National Space Conference
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MAPWAPS
MAPPING WOODY INVASIVE ALIEN PLANT SPECIES

Mapping the presence of woody invasive alien plants in the Luvuvhu Catchment of South Africa using multispectral Sentinel-2 satellite imagery

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MAPWAPS

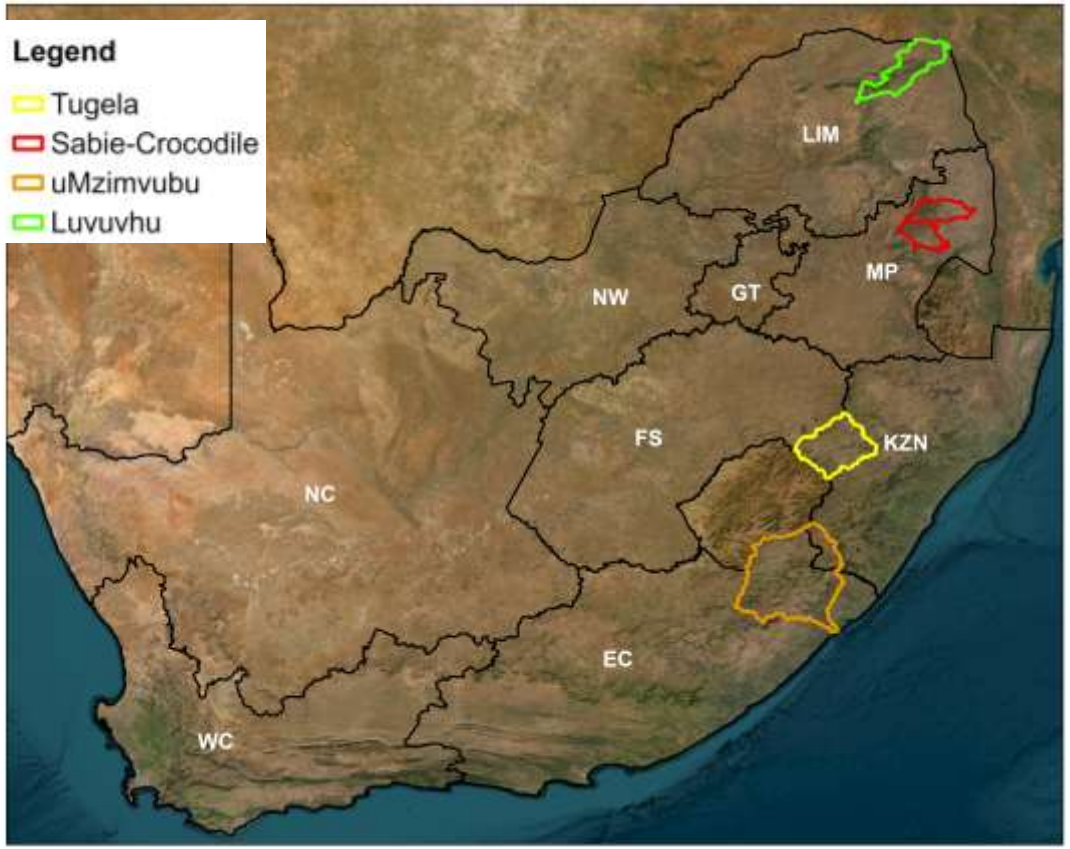
WATER RESEARCH COMMISSION

WRC Project: 2022/2023-00901

Mapping woody invasive alien plant species and their impacts in strategic water source areas

Aims – Use freely available satellite imagery to:

1. Map woody invasive alien plants in key SWSA's
2. Estimate the water use of woody invasive alien plants



Methods

- Hold stakeholder workshops to determine scope
- Collect geotagged photos of LULC as training data using Cybertracker
- Process training data on ArcGIS Pro
- Perform classification using Google Earth Engine
- Make all training data available on iNaturalist.org

