

Wetland inventory – international experience



research FOR A SUSTAINABLE FUTURE

Max Finlayson

- **What is a wetland**
- **Loss and degradation of wetlands**
- **What inventory has been done**
- **What is inventory**
- **Framework for inventory**

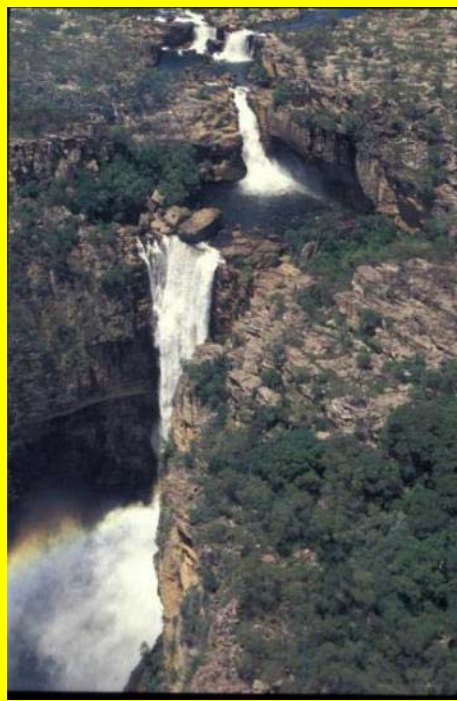
What is a wetland?

Wetland definition - Ramsar Convention on Wetlands

“Areas of marsh, fen, peatland or water, either natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.”



High altitude wetlands - streams, ponds, lakes, marshes, peats, karst systems, incl melt water channels from glaciers.



Lowland wetlands – many water regimes – seasonal and annual - vegetation types and – swamps, marshes, lakes, rivers, waterholes





Wetlands in dry lands –
fresh and saline; some
more often dry than wet



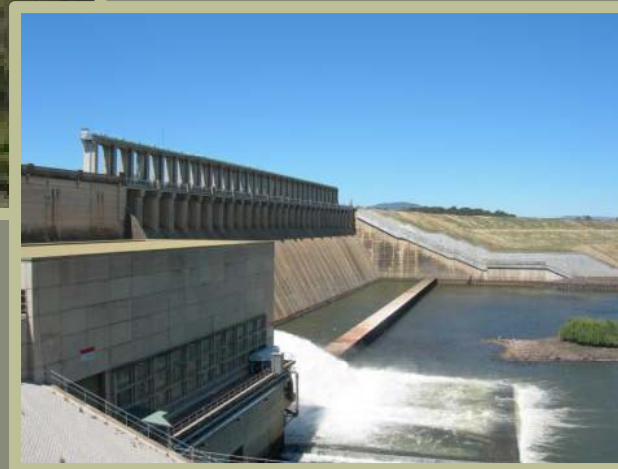
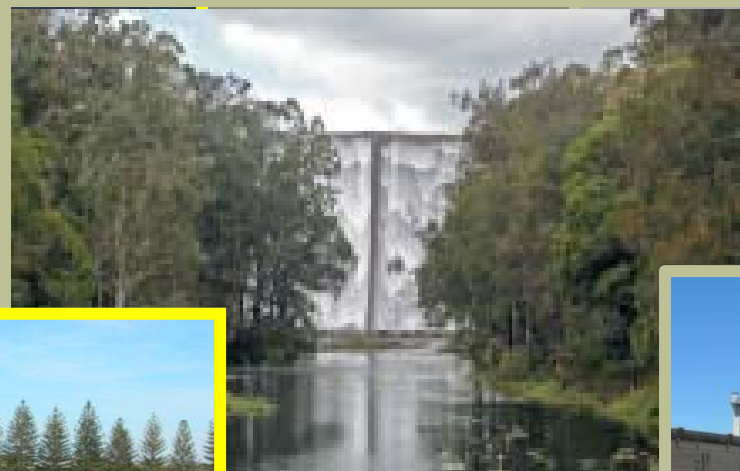
Coastal wetlands - diverse mangrove and tidal marsh – subject to tidal and freshwater flooding



Reef systems – coral
or limestone; inshore
and off-shore



Artificial wetlands



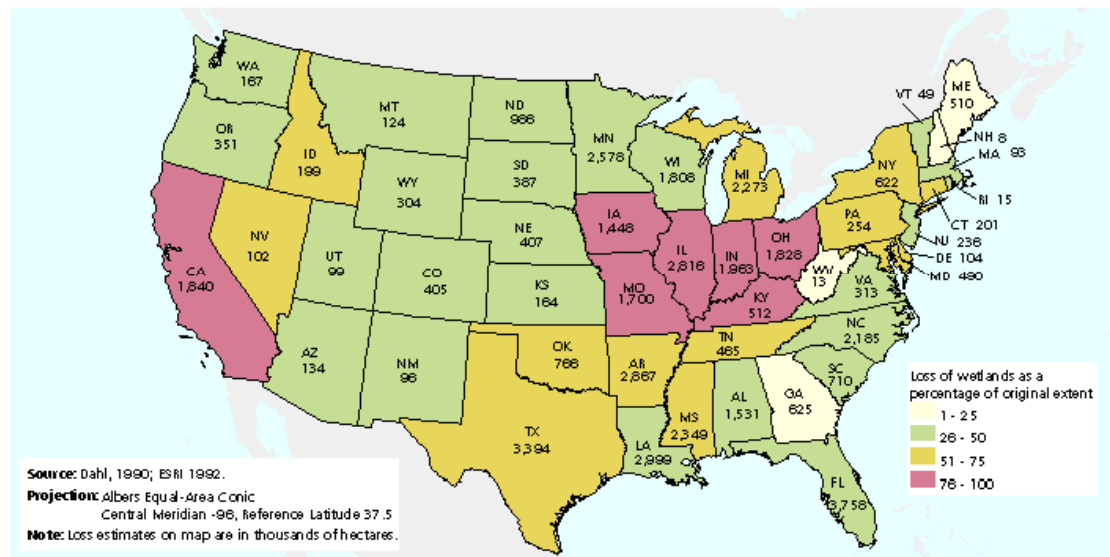
Loss and degradation of wetlands

- **More than 50% of marshes, swamps, small lakes in parts of Europe, North America, Australia & New Zealand**
- **Increased pressure in Asia, Africa and southern America, and small islands**
- **Wetlands/rivers are in faster decline than rainforests and savanna grasslands**

Wetland loss - USA

Map 5a

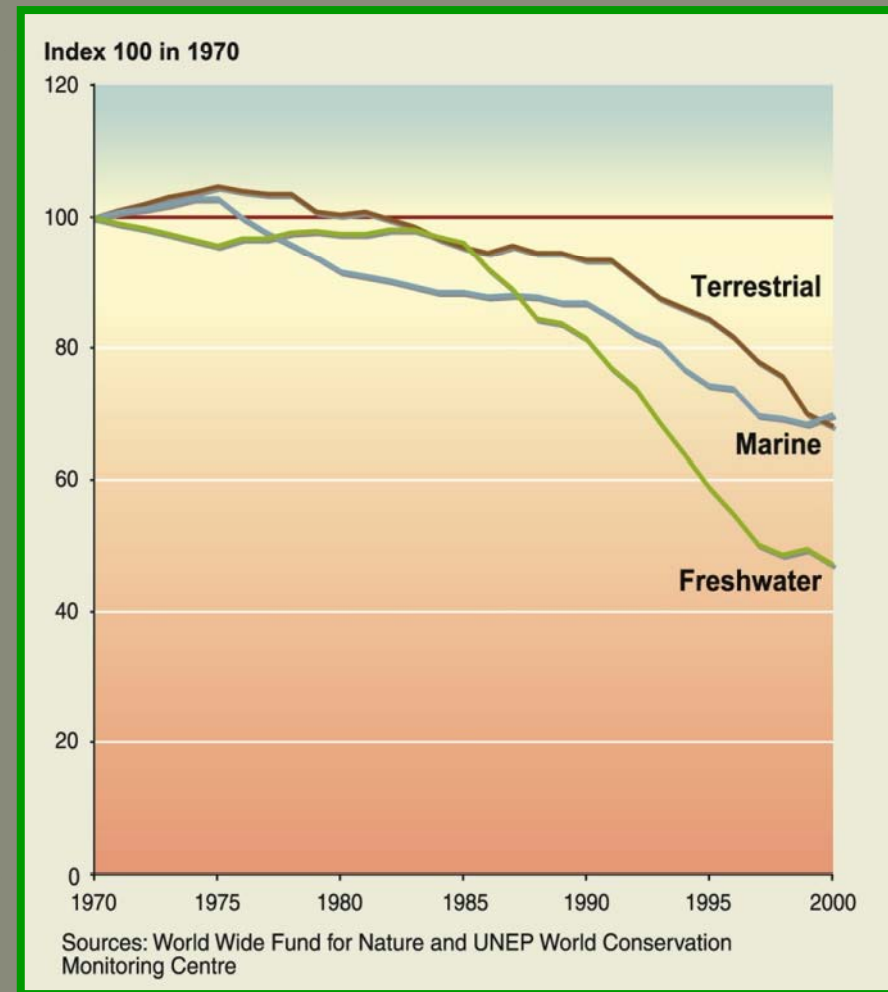
USA: Historical Wetland Loss by State, 1780s - 1980s



Living Planet Index – freshwater ecosystems in rapid decline

Trends for freshwater, marine and terrestrial vertebrate species 1970-2000

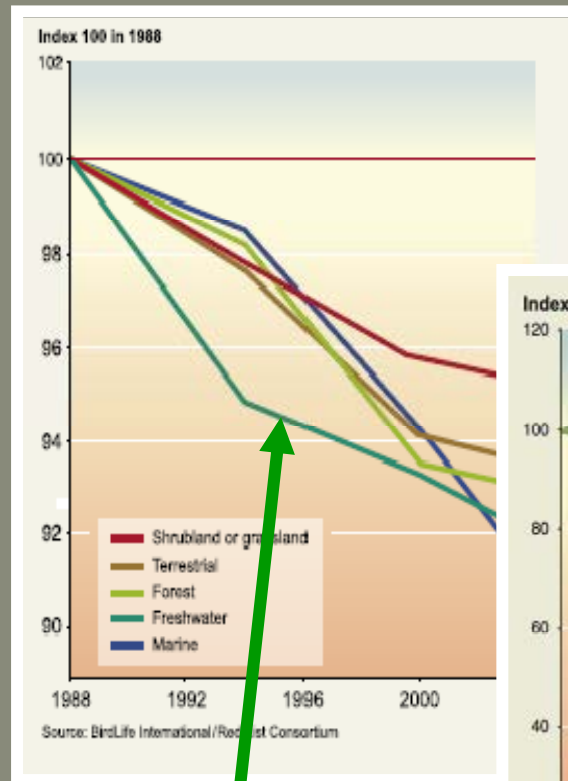
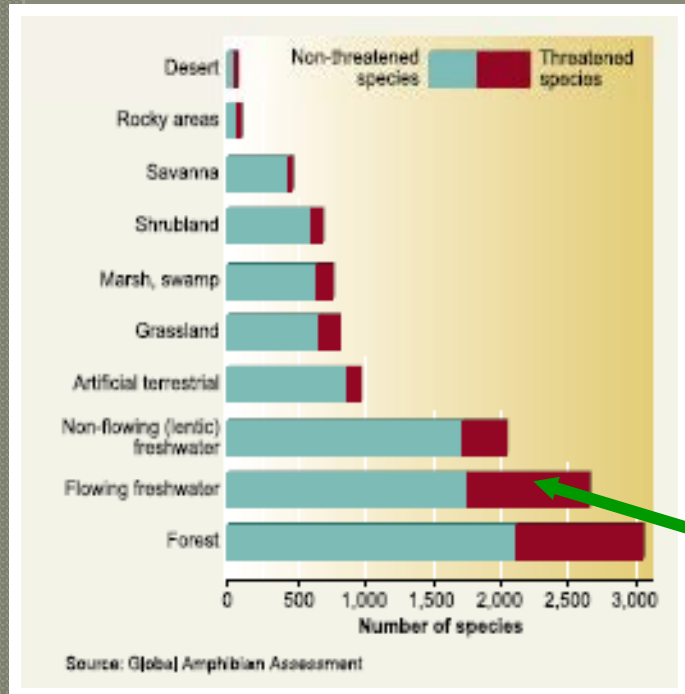
Data biased towards Europe & N America, especially bird species, lacking in fish data



