Are bioclimatic niche models useful in predicting invasions?

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Why bioclimatic niche models?

- Basic models used to predict species distributions
- Successful establishments in areas that match a set of ecological conditions in native range records
Aim

- To evaluate how useful bioclimatic niche models are in predicting invasions
Methods

Australian acacias in Southern Africa
- 69 species introduced into southern Africa
- Government introduced 46 species for forestry
- Currently 14 invasive and 5 are naturalized
Bioclimatic modelling

**Southern Africa**
To identify regions suitable for Australian acacias

- Annual mean temperature
- Min. Temp. of the coldest month
- Max. Temp. of the Warmest Month
- Annual Precipitation

**Model evaluation**

- Southern African Plant Invaders Atlas
  11 species (3471)

- Government forestry trials
  14 species (129)
Government forestry trials

- Experimental introductions since 19th century
- Failures and establishments recorded
- Invasion biology aspects
  - Presence and absence data
  - Gives indication of invasion (seedlings spreading from plantations)
- We used 14 species
- Can the models predict introduction outcome?

Poynton (2009)
Southern African Plant Invaders Atlas (SAPIA)

- Naturalized or invasive species in Lesotho, Swaziland & South Africa
- 11 Well established species
- Could the models have predicted the spread of these species?
Acacia dealbata

Representative species
**Acacia mearnsii**

The image shows a map of South Africa with various symbols and colors indicating the distribution and suitability of the Acacia mearnsii species. The map includes symbols for establishment points, failure points, and predicted suitable and unsuitable areas.
Model evaluation

The higher the value the closer the match

- Sensitivity - proportion of actual presences predicted present (omission error)

- Specificity - proportion of observed absences predicted absent (commission error)

- True skill statistics quantifies omission and commission errors
Representative species

- **Acacia mearnsii**
  - Sensitivity = 0.70 (GFT) & 0.78 (SAPIA)
  - Specificity = 0.33

- **Acacia dealbata**
  - Sensitivity = 0.91 (GFT) and 0.99 (SAPIA)
  - Specificity = 1
Prediction of introduction outcome

- Government forestry trials
  - Sensitivity value = 0.80
  - There is a good overall agreement between model prediction and successful introductions
  - Of all 129 records (63%) were correctly predicted
# Model performance

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of trials</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>TSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. acuminata</td>
<td>13</td>
<td>0.50</td>
<td>0.54</td>
<td>0.04</td>
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<tr>
<td>A. aneura</td>
<td>4</td>
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<td>0.00</td>
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<tr>
<td>A. baileyana</td>
<td>5</td>
<td>1.00</td>
<td>0.00</td>
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<tr>
<td>A. cultriformis</td>
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<td>-0.50</td>
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<tr>
<td>A. dealbata</td>
<td>13</td>
<td>0.91</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>A. decurrens</td>
<td>7</td>
<td>1.00</td>
<td>0.20</td>
<td>0.20</td>
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<tr>
<td>A. elata</td>
<td>9</td>
<td>0.50</td>
<td>0.20</td>
<td>-0.30</td>
</tr>
<tr>
<td>A. falciformis</td>
<td>4</td>
<td>1.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>A. longifolia</td>
<td>5</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>A. mearnsii</td>
<td>13</td>
<td>0.70</td>
<td>0.33</td>
<td>0.03</td>
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<tr>
<td>A. melanoxyylon</td>
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<td>0.00</td>
<td>0.00</td>
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<td>A. pendula</td>
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<td>0.33</td>
<td>0.67</td>
<td>0.00</td>
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<tr>
<td>A. pycnantha</td>
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<td>0.88</td>
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<td>-0.20</td>
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<tr>
<td>A. saligna</td>
<td>8</td>
<td>0.40</td>
<td>1.00</td>
<td>0.40</td>
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<tr>
<td>Overall</td>
<td>129</td>
<td>0.80</td>
<td>0.35</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Prediction of invasion success

- **SAPIA**
  - The overall sensitivity value = 0.87
  - Overall agreement between invaded range and model prediction is good
  - Of all 3000 records (87%) were correctly predicted
## Models performance

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of records</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. baileyana</em></td>
<td>86</td>
<td>0.95</td>
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<tr>
<td><em>A. cyclops</em></td>
<td>141</td>
<td>0.97</td>
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<tr>
<td><em>A. dealbata</em></td>
<td>717</td>
<td>0.99</td>
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<tr>
<td><em>A. decurrens</em></td>
<td>157</td>
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<tr>
<td><em>A. elata</em></td>
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<td><em>A. longifolia</em></td>
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<td><em>A. mearnsii</em></td>
<td>1916</td>
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<td><em>A. melanoxyilon</em></td>
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<td><em>A. podalyriifolia</em></td>
<td>56</td>
<td>0.91</td>
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<tr>
<td><em>A. pycnantha</em></td>
<td>83</td>
<td>0.99</td>
</tr>
<tr>
<td><em>A. saligna</em></td>
<td>53</td>
<td>0.98</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>3471</strong></td>
<td><strong>0.87</strong></td>
</tr>
</tbody>
</table>

Model evaluation with SAPIA data
Current and potential distributions

- A large portion of southern Africa is climatically suitable for Australian acacias
- Most biomes are predicted to be suitable with Fynbos as the most susceptible
- Suitable climates extending well beyond current distributions for species
Discussion

- Bioclimatic models accurately identified currently invaded range

- Models identified successful establishments in trials

- Climate is an important factor while explaining invasions
Implications for biodiversity planning

- Invasions second threat to biodiversity
- Models identify suitable areas for species
- Potential invaders can be identified and excluded
- Reduce impacts caused by invasions
- So models are useful as pro-active tool for invasion risk assessment
Acknowledgements

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  - Dr. John Wilson
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