Team

Dr. Alanna Rebelo, Prof. Karen Esler, Mr. Liam Cogill, Ms. Thandeka Skosana

Introduction

Woody invasive alien plants (IAPs) pose significant threats to South Africa

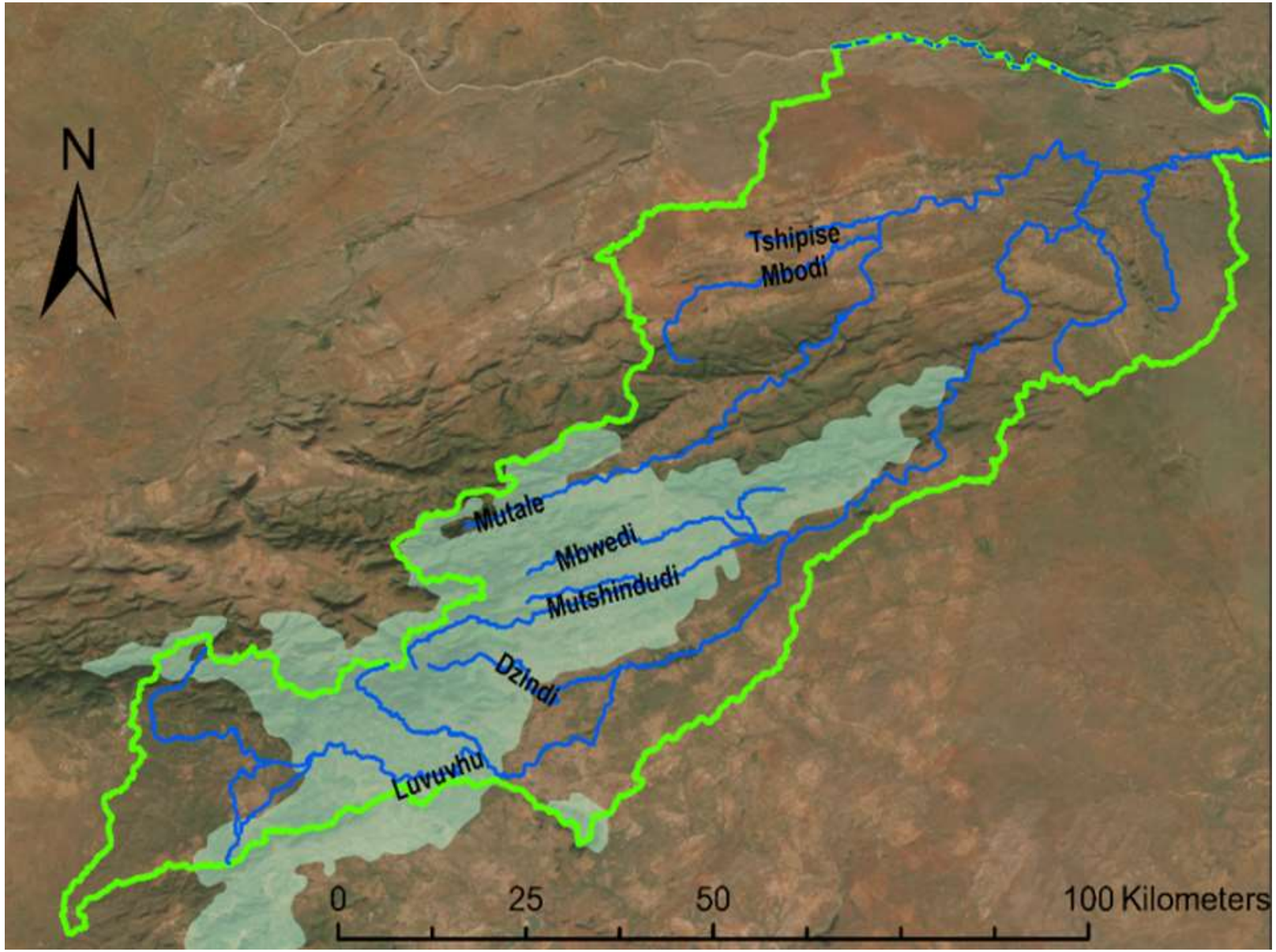
- Ecosystems
(Latimer et al., 2004, Pyšek et al., 2020)
- Economy
(Münch et al., 2019; Ndhlovu et al., 2011; Venter et al., 2020)
- Many more..
(Ehrenfeld, 2003; Jacobs et al., 2020; Naudé, 2012; Raizada et al., 2008; Tererai et al., 2013)

