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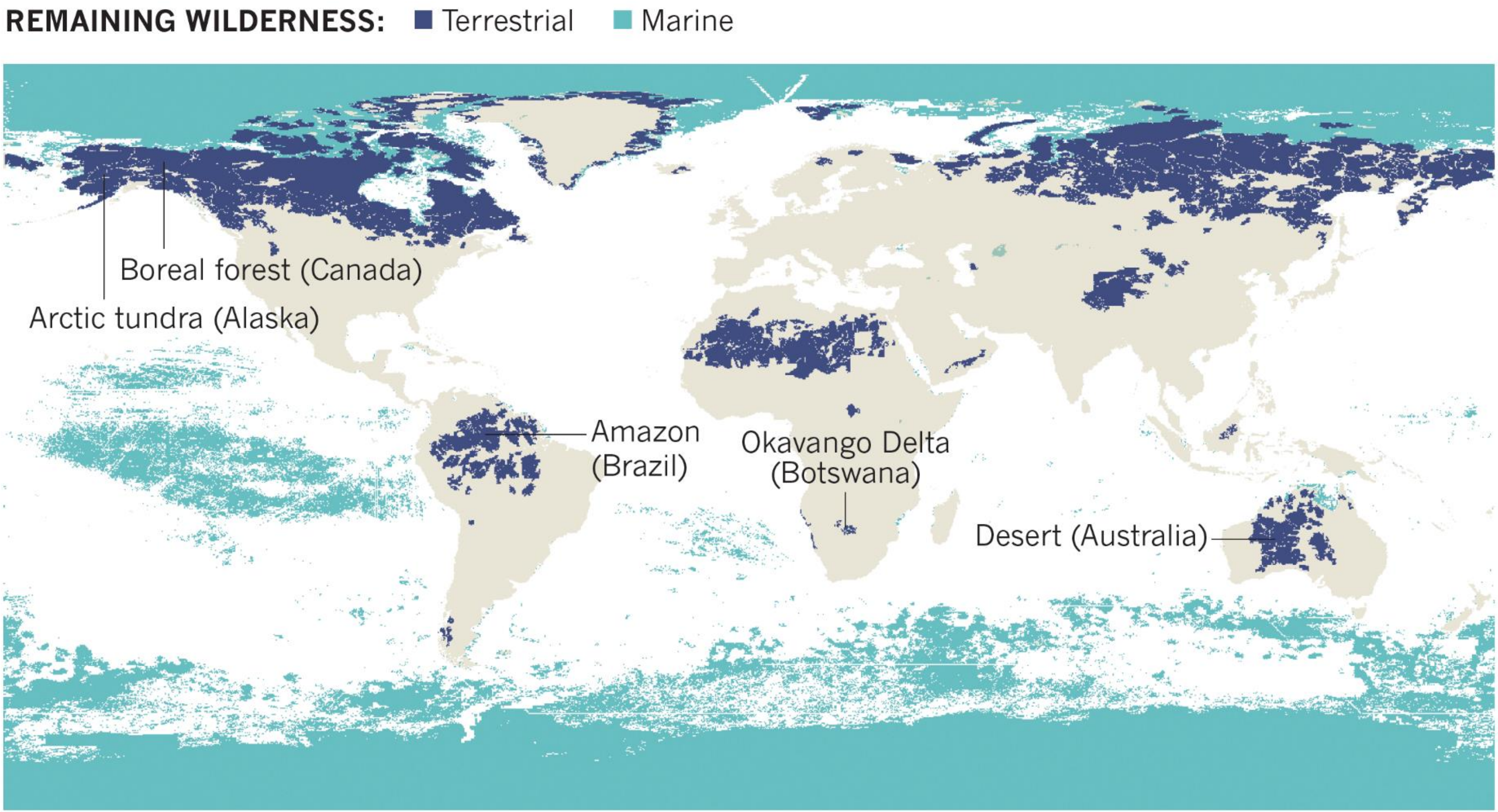
UK Research and Innovation

GCRF Global Challenges Research Fund

Introduction to conservation planning and spatial prioritisation

Sokoine University of Agriculture, Morogoro, Tanzania 5 June 2019

Diego Juffe Bignoli



Areas free of human pressure across 10,000 km2 Source: (Watson et al. 2018)

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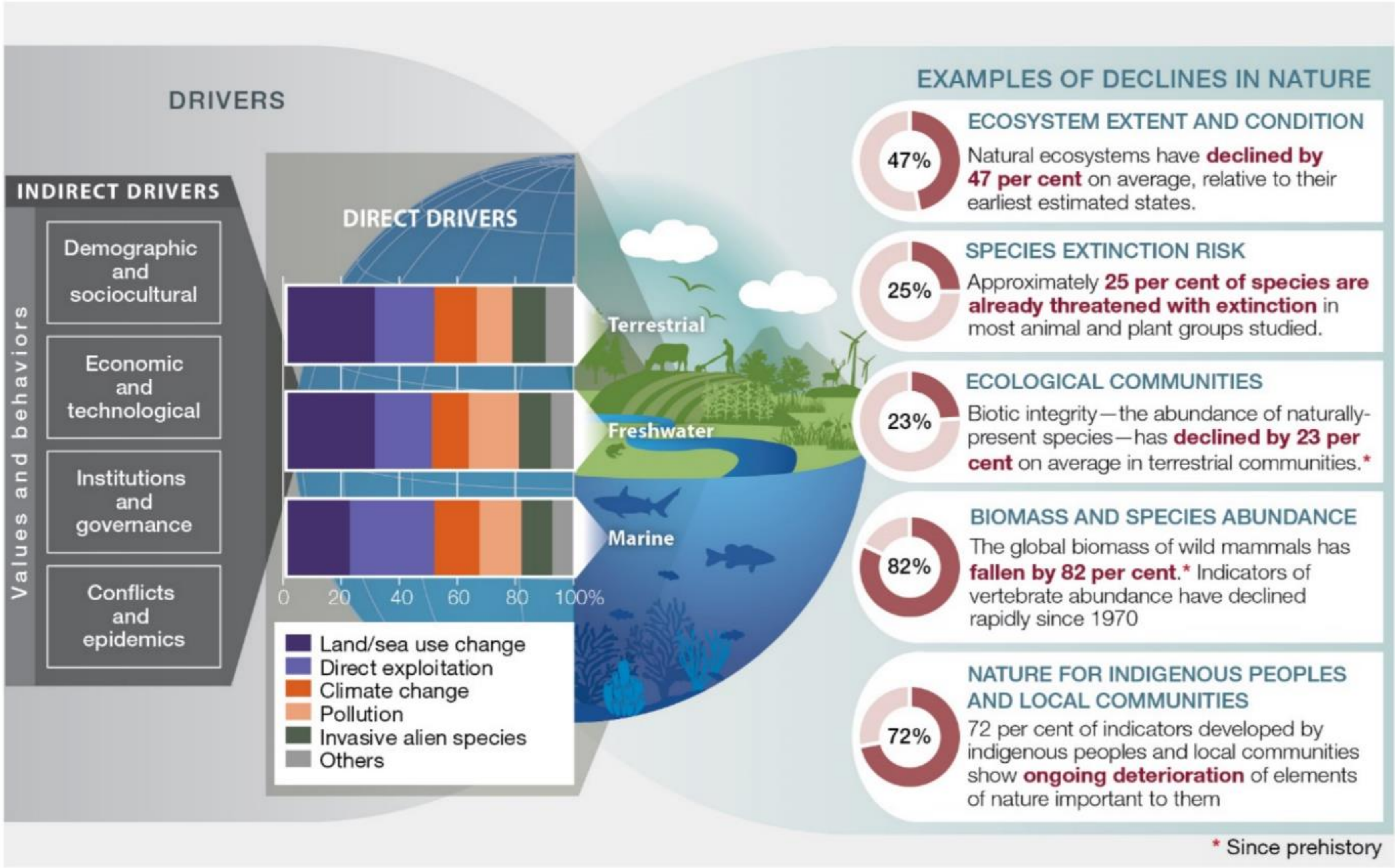
The global biodiversity crisis in short

1. **We live in a finite world** dominated by one species: Humans have modified 77% of the land and 87 % of sea (Watson et al. 2018).
2. As a consequence, **we are facing biodiversity loss at an unprecedented rate** in the history of earth.
3. **Biodiversity is ALL life on earth (including us)**… and underpins and provides with everything we need to survive as a species.



The first **IPBES' 2019 Global Assessment Report on Biodiversity and Ecosystem Services compiles evidence for all of this here:**
https://www.ipbes.net/system/tdf/spm_global_unedited_advance.pdf?file=1&type=node&id=35245

There are global agreements and processes in which most governments acknowledge there is an issue. For example:

- Convention on Biological Diversity (CBD)
- Convention in International Trade on Endangered Species (CITES)
- Convention on Migratory Species (CMS)
- Global Strategy for Plant Conservation
- The sustainable development goals (SDGs).

All have set up global goals and targets, regional and international networks and frameworks to stop the biodiversity crisis.

Target 11

By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Target 12

By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.

CBD example

https://www.cbd.int/sp/targets/

SUSTAINABLE DEVELOPMENT GOAL 15

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

PROGRESS & INFO (2018) | PROGRESS & INFO (2017) | PROGRESS & INFO (2016) | TARGETS & INDICATORS

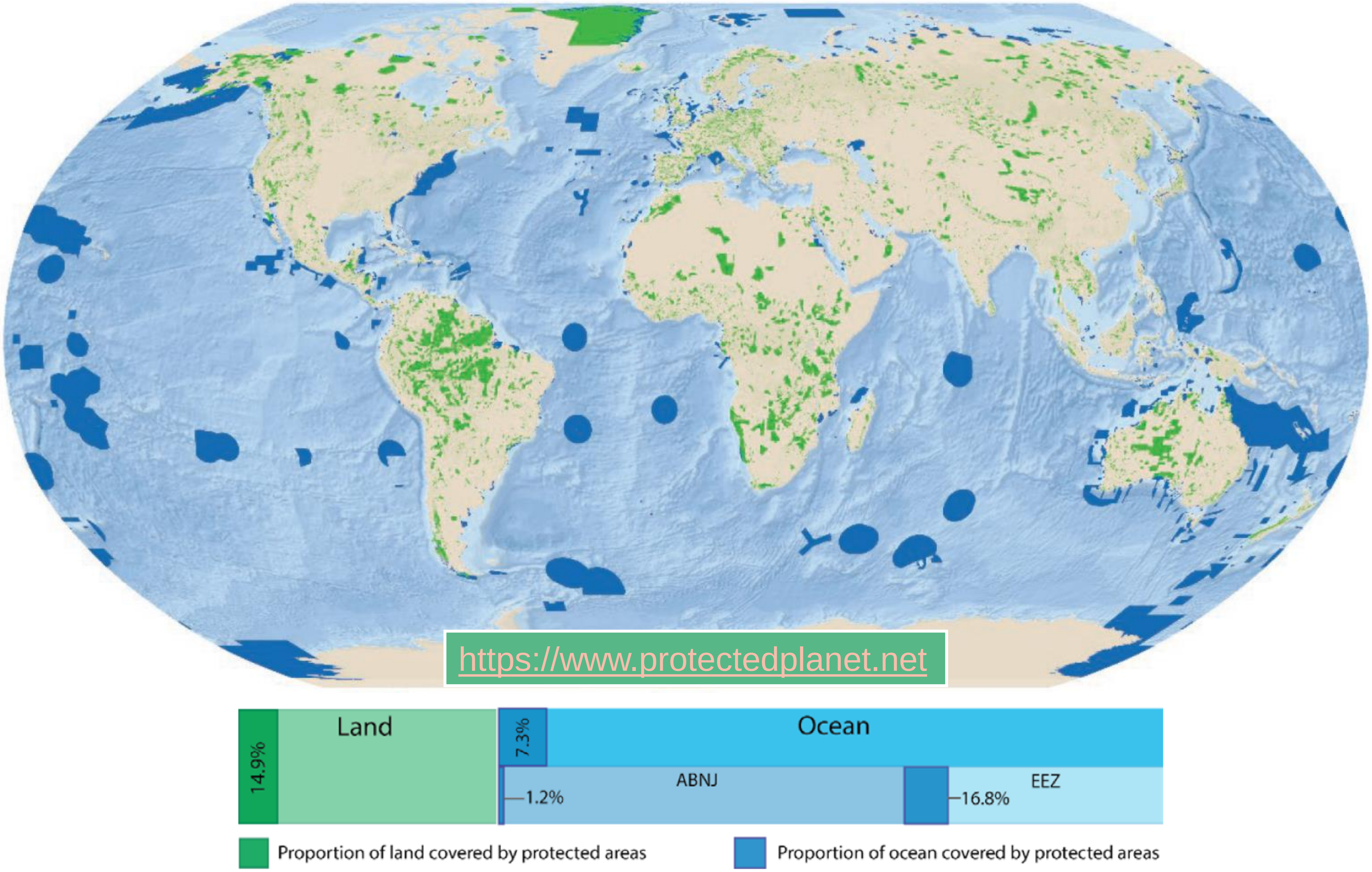
The global indicator framework was developed by the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) and agreed to, as a practical starting point at the 47th session of the UN Statistical Commission held in March 2016. The report of the Commission, which included the global indicator framework, was then taken note of by ECOSOC at its 70th session in June 2016. More information.

TARGETS		INDICATORS	
15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1	Forest area as a proportion of total land area
		15.1.2	Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15.2	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1	Progress towards sustainable forest management

SGDs example

ttps://sustainabledevelopment.un.org

…protected areas are a fundamental for conservation



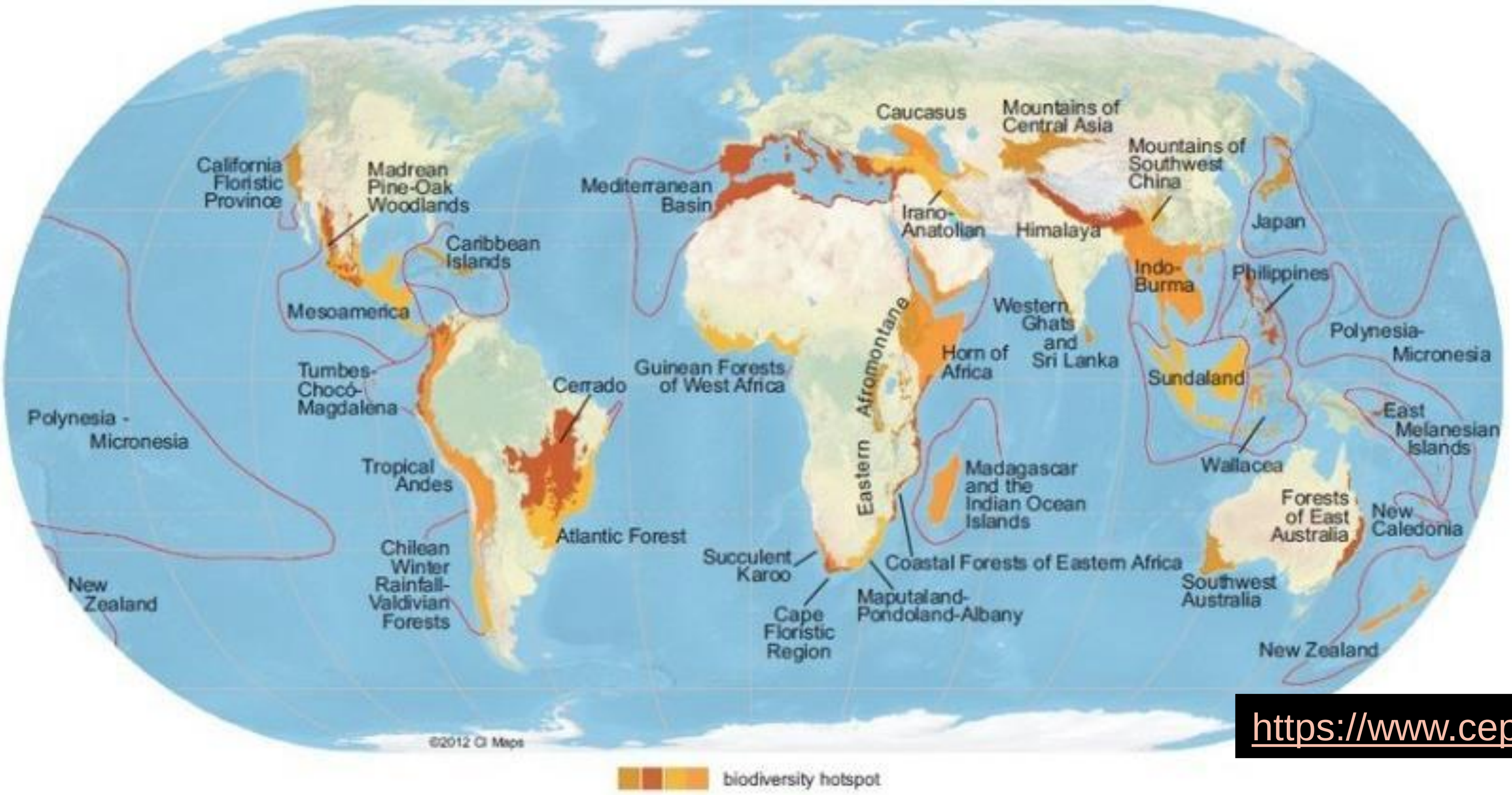
…but there are issues with protected areas

- They are not necessarily located in the most important places for biodiversity (Joppa Pfaff and 2009)
- They are being downgraded, downsized and degazetted (PADDD, Golden Kronen et al 2019)
- They lack sufficient resources to be effective (Coad et al. 2019, Adams et al. 2019)
- They are facing important pressures from the surrounding landscape (Shulze et al. 2017, Jones et al. 2018)

So where is biodiversity and which are the most important places?

