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Anticipating potential biodiversity conflicts for future biofuel crops in South Africa: Incorporating land cover information with Species Distribution Models

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INTRODUCTION

Research on global bioenergy, including biofuels, has centred on identifying the potential for bioenergy resources and the spatial distribution of these resources. Regions with suitable soil and climatic conditions that are marginal for conventional agriculture are likely to be targeted as potential production areas. The cultivation of energy crops is expected to follow practises similar to that of agriculture and forestry, placing increased pressure on biodiversity.

Historically, conservation areas have often been proclaimed in areas with poor agricultural potential, thereby avoiding likely trade-offs with agriculture or other potential land uses. However, energy crop cultivation threatens to bring a wider range of land types into production compared to conventional agricultural areas.

Using spatial techniques to determine the threat of land-use change is a useful tool in mitigating against potential biodiversity losses. We investigate the potential suitability and likely impacts of energy crops not currently grown in South Africa, focussing on the Eastern Cape as the study area (**Figure 1**).

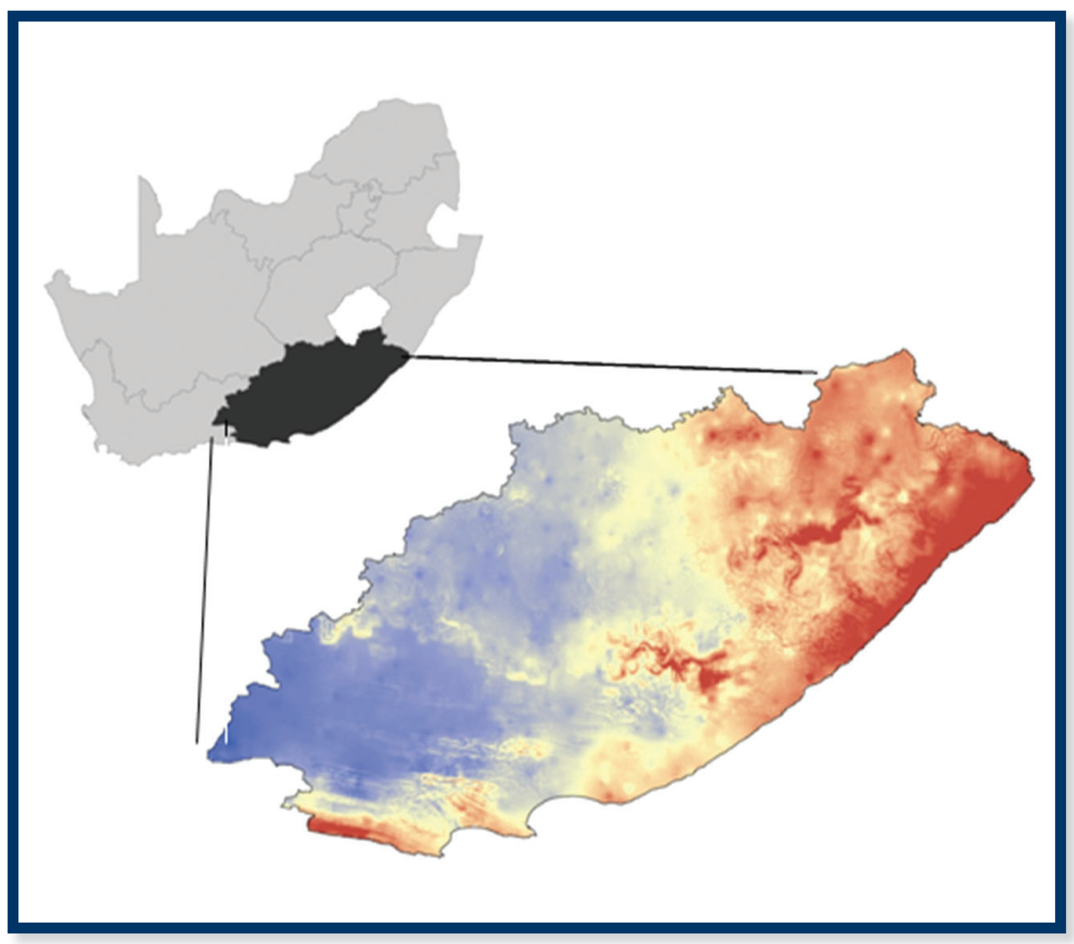

Figure 1: South Africa, indicating the location of the Eastern Cape study area with inset, showing annual rainfall pattern

KEY QUESTIONS

1) What are the potential areas for biofuel cultivation in the Eastern Cape?
2) Which energy crops of global interest are likely to survive in this region?
3) What impacts or conflicts to biodiversity are there likely to be?

