Monitoring the uMzimbuvu River Catchment

A citizen science approach to long-term monitoring

Dartmouth College ENVS FSP March 13, 2019 Julie Snorek

Outline

- Introduction
- The UMzimbuvu Catchment Partnership Program (UCPP) in South Africa
- Current monitoring activities of the UCPP
- Discussion of soil and land cover monitoring plan

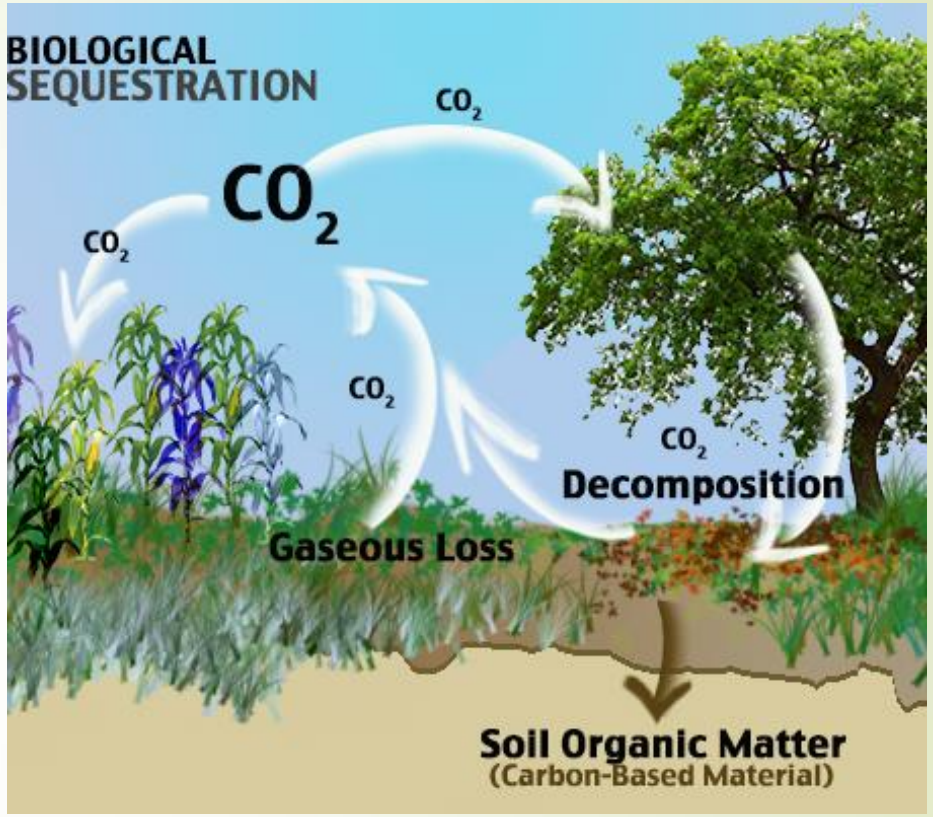
Introduction

Agricultural Practice & The Soil Sponge

- "With our strong emphasis on problems such as low crop yields, pests, and erosion, and on fixing these problems, it is easy to overlook what underlies most of these problems: soil health, soil structure, its ability to absorb, retain, and filter water." (Pershouse 2017)
- In the soil aggregate of sponge, organisms(mycorrhiza) take up sand, silt, and clay particles to form a living sponge

4 per 1000 Initiative

- Launched by France in 2015, during COP21 to the United Nations Framework Convention on Climate Change (UNFCCC).
- Reduce carbon dioxide emissions through an annual increase in soil organic carbon by 0.4 % in the world's top 30-40 cm of agricultural soils.
- As of May 2017, 34 countries have become partners, as well as numerous international organizations
- The Initiative received the Future Policy Vision Award in 2017



The role of agriculture in addressing climate change

Theory Of Change

Impact

Sustainable Restoration and Maintenance of Ecosystem Services in the Catchment Area to Support Local Livelihoods

Outcomes

Productive Grazing

Biodiversity

Soil Erosion

Water

Outputs

Vegetation Quantity & Quality

Alien Invasive Removal

Improved Infiltration & Retention

Surface Water Replenishment & Quality

Actions

Livestock & Grazing Management

Wattle Removal

Spring Development

Actors

UCPP → ERS CSA DEA LIMA District Municipality Local Partners

Inputs

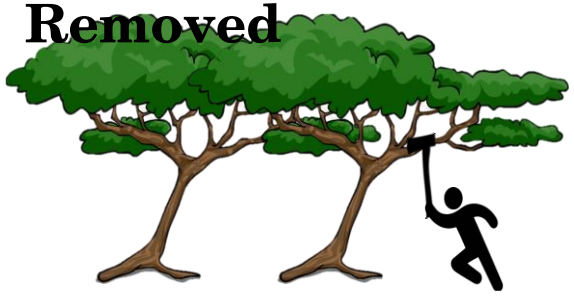
Human Capital Academic Knowledge Financial Resources

Current Monitoring Practices

From the FSP2018 Slide presentation to UCPP in Matatiele, South Africa

Current Monitoring Practices

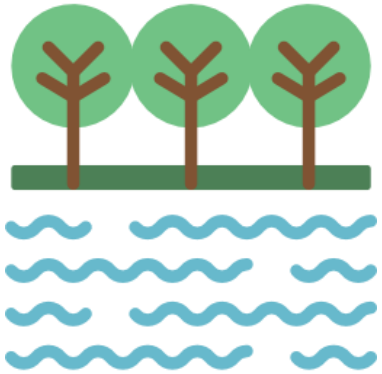
Hectares Wattle Removed



Grass Quality and Quantity

- → DPM (standing forage)
- → Quadrant (basal cover)
- → Veld Assessment
- → Fence line photos

Water Quality and Quantity



→Stream turbidity and flow volume
→Invertebrate diversity and abundance
→Multi-point Mini-SASS
→Wetland reconstitution
-Soak pits

Irregular data collection and little interorganizational information flow

Difficult to Understand Holistic Picture!

Invasive Wattle Removal

- Map hectares removed
- Evaluate restoration process

Rotational Grazing (rested/grazed areas)

- Examine rested versus grazed areas
- Perform Veld assessment
  - Disc Pasture Measurement for biomass
  - Levi Bridge for composition and basal cover
  - Soil sample (taken once)

Stream Assessment Scoring System

- Perform mini-SASS
  - Measure quantities of invertebrates
  - Turbidity and volume of water
  - Wetland soak pits

Monitoring the Umzimbuvu Catchment

Challenge: Performed irregularly, when time and human resources allow or to meet inconsistent monitoring demands of different funders

Solution: Broaden and systematize collection, analysis and dissemination of data to determine how activities are impacting water resources in both soil and in the wider basin

Other questions not being met by monitoring

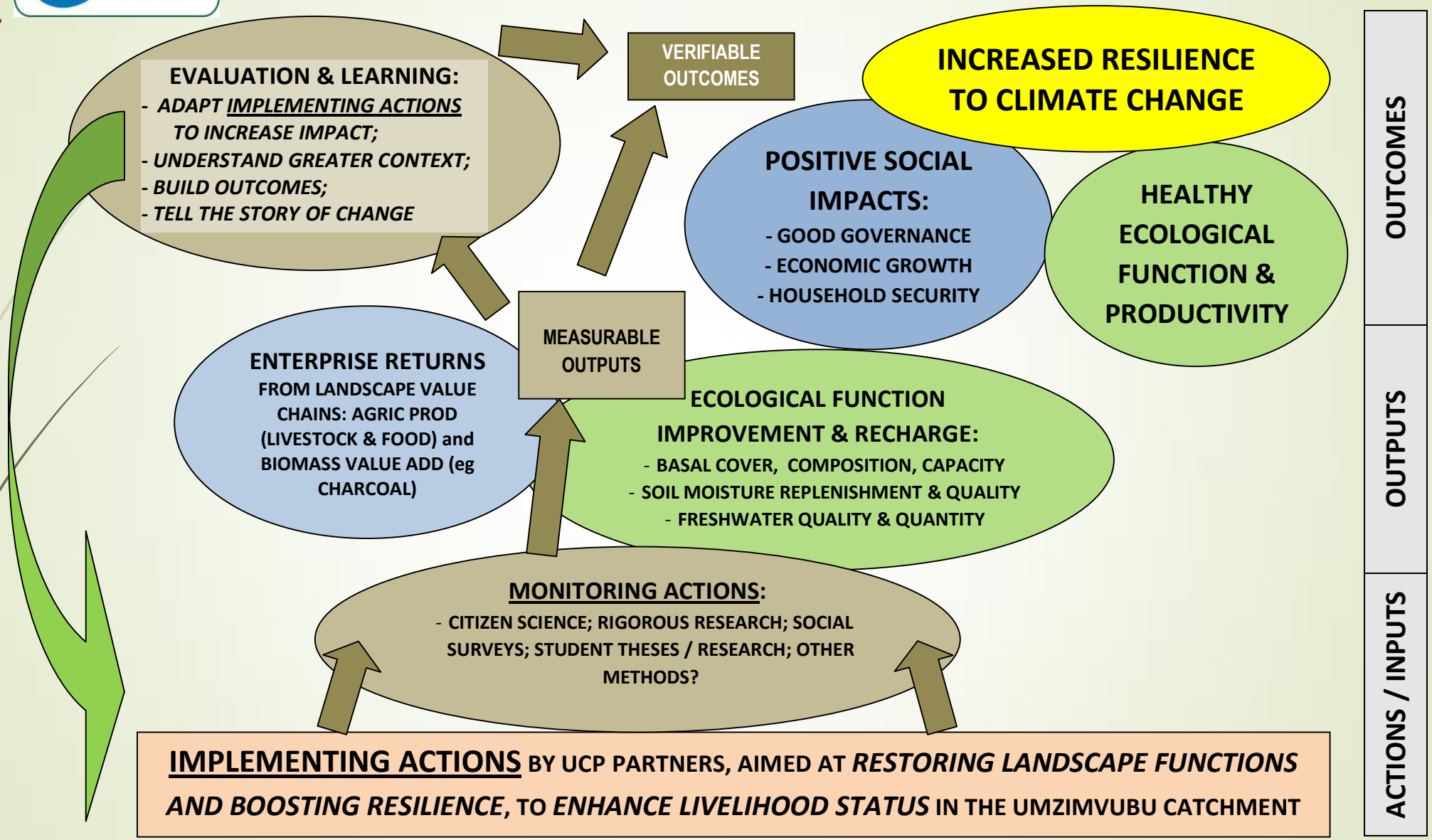
- What is the best way to manage wattle to get better soil quality and grass potential?
- What other issues are facing grasslands and shrublands (soil compaction, lack of N, overgrazing, other)?
- What is the impact of runoff on water quality?
- Others?

