Task 2

A GIS-based approach to a resource assessment for Marula at a national and regional scale

Resource Assessment Methodology Workshop (virtual)

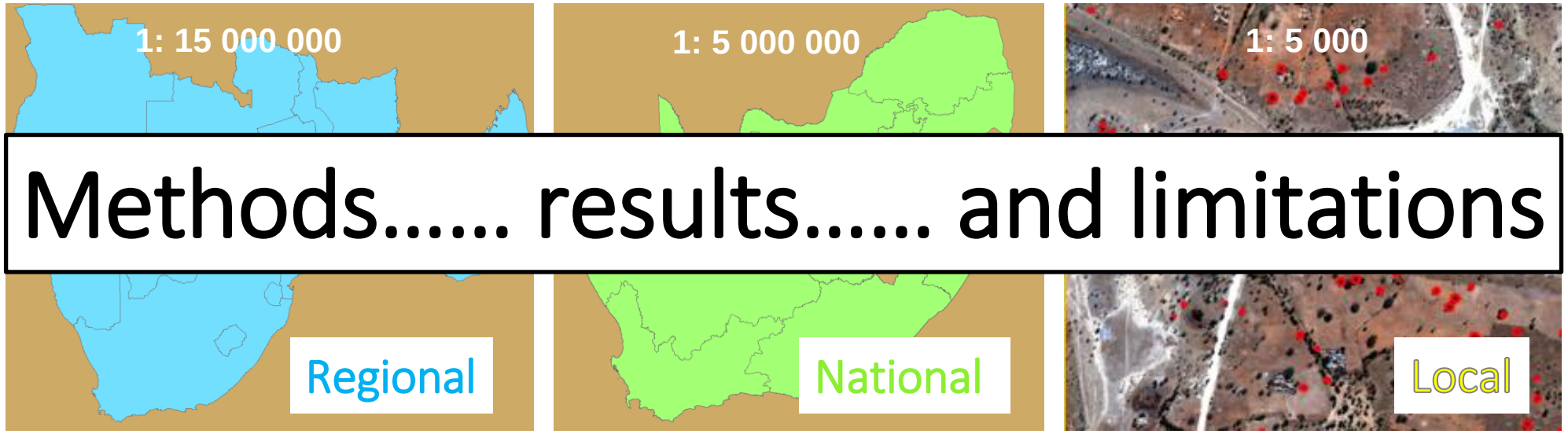
3 December 2020

Gillian McGregor and David Kinsler, Rhodes University Dept. of Geography

For Dr Derek Berliner

Outline

1. Development of desk-top methods
    a) collation of existing research: other RA, Marula research and spatial datasets
    b) development of desk-top mapping and analysis approaches at 3 scales:



Methods…… results…… and limitations

2. Combination of a)… and b)… for South Africa to get 'potential harvestable volume'
3. Development of an approach to identifying sites for long term monitoring
4. Concluding comments

Assumptions and limitations

- **The task**: scope of exercise
- **Spatial setting**: local to cross border resources
- **The resource**: differences in plants & environment
- **Resource use:** multiple stakeholders at many levels
- **Existing research:** uneven distribution and focus

1a) Collation of existing research

Table 1: Other resource assessments

Species	Methods	Comments
Pelargonium sidoides	Used quarter-degree square mapping, divided range into smaller, more manageable sites for field transects.	No desktop-based data collection. Small plant – suited to field based survey.
Aloe ferox	Desktop analysis with GIS, supported by substantial field survey. 'Super-sites' for monitoring.	Smaller range, therefore methods such as extensive field data collection possible. No climate modelling.
Cyclopia intermedia (Bergtee)	MAXENT modelling, MCS with GIS, 'expert mapping,' mapping of permits. Field surveys of populations to get typical plant densities and population structure. Harvest surveys to get typical yield per plant and yield per hectare.	Species with quite specific environmental preferences and restricted distribution, formal industry with organised stakeholder community. 50-70% overlap of desktop data with field mapping.

1a) Collation of existing research

Table 2: Estimates of yield per tree

"Fruit production data for wild trees are scanty and often anecdotal," (Shackleton *et al*, 2002, p.30)

There is wide and inexplicable inter-annual variation of fruit yields.

Shackleton, 2002	Rainfall	Yield/tree	Limitations
Hoedspruit Nature Reserve, (arid)	484mm	23.7kg	Adult trees, mean fresh mass of fruit per tree 36.8kg. Following season – almost no fruit. 20% below average rainfall in both seasons.
Wits Rural Facility (semi-arid)	651mm	55.9kg	
Bushbuckridge Nature Reserve (mesic)	870mm	34.3kg	

1a) Collation of existing research

Table 3: Spatial datasets

Variable	Comment	Source	Data scale	Suitability of use
National Vegetation Map (SA)	450 vegetation communities/ecosystems that share similar biotic and abiotic features. Includes threat levels.	SANBI, 2018	1: 50 000	National and local
Elevation		SRTM 1sec DEM	20m res	International, national and local
Aspect		SRTM 1sec DEM	20m res	International, national and local
Protected areas (SA)	Formally protected areas of SA	DEA, 2020	1:50 000	National and local
Protected Areas (SADC)	Best available record of formally protected areas in the SADC	Peace Parks Foundation2020	1:50 000	International
National Landcover	Based on Sentinel 2 satellite imagery, 20m resolution, classified into 73 classes according to the new gazetted land-cover classification standard (SANS 19144-2)	NLC 2018, DEA	1: 50 000	National and local
Topographic features	Includes basemap features: roads, rivers, contours, all man-made and natural features on the 1:50 000 map series.	CD:NGI, 2016. Provincial geodatabases.	1: 50 000	National and local
GSD 0,5m Colour aerial photography 2015 to 2019	High resolution colour imagery (RGB) with 50cm pixel sixe. Also available on request as multi-spectral imagery.	CD: NGI	0,5m	National and local
Worldview2 Imagery	High resolution multi spectral satellite imagery with 50cm pixel size available for any date.	DigitalGlobe (to purchase)	0,5m	International, national and local
Climatic	19 derived variables relating to temperature and rainfall.	BIOCLIM	250m and 500m	International and national
	A comprehensive collection of species locality records from national collections.	GBIF	various	International, national and local
(incorporating temp., landforms vegetation and land use)	431 ecosystem units. 278 units classified as natural/semi-natural vegetation (forestlands, shrub- lands, grasslands, bare areas etc.);153 classes of settlements and croplands	Sayre, R., *et al*, 2020	250m res	International, national
WWF Ecoregions	867 terrestrial ecoregions, in 14 biomes Represents original distribution of assemblages of species & communities, no anthropogenic classes.	Olson, D.M., *et al*, 2001	Moderate	International, national

1b): Development of desk-top mapping and analysis approaches at 3 scales

Method: Delineating the broad scale likely distribution of Marula (in SA and the SADC) using SDM

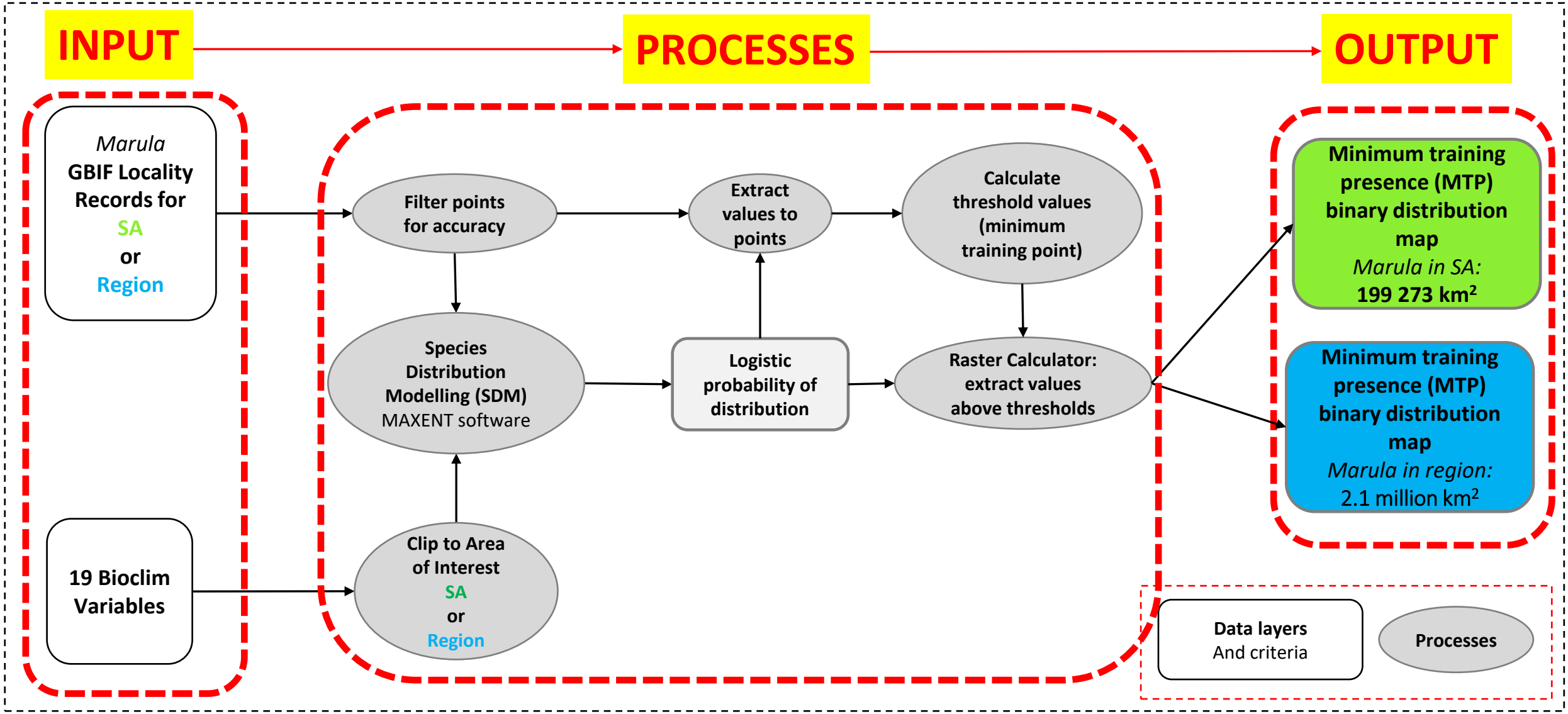


Illustration of typical steps in the desktop mapping process

Result 1b): National scale mapping

Probability of distribution using SDM (Maxent)

