Protecting Plant Species

Species Conservation - HT 2013 - Lecture 6/16

Is the conservation of species ***diversity*** *both* important *and* urgently required?

- ***If*** all currently threatened species became extinct in the next century and ***if*** that rate continued unabated then this current extinction event will have reached the rate of loss in the previous 5 mass extinction events by **2552** at the latest. (Barnosky *et al.* 2011)

- It appears to be true that, as a result of **Darwin's principle of divergence**, loss of species can harm the functioning of ecosystems. (Hector 2011)

- The affect of plant diversity on trophic levels falls off as you move from herbivores to carnivores & omnivores (Scherber *et al.* 2011) & carnivore density & diversity was not affected by vegetation structure. Not surprisingly **biological invasions, of all types, reduced diversity** at all trophic levels.

Is the conservation of species ***diversity*** *both* important *and* urgently required?

- Although species may appear functionally redundant when one function is considered under one set of environmental conditions, **many species are needed** to maintain multiple functions at multiple times & places in a changing world.

- Declines in local diversity, which are far more common than global extinctions, will also decrease ecosystem functioning & services so **local extinctions are important**.

- Even the few species that never promoted ecosystem functioning in this paper could promote **ecosystem functioning in other contexts**, or be a conservation priority for another reason for example ethical or aesthetic (Isbell *et al.* 2011)

Is the conservation of species ***diversity*** *both* important *and* urgently required?

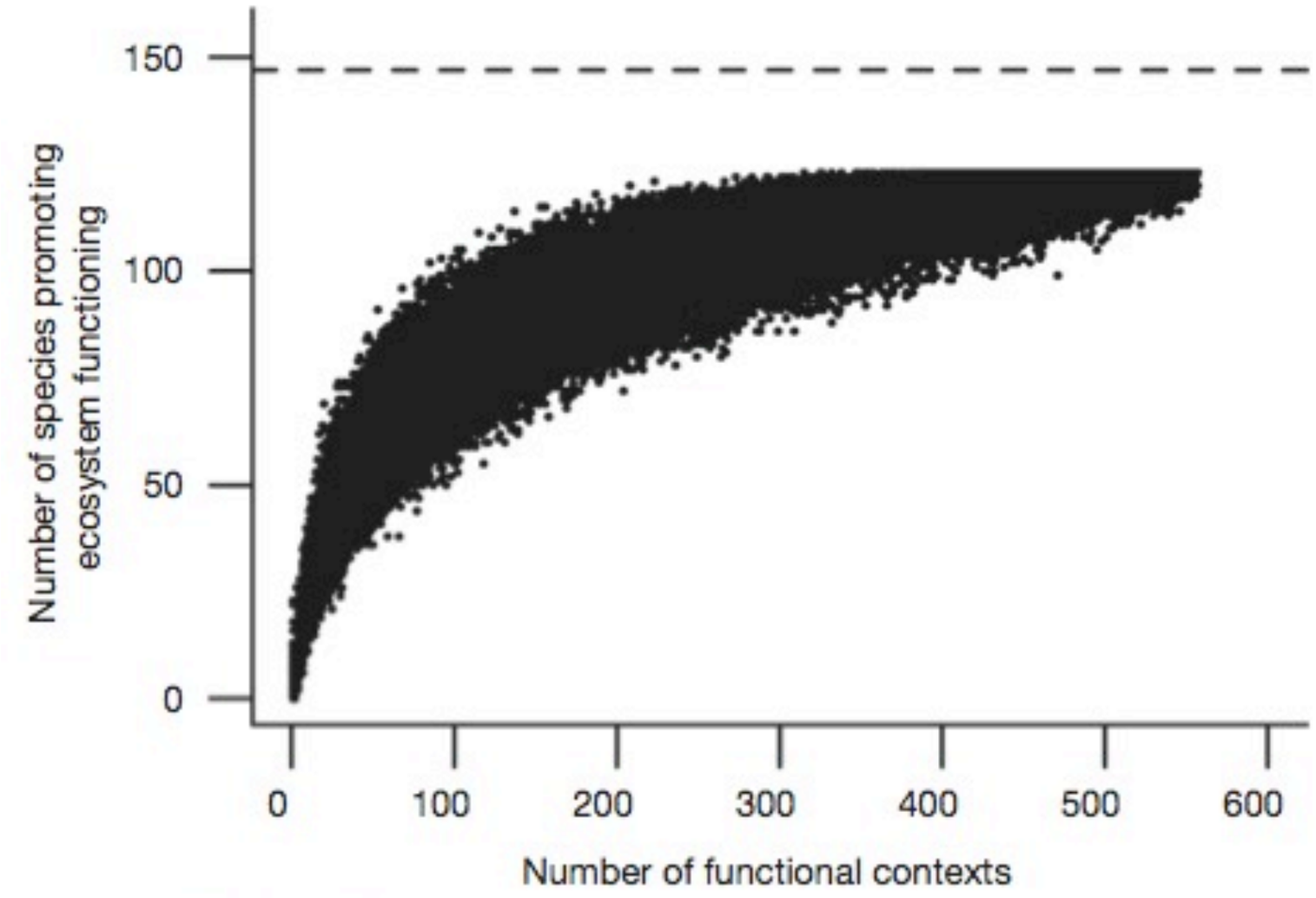
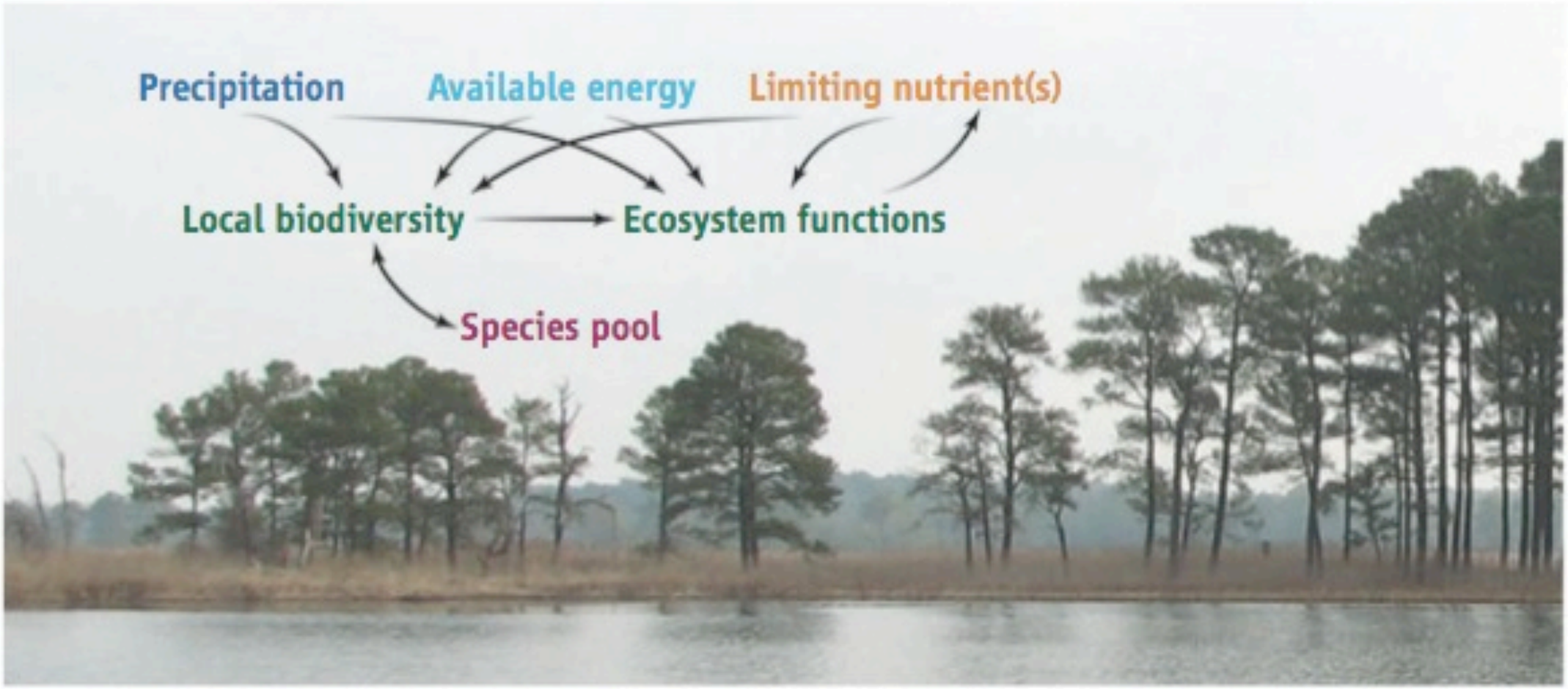


Figure 4 | The number of study species that promoted ecosystem functioning increased with the number of contexts considered across all studies. The points are the number of species that promoted ecosystem functioning when 1–557 contexts were sampled from all 557 contexts. The dashed line indicates the total number of studied species (147), which restricts the upper limit for these values. The *x* axis includes variation across years, places, functions, environmental change scenarios and species pools.

Is the conservation of species ***diversity*** *both* important *and* urgently required? (Willig 2011)



Complex relationship. The relationship between biodiversity (e.g., species richness) and associated ecosystem functions (e.g., net annual primary productivity) is governed by a suite of abiotic and climatic characteristics, as well as biotic feedback. To fully understand the underlying mechanistic bases for the biodiversity-productivity relationship and to predict how it might respond to climatic change and land use change, an effective synoptic network must minimally estimate these characteristics at multiple sites and scales, and must do so over the long term.

Issues connected to **Protecting Plant Species**

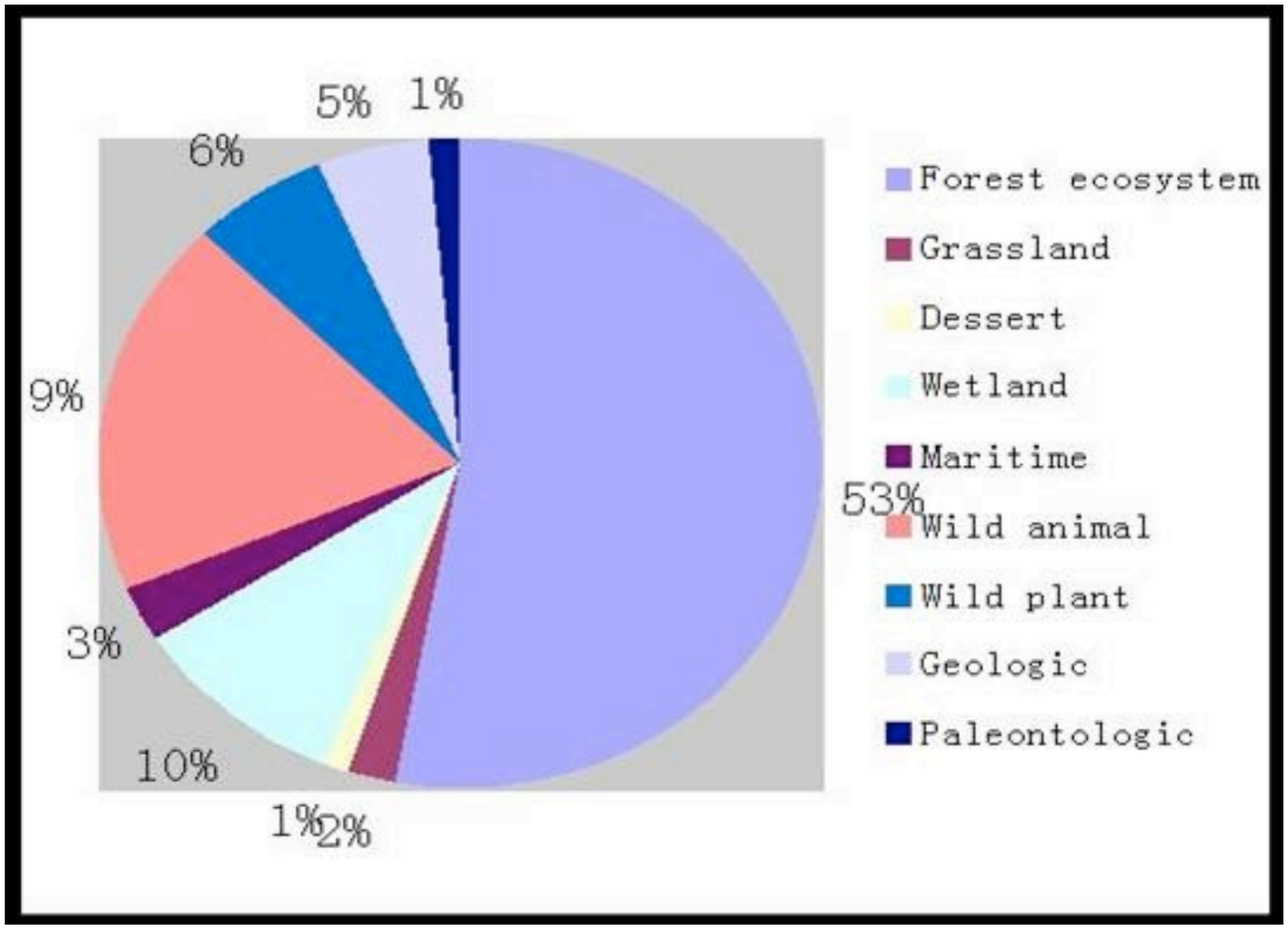
- Ecosystem protection dealt elsewhere in another option but included here for completeness & comparison with the other issues
- Important Plant Areas (IPAs)
- Production Lands
- Conservation of species *in situ*
- Conservation of species *ex situ*
- Non-native species
- The role of CITES
- Sustainable extraction

Ecosystem protection

- **GSPC target 4** - to secure 15% of each ecological region or vegetation type through effective management &/or restoration
- China has established 2,538 nature reserves covering 15% of the country, at a cost of £50M **but** since 1950 57% of the coastal wetlands have been destroyed and in the same time mangrove forests have declined by 73% and coral reefs by 80%.
- It is estimated that by 2020 another 5,800 sq.km. will be lost though this still leaves 385,000 sq.km. (x1.5 the area of the UK)
- China plan to have spent a further £1.55B on nature conservation *by 2015* (Qui 2011)

Ecosystem protection

- Types of ecosystem protected in China




China responds to the *Global Strategy for Plant Conservation*

10% of the world's flora covered by new national strategy

With over 30,000 plant species, China's flora forms a major part of the world's plant diversity. The development of a Chinese response to the Global Strategy for Plant Conservation (GSPC) thus comes as welcome news to the world's plant conservation community.

The Strategy has been developed by the State Forestry Administration, working with the State Environmental Protection Administration and the Chinese Academy of Sciences. Support for the initiative has also been provided by BGCI and the UK's Department for Environment, Food and Rural Affairs (DEFRA).

The Strategy, due to be launched at the 3rd Global Botanic Gardens Congress in Wuhan, China, provides a Chinese response to each of the 16 targets of the GSPC. Building on existing efforts to protect China's wild plants, the response particularly recognizes the need to balance development needs with conservation imperatives.

Given the size of the country and the huge diversity of plants that exist in China, conserving the entire flora represents a significant challenge. However, in developing the Strategy a review of the present status of plant conservation in China was undertaken, and this indicated encouraging progress in a number of areas. Concerns were raised over the need to build capacity in plant conservation and habitat restoration techniques and the ever- growing demand for Chinese plants taken from the wild, especially those with medicinal properties.

BGCI is working with the Chinese Botanical Garden Working Committee to implement aspects of the Strategy, with a particular focus on achieving the ex situ conservation and restoration targets of the GSPC.

Protection of primary forests

- Most forms of forest degradation have an overwhelmingly detrimental effect on tropical biodiversity though the effects varied with geographical location, taxonomic group and disturbance type. When it comes to maintaining tropical biodiversity, there is **no substitute for primary forests**. (Gibson *et al.* 2011)

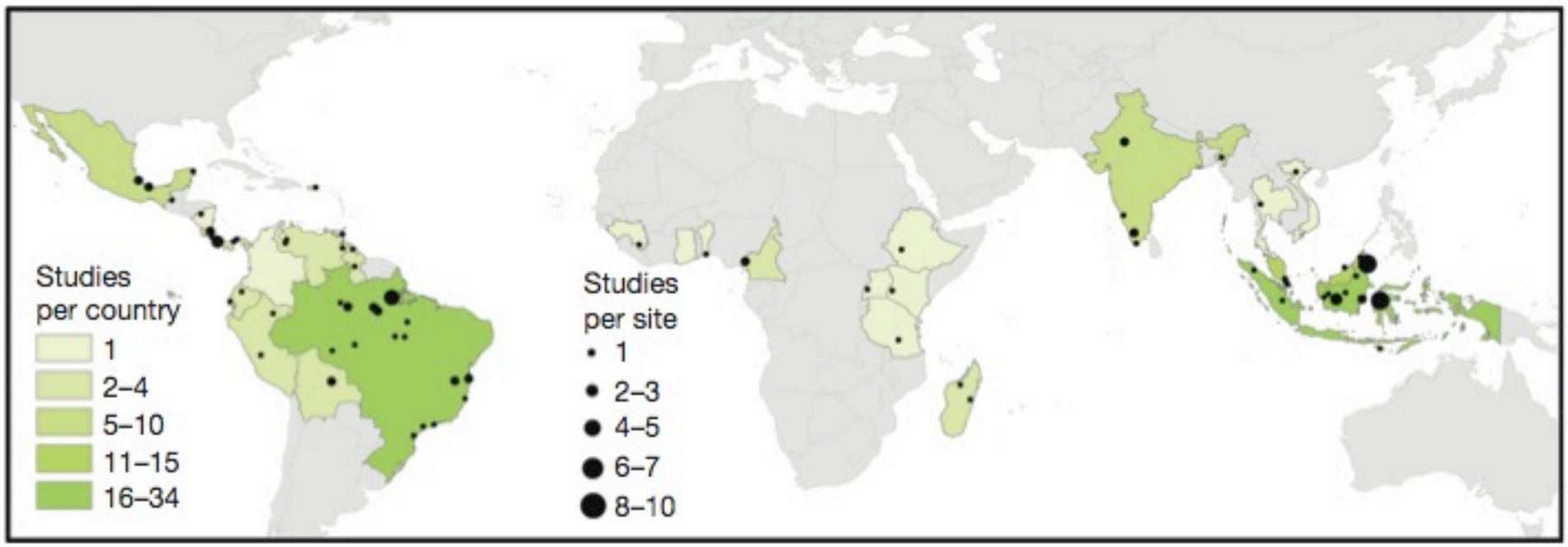
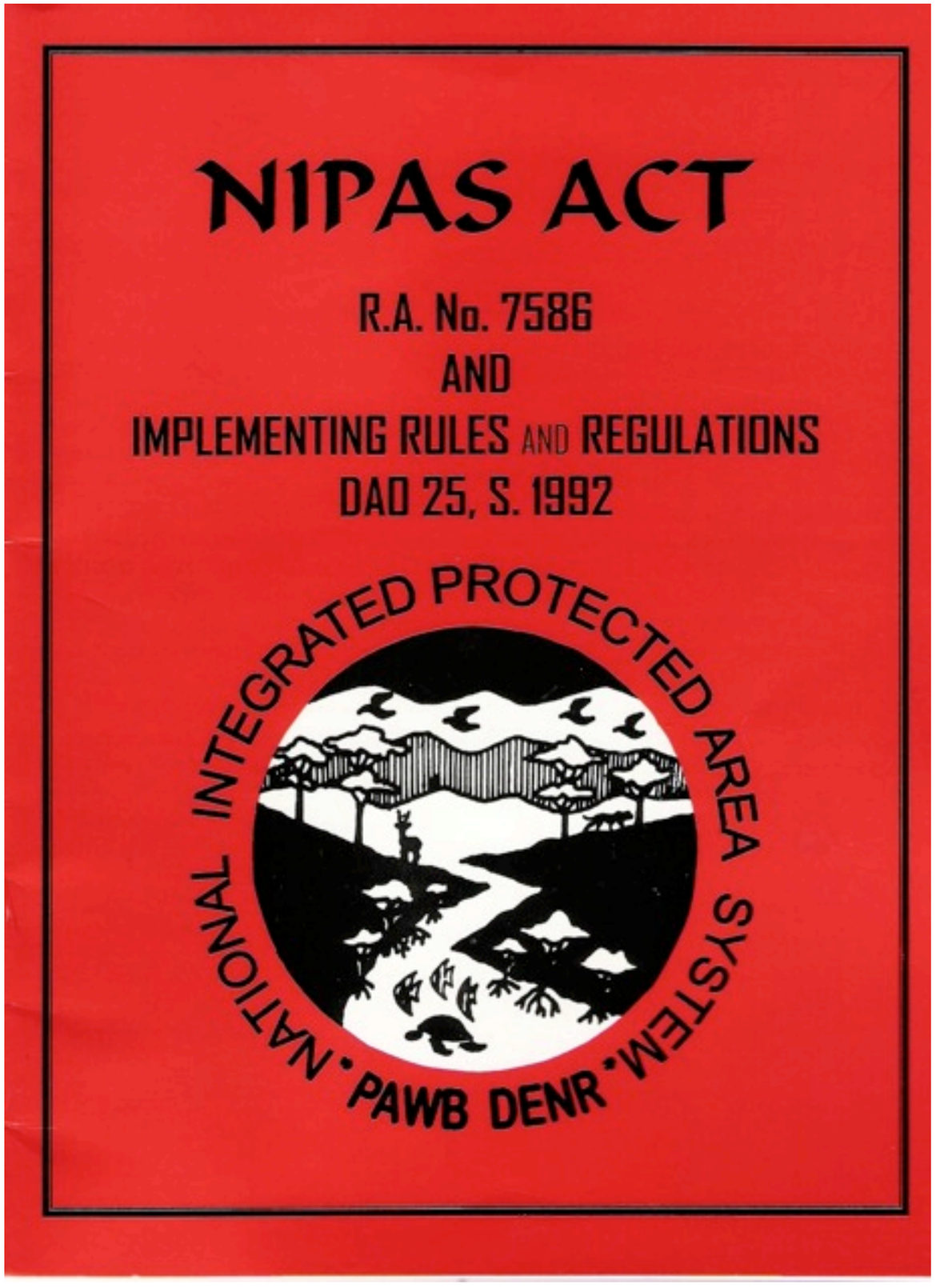
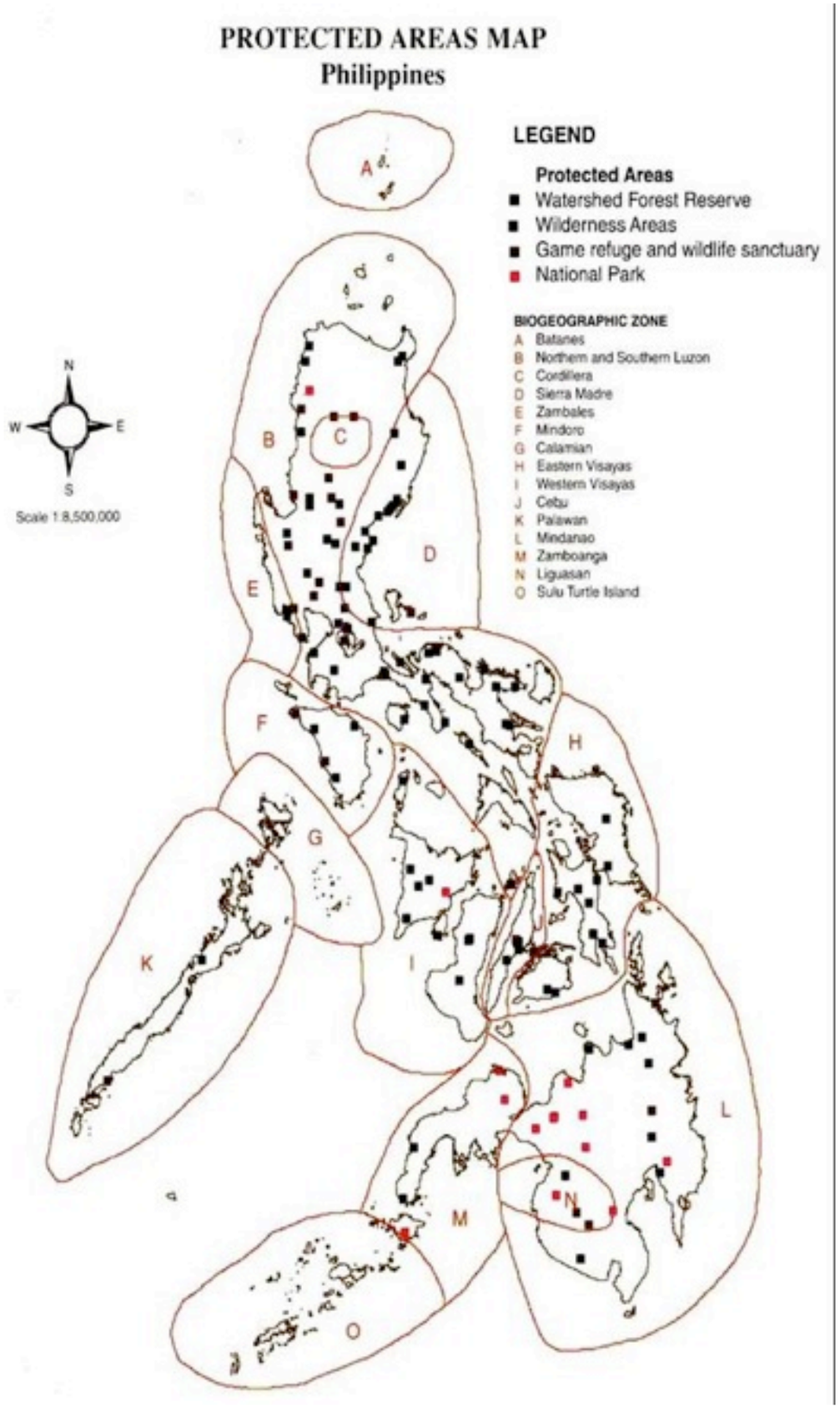


Figure 1 | Map of study sites by country and by study location. Country colour represents the number of studies per country ($n = 28$ total countries) and circle size represents the number of studies at each site ($n = 92$ total sites; only 82 sites with Global Positioning System coordinates are shown).

