Spatial units and ecosystem condition accounts
Testing results from South Africa

Virtual Technical Expert Forum on Ecosystem Accounting

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Presenter: Mandy Driver (SANBI)

Spatial units

Anisha Dayaram[1,2], Andrew Skowno[1,3], Anthony Rebelo[1], Kerry Sink[1,5], Jeanne Nel[4,5], Nancy Job[1]

Overview

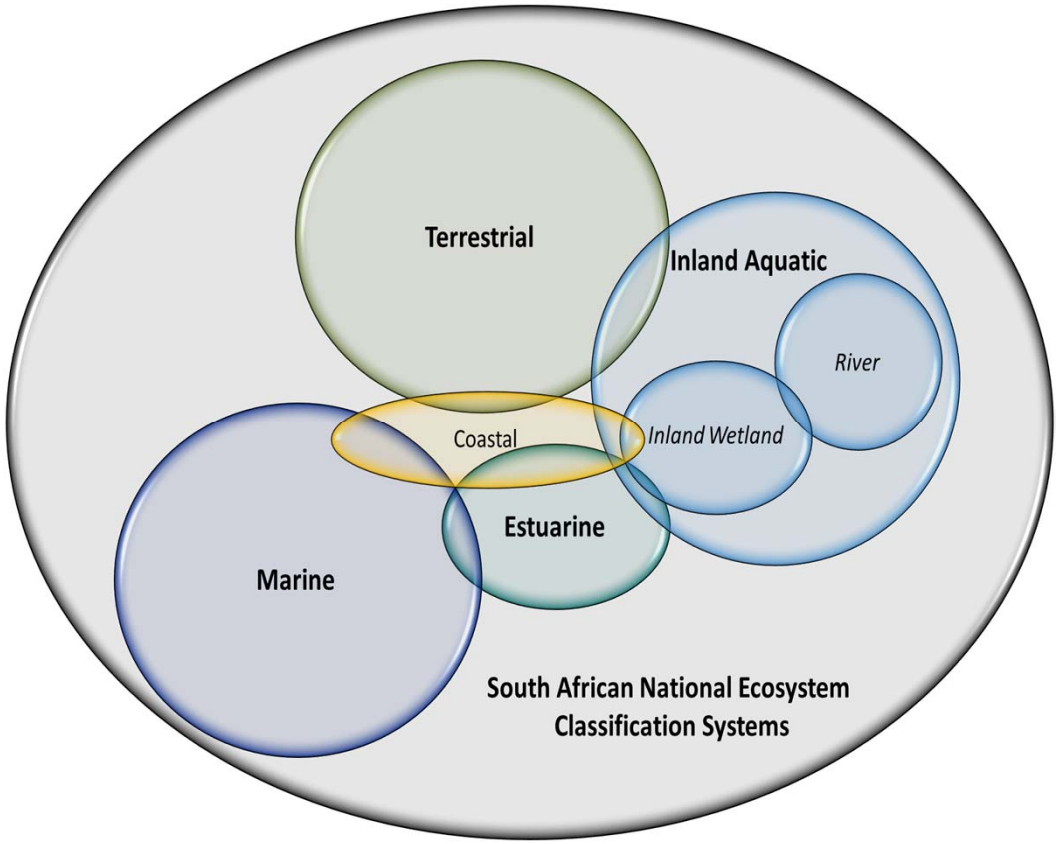
- Intro to SA National Ecosystem Classification System (SA-NECS)
- Results from crosswalk of SA-NECS to IUCN Global Ecosystem Typology (GET)
- Results from spatial correspondence between SA-NECS and USGS-Esri World Ecosystems

1. South African National Biodiversity Institute (SANBI); 2. University of Cape Town; 3. University of the Witwatersrand; 4. Wageningen Environmental Research; 5. Nelson Mandela University

South African National Ecosystem Classification System (SA-NECS) integrates ecosystem classification and mapping across realms

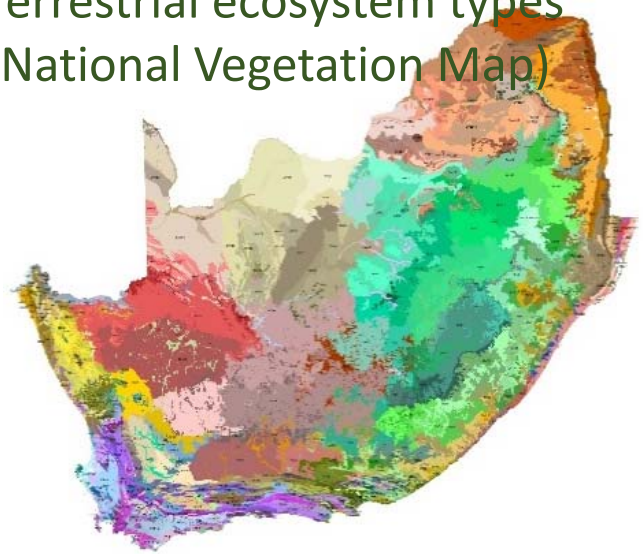
Realm	Classification system name
Terrestrial	National Vegetation Map
Inland aquatic (freshwater)	Classification system for wetlands and rivers
Estuarine	Ecosystem Classification for South African Estuaries
Marine	Marine Ecosystem Classification

