The effects of climate change on mountain ecosystems

Bernat Claramunt-López
Researcher

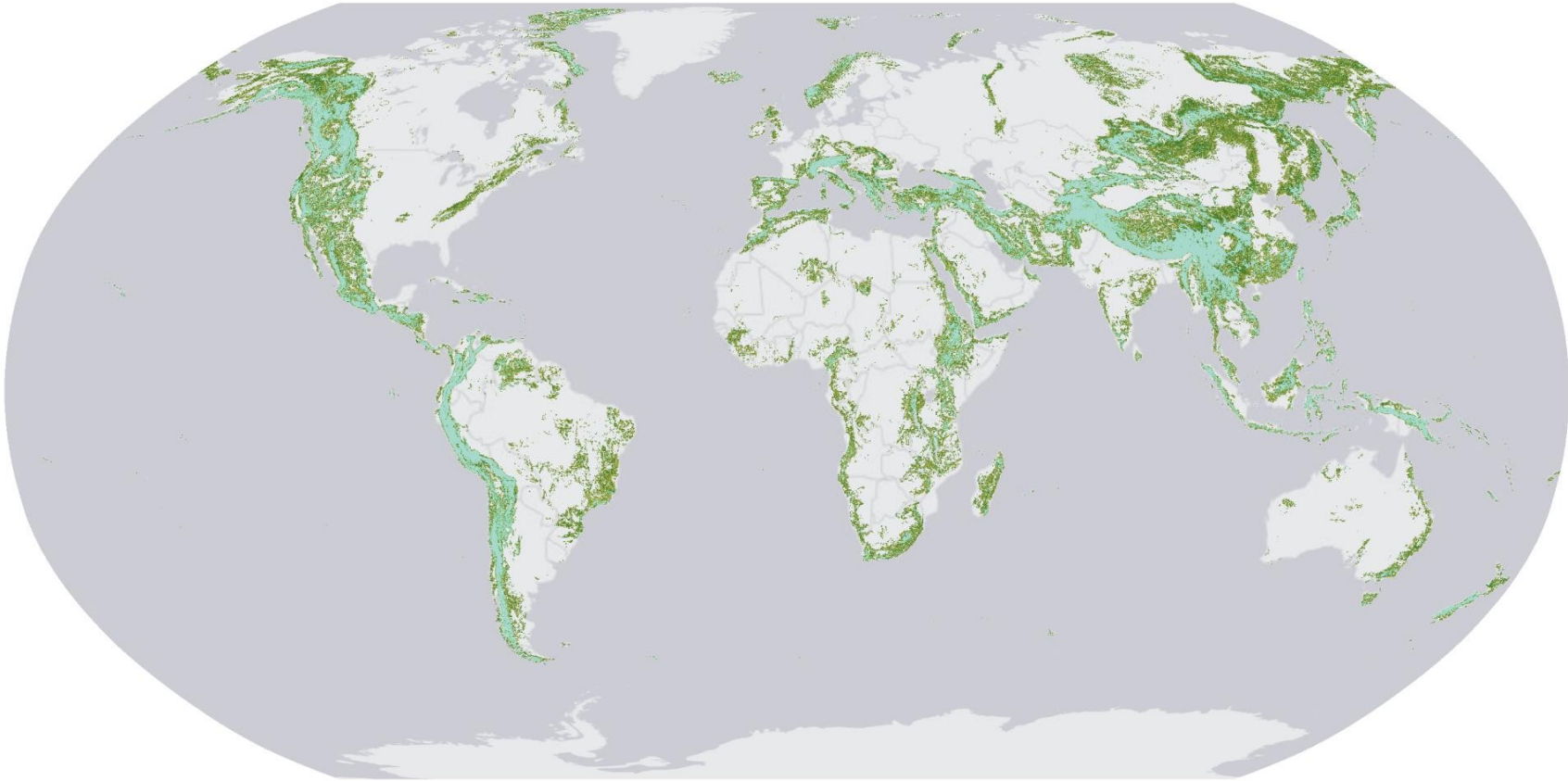
October 26th, 2021

What is a mountain ?

What is a mountain ?

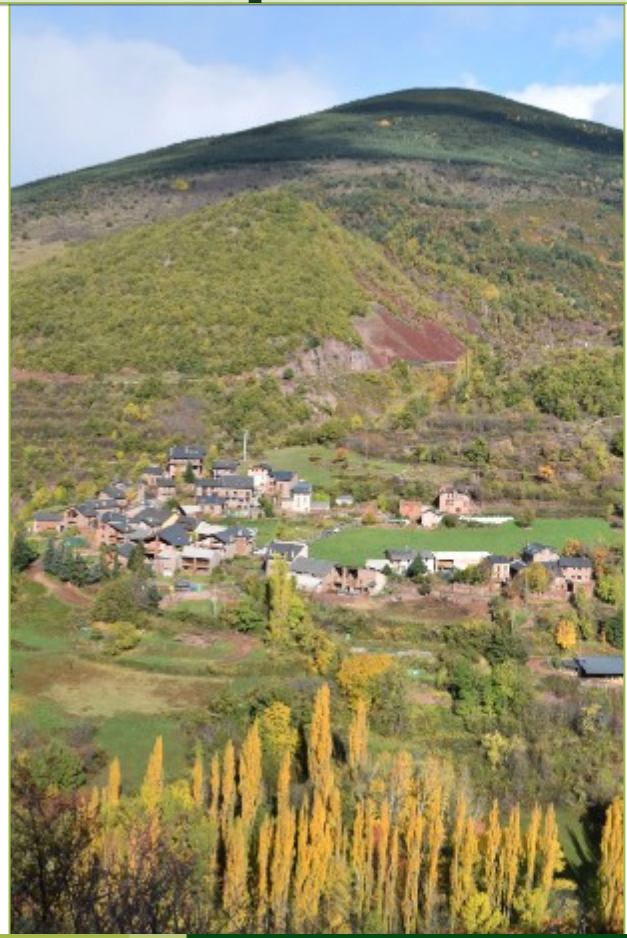
What defines a mountain?

- Slope
- Latitude
- Mostly agricultural
- Local perception
- Mostly rural
- Seasonal presence of snow