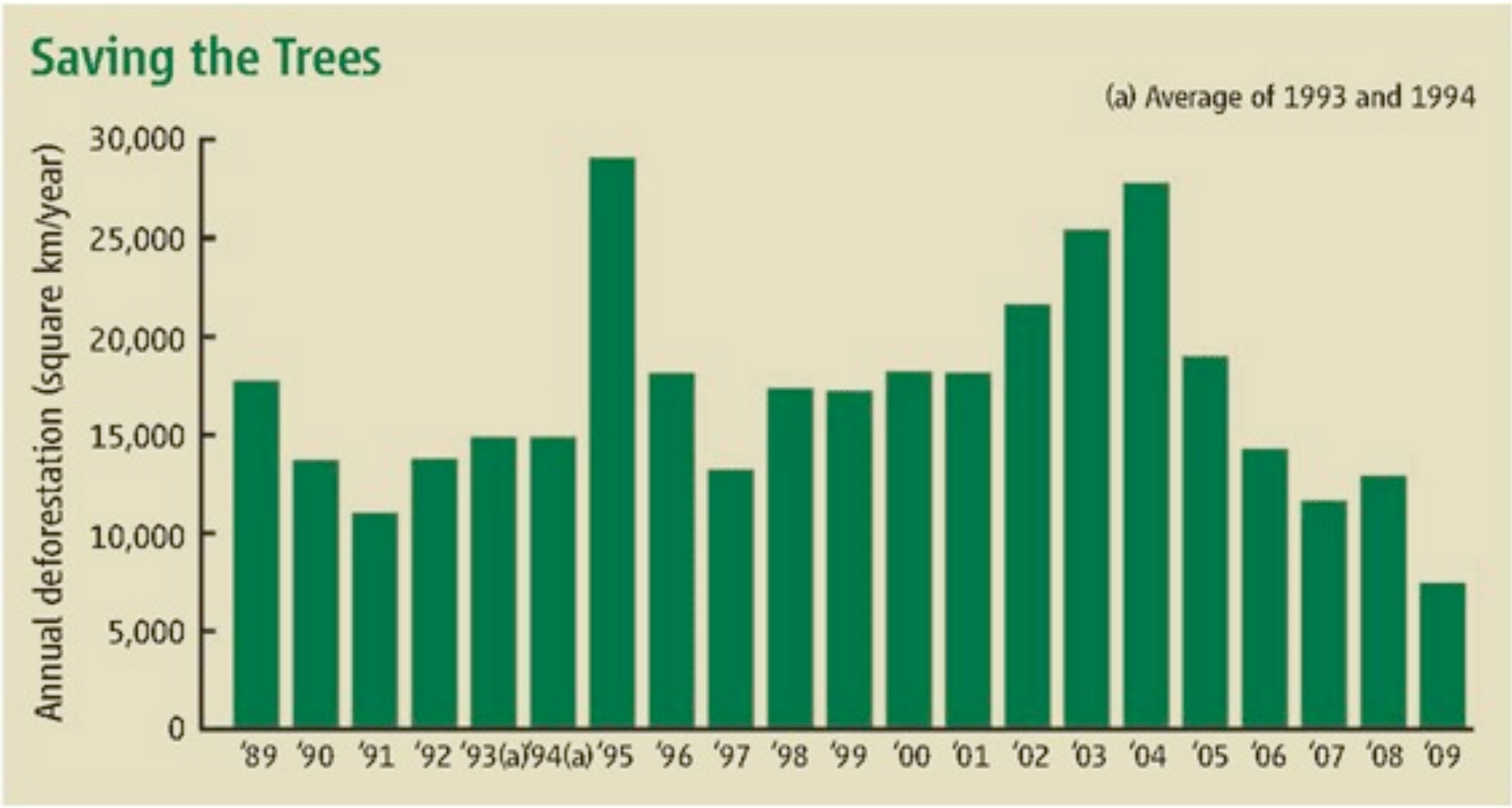




Philippines National Integrated Protected Areas Scheme (1992)
2,950,000 hectares (8.7%) of land in 89 protected areas

Deforestation in the Amazon Basin

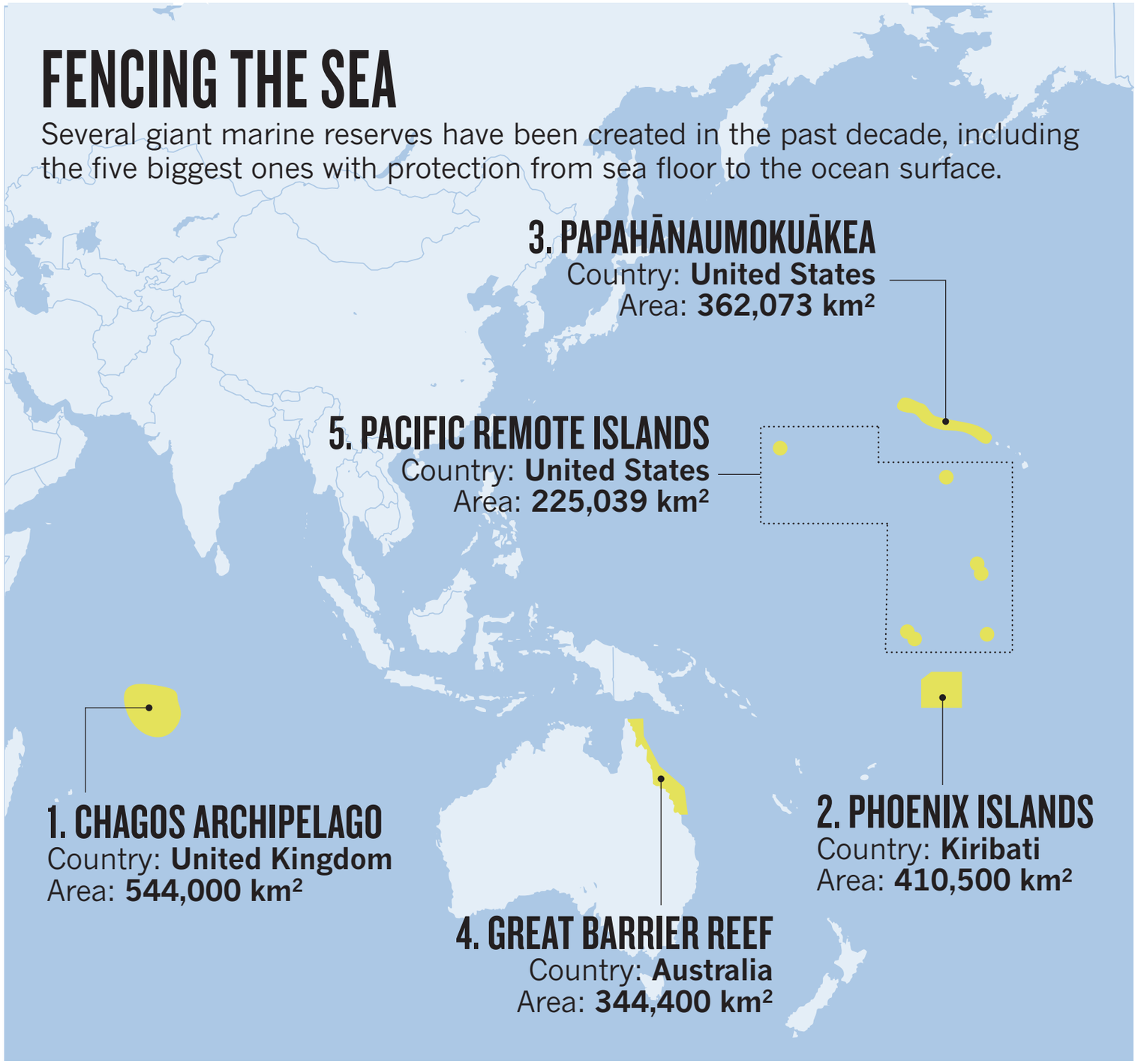
- there was an 80% drop in deforestation between 2004 & 2009 according to the Brazilian government (Regalado 2010)



While some types of ecosystem are well protected e.g. Mediterranean type regions and tropical islands, other such as mangrove swamps and meadows are not yet

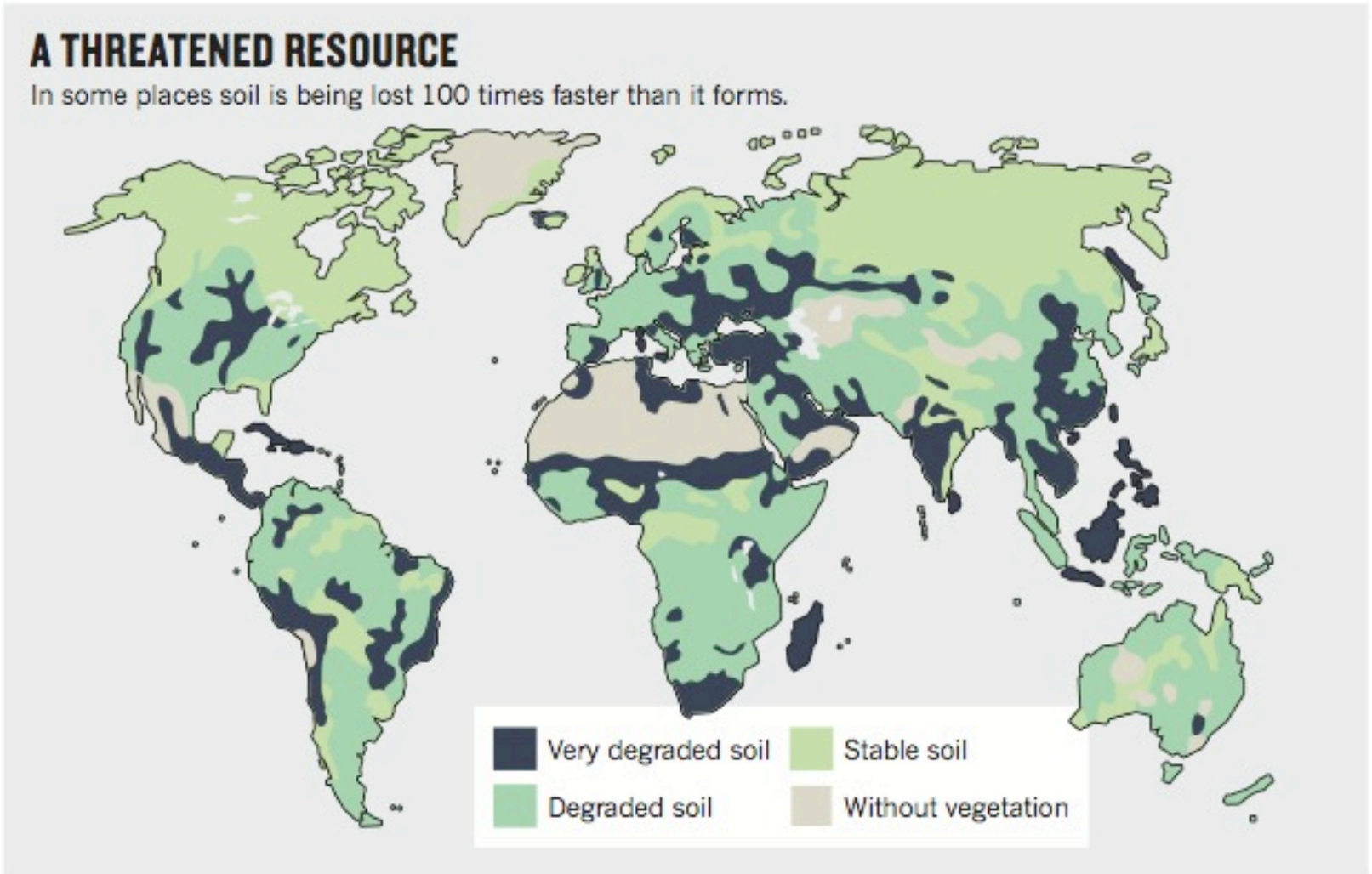
Marine ecosystem protection

- while more than 10% of terrestrial ecosystems are protected **only 1% of oceans are in marine protected areas** (MPAs). Mangroves & seagrasses are significant carbon sinks and their clearing contributes 1-2% of CO_2 emissions (Cressy 2011)



Soil protection

- In some places soil erosion is x100 the rate of soil deposition (Banwart 2011). This has implications for farming & conservation of habitats. Soil also stores carbon, filters water, and transforms nutrients.

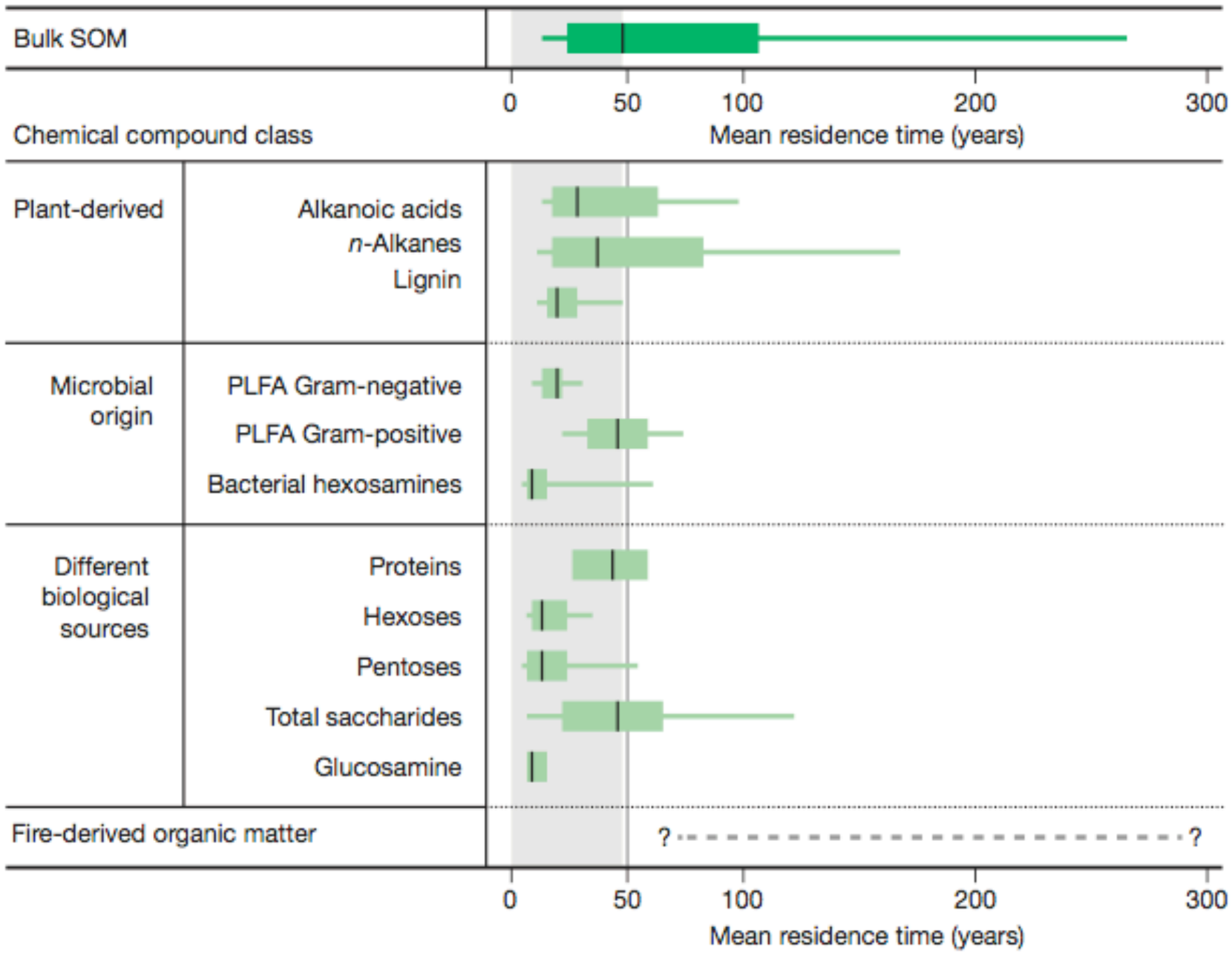


Soil protection & soil organic matter (SOM)

- Globally SOM contains x3 the amount of carbon as either the atmosphere or terrestrial vegetation.
- Largely **unknown** why some SOM persists for 1,000s years while other SOM decomposes very quickly
- Molecular structure alone does not control SOM stability; environment & biology seem to play an important control role
- New work is required to help climate change mitigation studies (Schmidt *et al.* 2011)

Soil organic matter (SOM)

- A synopsis of the persistence of different SOM (Schmidt *et al.* 2011)



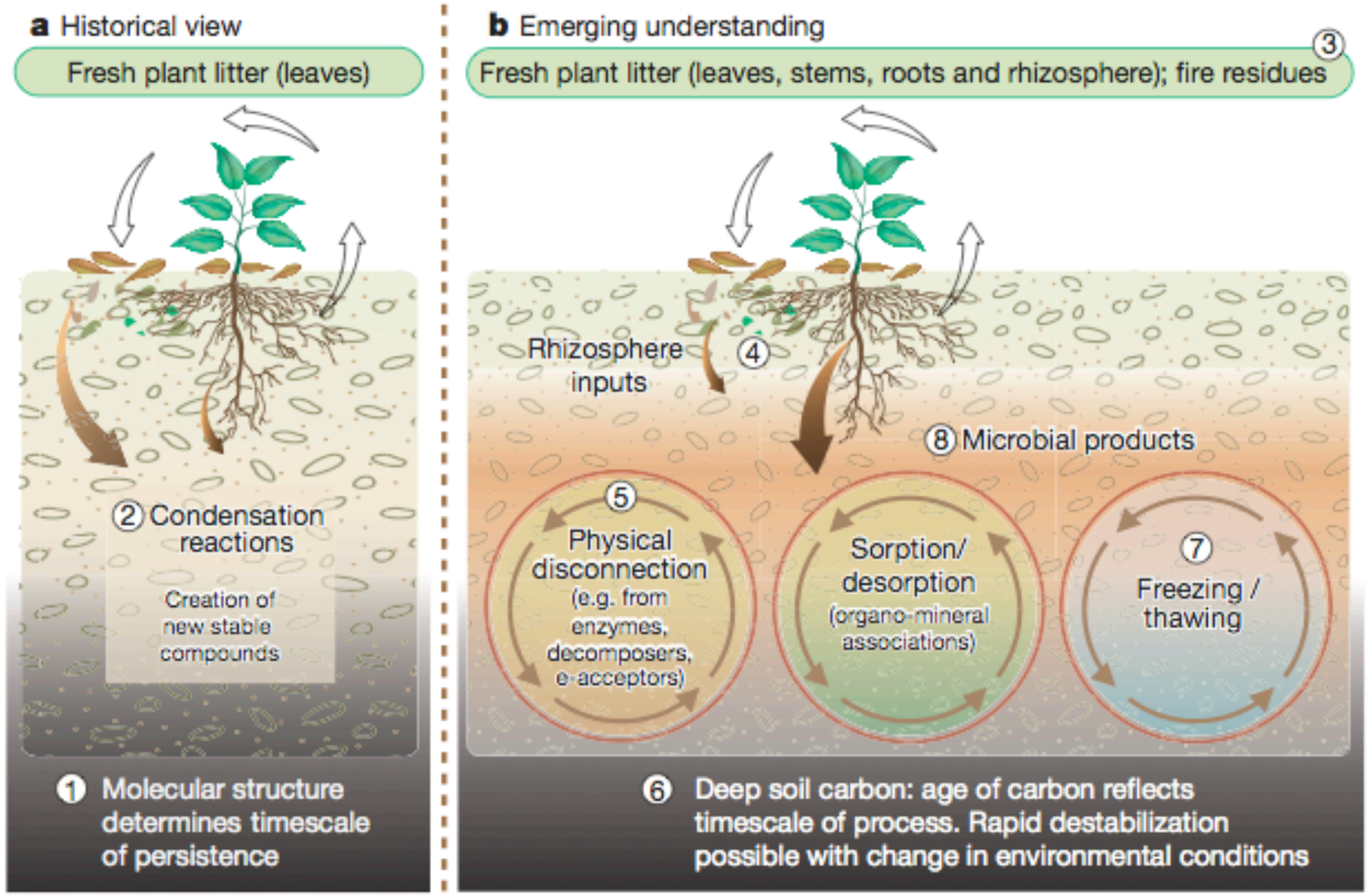
Soil organic matter (SOM)

- **New insights** into carbon cycling (Schmidt *et al.* 2011)

1. molecular structure & decomposition
2. soil humic substances (not yet verified by direct measurements)
3. fire-derived organic matter
4. influence of roots
5. physical disconnection
6. deep soil carbon
7. thawing permafrost
8. soil micro-organisms

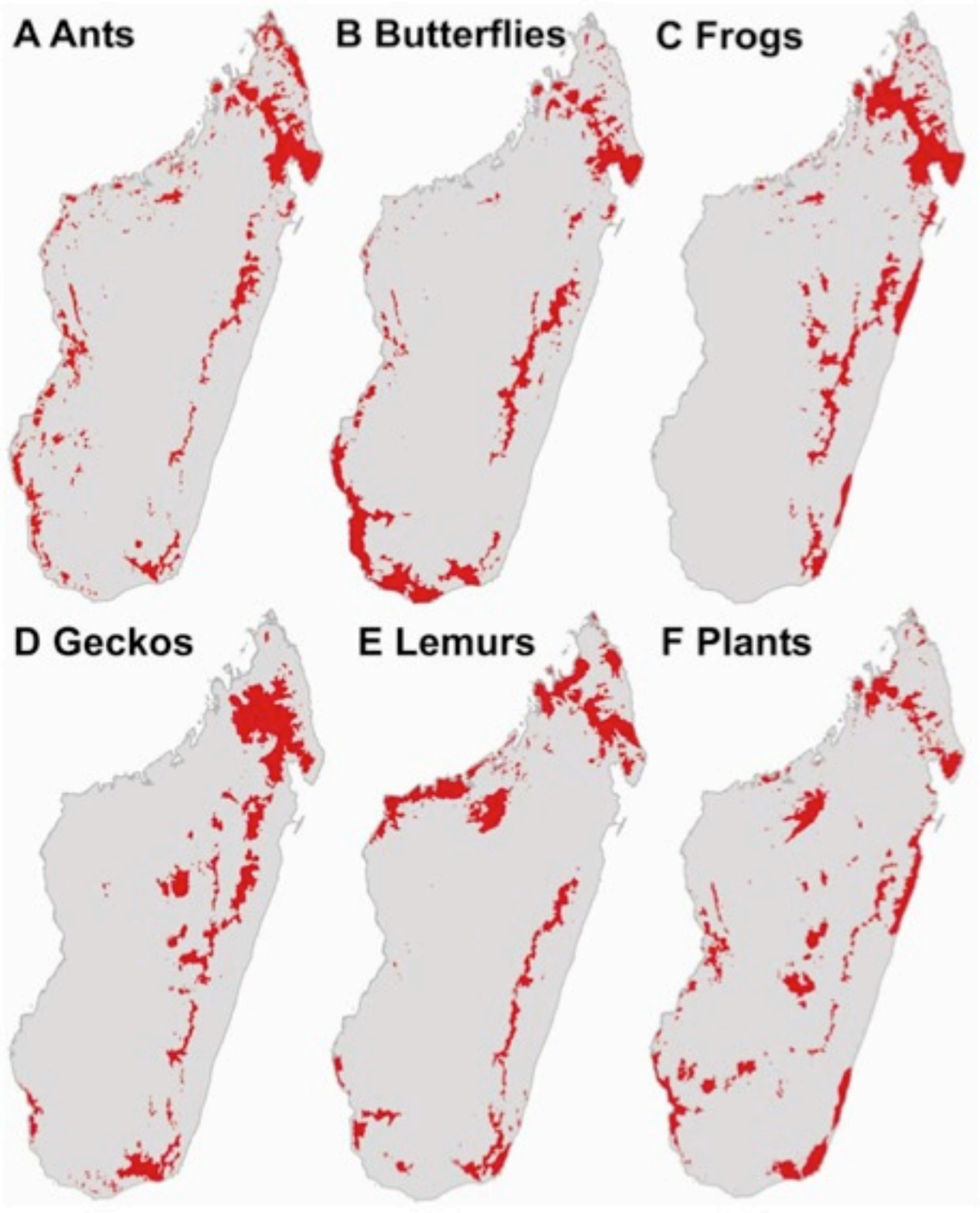
Soil organic matter (SOM)

- A synopsis of **all eight insights**, contrasting historical & emerging views of soil carbon cycling (Schmidt *et al.* 2011)



How do you choose which 10% to protect?

- Kremen *et al.* (2008) were commissioned to identify the best 10% of Madagascar to protect for 6 different taxa - lemurs, frogs, geckos, ants, butterflies & plants.
- The different groups were abundant in different regions & only 1.6% of the island fell in all 6 areas & 11.4% was found in just one of the solutions

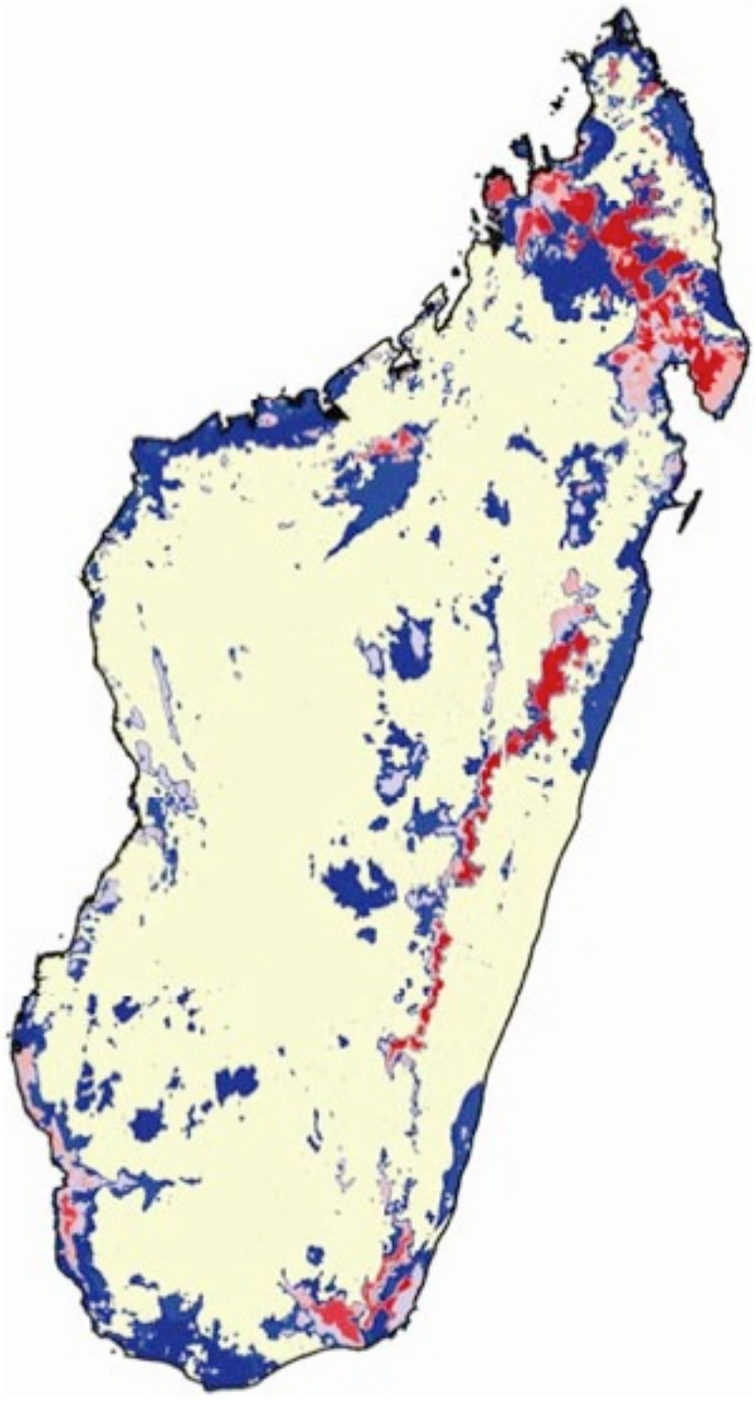


How do you choose which 10% to protect?

- If the six different solutions were combined they covered 26.4% of the island; the non-cream areas

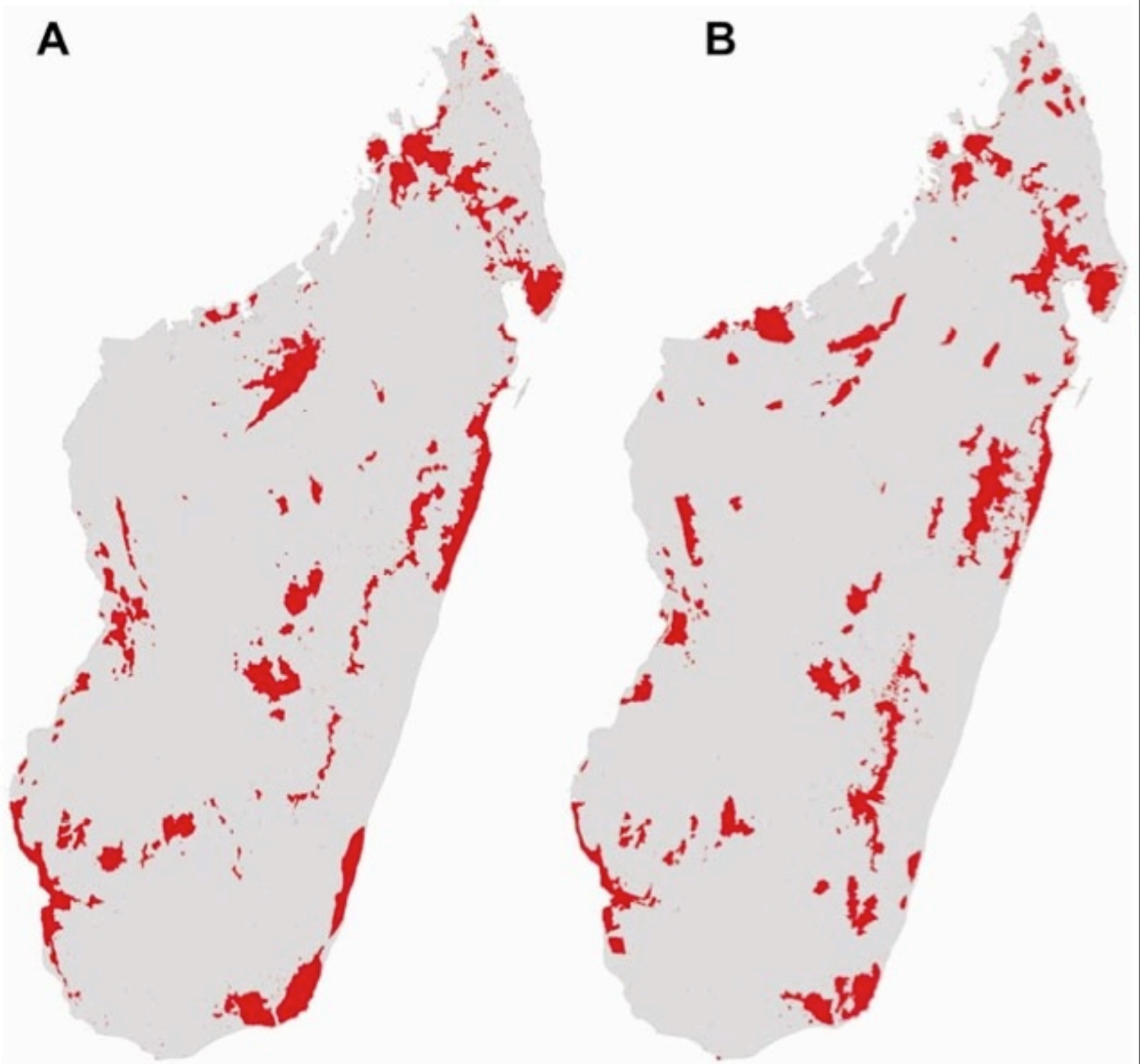
- The red area is the 1.6% of agreement.

- The blue area is the 11.4% which was good for just one group.