The **coast is a cross-realm zone** that includes elements from all four realms

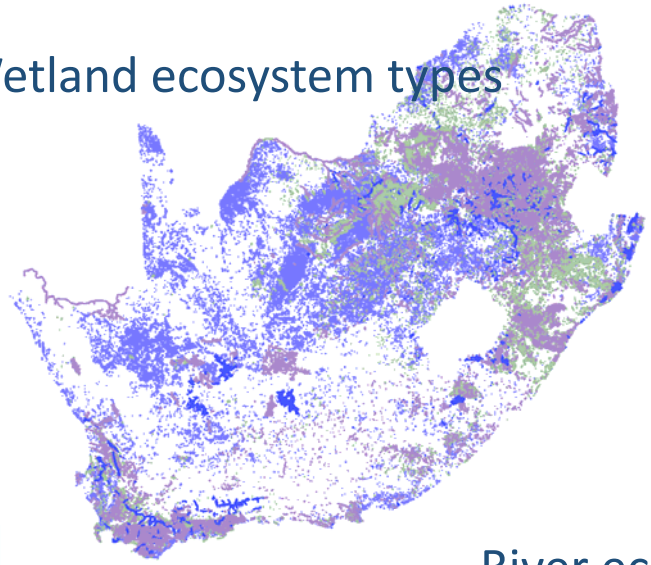


Approach broadly equivalent across all realms

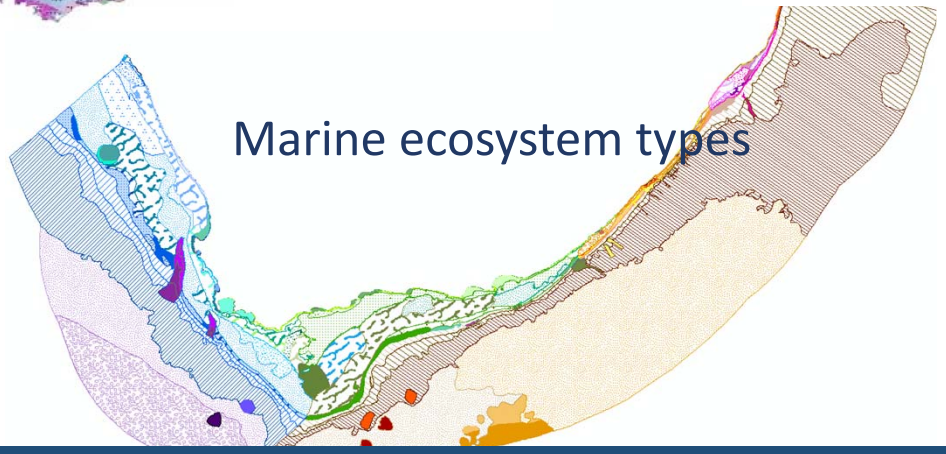
Terrestrial ecosystem types
(National Vegetation Map)