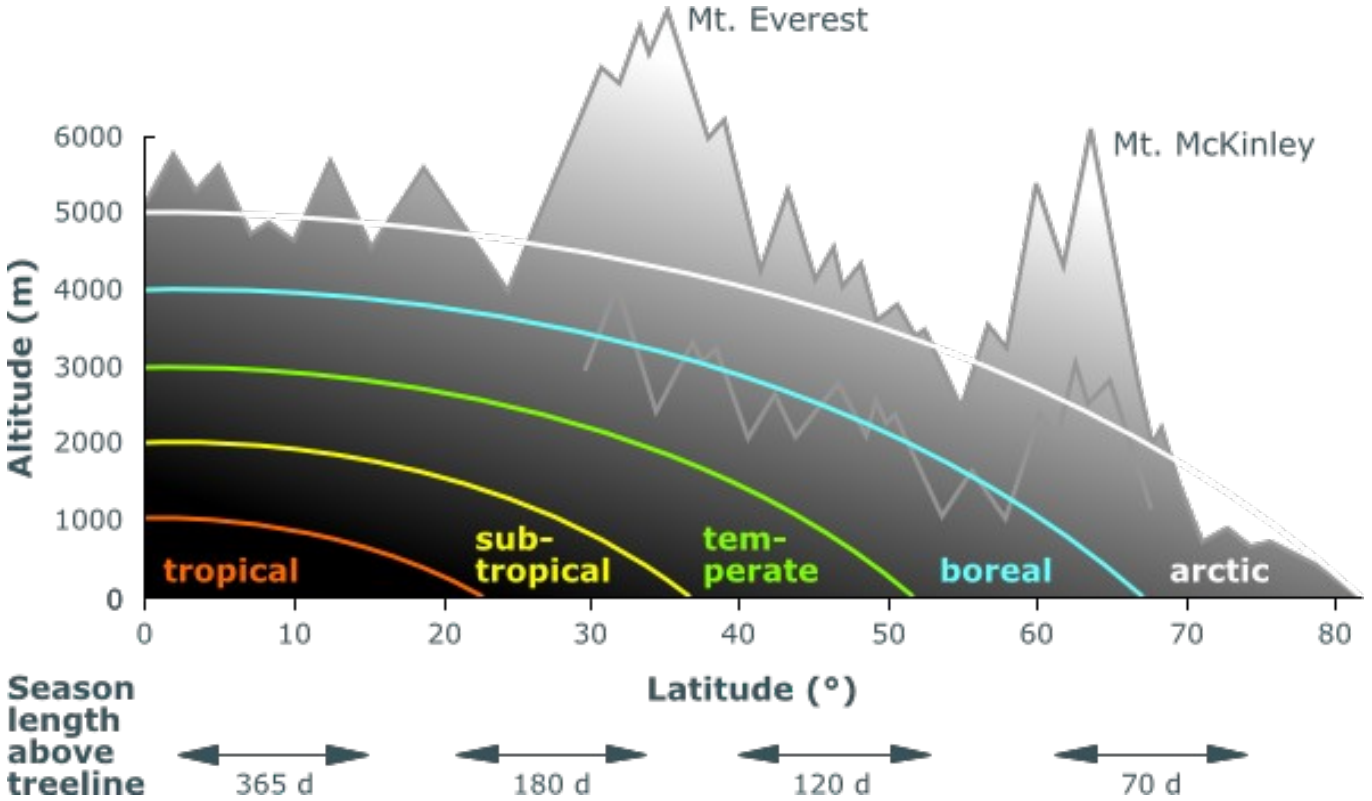
Sources: Esri, DeLorme, NAVTEQ

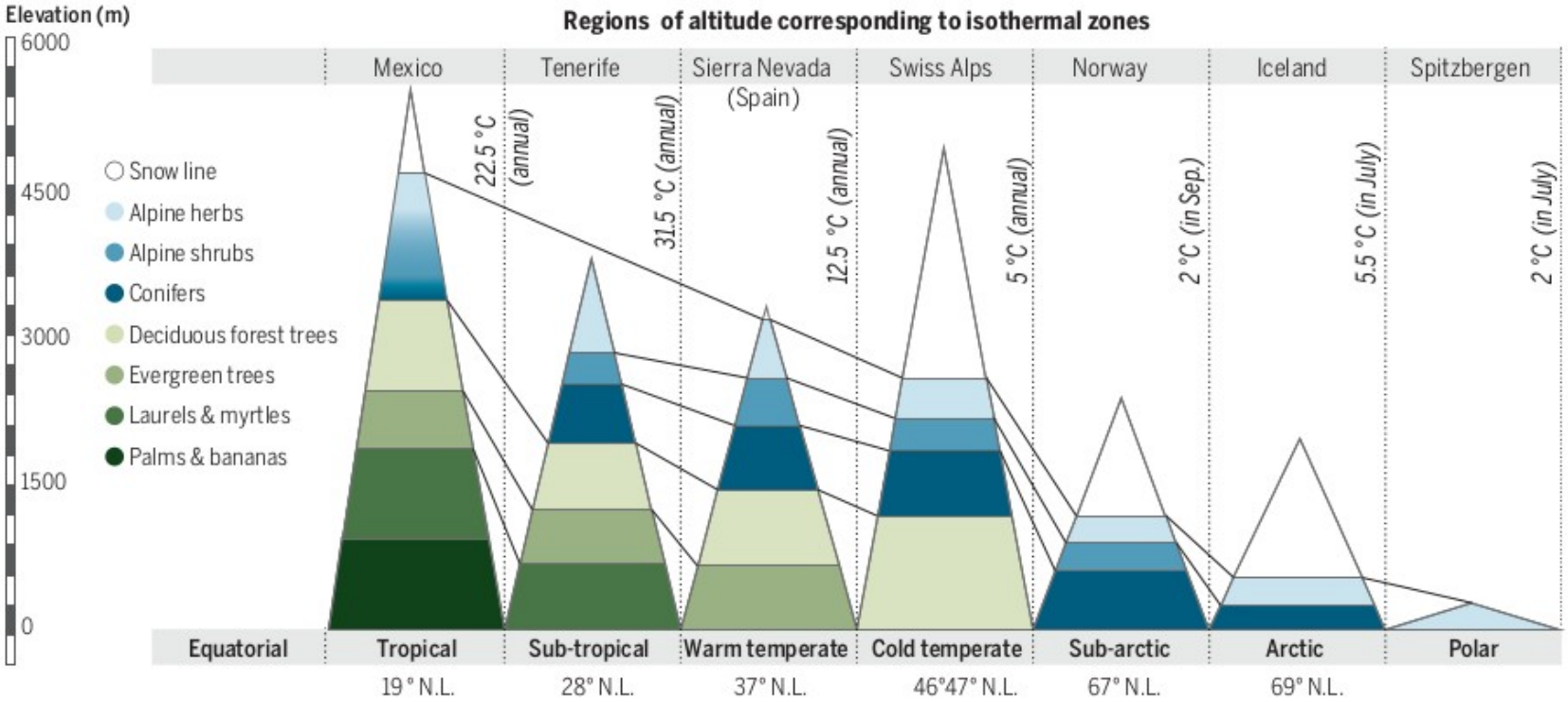
What makes mountains specially interesting for us?



Climate compression

Compression of climatic zones over short distances otherwise separated by thousands of kilometers of latitude



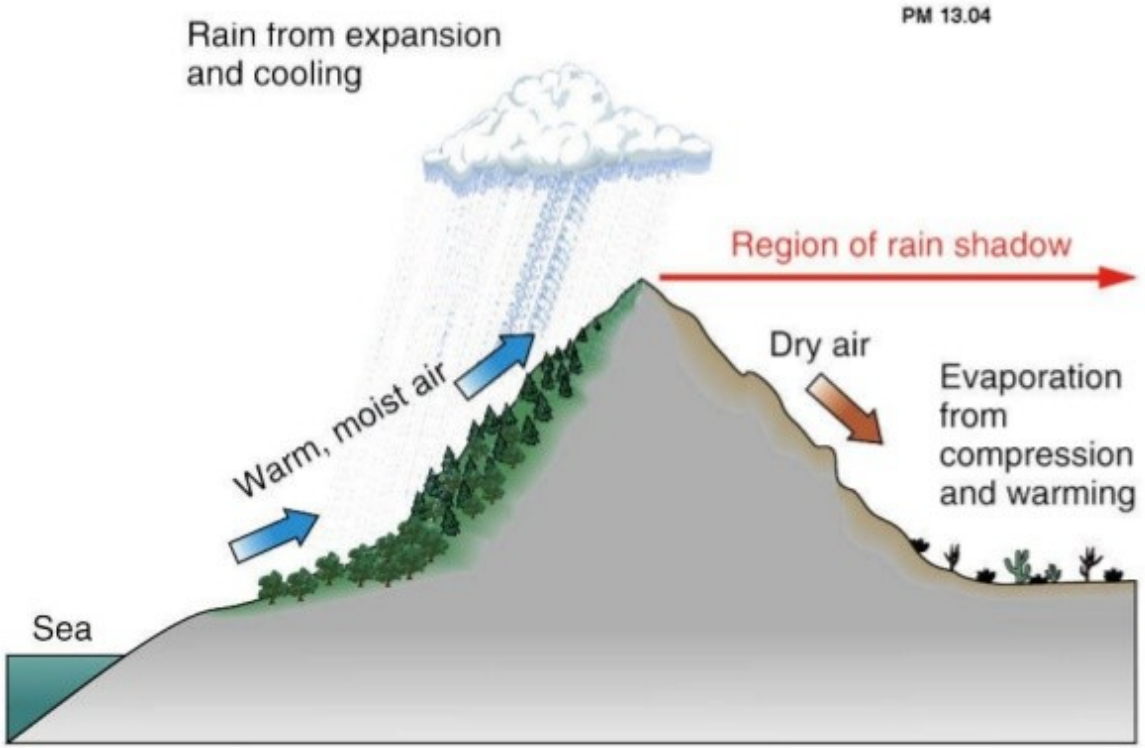


A tropical mountain may contain all the climatic zones of a single hemisphere.

