National resource assessment and monitoring programmes for bio-traded species: evaluations and recommendations

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Aims

1. Review of national scale resource assessments
2. Profiling target species*.
3. Describe principles and approach's for national scale resource assessments.

*Target species : Honeybush (2 spp.) , Rooibos, Pelargonium sidoides , Marula, Baobab, Buchu (*Agathosma betulina* and *A. crenulata*), Devils claw , Kalahari melon and Aloe ferox

Outline of presentation

- **PART 1. WHAT DO WE KNOW ABOUT THE STATUS OF BIOTRADED PLANTS ?**
- **PART 2. HOW DO WE KNOW HOW MUCH IS OUT THERE ?**
- **PART 3. KEY ISSUES AND PRINCIPLES IN RAs**
- **PART 4. CONCLUDING REMARKS**

PART 1: WHAT DO WE KNOW ?

THE STATUS OF BIOTRADED PLANTS

(with reference to sustainability)

Method: Literature reviews and expert interviews

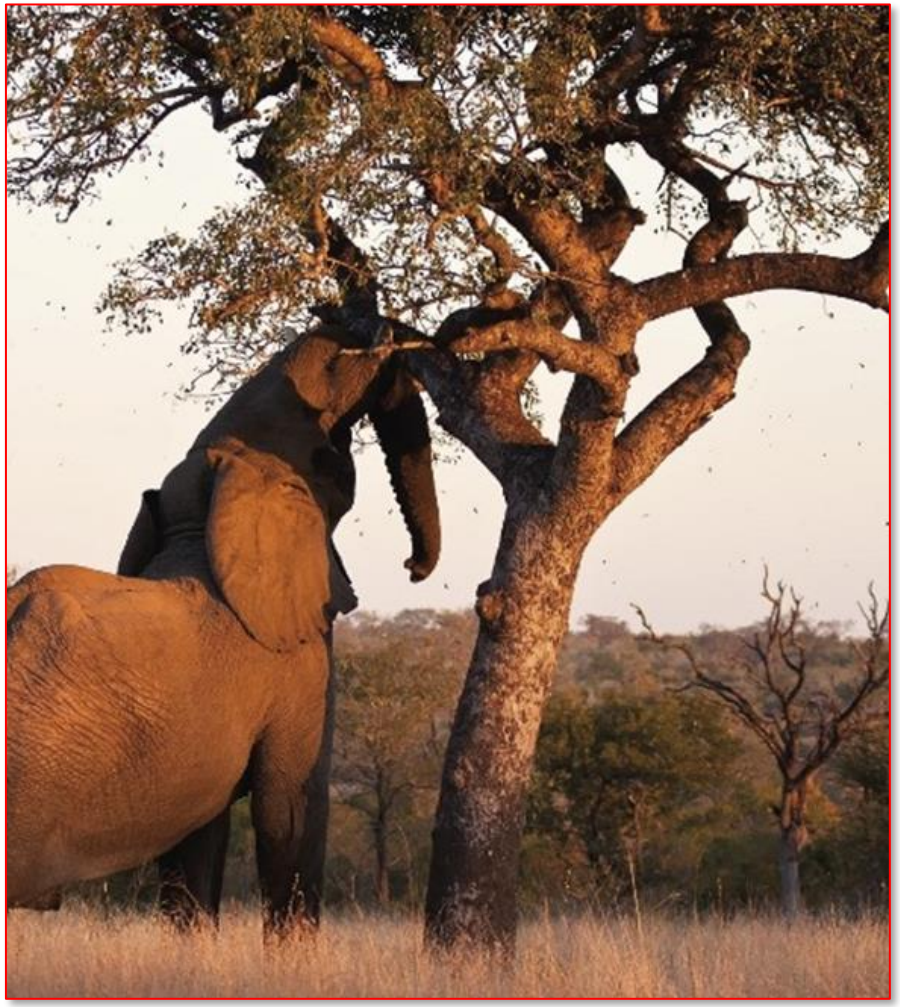
Species profiles

- Yields
- Productivity
- Population trends
- Threats
- etc..

Species resource assessments

- What has been done **?**
- Can these be used as a base line ?
- Impact of harvesting & Sustainability

Species profiles



Data categories	Data Fields
Species life history	Life form
	Reproductive type
	Age at first fruiting
	Yield of harvested part per plant (and per ha) or per year
	Propagation
	Domestication and cultivation
	Pattern of distribution
	Ecological role
Use	Part used
	Harvesting techniques and frequency
Management	Management Plans
	Studies on Harvesting pressure (legal and illegal)
	Studies to determine Sustainable Harvest Levels/ harvest guidelines
	Current monitoring
Conservation	Threats /drivers of change
	Trends over last ten years
	Status (red listed/CITES/NDF)
	Ecological Experts
Institutional aspects	Key actors and mandates (Gov, Industry, NGO)
	Projects /networks
	Certification

Baobab profile

- Long lived (>2000yrs.)
- Age at first fruiting : 100-200 yrs.
- Sustainable harvesting between 33-90% of total fruit (Venter, 2012)
- Threats: Poor or no recruitment with livestock
- Trends: (uncertain), very poor recruitment , possible impact of climate change on old trees

National resource assessments

No national, some local scale in southern Africa
Review of methods used and results

Species resource assessments: tables summarising literature (e.g. Aloe ferox)

Location	Part used	Scale of assessment	Aims & Method	Results/findings	Reference
South Africa	Leaves	National	Estimated from distribution records	The species is estimated to extend across an area of 10 000km2	Donaldson (1989)
South Africa/global		National/global trade	Estimate the amount of Aloe ferox currently being harvested and traded.	Discrepancies between reported export trade and imported. (1994 and 2003), over 3000 t	TRAFFIC, (2006)
South Africa	Leaves	National	map the current distribution and abundance of Aloe ferox occurrence, temperature.	Current harvesting levels do not seem to have impacted negatively Probability of occurrence only	DEA, 2014
South Africa		National	Map the distribution; field surveys to estimate relative density. Drivers of change	Preliminary results include: Identification of monitoring sites , density, drivers of change	Palmer and Weideman (2020) (Work in progress)

National resource assessments: are they available for the target species and can they be used as a **baseline** ?

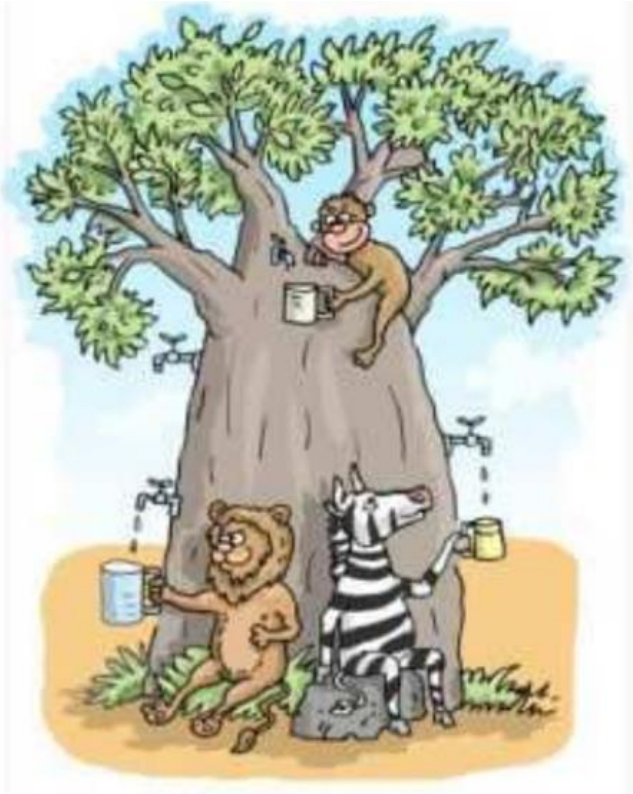
Species	National RA available	Can this be used as baseline	Good data on optimal levels harvesting	Understanding of impact of harvesting & threats	Biodiversity management plans	Non detriment finding study	Extent of Cultivation
Aloe Ferox	yes	yes	yes	yes	In development	yes	All wild
Baobab	no	no	yes	yes	no	no	All wild
Marula	Yes	no (?)	yes	yes	no	no	All wild
Buchu (A. betulina)	no	no	yes	yes	No	no	Most wild
Buchu (A. crenulate)	no	no	No	No	No	no	Most wild
P. sidoides	yes	maybe	yes	Yes	yes	yes	most wild
Kalahari melon	no	no	Yes	Yes	No	no	Wild and cultivated
Devils claw	yes	Yes	yes	yes	no	no	Most wild harvested Cultivation. increasing
Rooibos	Yes	?	yes	yes	no	no	Almost all cultivated
Honey bush	yes ?	Many species ?	yes	Yes	In development	Yes (?)	75% wild harvested.

Threats and drivers of change for targets species

Summed threat score

Threats	Aloe Ferox	Baobab	Marula	P. sideroides	Net score
Habitat loss and conversion	2	1	2	2	7
Legal resource use/overharvesting?	2	1	2	2	7
Livestock trampling and overgrazing	2	2	1	2	7
Wild herbivores	2	2	2	1	7
Illegal harvesting unpermitted	2	1	1	2	6
Climate change related	2	2	1	1	6
Increase in fire frequency/intensity	2	0	1	1	4
Bush encroachment	2	0	1	1	4
Other wildlife (baboons etc)	1	2	0	1	4
Diseases, pathogens	1	1	0	1	3
Threats to pollinators	0	2	1	0	3
Invasive alien species	1	0	0	1	2
Soil erosion, sedimentation	1	0	0	1	2
Subsistence/small scale use	0	0	0	1	1
Introduced genetic material	0	0	0	0	0

Scores: 0= not indicated, 1= potential, 2= significant , 3 =major



Functional species groups for monitoring ?

