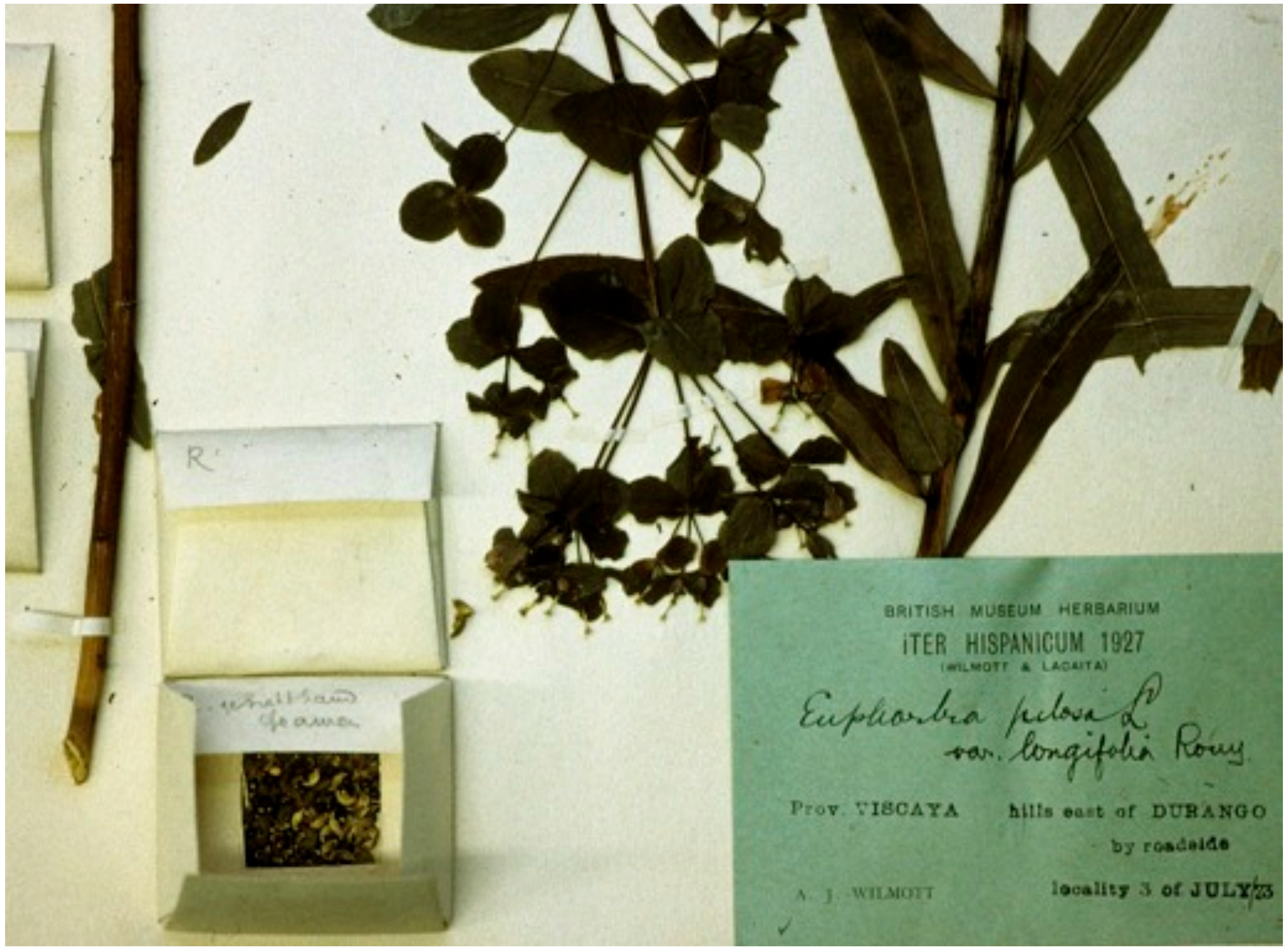
There is no technical obstacle to the conservation of every plant species ...

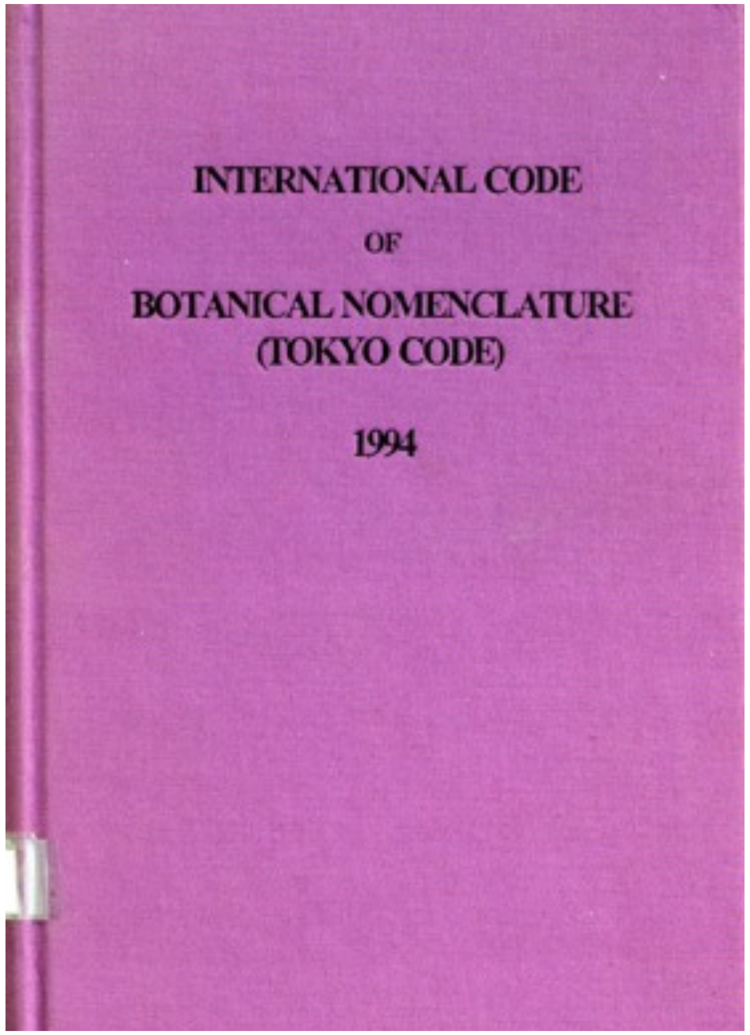
Species Conservation - HT 2013 - Lecture 8/16

The **obstacles** to the conservation
of every plant species are
ignorance *(too much)*
& **finance** *(too little)*

Ignorance: What is out there?
the taxonomic impediment

- **GSPC target 1** - to publish an on-line flora of all known plant species. Lead organisations RBG Kew & Missouri Botanical Garden
- The problem is that there are rules governing the naming of plants but there is no global system for assessing the quality of the work.



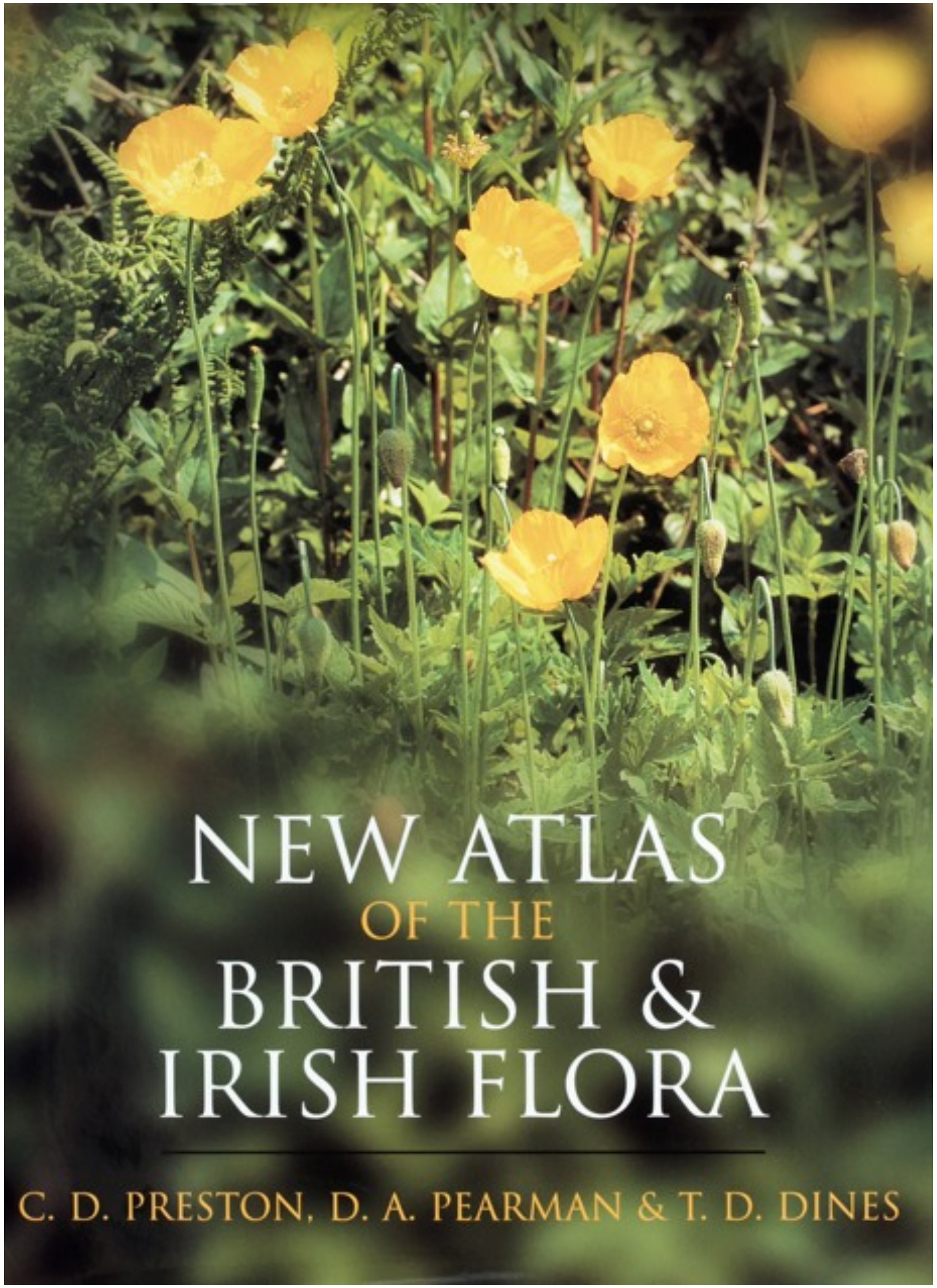


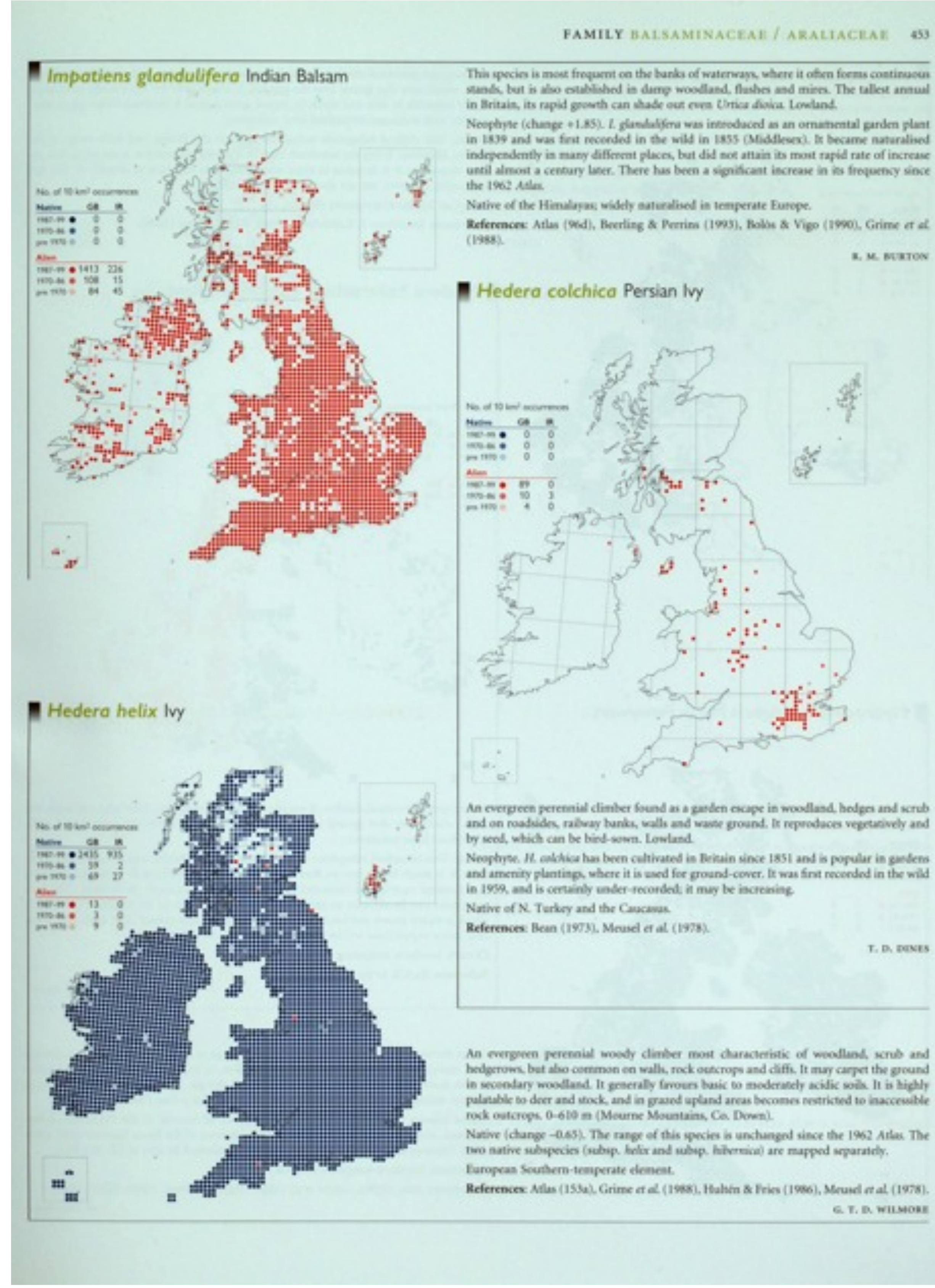
What is out there?
the taxonomic impediment

- There are **not enough people** working on the job but how many people would it take to bring the rest of the World up to the same standard of the UK **and** to maintain the data?

UK Checklists & floras 2006

		2002	2004	2006
FUNGI	Basidiomycotes	**No**	**No**	**Yes** - 2005
	Ascomycetes and other families	**No**	**No**	**No**
LICHENS		**Yes**	**Yes** – revised 2002/03	**Yes**
PROTISTS	Myxomycotes	**Yes**	**Yes**	**Yes**
ALGAE	Charophytes (stoneworts)	**Yes**	**Yes**	**Yes** - updated annually
	Freshwater and terrestrial algae	**Yes**	**Yes** - 2nd edition 2003	**Yes**
	Marine algae	**No**	**Yes** - 2003	**Yes** – 2nd edition 2006
PLANTS	Vascular plants (seed plants & ferns)	**Yes**	**Yes**	**Yes** - updated annually
	Bryophytes (mosses & liverworts)	**Yes**	**Yes**	**Yes** – updated 2005




FAMILY BALSAMINACEAE / ARALIACEAE 453

Impatiens glandulifera Indian Balsam

This species is most frequent on the banks of waterways, where it often forms continuous stands, but is also established in damp woodland, flushes and mires. The tallest annual in Britain, its rapid growth can shade out even *Urtica dioica*. Lowland.

Neophyte (change +1.85). *I. glandulifera* was introduced as an ornamental garden plant in 1839 and was first recorded in the wild in 1855 (Middlesex). It became naturalised independently in many different places, but did not attain its most rapid rate of increase until almost a century later. There has been a significant increase in its frequency since the 1962 *Atlas*.

Native of the Himalayas; widely naturalised in temperate Europe.

References: Atlas (96d), Beerling & Perrins (1993), Bolòs & Vigo (1990), Grime *et al.* (1988).

R. M. BURTON

Hedera colchica Persian Ivy

An evergreen perennial climber found as a garden escape in woodland, hedges and scrub and on roadsides, railway banks, walls and waste ground. It reproduces vegetatively and by seed, which can be bird-sown. Lowland.

Neophyte. *H. colchica* has been cultivated in Britain since 1851 and is popular in gardens and amenity plantings, where it is used for ground-cover. It was first recorded in the wild in 1959, and is certainly under-recorded; it may be increasing.

Native of N. Turkey and the Caucasus.

References: Bean (1973), Meusel *et al.* (1978).

T. D. DINES

Hedera helix Ivy

An evergreen perennial woody climber most characteristic of woodland, scrub and hedgerows, but also common on walls, rock outcrops and cliffs. It may carpet the ground in secondary woodland. It generally favours basic to moderately acidic soils. It is highly palatable to deer and stock, and in grazed upland areas becomes restricted to inaccessible rock outcrops. 0–610 m (Mourne Mountains, Co. Down).

Native (change −0.65). The range of this species is unchanged since the 1962 *Atlas*. The two native subspecies (subsp. *helix* and subsp. *hibernica*) are mapped separately.

European Southern-temperate element.

References: Atlas (153a), Grime *et al.* (1988), Hultén & Fries (1986), Meusel *et al.* (1978).

G. T. D. WILMORE

The most comprehensively surveyed country in the World

Taxonomists required

- **GSPC target 15** - to train sufficient numbers of people to achieve the targets of the strategy
- How many to “do” target 1?
- Let’s **assume that the UK is “done”** and that we have a complete accurate flora and we know the distribution & hence conservation status of all the UK native species.
- The land area of the World is x600 that of the UK
- The study of the UK flora began properly 400 years ago, or 10 professional life times
- In the UK we have 100 county recorders per county and using Oxfordshire as typical there are 20 active, good field, botanists in each county that means that the UK has 2,000 botanists or one per 30,000 citizens.

Taxonomists required

- If you **extrapolate** back to 1600 when there were 4 million people living in the UK then over the past 400 years approximately 7,000 people have contributed to the current understanding of the British flora, or 280,000 years of work.

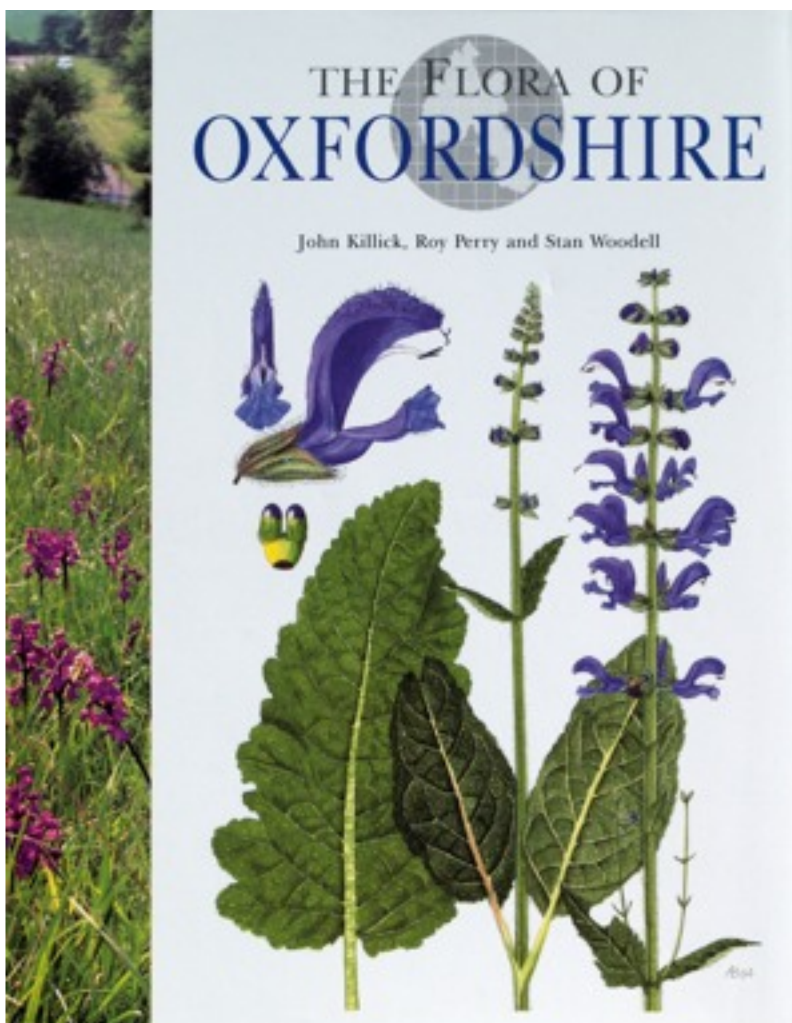
- The world's land area is 600 times that of the UK so it would take 168 million years of work to catalogue the World as well as the UK or 42,000,000 careers from a standing start. If we assume that the plant list is 7/8 done, then we need another **5,250,000 botanists** working for the next 40 years **to finish the job**.

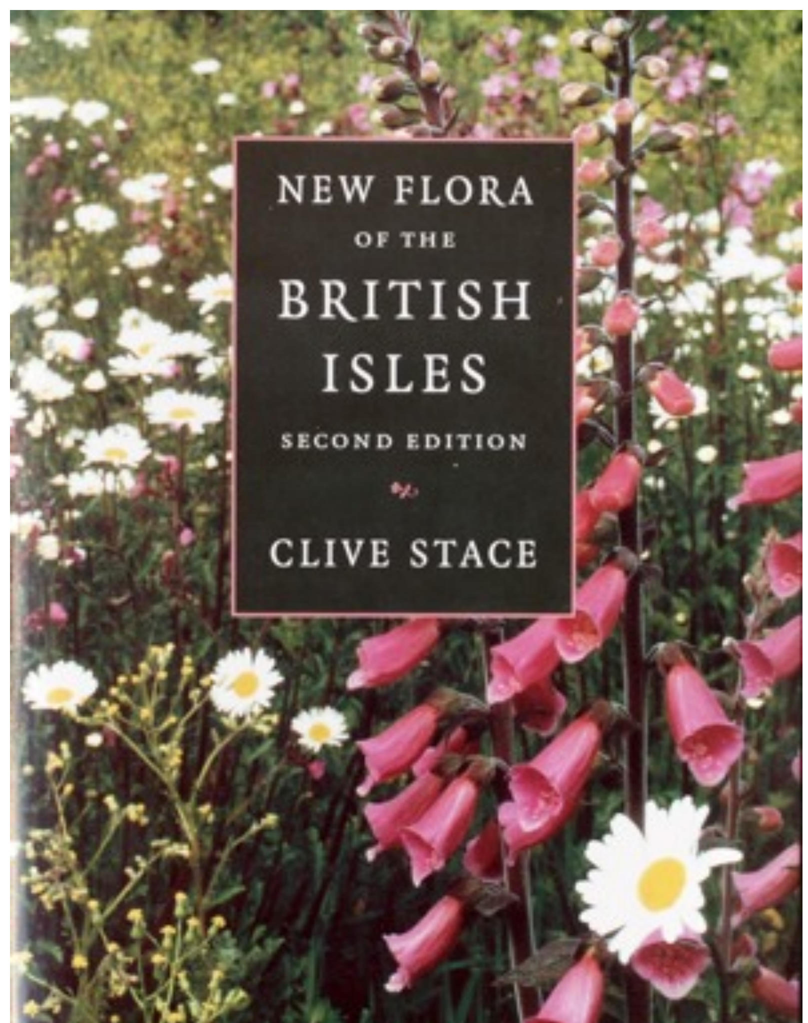
- Once the job is finished it would take **1,200,000 botanists to keep the list up to date** if it takes 2,000 botanists to do UK which is 1/600 the area of the world.

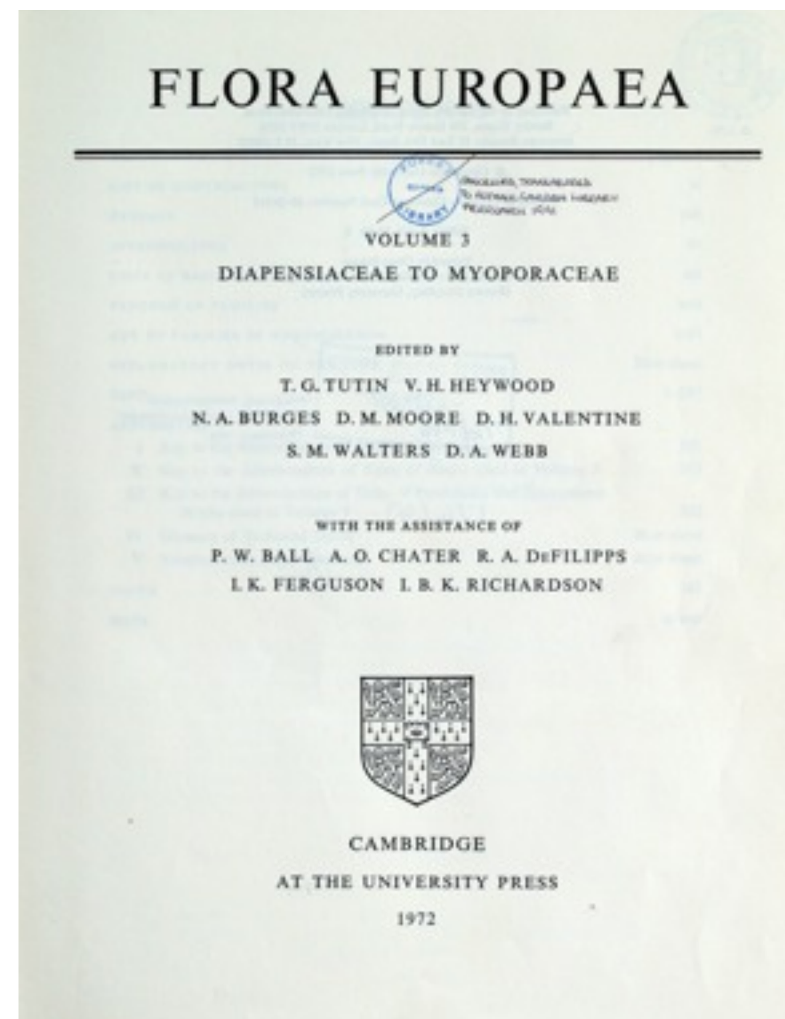
Kew
ROYAL BOTANIC GARDENS

Floras, Monographs & Checklists

- **Floras** are detailed accounts of geographical regions, usually political & not botanical
- Countries like to have as many endemic species as possible & so **taxonomic inflation** occurs with varieties being raised to the rank of species



