CLIMATE AND LAND-USE CHANGES IN A COUPLED DEMOGRAPHIC AND BIOCLIMATIC ENVELOPE MODEL

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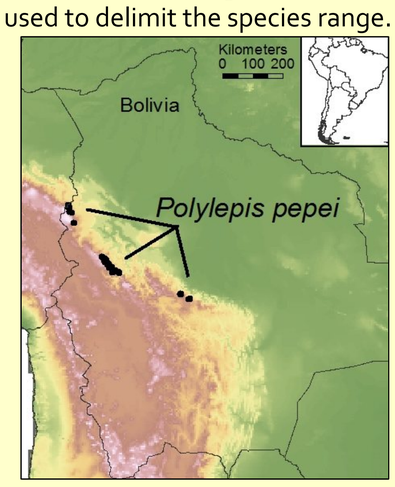
Linked climate and population models:

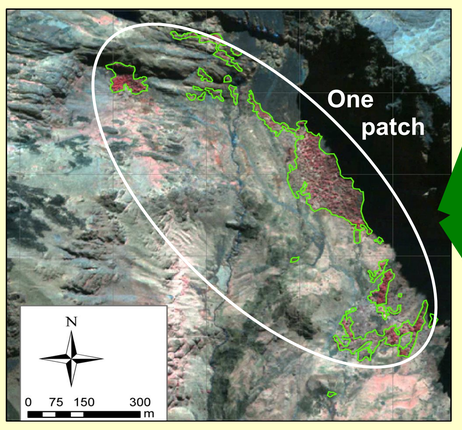
- How can population models best take into account climate change?[1]
- What are the effects of land-use changes and climate change on a rare species?

Investigated Species

Polylepis forests form tree lines in South America. *Polylepis pepei* (VU on IUCN Red list) currently has a very fragmented distribution (500 m altitude range). Satellite images were used to delimit the species range.



Occupied range in Bolivia: 330 hectares
Current population: 1.1 millon individuals
Number of patches: 125



Demographic Model

Data for calculating probabilities of transition between size classes came from published literature and trees with same life history.

Size class distribution (value is maximum cm height in class) from field measurements.

Size-classified transition matrix:

Time / seed	10	20	40	80	200	400	600	>600
seed	0.46			1	9	104	105	143
10	0.03	0.41	fire	0.01	0.5	5.62	5.68	7.7
20		0.04	0.41	climate change				
40			0.13	0.54				
80			grazing	0.19	0.81	wood-cutting		
200					0.03	0.94		
400						0.02	0.95	
600							0.01	0.96
>600								0.01	0.9

(Time + 1)

For each threat to survival multiply the transition probabilities:

For Land-use: +/- 10%

For Climate: Habitat Suitability score

Bioclimatic Envelope Model

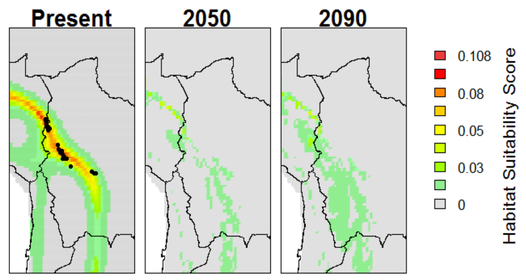
Current climate: Climatic Research Unit CL2.0, 10-minute resolution.

Future climate: HADCM3, scenario b1.

Environmental variables:

- mean summer temperature
- fall precipitation

GAM modelling method[7]



Result: population size per patch

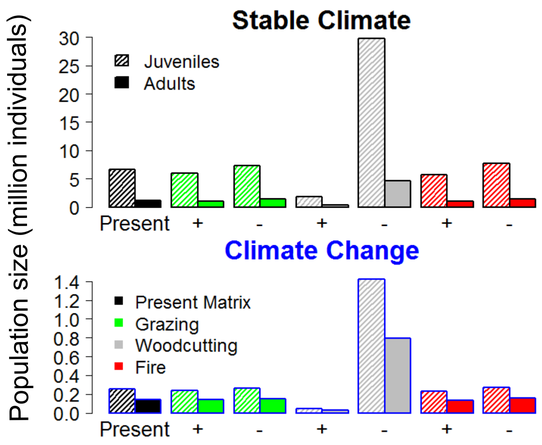
Simulate 40 years; incorporate Habitat Suitability

Result: Habitat Suitability score per patch

Repeat simulations for other time periods

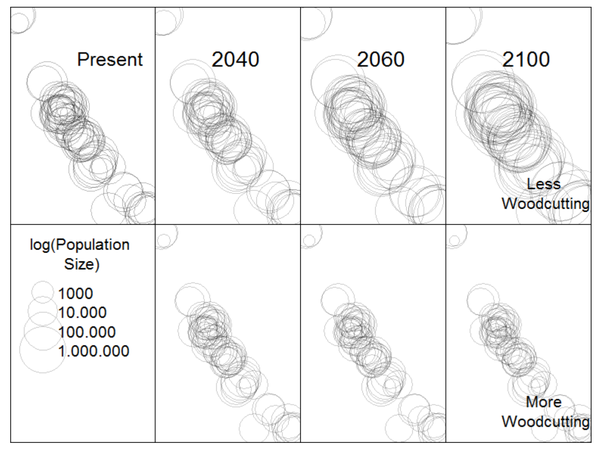
Results

1. Estimated abundance with +/- land-use changes



Population size for each threat to survival in 2040. Note change in scale on y-axis. With climate change there is a higher predicted proportion of adult trees (refugia), since in this model they are not affected by climate change.

2. Patch population size with more or less woodcutting



Map of a subset of patches. Each circle is the log-transformed population size under stable climate. With less woodcutting patches increase in size. With increased human impact population sizes decrease.

Conclusions

Climate changes affected population sizes more than land-use changes.

Reducing wood-cutting would be the most effective local conservation strategy.

Future Work

Incorporate allee effects, density dependence, long distance dispersal.

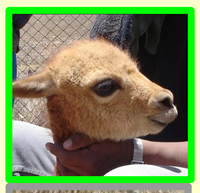
Include other species, biotic interactions and feedbacks, such as interactions between fire, cloud cover and water-storing moss layers.[5]

Improve effects of climate change to include experimental physiological effects.

Validate demographic model, through long-term inventories[6], dendrocronology and past range shifts through pollen analysis.

Model scale: grid-based or patch-based?

Threats to survival



Grazing - Grazing damage is mostly done to juvenile trees < 1m tall.[2]

Woodcutting - The largest trees are cut down.

Fire - Juvenile Polylepis trees often die after a fire.[4]

Climate Change - Unknown effects. Experiments show that germination is influenced by temperature.[4]

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