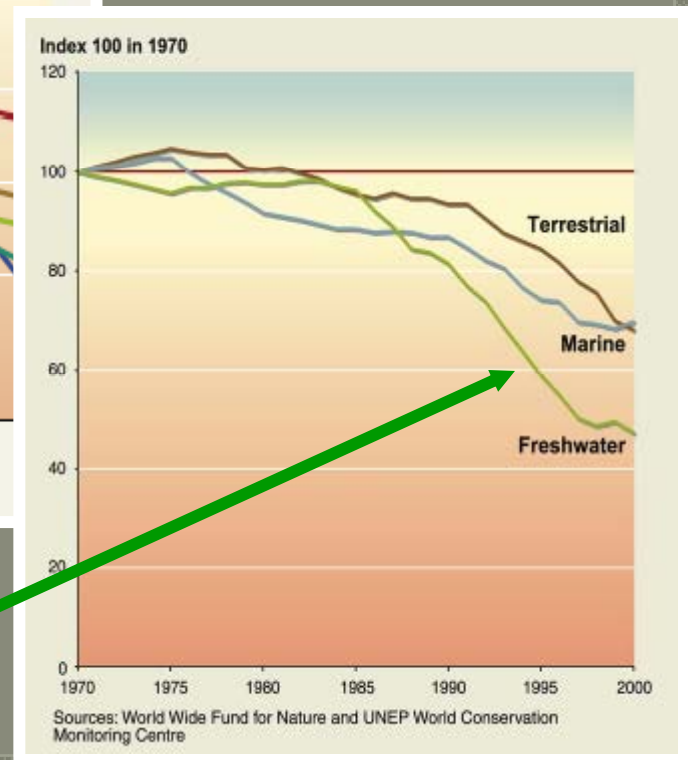
Condition of freshwater species

Red List for birds in different ecosystems

Number of threatened amphibians



Living planet index



Freshwater ecosystems

Population status of wetland vertebrates

- ◎ Waterbirds – 20% extinct or threatened
- ◎ Mammals – 30% decline (dolphins, manatees, porpoises)
- ◎ Fish (freshwater) – 20% threatened or extinct
- ◎ Amphibians – 30% threatened (not all are aquatic)
- ◎ Turtles – 50% threatened
- ◎ Crocodiles – 45% threatened



Invasive species



Water regulation



Coastal development



Over harvesting



Climate change



Fire regimes



Pollution

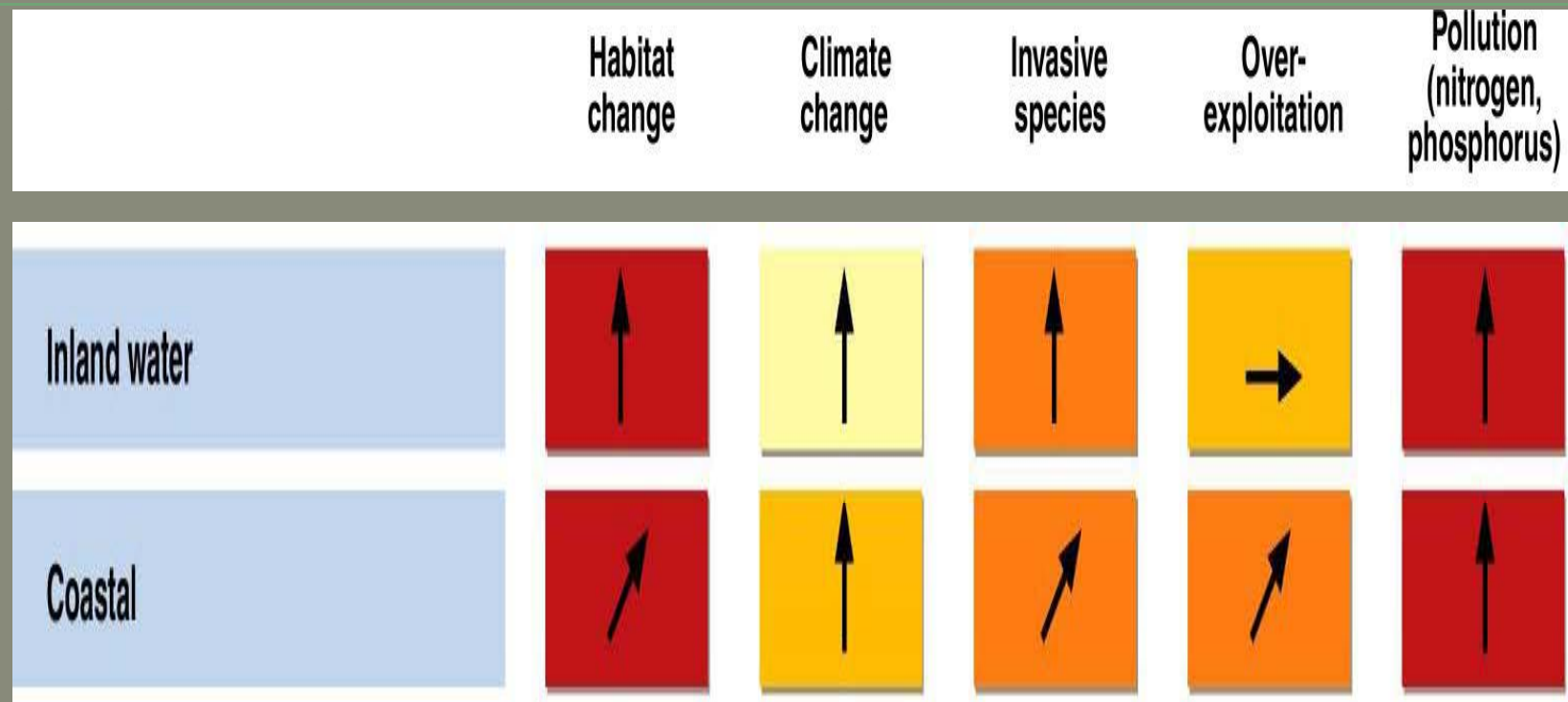


Agriculture

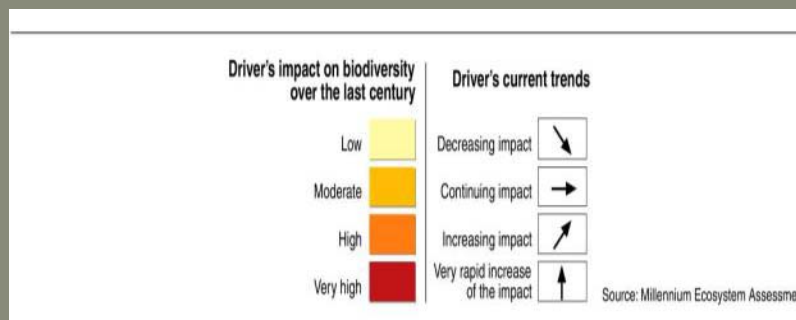


Irrigation

Global scenario for wetlands – increased pressures and further loss and degradation

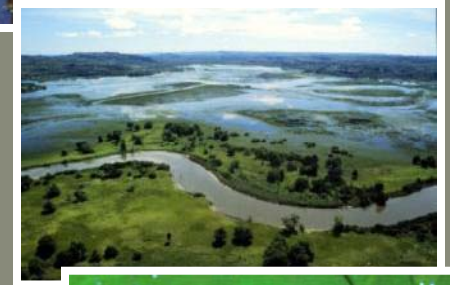


Millennium Ecosystem Assessment 2005



Global and national inventory effort

- **Impressive basic coverage – continental scale wetland inventory**
- **Distribution of major wetlands - known and mapped**
- **Known occurrence of most major wetland species – plants and vertebrates – limited population data**
- **Information available about main management problems on some sites**



Common problems with wetland inventory have been identified and discussed

Wetlands not well defined or different definitions

Different classifications have been used

Inaccurate data – often not checked when re-used

Poorly recorded data – where is the original data?

Incomplete information

Programs too ambitious and not completed

Inadequate publication & distribution of information

Lack of standardised methods

Ramsar global review of wetland inventory

- Not possible to make reliable estimates of the extent of wetlands, globally or regionally – many countries do not have a wetland inventory
- Good example of wetland inventory processes exist - the MedWet program
- Many inventories only provide an inaccurate estimate of the extent of wetland area or condition
- On the whole, wetland inventory was incomplete and difficult to undertake
- Despite these problems an estimate of global wetland area was compiled – based on national data – it was an under-estimate and much higher than previous estimates

Formal resolution on wetland inventory in 1999

Recognised that the wetland information base was globally and regionally uneven, inaccurate, outdated, absent, or misplaced

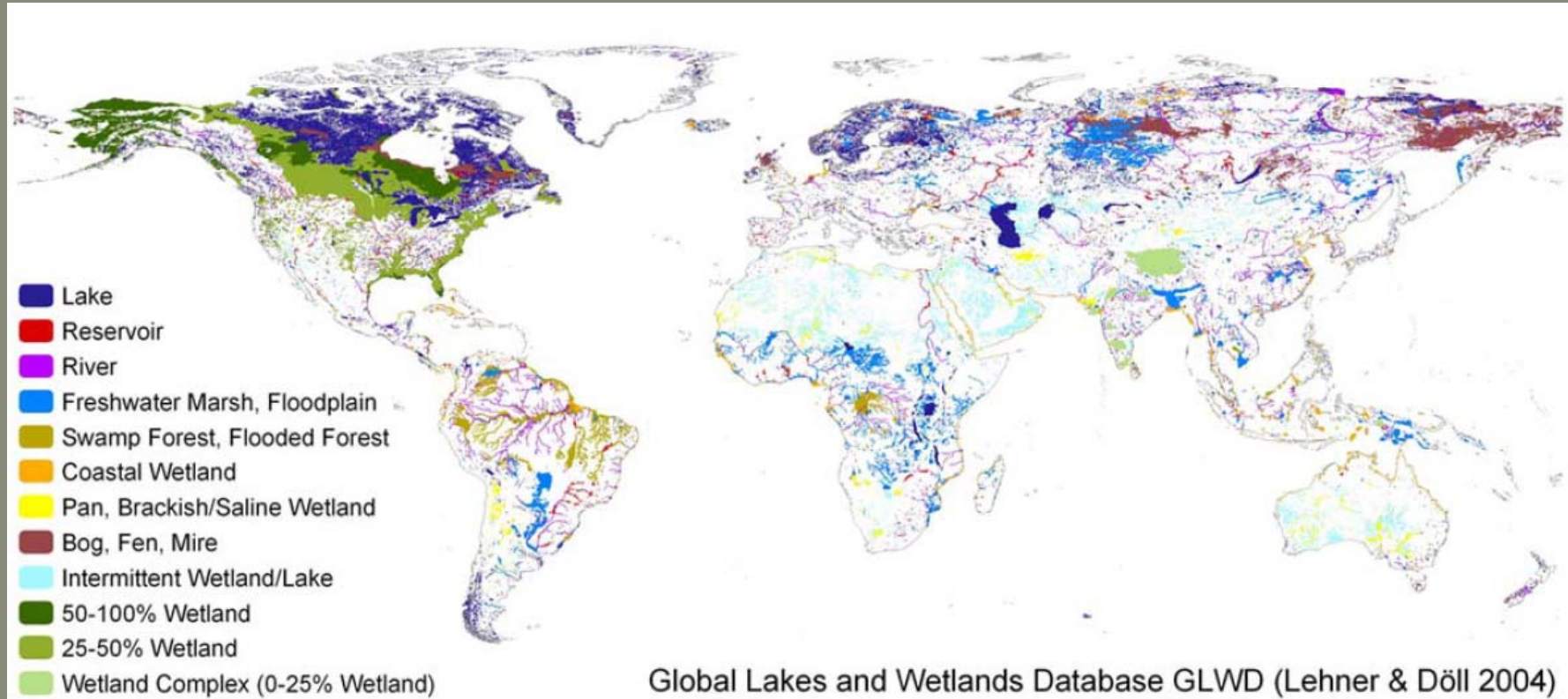
Requested a framework and manual for planning wetland inventory to provide standardised and consistent approaches

All countries should complete national wetland inventories

Existing methods for wetland inventory and data management needed to be reviewed and new ones developed

Greater use should be made of remote sensing and GIS

Global database and map developed in 2004 from multiple data sources



Provided estimates of wetland area different to those in the Ramsar global review

Estimates of wetland extent (million hectares)

	Finlayson et al. 1999	Lehner & Doll 2004
Africa	123	131
Asia	204	286
Europe	258	26
South America	415	159
North America	242	287
Oceania	36	28
Total	1278	917

What is inventory?