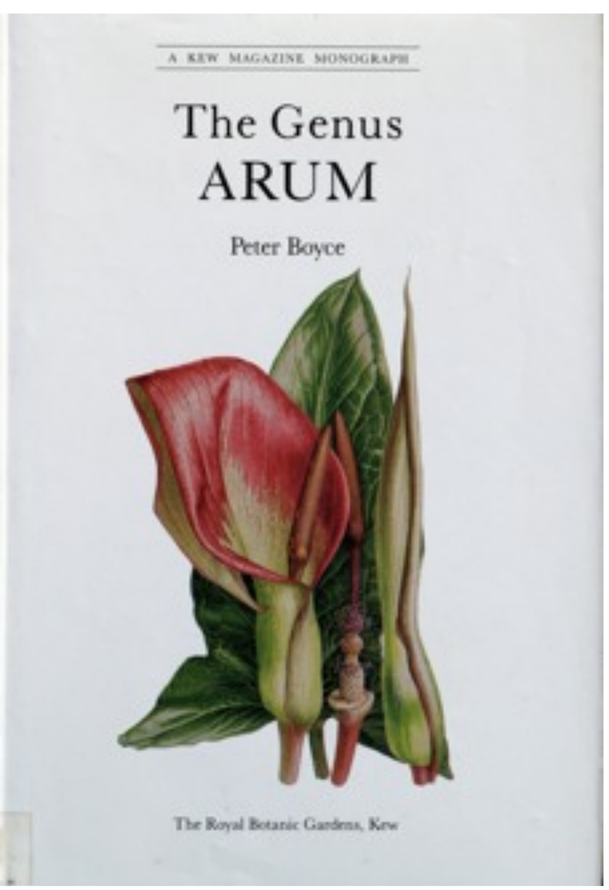


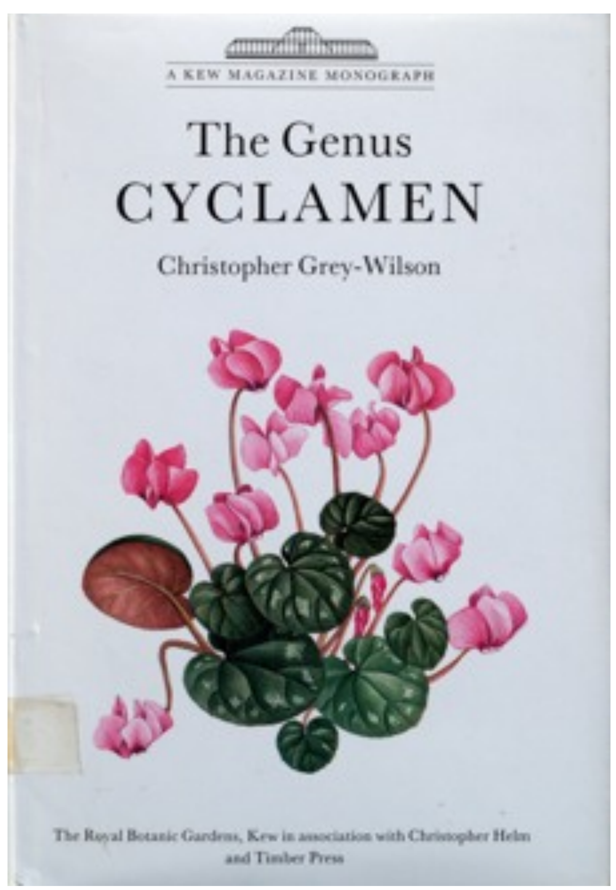


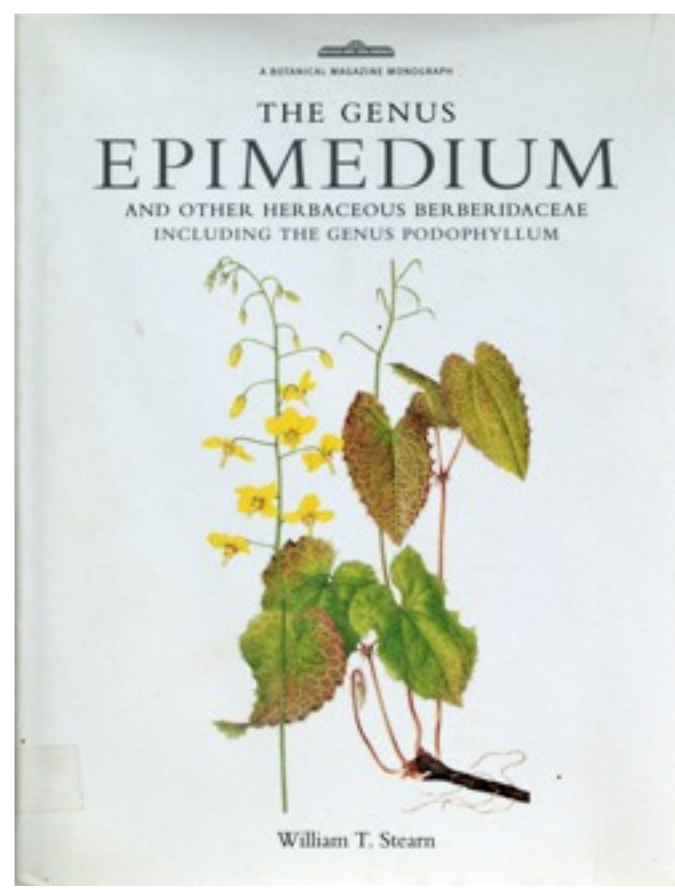
Floras, Monographs & Checklists

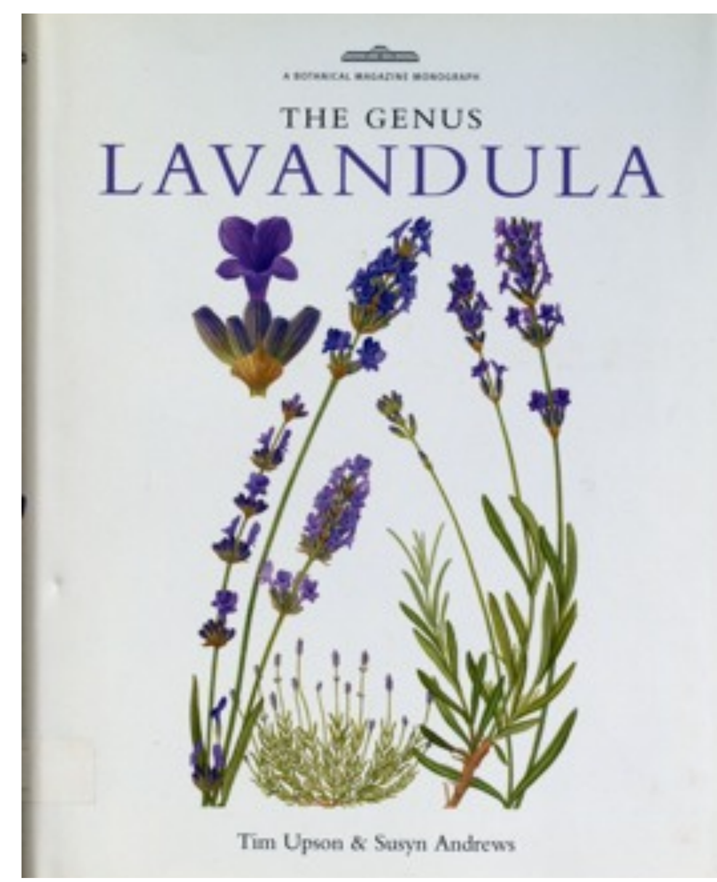
Kew
ROYAL BOTANIC GARDENS

- **Monographs** are accounts of a genus or part of a genus.
- They are written with a global view and therefore tend to take a **broader view of species delimitation** than national or regional floras









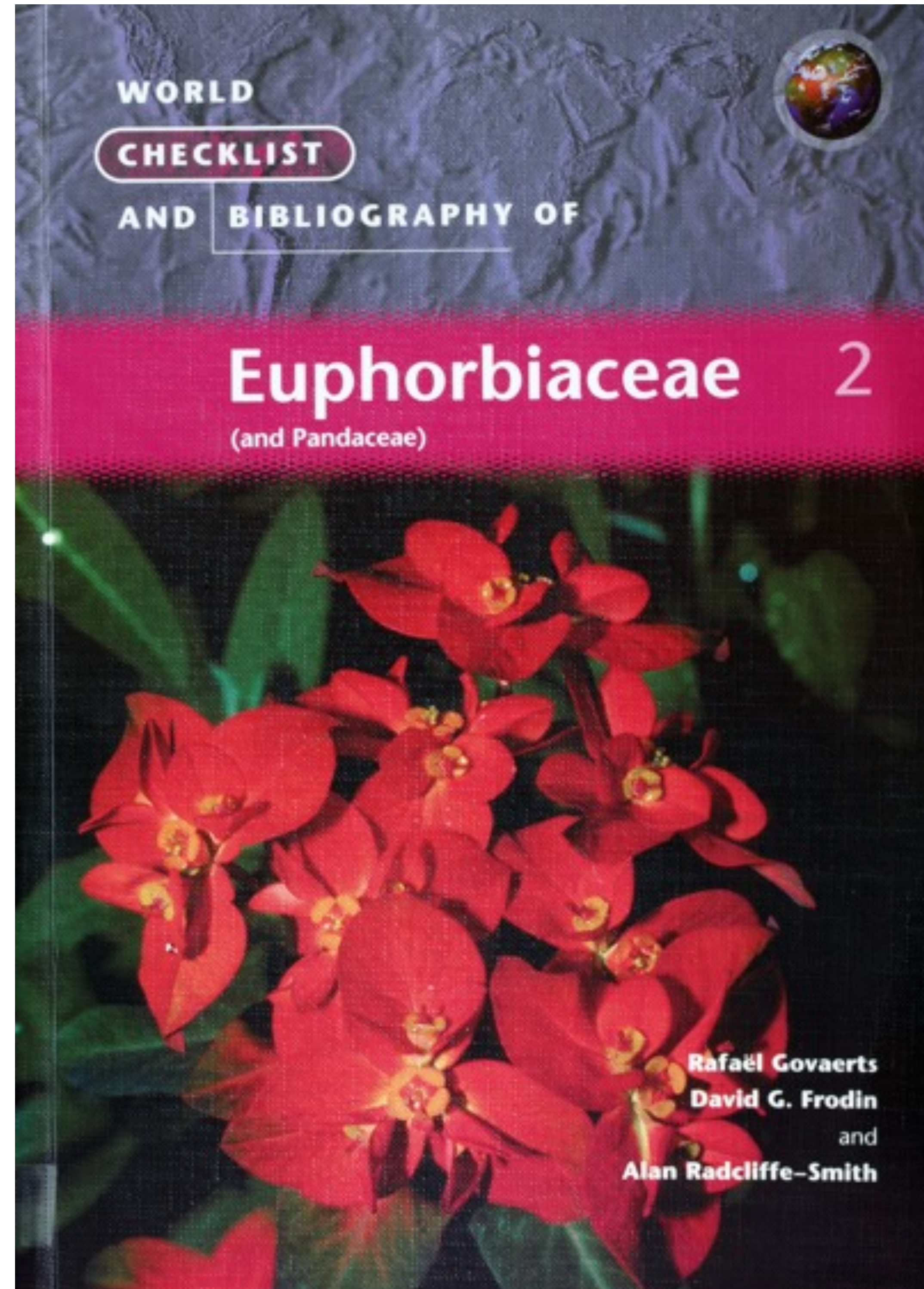
A new monograph of *Lupinus*
Colin Hughes

- Amphiatlantic distribution in 35 Countries
- Last monograph in 1875 by Agardh
- **1,800 legitimate names for c. 250 species**
- some flora treatments e.g. California, & the intermountain basin of Paraguay

Plants from wild-collected seeds being grown at the Botanic Garden for DNA extraction

Floras, Monographs & Checklists

- **Checklists** are lists of the accepted names for the species and genera in a family, class or order.
- They list synonyms, illegitimate names and taxonomic authorities (the person who first used the name)
- They contain no descriptive information but contain **references**
- http://www.ipni.org/ is an on-line list of legitimate & current names



Progress towards GSPC T1

Paton et al (2008) Taxon **57**(2) p602-611

- “Never before have so many governments simultaneously called for prompt action from taxonomists and [therefore] recognized the central importance of the taxonomists’ contribution to conservation activities”.
- “If the taxonomic community ignores this call to action, **why should governments and politicians listen** to the the concerns of taxonomists?”

Table 1. Progress towards Target 1 of the GSPC.

Group	URL	Accepted species listed
Bryophytes	http://mobot.mobot.org/W3T/Search/most.html	13,370
Ferns and fern allies	http://homepages.caverock.net.nz/~bj/fern/	12,838
Cycads	http://plantnet.rbgsyd.nsw.gov.au/PlantNet/cycad/wlist.html	279
Conifers	2007 annual checklist www.catalogueoflife.org	1,016
Ephedra	www.kew.org/wcsp/	65
Gnetum	www.kew.org/wcsp/	29
Welwitschia	www.kew.org/wcsp/	1
Ginkgo	www.kew.org/wcsp/	1
Total non-flowering plants		**27,599**
Flowering plants	Currently available—see Appendix in Taxon online issue	140,341
Flowering Plants	Being compiled, on course for completion by end 2007 (Asteraceae by 2010, see text)	34,156
Total flowering plants (estimated working list available by end of 2007. see text)		**174,497**
Total		**202,096**

Progress towards GSPC T1

Paton et al (2008) Taxon **57**(2) p602-611

- 177,785 species are yet to be integrated into the working list of which 133,000 (70% of the gap) are in just 33 families
- Most of the families (and the vast majority of the species) yet to be listed are widespread cosmopolitan or pan-tropical groups

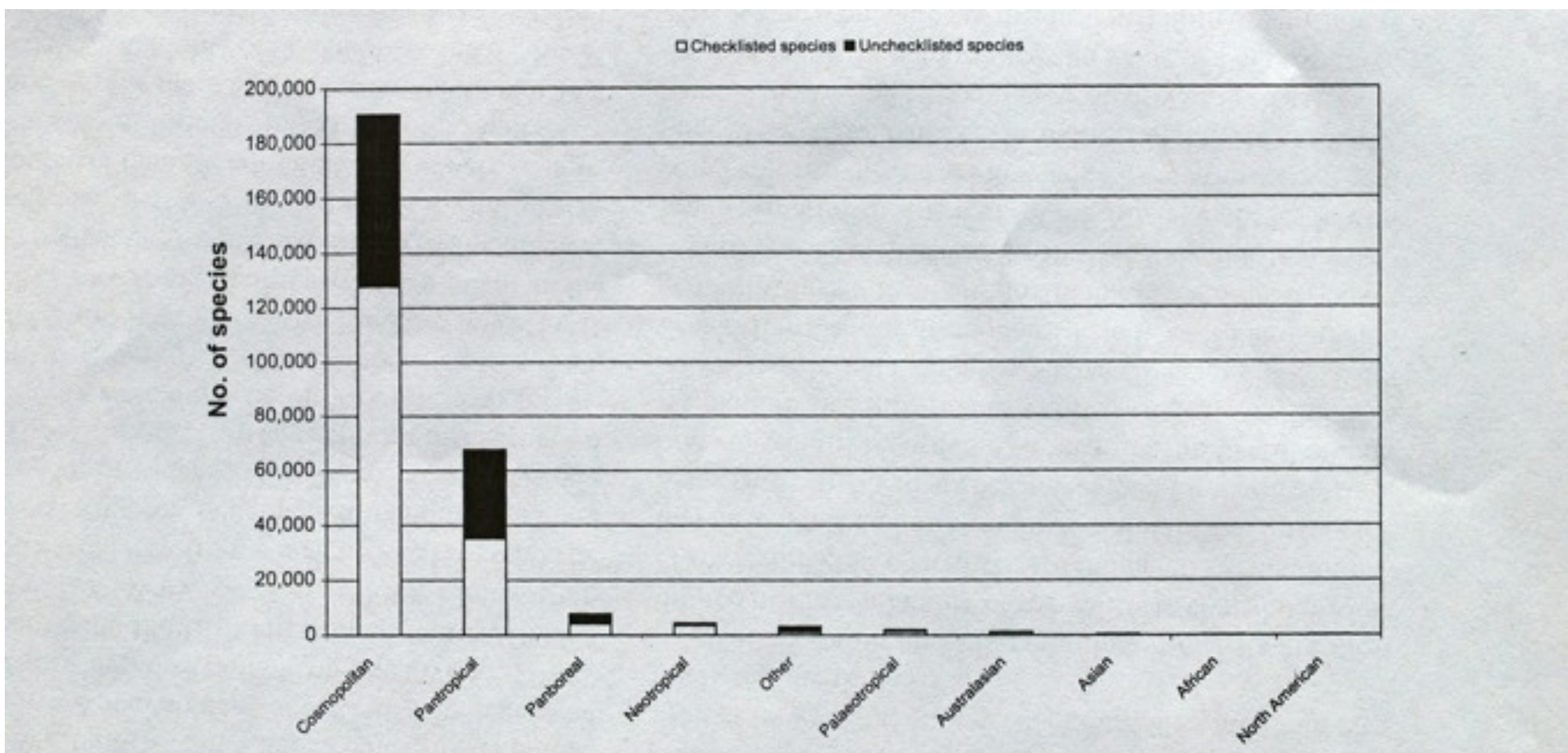


Fig. 3. Proportions of listed and unlisted species in the different distribution patterns. Numbers of listed species derived from online working lists; estimates of species numbers in families without working lists estimated from Stevens (2006).

Progress towards GSPC T1

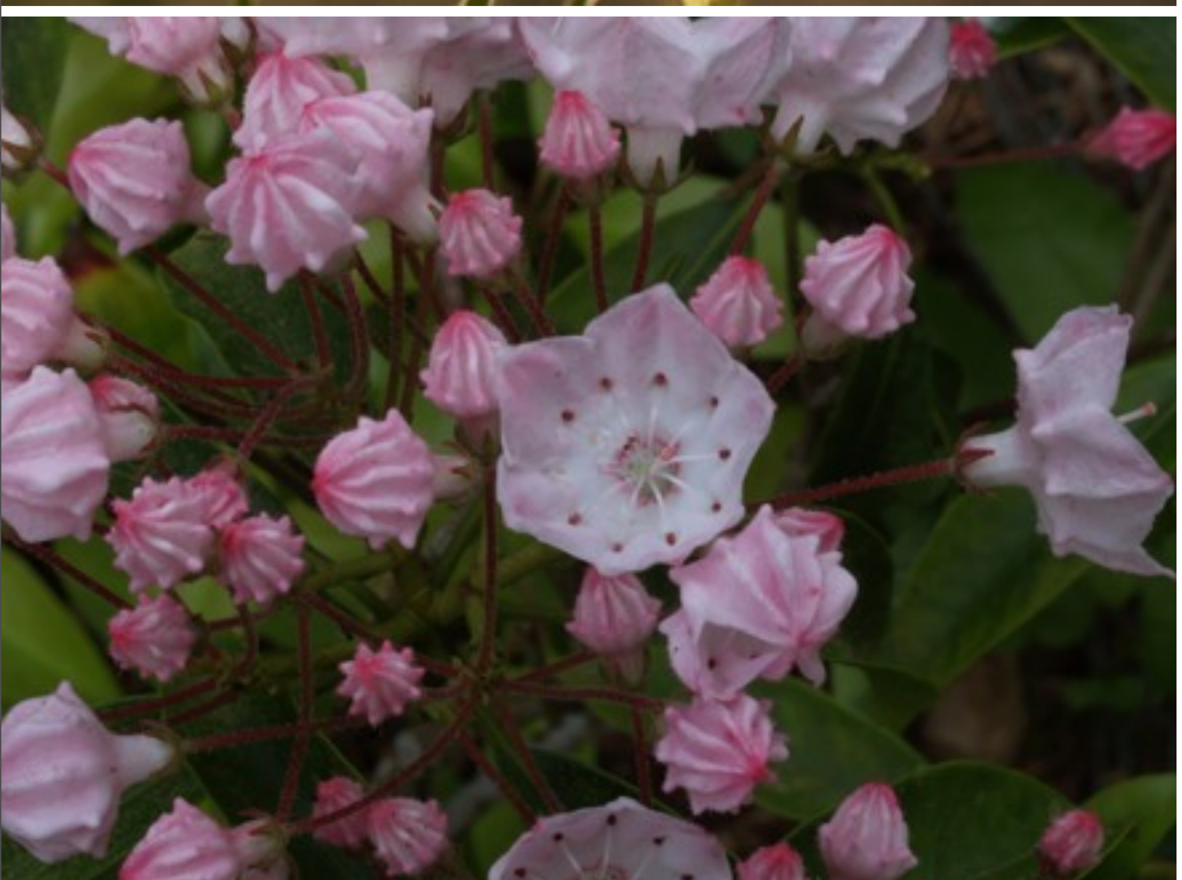
Paton et al (2008) Taxon **57**(2) p602-611

- **Possible reasons** why some families have not yet been worked on and thus lists not completed and vice versa
- Since 9 of the 10 largest families have been completed size is not a problem (and the 10th family, the Asteraceae, is being completed at present)
- Although most of the groups yet to be listed are pan-tropical or cosmopolitan, most of the pan-tropical or cosmopolitan groups have already been completed
- Among the unlisted groups are some **ancient groups** (Apiaceae), **ethno-botanically important** (Apocynaceae, Brassicaceae & Solanaceae), **widely cultivated ornamentals** (Ericaceae, Boraginanceae), Ranunculaceae etc) **scientifically important** (Proteaceae) **dominated by one large genus** (Solanaceae, Moraceae, Ericaceae)

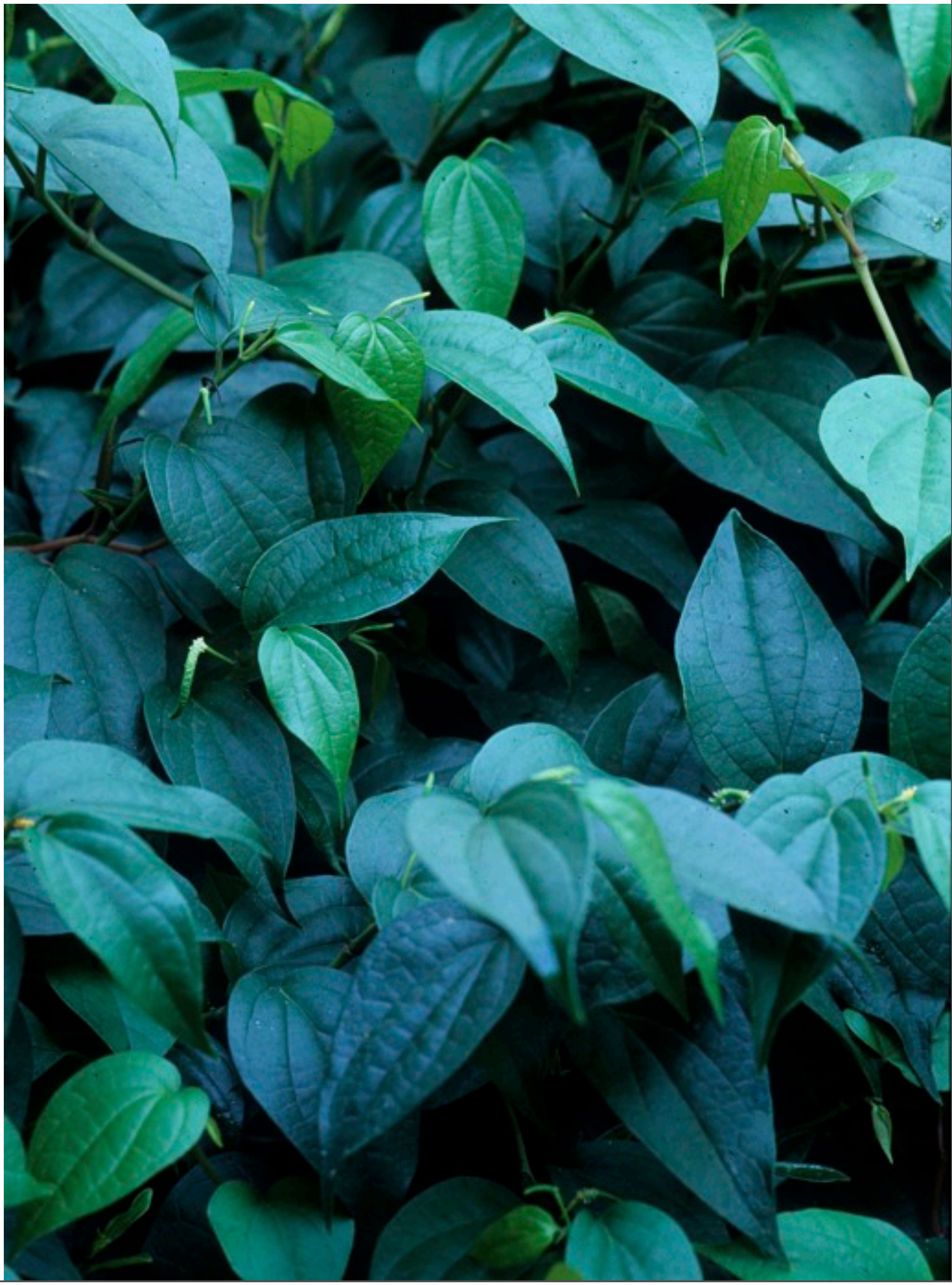
Ancient groups - Apiaceae (3,780)

ethno-botanicaly important (Apocynaceae, Brassicaceae & Solanaceae)

widely cultivated ornamentals (Ericaceae, Boraginanceae, Ranunculaceae etc)



scientifically important (Proteaceae, Lauraceae, Piperaceae)



Family dominated by one large genus (Solanaceae, Moraceae, Ericaceae)

Succulent plants (Cactaceae, Aizoaceae, Crassulaceae)

Insufficient taxonomic data (Acanthaceae, Orobanchaceae, Plantaginaceae, Scrophulariaceae)

Progress towards GSPC T1

Paton et al (2008) Taxon **57**(2) p602-611

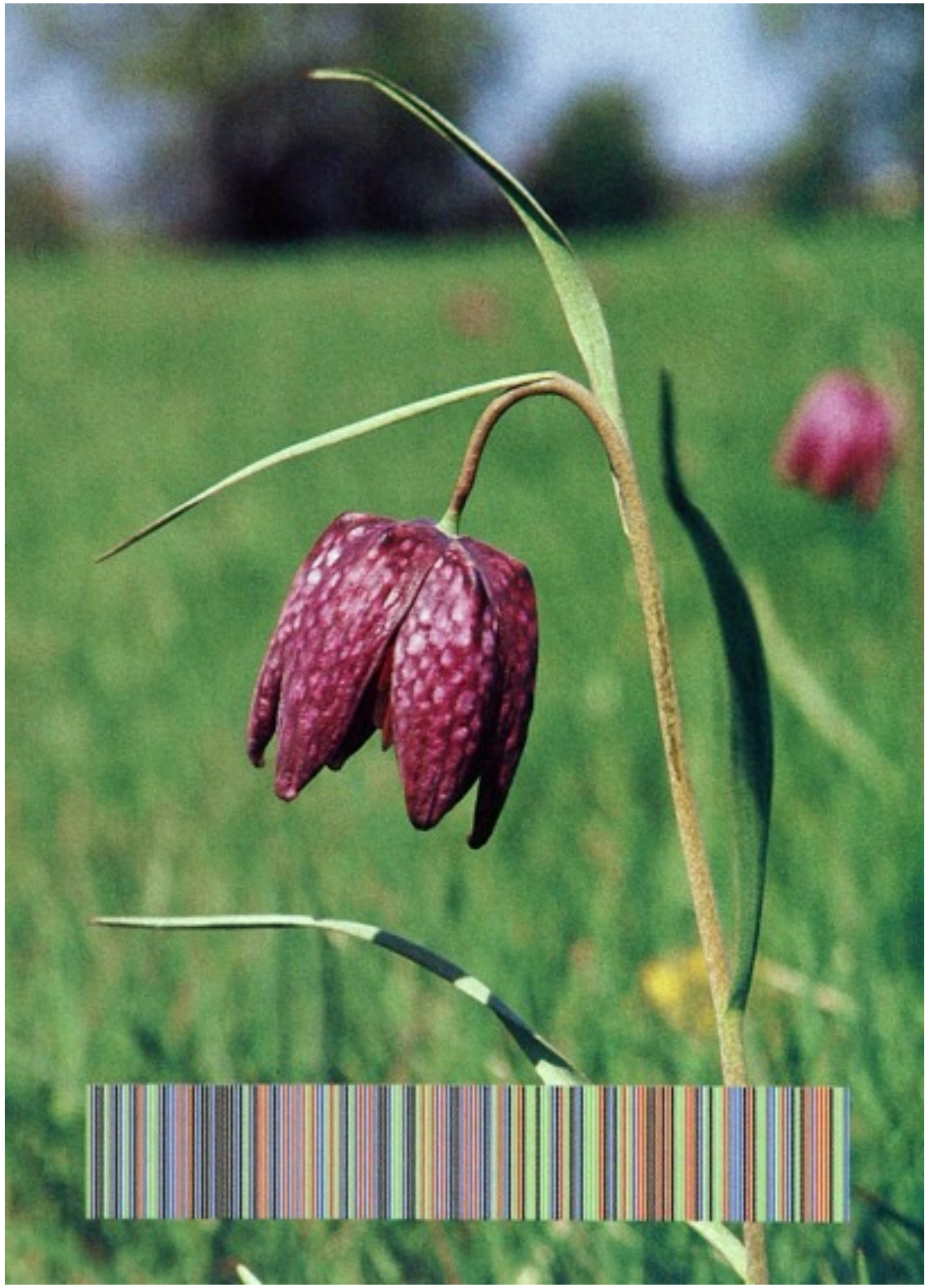
- **Actual reasons** why some families have not yet been worked on and thus lists not completed
- **Lack of taxonomic expertise** (just 120 people from 20 countries have worked on the list to date)
- Existing expertise being **employed elsewhere** such as flora writing
- The **tyranny of the RAE** and high-impact journals

  Perfectionist taxonomists
- **"A man would do nothing if he waited until he could do it so well that no one would find fault with what he has done."** Cardinal Newman

Plant Bar Codes

Royal Botanic Garden Edinburgh

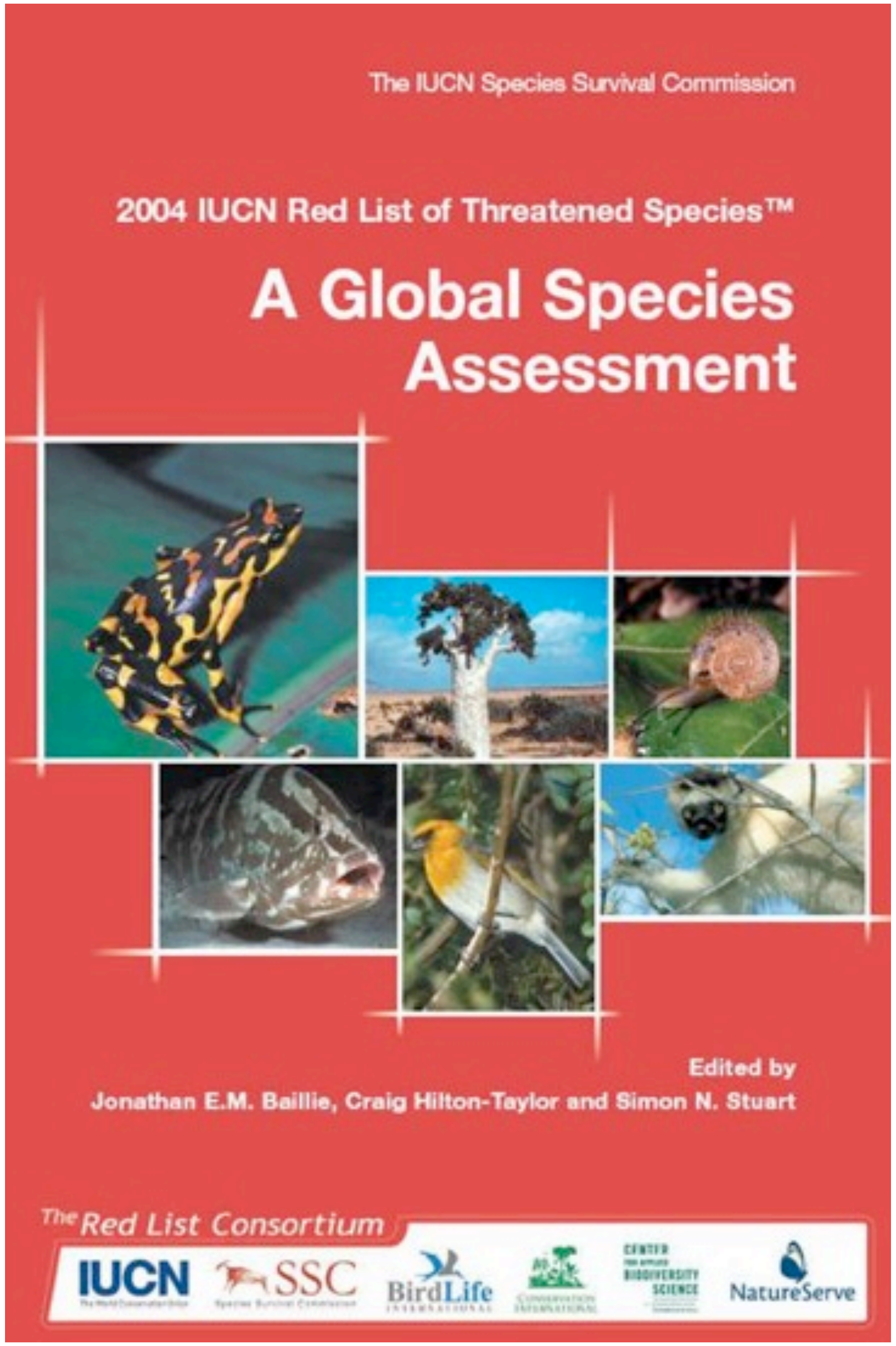
- Works well for animals but **not** for plants
- The Consortium for the Barcode of Life (CBOL) is the authority on this matter.
- A two- or three-locus bar code is the best that is available at present
- Science (2009) **325** p526



Ignorance: Which plants species are **threatened with extinction?**

IUCN
The World Conservation Union

- **GSPC target 2** - to publish an assessment of the conservation status of all <u>known</u> plant species
- **Target 1** does not have to be completed for the work on this one to start. As new species are described their conservation status can be included as a standard piece of data
- However, there is evidence that **many un-named species are sitting in herbaria waiting to be examined and the conservation status data for these may not have been collected**. (Bebber et al 2010)



Herbaria are the major frontier for species discovery (Bebber et al 2010)

IUCN
The World Conservation Union

Time-lag: A herbarium specimen of *Strobilanthes paniculiformis* collected in 1885 in the Naga Hills of eastern India was described and published only 121 years later. Specimen: copyright The Board of Trustees of the Royal Botanic Gardens, Kew, reproduced with the consent of the Royal Botanic Gardens, Kew. Photograph: Sudhansu Sekhar Dash.

