The IUCN Global Ecosystem Typology

IUCN Ecosystem Red List Thematic Group

Prof. David Keith

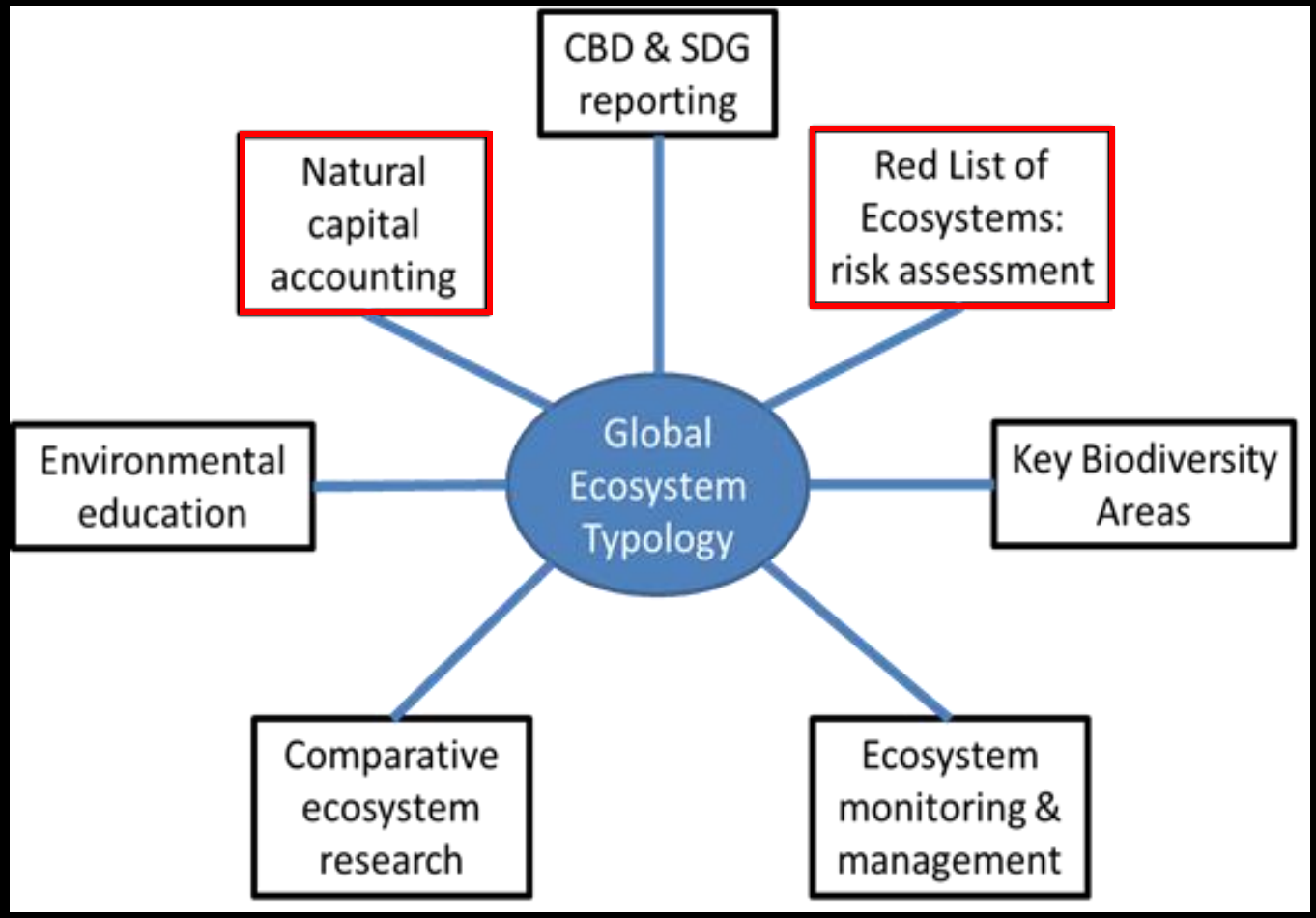
UNSW, Australia *david.keith@unsw.edu.au*

