SAEON Observation Framework

Tim O'Connor

National Research Foundation | SAEON South African Environmental Observation Network

“There is nothing so tedious as enduring the verbiage of those intent on convincing you of their plans, replete with an infinite amount of detail, when all that is required is some clear-headed action.”

Anonymous Russian writer, 1911

SAEON Observation Framework

Mission:

Distinguish the effect of anthropogenic change from that of natural variability on the composition, structure, and functioning of the country’s ecosystems

Challenge:

How to design an observation approach for meeting this need

Original Blueprint

Six main themes (from Van Jaarsveld & Biggs 2000):

- Global change
- Biodiversity
- Biogeochemical cycling
- Productivity
- Hydrology and sediments
- Disturbance and rare events

Themes restated as:

Driver variables:

- Natural
- Anthropogenic

Response variables:

- Structure and functioning of systems

On a biome basis.

Table of drivers and responses considered by SAEON

Anthropogenic and Natural Drivers	**Response Variables**
Climate change	**Biodiversity**
CO_2 loading	Biogeochemical cycling
(Marine currents)	Primary production
Sea-level rise	Secondary production
Ultra-violet radiation	Sediments
Land use and management	Hydrological functioning
(Coastal marine use & management)	Disturbance regimes
Harvesting	(Marine currents)
Acid deposition	
Nutrient loading	
Pollution (plus poisons)	
Disease	
Pests	
Alien organisms	
Disturbance regimes	
Hydrological functioning	
Sediments	
Large infrequent events	

What is missing?

Drivers of the drivers:

- i.e., local, national and global socio-economic systems

Example: Observation of Biodiversity

- Definition and measurement of biodiversity
- Observation design for *Understanding* causes of biodiversity change
- versus simply *Surveillance* of change

Other response variables approached in a similar manner

What is Terrestrial Biodiversity?

Unit	Comments	Variables
Biomes	Defined: Mucina & Rutherford 2006	Extent and biome-wide structure
Ecosystems	Vegetation types in Mucina & Rutherford 2006 (legal status)	a. Biodiversity integrity (composition) b. Spatial extent and landscape structure
Species	Well studied	a. Distribution b. Abundance c. Population structure
Genes	Not practicable = scientific frontier	(Domestic crops)

Example of grassland biodiversity: multiple drivers

Anthropogenic	Natural
Climate change (precipitation, temperature, frost, wind)	Climate
CO_2 loading	Extreme climatic events
Land transformation (direct, indirect)	Other rare events
Land use	Disturbance regime
Land management (grazing system, fire)	Extreme disturbance events
Harvesting (eg medicinal)	
Nutrient/acid deposition (emissions)	
Alien invasives (plant & animal)	
Altered disturbance regime (eg fire)	
Poisons (eg herbicides & pesticides)	
Pollution (emissions)	
Disease (eg rinderpest)	
Pests (eg insect outbreaks)	

Scale of observation challenge

- Multiple, complex **anthropogenic drivers** acting simultaneously & synergistically
- Naturally variable systems
- Interaction between drivers & variability
- Non-independence of response variables

Q: Can observation hope to understand the causes of change?