Species	Life form /size	Longevity (years)	Reproduction	Distribution	Resilience to overharvesting
Marula	Tree	100-200	Seeds	Scattered wide	High
Baobab	Tree	500-2500	Seeds	Scattered wide	High
Aloe ferox	Small tree	10-20 (?)	Seeds/shoots	Clumped /wide	High -medium
Honeybush C. intermedia C. subternata	shrub	5-10 (?) 30 Fire interval dependent	 Resprouter Reseeder	 Clumped/wide Clumped/localised	 Medium Low
Buchu	Small shrub	5-10 (?)	Seeds	Clumped/ localised	Medium
Pelargonium	Small shrub	5-10 (?)	Roots and seeds	Scattered /localised	Medium -low
Rooibos	Small shrub	5-10 (?)	Seeds	Production mainly from cultivated plants.	High –medium (wild populations)
Devils claw	Creeper	2-5 (?)	tubers and seed	Clumped localised	Medium -low
Kalahari melon	Creeper	Annual	Seeds	Production based on cultivation	Low

Suggested ‘monitoring groups’ with potential implications

Group	Species	Implications for monitoring
1. Large long-lived trees, widely distributed and scattered	Baobab, Marula	Remote sensing, modelling with ground truthing of sample sites & bark damage assessments in permanent plots
2. Small trees, clumped and widely distributed	Aloe ferox	Integration of monitoring across all scales
3. Small shrubs, localised, scattered or clumped. Cultivation a key factor	Honeybush Buchu Rooibos	Representative ground-based monitoring only. Stratified ground-based monitoring of wild harvested populations. Consider involving harvester collectives
4. Small tuberous, herbaceous plant, low densities (roots harvested)	Pelargonium sidiodes	Essentially ground based monitoring Permanent plots. Comparison between heavily harvested vs unharvested. Low density (0.3 – 1 plant per m2 in areas where this species occurs).
5. Low growing tuberous creepers localised, mainly wild harvest (of tubers)	Devils claw	Localised ground-based monitoring only (recording if primary tubers are taken as well as secondary tubers). Note that growth/population dynamics is best in disturbed sandy areas & reduces with bush encroachment
6. Low growing annual, extensively cultivated.	Kalahari melon	Many varieties with different uses recognised by local farmers. Need to consider the need to monitor given reliance on cultivation as an annual crop.

Can functional groups be used to predict resilience to overharvesting, time scales to detect change ect.

Short –lived Shrubs roots/tubers harvested

decreased

Resilience to over-harvesting. Time scales to detect change. Ability to use remote sensing .

Increased

Long lived trees Fruits harvested

Comments on the review of national resource assessments

- There is a general lack of robust data on the national population stocks, trends and sustainability for most species reviewed

- Three species with good RA s could be used as a baseline for future monitoring (P*elargonium sidoides, Aloe ferox,* Devils claw)

- Several good studies at local scales for most target species (e.g. Baobab, Marula).

- Increase trend for cultivation for some species (Rooibos, Honey bush, Buchu)

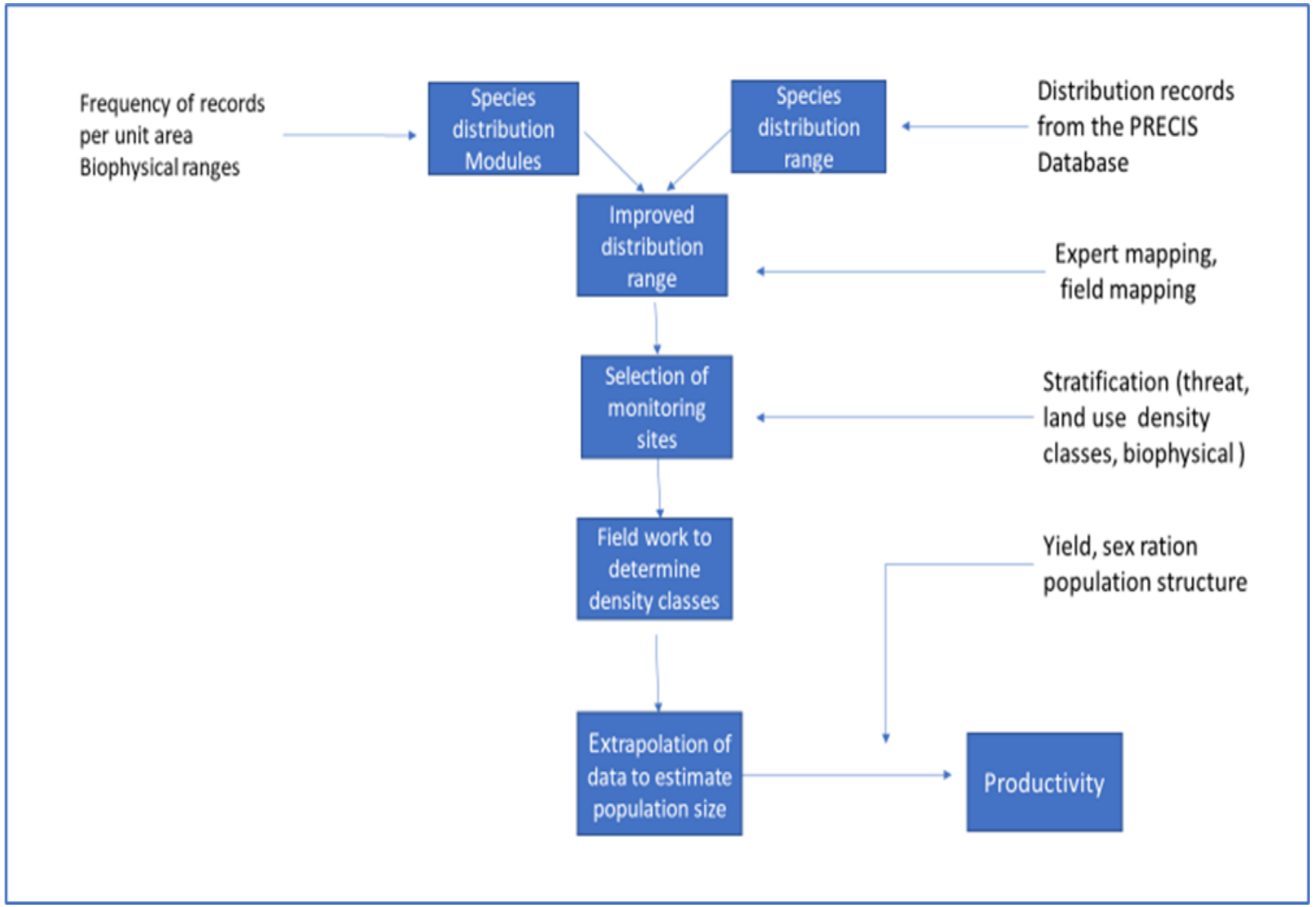
- Recruitment rates for the two long lives species are poor

PART 2: HOW MUCH IS OUT THERE ?

Unlike sheep our resource is wild widespread, scattered, embedded amongst other vegetation, with uncertain distribution, and mostly not visible from the air (similarities to monitoring fish stocks ?)

Taking stock: how do we count the sheep?

Can we identify generalised steps in developing a resource assessment & monitoring programme for a target species ?



RA 101

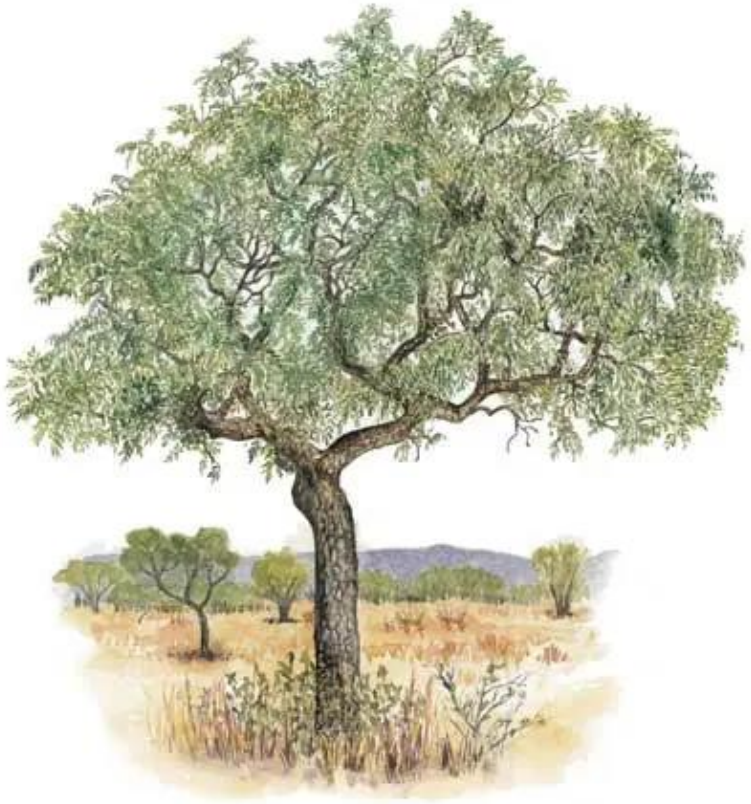
Generalised steps of resource assessments

