SALLnet: South African Limpopo Landscapes Network

Report from the Final SALLnet Meeting – 21 June 2022: Management recommendations for macadamia orchards

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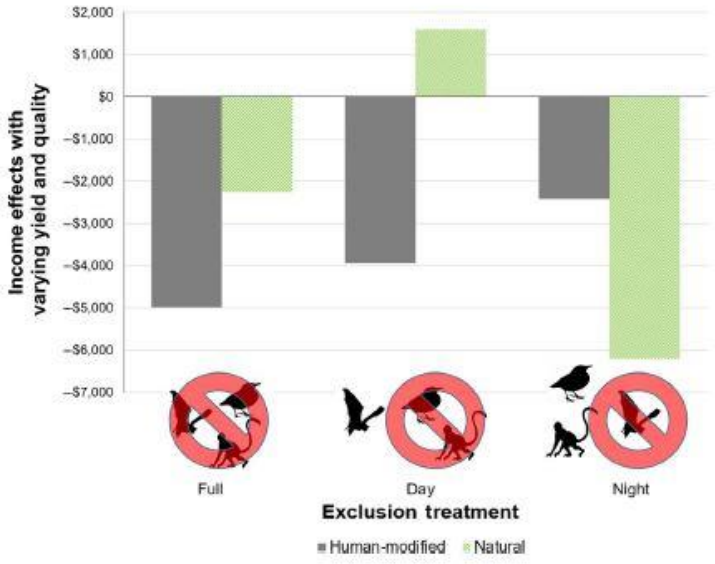
Topic 1: Ecosystem services and disservices within the macadamia landscape

- An economic model for the avoided cost of bat predation on stinkbugs, calculating both the direct (reduced stinkbug damage due to bat predation) and indirect (reduced pesticide use) avoided costs, estimated this ecosystem service at approximate 0.53–1.29% of the annual economic value of the national crop. This amounts to US$57-139/ha/yr of bat predation services to the South African macadamia industry.
- However, comparing the impact of biocontrol, provided by bats and birds, with that of crop raiding by vervet monkeys on yield in South African macadamia orchards through exclusion experiments in different landscape settings has shown that crop raiding occurred only close to natural vegetation and caused yield losses of about 26%. Biocontrol by bats and birds was higher near natural vegetation and prevented biocontrol through the exclusion of bats and birds resulted in yield losses of up to 60%. Also in economic terms, the effects of biocontrol by bats and birds (USD ~5,000 ha/year) were more important than the losses of crop raiding (USD ~1,600 ha/year).



Income effects (losses and gains) resulting from varying yield and quality over treatment and landscape setting, respective to each control

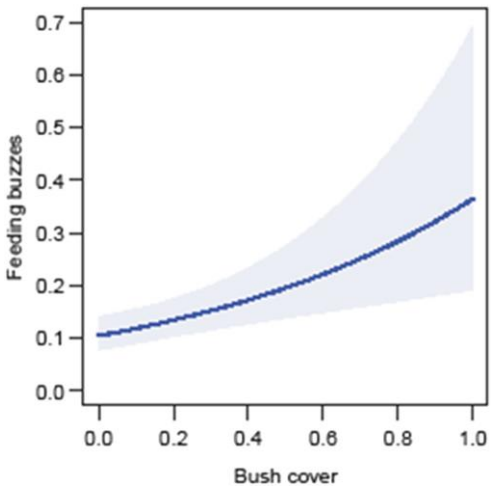
What does this mean?

Both, ecosystem services and disservices, are linked to the vicinity of forest patches, which means that the removal of natural vegetation to limit monkey abundances would also limit biocontrol service provision. On the other hand, retaining substantial reserves of unplanted natural habitat patches in close proximity to macadamia orchards, helps to maintain bat biodiversity and reduce the long-term dependency on pesticides as well as resistances.

Furthermore, farming practices should include ‘‘acceptable losses” through the reduced use of pesticides, which should be based on scouting rather than calendar spraying. Timing of pesticide spraying is critical to avoid direct contact with bees, bats and birds (best after midnight).

Topic 2: Effects of land use in and around macadamia on bat communities

- The acoustic monitoring of bat species in Limpopo macadamia orchards has shown that natural and semi-natural vegetation promote bat activity in macadamia orchards, and potentially bats' provision of the ecosystem service of pest control.
- Comparing bat communities in three land use types (a nature reserve, macadamia orchards with and without adjacent natural habitat patches) further showed that certain bat species have already been largely excluded from simplified agricultural landscapes.



The relationship between foraging activity of certain bat species increases with the habitat cover of bush in macadamia orchards, Levubu, South Africa.

