Malagasy Grass Flora Dynamics: An Exploration of Environmental Influences on Grassy Functional Traits

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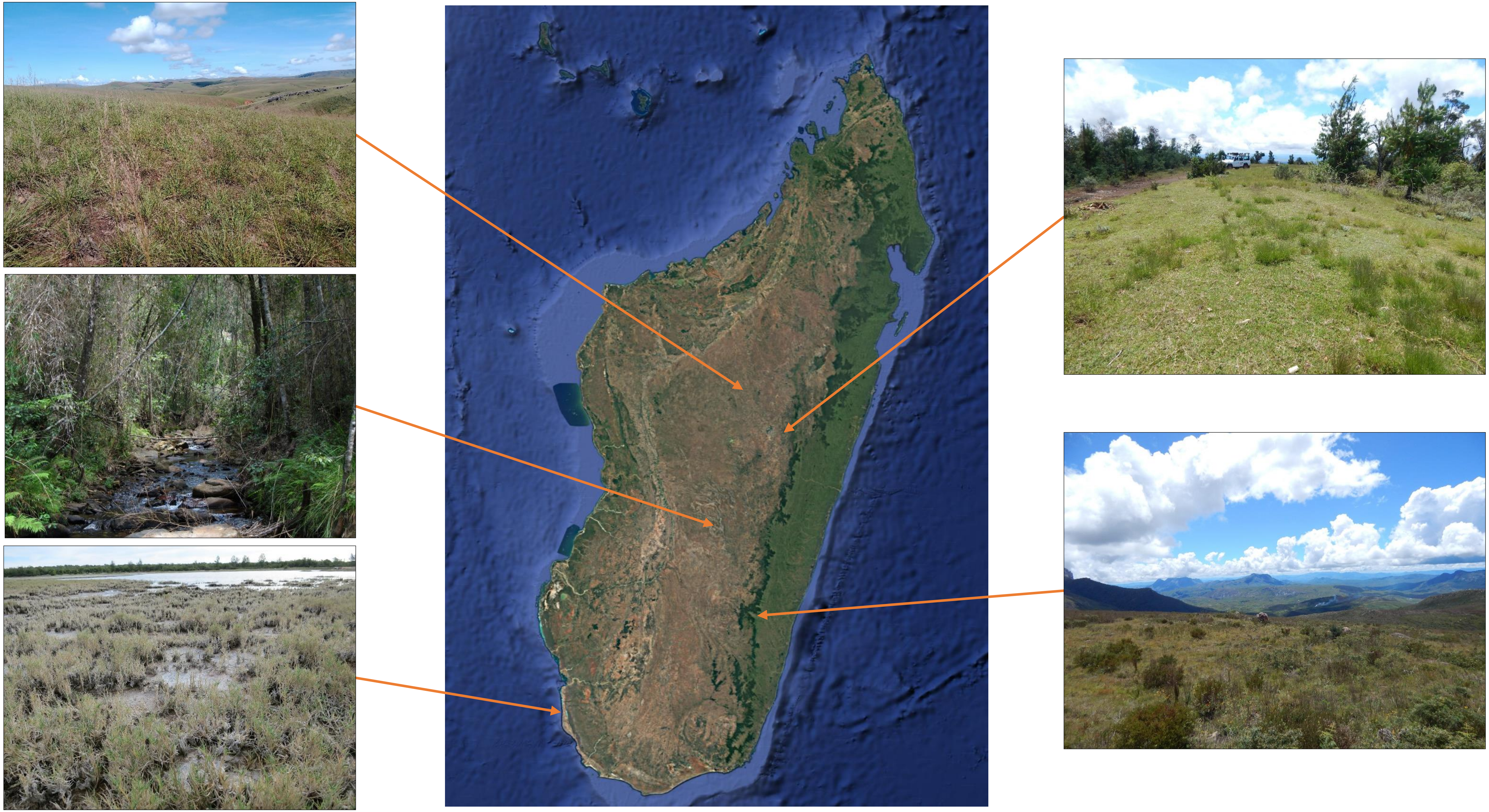
Royal Botanic Garden Edinburgh