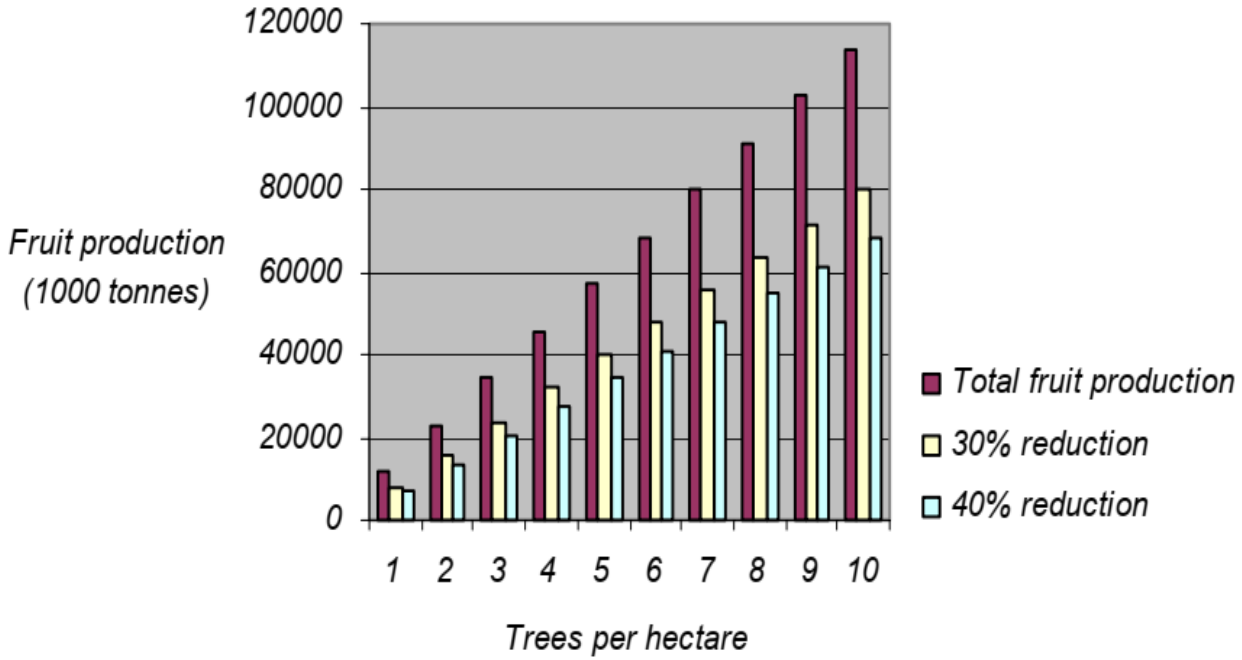
- From species distribution records, map target species (existing records)
- Model distribution using correlations with environmental variables with distribution records
- Expert mapping to review modelled distribution
- Improve distribution map
- Develop a species density model based on existing field work and data
- Stratification of species distribution map based on density , land use , and harvesting pressure
- Select permanent monitoring sites
- Ground based monitoring
- Revised density model
- Approximate total population size

Generalised steps, methods and scales of resource assessments

Objectives	Methods	Scale
Determine distribution range	SANBI data bases (GBIF, PRECIS Database, National Herbarium) Other records from industry Expert mapping	Macro
Develop species distribution models	Frequency of records per unit area MAXENT probability of occurrence, see below)	Macro
Improved distribution range based on secondary data analysis	Analysis of data from expert mapping and field mapping	Macro and Integration of scales
Selection of monitoring supersites	First order stratification based on of land use/land tenure classes, or alternatively density classes	Meso (landscape)
Selection of monitoring sites within supersite	Randomized , or use second order stratification using a) harvesting pressure , or b) drivers of change (e.g. grazing gradient)	Meso/Micro
Monitoring of sample sites	Ground based and/or remotely sensed (experimental design for adequate replication and statistical significance, avoiding pseudo replication)	Micro (ground)
Extrapolation of data from transects to estimate population densities and overall population size	Using ground data to calibrate GIS model to calibre high, medium, low densities across all distribution range Include: harvest records	Integration of scales

Modelling Marula production from **tree density**

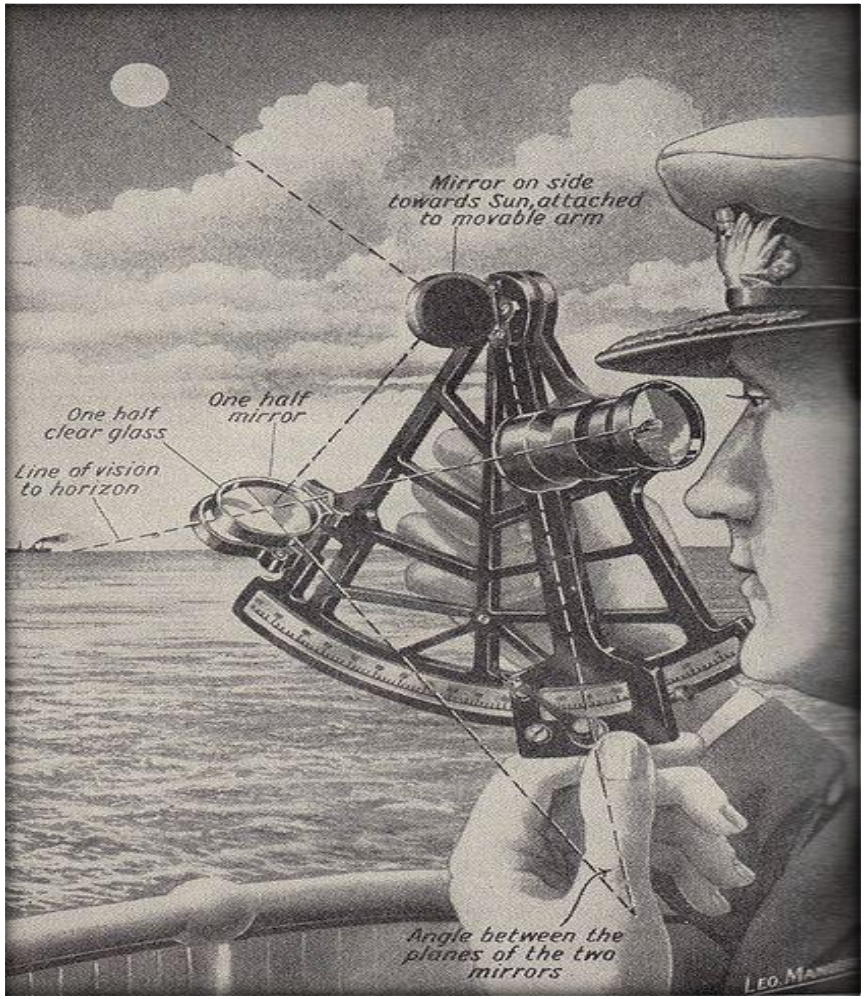




Locality	MAR (mm)	Density	
		Stems/ha	%
Arid	500	16.8	0.3
Semi-arid	670	107.5	1.9
Mesic	> 850	37.7	0.2

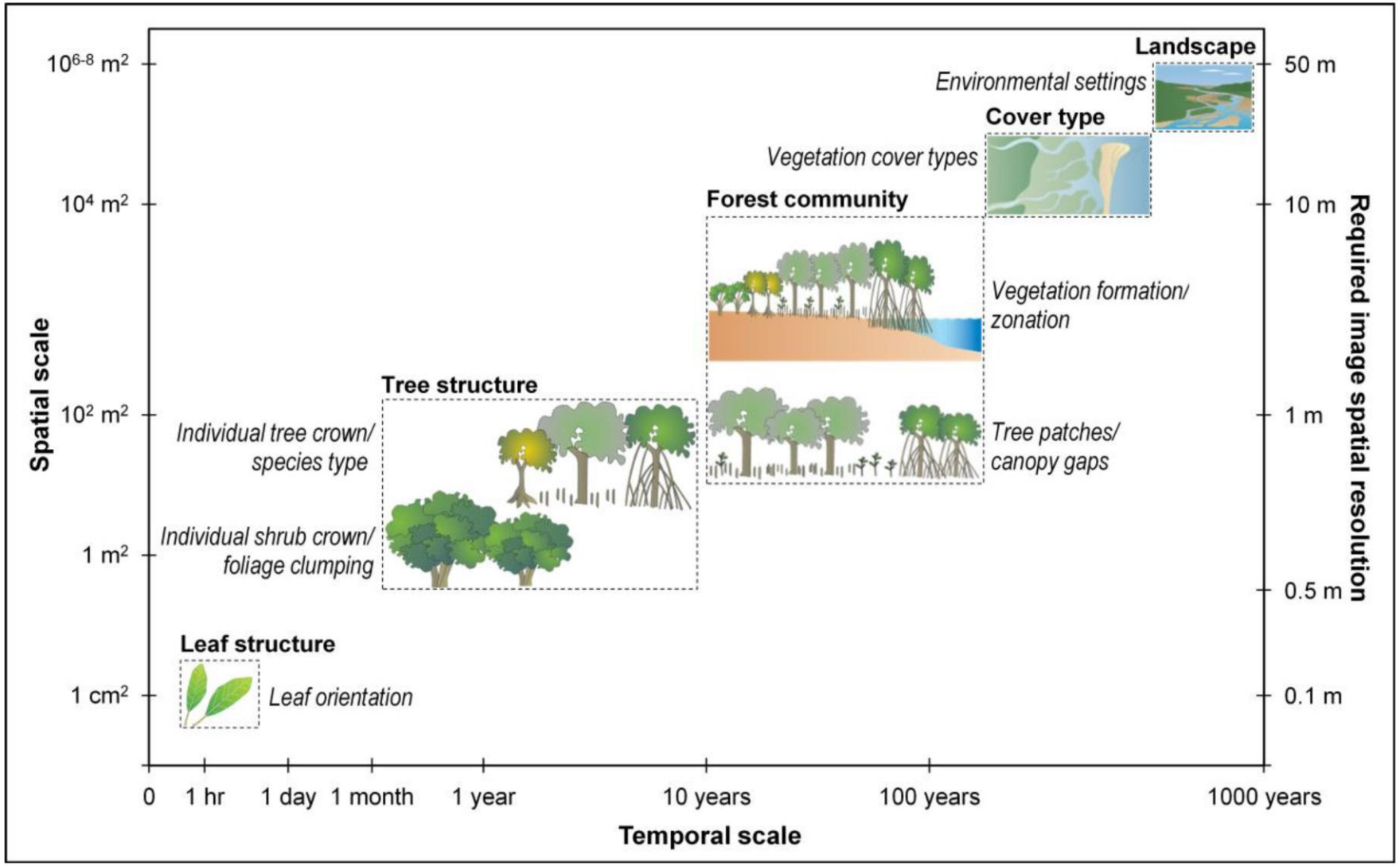
Shackleton (1997)