Which plants species are **threatened with extinction?**

- How good is the data? (Paton 2009)

Volume 2 • Number 1 • January 2005

Cuttings

Botanic Gardens Conservation International • Quarterly Newsletter

2004 Red List of Threatened Species released

Eight out of every eleven plants surveyed under threat

The World Conservation Union's (IUCN) Global Species Assessment and the 2004 Red List of Threatened Species were released at the 3rd World Conservation Congress, which took place in Thailand during November 2004. The most comprehensive evaluation ever undertaken of the status of the world's biodiversity included the first full assessments for conifers and cycads. For these groups, 25% and 50% of species respectively are considered under threat. Overall of 11,000 plants evaluated over 8,000 are at risk. However, with less than 3% of the world's described plant species having been evaluated, much remains to be done.

The IUCN Red Lists are based on information collected by the members of the Species Survival Commission (SSC). The plant work of the SSC was given focus at the meeting through presentations by the Galapagos Plant Specialist Group, the Medicinal Plant Specialist Group, Plantlife International and an overview paper on the contribution of the SSC Plant Conservation Programme to the Global Strategy for Plant Conservation.

With the Global Strategy for Plant Conservation 2010 targets in mind, the Plant Programme meeting has recommended ways to increase the efficiency of Red Listing. Development and availability of the Species Information System (SIS) for data input and analysis will greatly help with this. New activities for expanded red-listing include SSC initiatives to red-list strategic families.

Co-chairs of the SSC Plant Programme were honoured with SSC awards, Mike Maunder (Director, Fairchild Tropical Botanic Garden) receiving a Citation of Excellence and David Given (Director, Christchurch Botanic Garden) being one of four recipients of the Sir Peter Scott Award for Conservation Merit, SSC's highest honour.

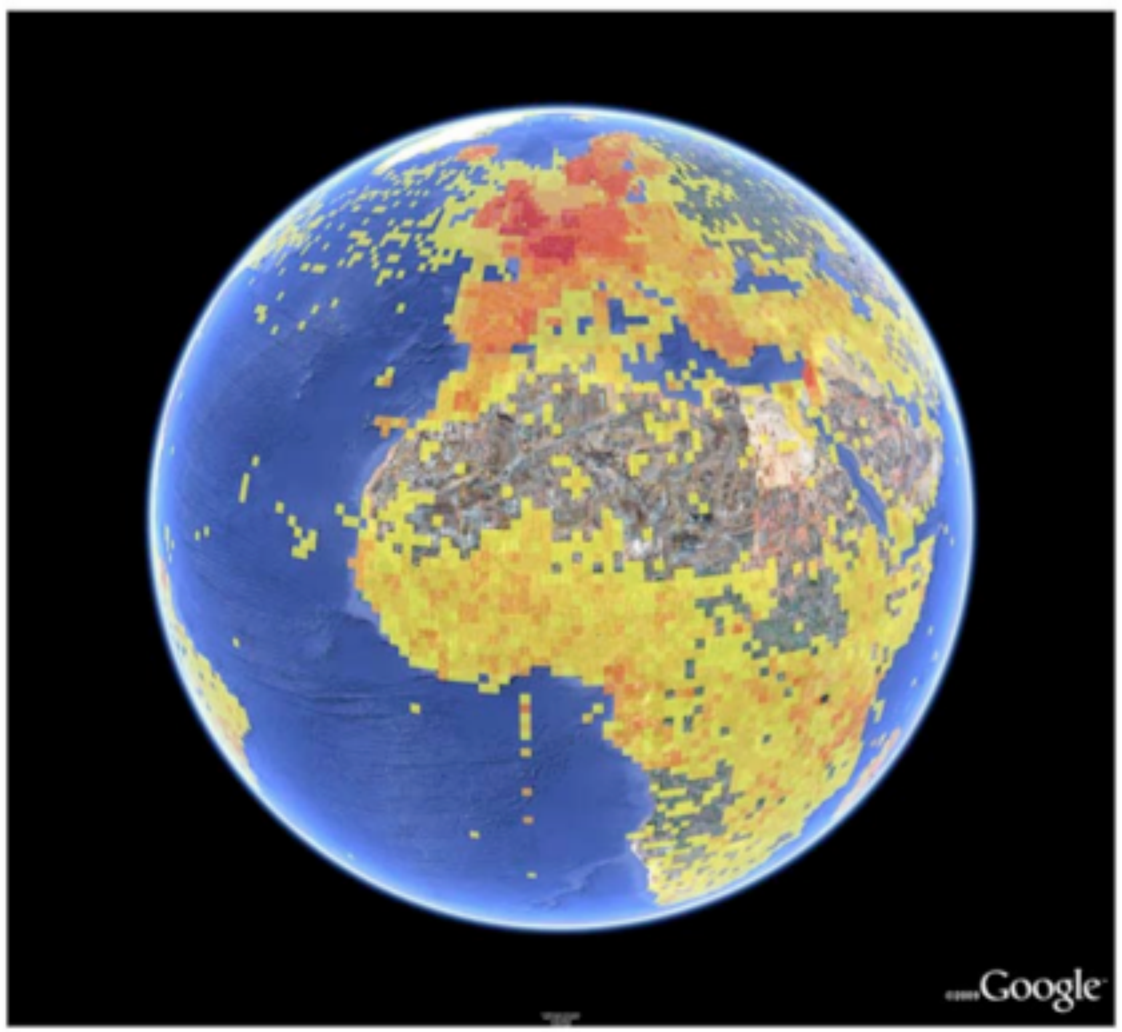
Further information: www.iucn.org and www.iucnredlist.org

In this issue: Cuttings goes Japanese • New plant species identified Europe's first Wollemi Pine • African awards • Today, tomorrow, forever

BGCI
Plants for the Planet

Which plants species are **threatened with extinction?**

- How good is the data? (Paton 2009)
- The Global Biodiversity Information Facility (*below*) has freely available information on species distribution



TRENDS in Plant Science

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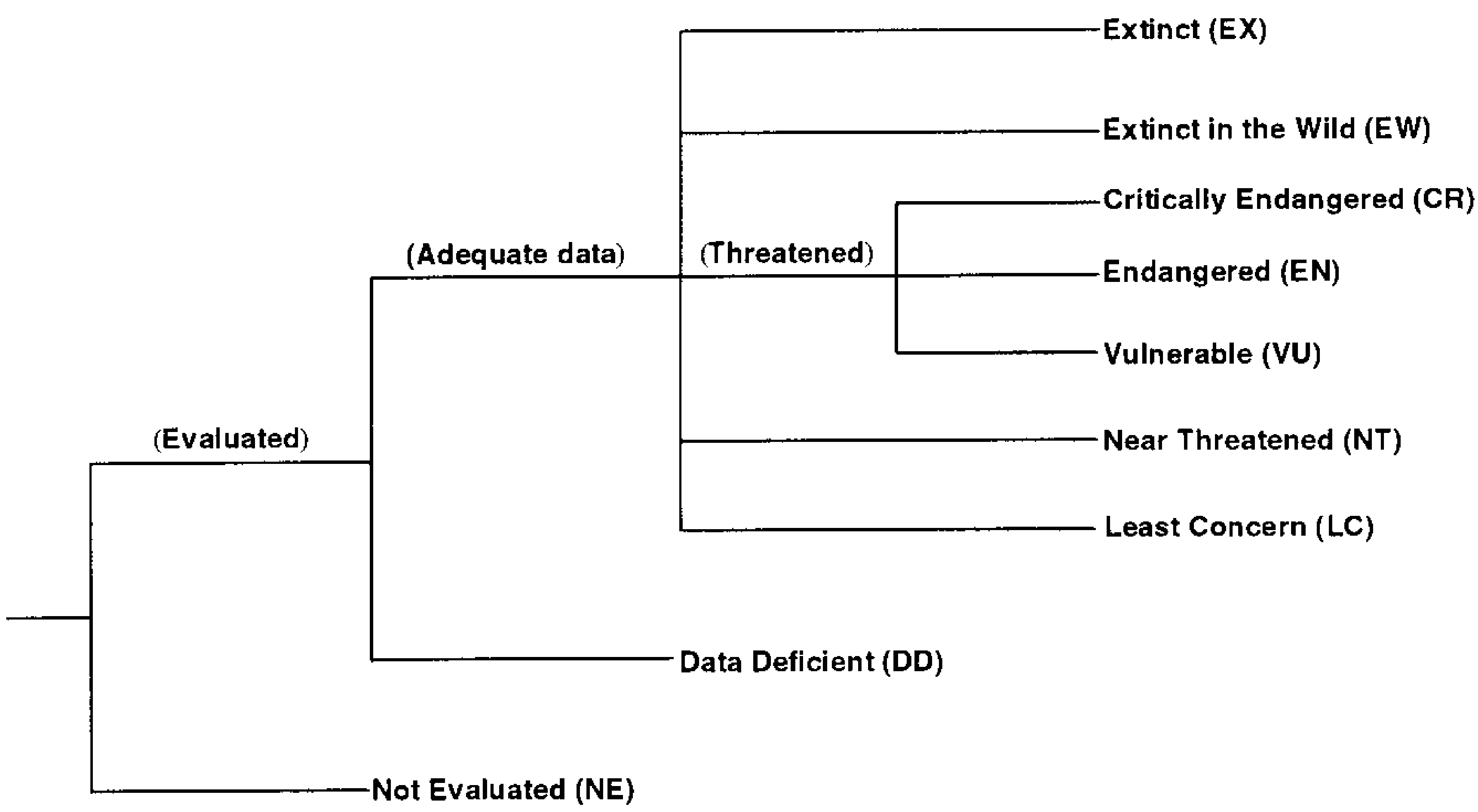
IUCN **RED LIST** categories

from lecture 5/16



Extinct *Archeanthus linnenbergii*

Extinct in the wild *Franklinia alatamaha*

Critically endangered
Euphorbia handiensis
Lanzarote

Endangered
Euphorbia stygiana
Azores

Vulnerable
Euphorbia glauca
New Zealand

IUCN Red List Categories

IUCN RED LIST CATEGORIES post 1994

adapted from Walter & Gillett (1998) & PLANT TALK 26 p34 (Oct 2001)

03/01/2006 12:04

- Monitoring
  - Evaluated
    - Adequate data
      - **Extinct** (EX) – applied where there is no reasonable doubt that the last individual has died. The time required since the last sighting is proportional to the life cycle of the species.
      - **Extinct in the Wild** (EW) – applied when the species is only known to be present in cultivation or as a naturalised population well outside its past range.
      - **Threatened** (See criteria)
        - **Critically Endangered** (CR) – applied when a species is facing an extremely high risk of extinction in the wild in the immediate future.
        - **Endangered** (EN) – applied to a species that is facing a very high risk of extinction in the wild in the near future as defined by the criteria
        - **Vulnerable** (VU) – this is applied to a species if there is a high risk of extinction in the wild in the medium term future
      - **Lower Risk** (LR)- this is applied when the species does not qualify in any of the levels of threatened
        - Near threatened (NT) – applied to species close to vulnerable
        - Conservation dependent (CD) – applied to a species that is currently the subject of a SRP and if that SRP stopped the species would qualify for a threatened category within 5 years
        - Least concern (LC) – applied if none of the above is appropriate
    - **Data deficient** (DD) – applied to a well studied species where there is insufficient data to make an assessment or where many years have passed since data was collected
  - **Not evaluated** (NE) – this is applied when no attempt has been made to assess the species. This is where you would put a species that is so common that monitoring is a very low priority

The criteria: In order to place a species in one of the 3 threatened categories the conservation worker evaluates that species against these categories all of which have quantitative values for each level of threatened-ness.
Only one criterion has to be met for a species to be classified as threatened.

A	Declining population
B	Small distribution plus decline or fluctuation
C	Small population plus decline
D	Very small or restricted population
E	Quantitative analysis (QA)

Criteria for endangered & vulnerable species

THE CRITERIA FOR CRITICALLY ENDANGERED, ENDANGERED & VULNERABLE SPECIES

summarised from Walter & Gillett (1998) – see the original for more detail

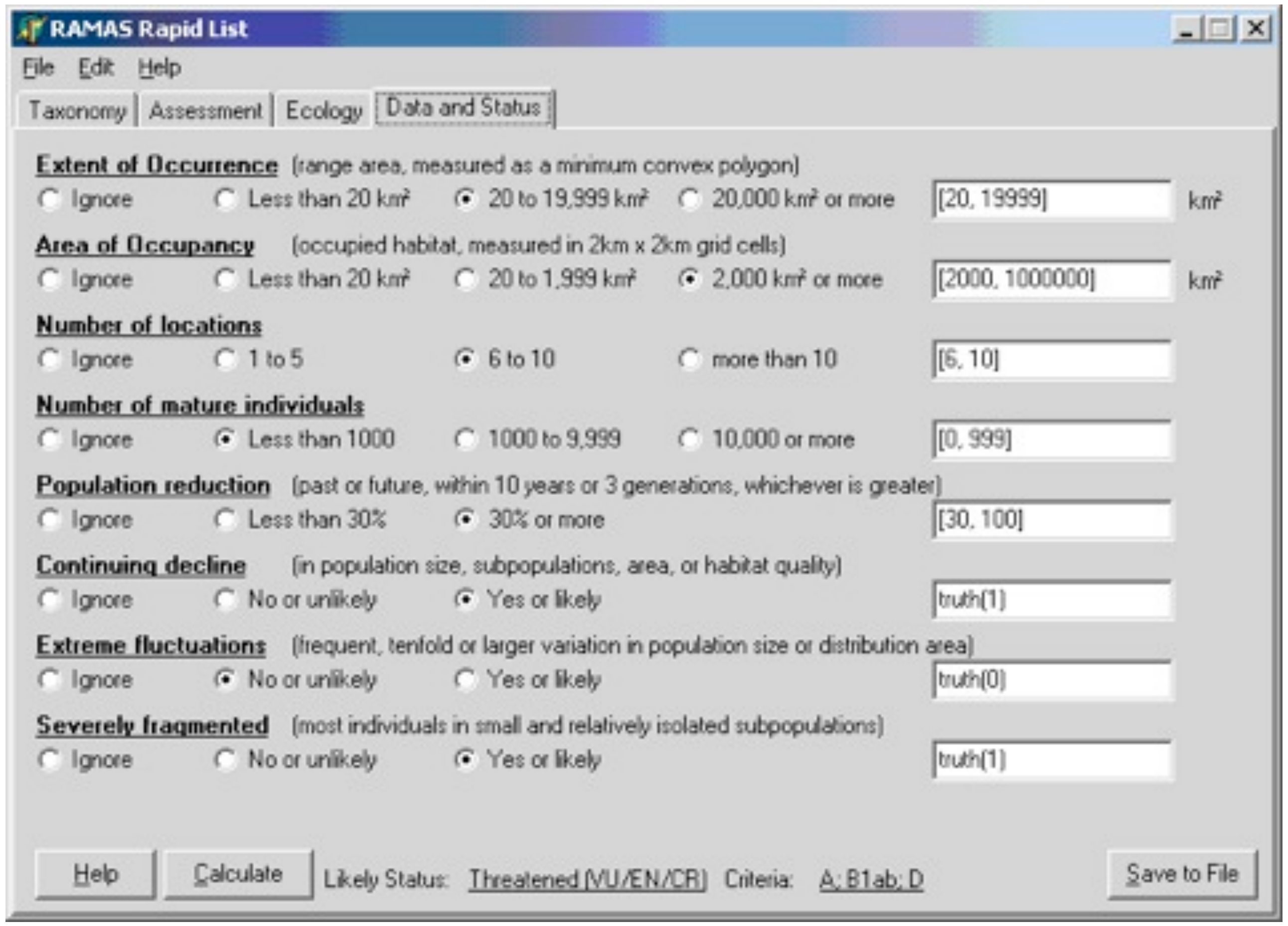
CATEGORY	CRITERIA A	B	C	D	E
CRITICALLY ENDANGERED	An observed reduction of >80% in the past 10 years or 3 generations* **or** a predicted reduction of the same size in the next ten years or 3 generations*	Extent of occurrence <100km^2 or area of occupancy <10km^2 plus one-site only or fragmentation, decline & fluctuations	Population fewer than 250 mature individuals & decline of >25% (in 3 years or one generation*) or very fragmented distribution or all in one place	Population fewer than 50 mature individuals	QA showing that the probability of extinction is >50% in 10 years or 3 generations*
ENDANGERED	An observed reduction of >50% in the past 10 years or 3 generations* **or** a predicted reduction of the same size in the next ten years or 3 generations*	Extent of occurrence <5000km^2 or area of occupancy <500km^2 plus one-site only or fragmentation, decline & fluctuations	Population fewer than 2,500 mature individuals & decline of >20% (in 3 years or one generation*) or very fragmented distribution or all in one place	Population fewer than 250 mature individuals	QA showing that the probability of extinction is >10% in 100 years
VULNERABLE	An observed reduction of >20% in the past 10 years or 3 generations* **or** a predicted reduction of the same size in the next ten years or 3 generations*	Extent of occurrence <20,000km^2 or area of occupancy <2,000km^2 plus one-site only or fragmentation, decline & fluctuations	Population fewer than 10,000 mature individuals & decline of >10% (in 3 years or one generation*) or very fragmented distribution or all in one place	Population fewer than 1,000 mature individuals	QA showing that the probability of extinction is >10% in 100 years

* Whichever is the longer

IUCN **RED LIST** categories

from lecture 5/16

- http://www.ramas.com/RapidList.htm



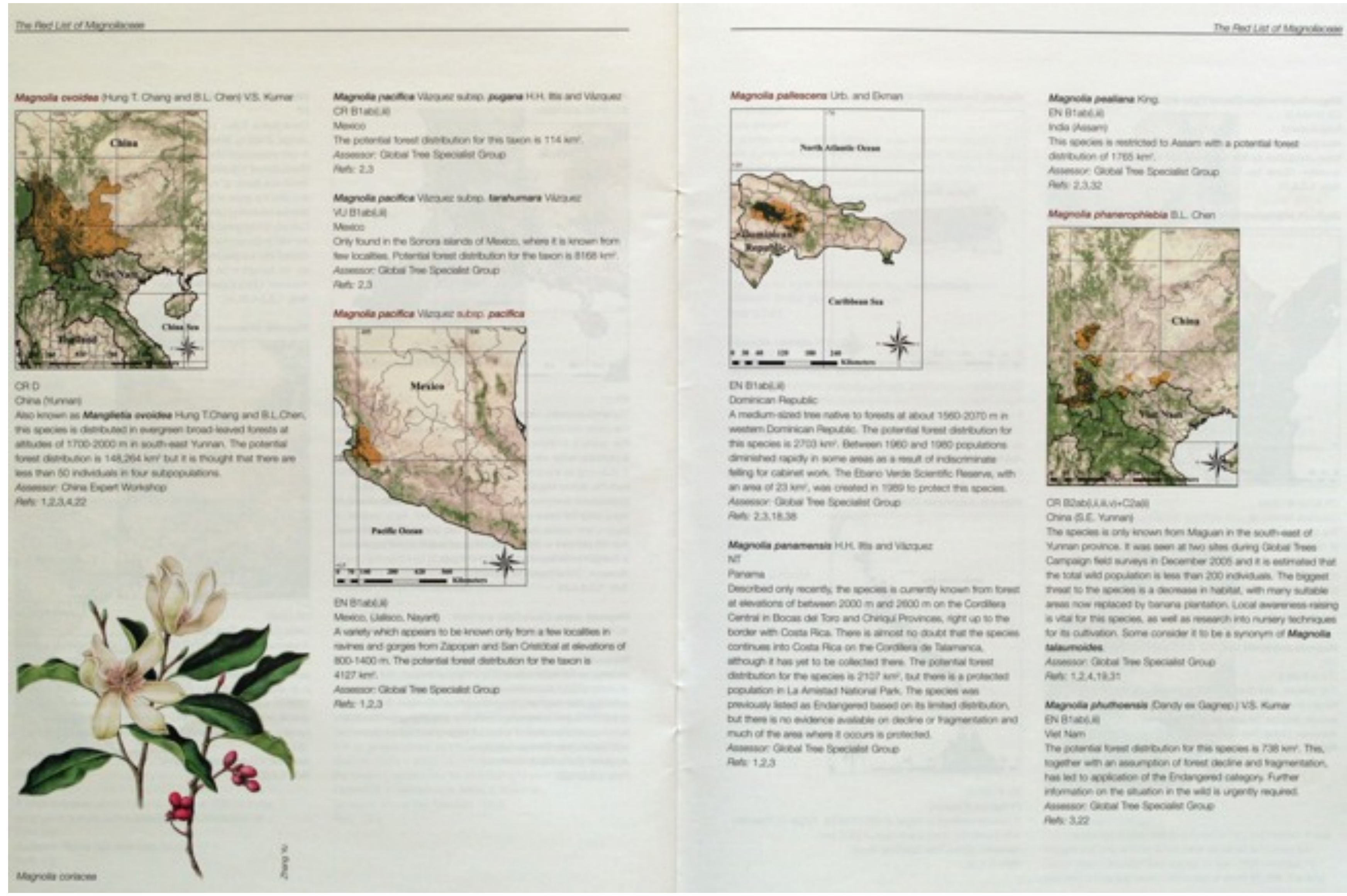
- The **full assessment is too slow**, so RapidList has been introduced to reduce the categories to **Extinct**, **Threatened**, **Not Threatened**, and **Data Deficient**

- See Schatz (2009) for more opinion & facts

FAUNA & FLORA International

BGCI Plants for the Planet

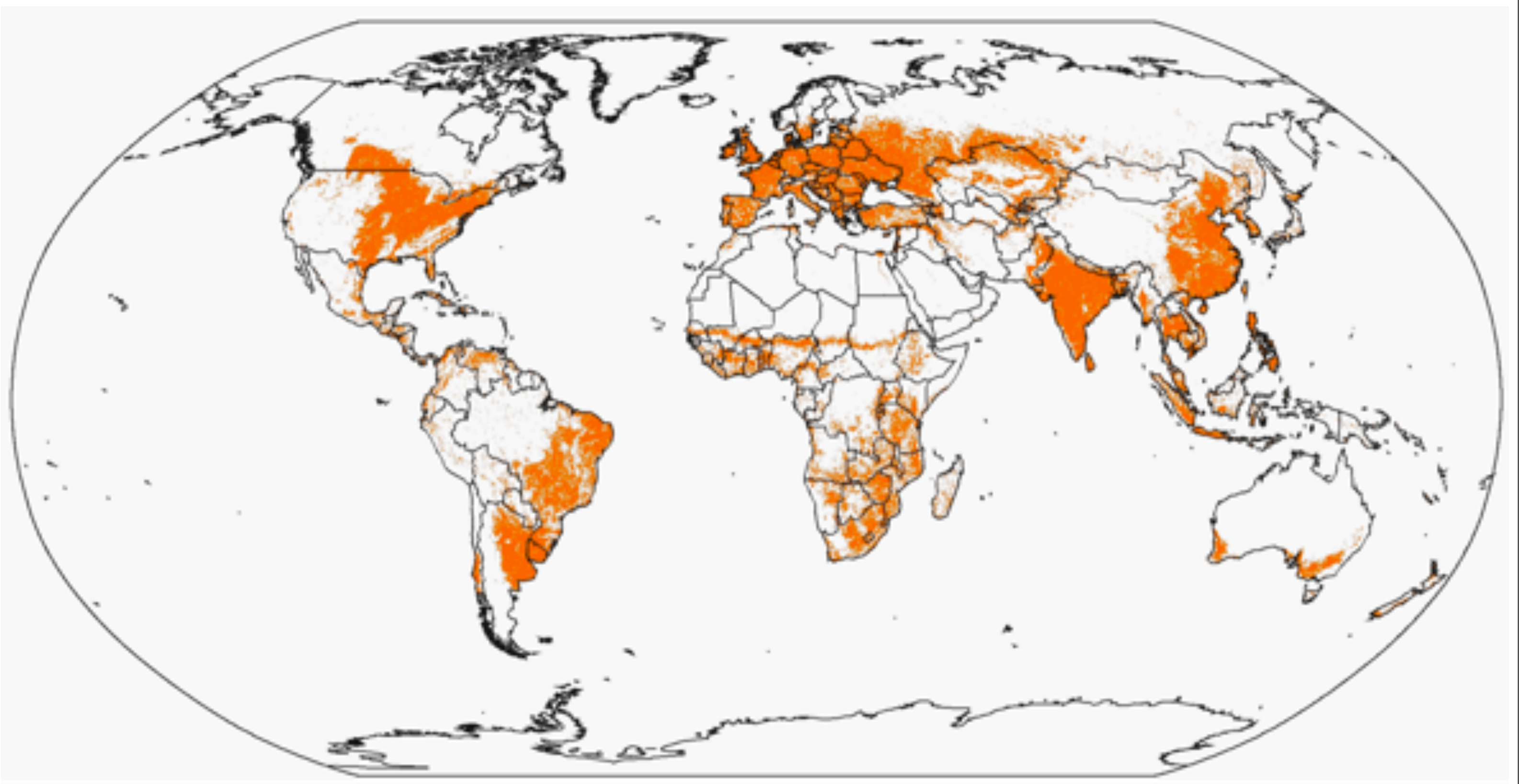
IUCN The World Conservation Union

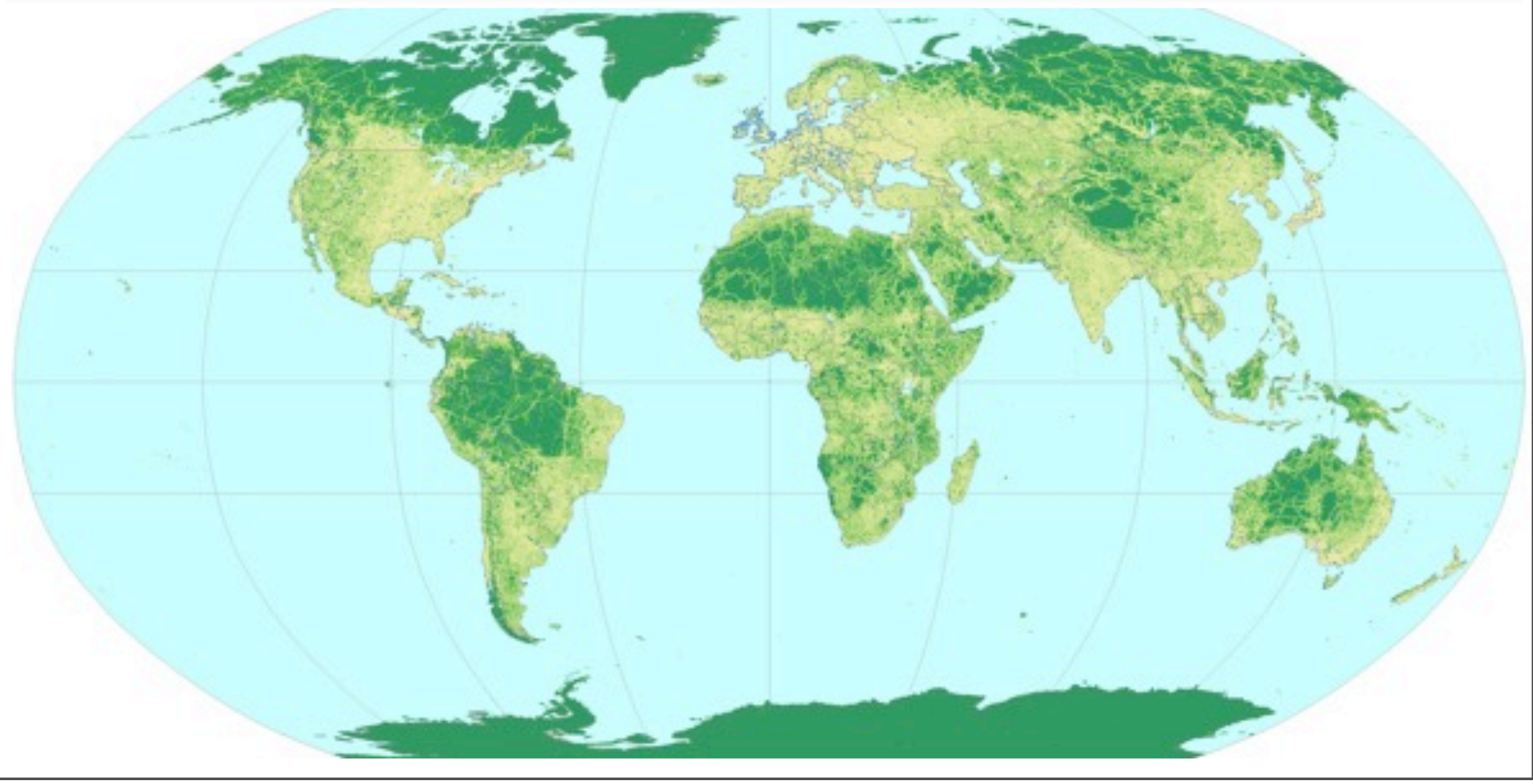


Monographic **Red Lists** - the way forward

Quercus, *Rhododendron*, *Acer* & *Magnolia* done

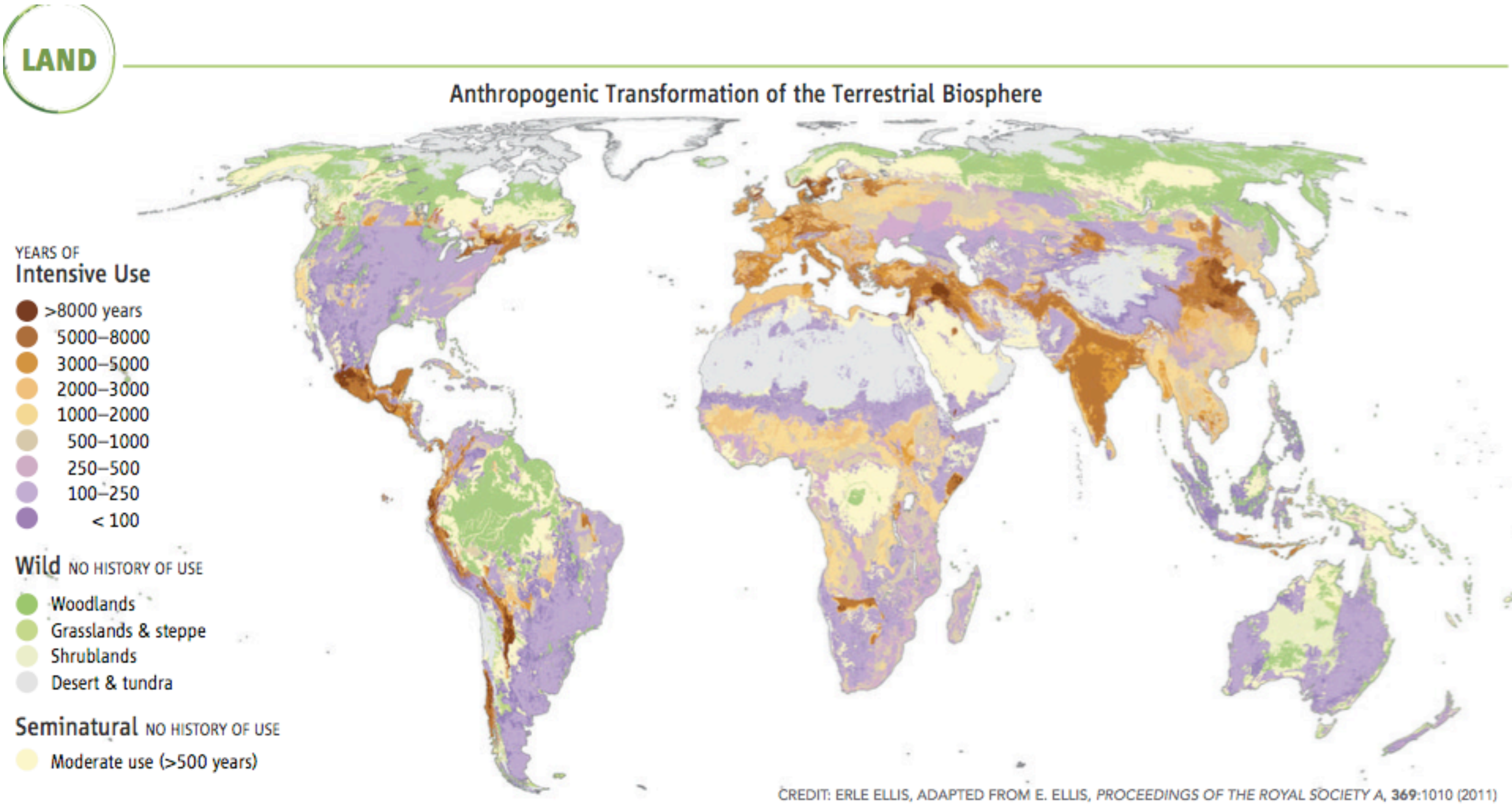
Economic pressures:
Too many people Too little land