Inventory

Collect information to describe the wetland - provide a basis for assessment and monitoring



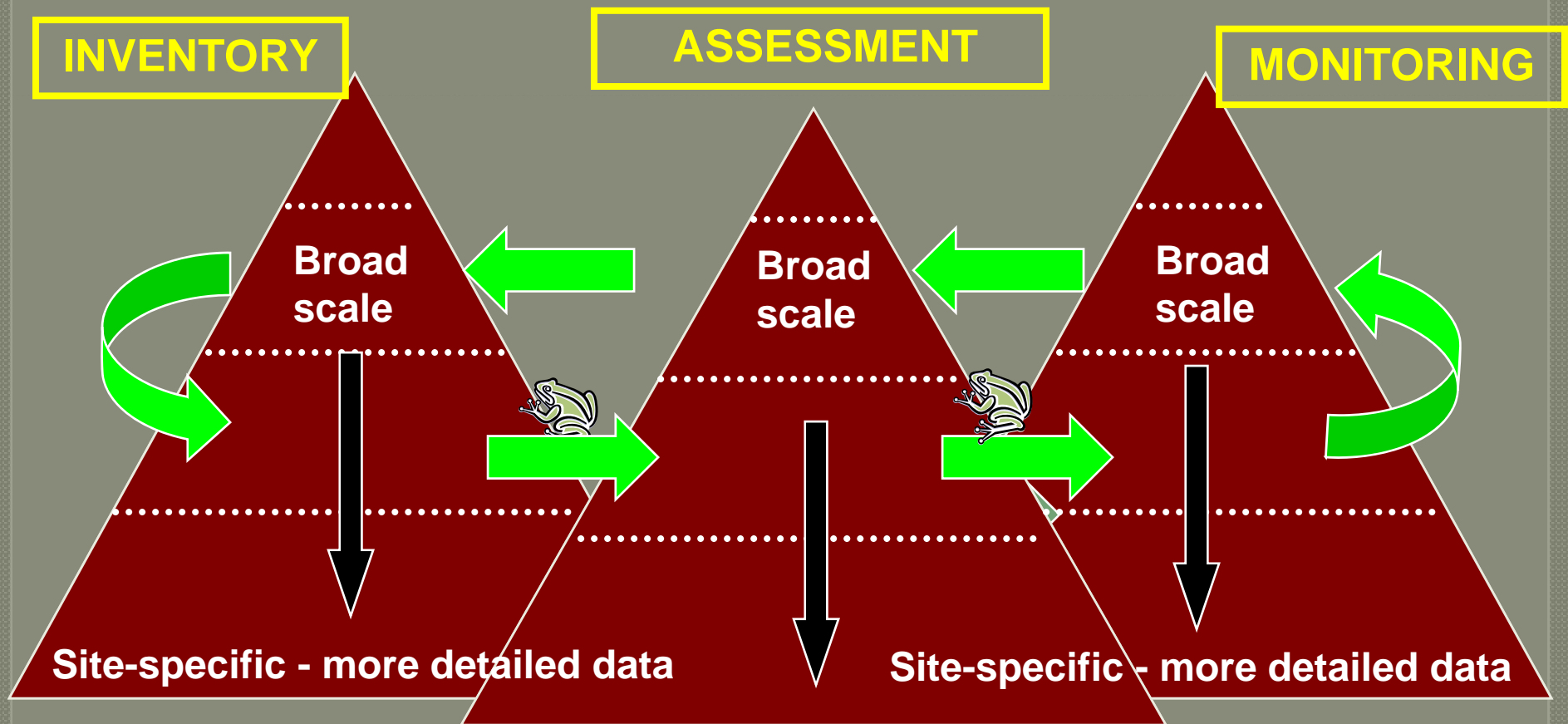
Assessment

Identify the value, status of and threats to the wetland - provide a basis for monitoring

Monitoring

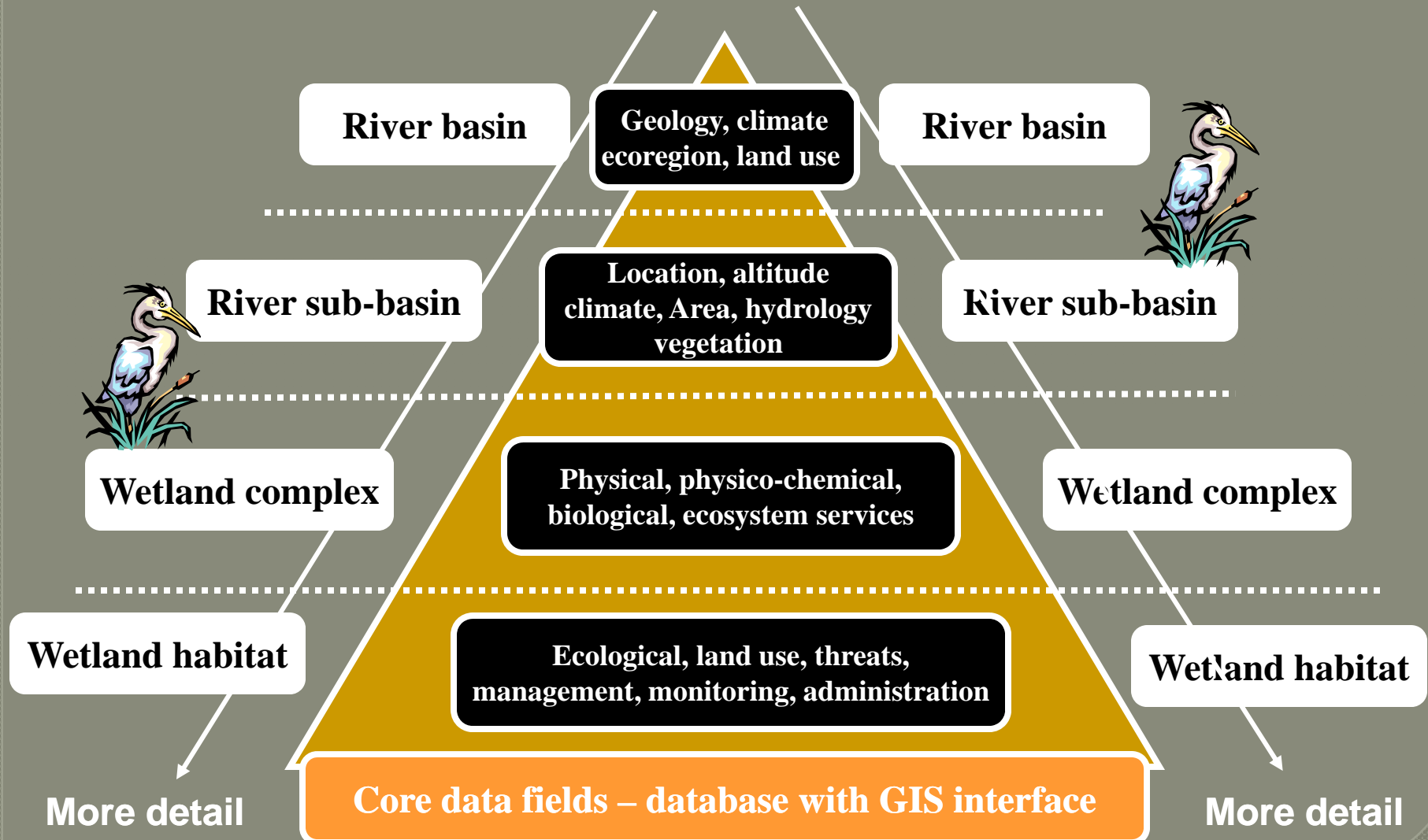
Collect information for management based on hypotheses derived from assessment

Integrated multi-scalar wetland analyses

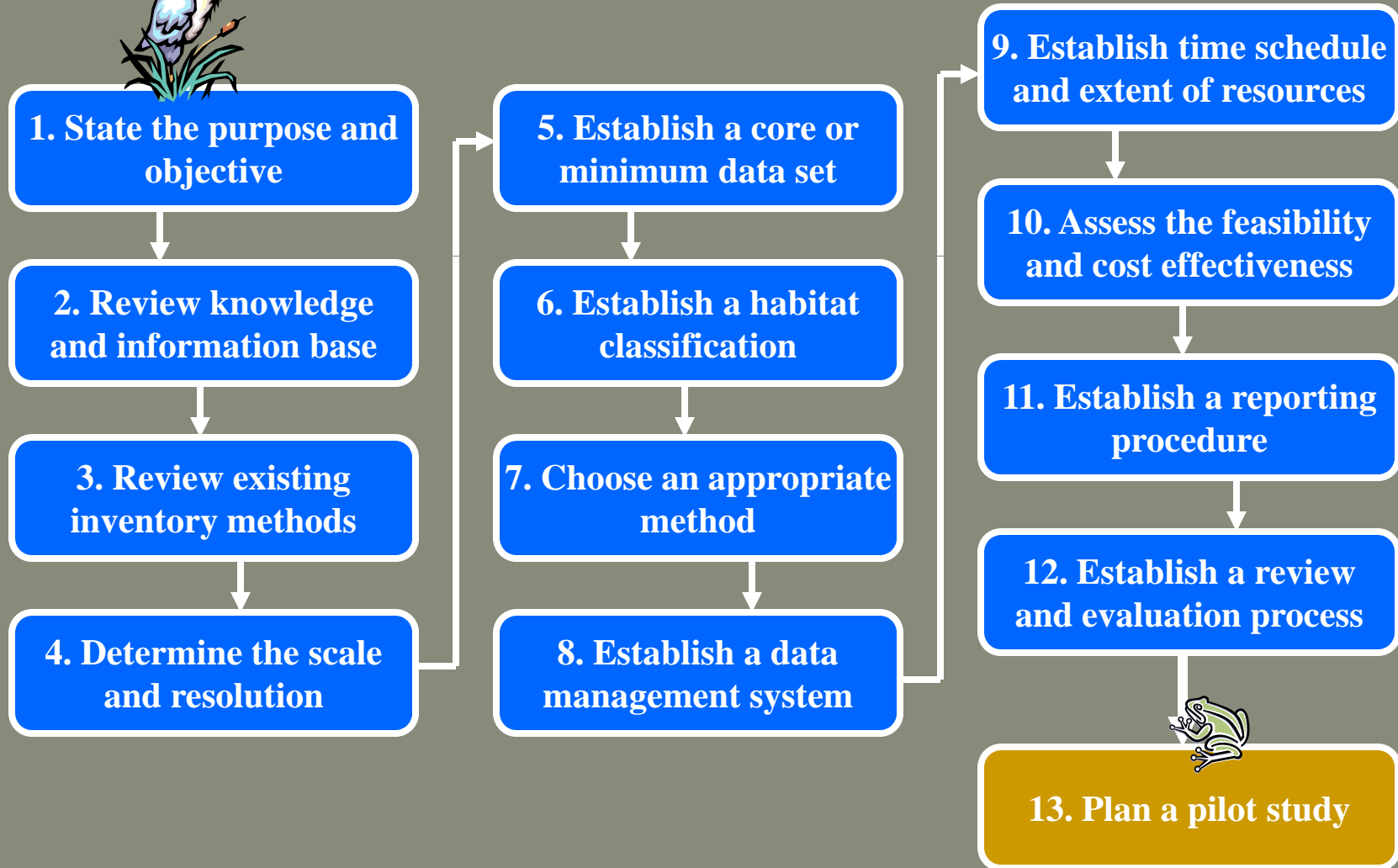


Undertake assessment and monitoring at same scale as information was collected in the inventory – scale is important

Inventory - multi-scalar, hierarchical approach with standardised core data



Framework for designing a wetland inventory to describe ecological character



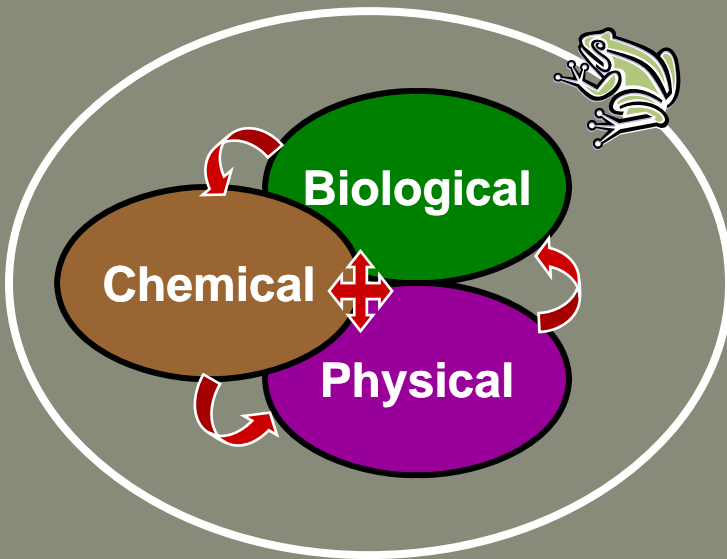
What is ecological character?

Ecological character is now defined by the Ramsar Convention on Wetlands as:

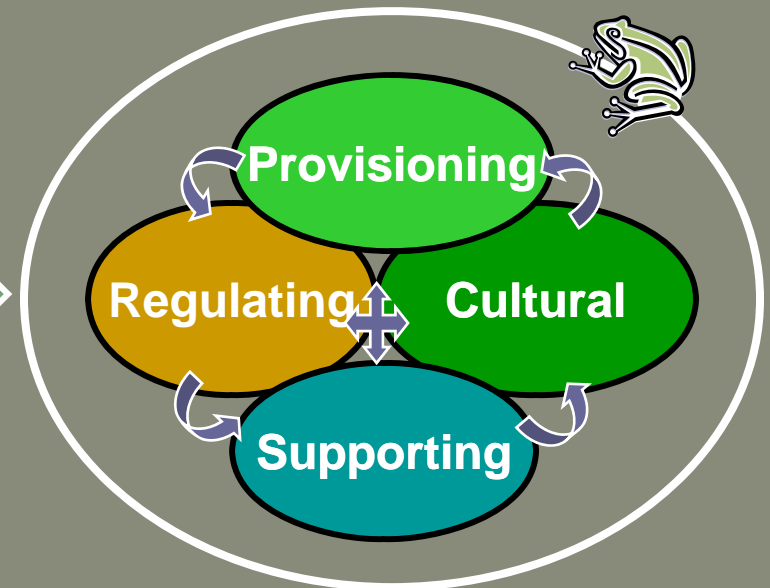
- the combination of the **ecological components, processes and (ecosystem) services** that characterize the wetland

Changed in 2005 to include ecosystem services as part of the character, not just dependent on the character

Ecological character is the combination of the **ecological components** and **processes** which maintain the wetland and its **ecosystem services**