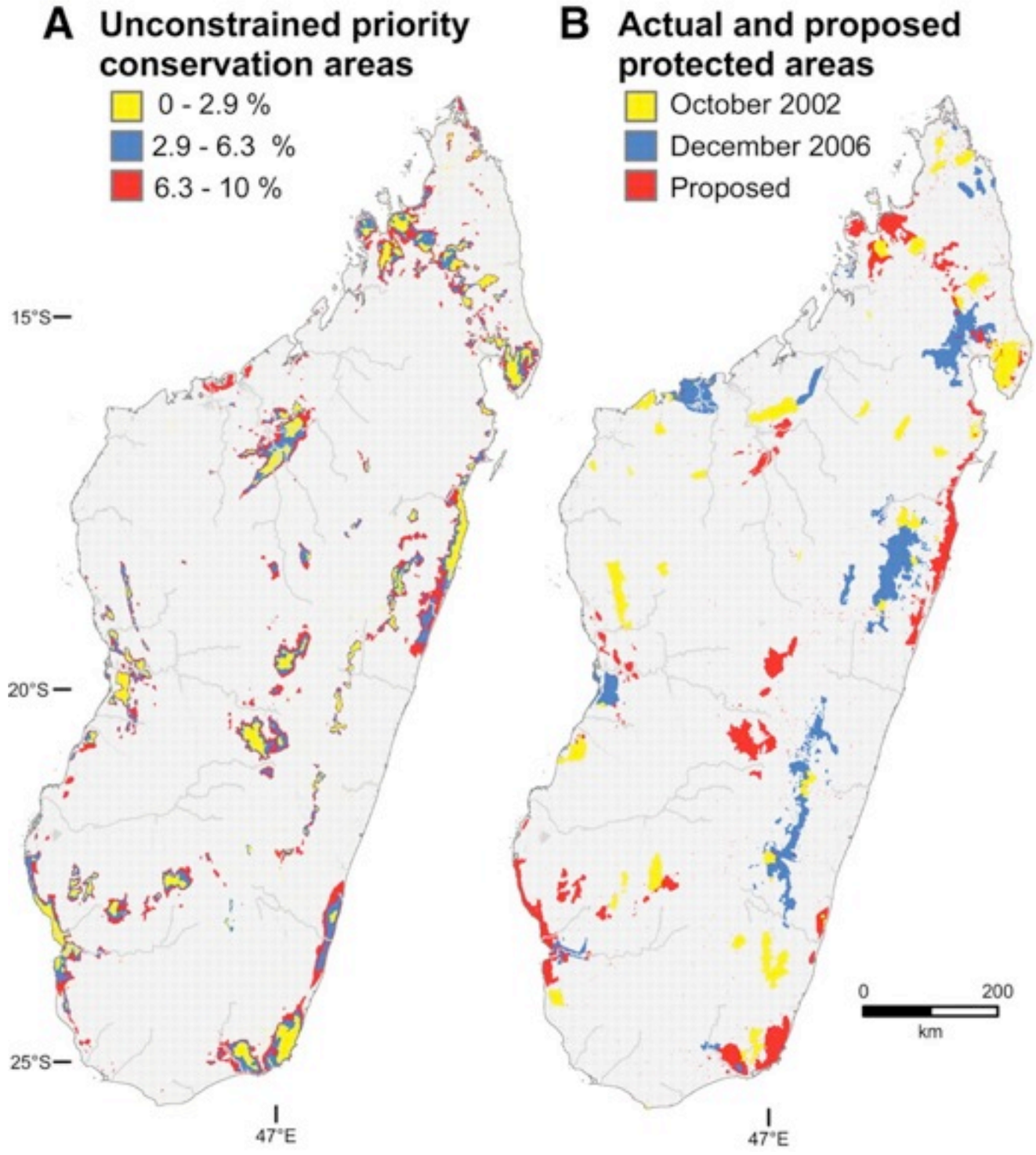
How do you choose which 10% to protect?

- **A** shows the best 10%
- **B** shows the best 10% if a smoothing parameter is added to give fewer larger protected areas



How do you choose which 10% to protect?

- **A** shows the best solution if starting anew
- **B** shows the best 10% if you accept the land already protected.
- Should you **abandon reserves** if they are not in the best place?
- Plants were **the best surrogate** if only one taxon can be measured



Important Plant Areas (IPAs)

- **GSPC target 5** - to protect 75% of the most important areas for plant diversity with effective management in place for conserving plants & genetic diversity

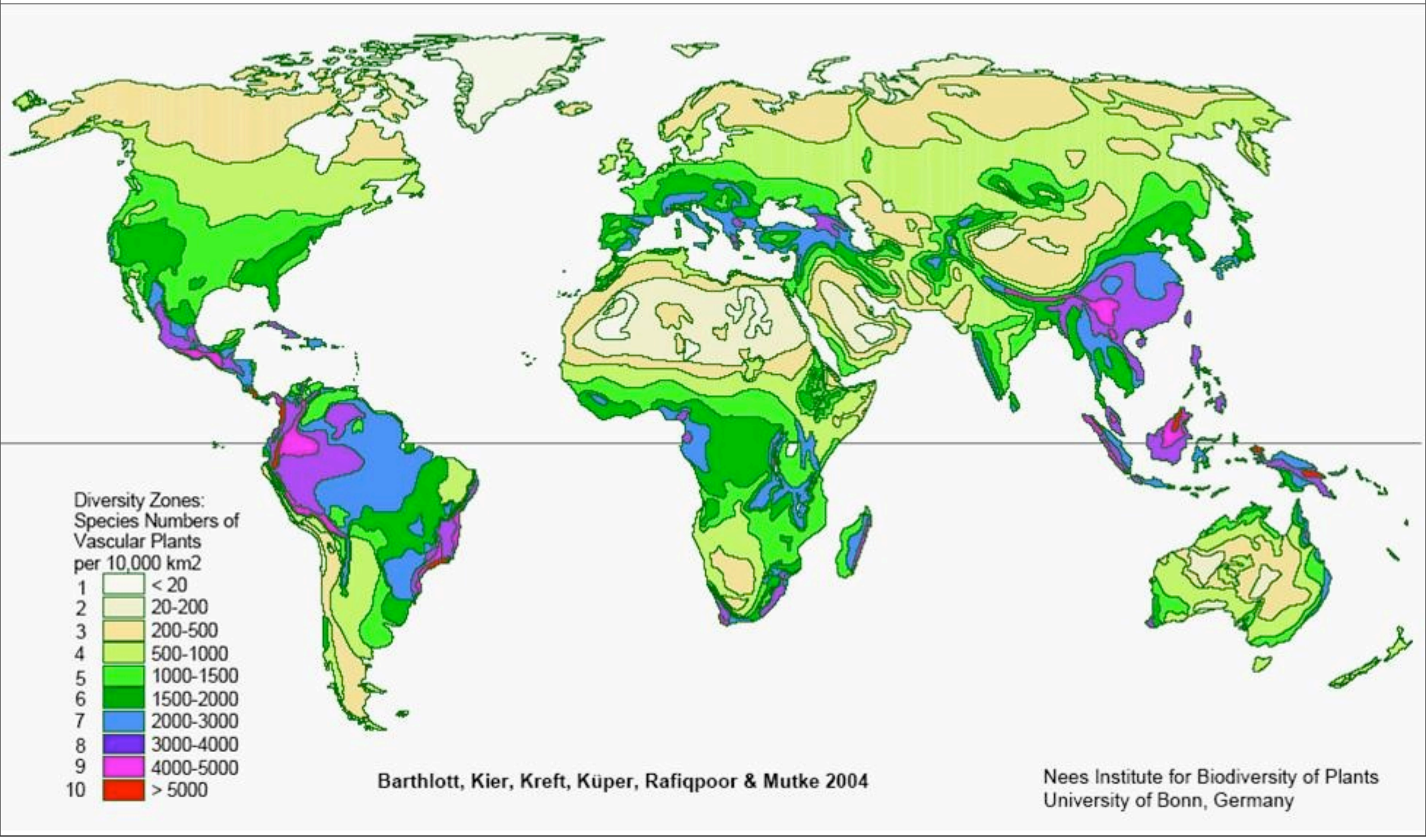
- IUCN definition of a protected area: " a clearly defined geographical space, recognised, dedicated & **managed**, through legal of other **effective** means, to achieve the long-term **conservation of nature** with associated ecosystem services & cultural values"

- The view that the impact of climate change may make this target (and *in situ* conservation in general) ineffective, is **not substantiated**

Important Plant Areas (IPAs)

Plantlife

IUCN
The World Conservation Union



Important Plant Areas (IPAs)

- the distribution of biodiversity is very **uneven** (Normile 2010) and the origin of that diversity is controversial and varied (Rull 2011)
- Indonesia contains 10% of the World Flora, 12% of mammals (670) & 17% of reptiles, amphibians & birds.
- Borneo alone has 15,000 spp of flowering plants 34% endemic

Conservation and discovery. Indonesia is trying different approaches to protect and preserve natural habitat in the Heart of Borneo, Harapan Rainforest, and Foja Mountains.

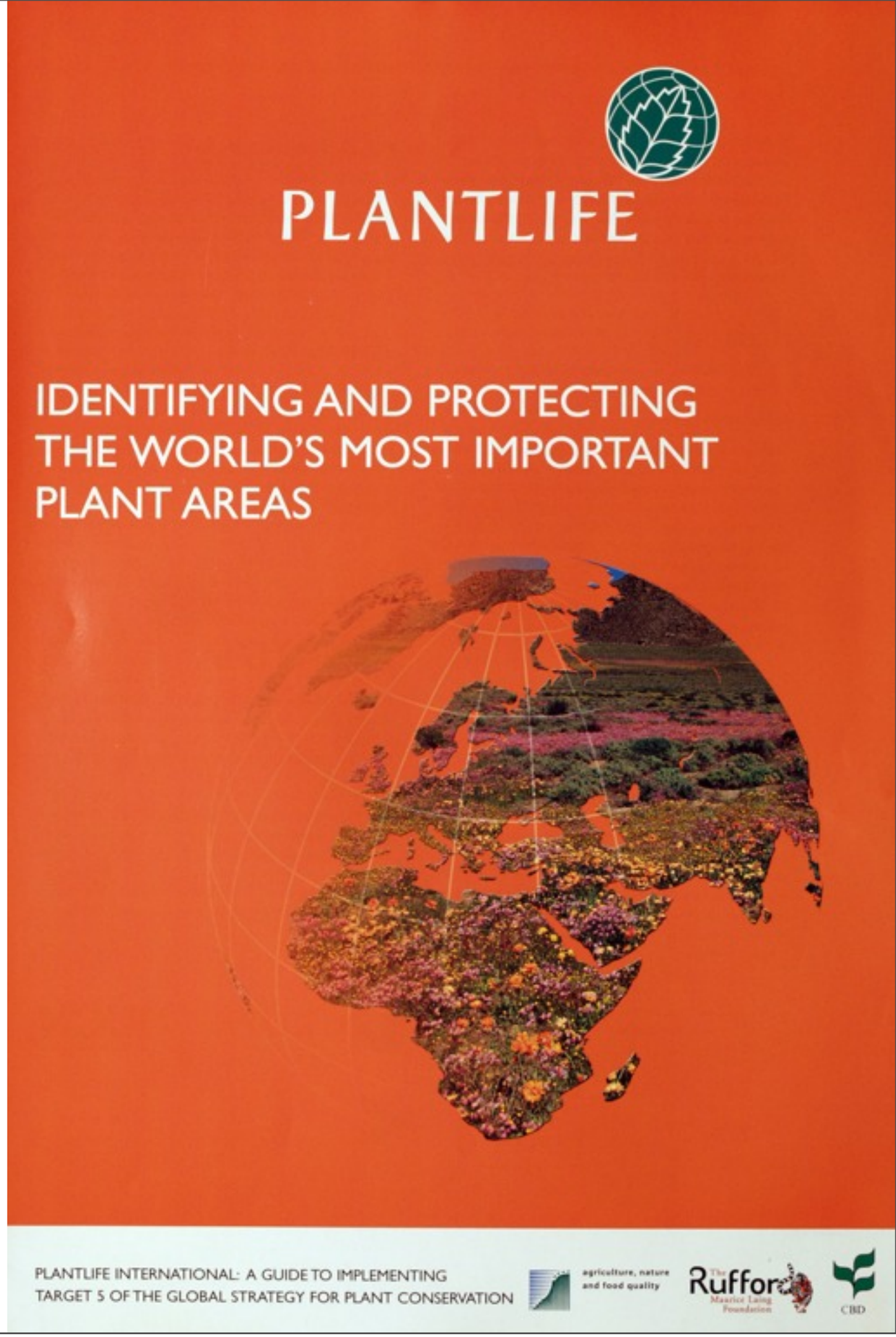
Important Plant Areas (IPAs)

- the **recovery after logging can be reasonable**. After 2 rounds of logging, 75% of birds & beetles returned as opposed to just 30% of birds being in oil palm plantations (in Normile 2010)
- Illegal logging has reduced by 70% in Indonesia since 2000 but it may still account for c.50% of all logging
- The Heart of Borneo area includes 220,000 sq. km. of protected forest spread across Borneo & Indonesia (the same size as the UK)

The Global Environment Facility was established to fund CBD initiated conservation

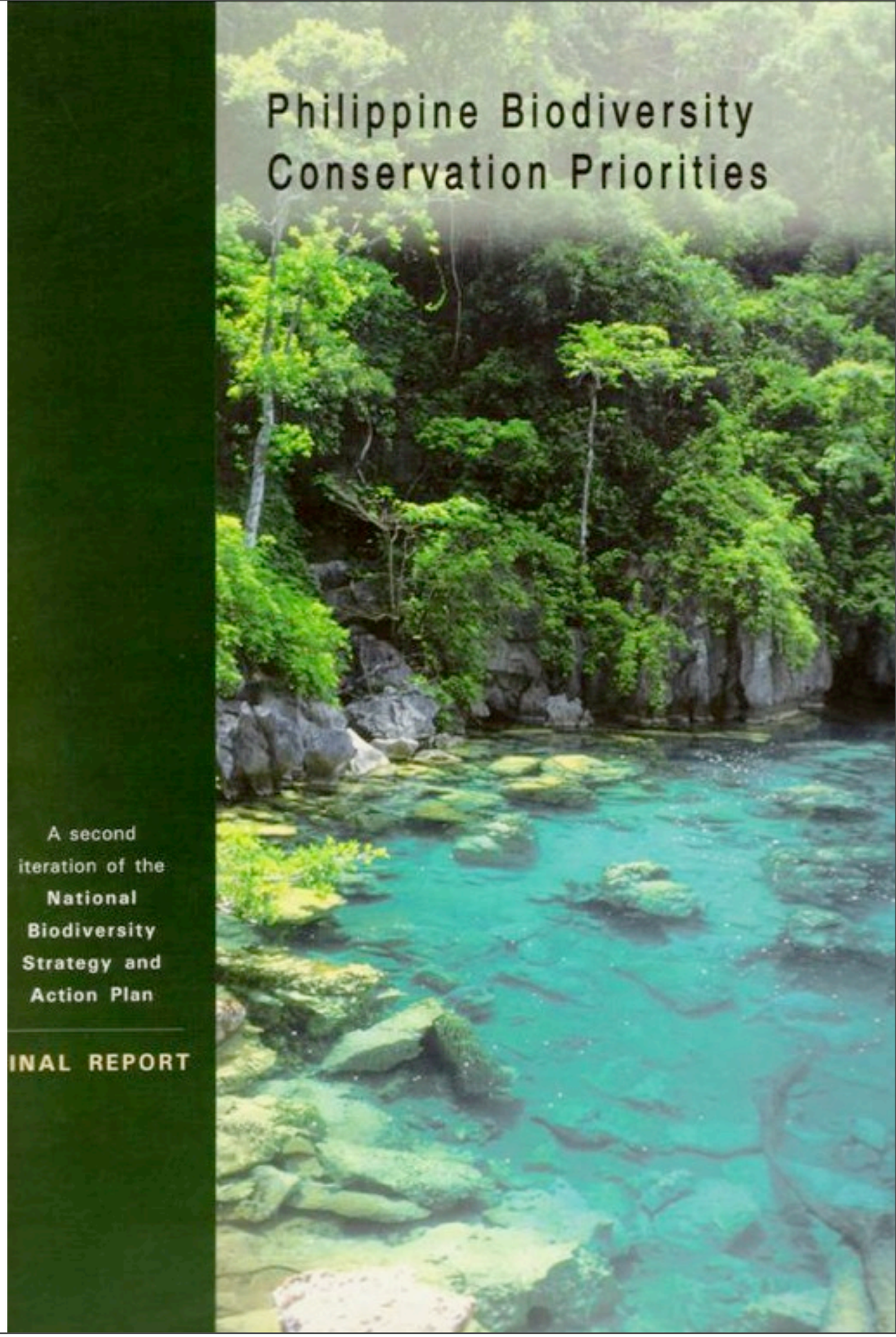
- A pilot project is being carried out across Armenia, Bolivia, Madagascar, Sri Lanka & Uzbekistan

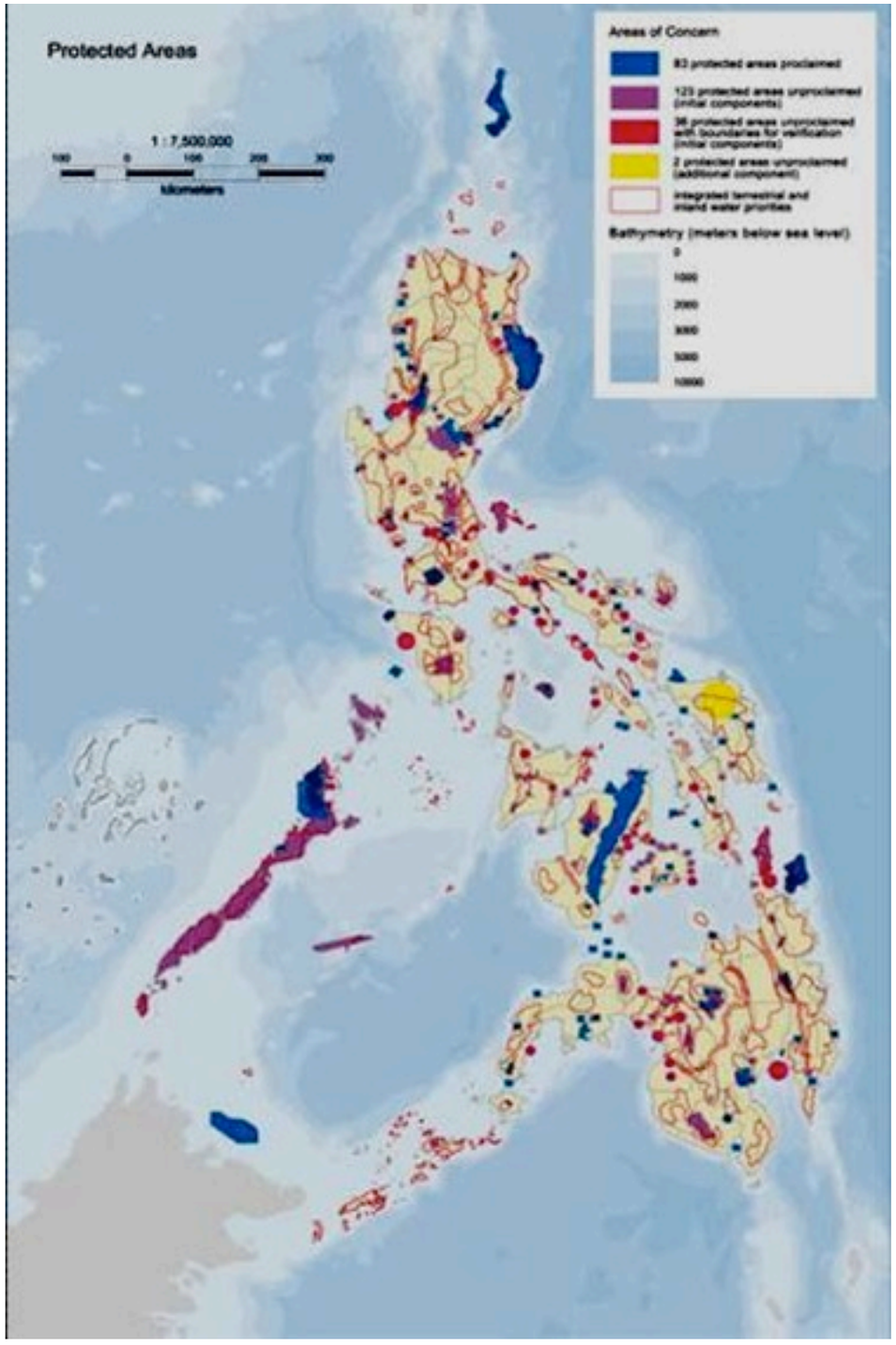
- to date 15.8% of the land in these countries is protected

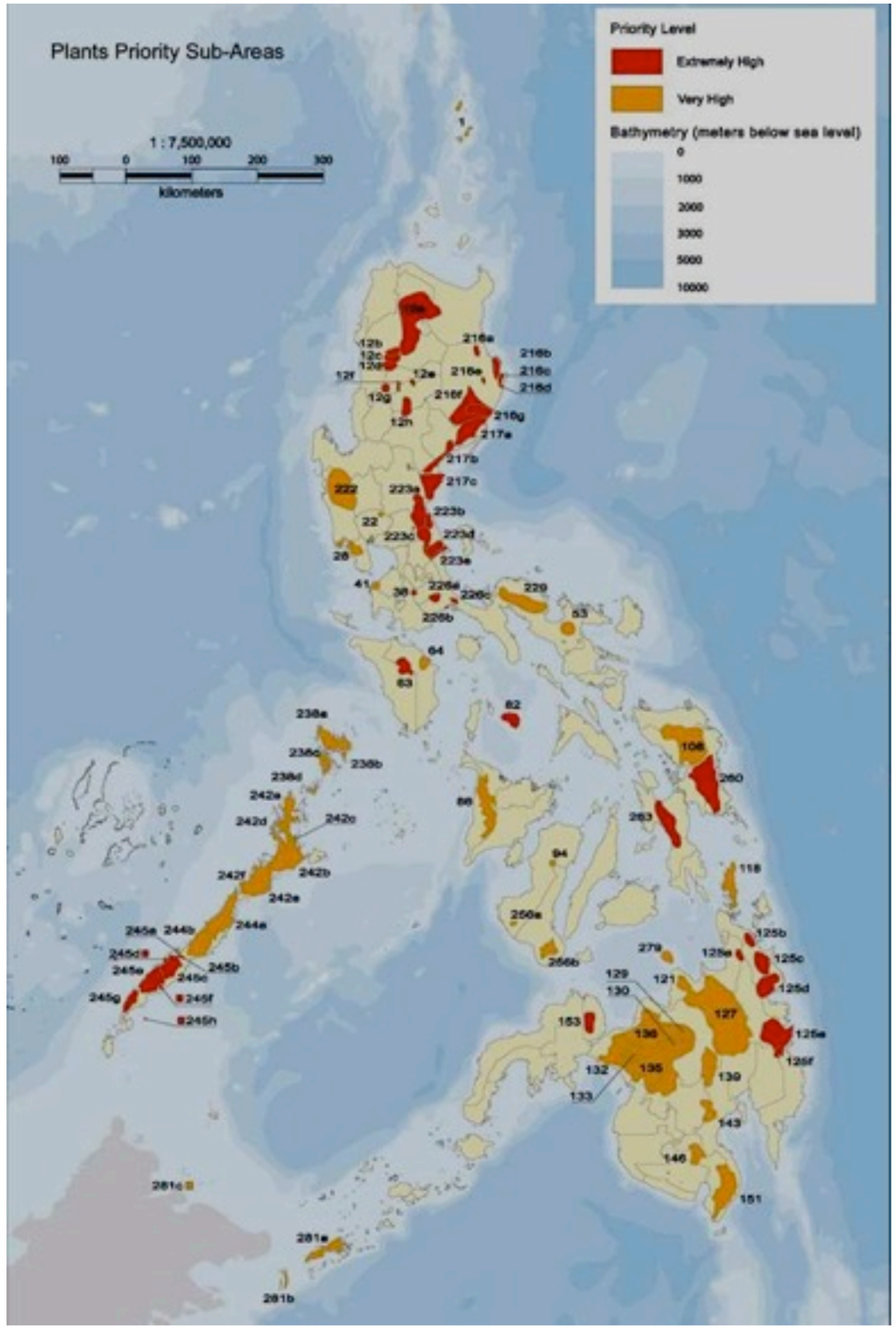


Philippine NBS&AP

- **Mapped** the areas of highest biodiversity
- **Mapped** the distributions of endangered species
- **compared** the above with the existing protected areas



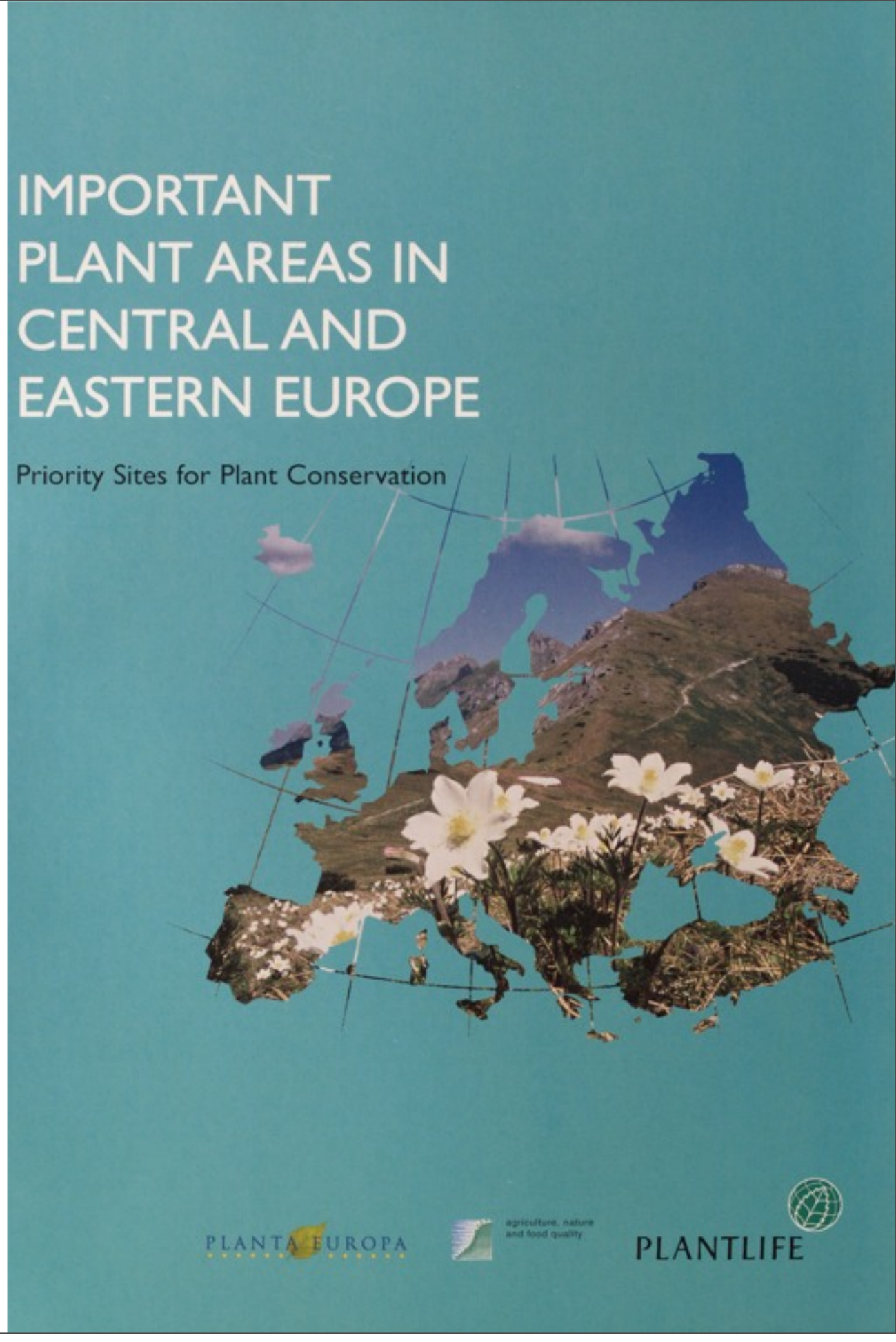




Only 39 of the protected areas *(on the left)* overlapped with the important plant areas *(on the right)*

