

# Nature's bounty requires wise stewardship: Good Agricultural Practices in the macadamia industry can enhance economic gains

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**University of Venda**

*Creating Future Leaders*

**South African Limpopo Landscapes  
Network - SPACES 2: SALLnet**

**1<sup>st</sup> Annual Meeting Sept. 2019**



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*Pietman*



*Pietman*



*Pietman*



*Pietman*



**Mopani Psylla (*Retroacizzia mopani*)**



**Minute pirate bug (*Orius spp.*) feeding on *Retroacizzia mopani*, the Mopani Psylla**

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# Outline

Background

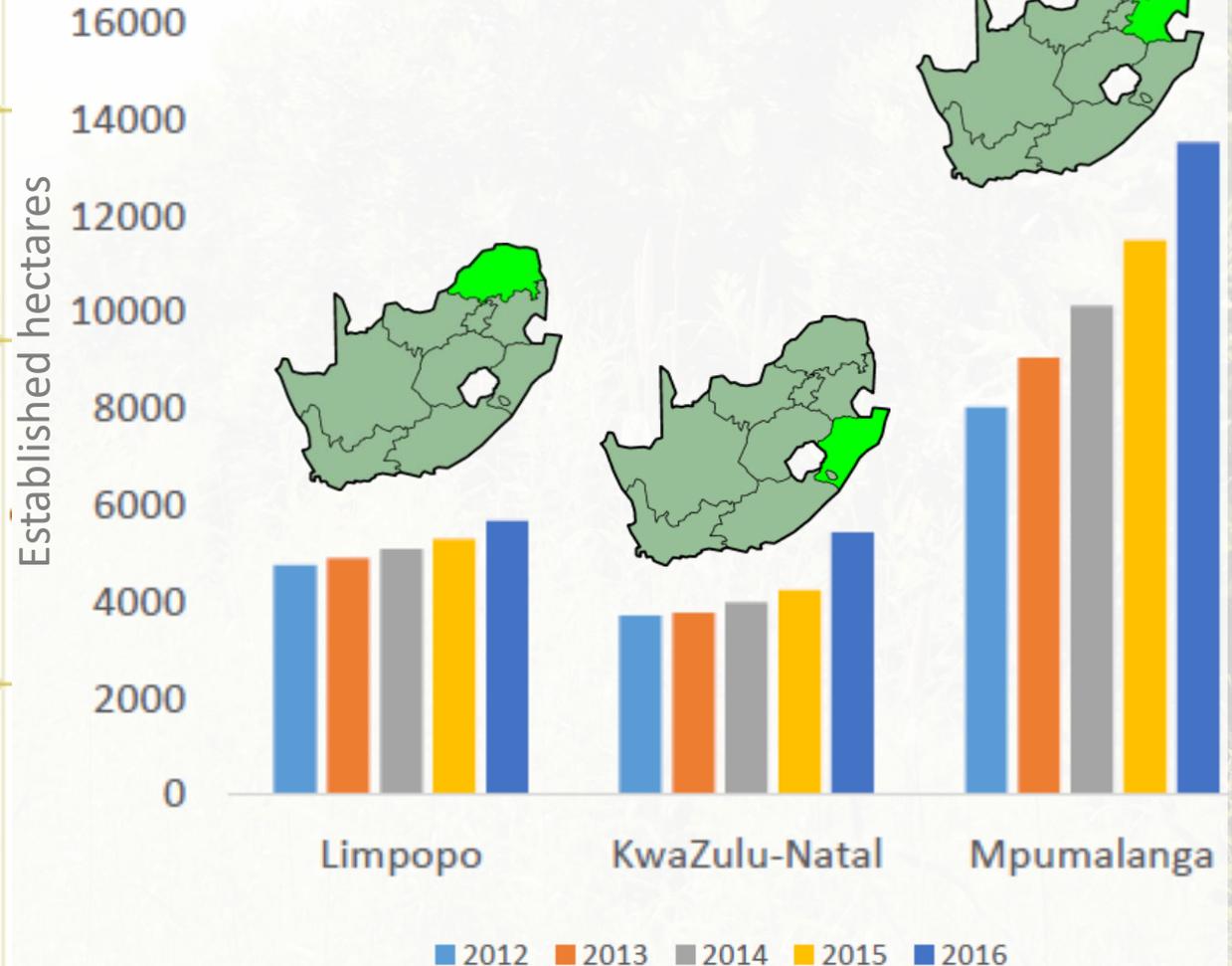
- Industry
- Monoculture
- Pest pressure
- Control strategies

Integrated  
pest  
management

- Understand pest-dynamics
- Control pests effectively & increase macadamia yield
  - Pollination services
  - Resistance management & physical barriers
  - Biological services

# Industry

Macadamias	
Number of growers	± 700
Area planted (ha)	± 32 500
Annual Production (ton in-shell nuts)	44 610 (2017) 56 550 (2018) 58 500 (2019 forecast)
Markets	50% inshell: Mainly China 50% kernel: Mainly USA (51%) and EU (35%)
Current Growth	> 5 000 ha / annum; growing exponentially



