IS BERENTY FOREST THREATENED? A NOVEL DENDROECOLOGICAL PILOT STUDY OF FOREST AGE AND HEALTH IN SOUTHEASTERN MADAGASCAR.

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BACKGROUND: human activities and climate warming severely threaten Madagascar's unique biodiversity. The country as a whole is rated by Maplecroft's Climate Change Risk Atlas 2010 as being at extreme risk from climate change. Ecosystem resilience is declining and gallery forests among Madagascar's most endangered forest types have been identified as critically in need of protection. Berenty Reserve is a small private reserve of gallery forest by the Mandrare River set in the semi-arid spiny ecoregion of the far southeast. Scientific interest over 40 years at Berenty has been that of a protected forest fragment serving as a scale model for larger primate reserves. Dr Alison Jolly, who began her work on Berenty in 1963, noted that the forest has been visibly drying for several decades. To provide a basis for future management decisions for the Reserve, Alison asked Vanessa to apply dendroecological techniques to investigate tree age and health in the forest.

RESEARCH GOALS are to determine tree age and regenerative status and to isolate and assess the impact of the main factors affecting growth using *Tamarindus indica*, the dominant forest tree, and *Alluaudia procera* from the spiny-forest as indicator species. More widely, this pilot study using dendroecological methods for assessing forest health could be important for the eventual reconstitution of species richness, in particular in the projected Mandrare River Biosphere Reserve.

The novel aspects of this present work are the combination of geomorphological techniques including a consideration of river dynamics and riverbank profiles, with dendroecological analysis.

THE HYPOTHESIS is that changes in river run-off caused by severe deforestation and soil erosion in the river's headwaters together with climate change are lowering the water table causing premature tree death and curtailing regeneration.

SUMMARY OF WORK TO DATE

Berenty forest is a dynamic entity: trees and other plants grow, mature, reproduce, age, and die, soils build and erode; animal populations come and go; weather changes daily, climate varies over longer periods, and the river will change its course. Conservationists cannot hope to keep the habitat exactly as it is, but with sufficient knowledge of local ecology they may be able to guide some of the changes.

The hypothesis concerning lowering of the water table was not supported by the evidence since tamarinds outside the forest, growing 10 m above the forest floodplain, showed no decline in health. It can be assumed that their taproots are of sufficient length to reach water. However, careful monitoring of water levels in the main well and on the adjacent riverbank is recommended to show how levels change in relation to river levels and rainfall. Measurements should be taken during periods when demand for water from the tourist resort is low and on the same date as the meteorological data is recorded.

A study of root damage showed that anatomical changes can sensitively reflect changing conditions with vessel changes being reversible. Previous studies, all carried out in montane temperate environments, have looked at vessel changes in roots subject to river erosion (e.g. Malik and Matya 2008; Hitz *et al.* l. t2008). Others have focused on soil-surface degradation in the vertical dimension (e.g. Gärtner *et al.* 2001; Gärtner 2007; Corona *et al.* 2011). This is the first study to use roots as indicators of riverbank flood damage in a semi-arid zone.

The root sections revealed all the documented flooding events with the exceptional flood in 1998 initiating the current phase of bank erosion: maximum bank retreat rates (at least for the bank sections we examined) are relatively slow: 9-10 m in 50 years, but much faster rates may be obtained where the riverbanks are unprotected by vegetation. This could have a domino effect on the forested banks further downstream (Magdaleno and Fernández-Yuste 2011).

Before undertaking any conservation measures it is vital to know the age structure of a forest. The generally accepted 200-year life span of tamarinds as well as the known maximum 60-year planting age of Ankoba, a small extension of the main forest of Malaza, was supported by our dating approach derived from averaged ring-width measurements, trunk circumferences and seedling growth rates. Successful age determinations added a measure of confidence to out ageing of the two largest trees in our survey (5.33 and 5.66 m stem circumferences) that have survived in exceptionally favoured habitats for approximately 351 and 373 years respectively. The age span of the larger number of tamarinds in Malaza forest suggests that the dieback of the majority of tamarinds aged between 141 and 216 years that concerned previous workers (eg. Blumenfeld-Jones et al. 2006; Mertl-Millhollen *et al*. 2006) is due to normal mortality rather than specific fungus, disease, pests or visitors. The clustering of young tamarinds on the riverbank found by Blumenfeld-Jones *et al*. (*op cit.*) is likely due to seedling requirement for light, moisture, also possibly fresh sediment deposition for their roots and less over-shading by mature tamarinds. The mature age structure of the forest may largely be due to forest history and management: normal forest regeneration should take place around the boundaries of the forest and in gaps in the canopy left by fallen trees, but the Berenty boundary is circumscribed by farmland and cattle range, while gaps in the canopy and open spaces that were formerly grazed by cattle are dominated by invasive *Cissus quadrangularis*, grasses and shrubs. If the forest is to survive in the longer

term, there needs to be proactive management of seedling regeneration in the open spaces.
The effects of climate change remain to be analysed. It will be interesting to see if tree-rings can throw more light on tree health, climate change and event frequency. Average temperature on Madagascar may have been rising over recent decades, but at Berenty there has been considerable variability especially since the 1980s. In general, climate warming is predicted to bring more intense rainfall events (but possibly less overall rainfall) and more frequent droughts (New *et al*. 2006).

COLLABORATION, AND FUTURE WORK

The project was carried out in collaboration with Professor Hantaniriva Rasamimanana, Ecole Normale Superieure, University of Antananarivo and her students, specifically Sahoby Marin Raharison, studying the evolution of Madagascar's forest fauna and flora; also Dr A. Mertl-Míllhollen, Department of Anthropology, University of Oregon and other researchers working at Berenty Reserve. Dr Holger Gärtner of the Swiss Federal Research Institute WSL kindly made microtome slides of a number of the root sections. The importance of the private ownership of Berenty by the de Heaulme family (owners for over 70 years) is that this has kept the Reserve safe from loggers (a prime cause of deforestation) and hunters for 'bush meat' particular scourges during periods of political instability and famine.

Future work on tree rings and climate will be carried out in collaboration with Professor Mark New, director of the African Climate and Development Initiative University of Cape Town and University of Oxford.

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