Pollen diversity and protein content in differentially degraded semi-arid landscapes in Kenya

Pamela Ochungo, Ruan Veldtman, Rahab Kinyanjui, Elfatih M. Abdel-Rahman, Michael Muturi, Michael Lattorff, Tobias Landmann

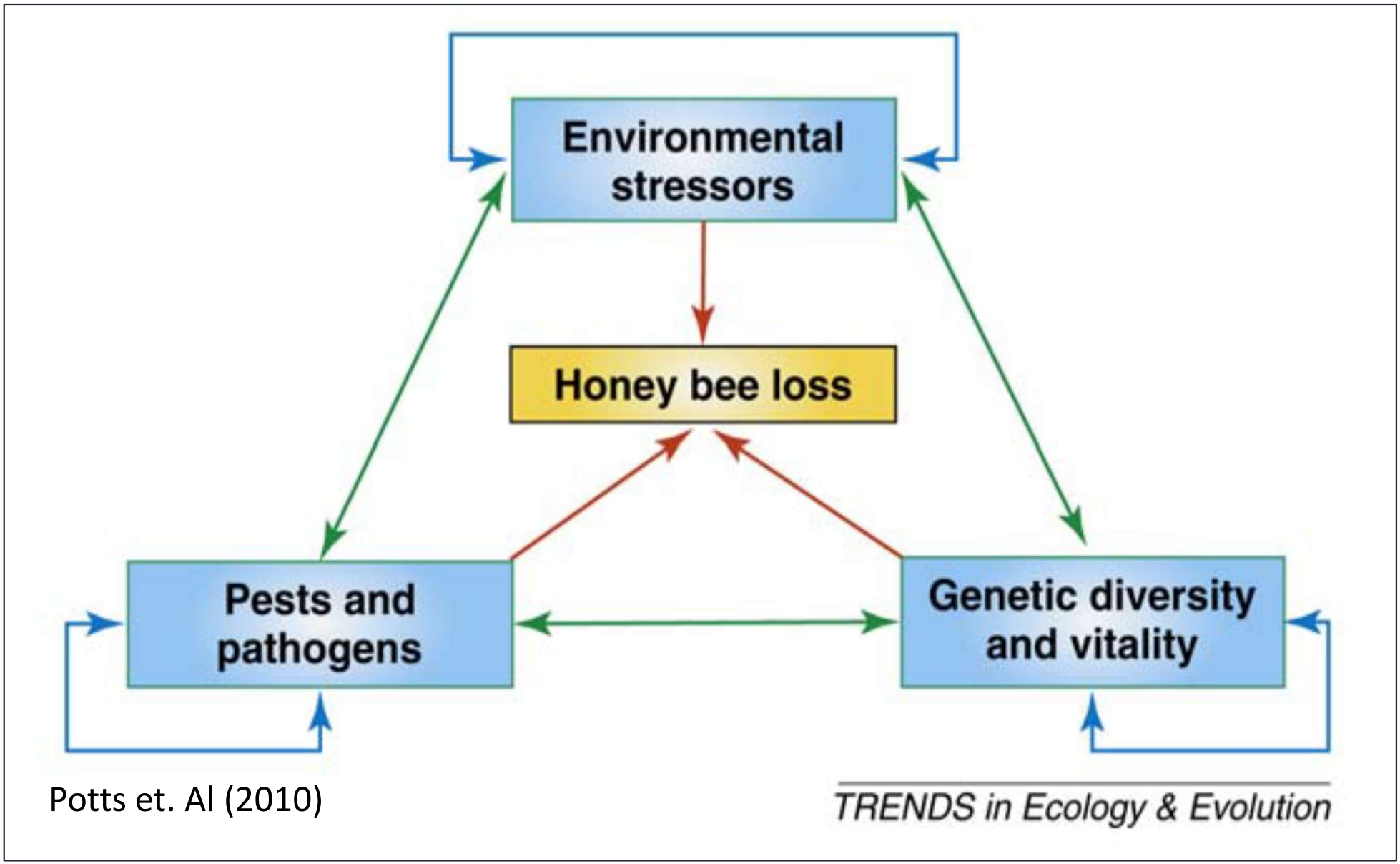
Significance of Honeybees