The University of Edinburgh

Royal Botanic Gardens Kew



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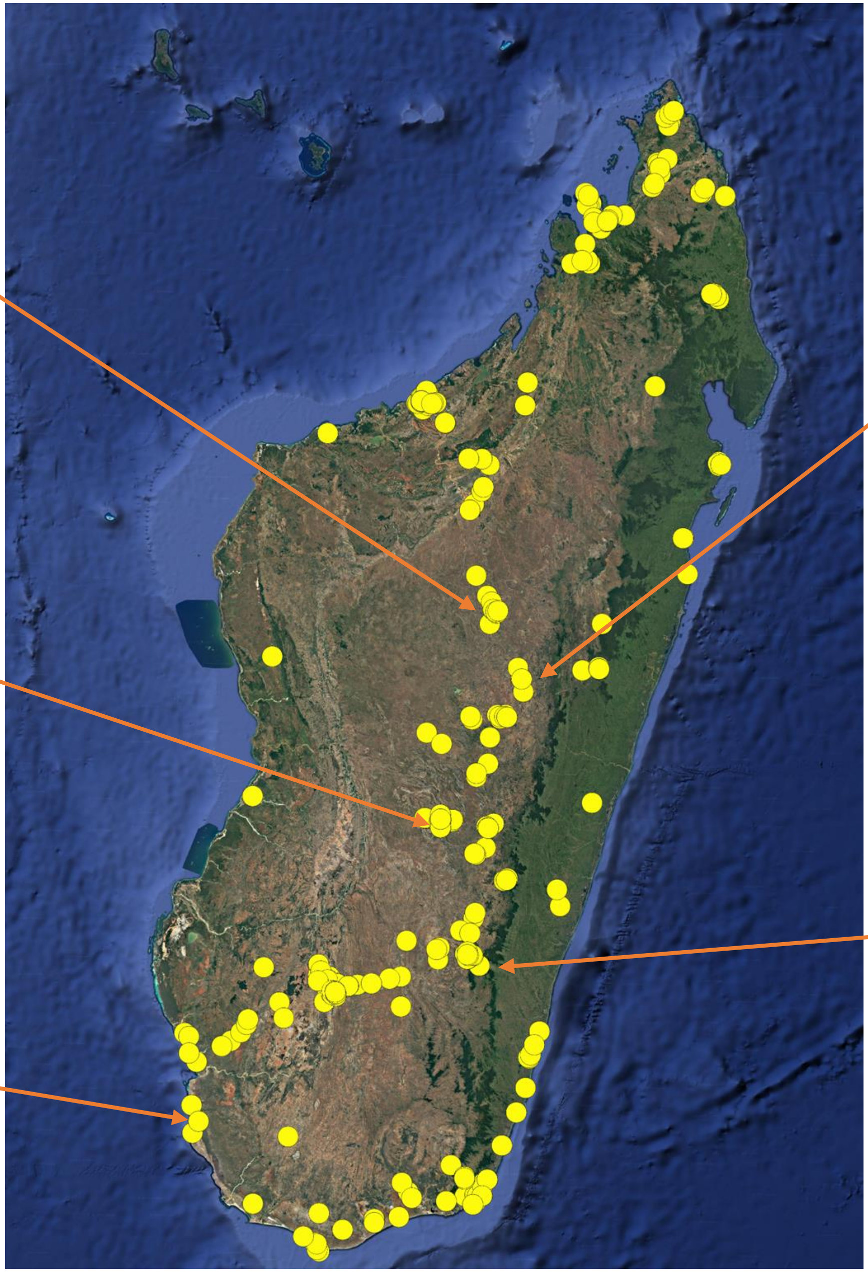

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How do environmental drivers correlate with and predict variation in grass traits related to the size and leaf economic spectra?