PART 3: KEY ISSUES AND PRINCIPLES



Monitoring across multiple scales

- Different information at different scales. Integration between scales.
- Use of appropriate tools at each scale



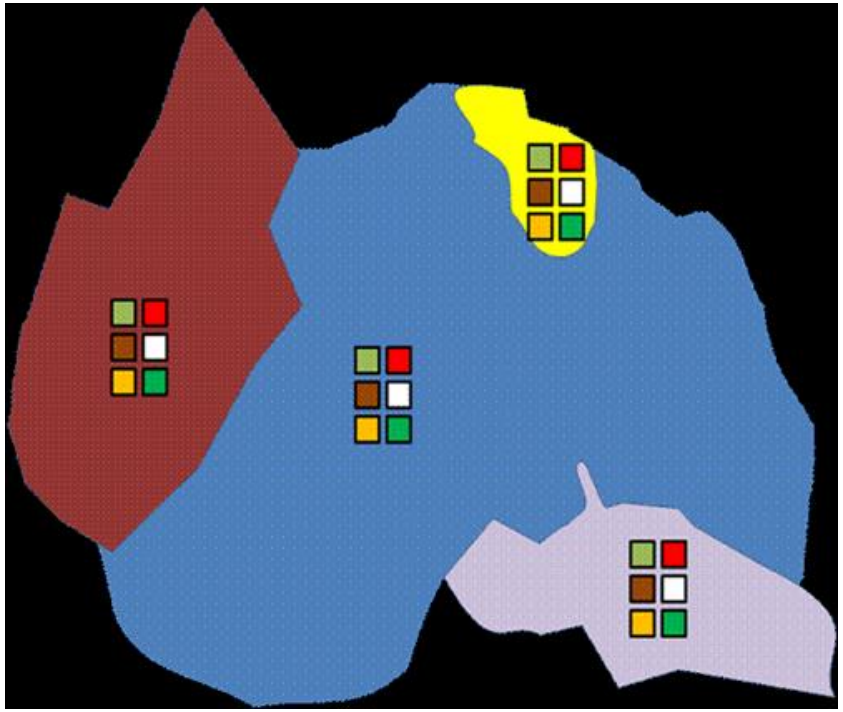
Implication of scale of monitoring

Spatial Scale	Time scale	Key tools	Who?	Administrative scale	Key limitations	Main advantages
Local	Annual, bi-annual	Sample plots/transects	Community Research NGO Industry boards/collectives	Community, village Forest section	Limited samples size, time consuming	Easy to replicate Additional data collected as well such as impact yield Suitable for small species
Landscape	2-5 years	Areal imagery, drones, google earth, road counts, LADAR	Local Government researchers NGOS	Forest management unit, local community, district administration	May require ground truthing Only certain species detectable	Habitat condition, landscape process analysis (erosion, overgrazing)
Regional/national	5 years +	Satellite imagery, GIS modelling (Max ENT)	National government SOE's researchers NGOS	Provincial, national, regional	May only be feasible for certain species (trees or clumped distribution). Requires ground truthing. Absolute determination may not be possible.	Possible to develop national level standardised methods. For policy formulation, national quotas, trade agreements.

Accounting for known driving variables in experimental design

- Typically known drivers of change will be harvesting pressure, land use pressure, climate change