METHODS

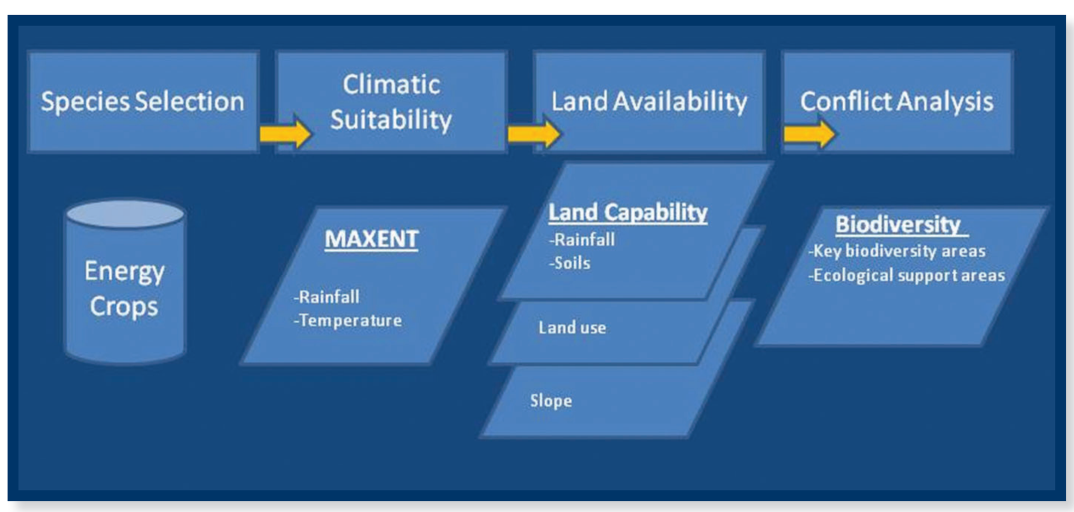

Figure 2: Framework for analysis

We propose a framework that includes four components (**Figure 2**):

- *Step 1: Identification of energy crops and climate matching*
  - Species were selected following a literature review for popular energy crops as determined by the ISI Web of Science
  - The Species Distribution Model – MAXENT – was used to determine potential climatic matches using global environmental variables and easily obtained presence records from online databases.
- *Step 2: Land availability analysis*
  - South Africa's land cover data for all remaining natural areas were extracted. These were filtered to ***exclude*** steep areas (a slope of > 16 degrees) and ***include*** a measure of land quality (based on the Land Capability of the Agricultural Research Council).
- *Step 3: Important biodiversity areas*
  - An important limiting factor for potential land is the location of high biodiversity areas. For this we used three different methods to identify biodiversity areas:
    1) Protected areas only
    2) Areas identified as biodiversity hotspots (www.BGIS.co.za)
    3) Areas identified as important for ecological processes (extracted from the Conservation Plan for the Eastern Cape).
- *Step 4: Conflict of Overlap*
  - Conflict was identified using an overlap analysis method in ARGIS to determine potential conflict with biodiversity areas. This was assessed for the distribution of energy crops analysed (Step 1) and all remaining areas identified for cultivation potential (Step 2).

RESULTS

- Species distribution models indicate that energy crops are likely to have varying potential in the Eastern Cape (**Figure 3**). Despite wide environmental tolerances, extremely marginal areas where rainfall is likely to be a limiting factor are avoided.