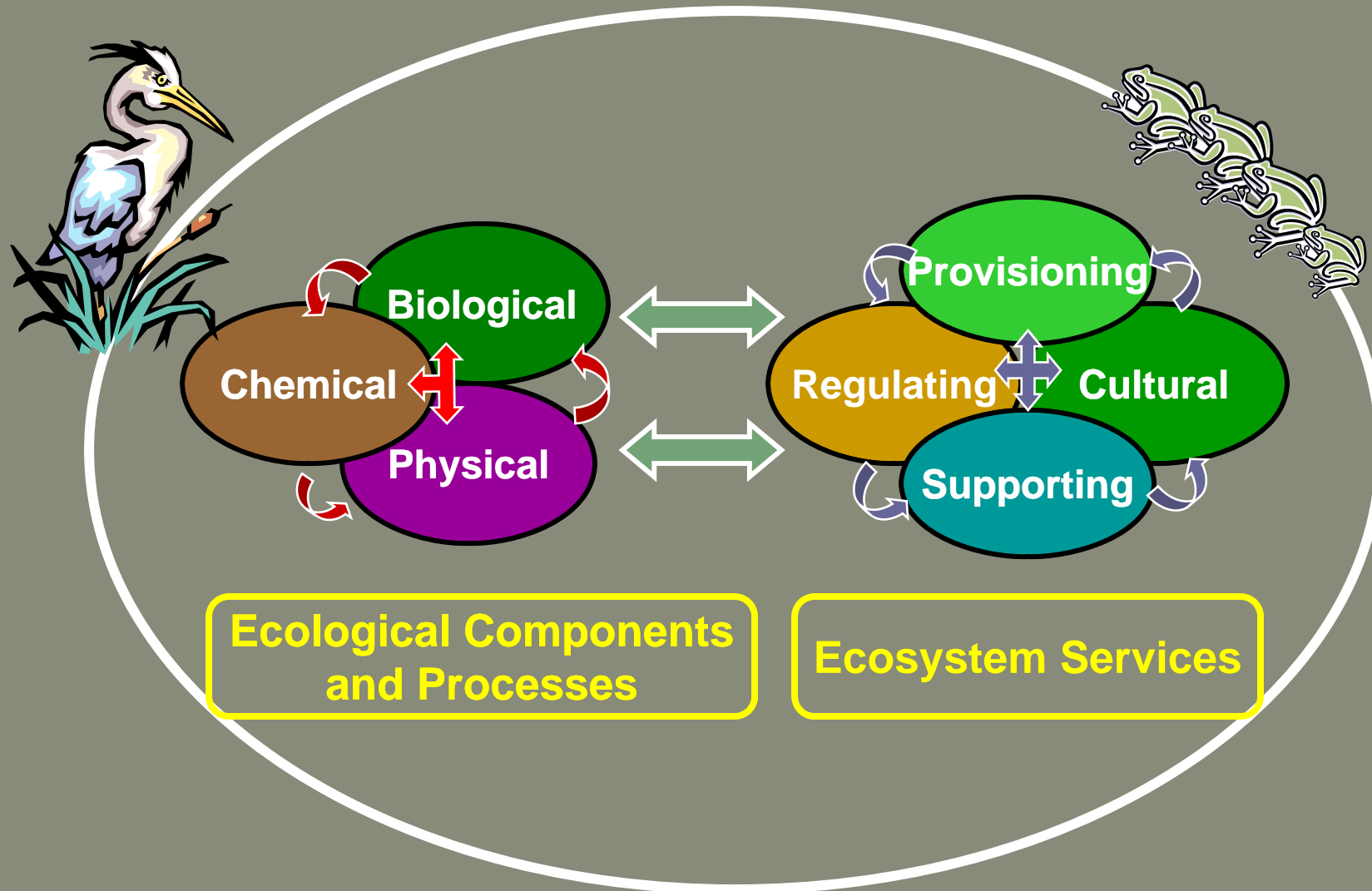


**Wetland Ecological
Components and Processes**



**Wetland Ecosystem
Services**

Ecological character is the combination of the **ecological components, processes** and **ecosystem services** that characterise the wetland



ECOSYSTEM SERVICES

Supporting

- NUTRIENT CYCLING
- SOIL FORMATION
- PRIMARY PRODUCTION
- ...

Provisioning

- FOOD
- FRESHWATER
- WOOD AND FIBER
- FUEL
- ...

Regulating

- CLIMATE REGULATION
- FLOOD REGULATION
- DISEASE REGULATION
- WATER PURIFICATION
- ...

Cultural

- AESTHETIC
- SPIRITUAL
- EDUCATIONAL
- RECREATIONAL
- ...

Description of ecological character

Provides a baseline against which change is assessed, including against the criteria used for listing as internationally important.

An inventory effort is required to describe the ecological character

An effective monitoring program is required to determine if any change has occurred and whether this is outside the range of natural variability

Ramsar framework for wetland inventory

1. State the purpose and objective

Make a clear statement about the reason(s) for doing the inventory and why the information is required, as the basis for choosing a method, spatial scale and minimum data set.

Wetland inventory has multiple purposes:

:

- identify priority sites for conservation and management
- listing wetlands of national or international importance
- describing the occurrence of wetland species
- describing the extent of natural resources such as peat, fish or water and providing information for management
- establishing a baseline for measuring change in the ecological character of wetlands
- promoting awareness of the value of wetlands

Ramsar framework for wetland inventory

2. Review the knowledge and information base

Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.

Be aware that a lot of information may occur in water management, fisheries or agricultural reports.

Ramsar framework for wetland inventory

3. Review existing inventory methods

Review available methods and seek expert technical advice to ensure that the methods used can supply the required information and that suitable data management processes are established.

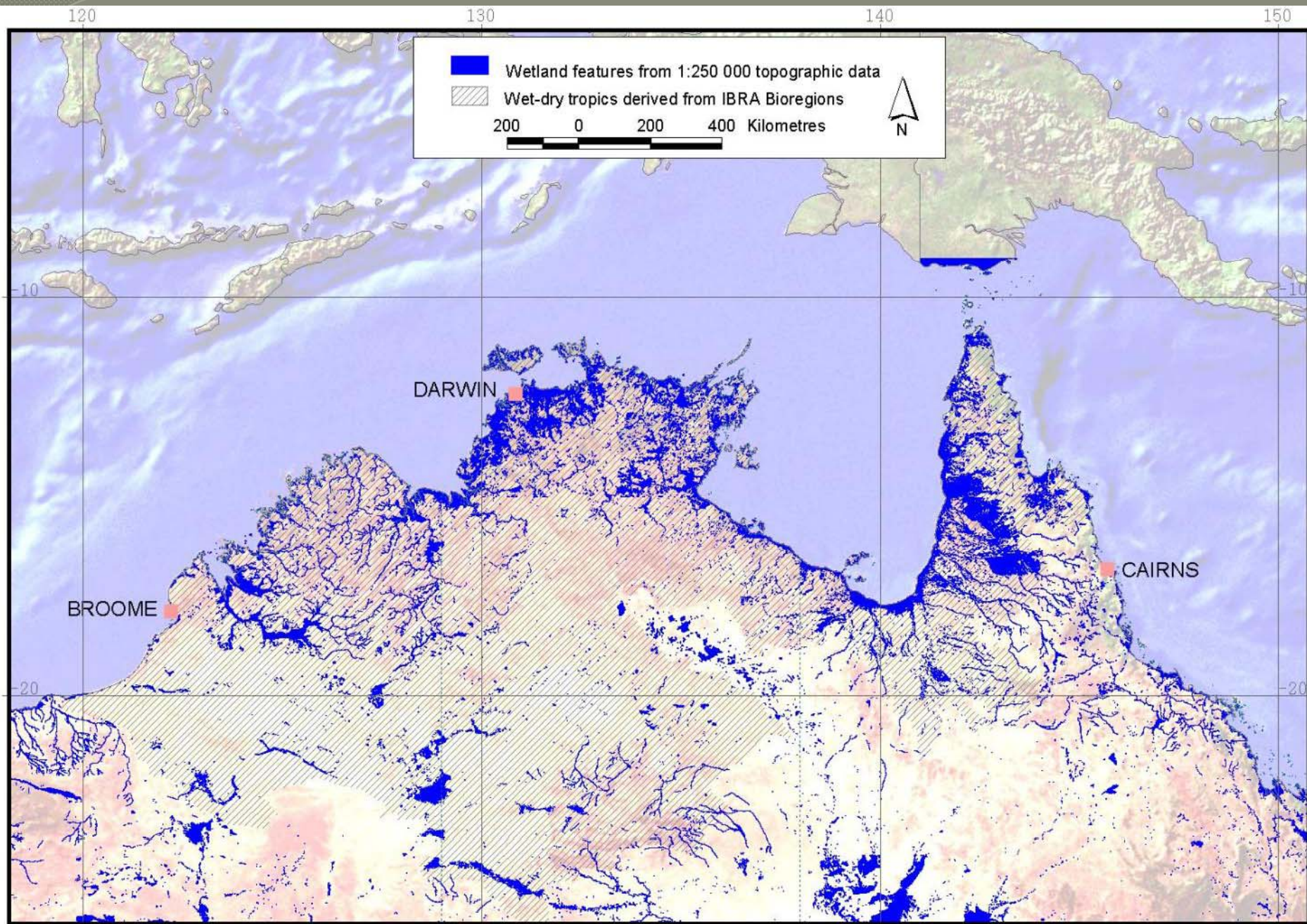
Ramsar framework for wetland inventory

4. Determine the scale and resolution

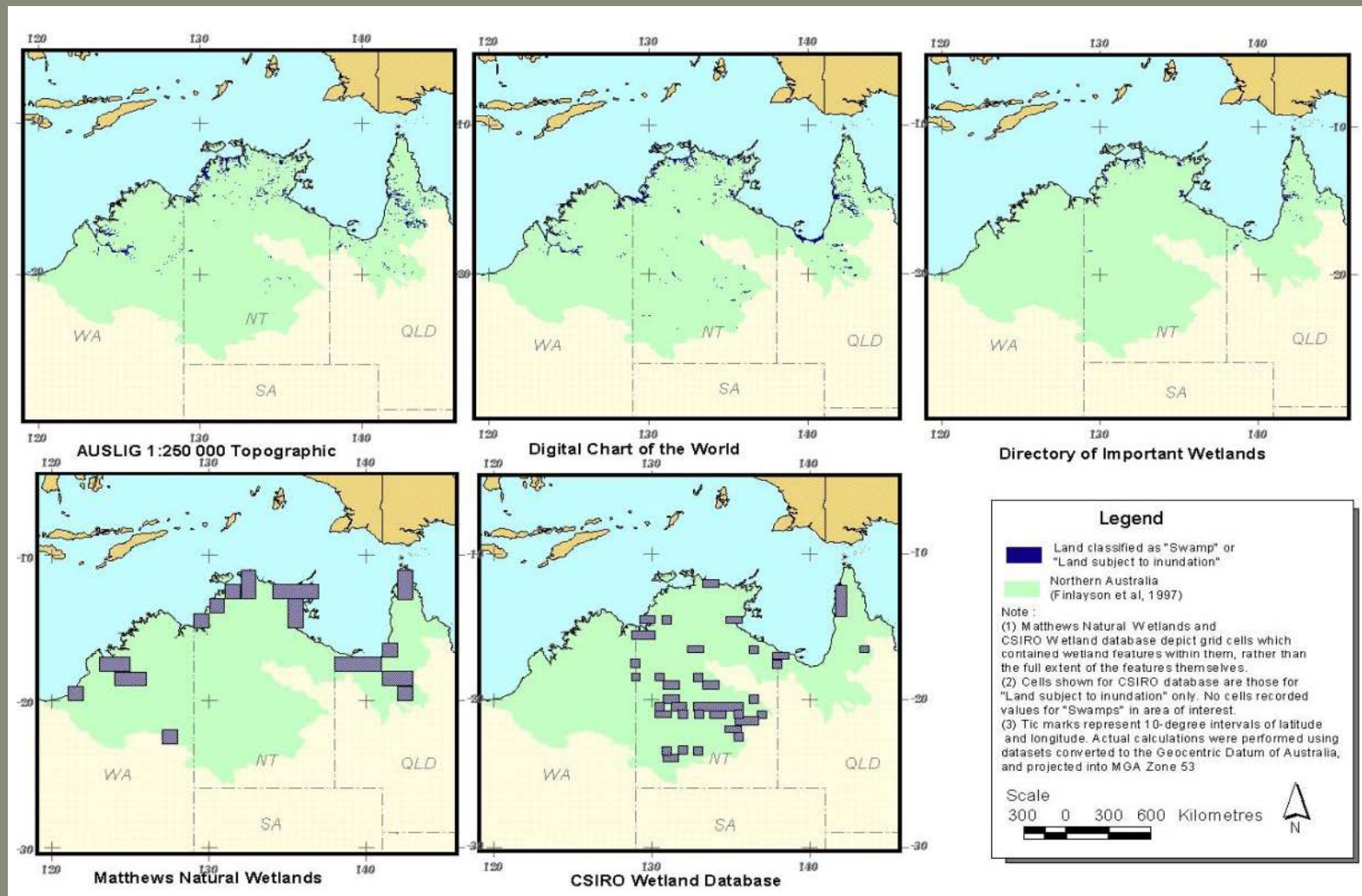
Determine the scale and resolution that will enable the purpose and objective to be achieved.

The scale is inseparable from the objective and method used for the inventory.