# Background



Monoculture



Pest pressure



Control Options



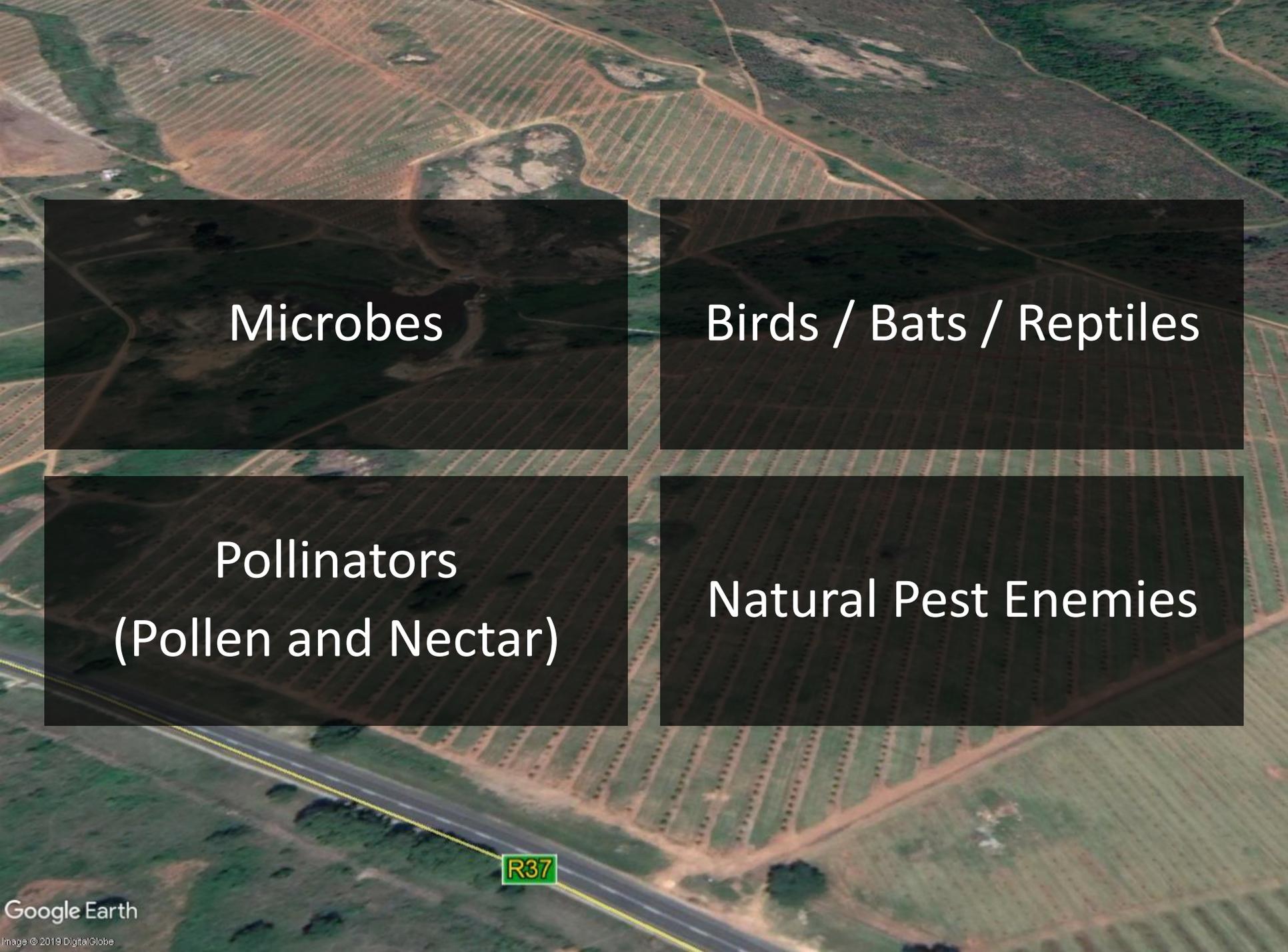
IPM







R37

An aerial photograph of a large agricultural field, likely a vineyard, showing rows of plants and dirt paths. The field is divided into several sections by roads and paths. A road labeled 'R37' is visible at the bottom. Four dark rectangular boxes with white text are overlaid on the image, arranged in a 2x2 grid. The text in the boxes lists various biological groups: Microbes, Birds / Bats / Reptiles, Pollinators (Pollen and Nectar), and Natural Pest Enemies.

Microbes

Birds / Bats / Reptiles

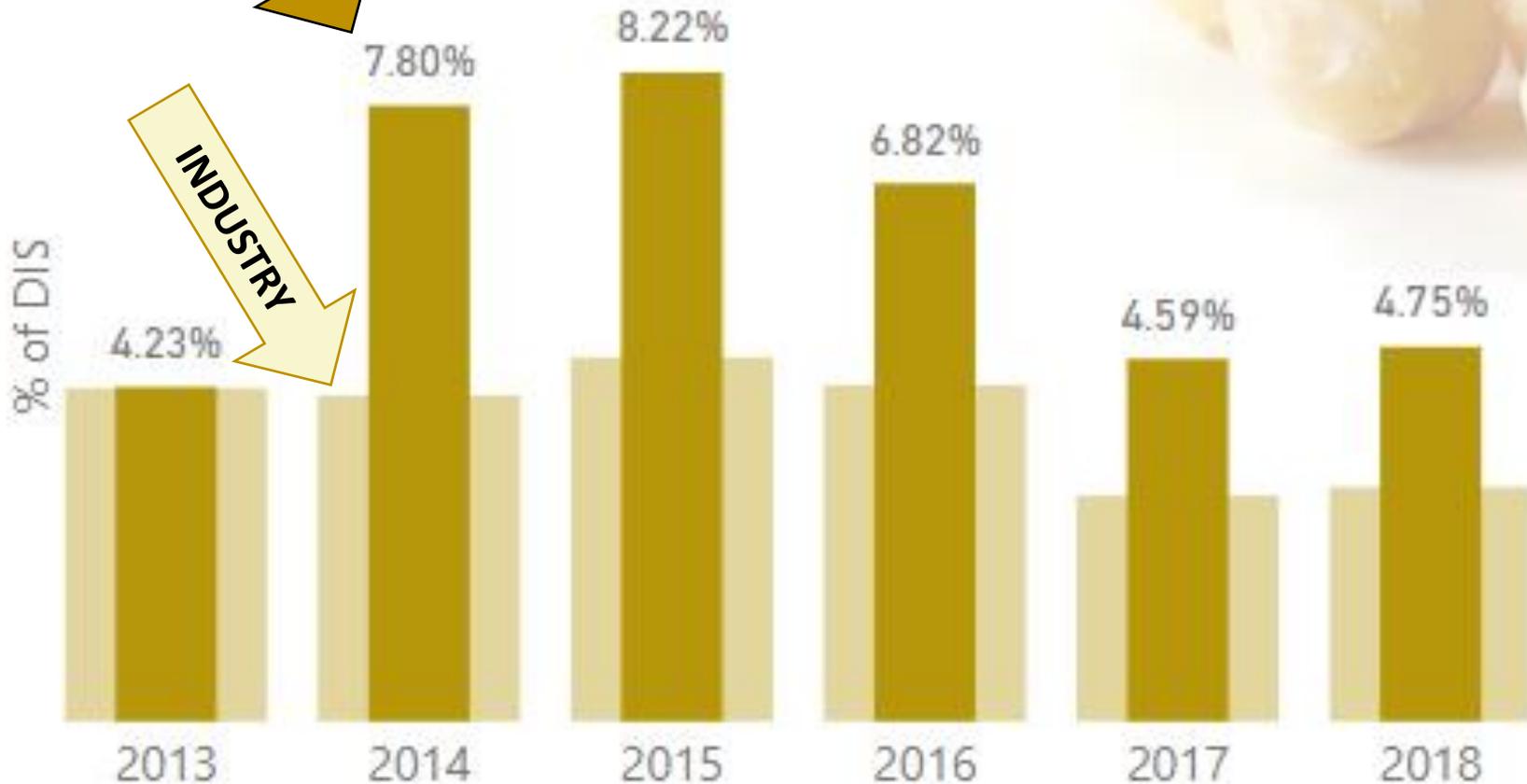
Pollinators  
(Pollen and Nectar)

