# GEF5 Project Concept Note

# Very High Resolution Remote Sensing of Carbon Stocks in Subtropical Thicket

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# Problem Identification

Subtropical Thicket has been degraded by overgrazing over much its range (Thompson et al. 2009). There is significant interest and a growing body of research in thicket restoration through the planting of *Portulacaria afra* (Spekboom) (Mills et al. 2010; Marais, Cowling & Powell 2009). Restoration projects will generate employment, restore ecosystem services and produce carbon credits that can be traded to offset restoration costs. There is a need for spatial information, in the form of total above-ground carbon (TAGC) stock and *P. afra* canopy cover maps, to support the planning and monitoring of restoration projects.

Restoration is planned for large areas of the Little Karoo and Eastern Cape. Map scales of at least 1:10000 are required to provide sufficient accuracy for farm-level restoration planning. The production of detailed, carbon stock and canopy cover maps using manual methods at these scales is prohibitively time-consuming and expensive, particularly for large areas (Eisfelder, Kuenzer & Dech 2012; Powell 2009; Lu 2006).

While receiving increasing attention, use of very high resolution (VHR) imagery for estimation of environmental variables is still fairly uncommon, especially over large areas such as the Little Karoo or Eastern Cape (Eisfelder, Kuenzer & Dech 2012; Lu 2006). Possible sources of VHR imagery are commercial satellite programs such as the WorldView series of satellites operated by DigitalGlobe or aerial imagery from the Chief Directorate: National Geo-spatial information (NGI). NGI routinely acquires VHR multi-spectral data with national coverage. This imagery represents a rich source of information, but to date it has only been used for topographical mapping and photo-interpretation, and has not been exploited for quantitative remote sensing.   
  
An automated or semi-automated image analysis technique that is robust to the inherent temporal, topographic and radiometric variations in VHR imagery is needed to monitor TAGC and *P. afra* canopy cover dynamics in the Subtropical Thicket biome.

# Aims and Objectives

The research aim is to develop an automated or semi-automated image analysis technique to accurately estimate *P. afra* canopy cover and total above-ground carbon (TAGC) in pristine and transformed Subtropical Thicket, over large areas.   
  
To achieve the research aims, the following objectives have been set:

1. Review the literature on thicket restoration, canopy cover and carbon stock mapping in arid environments, as well as canopy cover and carbon stock mapping using VHR imagery.
2. Carry out a field study to establish suitable canopy cover reference sites and determine the actual (ground truth) canopy cover for each site.
3. Source and rectify VHR imagery of the study area. Develop a technique for radiometric correction of the imagery.
4. Design a canopy cover mapping algorithm that uses a classifier to accurately distinguish *P. afra* from surrounding vegetation.
5. Apply the classifier to imagery of the study area and interpret and evaluate the results.
6. Conduct a second field study to accurately locate the Baviaanskloof Nature Reserve (BNR) carbon stock ground truth plots in the aerial imagery and establish further canopy cover ground truth.
7. Using the available BNR carbon stock ground truth, develop a regression technique to determine TAGC from the VHR imagery.
8. Evaluate and interpret the carbon stock results.

# Methodology

This research investigates the use of quantitative remote sensing methods for estimating *P. afra* canopy cover and total above-ground carbon (TAGC) stocks in Subtropical Thicket. Remote sensing methods are common for carbon stock estimation (Goetz et al. 2009; Lu 2006) and will help facilitate cost-effective canopy cover and carbon stock estimation of large areas at repeated intervals. Image processing, pattern recognition and non-linear regression techniques will be used to develop the mapping algorithms. The work is intended to be applied research. Emphasis will be placed on producing maps that are both useful and usable.

The study area is divided into two portions for the two main components of the research. The first portion is in the Little Karoo as defined in Vlok, Cowling & Wolf (2005), which will be used for testing and implementing the *P. afra* canopy cover mapping technique. The second portion is in the Baviaanskloof, where existing carbon stock ground truth of Powell (2009), is located. The TAGC mapping technique will be developed and applied to this data.

There is a tendency for environmental remote sensing to be conducted in an isolated way that does not allocate adequate importance to understanding complex human and ecological processes affecting the data being analysed (Turner 2003). This naïve approach can lead to models that do not generalise well over varying spatial and temporal conditions. To avoid these problems, this research will be conducted in collaboration with a botanist and an ecologist who are well-acquainted with the study areas. These experts will provide valuable guidance with regards to ground truthing, map production and result interpretation.

# Budget

## Running Costs:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description** | | **Qty** | **Unit Cost (USD)** | **Amount (USD)** |
| Field trip |  |  |  |  |
| Travel costs (1500km @ $0.10/km) |  | 1500 | $ 0.10 | $ 143.12 |
| Food & accommodation (21 nights) |  | 21 | $ 22.97 | $ 482.44 |
| Data storage (1 x 2TB external hard drives) |  | 1 | $ 122.52 | $ 122.52 |
| WorldView-2 8 band 0.5m ortho ready imagery (136km² @ $14/km² ) | | 136 | $ 14.00 | $ 1 904.00 |
| Imagery download (16GB @ $2.76/GB) |  | 16 | $ 2.76 | $ 44.67 |
|  |  |  |  |  |
| DJI Phantom 3 Pro quadcopter with extra battery and car charger (UAV) | | 1 | $ 1 653.32 | $ 1 653.32 |
| Pix4D 1 month license (UAV orthorectification software) |  | 2 | $ 350.00 | $ 700.00 |
|  |  |  |  |  |
|  |  |  | **SUBTOTAL** | $ 5 050.08 |

Scholarship: Approx. R110 000 p.a. for two years (TBC)

# Contribution

Carbon stock measurements are generally performed using field-based allometric techniques which are extremely time consuming and costly when performed manually and are not practical on a large scale (Eisfelder, Kuenzer & Dech 2012; Lu 2006). The impracticality of allometry for large areas is confounded in the Subtropical Thicket biome due to its density, heterogeneous nature and complex growth forms (Powell 2009). The main contribution of this research lies in the automation of carbon stock measurements. A remote sensing carbon stock mapping technique would provide significant cost and time savings over manual field-based methods. It has the potential to be an important enabler for thicket restoration and could significantly ease the cost, time and administrative burden of qualifying for carbon trading schemes such as the VCS and CDM. Lessons learnt in the development of this technique could be helpful in producing similar maps of other South African biomes. Successful canopy cover and carbon stock mapping algorithms could also be used to help deepen understanding of the ecology, carbon cycle and restoration dynamics of Subtropical Thicket. This work also presents a number of challenges from a technical remote sensing perspective and would thus help develop local scientific knowledge and ability in these areas.

# References

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