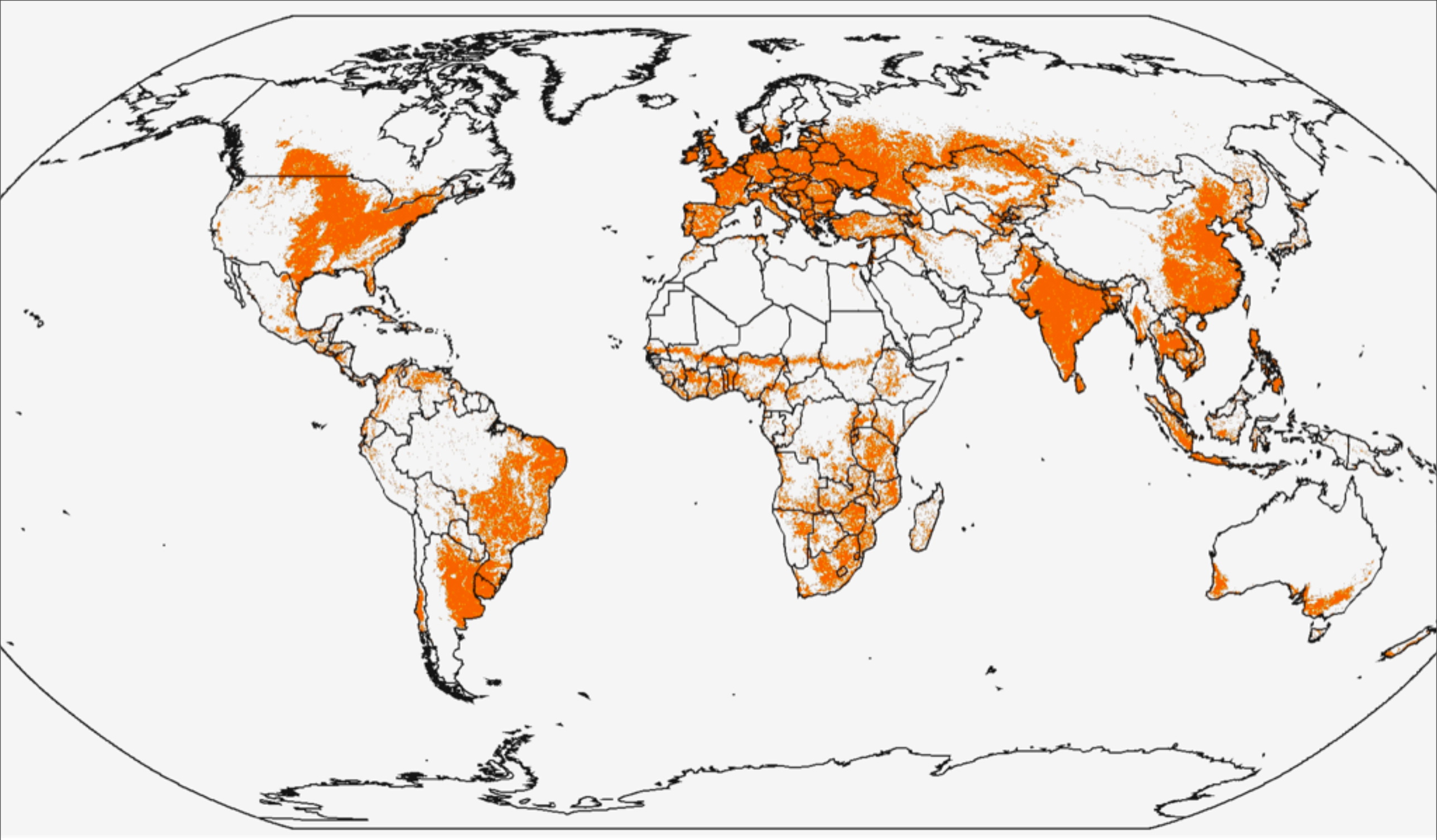
IPAs in Europe

- The Czech Republic has a flora of 2,550 species
- 61% of these species are threatened status
- 75 IPAs have been established covering 146,051 ha
- More than **67 countries** are participating actively in programmes to identify and to protect IPAs



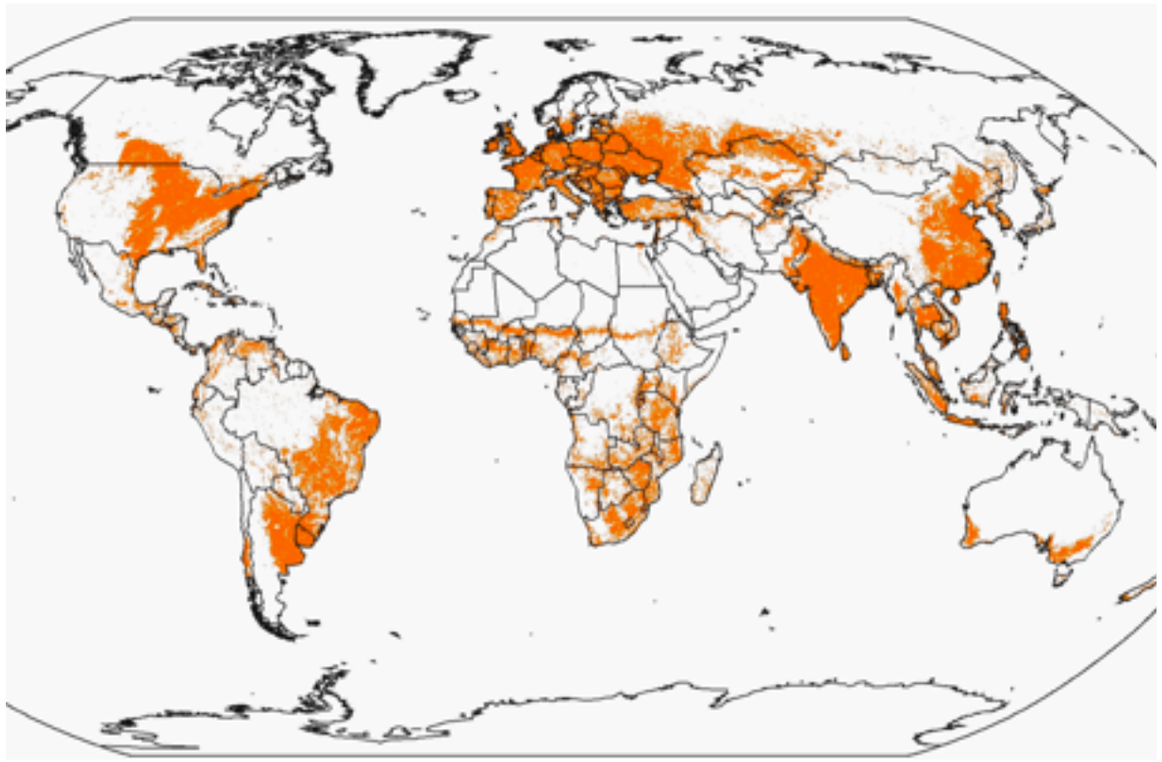
Production Lands

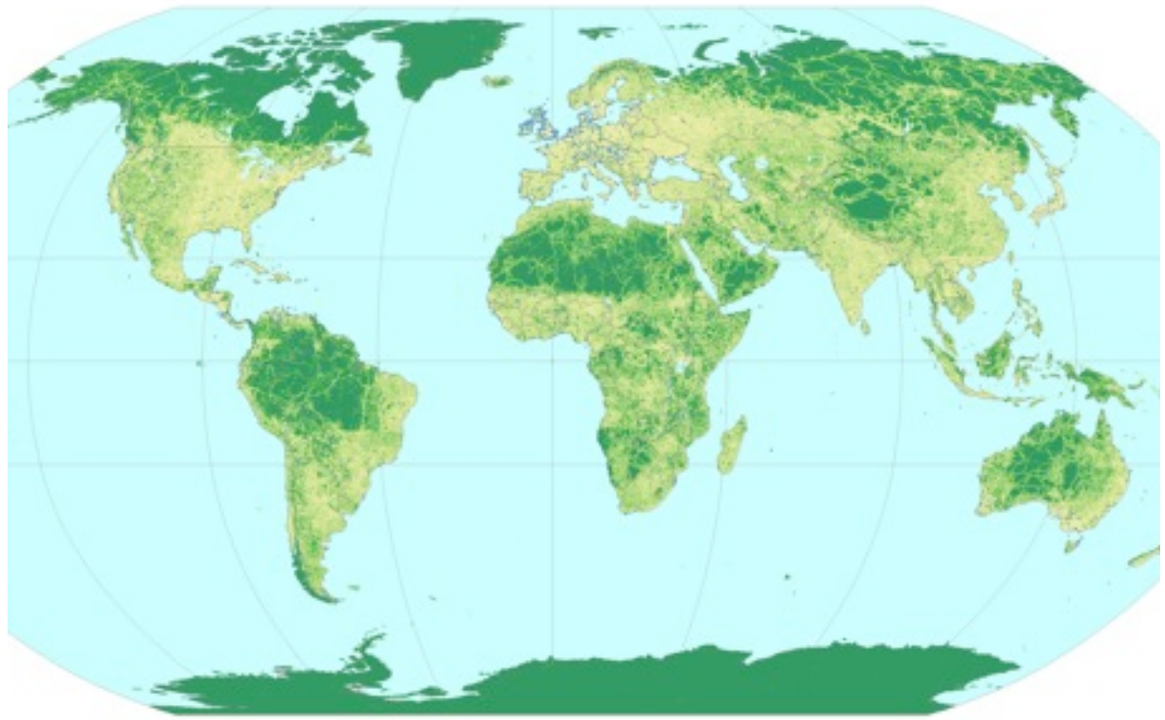
- **GSPC target 6** - to manage 75% of production lands in each sector sustainably, consistent with the conservation of genetic diversity
- In China £1.34B *per annum* will be given to **farmers & nomadic peoples** in western China to conserve grasslands (Qui 2011)
- In the EU there is a similar scheme - **Environmental Stewardship**. In the US there are payments for environmentally friendly farming (Rands 2010)



Production lands cover 25%
of the total land area on Earth

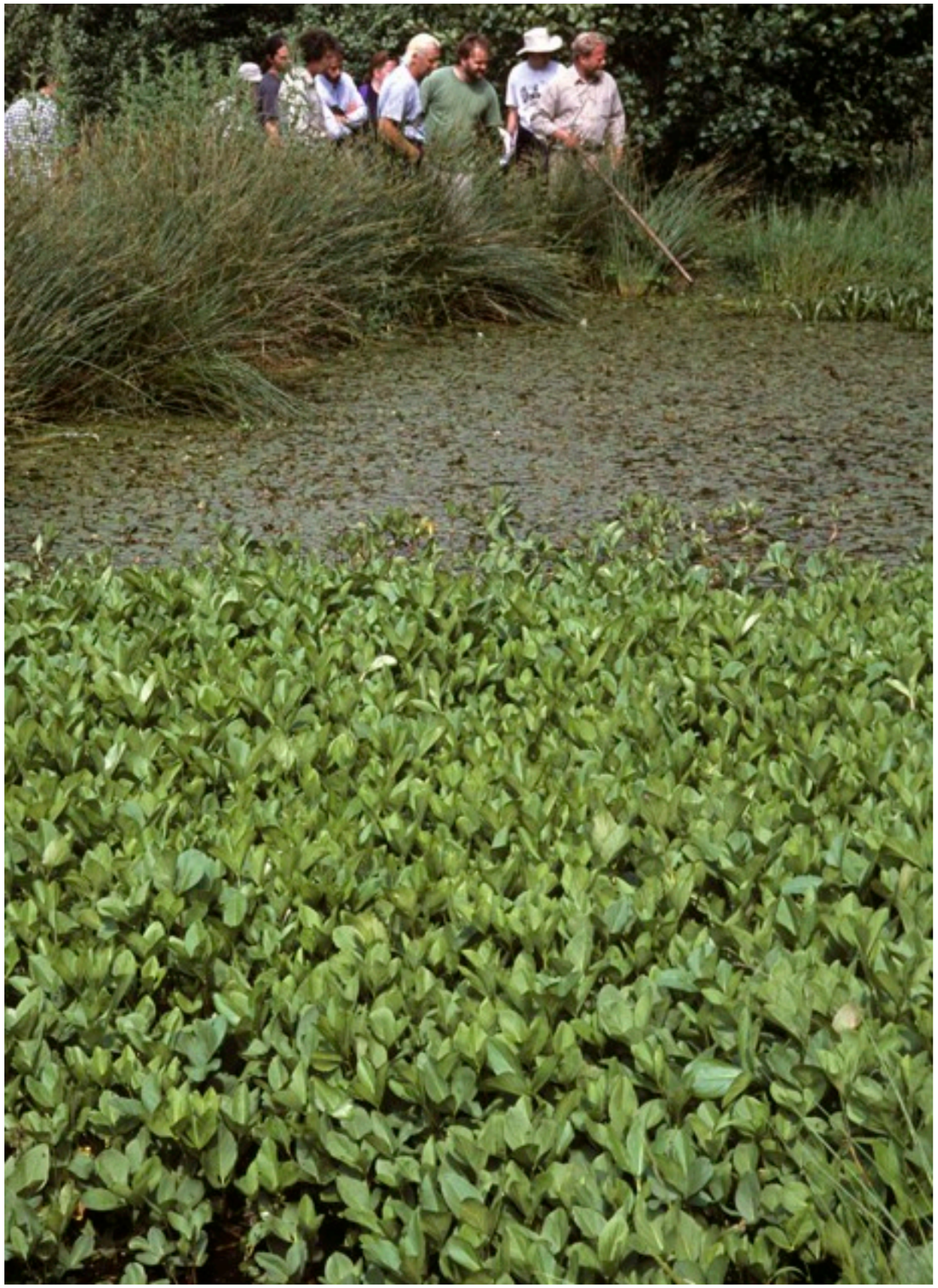
Between 1950 & 2000 more land
was converted to production
land than between 1700 & 1950

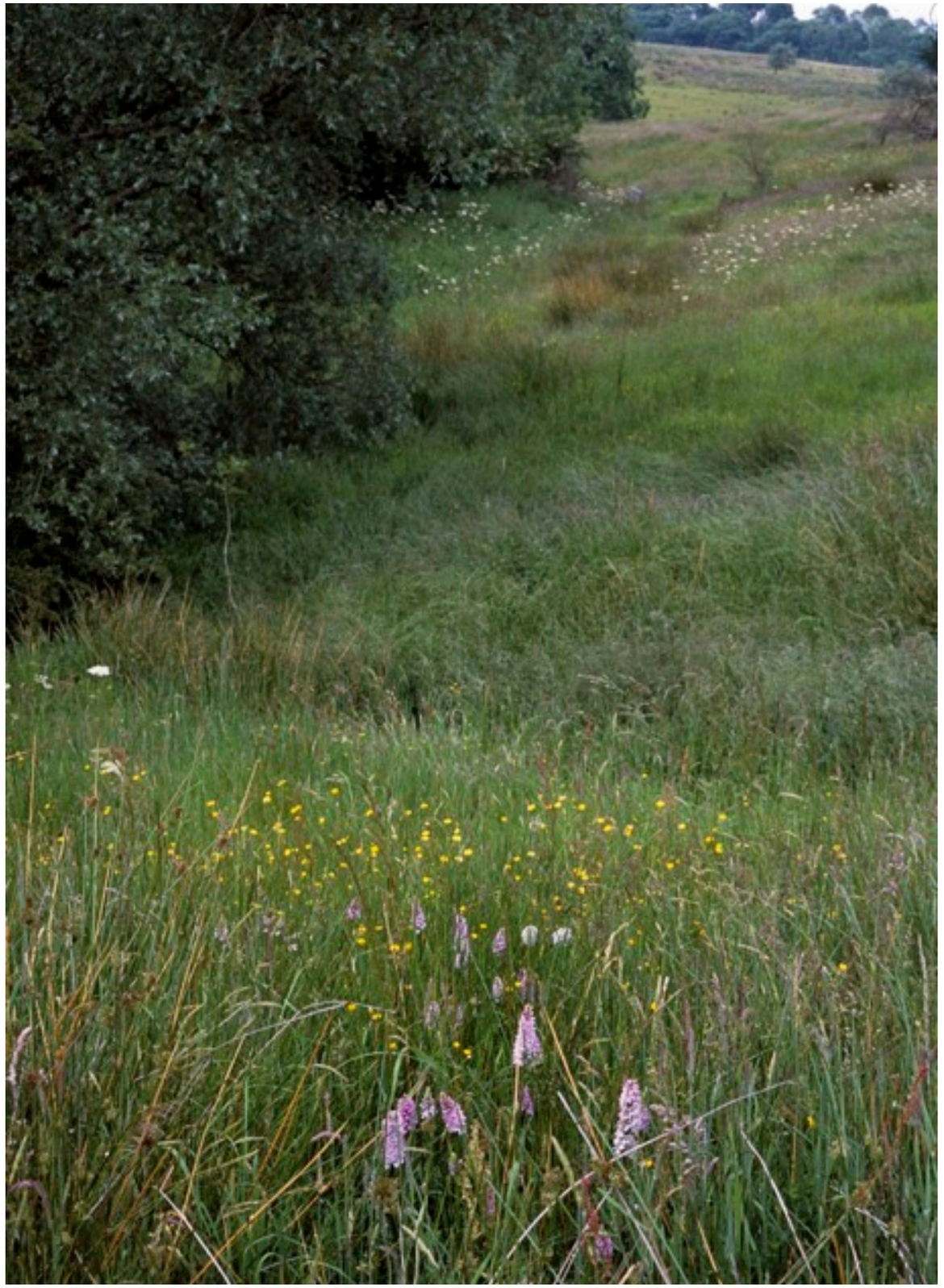




Not surprisingly production lands *(on the left)* and wilderness areas *(on the right)* are mutually exclusive by definition BUT does production land have to be a biodiversity-free zone?

Land Sharing *(on the left)* is where production and the protection of wildlife happen on the same land as opposed to **Land Sparing** *(on the right)* is where intensive production and the protection of wildlife happen on the different land. Phalan *et al.* (2011a) using birds & trees as indicators showed that **land sparing is less harmful to the wildlife and less damaging to crop yields but not for every species**. See Fischer *et al.* (2011) & Hayashi (2011) & Phalan et al. (2011b) for further discussion.





Land-sharing in Lincolnshire. *Menyanthes trifoliata* (native & threatened bog bean) growing in a pond on an organic farm that is also a SSSI

Conservation in production forest (2005)

- 11% of total forest area is designated as primarily for the conservation of biodiversity

- 65% of total first area has conservation of biodiversity as one of its designated functions

- Cork oak woodland in Iberia is a production system that produces a sustainable crop as well as supporting a species rich flora.

Food & biodiversity (**Godfray** 2011)

- The land-sharing vs. land-sparing assessment must include ecosystem services, carbon sequestration and provision of water on one hand and crop yield, food quality, and food security on the other.
- ***"Real decisions in conservation are dominated by politics & economics, and governments will have the luxury of acting on biodiversity only if their populations enjoy food security. Protecting biodiversity and ensuring food security are part of a single agenda."***

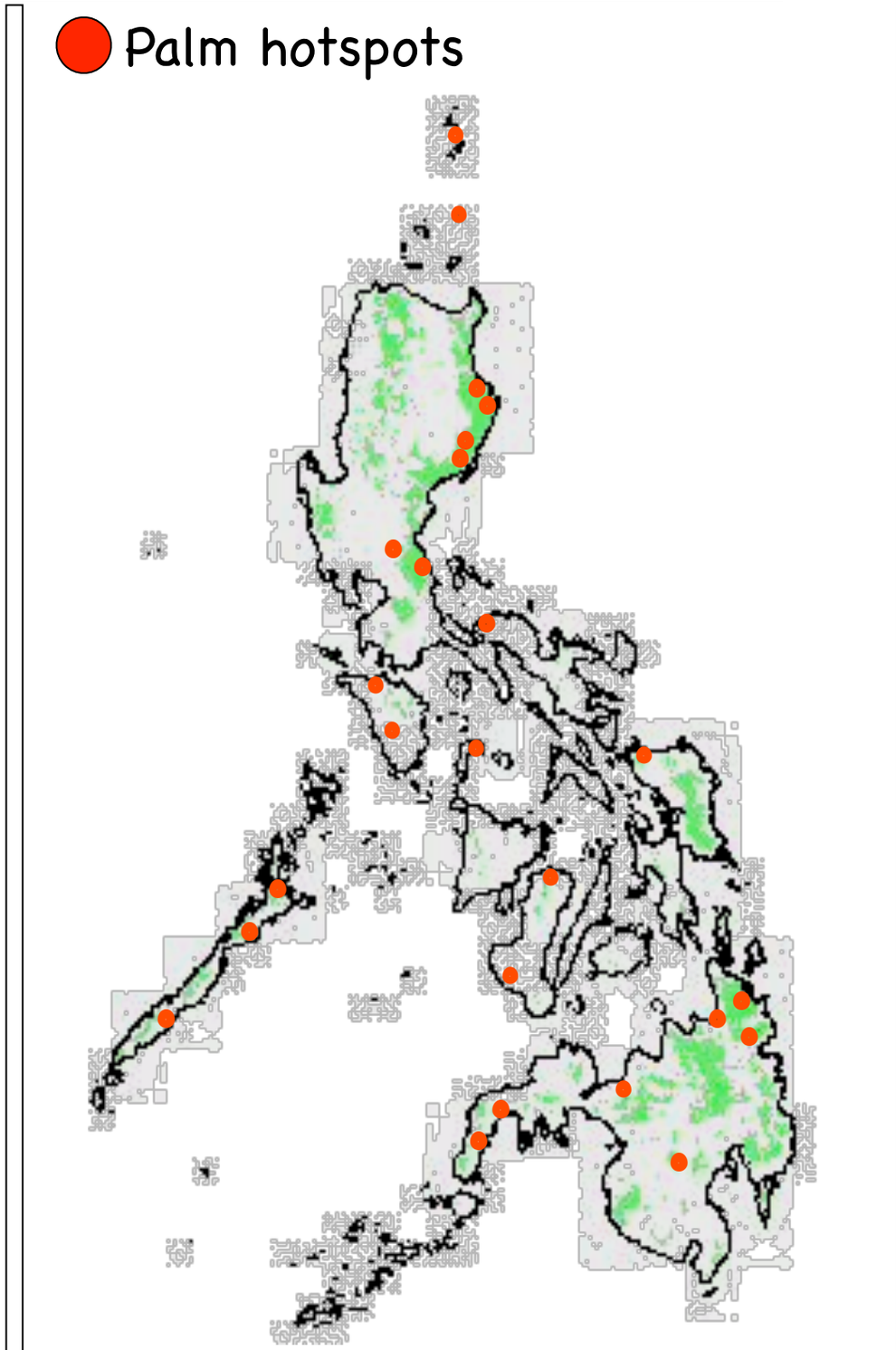
Conservation of species *in situ*

- **GSPC target 7** - to conserve 75% of known threatened species *in situ*

- It is normally assumed that conserving a threatened species in its habitat is the best strategy because the habitat can provide all of the needs of the threatened species **BUT** the same habitat includes the threat that has resulted in the decline of the species and **the threat must be removed**. For this reason few plant re-introductions have rarely worked in the past.

Palm Conservation in the Philippines

- *In situ* requirements will vary from species to species and we are trying to conserve 10,000s of species
- 16 hot-spots have been identified for the palm family
- Only 13 of these were found to be in newly defined IPAs
- Only 5 were in existing protected areas
- *in situ* conservation of species is complicated by the **non-overlapping distribution** of the threatened species



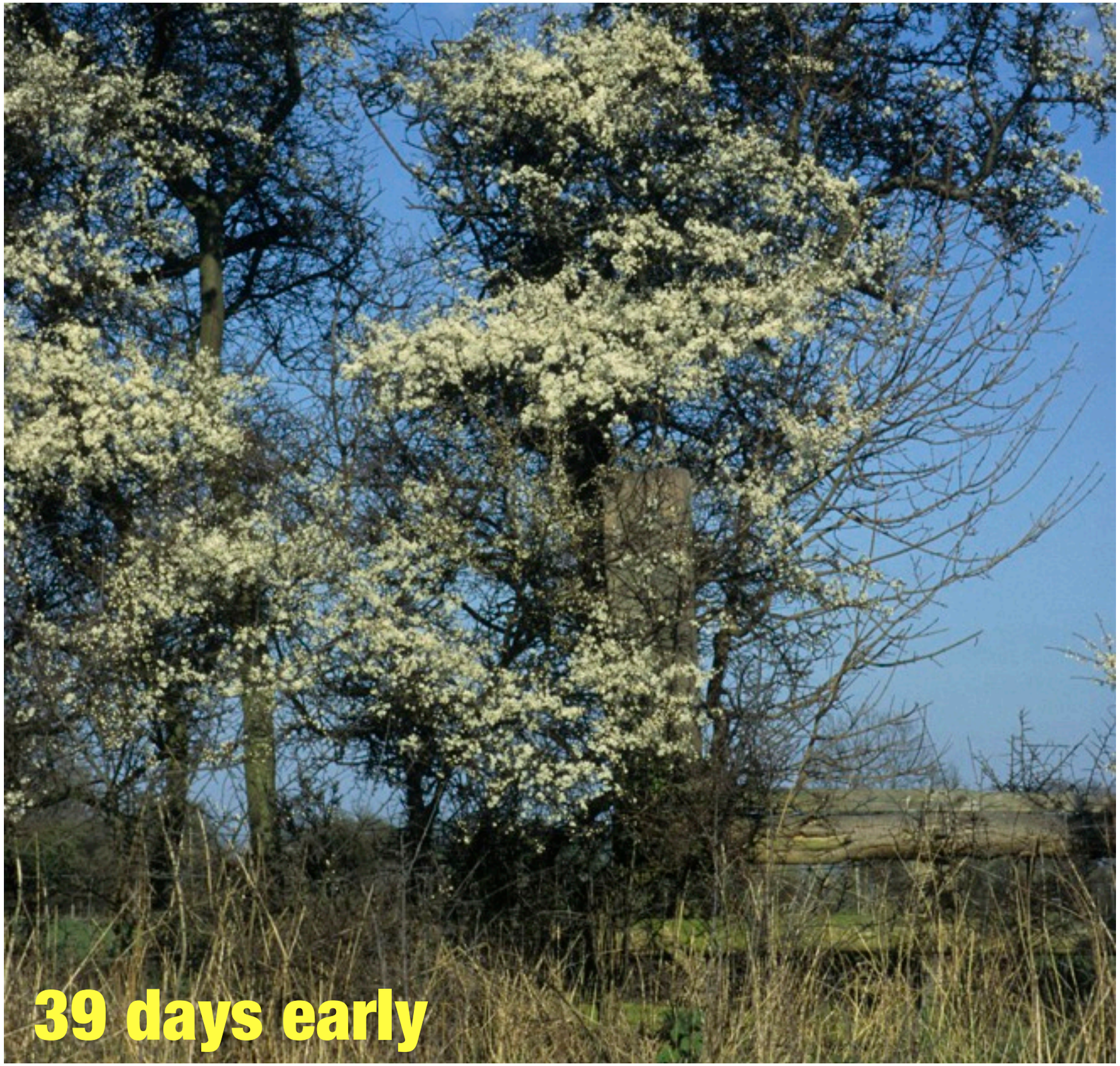
Conservation of species *in situ*

- **Advantages**

1) Communities are conserved and with them all aspects of the plant's biology such as pollinators & mycorrhizal fungi
2) Wider ecological services are also preserved and maintained
3) Genetic diversity is more likely to be conserved due to larger numbers of individuals being present
4) In situ conservation of **iconic species** can be attractive to donors

- **Disadvantages**

1) Time-consuming, indefinite, and regular monitoring is required
2) **Site security** is essential
3) Threats are often difficult & expensive to remove
4) Management will be involved
5) Changing climate **can Nature keep up?**



In 2004 these species flowered between 14 & 39 days earlier than the historical average (*clockwise from main picture:* sloe, wood anemone, buttercups, snowdrops)

Climate change & conservation of species *in situ*

- Loarie *et al.* (2009) proposed **a new index for the velocity of climate change**

- Velocity is lowest in mountainous regions and highest in deserts & flooded grasslands

- Only 8% of current protected areas will be in the right place in 100 years time

- Small protected areas exacerbate the problem whereas larger areas may mitigate the problems

Conservation of English bluebells

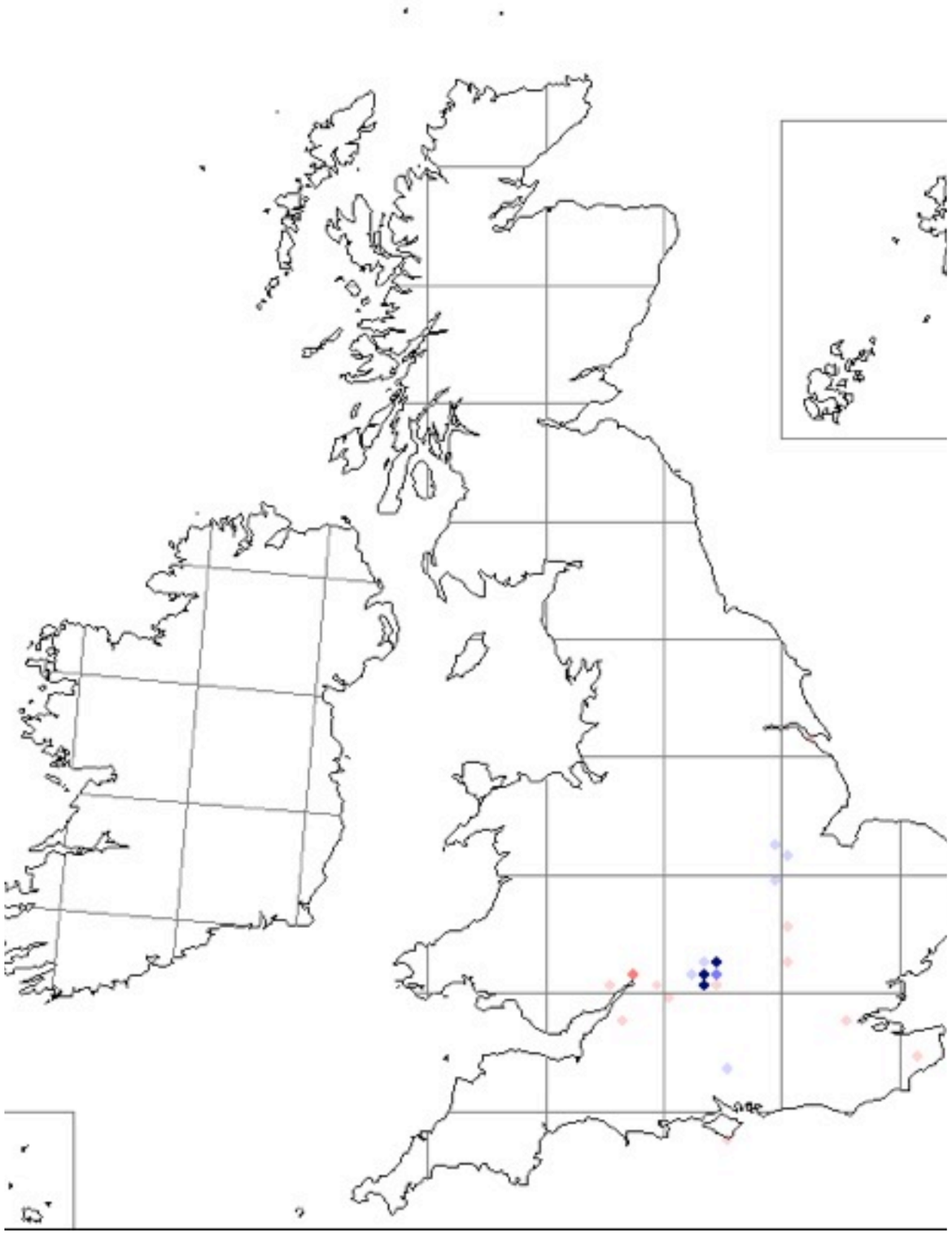
- 50% of English bluebells grow in England. The habitat favoured by bluebells is declining but where they are found they are often locally abundant. Bluebells woods are an iconic sign of Spring in England.
- In addition to loss of habitat English bluebells are subject to genetic “pollution” following hybridisation with Spanish bluebells which are considered to be a distinct species despite complete genetic compatibility with English bluebells. Is there just one species - European bluebell?