Natural Pest Enemies

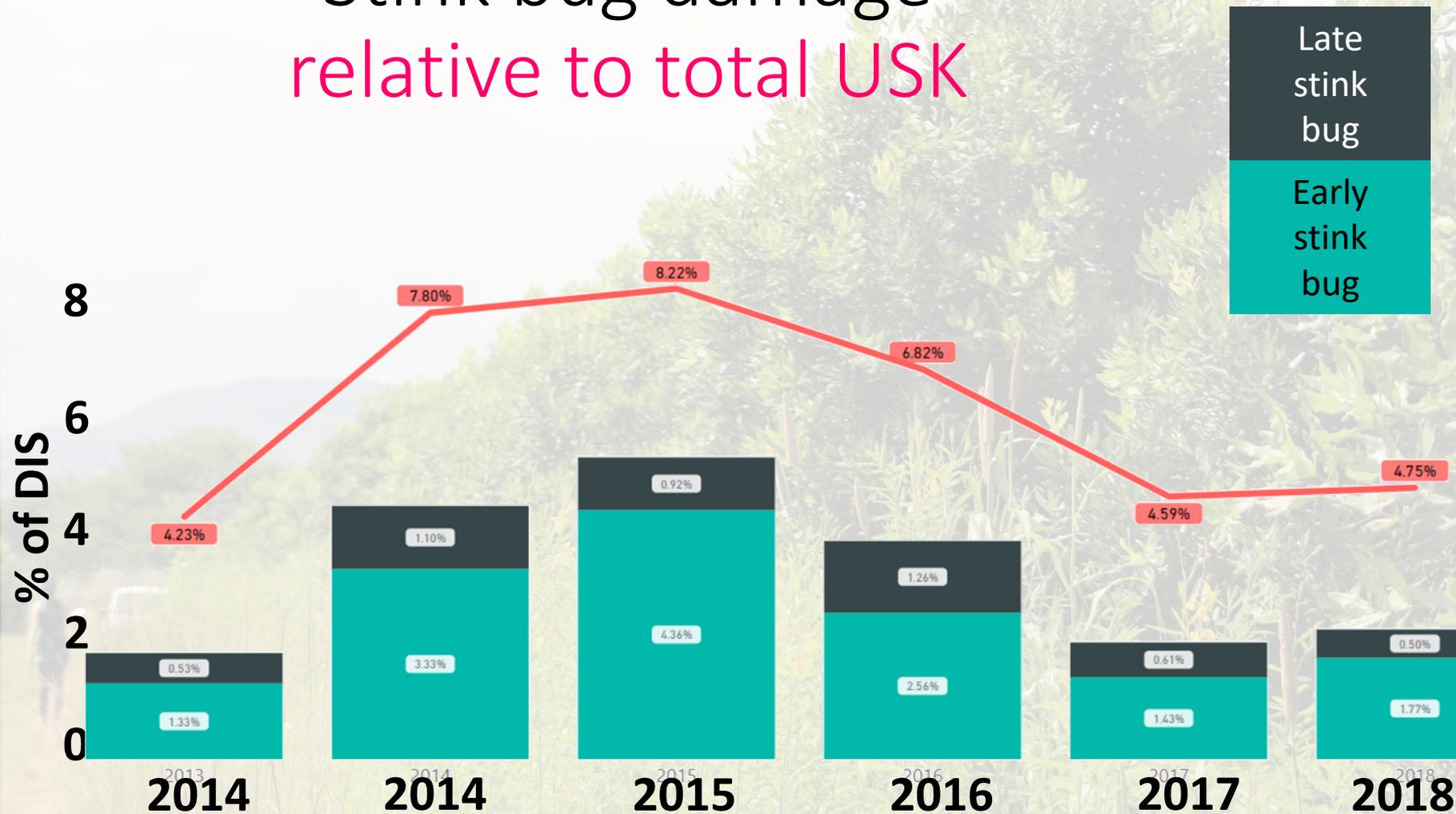
# Unsound kernel (USK)

LEVUBU

INDUSTRY



# Stink bug damage relative to total USK



# Production costs

± R 55 000 /ha /year (31 % of gross income)

Wages = 43 % ...

Chemicals aimed at pest and disease control = 12 % ...

Oil, diesel and petrol = 10 % ...

Fertilizer = 9 % ...