Source: M.V. Kitahara

Source: Dr. Gary Reuter, University of Minnesota Bee Lab

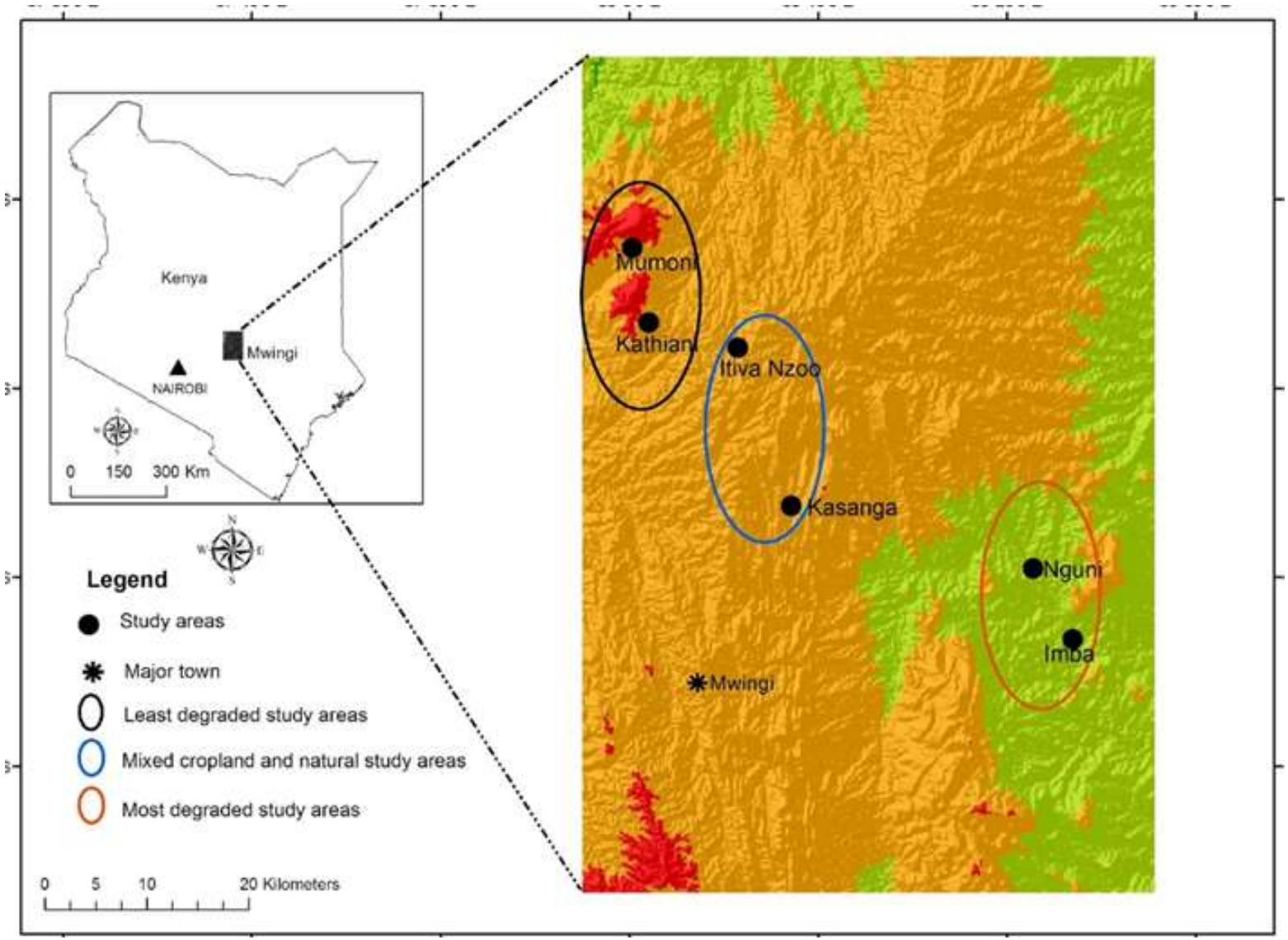
- *Apis mellifera:* ESS- pollination
- Humans highly dependent on bees - 1/3 of all food
- More than 1 in 10 honeybees is at risk of extinction - IUCN Red List for Bees