- Stratification of monitoring sites based on driving variables

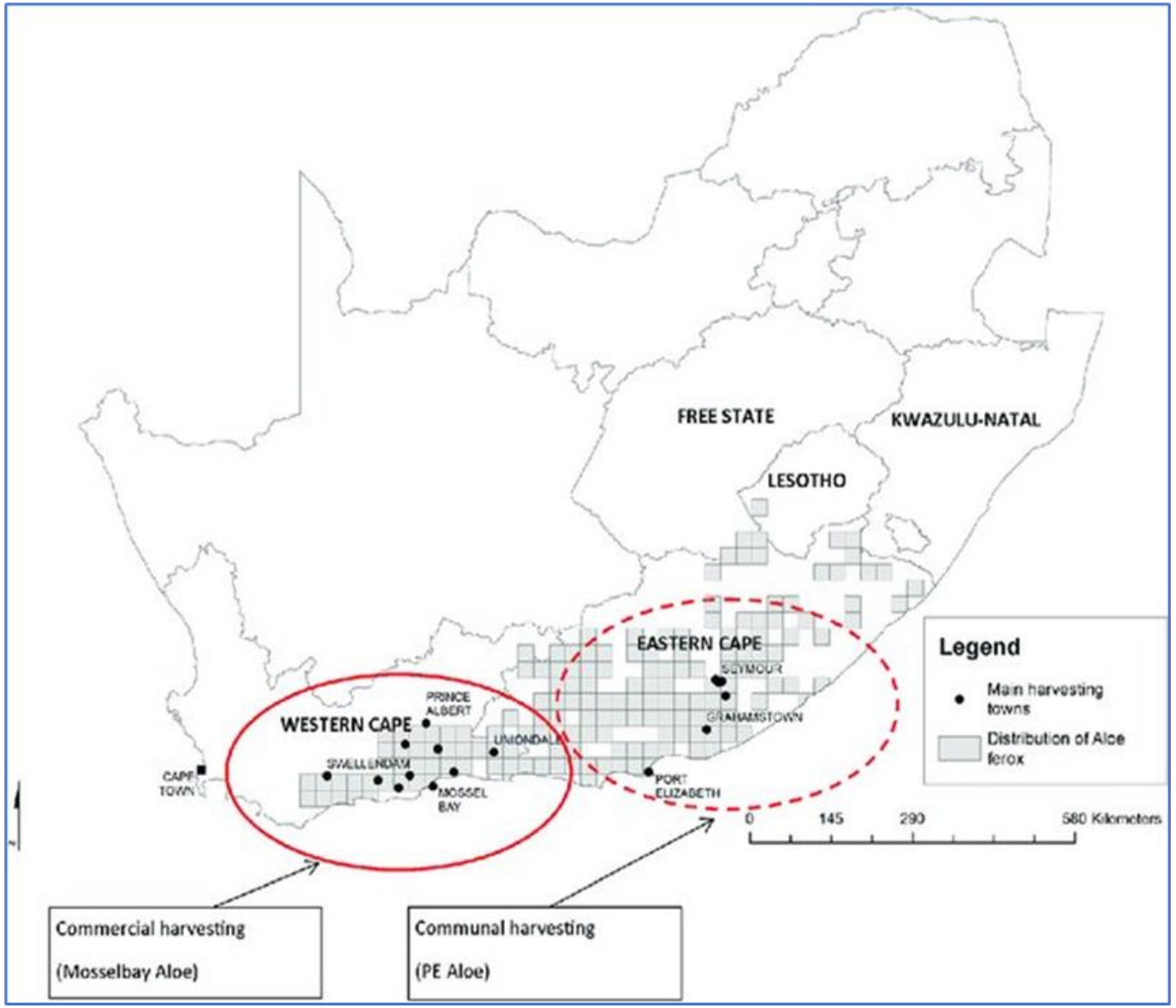


Hypothetical stratification of study area for allocation of motoring plots

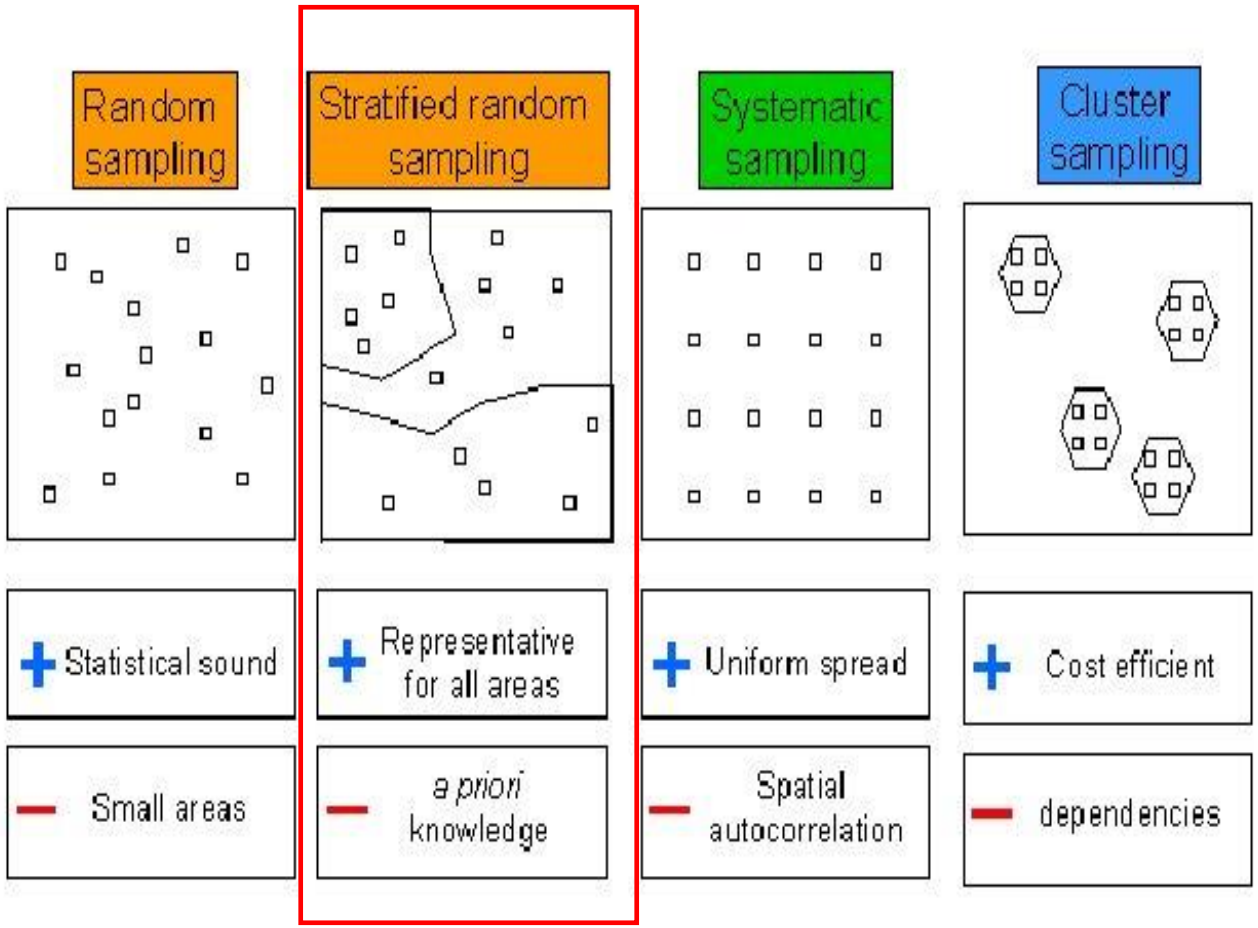
What is stratification?

Stratified sampling involves the division of the target population into known (a priori) smaller sub-groups with shared characteristics

For example differences in commercial and communal harvesting of *Aloe ferox*

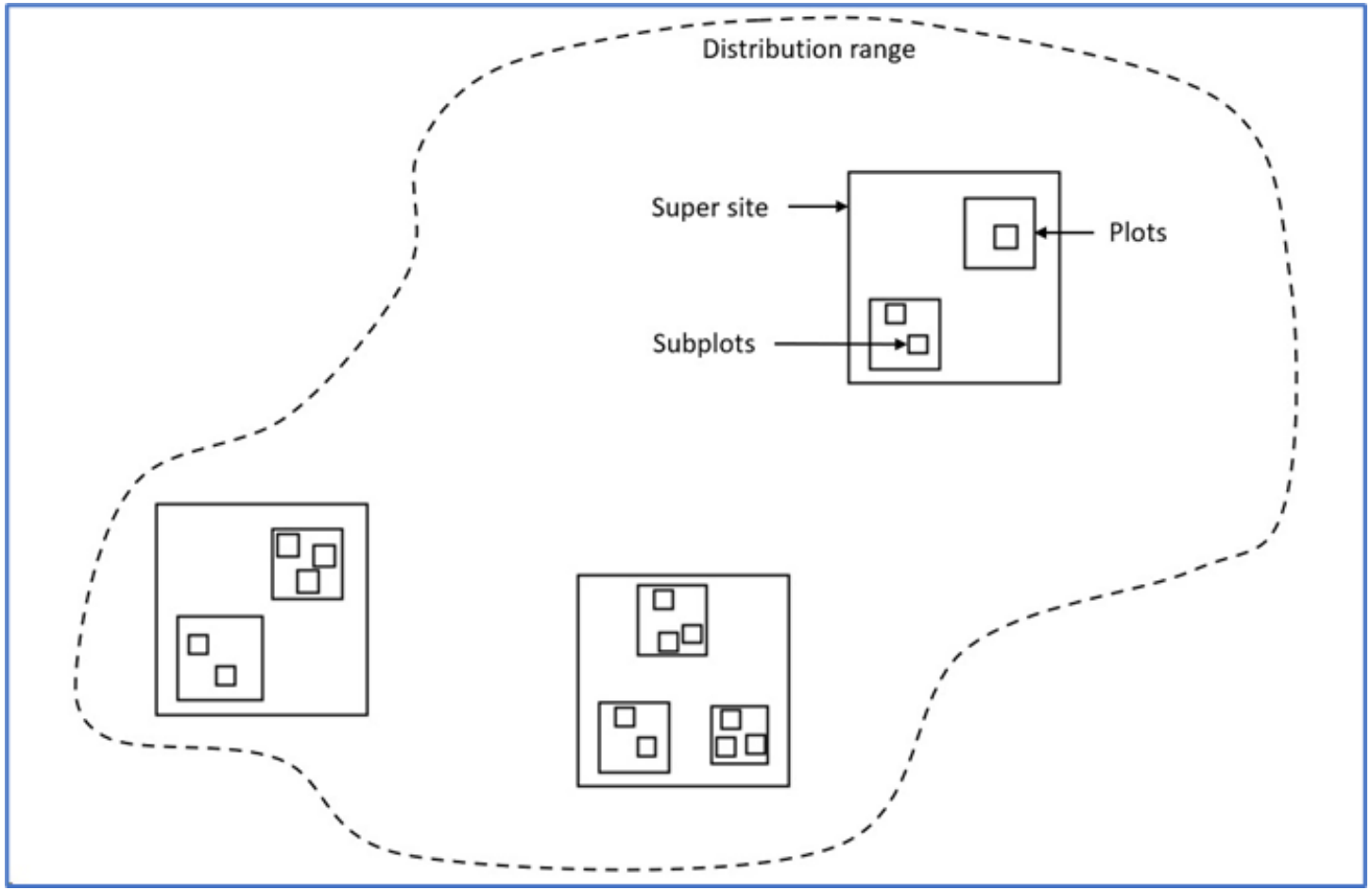


A note on stratified random sampling



Supersites: a multiscale approach to resource monitoring

- Supersites are the largest unit of a nested set of monitoring plots
- Super sites are monitored across different scales using a nested plot design