Approaches for identifying areas of importance for biodiversity

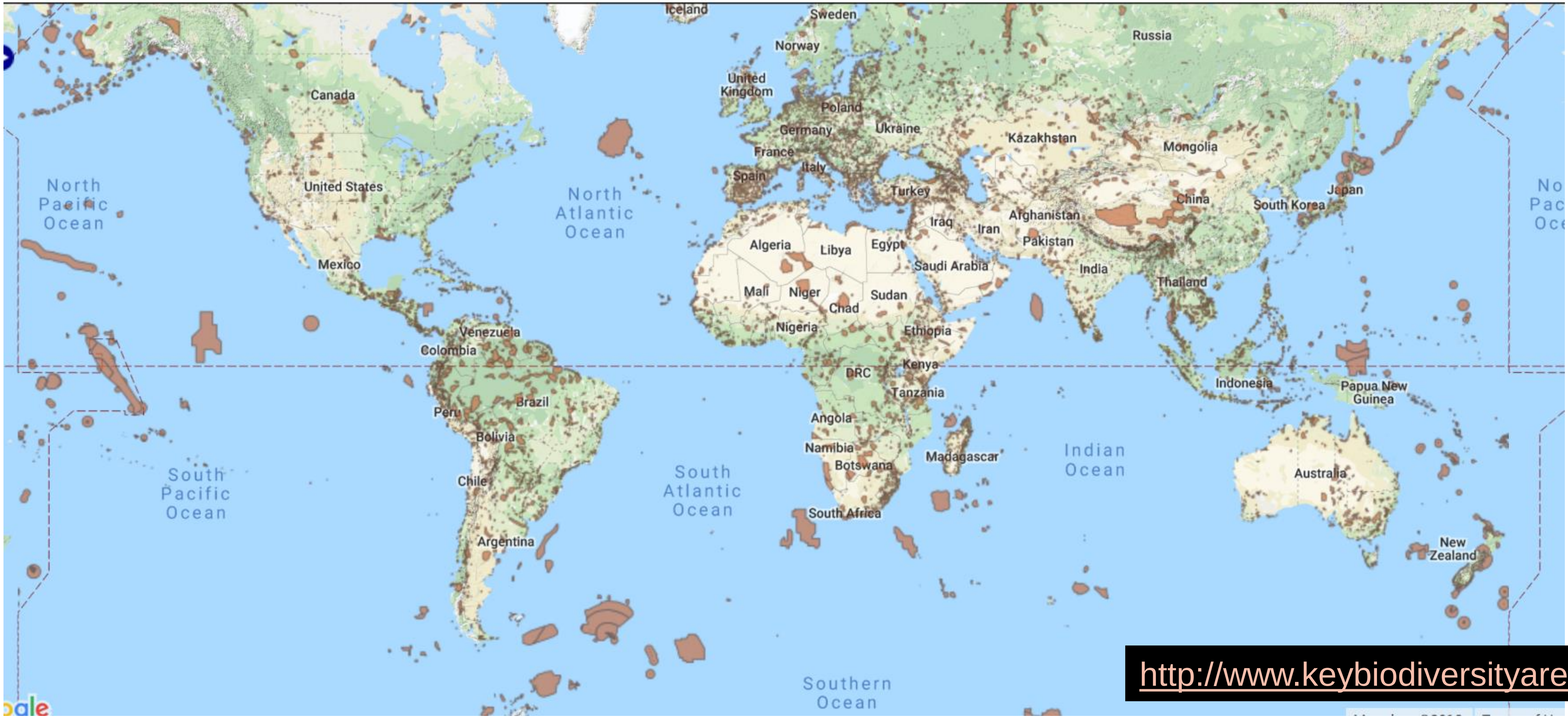
Large scale (Global/regional) approaches: Biodiversity Hotspots



https://www.cepf.net/node/1996

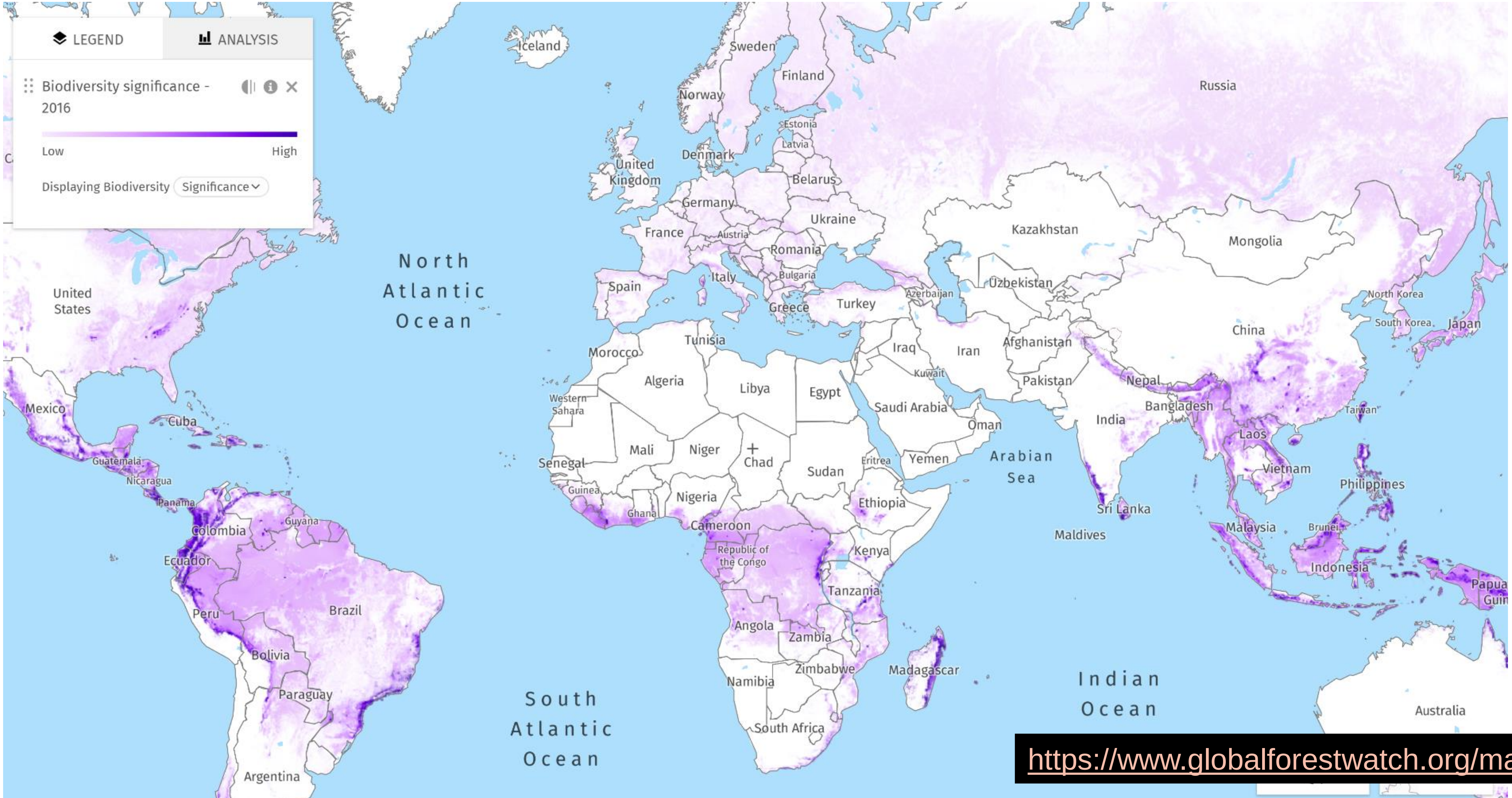
Approaches for identifying areas of importance for biodiversity

Site level approaches: Key Biodiversity Areas (KBAs)



http://www.keybiodiversityareas.org/

Approaches based on combination of datasets



https://www.globalforestwatch.org/map

Great! When know, at a global level, where some important areas for biodiversity are but we have a problem…

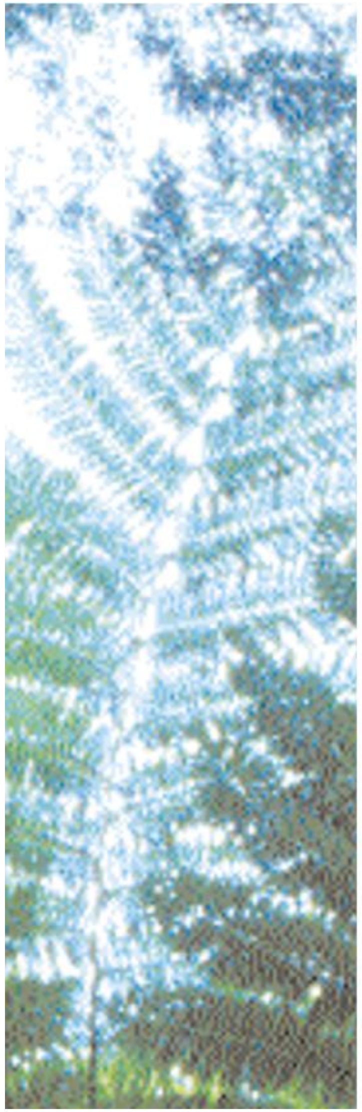
Resources and space are limited

there are many different stakeholders competing for the use of the land

…and it will not be possible to protect everything

Conservation planning: When and where do we invest time, money and effort to do conservation and how do we allocate resources efficiently?

Systematic Conservation Planning (SCP)



insight review articles

Systematic conservation planning

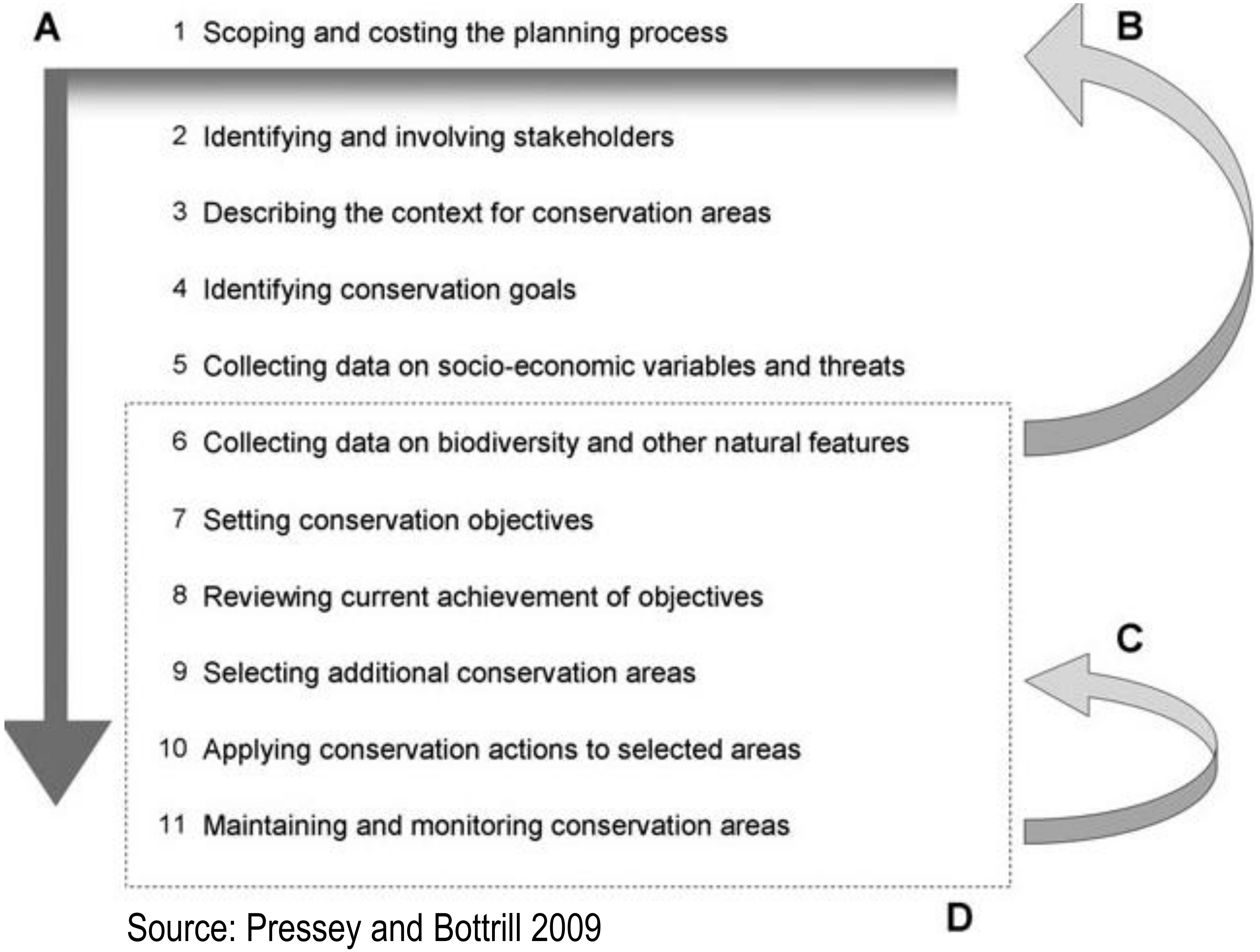
C. R. Margules* & R. L. Pressey†

*CSIRO Wildlife and Ecology, Tropical Forest Research Centre, and the Rainforest Cooperative Research Centre, PO Box 780, Atherton, Queensland 4883, Australia

†NSW National Parks and Wildlife Service, PO Box 402, Armidale, New South Wales 2350, Australia

The realization of conservation goals requires strategies for managing whole landscapes including areas allocated to both production and protection. Reserves alone are not adequate for nature conservation but they are the cornerstone on which regional strategies are built. Reserves have two main roles. They should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence. Existing reserve systems throughout the world contain a biased sample of biodiversity, usually that of remote places and other areas that are unsuitable for commercial activities. A more systematic approach to locating and designing reserves has been evolving and this approach will need to be implemented if a large proportion of today's biodiversity is to exist in a future of increasing numbers of people and their demands on natural resources.