Drivers of honeybee declines



Potts et. Al (2010)

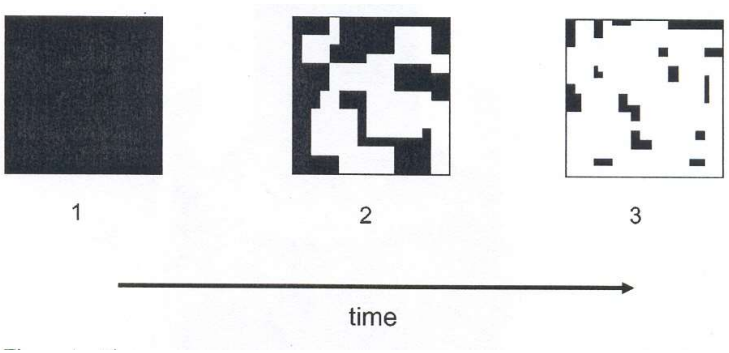
Study Area: Mwingi Central



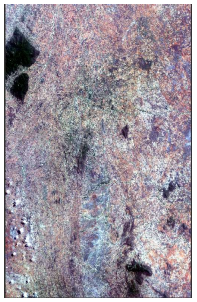
Sampling design

- 2 sites per contrasting landscape type, total 6 sites
- 10 hives per site
- Colonization – natural swarming
- Multi-seasonal data collection

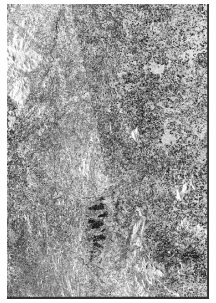
Mapping Landscape setup



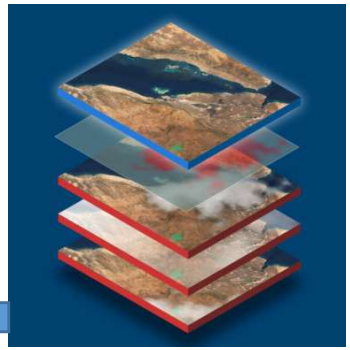
Fragmentation metrics:
Composition, connectivity,
Shape and heterogeneity



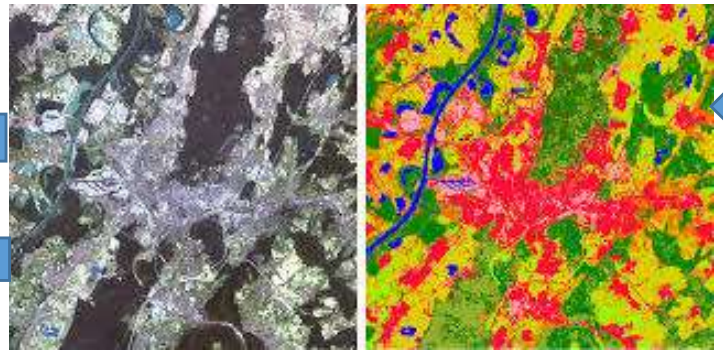
Sentinel-2
(optical)



Sentinel-1
(radar)