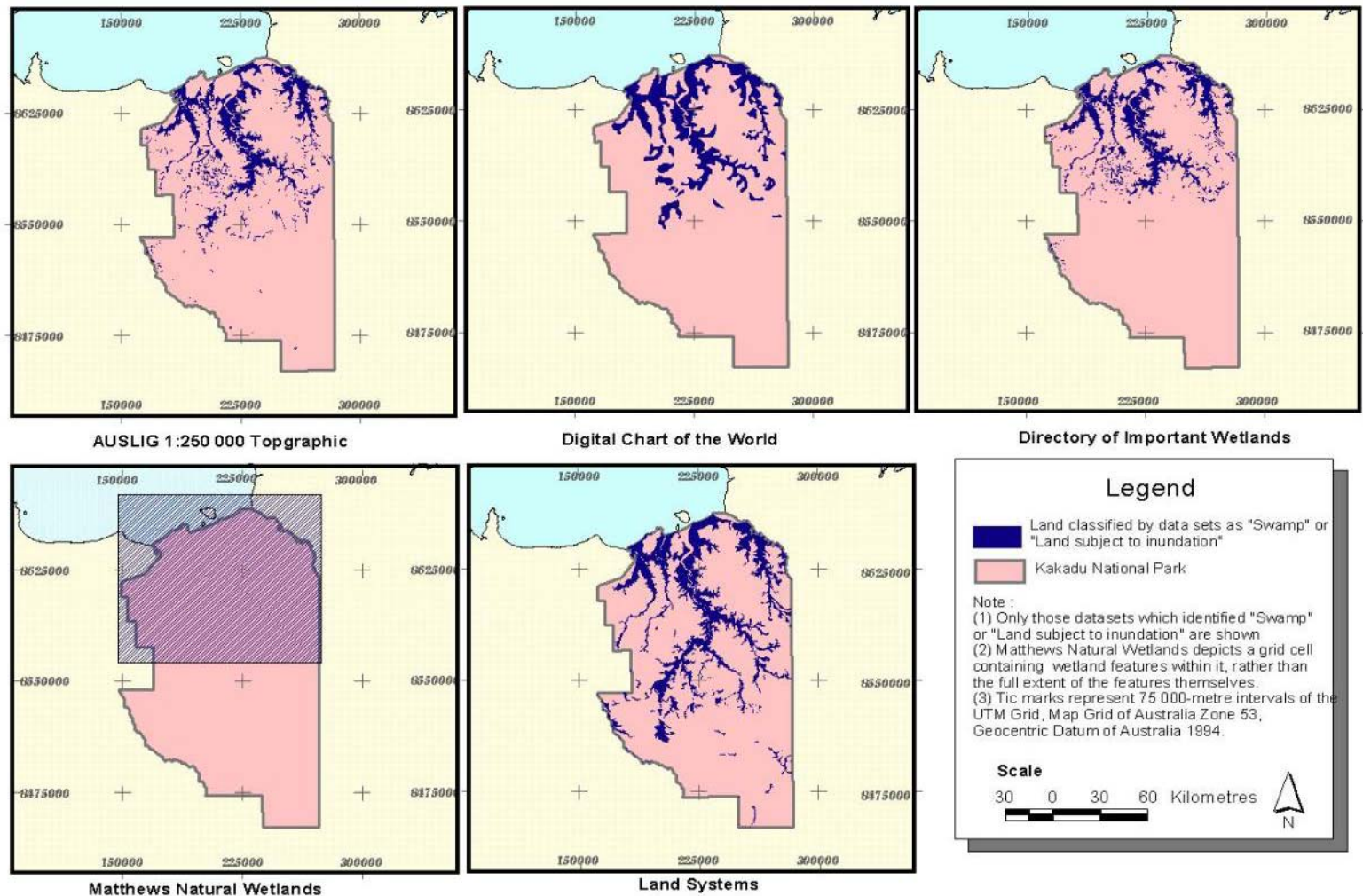
It is related to the size of the geographic region and the accuracy needed.



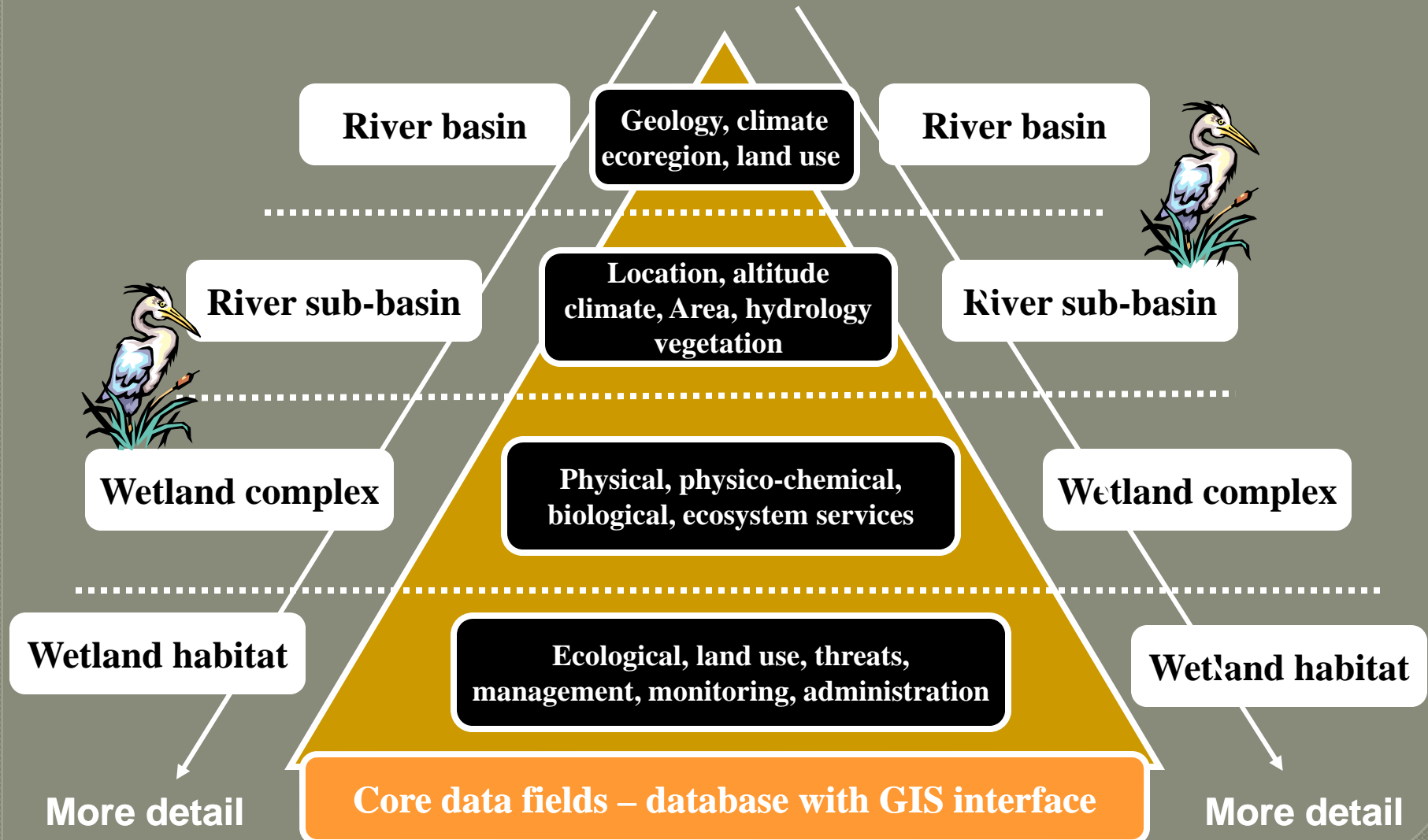
Major differences in data on wetland extent - detail related to mapping scale – northern Australia

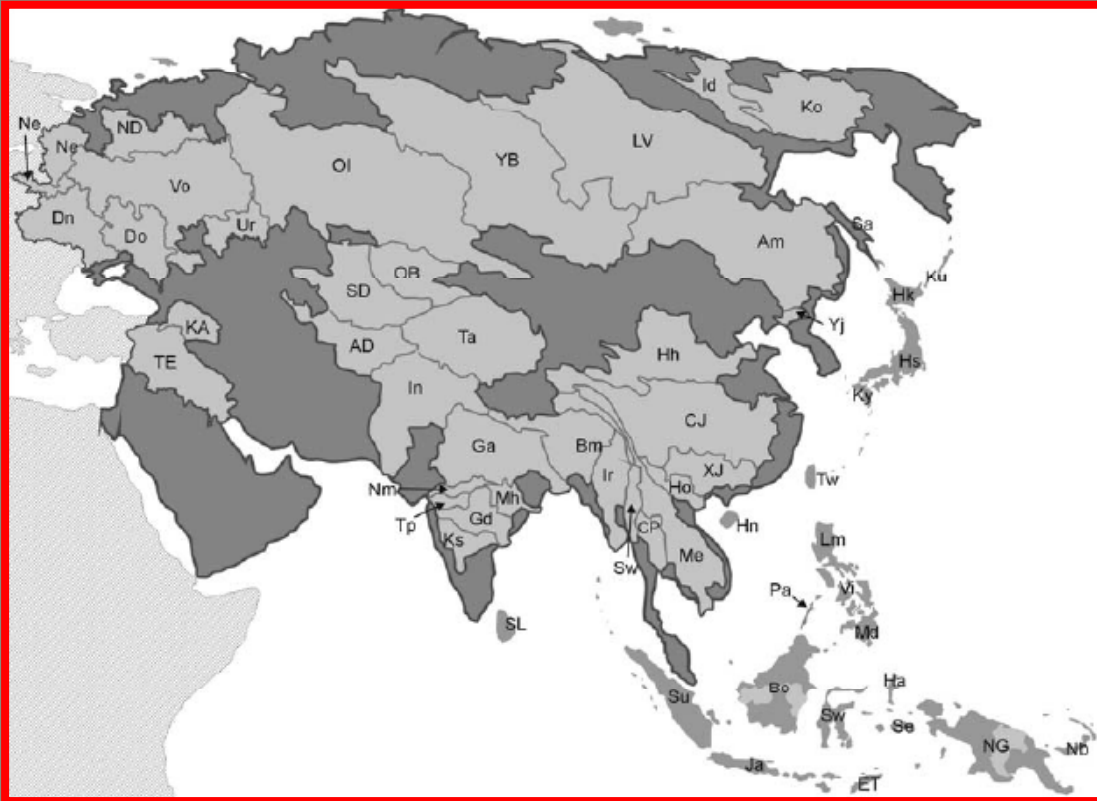


Less variable the smaller the geographic area – Kakadu National Park, northern Australia



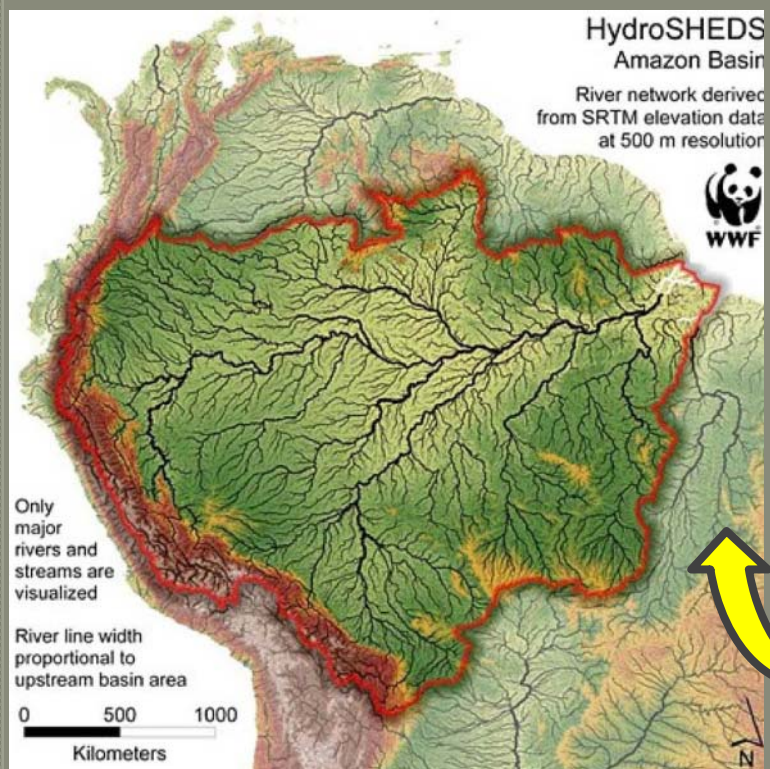
Asian Wetland Inventory adopted a multi-scalar, hierarchical approach with standardised core data collected at each scale