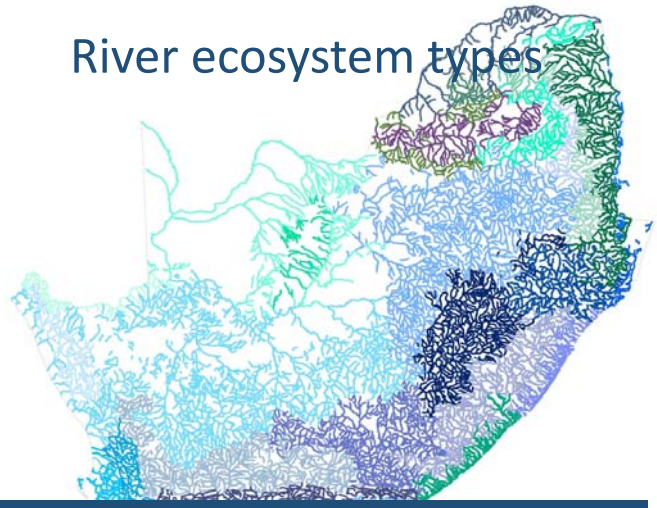
Wetland ecosystem types



Marine ecosystem types



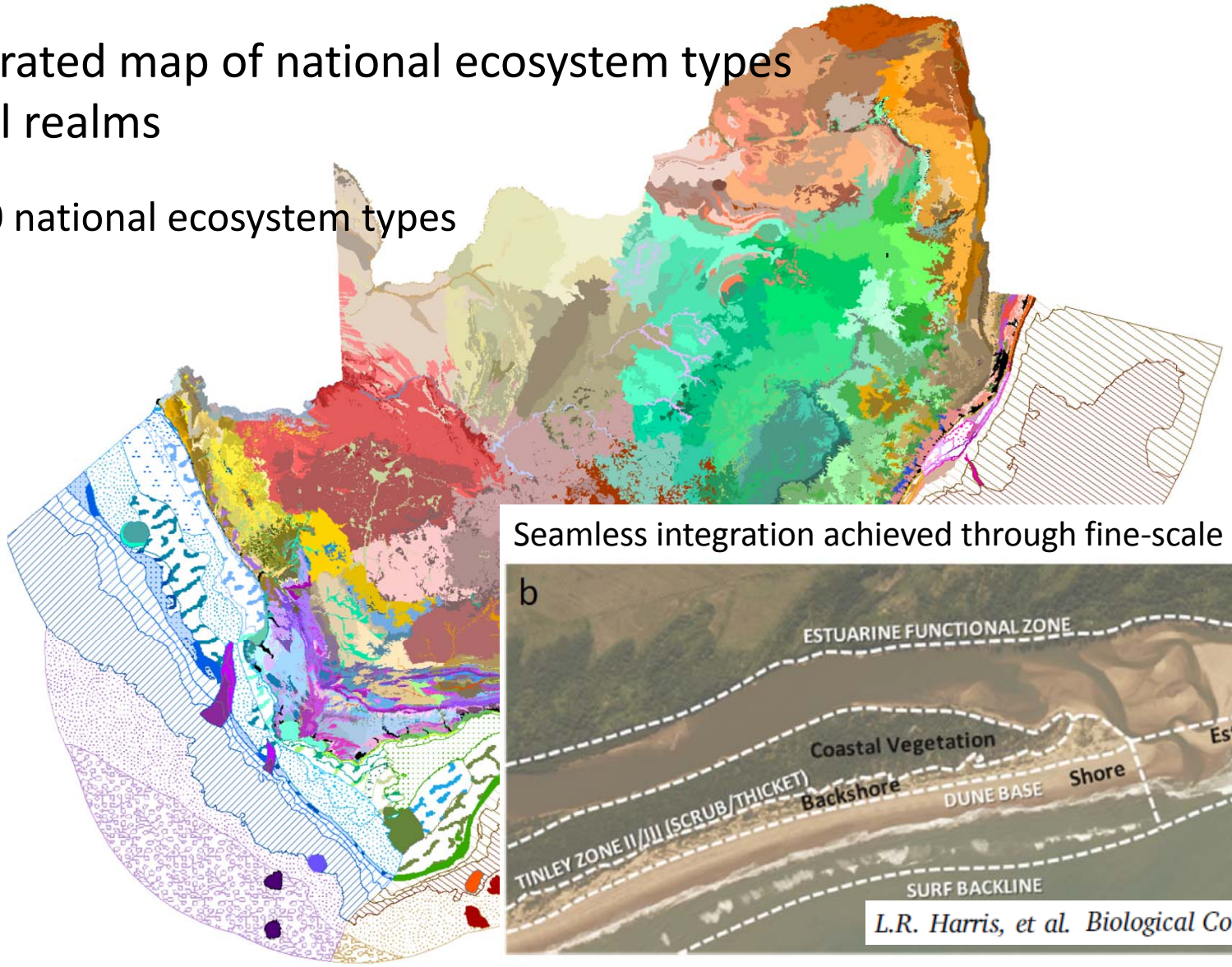
River ecosystem types



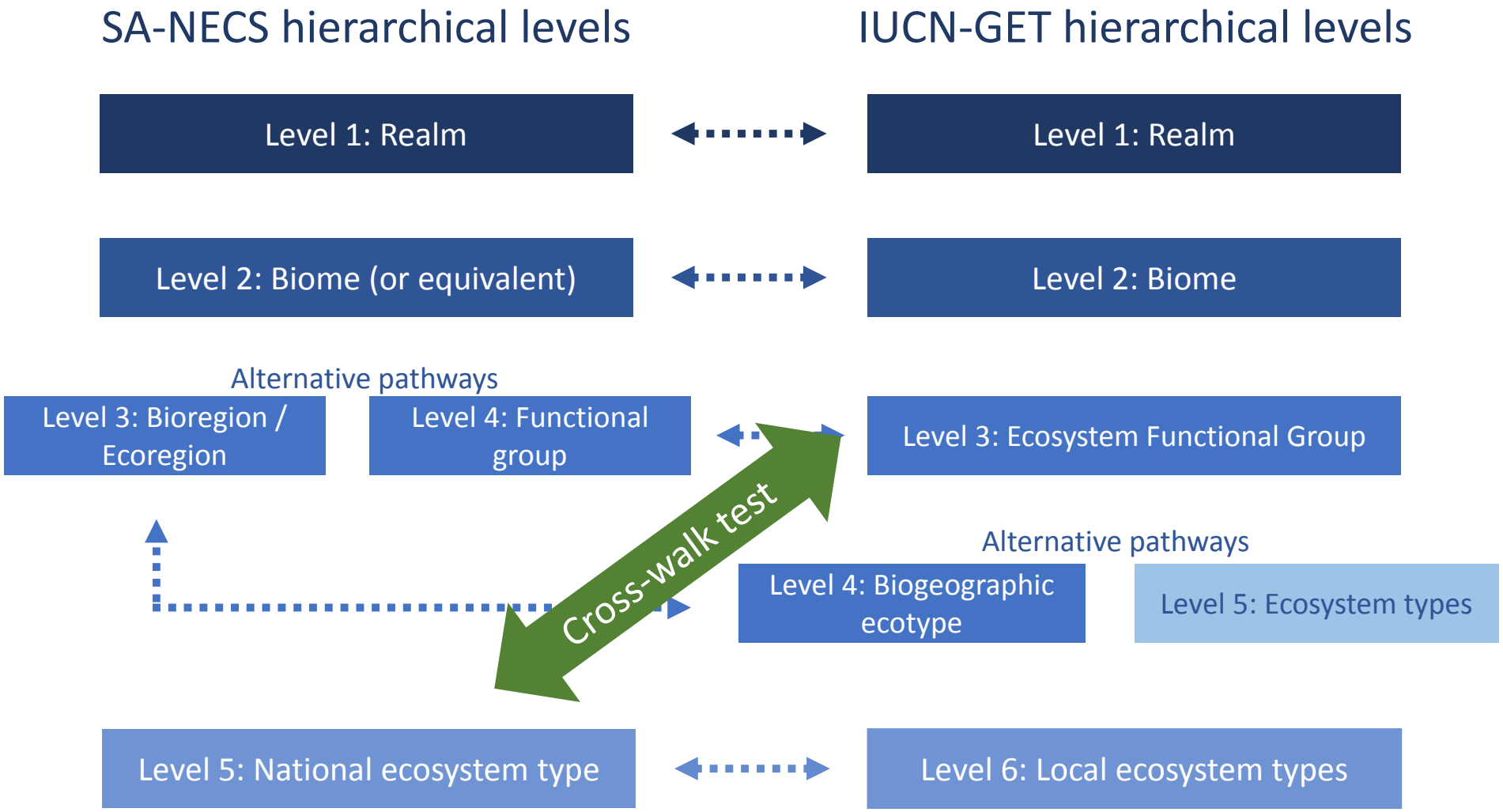
Ecosystem types mapped based on **historical extent** (or as close as possible)