Random forest algorithm
-classification



Honeybee relevant habitats

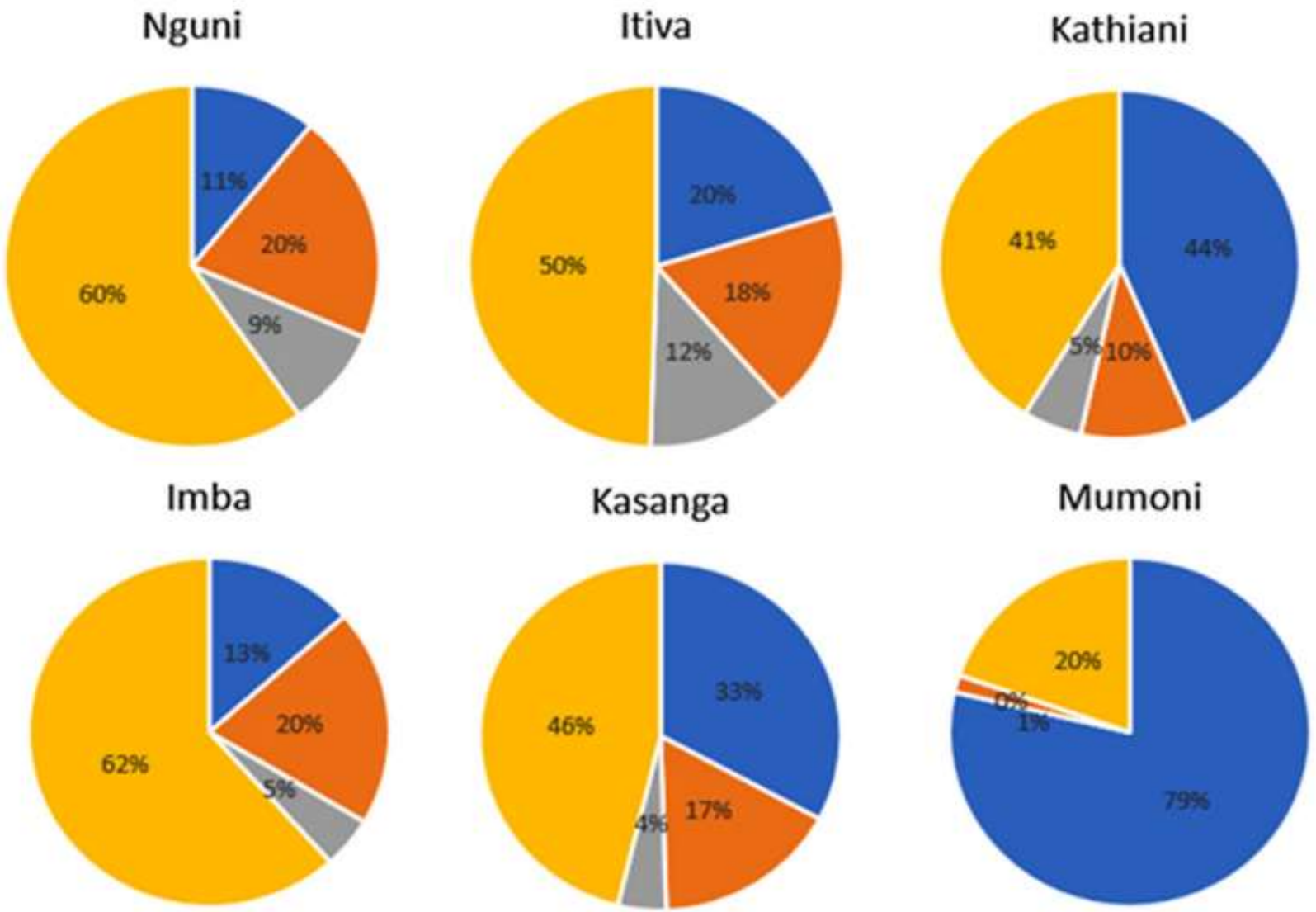
		Reference Data			
		Water	Forest	Urban	Total
Classified Data	Water	21	6	0	27
	Forest	5	31	1	37
	Urban	7	2	22	31
	Total	33	39	23	95

Accuracy metrics

Objective

To establish pollen sources for honeybees as well as pollen nutritional content at and around representative hives.