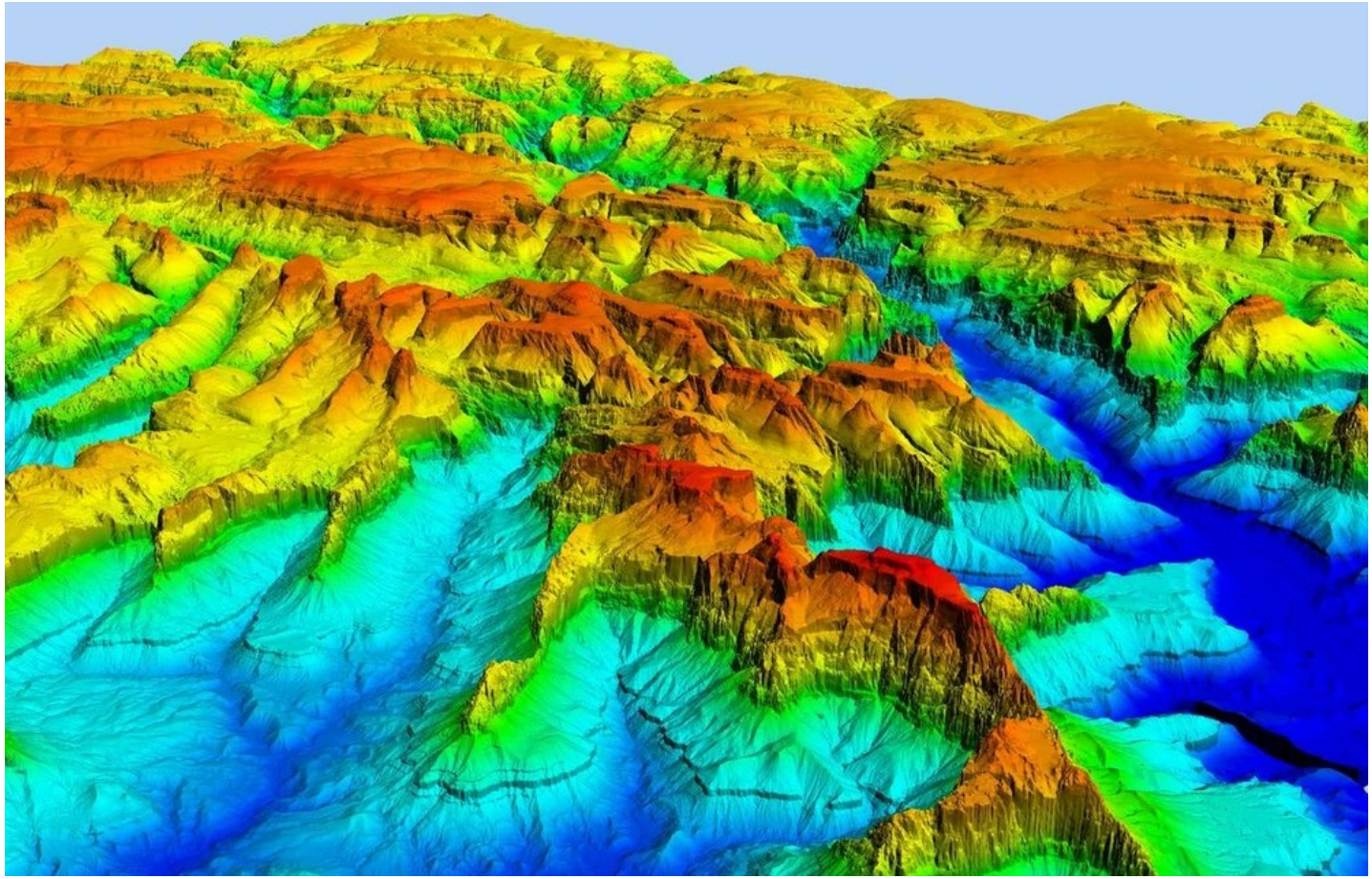
Rahbek et al 2019

Topography

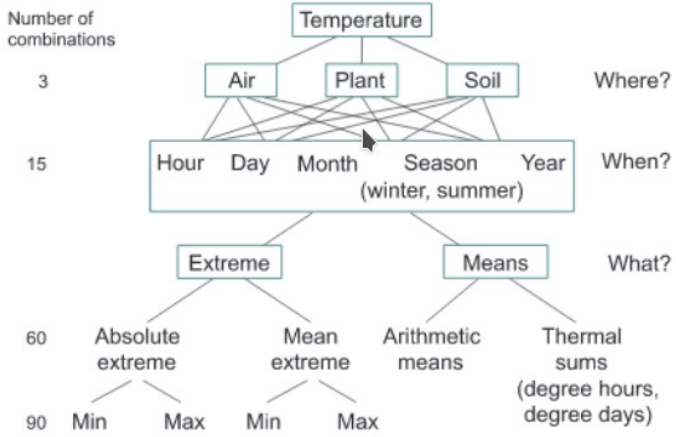
The windward side of a mountain has more precipitation than the leeward (sheltered) side