Electricity = 8 % of the total production cost

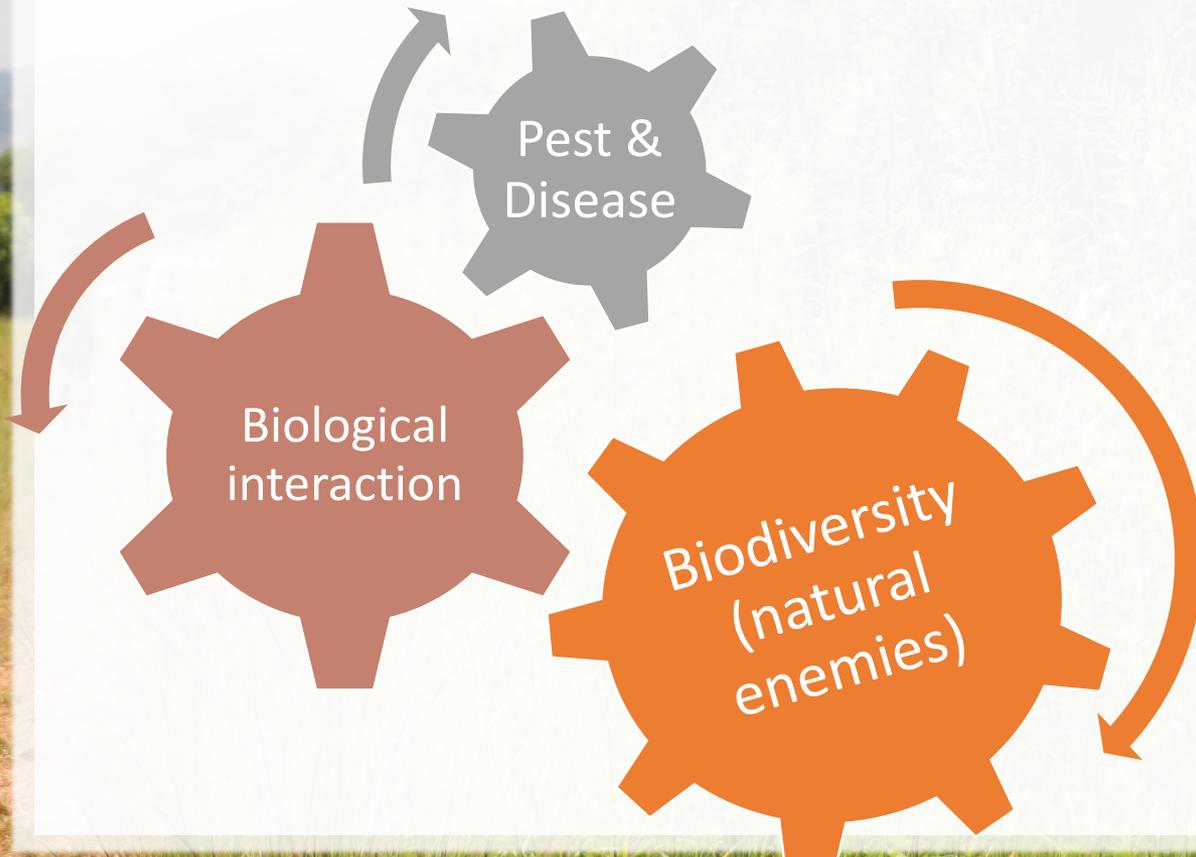
# Control strategy

- Monitor, apply control, monitor
- Chemicals in combination with biology
- Integrated system



# Control strategy

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# Integrated pest management

- Understand the pest-dynamics
  1. PhD study on the physiological biology of the two-spotted stink bug (in progress)
  2. Honours study describing the developmental stages of the two-spotted stink bug (in progress)
- Control pests effectively & increase macadamia yield
  - Pollination services
    3. Primary study on the negative effects of imidachloprid used commercially in macadamia orchards (completed)
    4. Masters study on pollination services in and around macadamia orchards (in progress)
  - Resistance management & physical barriers
    5. Monthly study groups: information sharing (ongoing)
    6. PhD study on two-spotted stink bug population genetics & describing the resistance that exists against common actives used on the farms (in progress)
    7. Honours study on insecticide-impregnated nets to control stink bug nymphs (completed)
  - Biological services
    8. 2x PhD studies on bats as biological control agents (completed)
    9. Honours study on mating disruption to control macadamia nut borer (completed)

# Monthly study groups

## Information sharing & training

Irrigation

Cultivars

Pests

Diseases

Nutrition

Soil health

New  
Orchards

Market  
standards

Climate  
change

Cultivars

Latest Research &  
Technology

# Biological control of stink bugs

- Bats and birds are known ecosystem service providers
- High pest pressure on macadamia industry; economic loss of stink bugs to the South African industry of USD 6,823,827 (2017) or R 8 275 /ha/season
- Extensive spraying regime



# Bats as biocontrol agents

- Feed on major macadamia pest insects
  - Green vegetable bug, *Nezara viridula*
  - Two spotted stink bug, *Bathycoelia distincta*
  - Macadamia nut borer, *Cryptophlebia batracopha*
- Potentially decrease insect damage & increase profits
- Natural vegetation a source for biodiversity and service providers



Crisol-Martinez et al. 2016. Using Next-Generation Sequencing to Contrast the Diet and Explore Pest-Reduction Services of Sympatric Bird Species in Macadamia Orchards in Australia. PLoS ONE 11(3)

Weier et al. 2019. Insect pest consumption by bats in macadamia orchards established by molecular diet analyses. Global Ecology and Conservation.

# Ecosystem services and disservices by birds, bats and monkeys

The ecological disservice (crop raiding) effect by monkeys was outweighed by the biological control service provided by bats

Ecological services and disservices were promoted by natural vegetation

**Exclusion of bats and birds resulted in yield drops of up to 60% or losses of  $\pm$  R 67 500 /ha /season (37.5% of gross income)**