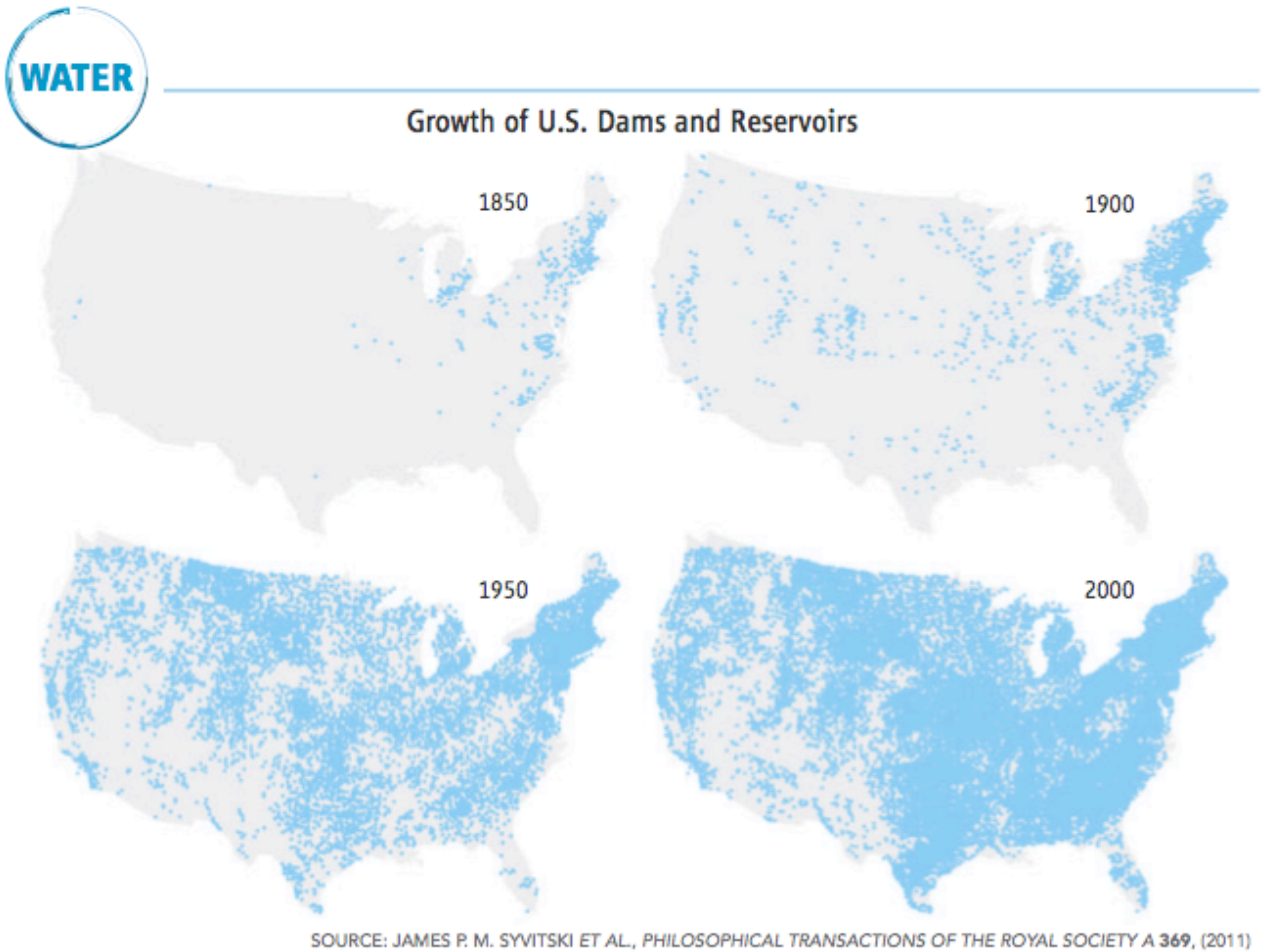


- Top - production lands
- Bottom - wilderness
  from lecture 6/16

Economic pressures:
Too many people Too little land



Economic pressures:
Too many people Too little land

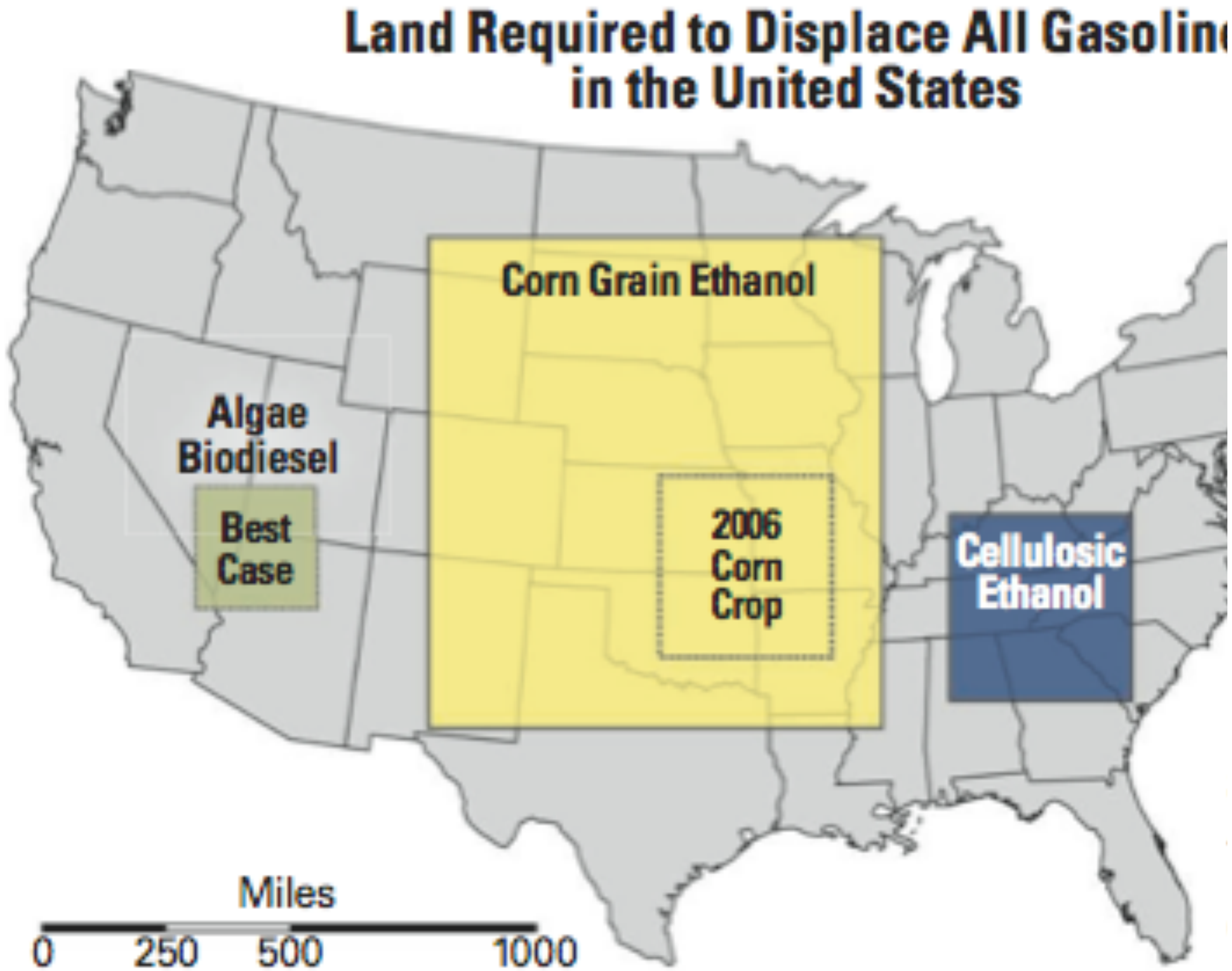


- The next dust bowl drought across America could come by 2050. Romm (2011)

Economic pressures: Biofuels

Service 2011

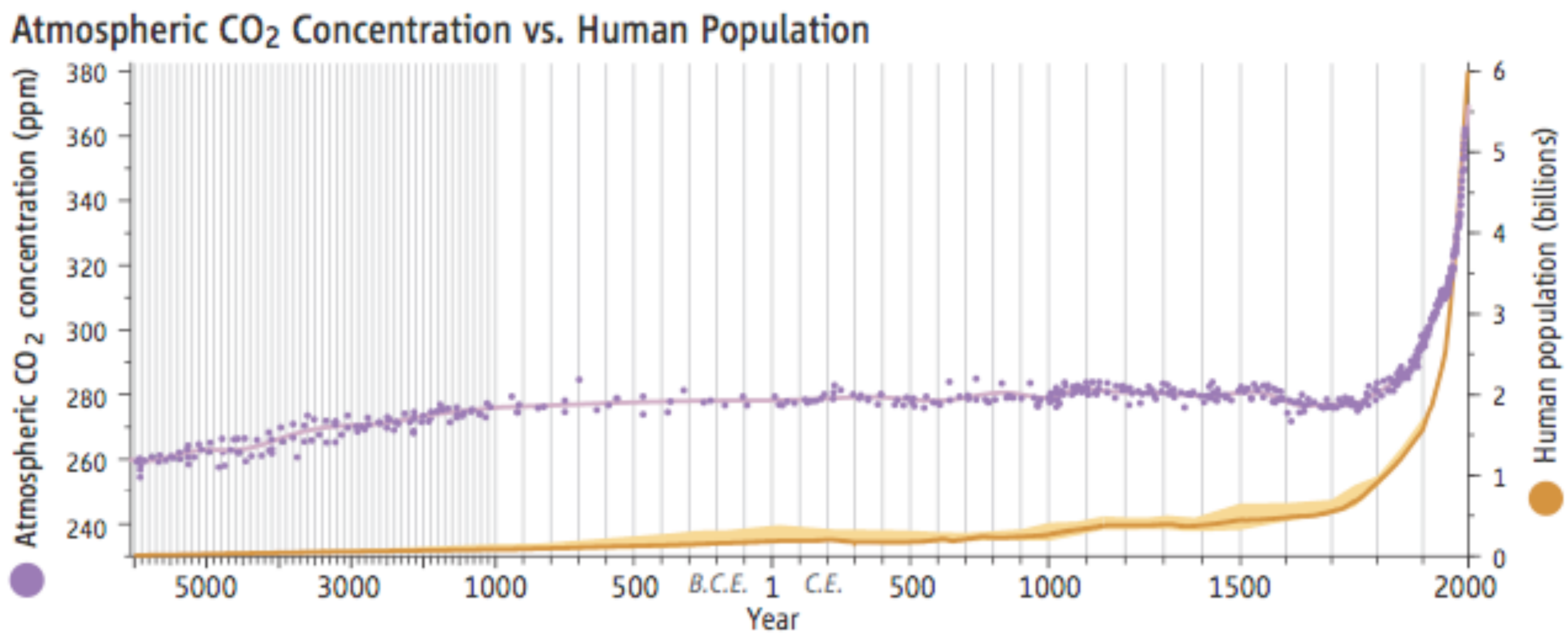
- **Algal-based biofuels** will require less land than alternatives
- Less fresh water is required for Algae biodiesel

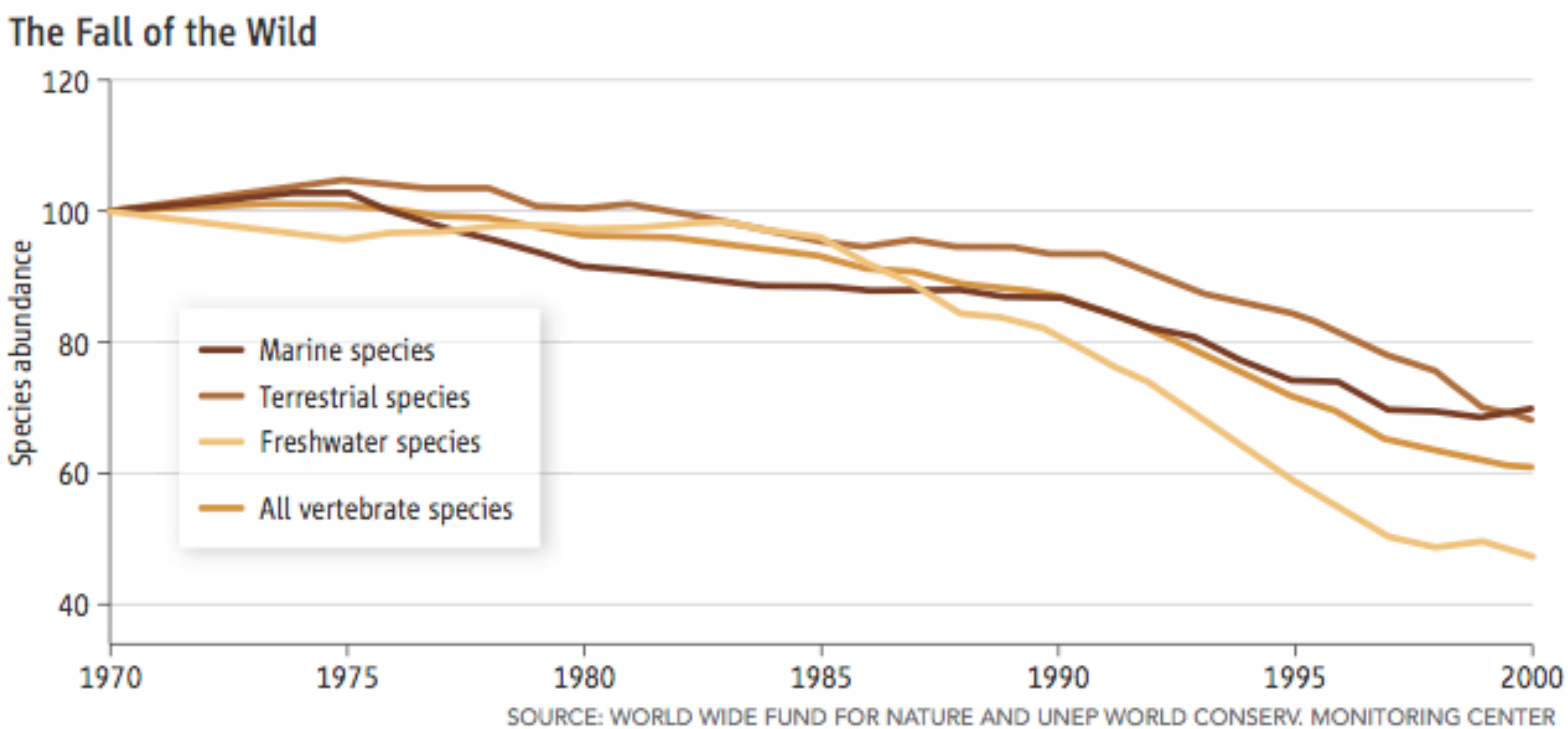


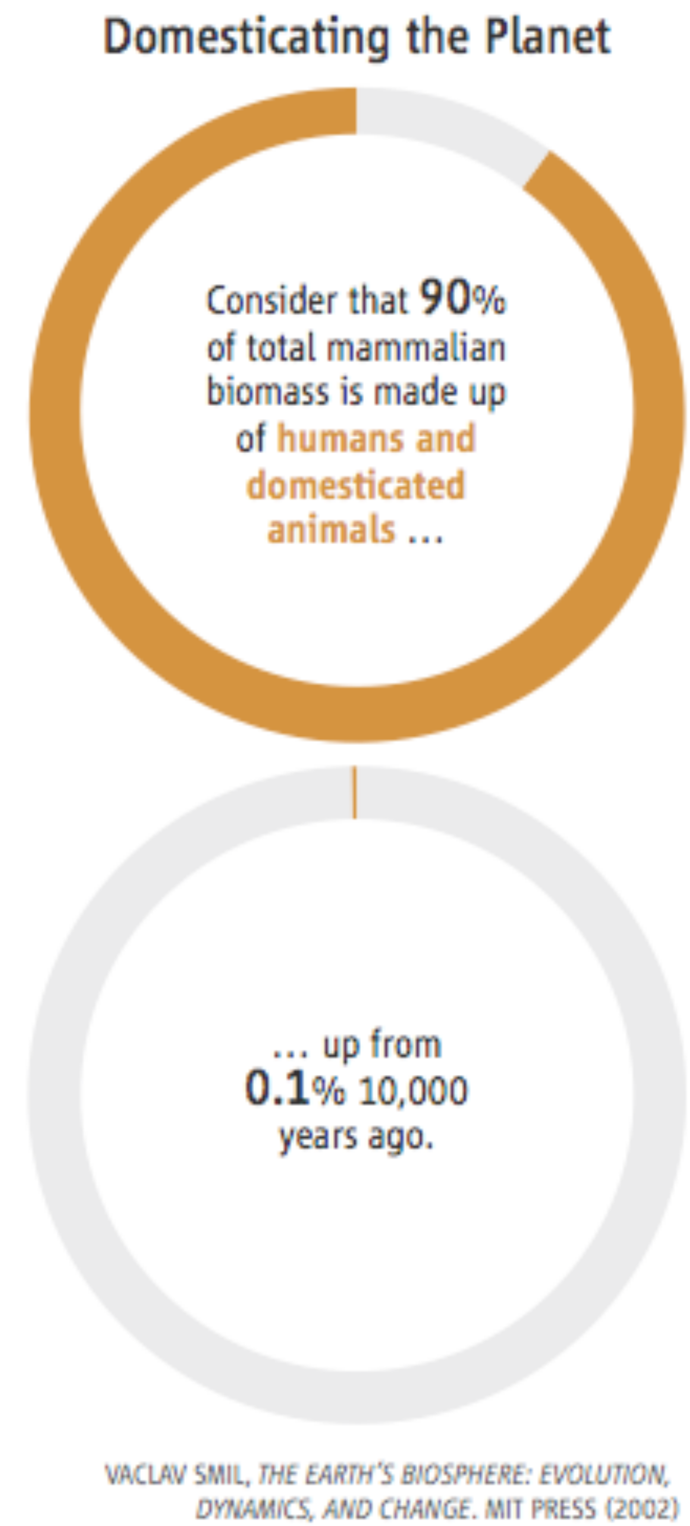
Competitive advantage. Fast-growing algae yield more fuel per hectare than other biofuel producers.

Economic pressures:

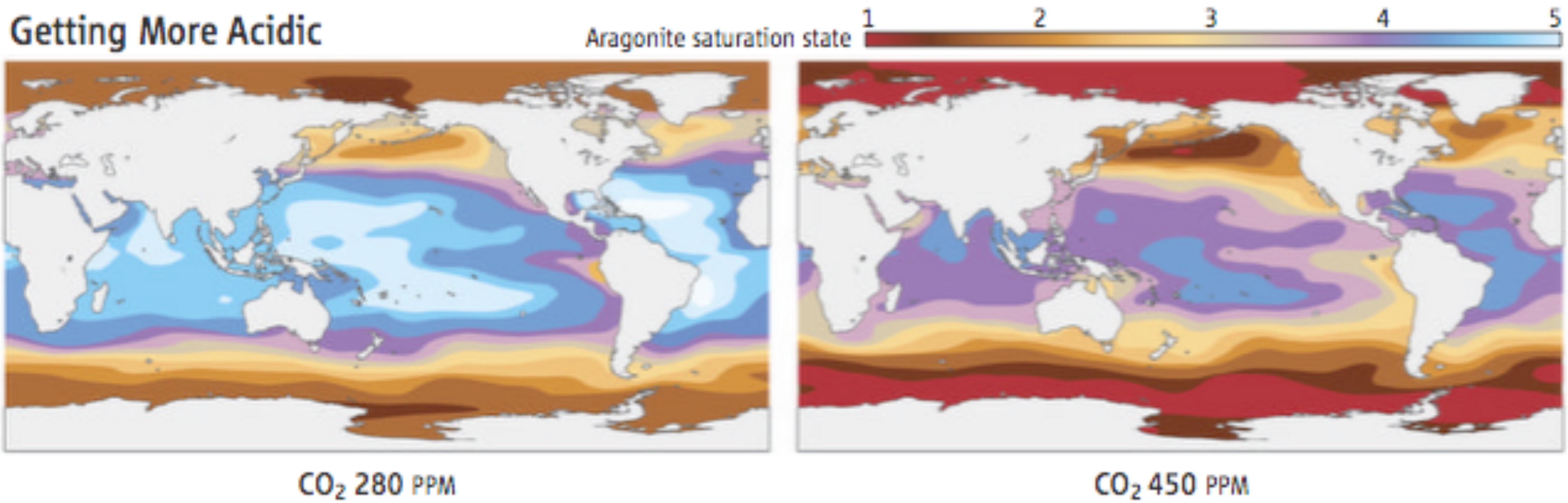
Too many people Too little land



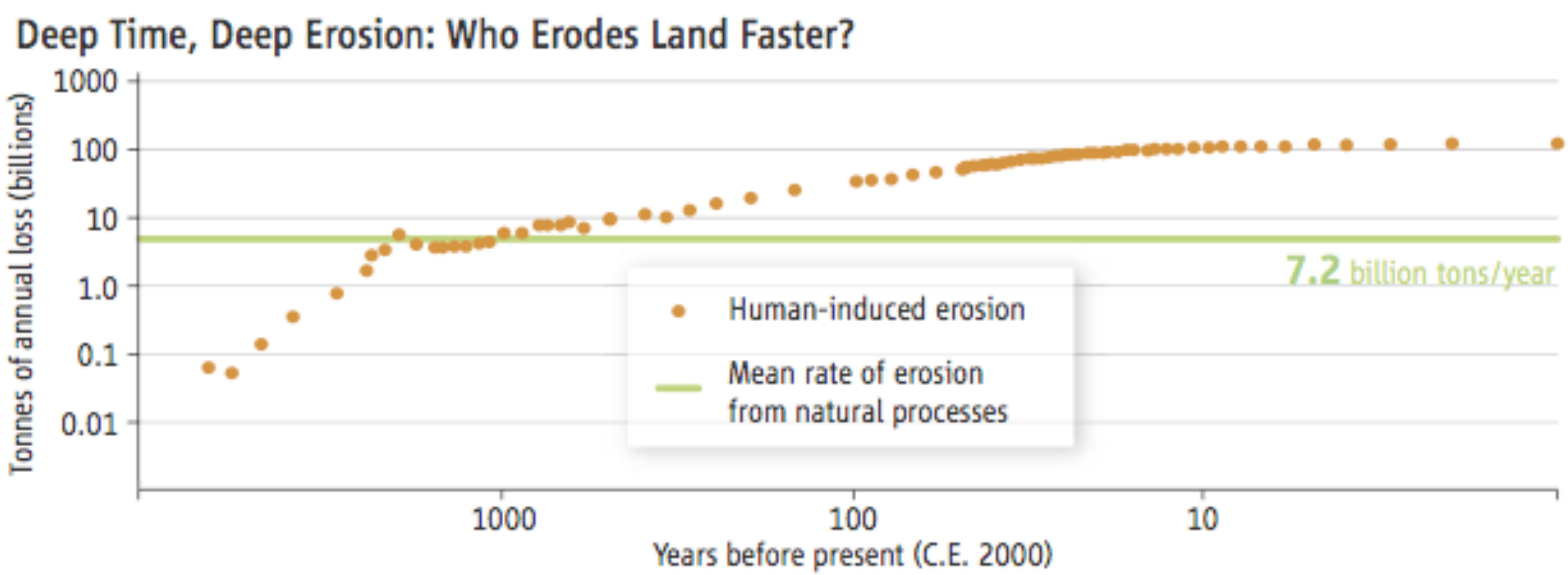




Economic pressures:
Too many people Too little land



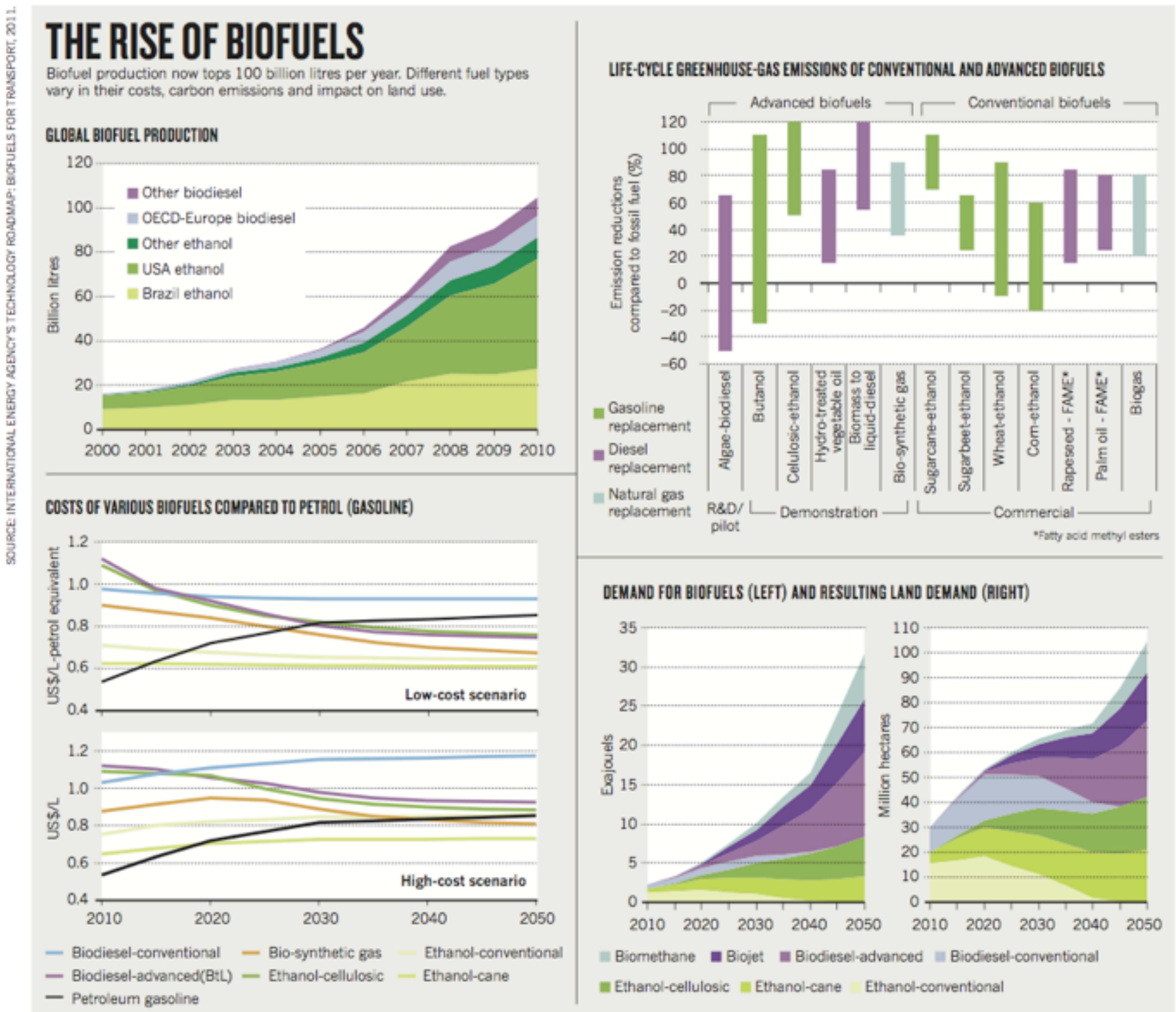
SOURCE: O. HOEGH-GULDBERG *ET AL.*, *SCIENCE* **318**, 5857 (14 DECEMBER 2007)