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Hypothesise plant-environment relationships

Environmental Drivers
Temperature
Fire
Grazing
Nutrient Availability
Water Availability

Properties of Plants
Competition
Digestibility
Disturbance
Productivity
Tolerance

Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
Inflorescence Height (cm)	↑	↓	↑	↑	↓
Culm Diameter (cm)	↑	↓	↑	↑	↓
Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑

How do environmental drivers correlate with and predict variation in grass traits related to the size and leaf economic spectra?

Hypothesise plant-environment relationships

Measured Six Functional Traits

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Temperature
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Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
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Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑

How do environmental drivers correlate with and predict variation in grass traits related to the size and leaf economic spectra?

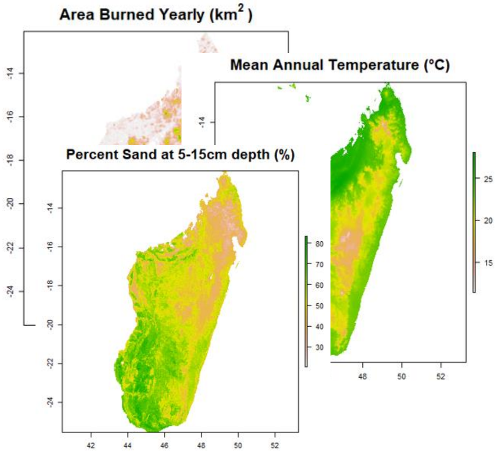
Hypothesise plant-environment relationships

Measured Six Functional Traits

Extracted Five Environmental Variables

Environmental Drivers	→	Properties of Plants
Temperature		Competition
Fire		Digestibility
Grazing		Disturbance
Nutrient Availability		Productivity
Water Availability		Tolerance

Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
Inflorescence Height (cm)	↑	↓	↑	↑	↓
Culm Diameter (cm)	↑	↓	↑	↑	↓
Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑



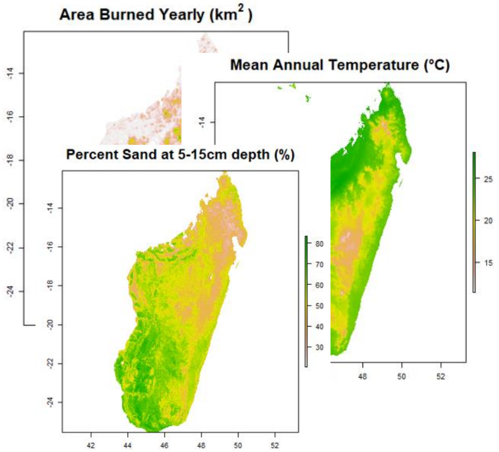
How do environmental drivers correlate with and predict variation in grass traits related to the size and leaf economic spectra?

Ives et al., 2023

Hypothesise plant-environment relationships → Measured Six Functional Traits → Extracted Five Environmental Variables → Test Trait-Environment Relationships

Environmental Drivers		Properties of Plants
Temperature	→	Competition
Fire		Digestibility
Grazing		Disturbance
Nutrient Availability		Productivity
Water Availability		Tolerance

Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
Inflorescence Height (cm)	↑	↓	↑	↑	↓
Culm Diameter (cm)	↑	↓	↑	↑	↓
Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑



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How do environmental drivers correlate with and predict variation in grass traits related to the size and leaf economic spectra?

