(a) **Name of proposing person(s):** David Francois Joubert.

(b) **Title of project:** Spatial and temporal dynamics of bush thickening by *Acacia mellifera* in the Highland Savanna of Namibia.

(c) **Regional focus and limits:** The project aims to focus on the Highland Savanna in Namibia. However, the author intends to draw on his findings to develop generalities regarding bush encroachment along an aridity gradient (from mesic savannas to arid savannas) and for other species besides *Acacia mellifera* (generalities related to life histories).

(d) **Contribution of project to 5 overarching themes of BIOTA:**

1. **Natural dynamics in space and time:** The title indicates the contribution. The project aims to investigate spatial dynamics of bush encroachment from which other inferences can be made, including temporal ones. Naturally though the research would not be undertaken at existing laboratories.

2. **Understanding natural processes of change:** The project would help to understand the role of fire, pollination, seed banks and soil moisture levels in the transitions of open semi-arid savannas into closed thickets.

3. **Understanding human use, value and impact in space and time:** The project would help to understand the link between management interventions and climatic events in the onset of bush encroachment, particularly the coincidence of timing.

4. **Interventions (strategies, tools, techniques) for sustainable use of biodiversity and biodiversity management:** The project feeds into the next proposed project on DSS (Decision Support Systems for Bush Encroachment). This project will help to refine the already drafted DSS, since it will generate understanding of the process of bush encroachment, upon which the DSS is based.

5. **Inform policy on local, national, and international level:** As for 4, the project feeds into the next proposed project on DSS (Decision Support Systems for Bush Encroachment).

(e) **Proposed co-operating partners:** Professor Nico Smit; Professor Florian Jeltsch; Dr. Axel Rothauge, Ms Carol Steenkamp. Anyone who is interested and who believes they can contribute.

(f) **Key questions:**

There are two main parts to this project:

- **Part 1:** Spatial and temporal dynamics of bush thickening. An overview.
- **Part 2:** Transition dynamics of bush thickening (mainly dealing with the transition between grass and bush states).
- **Part 3:** A revised model of bush thickening by *Acacia mellifera*

**Research questions:**

- How do bush thickets develop spatially?
- **Hypothesis 1:** Bush thickets originate and expand in discrete discontinuous stages related to favourable rainfall phases (periods of 2-3 consecutive seasons of high and favourably distributed rainfall). What spatial patterns are currently observed in the field?
- **Hypothesis 2:** Bush thickets (patches) have a concentric ring pattern consisting of older trees (or a single tree) on the inside, with successive rings of younger recruits around the central ring. Each of these concentric rings typically consists of even aged individuals, which differ markedly in age from individuals in other rings.
- **Hypothesis 3:** Bush thickets (patches) are distributed in a random clumped fashion in the open savanna landscape matrix but expand to join each other to form a continuous landscape with time and favourable conditions. When did bush thickets develop previously?
- How episodic are bush thickening events?
- Are they continuous?
- What other environmental factors influence or determine the arrangement of thickets?
- What are the climatic, biotic and fire conditions which determine the switches from open savannas to closed thickets?
- **Hypothesis 4:** Seed production is strongly correlated with flower production and is not limited by pollinators.
Exploratory questions: What are the major pollinators?

**Hypothesis 5:** *Acacia mellifera* is able to self pollinate.

What are the major factors determining the direction of transitions from grassy state to bushy state?

How do rainfall and fire influence seed production and seedling survival?

**Hypothesis 6:** Seed production is positively correlated with rainfall. Seed production is absent or minimal during seasons of below average rainfall.

**Hypothesis 7:** Seedling survival requires effective rainfall events of approximately 5 mm every week to ensure survival of seedlings.

**Hypothesis 8:** Seed predators (such as small rodents) can significantly reduce the density of a cohort.

**Hypothesis 9:** Seedling survival after fire is minimal in the first year but significantly greater thereafter (even in the second year).

How do other factors such as seed predation and seedling herbivory influence the ultimate density of thickets?

(g) **Key activities:**

1. The spatial nature of bush thickening will be tested in a number of areas in the Highland Savanna. I would like to map bush thickets of varying sizes along existing transects at Neudamm and determine spatial patterns at different levels, local and landscape. This includes determining the degree of clumping, the arrangement of thickets in relation to other thickets, the spatial arrangement within thickets (referring also to the arrangement of ages) and from this the dispersal patterns.

2. Aerial photography (time series) will be analysed to determine landscape level temporal and spatial patterns of bush thickening. A review of the existing methodologies to determine the most suitable spatial analysis would form part of the scope of the study (1 and 2 would provide fine scale and coarser scale spatial pattern of invasion).

3. The age of existing thickets will be determined, also spatially. In this, I will determine whether thickets are arranged in blocks or waves of different ages, radiating in concentric rings of same aged individuals from older individuals of the same age in the centre, to rings of progressively younger individuals of the same age to the outside.

4. This could be correlated with the ages of individual trees as determined through growth rings. The feasibility of this is currently being tested by the author and Carol Steenkamp who has experience in age determination of woody savanna species. Preliminary marginal parenchyma counts will be correlated with regrowth of known age and with carbon dating.

5. Ultimately, an approximation of bush timing events and dispersal patterns would be determined from all of the above.

6. Furthermore, multiple regression (or other) techniques will be used to determine how the pattern of bush thickening is associated with other factors, such as aspect, slope degree, slope position, soil depth, fire and other management history (obtained from farmer interviews).

7. It is hoped that spatial pattern analysis will provide insights into the underlying processes of bush thickening, particularly when combined with age determination work and experimental work on transition conditions.

8. The role of rainfall events and soil moisture in determining transition events will be investigated (this has been investigated from 1998 to 2004, but I feel it requires more rigorous experimental work)

9. Experimental rainfall simulation trials could determine a relationship between rainfall, flowering and seed production (this is compared with results of my current studies)

10. Experimental rainfall simulation trials determine a relationship between rainfall and seedling survival (in both cases soil moisture is monitored).

11. Pollinating mechanisms could be investigated to determine whether *A. mellifera* can self pollinate and what the major pollinating agents are,

12. The role of seed predators and germination in inhibiting/preventing transitions could be investigated. In this, the impact of seed predators on seed production and survival in areas of low and high seed production could be determined.

13. The role of fire in preventing transitions is investigated. Experimental burning trials test the effect of fire on killing seedlings and gullivers. Seedlings and gullivers of different sizes and ages are subjected to hot burns (perhaps of two different intensities).

14. The research evidence (mine and others) is reworked into a revised model, based on the state-and-transition model of vegetation change in semi-arid savannas.

15. This is quantitatively represented in a spatially-explicit predictive model.