Objectives moving forward

- Reaffirm collective agreement of measurable objectives that support UCPP's overall goal and desired outcomes
- Streamline monitoring and collection of data
- Establish a monitoring and data analysis protocol; define how results will be interpreted and disseminated
- Build capacity amongst local citizens, youth, and citizen scientists
- 
  Build outreach and fundraising capacities through objective, clearly documented outputs

Proposed Monitoring Plan

DRAFT FRAMEWORK FOR M&E TO RESTORE UMZIMVUBU WATERSHED



Communi-cations Strategy

MONTHLY NEWSFLASHES EMAILED TO NETWORK

QUARTERLY UPDATES PRESENTED TO PARTNERS AND PUBLISHED ON WEBSITE

DARTMOUTH COLLEGE STUDENTS PRESENT FINDINGS FROM DATA TO COMMUNITY

VIDEO TUTORIALS ON CITIZEN SCIENCE IN PRACTICE

ECOLOGICAL OUTPUTS IN VIDEO, NEWSPAPERS, RADIO BROADCASTS

PUBLICATIONS IN SCIENTIFIC JOURNALS

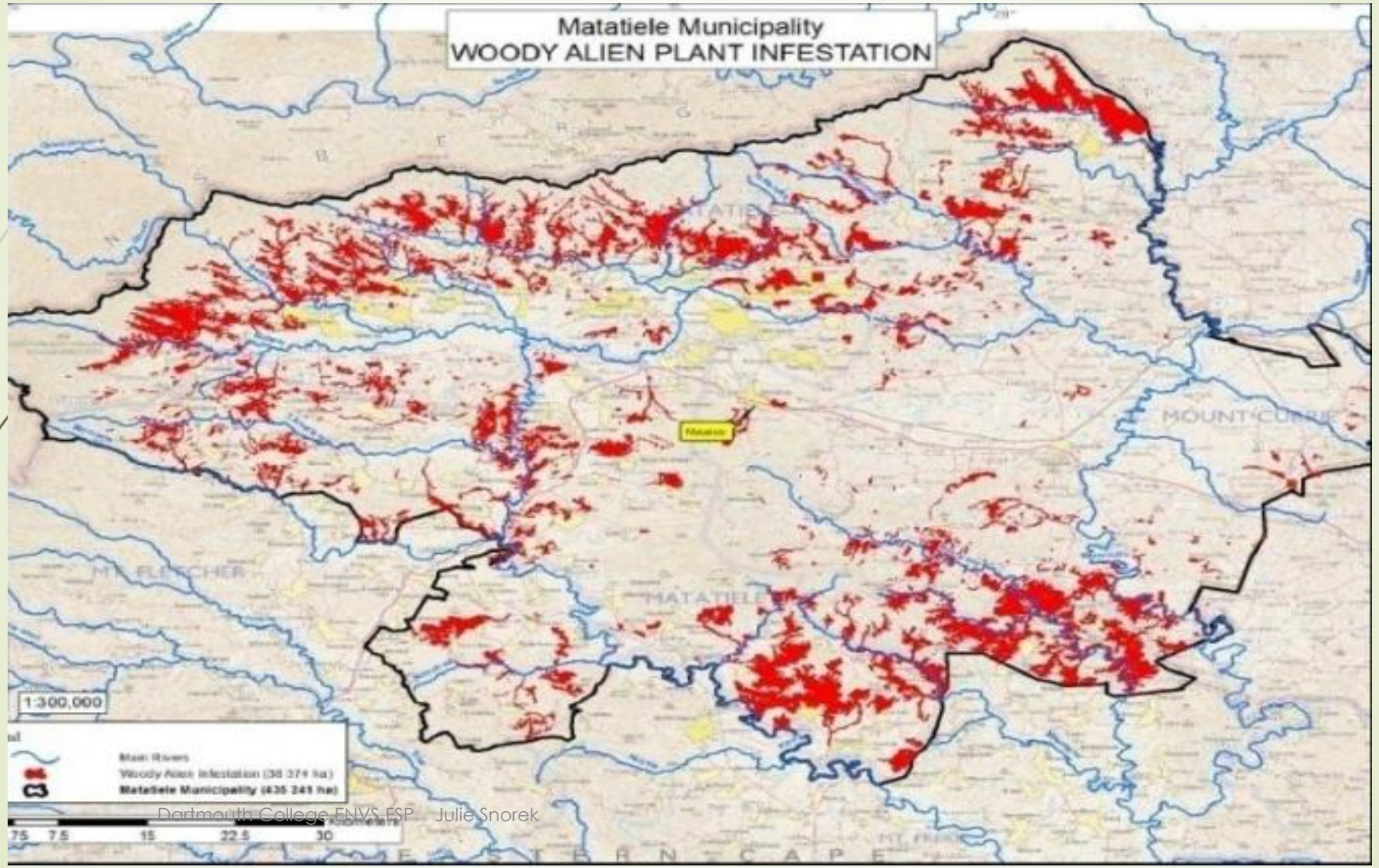
PRESENTATIONS AT REGIONAL AND INTERNATIONAL CONFERENCES

NETWORK CITIZEN SCIENCE EFFORTS: WESSA, GROUNDTRUTH, ENDANGERED WILDLIFE TRUST

Where do we measure social and ecological change?

- Where land managers are interested in having more data
- Where slope, aspect, and vegetation are representative of larger areas
- Where soil series or crop yield is somewhat typical of larger areas
- Where is indicated on remote sensing images of soil water and wattle removal (ground truthing)