- Water
(Le Maitre et al., 2000, 2015, 2016; Moncrieff et al., 2021)

- SWSAs NB and take up 10% of SA land area and produce 50% of SA freshwater
(Le Maitre et al., 2018; Lötter & Le Maitre, 2021; Nel et al., 2017)

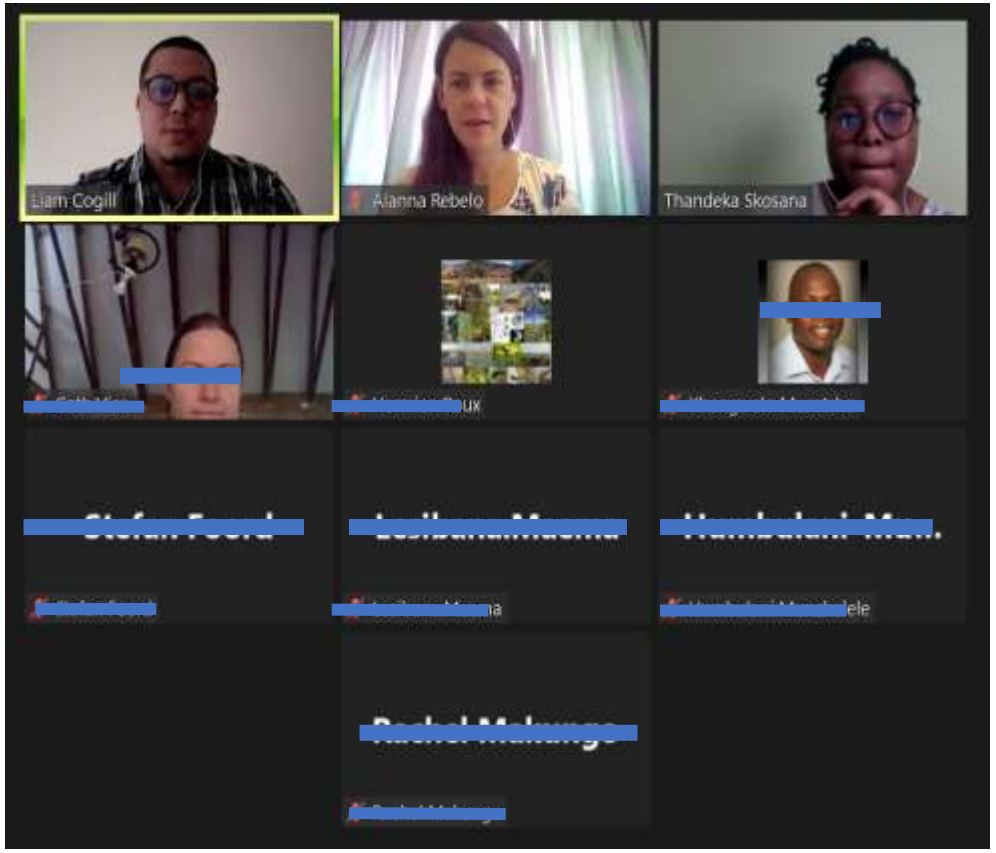
- IAPs therefore especially problematic in water scarce country

- To effectively manage these IAPs, accurate updatable maps are required



Methods

Virtual stakeholder workshop



- Key woody invasive alien plant taxa of concern
- Practical considerations
- Gain perspective of the key invasive alien plant issues in the landscape

Fieldwork campaign

CyberTracker

- Collect geotagged photographs of LULC via road network
- Captured on the CyberTracker App