A/Prof. Emily Nicholson

Deakin University, Australia e.nicholson@deakin.edu.au

2019 Forum of Experts on SEEA Experimental Ecosystem Accounting, June 2019

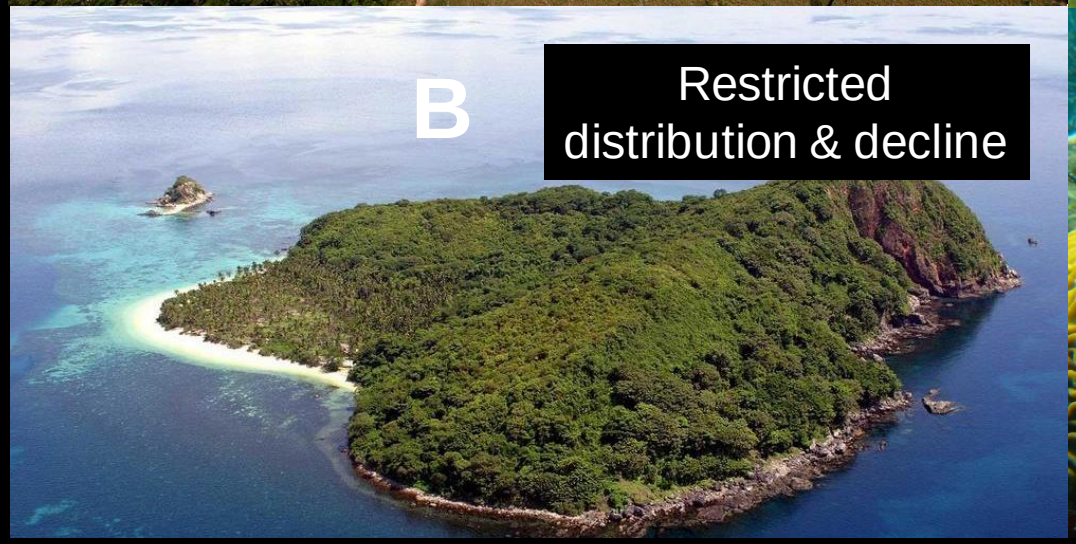
Broader needs for an ecosystem typology

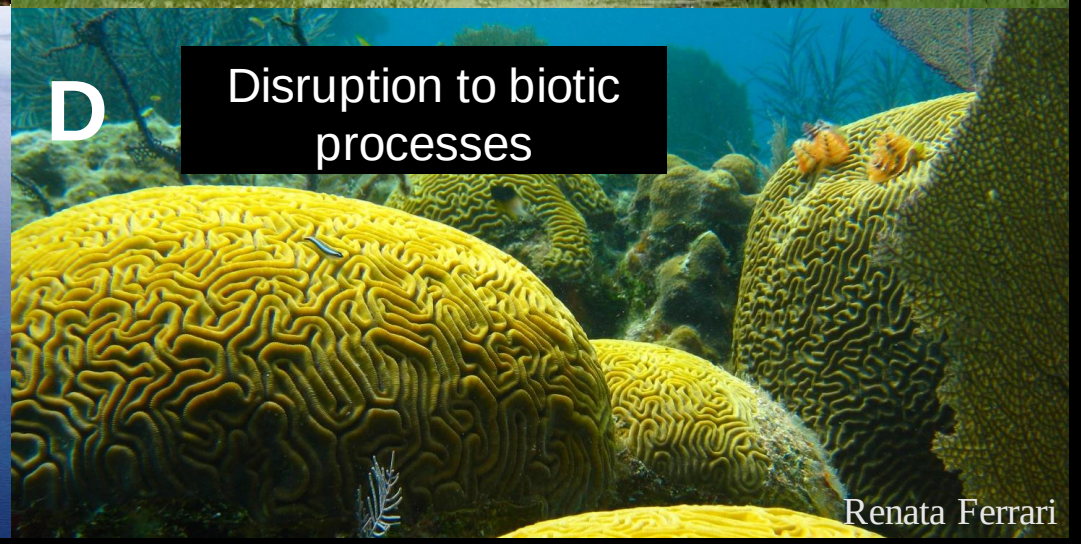


Global Ecosystem Typology: principal goals

1. Enable generalisations about ecosystem change
   - grouping ecosystems that share similar functional traits, threats, drivers and indicators
2. Facilitate translation across existing typologies
   - leverage past investments & current usage through a common terms & comparative framework
3. Promote efficient use of scarce data
   - through inferences about similar ecosystems
   - by integrating local expertise (bottom-up versus top-down)
4. Support conservation planning
   - systematic and consistent definition of assessment units worldwide
   - guide delineation of units for risk assessment (IUCN Red List of Ecosystems) & spatial planning

What is the IUCN Red List of Ecosystems?

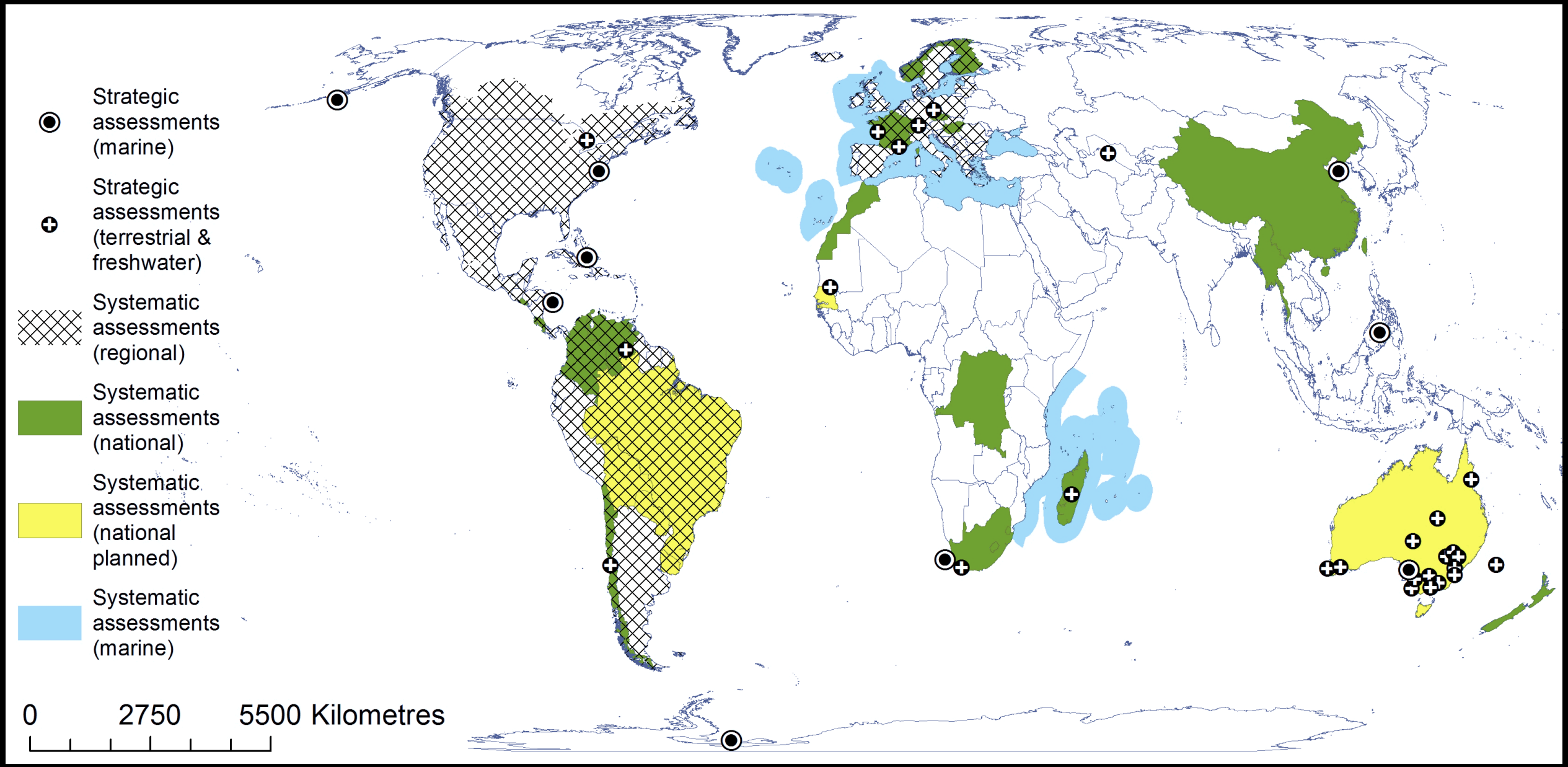




IUCN

CO CR EN VU NT LC DD NE

What is the IUCN Red List of Ecosystems?



Why yet another classification?

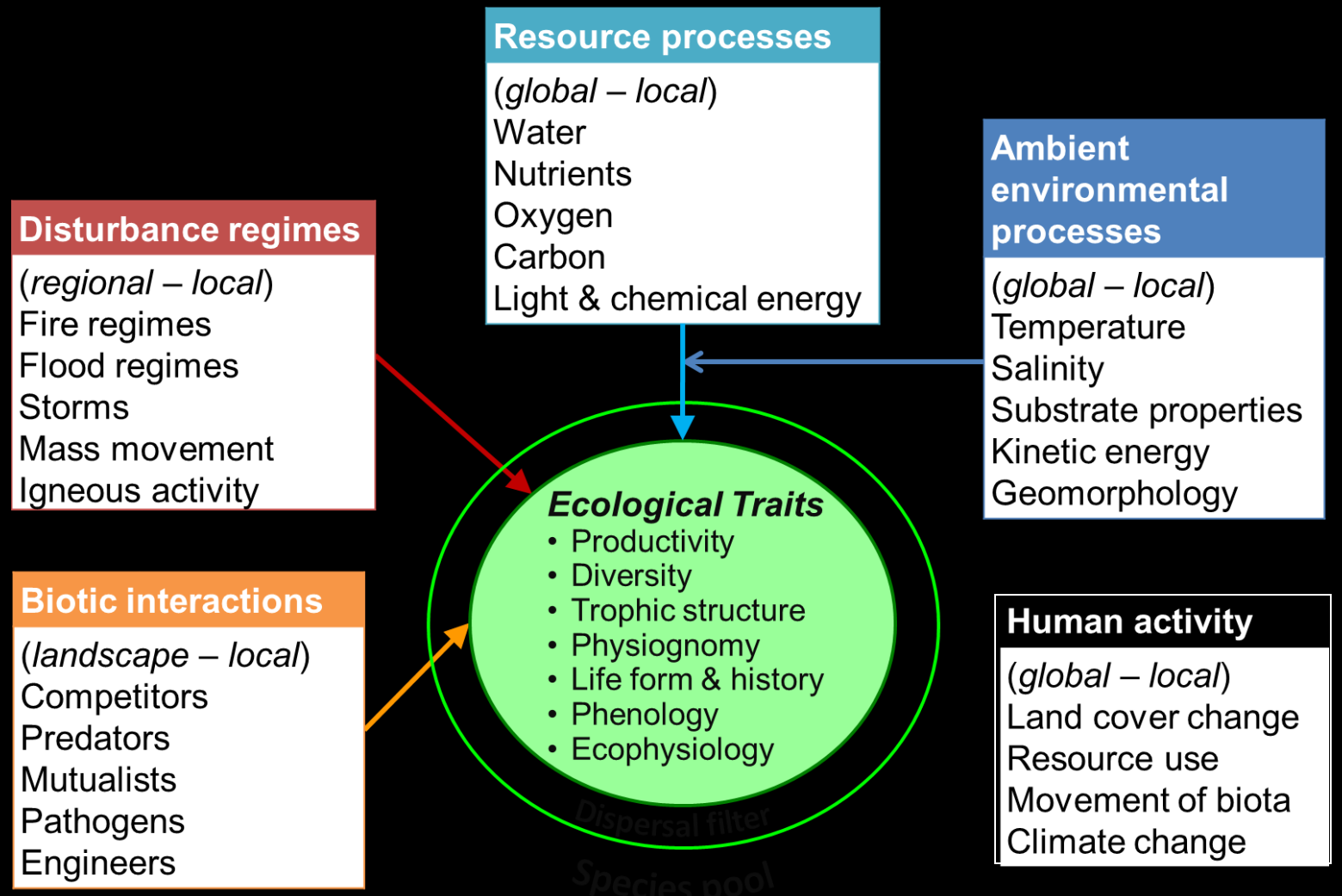
Design criteria:

1. Represent ecological processes & function
2. Represent variation in biota
3. A scalable structure (nested/herarchical)
4. Consistent coverage across the biosphere
5. Spatially explicit (mappable units)
6. Parsimonious

Reviewed 20 existing global ecological typologies
None met all 6 design criteria

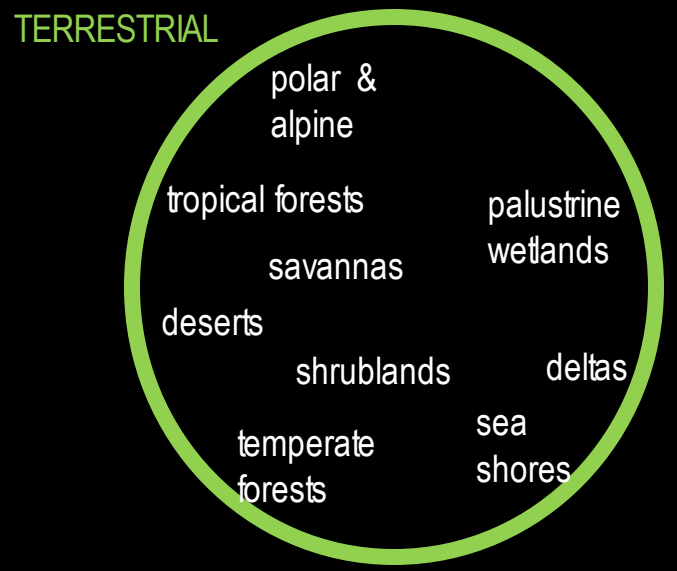
Establishing a theoretical foundation

- ecosystem assembly theory
- shared traits and key ecological processes
- focus on ***ecosystem function***



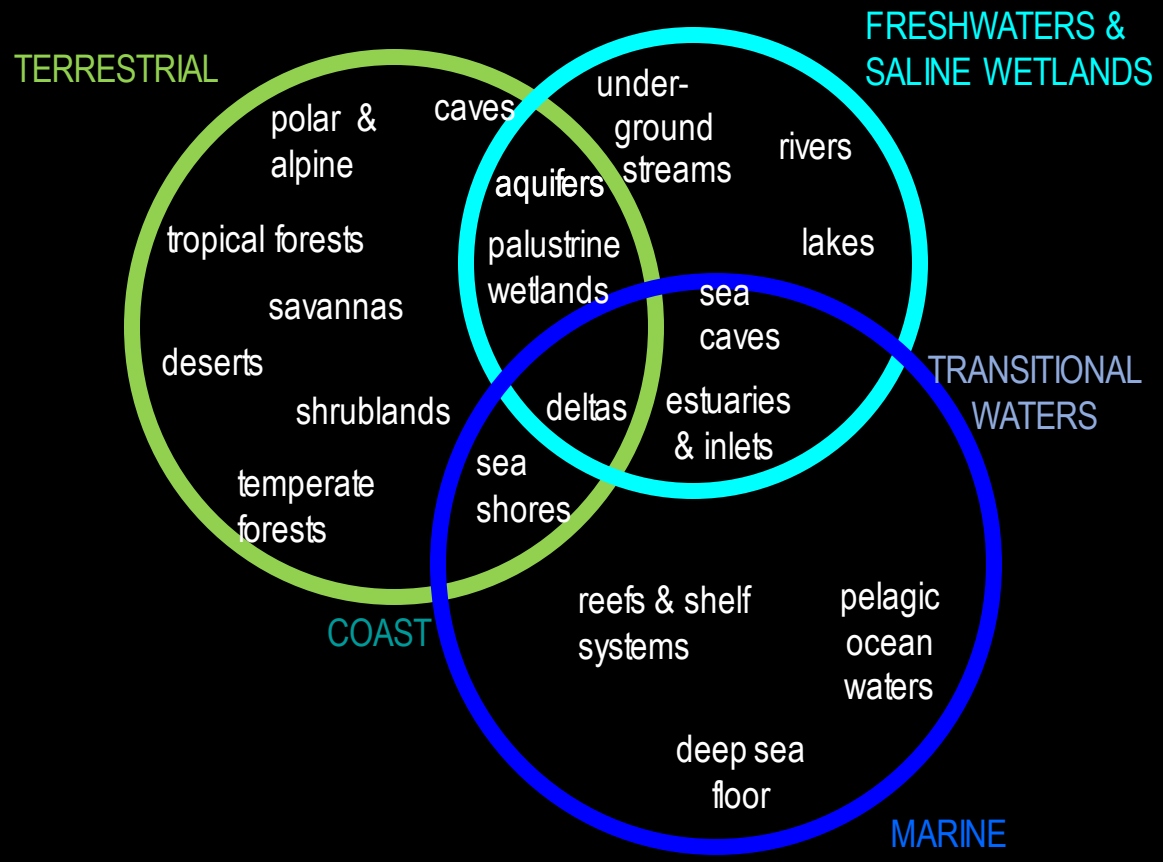
Upper typological levels: *realms & biomes*

- Distinguishing five fundamental ecological media
- Recognising ecological continua: *'transitional realms'*
- 24 biomes