Integrated map of national ecosystem types for all realms

~1000 national ecosystem types

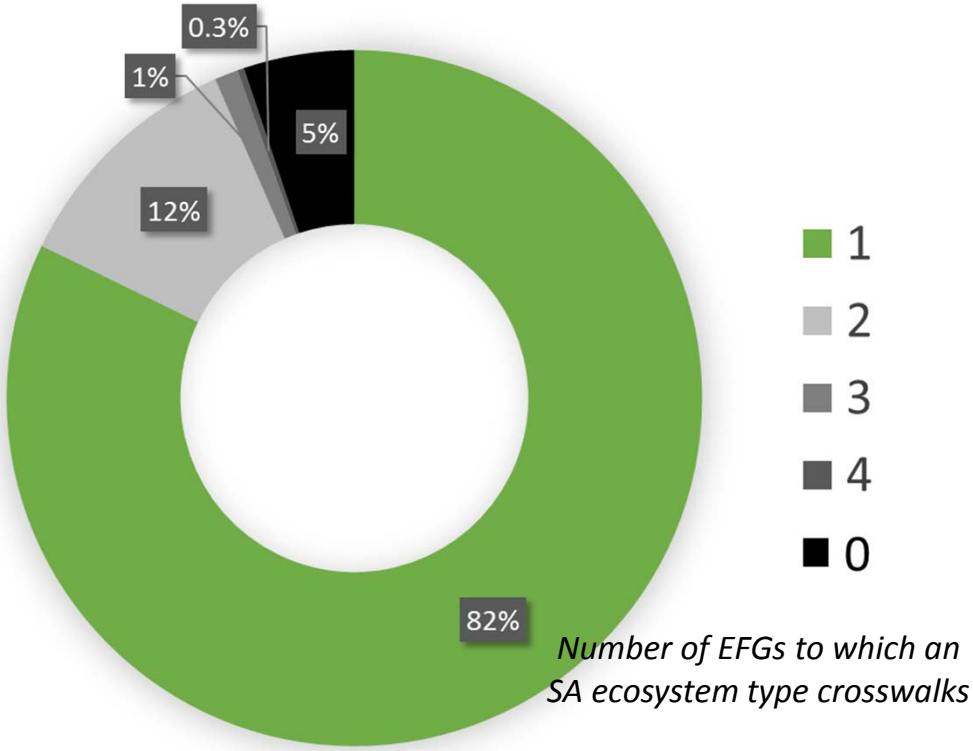


Seamless integration achieved through fine-scale mapping along the coast


SA-NECS hierarchical levels
IUCN-GET hierarchical levels
Level 1: Realm
Level 1: Realm
Level 2: Biome (or equivalent)
Level 2: Biome
Alternative pathways
Level 3: Bioregion / Ecoregion
Level 4: Functional group
Level 3: Ecosystem Functional Group
Cross-walk test
Alternative pathways
Level 4: Biogeographic ecotype
Level 5: Ecosystem types
Level 5: National ecosystem type
Level 6: Local ecosystem types

Results of IUCN-GET crosswalk

- 82% of SA's ecosystem types can be cross-walked to one of the IUCN-GET Ecosystem Functional Groups (L3)
- Looked for best available fit for each national ET
  - Even for those considered a 100% match, the national ET description and EFG description were not necessarily *exactly* the same



General indication of fit of all South African national ecosystem types within the IUCN GET Ecosystem Functional Groups, for all realms combined

However, results vary by realm

Terrestrial	Rivers	Wetlands	Estuarine	Marine
Overall good crosswalk of SA types to GET EFGs. Challenges with a few mosaic types and some forest types.	**Overall strong** crosswalk of SA types to GET EFGs	**Several challenges** e.g. • SA floodplain ETs crosswalk to multiple GET EFGs • SA valley bottoms don't fit well into any GET EFGs • SA lakes and seeps fit relatively well	**Overall good** crosswalk of SA types to GET EFGs	**Overall poor** cross-walk of SA types to GET EFGs: • Benthic and pelagic coupled in SA, but split in GET • Mosaic types recognised in SA (e.g. mixed shores, mixed sand/mud/rock substrates) but not in GET → SA ETs often crosswalk to multiple GET EFGs

Coherence between South African terrestrial ecosystem types and USGS-Esri-NC World Ecosystem map product

- **Only tested for terrestrial realm**
- Not a good fit
  - Most SA terrestrial ecosystems types fit into 2 or 3 or even 4 WTE units
- Partly because WTE uses landform (plains/hills/table lands/mountains) high up in the hierarchy
- IUCN-GET is closer to SA approach to conceptualising and classifying ecosystems
- WTE spatial units not useful for terrestrial realm SA but could be useful in data poor contexts
- Results may be different for other realms

Number of World Terrestrial Ecosystem classes shared within an SA terrestrial ecosystem type

Take home messages

- We support the IUCN-GET as the reference classification for SEEA
- Some conceptual differences between SA-NECS and GET:
  - Coupling or splitting benthic and pelagic in marine realm
  - SA-NECS recognises mosaic types in terrestrial and marine realms, GET doesn't
  - Approach to wetland hierarchy is different
- IUCN-GET Level 3 (EFGs) is appropriate for global reporting of ecosystem accounts
  - We will also report at finer level in our national ecosystem accounts
- May be useful to formalise a Global Ecosystem Classification Committee to deal with ongoing refinement?

Ecosystem condition account

- Jeanne Nel[2,3], Mandy Driver[1], Aimee Ginsburg[1]

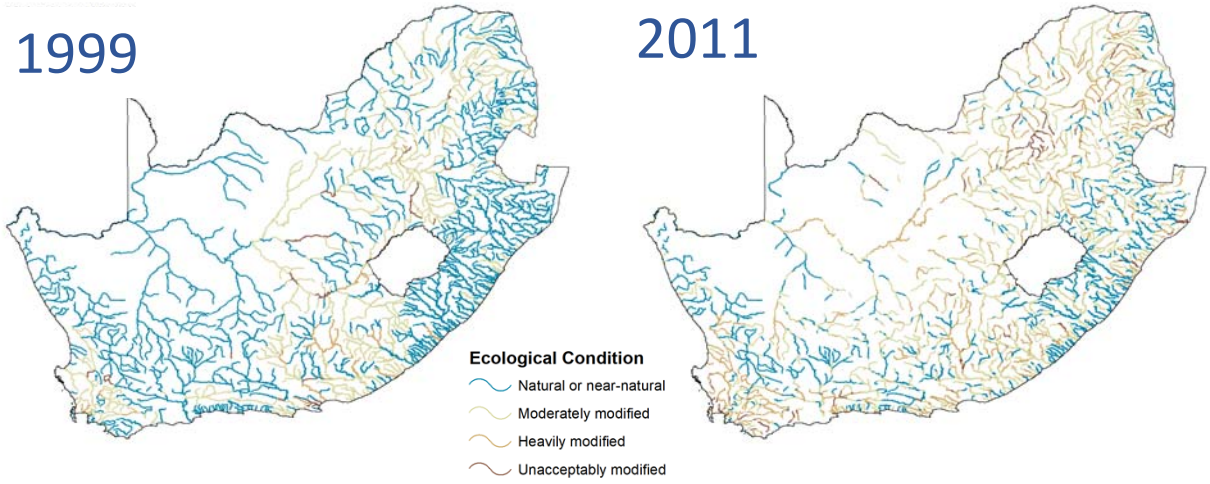
Testing based on National River Ecosystem Accounts developed as part of **Advancing Natural Capital Accounting** (ANCA) project in 2014/15

1. South African National Biodiversity Institute (SANBI); 2. Wageningen Environmental Research;
3. Nelson Mandela University