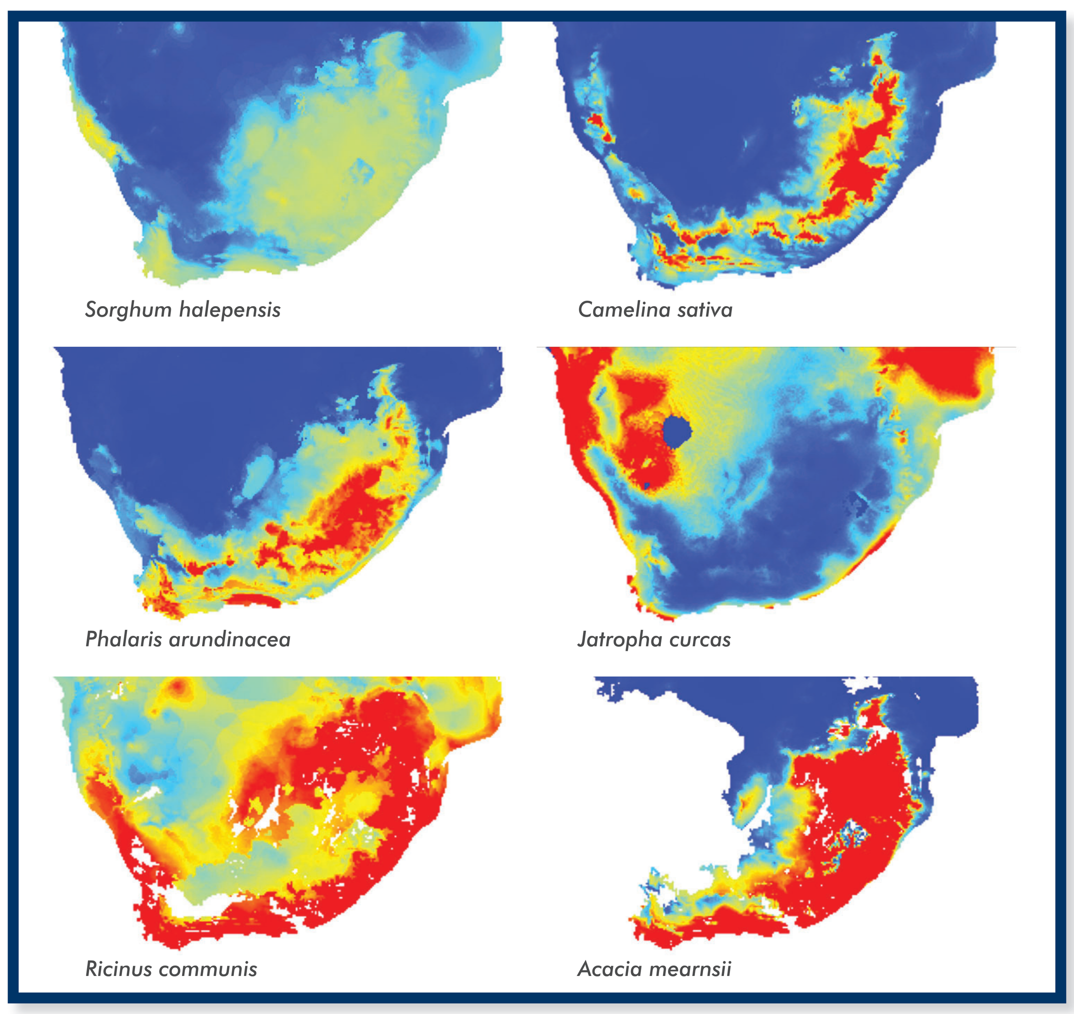

Figure 3: Species Distribution Model outputs for six potential energy crops. Cool colours (blue) indicate low probability of occurrence and warm colours (red) indicate a high probability of occurrence. *Acacia mearnsii*, an invasive species in South Africa and the Eastern Cape, is included in this analysis due to potential interest in it as a biomass crop

- The total area likely to accommodate energy crops are indicated in **Table 1**. Land suitability reduces from 77% to 45% of the Eastern Cape once all exclusions are taken into account.