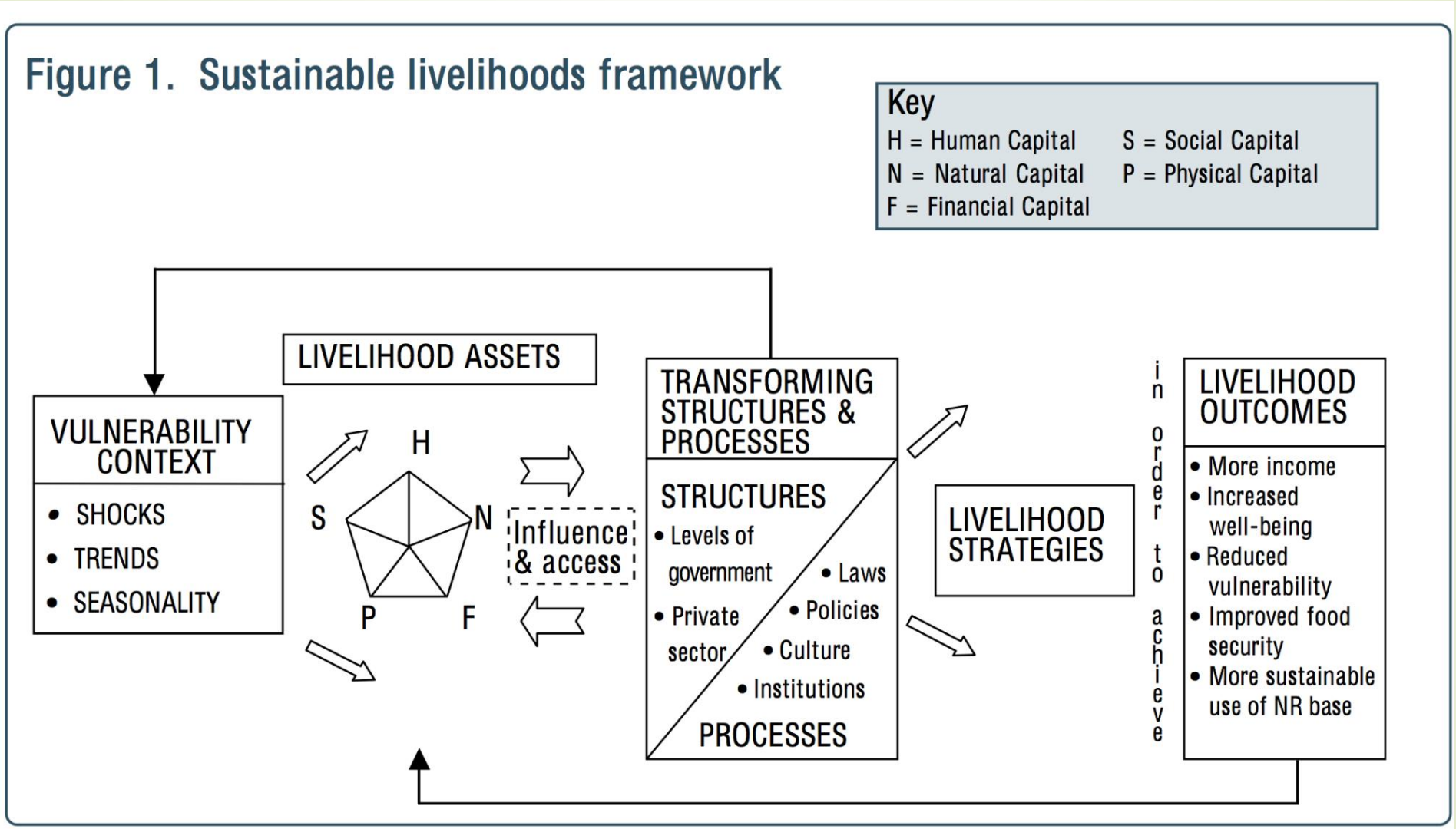
Research Theme 1: LULC changes



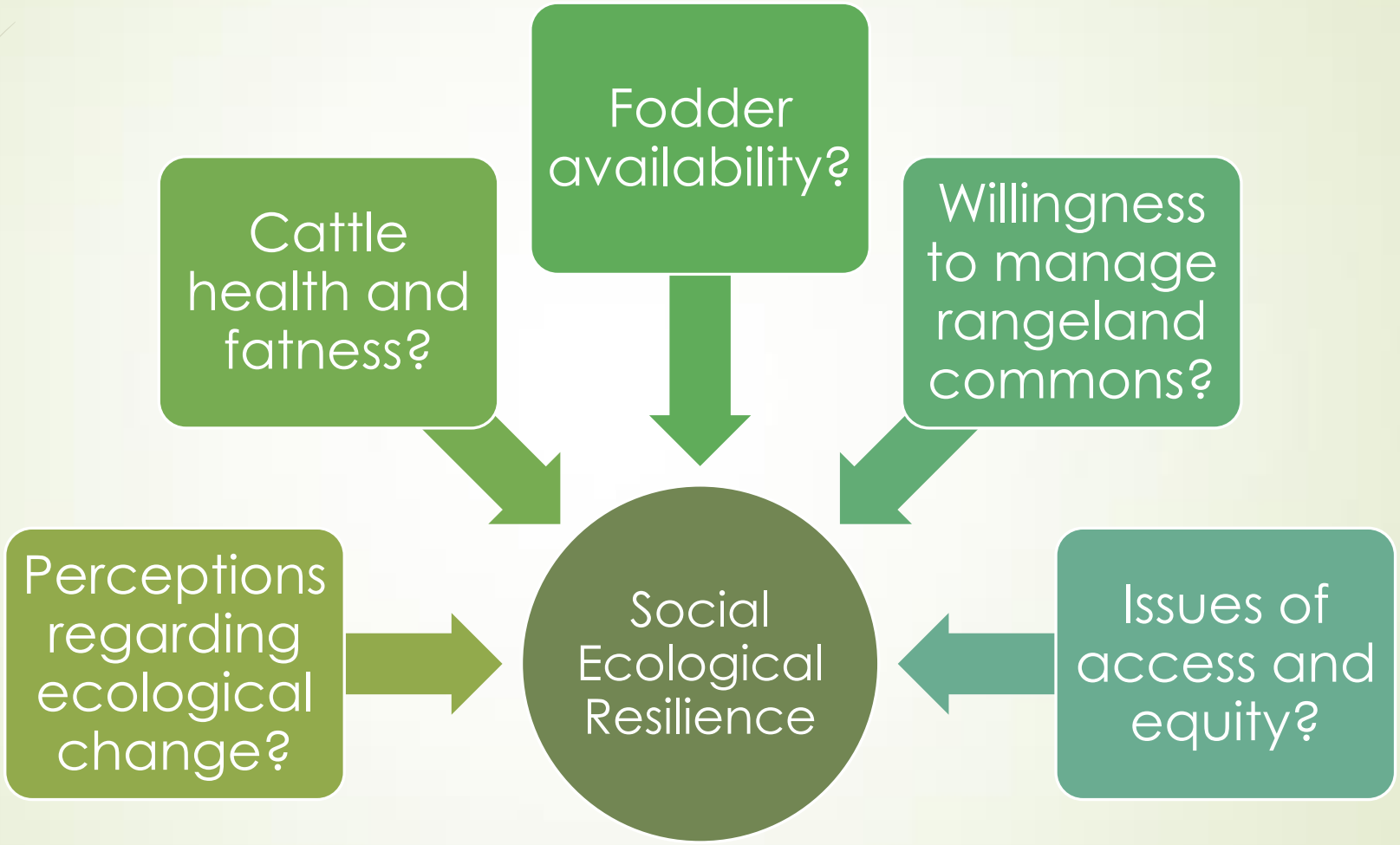
Research Theme 1: Landscape change

- Use remote sensing images to determine land use and land cover (LULC) changes
  - Wattle Removal
  - Ground Cover
  - Soil Quality
- Ground Truthing the change from RS images
  - Examine woody – grass cover changes for wattle removal sites
  - Measure pasture through current practices
  - Incorporate new soil measurement
- Combine with Meat Naturally's RS/Ground Truthing