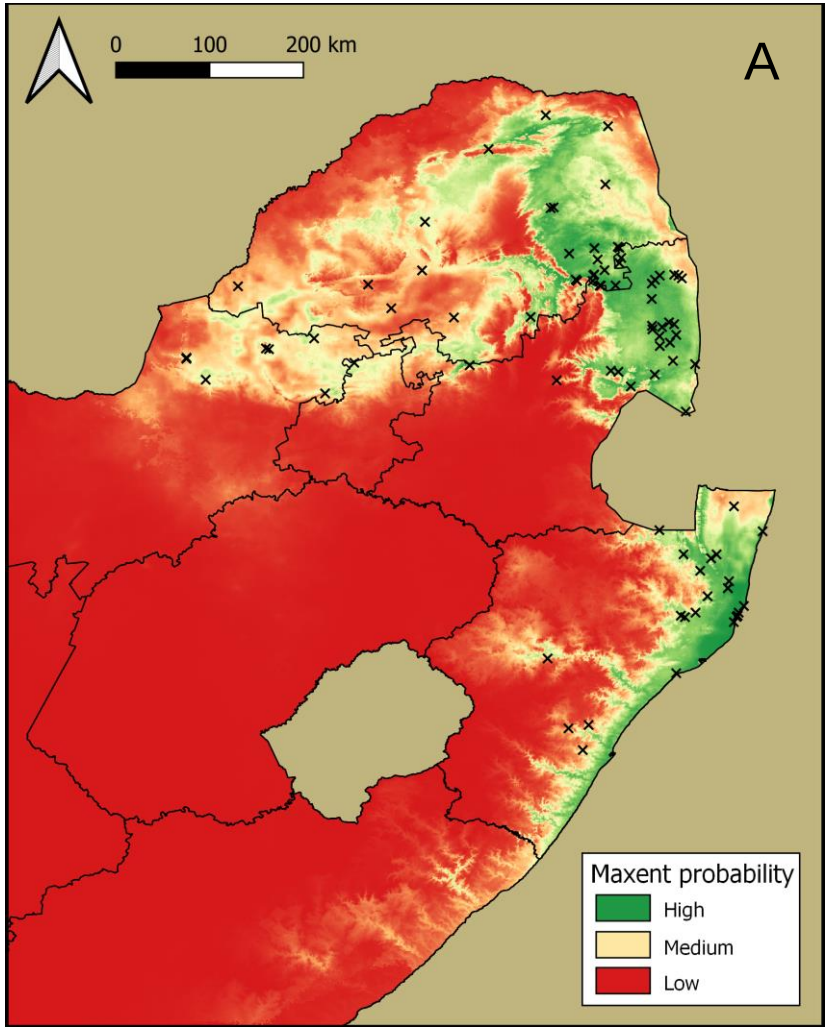


Figure 1: Full probability map

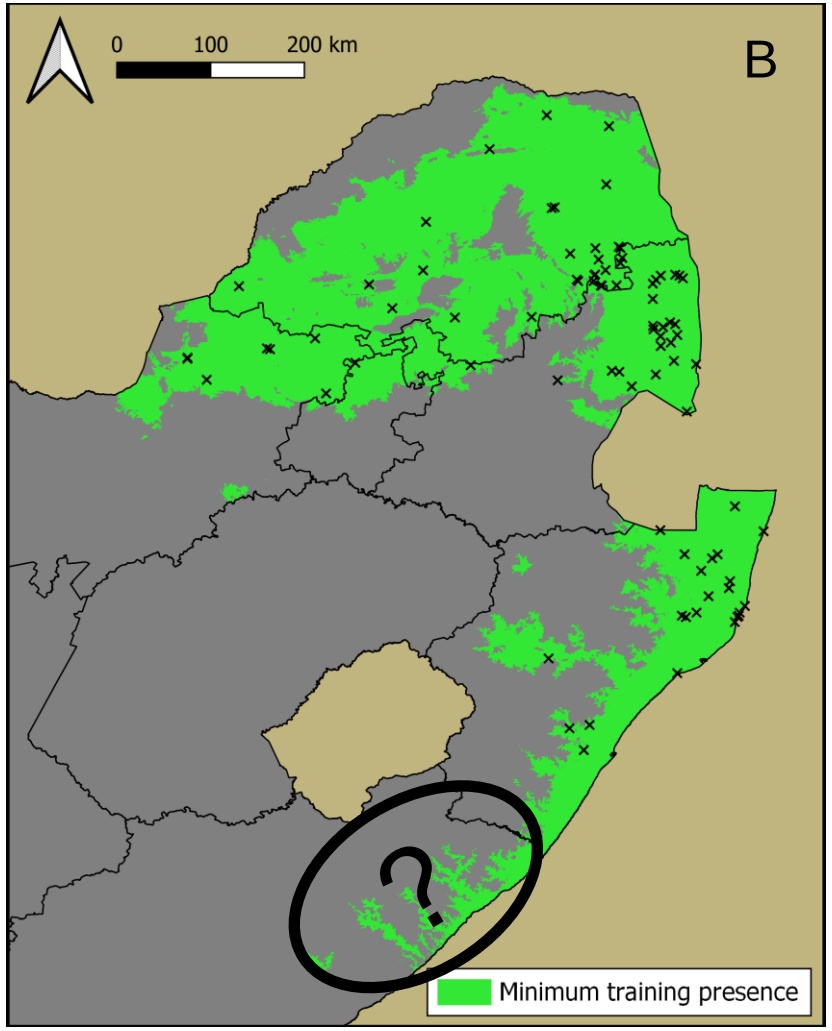


Figure 2: Binary map - High Probability vs Not Present

Result 1b): Regional scale mapping

Probability of Distribution using SDM (Maxent)