Extent and condition of river ecosystem assets

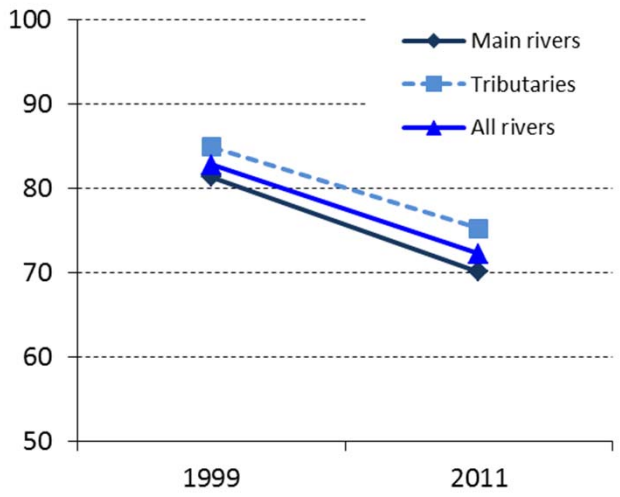
Based on data from two national assessments of river condition by Department of Water & Sanitation

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA



→Ecological Condition Index

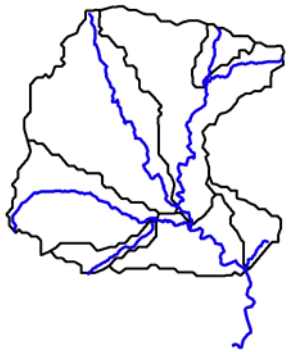
	Main rivers	Tributaries	All rivers
1999	81.3	84.9	82.8
2011	70.1	75.2	72.2
Change between 1999 and 2011	-11.2	-9.7	-10.6



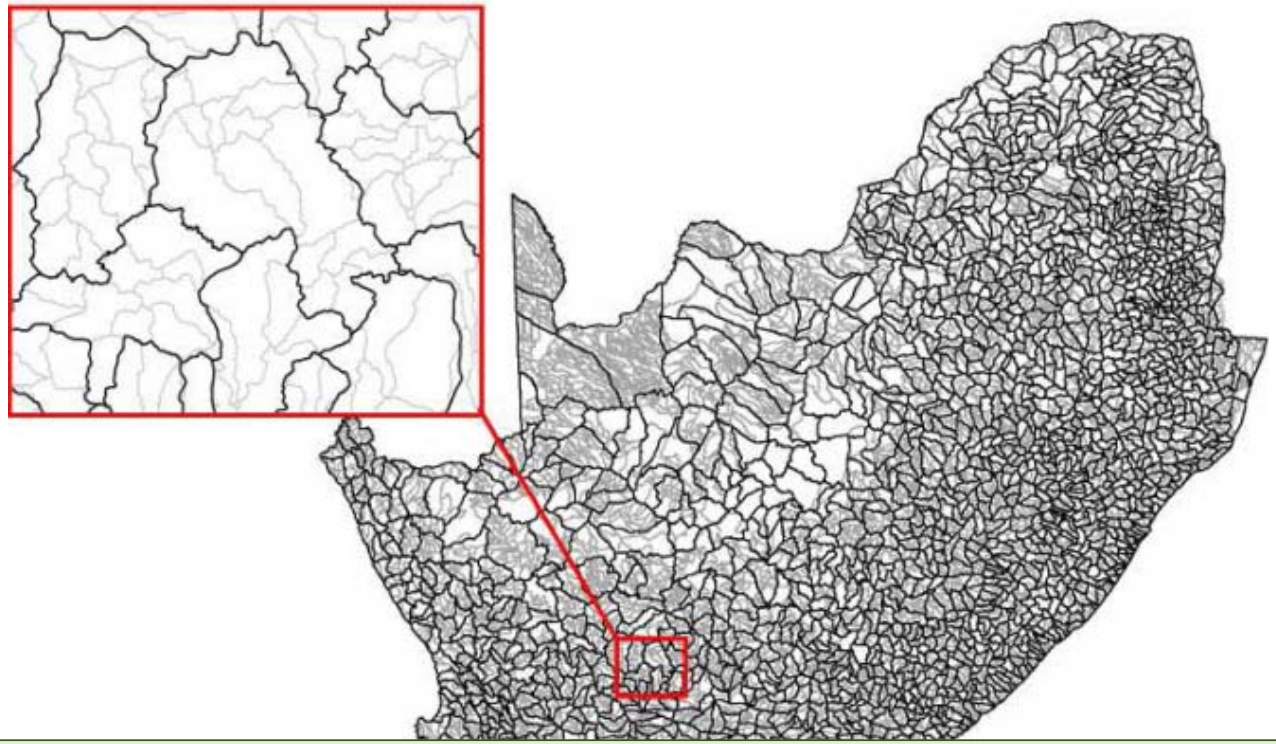
Overall **10% decline** in ecological condition of rivers 1999 - 2011

Rivers are nested in **catchments / river basins**
System of primary through to quinary catchments (5 levels)