The 11 SCP steps



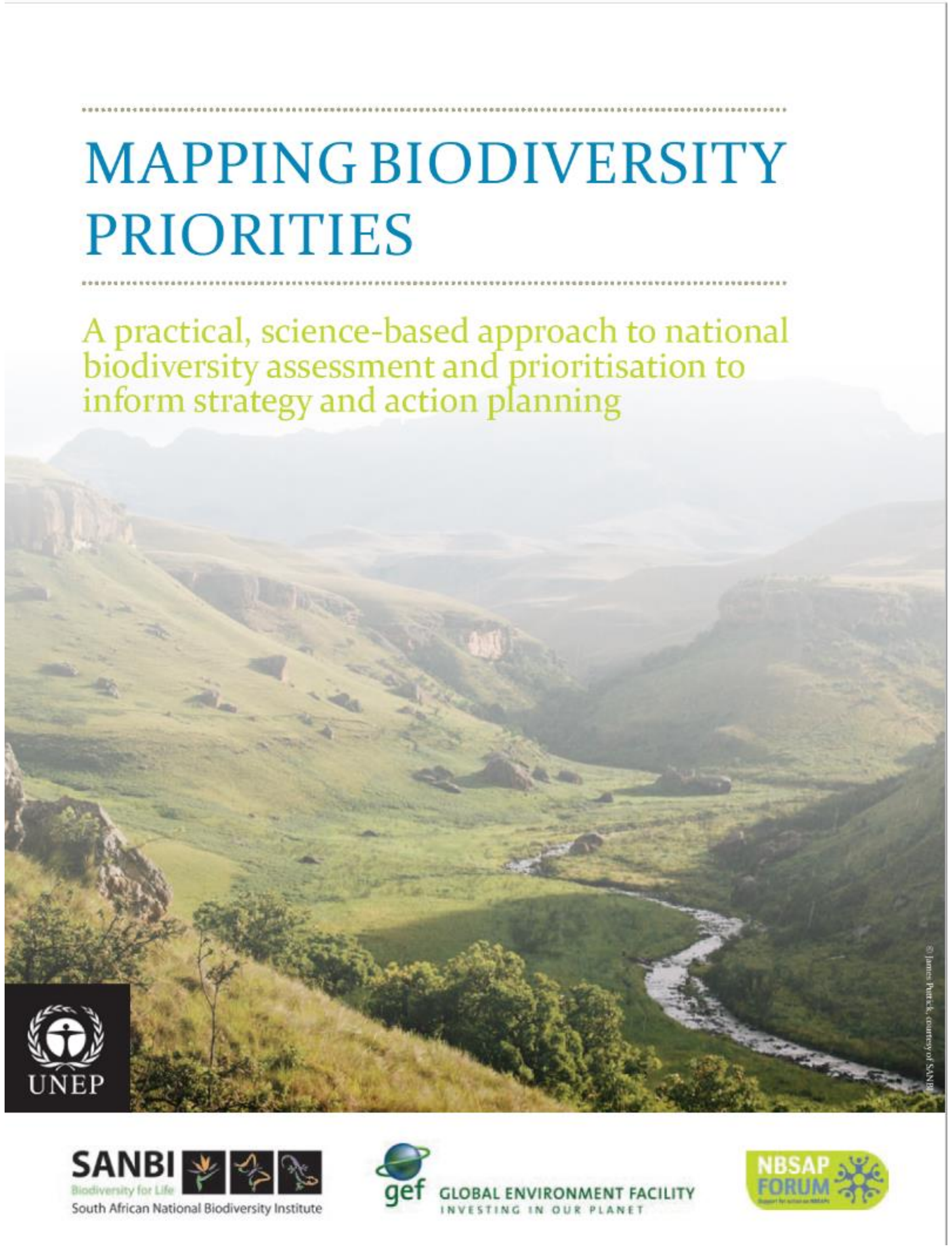
Source: Pressey and Bottrill 2009

A : Stakeholder engagement throughout the process

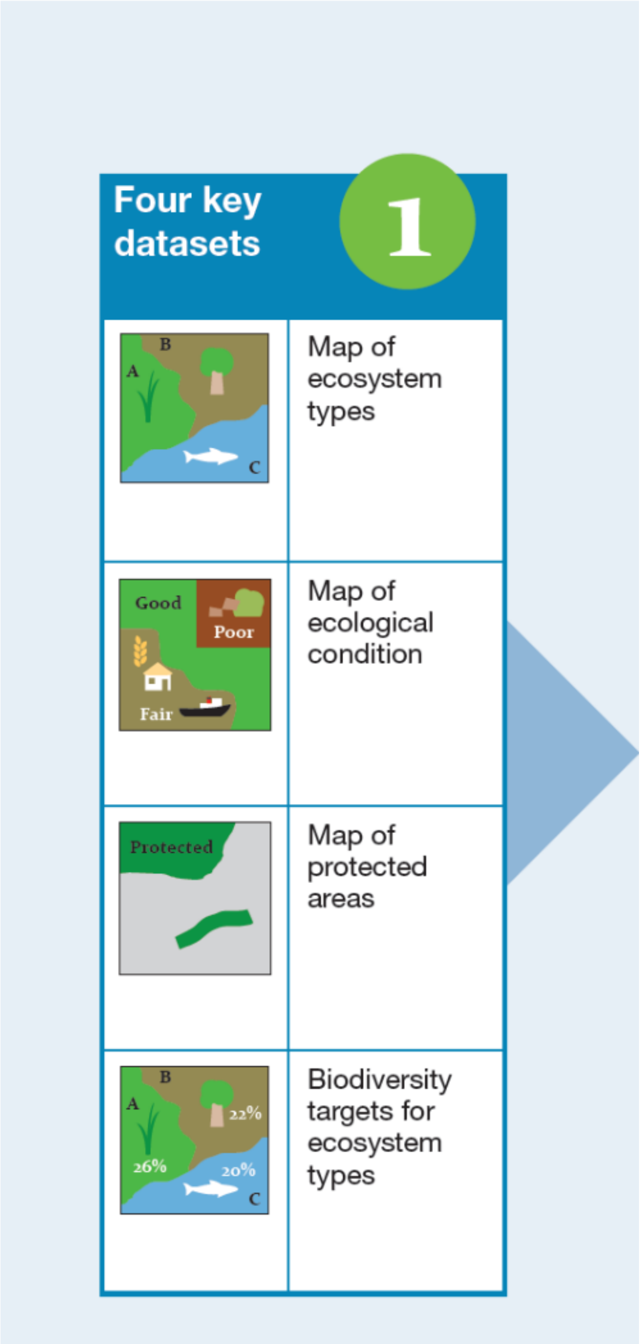
B: Revisions on boundaries of planning area based on data collection results

C:Lessons learned from management and monitoring

D:Spatial prioritisation after the social, economic and political context has been defined through steps 1 to 5



A nice simplified 3 step approach to help countries identify their priorities based on SCP principles developed by SANBI and UNEP-WCMC in 2016 (see key literature folder).

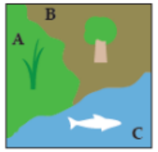
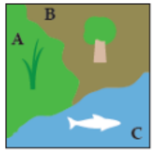
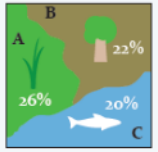
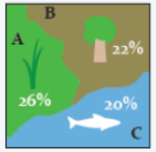
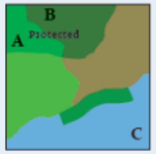
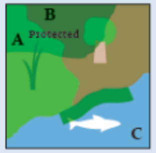
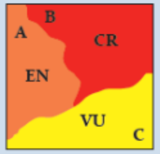


1.What biodiversity does your country have and where is it?

Assessment

Biodiversity assessment provides two useful high-level indicators of biodiversity status:

2

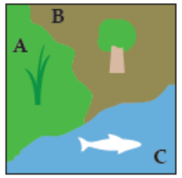
Ecosystem threat status		Ecosystem protection level	
	**Step 1:** Map and classify ecosystem types.		**Step 1:** Map and classify ecosystem types.
	**Step 2:** Set biodiversity targets for ecosystem types.		**Step 2:** Set biodiversity targets for ecosystem types.
	**Step 3:** Map ecological condition.		**Step 3:** Map existing protected areas.
	**Step 4:** Determine the proportion of each ecosystem type that is still in good ecological condition.		**Step 4:** Determine the proportion of each ecosystem type that is included in the existing protected area network.
	**Step 5:** Evaluate this proportion against the biodiversity target and other thresholds to assign ecosystem threat status category.		**Step 5:** Evaluate this proportion against the biodiversity target to assign ecosystem protection level category.

2.What is the state of biodiversity across the landscape and seascape?

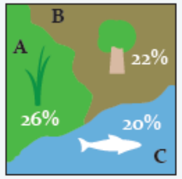
3.Where and how act first to manage and conserve biodiversity?

Prioritisation

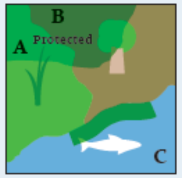
Prioritisation identifies a portfolio of geographic areas important for conservation action:



Step 1: Map and classify ecosystem types.



Step 2: Set biodiversity targets for ecosystem types and other biodiversity features.



Step 3: Evaluate how much is already protected relative to biodiversity targets.

Step 4: Identify priority areas for meeting the remaining targets, in the most efficient configuration, favouring areas that remain in good ecological condition where possible.

Step 5: Identify appropriate conservation actions for priority areas.

Step 6: Develop interpretive products to guide actions.

Options to include additional spatial data if available:

Additional biodiversity data e.g. species, ecological processes

Ecological infrastructure or supply of ecosystem services

Constraints e.g. conflicting land-uses

Opportunities e.g. conservation initiatives

Spatial prioritisation: an assessment within the SCP process to inform decision making about the spatial location of actions to be applied across the landscape and seascape (Ferrier and White 2012)

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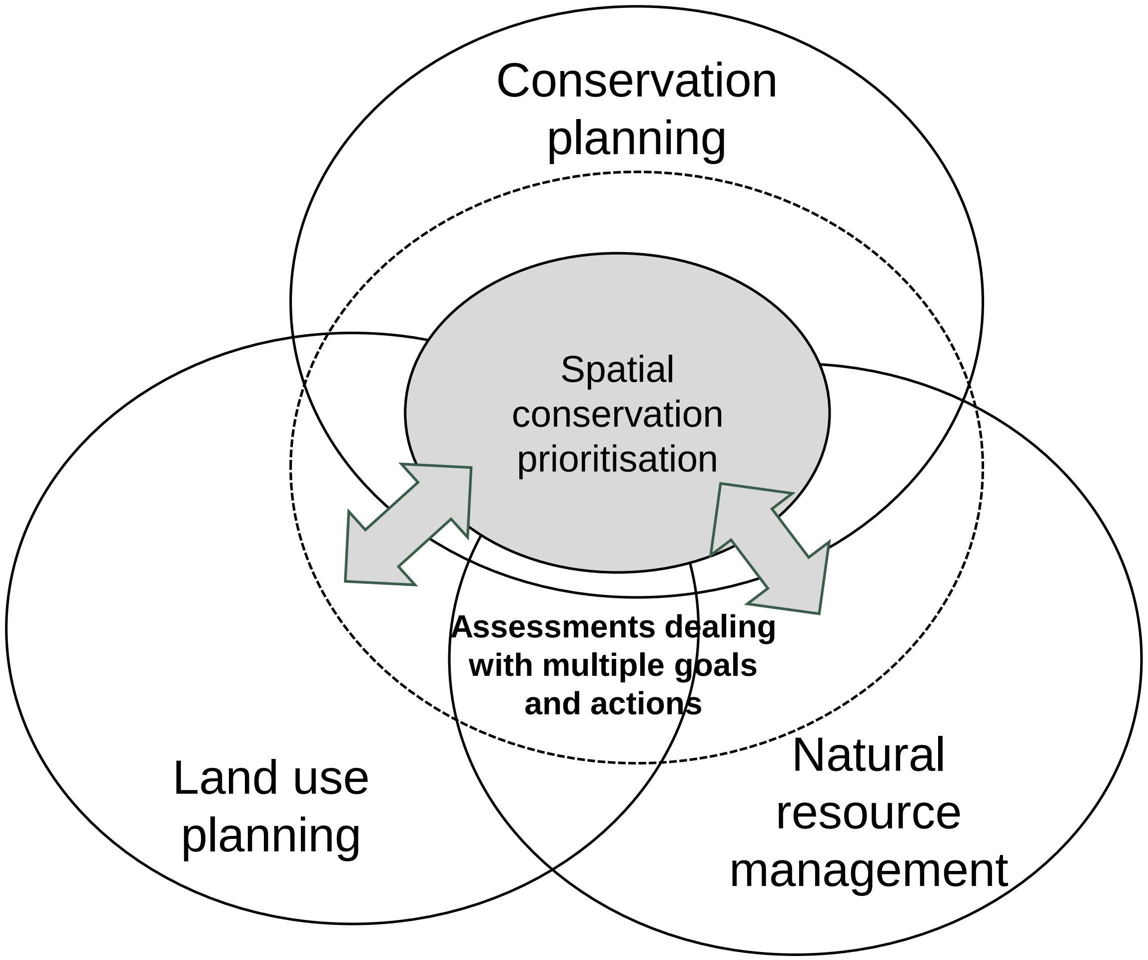
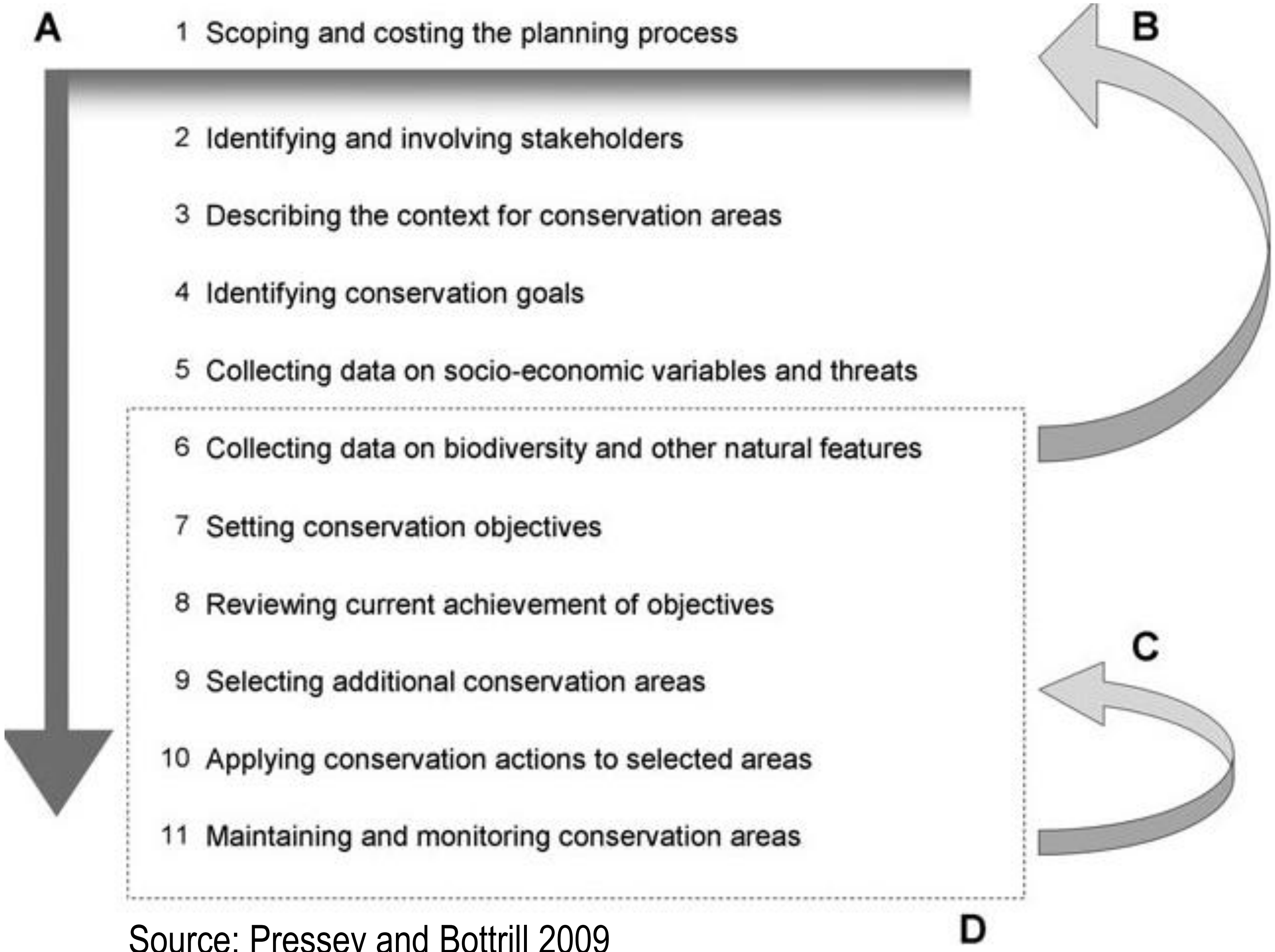
Where does Spatial prioritisation fit?



Source: Moilanen et al. 2009

Where does Spatial prioritisation fit?



Source: Pressey and Bottrill 2009

Mostly steps 5 to 9 involve spatial prioritisation

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Spatial prioritisation: 9 key concepts

1. Comprehensiveness
2. Representativeness
3. Surrogacy
4. Adequacy
5. Persistence
6. Complementarity
7. Irreplaceability
8. Vulnerability
9. Cost-efficiency

?