Defining degradation



Pie charts showing the relative proportion of four potential honey bee foraging habitats i.e. proportions of woody vegetation, hedges, grasslands and croplands in the six study sites

Pollen collection and identification

- Bee bread collected from 3 hives in every apiary at every
  data collection
- Total of 35 bee bread samples collected: 11 in low, 14 in moderate, and 10 in high landscape degradation classes) consisting of mixed pollen were collected.
- The bee bread was stored in falcon tubes at -20^{o}C while in the field, and subsequently at -80^{o}C in the laboratory for long term storage and analysis

Pollen diversity analysis

- Pollen composition - species level and family level
- Species accumulation curves (sample and individual rarefaction, Mao Tau's)
- Rank abundance dominance (RAD) models to compare species evenness in all the sites –radfit() function
- Alpha diversity - at the six sites, diversity ordering using the Renyi index, Kruskal-Wallis rank sum test at 95% confidence level
- R version 3.5.3 (R core team, 2019). Package 'Vegan'

Pollen diversity analysis

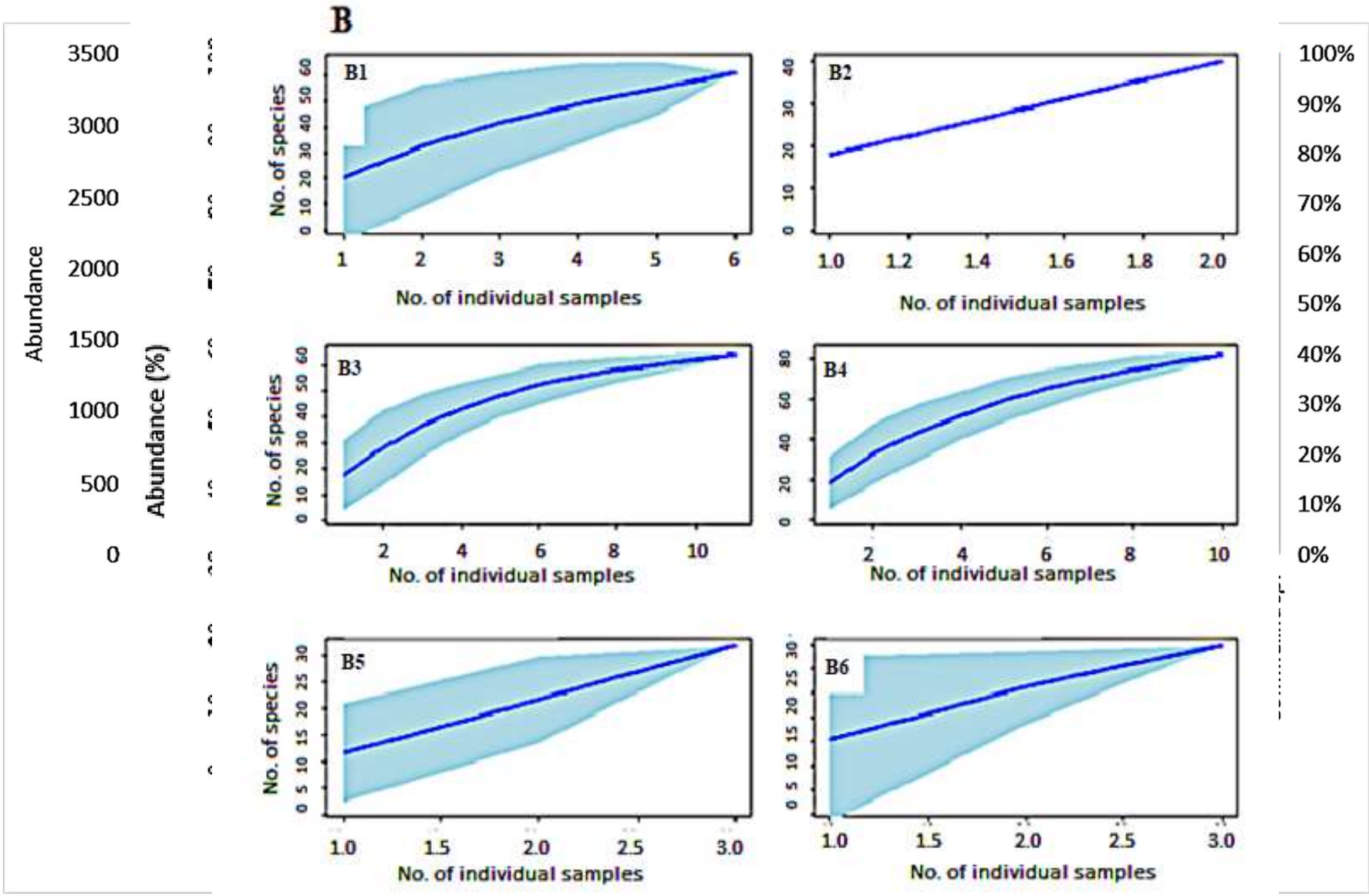
- Non-Metric Dimensional Scaling (NMDS) - beta diversity of pollen
- K=4 dimensions produced the lowest stress value (< 0.2)
- The Bray-Curtis distance matrix - dissimilarity matrix
- Permutational multivariate analysis of variance (PERMANOVA)
- Pairwise similarity percentage (SIMPER) test

