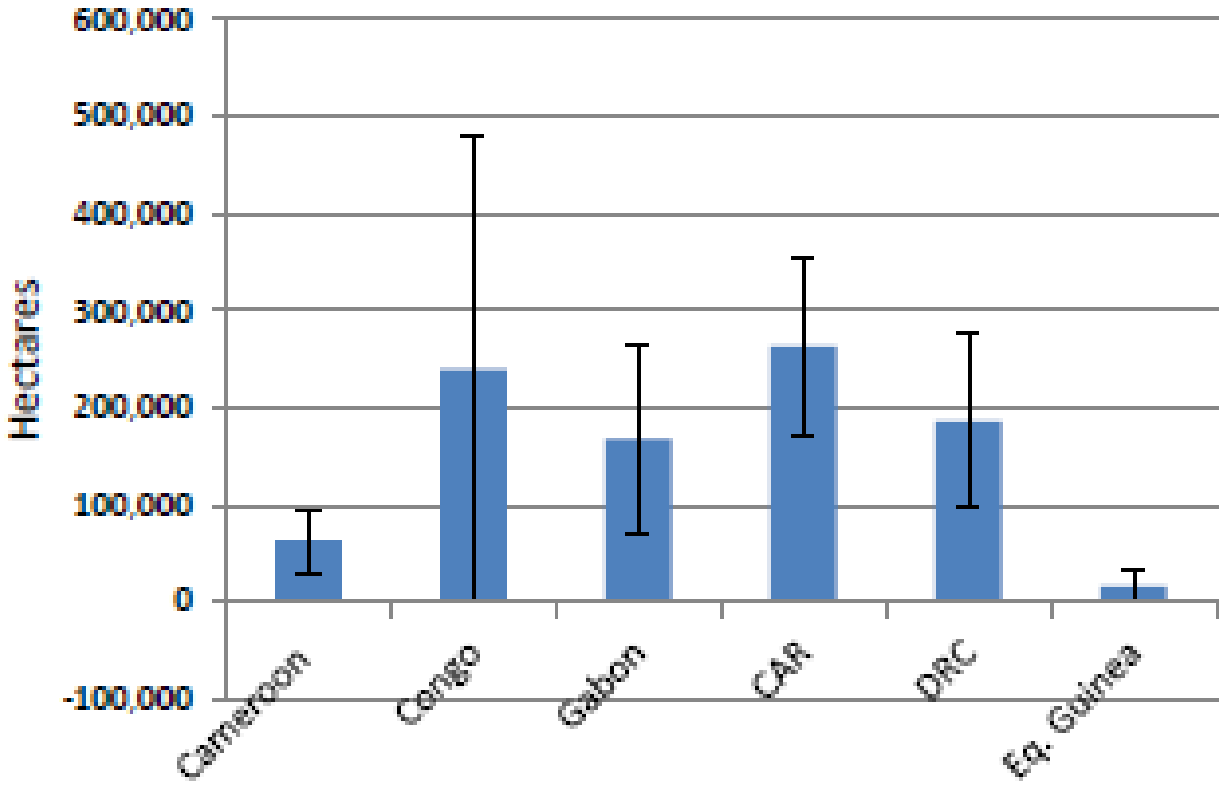



450000
950000
10000000
9500000
Region of Loreto
City of
Iquitos
River Ucayali/Amazon
Colombia
Brazil
Peru
Bolivia
Villages
Indigeneous lands
Floodplains
0 50 100 200 km


Forest concessions
Production forests
Protected areas
Other
0 50 100 200 km

Challenge: structure and forest concession

- Latin America: concession avg 5-10,000 ha
- Africa: > 100,000 ha
- Asia: 10s – 000s ha



Average size forest concessions Central Africa, FAO 2016

Solutions ?

- Revise concession approach to mirror genetic structure
- (would also dovetail nicely with proposed FGR conservation strategies)

Challenges

Diversity & the taxonomic gap

Legality & spatial structure gap

Implementation gap

Challenge: implementation gap

- Urgent need for controls within producer countries
- Capacity & characterisation of resources limited
- Major investment and support necessary to establish and maintain capacity

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