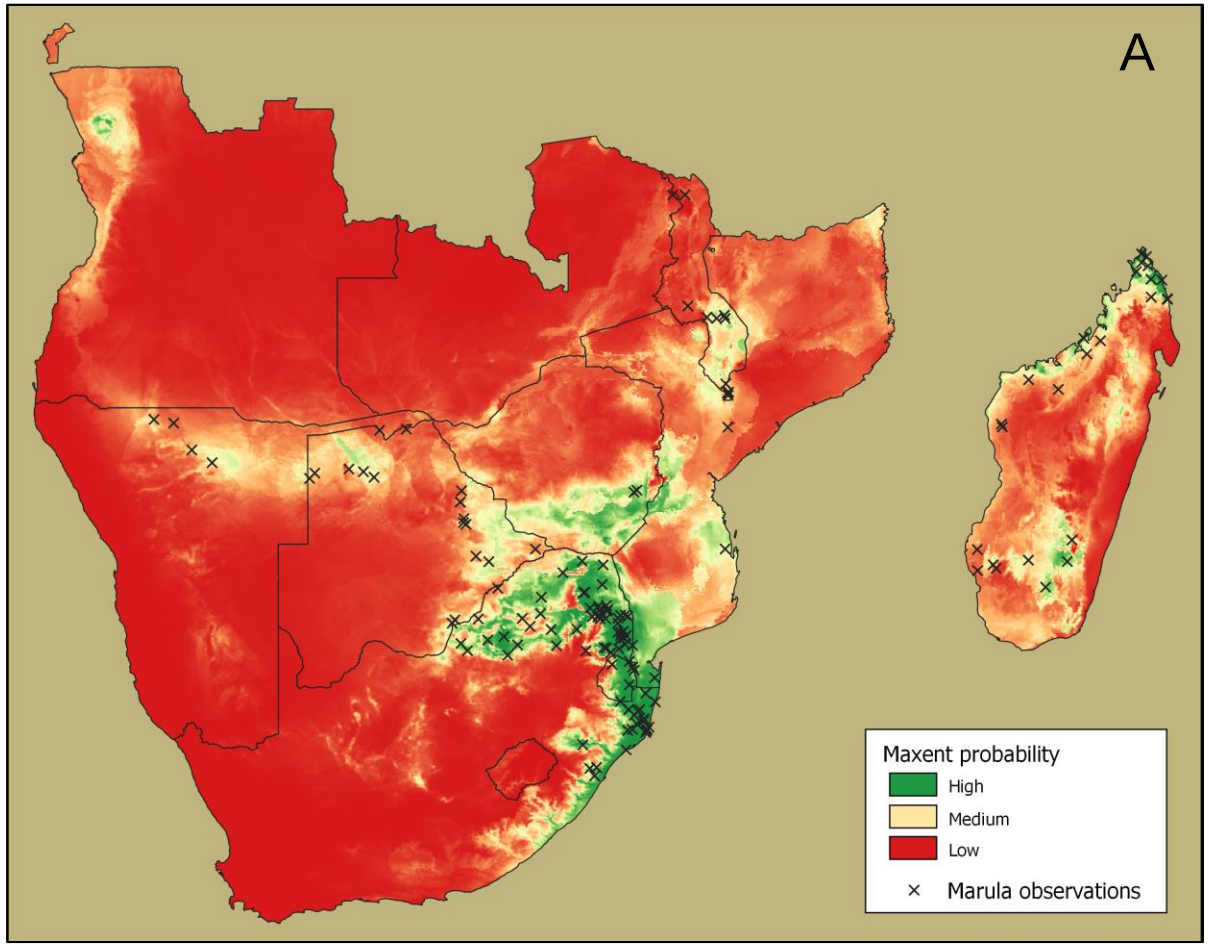


Figure 3: Full probability map

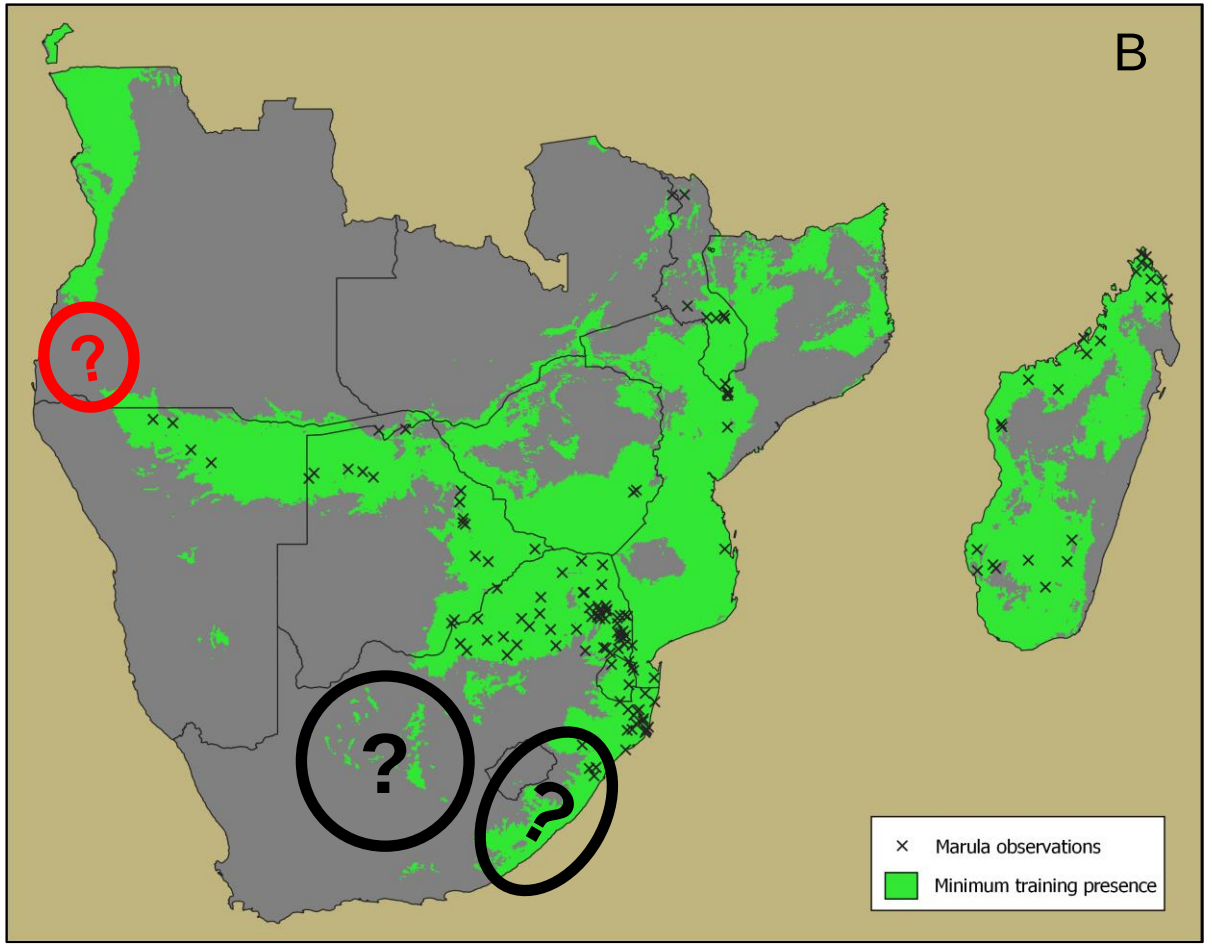
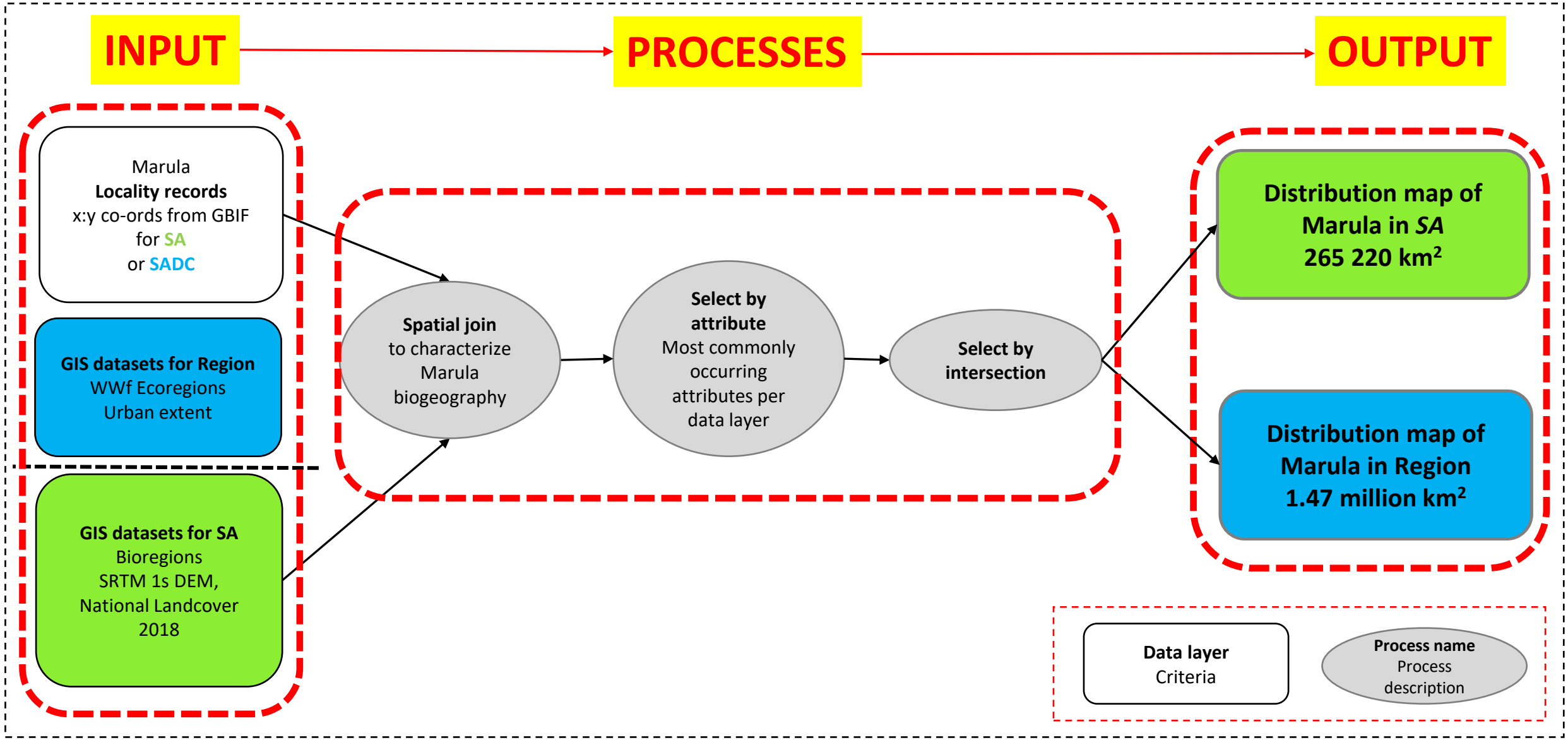


Figure 4: Medium to High Probability vs Not Present

Method 1b): Delineating the broad scale likely distribution of Marula (in SA and Region) using GIS