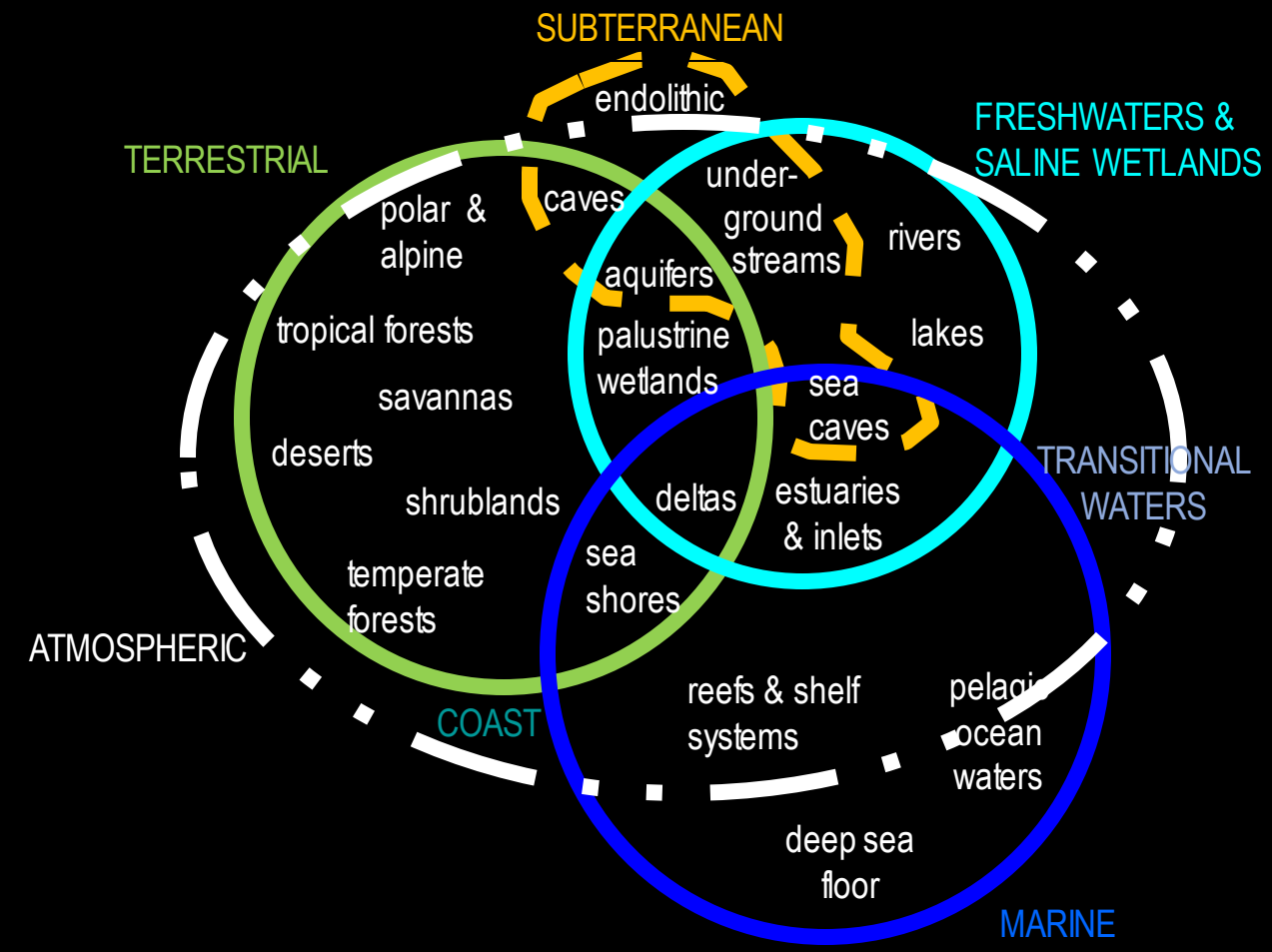
Upper typological levels: *realms & biomes*

- Distinguishing five fundamental ecological media
- Recognising ecological continua: *'transitional realms'*
- 24 biomes



Upper typological levels: *realms & biomes*

- Distinguishing five fundamental ecological media
- Recognising ecological continua: *'transitional realms'*
- 24 biomes



Level 3: ecosystem functional groups

Defined by shared ecological traits & key ecological processes & functions

100 groups across 4 realms & their transitions,

86 natural/seminatural, 14 anthropogenic across all biomes & realms

Terrestrial

T1 Tropical-subtropical forests	T1.1Tropical/Subtropical lowland rainforests
T1 Tropical-subtropical forests	T1.2 Tropical/Subtropical dry forests and scrubs
T1 Tropical-subtropical forests	T1.3 Tropical/Subtropical montane rainforests
T1 Tropical-subtropical forests	T1.4 Tropical heath forests
T2 Temperate-boreal forests & woodlands	T2.1 Boreal and montane needle-leaved forest and woodland
T2 Temperate-boreal forests & woodlands	T2.2 Temperate deciduous forests and shrublands
T2 Temperate-boreal forests & woodlands	T2.3 Cool temperate rainforests
T2 Temperate-boreal forests & woodlands	T2.4 Warm temperate rainforests
T2 Temperate-boreal forests & woodlands	T2.5 Temperate pyric humid forests
T2 Temperate-boreal forests & woodlands	T2.6 Temperate pyric sclerophyll forests and woodlands
T3 Shrublands & shrub-dominated woodlands	T3.1 Seasonally dry tropical shrublands
T3 Shrublands & shrub-dominated woodlands	T3.2 Seasonally dry temperate heaths and shrublands
T3 Shrublands & shrub-dominated woodlands	T3.3 Cool temperate heathlands
T3 Shrublands & shrub-dominated woodlands	T3.4 Rocky pavements, screes and lava flows
T4 Savannas and grasslands	T4.1 Trophic savannas
T4 Savannas and grasslands	T4.2 Pyric tussock savannas
T4 Savannas and grasslands	T4.3 Hummock savannas
T4 Savannas and grasslands	T4.4 Temperate wooded savannas
T4 Savannas and grasslands	T4.5 Temperate grasslands
T5 Deserts and semi-deserts	T5.1 Semi-desert steppes
T5 Deserts and semi-deserts	T5.2 Thorny deserts and semi-deserts
T5 Deserts and semi-deserts	T5.3 Sclerophyll deserts and semi-deserts
T5 Deserts and semi-deserts	T5.4 Cool temperate deserts
T5 Deserts and semi-deserts	T5.5 Hyper-arid deserts
T6 Polar/alpine	T6.1 Ice sheets, glaciers and perennial snowfields
T6 Polar/alpine	T6.2 Polar/alpine rocky outcrops
T6 Polar/alpine	T6.3 Polar tundra
T6 Polar/alpine	T6.4 Temperate alpine meadows and shrublands
T6 Polar/alpine	T6.5 Tropical alpine meadows and shrublands
T7 Intensive anthropogenic terrestrial systems	T7.1 Croplands
T7 Intensive anthropogenic terrestrial systems	T7.2 Sown pastures and old fields
T7 Intensive anthropogenic terrestrial systems	T7.3 Plantations
T7 Intensive anthropogenic terrestrial systems	T7.4 Urban and infrastructure lands

Freshwater & transitional

F1 Rivers and streams	F 1.1 Permanent upland streams
F1 Rivers and streams	F 1.2 Permanent lowland rivers
F1 Rivers and streams	F1.3 Freeze-thaw rivers and streams
F1 Rivers and streams	F 1.4 Monsoonal upland stream
F1 Rivers and streams	F 1.5 Monsoonal lowland rivers
F1 Rivers and streams	F 1.6 Arid episodic lowland rivers
F2 Lakes	F2.1 Large permanent freshwater lakes
F2 Lakes	F2.2 Small permanent freshwater lakes
F2 Lakes	F2.3 Seasonal freshwater lakes
F2 Lakes	F2.4 Freeze-thaw freshwater lakes
F2 Lakes	F2.5 Ephemeral freshwater lakes
F2 Lakes	F2.6 Permanent inland salt lakes
F2 Lakes	F2.7 Ephemeral salt lakes
F2 Lakes	F2.8 Artesian springs and oases
F2 Lakes	F2.9 Geothermal wetlands
F3 Artificial wetlands	F3.1 Large reservoirs
F3 Artificial wetlands	F3.2 Constructed lacustrine wetlands
F3 Artificial wetlands	F3.3 Rice paddies
F3 Artificial wetlands	F3.4 Freshwater Aquafarms
F3 Artificial wetlands	F3.5 Canals and storm water drains
FM1 Transitional waters	FM1.1 Deepwater coastal inlets
FM1 Transitional waters	FM 1.2 Permanently open riverine estuaries and bays
FM1 Transitional waters	FM 1.3 Intermittently closed coastal lagoons
FT 1 Palustrine wetlands	FT 1.1 Tropical flooded forests and peat forests
FT 1 Palustrine wetlands	FT 1.2 Seasonal floodplain marshes
FT 1 Palustrine wetlands	FT 1.3 Subtropical/temperate forested wetlands
FT 1 Palustrine wetlands	FT 1.4 Episodic arid floodplains
FT 1 Palustrine wetlands	FT1.5 Boreal, temperate and montane peat bogs
FT 1 Palustrine wetlands	FT1.6 Boreal and temperate fens
MFT1 Brackish tidal systems	MFT 1.1 Coastal river deltas
MFT1 Brackish tidal systems	MFT1.2 Intertidal forests and shrublands
MFT1 Brackish tidal systems	MFT 1.3 Coastal saltmarshes