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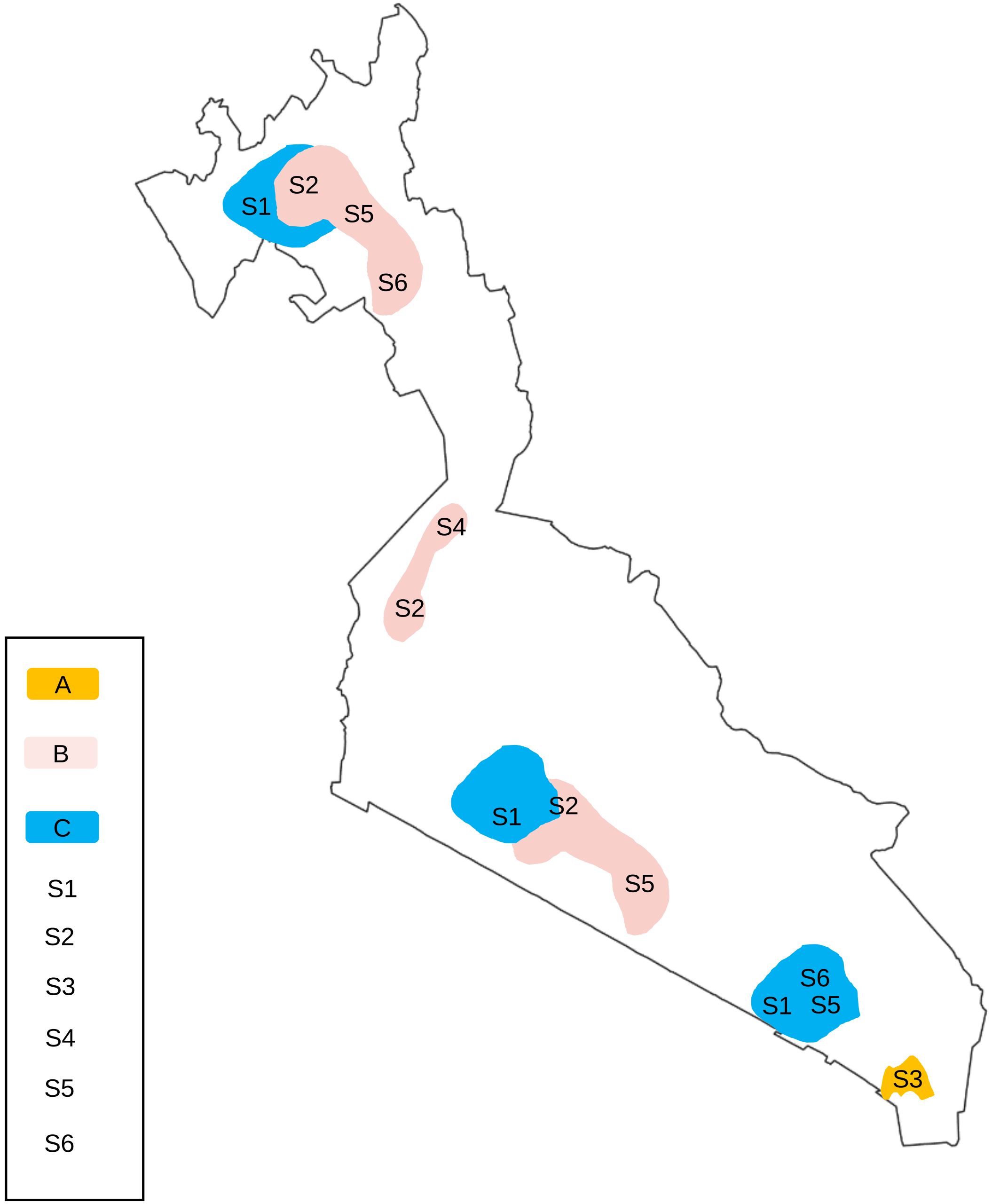
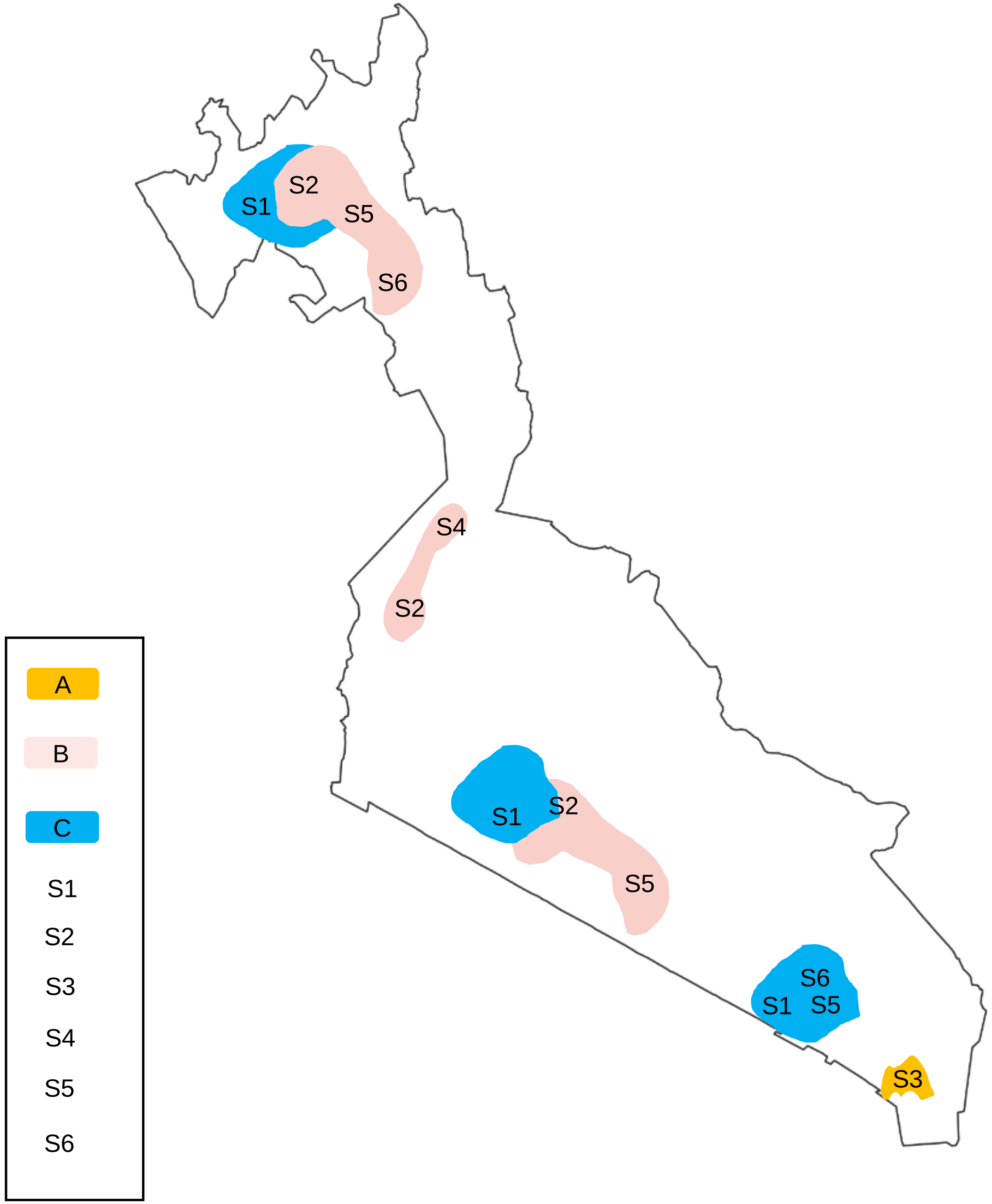


Theory and practice

We will define the 9 concepts and then discuss them together through a very simple made up case study

Sampling all biodiversity

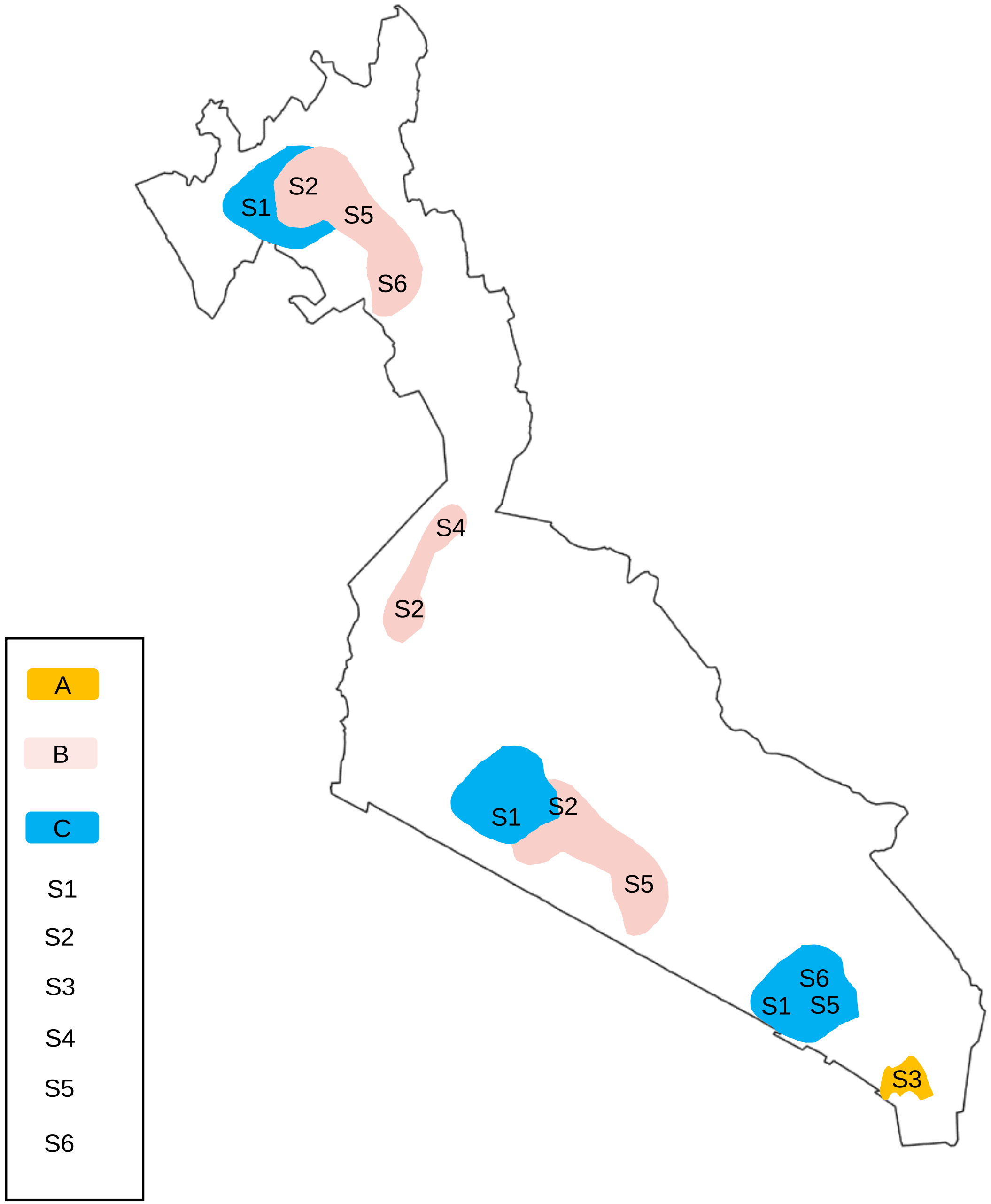
- **Comprehensiveness**: The network includes a portion of every element of biodiversity (composition, structure and function).
- **Representativeness**: Each biodiversity feature included in the network is representative of that feature.



A comprehensive and representative network should include at least one representative sample of S1 to S6 and habitats A, B, C.

Surrogacy

- Often, we are not able to sample all biodiversity of the study area.
- Well sampled biodiversity features can act as **surrogates of other biodiversity features**: keystone species, species assemblages, ecosystems, etc.
- Not a perfect solution not a one solution



Imagine we don't know where species are and we use habitats A and B as surrogates. If we do that, we would miss species 1

Adequacy and persistence

- A representative and comprehensive networks does not guarantee conservation
- The network has to be **adequate** to ensure the **persistence** of biodiversity over time (adequate targets and features, ecological processes, connectivity)

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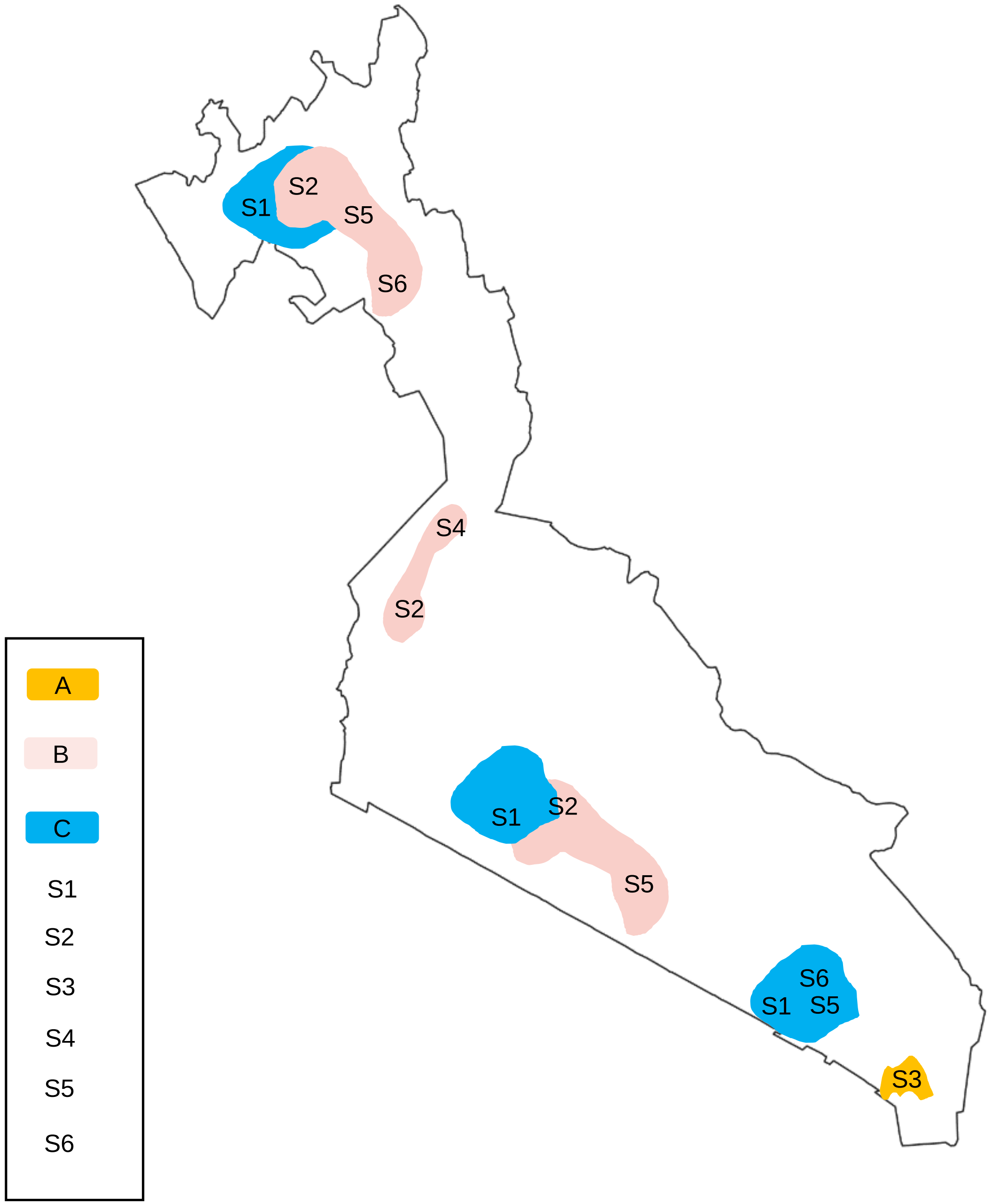

We only have resources for 3 sites and we want to have a network with all species at least once. How do we know one species per site will be enough?

Target setting can often be complex because of lack of data, somehow arbitrary, or a political decision.

Complementarity

- Considering **the contribution of each individual site in the network** to achieving the goals of the network.