Rugosity



High environmental diversity

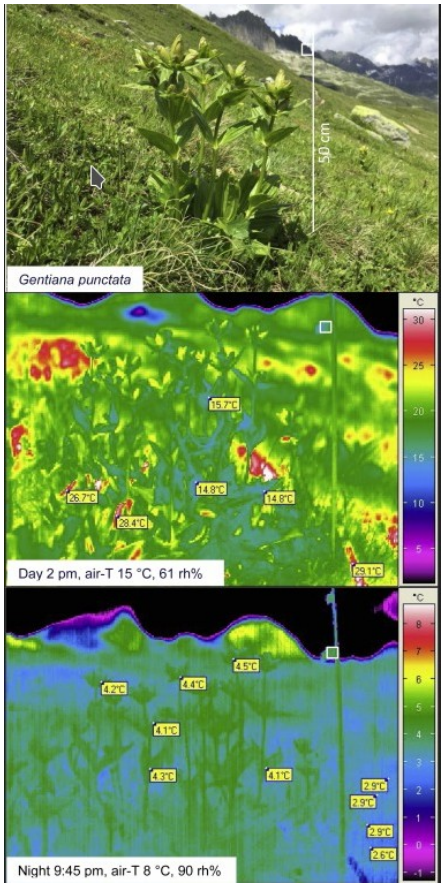


Review

The 90 ways to describe plant temperature☆

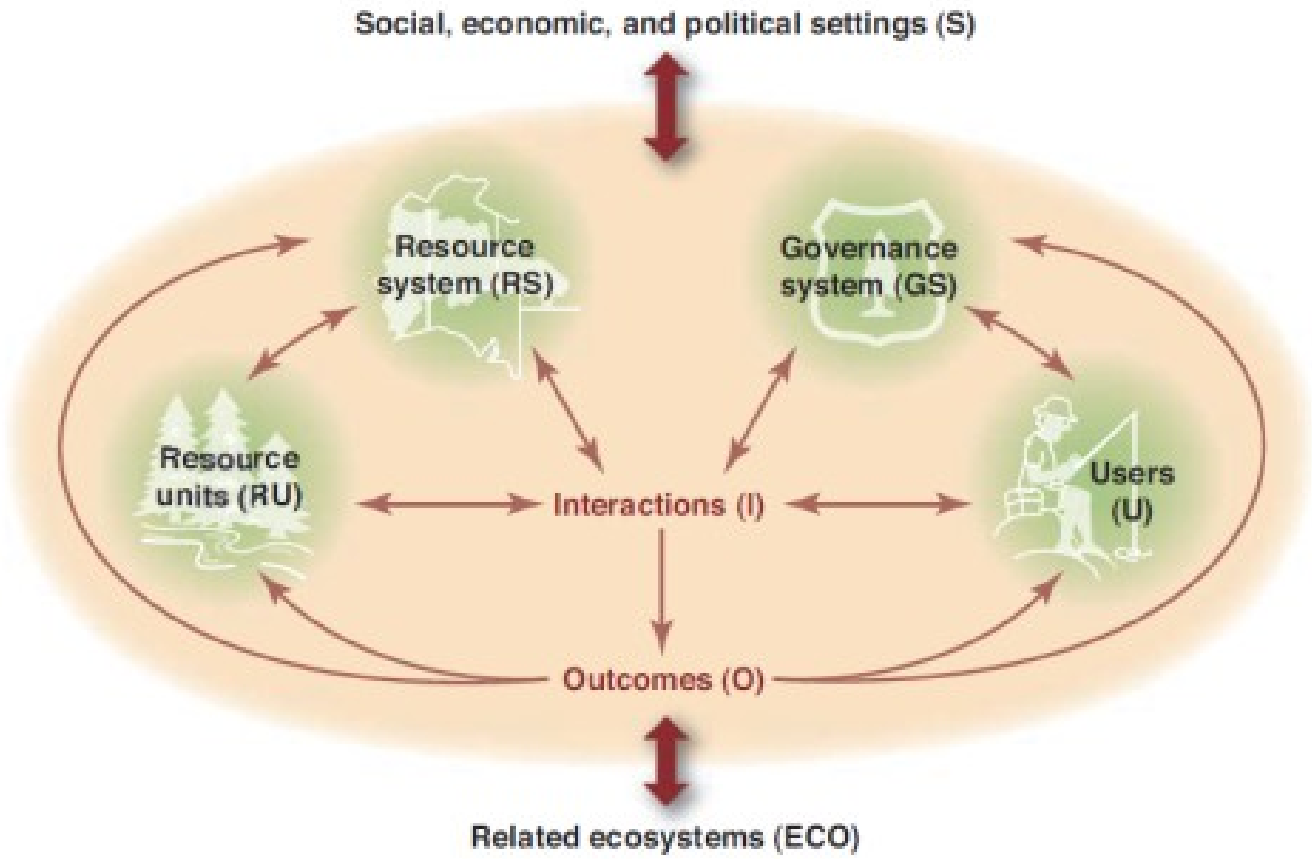
Christian Körner*, Erika Hiltbrunner

Institute of Botany, University of Basel, Schönbeinstrasse 6, 4056 Basel, Switzerland