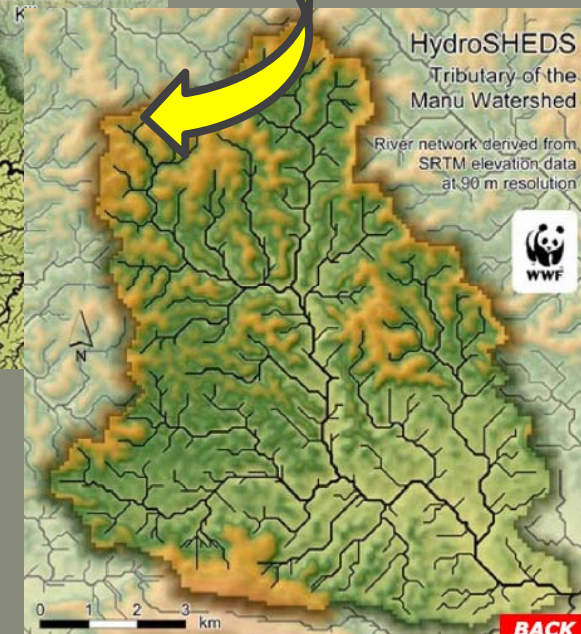
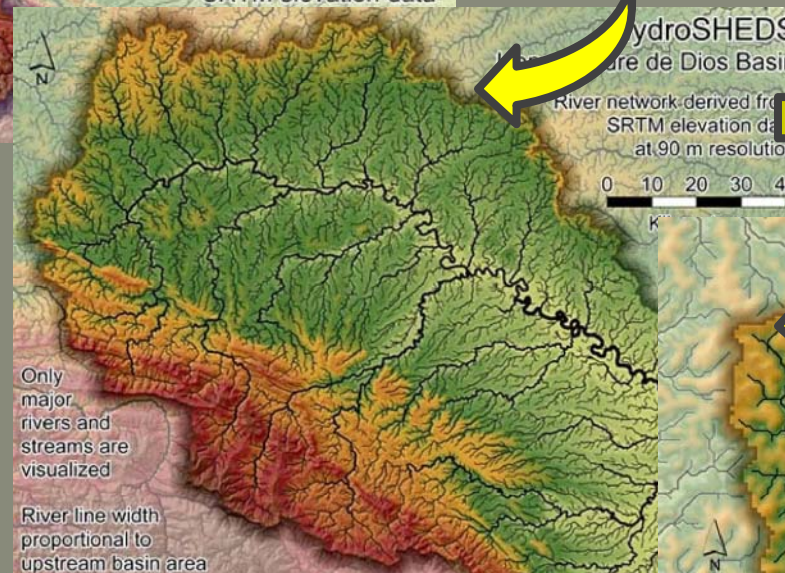
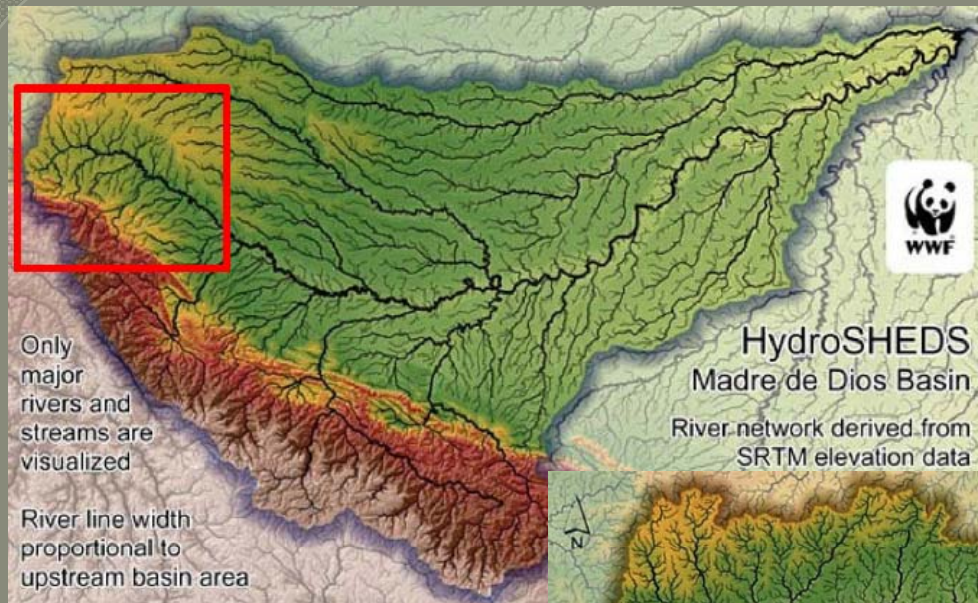




The Asian Wetland Inventory adopted a large river basin approach with four scales for mapping and data collection

- 1: 500 000 to 1:1 000 000 scale maps for major river basins
- 1:250 000 to 1: 500 000 scale maps for sub-basins and coastal sub-regions
- 1:100 000 to 1:250 000 scale maps for wetland complexes
- 1:10 000 to 1:50 000 scale maps for wetland habitats





HydroSHEDS is available at
<http://www.worldwildlife.org/science/projects/freshwater/item1991.html>

Ramsar framework for wetland inventory

5. Establish a core or minimum data set

Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features.

This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.

5a. Establish a core or minimum data set

The core data can be divided into two components - biophysical and major management features of the wetland.

The decision on whether to undertake an inventory based only on core biophysical data or to also include data on management features will be based on individual needs.

**The Asian Wetland Inventory has adopted 4 data layers to correspond with the 4 scales that are used.
Different data is collected at each scale.**

5b. Core data - biophysical features

Site name (official name of site and catchment)

Area and boundary (size and variation, range and average values)

Location (projection system, map coordinates, map centroid, elevation)

**Geomorphic setting (within the landscape, biogeographical region) and
general description (shape, cross-section and plan view)**

Climate – zone and major features

Soil (structure and colour)

Biota (vegetation zones, animal populations, rare/endangered species)

Water regime (depth, periodicity, flooding, source of water, groundwater)

Water chemistry (salinity, pH, colour, transparency, nutrients)

5c. Core data - managerial features

Landuse in the wetland and river basin

Pressures on the wetland and river basin

Land tenure and administrative authority for the wetland

**Conservation and management status of the wetland
including legal instruments and social-cultural traditions that
affect management**

Ecosystem goods and services derived from the wetland

Management plans and monitoring programs in place

Ramsar framework for wetland inventory

6. Establish a habitat classification

Choose a habitat classification that suits the purpose of the inventory.

It is unlikely that a single classification would be accepted for all purposes.

A classification can be developed from the core biophysical data - hydrology, geomorphology, vegetation cover, water quality (nutrients, salinity...)

Ramsar framework for wetland inventory

7. Choose an appropriate method

Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits of the alternatives.

Ramsar framework for wetland inventory

7a. Comparison of methods

I

Inventory methods

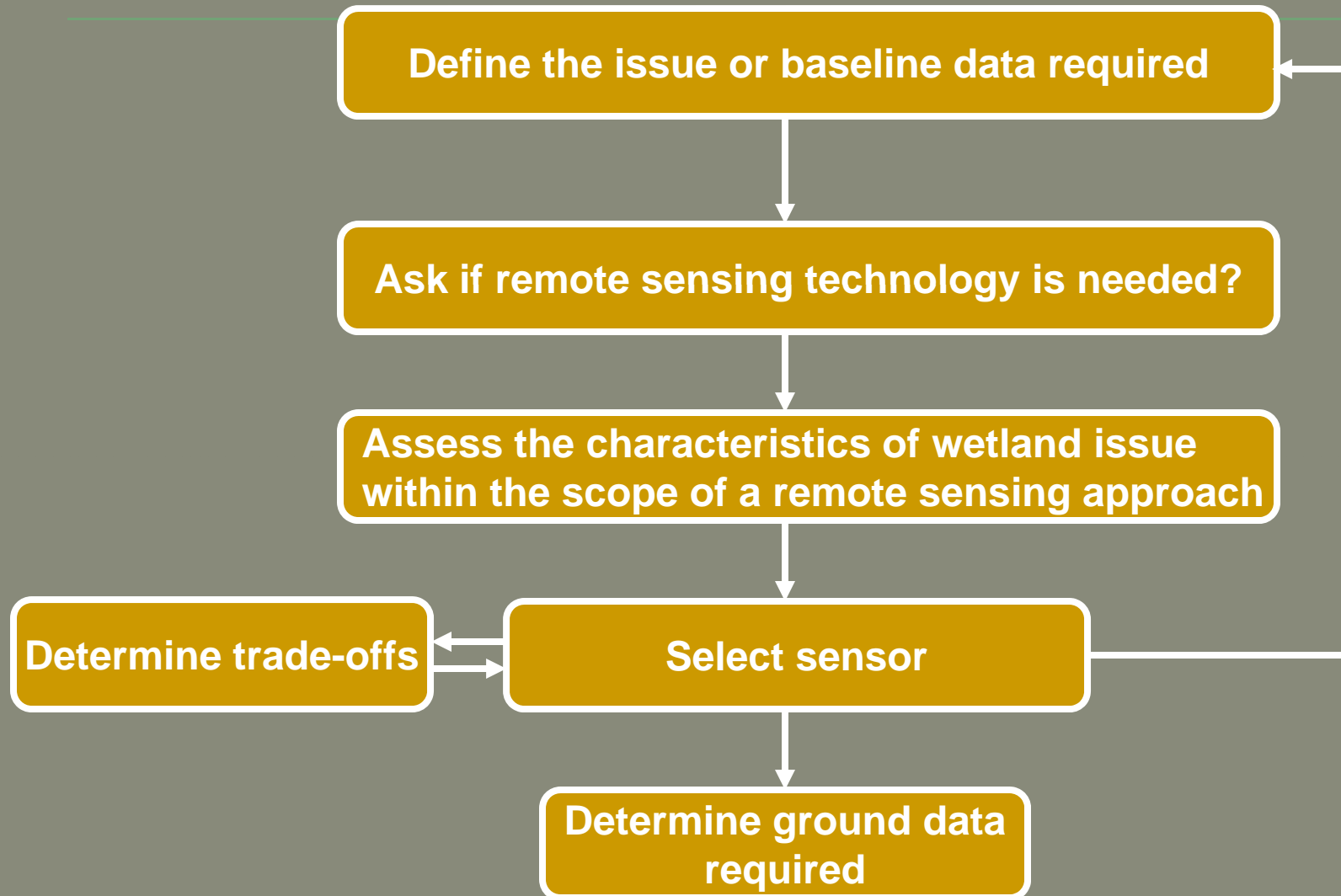
- Mediterranean (MedWet) inventory
 - US national wetland inventory
- Ugandan national wetland program
 - Asian wetland inventory
 - Himalayan wetland inventory

Types of satellite data applicable for wetland mapping at different scales

Table 1: Summary of potential satellite data types applicable for wetlands resources mapping
(based on van Valkengoed 2007)

Area of site (km ²)	Preferred (minimum scale of map)	Minimum mapping unit	Satellite data type		Spatial resolution	Tentative cost (in US\$)
10,000	1:1,000,000	–	Low resolution	SPOT-vegetation NOA	1 km	Available for free down-loading
1,000 to 10,000	1:500,000	–		MERIS	250-500m	
500 to 1000	1:250,000	20 ha (450 x 450m)			250-500m	
250 to 500	1:100,000	–	MODIS		30m	0.01¢ to \$3.50 per km ²
100 to 250	1:50,000	5 ha (225 x 225m)	Low resolution	MERIS	30m	
10 to 100	1:25,000	3 ha (170 x 170m)	MODIS		15-30m	\$3.50 to \$80.00 per km ²
<10	1:5,000		Medium resolution	Landsat TM/ ETM+	5-10m	
				Landsat 7 (ETM+)	0.6-4m	
			ASTER			

Choosing remote sensing methods



Wetland delineation

Where is the boundary of the wetland?

Based on multiple features – sometimes obvious, but at other times not. Times series and ground data may be needed.

Vegetation, soils and land features, and the water regime are generally used to establish the boundary.

Remote sensing using automated or semi-automated methods is increasingly being used. These can be reasonably accurate, but there is still no replacement for good ground knowledge based on training and experience.

Table 2: Wetland area in national database, and area delineated in this study

Name	Area in wetland database	Area delineated in study
Lake Brewster	6,140	10,110
Booligal wetland	5,000	9,510
Lachlan swamp	6,600	10,490
Great Cumbung swamp	16,000	16,240



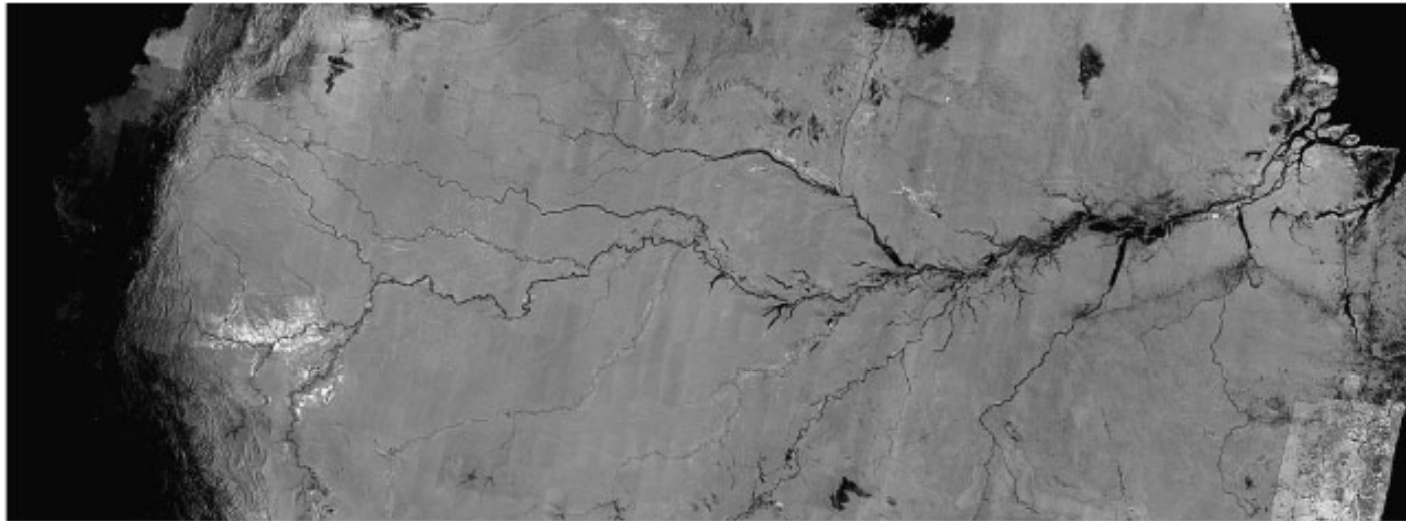
Extent of flooding – where does the “wetland” end and the “land” start?