- **Quaternaries ~2000**
  Average size ~650 km^2



- **Quinaries** ~8500
  Average size ~170 km^2



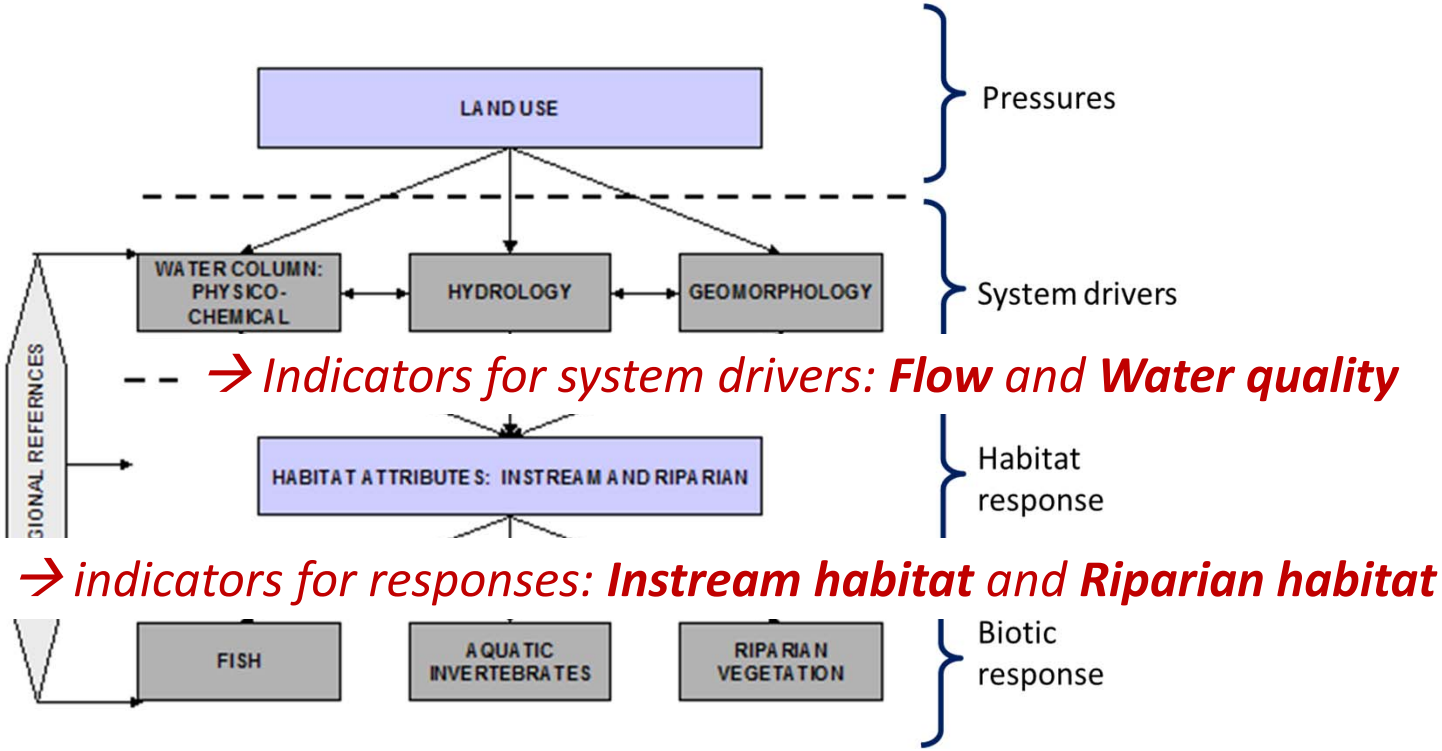
Basic Spatial Unit for river accounts:
mainstem river reach within a quinary catchment

We are going to look at

- Selection of indicators
- Reference condition
- Applicability of the three-stage approach
- (Aggregation)
- Take home conclusions

Selection of indicators guided by conceptual framework for assessment of river ecosystem condition

- Based on 30 years of global river science
- Similar characteristics to the SEEA Ecosystem Condition Typology (ECT)
- Differs from SEEA ECT in that it uses driver-response framing



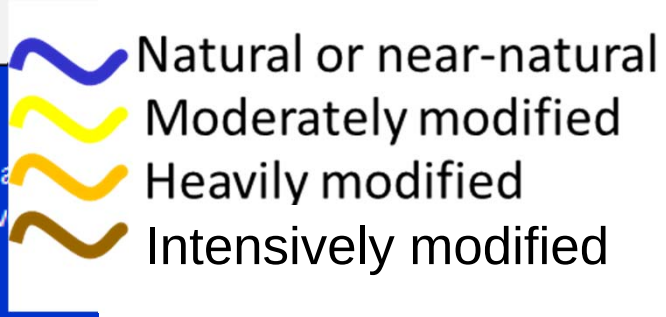
Kleynhans CJ, Louw MD. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Reference levels and reference condition

- We always use a reference condition of “natural”
  - i.e. prior to major human modification
- This doesn’t mean that all ecosystems should be in natural condition
  - e.g. some rivers are hard-working rivers that are intensively used
- Indicators, sub-indices and index are expressed in terms of their distance from natural

Ecosystem condition categories are useful, from natural through to intensively modified

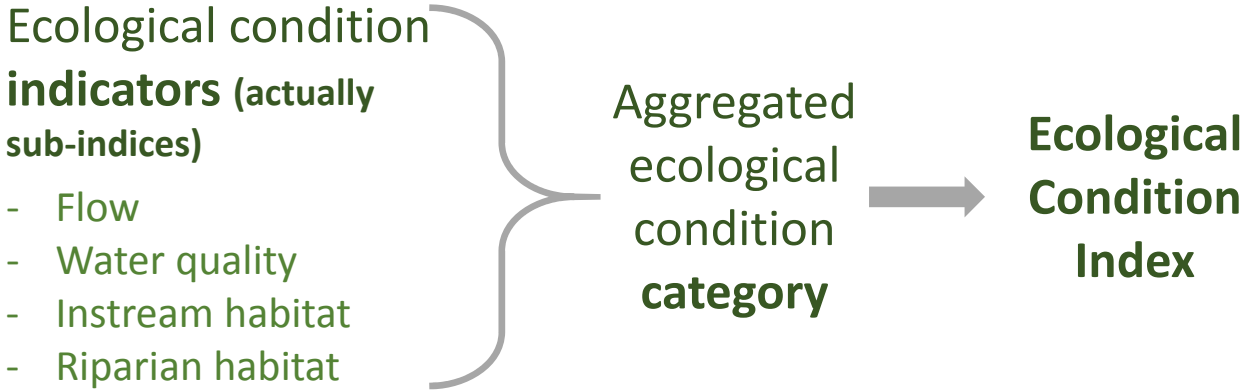
Ecological category	Description	
A	Unmodified, natural	Unmodified
B	Largely natural, few modifications	Largely natural with few modifications. A sma change in natural habitats and biota may hav taken place but the ecosystem functions are essentially unchanged
C	Moderately-modified	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged
D	Largely-modified	Largely modified. A large loss of natural habi biota and basic ecosystem function
E	Seriously-modified	Loss of natural h nd basic ecosystem functio
F	Critically/Extremely-modified	been modified completely with an ost complete loss of natural habitat and biota.