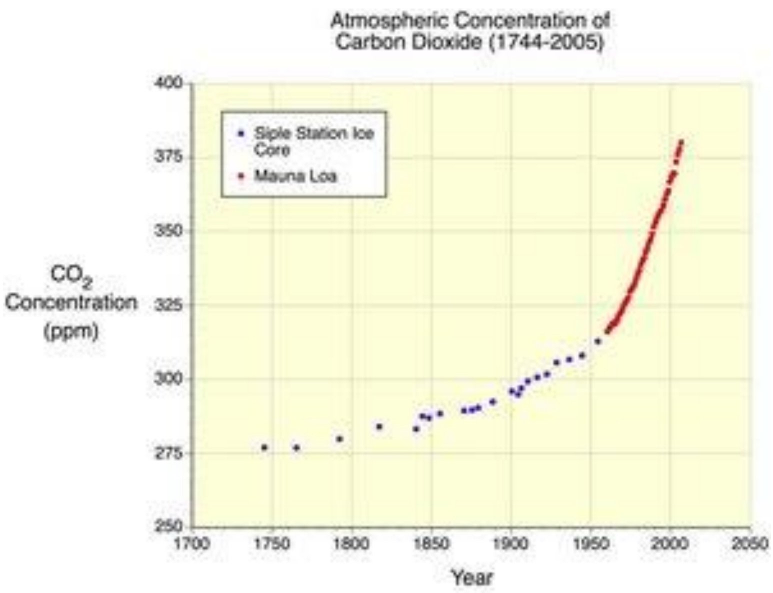
A: Distinguish effect of individual drivers through their spatio-temporal signature

Spatio-temporal profiles

Type of driver	**Examples**
Temporally discrete	Large infrequent events
Spatially discrete	Land use & management
Gradients	Climate change, nutrient loading
Natural spatial variability	Fire, alien invasives
No spatial variation, long-term temporal	CO_2 loading
Specific effects	Harvesting, disease, poison

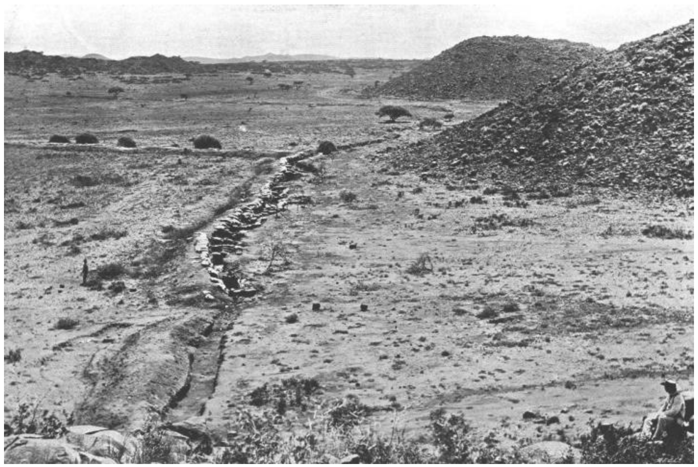
Case 1. Most difficult: no spatial & long-term temporal pattern

CO_2 fertilisation



- Globally uniform (mixing)
  - (seasonal variation)
  - (slight N-S difference)
- No spatial comparisons possible
- Overall a constant rise
- Possibly relate response to rate of CO_2 rise
- 50 yr history so should already see effects

Loss of grassland to savanna woody ingress



Source: MT Hoffman

- Grassland transformed to savanna
- Projection of impact has depended on deep process-level understanding: C_3 vs C_4; bush encroachment dynamics

What about grassland changes?

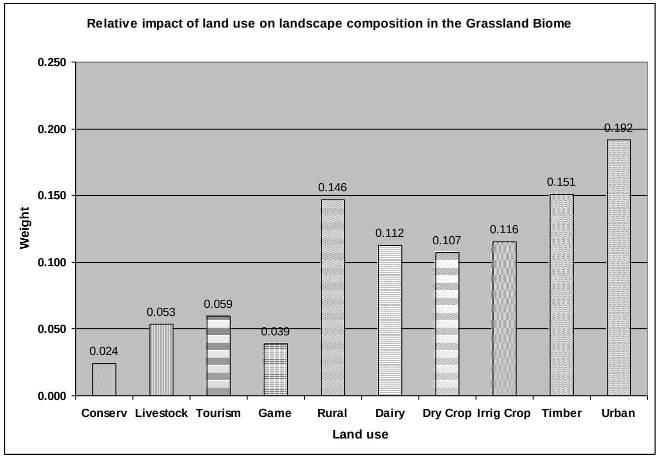
Festuca costata and *Pteridium aquilinum* – were these C_3 species always so conspicuous in Berg C_4 grassland?