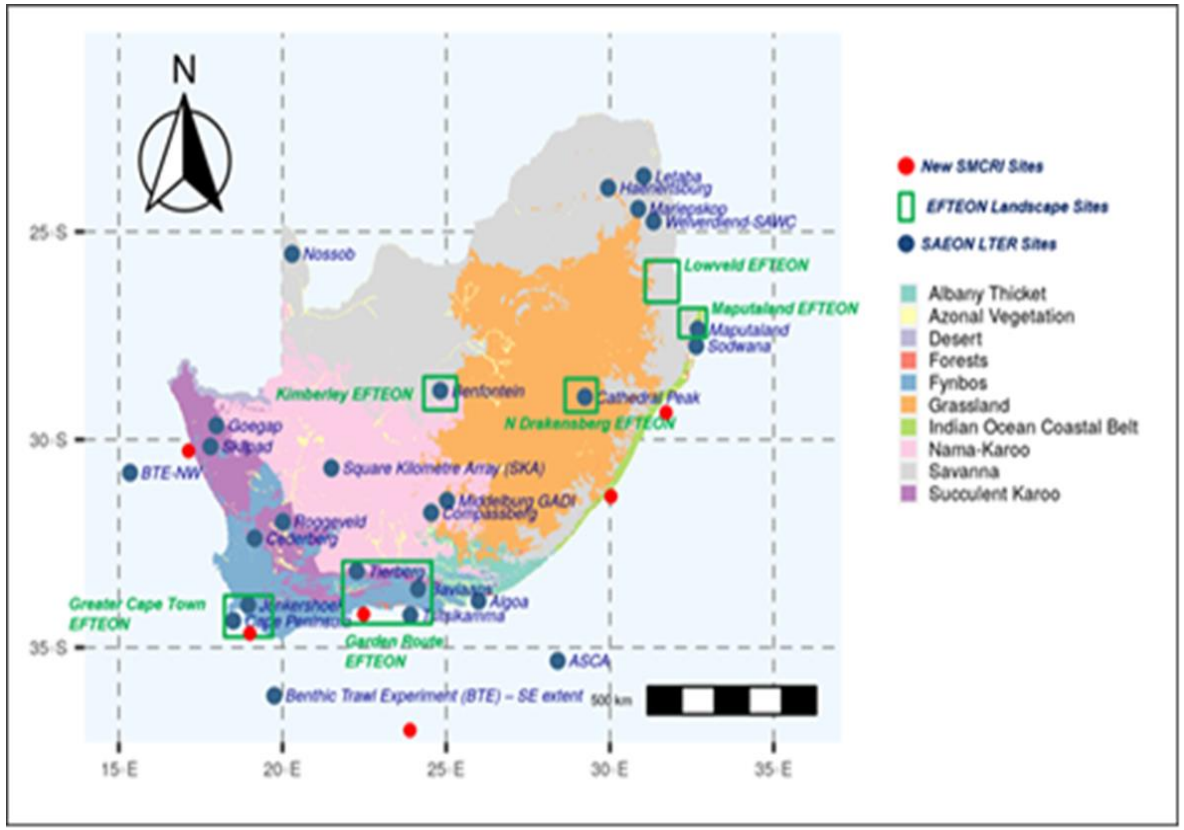


Nested plot design and stratification of driving variables

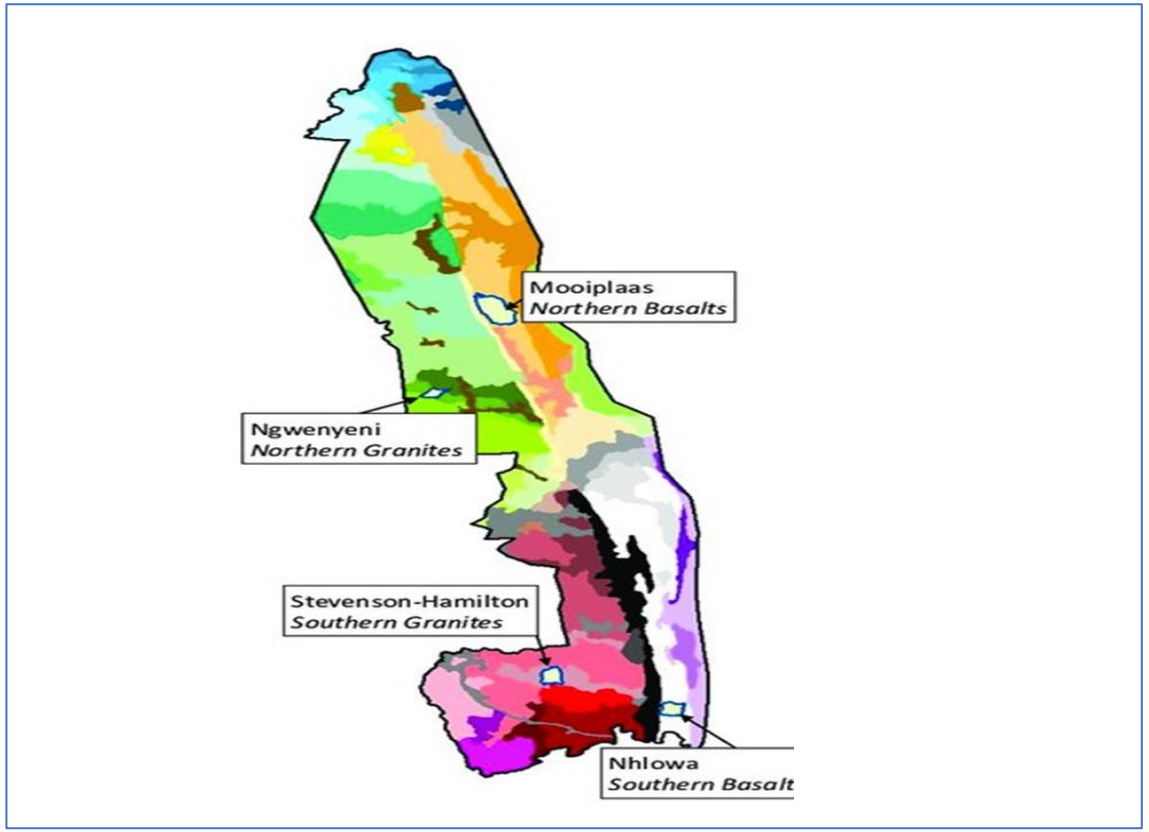
Monitoring unit	Approximate size range	Main tools	Stratification (treatments) at each scale
Super sites	100 -10 000 ha	Remote sensing imagery	Harvesting pressure (high/medium/non)
Plots	1 -10 ha	Drone, LIDAR	Land use/land tenure
Sub plots	100 m2 or 500m	Ground based	Biotic gradients

Supersite concept in other research organizations

SAEON LTER and EFTEON



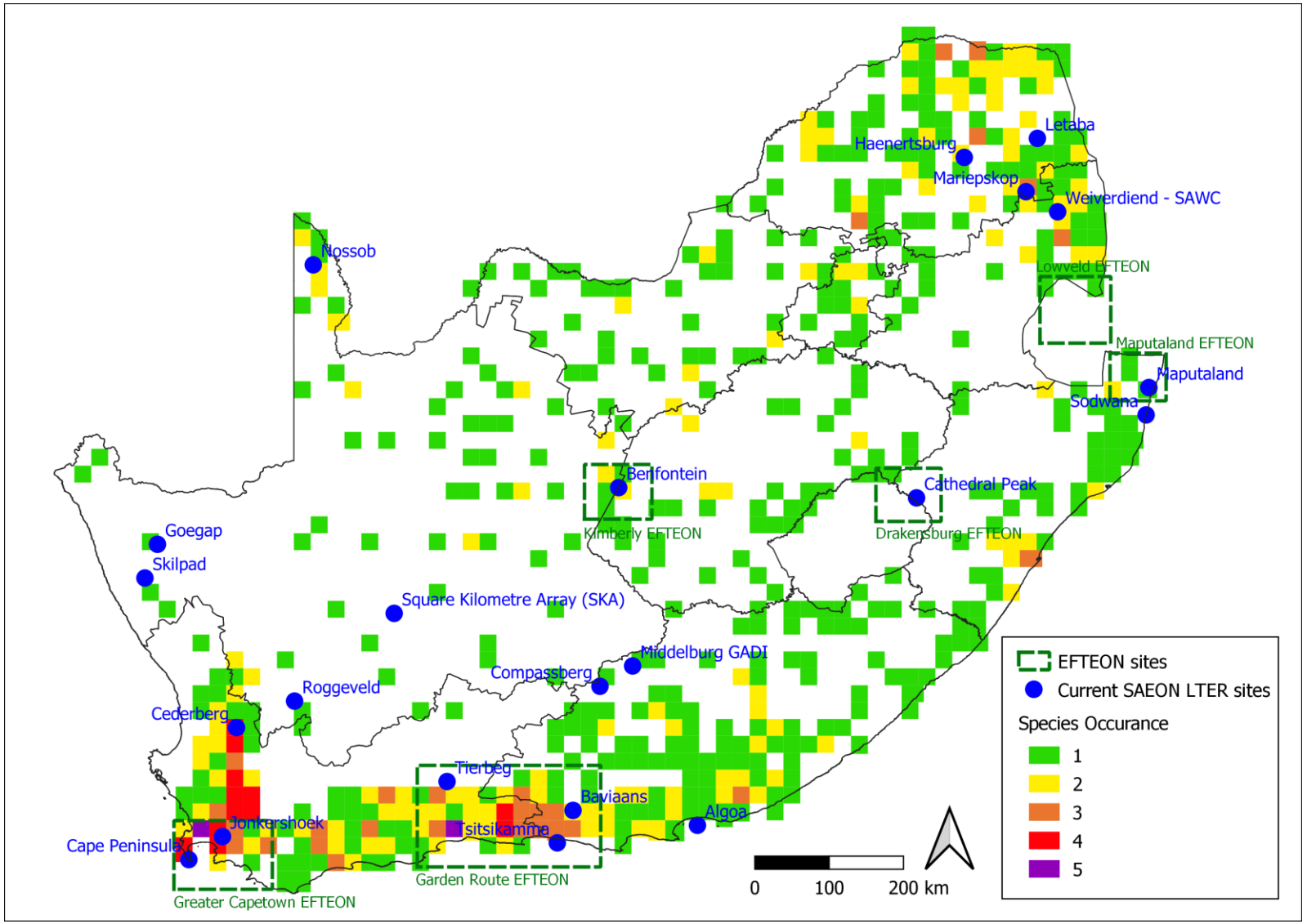
Kruger NP research supersites



Long-term research sites to facilitate cross disciplinary multi-scale learning in data-rich environments
Monitoring of changes in ecosystem processes over large scales and long time periods