**The exclusion of monkeys increased yield up to 26% and income of  $\pm$  R 21 600 /ha /season (12% of gross income)**

# Impacts of agricultural intensification in macadamia orchards on functional diversity of bats using acoustic surveys

**Open Air**



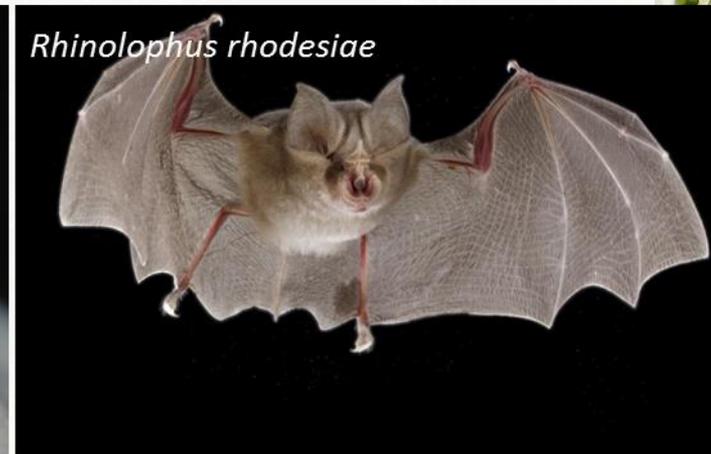
**Clutter  
Edge**



**Clutter**



# High diversity rare bat finds are common!



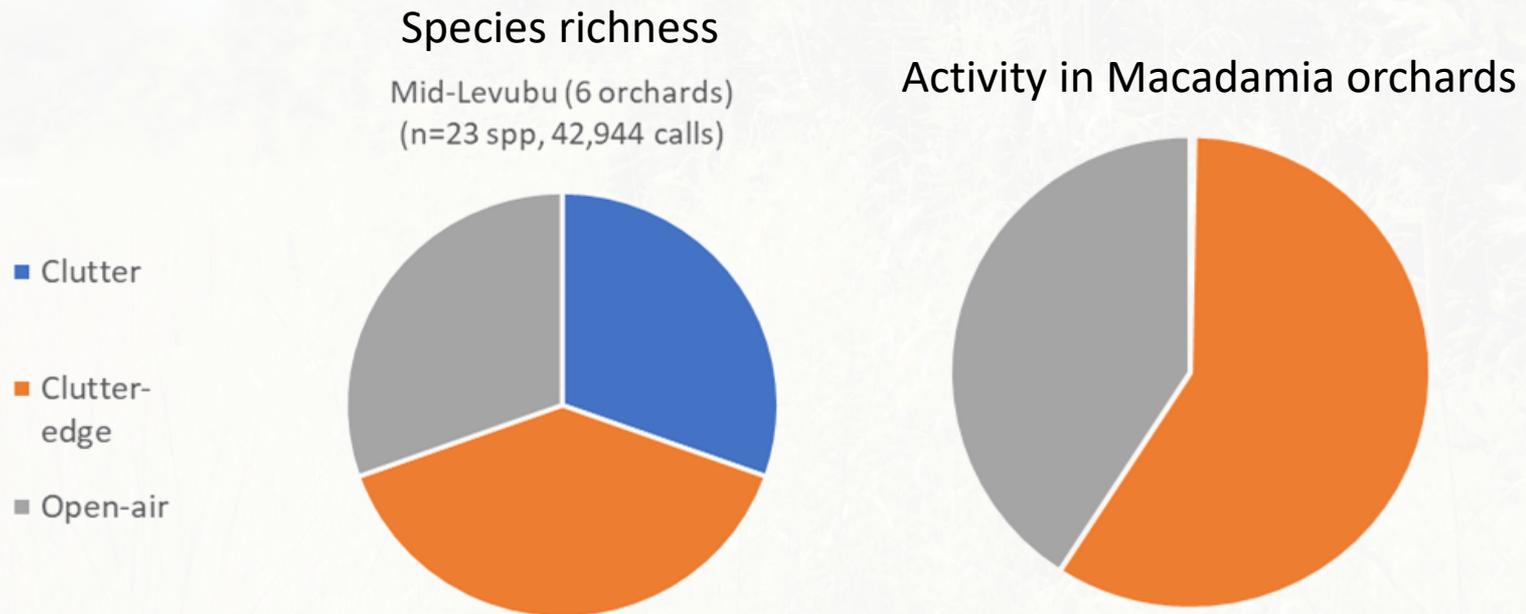
Merlin D. Tuttle

Taylor et al., 2015. Rediscovery of the "extinct" Transvaal free-tailed bat (*Tadarida ventralis africana*) in South Africa, with an additional record of the Malagasy free-tailed bat (*T. fulminans*) from northern Mozambique. *Durban Museum Novitates* 38: 50-55.

Taylor et al., 2019. Integrative taxonomy resolves species limits and identification of cryptic small rhinolophid bats in Southern Africa, with the description of three new species from Mozambique. *Zoological Journal of the Linnean Society* 184 (4): 1249–1276

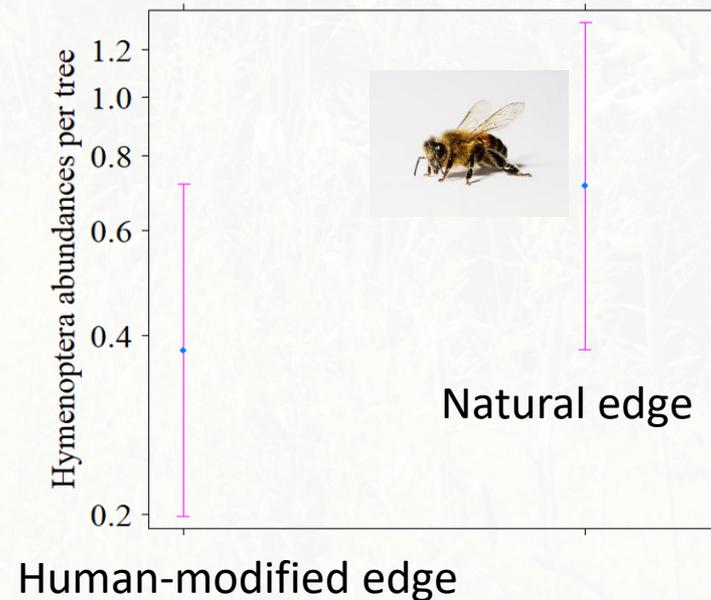
# Impacts of natural habitat removal

- Clutter-feeder bats were not active in macadamia orchards



# Impacts of natural habitat removal

- Clutter-feeder bats were not detected in macadamia production regions
- Hymenoptera abundances in macadamia orchards were lower at human-modified than natural habitats