These categories come in handy especially for reporting the account

Applicability of the three-stage approach

Our original river ecosystem condition account was constructed and presented in three steps



- So three stages broadly applicable, but nevertheless some challenges

EEA Stage 1: Accounting table for variables

Table 5.3: Ecosystem condition variable account

ECT Class	Variables		Ecosystem type		
	Descriptor	Measurement unit	Opening level	Closing level	Change in level
Physical state	Variable 1				
	Variable 2				
Chemical state	Variable 3				
Compositional state	Variable 4				
	Variable 5				
Structural state	Variable 6				
Functional state	Variable 7				
Landscape level characteristics	Variable 8				

This table was not possible for us to complete…

…for two main reasons

1. Variables were not always explicitly quantified
   - Often a proxy was used
   - Often strong reliance on expert knowledge
   - Most river condition assessments (SA and global) use a combination of empirical data AND expert judgement – poses a problem for this table
2. Even if the data were available, it usually would not be meaningful to aggregate readings for a single variable across all BSUs or EAs in an ET

Table 5.3: Ecosystem condition variable account

ECT Class	Variables		Ecosystem type		
	Descriptor	Measurement unit	Opening level	Closing level	Change in level
Physical state	Variable 1				
	Variable 2				
Chemical state	Variable 3				
Compositional state	Variable 4				
	Variable 5				
Structural state	Variable 6				
Functional state	Variable 7				
Landscape level characteristics	Variable 8				

EEA Stage 2: Accounting table for indicators

Table 5.4: Ecosystem condition indicator account

ECT Class	Indicators	Ecosystem type					
		Variable values		Reference level values		Indicator values (rescaled)	
	Descriptor	Opening value	Closing value	Unfavourable	Favourable	Opening value	Closing value
Physical state	Indicator 1						
	Indicator 2						
Chemical state	Indicator 3						
Compositional state	Indicator 4						
	Indicator 5						
Structural state	Indicator 6						
Functional state	Indicator 7						
Landscape/seascape characteristics	Indicator 8						

This table was also not possible for us to complete…

…for one main reason

- In practice, *several variables were integrated directly into a sub-index* to estimate how a sub-index has changed from its natural refer condition
  - i.e. skipping the step of of converting a single variab to a single indicator
- The integration combines data ar ledge
- Also requires interpreti mpact of changes at the site-level in terms of t tent and intensity across a BSU

In an ideal world one would have such an account, but unlikely to be pragmatic for most countries
Could possibly use for small sub-national EAAs

Sub-indices and associated variables (or proxies)

System drivers

Habitat responses

SUB-INDICES			
FLOW Changed flow and flood regimes	WATER QUALITY Changed physico-chemical conditions	RIPARIAN HABITAT Changed riparian and river wetland zones due to flow modification and physical changes (assesses structure for biota and functioning)	INSTREAM HABITAT Temporal and spatial change to runs, rapids, riffles, pools (assesses structure for biota and functioning)
VARIABLES or proxies for variables			
Presence of urban and agriculture land use, presence of inter basin transfers, weirs, dams, water abstraction data, agricultural return flows, sewage releases.	Extent of algal growth and macrophytes (e.g. water hyacinth). Activities such as mining, cultivation, irrigation (i.e. agricultural return flows), sewage works, urban areas, industries, etc.	Land use/cover quantified 10m, 50m and 100 m from river. Activities such as agriculture, mining, urban areas, inundation etc. Presence and impact of alien invasive woody vegetation.	Land use/cover on erosion, water abstraction data, presence of weirs and dams, presence of habitat modifying introduced biota (e.g. carp, crustacea and molluscs), presence of eutrophication and associated algal growth and macrophyte expansion (e.g. water hyacinth)

EEA Stage 3: Accounting table for sub-indices and ecosystem condition index

Table 5.5: Ecosystem condition index account

ECT Class	Indicators		Ecosystem type	
			Index value	
	Descriptor	Indicator weight	Opening value	Closing value
Physical state	Indicator 1			
	Indicator 2			
	Sub-index			
Chemical state	Indicator 3			
Compositional state	Indicator 4			
	Indicator 5			
	Sub-index			
Structural state	Indicator 6			
Functional state	Indicator 7			
Landscape/seascape characteristics	Indicator 8			
Ecosystem condition index				

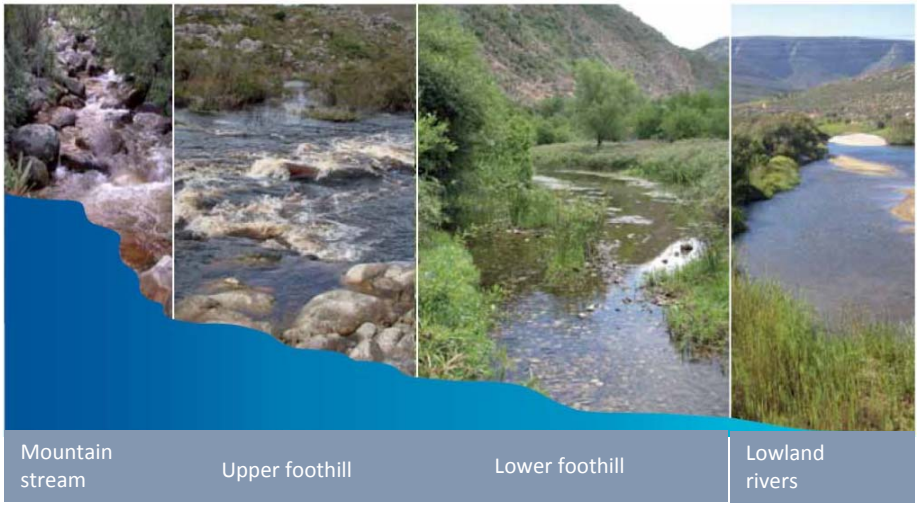
This table we could (mostly) do!

South African river ecosystem functional groups

8 functional groups classified from a combination of

2 hydrological regimes

4 longitudinal zones



Permanent | Seasonal / Episodic

Upland streams | Lowland rivers

Aligns well with IUCN-GET ecosystem functional groups

Stage 3 accounting table, aggregated to eight SA river ecosystem functional groups (new table produced for this testing exercise)