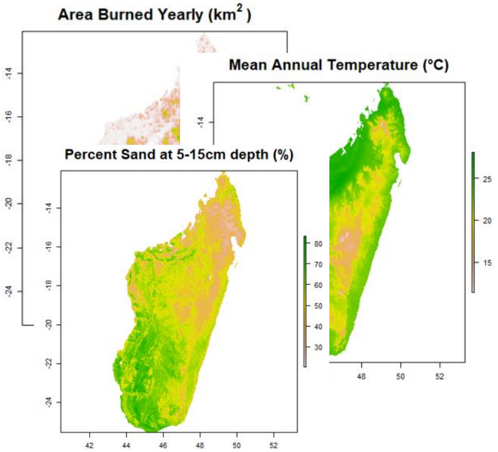
Ives et al., 2023

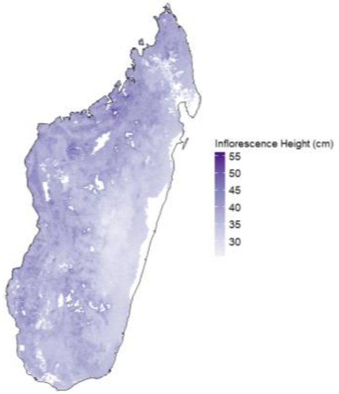
Hypothesise plant-environment relationships → Measured Six Functional Traits → Extracted Five Environmental Variables → Test Trait-Environment Relationships → Predict Trait Distribution

Environmental Drivers
Temperature
Fire
Grazing
Nutrient Availability
Water Availability

Properties of Plants
Competition
Digestibility
Disturbance
Productivity
Tolerance

Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
Inflorescence Height (cm)	↑	↓	↑	↑	↓
Culm Diameter (cm)	↑	↓	↑	↑	↓
Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑





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Environmental Drivers
Temperature
Fire
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→

Properties of Plants
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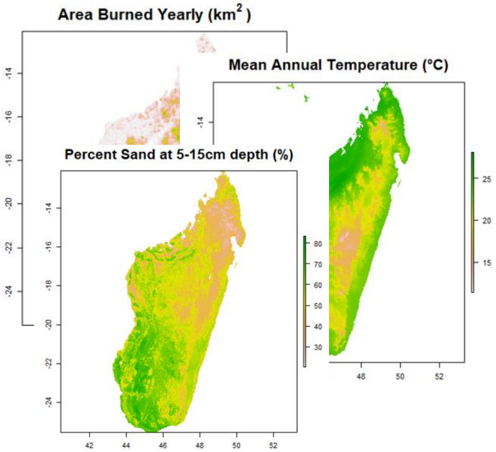
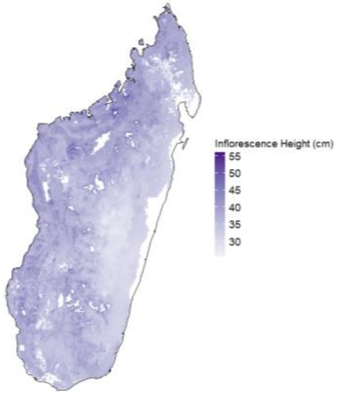
Hypotheses	*Temperature*	*Nutrient deficiency*	*Water availability*	*Fire*	*Grazing*
Inflorescence Height (cm)	↑	↓	↑	↑	↓
Culm Diameter (cm)	↑	↓	↑	↑	↓
Leaf Length (cm)	↑	↓	↑	↑	↓
Leaf Width (cm)	↑	↓	↑	↓	↑
Leaf Thickness (mm)	↓	↑	↓	↑	↓
Leaf Nitrogen (%)	↑	↓	↓	↓	↑





	Temperature	*Nutrient Availability*	*Water Availability*	*Fire*	*Grazing*
Hypotheses	**Mean Annual Temperature (°C)**	**Percent Sand 5-15 cm depth (%)**	**Aridity Index**	**Yearly Mean Burned Area (km^2 year^{-1})**	**Global Human Modification Index**
Inflorescence Height (cm)	↑	↓	↑	↑	↓

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	Temperature	*Nutrient Availability*	*Water Availability*	*Fire*	*Grazing*
Hypotheses	**Mean Annual Temperature (°C)**	**Percent Sand 5-15 cm depth (%)**	**Aridity Index**	**Yearly Mean Burned Area (km^2 $year^{-1}$)**	**Global Human Modification Index**
Inflorescence Height (cm)	↑	↓	↑	↑	↓

Results	**Mean Annual Temperature (°C)**	**Percent Sand 5-15 cm depth (%)**	**Aridity Index**	**Yearly Mean Burned Area (km^2 $year^{-1}$)**	**Global Human Modification Index**
Inflorescence Height (cm)	↑*	↓*	**ns**	↑*	**ns**