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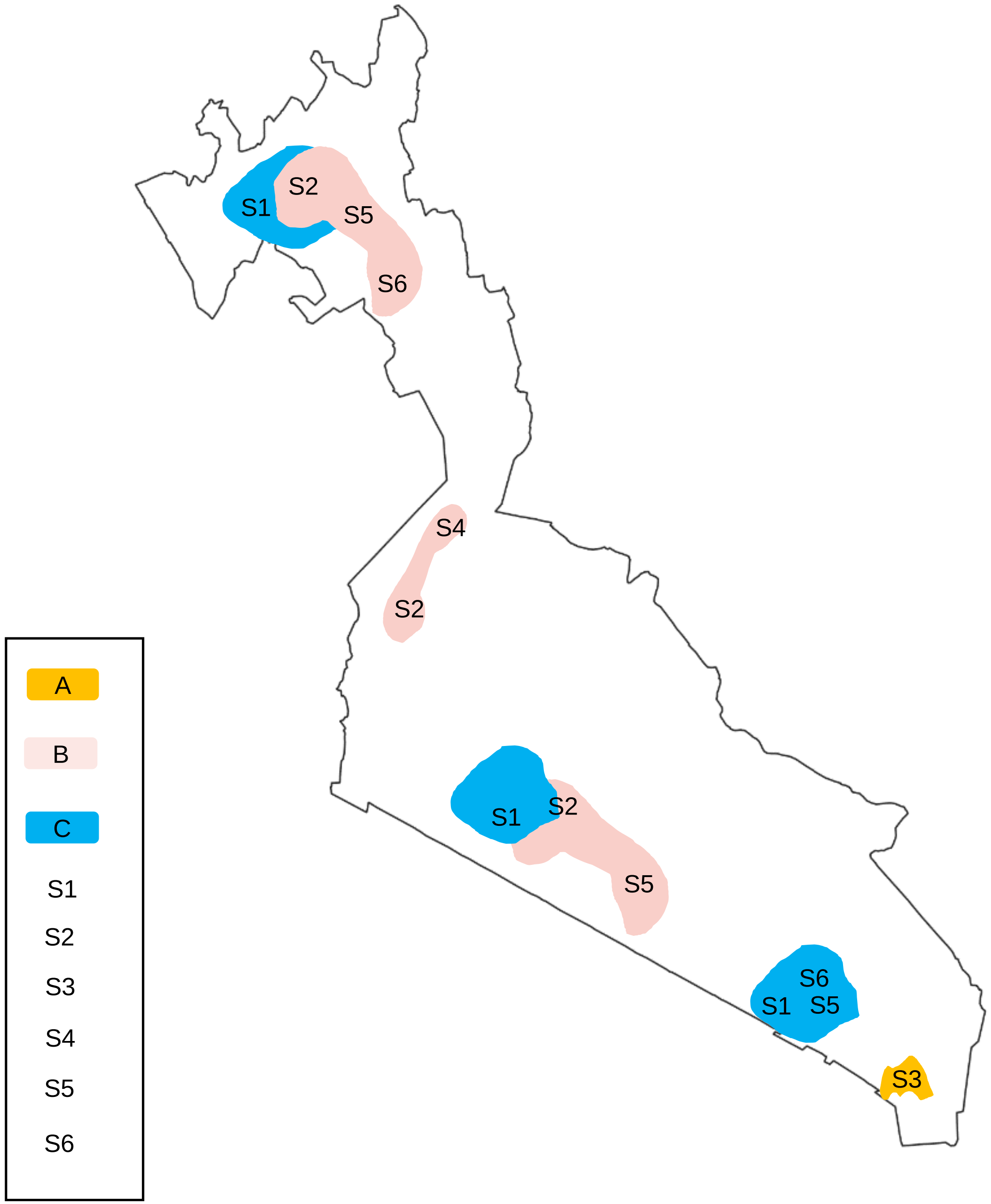
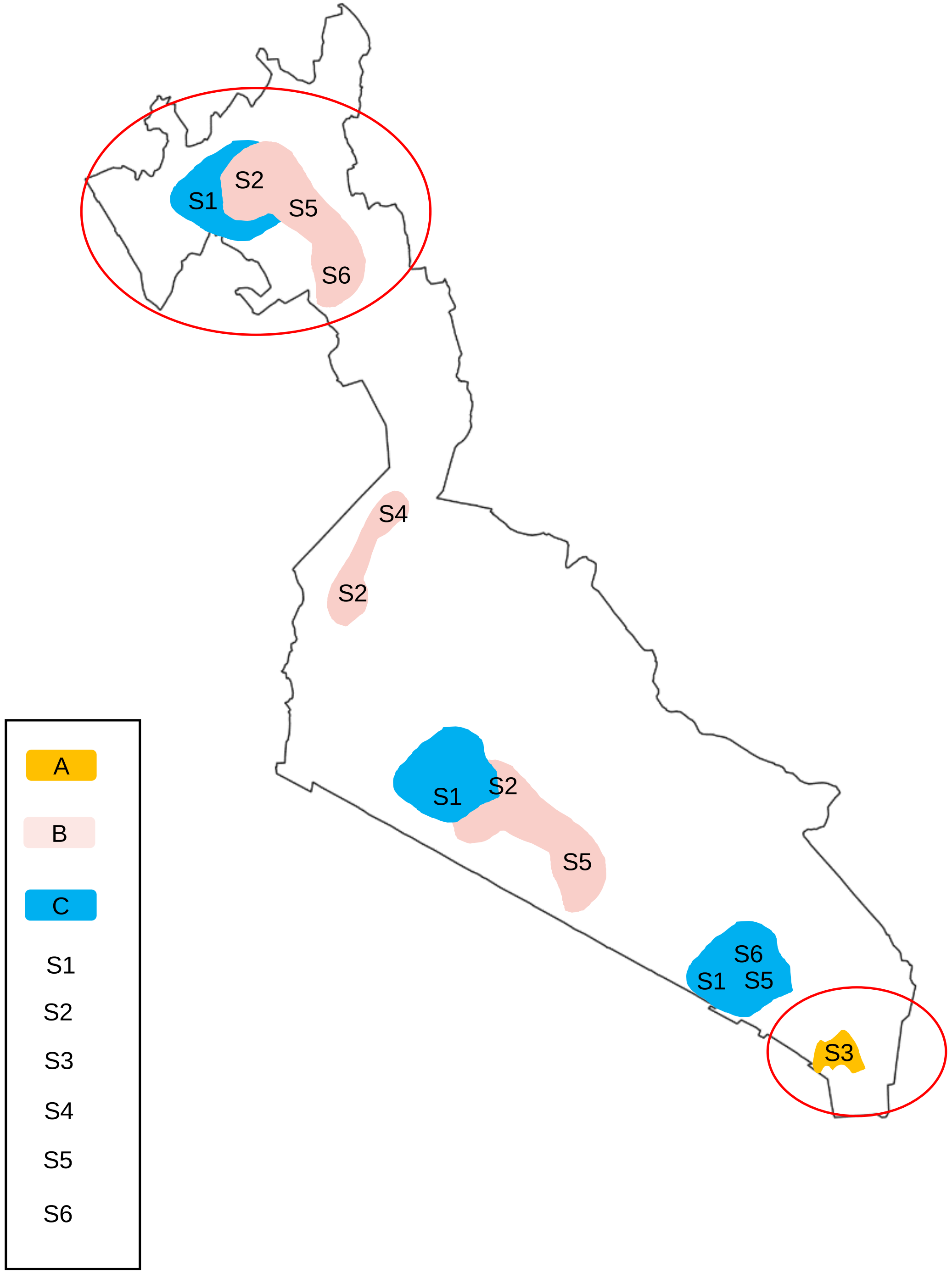


We only have resources for 3 sites and we want to have a network with all species at least once. Which ones we choose?

If we pick up the 3 richest sites we will miss species 3 and species 4. If we pick up 2 rich sites we would still need 2 sites more to capture all species

Scoring approaches Vs Complementarity based approaches

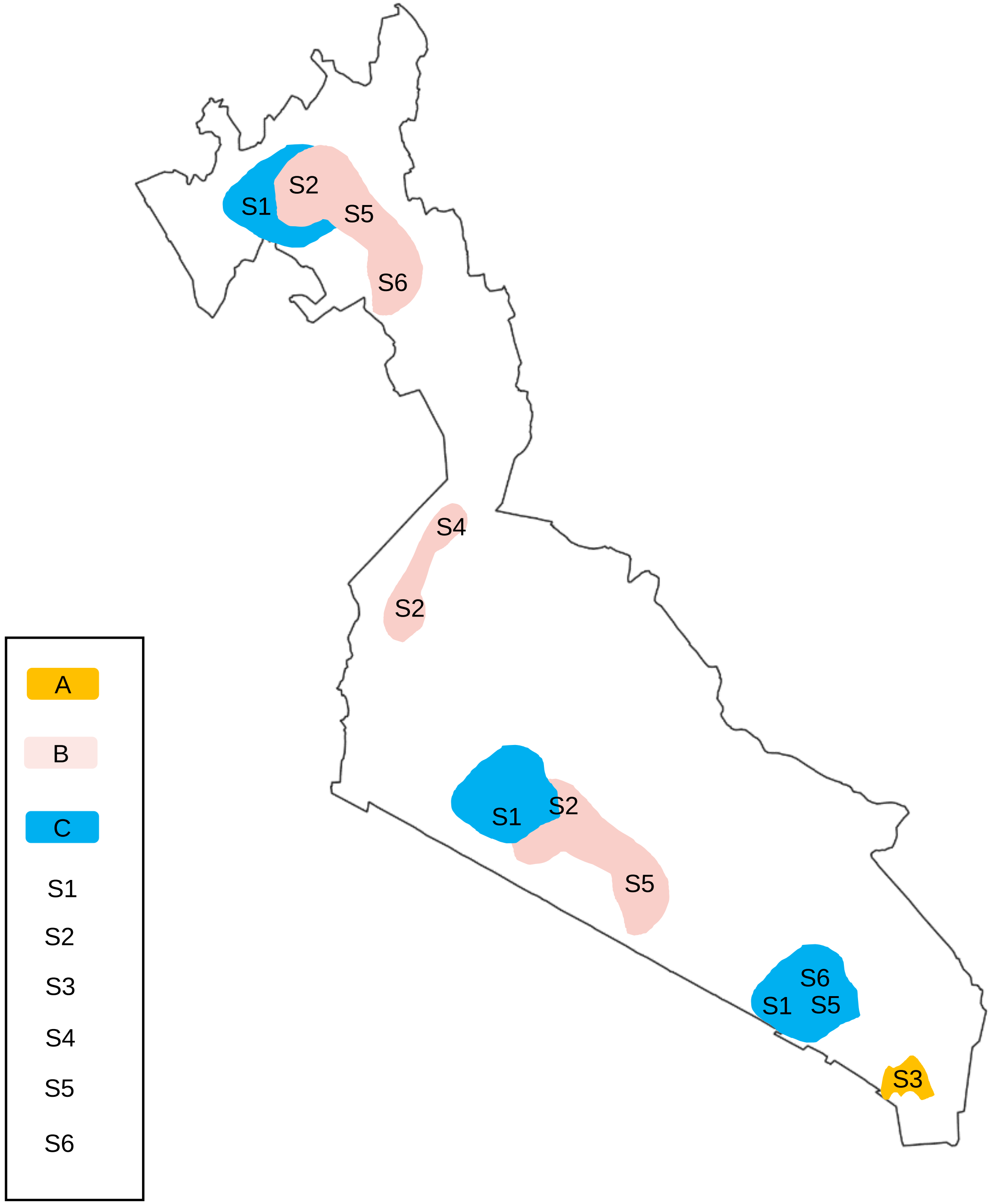


Scores biodiversity in a site based on species richness, level of endemism or conservation status

Sites with the highest scores are considered a priority for conservation

Usually multiples by a factor. For example:

Score = Number of species + 1.5 X (number of threatened species + 2.5 X (number of endemic species)



Advantages:

- Easy to understand and to apply

Disadvantages:

- Do not consider complementarity
- Do not result in representative and comprehensive networks
- Do not provide efficient solutions to create a conservation network (each site is scored individually)
- Usually do not consider constraints to the system (threats, costs, etc)

Irreplaceability

- The importance of one planning unit to achieving conservation goals of the network.

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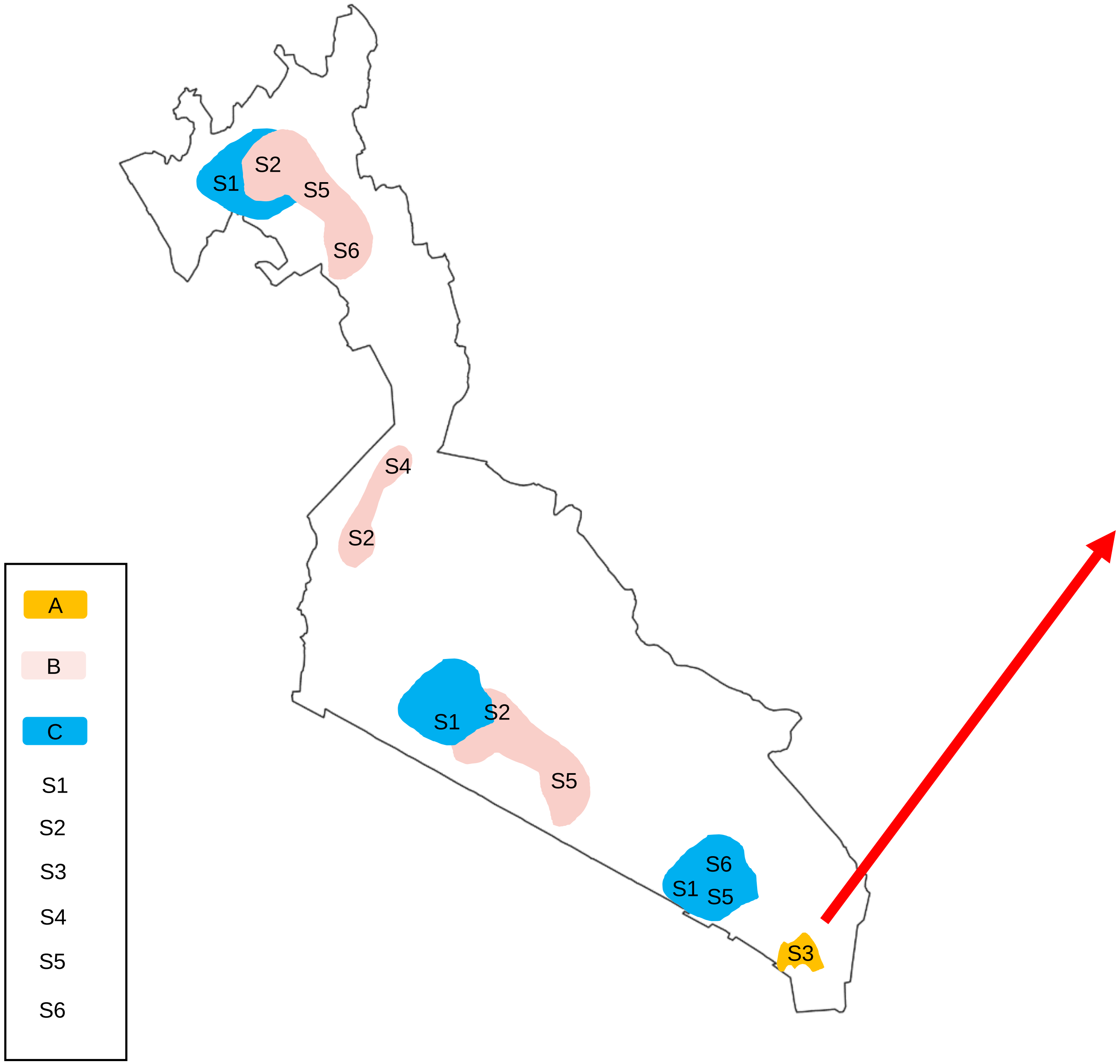
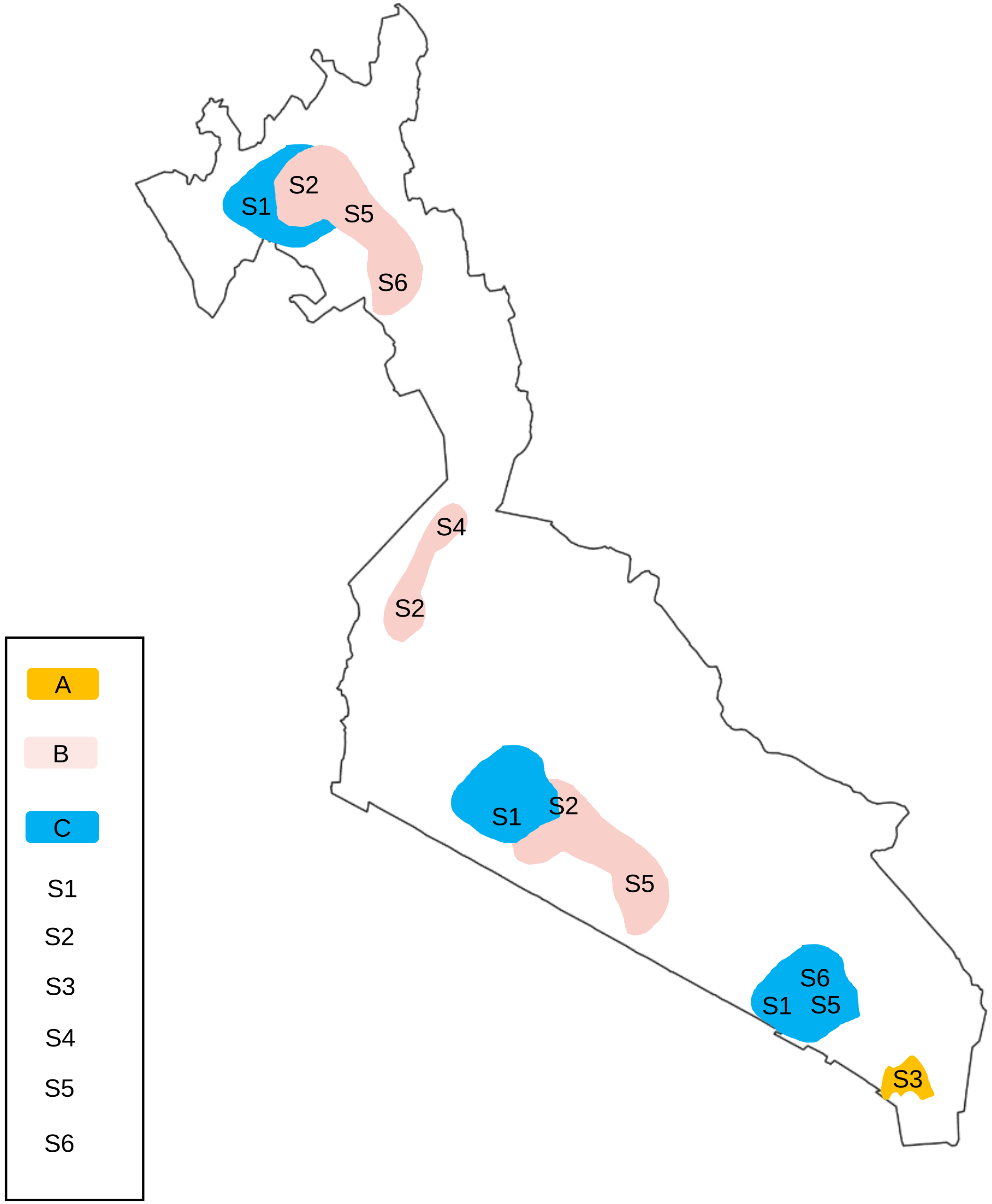


We only have resources for 3 sites and we want to have a network with all species at least once Which ones would have higher irreplaceability?