Pollen protein extraction and determination test

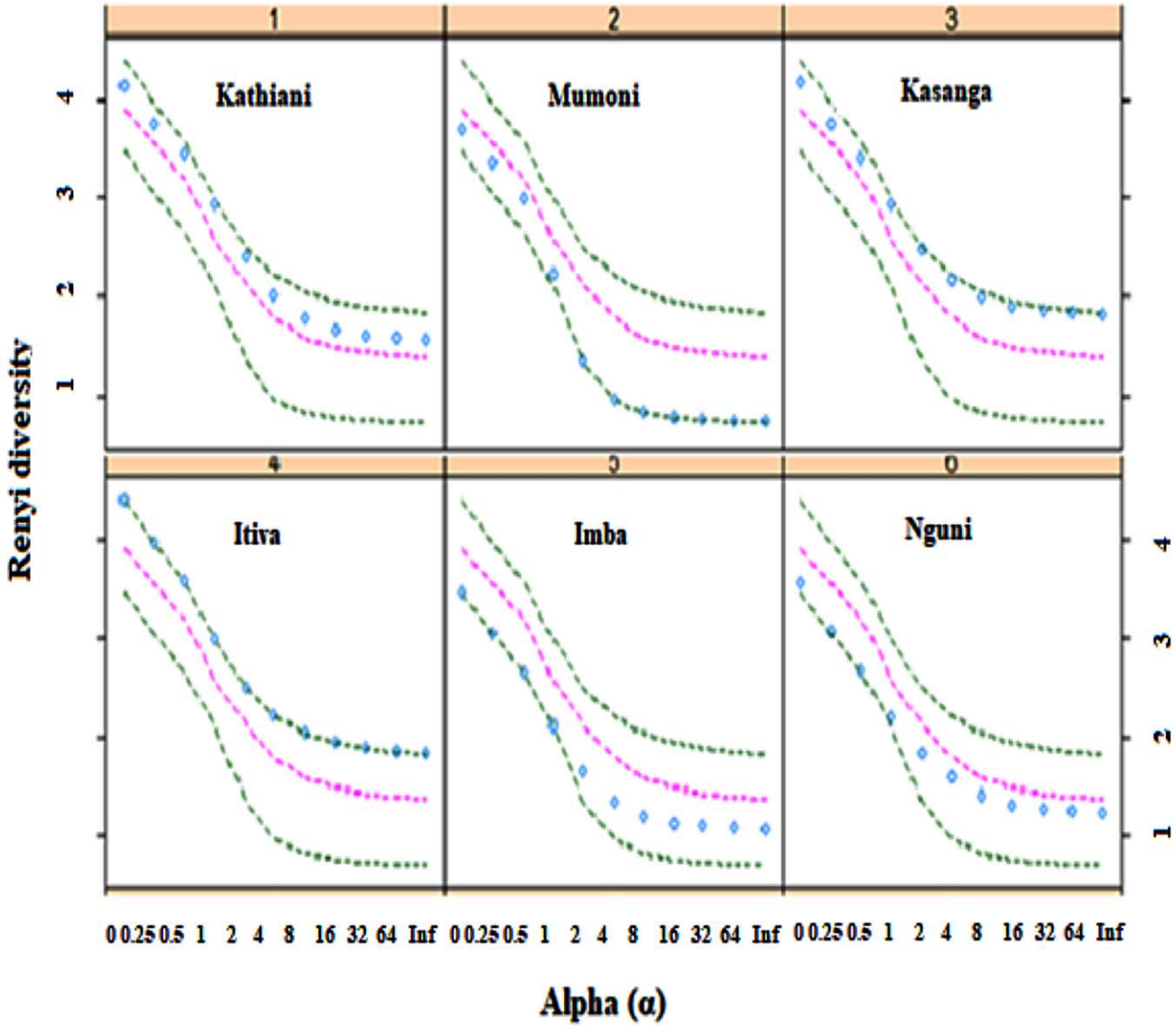
- Using a pestle and mortar, each bee bread sample was crushed, and a sample of 0.025 g was taken as per de Sá-Otero et al. (2009a) suggestions and then transferred into a microcentrifuge tube.