Conservation of English bluebells at the Harcourt Arboretum, Nuneham Courtenay

- English bluebells can reproduce vegetatively meaning that populations can be clonal and lacking genetic diversity. Such populations have limited species conservation.
- Work carried out by Stephen Harris & two undergraduates has shown that the population of bluebells at the Arboretum is distinct for other local populations and comprises genetically varied individuals that are interbreeding freely.

Conservation of rare Oxfordshire native species

- Oxfordshire is home to a number of nationally rare species including *Apium repens* which is a species listed in the Wildlife & Countryside Act 1981
- The Rare Plants Group of the Ashmolean Natural History Society of Oxfordshire has 15 species that it monitors throughout the county including *Aristolochia clematitis* (*below*). In addition they monitor the Triangle at Wytham where more than 200 species of arable fields have been recorded in 2010.
- The work of this group is supported by a many agencies & NGOs including the Department of Plant Sciences.



Stachys gemanica (downy woundwort) is a rare British Native with a few populations in bridleways near Witney. *In situ* management of these populations involves scarifying the paths and monitoring plus seed storage. This work has been led by Jo Dunn MBE

The role of fire in habitat management

- **Wildfire is a natural component** of many habitats. Many plants are able to survive fire, either from seeds in the soil or canopy seed bank (seeders), or by growing back from parenting organs below the soil or from main stems (sprouters).

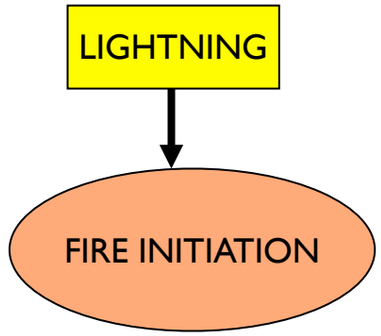
- **Mismanagement** of fire regimes can lead to loss of species and a reduction in biological diversity. This is a particular problem in the world's Mediterranean-type environments.

Fire regime interactions

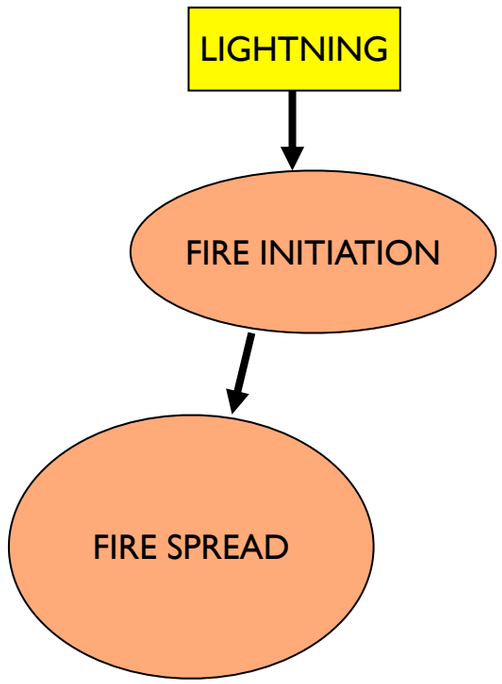
Fire regime interactions

LIGHTNING

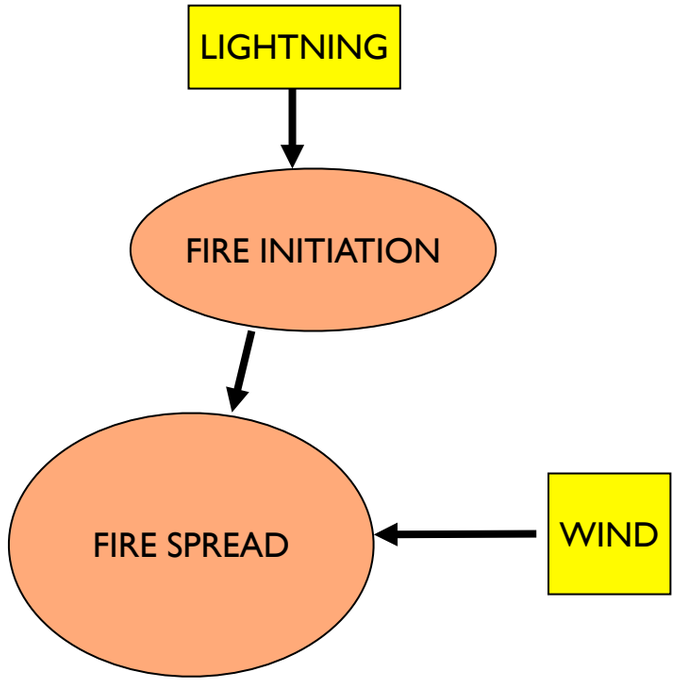
Fire regime interactions



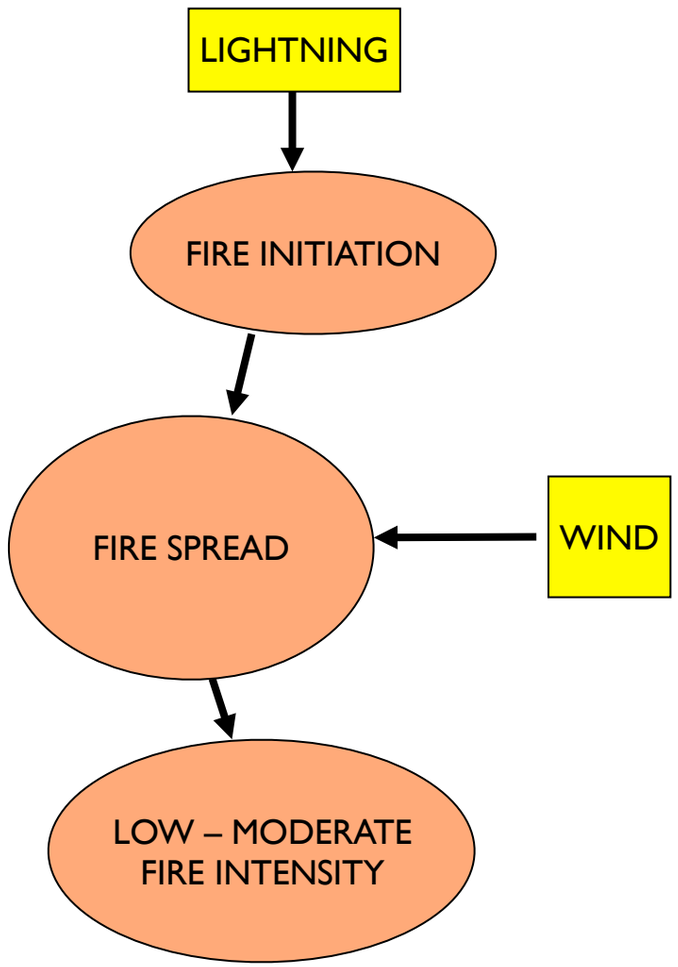
Fire regime interactions



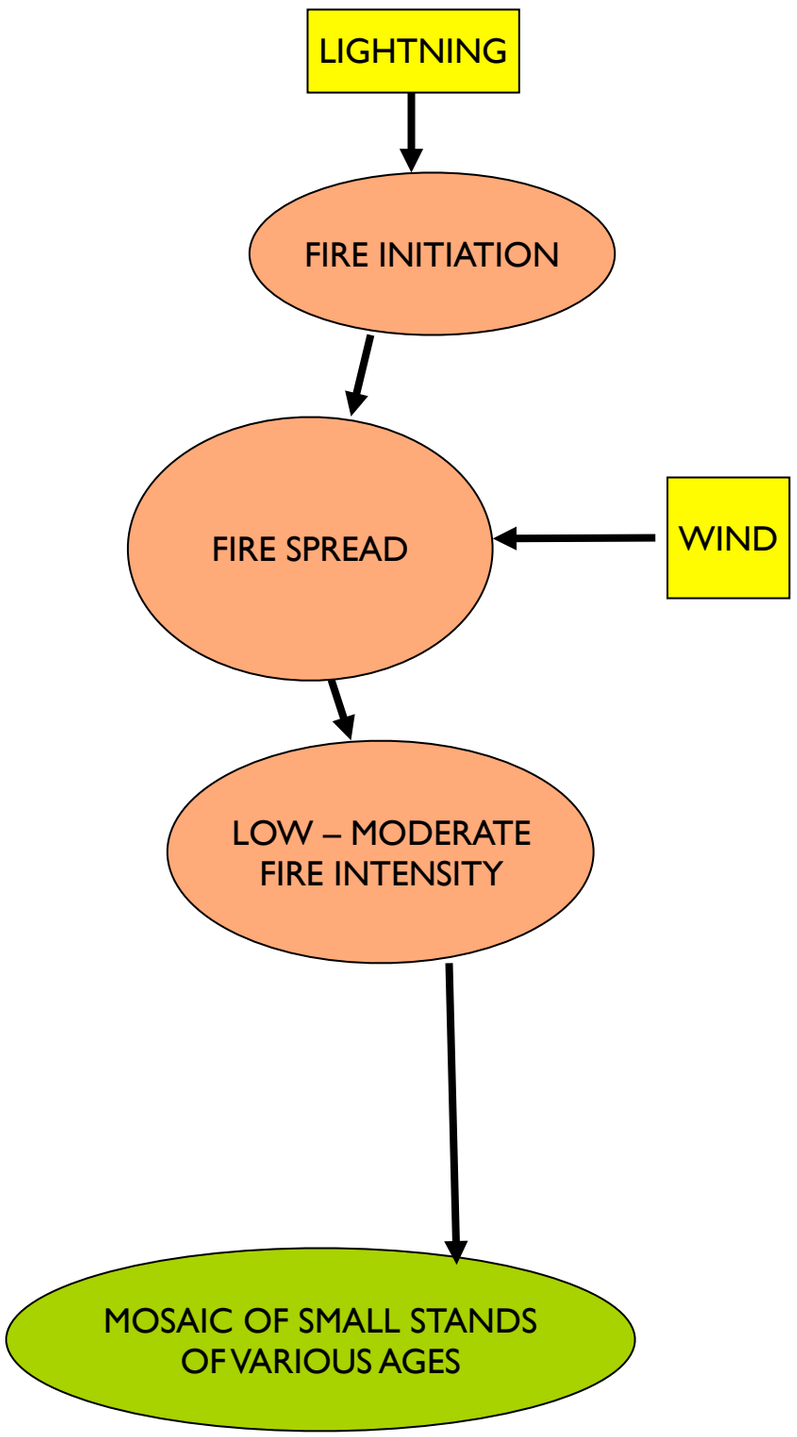
Fire regime interactions



Fire regime interactions



Fire regime interactions



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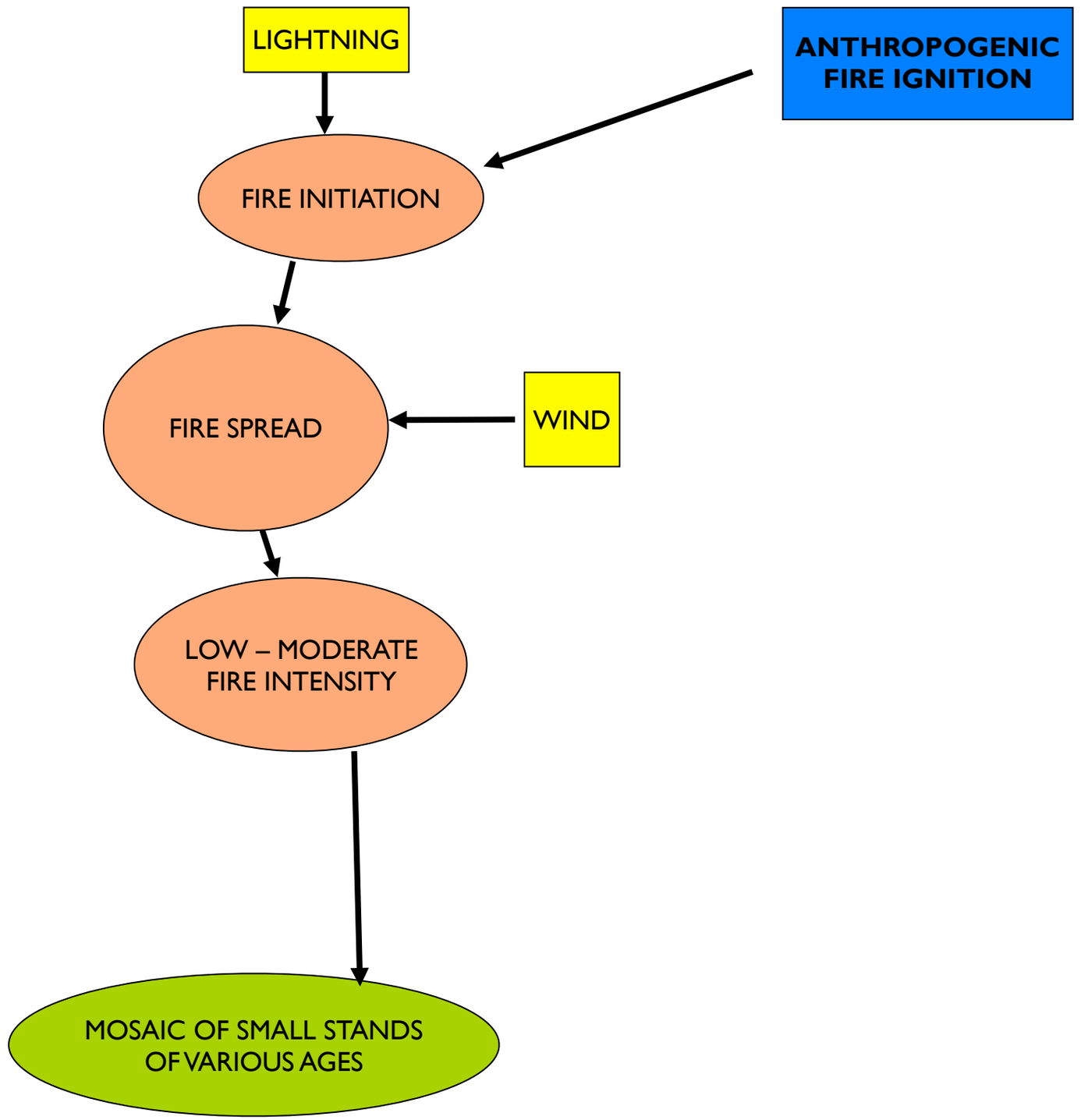
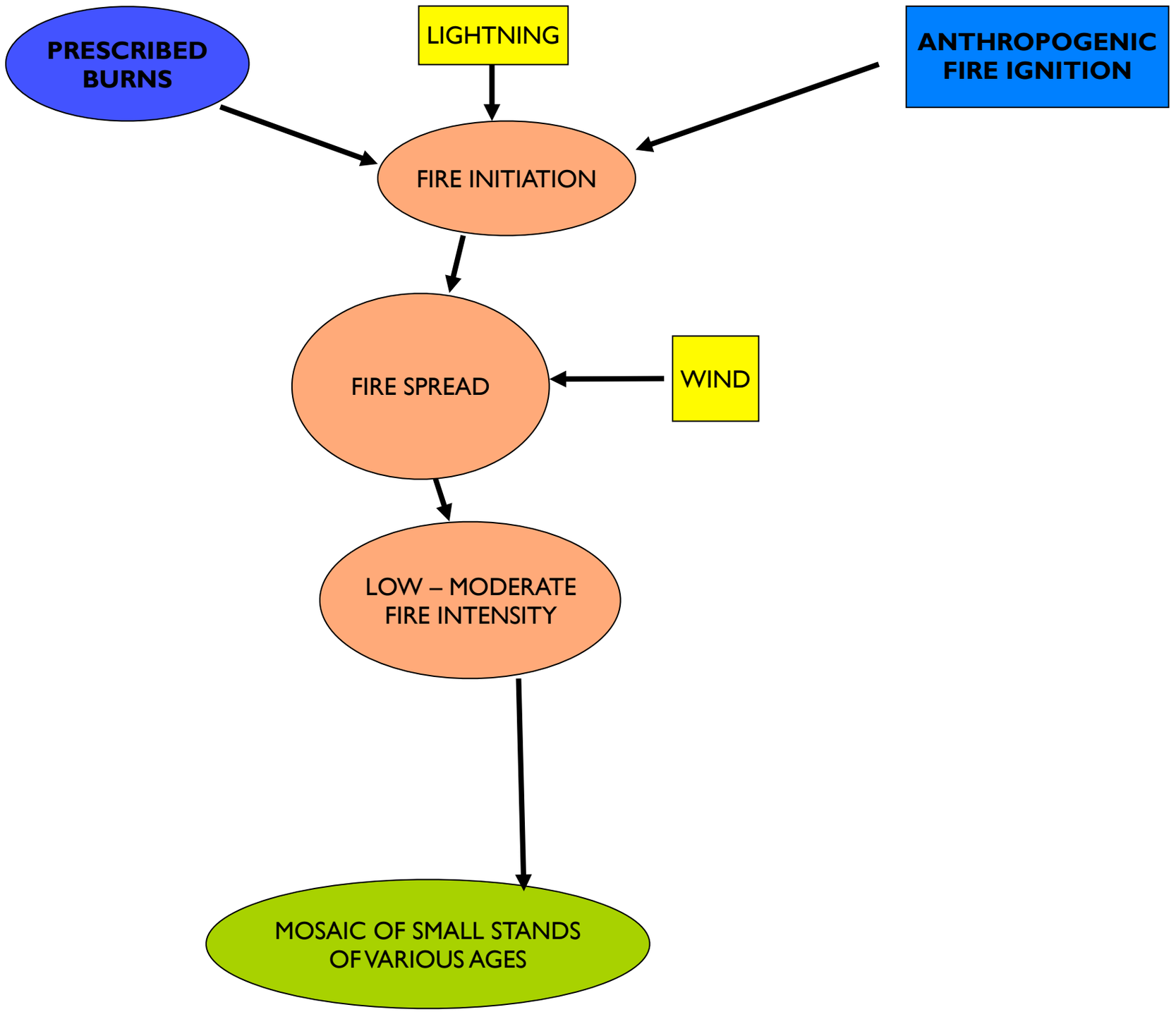


Fire regime interactions



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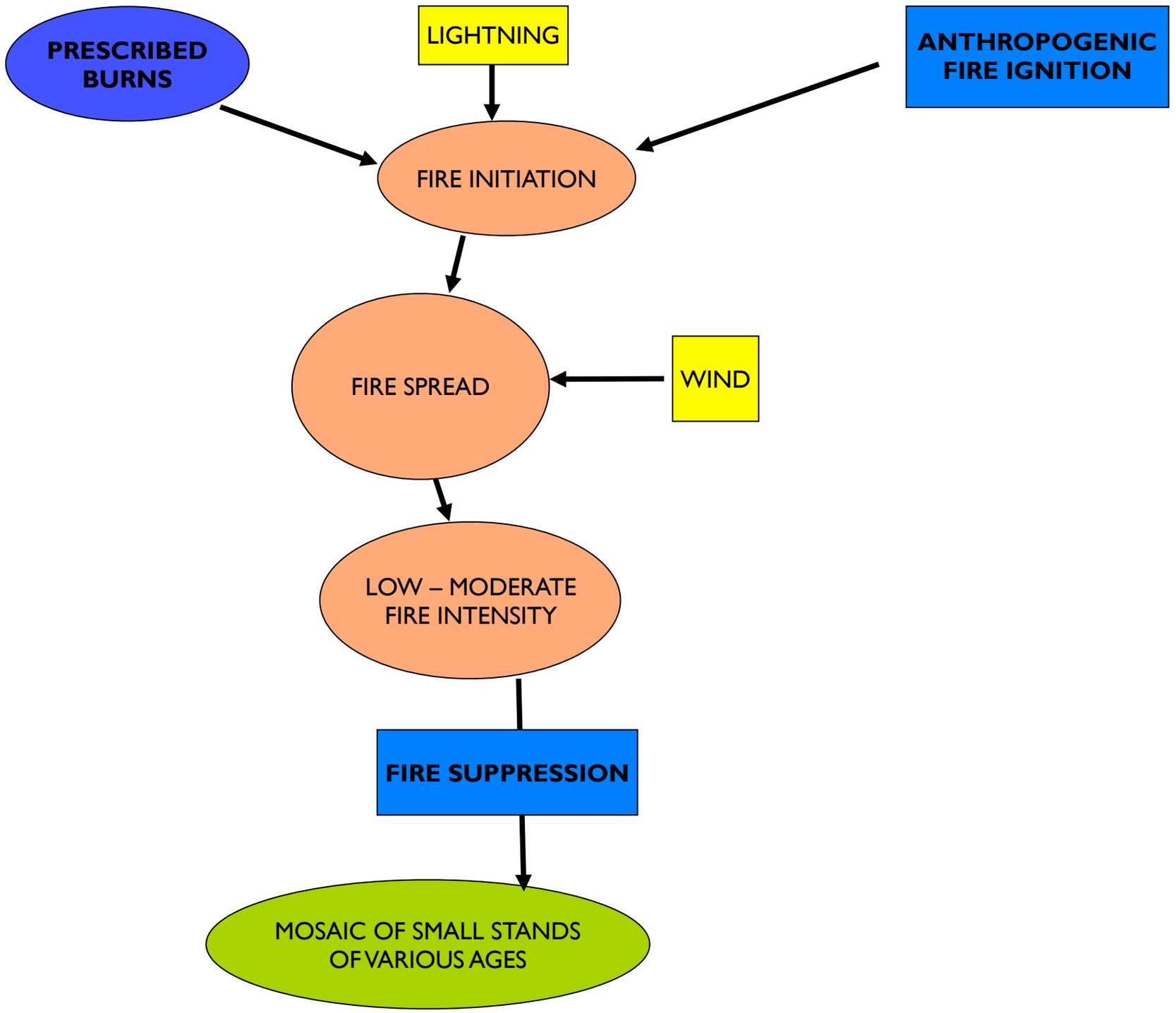
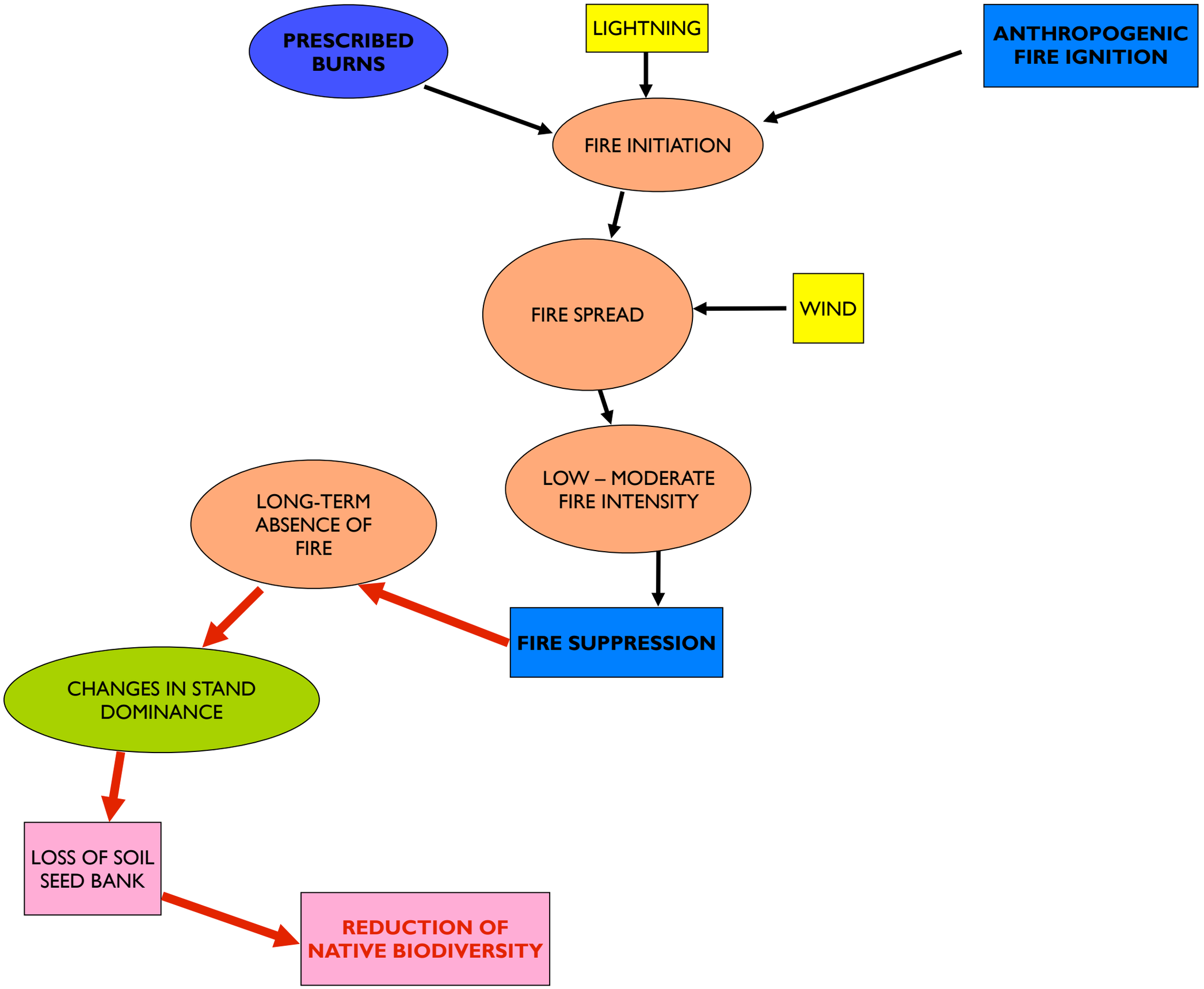