SOURCE: BRUCE H. WILKINSON, *GEOLOGY* **33**, 3 (MARCH 2005)

Economic pressures: Biofuels

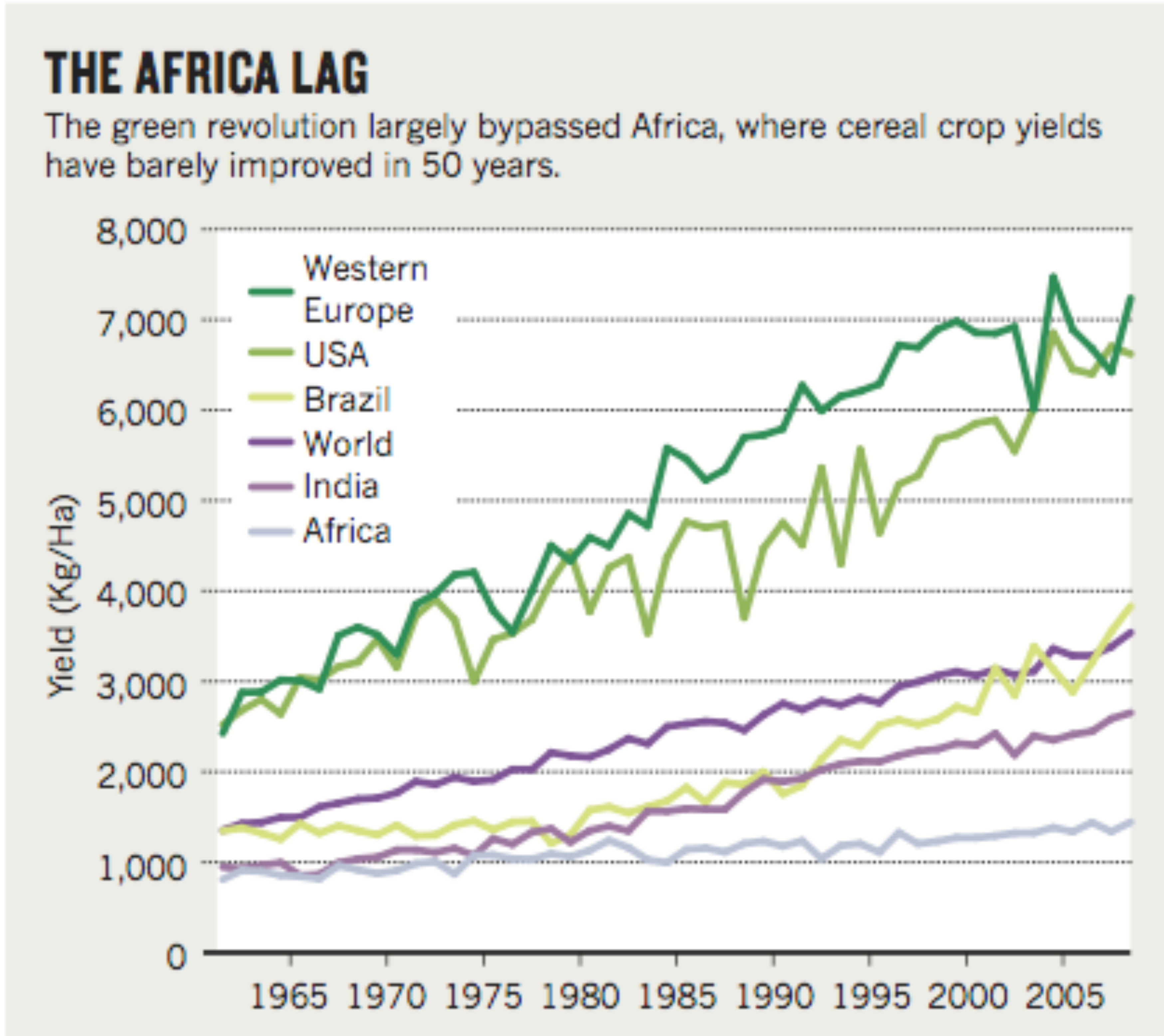
Nature Outlook Special **474** 23 June 2011



Economic pressures: Biofuels

Nature Outlook Special **474** 23 June 2011

- “**African countries might be able to benefit** from the production of bio-energy from non-edible crops grown on marginal land”
- the impact of this on the biology of the region has not been assessed



Economic pressures

Rubber Plantations (Mann 2009)

- Villages are having to move due to **rubber** plantations now covering 300,000 ha that are draining water from the wells as surface water run-off increased x3 & **soil erosion up by x45**
- 1976-2003 rubber expanded x10 & the tropical montane forest shrank by 80% to just 10% of Xishuangbanna.
- 1988-2003 saw **x10 increase in income** for farmers & by 2020 there will be a 10% underproduction of rubber worldwide.

If not rubber? Villagers in Ban Namma, Laos, are counting on rubber to pull them out of poverty; cleared fields in the nearby hills were being prepared for rubber plants.

Where the rubber meets the land. Morning fog hangs over a hillside cleared for rubber in Laos's Luang Namtha Province (*right*). Fog dissipates earlier in the day than in the past in the Golden Triangle, altering the area's hydrology. Young rubber trees in Xishuangbanna (*left*).

Ignorance:
Restoring forests & ecosystem services on degraded lands

Chazdon (2008) *Science* **320** p1458

- This is **not yet a precise science**
- In China, 28 Mha of plantation were established between 2001 & 2007. These can play a role in landscape restoration & faunal conservation **if** they are managed as **components of a heterogeneous landscape mosaic**
- Passive methods (doing nothing) can be more successful than intensive intervention
- **Local knowledge**, diverse species plantings (economic & ecological), & regional economic development strategies are essential for success

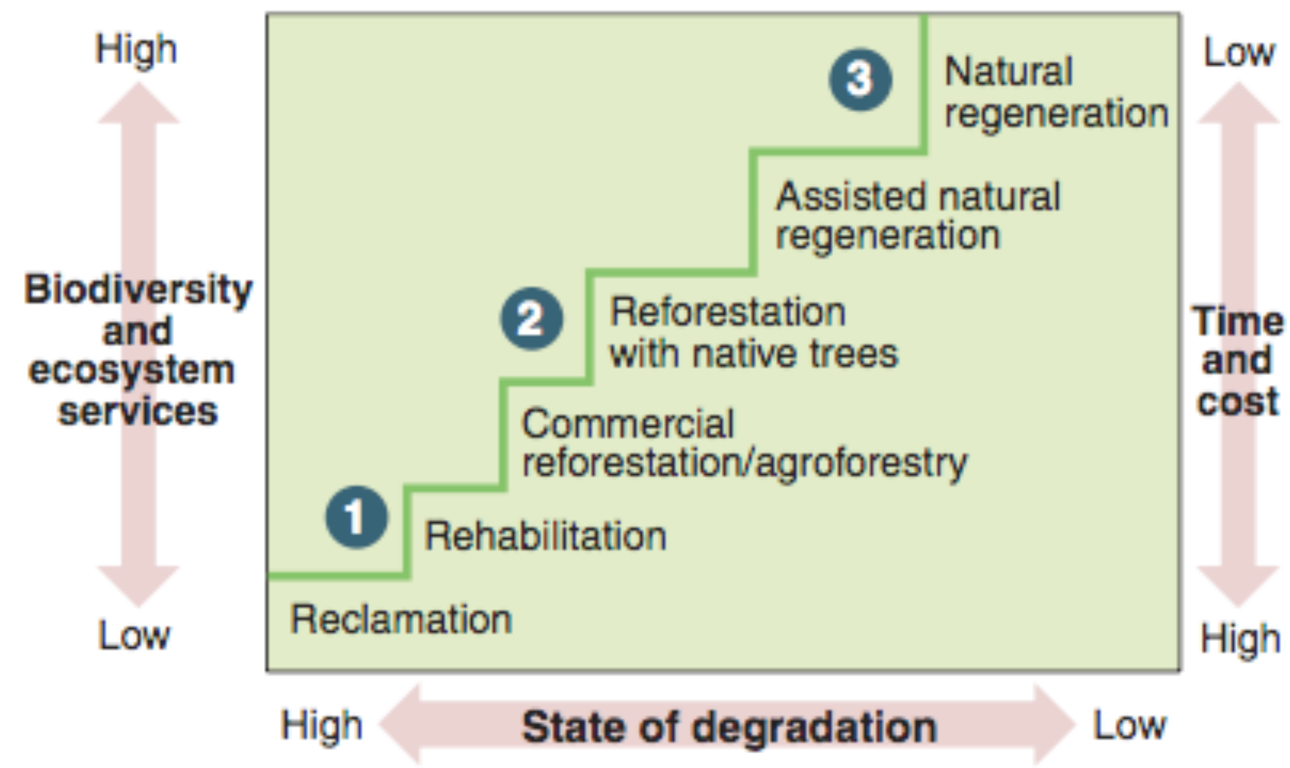


Fig. 1. The restoration staircase. Depending on the state of degradation of an initially forested ecosystem, a range of management approaches can at least partially restore levels of biodiversity and ecosystem services given adequate time (years) and financial investment (capital, infrastructure, and labor). Outcomes of particular restoration approaches are (1) restoration of soil fertility for agricultural or forestry use; (2) production of timber and nontimber forest products; or (3) recovery of biodiversity and ecosystem services.

Ignorance:
Terrestrial ecosystem responses to species gains & losses

Wardle *et al.* (2011) **332** p1273

- There is a new emphasis on **functional rather than taxonomic diversity**
- We know more about the affects of species gain (invasions) than we do about the loss of individual species
- **Loss & gain** are normal processes
- As a result we may see increased tolerance towards and use of non-native tree species in forests

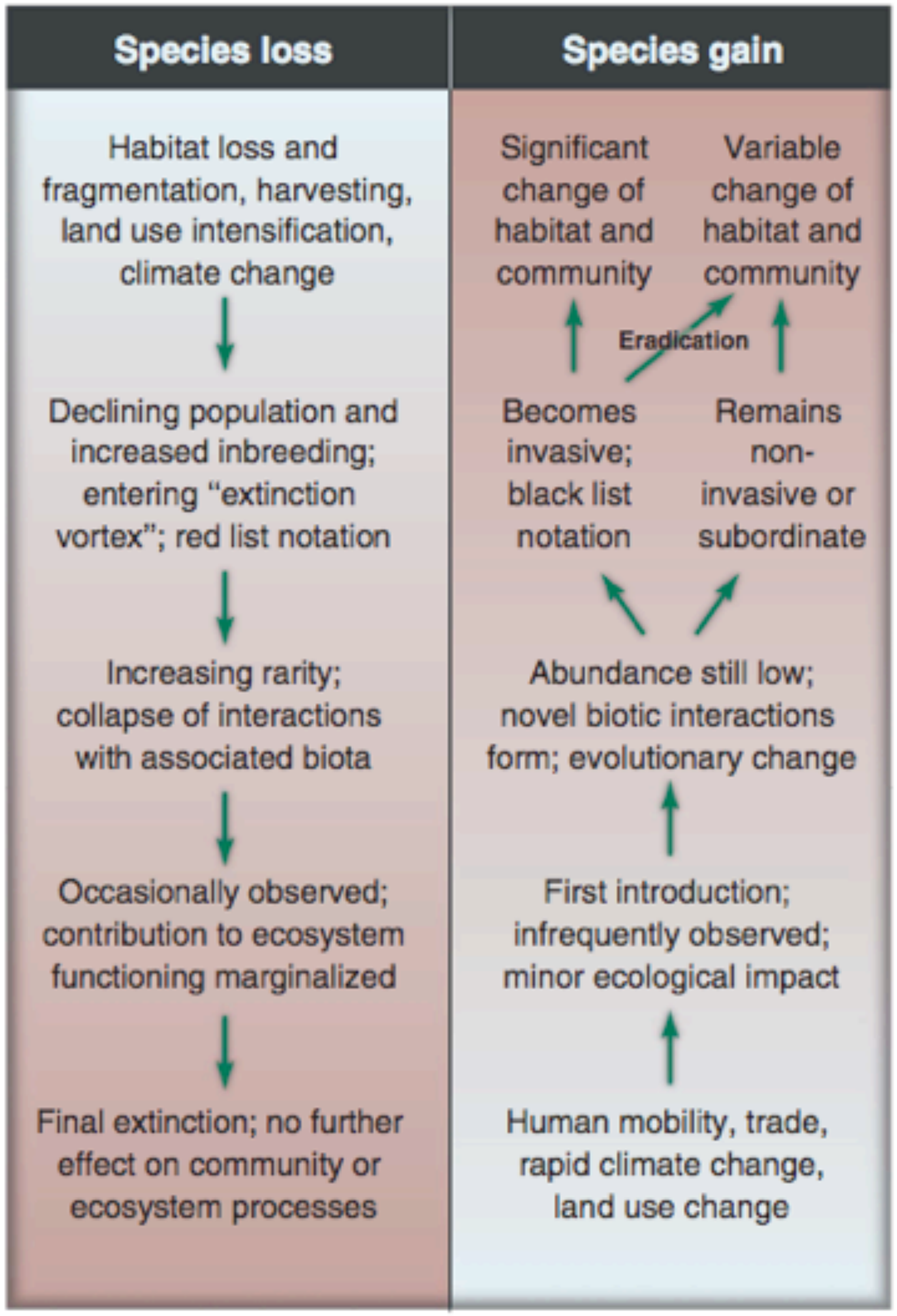
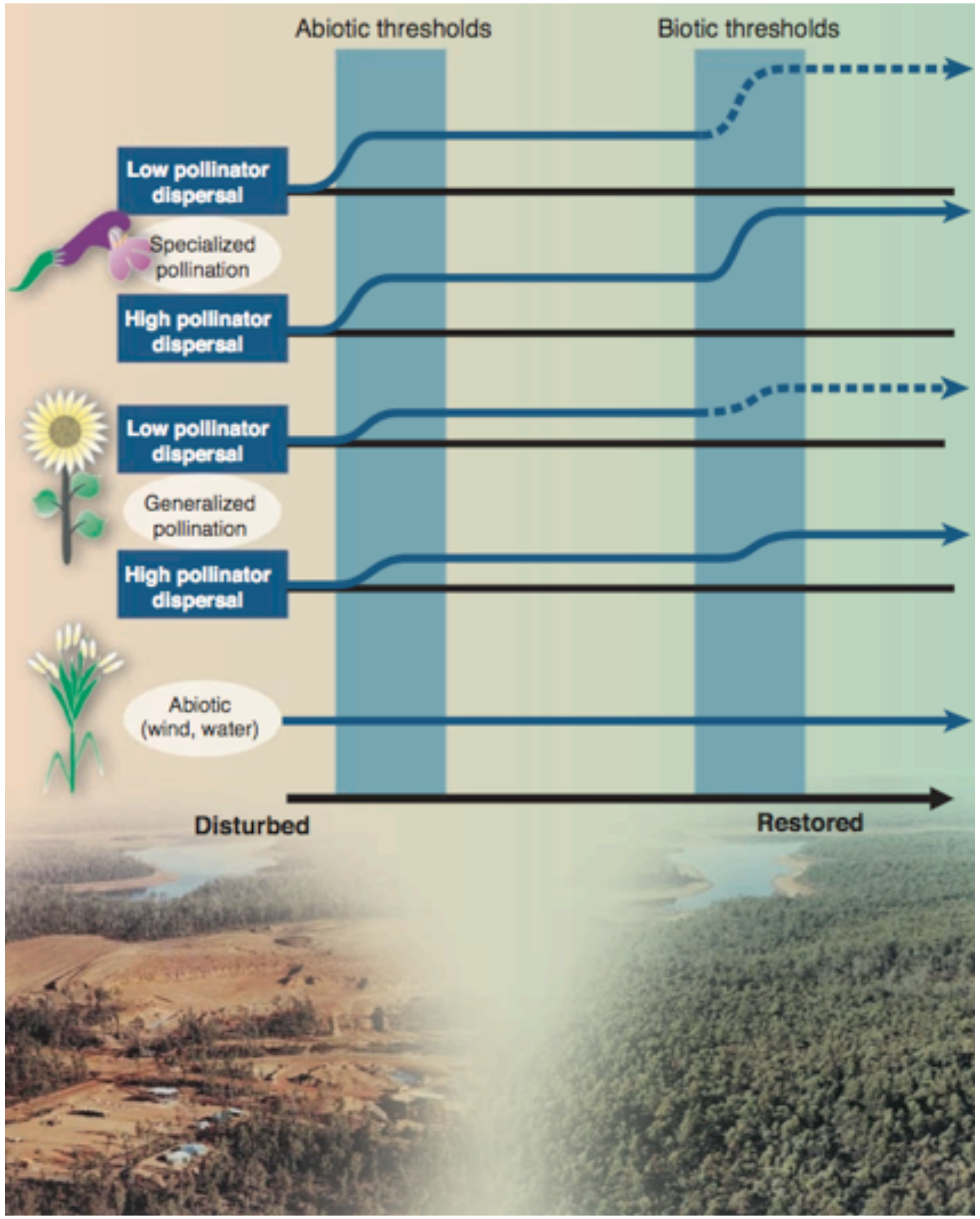


Fig. 1. The sequence of events generally associated with species loss and gain over time, revealing conceptual parallels and differences between the two processes.

Ignorance:

The role of pollinators in restoration Dixon 2009

- The re-establishment of pollinators in restored habitats is not always easy.
- Wind pollination is the least problematic
- **Generalised** pollination syndromes are easier to reestablish than **specialised** syndromes
- Pollinators that can move freely are easier to reestablish than those with limited dispersal potential
- dashed lines are where captive breeding and assisted migration is required



Ignorance:
The role of pollinators in restoration Dixon 2009

- Animal-based pollination services sustain reproductive potential & genetic resilience in ecosystems
- Specialised pollinators are often the **first casualties** of degraded ecosystems but the loss of generalised pollinators has a **more pervasive impact**
- **60%** of global landscape disturbed by humans are in the 25 biodiversity hotspots (Myers et al 2000)
- **70%** of the land in these 25 biodiversity hotspots has been cleared and fragmented
- Pollinators (both general and specialised) with **low dispersal potential** are especially at risk
- **plants in hotspots are more likely to have specialised pollinator syndromes**

Ignorance:
The role of pollinators in restoration Dixon 2009

- **Climate change** predicts a reduction in growing seasons especially in Mediterranean-type regions
- less precipitation, shifts in seasons, reduced plant vigour, delayed plant maturation & reduced nectar production, and asynchrony of pollinator & flowering, **affect pollinator populations negatively**
- Proximity of undisturbed habitats facilitates restoration project success, (such as at the Harcourt Arboretum in the previous lecture)
- Corridors are important as are **framework species** that provide a major amount of nectar & pollen, **bridging species** that provide resources in otherwise quiet times, and **magnet species** that have attractive flowers that bring in the pollinators for the drab flowers that would otherwise be missed
- Agricultural headlands are very important here

Ignorance:
The role of pollinators in restoration Dixon 2009

- Restoration of landscapes will depend on **understanding** the following:

- (1) the **dispersability & migration** of pollinators

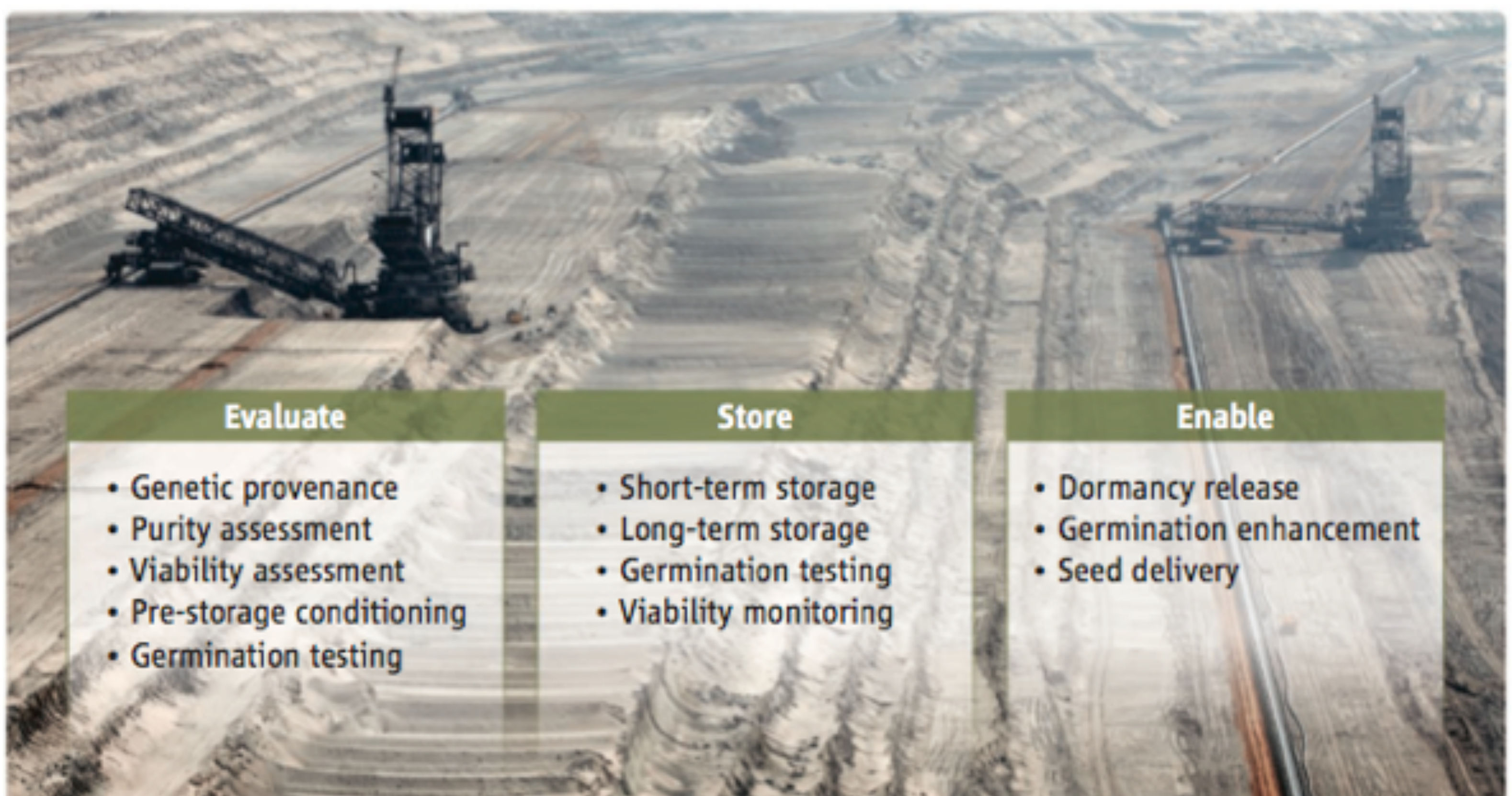
- (2) the plant species that **facilitate and assist** pollinator migration (the framework, bridging, & magnet species)

- (3) the **foraging patterns** of pollinators in relation to seed quality and heterozygosity

Economics: restoration seed banks - a matter of scale

Merritt & Dixon (2011) *Science* **332** p424

- The **Gondwana Link** project aims to restore 10,000s ha of former farmland creating a corridor over 1,000 km long.
- **Pilbara** 20,000 ha of former mine to be restored. At 6kg/ha & $749 per kg the cost of seeds is **M$89.88**. It needs **120 tonnes of seed**.
- Few if any seed banks contain this amount of seed



Integrated seed curation and research functions of a restoration seedbank.

Ignorance: restoration seed banks - a matter of scale

Merritt & Dixon (2011) *Science* **332** p424

- *Shortfalls in seed banks for restoration include:*
- lack of knowledge of **seed phenology**, development & maturation to optimise collection times
- lack of accurate **data**
- inability to break **dormancy**
- poor **storage** procedures
- **low seedling establishment** (often <10%)
- insufficient stock
- lack of collecting capacity when required *Science* **330** p584 (right)

Dipterocarp tree seedlings. Many endangered Indonesian trees rarely produce seeds.

Economics:
Non-native species Norton (2009) *Science* **325** p569

- Species invasions impose key **biotic** thresholds limiting the success of ecological restoration programmes. **Abiotic thresholds are easier to reverse**

- The thresholds are often **permanent** such as local/global extinctions of seeds dispersers (*right*) or **long-term, unending, & expensive** due to on-going control of the invading species

- New Zealand is a good large model in which to study the role of non-native invasive species. To date 30 mammals, 34 birds, 2000 inverts & 2200 plants are fully naturalised.

- **Only some mammals and some plants can be controlled**. An absence of natural enemies & inherent adaptation to anthropogenic disturbance, including grazing, favours these species.

Fig. 1. Forest canopy trees such as *Beilschmiedia tawa* are dependent on kereru (*H. novaeseelandiae*) for dispersal of their large (>1.4 cm in diameter) fruits, because other potential dispersers are extinct or very rare. [Photos: D. Norton and A. McIntosh]

Economics:

Non-native species Norton (2009) *Science* **325** p569

- **Species invasions may be positive**. European gorse can act a nurse plant in restoration projects (*right*) as the gorse shades out the invasive grasses that would prevent the *Pittosporum eugenioides* from regenerating. But later intervention is required to introduce late successional species
- Removing grazing may allow other invasive plant species to proliferate. *Olearia adenocarpa* is being eliminated by grazing but without grazing the invasive grasses swamp seedlings of the *Olearia*.

Fig. 2. Seedling of the native forest tree *Pittosporum eugenioides* regenerating under a canopy of the invasive woody weed gorse (*U. europaeus*) that has become established on abandoned farmland. As the gorse senesces, native forest species will replace it, although the subsequent forest composition may be different from that which develops through a succession dominated by native successional species. [Photo: D. Norton]

Economics:

Non-native species Norton (2009) *Science* **325** p569

- Restoration is an essential strategy in the conservation tool box but if **a non-native invasive species** is one of the biotic problems then there are three general predictions
- **(1)** outcomes will be **novel** because the exotic species will never be eradicated and several exotic species may be part of the community
- **(2)** where there are multiple invasions **all the invasives** will need to be controlled because removing only one will facilitate another
- **(3)** where eradication is not possible then to factor in ongoing control indefinitely - **long-term resource commitment**.

Economics:

Non-native species in the UK Carpenter (2011) *Science* **332** p781

- At the end of 2011 the Scottish Parliament allocated £15M to Forestry Commission Scotland to rid 66,000 ha of *Rhododendron ponticum.* This is **also** to slow the spread of *Phytophthora ramorum*

- Japanese knotweed (*Fallopia japonica*) partial eradication costs $288M *per annum* (Olympic Park £70M alone) & a total of £2B *per annum* for all invasives

- The **first release** of a pest against a weed in the EU. *Aphalara itadori*, a psyllid or louse that appears to be host specific. If it reduces the knotweed by 1% it will pay for itself

Horizon-scanning for invasive non-native plants in GB

Sophie Thomas PlantLife (2011)
http://www.plantlife.org.uk/publications

- In 2010 PlantLife published **Here today Here tomorrow** report with a Rapid Risk Assessment that gave a star rating to 599 non-native plant species

Of the 599 non-native freshwater and terrestrial plants that have already been assessed by Plantlife and the Freshwater Biological Association (under a contract from Plantlife):

92 are given a 5-star 'Critical' ranking: Plantlife recommends as a matter of priority that they are subject to the more detailed risk assessment, as commissioned by the GB Non-Native Species Secretariat;

55 are ranked 'Urgent' (4 star): Plantlife highly recommends they are subject to the more detailed risk assessment;

72 are ranked 'Moderate Risk' (3 star): Plantlife recommends they are subject to the more detailed risk assessment; and

380 are ranked 'Low Risk' (1 star): no further assessment is considered necessary at present.

Ranks assigned to each plant are listed on pages 13-18.