- Protein was extracted from the samples by applying the method used by de Sá-Otero et al., (2009).

Species accumulation curves



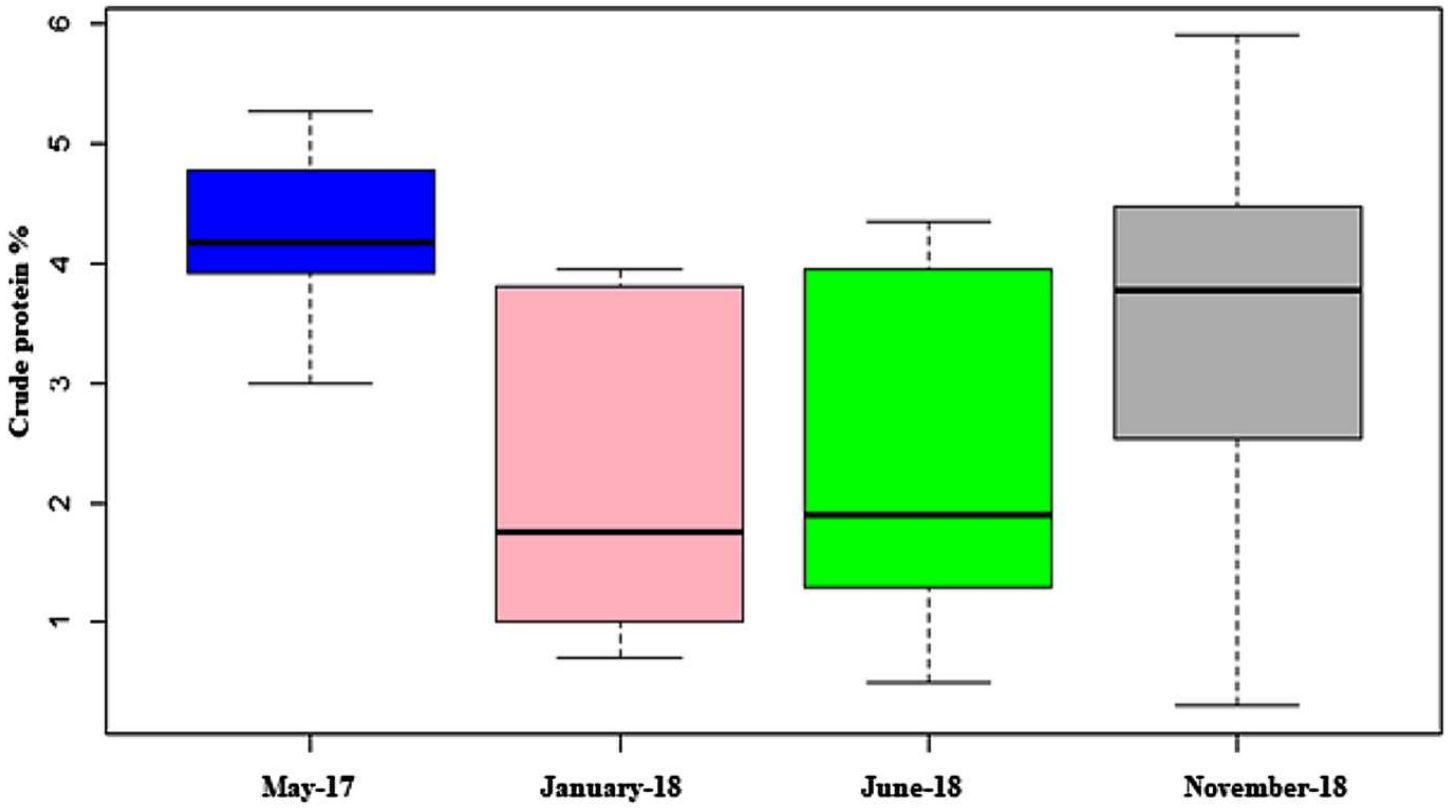
Renyi diversity index



p-value = 0.01157, Kruskal-Wallis Chi-squared = 14.732, df = 5).

	oni	Kasanga	Itiva	Imba	Nguni
	.98	4902.03	8445.82	1518.54	1939.6
	.05	891.75	2066.45	360.01	261.96
	.74	1246.64	1672.69	255.39	464.33
	.44	2334.03	2877.14	346.76	713.07
Mandelbrot	330.57	300.44	564.06	694.12	176.2	265.96

Protein analysis



Kruskal-Wallis
chi-squared = 9.8298,
df = 3, p-value = 0.02007

Discussion

- Pollen collected from moderately degraded landscapes displayed the highest plant diversity
- RAD curves: low plant species evenness corresponded to low plant species diversity as shown by the Renyi diversity index.
- Individual rarefaction curves indicated that no sites reached an asymptote.
- Only four plant species contributed to at least 50% of the cumulative number of the identified 124 plant species hence possible pollen preferences.
- Protein content of pollen varied significantly by time of collection (month).

(Burnett et al., 1998; Honnay et al., 2003; Statzner & Moss, 2003)

Conclusions

- *Terminalia* spp., *Cleome* spp. and *Acacia* spp dominate the pollen types collected across the six study sites, implying that honeybees could have certain preferences for these plants.
- These plant species could be prioritized for conservation and to ensure sustainable availability of preferred honeybee foraging resources in the region.
- Species accumulation curves for each site did not reach an asymptote, which could indicate that the diversity of plants providing resources for the bees in the study area is very high.
- Heterogeneous landscapes consisting of both semi-natural vegetation and croplands are shown to be most suitable for honeybees by displaying the highest pollen diversity
- Honeybee colonies in the region could consequently be established in these heterogeneous areas for maximal benefits

Acknowledgement

DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

UNIVERSITEIT STELLENBOSCH UNIVERSITY

PennState

NATIONAL GEOGRAPHIC

icipe

Thank you!