Fire regime interactions



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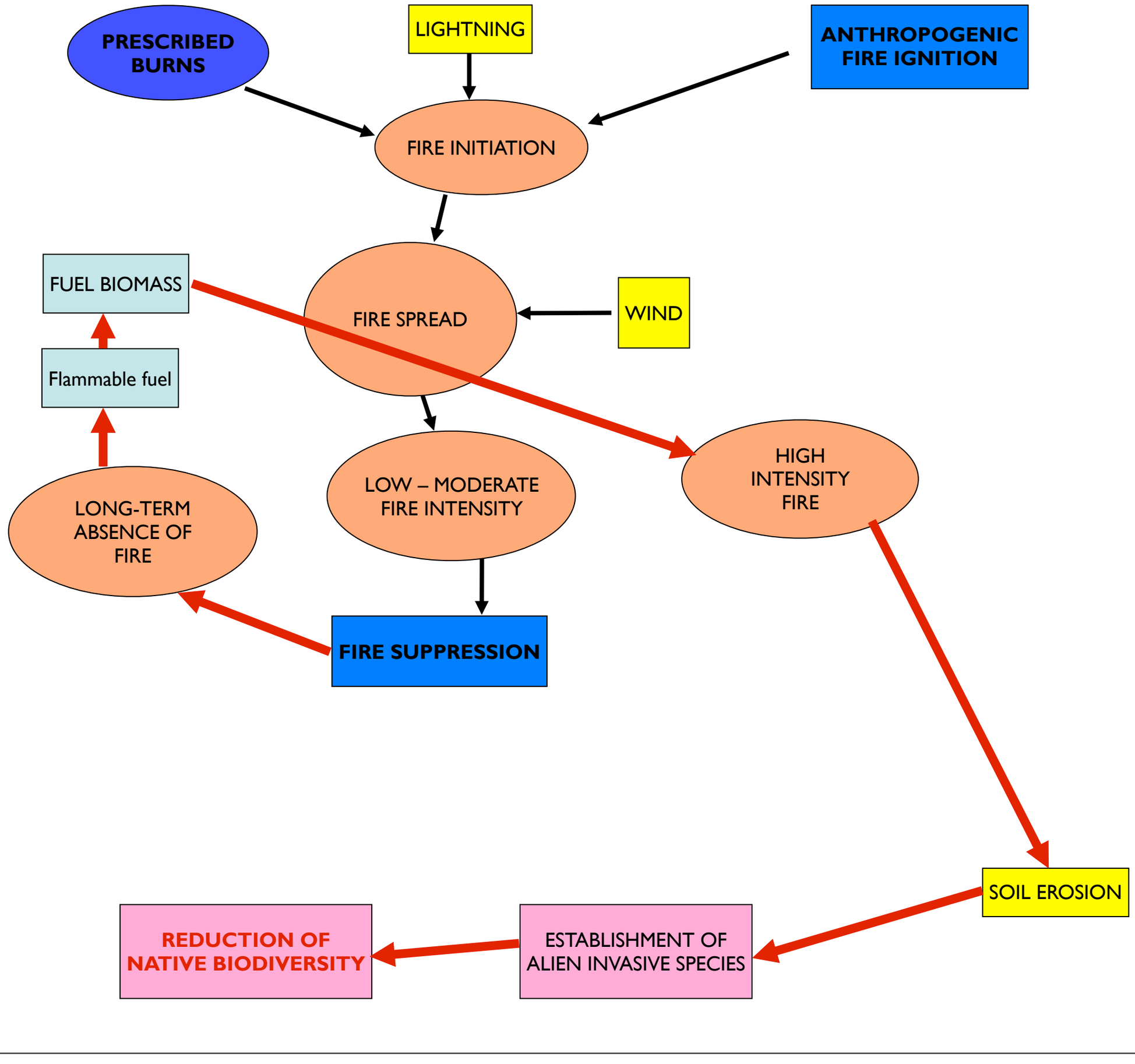
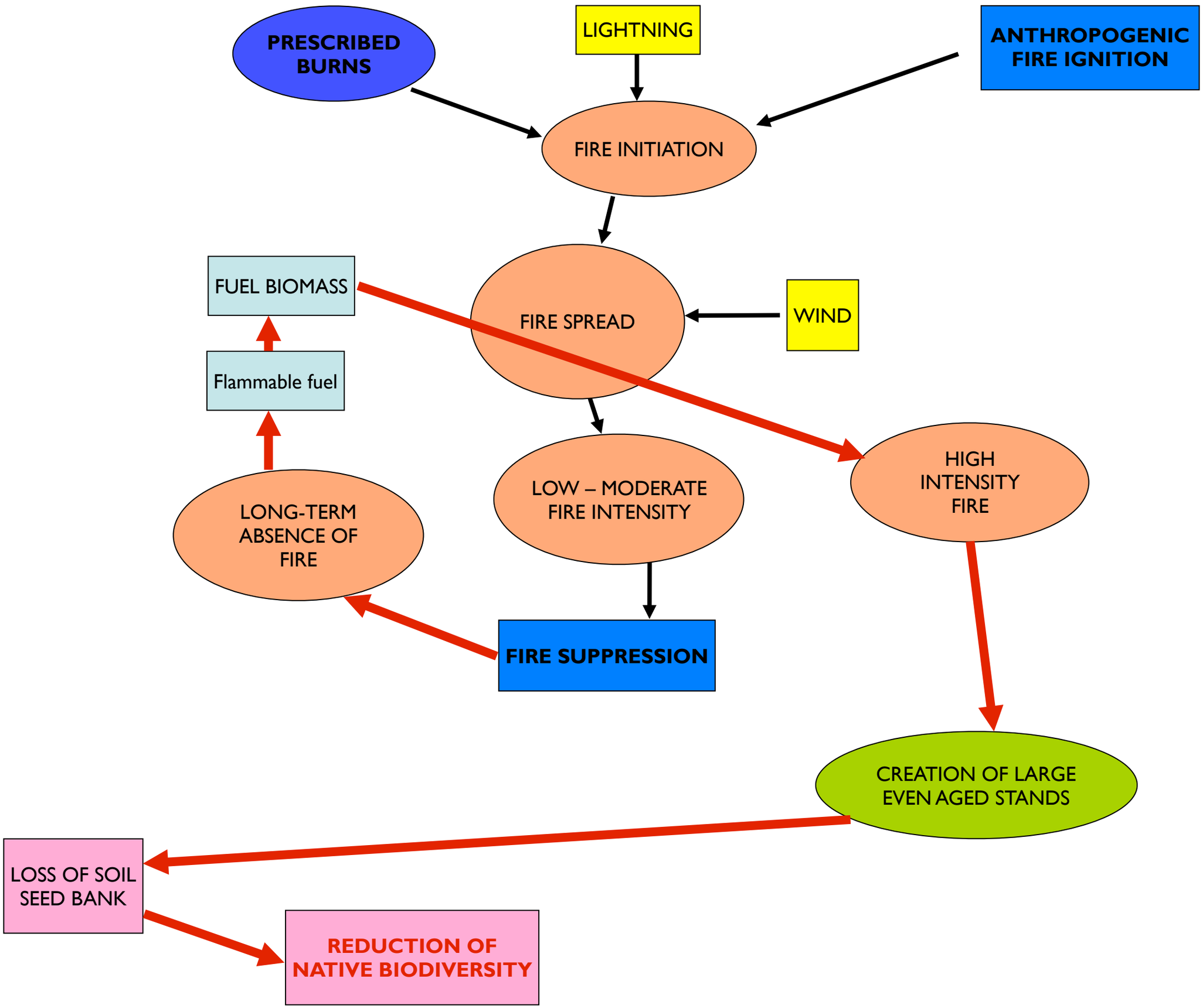
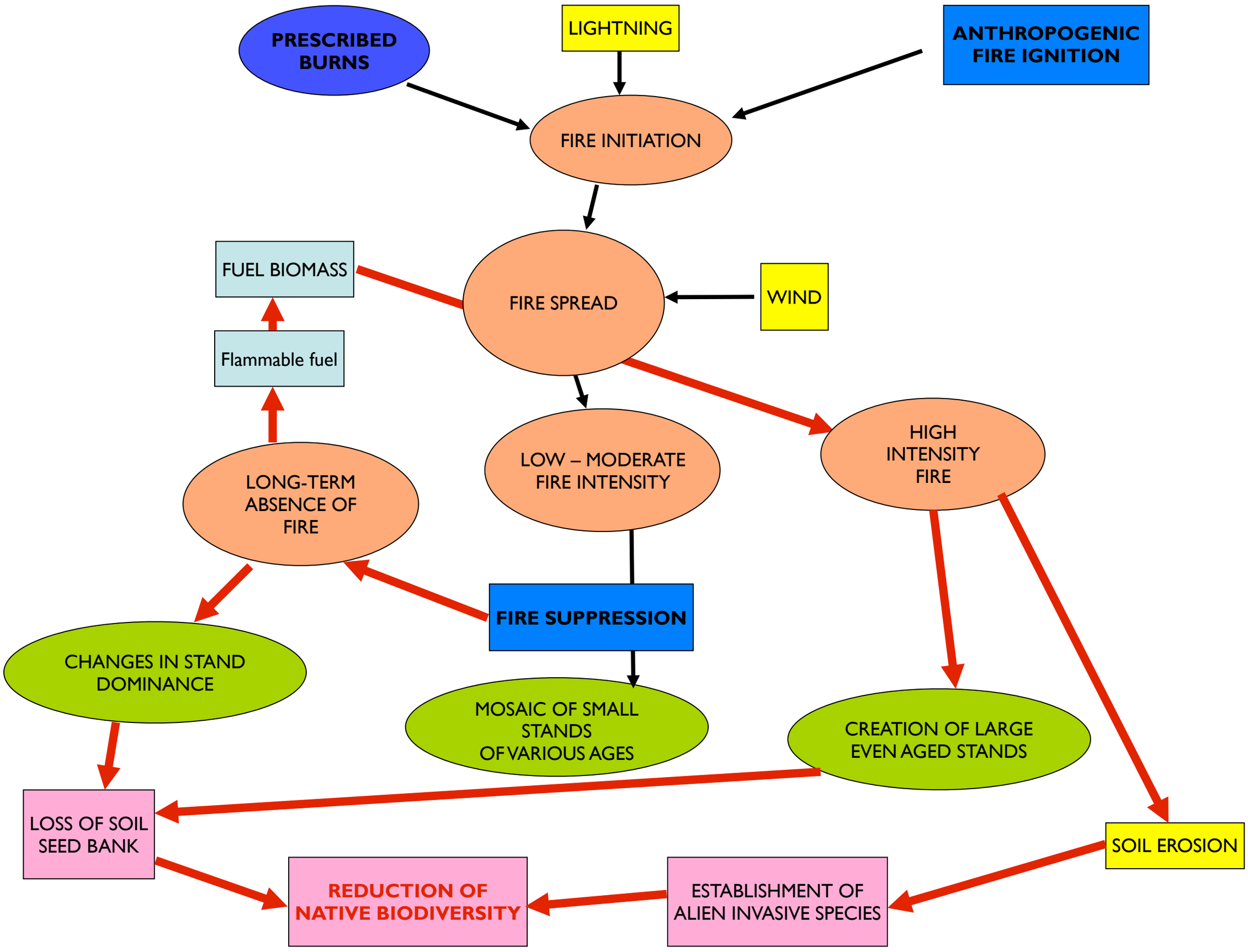


Fire regime interactions



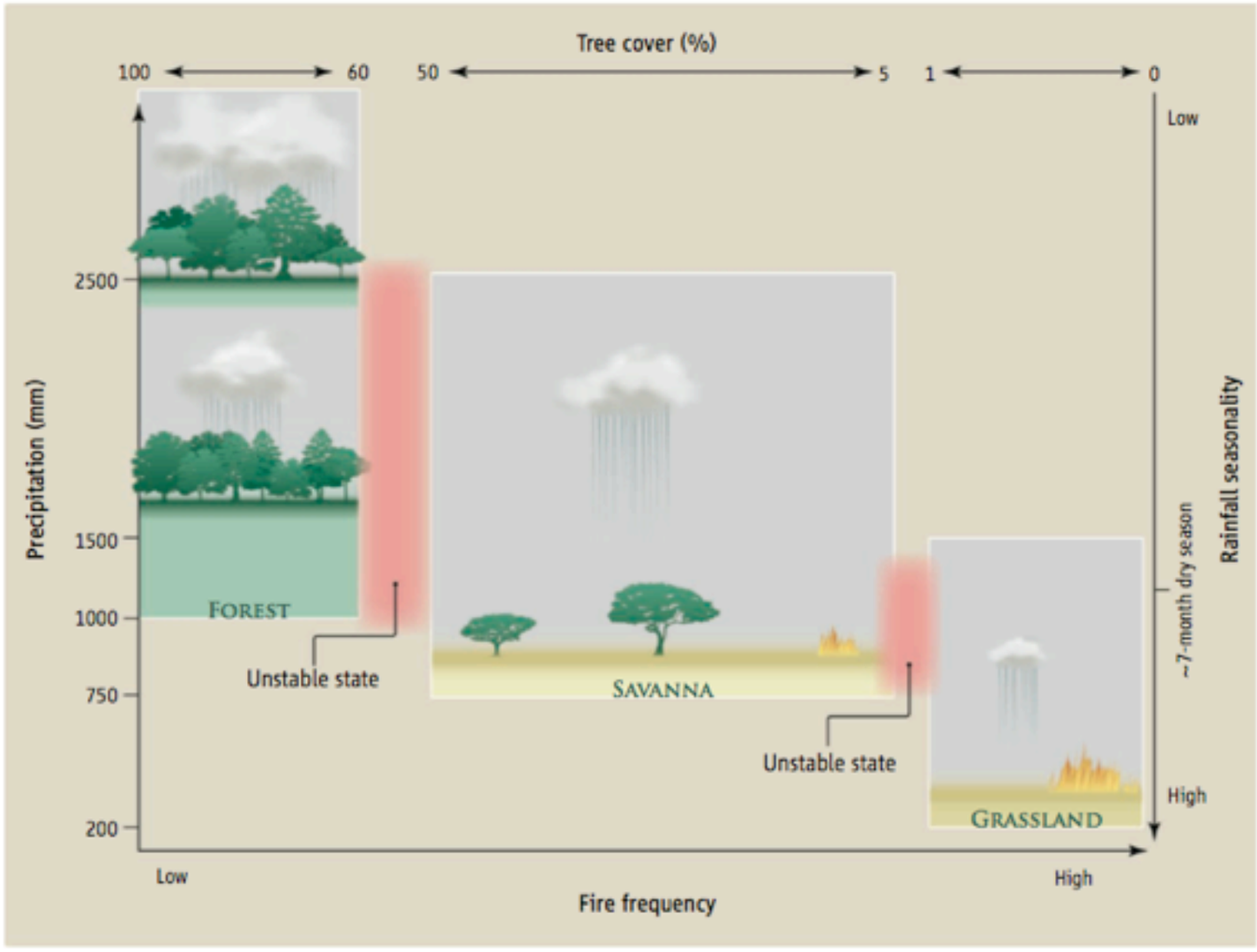
Fire regime interactions



Feedbacks in fire influenced biomes

Science (2011) **334** p188

- Biological successions in fire influenced environments appear to be **locked in self-reinforcing feedbacks** and that transitions form one type to another is the result of non-linear stochastic events
- This being the case means that as the climate changes such biomes **may change in unpredicted ways**



Conservation of species *ex situ*

- **GSPC target 8** - to conserve 75% of known threatened species *ex situ* collections
- The lead organisations for this target already held a number of threatened species. There is a botanic garden in almost every country in the world and a new gardens are still opening. (Pennisi 2010)
- This target has been reached for the UK as result of the Millennium Seed Bank Project, part of the Royal Botanic Gardens Kew. By 31st December 1999 every British native species, except one, has been brought into the MSBP.

October 2000 ISSUE 18 ISSN 0967-8018

KEW Scientist

ROYAL BOTANIC GARDENS KEW

News from The Living Collections, The Herbarium and The Laboratories at Kew & Wakehurst Place

SEED BANK FOR THE MILLENNIUM

The Wellcome Trust Millennium Building that will hold seed from 24,000 wild plant species in its vaults.

HOME to the Millennium Seed Bank project and the Seed Conservation Department, the Wellcome Trust Millennium Building at Wakehurst Place opened its doors to the public on Saturday 26 August 2000.

Designed by architects Stanton Williams and built by the construction company Longley, the building occupies a ground area of 5,500 square metres on land owned by Kew adjacent to Wakehurst Place. Being sited in an area of outstanding natural beauty, the Wellcome Trust Millennium Building was designed to harmonise with neighbouring agricultural buildings and the sixteenth century mansion house. The stainless steel barrel-vaulted roofs have already dulled to a colour that matches the lead work on the mansion but without any adverse effects on ground water quality.

The functionality of this prestigious building, however, is more important than its visual character. By the year 2010 the large underground vaults, designed for a 500-year life span, will store seed from about 24,000 wild plant species, mostly from dryland areas. These seed collections will be secured by legally binding agreements between Kew and its international partners.

This global resource will allow staff and research visitors to widen scientific understanding of comparative seed biology. This knowledge, shared with Kew's partner institutions through publications and training, will raise capacity for effective and sustainable conservation, particularly in regions where human livelihoods are most dependent on wild plant species.

The exhibition in the Orange Room providing information on seed conservation to visitors.

For a project supported directly by public funds from the National Lottery, it is appropriate that there is a major public exhibition at the centre of the building. In the Orange Room (named in recognition of the Premier Sponsor of the Appeal, Orange plc) visitors can learn about Kew's seed conservation work through a variety of exhibits and computer-aided interactive displays, as well as watch scientists working in the adjacent laboratories. In the first month after opening, over 15,000 people visited this new facility.

Contact: Roger Smith (01444 894612)

helping to create a brighter future . . .

1

Conservation of species *ex situ*

- Botanic Gardens Conservation International (BGCI) was first established in 1987 as the Botanic Gardens Conservation Secretariat.
- In 20 years, BGCI has grown to become a leading international organisation working to save the world's imperilled flora.
- The **BGCI web site** contains a vast amount of information about *ex situ* conservation programmes around the World.
- www.bgci.org/global/

Conservation of species *ex situ*

- **Advantages**

1) Conserving species one at a time is conservation on **a human scale**
2) Monitoring is easier
3) Plants are protected from stochastic events & climate changes
4) the threatened plants are separated from their threats

- **Disadvantages**

1) Other aspects of the plant's habitat are not conserved
2) Genetic diversity can be low due to space restriction
3) Hybrids can arise when otherwise isolated species are grown together
4) Selection of plants better suited to living *ex situ* thereby compromising re-introduction programmes

Volume 2 • Number 2 • April 2005

Cuttings

Botanic Gardens Conservation International Quarterly Newsletter

9,000 plants safe from extinction

Botanic gardens provide safe haven for over a quarter of known threatened plants

A recent study by BGCI indicates that approximately 9,000 plants which are threatened in the wild, are in fact in cultivation in botanic gardens around the world. This number makes up about one quarter of the plants presently known to be at risk, but is only a small percentage of the possible total. Although the 1997 IUCN list of endangered plant species listed 34,000 plant species as endangered worldwide, scientists estimate that anything up to 100,000 plants may be under serious threat of extinction due to mass habitat destruction and global climate change. BGCI's survey involved the development of a new tool, the Plant Search Database. It allows botanic gardens to check for the first time what they hold in their collections against an international list of plants, recorded alongside their status in the Red Book of Threatened Species maintained by IUCN-The World Conservation Union.

With over 200 million visitors a year and approximately 6.1 million living plant collections, botanic gardens are uniquely placed to act as sanctuaries for plants, as well as educating people about the devastating impact humankind has on many species. The work of botanic gardens in plant conservation is of vital importance at this time when, for tens of thousands of plants, it is 'one minute to midnight'.

Notes:
BGCI's plant search database is accessible to all through BGCI's website (www.bgci.org). The database includes plant records provided by over 500 botanic gardens worldwide. BGCI is keen to receive further plant records from any garden which has not yet contributed data.

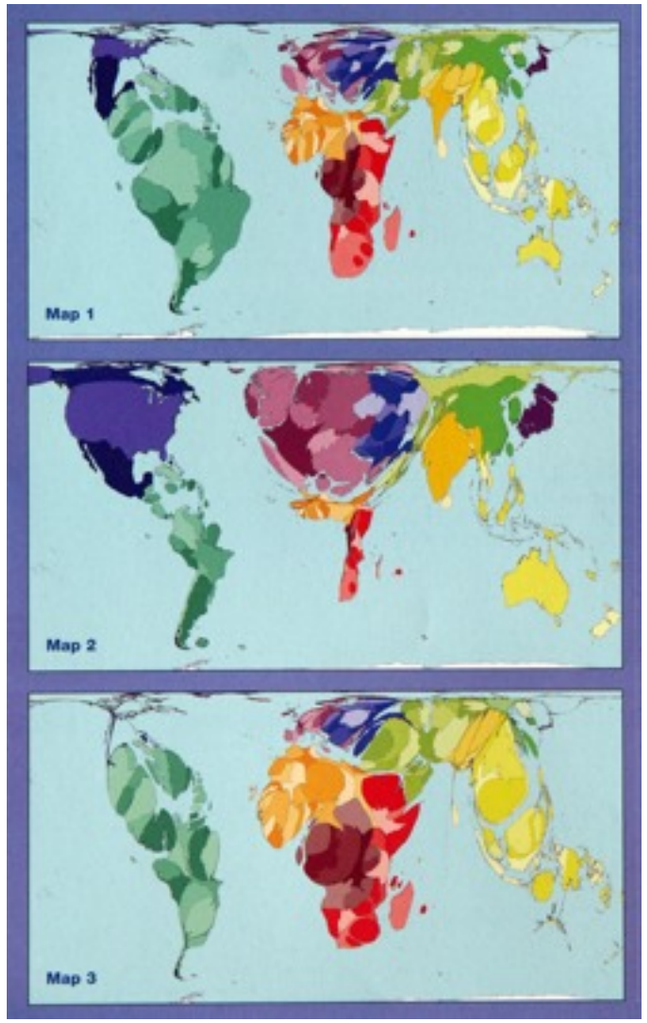
For further information, please contact info@bgci.org.

In this issue: Changing role for Peter Wyse Jackson • Addressing the big issues Studying the canopy • Healthy eating in New Zealand • New projects in Argentina

BGCI
Plants for the Planet

2005 - 9,000 threatened species in botanic garden. By **2007** this had risen to 12,000 threatened species.

By **2009** there were 15,000 threatened species living in Botanic Garden & Arboretum Collections world wide.



New botanic garden unveiled in South Africa

Conserving the 'bulb capital of the world'

In this region, which includes large natural patches of Renosterveld fynbos and succulent Karoo vegetation, are threatened with extinction.

Speaking at the unveiling, Environmental Affairs Minister Marthinus van Schalkwyk said the South African National Biodiversity Institute (SANBI) would use the garden "to promote nature-based tourism, the conservation of the area's unique biodiversity, environmental education opportunities and long-term ecological research in this botanical hotspot of global significance."

The Neuwoudtville National Botanical Garden will open to the public from January 2008.

Further information:
www.sanbi.org

Sprawling across over 6,000 hectares of one of the world's most floristically diverse regions, the Neuwoudtville National Botanical Garden has recently been unveiled in South Africa's Northern Cape.

Forming the country's 9th national botanic garden, Neuwoudtville is designed to serve as a centre for biodiversity research in the world-renowned Bokkeveld Plateau. Often dubbed the 'bulb capital of the world', an astounding 40% of the plateau's flora is made up of bulbous plants, producing spectacular displays of wild flowers each autumn and spring.

Some 1,350 plant species have so far been recorded on the plateau, including some 80 range-restricted or endemic species, which make up 6% of the flora. Sadly almost a third of the plants

Map 1- the World distorted in line with the distribution of plant species per country
Map 2 - the World distorted in line with the distribution of botanic gardens per country
Map 3 - the World distorted showing the relationship between gardens & native species
Japan has a flora of 4,500 species, 33% of which grow nowhere else

Ex situ conservation in China

- In 2002 the Chinese Academy of Sciences established a comprehensively planned & geographically structured *ex situ* conservation programme
- This covered **31,000 species** native to China (c.8% of the World Flora)
- A 15-year master plan exists to conserve all of the 2,000 threatened species

Ex situ conservation in China

- By 2005 50% of the threatened species of China were being conserved in the three major Gardens in the Scheme; Xishuangbana BG *(left)*, South China BG Guangzhou & Wuhan BG

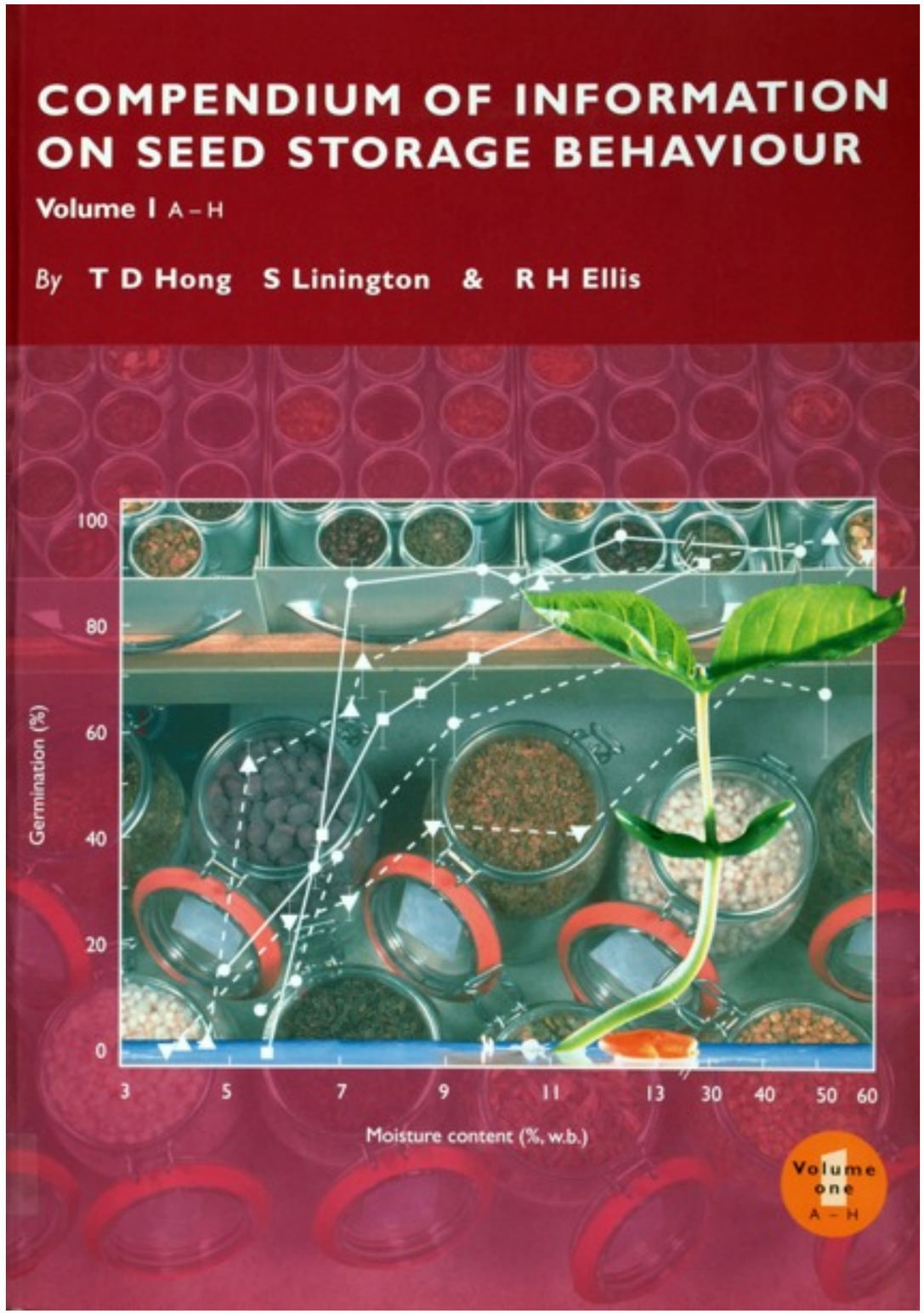
- **Model programmes** have been drawn up for 2,000 species *(including Sinojackia xylocarpa right)*. The programme covers the genetic integrity of collections, genetic diversity, inbreeding depression, hybridisation, and genetic adaptation to cultivation

Artificial Seed Banks

Panacea for all ills or frozen evolution?