Research Theme 2: Landscape & livelihoods



Research Theme 2: Landscape & livelihoods

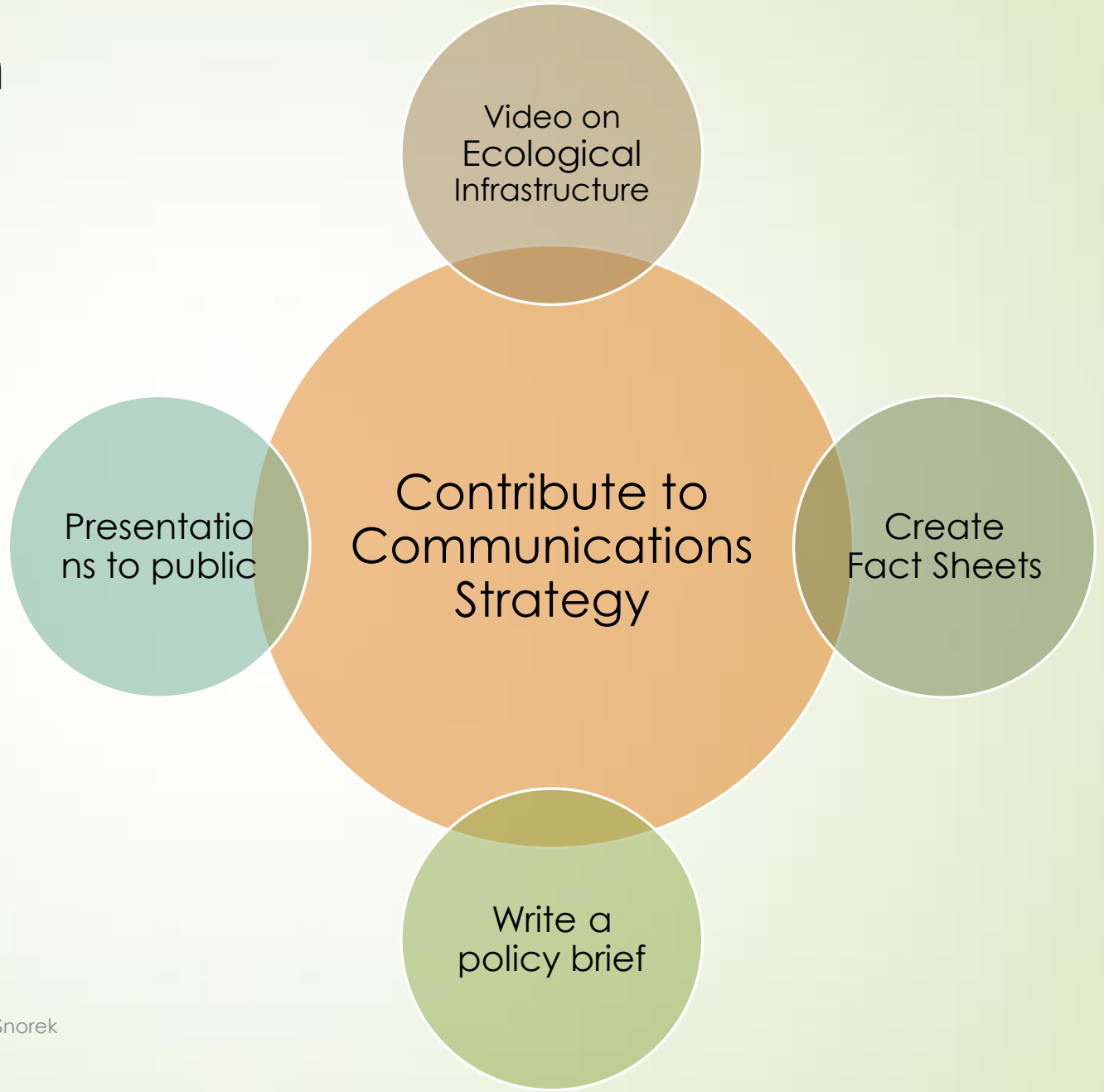


Research Theme 3: Youth Empowerment

Research Theme 3: Youth Empowerment

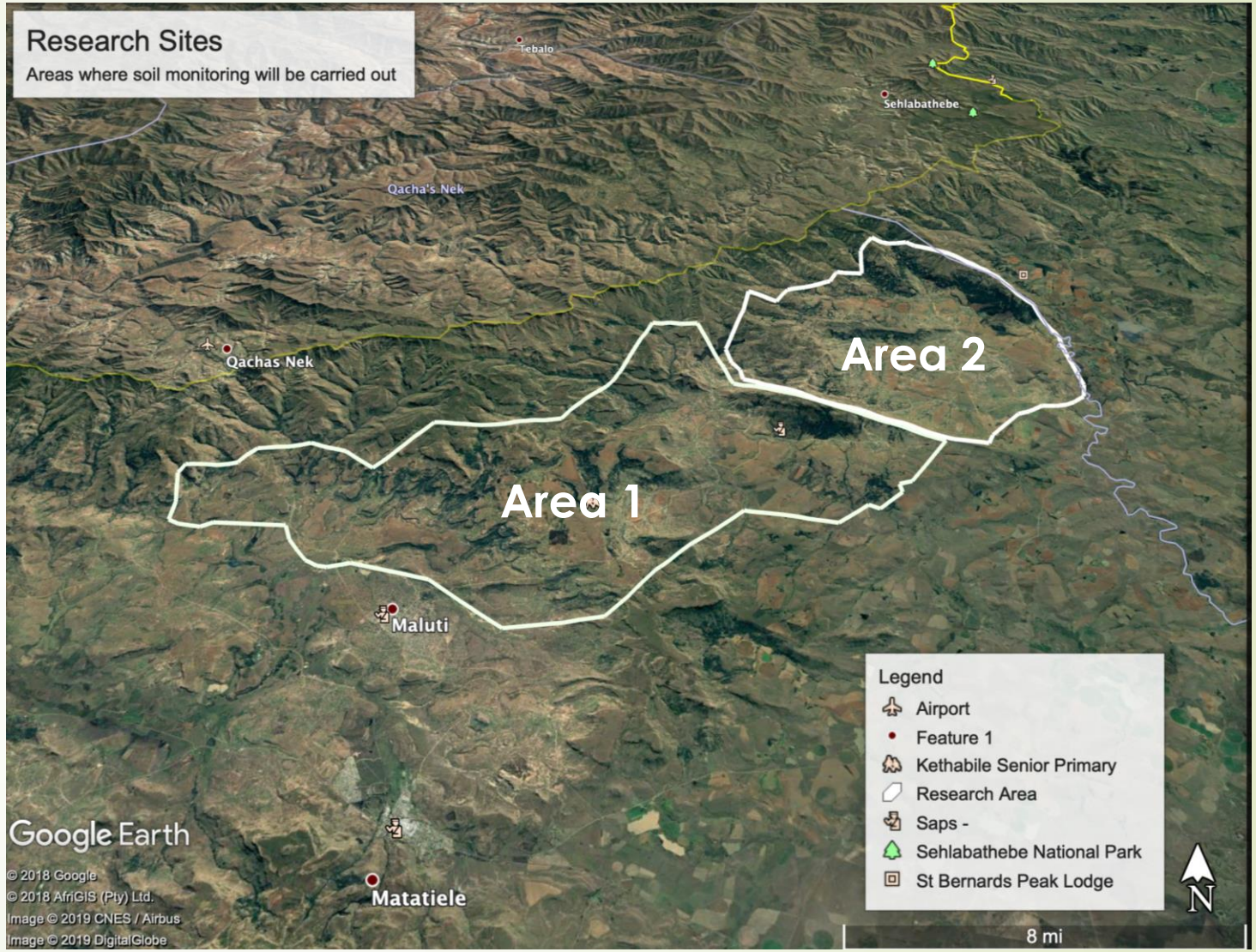
- EcoFutures Impacts – What are they?
  - 38% youth unemployment
  - Erosion and ecological restoration needed
  - Need to develop an Ecological Infrastructure economy
- "We can make a business of fixing the environment" (EcoFutures youth)
- Questions:
  - How has this experience changed/empowered you?
  - How is this work improving society?
  - How has this program changed your life and perspectives?
  - Qualitative evidence of speaking skills

Other Dartmouth College Outputs



Research Sites

- 4 Traditional Authority Areas
  - Sibi Area
  - Makhoba Area
  - Mafube Area near Belford Dam
  - Mzongwona Area
  - Thaba Chica/Motseng Area
- Area 1 = 287 square km
- Area 2 = 179 square km



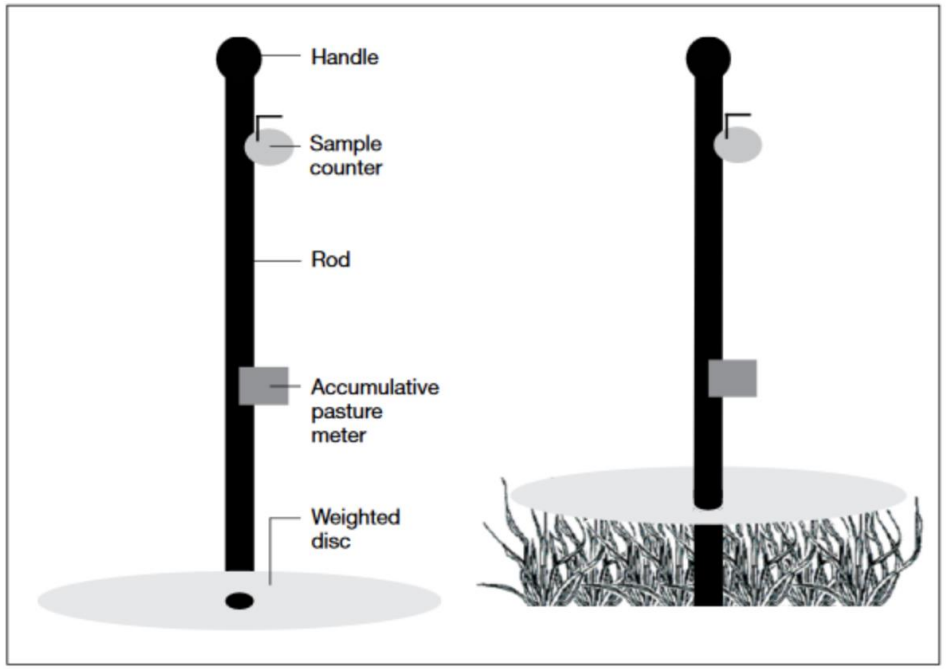
Veld Monitoring

Current Measurements

- **Veld Assessment**
- Point methods are used to determine the frequency of each species
- Species are determined at points along the transect
- 200-point measurements collected along a transect
- Ecological index method used to determine veld health

Veld Monitoring

Figure 2. How Rising Plate Meter Works



- The accumulative pasture meter is connected to the rod by a gear.
- The weighted disc slides on the rod as it is gently lowered into the sward.
- The rod makes the accumulative pasture counter spin by turning the gear as the rod is pushed into the sward.

Current Measurements

- **Disc Pasture Measurement** (determines measures plant height and density)
- Measures the volume of forage compressed beneath a plate of known weight (Bransby et al. 1977)
- Measured by dropping a plate from a predetermined height above the soil surface, then measuring the height at which the plate comes to rest

Veld Monitoring

Current Measurements

- **Quadrant with transect**
- Field observation transects (equal length intervals where observations will be made)
- Material needed:
  - Field data sheets
  - Flags to mark transect area 100-meter tape measure
  - Anchors (stakes) to hold line
  - GPS
  - Smart Phone or camera
    - Identify landmarks near transect
    - Identify plants

Increased soil moisture retention

- “Grass will regrow.
- Our medicinal plants will come back.
- Rangeland will improve.
- Will have more clean water in rivers and streams.
- Livestock will be more productive.
- More moisture retention, more desired vegetation
- The water table will be maintained and yield more and clean water
- Erosion will decrease and further erosion will be prevented.
- More fertile land will be available for our children.”

Results

“Increased soil moisture
Increased vegetation cover
Increased moisture in the air
Increased vegetation cover
Improved organic matter
Improved soil fertility
Increased organism activity in the soil
Improved soil productivity.”

KHORA (PLENTY!!!!)

Soil Monitoring

Proposed Measurements

1. Bulk Density (g/cm^3)
2. Total Carbon (g as % of total soil)
3. Organic Carbon (g as % of total soil)
4. Total Nitrogen (%)
5. Electrical conductivity (Ds)
6. Infiltration Rates (time)

1. Measuring Bulk Density (BD)

- BD = the weight of soil in a given volume (cm^3), good for comparing management practices
- BD establishes suitability for root growth and soil permeability
- When soil's BD < 1.6 g/cm^3 this restricts growth & increases compaction
- Method – collect known volume of soil using a metal ring pressed into the soil and determine weight after drying

$$BD = M_{solids} \div V_{soil}$$

1. Measuring Bulk Density (BD)

- Checklist for measurement
  - A steel ring (tin, 10 cm height, 7 cm diameter)
  - Shovel or trowel
  - Wood block and mallet
  - Calculator
  - Oven proof dish
  - Oven or convection microwave
  - Plastic bag for sampling
  - Ruler
  - Marker pen
  - Scissors
  - Kitchen scale or balance (grams)

Steps to: Measuring Bulk Density (BD)

- Prepare undisturbed flat horizontal surface
- Hammer steel ring into soil with wood block, avoid compacting the soil
- Excavate the ring without disturbing or loosening the soil it contains and carefully remove it with soil intact
- Remove any dirt on outside of ring and cut plants or roots at the surface or base of soil
- Pour the soil into the plastic bag and mark it with the date and location
- Error can occur if soil is disrupted while sampling, inaccurate trimming and inaccurate measuring of the volume of the ring

Figure 2: *Bulk density ring with intact soil core inside.*

2. Measuring Infiltration

- The vertical movement of water into the soil's pores
- Fosters an increasing awareness of how soil accepts water
- Furnishes a repeatable observation that might show change in soil structure and water cycle function
- Lots of variability in soil infiltration
  - Across short distances
  - With soil surface conditions, moisture, and by season of the year and stages of plant growth
  - This, in turn, influences pore and aggregate structure and activities of soil organisms.