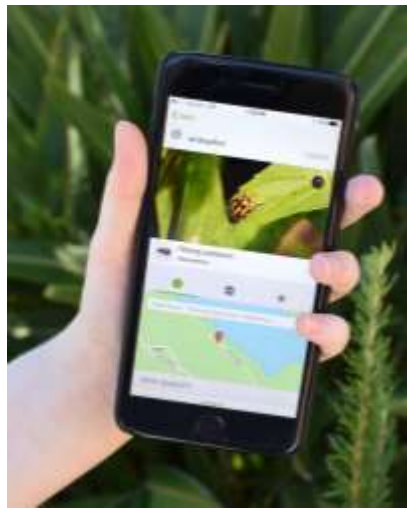
Methods

Fieldwork campaign

Sentinel-2 Classification

```
Imports (3 entries)
  var S2A: ImageCollection "Sentinel-2 MSI: MultiSpectral Instrument, Level-2A"
  var LuvuvhuSite: Table users/lscogill4/Luvuvhu_Soutpansberg
  var LuvuvhuPoints: Table users/lscogill4/Luvuvhu_2
/// Classification of Sentinel 2: Classification 1 ///

// Image collection defined & apply relevant filters
var image = ee.ImageCollection(S2A)
    .filterDate("2023-06-25", "2023-06-27")
    .filterBounds(LuvuvhuSite)
    .sort("CLOUD_COVERAGE_ASSESSMENT");
    print(image, "S2Ascene1");
    Map.centerObject(LuvuvhuSite, 9);

//
// Add Study site as map layer
Map.addLayer(LuvuvhuSite, {opacity: 20}, "LuvuvhuSite");

//
// Conduct mosaic of S2 scene and clipping to study site
var mosaic = image.mosaic();
Map.addLayer(image, {opacity: 0.2}, 'spatial_mosaic');

var imageclipped = mosaic.clip(LuvuvhuSite)
print("imageclipped", imageclipped);
Map.addLayer(imageclipped, {bands: ['B4', 'B3', 'B2'], max: 3000}, 'image_clipped');

//
//Add relevant indices for classification 1
//1.NDVI
```

Data uploads



iNaturalist

GitHub

- Training data processed in ArcGIS Pro
- Sentinel-2 multispectral classification with Support Vector Machine in open source Google Earth Engine
- Series of classifications including strategic bands and indices
- Total overall accuracy assessment via Confusion Matrix

Results

Virtual stakeholder workshop

LULC Classes:

Colour	LULC Class
	Irrigated Agriculture
	Dryland Agriculture
	Orchards
	Grassland
	Indigenous Bush
	Water
	Wetland
	Bare Ground
	Urban
	Indigenous Forest
	Gum
	Pine
	Other Invasive Alien Trees
	Mauritius Thorn
	Lantana
	Triffid Weed
	Bugweed