Result 1b): National scale mapping

Distribution map for Marula using GIS

Map 1

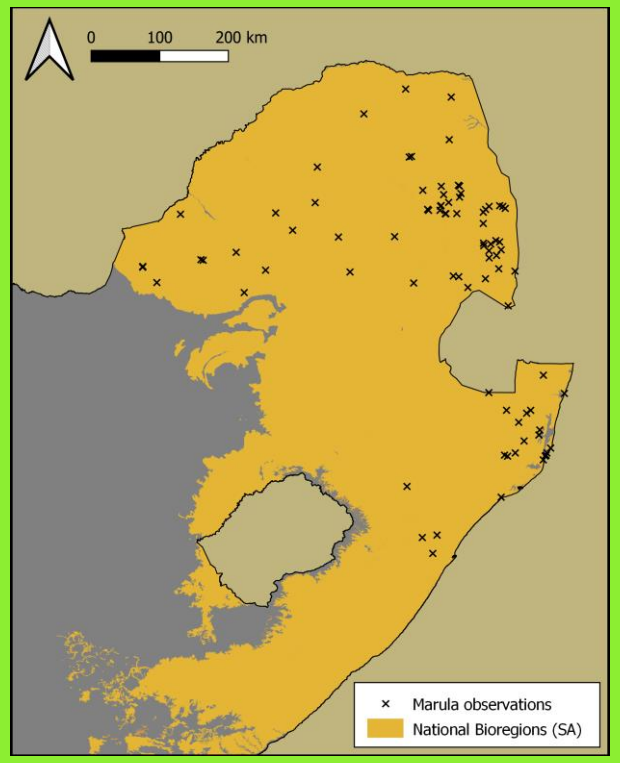


Figure 5: Bioregions

Map 2

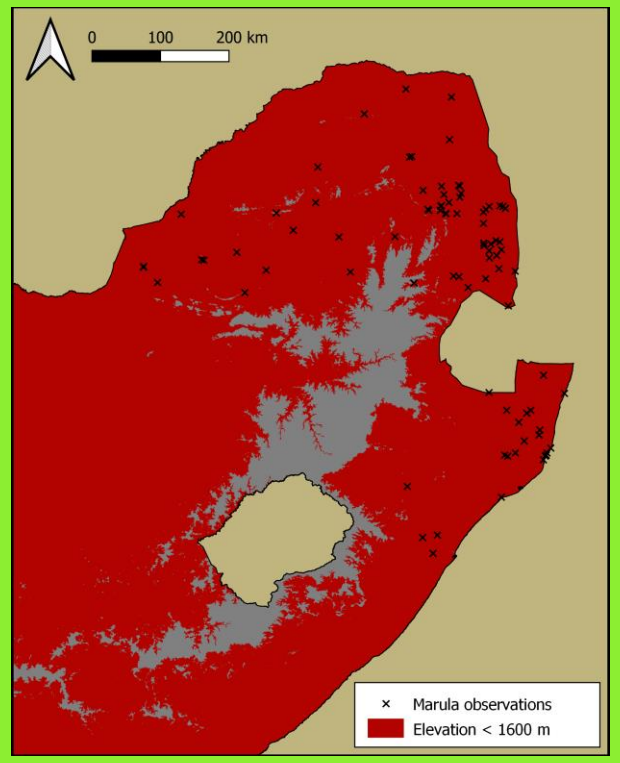


Figure 6: Elevation

Map 3

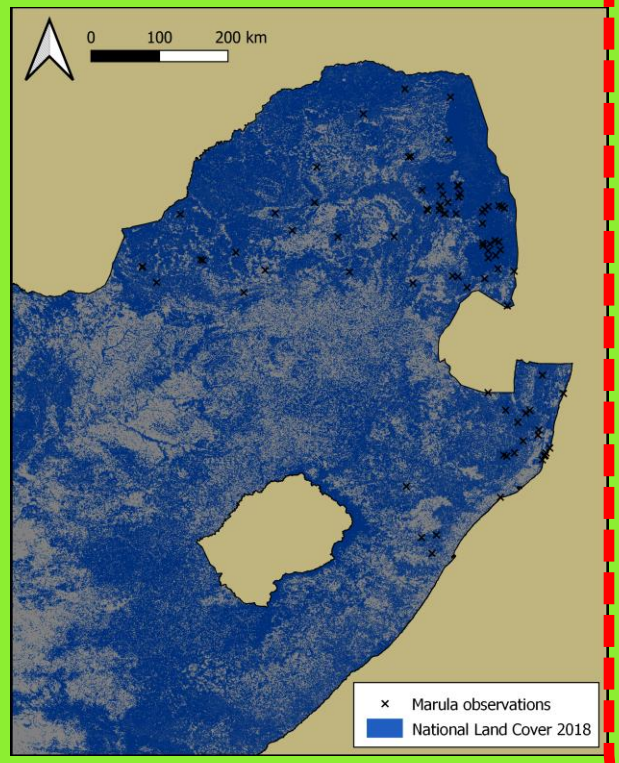


Figure 7: Landcover

Map 4

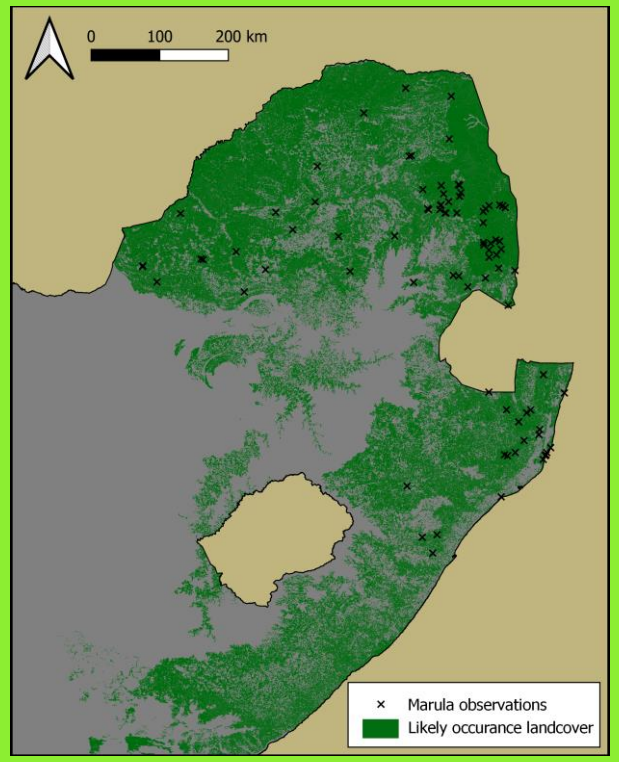


Figure 8: Combination

Result 1b): Regional scale mapping

Regional distribution map for Marula using GIS, no urban areas

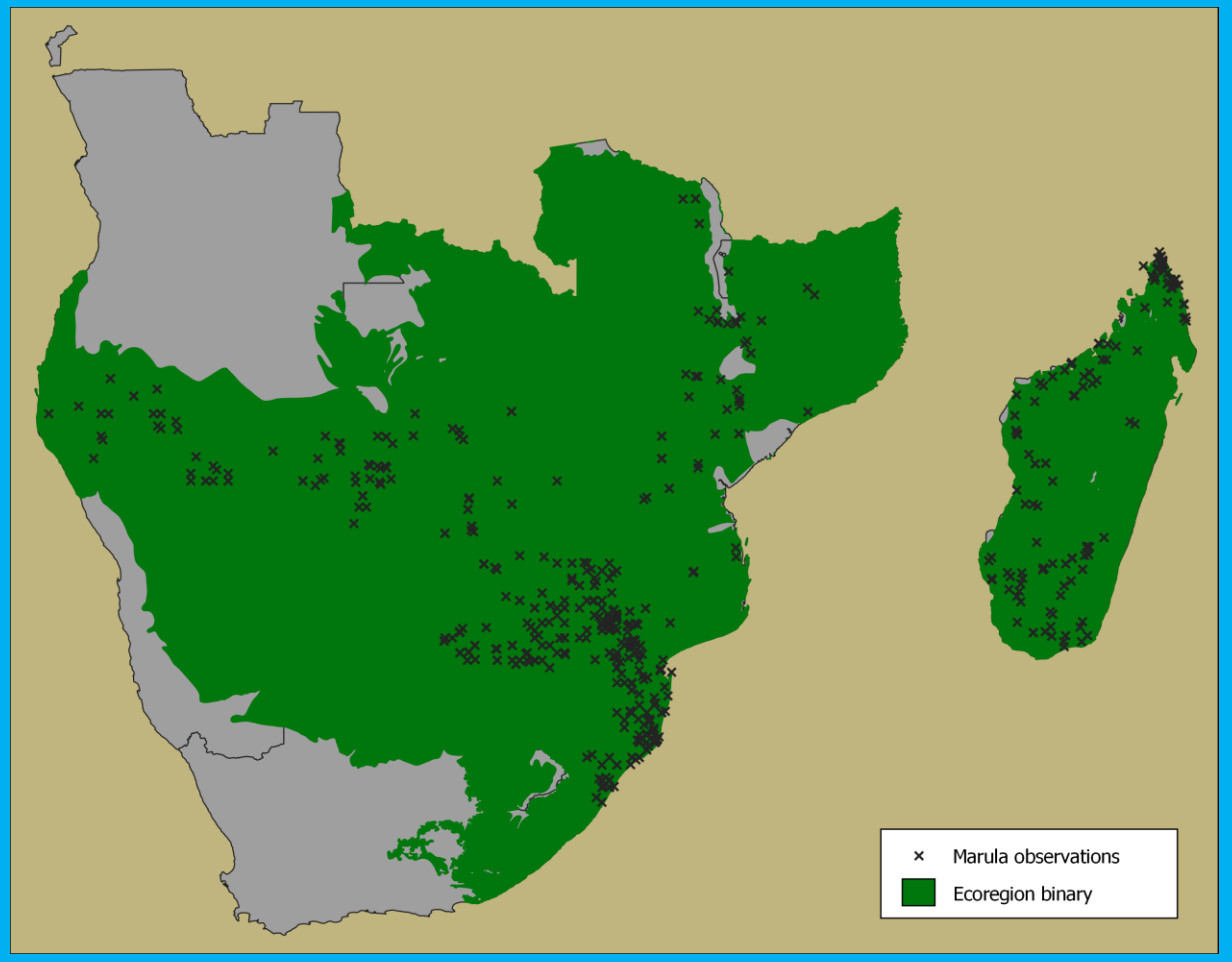
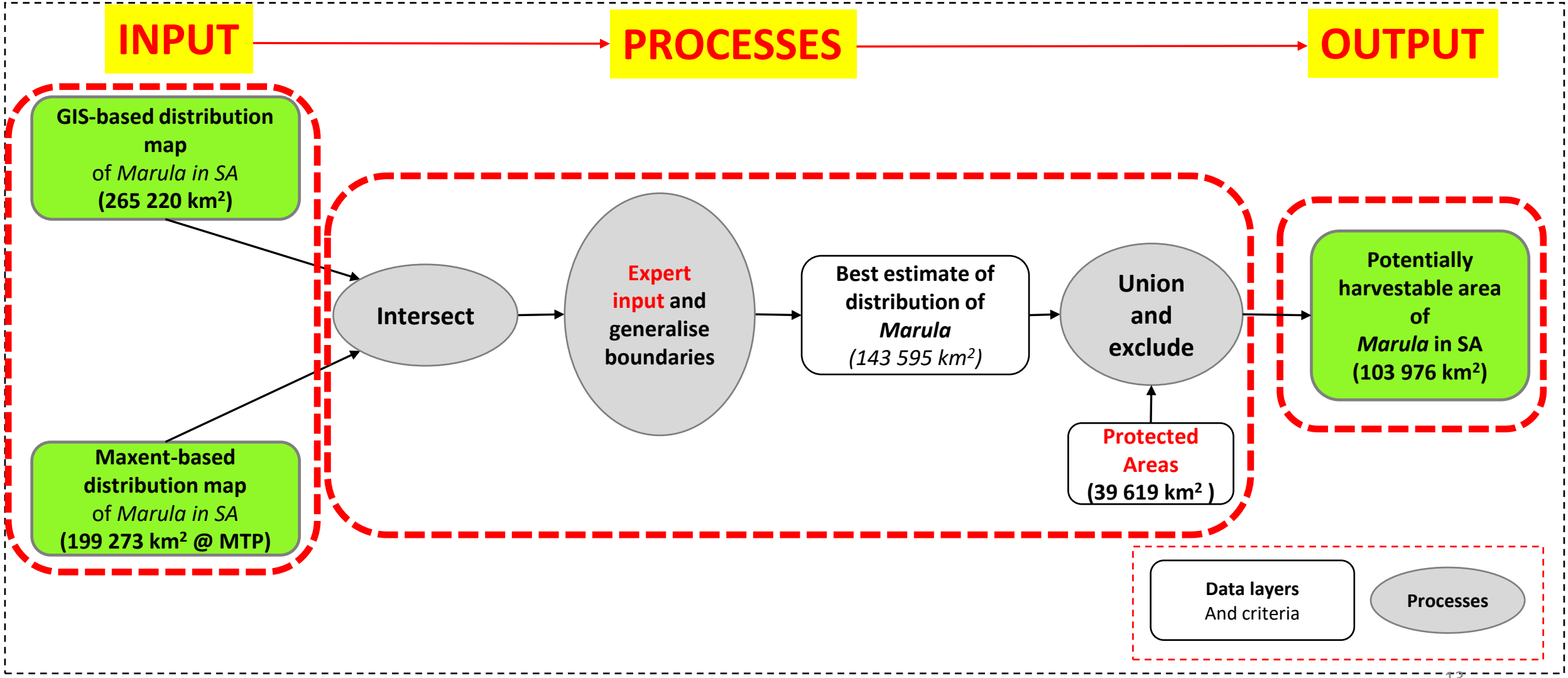