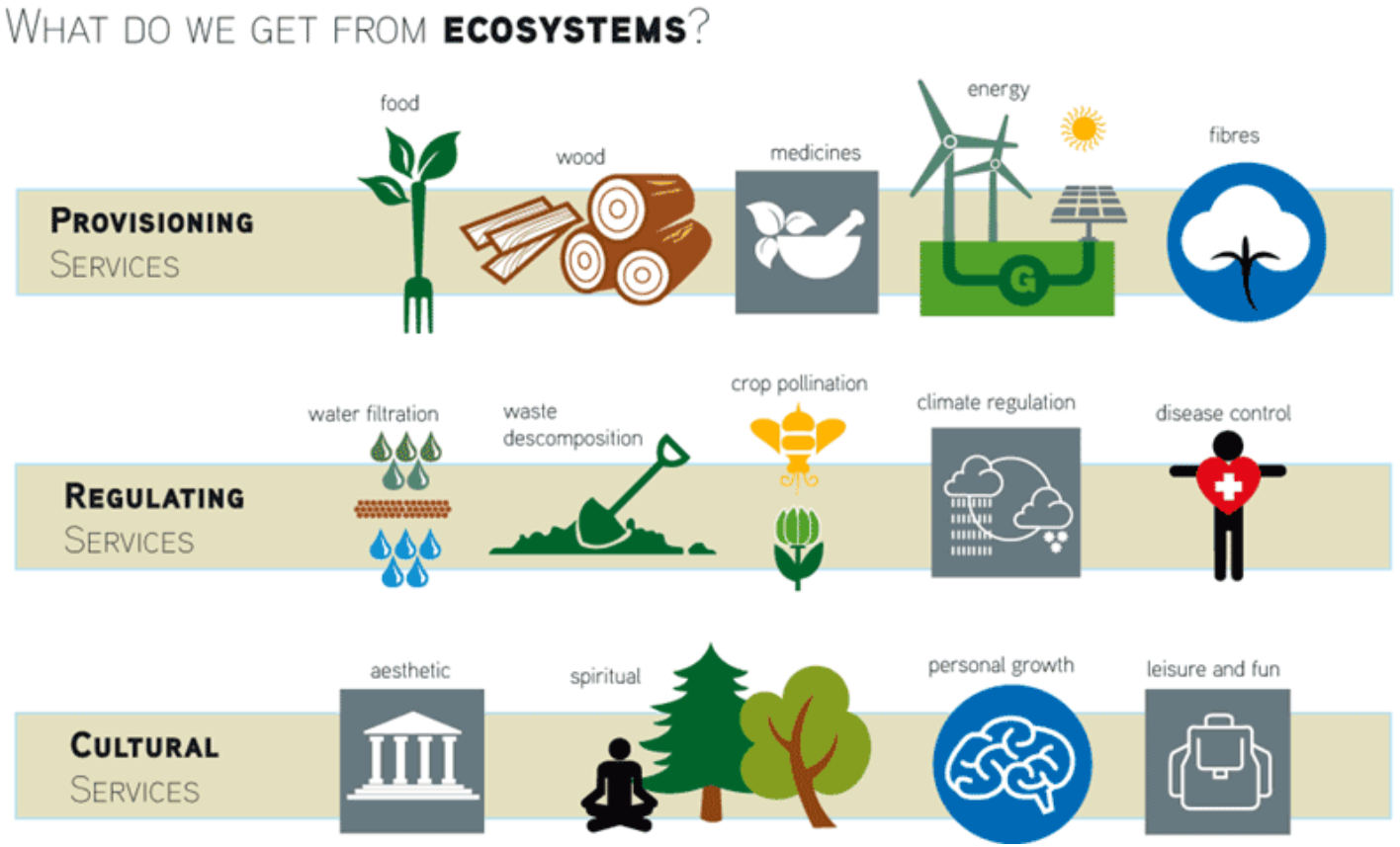


A system

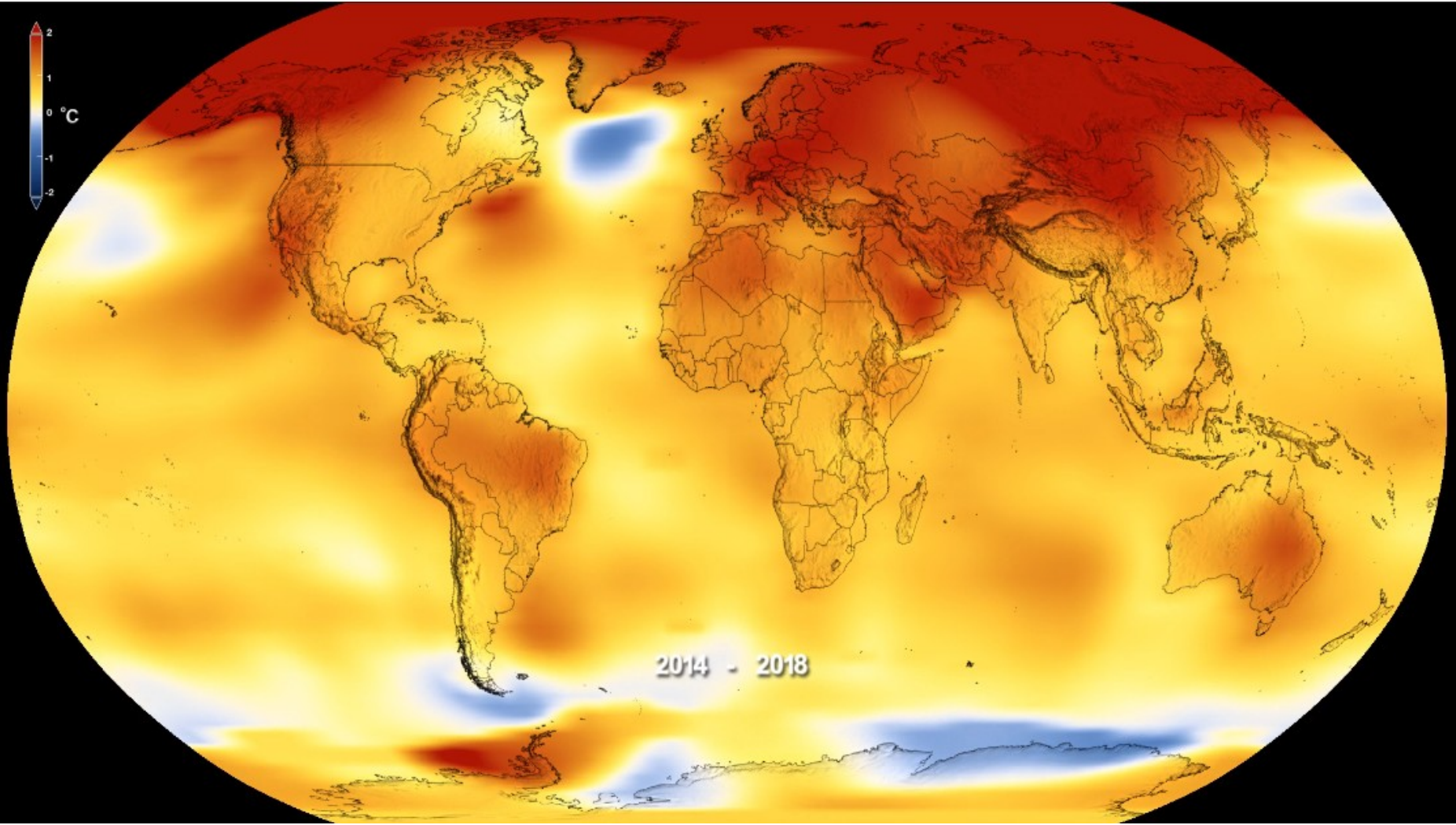
A social-ecological system



A “service provider”

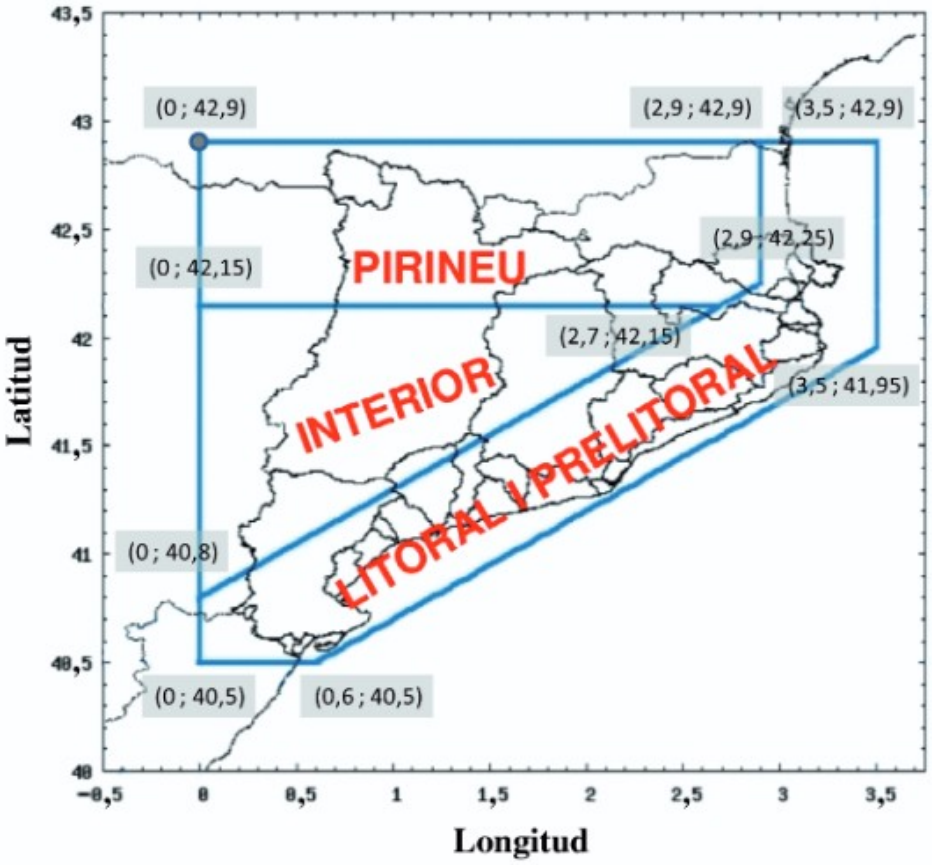


?


2
1
0 °C
-1
-2
2014 - 2018

Climate change in Catalonia

The Third Catalan Report of Climate Change
http://cads.gencat.cat/ca/detalls/detallarticle/Tercer-informe-sobre-el-canvi-climatic-a-Catalunya-00003



Climate change in Catalonia

		Hivern	Primavera	Esti	Tardor
Litoral/ Prelitoral	ΔT (°C)	0,6 (0,0/1,2)			0,8 (0,4/1,2)
	ΔPPT (%)				–7,9 (–27,6/23,4)
Interior	ΔT				0,8 (0,4/1,2)
	ΔP				–4,3 (–25,9/26,0)
Pirineu	ΔT		1,5)	0,9 (0,5/1,5)	0,7 (0,4/1,3)
	ΔPP	(–14,2/32,6)	–0,8 (–22,9/16,9)	–2,5 (–16,8/11,9)	–2,7 (–23,1/15,8)