- Top-ranked models have cumulative AIC weight of 0.9
- R^2 ranged from: ~0.77-0.79

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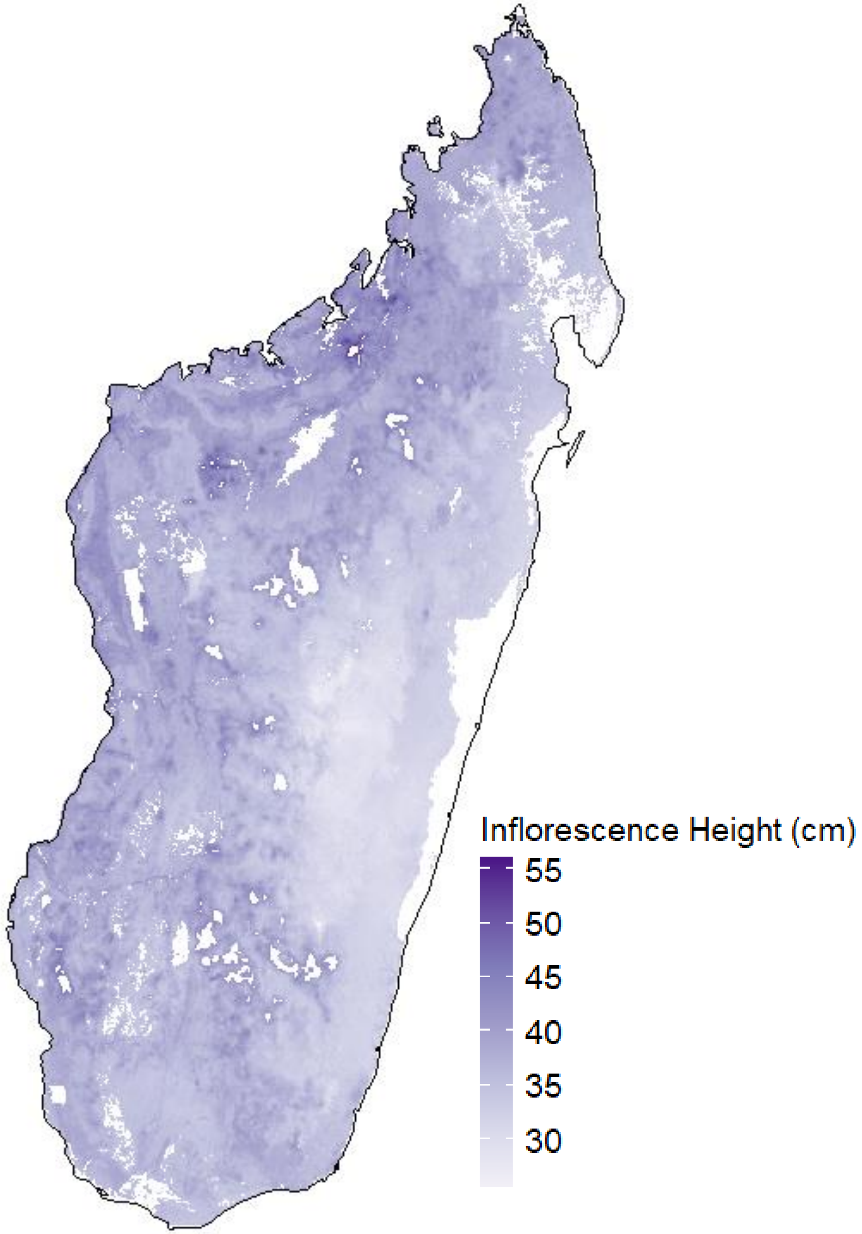
Inflorescence Height (cm)
55
50
45
40
35
30