Figure 9: WWF Bioregions where Marula occurs

Method 2): Combining result 1a) and b) to get best estimate & potentially harvestable area of *Marula* (SA)



Result 2): National scale mapping

Best estimate of distribution for Marula in SA (SDM, GIS & 'expert' edits)

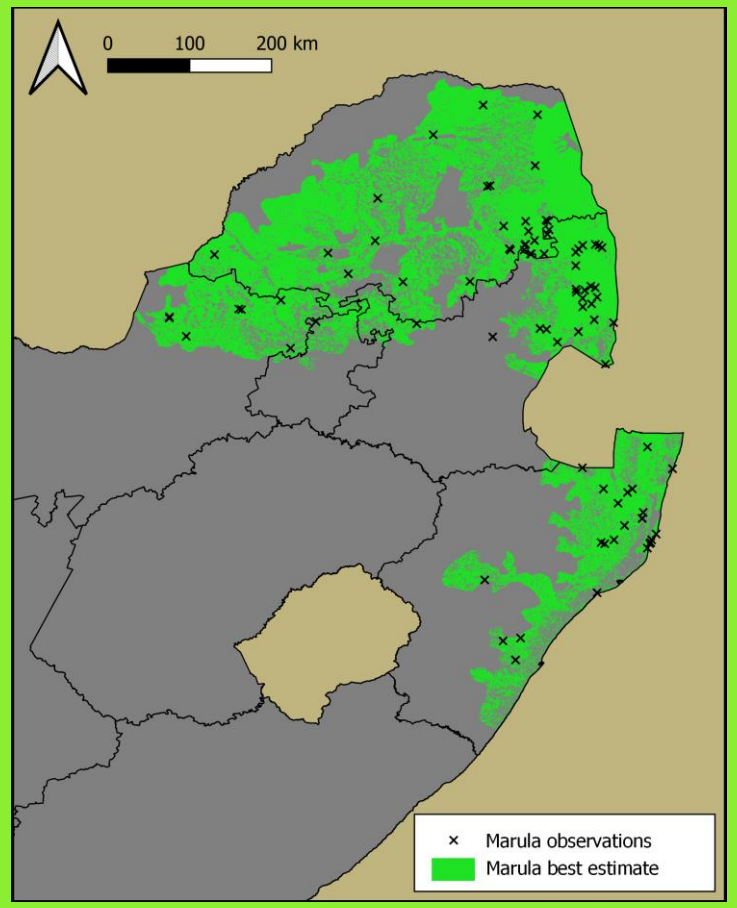


Figure 10: 'Trimmed with 'Expert' input

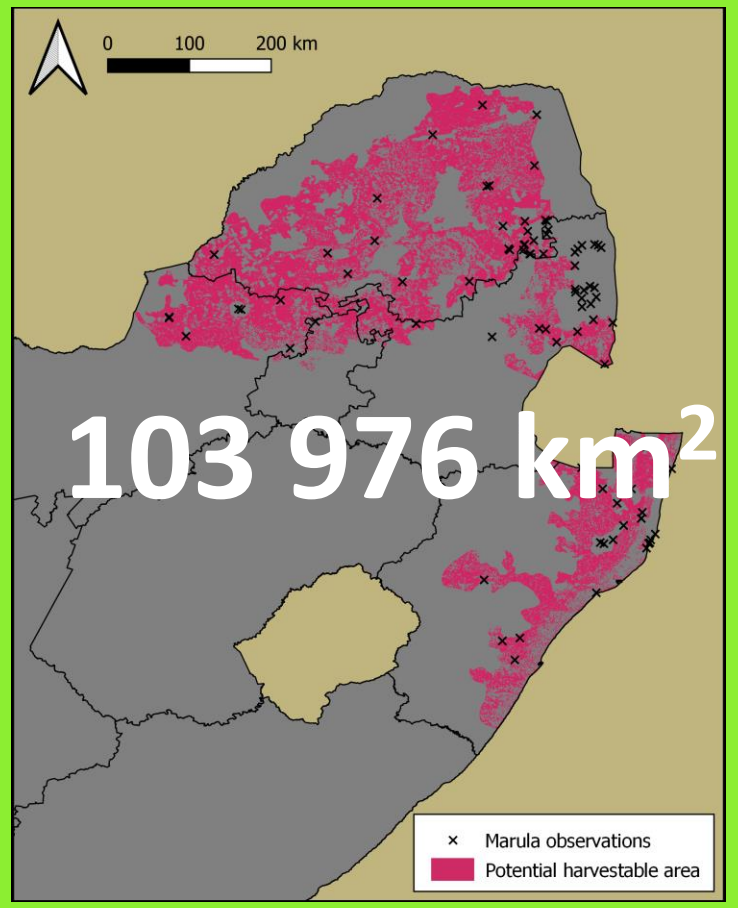


Figure 11: Protected areas excluded to give 'potentially harvestable area' of *Marula*

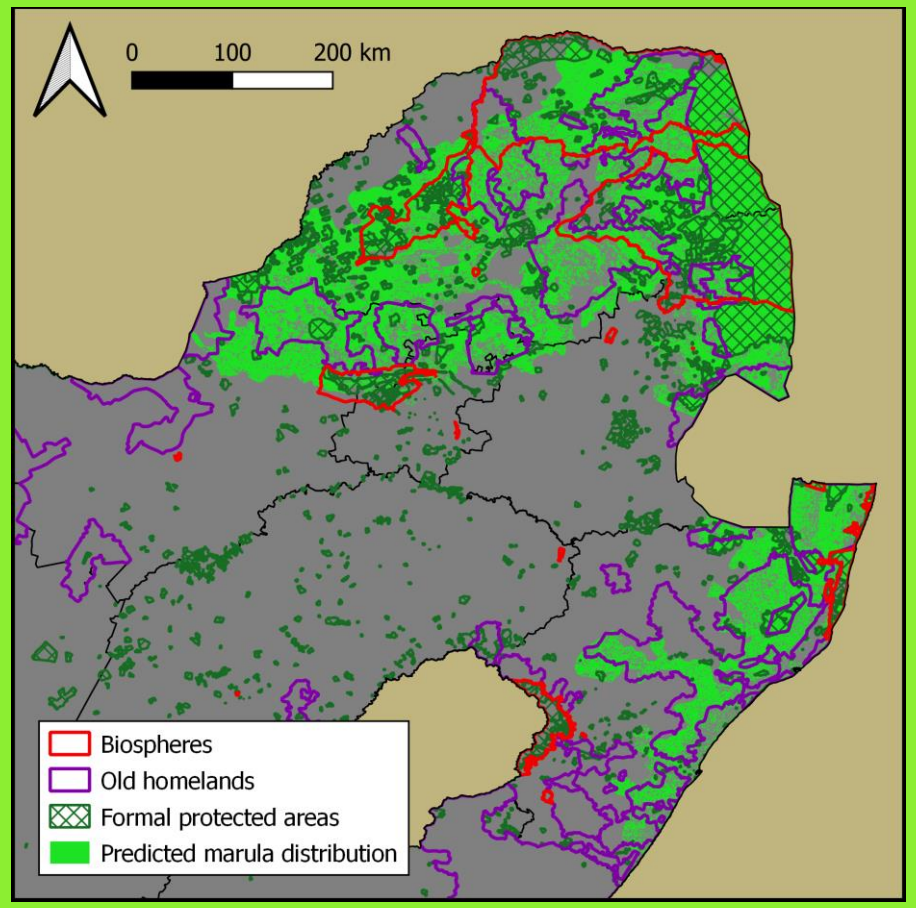


Figure 12: Map of land tenure… potentially useful

Result 1b): Regional scale mapping

Best estimate of regional distribution for Marula combining GIS and SDM (Maxent)

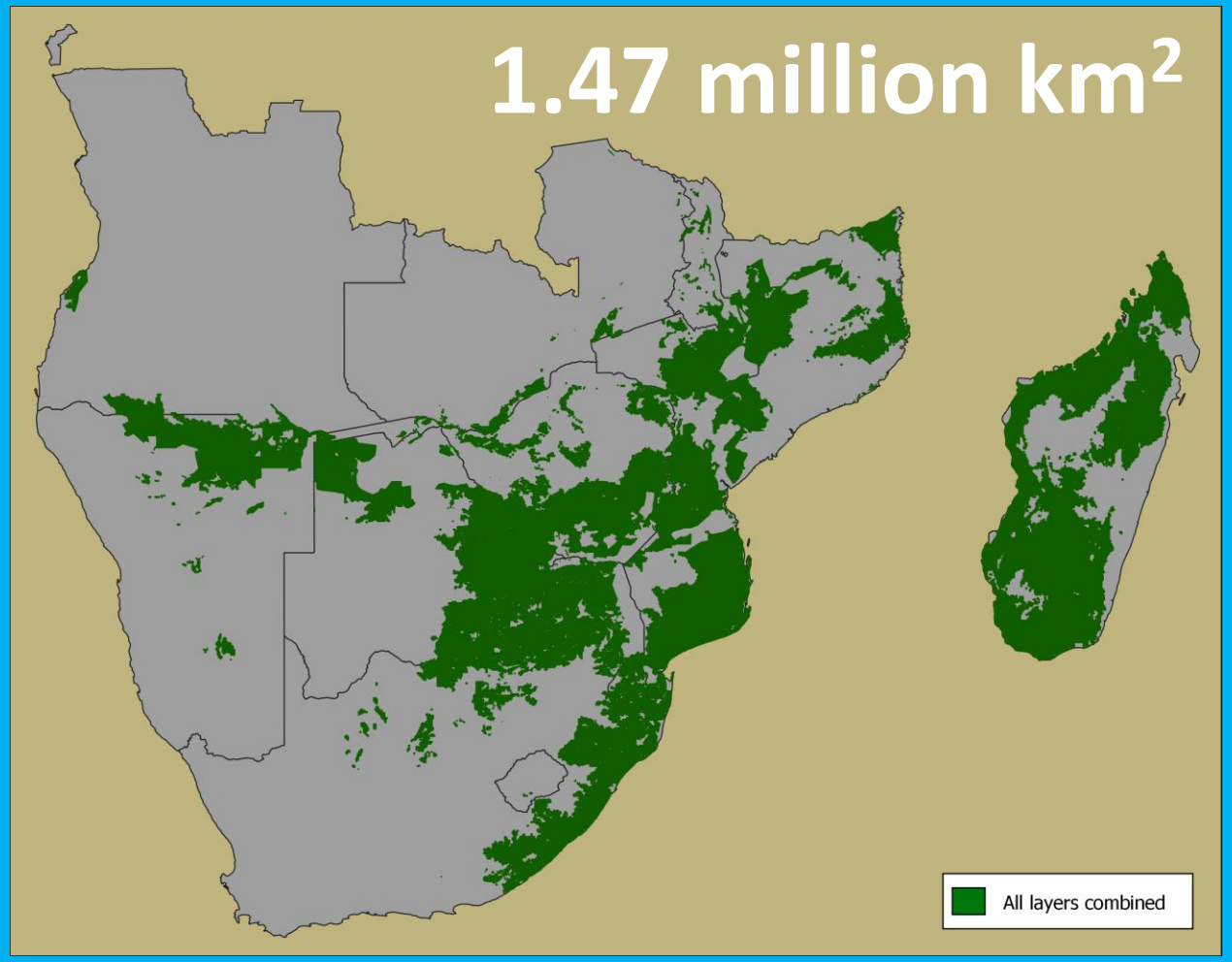


Figure 13: Regional estimate of distribution

*** No 'expert input'**

2: Combined Results

Tree density & yield values (1a) + mapping (1b)