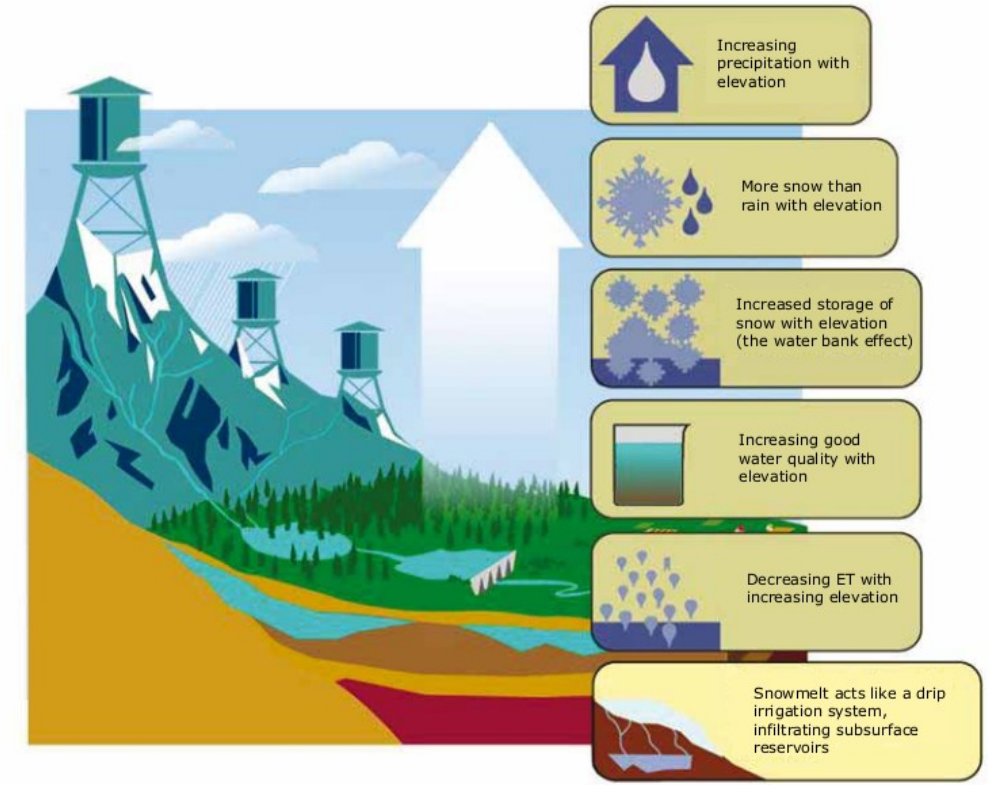
DROUGHT

Water

The water towers

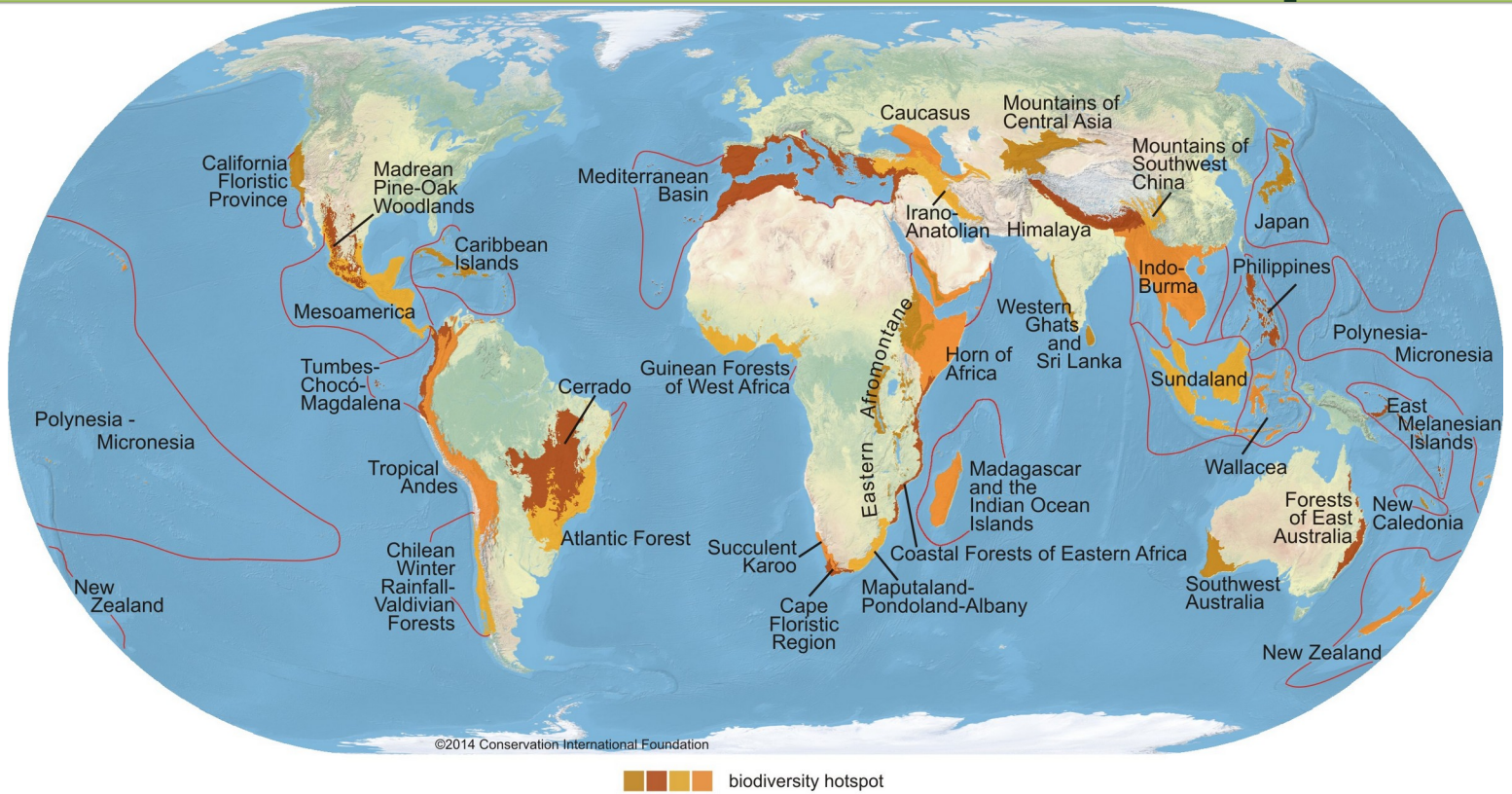
Water uses:

- Agriculture
- Biodiversity
- Energy
- Forestry
- Households
- Industry
- Navigation
- Tourism



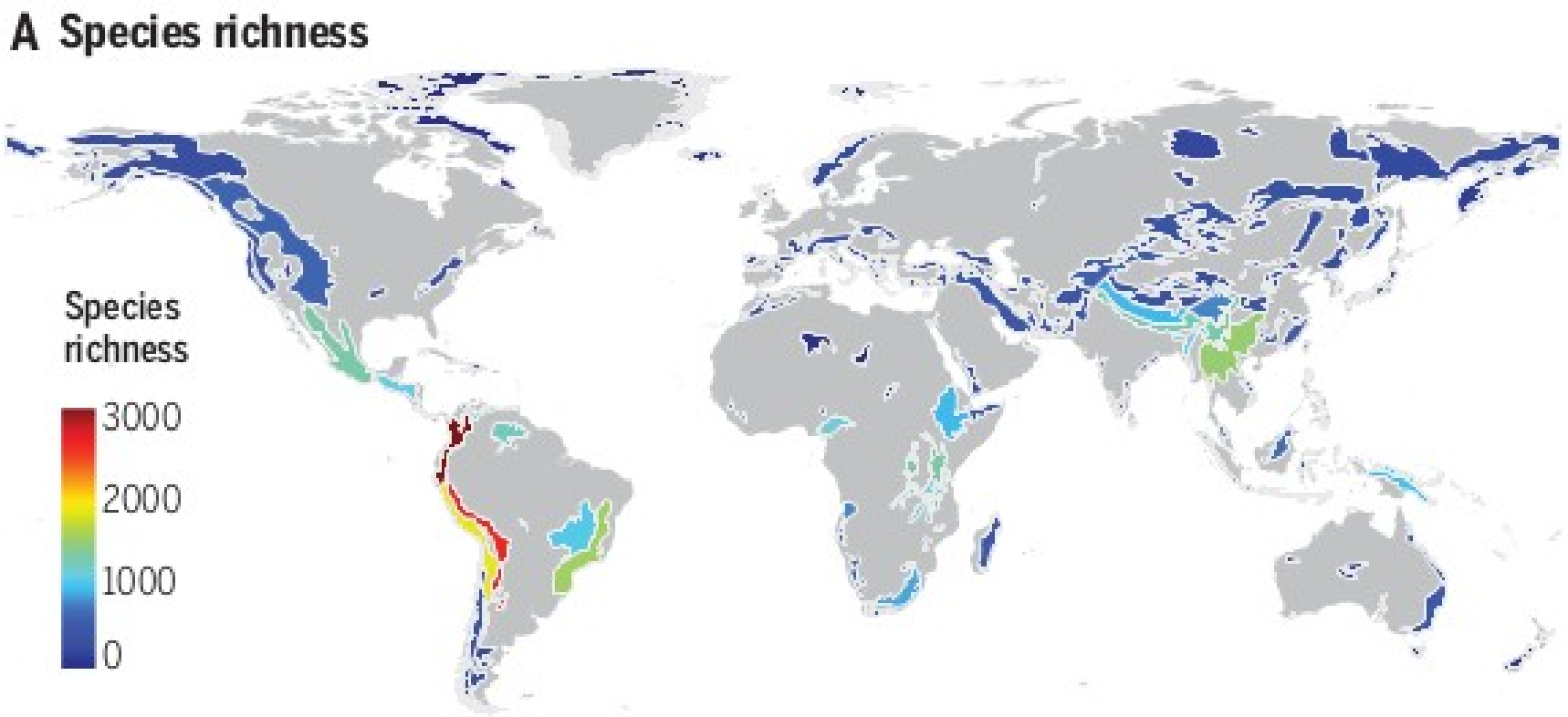
Source: www.icpdr.org/icpdr-files/14181.