This one would have a very high irreplaceability score (IC) because we need it to meet our targets in all cases.

Vulnerability

- Likelihood of biodiversity loss caused by current or impending threatening processes.
- Can also be seen as composed by 3 dimensions: exposure to a threat, intensity of threat, and impact cause by the threat.



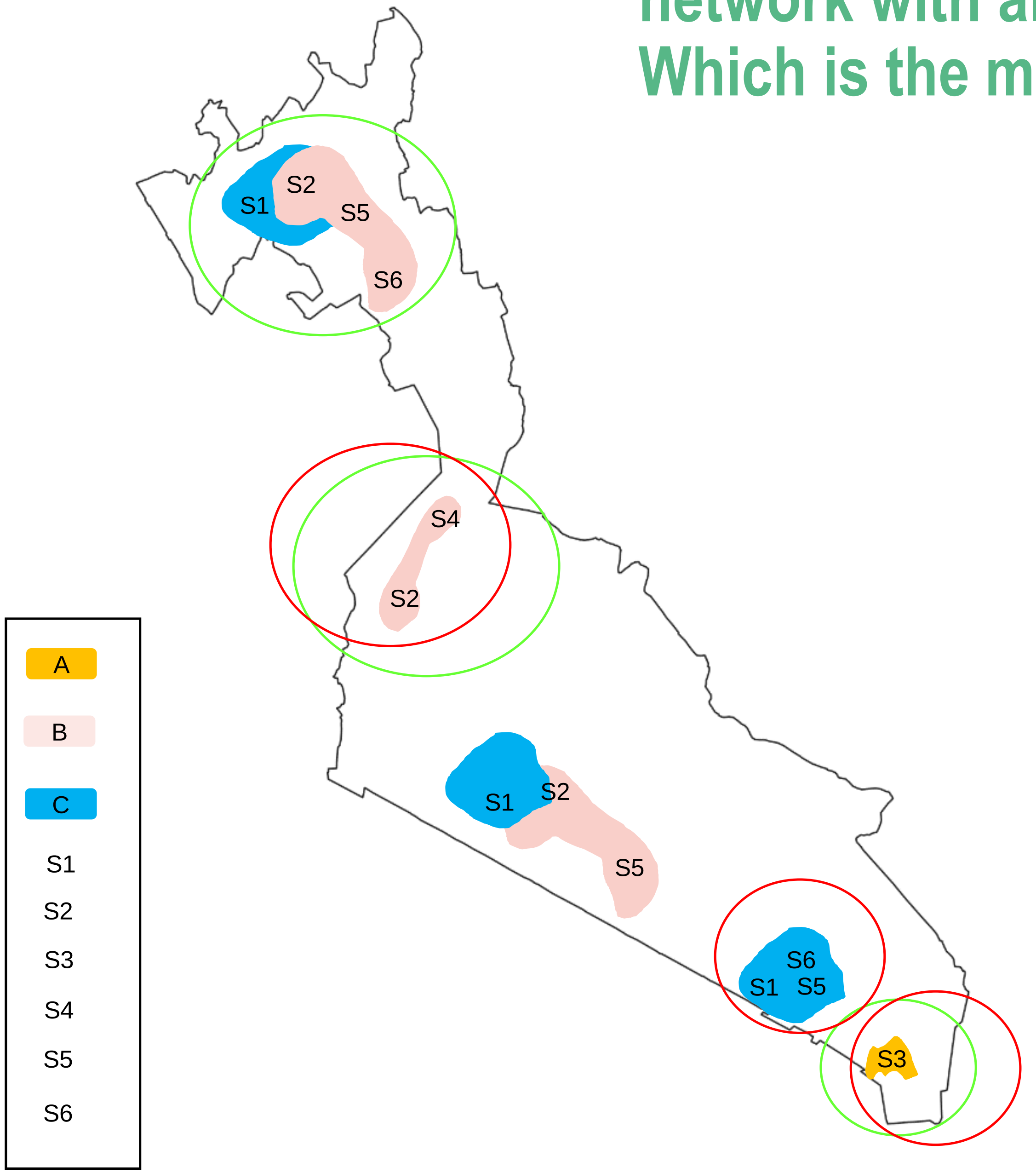
In our example we have not mapped threats because it is a simplification

Species 3 is likely to be vulnerable because it is an endemic that only occurs in one site. If a threat to this species exist it can go extinct.

Cost-efficiency

- A network of priority areas that is comprehensive, representative and adequate **at a least possible cost**
- Examples of costs: area, opportunity costs, cost of a conservation actions, threatening processes

We only have resources for 3 sites and we want to have a network with all species at least once. Our cost is hectares. Which is the most cost-efficient solution?

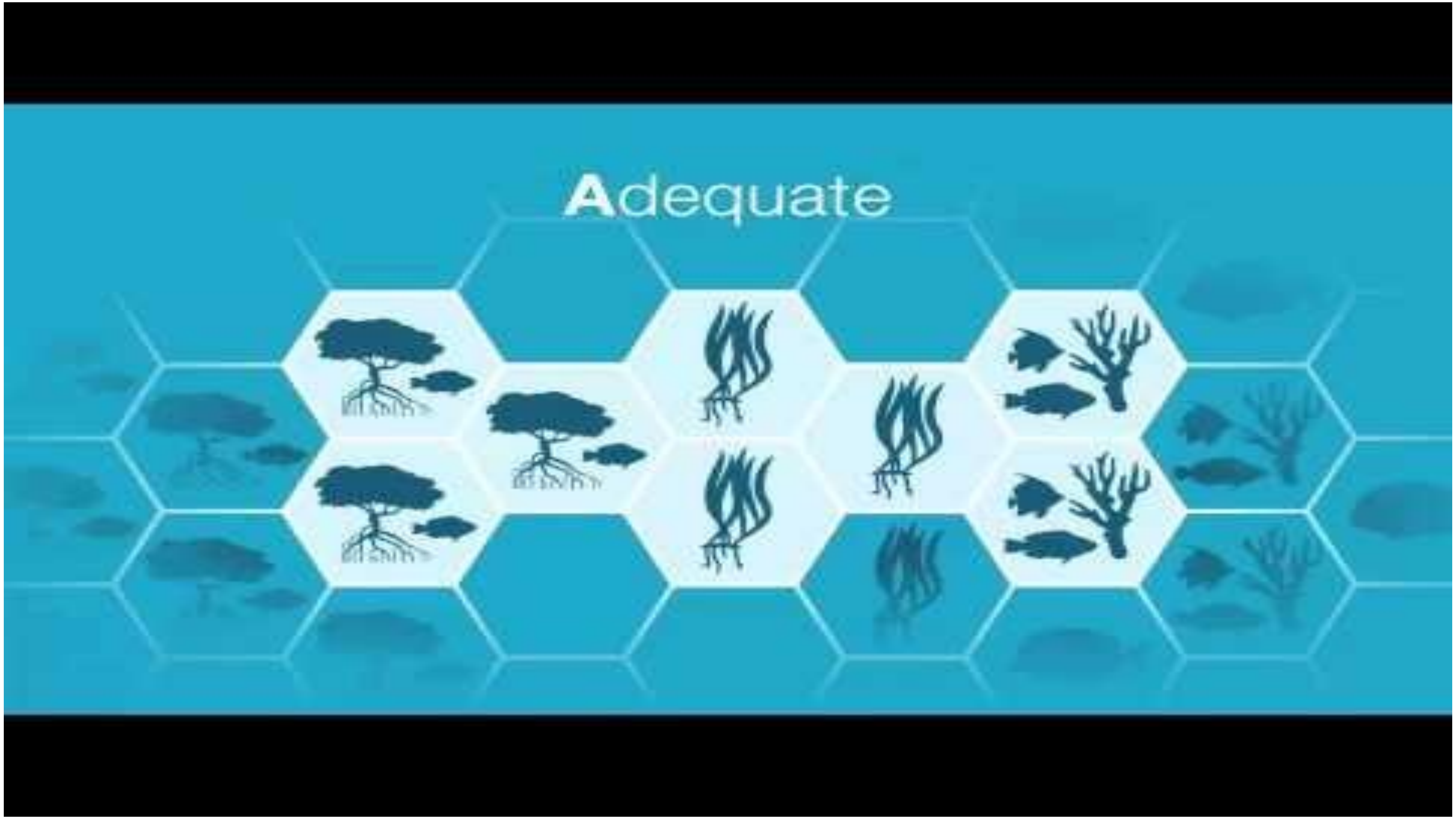


These 3 sites in green will allow us to meet our targets with the resources available.

But the red ones use less area so they would be a more cost efficient solution if we aim to minimise area.

…and this is a very simple case study : (

Short video

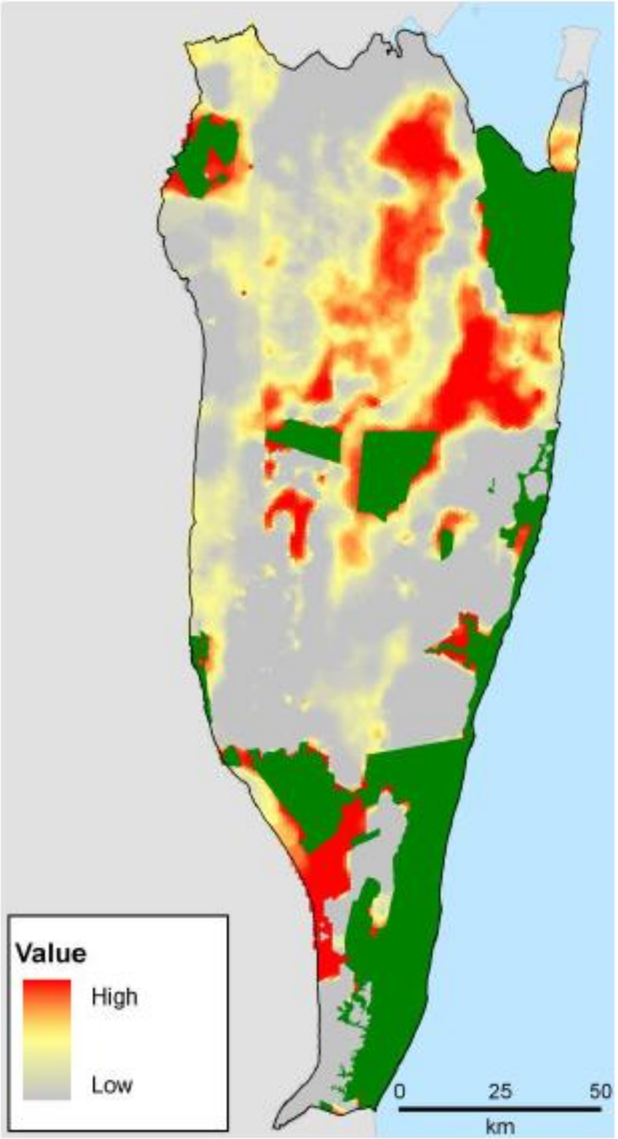


https://www.youtube.com/watch?v=1lDeKJJO7s8

Don’t panic! We have computers to help us!

Spatial prioritisation software

- Marxan
- Marxan with zones
- C-plan
- Zonation
- Cluz
- PrioritizR



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How does spatial prioritisation software work?

Re-adjust, test and run different scenarios

1.Create input files

- Planning units
- Biodiversity and Ecosystem services locations
- Threats and constraints
- Target for each feature