Horizon-scanning for invasive non-native plants in GB

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Latin name*	Common name	Star rating
Geranium ibericum x platypetalum	Caucasian crane's-bill	★
Geranium macrorrhizum	Rock crane's-bill	★
Glossostigma diandrum		★★★★★
Glossostigma elatinoides		★★★
Gratiola officinalis	Hedge hyssop	★★★
Griselinia littoralis	New Zealand broadleaf	★
Gunnera tinctoria	Giant-rhubarb	★★★★
Gymnocoronis spilanthoides	Senegal tea plant	★★★
Hebe brachysiphon	Hooker's hebe	★
Hebe dieffenbachii	Dieffenbach's hebe	★
Hedera colchica	Persian ivy	★★★★★
Helianthus annuus	Sunflower	★
Helleborus argutifolius	Corsican hellebore	★
Helleborus orientalis	Lenten-rose	★
Hemianthus callitrichoides	Pearl grass	★
Hemianthus micranthemoides	Nuttalls' mudflower	★
Hemigraphis colorata	Purple waffle	★
Hemigraphis exotica		★
Heteranthera bettzinckiana		★
Heteranthera dubia	Buffalo grass	★
Heteranthera zosterifolia	Stargrass	★
Heuchera sanguinea	Coralbells	★
Holodiscus discolor	Oceanspray	★
Hottonia inflata	Featherfoil	★
Houttuynia cordata	Lizard tail	★★★★★
Hyacinthoides hispanica x	Spanish bluebell	★★★★★

Latin name*	Common name	Star rating
Iris orientalis	Turkish iris	★★★★
Isoetes japonica		★
Isoetes velata		★
Juncus 'Curly Gold Strike'		★
Juncus decipiens 'Curly-wurly'		★
Juncus ensifolius	Swordleaf rush	★★★★★
Juncus 'Goldstrike'		★
Juncus repens	Lesser creeping rush	★
Juncus xiphioides	Iris-leaved rush	★★★★
Kerria japonica	Kerria	★★★
Kniphofia uvaria	Red-hot-poker	★★★★
Kniphofia x praecox	Greater red-hot-poker	★★★★
Lagarosiphon major	Curly waterweed	★★★★★
Lagarosiphon muscoides		★★★★★
Lagenandra ovata	Malayan sword	★
Lagenandra thwaitesii		★
Lamiastrum galeobdolon subsp. *argentatum*	Variegated yellow archangel	★★★★★
Laurus nobilis	Bay	★★★★★
Lavandula angustifolia x latifolia	Garden lavender	★
Lemna minuta	Least duckweed	★★★★
Ligustrum ovalifolium	Garden privet	★★★★★
Lilaeopsis brasiliensis	Brazilian microsword	★
Lilaeopsis mauritiana		★
Lilaeopsis novae-zelandiae		★
Limnobium laevigatum	Amazon frogbit	★
Limnobium spongia	American spongeplant	★★★★★

Horizon-scanning for invasive non-native plants in GB

Sophie Thomas PlantLife (2011)

http://www.plantlife.org.uk/publications

Plantlife

Esmée Fairbairn Foundation · Natural England · fba Freshwater Biological Association

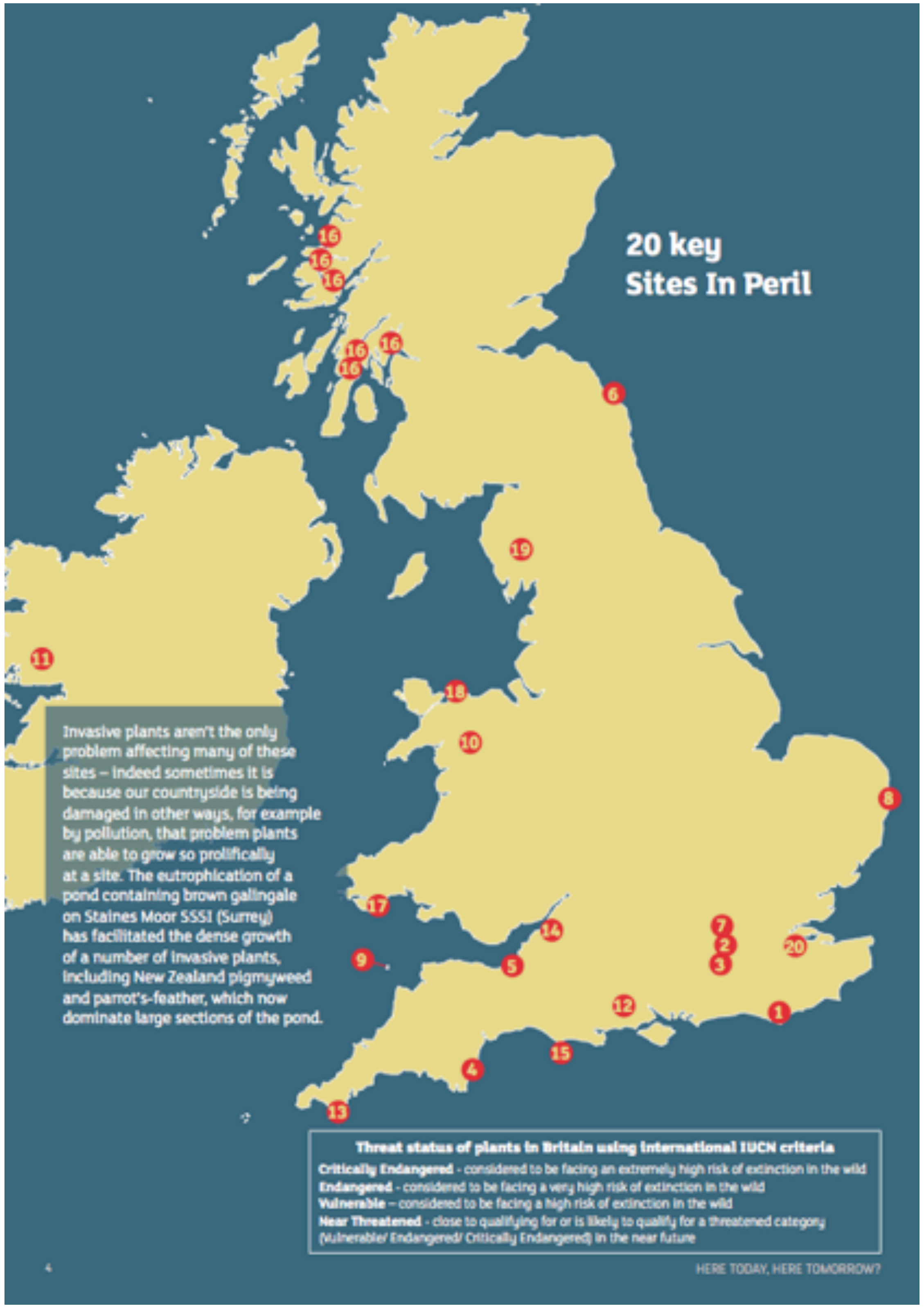
Question	Maximum score
Q1. What is its rate of spread in the UK?	4
Q2. To what climate is the plant suited?	3
Q3. Is it an environmental weed in natural and valued habitats/designated sites?	4
Q4. Has the plant become naturalised where grown (globally)?	2
Q5. Does the plant have a history of repeated cultivation (and associated introductions) in the UK?	2
Q6. Is the plant naturalised beyond its native range?	2
Q7. Is it a congeneric weed?	2
Q8. Is it unpalatable to grazing animals (including for reasons of toxicity/spines/thorns)?	1
Q9. Can it tolerate a wide range of soil conditions (within the aquatic or terrestrial system)?	1
Q10. Does it have a climbing or smothering growth habit, and/or form dense thickets?	4
Q11. Does/can it produce viable seed in the UK?	1
Q12. Does/can it reproduce by vegetative fragmentation?	2
Q13. What is its minimum generative time (years)?	1
Q14. Are propagules (likely to be) dispersed unintentionally (plants growing in heavily trafficked areas)?	1
Q15. Are propagules (likely to be) dispersed intentionally by people?	1
Q16. Are propagules (likely to be) dispersed as a produce contaminant?	1
Q17. Are propagules adapted to wind dispersal?	1
Q18. Are propagules water dispersed?	1
Q19. Are propagules bird/other animal dispersed?	1
Q20. Does the plant have prolific seed production?	1
Q21. Is there evidence that a persistent propagule bank is formed (at least 1 year)?	1
Q22. Does it tolerate or benefit from mutilation/cultivation/herbicides?	1

Horizon-scanning for invasive non-native plants in GB

Sophie Thomas PlantLife (2011)

http://www.plantlife.org.uk/publications

- In 2010 PlantLife published *Here today Here tomorrow* report which identified not only problem **species and sites at particular risk**



Economics: Embracing invasives in the Galapagos

Vince (2011) *Science* 331 p1383

- English blackberries cover 30,000 ha & reduce species diversity by 50% in these places. Darwin found 17 spp in 1835, now there are 900 spp and yet **95% of the native species are still there**.
- A $1M programme to eliminate 34 plant species only worked for four. Disturbance caused by restoration programmes have facilitated new invasions. BUT in heavily impacted areas the **invasives can stabilise soil, reduce water run off and create shade**
- In Puerto Rico a study shows that **invaded ecosystems are NOT static** and that natives do return
- Hobbs *et al* (2006 - Global Ecology & Biogeography) suggested that **novel ecosystems can supply ecological services** such a nutrient recycling & pollinator nutrients & **hybrid ecosystems can be more diverse than undisturbed areas**.
- **Don't judge species on their origins** Davis *et al* (2011) *Native* **474** p153 **WORTH READING**

Ignorance: Political targets & Biological needs

- The evidence reviewed here (Svancara et al. (2005) *BioScience* vol.55 No.11) suggests that the average percentages of area recommended for evidence-based targets were nearly **three times** as high as those recommended in policy-driven approaches.

- However, the evidence here (He & Hubbell (2011) *Nature* **368** p368) shows that extinctions caused by habitat loss require greater loss of habitat than previously thought. The **over estimate** can be higher than 160%

Ignorance: Political targets & Biological results

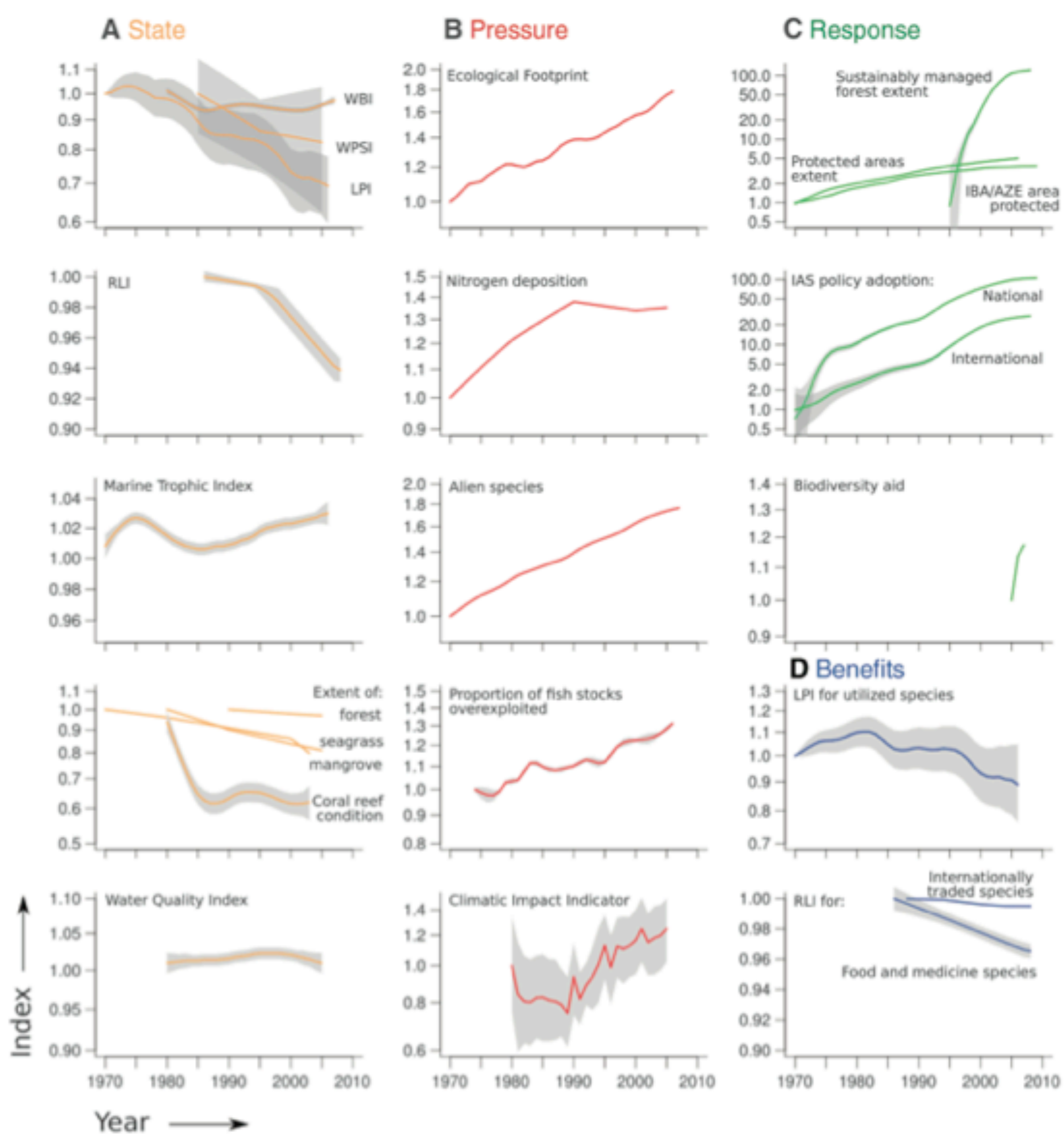
Butchart *et al* (2010) *Science* **328** p1164

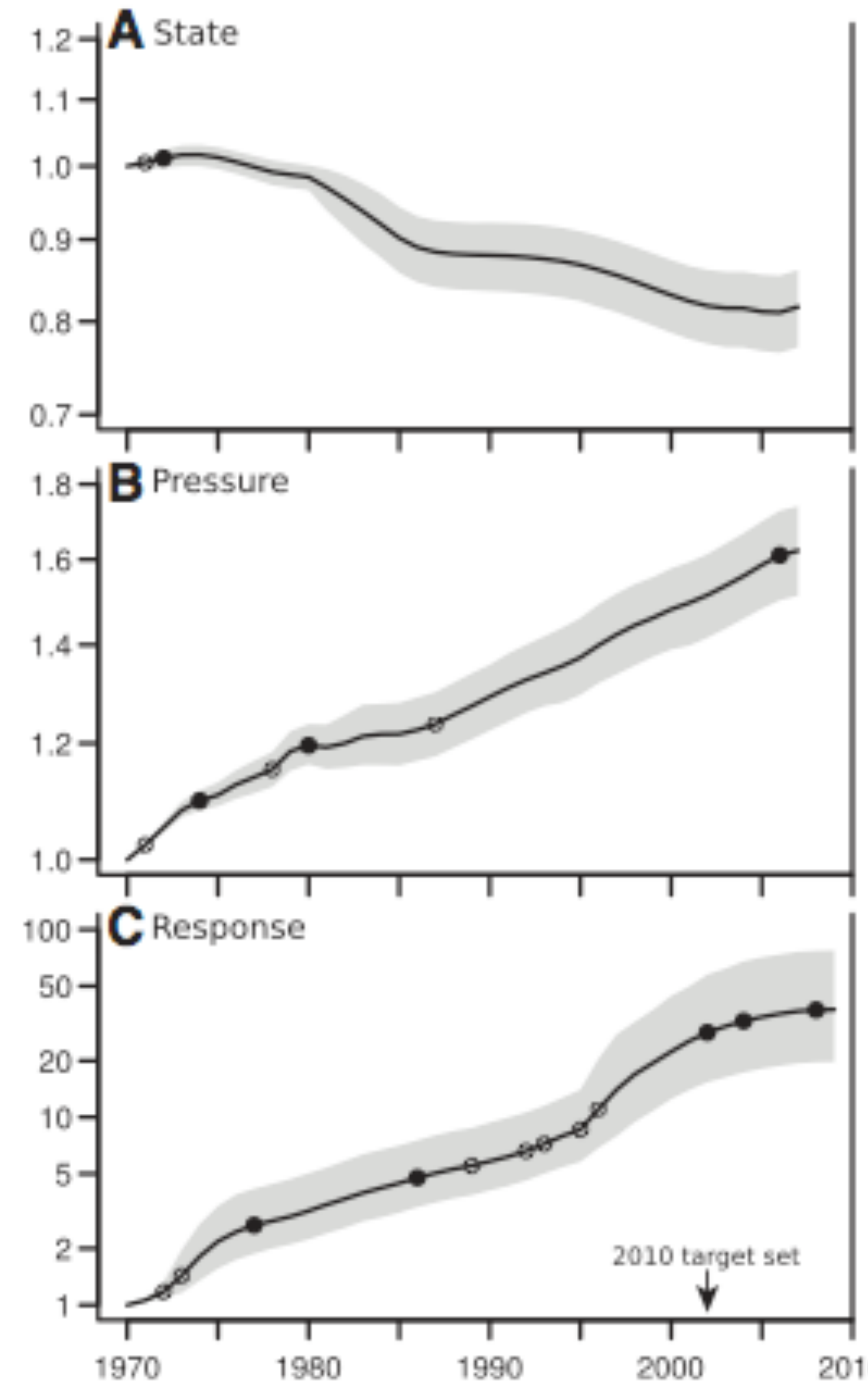
Table 2. Examples of successes and positive trends relevant to the 2010 target (*5*).

Indicator	Successes and positive trends
	State
Living Planet Index of Palearctic vertebrate populations	Increased by 43% since 1970 (e.g., Eurasian beaver and common buzzard)
Waterbird populations in North America and Europe	Increased by 44% since 1980 owing to wetland protection and sustainable management (but populations remain below historic levels).
Species downlisted on the IUCN Red List	Species qualifying for downlisting to lower categories of extinction risk owing to successful conservation action include 33 birds since 1988 (e.g., Lear's macaw), 25 mammals since 1996 (e.g., European bison), and 5 amphibians since 1980 (e.g., Mallorcan midwife toad).
Wild Bird Index and Red List Index for species listed on the European Union Birds Directive	Annex 1–listed species' population trends have improved in EU countries (*27*) and extinction risk reduced (RLI increased 0.46% during 1994–2004) owing to designation of Special Protected Areas and implementation of Species Action Plans under the directive (e.g., white-tailed eagle).
Extinctions prevented	At least 16 bird species extinctions were prevented by conservation actions during 1994–2004, e.g., black stilt (*28*).
Water Quality Index in Asia	Improved by 7.4% since 1970.
	Pressures
Deforestation in Amazonian Brazil	Slowed from 2.8 million ha in 2003–2004 to 1.3 million ha in 2007–2008, but it is uncertain to what extent this was driven by improved enforcement of legislation versus reduced demand owing to economic slowdown.
	Responses
National biodiversity strategies and action plans (NBSAPs)	87% of countries have now developed NBSAPs and therefore have outlined coherent plans for tackling biodiversity loss at the national scale.
Protected areas (PAs)	Nearly 133,000 PAs designated, now covering 25.8 million km^2: 12% of the terrestrial surface (but only 0.5% of oceans and 5.9% of territorial seas), e.g., Juruena National Park, Brazil, designated in 2006, covering 19,700 km^2 of Amazon/cerrado habitat.
Invasive alien species (IAS) policy, eradication, and control	82% of eligible countries have signed international agreements relevant to preventing the spread and promoting the control/eradication of IAS. Successful eradications/control of IAS include pigs on Clipperton Atoll, France (benefiting seabirds and land crabs), cats, goats and sheep on Natividad, Mexico (benefiting black-vented shearwater), and red fox in southwest Australia (benefiting western brush wallaby).
Official development assistance for biodiversity	Increased to at least US$3.13 billion in 2007.

Ignorance: Political targets & Biological results

Butchart *et al* (2010) *Science* **328** p1164





Ignorance: Political targets & Biological needs

Butchart *et al* (2010) *Science* **328** p1164

- While, there have been encouraging achievement between 2000 & 2010 to reverse the loss of biodiversity more needs to be done in the following areas:
- **(1)** reversing detrimental **policies**,
- **(2)** full integration of biodiversity into broad-scale, land-use **planning**
- **(3)** incorporation of the **economic** value of biodiversity into decision making
- **(4)** accurate **targeting**, sufficient funding, & implementation of policies that tackle biodiversity loss
- **(5) sustained investment** in coherent biodiversity monitoring and in the indicators needed to track & improve the efficiency of these responses

Setting global biodiversity conservation priorities

Brooks *et al.* (2006) *Science* **313** p58

- However, which ever measure you use, the same areas come out as priorities: Mediterranean-type regions & the tropics

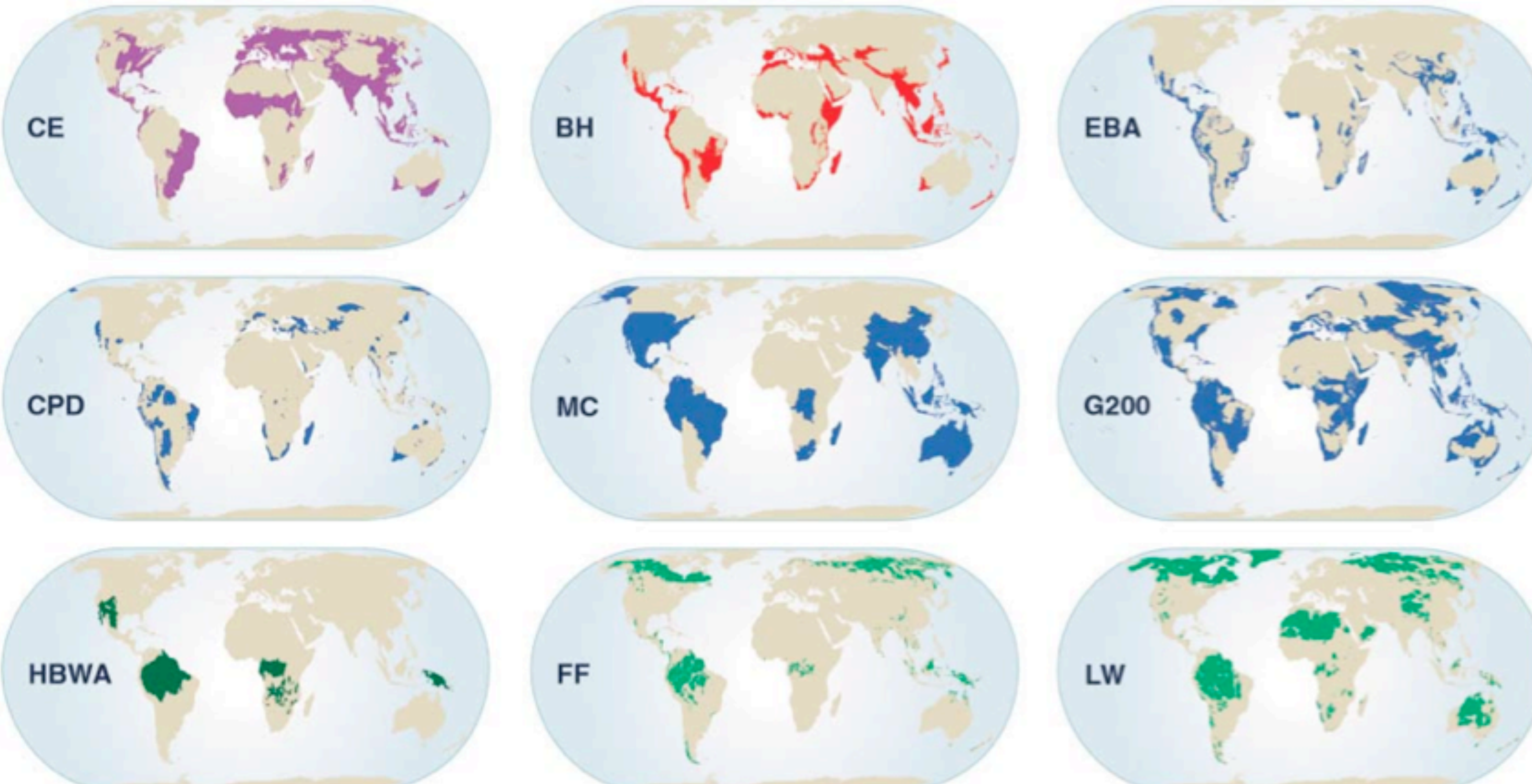


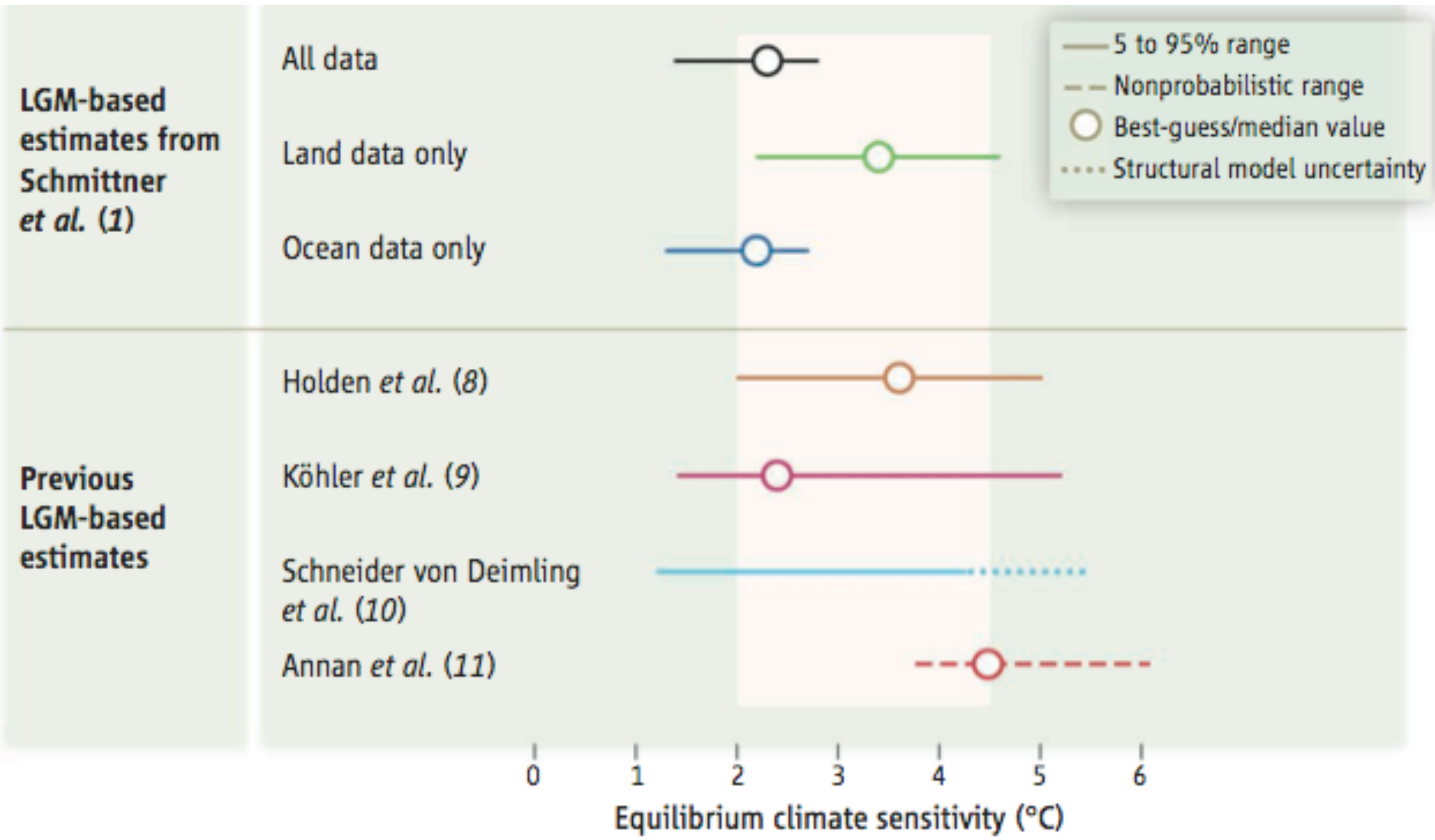
Fig. 2. Maps of the nine global biodiversity conservation priority templates: CE, crisis ecoregions (*21*); BH, biodiversity hot spots [(*11*), updated by (*39*)]; EBA, endemic bird areas (*15*); CPD, centers of plant diversity (*12*); MC, megadiversity countries (*13*); G200, global 200 ecoregions [(*16*), updated by (*54*)]; HBWA, high-biodiversity wilderness areas (*14*); FF, frontier forests (*19*); LW, last of the wild (*20*).