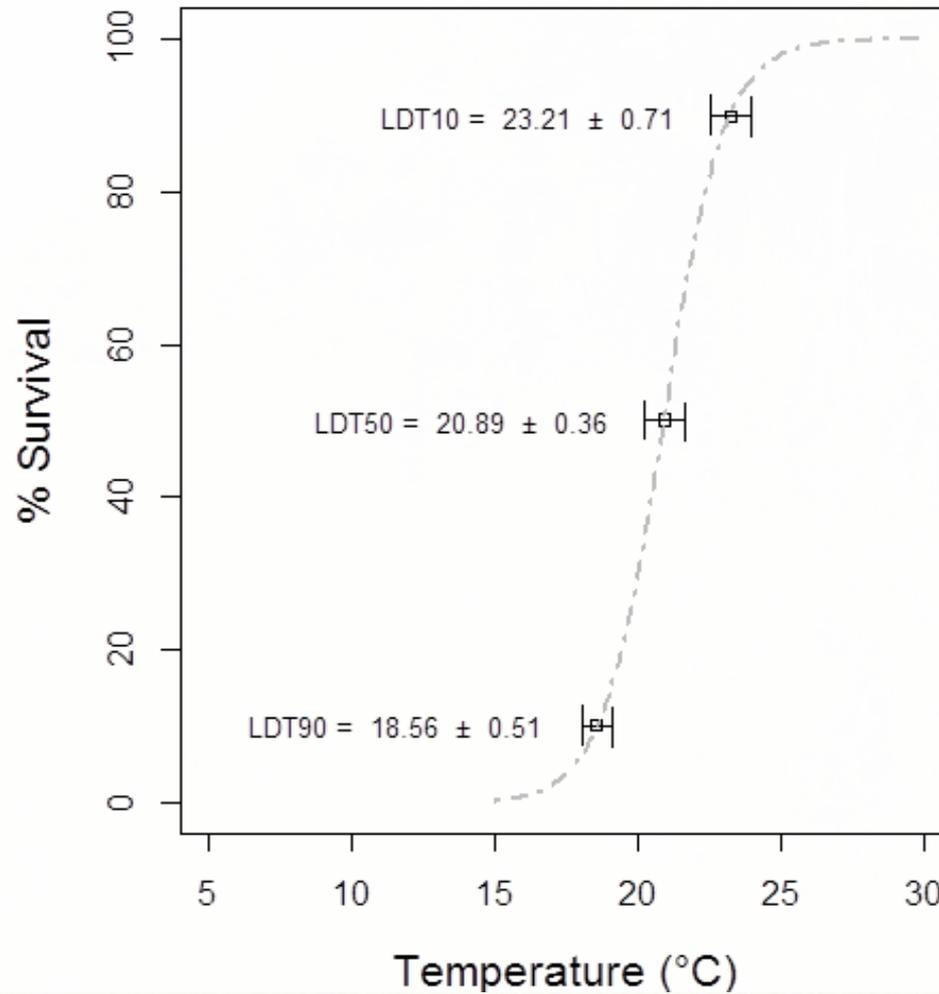


# Implementation

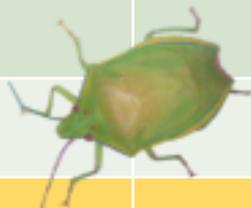
- Positive reception by farmers
  - Understanding of the value of ecosystem services
  - Willingness to protect and encourage service providers
  - BUT: impacts of bush clearing and insecticides???
- 
- Going forward
    - Size and connectivity of natural areas
    - Climate change impacts on ES (new experiments)
    - Anthropogenic impacts on bat communities

# Outcomes

Two spotted stink bug egg survival

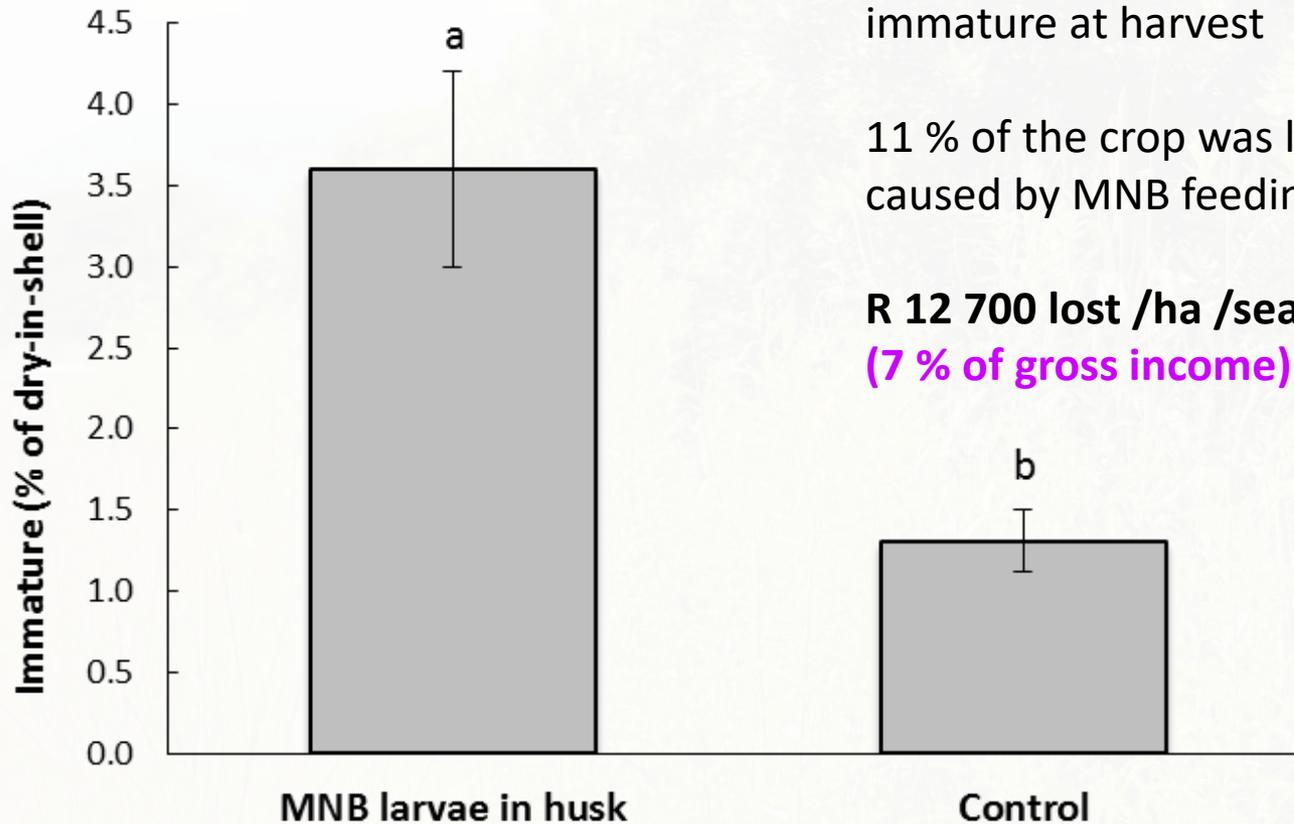


Life stage	Time (days)	Room temperature (°C)	Heat units (DD)
Egg - 1 <sup>st</sup> instar	8	19.02 ± 2.52	32.13 ± 0.10
1 <sup>st</sup> instar - 2 <sup>nd</sup> instar	8	18.66 ± 2.07	29.29 ± 0.09
2 <sup>nd</sup> instar - 3 <sup>rd</sup> instar	9	19.72 ± 1.86	42.5 ± 0.08
3 <sup>rd</sup> instar – 4 <sup>th</sup> instar	10	19.81 ± 1.76	48.08 ± 0.07
4 <sup>th</sup> instar – 5 <sup>th</sup> instar	13	20.24 ± 1.67	68.1 ± 0.07
5 <sup>th</sup> instar – adult	11	20.21 ± 2.39	57.35 ± 0.10
<b>TOTAL</b>	<b>59 days</b>	<b>@ 19.61 °C</b>	<b>= 277 DD</b>