2. Measuring Infiltration

- Checklist for measurement
  - A steel ring (10 cm height, 7 cm diameter, 1.5 mm thick)
  - One edge should be sharp so it can cut through the soil (45 degrees cut)
  - 15-cm steel ruler
  - Wood block and mallet
  - Timer or stop watch
  - Liter of water
  - Mobile device for recording data, taking photos, georeferencing
  - Plastic bag or wrap
  - Sign board for labeling photos

Steps to: Measuring Infiltration

Select a location and place rings

Hammer steel ring into soil with wood block, avoid compacting the soil

Place plastic bag over the ring, measure and pour in 1 inch of water

Slowly tug the plastic bag out from the water and hit your timer

Time the disappearance of the water

Use multiple rings in one site to avoid errors


00:04.07

SOIL DESCRIPTION FORM

Area_____Date_____Stop No_____

Soil description

Soil series_____

Classification_____

Location_____

Vegetation/ crop_____

Parent material_____

Physiography_____Drainage_____

Relief _____Permeability_____

Elevation (m) _____Moisture_____

Slope (%)_____Stoniness_____

Aspect_____Erosion_____

_____

Horizon	Depth (cm)	Colour		Texture	Structure	Consistence			Roots	Pores	Mottles		
		Dry	Moist			Dry	Moist	Wet			pH	Bndy	Con cr

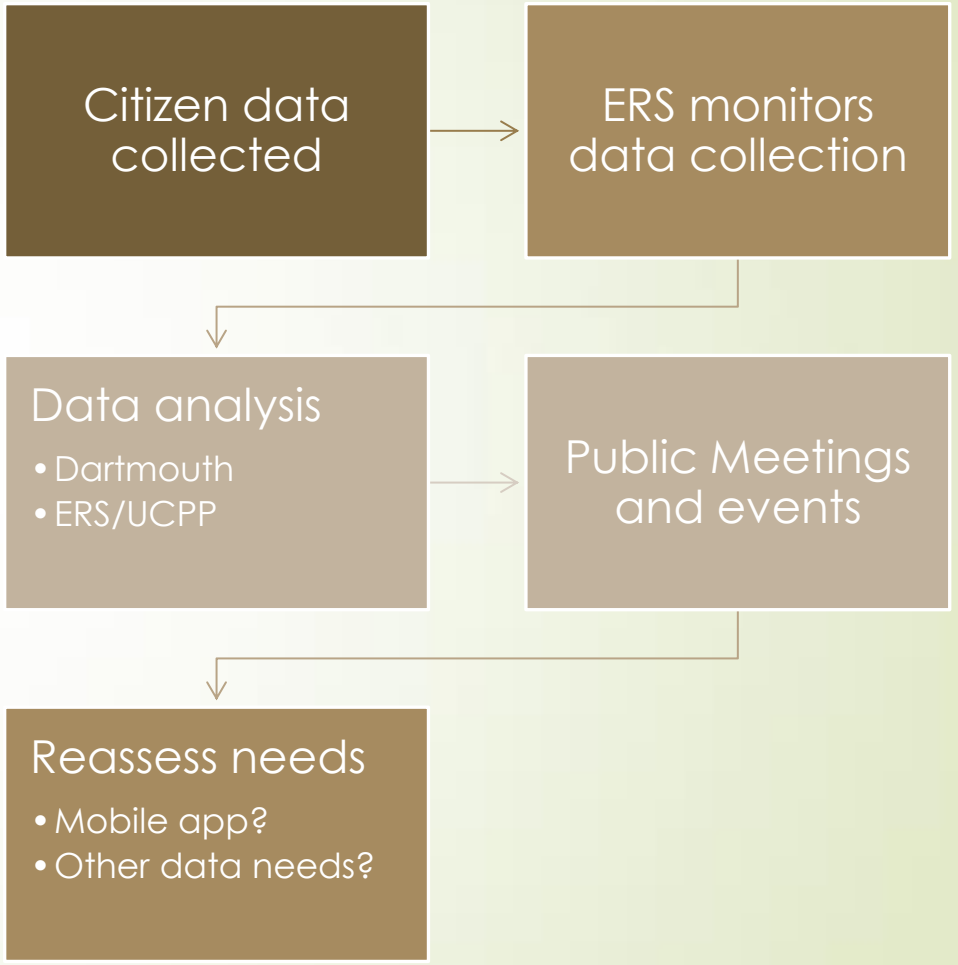
Additional notes

_____

Described by: _____

Dissemination of Our Learnings

- Monthly newsflashes to members
- YouTube series on CitSc tools, usage, and outputs
- Quarterly updates to UCPP and published on website
- Present data and interpolations at conferences and seminars (Grasslands Congress, Biodiversity Stewardship, SANBI Ecological Infrastructure, etc.)
- Send out 2 press releases per year to SA's national papers
- Link with other CitSc networks such as WESSA, GroundTruth, Endangered Wildlife Trust



Concrete Goals

- Ten new citizens scientists collecting and sharing high quality monitoring data
- Appropriate media developed and demonstrating benefits of the better management practices
- Community understanding of protecting the catchment's ecosystem health enhanced
- One scientific journal article and an easy-to-use mobile monitoring app developed

Core Team – CitSc NatGeo Grant

Julie L. Snorek (Dartmouth College): Social Environmental Scientist, coordinating grant preparation and submission, co-facilitating with Dartmouth M&E component

Michael Cox (Dartmouth College): Professor of Environmental Studies focused on community-based natural resource management and technological transitions in agricultural systems

Jonathon Chapman (Dartmouth College): Technical support for remote sensing analysis of soils and land use land cover change over time (Hanover-based)

Dali Lab (Dartmouth College): M&E application design for field testing in Year 2

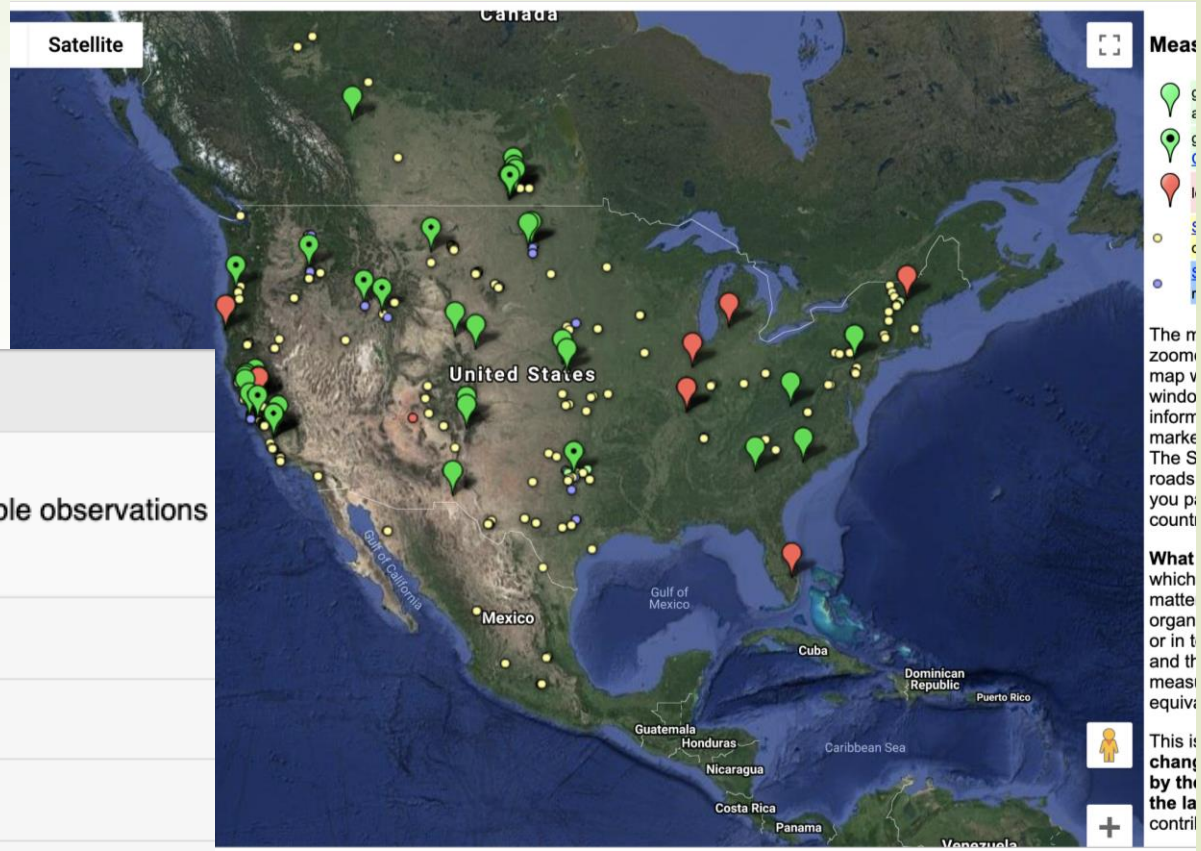
Nicky McLeod (ERS): Field and data management, recruitment and training of CitSc Coordinator, BSc (Hons.) Environmental Science

Sissie Matela (ERS): Ecological Monitoring, training of citizen scientists, and Liaison with Trad. Authority, MSc in Soil Science

Aimee Ginsberg (Natural Science Professional): Facilitation and coordination, Strong background in SA's ecological services, with focus on water-based systems, MSc Zoology

Dr. Boyd Escott (Ezemvelo KZN Wildlife-Scientific Services): Support overall design validation, training of CitSctists, and be available for consulting during Dartmouth student visits (proposed team member)