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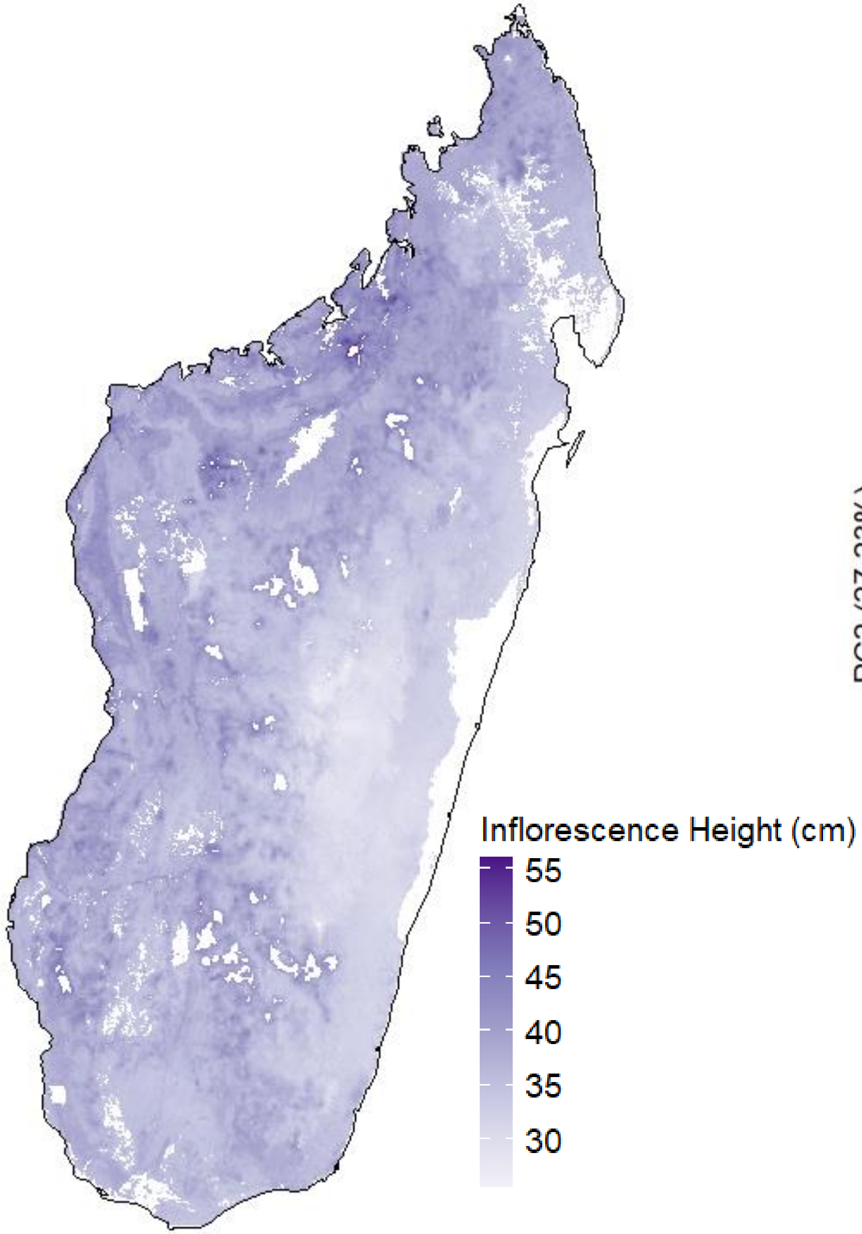
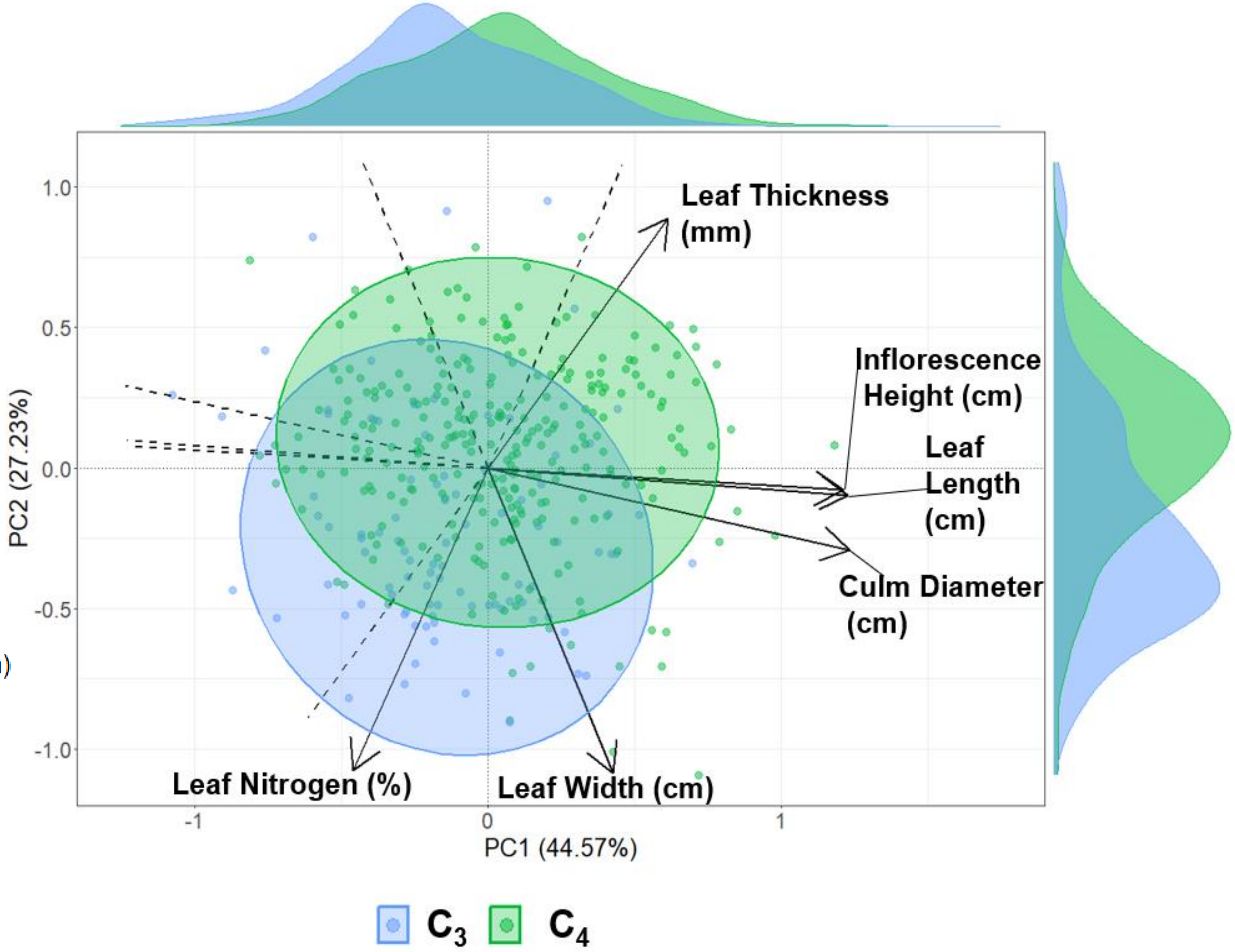

Inflorescence Height (cm)
55
50
45
40
35
30


Leaf Thickness (mm)
Inflorescence Height (cm)
Leaf Length (cm)
Culm Diameter (cm)
Leaf Nitrogen (%)
Leaf Width (cm)
PC2 (27.23%)
PC1 (44.57%)
1.0
0.5
0.0
-0.5
-1.0
-1
0
1
C_3
C_4

In Summary….

- Herbarium collections are valuable for studying trait-environment relationships and trait coordination
- Trait differentiation enhances understanding of life history strategies
- Framework for evidence-based trait modelling and predictions

A special thanks to my collaborators:

Caroline Lehmann, Graham Stone, Bat Vorontsova, Frazer Sinclair, Gareth Hempson, Sally Archibald, Cedriqué Solofondranohatra, Nantenaina Rakotomalala, Adam Devenish, Olinirina Nanjarisoa, and Gemma Bulbulian,

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