60% of your time

2.Software

- Set software settings
- Run the software

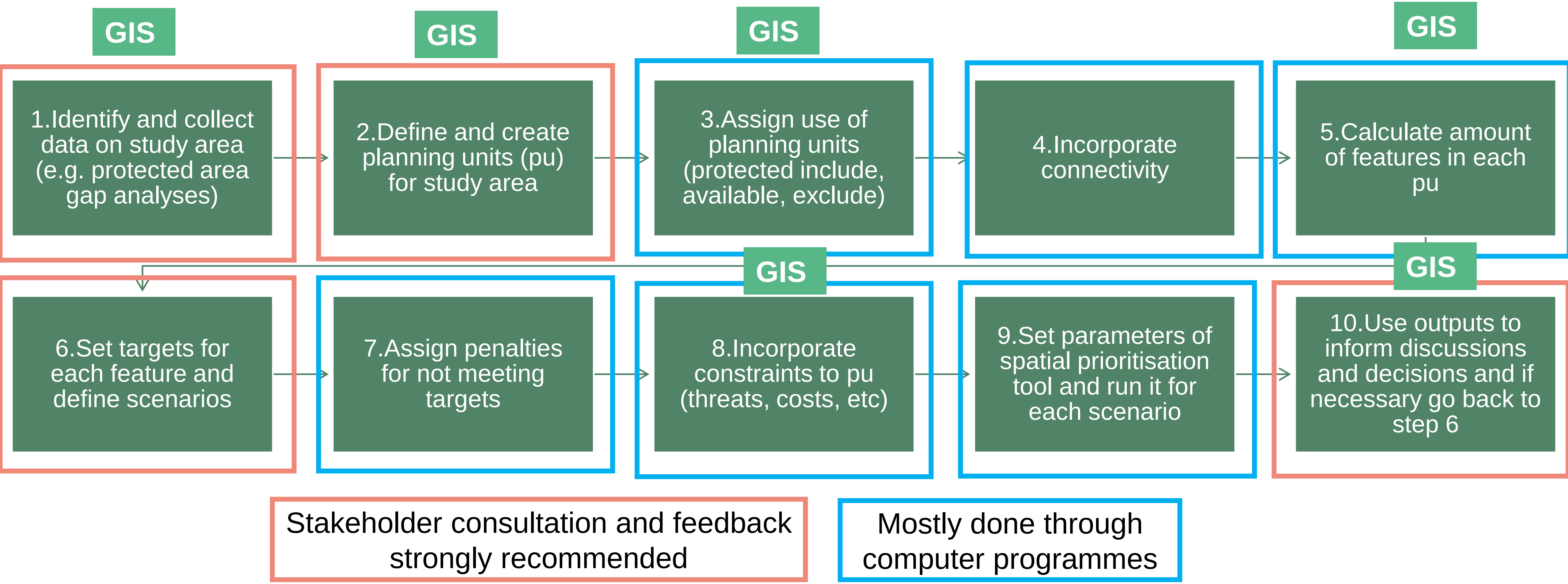
10% of your time

3.Outputs

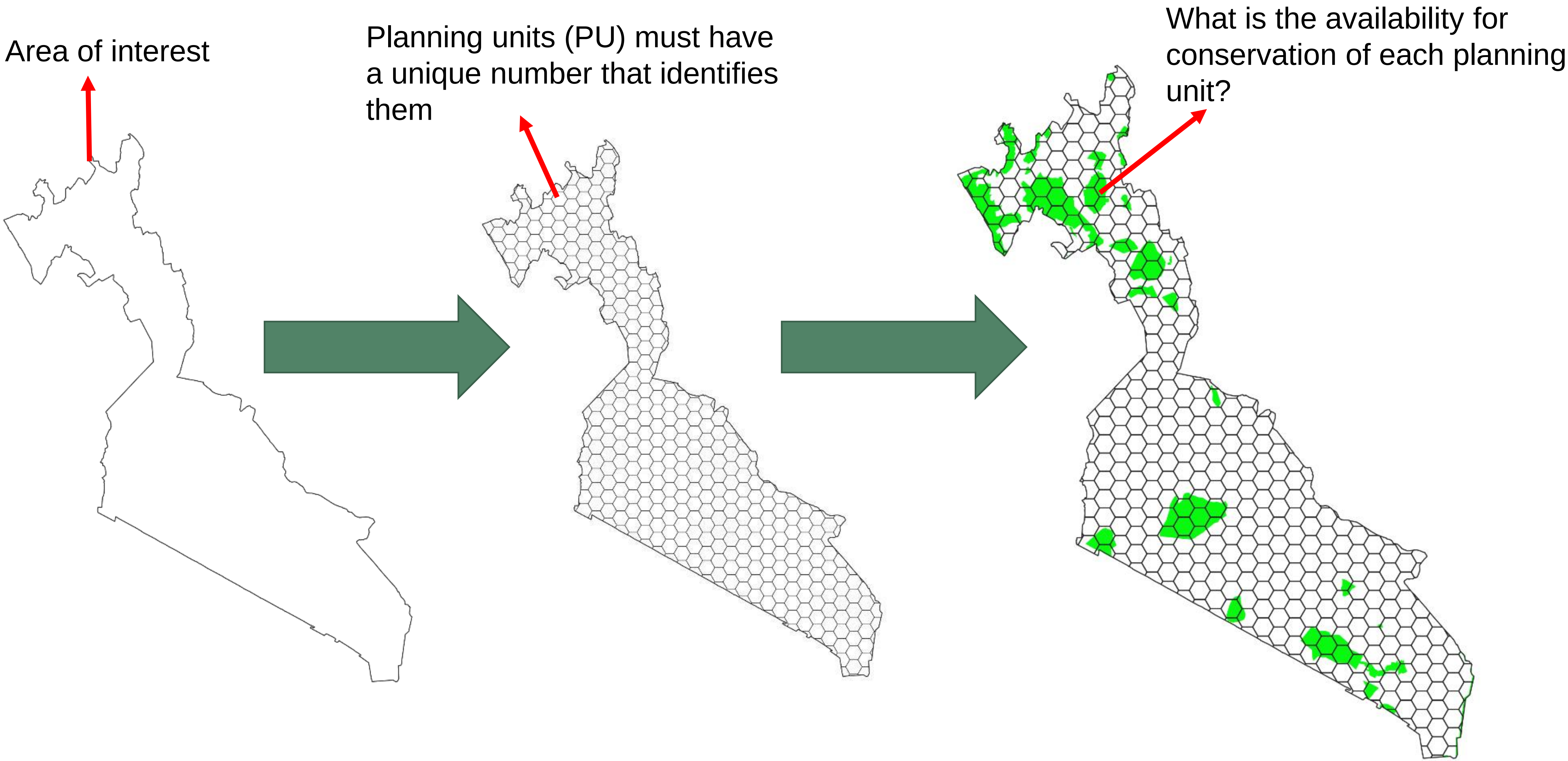
- Process and interprest results
- Discuss results with target audience

30% of your time

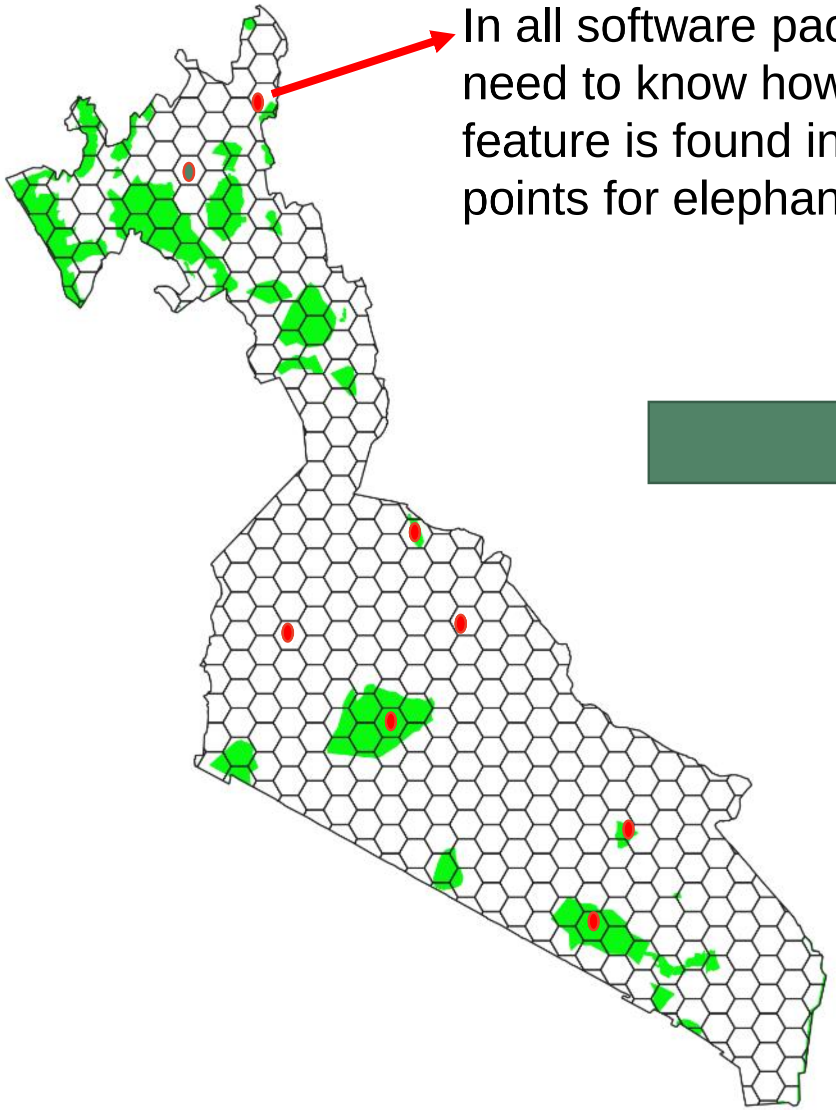
Generic workflow for most Spatial prioritisation software (not always linear)



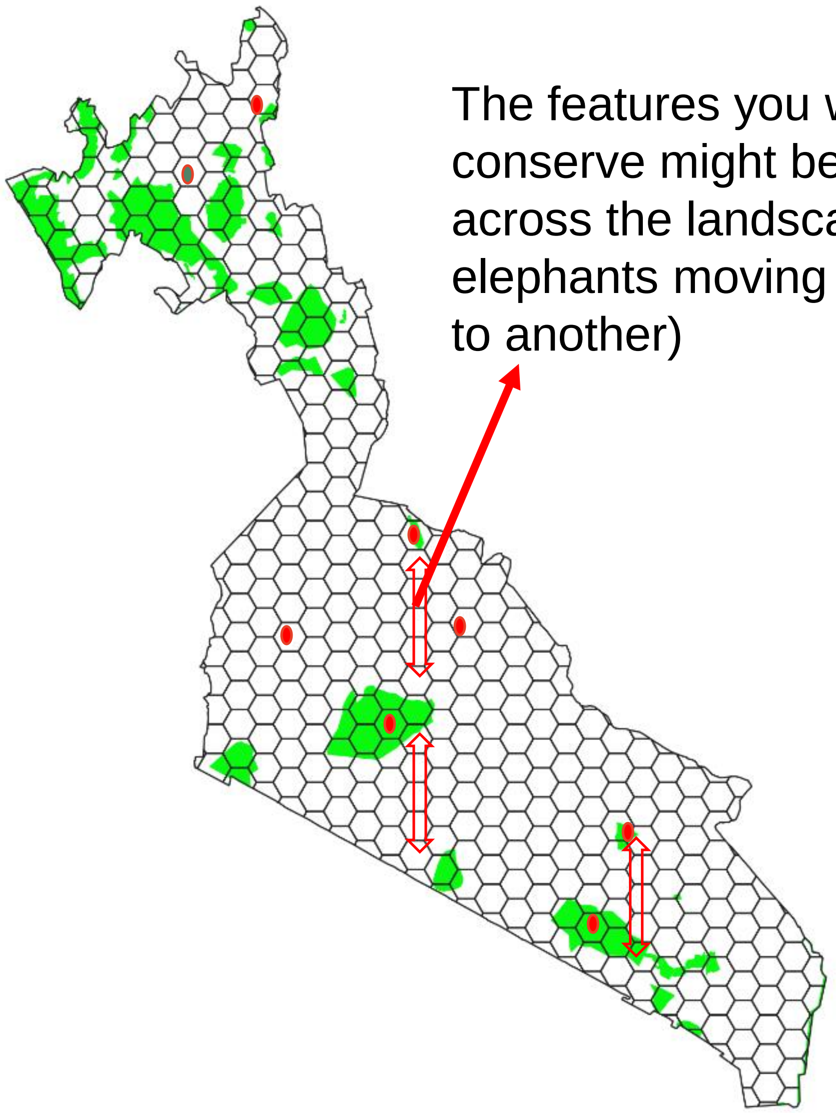
Defining and understanding planning units



Features in planning units

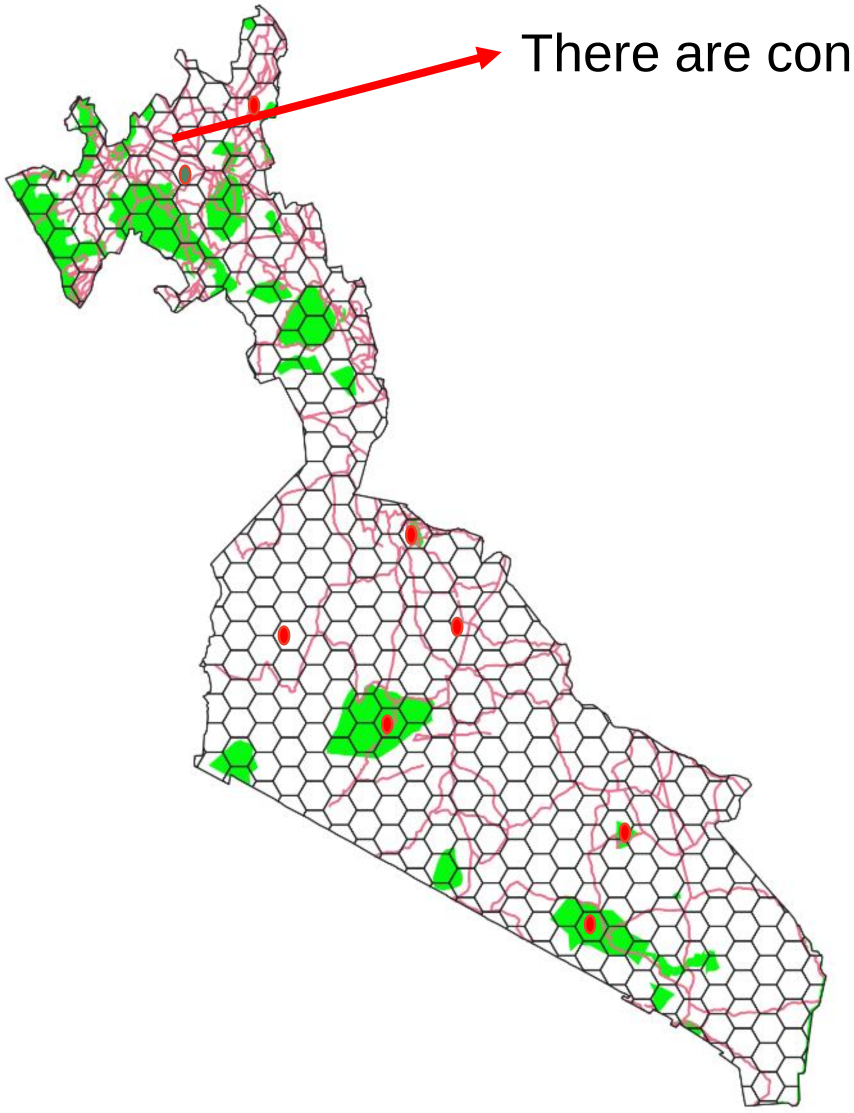


In all software packages you need to know how much of each feature is found in each PU (i.e points for elephant locations)



The features you want to conserve might be connected across the landscape (i.e. elephants moving from one place to another)

Threats and constraints

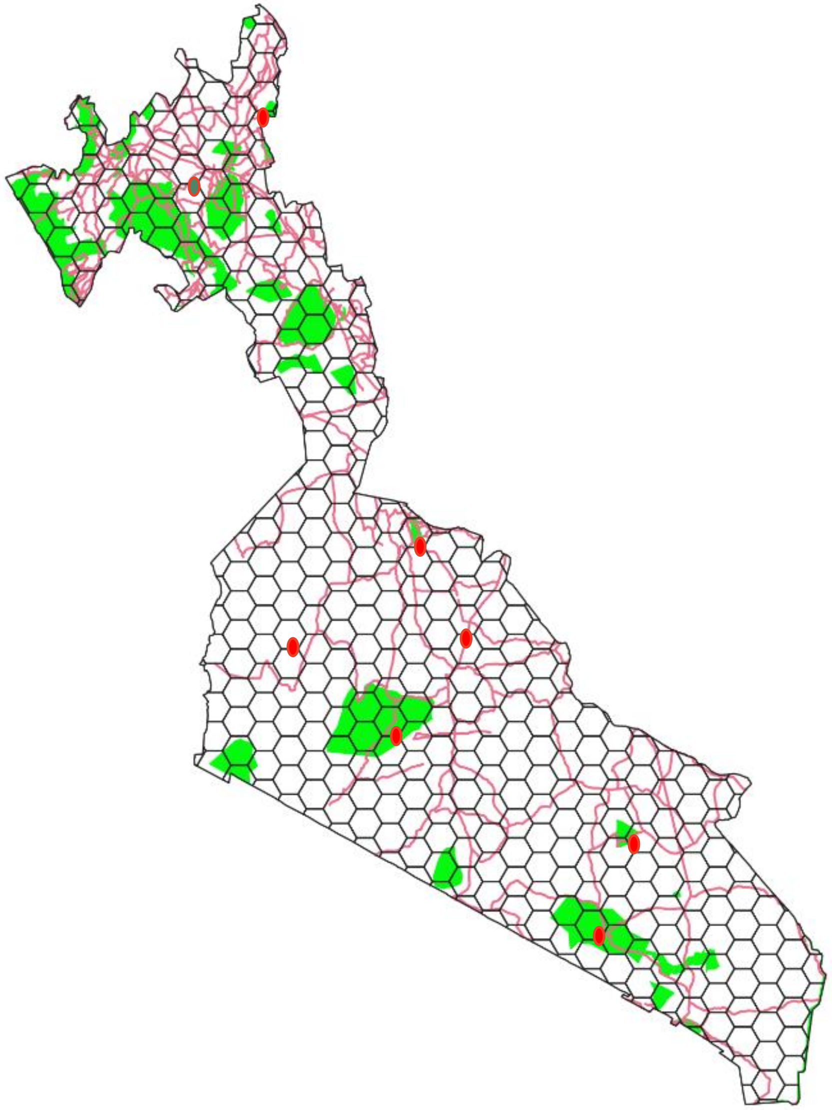


There are constraints to conservation (i.e. roads)

The software will need you to assign the costs of achieving your conservation goals for each PU

- Cost of land
- Area
- Willingness to do conservation
- Wilderness

Targets



Defining how much of each conservation feature you would like to include in your network

- Number of species in different places
- Area of a particular habitat or place of importance
- % of given population or habitat

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Some tools to run spatial prioritisation

There are a few but there are two widely used and a relatively new one that I like:

1. Marxan
2. Zonation
3. PrioritizR

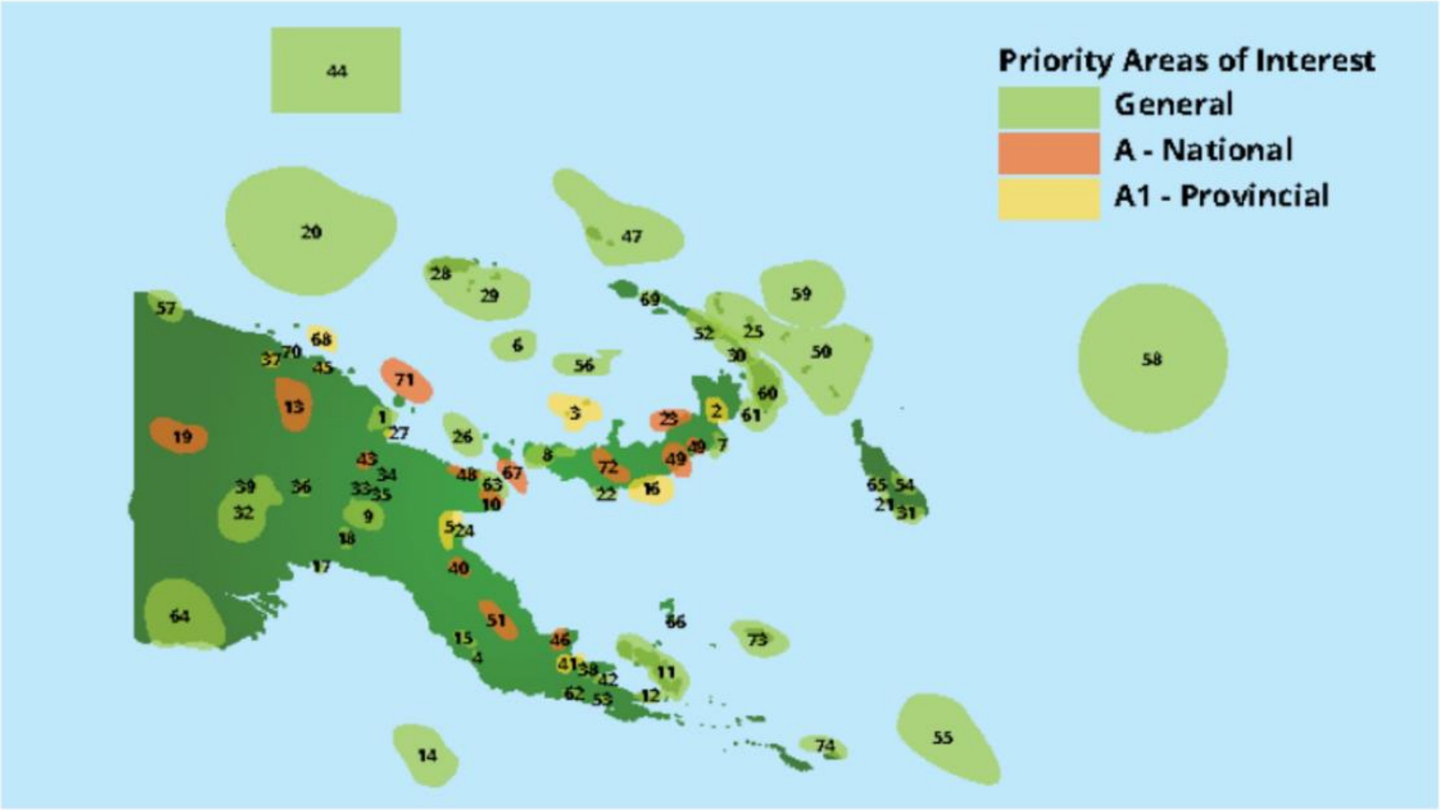
Marxan – a very simple .exe file

Inputs: csv files with planning units, conservation features, land use, conservation targets, cost, settings.

What does it do?: runs a simulated annealing algorithm to select planning units that meet conservation targets at a minimum cost.

Outputs: a portfolio of sites that meet the targets at a minimum cost, target performance, selection frequency.

http://marxan.org/



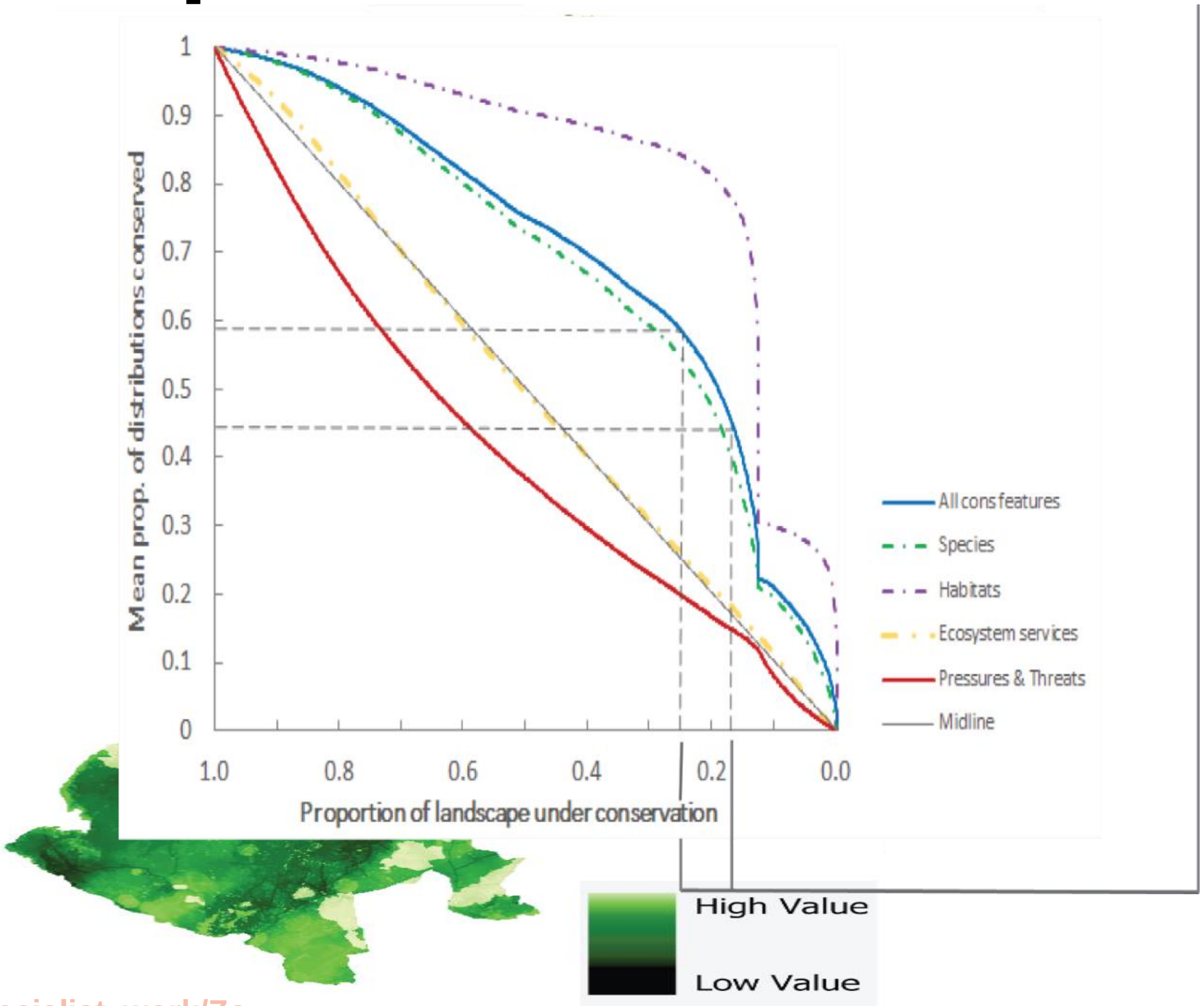
Marxan with zones adds another level of complexity

Zonation – a more sophisticate .exe file

Inputs: rasters, conservation features, land use, weights, settings.

What does it do?: uses a meta-algorithm to iteratively removes the sites (cells) that cause the smallest marginal loss.

Output: A hierarchical prioritization of the landscape based on the occurrence levels of biodiversity features in sites (cells).



https://www.syke.fi/en-US/Research__Development/Ecosystem_services/Specialist_work/Zonation_in_Finland/Zonation_software

PrioritizR – an R package

prioritizr 4.1.0.1 | Get started | Reference | Articles | Changelog

Systematic Conservation Prioritization in R

The *prioritizr R* package uses integer linear programming (ILP) techniques to provide a flexible interface for building and solving conservation planning problems. It supports a broad range of objectives, constraints, and penalties that can be used to custom-tailor conservation planning problems to the specific needs of a conservation planning exercise. Once built, conservation planning problems can be solved using a variety of commercial and open-source exact algorithm solvers. In contrast to the algorithms conventionally used to solve conservation problems, such as heuristics or simulated annealing, the exact algorithms used here are guaranteed to find optimal solutions. Furthermore, conservation problems can be constructed to optimize the spatial allocation of different management actions or zones, meaning that conservation practitioners can identify solutions that benefit multiple stakeholders. Finally, this package has the functionality to read input data formatted for the *Marxan* conservation planning program, and find much cheaper solutions in a much shorter period of time than *Marxan*.

https://prioritizr.net/index.html

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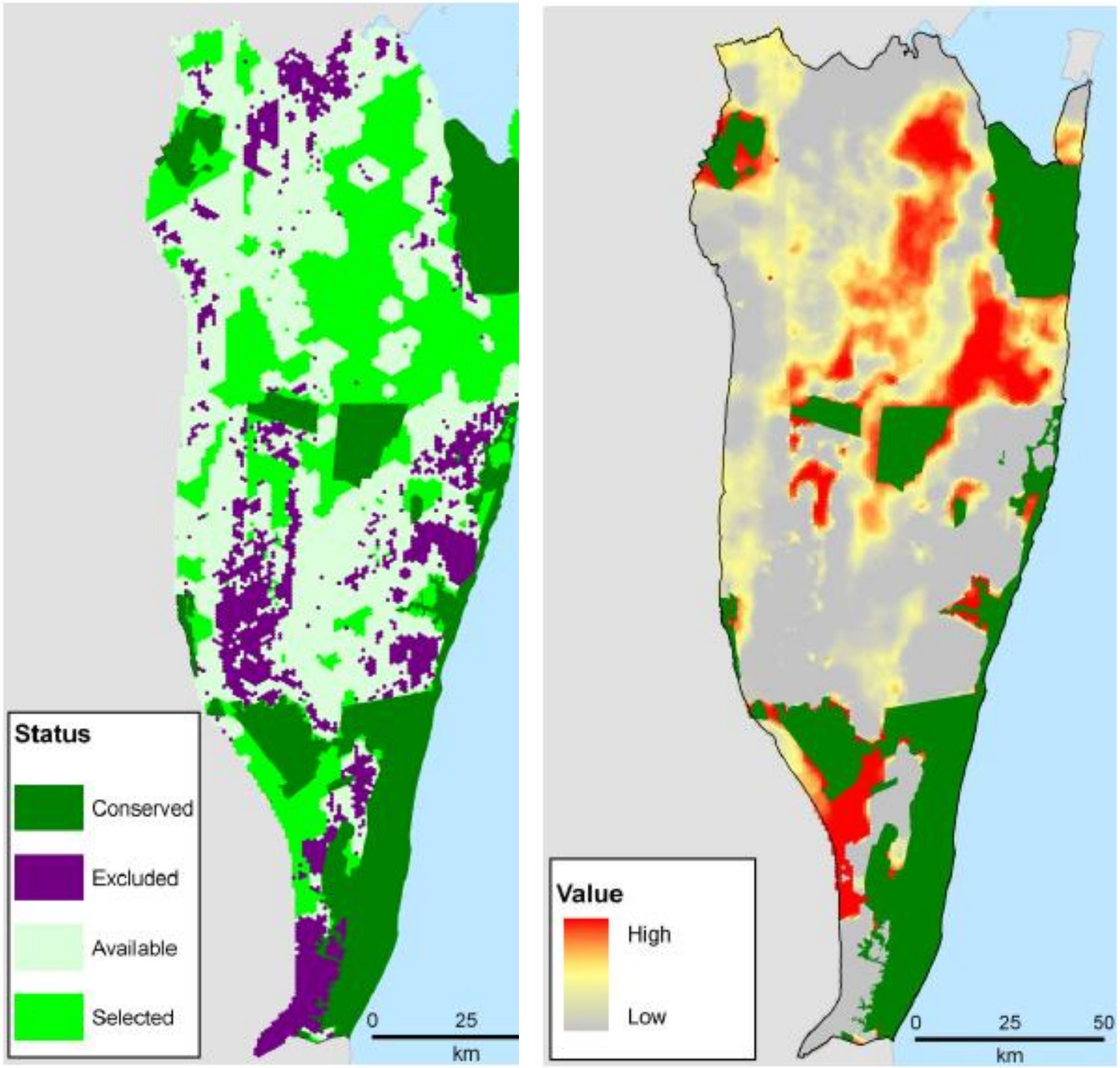
Using and understanding outputs and linking these to GIS



Source: Smith et al. 2018

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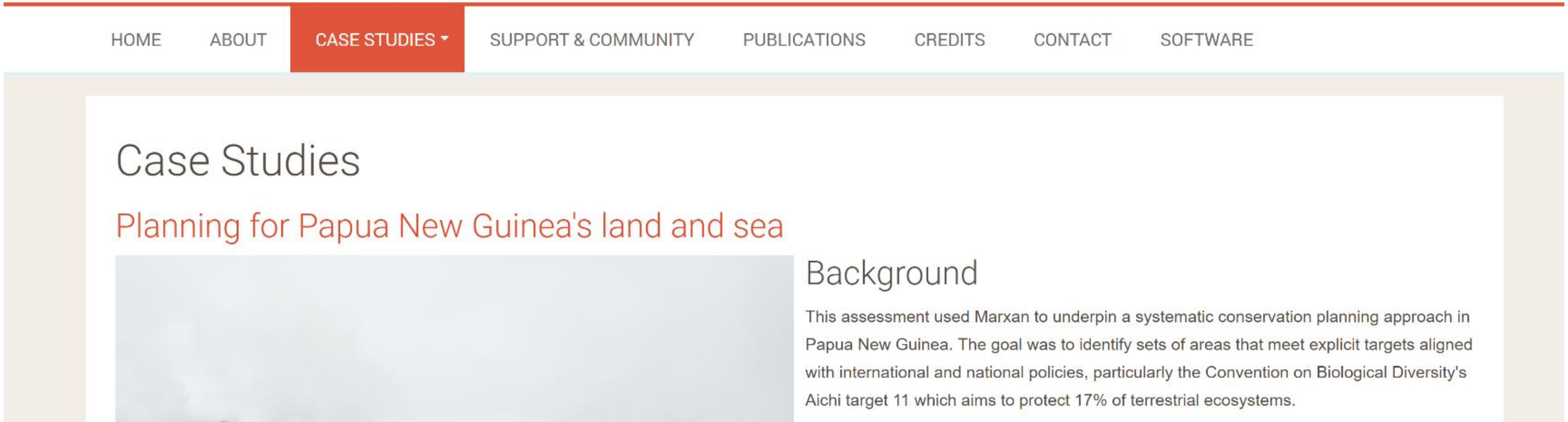
How is it used? Lets take a break to read some examples!

MARXAN
conservation solutions

http://marxan.org/case-studies.html



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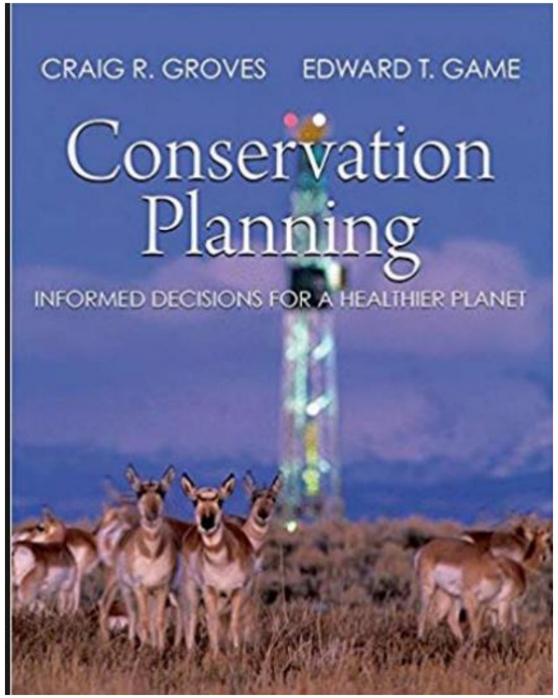
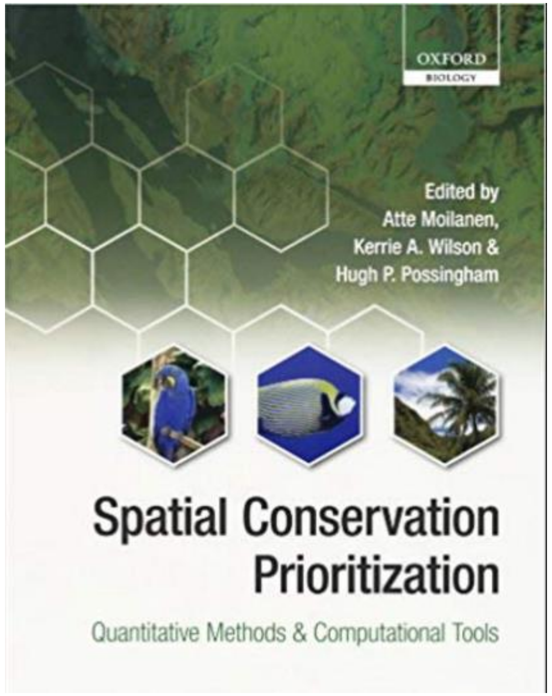
Further reading…there is a lot

- A folder with 21 papers/report (in this training)
- Two books (not provided in this training)



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