Mobile Applications

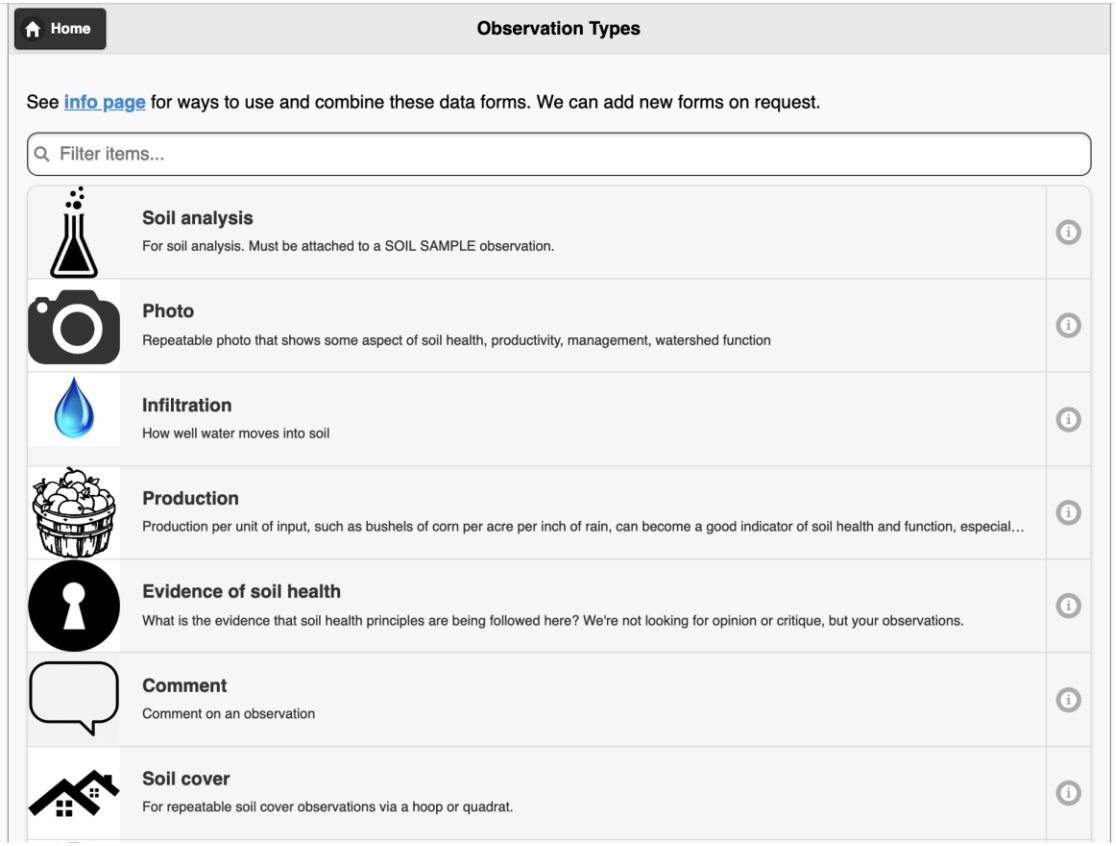


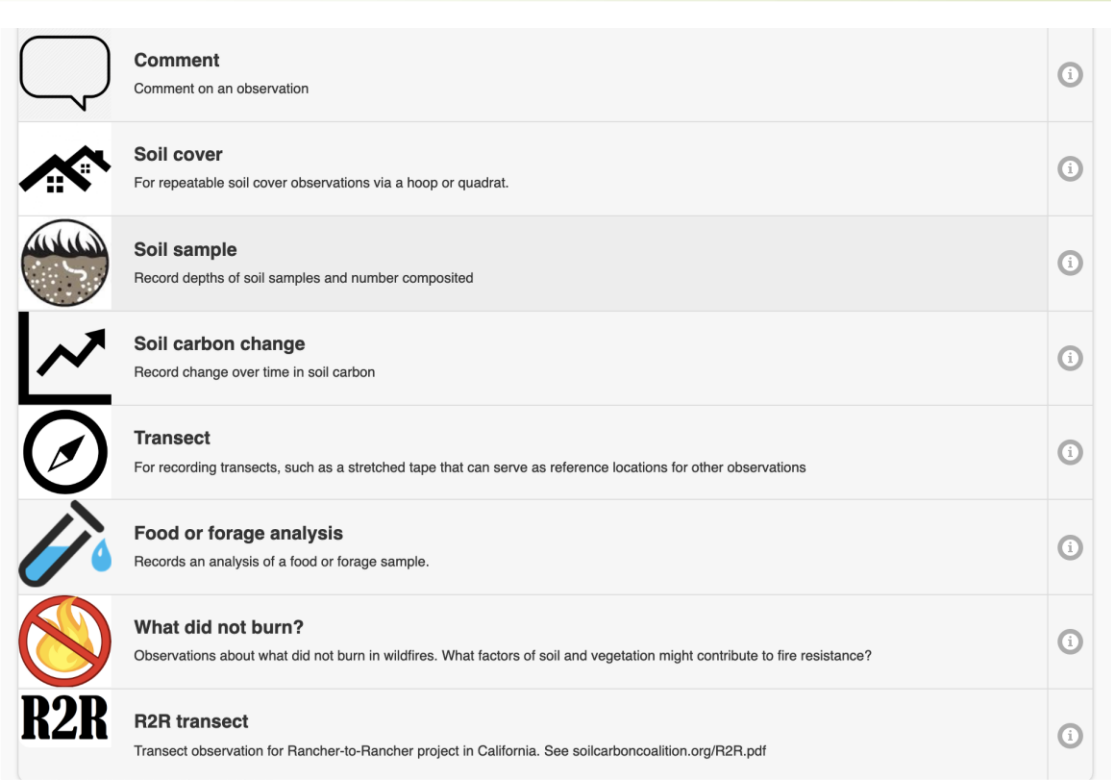
atlasbiowork

The **Atlas of Biological Work** is an open network for sharing local and repeatable observations function. Info and instructions.

- **Add new point site + data**
- **Recent data**
- **Data types**
- **Recent sites**
- **New site (must be online)**
- **Log In**

soilcarboncoalition.org
atlasbiowork v.302 • powered by wq

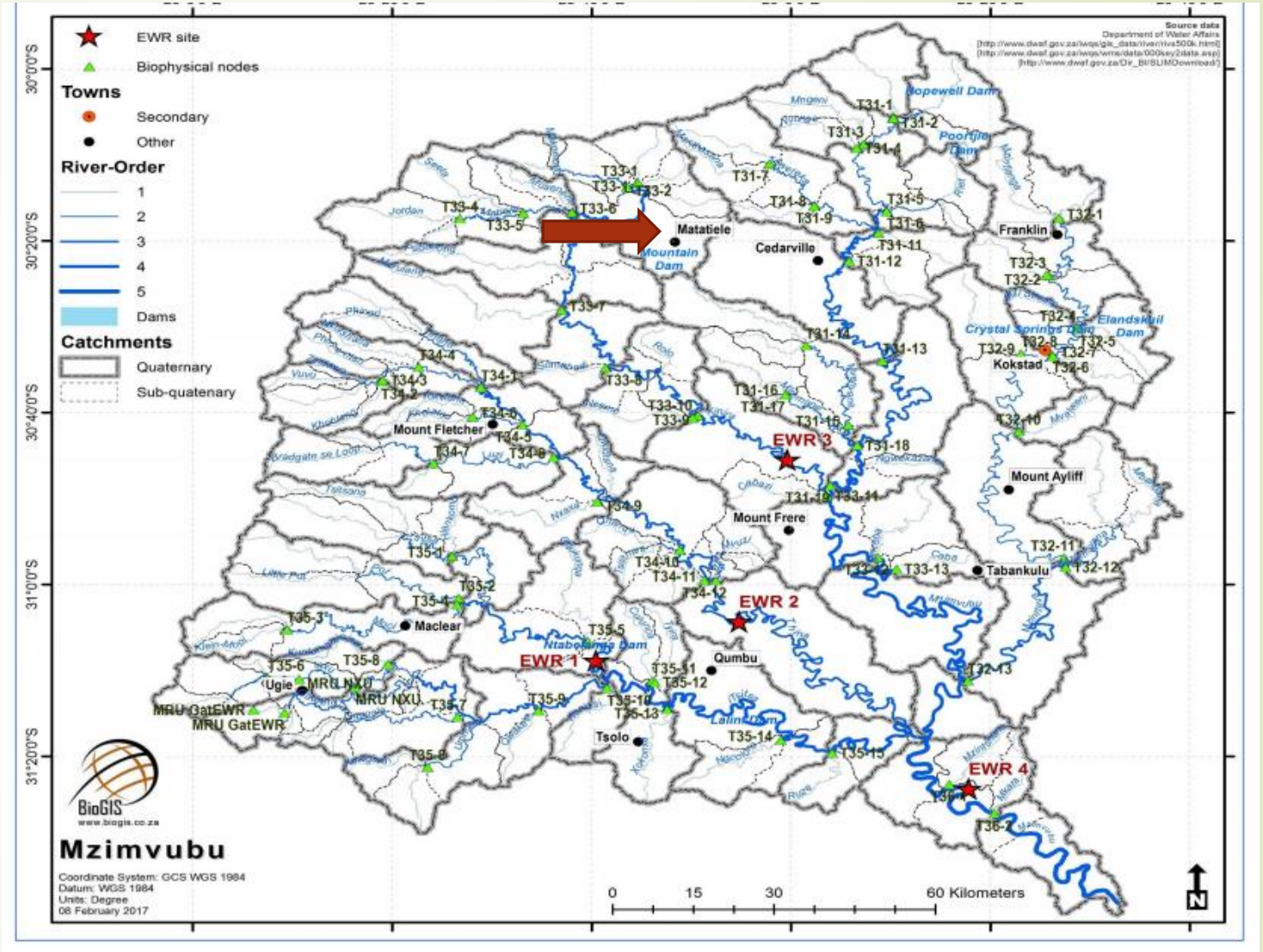

Home
Observation Types
See info page for ways to use and combine these data forms. We can add new forms on request.
Filter items...
Soil analysis
For soil analysis. Must be attached to a SOIL SAMPLE observation.
Photo
Repeatable photo that shows some aspect of soil health, productivity, management, watershed function
Infiltration
How well water moves into soil
Production
Production per unit of input, such as bushels of corn per acre per inch of rain, can become a good indicator of soil health and function, especial…
Evidence of soil health
What is the evidence that soil health principles are being followed here? We're not looking for opinion or critique, but your observations.
Comment
Comment on an observation
Soil cover
For repeatable soil cover observations via a hoop or quadrat.