Ignorance:
the affects of climate change on biology

- Climate Change predictions are still controversial (Hegerl & Russon (2011) Science **334** p1360) *(below)*

- Vital details of global warming are eluding forecasters (Kerr (2011) *Science* **334** p173)

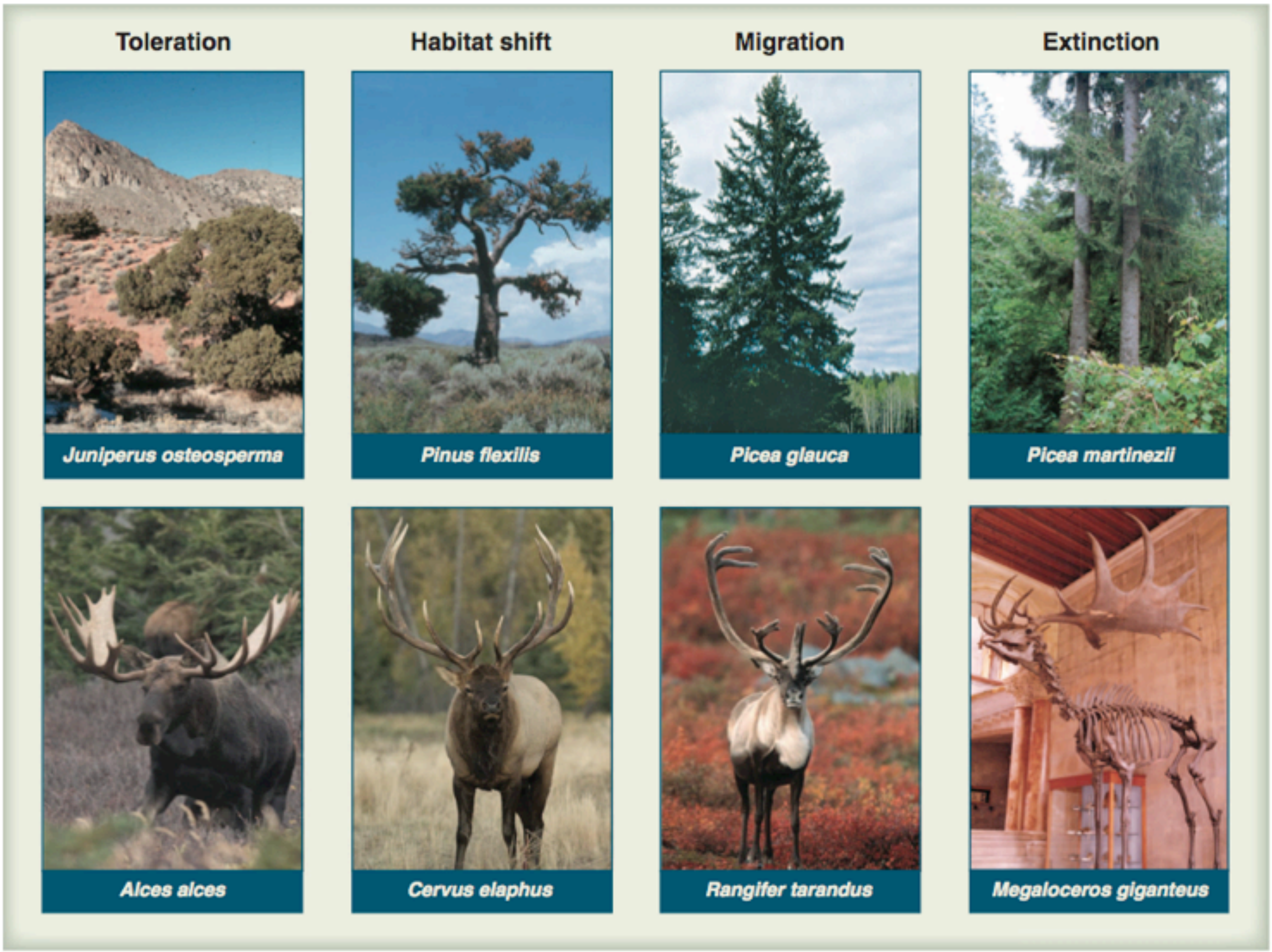
- **Usable knowledge is in short supply** (Kerr (2011) *Science* **334** p1052)



Ignorance: Beyond predictions: biodiversity conservation in a changing climate - assessing vulnerability

Dawson *et al.* (2011) *Science* **332** p53

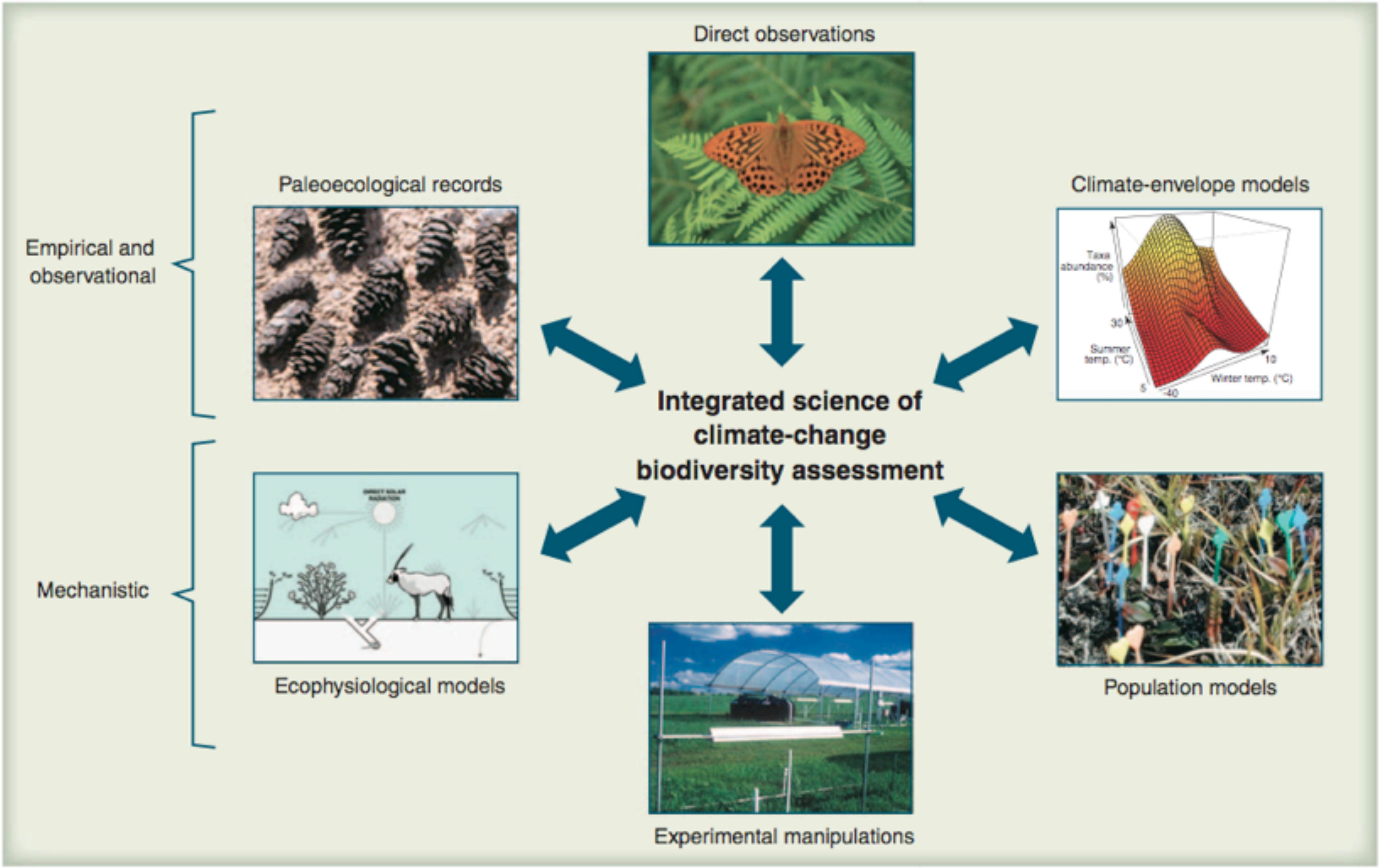
- When there is change species have three "options"



Ignorance: Beyond predictions: biodiversity conservation in a changing climate - assessing vulnerability

Dawson *et al.* (2011) *Science* **332** p53

- A new integrated assessment approach is required mixing past & present realities with models & experiments



Ignorance: Beyond predictions: biodiversity conservation in a changing climate - assessing vulnerability

Dawson *et al.* (2011) *Science* **332** p53

- **Vulnerability assessments** enable us to look into the future using **Exposure**, **Sensitivity**, and **Adaptive Capacity** as contributory factors

Vulnerability is the extent to which a species or population is threatened with decline, reduced fitness, genetic loss, or extinction owing to climate change. Vulnerability has three components: exposure (which is positively related to vulnerability), sensitivity (positively related), and adaptive capacity (negatively related).

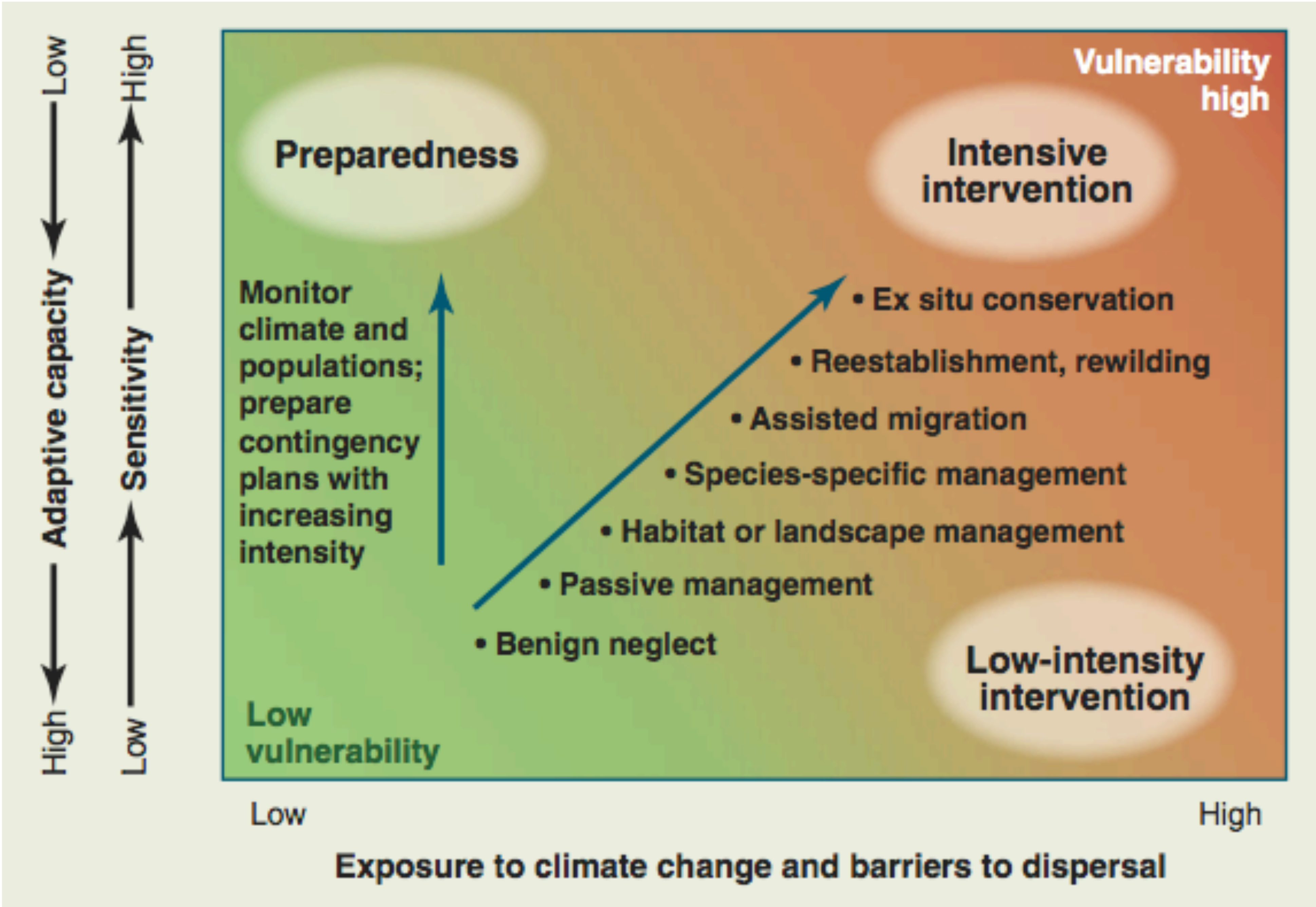
Exposure refers to the extent of climate change likely to be experienced by a species or locale. Exposure depends on the rate and magnitude of climate change (temperature, precipitation, sea level rise, flood frequency, and other hazards) in habitats and regions occupied by the species. Most assessments of future exposure to climate change are based on scenario projections from GCMs often downscaled with regional models and applied in niche models.

Sensitivity is the degree to which the survival, persistence, fitness, performance, or regeneration of a species or population is dependent on the prevailing climate, particularly on climate variables that are likely to undergo change in the near future. More sensitive species are likely to show greater reductions in survival or fecundity with smaller changes to climate variables. Sensitivity depends on a variety of factors, including ecophysiology, life history, and microhabitat preferences. These can be assessed by empirical, observational, and modeling studies.

Adaptive capacity refers to the capacity of a species or constituent populations to cope with climate change by persisting in situ, by shifting to more suitable local microhabitats, or by migrating to more suitable regions. Adaptive capacity depends on a variety of intrinsic factors, including phenotypic plasticity, genetic diversity, evolutionary rates, life history traits, and dispersal and colonization ability. Like sensitivity, these can be assessed by empirical, observational, and modeling studies.

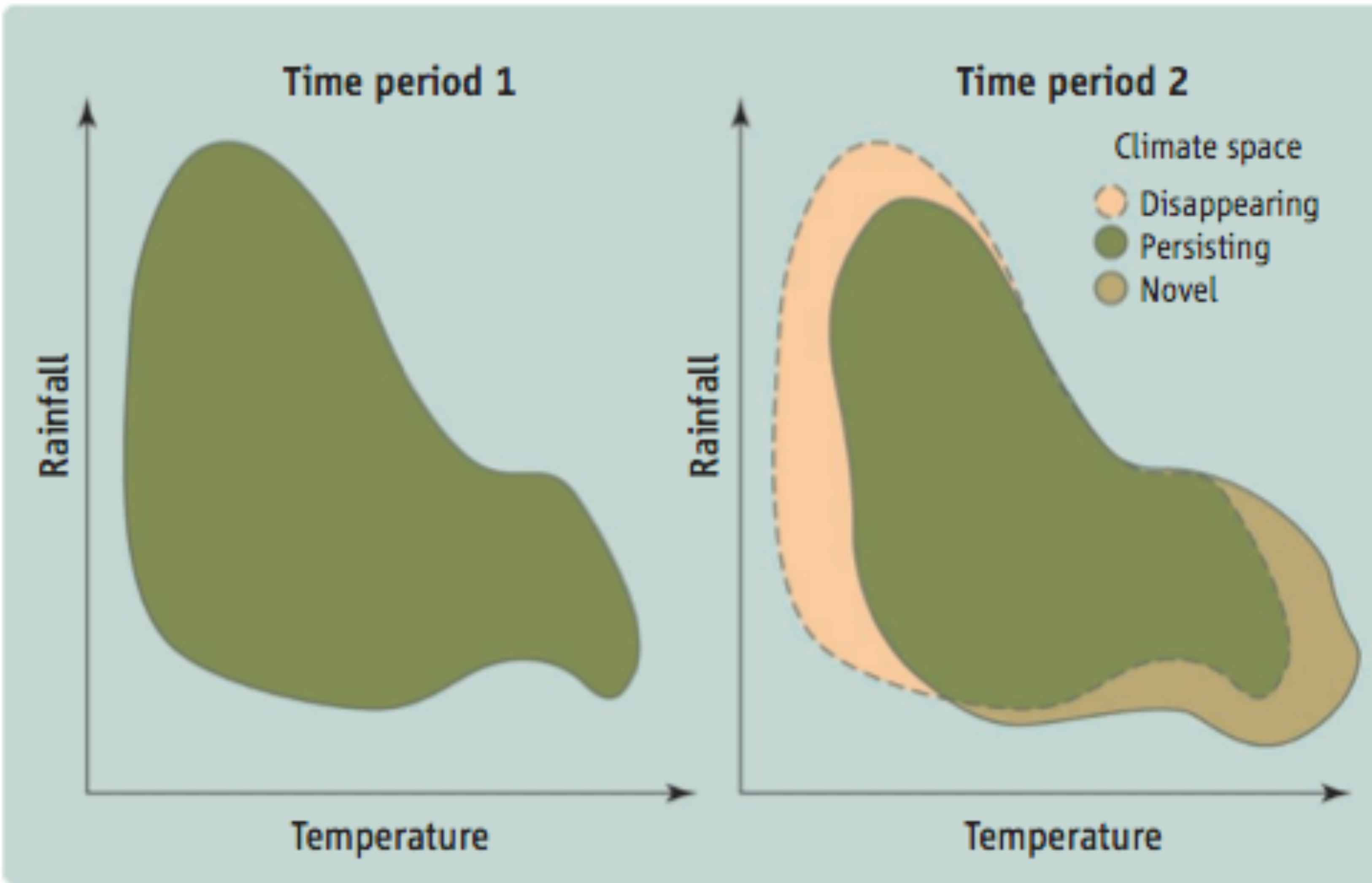
Ignorance: Beyond predictions: biodiversity conservation in a changing climate - assessing vulnerability
Dawson *et al.* (2011) *Science* **332** p53

- The relative balance of **Exposure**, **Sensitivity**, and **Adaptive Capacity** will determine the appropriate response



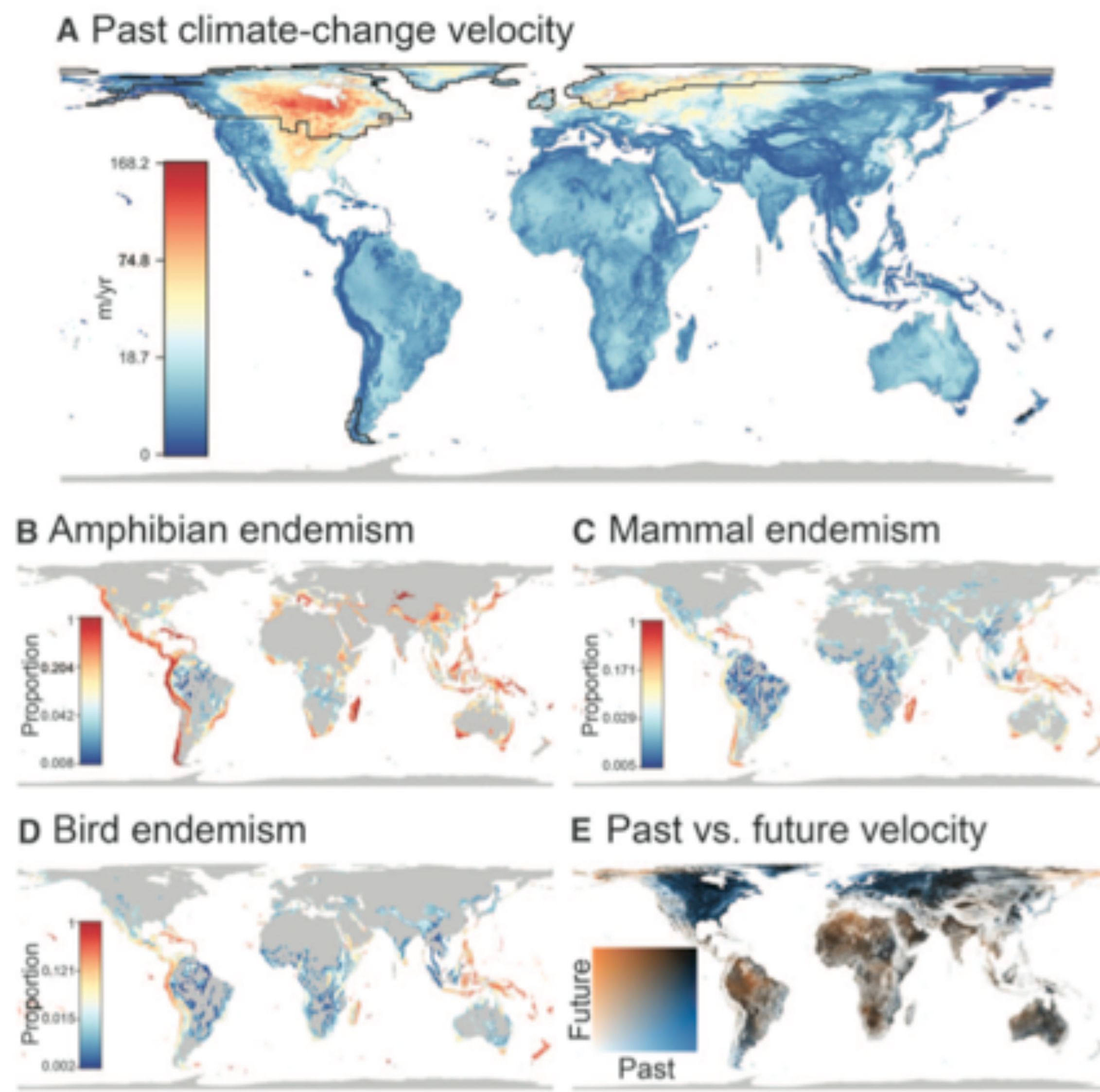
Ignorance:
the affects of climate change on biology

- The conservation status of not only species should be assess but the conservation status of "**climate space**" Ohlemuler (2011) *Science* **334** p613
- Despite the view that marine environments are more buffered against it appears that change in marine ecosystems can be faster than on land with a complex mosaic of shifts (Borrows *et al* (2011) *Science* **334** p652)



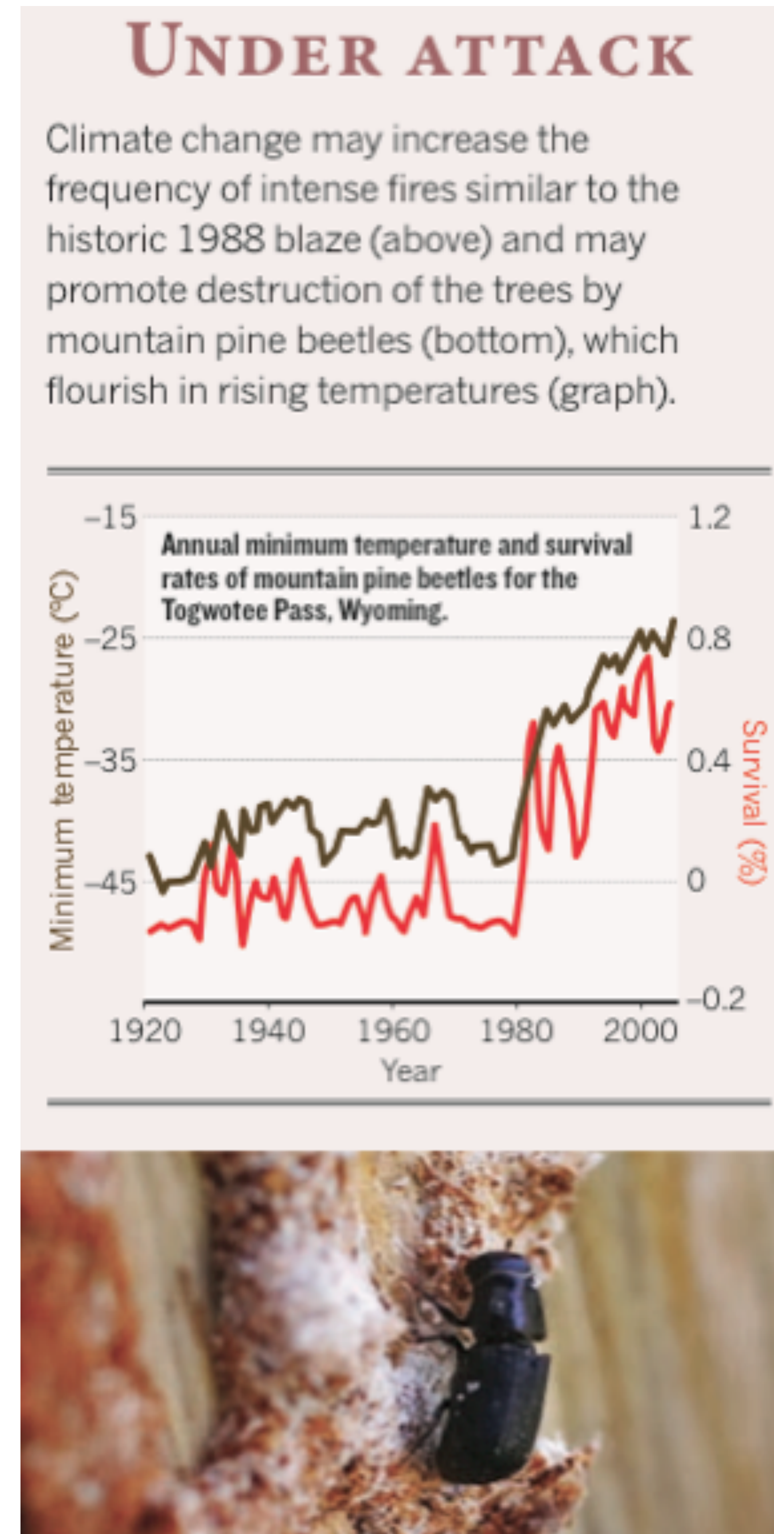
Ignorance:
the affects of climate change on biology

- The effects of climate change on biodiversity will depend on the climate displacement rate (or **climate-change velocity**) and how this changes a species ability to migrate (Sandel *et al* (2011) *Science* **334** p660)
- Historically, regions with high velocity change have no small ranged amphibians, mammals & birds.
- There **is a link** between dispersal ability and extinction risk due to climate change
- Low-velocity areas are essential **refuges** for small-ranged species



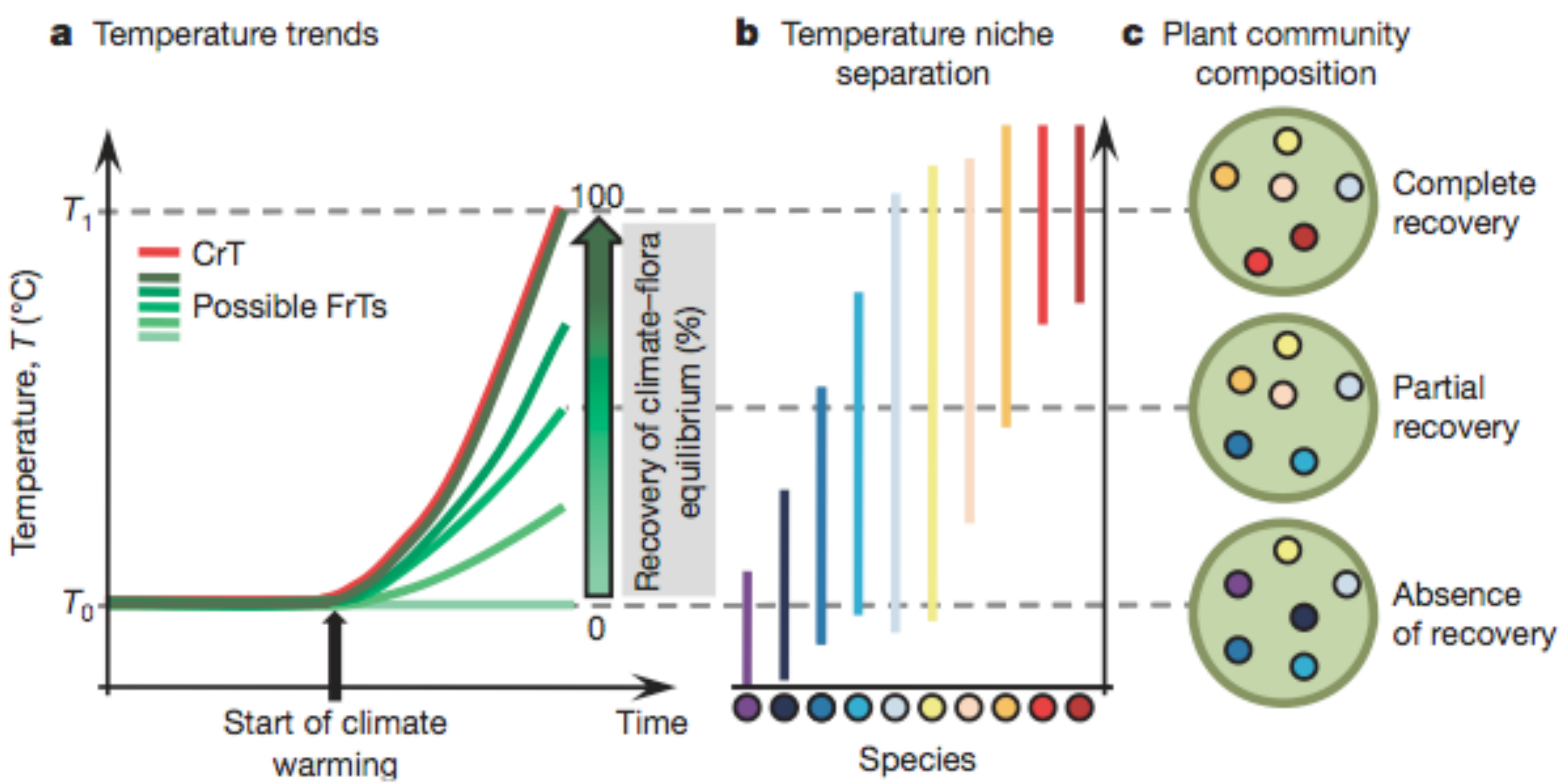
Ignorance:
the affects of climate change on biology

- >74% of climate change is human-made (Nature 4th December 2011) but biodiversity's ills are not all down to climate change (*Nature on-line* 20th March 2011)
- There may be an **increase in wildfire** in Yellowstone NP that would change the balance of species and alter successions (Westerling *et al* 2011 PNAS)
- **Not all species will lose out** as a result of climate change. For example, pine beetles flourish after fires and at higher temperatures (Marris 2011 *Nature* **469** p150)



Ignorance:
the affects of climate change on biology

- Climate change drives latitudinal & altitudinal shifts in species distributions leading to novel communities. There is a **lag** between the climate change and these new assemblages.
- Mountain populations and lowland forests are at greatest risk, due to reduced opportunity for short-distance escapes & greater habitat fragmentation (Bertrand *et al* (2011) *Nature* **479** p517)



Ignorance:
Climate Change & Genetics

- Work on cold, fresh water invertebrates show that **Evolutionary Significant Units** (genetically distinct populations of a species) exist (Gewin *Nature on-line 21 August* **2011**)
- It was found that if the IPCC business-as-usual scenario is followed then 79% of the ESUs will be lost. This cryptic diversity may be very important for future evolution
- To understand the long-term genetics of species in relation to climate change a **seed bank** is being set up where seeds are stored for 5, 10, 50+ years, sampled and compared with “wild” populations that have tried to adapt to climate change. 34 species are being stored with a variety of flowering times and pollination syndromes (Pennisi (2011) *Science* **333** p1693)

Ignorance

Loss of knowledge Wu & Petriello (2011) *Science* **331** p30

- **GSPC target 13** - to maintain indigenous & local knowledge associated with plant resources to support sustainable livelihoods, food security & health care
- This was the target that was most comprehensively missed
- Successful, long-term conservation requires local knowledge and collaboration

Ignorance
Lack of coordination across the World

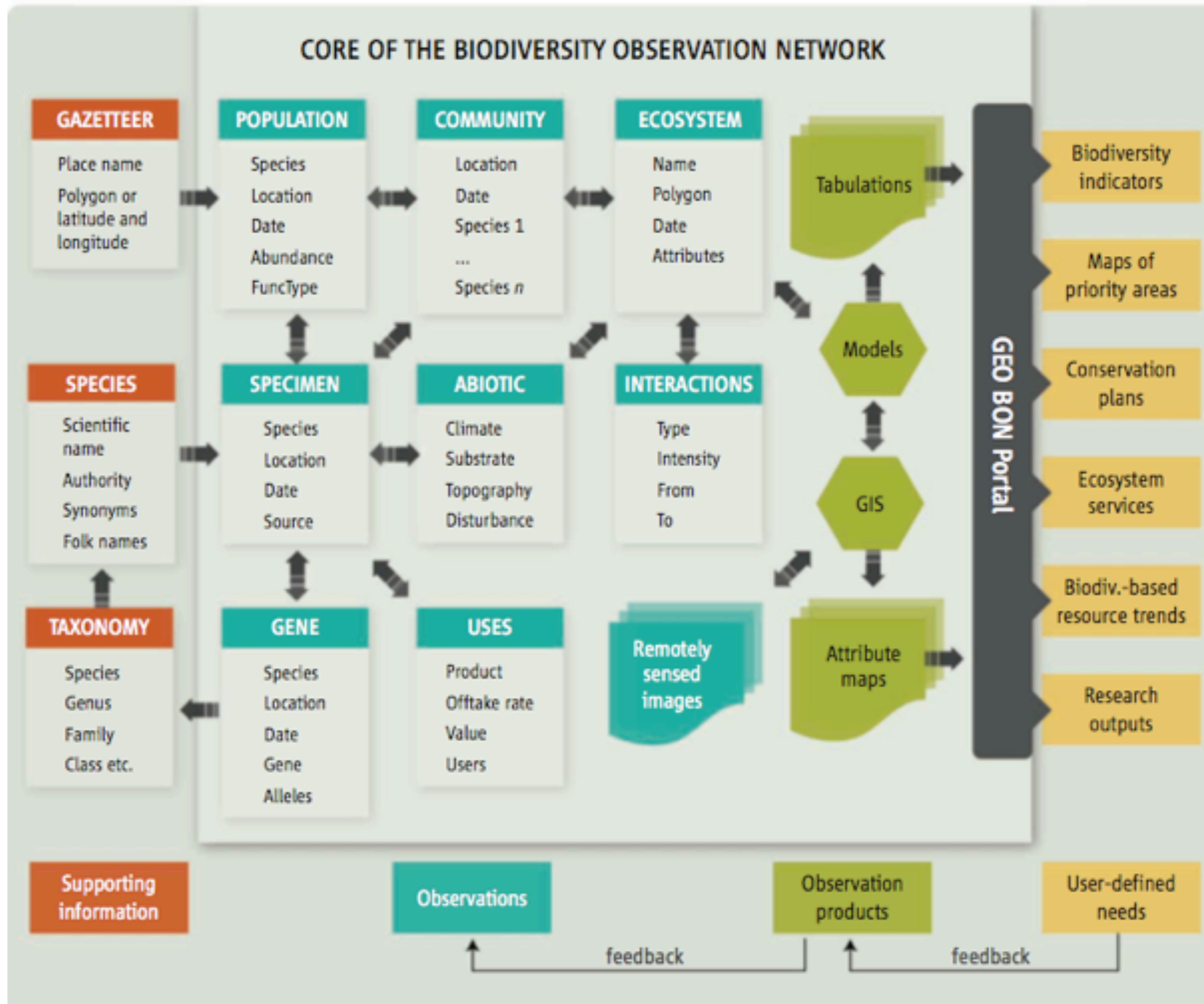
- **GSPC target 16** - to establish or strengthen institutions, networks & partnerships for plant conservation
- NutNet has **68 sites in 12 countries** looking at how a variety of grasslands respond to global change (Stokstad (2011) *Science* **334** p308

Diversity. NutNet sites include 1747 plant taxa in many ecosystems, such as (see photos, *left to right*) subalpine grassland, alpine meadow, desert, pasture, sagebrush steppe, and savanna.