Mountains biodiversity

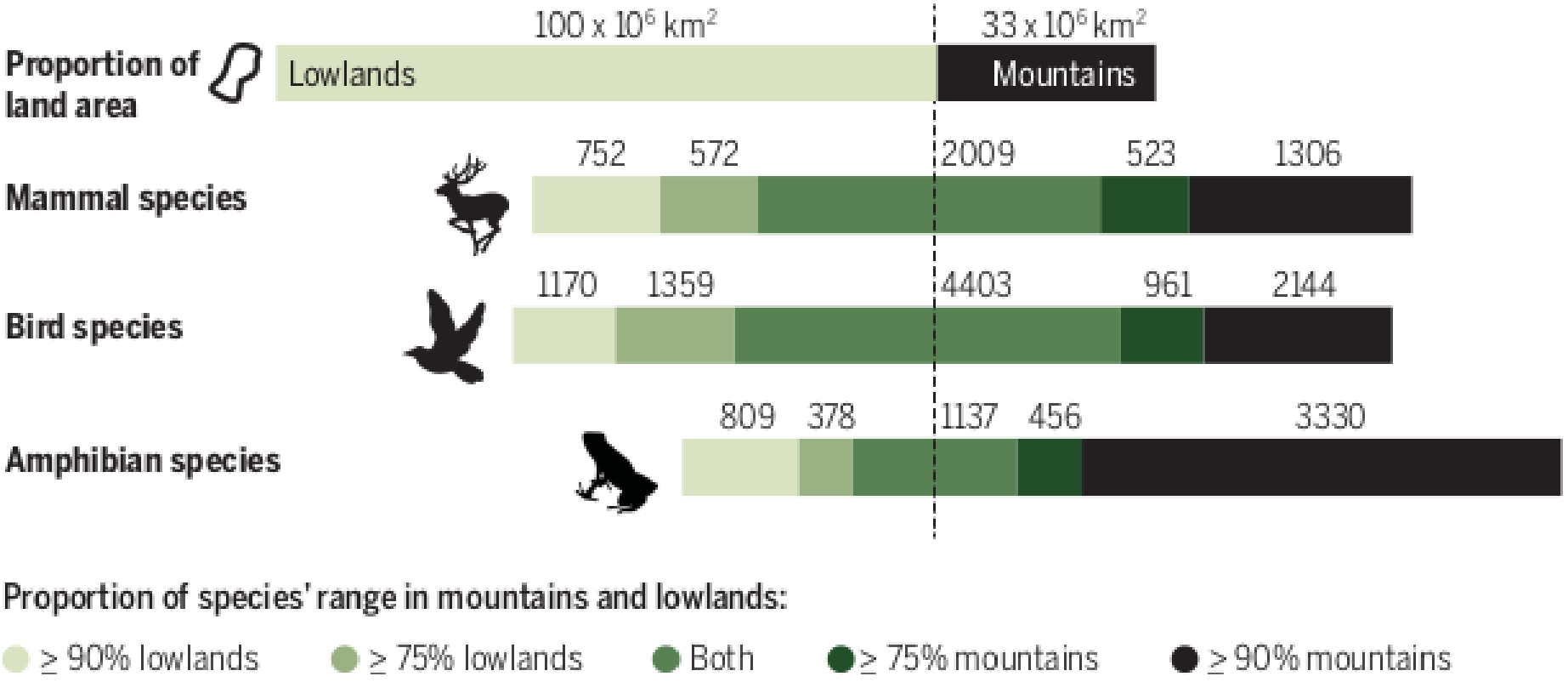


Mountain regions are home to more than 85% of the world's species of amphibians, birds, and mammals, many entirely restricted to mountains.