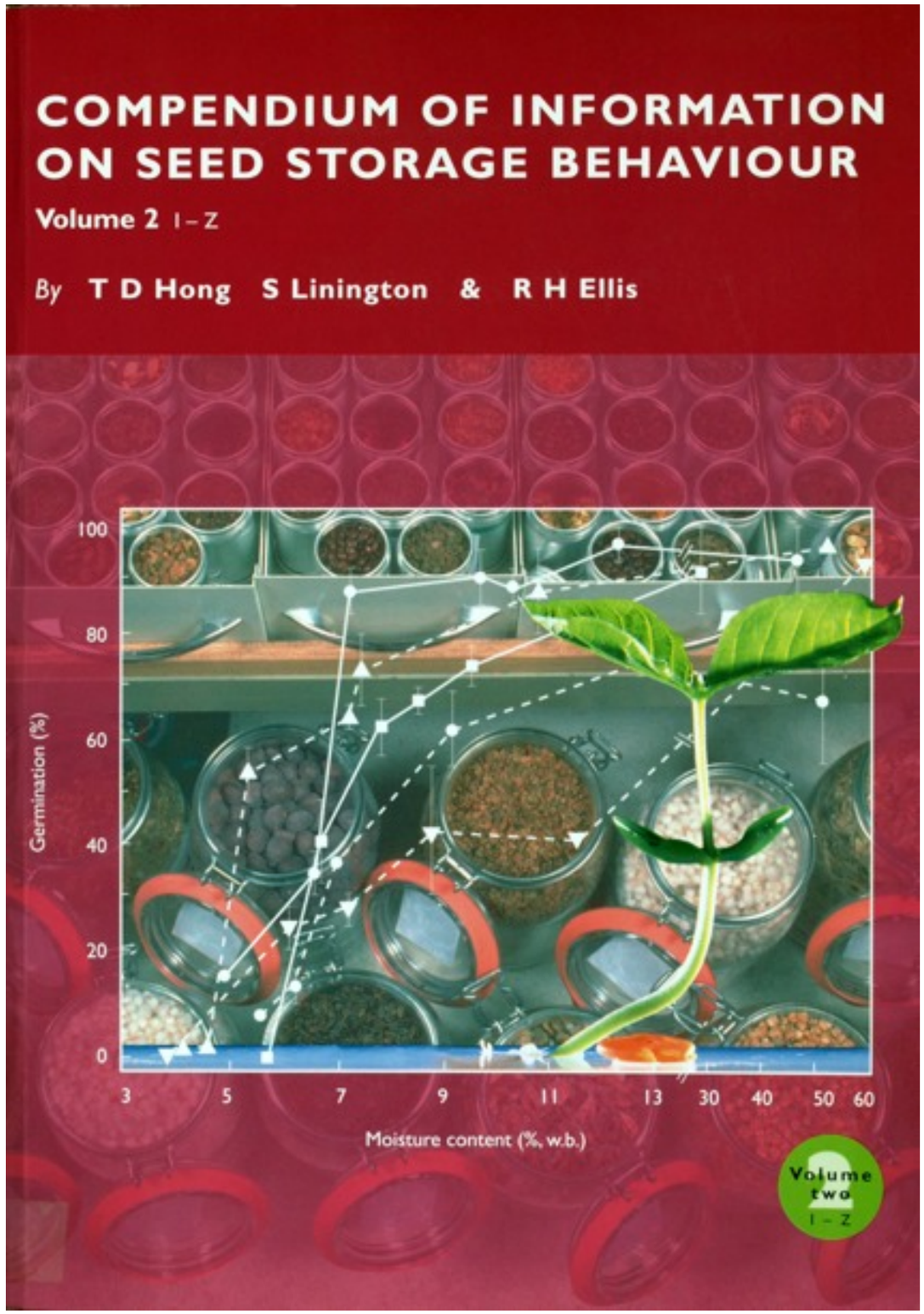
Advantages of seed-banks

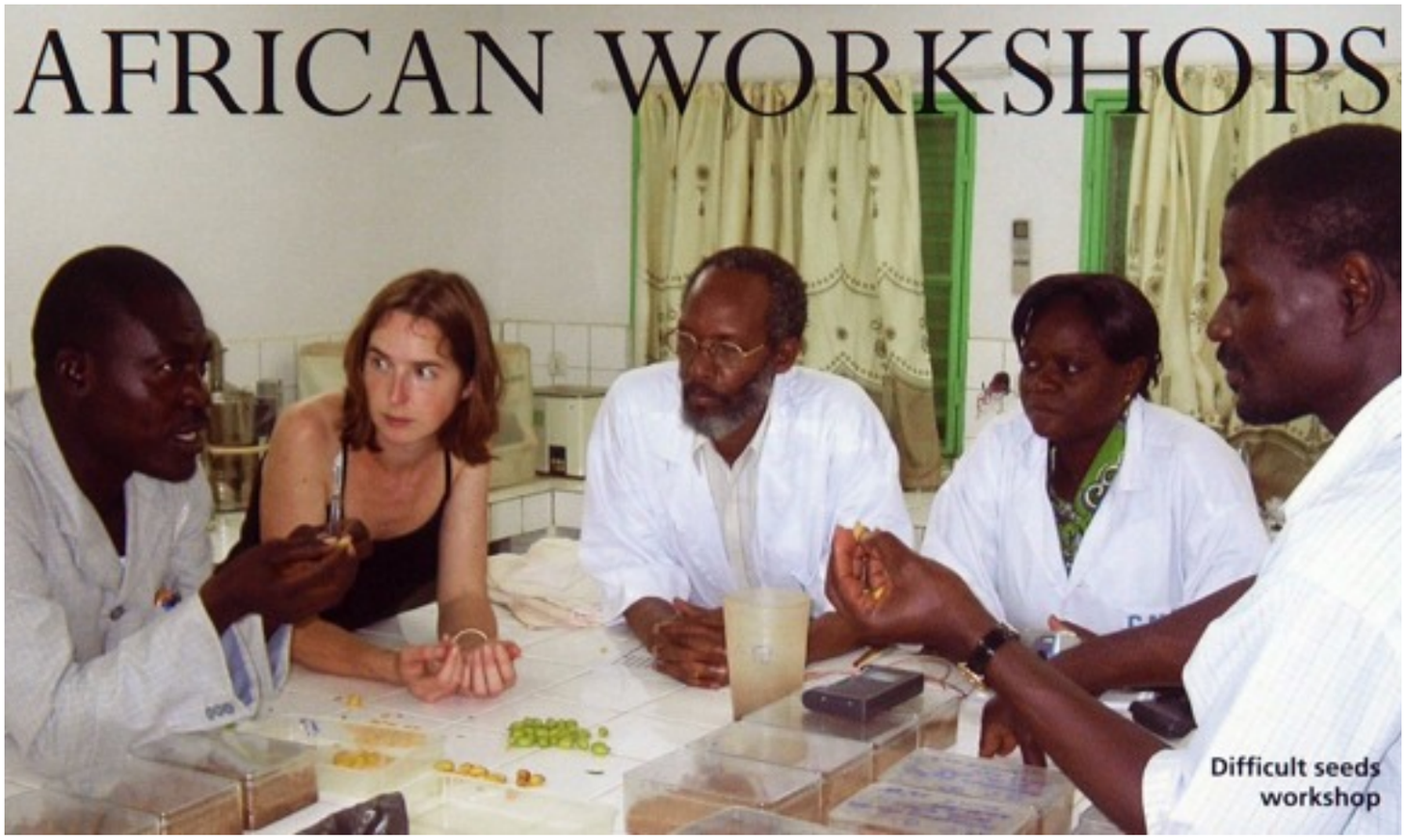
- Large gene bank
- Simple daily maintenance
- Protected from stochastic environmental threats
- Space efficient
- **Centres of expertise & research**
- Opportunities for twinning & support
- Focus for raising awareness
- Donor-friendly



Disadvantages of seed-banks

- On-going, expensive technical maintenance
- Other biotic factors are absent
- Genetic drift and selection possible
- Not all species are suitable
- **Ambiguous educational message**
- Not an end in itself





The Millennium Seed Bank Project (MSBP) has received strong political support. It has also been the **catalyst** for joint international projects involving training, capacity building, benefit sharing, and plant collection.

MSBP & international collaboration

- **Slovakia** - Flora of 4,713 spp of which 747 are threatened. 488 spp endemic to Slovakia. 198 spp collected & stored **at MSBP & in the Slovak Seed Bank**
- **Jordan** - following 2 very dry years (2008 & 2009) collections were made of plants capable of surviving and flowering in very dry conditions
- **Burkina Faso** - **1,000 spp** (50% of the Flora) collected by 2010 with duplicate collection in CNSF in Burkina Faso. **Community-based projects** are in place that use the collections for ecosystem restoration and seeds are being used to develop new farming methods.
- **Malawi** - Over 1,000 spp. collected (>25% of the flora.) Narrow-range **endemic species** are common and difficult to identify.
- **South Africa** - Pressures from human encroachment and uncontrollable fires make seed banking very important. *Erica greyi* was **rediscovered** after last being seen in 1897 but the last large population has been wiped out by a fire

MSBP & international collaboration

- **Kunming, China** - *Primula mallophylla*, last seen in the wold in 1816 found in the Dabasham Mountains in northern Chongqing.
- It is **endemic** to this region growing above 2,100m in wet meadows and damp woodland. It was classified as extinct but is now “just” endangered
- Seeds are now in the MSBP

MSBP & international collaboration

- **Madagascar** - Kew's only overseas office is the Kew Madagascar Conservation Centre (KMSC) because it is a top biodiversity hotspot with 12,000 plant species at 90% endemism
- 1/3 humid forests cleared since 1970s & highest **soil erosion** in the World at 20,000 - 40,000 tonnes per km^2 *per annum*
- 57,000 km^2 Systeme d'Aires Protégées de Madagascar formed as a result of the "**Durban Vision**" of former President Ravalomanana to which Kremen et al. contributed.
- Kew is working in the **265 km^2 protected area** in Itremo Massif
- Local by-laws have established buffer zones in which the local community can collect food, fuel-wood & wild silk. **There is now a sustainable cottage industry producing silk fabric.**

MSBP & international collaboration

- **Madagascar** - a second project involves the conservation of *Angraecum longicalcar* which is reduced to 10 plants in its habitat due to fire, mining & collection.
- Following hand pollination seeds have been collected & now 800 plants are growing in the National Botanic Garden
- **50 local children** are involved in the cultivation and planting out of these orchids behind fire breaks
- In exchange for the work the school has been provided with equipment and books
- Kew aims to collect seed of 75% of the 1,000 orchids native to Madagascar to store at -196ºC in the MSBP

MSBP & international collaboration

- **Madagascar** - a third project involves the creation of the **Silo National des Graines Forestieres** which will contain 25% of the native species by 2020
- The collection will concentrate on 5 groups of plants
- **endemic** species
- trees for use in **restoration** projects
- **culturally** important species such baobabs (*right*)
- **economically** important plants such as yams
- **endangered** species that exist outside the protected areas

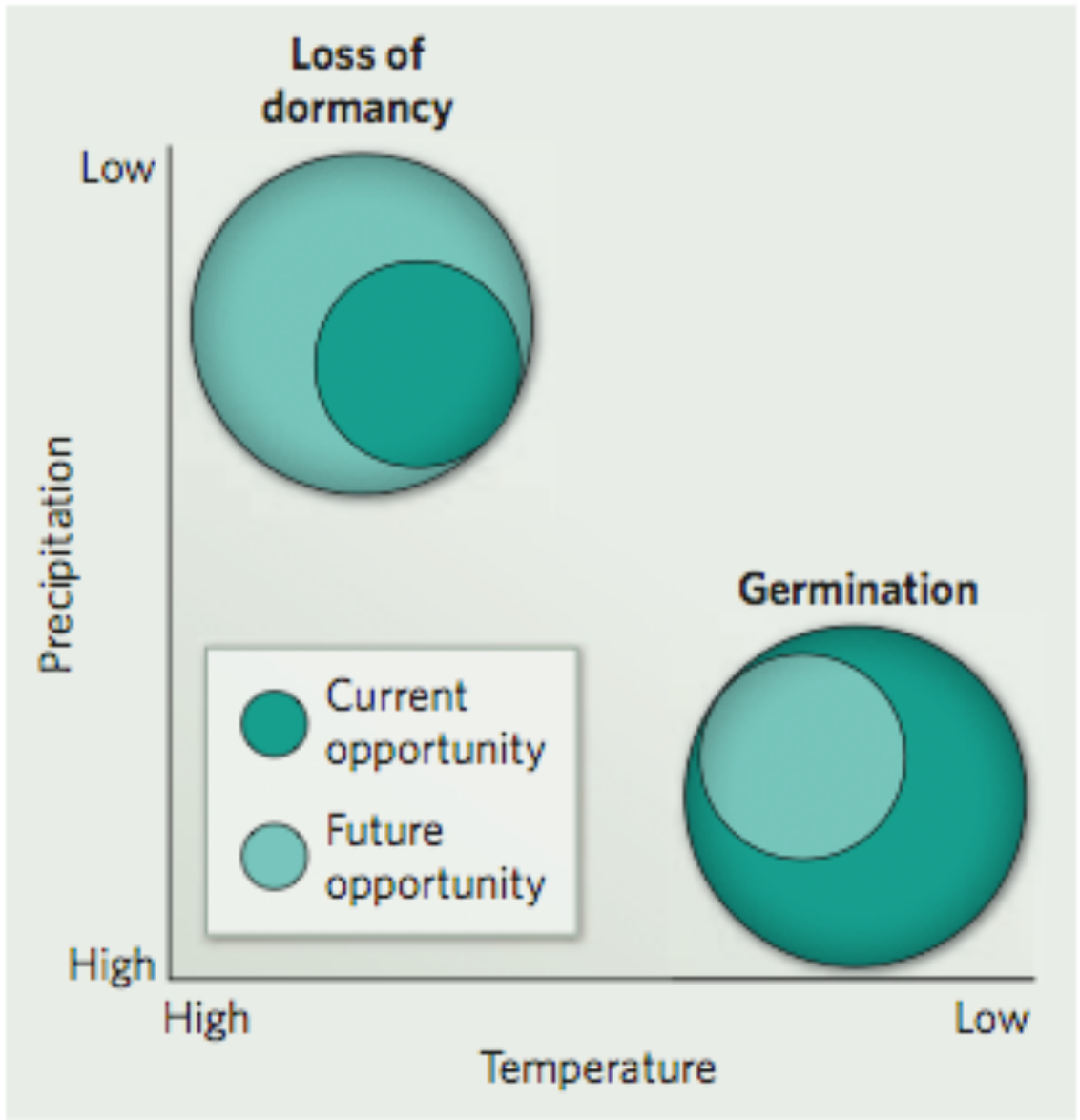


Figure 1 | Changes in climate could affect the success of stored seeds. For seeds that need warm, dry conditions for dormancy to end, and cool, moist conditions to germinate — such as Western Australia's kangaroo paw — future warming and drying may enhance dormancy loss, but offer a smaller window for germination.

Walck & Dixon 2009

"To be sure that seeds are relevant in a climate-changed World ... we must harvest **as much genetic diversity as possible** ... and collect not 100g of seed but up to 100kg of seeds ... to capture sufficient genetic diversity to rebuild the world's ecosystems"

A cautionary tale from New Zealand

Nature 17th November 2011

- *Powelliphanta augusta*, carnivorous snail from mountain ridge on South Island first discovered in 1996 during a survey prior to coal mining started.

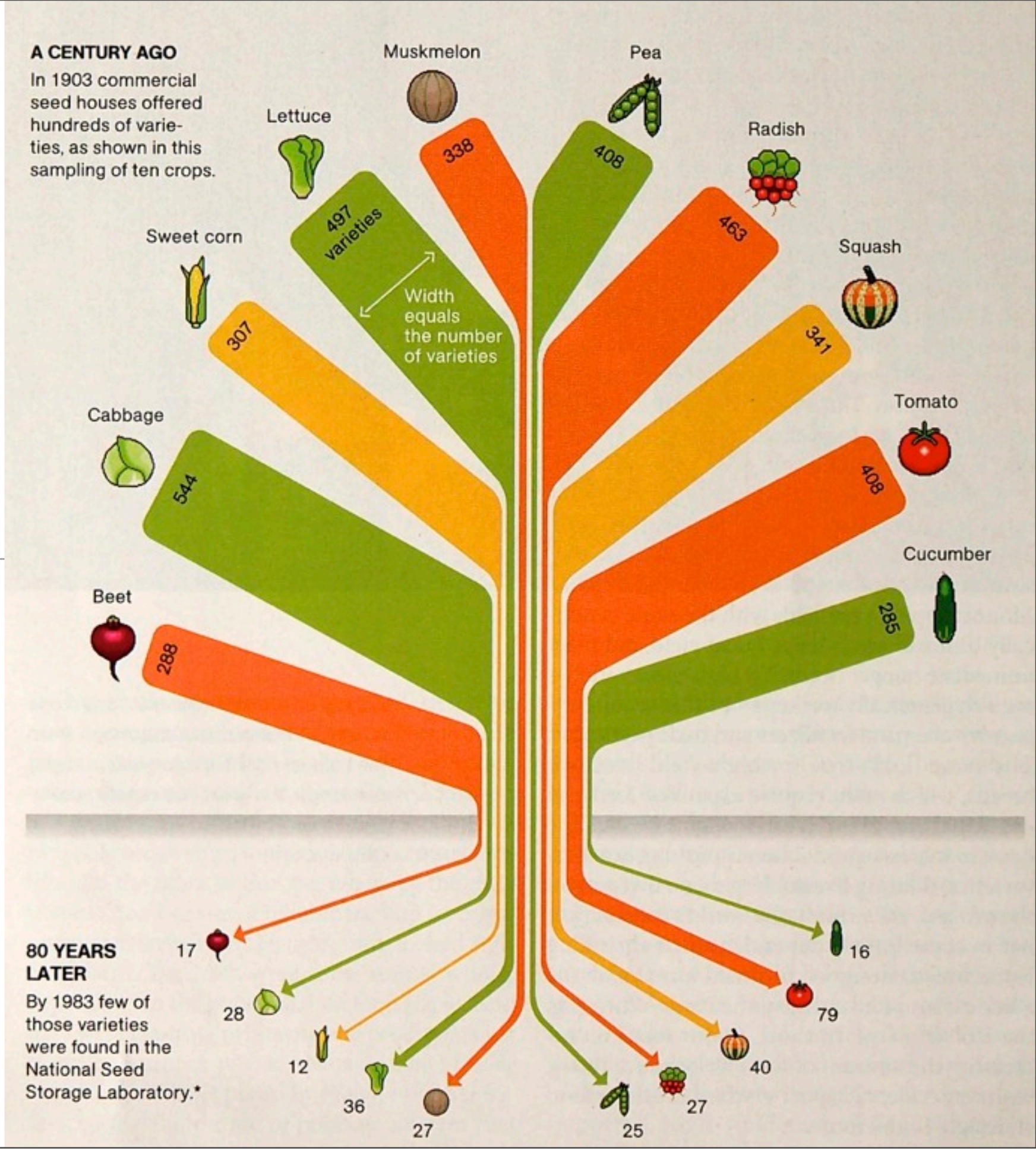
- 4,000 individuals moved and 1,600 placed in chiller unit at 10ºC. The unit failed over a public holiday & 800 snails died.

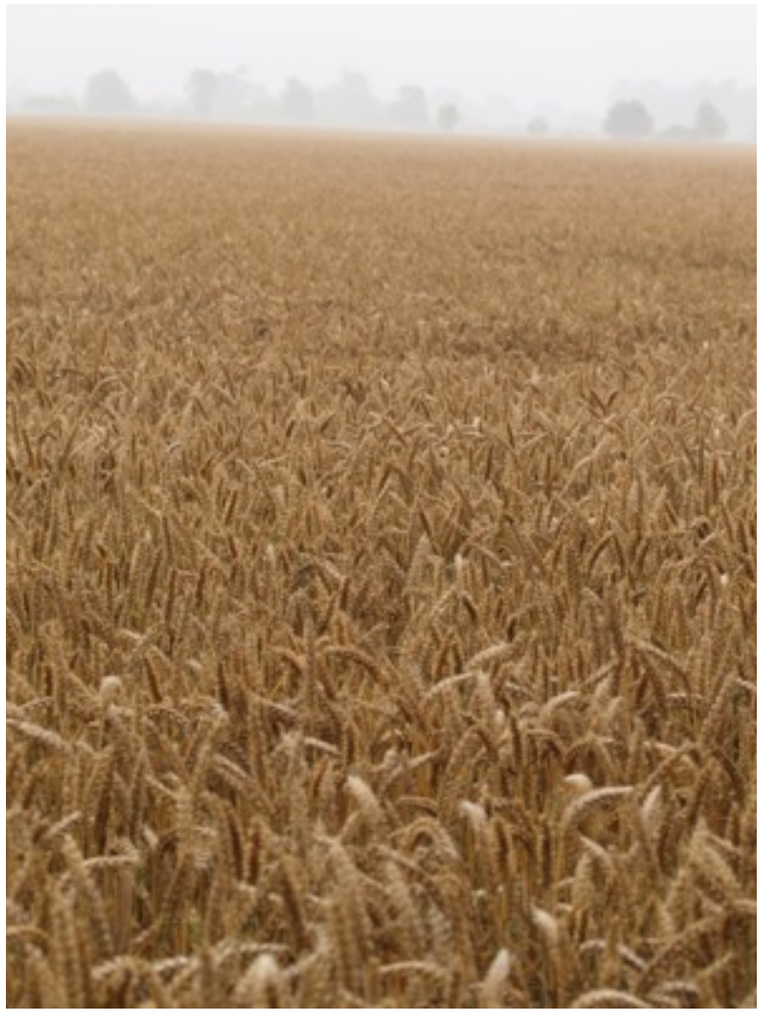
Crop species & varieties

- **GSPC target 9** - to conserve 70% of the genetic diversity of crops at their wold relatives and other socio- economically valuable plants.
- Artificial seed banks began with annual food crops such as at Rothamsted in Hertfordshire *(right)*

Diminishing gene-pools

Most of the 1903 varieties of crops in the US have been **lost** along with their genotypes
(Source National Geographic)





The International Rice Research Institute (IRRI) in the Philippines & the International Maize & Wheat Improvement Centre (CIMMYT) in Mexico hold large collections of varieties.

Home gardens in Cuba contain more genetic diversity of lima beans than the FAO seed bank

Crop species & varieties

- The UK holds the **base collections** of onions, brassicas, carrots, & lettuce with >13,800 accessions in long term storage at -20ºC
- Each batch of seeds are dried at 15% RH and 15ºC to 5% moisture content
- **Harrington's rules of thumb**: each 1% reduction in seed moisture content doubles the lifespan; each 5ºC reduction in storage temperature doubles the lifespan. FAO recommends seed moisture content 3-7% depending on taxa and storage at -18ºC or below
- **Labelling** and record keeping is critically important (Nature on-line 11 March 2011)
- Vegetative crops such as bananas have to be stored as propagules. Bioversity International in Rome found that mutations occurred during storage.

Crop species & varieties

- The International Treaty on Plant Genetic Resources for Food & Agriculture is central to MDG 1 & 7 (Nature on-line 18th March 2011)
- Gene banks are expensive to maintain and in many countries, including Russia (Parfitt 2010) and Australia (Finkel 2010) they are under threat & in UK.

The International Treaty
ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

International Treaty on Plant Genetic Resources for Food and Agriculture

Crop species & varieties
A **conflict** of agreements?

- **Convention on Biological Diversity (1992)**
  Article 15.1 – recognizes the sovereign rights of States over their natural resources, the authority to determine access to genetic resources rests with national governments and is subject to national legislation.
- Article 15.2 – Contracting Parties shall endeavour to facilitate access to genetic resources for environmentally sound uses.
- Nature online 18 March 2011

- **International Treaty on PGRFA (2004)**
  The Contracting Parties to the Treaty, in the exercise of their sovereign rights over their Plant Genetic Resources for Food & Agriculture (PGRFA), have established a Multilateral System both to facilitate access to PGRFA and to share, in a fair and equitable way, the benefits arising from the utilization of these resources, on a complementary & mutually reinforcing basis in harmony with the CBD.

New gene-pools

Not only current food crop seeds need to be saved but also seeds from fibre plants, control wind erosion, and shade livestock.
(Source National Geographic)

Non-native, invasive species

GISP
The Global Invasive Species Programme

- **GSPC target 10** - to prevent new biological invasions & to manage important areas for plant diversity that are invaded.
- Natural climate changes and land movements have been the drivers for plant and animal migrations in the past
- The migration of *Homo sapiens* has **broken down natural barriers** to the distribution of some species during the past 50,000 years
- Anthropogenic climate change in the future will force migrations and will lead to **new species distributions and novel communities**. www.gisp.org/

Non-native, invasive species

GISP
The Global Invasive Species Programme

- There is currently some discussion about the true extent of the damage caused by invasive species. By definition, ***invasive species are those that cause a change in a community that can endanger other species***. [see Nature **475** p36 (7 July 2011) and Nature **467** p369 (23 September 2010)]
- The GISP website contains a great deal of information

Non-native, invasive species

GISP
The Global Invasive Species Programme

- A **native** species is one that was present before humans arrived.
- An **archaeophyte** is an honorary native; in the UK these are plants that arrived before 1500.
- A **neophyte** is a plant that has arrived since 1500 due to the activity of humans.
- A non-native, **invasive** plant species is a non-native species that spreads naturally in natural and semi-natural habitats and that produces a significant change in the composition, structure, & ecosystem processes.
- **Native species can invade** a new area in their current distribution and they can be very aggressive such as bracken, brambles & ivy in the UK

Non-native invasive species

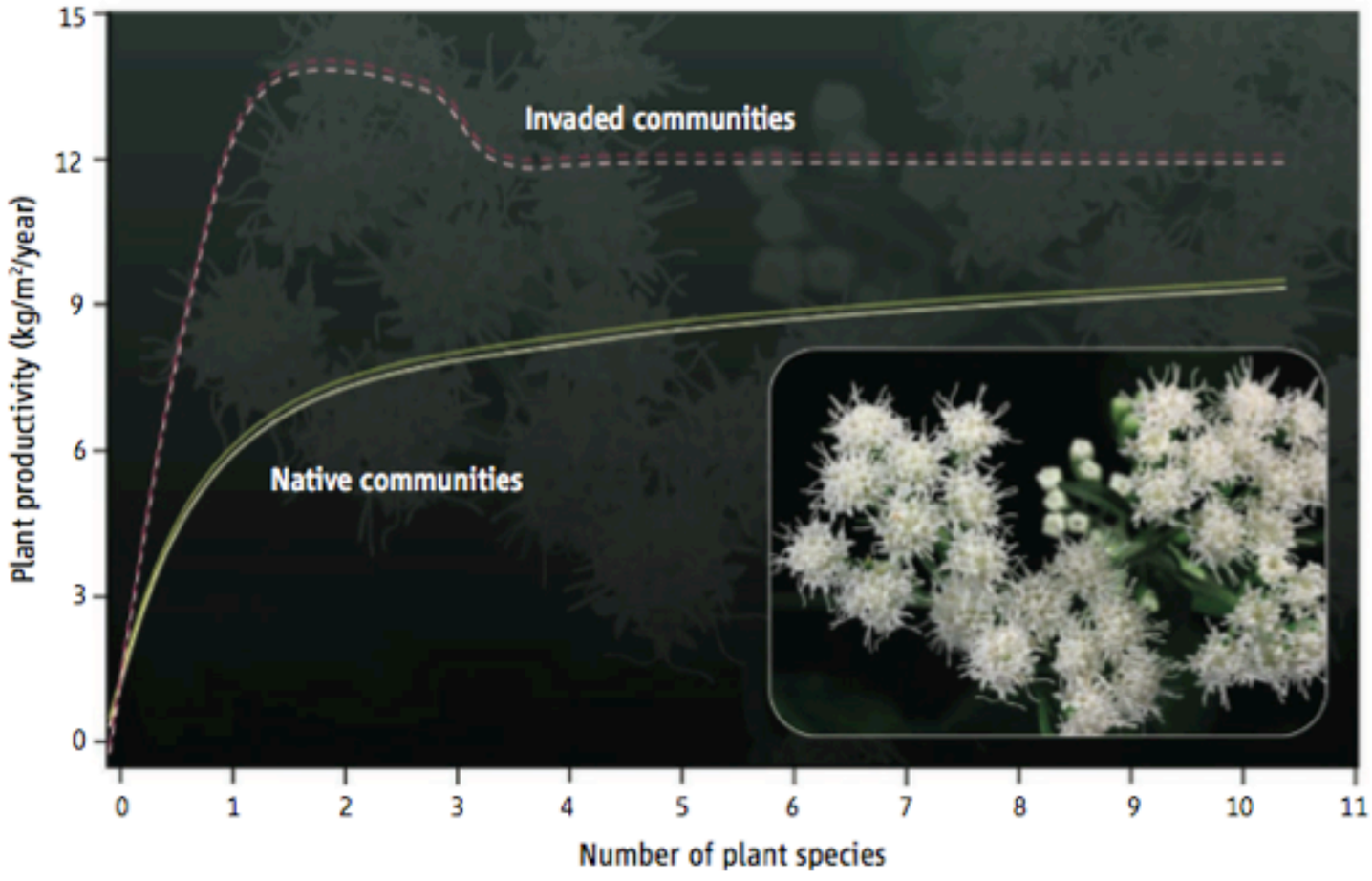
GISP
The Global Invasive Species Programme

- **Ecosystem services** are affected by non-native invasive species
  1. **provisioning**: food, water fibres & fuel
  2. **regulating**: climate, erosion & disease regulation
  3. **cultural**: spiritual, aesthetic, recreation & education
  4. **supporting**: primary production & soil formation

Non-native invasive species

GISP
The Global Invasive Species Programme

- The changes that are induced by biological invasions include **loss** of species, **changes** in fire regimes, **changes** in soil chemistry, and an **increase** in productivity (Rout & Callaway 2009)

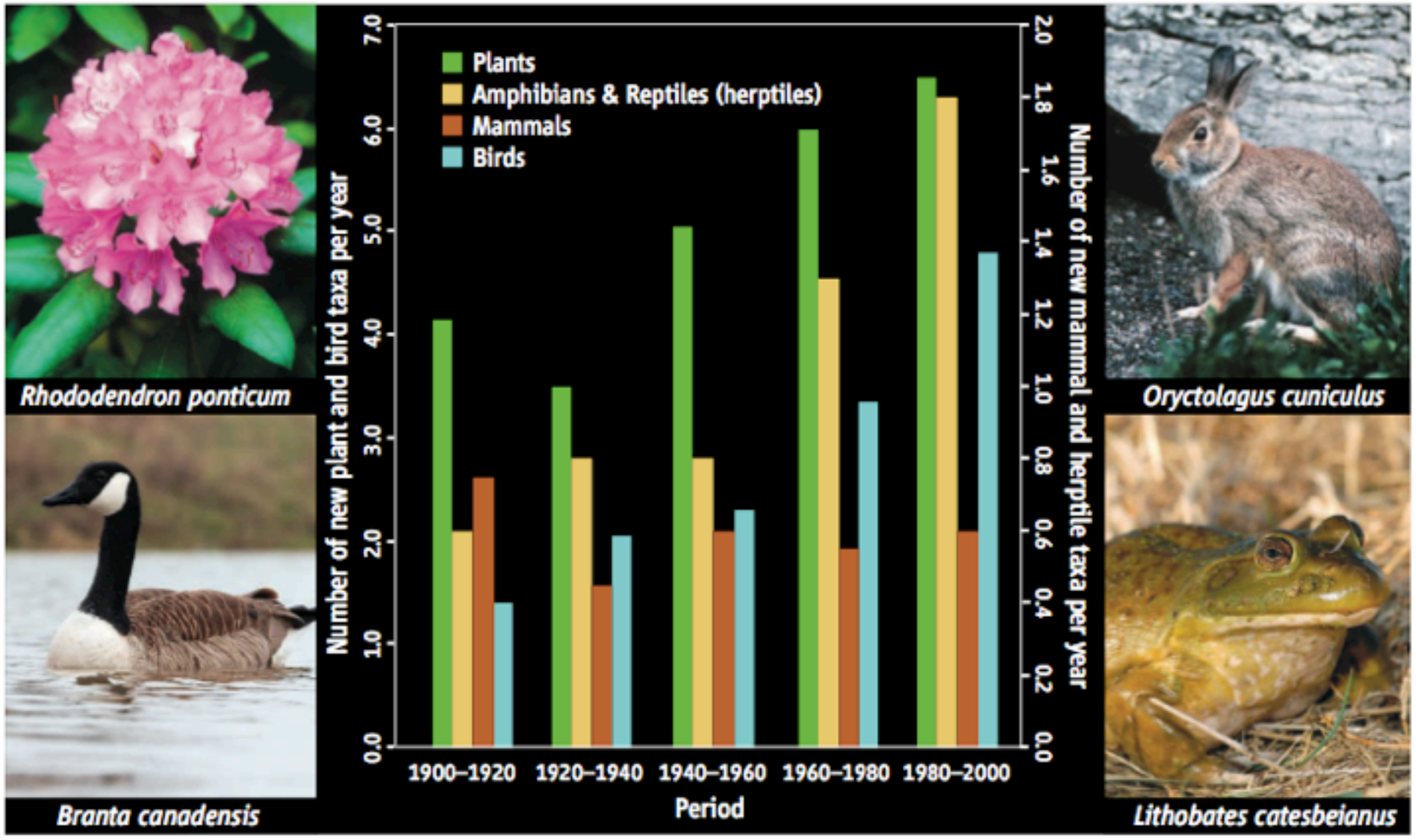


Diversity and productivity. Plant productivity increases to an asymptote as plant diversity increases [solid line; derived from (*2*) with permission from the Ecological Society of America]. Higher productivity correlates with losses in native species richness, and invasives dominate [dashed line; estimated from (*6*); see (*17*)]. The asymptote remains higher due to invader presence in the system at lower relative densities. (**Inset**) The photo shows *A. adenophora*.