What does this mean?

All of our results from SALLnet relating to bats in macadamias highlight the importance of a heterogeneous landscape in and around macadamia orchards, which provides connectivity, foraging and roosting sites through natural and semi-natural edge vegetation and corridors to promote the diversity of bat species and their ecosystem service provision. Adding roosting opportunities (e.g. bat houses) might further improve biocontrol services especially in areas where many old trees have been removed already.

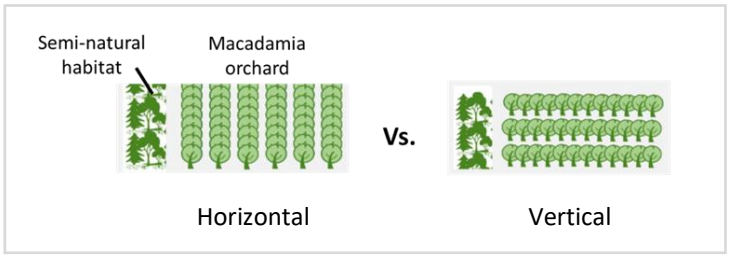
Topic 3: Pollination services in macadamia orchards

- Semi-natural vegetation on and around macadamia orchards represent habitats for pollinators. The abundance and species richness of bee pollinators decrease with increasing distance from the semi-natural habitat to the inner part of the macadamia orchard.
- Honey bees (*Apis mellifera* L.) are the main pollinators of macadamia in the Levubu production area. Insect pollination increases the initial nut set by more than 300% and the final nut set by more than 1000%.
- Nut set increases with increasing flower visitation rates. The initial nut set is 80% higher at the edge compared to the orchard center.
- Higher cover of semi-natural habitats within a 1 km radius around the macadamia orchards increases the flower visitation and outperforms the supplementation of honeybee colonies.
- Additionally, flower visitation rates and nut set can be increased if macadamia trees are planted in vertical rows (perpendicular) to semi-natural habitats.

Honey bee visiting a macadamia flower

Initial nut set

Final nut set



Orientation of macadamia tree rows

What does this mean?

Adopting smart orchard designs (e.g. vertical orientation of macadamia tree rows) is a good strategy to enhance macadamia flower pollination and nut set.
Keeping semi-natural habitat surrounding macadamia orchards and implementing patches or strips of semi-natural vegetation in macadamia orchards are recommended to effectively maintain and promote insect pollinators.

Topic 4: Irrigation and water use efficiency of macadamia trees

- Regional projected decreases in streamflow and groundwater levels pose a threat to future water availability for commercial irrigated farming in southern Africa, including for macadamia production in Limpopo. This stresses the need to increase orchard water use efficiency by better meeting tree water requirements.
- There is increasing compelling evidence (from several long-term field experiments conducted in orchards with different tree ages and cultivars) of lower water requirements for macadamia trees than previously recommended amounts (see table below), often leading to over-irrigation of orchards.

- Long-term field experiments showed that macadamia trees have a conservative water use behavior, however differences between cultivars exist (e.g. 'HAES 849' is more water conservative than 'Beaumont').
- Microclimate has a strong control over tree transpiration, whereby trees close their stomata in hot and dry conditions to maintain a favorable plant water status. Such limitations in transpiration are independent from soil water availability (e.g. from increased irrigation amounts).

	Rainy season		Dry season	
	Measured	Recomm. (*)	Measured	Recomm. (*)
Daily tree water use (litres/day)	30-40	80-100	20-30	30-50
Daily tree water use (mm/day)	0.9-1.3	2.5-3.1	0.6-0.9	0.9-1.6

* typical daily water requirements of macadamia trees, planted at a density of 312 trees per hectare and with a canopy coverage of 60%, as recommended by SAMAC in 2007

What does this mean?

There is a need to increase water use efficiency of macadamia orchards by:
- better quantifying macadamia tree water requirements in different seasons and environmental conditions;
- choosing water efficient irrigation systems (e.g. low flow drip irrigation system);
- continuously monitoring soil water status of orchards;
- adopting water saving practices like mulching (i.e. covering the soil in the drip line with husks, dry leaves and pruning materials, which can reduce orchard water consumption by limiting soil evaporation and increasing soil water retention).

Macadamia trees will not respond to increased water availability under hot and dry climatic conditions. Heavily irrigating under such conditions would lead to over-irrigation and reduced water use efficiency. The observed differences in water use between different cultivars stress the need for a more precise quantification of macadamia tree water use, allowing to increase orchard water use efficiency. More experiments and model simulations are needed to close this knowledge gap.