Are C_3 herbaceous plants such as *Festuca costata* and *Pteridium aquilinum* increasing in C_4 grassland due to CO_2?

- **Need monitoring and process-based research**.

Case 2. Spatially discrete - couldn't be easier (land use)

Impact of land use on grassland biodiversity integrity

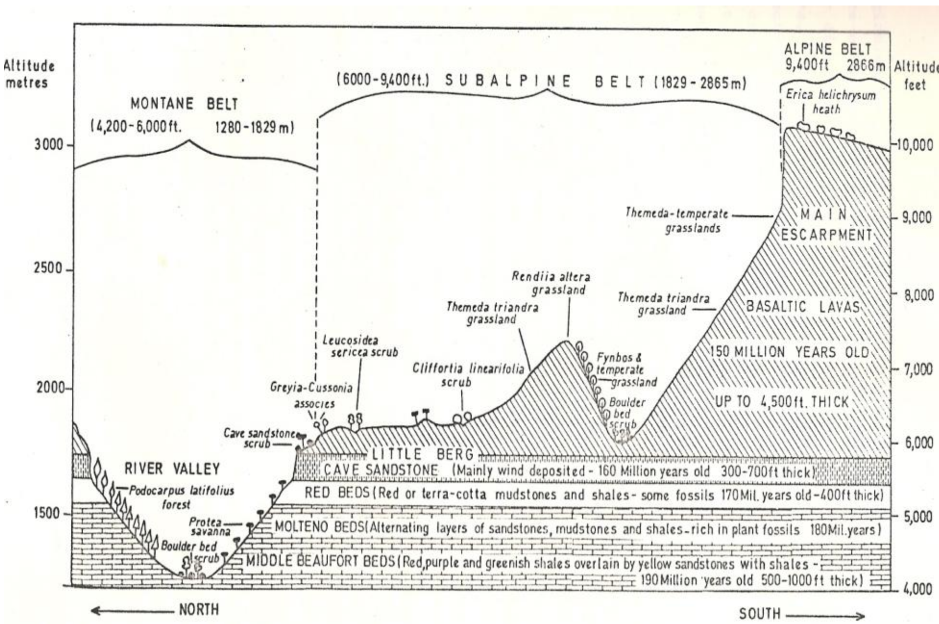


- Livestock - use of natural asset
- Transformed - biodiversity integrity compromised
- Landscape = highly replicated experiment (why hardly used??)
- Land transformation - temporal comparison

Case 3. Temporally discrete – right place, right time

Large, infrequent events are discrete in time - requires appropriate temporal resolution

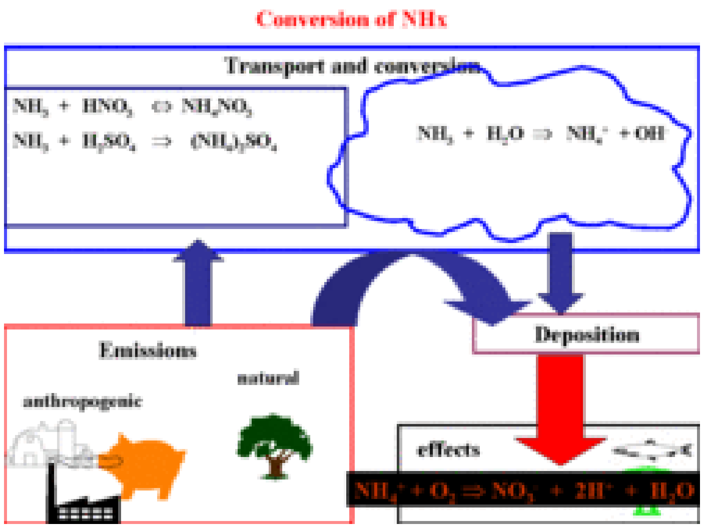
Case 4a. Gradients – following a shift in space with climate change