Non-native invasive species

GISP
The Global Invasive Species Programme

- During the 20th century the number of **new species arriving** in Europe **increased** for all groups except mammals (Hulme et al. 2009). This data does not include infectious diseases of plants & animals



Alien taxa newly recorded as established in Europe per annum (*1*).

The stages of an invasion

GISP
The Global Invasive Species Programme

1. **Introduction** by human vector
2. **Naturalisation** outside cultivation
3. **Facilitation** such as disturbance
4. **Spread** with or without intentional human help
5. **Interaction** with other plants and animals
6. **Permanent**, often monospecific, populations

Rhododendron ponticum

Members of the Fabaceae that are invasive species; *Mimosa pigra*, *Acacia saligna* & *Lupinus constanentii*.

Predicting invasions

GISP
The Global Invasive Species Programme

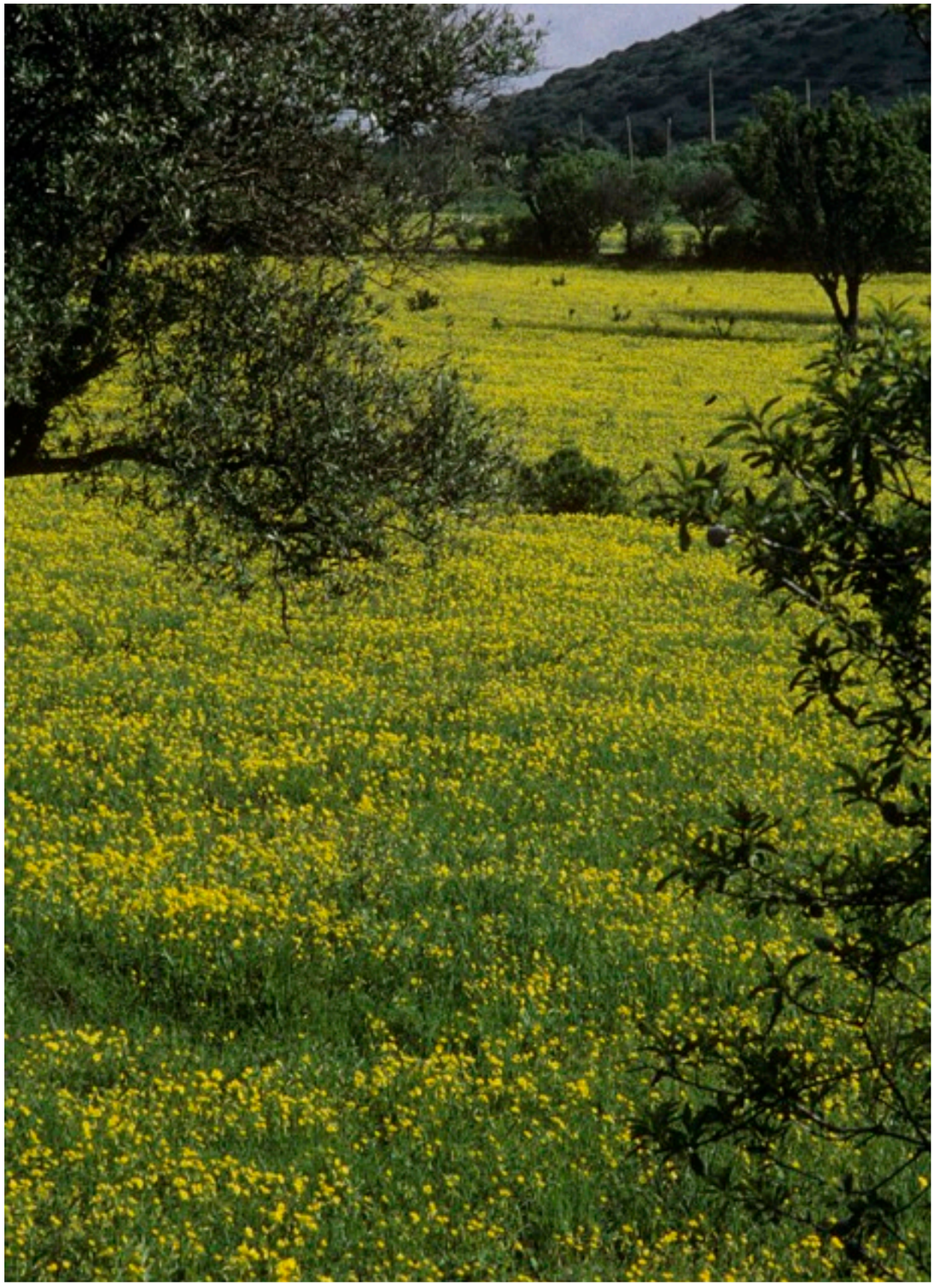
- *The degree of adaptation of species to the climates under which they grow is often over-rated. We may infer this from our frequent inability to predict whether or not an imported plant will endure our climate* (Darwin 1859)

- **Prediction is very difficult if not impossible**. *Clematis vitalba* (below) is benign in UK but invasive in NZ

Predicting invaders

GISP
The Global Invasive Species Programme

- Common characters of invasive plant species
- large annual seed production
- long-term seed viability in the soil seed bank
- self-compatible or generalist pollination syndrome
- vegetative propagation easy
- rapid growth
- long-distance seed dispersal
- smothering leaf canopy
- **very difficult to kill**



Oxalis pes-caprae from South Africa spreading in southern Portugal without producing one viable seed. Dispersal is by small bulbs on the feet of farm animals

Nothoscordum - the next invasive species?

Controlling invasions

GISP
The Global Invasive Species Programme

- If invasions could be controlled then they would not be a problem

- Control strategies include physical control, chemical, and biological.

Invasion potential is still not considered when species are introduced into cultivation despite 19 of 34 serious weeds in UK were originally from 18th & 19th century botanic gardens

Euphorbia esula from central Europe growing by the A414. In North Dakota there are 1,000,000 acres of land infected with this species and the State cattle herd has been reduced by 46,000 animals. This sighting has been reported to Defra and plants removed from the Botanic Garden in Oxford.

Carpobrotus edulis from South Africa in Cornwall. Early action is essential

The TENS rule

GISP
The Global Invasive Species Programme

ALIEN SPECIES IN BRITAIN & IRELAND – some numbers to ponder

The TENS RULE in British flowering plants[1]		
	Number of species	% of the total number of imported species
Total imported and in cultivation[2]	12,642	
Total found on uncultivated land at least once	1,642	13.1
Total established as self propagating populations	210	**1.6**
Species that have become pests	39	0.3
Species that have become severe pests	14	.1

Native & introduced plants of the British Isles[3]					
	1928 figures[4]	% of the total flora	1994 figure	% of the total flora	% of spp in B.I.
Species in cultivation			70,000[5]		100
Native species	1,700[6]	46	1,700	32	2.4
Species recorded on uncultivated land at least once	1,999	54	3586	68	5.1
Species established as self propagating populations	293	8	885	17	**1.3**
Number of hybrids between native & alien species			60	1	0.09

The numbers in the boxes show a good level of agreement. Put simply this means that there is more than a 1:100 chance of a plant that is brought into the UK escaping from cultivation into a non-cultivated habitat. Does this mean that there should be a total ban on the further import of non-native species?

[1] Adapted from Williamson M. (1997) Biological Invasions ISBN 0 412 59190 1
[2] probably an underestimate since RBG Kew alone grows in excess of 30,000 species
[3] Adapted from Clement E.J. & Foster M.C. (1994) Alien plants of the British Isles ISBN 0 901158 23 2
[4] Druce G.C. (1928) British Plant List Arbroath
[5] RHS Plant Finder (2000)
[6] Clapham A.R., Tutin T.G. & Warburg E.F. (1978) Excursion Flora of the British Isles ISBN 0 521 04656 4

UK problems

"Britain's benign climate"

Knotty problem Call to root out invaders

Rhododendron ponticum Spreads fast and can quickly colonise large swaths of land, where it chokes off other plants and leaves little room for native flora to flourish

Giant hogweed Hugs waterways and river valleys and can grow up to 5m, crowding out native plants and wildlife. Its sap can burn skin when exposed to sunlight

Hottentot fig Found in coastal areas, this plant may look glorious on cliffs but displaces native beauties such as sea pink, sea campion and buckshorn plantain

Japanese knotweed The worst of the bunch. Grows up through concrete, breaking apart walls and foundations and choking drains. Extremely hard to control

By Fiona Harvey, Environment Correspondent

Gardeners, beware. That herbaceous border could be harbouring a monster.

Invasive plants are

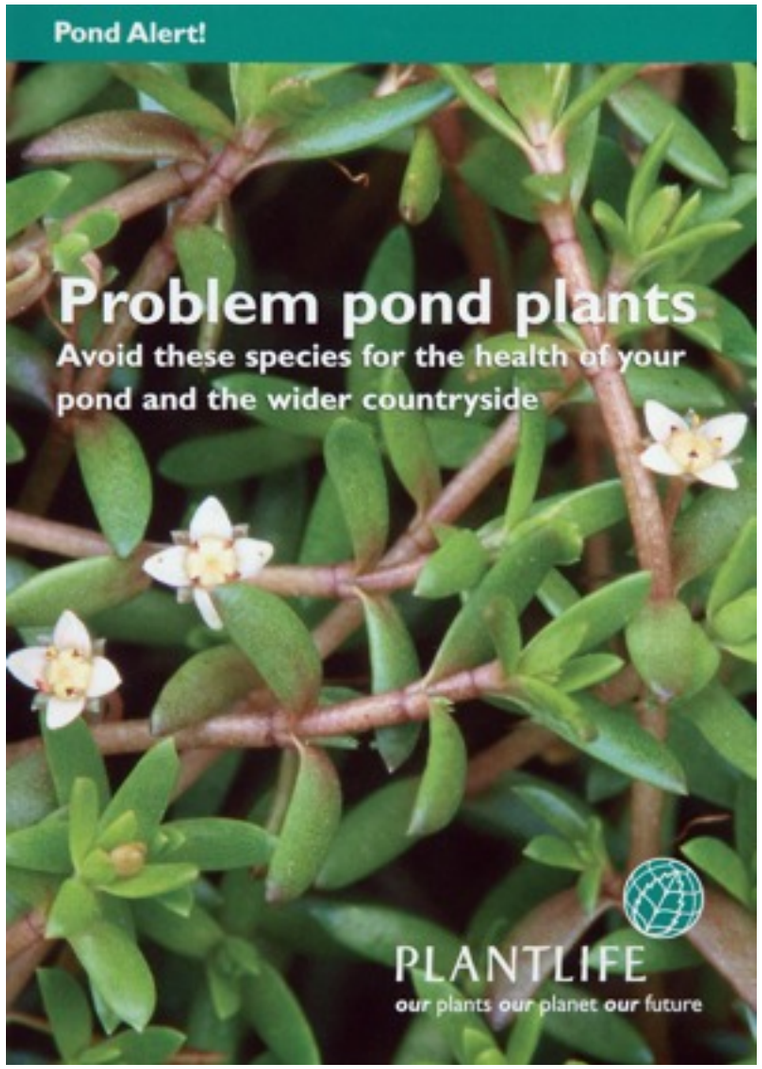
nothing there is a real possibility that a few non-native invasive plants will survive and we will lose the beauty and diversity of our landscape," warned Simon Ford, nature

bright foliage. But some of these plants, such as Japanese knotweed, giant hogweed and Spanish bluebells, grow faster and much more aggressively in the UK's benign climate

that doubles in size every two or three days, destroying waterways; and New Zealand pygmy weed, which has colonised ponds once home to great crested newts.

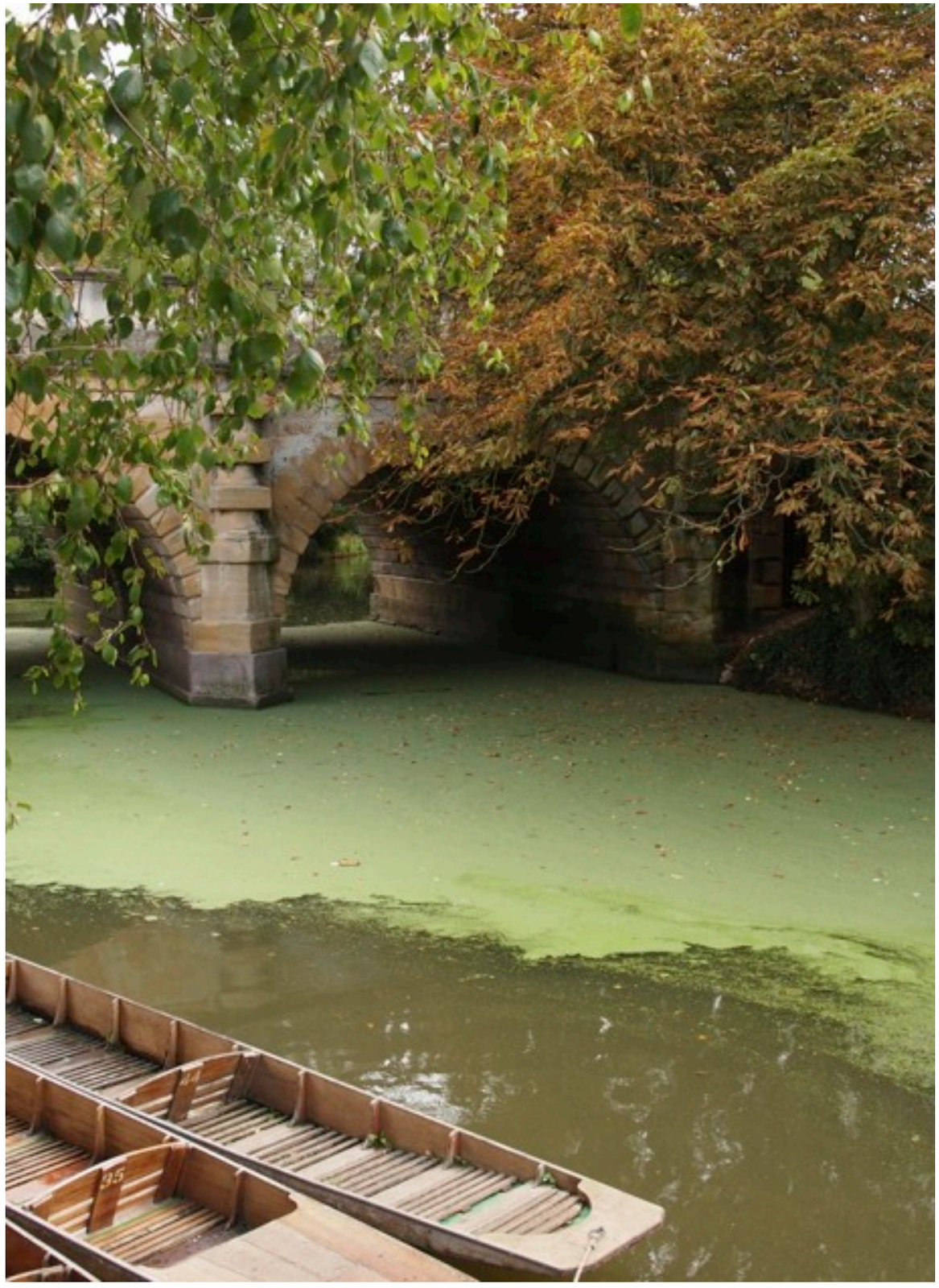
Plantlife


Pond Alert!
Alternative plants
Use native plants in your pond for the good of Scotland's wildlife
PLANTLIFE
our plants our planet our future


Pond Alert!
Problem pond plants
Avoid these species for the health of your pond and the wider countryside
PLANTLIFE
our plants our planet our future


Pond Alert!
Labelling
Make sure you know about the plants you are buying
PLANTLIFE
our plants our planet our future

British **natives** for the Garden



Azolla filiculoides & the weevil that eats it but not fast enough

Himalayan balsam, in Hampshire

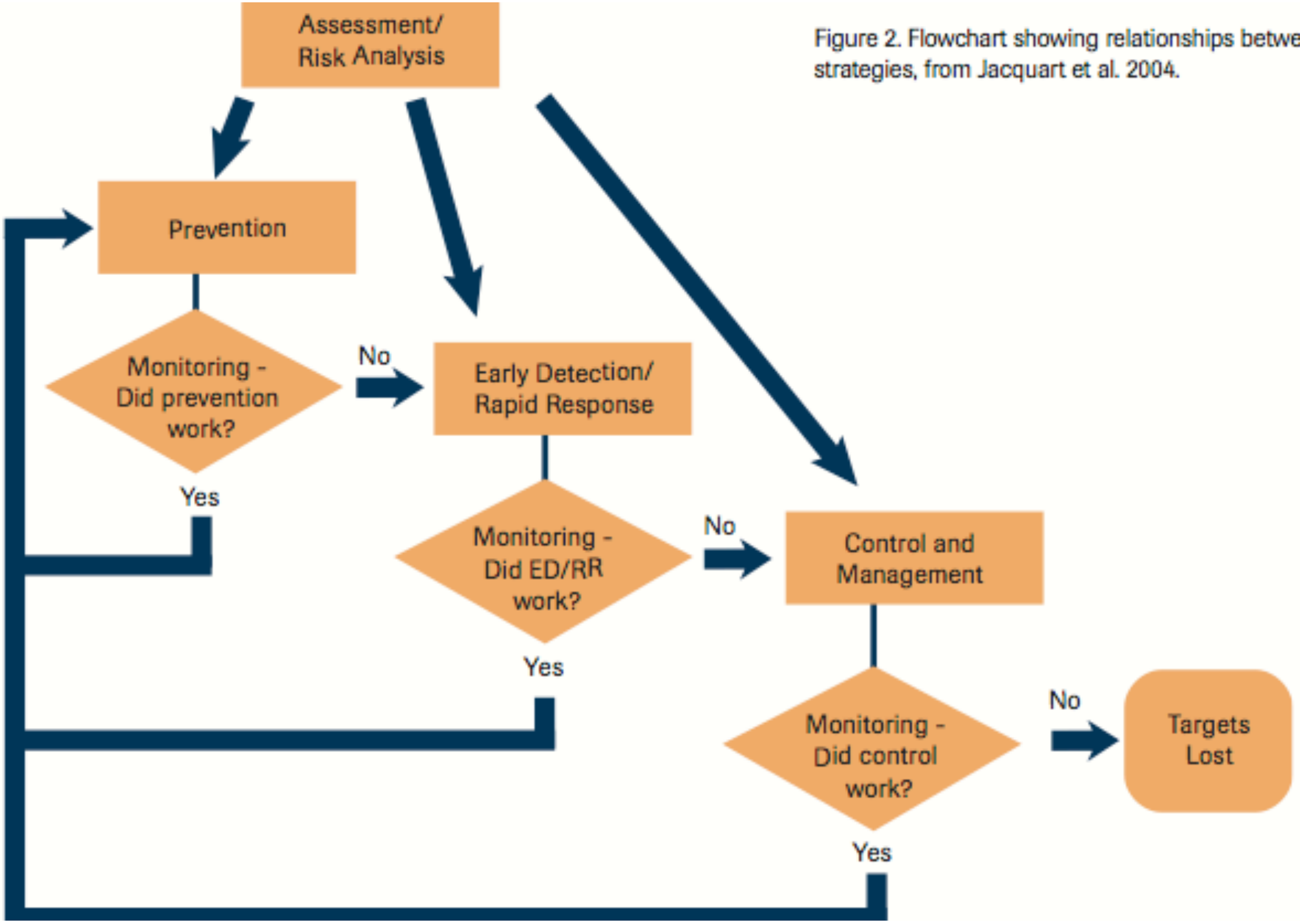


Figure 2. Flowchart showing relationships between strategies, from Jacquart et al. 2004.

taken from Tu (2009) - **PREVENTION** must be the best answer (Segura 2011)

The role of CITES

- **GSPC target 11** - to prevent **any** species of plant being endangered by international trade

- 1) **Increased custom cases** of dealing with trade of CITES listed material.
  (Timber plants, medicinal plants, plants used in cosmetics, pot pourri, horticultural trade, cultural uses.)

2) DNA bar-coding will help with identification

3) EU controls are in place to protect UK species from over-exploitation and/or control use of wild plant resources from other countries.

The result of CITES controls

- Trade in ornamental plants from the Philippines

1) 75% of exported native species are wild collected
2) Many of these plants are collected in protected areas
3) There is a voracious demand for orchids in particular
4) There are **insufficient nurseries** in the Philippines
5) An accreditation scheme has been introduced

Sustainable extraction

- **GSPC target 12** - to source sustainably, all wild harvested, plant-based products.
- Anyone who spends money can contribute to this target

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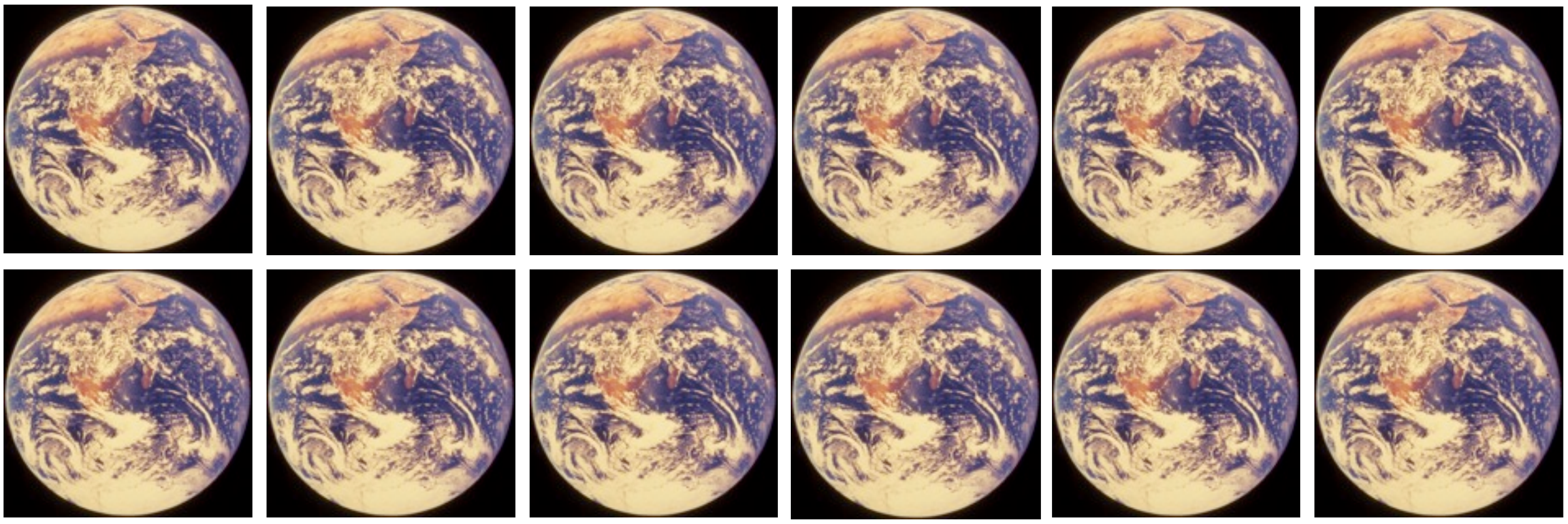
Sustainable extraction

- **GSPC target 12** - to source sustainably, all wild harvested, plant-based products.
- Anyone who spends money can contribute to this target
- If the whole world used the same resources as the **USA** we would need **twelve** worlds.



Eucommia ulmoides that has been harvested to extinction in the wild for use in Traditional Chinese Medicine. The same problems exist in Africa (see 2nd year lecture)

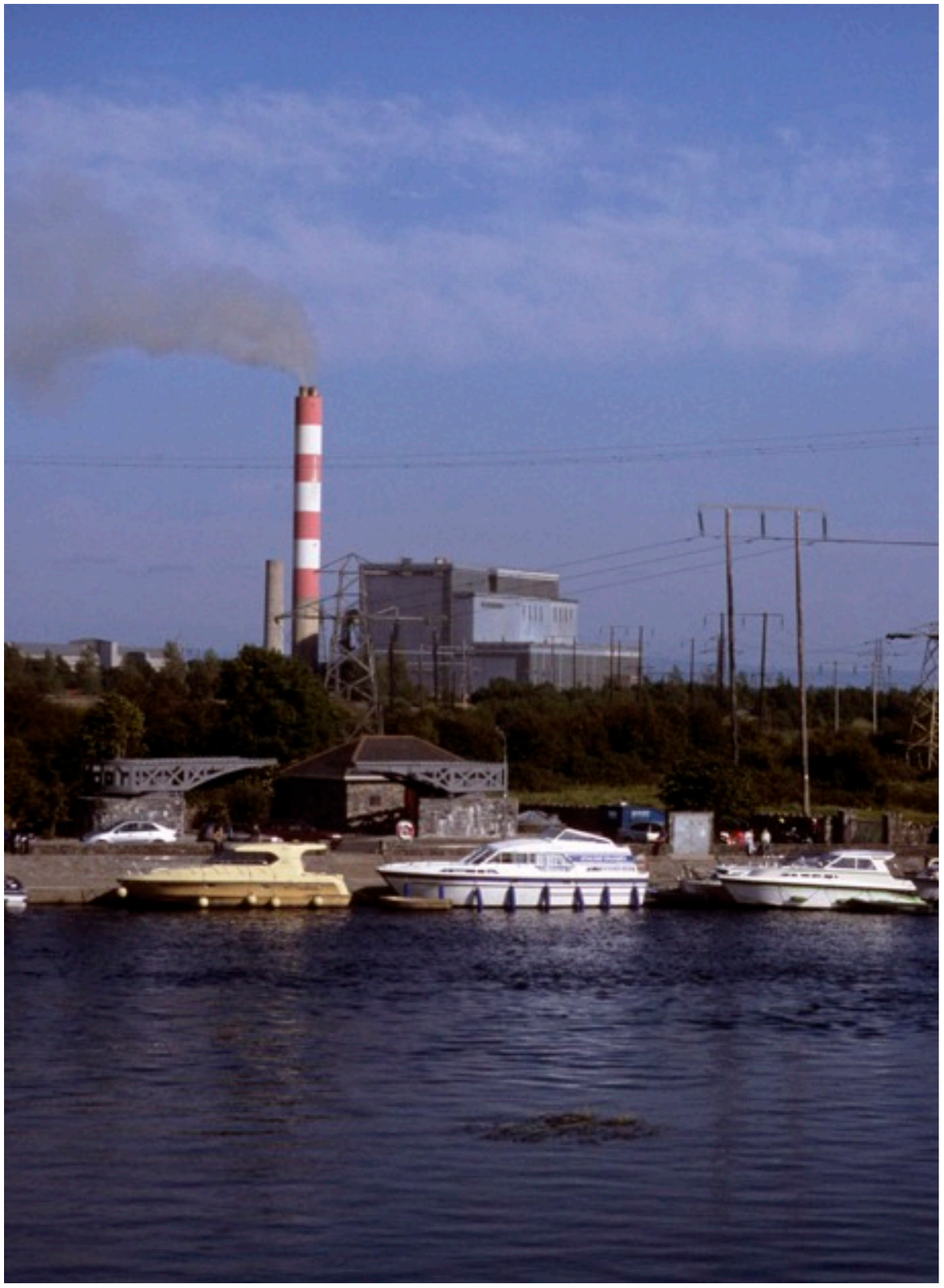
The Forest Stewardship Council (**FSC**) was founded in 1993. There are working groups in more than 50 countries. It is supported by WWF, Greenpeace &, in the UK, the Woodland Trust. Timber carrying the logo is from well-managed forests

Premium prices paid for FSC timber means that those working in the forests and timber mills can have appropriate health & safety equipment

Who damages forests?

- 2011 study looked at biodiversity conservation & forest-based livelihoods in 84 sites across East Africa & South Asia. (Persha *et al.* 2011) Positive & negative effects were found **BUT** participation in forest governance institutions by local forest users is strongly associated with jointly positive outcomes for forests.
- A second 2011 study showed that poor residents of forests do **not** cause the most deforestation. (Nature online 15 June 2011). Data collected from 8,000 households in 24 countries including China, Zambia & Indonesia, showed that firewood accounts for 20% of family income and timber 10%. However, the richest 20% of households in the study caused 30% more deforestation than the poorest 20%. REDD+ will only work if they are implemented from the bottom up.

In Dorset, Anna Lewington has resurrected the reed-beds providing roofing for thatched buildings



The use of moss peat in horticulture is to be banned from 2030. Current extraction of peat in Ireland cannot be sustained. Peat is also used in the generation of Irish electricity.

Next ...
Repairing the Damage