Rainfall zone	Criteria/range	Extrapolated stem count	Extrapolated annual fruit yield* in tonnes
Arid (500 mm)	7 557 km^2 (16%)	12.7 million	150 thousand
Semi-arid (670 mm)	22 991 km^2 (49%)	247 million	6.9 million
Mesic (>850 mm)	16 602 km^2 (35%)	62.5 million	1.05 million
Total	**47 150 km^2**	**332.2 million**	**8.1 million**

Yield based on potentially harvestable area in communal lands (former homelands)

Methods 1b): Local scale mapping examples

David Kinsler, Rhodes University

Types of Image Sources

Satellite imagery

- Varying resolutions (10m – 0.4m)
- Some open source, high resolution usually not
- Multi-spectral

Aerial (aeroplane) imagery

- South African GSD imagery (free)
- Tasked flights (expensive)

Drone imagery

- Relatively cost-effective
- Ultra high resolution (>2cm)
- Can be multi-spectral
- Limited area coverage

Planet Scope Dove Satellite

Sentinel-2

WorldView-2

DJI multi-spectral drone

Results 1b): Local scale mapping examples

Manual digitising

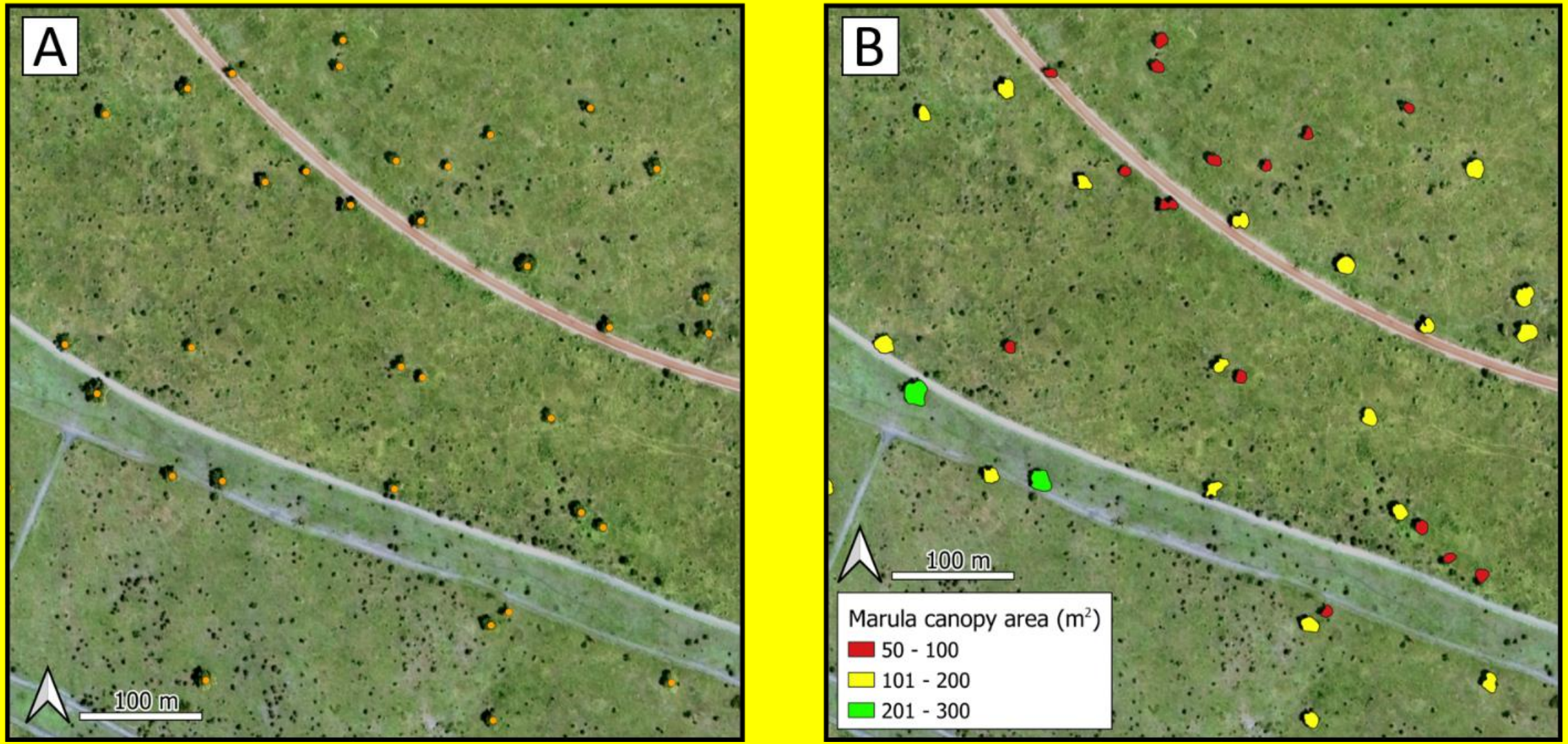


Figure 15: Worldview-2 Imagery, central Kruger Park, South Africa

Results 1b): Local scale mapping examples

Image classification: e.g. Unsupervised Classification

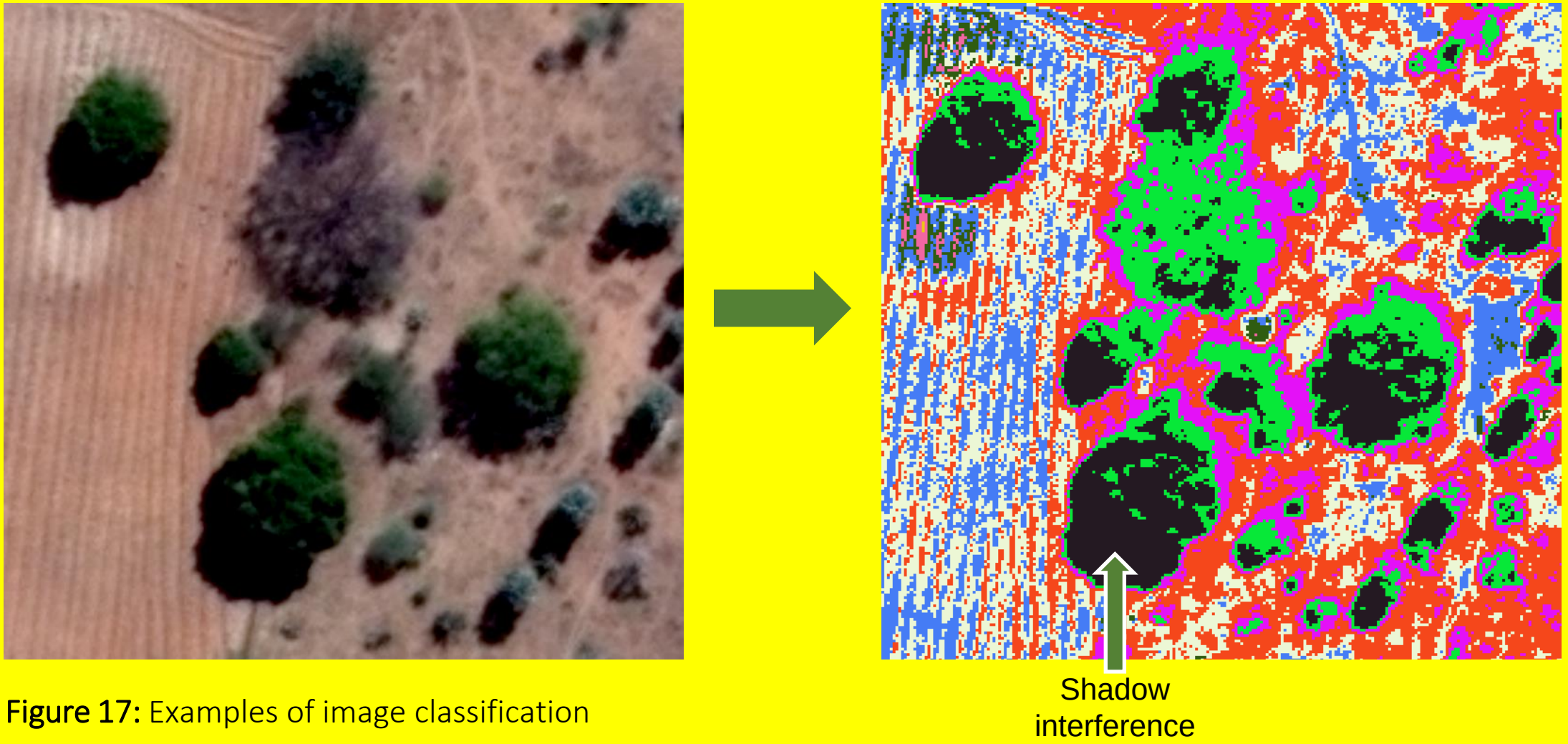


Figure 17: Examples of image classification

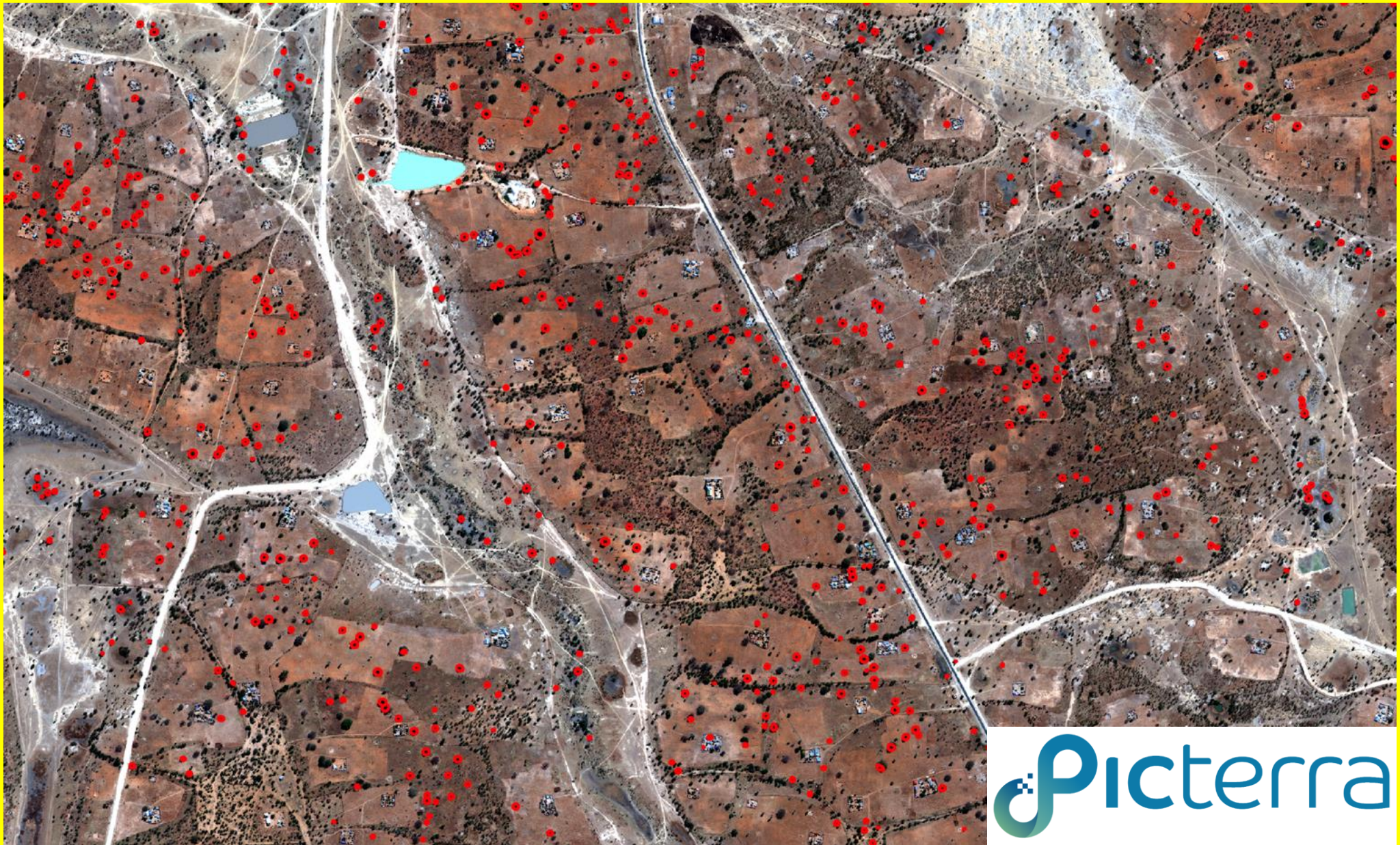
Results 1b): Local scale mapping examples

Image classification (object detection)

Figure 18: Examples of object detection

Results 1b): Local scale mapping examples
Object detection

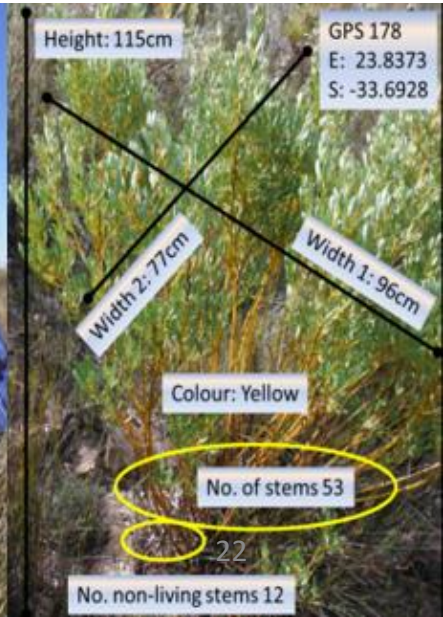
Figure 19: Examples of object detection with ‘Picterra’



In support of all methods described

Field-based surveys, ground-truthing, verification, certainty

- Ground-truthing of desktop-based analyses is required to verify results
- Accurate reference data is needed to ‘train’ models, and improve accuracy
- Some species - can only be accurately mapped by field surveys
- Field surveys will still be required to do a ‘full’ resource assessment yielding reliable results