# Macadamia Nut Borer

- Crop losses due to kernel immaturity



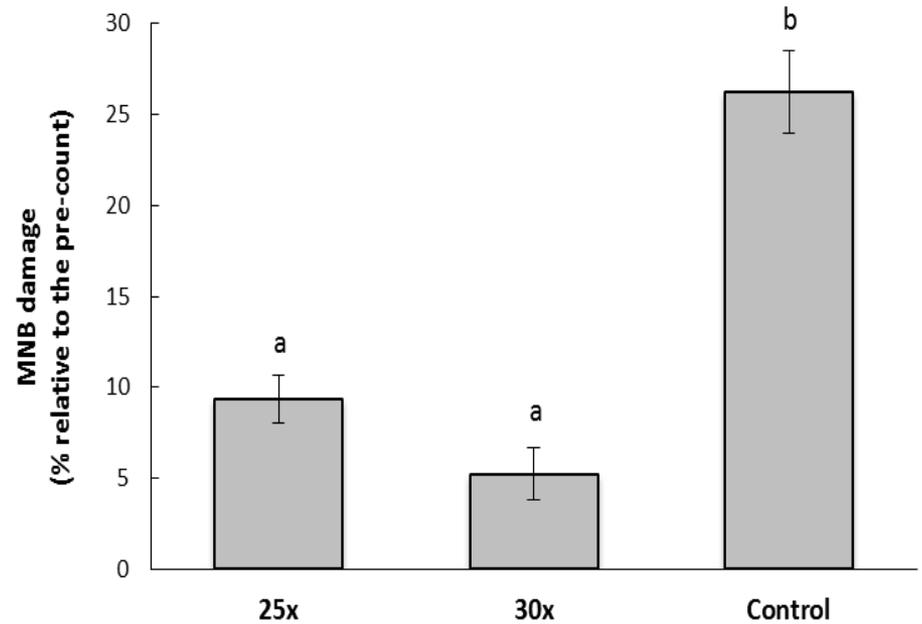
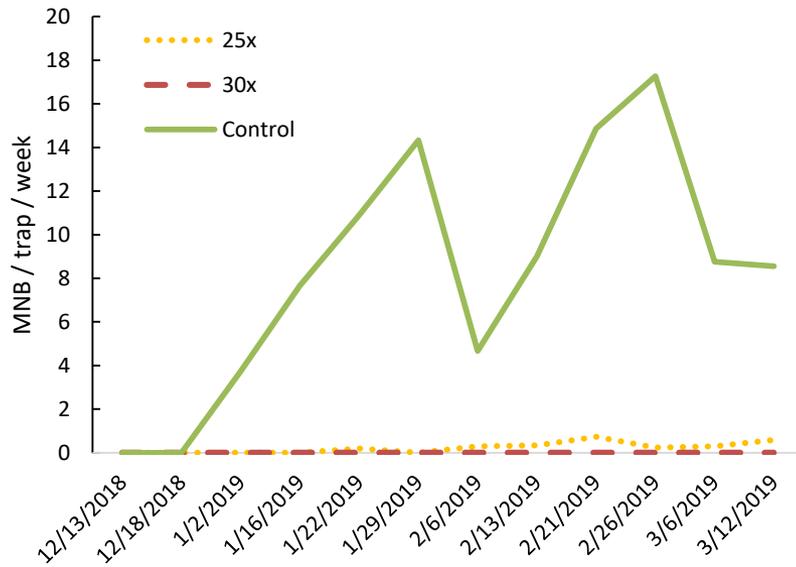
22 % of the nuts infected by MNB were immature at harvest