- **Prediction:** ecosystem/species shifts in response to climate shifts
- **Example:** altitudinal shifts in montane landscapes (eg *Festuca costata* recedes upslope)

(Killick 1963)

Case 4b. Gradients from a point source of impact



Emissions, transport, and deposition of NHx

1. Gradient of NHx deposition from industrial centres, power stations
2. Geographic footprint depends on wind patterns

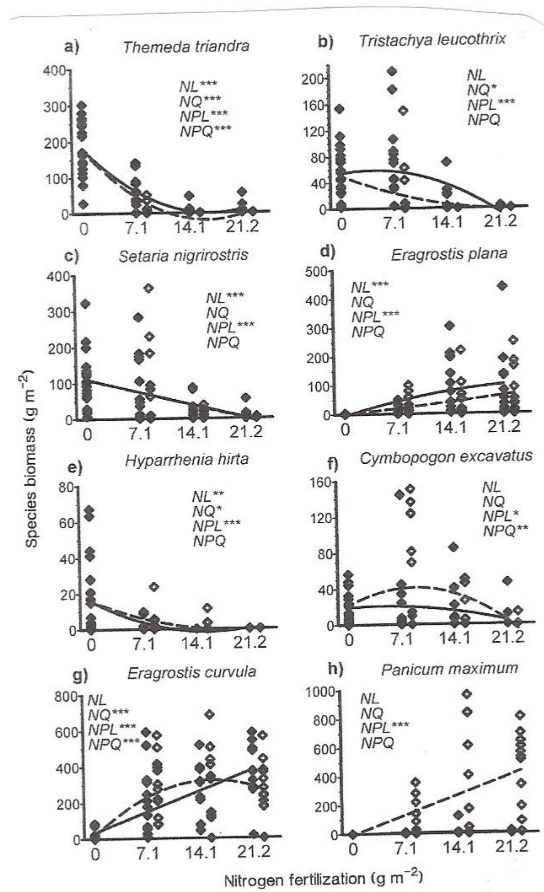
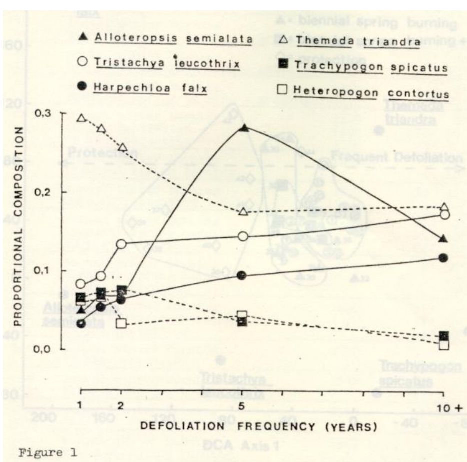


Fig. 3a-h. Relation between the level of N-fertilization and the biomass of eight common grass species (1999 data) in the Ukulinga long-term grassland fertilization experiment.

1. Aerial deposition can match fertiliser application
2. Increasing N concentrations can transform grassland communities

Case 5a. Natural spatial variability

Catchment IX, Cathedral Peak



Source: Eversons

Fire:

- Fire regime determines grassland composition
- Spatial variation in fire frequency
- Change in fire regime allows temporal comparison

Case 5b. Natural spatial variability

Alien invasive organisms:

- Woody impact: loss of area; fertilisation through N fixation for some
- Landscape variation in alien abundance affords comparison of impact
- Different alien species may have different impacts that need to be addressed individually
- Impact of herbaceous alien species is difficult to observe

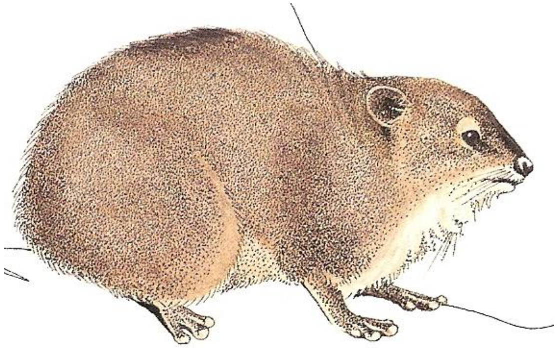
Case 6a. Species-specific effects

Most heavily traded plant species by volume on the Durban market (Mander 1997)