3. Method: Developing an approach to monitoring (For SA, all species)

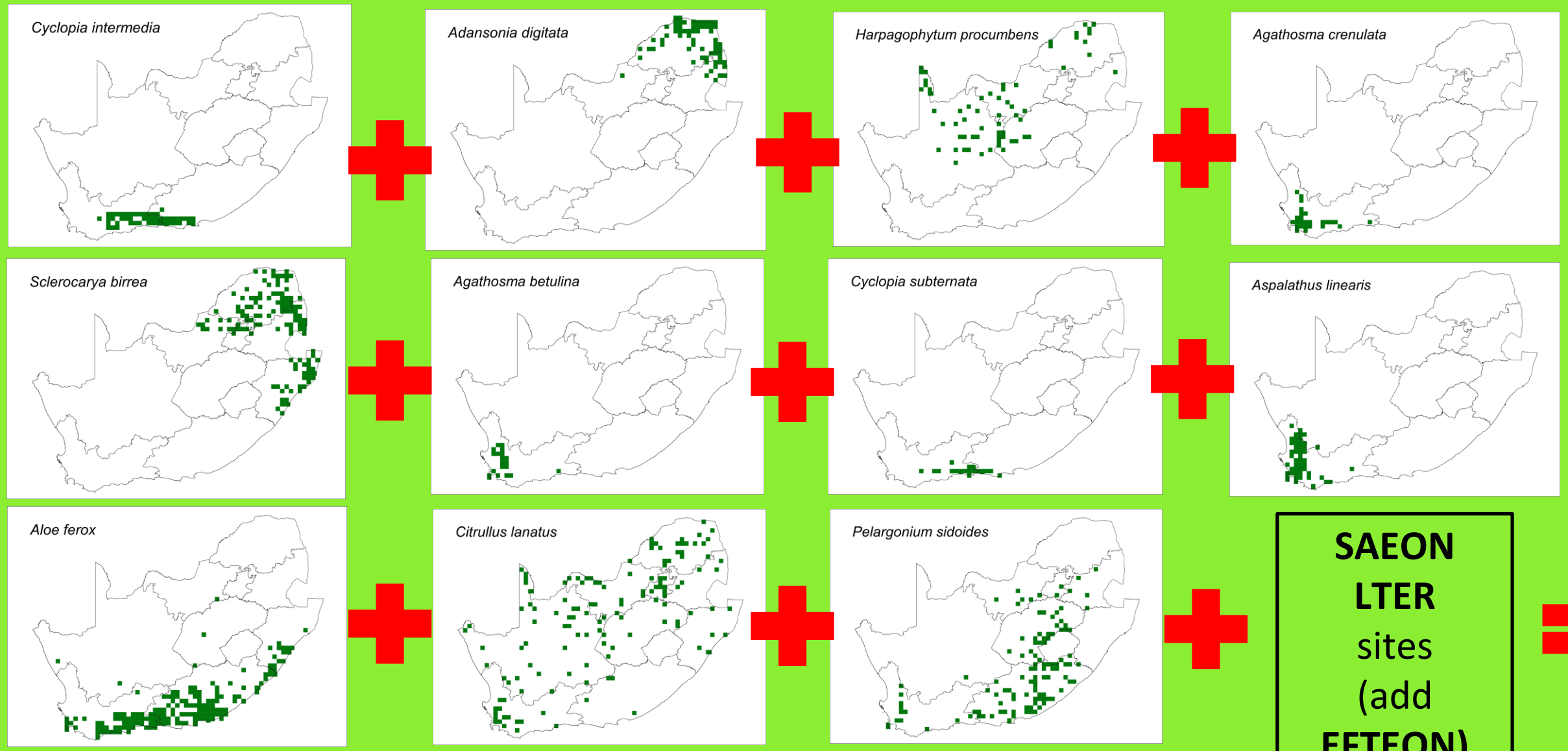


Figure 20: Species maps for identifying monitoring sites

3. Result: Developing an approach to monitoring

For SA – all species overlaps and SAEON LTER sites

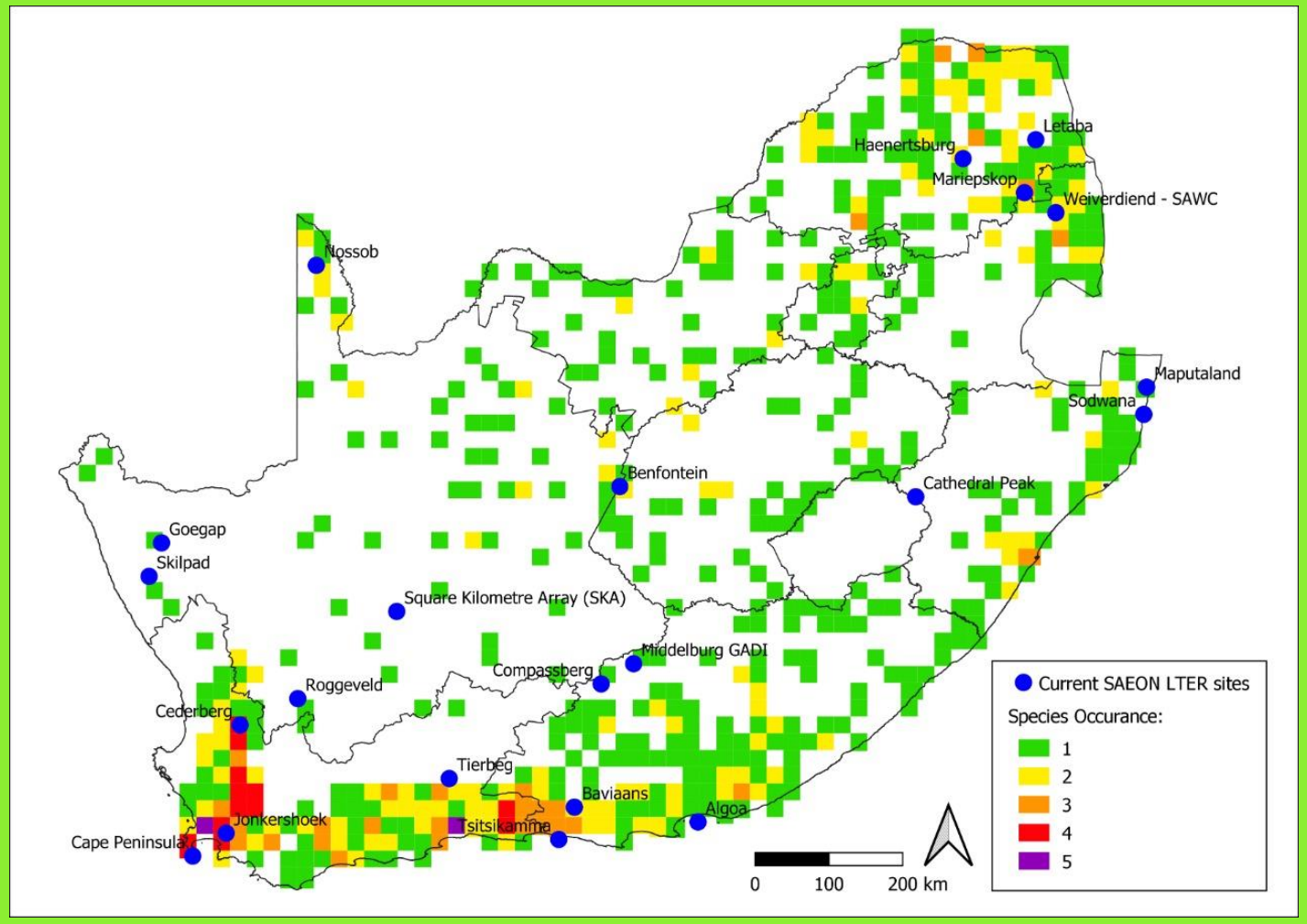


Figure 21: Potential sites for monitoring in SA

3. Result: Developing an approach to monitoring

Identifying potential regional monitoring sites for Marula

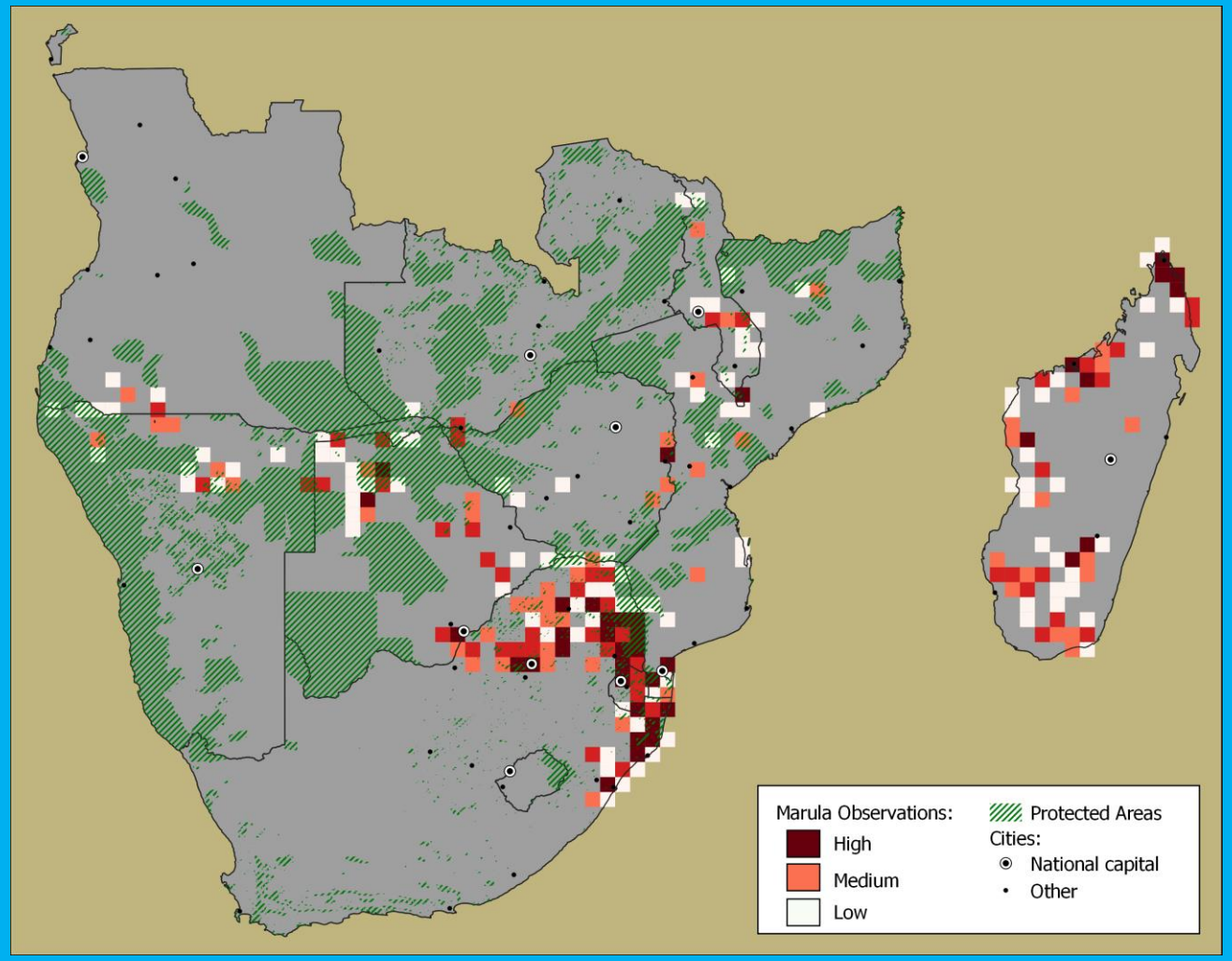


Figure 22: Potential sites for monitoring in the Region

4. Concluding comments

Principles of a GIS based approach to resource assessment and monitoring

1. There are many suitable resources available that can contribute towards a methodical and rigorous GIS based desktop approach
2. Aim to use repeatable and reputable methods/tools/software at national and regional scale as a starting point for distribution mapping, eg: SDM and GIS based MCS
3. National scale assessments can be carried out in greater detail depending on availability of suitable and accurate spatial data
4. For local scale mapping – there is tremendous potential for desktop method development, which can feed in to national/regional scale
5. ‘Expert knowledge’ can be used for input and refinement at any scale
6. Monitoring site selection should consider species specific requirements, logistics and existing focus areas as well as have a clear aim
7. All of the above must be verified and supported by improved, co-ordinated field data collection across various areas of survey.
8. There is no “…‘recipe book’ of methods, applicable to every situation.” (Cunningham, 2002)

Applied Ethnobotany People, Wild Plant Use and Conservation

