Mapping malaria vectors in South East Asia
Combining remote sensing and ecological niche model analysis

DYNMAP
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Background:
Remote Sensing derived product potentially useful for malaria control

BUT Up-to-date detailed useful information is rarely available

- Coarse/medium resolution offer cheap frequent timely info but not enough details
- High resolution images available but on small areas and at high cost
- Derived product such as land cover are more adapted to non specialist but often out of date due to the lengthy production process

Available choices = NOT relevant for the purpose

DYNMAP innovation project:
Dynamic predictive mapping using multi-sensor data fusion: Demonstration for malaria vector habitat

Objectives:
1. Develop a Bayesian Data Fusion method to provide up-to-date land descriptors
2. Perform predictive mapping of major malaria vector *Anopheles dirus*
Table of content:


2. Data and methodology

3. An. dirus s.l. potential distribution: long term abiotic factors.

4. Approaching the realised niche: medium scale biotic factors

5. Local scale: delineating dry and wet season habitat for An. dirus

6. Conclusion
Table of content:


2. Data and methodology


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6. Conclusion
<table>
<thead>
<tr>
<th>Presence/Absence data only</th>
<th>Use Presence/Absence data only</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Abundance between species ~ sensitivity to collection method</em></td>
<td></td>
</tr>
<tr>
<td>Catch</td>
<td></td>
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</tbody>
</table>

| Use Presence data only or give more weight to presence data |
| Absence ~ Difficult to catch, Sampling strategy not adapted, Temporary adverse condition |
| Catch |

| Do not use double absence |
| Absence for two species ~ Not necessarily association |
| Catch |
Ecological Niche Modelling concepts
Soberon (2007) hierarchical framework

Abiotic factors
- Physical limits
  - fundamental
  - realised
  - occupied

Accessibility
- Dispersal capacity

Biotic factors
- Interactions

Abiotic
- Slow changing
- Large region
- Coarse resolution
- Museum records

Biotic
- Fast changing
- Small region
- Fine resolution
- Field records
Table of content:


2. Data and methodology


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6. Conclusion
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Abiotic factors **Long term data**
- Rainfall (abundance/pattern)
- Temperature
- Topography and soil type
- Relative humidity
*Worldclim, CRU cl2.1, USGS GTOPO30, FAO*

Biotic factors **Up-to-date**
- Forest cover for 2005
  *Globcover (ESA) modified*

Biotic factors **Up-to-date data**
- Detailed satellite images spot (HRV) for 2005

200 museum records covering Asia

50 sites in Cambodia and Vietnam
Covering 2004 to 2006 in 3 sites
Table of content:


2. Data and methodology


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MAXENT

Define the suitable niche using information derived from environmental factors values in the cells occupied by individual

Ecological modelling technique based on the maximum entropy principle
Using presence only data
Good performance for transferability in area with sparse data

Good model performance
Run using 50% set aside as test sample
Definition of a threshold value to transform probabilities into presence/absence

Maximise the sum of specificity and sensitivity
Table of content:


2. Data and methodology


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5. Local scale: delineating dry and wet season habitat for *An. dirus*

6. Conclusion
4. Approaching the realised niche: medium scale biotic factors

Publication
Table of content:


2. Data and methodology


4. Approaching the realised niche: medium scale biotic factors

5. Local scale: delineating dry and wet season habitat for *An. dirus*
   - Seasonal vector habitat
   - A new Bayesian Data Fusion (BDF) method for updating local scale land descriptors

6. Conclusion
Delineation of restricted zone for dry season vector habitat

3 forested study areas with contrasted seasons

Cambodia

Vietnam

Need for up-to-date land descriptors

Bayesian data Fusion method
Bayesian data Fusion: Fusion of images from different resolution

Tests

Multispectral / panchromatic images:
- Spot 5 HRG
- Landsat ETM

Multi-sensor fusion:
- Spot HRG and vegetation

Publication


Good performance
Fusion Multi-spectral and panchromatic images (spot)

\[ \mathbf{Y} = \mathbf{g(Z)} + \mathbf{E} \]

\[ f(z|y) \propto f_Z(z) f_E(y - g(z)) \]

\[ f(z|y) \propto f_Z(z) \prod_{i=1}^{n} f_{E_i}(y - g(z)) \]

<table>
<thead>
<tr>
<th>( B_1 )</th>
<th>( B_2 )</th>
<th>( B_3 )</th>
<th>( B_4 )</th>
<th>Pan–Intensity</th>
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</thead>
<tbody>
<tr>
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<td>0.97</td>
<td>0.98</td>
<td>0.97</td>
<td>0.80</td>
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</table>
Bayesian data Fusion: temporal fusion

Good performance for visual interpretation but too much noise for land cover classification

**Test**

- Spot 5 HRG - VEGETATION
- LANDSAT - VEGETATION
- VEGETATION 1-10-100 km

**Publication**

Fusion VEGETATION 1km, 10km - 100km

2005

Coarse

Detailed

2004
Conclusion

• Hierarchical framework concept of ecological niche mapping offer opportunities for integration of multi-scale analysis

• The project achieved successful predictive mapping of potential distribution for *An. dirus s.l.* at a scale of 300m resolution

• The new Bayesian data Fusion (BDF) method show good performance for pan-sharpening of same sensor or multi-sensor images

• Multi-temporal fusion experiments carried on during this innovation project showed promising results but not sufficient to derive up-to-date land descriptors

Perspectives

• New multi-temporal fusion experiments are currently carried on in the context of normalisation of high resolution image using low resolution for uniformisation prior to mosaic building

• Local study sites are currently investigated using land descriptor derived from available detailed images