Results

Fieldwork observations: Ecological Expertise - The Landscape

- Many community crop fields and gardens irrigated from rivers and dams

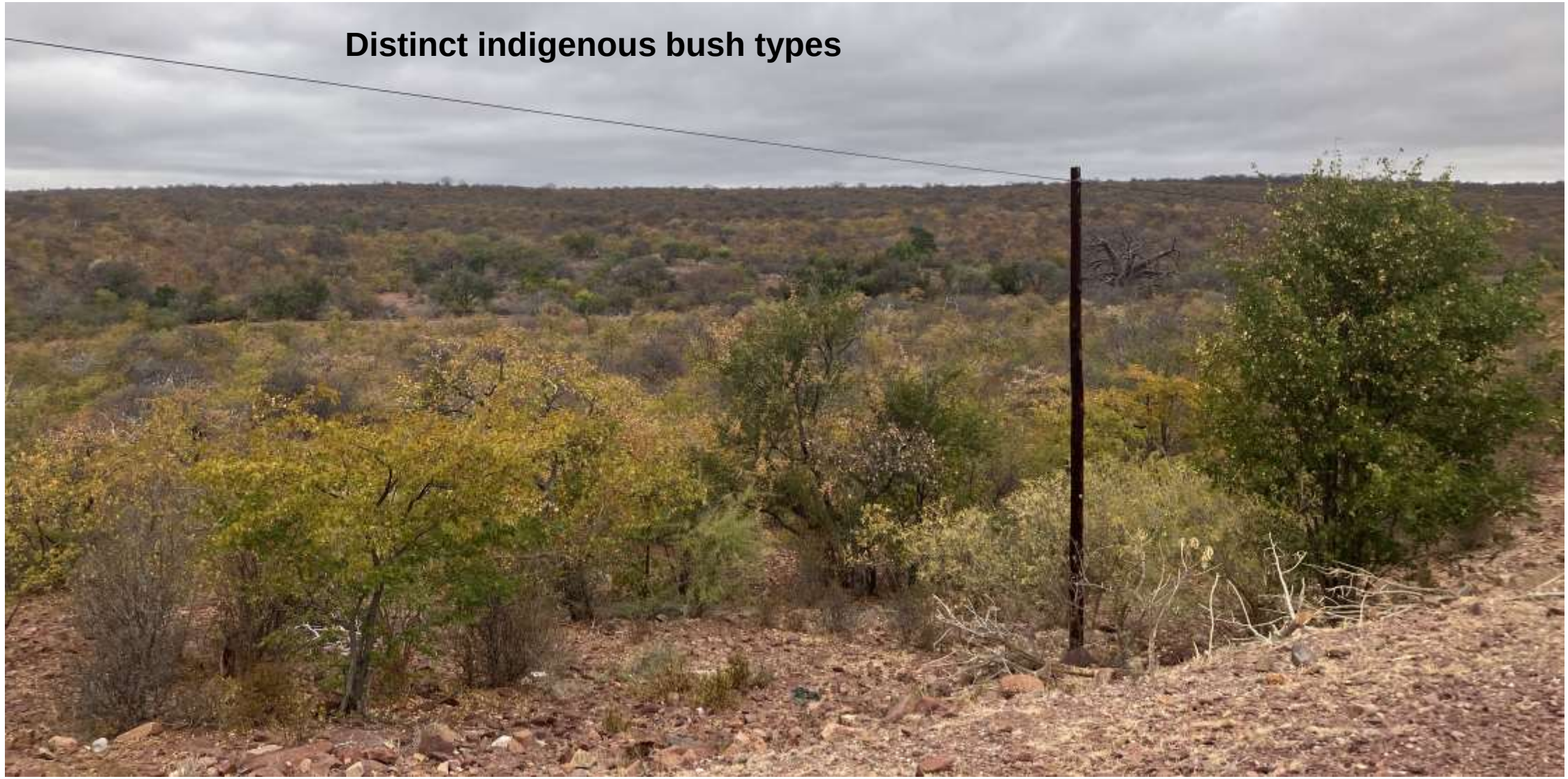
Results

Fieldwork observations: Ecological Expertise - The Landscape

- Various distinct agricultural activities: such as tea and maize
- Different orchard types: Banana, Macadamia and Pecan, as well as Guava, Avocado, Mangoes

Results

Fieldwork observations: Ecological Expertise - The Landscape



Central - Southern regions: *Vachellia, Senegalia, Dichrostachys, Euphorbia, Terminalia, Aloe*, *Dovyalis,* etc.
Northern: *Colophospermum mopane* and *Combretum* dominant, with lower densities of *Senegalia, Vachellia*, and *Dichrostachys*

Results

Fieldwork observations: Ecological expertise - Invasive Alien Plants

- Gum and Pine plantations

Results

Fieldwork observations: Ecological Expertise - Invasive Alien Plants

Research Question

What level of detail is required to get the best mapping results and accurately separate LULC’s?