“ At one stage, during the long process of writing this manual, it crossed my mind that it would be better to produce a manual on methods which was composed of just one Zen-like sentence: ‘The only method is that there is no method.’ There would have been method in this. In a field as complex as conservation, one cannot hope to produce a ‘recipe book’ of methods, applicable to every situation.” (Cunningham, 2001)

Key References

Cunningham, T., 2001. *Applied Ethnobotany People, Wild Plant Use and Conservation*. Earthscan Publications, London.

De Castro, A., Vlok J., Mcllelan W. 2010. *Field survey of the distribution of Pelargonium sidoides and size of selected sub-populations.* Resource Assessment: study conducted for the South African National Biodiversity Institute.

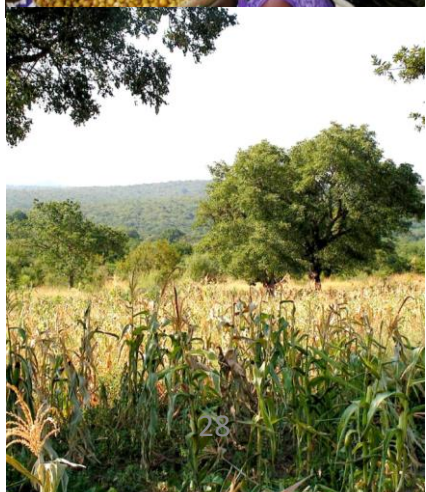
Hall, J.B., O'Brien, E.M., Sinclair, F.L. 2002. *Sclerocarya birrea: a monograph*. School of Agricultural and Forest Sciences, Publication Number 19, University of Wales, Bangor.

McGregor, G.K, 2020. *Unpublished Phd notes*. Rhodes University, Grahamstown

Palmer, T. & Weidemann, C., 2020. *Aloe ferox Resource Assessment.* Biotrack South Africa (Pty) Ltd February 2020. (Project Q6546/2019).

Shackleton, C. M., 2002. Growth and fruit production of *Sclerocarya birrea* in the South African lowveld. *Agroforestry systems*, 55(3), pp.175-180.

Shackleton, S.E., Shackleton, C.M., Cunningham, T., Lombard, C., Sullivan, C.A. and Netshiluvhi, T.R., 2002. Knowledge on *Sclerocarya birrea subsp. caffra* with emphasis on its importance as a non-timber forest product in south and southern Africa: a summary: part 1: taxonomy, ecology and role in rural livelihoods. *The Southern African Forestry Journal*, 194(1), pp.27-41.

Photographs

Marula: T. Cunningham, https://safarinear.com/marula-fruit/ ; https://www.southafrica.net/gl/en/travel/article/amarula-marula-tree-magic
Aloe: https://aneasterncapeperspective.wordpress.com/2017/04/07/what-about-the-eastern-cape/
Pelargonium: www.kumbaluNursery
Honeybush: G.K.McGregor