Subterranean

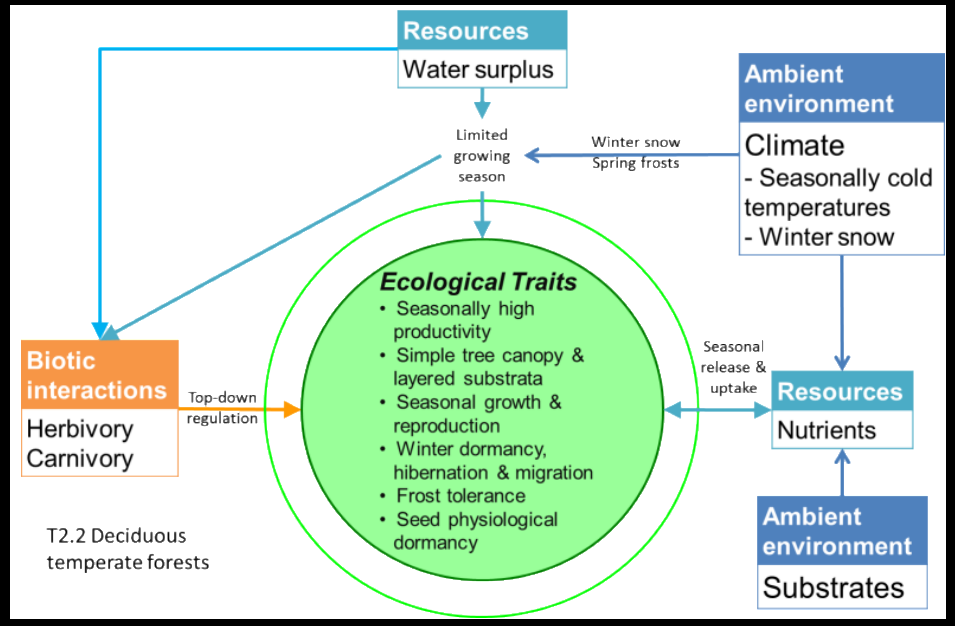
S1 Lithic subterranean systems	S1.1 Aerobic caves
S1 Lithic subterranean systems	S1.2 Endolithic systems
S2 Subterranean freshwaters	S2.1 Underground streams and pools
S2 Subterranean freshwaters	S2.2 Groundwater aquifers
S3 Tidal subterranean systems	S3.1 Anchialine caves
S4 Anthropogenic subterranean systems	S4.1 Subterranean excavations
S4 Anthropogenic subterranean systems	S4.2 Water pipes and subterranean canals

Marine & transitional

M1 Marine shelves	M1.1 Seagrass meadows
M1 Marine shelves	M1.2 Kelp forests
M1 Marine shelves	M1.3 Photic coral reefs
M1 Marine shelves	M1.4 Shellfish beds and reefs
M1 Marine shelves	M1.5 Marine animal forests
M1 Marine shelves	M1.6 Subtidal rocky reefs
M1 Marine shelves	M1.7 Subtidal sandy bottoms
M1 Marine shelves	M1.8 Subtidal muddy bottoms
M1 Marine shelves	M1.9 Upwelling zones
M2 Pelagic ocean waters	M2.1 Epipelagic ocean waters
M2 Pelagic ocean waters	M2.2 Mesopelagic ocean waters
M2 Pelagic ocean waters	M2.3 Bathypelagic ocean waters
M2 Pelagic ocean waters	M2.4 Abyssopelagic ocean waters
M3 Deep sea floors	M3.1 Continental and island slopes
M3 Deep sea floors	M3.2 Marine canyons
M3 Deep sea floors	M3.3 Abyssal plains - soft substrate
M3 Deep sea floors	M3.4 Seamounts, ridges and plateaus
M3 Deep sea floors	M3.5 Deepwater biogenic beds
M3 Deep sea floors	M3.6 Hadal trenches and troughs
M3 Deep sea floors	M3.7 Chemosynthetically-based ecosystems
M4 Artificial marine systems	M4.1 Submerged artificial structures
M4 Artificial marine systems	M4.2 Marine aquafarms
MT1 Shoreline systems	TM 1.1 Rocky Shores
MT1 Shoreline systems	TM 1.2 Muddy Shores
MT1 Shoreline systems	TM 1.3 Sandy Shores
MT1 Shoreline systems	TM 1.4 Boulder/cobble shores
MT2 Coastal vegetation	TM 2.1 Coastal shrublands and grasslands
MT3 Artificial shorelines	TM 3.1 Artificial shores

Ecosystem functional groups

- Based on literature review, expert input & review
- Descriptive profiles for all 100 Ecosystem Functional Groups
  - see sample set in background material
  - pitched at non-specialist users
  - ecological traits, key drivers, distribution, key references
  - photograph, diagrammatic model of key components & processes
  - indicative maps



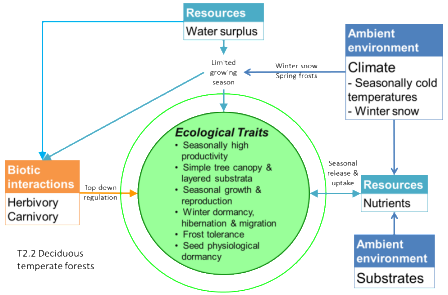
Contributors: DA Keith, NA Brummitt, F Essl, D Faber-Langendoen