Results

Sentinel-2 – Support Vector Machine Classification

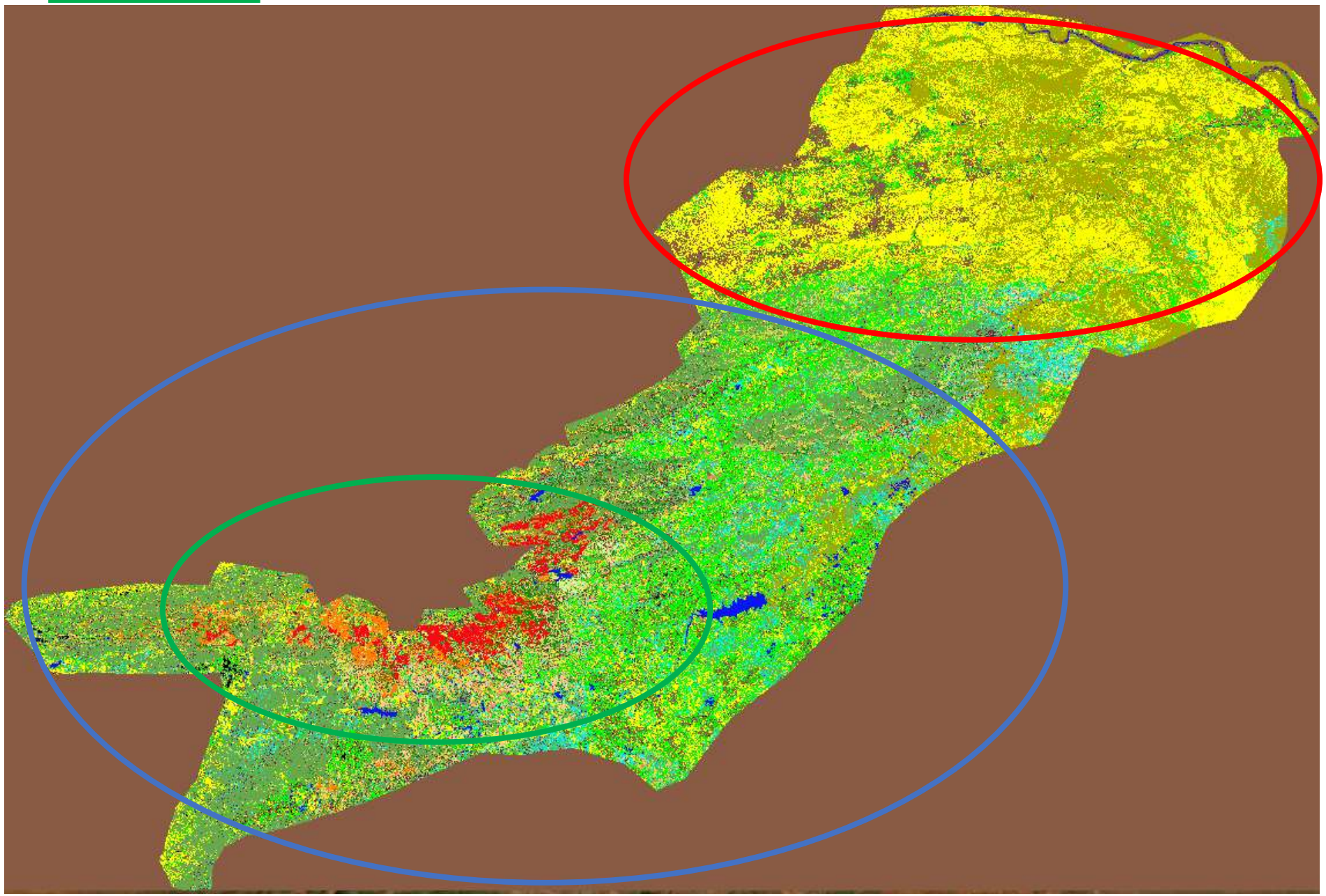
All bands and indices from Sentinel-2 + ALOS landforms and ALOS elevation

Bands: B2, B3, B4, B5, B6, B7, B8, B8A, B11, B12, NDVI, Chlogreen, LAnthoC, LCaroC, LChloC, BAI, GI, gNDVI, MSI, NDrededgeSWIR, NDTI, NDVIre, NDVI1, NDVI2, NHI, EVI, EVI2, EVI2_2, MSAVI, NormG, NormNIR, NormR, RededgePeakArea, RedSWIR1, RTVIcore, SAVI, SRBlueRededge1, SRBlueRededge2, SRBlueRededge3, SRNIRnarrowBlue, SRNIRnarrowGreen, SRNIRnarrowRed, SRNIRnarrowRededge1, SRNIRnarrowRededge2, SRNIRnarrowRededge3, STI, WBI, NDMI, NDBR, ALOS landforms, ALOS elevation