Table 1: Overview of land resources

	Area (Mha)	Area (%) of Eastern Cape
Total area	**16.8**	**100**
Excluded area (currently in use or severely degraded)	**3.97**	**22.5**
Remaining natural areas after accounting for slope	**13.1**	**77.4**
Suitability assessment	**7.7**	**45.7**
Land capability 1–4	2.3	13.7
Land capability 5	1.5	8.77
Land capability 6	3.9	23.1
Biodiversity areas	**15.5**	**92.2**
Protected areas	0.93	5.5
Potential protected area expansion (A)	2.74	16.3
Important biodiversity areas (B)	2.84	16.8
(A+B)	4.44	26.3
Ecological support areas	9.20	54.5

- Protected areas account for 2–5% of total land area (**Figure 4**). This increases to 26% when all areas of high biodiversity are included. Ecological support areas are mapped as contributing up to 91% of biodiversity importance.

The potential use of ecosystem services maps could serve as a proxy for the broader role of the environment to provide goods and services that need to be maintained in the landscape.

- Conflict analysis indicates areas of convergence where all energy crops have a high suitability potential (**Figure 5**).

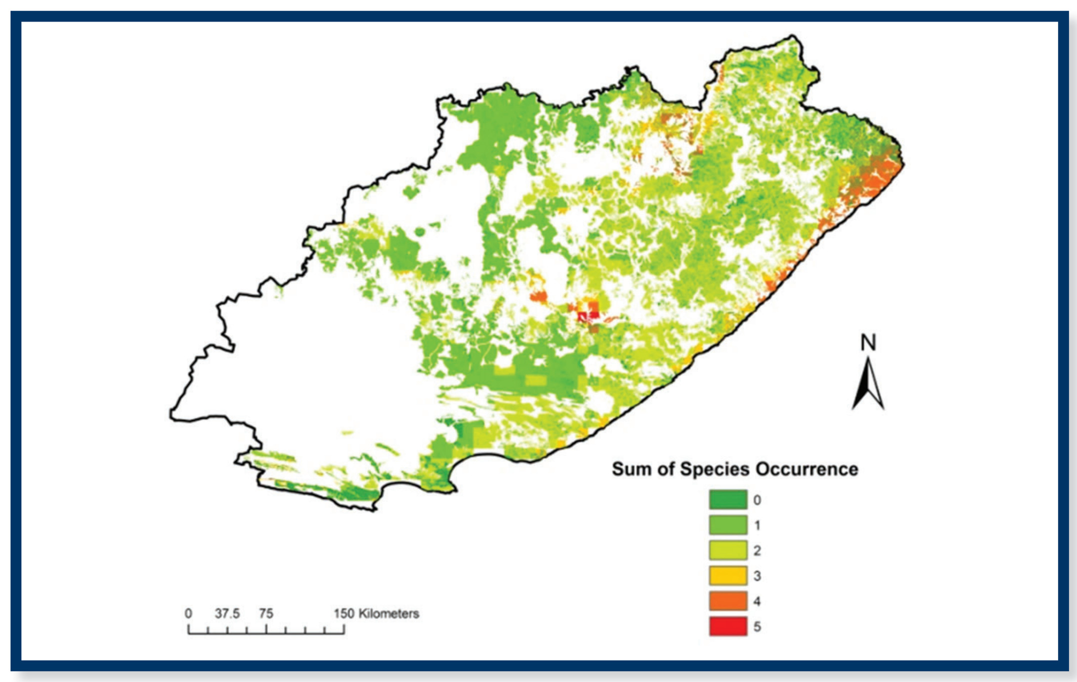

Figure 5: The sum of species distribution outputs indicating areas of potential conflict where multiple species are likely to co-exist

DISCUSSION

- This approach anticipates likely habitat transformation and provides an opportunity to mitigate potential conflict with biodiversity areas. Adopting a spatial approach highlights where likely threats are to be anticipated.
- Energy crops are topical in the literature because of the potential to occupy marginal lands, therefore not competing with resources required to produce food and feed. However, we see that marginal areas are also important areas for biodiversity. The formal protected area network does not adequately protect biodiversity in the region.
- The conservation sector recognises the importance of ecological support areas, yet the global modelling of biofuel production does not have the tools to adequately account for these areas. Potential use of ecosystem service maps could serve as a proxy for the broader role of the environment to provide goods and services that need to be maintained in the landscape.

CONCLUSION

Lessons from this research could guide global bioenergy studies to include ecological support areas beyond the protected area network. Biodiversity could be threatened where marginal areas targeted for cultivation also contribute to conservation targets.