11 % of the crop was lost to immaturity caused by MNB feeding

**R 12 700 lost /ha /season due to MNB**  
**(7 % of gross income)**

Pairwise t-test:  $t_{4.8} = 3.6$ ,  $p < 0.05$

# MNB: Mating disruption



ANOVA: LR Chi-square = 29.3, d.f. = 2,  $p < 0.001$

# Stink bug control



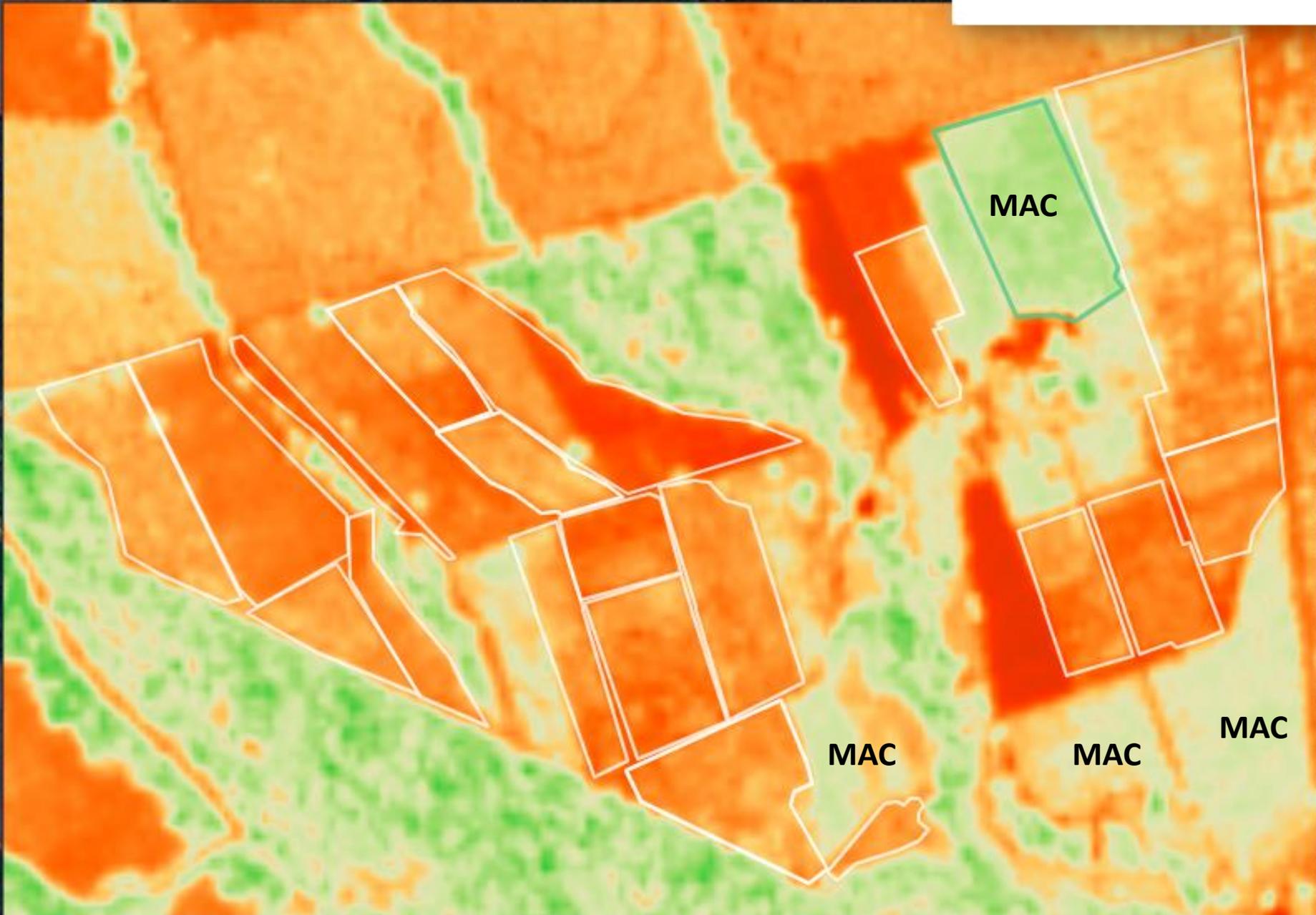


**MAC**

**MAC**

**MAC**

**MAC**



MAC

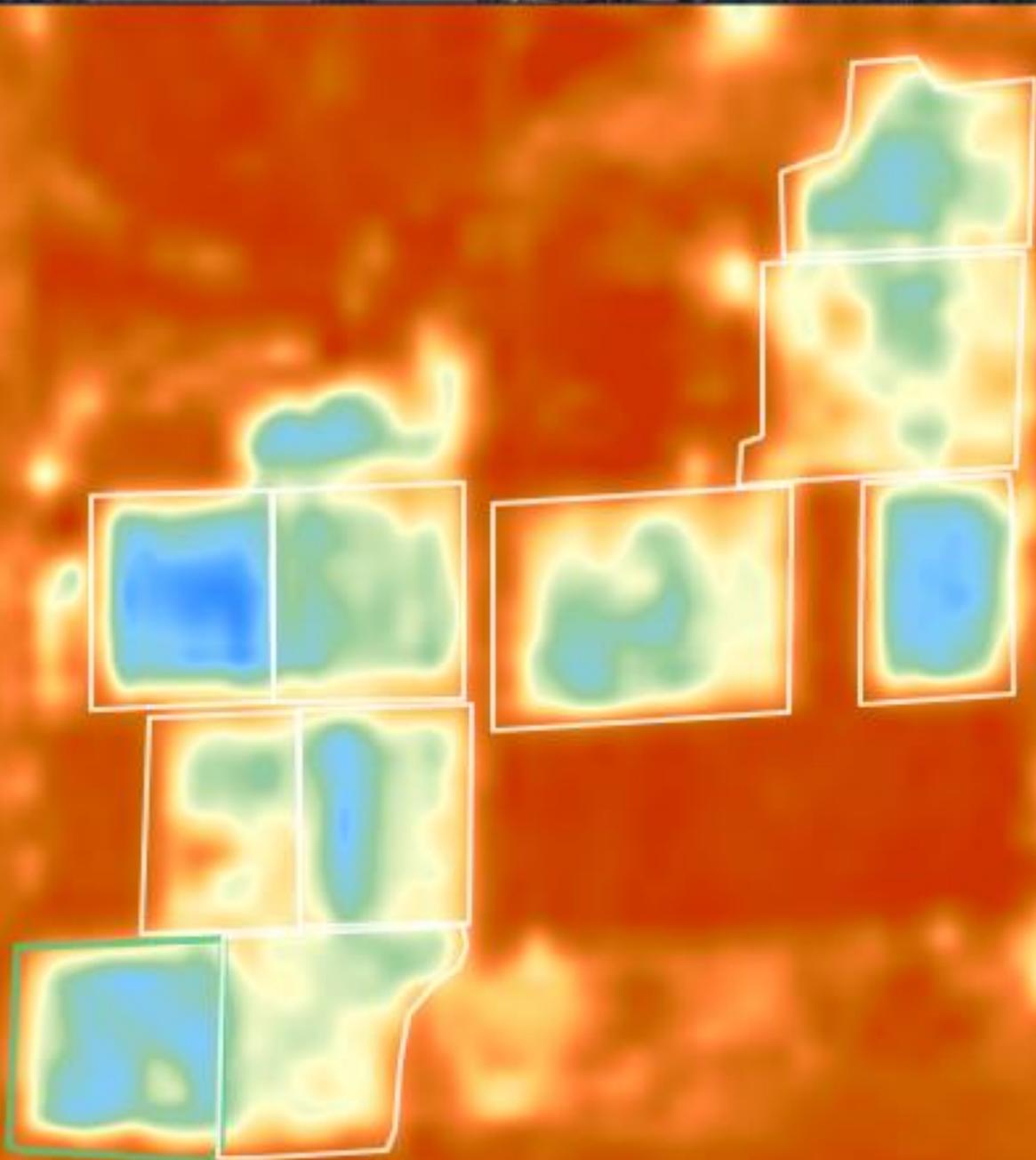
MAC

MAC

MAC



**Blok 1** moisture index data



# Weather stations



Forecast



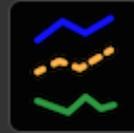
Frost Forecast



Spray  
Conditions



Station data



Station  
comparison



Weather Models



Insects



Diseases



Live Station  
Data



Fire Risk Index



# Acknowledgements



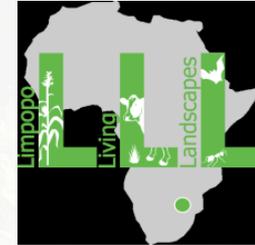
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Thank you