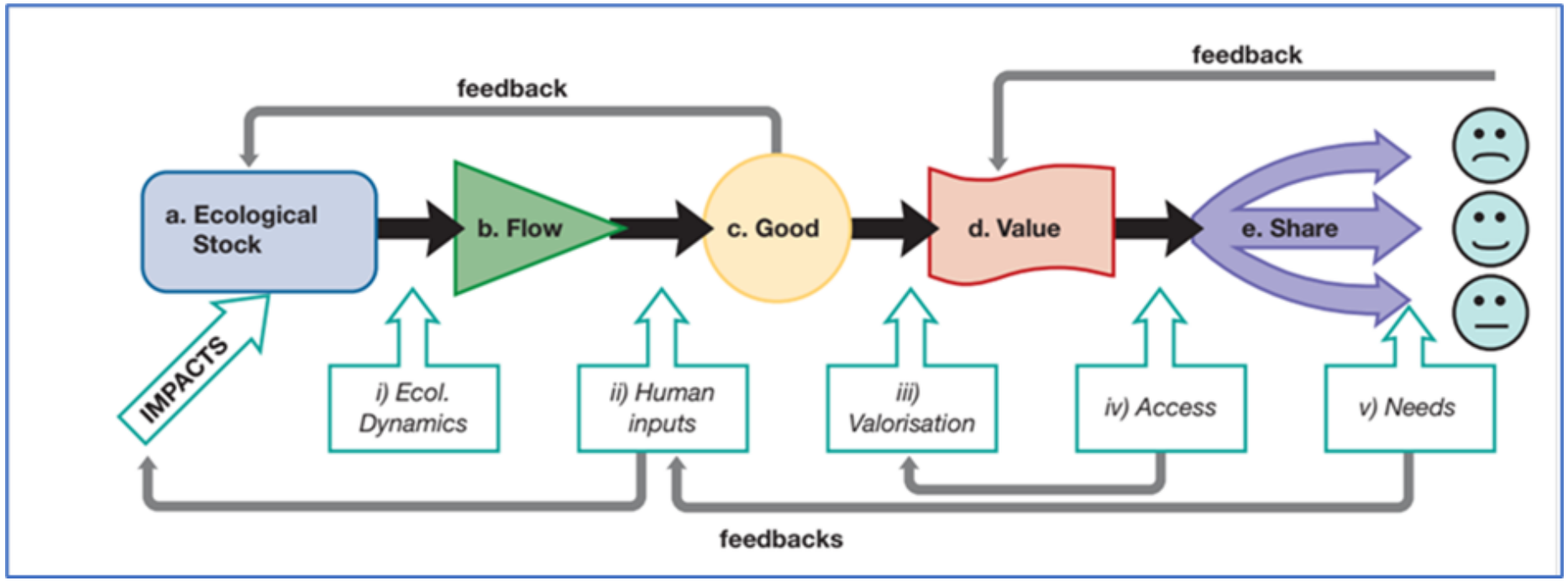
Identifying supersites for monitoring of harvested wild plants

Optimal sites are those where multiple target species overlap within existing research sites such as SAEON LTER and draft EFTEON sites



Numbers of target species occurring in QDS (blue dots are SAEON monitoring sites)

Consider an ecosystem service monitoring framework (wild plant resources as a provisioning service)

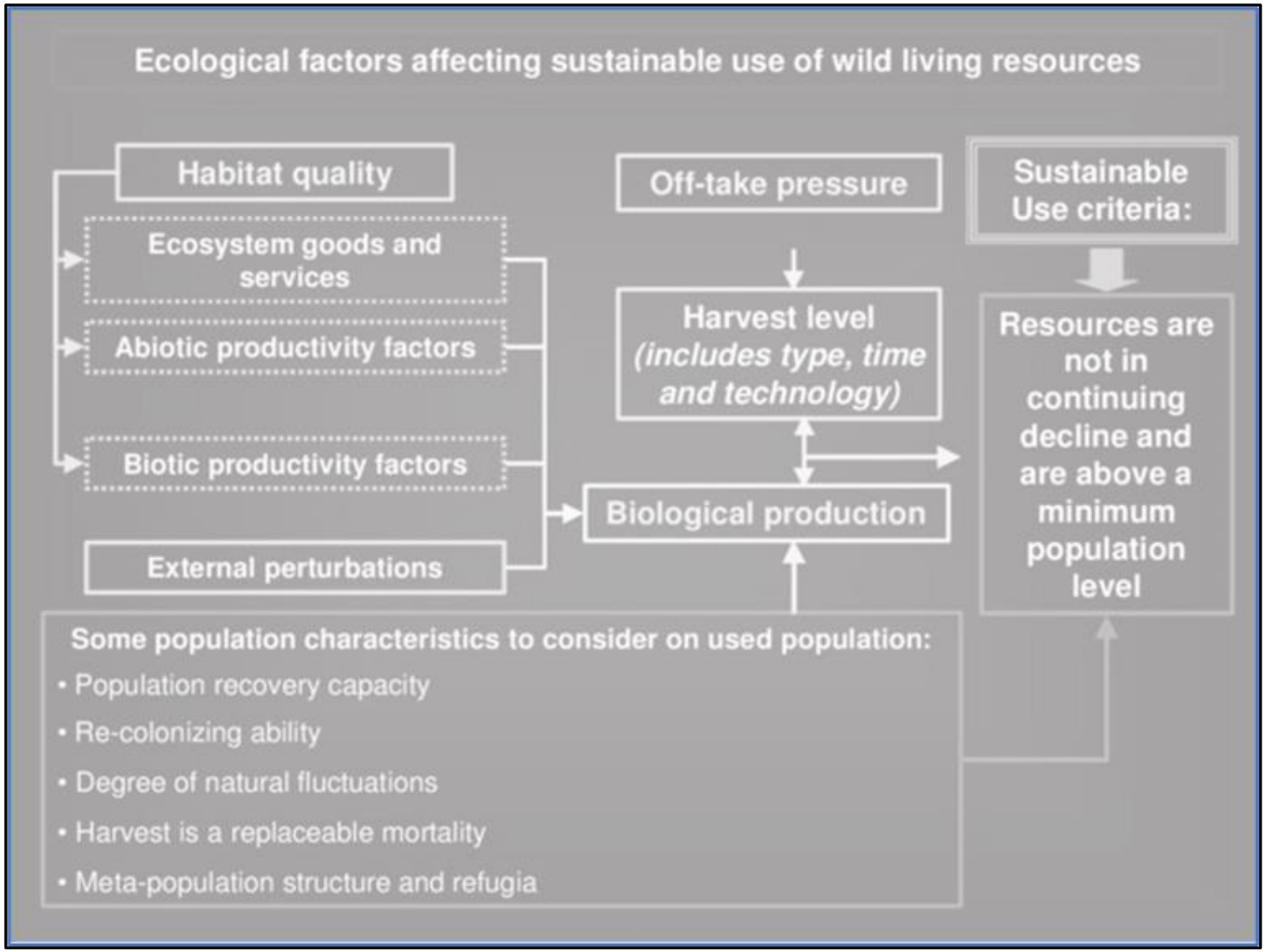


- Ecosystem value chains
- Land use trade-offs
- Feedback loops and adaptive management

Using an ecosystems approach as a contextual framework

Consider:

- the health of the host ecosystems
- Structure and function of host ecosystem

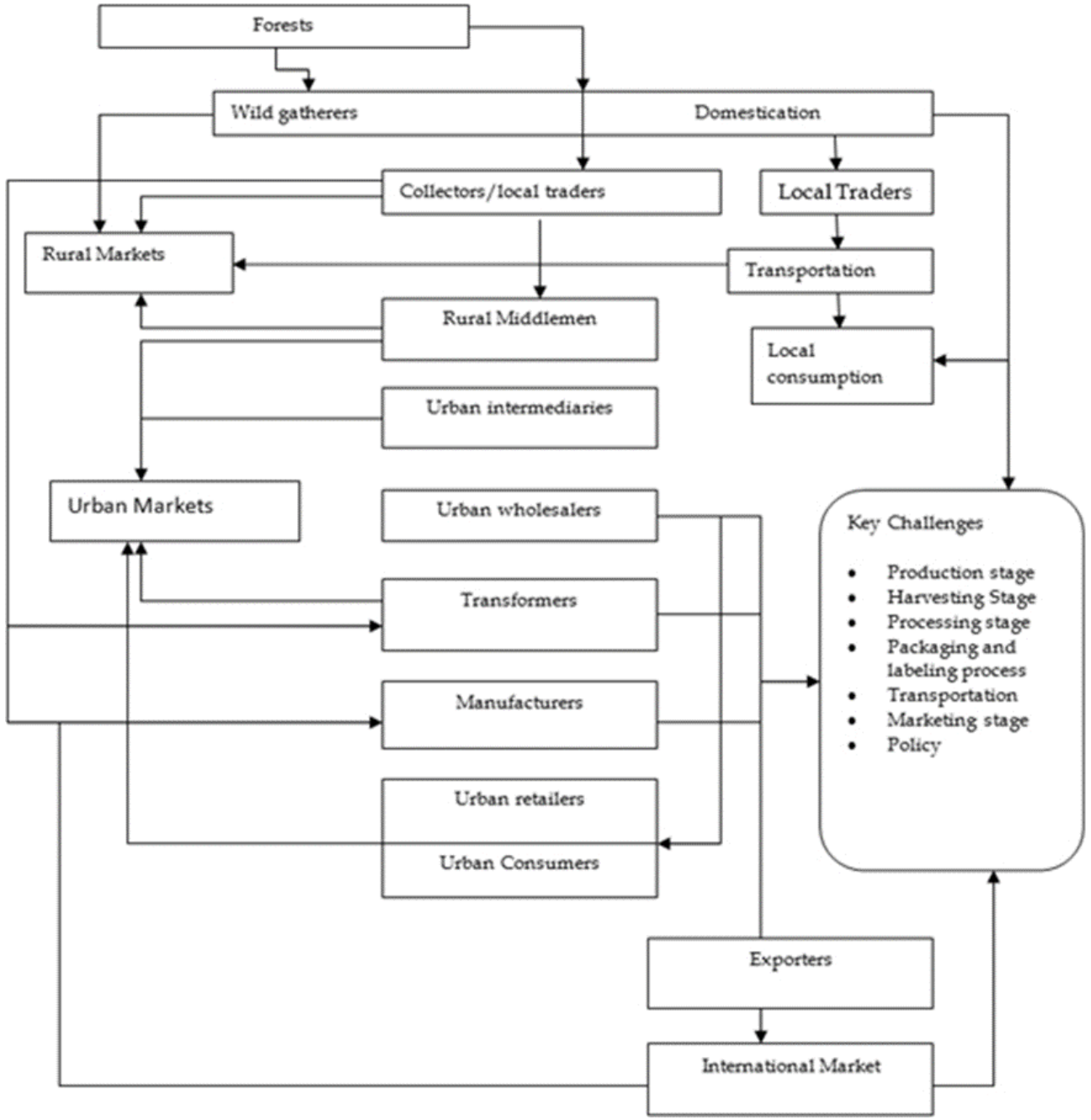


What to measure, and what indicators to use ?