Ignorance & finance: Which regions and species are **threatened with extinction?**

GROUP ON EARTH OBSERVATIONS

- Towards a Global Biodiversity Observing System (Scholes et al. 2008)
- The GEO BON (*right*) hopes to bring together the many and various sources of biological information.
- There appears to be **both too much information and too little information**



Integrated biodiversity observation system. The core data types, observation products, and end uses of an integrated bi diversity observation system are shown. Most of the elements already exist, but are incomplete or dispersed among a wide ran of partners. The proposed implementation strategy involves linking them by using data-sharing protocols, followed by increment needs-led, and opportunistic growth. GIS, geographic information systems.

Finance
How much does the monitoring cost?

- Scholes *et al* (2008 *Science* **321** p1044) calculated it would cost between $309M & **$772M** *per annum* to survey the World
- Andelman (2011 *Nature* **475** p290) claims it would cost **$10M**
- The difference is the employment of technology and local communities and a worldwide network of people in their own countries.
- Andelman also believes that the surveying can be on the scale that is required
- www.teamnetwork.org

A pilot project in Tanzania using highly targeted on-the-ground sampling.

Finance:

How much does the protection cost & who pays?

Finance:
How much does the protection cost & who pays?

- The Heart of Borneo Park in Borneo has been protected when **Norway pledged $1B** in return for a 2-year moratorium on new logging permits. WWF & Nature Conservancy have also given $2M in a **debt-for-nature** arrangement.
- The **Yasuni NP** in Ecuador has a 28,000 km^2 core with the highest level of species diversity on Earth. 1,500 spp of trees for example & 100,000 spp inverts per hectare - mega-diversity
- Unfortunately there is the ITT **oil field**, the second largest in Ecuador worth $7,200M, under the Yasuni NP.
- President Rafael Correa of Ecuador offered to accept $3,600M in exchange for not issuing oil extraction concessions.
- A first instalment of $100M was needed by the end of 2011 - **no decision has been made yet**

Make a deal. If paid billions of dollars, Ecuador will prevent oil exploration in Yasuni.

Innovative finance

Genes for schools & greenhouses (Jones 2011 *Nature* **476** p19)

- Valeria Souza has been granted **a permit to extract microbial genes** from pools that are threatened by unsustainable water extraction. So far genes have been found for breaking down complex organic molecules that could be used in bioremediation, and that **enable the uptake of phosphorous in a form not usually available to life**. The latter may be very valuable
- The agreement comes under the terms of the **Nagoya Protocol** (signed by 41 states including the EU & Mexico but not China & USA)

Groundwater loss threatens the coral-like formations of stromatolites in the Cuatro Ciénegas basin.

A few, final, general thoughts ...

Ecological Restoration in the light of Ecological History

Jackson & Hobbs (2009) *Science* **325** p567

- **"Nature is ever shaping new forms: what is, has never yet been; what has been, comes not again"** Goethe (1783) *On Nature*
- Restoration targets are based on what was there before
- "*Natural states*" are generally assumed to be what was there just before the European colonisation and the onset of land clearance, agriculture, grazing & wildfire control.
- **Three revisions** to this view **(1)** pre-Europeans exerted significance influence on the vegetation **(2)** non-human climate change makes restoration to a historic standard anachronistic **(3)** changes wrought by humans have ecological legacies that are impossible to reverse or override
- For many parts of Europe, Asia, & Africa, **undisturbed landscapes are too remote in time to provide restoration targets**

Ecological Restoration in the light of **Ecological History**

Jackson & Hobbs (2009) *Science* **325** p567

- Paleoecological & paleoenvironmental records exist for much of the world for the past 20,000 years since the last glacial maximum. There are three messages from this data
- **(1)** Environmental & ecological changes are normal; the World is in constant flux. Few major terrestrial ecosystems have existed *in situ* for more than 12,000 years and most are much younger. Everywhere has experienced a series of ecosystems, so there is no inherent natural ecosystem or landscape configuration for any region
- **(2)** A multitude of ecological combinations arise & dissolve as the environment changes. The late-glacial communities have no analogue at present
- **(3)** The paleoecological records show that for a given place there are **many, alternative "natural" states** that may be very different

Ecological Restoration in the light of **Ecological History**

Jackson & Hobbs (2009) *Science* **325** p567

- Ecological restoration should be set free from the shackles of objectively identifiable natural states for ecosystems & locations.
- Restoration projects should
- **(1)** emphasise **the restoration of ecosystem function, goods, & services**
- **(2)** view **novel ecosystems** are inevitable with combinations of species that have never co-occured before
- **(3)** accept that the **restoration is dynamic** and further change should be expected
- **We must not forget that preventing damage is more cost effective than trying to repair damage**
- **If ecological restorations are not species specific then specific species conservation should always be** *ex situ* **as well as** *in situ*

Home, home, outside the range: moving species

Stone (2010) *Science* **329** p1592

- If we accept the idea of novel communities the **Assisted Colonisation** is a logical strategy. It is similar to *ex situ* populations in botanic gardens & arboreta
- “it is senseless to consider species distributions as somehow fixed and “natural” & that the establishment & occurrence of a species elsewhere is therefore unnatural”

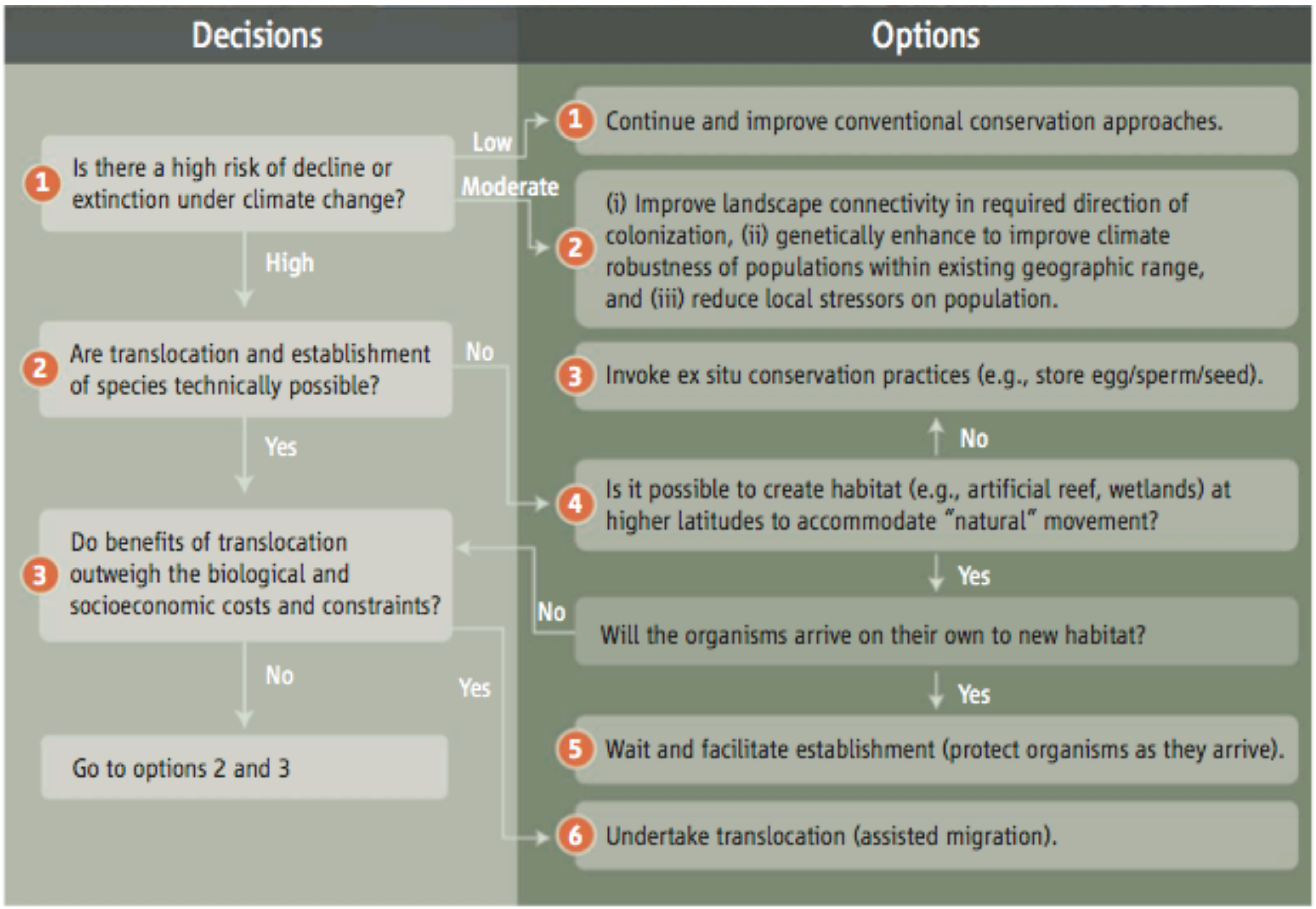
Forlorn. Found only on a single hill in rugged Guangxi Province (*left*), *Geodorum eulophioides* may be a candidate for assisted colonization.

Clinging to life. Orchid researcher Hong Liu says that as southwest China warms, assisted colonization may be “unavoidable” for some species.

Assisted colonisation & rapid climate change

Hoegh-Guldberg (2008) *Science* **321** p345

- If we accept the idea of **assisted colonisation** the we need to **assess the risks and benefits** before we proceed



Decision framework for assessing possible species translocation. Assessing the feasibility of whether or not to attempt the movement of a species to prevent its extinction or ecosystem collapse.

Biodiversity conservation: beyond 2010

(Rands et al 2010)

- **As the perceived benefits derived** from biodiversity fall so does the response from people to reverse the decline.
- In the past 40 years the rate of increase in interest in conservation has declined but the pressure on biodiversity has increased and it's state has declined.
- The decline in the state of biodiversity reduces so does the perceived benefits
- **As the perceived benefits derived ...** & so on

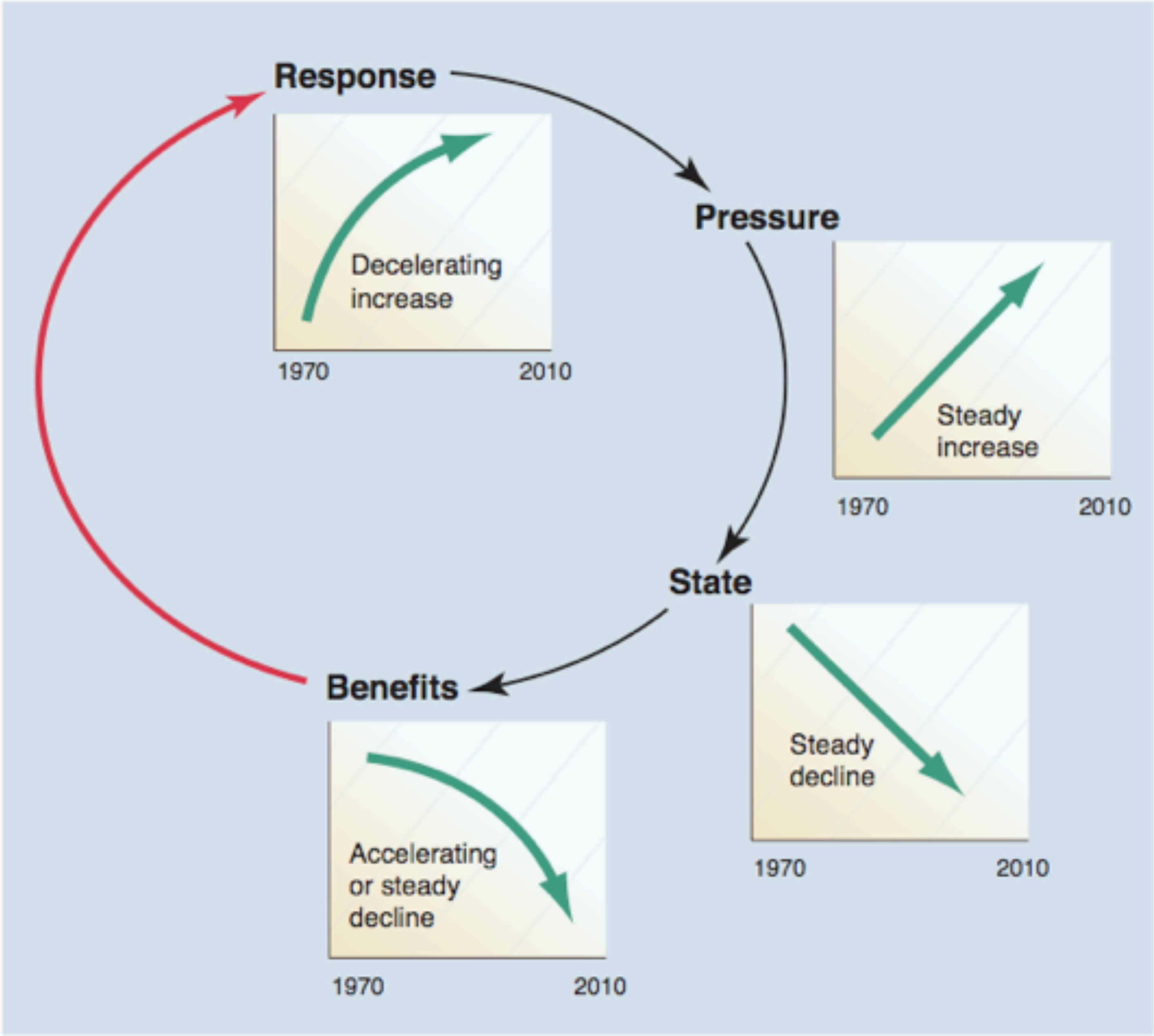


Fig. 3. The feedback loop between responses to biodiversity loss, the pressures on biodiversity, the state of biodiversity, and the benefits it provides. The arrow linking benefits to responses is highlighted because of its particular importance: Responses are put in place in relation to how far the maintenance of biodiversity is valued as a benefit to society and individuals. Thumbnail graphs show the overall trend in each of these aspects over the past 4 decades [simplified from (7)]. Although responses continue to grow, the rate of increase is slowing and not keeping pace with the steady rise in pressures. A corresponding steady decline in state is linked to a steady or possibly accelerating decline in benefits.

Biodiversity conservation: beyond 2010

(Rands et al 2010)

- There are three, equally important stages or tiers that must be in place for conservation to work
- Despite more knowledge being needed it is **social behaviour and practical infrastructures that are lacking** to deliver the desired outcomes.
- Legislation & technology are not lacking

Table 1. The three different tiers within which responses to biodiversity loss are typically located. Each tier is equally important, but experience suggests that the crucial element that is missing from many current initiatives is the middle tier. It is important to ensure that appropriate institutions and governance structures exist to enable the effective use of targeted instrumental interventions to address biodiversity loss. [Adapted from (*80*)]

Tier 1: Foundational	• Knowledge about social and biological dimensions of biological loss
Tier 2: Enabling	• Institutions/ governance • Social/behavioral patterns
Tier 3: Instrumental	• Legislation • Markets/incentives • Technology

Plant species richness & ecosystem multi-functionality

Midgley (2012) & Maestre *et al.* (2012) Science **335** p174 & p214

- Previous experiments have suggested that biodiversity enhances the ability of ecosystems to maintain multiple functions such as carbon storage, productivity & the build-up of nutrient pools
- This is a global empirical study relating plant species richness & abiotic factors to multiple ecosystem functions in drylands
- Drylands cover 41% of the World's land area and they support 38% of the human population
- **Multiple ecosystem functions in drylands are positively & significantly related to species richness**
- Species richness is always a predictor variable

Plant species richness & ecosystem multi-functionality

Midgley (2012) & Maestre *et al.* (2012) Science **335** p174 & p214

- **Red** = plant species richness
- **Green** = abiotic variables (sand content of soil & slope)
- **Blue** = climatic variables
- **Gold** = geographical variables (elevation, latitude, longitude, & elevation)
- **A** = ecosystem multi-functionality i.e. the ability of ecosystems to maintain multiple functions & services sumultaneously
- **B** = carbon cycling
- **C** = nitrogen cycling
- D = phosphorous cycling

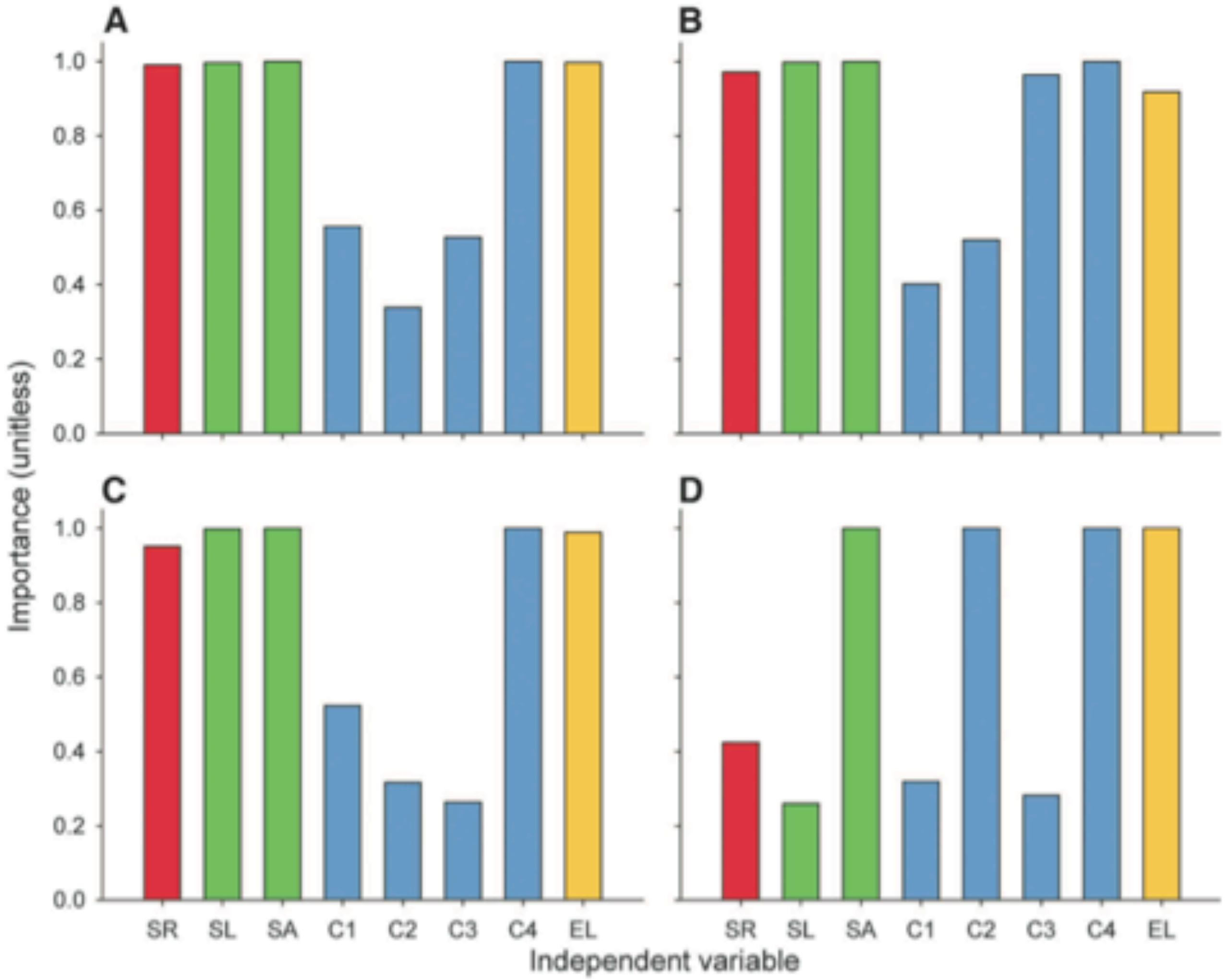
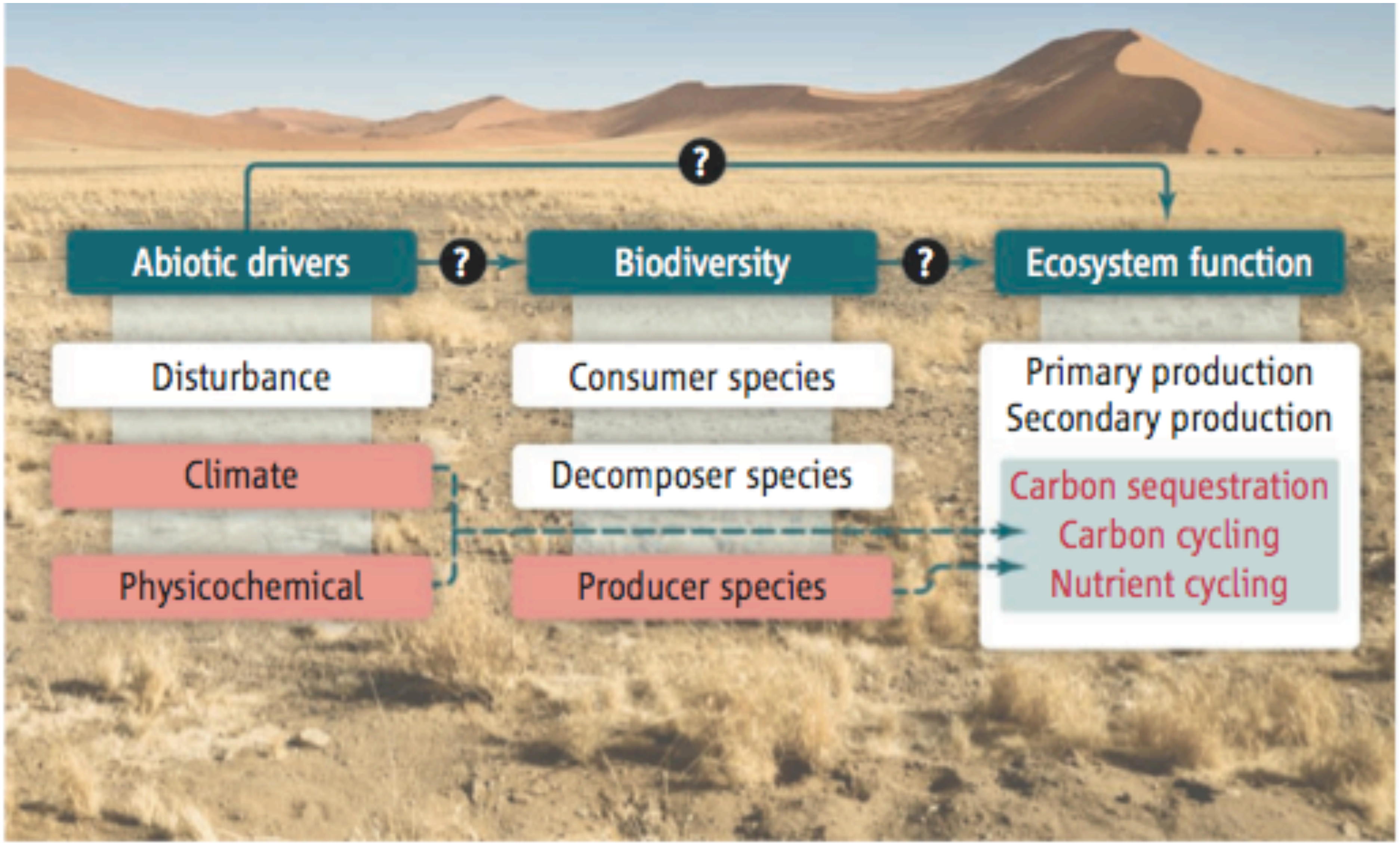


Fig. 2. Relative importance of perennial plant species richness (red column) and other predictor variables in models of ecosystem multifunctionality (**A**) and C (**B**), N (**C**), and P (**D**) cycling. The height of each bar is the sum of the Akaike weights of all models that included the predictor of interest, taking into account the number of models in which each predictor appears. Variable abbreviations are as in Table 1.

Plant species richness & ecosystem multi-functionality

Midgley (2012) & Maestre *et al.* (2012) Science **335** p174 & p214

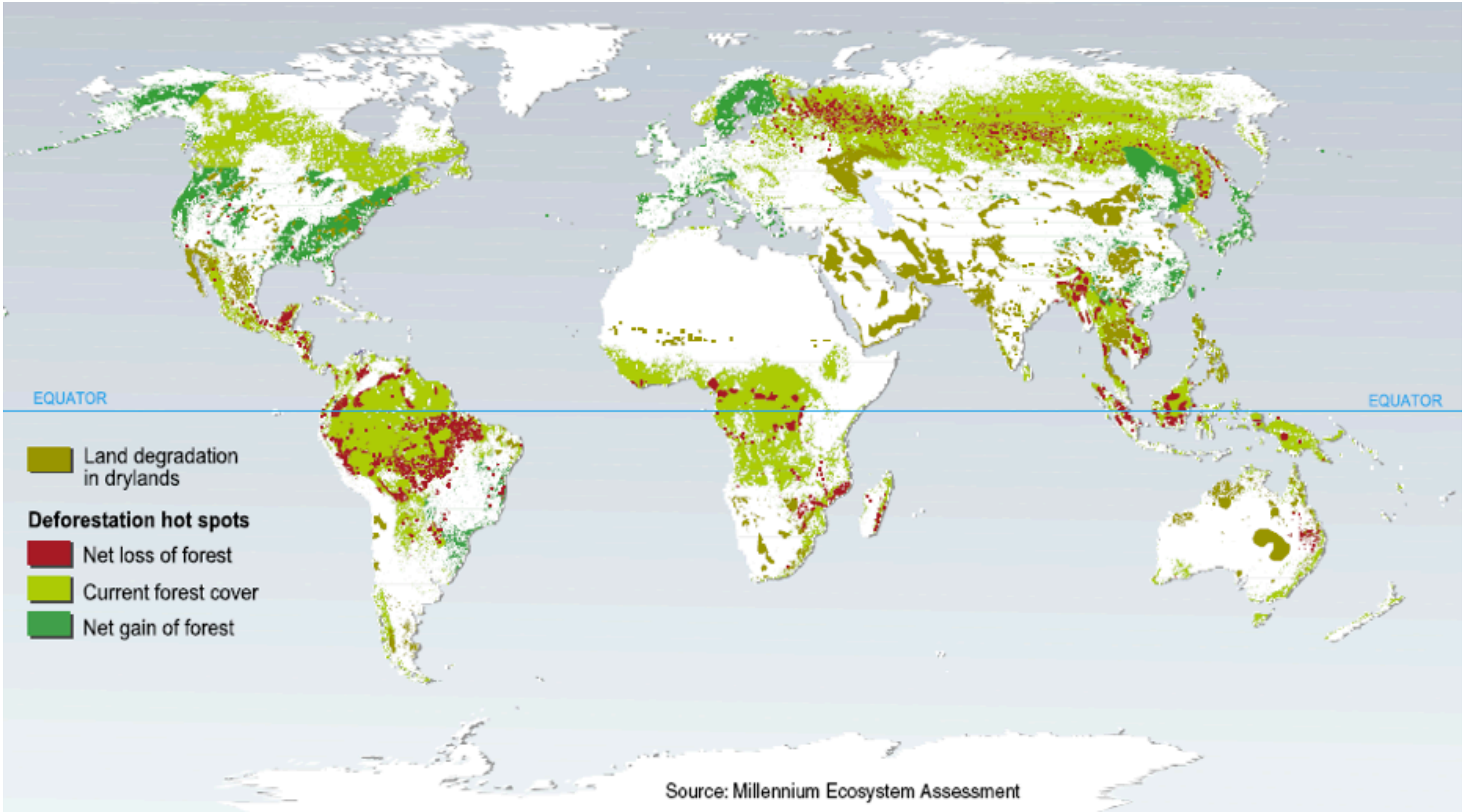
- Biodiversity needs species because **plant biodiversity is crucial to buffer negative effects of climate change and desertification in drylands**
- Therefore **species must be conserved** but we do not have all the answers



Remember It is not too late: There are still wildernesses out there

United Nations

- UN 2000 Millennium Ecosystem Assessment



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