Classification	Description	Invasive Alien Plant Classes	Accuracy
1	All LULC's including separate invasive alien plant classes	Gum, Pine, Mauritius Thorn, Bugweed, Lantana, Chromolaena, Other Invasive Alien Plants (Bamboo, Wattle, etc.)	0.75
2	Same as 1, but exclude 'Other Invasive Alien Plants' and merge Lantana, Chromolaena, Mauritius Thorn, Bugweed into an 'Invasive Merge' class	Gum, Pine, Invasive Merge (Chromolaena, Lantana, Bugweed, Mauritius Thorn)	0.85
3	Same as 1, but merge all invasive alien plant classes into one big 'Invasive Merge' class	Invasive Merge (Pine, Gum, Chromolaena, Lantana, Bugweed, Mauritius Thorn)	0.83

Results

Sentinel-2 Classification



Colour	LULC Class
	Irrigated Agriculture
	Dryland Agriculture
	Water
	Wetland
	Bare Ground
	Urban
	Indigenous Forest
	Gum
	Pine
	Invasive Merge
	Orchards_Other
	Orchards_Banana
	Orchards_Nuts
	Tea
	Indigenous Bush_Mopane
	Indigenous Bush_Other

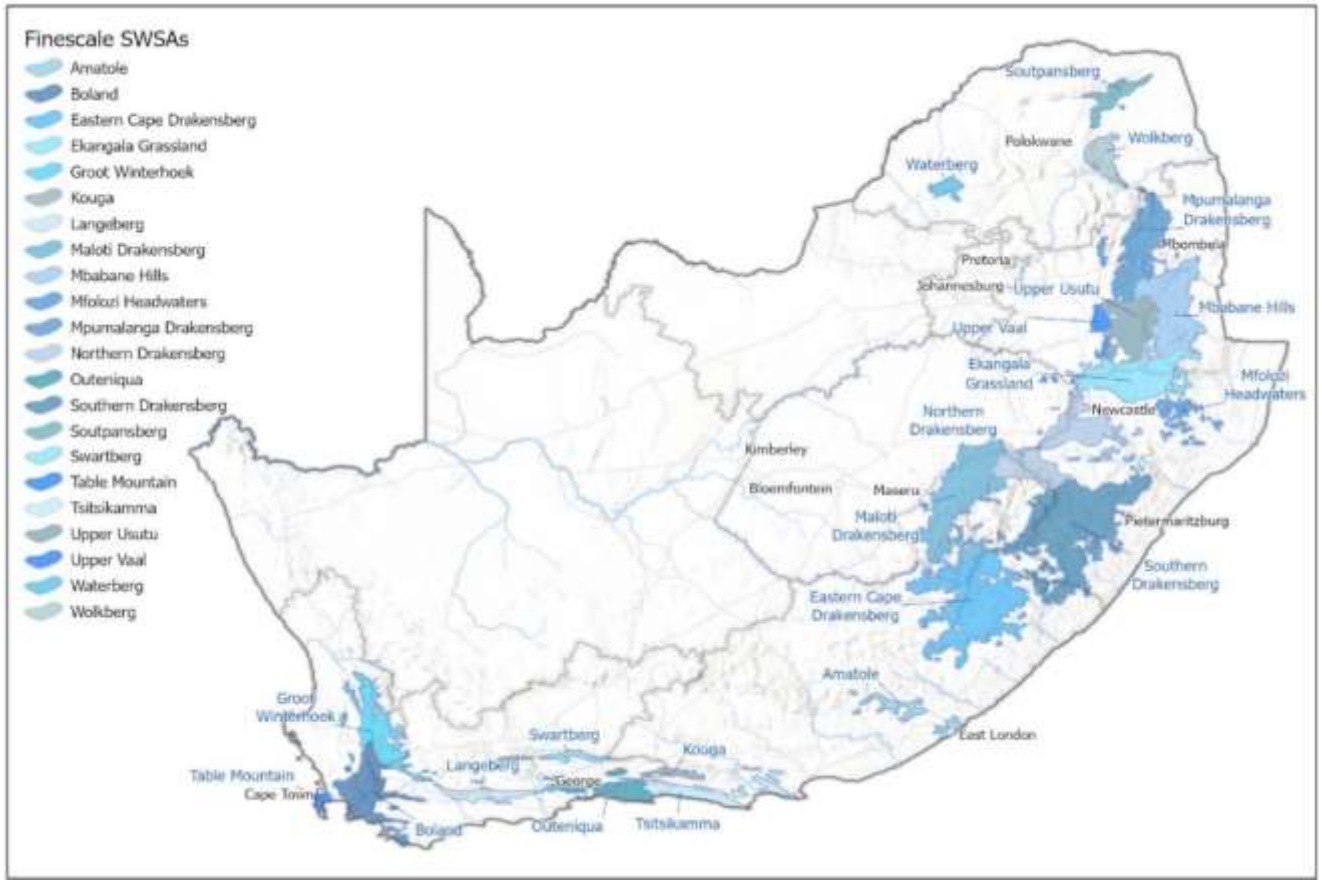