Monitoring components	Indicators
Total stocks	Plants/ha, distribution extent
Population health	Recruitment rates, population size structure
Quality of the natural habitat	Extent of land use change, degradation, biodiversity loss
Productivity of the resource	Yield per ha, fruit size per plant
Harvesting pressure	Kg per plant, tons per ha
The quality of the harvested resource	Size of fruit, chemical composition of part harvested
Early warning indicators of overuse	Lower yields per area/ harvesting effort Higher prices Smaller and poorer quality products

Monitoring trade data

Strategic points along the value chain , where data can collected on quantities harvested, sold, exported, imported etc.



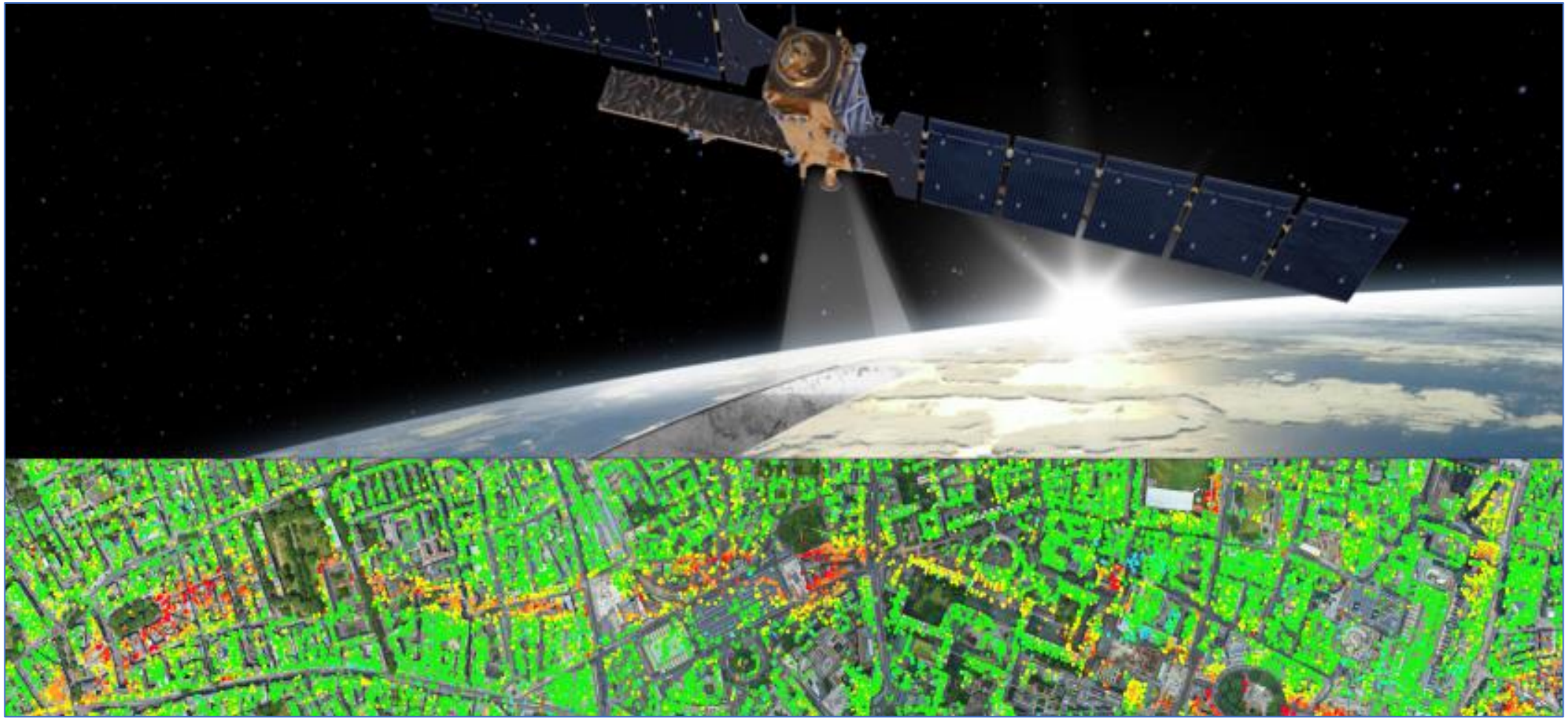
Monitoring data points along value chains

Value Chain	Quantity data (weight/vol/monetary)	Sources	Limitations
Producers Wild Farms	Annual production	Government: Permit quotas Producer associations: levies/ production records Export Control Boards	Illegal harvesting No permit system in place Non-members of producer Associations No ECB for the product
Intermediaries	Annual intake/ purchases	Intermediary records	Records unavailable/non disclosure
Processors	Annual intake Annual outgoing (volume /weight conversion rates)	Processor records required by permit system Processor records, or if unavailable, can be inferred from incoming if conversion rate known	 Conversion rates may vary Records unavailable
Local retailers	Annual intake Annual outgoing	Retailer records	Records unavailable
Exporters	Annual Exports Sales	Export Permit Export Control Boards Customs statistics CITES Trade Database Exporter records Producer association export records or can be inferred if the ratio of export to domestic distribution is known for the species.	Only required for CITES listed species Not species specific No ECB for the product Not species specific Not CITES listed Records unavailable Records unavailable Ratios may change over time
Importers	Annual Imports Sales	CITES Trade Database Eurostat trade data online Importer records	Omissions and errors in CITES reports Not CITES listed Records unavailable

Who managers , monitors, and curates the data? (institutional responsibilities)

Organisation	Mandate	Suggested role in National monitoring programme
UNCTAD BioTrade Principles and Criteria (P&C)	International monitoring and regulation , of traded wild resources	BioTrade P&C provide an overall framework for a long-term monitoring programm bio-traded species
SANBI	Monitor and report regularly to sustainable use of indigenous biological resources, and threated species. National Biodiversity Frameworks /bioregional plans	Coordinate, research and monitoring. Reporting Curation and storage of monitoring data
DEFF	leadership, alignment and adherence to national and international policy and legislation	Oversight , regulation and policy implementation around formalising bio trade and bioprospecting. Administering and enforcement of permitting systems. Oversee the development of Biodiversity Management Plans for bio traded specie Curation and storage of monitoring data
Universities Research institutes CSIR Consultants	Multi-disciplinary research and technological innovation for industrial and scientific development	Research and innovation in methods of resource monitoring, harvesting, processir and potential uses of bio traded plants
SAEON	To detect, understand and predict environmental change in South Africa. Six regional research nodes	Monitor the impact of climate change on bio traded plants
TRAFFIC	Monitors and investigates wildlife trade and conservation policies and programmes. collaboration the CITES Secretariat.	Strengthening the implementation and enforcement of CITES Trade monitoring (import and export of bio traded species)
Industry / Producer Associations /Councils	Responsibly promote the respective industry and protect the interests of the consumer and industry stakeholders	Promote responsible harvesting and sustainable resource management amongst producers Support the development of sustainable harvesting guidelines and protocols Co-operate and collaborate in resource assessment and monitoring programme at various levels (management unit to national) Provide information on harvesting sites and quantities
Certification Schemes Fair-Wild Organic	Ensuring sustainable harvesting of wild resources	Principles, criteria and indicators to measure sustainable harvesting of bio-trade species Monitoring of compliance with sustainability principles, criteria and indicators

PART 4: CONCLUDING REMARKS



Resource assessments come in three flavours

a. Total **stock** assessment (production potential)
b. Understanding **direction trends** in stocks (changes over time, consideration of multiple drivers).
c. **Sustainability** of harvesting (recovery & recruitment rates)

Notes

1. Currently no standardised and repeatable methods.
2. For **total stock assessment** good estimates using models may be sufficient.
3. For understanding **directional trends,** accuracy, repeatability and broad scale sampling essential.
4. For **sustainability assessment,** focused sampling of harvested areas may be sufficient

Recommendations

1. Adopt an ecosystems approach to monitoring:
   integrated holistic research frameworks;
   understand driving variables on target species;
   understand structure and function of host ecosystems.

2. Development of statistically sound sampling, and experimental design protocols.

3 Multiscale approaches that combines ground surveys, areal photography and remote sensing.

4. Use of large scale permanent sampling sites:
   supersites with multiscale nested plots;
   multiple target species within one super sites;
   synergies with other long term monitoring programmes (SAEON, Academia etc.).

5. Development of calibrated predictive models (for e.g. density, productivity, yields, harvest rates)

6. Explore technological advances (LIDAR, high resolution multispectral imagery, AI, machine learning),
7. Consider treating some wild biotreated species as ecological indicators in long term environmental change monitoring programmes (Marula, Aloe, baobab are possible keys stone species)

Thankyou for your attention