Harvesting:

- Specific targets in high demand: eg medicinal, cycads, rhinos, etc
- Therefore species-centred observation of population response
- Well-developed toolbox for study of population viability
- ‘Control’ populations useful but not essential
- Observation supports population study

Case 6b. Species-specific effects



Disease:

- Although closely related, what is a key difference between an elephant and a dassie?
- If an elephant dies from disease - vets soon have a diagnosis
- 90’s dassie epidemic - hardly noticed and poorly understood
- Observation success depends on knowledge of impact at a population level
- Some diseases (rinderpest, anthrax, avian bird flu) have more general impacts
- Novel diseases cannot usually be anticipated

Case 6c. Multitude of specific impacts, few generalities?

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Alien invasive

RIP

Pollution and poisons:

- There are many forms of pollution and many types of poison.
- Some have widespread effects, some quite specific effects
- Deep knowledge is needed for understanding their impact; discovery often serendipitous (DDT)
- Unless generalities known, needs to be treated pollutant by pollutant, poison by poison
- Observation is species based

What about interactions among drivers?

- Interactions may be more important than main effects in reshaping ecosystems
- Some first-order interactions may be assessed if appropriate spatial design is employed
- Example: Climate change by land use if land use replicated along a climate change gradient
- Land management and fire would usually be nested within land use

What about responses?

Spatio-temporal profile

- Species differ in their spatial scale of living
- Spatial scale of species < scale of driver. If species has a large home range >> size of land use property then cannot use as an indicator.
- Time lags: acid deposition, snails, thrushes (eg coal mining)
- Propagation through trophic web: indirect, interactive & conditional effects

Implications

- Appropriately chosen groups
- Well understood groups
- Appropriate temporal resolution of observation

Bottom line:
Correspondence needed between resolution of observation of drivers and of responses

Synopsis of key issues thus far

1. Identify drivers responsible for specific changes through spatio-temporal profile of driver plus spatio-temporal profile of response variable
2. SAEON will document change, partners required to undertake process-level research for deeper understanding of change
3. One on-the-ground observation design does not fit all
4. Depending on response in question, design may vary from an intensively monitored core site (eg carbon balance with flux towers) to a widely geographically distributed network of sites (eg species distributional changes)
5. Starting point: *a priori* projection of response (ie question-centred observation)

It’s all in the detail

Lessons from Lindenmayer and Likens 2010

- Real planning at a project level
- “One size does not fit all”
- Project planning should be “question” or “hypothesis” driven
- Within a clearly stated conceptual construct
- So how should SAEON achieve this?

Projection – cornerstone of effective observation

At a biome or lower level, for each individual response:

- Detailed projection of expected response to multiple drivers
- Web-based – allowing ongoing access, review and updating
- Process provides appreciation of complexity.
- Observation design in accordance with expected influences on change
- Conducted at level of individual nodes

Complementary Approaches

EG: Ecosystem Approach

- Driver-response approach described above has decomposed the real world
- But real world functions as a whole
- Ecosystems offer an appropriate real-world unit for confronting complexity of drivers and responses
- Requires a spatially defined ecosystem
- Requires pre-existing monitoring
- Ecosystems with intervention offer greater scope for learning about their functioning

Example of suitable ecosystem: St Lucia estuary - all about fresh water inflow

Conclusion to SAEON Framework

- Understanding what causes changes, not simply observation of change
- Observation structure of drivers and responses should allow
- Pursuit of deep understanding is an essential complementary, yet distinct, endeavour
- Question (projection) driven observation
- Too much to tackle – careful selections needed