			Permanent mountain streams		Non-permanent mountain streams		Permanent upper foothills		Non-permanent upper foothills		Permanent lower foothills		Non-permanent lower foothills		Perm[illegible]		[illegible]		[illegible]		[illegible]rs	
Class	Sub-index	Condition interval relative to reference condition	1999 River length (km)	2011 River length (km)	1999 River length (km)	2011 River length (km)	1999 River length (km)	2011 River length (km)	1999 River length (km)	2011 River length (km)	1999 River length (km)	2011 River length (km)	1999 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] length (km)
Physico-chemistry	Water quality	None (0)/Small (1)	810	673	311	265	9,673	7,996	4,584	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	40,579	34,810
		Moderate (2)	296	283	98	95	3,883	3,873	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	24,634	21,043
		Large (3)	36	125	22	58	759	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	308	0	0	5,518	11,667
		Serious (4)/Critical (5)	15	19	5	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	17	0	0	1,943	3,439
		No data	0	57	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	143	0	332	3,637	3,637	3,637	5,352
Structure	Riparian habitat	None (0)/Small (1)	327	389	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2,308	909	117	0	0	22,471	22,421
		Moderate (2)	498	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4,898	5,323	270	719	0	0	32,951	29,328
		Large (3)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,731	1,584	2,386	213	215	0	0	14,164	15,420
		Serious (4)/Critical [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	190	398	626	696	24	32	0	0	3,088	4,755
		No data	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	67	0	207	0	68	0	332	3,637	3,637	3,637	4,388
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14,030	9,425	6,292	5,058	5,049	2,493	954	491	0	0	39,738	28,491
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,929	10,519	10,938	3,308	3,144	4,435	4,423	432	506	0	0	26,188	26,612
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	323	817	2,593	5,768	350	1,288	905	3,260	8	76	0	0	5,446	13,620
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	568	67	230	538	1,483	67	320	392	538	23	11	0	0	1,301	3,200
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	24	0	52	0	67	0	207	0	68	0	332	3,637	3,637	3,637	4,388
Functi[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	173	8,470	5,493	2,997	3,020	12,633	7,701	5,283	4,638	2,882	1,565	948	478	0	0	34,084	23,538
		[illegible]	[illegible]	[illegible]	177	130	3,773	4,381	2,681	1,969	8,183	7,527	3,592	3,061	3,674	2,711	417	389	0	0	22,814	20,499
		[illegible]	[illegible]	233	53	95	1,717	2,907	684	1,254	4,341	6,704	667	1,632	2,738	3,317	10	204	0	0	10,328	16,345
		[illegible]	34	66	22	29	599	1,479	265	272	2,522	5,240	476	432	1,487	3,045	41	13	0	0	5,447	10,576
		[illegible]	0	57	0	9	0	299	0	112	0	509	0	255	0	143	0	332	3,637	3,637	3,637	5,352
Ecologica[illegible] condition Index		[illegible]atural/semi-natural	844	505	297	177	10,312	5,540	4,742	2,930	16,343	7,100	7,340	3,829	5,373	1,832	1,290	528	0	0	46,541	22,441
		Moderately modified	272	417	111	141	3,762	5,827	1,609	2,467	9,537	12,637	2,283	4,239	4,640	5,263	101	792	0	0	22,315	31,782
		Heavily modified	25	214	21	107	412	2,730	209	1,140	1,422	6,627	293	1,737	407	3,326	2	80	0	0	2,791	15,960
		modified	16	21	6	11	73	462	67	90	378	1,317	102	213	361	361	23	17	0	0	1,026	2,492
		No data	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,637	3,637	3,637	3,637

However:
- We included only sub-indices and index, not individual indicators
- As soon as there are too many ecosystem types, this format becomes cumbersome
- It doesn't include information about increases and decreases (absolute and %)

A possible alternative format for Table 3, from our original accounts

- Contains more information on increases and decreases
- Presented here for all rivers, but could have a set for each ecosystem type
- Only sub-indices are shown here but this table could be extended to show the Ecological Condition Index

Kilometres	Degree of modification from natural					Total
	None/ small	Moderate	Large	Serious/ Critical	No Data	
FLOW						
Opening stock 1999	**34 084**	**22 814**	**10 328**	**5 447**	**3 637**	**76 310**
Opening stock as a % total river length	45	30	14	7	5	100
Increase/decreases	-10 546	-2 316	6 017	5 129	1 715	
Increases/decreases as % opening stock	-31	-10	58	94	47	
Opening stock 2011	**23 538**	**20 499**	**16 345**	**10 576**	**5 352**	**76 310**
Opening stock as a % total river length	31	27	21	14	7	100
WATER QUALITY						
Opening stock 1999	**40 579**	**24 634**	**5 518**	**1 943**	**3 637**	**76 310**
Opening stock as a % total river length	53	32	7	3	5	100
Increase/decreases	-5 769	-3 591	6 149	1 496	1 715	
Increases/decreases as % opening stock	-14	-15	111	77	47	
Opening stock 2011	**34 810**	**21 043**	**11 667**	**3 439**	**5 352**	**76 310**
Opening stock as a % total river length	46	28	15	5	7	100
STREAM BANK/RIPARIAN HABITAT						
Opening stock 1999	**22 469**	**32 951**	**14 164**	**3 088**	**3 639**	**76 310**
Opening stock as a % total river length	29	43	19	4	5	100
Increase/decreases	-50	-3 612	1 255	1 667	740	
Increases/decreases as % opening stock		-11	9	54	20	
Opening stock 2011	**22 418**	**29 339**	**15 420**	**4 755**	**4 379**	**76 310**
Opening stock as a % total river length	29	38	20	6	6	100
INSTREAM HABITAT						
Opening stock 1999	**39 736**	**26 188**	**5 446**	**1 301**	**3 639**	**76 310**
Opening stock as a % total river length	52	34	7	2	5	100
Increase/decreases	-11 245	426	8 180	1 898	740	
Increases/decreases as % opening stock	-28	2	150	146	6 840	
Opening stock 2011	**28 491**	**26 615**	**13 626**	**3 200**	**4 379**	**76 310**
Opening stock as a % total river length	37	35	18	4	6	100

Take-homes from condition account test

- Selection of indicators
  - The Ecosystem Condition Typology is a useful starting point
  - But even better to have a conceptual framework to guide selection of indicators for the realm concerned
- A reference condition of natural works well (and doesn't imply that all ecosystems should be natural)
  - Condition categories from natural through to intensively modified are useful
  - Measurements can be scaled according to distance from natural
- Support the staged approach, but suggest simplifying to two stages
  - Stage 1: Account for indicators and/or sub-indices
    - Indicators on their own leave people hanging
  - Stage 2: Ecosystem condition index account
- Tables of variables are not the same as a variable account
  - Useful for organizing raw data systematically, but unlikely to be meaningful in themselves
  - A step in preparing accounts-ready data
  - Not meaningful to aggregate individual variables spatially across a whole ET