T2.2 Deciduous temperate forests

Biome: T2 Temperate-boreal forests and woodlands. ***Realm***: Terrestrial

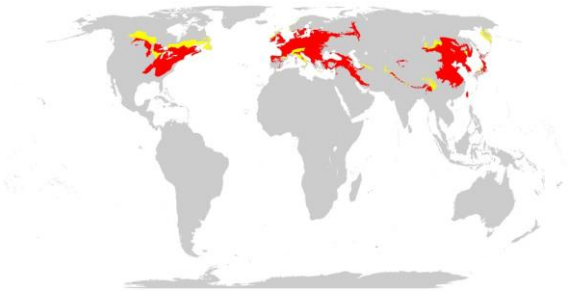
Ecological traits: These structurally simple, winter deciduous forests have high productivity and LAI in summer. Winter dormancy, hibernation and migration are common life histories among plants and animals enabling cold avoidance. Local endemism is comparatively low and there are modest levels of diversity across most major taxa. The forest canopy is comprised of at least two-thirds deciduous broad-leaf foliage (notophylll-mesophyll) with high SLA and up to one-third evergreen (typically needle-leaf) cover. As well as deciduous woody forms, annual turnover of above-ground biomass also occurs some in non-woody geophytic and other ground flora, which is insulated from cold beneath winter snow and flowers soon after melt before tree canopy closure. Annual leaf turnover is sustained by fertile substrates and water surplus, with nutrient withdrawal from foliage and storage of starch prior to fall. Tissues are protected from cold by supercooling rather than extra-cellular freeze-tolerance. Dormant buds are insulated from frost by bracts or by burial below soil in some non-woody plants. Fungal and microbial decomposers play vital roles in cycling carbon and nutrients in the soil surface horizon. Despite highly seasonal primary productivity, the trophic network includes large browsing herbivores (deer), smaller granivores and herbivores (rodents, hares) and mammalian predators (canids, felines). Most invertebrates are seasonally active. Behavioural and life history traits enabling of animals to persist through cold winters, include dense winter fur, food caching, winter foraging, hibernation, dormant life phases and migration. Migratory animals provide allochthonous subsidies of energy and nutrients, and promote incidental dispersal of other biota. Browsing mammals and insects are major consumers of plant biomass and cyclers of nitrogen, carbon and nutrients. Deciduous trees may be early colonisers of disturbed areas later replaced by evergreens, but are also stable occupants across large temperate regions. Tree recruitment is limited by spring frost, allelopathy and herbivory, and occurs semi-continuously in gaps. Herbivores may influence densities of deciduous forest canopies by regulating tree regeneration. Deciduous leaf fall may exert allelopathic control over tree seedlings and seasonal ground flora.

Deciduous forest prior to autumn leaf fall
Source: https://pxhere.com/en/photo/17429, CC0



Key ecological drivers: Phenological processes in these forests are driven by large seasonal temperature ranges, (mean winter temperatures <-1°C, summer means up to 22°C), typically with substantial winter snow and limited growing season, with 4-6 months above 10°C, and severe post-thaw frosts. Fertile soils, especially with high N levels, and an overall water surplus, support deciduous leaf turnover. Fires are generally uncommon.

Distribution: Cool temperate Europe (southwest Russia to British Isles), northeast Asia (northeast China, southern Siberia Korea, Japan) northeast America. Limited occurrences in warm temperate zones of south Europe and Asia, and midwest USA.



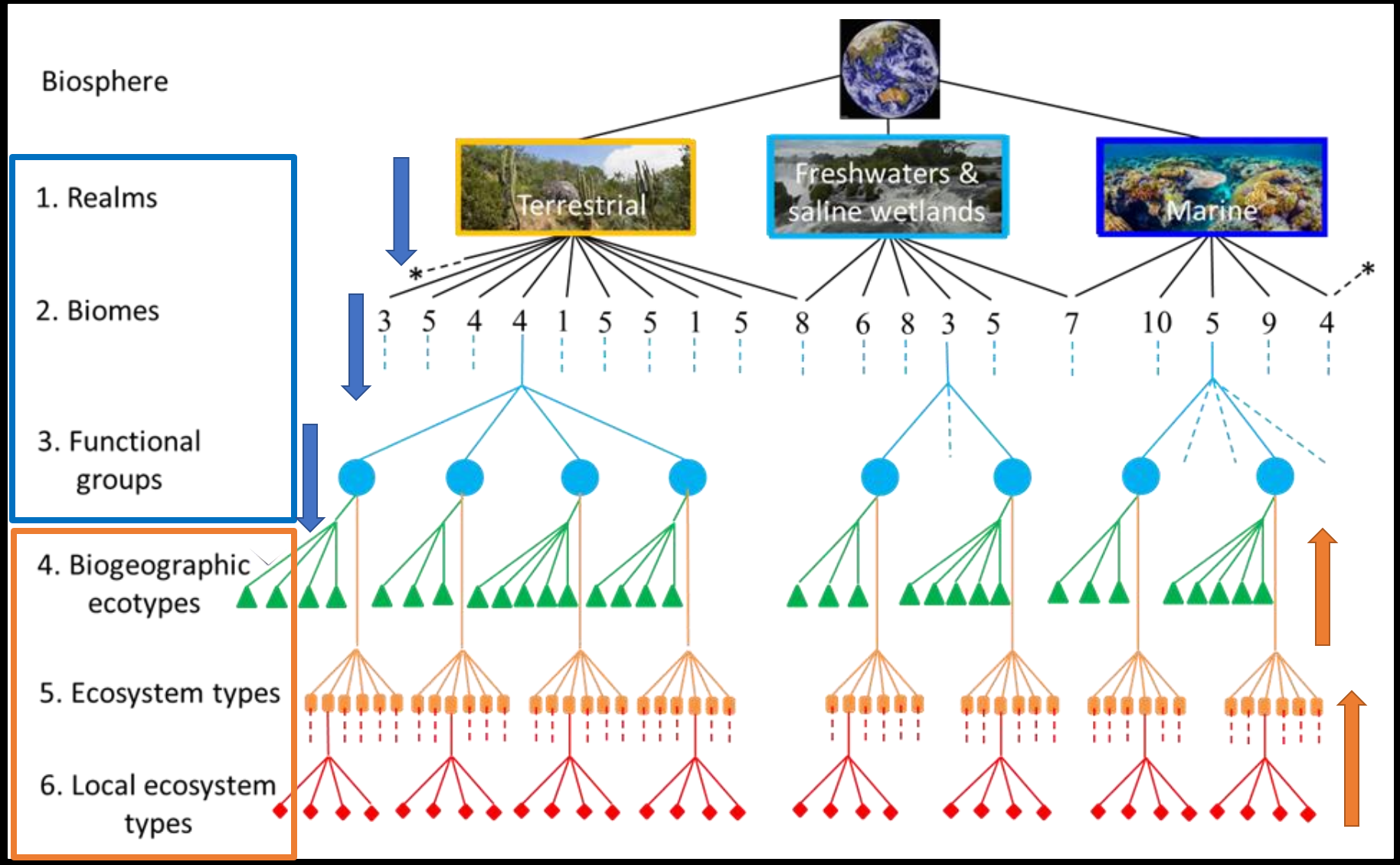
References:

Röhrig E, Ulrich B (1991) Temperate deciduous forests. Ecosystems of the world. Vol. 7. Elsevier, Amsterdam.

Box EO, Fujiwara K (2015) Warm temperate deciduous forests. Springer, Cham.

Hierarchical structure

- representation of *function* – upper levels, top-down
- representation of ***composition*** – lower levels, bottom-up

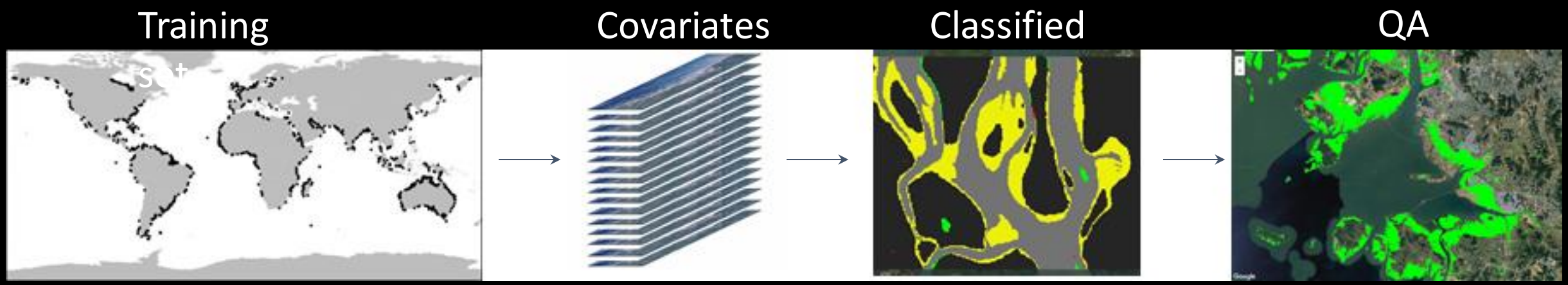


Ongoing development: upgrading maps of ecosystem functional groups from indicative to high-resolution global maps