Comment
Comment on an observation
Soil cover
For repeatable soil cover observations via a hoop or quadrat.
Soil sample
Record depths of soil samples and number composited
Soil carbon change
Record change over time in soil carbon
Transect
For recording transects, such as a stretched tape that can serve as reference locations for other observations
Food or forage analysis
Records an analysis of a food or forage sample.
What did not burn?
Observations about what did not burn in wildfires. What factors of soil and vegetation might contribute to fire resistance?
R2R
R2R transect
Transect observation for Rancher-to-Rancher project in California. See soilcarboncoalition.org/R2R.pdf

Discussion and Questions

The uMzimbuvu River Catchment

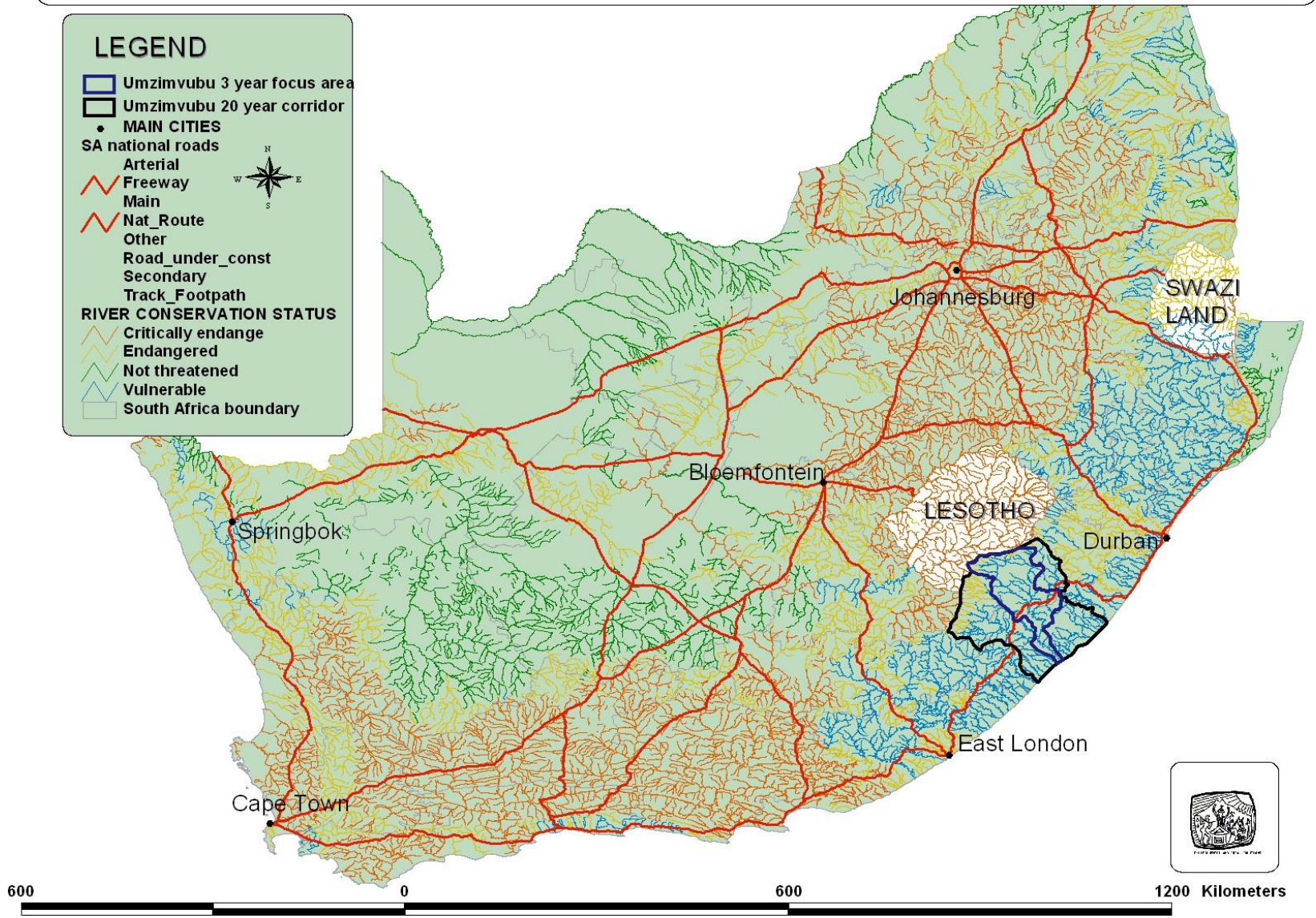
- 200 km from Maloti-Drakensberg watershed on Lesotho escarpment to Port St. Johns
- Mzimbuvu is a near-natural river (NFEPA Assessment; Nelef et al. 2011) classified as 'vulnerable'
- Main uses include irrigation for agriculture and municipality use
- 11 small dams along main and tributaries, no major dams
- 200,000 people living in the basin
- More than 2 million hectares in the Eastern Cape, 70% communal land



The Umzimbuvu Catchment Partnership Programme (UCPP)

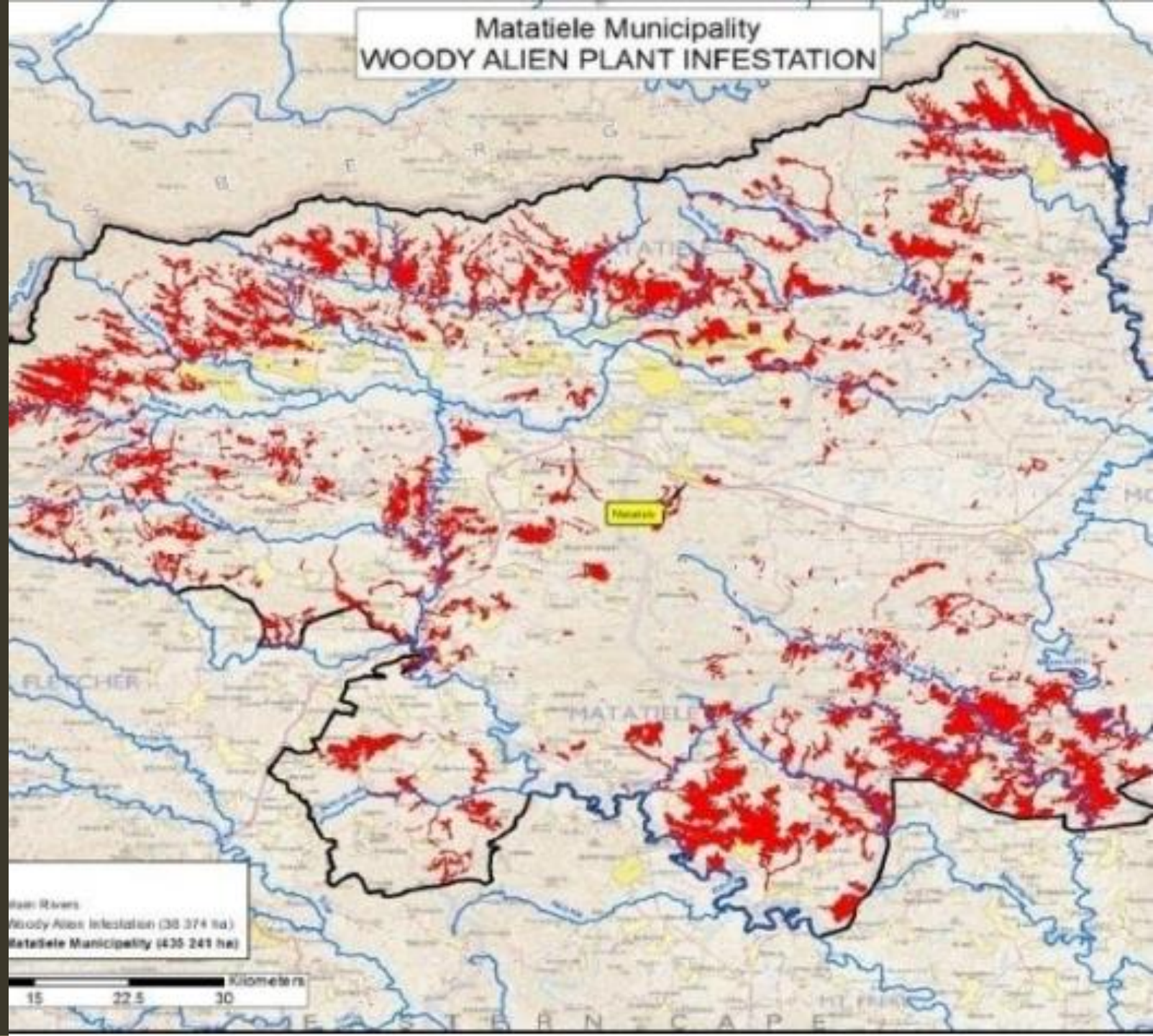
UMZIMVUBU CATCHMENT CONSERVATION CORRIDOR WITHIN RIVER CONSERVATION STATUS IN SOUTH AFRICA

CONSERVATION SOUTH AFRICA
Member of the CI Network



Wattle Removal (Working for Water)

- Black wattle (Acacia mearnsii, De Wild.)
- Pioneer species, highly water consuming, reduces annual runoff by 7%
- Soil carbon stock decrease with age of wattle stands (Oelofse et al. 2015)



Meat Naturally's Sustainable Rangelands model

Increase quality of natural capital

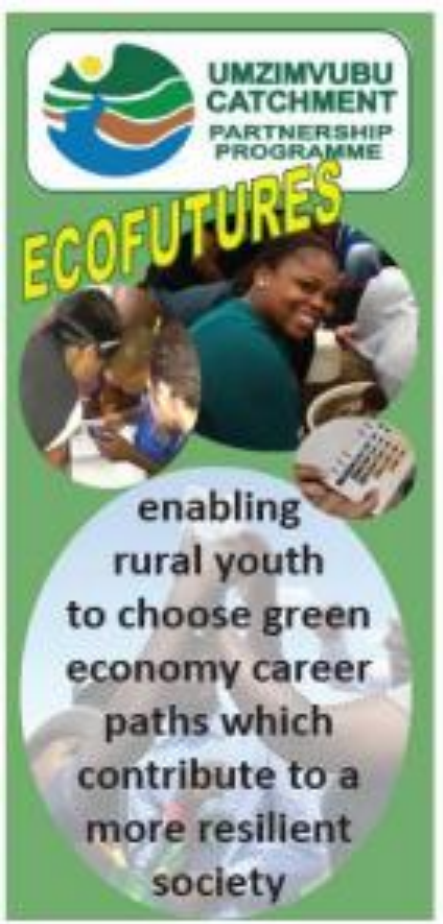
Increased technical husbandry interventions

Cattle auction system

Rotational grazing / rest to improve fodder stock and build resilience

Above left: night kraal site showing post-clearing trample recovery on left and control are on right, under scenario 4. Above right: initial auction for Mzongwana community, which sold 80 cattle for 60 households, realising R400 250.