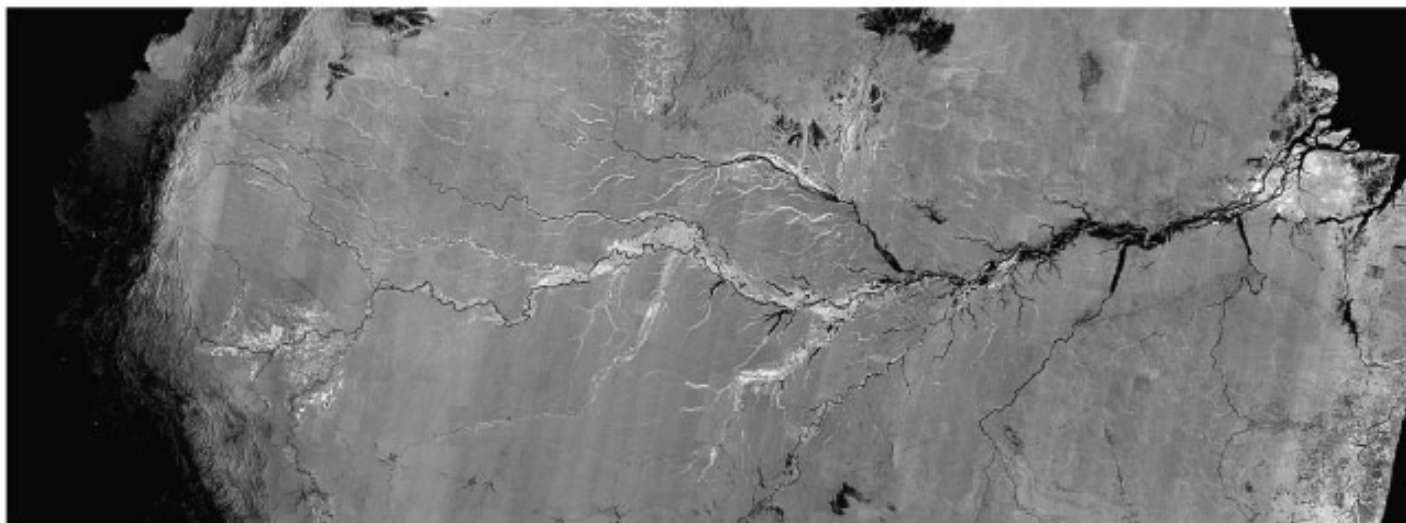
Wetlands are defined as lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.

For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

US Federal Geographic Data Committee



(a)



(b)

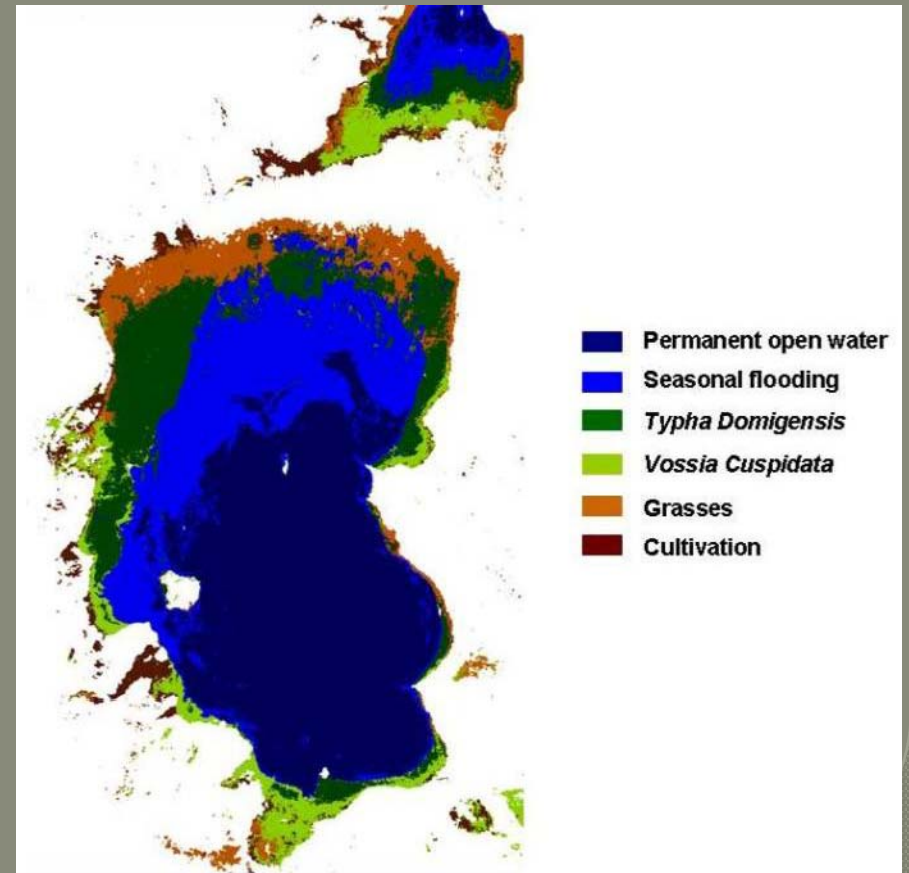
Figure 8. (a) The Central Amazon basin during low water (October 1995). Extract from the JERS-1 L-band SAR mosaic over South America. © JERS-1/GRFM /JAXA/METI. (b) The Central Amazon basin at high water (July 1996). Bright areas indicate below canopy flooding. Global Rain Forest Mapping project © JPL/JRC/JAXA/METI.

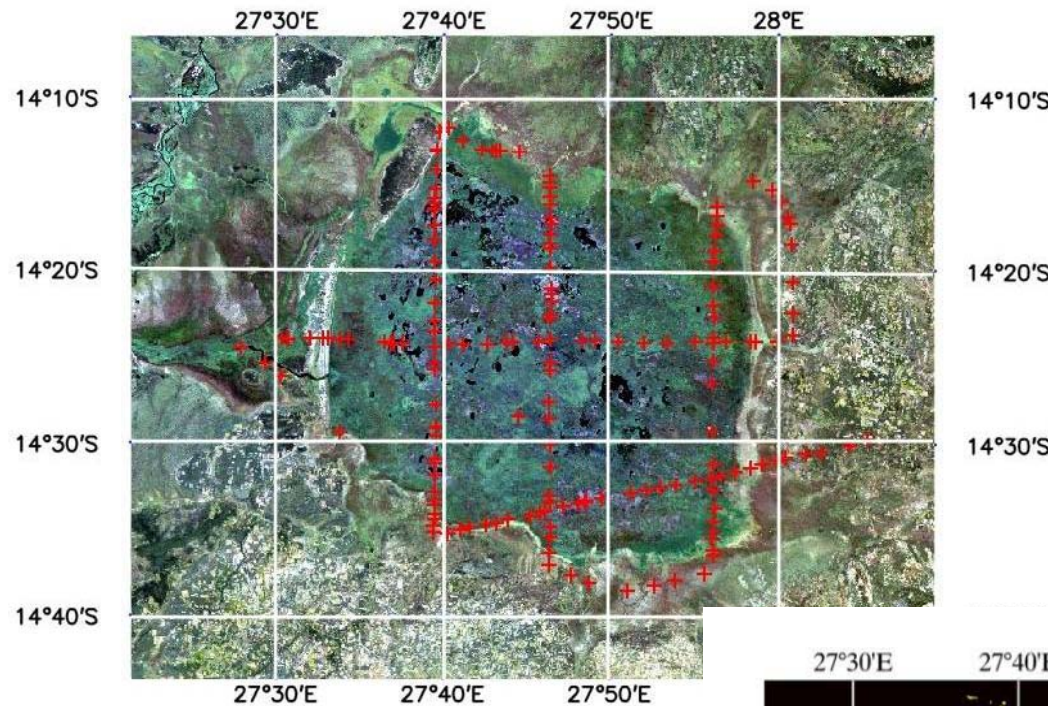


Lake Chilwa, Malawi

2228 km² – partly accessible

Ground survey, air photos
and satellite imagery

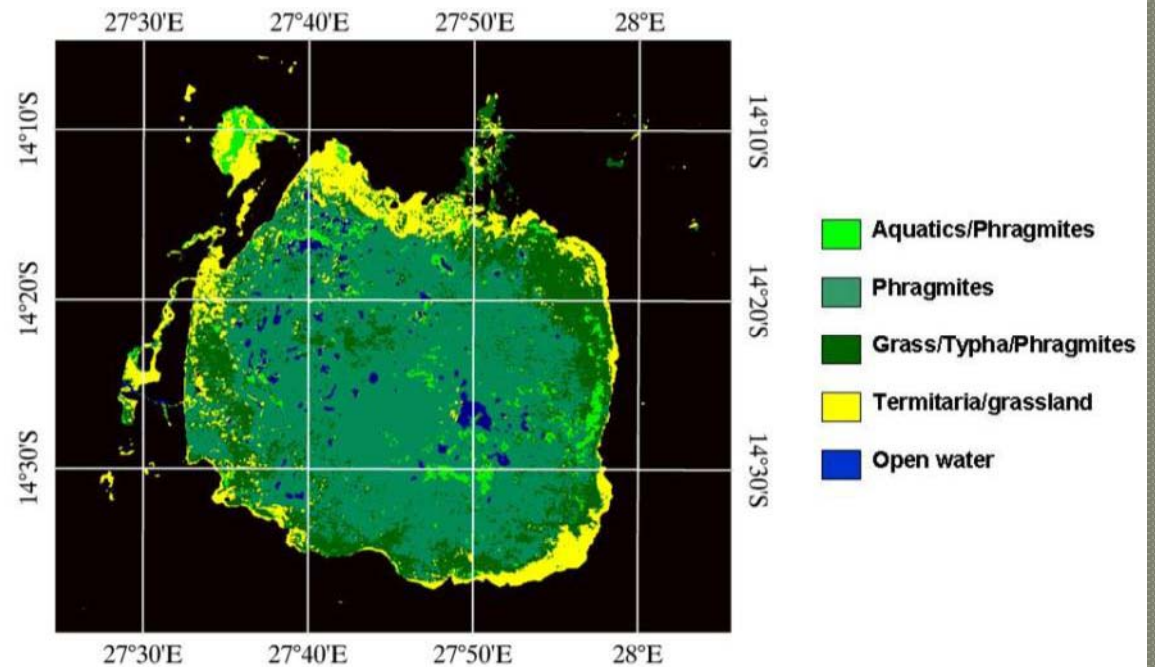




Lukanga wetland, Zambia

2500 km² – inaccessible

Hand held air photos
and satellite imagery



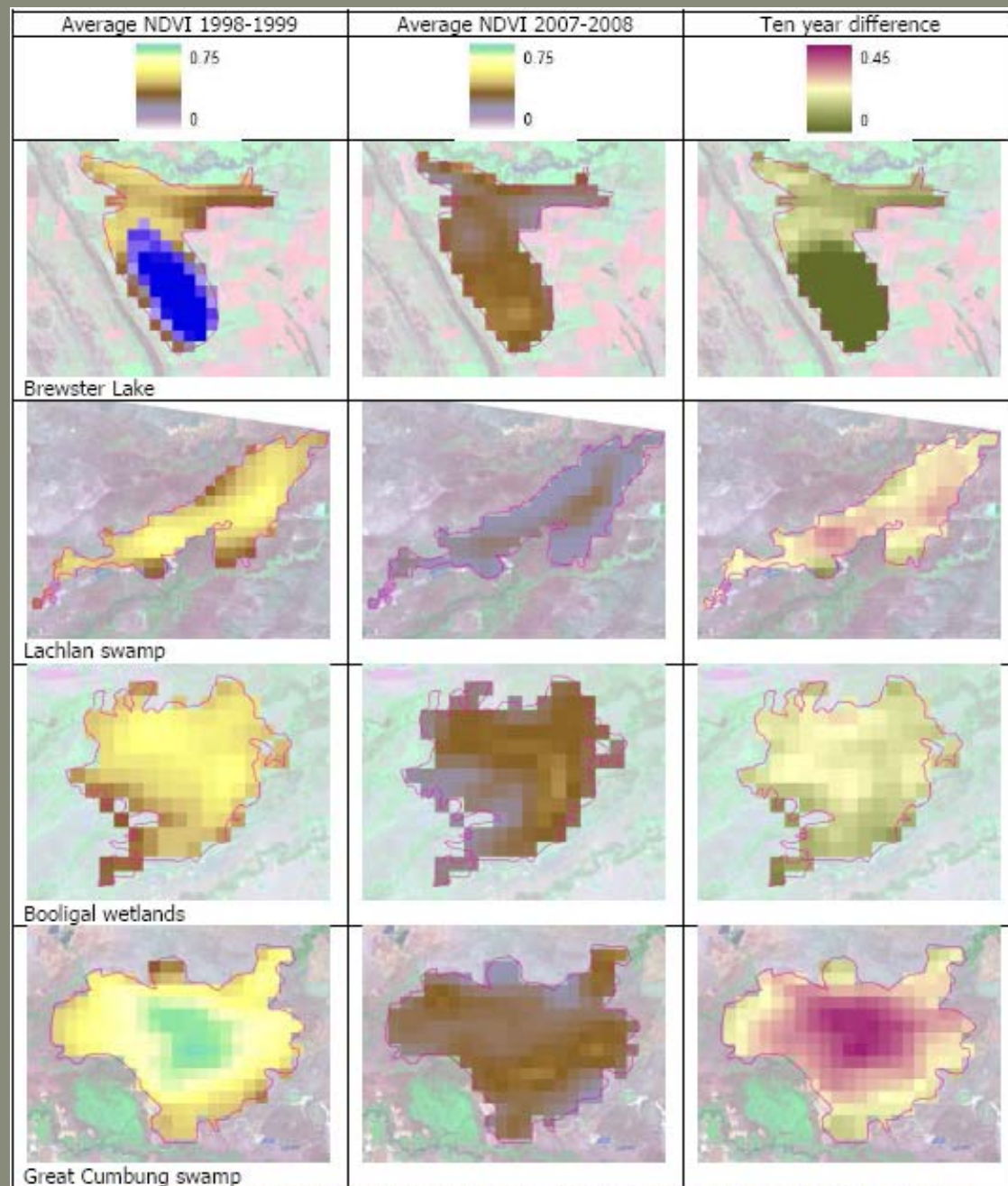


Figure 7: Average NDVI for November - May period maintaining spatial variability using SPOT-Vegetation data