Global scale

Pixel-based “ecosystem distribution model” proven for our needs

Includes information that explain the observed distribution of ecosystems: spectral, topographic and climate covariates



Ongoing development: upgrading maps of ecosystem functional groups from indicative to high-resolution global maps

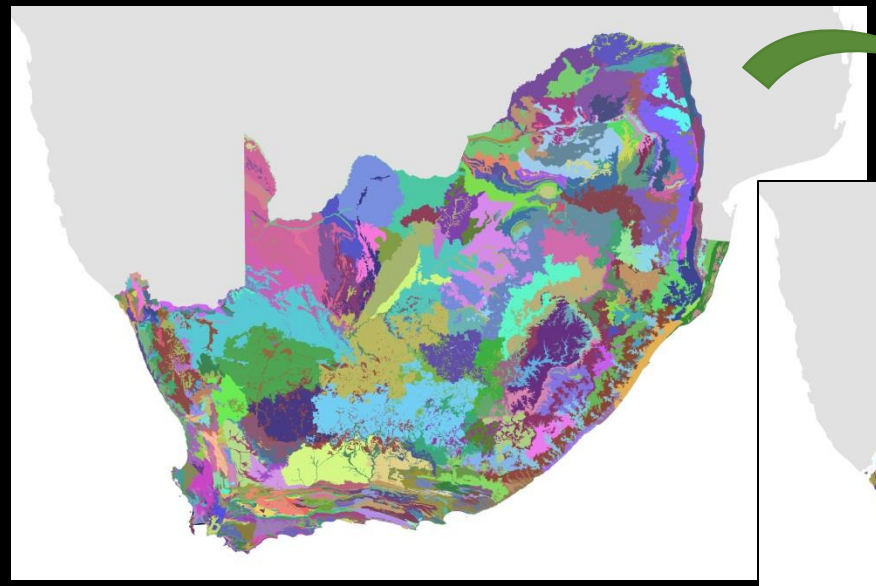
M1.3 Photic coral Reefs
Allen Coral Atlas:
sub-10m reef maps

TM1.2 Muddy shorelines
Global map @30m resolution
30 year time-series

MFT1.2 Intertidal forests & shrublands
Global Mangrove Watch:
mangroves @30 m resolution

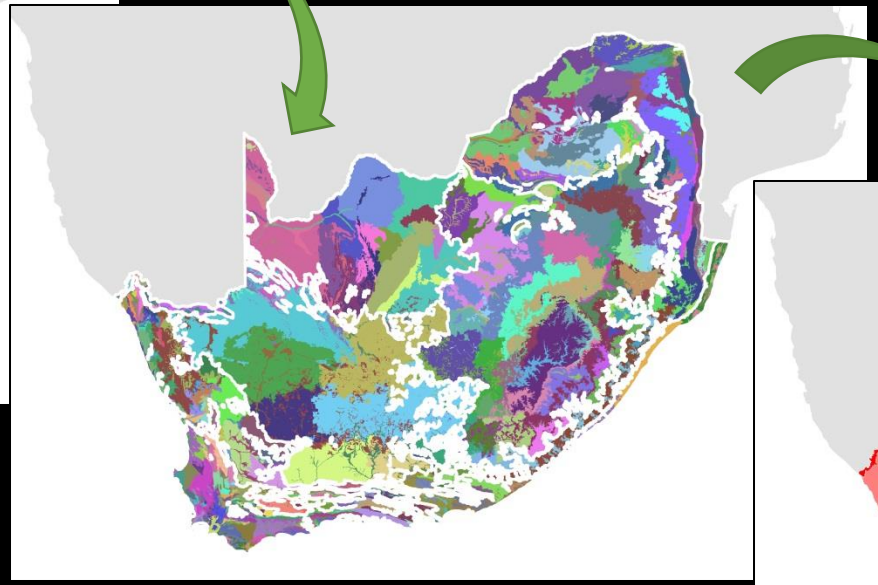
Application: integration with existing local classifications

South Africa case study

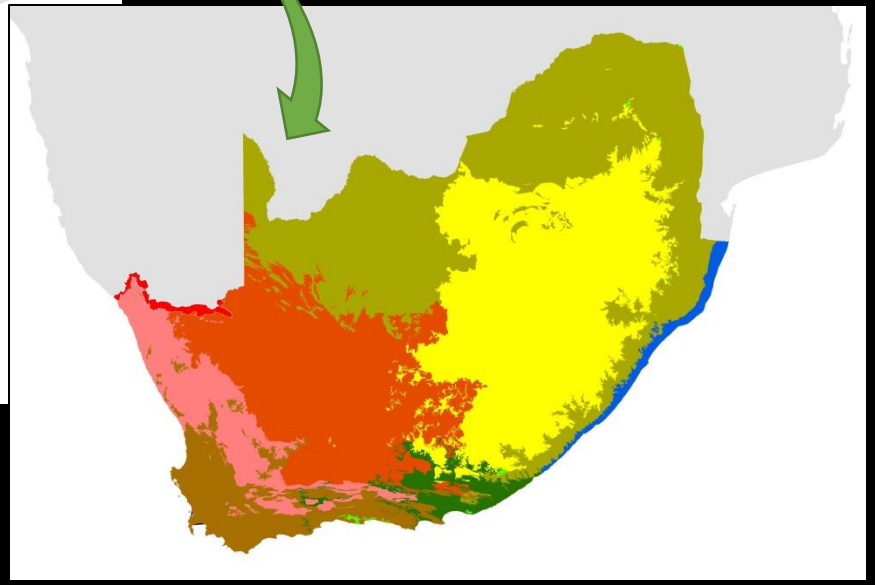


435 national vegetation types

- Global Ecosystem Typology Level 6



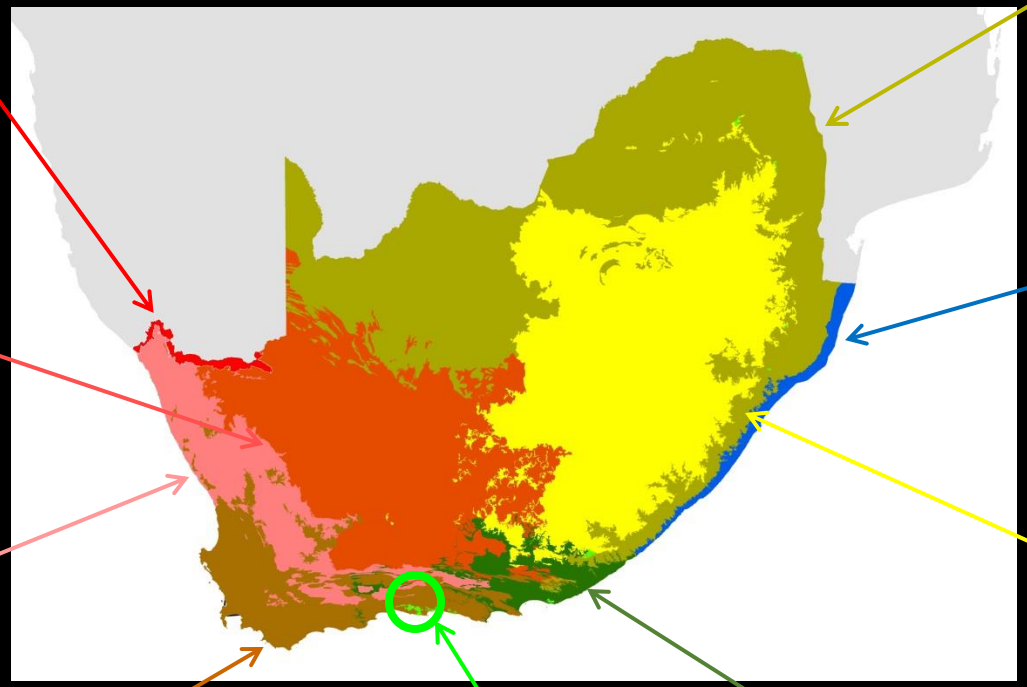
Aggregate & assign national vegetation types to IUCN Ecosystem Functional Groups