Citizen science through EcoFutures

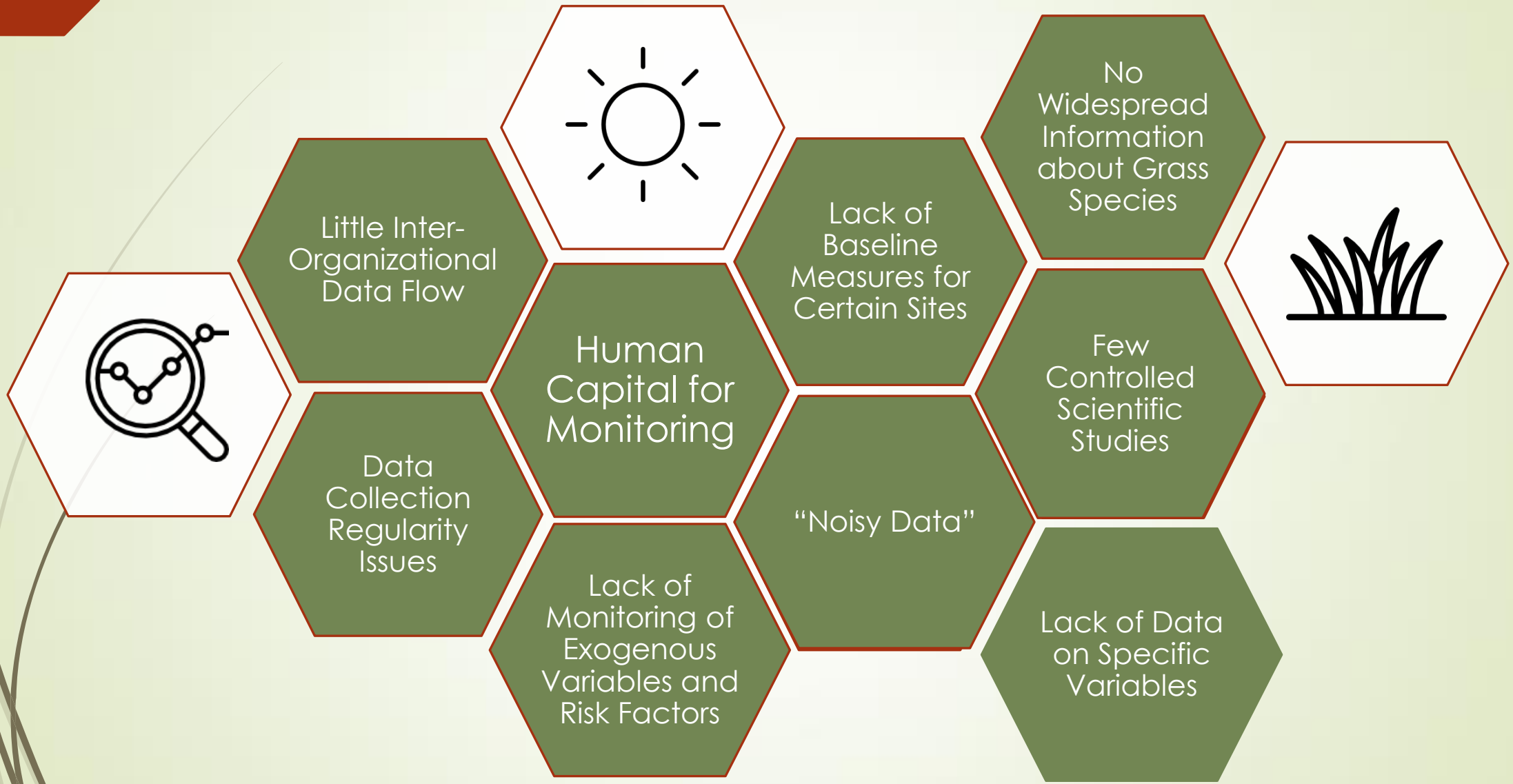


Hands-in introductory training to citizen science techniques

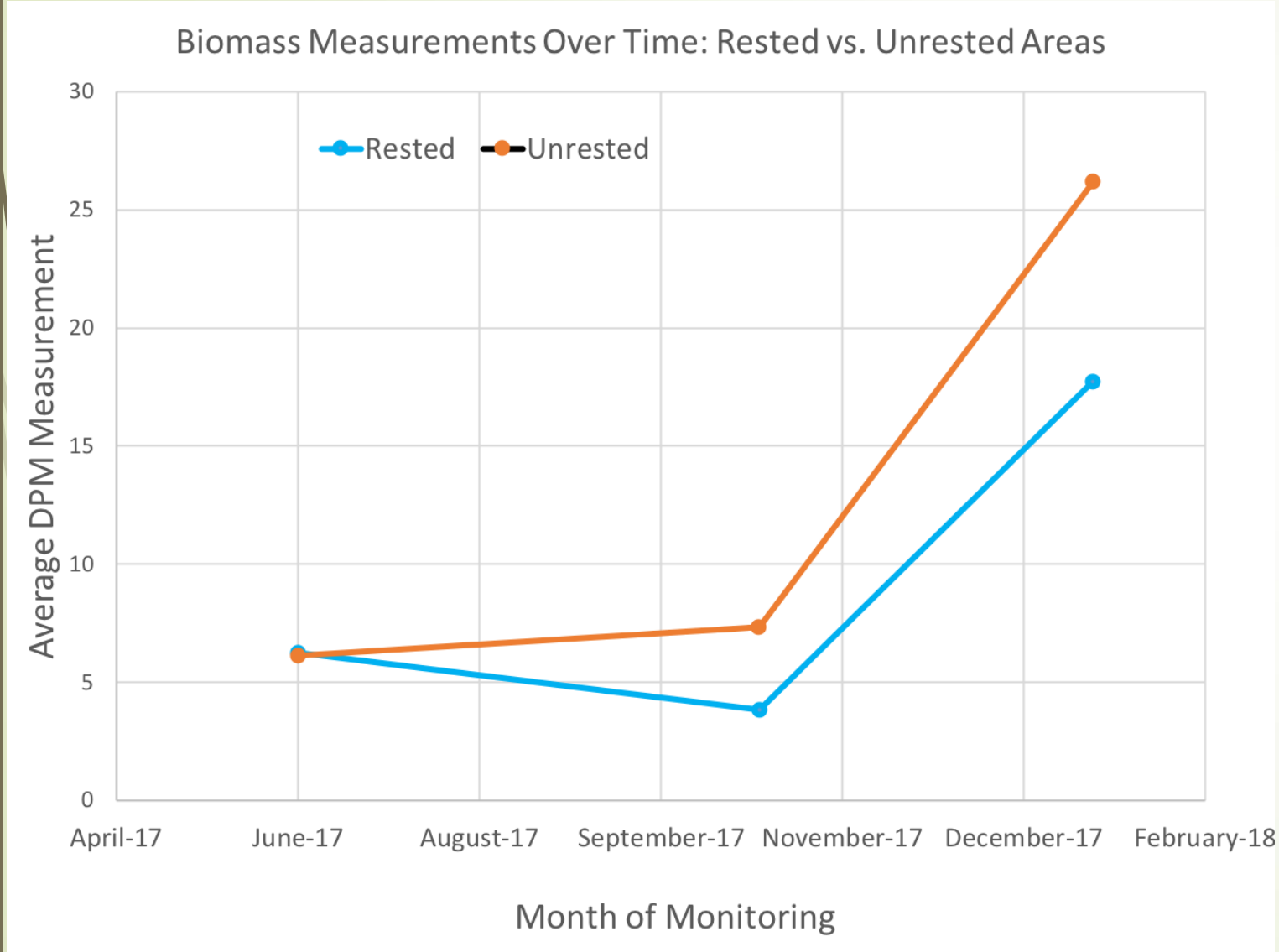
ECOFUTURES is a collaborative concept developed and driven by UCPP partners, facilitated by ERS with WWF Nedbank Green Trust support. Conservation SA is collaborating on a key component of the enterpreneurial training with support from CITI Foundation.

UMZIMVUBU CATCHMENT PARTNERSHIP PROGRAMME | WWF NEDBANK GREEN TRUST | WWF | ERS environmental and rural solutions | CONSERVATION SOUTH AFRICA Member of the CI Network | Citi Foundation | citi

Monitoring Gaps



Findings from FSP study



- 5 cm less growth in rested area
- Interpretations: Error, Monitoring, and Theory
- Takeaways and Other Applications of Controlled Study

What caused deficiencies in regrowth in the rested rangelands?

- Data is inaccurate – not viable measurement (Veld assessment)
- Three assessments over 5 months is too few
- Resting period was too short to show response in 5 months (due to compacted soil, other factors)
- Insufficient fertilizer in the rested areas (livestock promote grassland resilience)
- Rested and unrested sites are not comparable (due to elevation, soil type, vegetation, social factors, etc.)
- Other reasons you can think of?