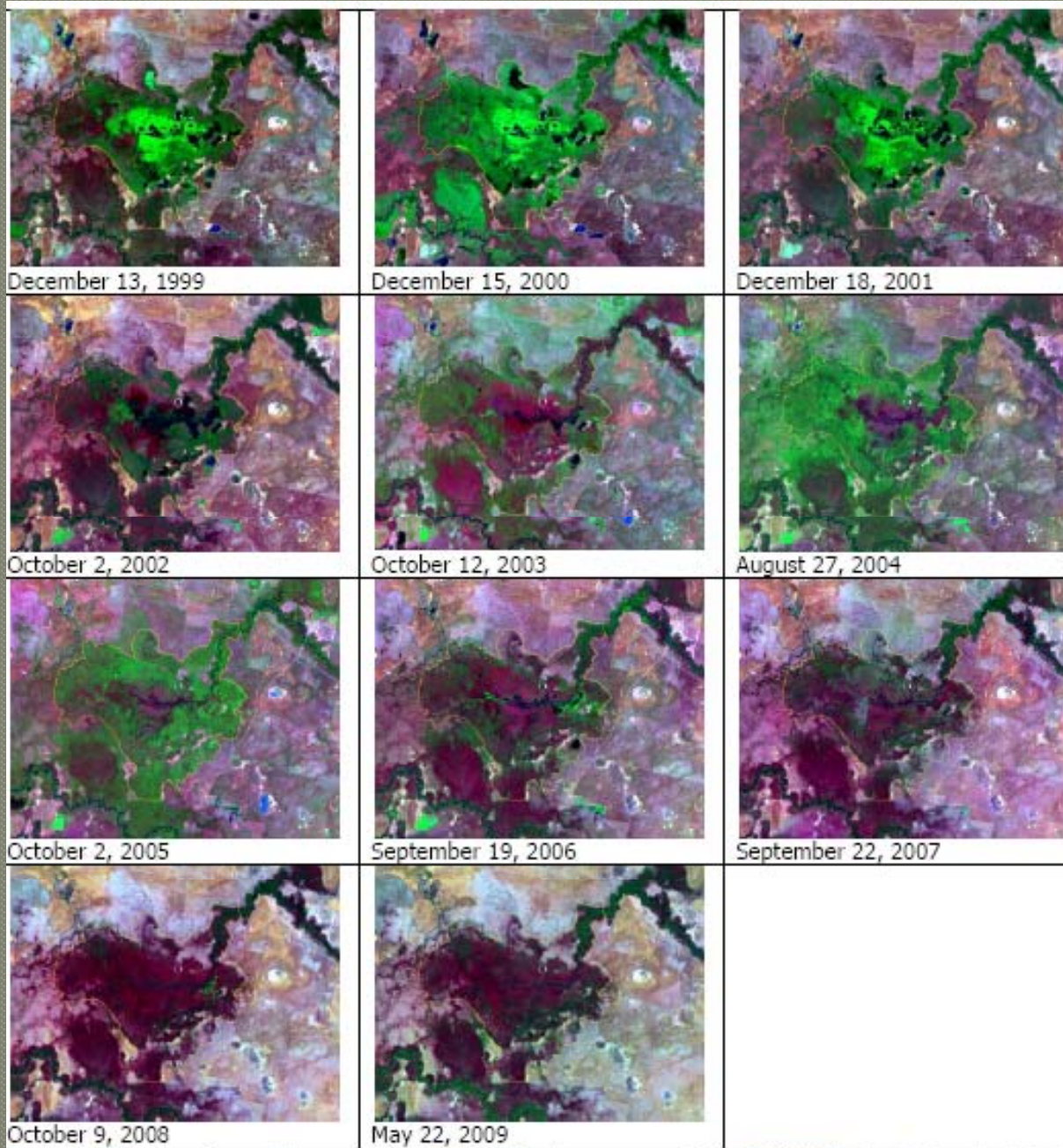


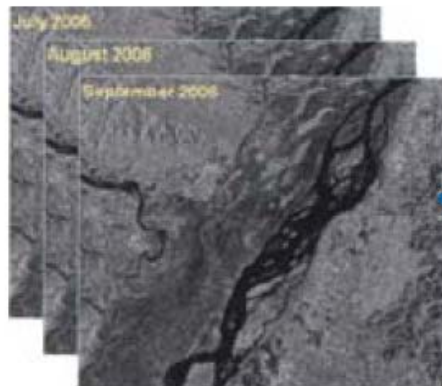
Figure 2: Overview of vegetation response of Great Cumbung swamp from 1999-2009 using false color (band 7,4,2) Landsat images.

Changes in wetland vegetation due to drought – lack of water.

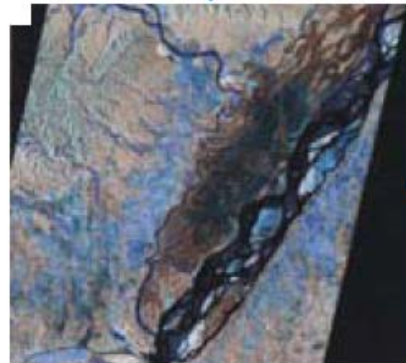
Geomorphology of the wetland is still evident.

Delineation depends on multiple criteria (or a lawyer with good shoes)

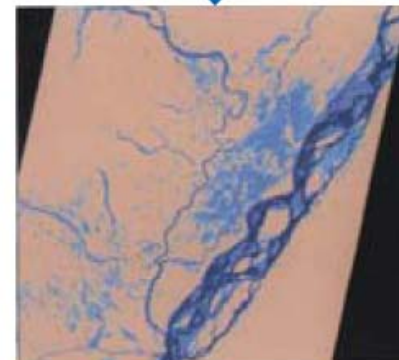
Radar image-based water cycle regime mapping of the Koshi Tappu Wildlife Reserve



ASAR radar raw imageries acquired
for different seasons



Composite of images



Water cycle regime

Ramsar framework for wetland inventory

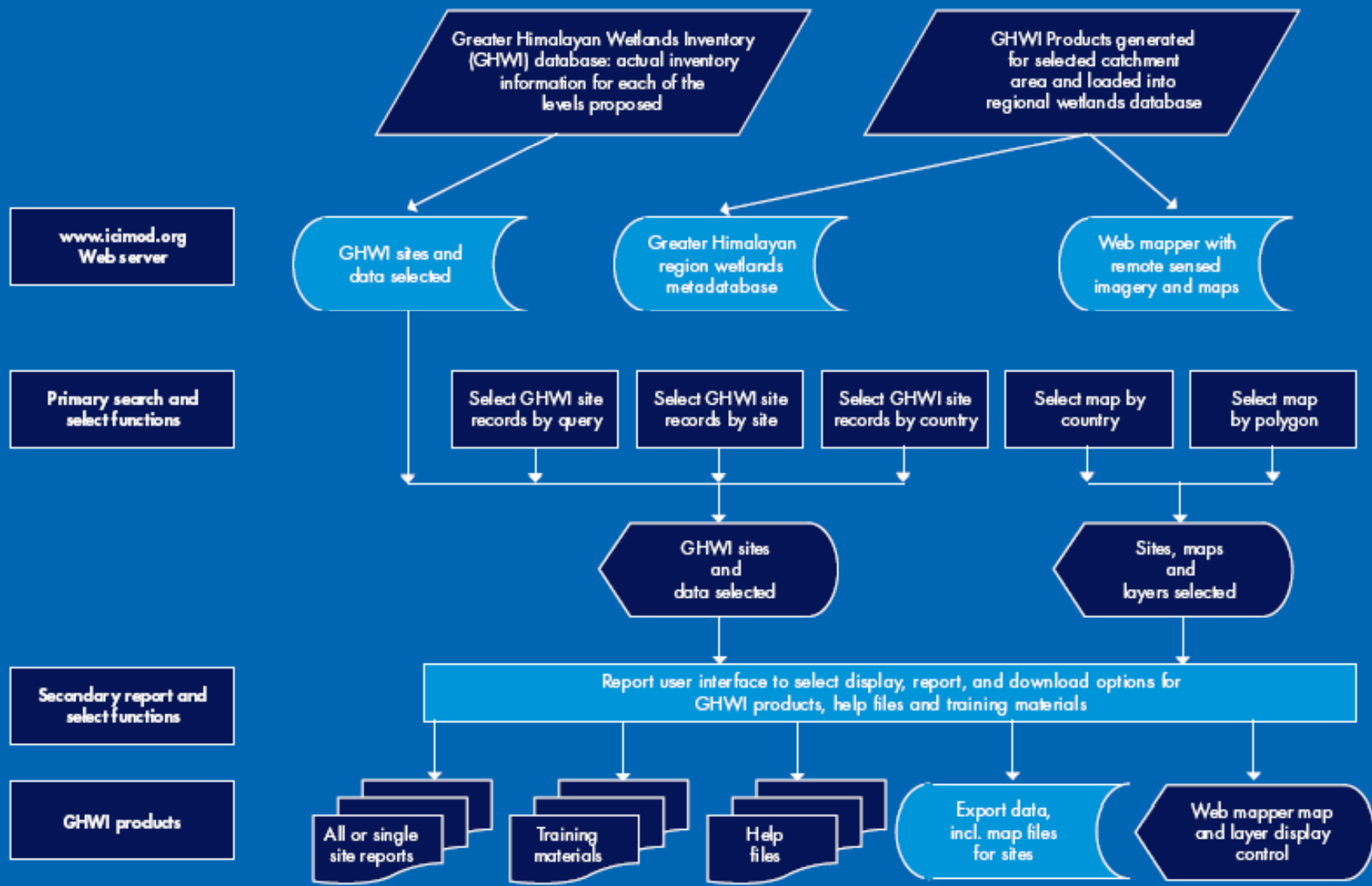
8. Establish a data management system

Establish clear protocols for collecting, recording and storing data, including archiving, to enable the source of the data and its accuracy to be determined.

Identify suitable rigorous and tested methods for all data analysis and interpretation and document these.

Use a meta-database to record information about the inventory and details of data ownership and access.

Figure 5: Data model for the relationship between the GHWI database, metadatabase and web mapper tool



Ramsar framework for wetland inventory

9. Establish a time schedule and extent of resources

Establish a time schedule for planning the inventory, for collecting, processing and interpreting the data, for reporting the results, and for reviewing the program.

Establish the extent and reliability of the resources available and make plans to ensure that data is not lost.

Ramsar framework for wetland inventory

10. Assess the feasibility and cost effectiveness

Assess whether or not the program, including reporting of the results can be done within the management system and with the money available.

Determine if the costs of data acquisition and analysis are within budget and that the budget is available for the program to be completed.

Asian Wetland Inventory - wetland delineation

- principal purpose is to delineate/map the wetlands, to distinguish wetland habitats from the intertidal zone to the landward, and to display this on GIS-based maps
- this would occur at four different scales with the amount of detail dependent on the purpose of the inventory and the size and importance of the wetland

Ramsar framework for wetland inventory

11. Establish a reporting procedure

Establish procedures for interpreting and reporting all results in a timely and cost effective manner.

The report should be succinct/concise and indicate whether or not the objective has been achieved and contain recommendations for management action, including whether further data is required.

Ramsar framework for wetland inventory

12. Establish a review and evaluation process

Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting, and supply information to adjust or even terminate the program.

Ramsar framework for wetland inventory

13. Plan a pilot study

Test and fine-tune the method and specialist equipment being used.

Assess the training needs for staff involved.

Confirm the means of collating, collecting, entering, analysing, interpreting and reporting the data.

Check that any remote sensing data collection can be supported by ground-truthing.

Wetland Inventory

- **Wise use of wetlands depends on having sufficient knowledge and information – a well planned inventory can provide this information.**





Thank-you



You cannot solve the problem with the same kind of thinking that created the problem. *Albert Einstein*