9 Ecosystem Functional Groups for global ecosystem accounting

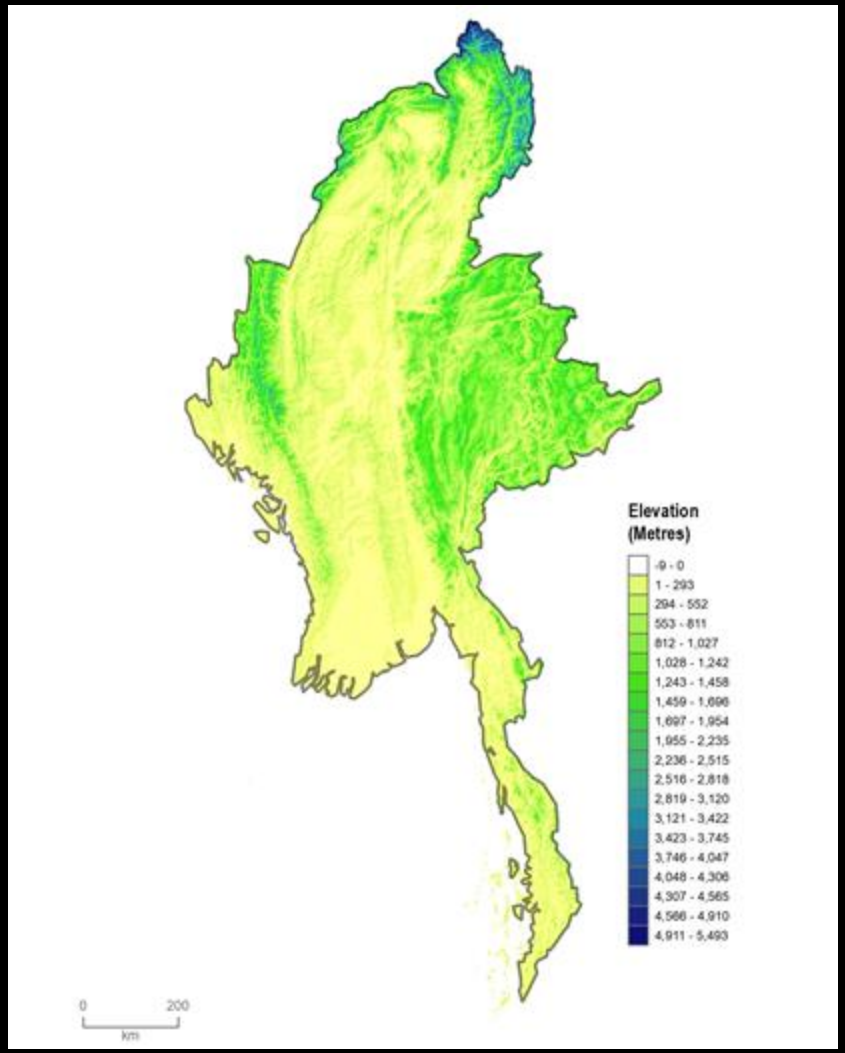
- Global Ecosystem Typology Level 3

Application: integration with existing local classifications



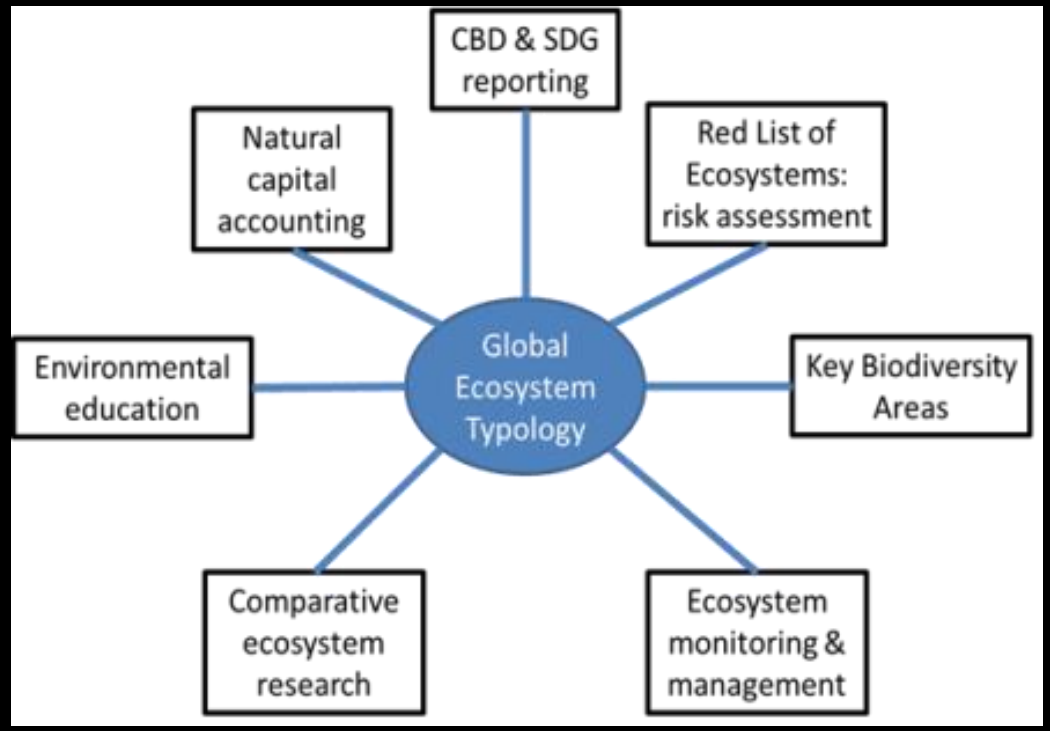
Application: supporting development of new classifications

- Myanmar *National* Ecosystem Assessment
- 35 ecosystem functional groups
- GEF & Wildlife Conservation Society implementation
- >60,000 training samples
- Extensive field work, image interpretation (via a GEE App), literature review & expert elicitation



Synergies & opportunities between SEEA-EEA & IUCN typology & RLE

- Global Ecosystem Typology as spatial units: representation of ecological processes & ecosystem function through “functional groups”
- Red List data (threatened status)
- Conceptual models from RLE assessments
- Relevant indicators of ecosystem condition



The IUCN Global Ecosystem Typology

Prof. David Keith UNSW, Australia *david.keith@unsw.edu.au*
A/Prof. Emily Nicholson Deakin University, Australia *e.nicholson@deakin.edu.au* @n_ylime

http://iucnrle.org/ http://conservationscience.org.au