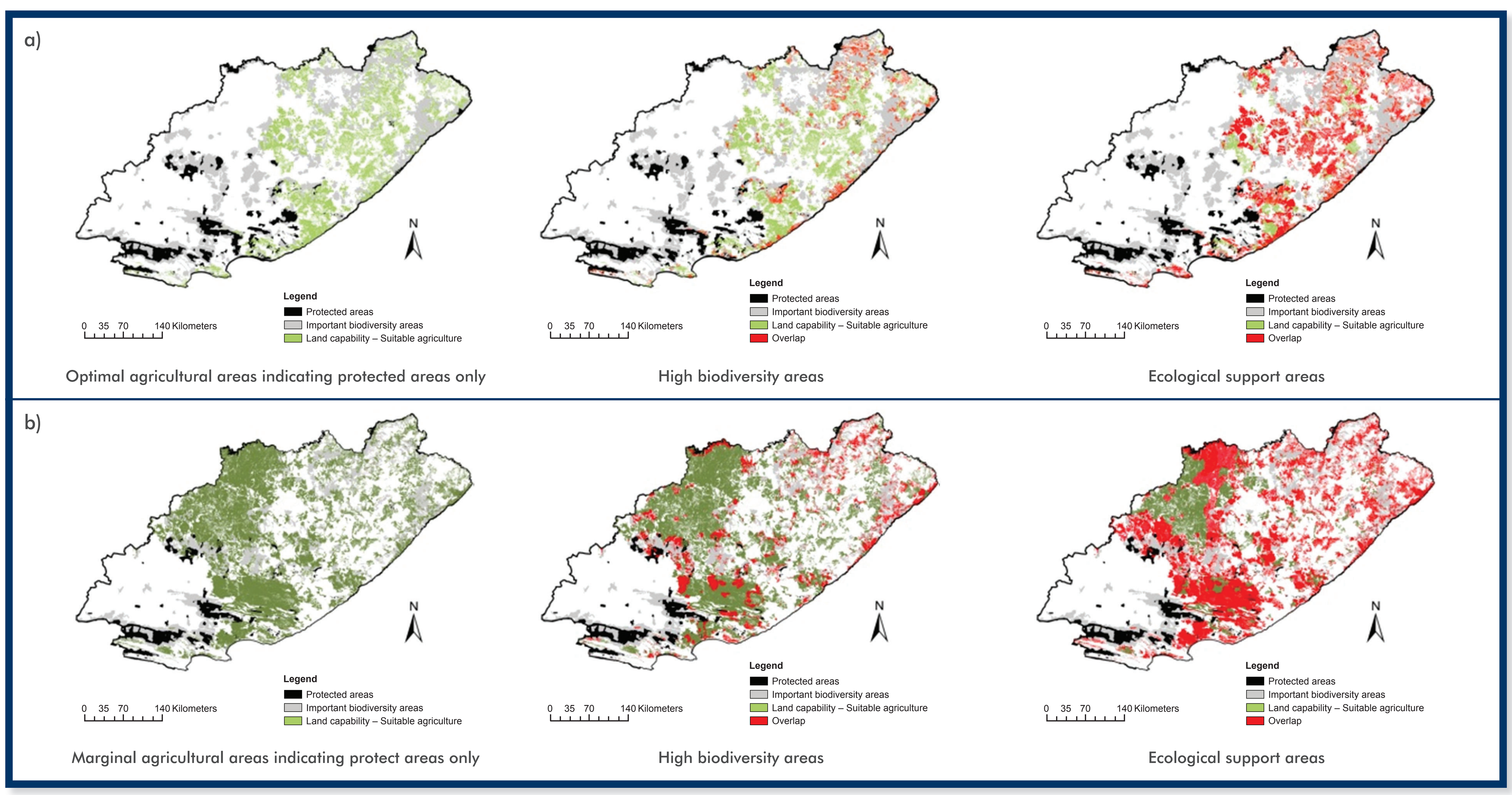

Figure 4: Maps indicating the increasing potential for conflict as additional biodiversity layers are introduced into the analysis a) optimal and b) marginal areas

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