Results

Sentinel-2 Classification

Colour	LULC Class
	Gum
	Pine
	Invasive Merge
	Indigenous Forest

Closing Remarks

- Map can be used by managers and citizens to improve regional strategies for woody invasive alien plant control
- Can estimate the extent of invasive alien plants across the landscape at a catchment scale
- Planning and prioritising IAP clearing operations
- Detecting new infestations in areas that were previously not on our radar
- Can be replicated in other strategic water source areas

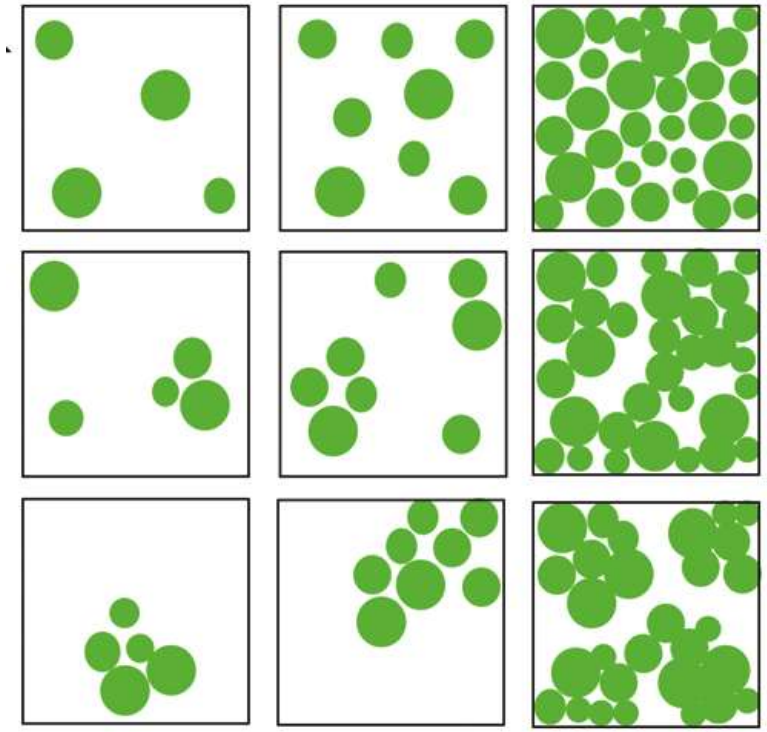


Closing Remarks

These maps can further serve as a foundation for additional invasive alien plant studies

Integration of remote sensing and machine learning:

- Invasive Alien Plant water use estimations
- Invasive Alien Plant density
- Cost Benefit Analyses



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Thank you for listening!

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