Biodiversity



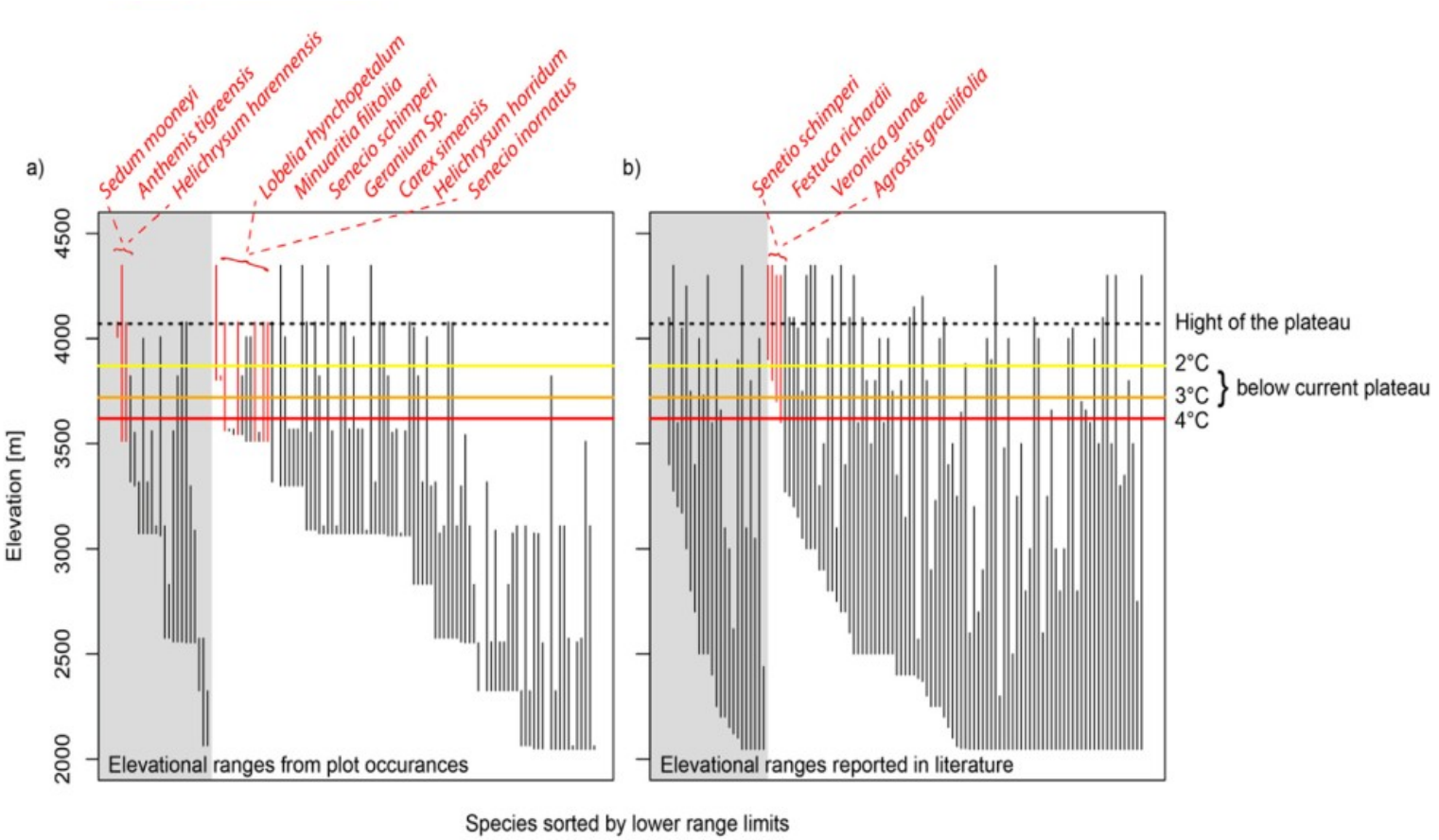
Rahbek et al 2019



Rahbek et al 2019

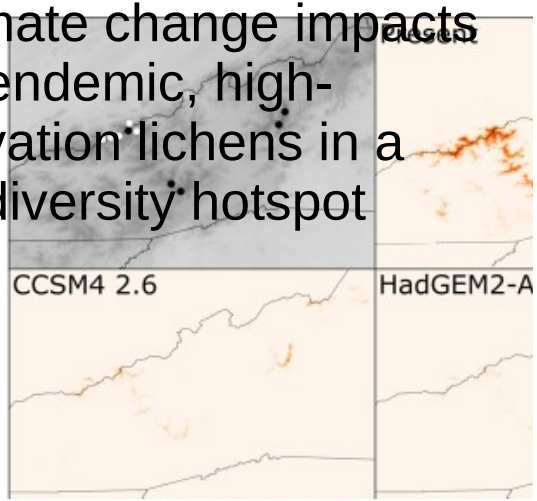
Responses to global change

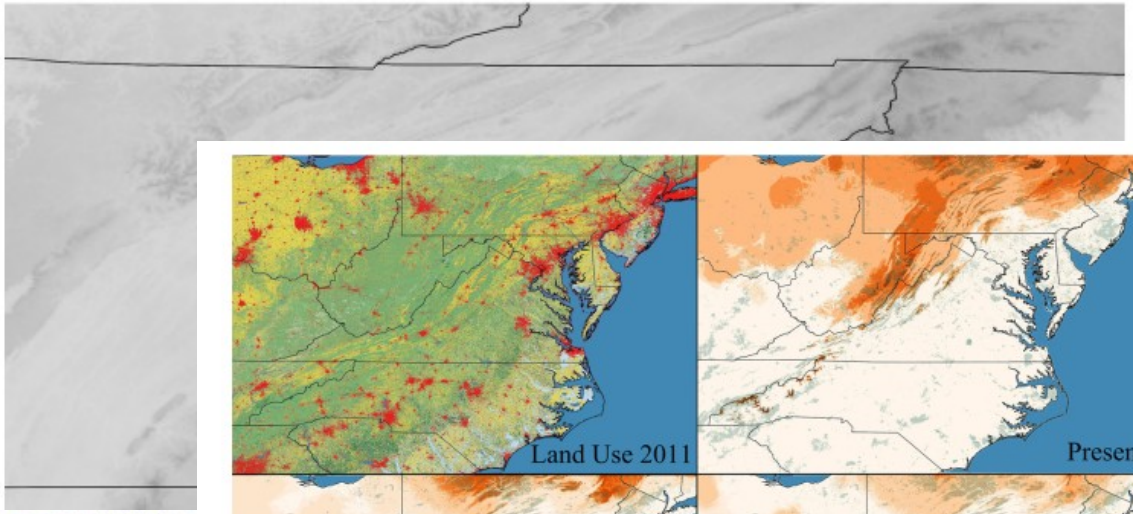
Dead end for endemic plant species? A biodiversity hotspot under pressure

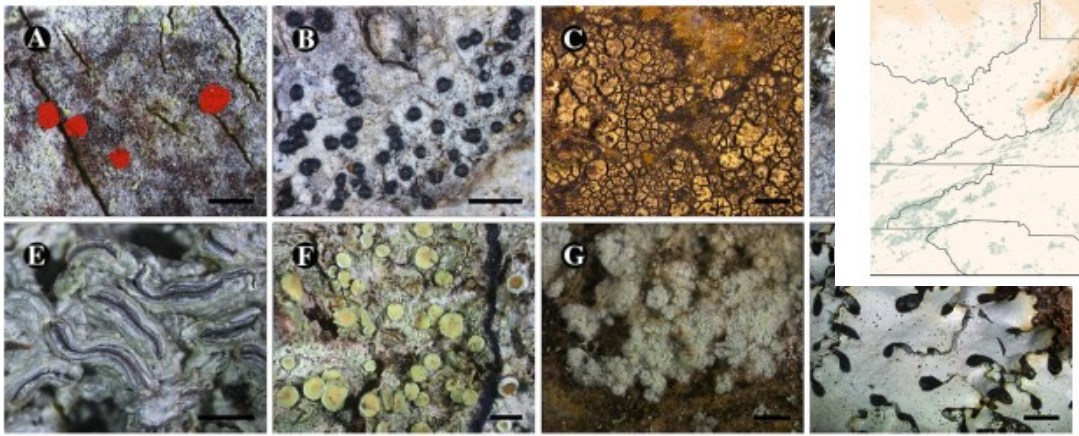


Kidane et al 2019

Climate change impacts on endemic, high-elevation lichens in a biodiversity hotspot







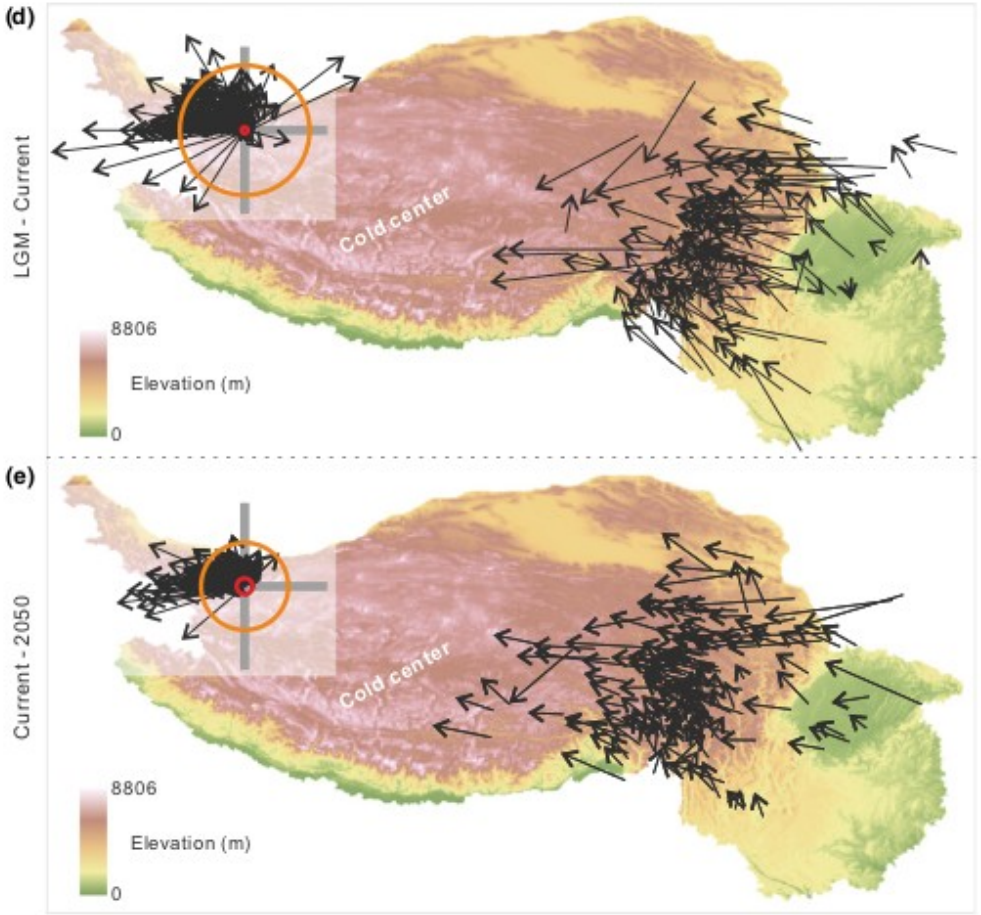


FIGURE 1 Change in the distribution of the climatic niche of 151 representative plants in the Hengduan Mountains and adjacent regions from the LGM to 2050 (RCP8.5). (a) Trend in change in mean elevation. (b) Trend in change in mean latitude. (c) Trend in change in mean longitude. "//" represents the long interval between the LGM and the current (about 21,000 years). (d and e) Distance (magnitude) and direction of change at the centroid of the climatic niche (represented by the arrows) over each period. The wind roses summarize the distance and direction of shift for all the studied plants during each period. The coloured rings on each wind rose represent the amplitudes of shift in distribution of climatic niche (orange) and the 10-year shift velocities for distribution of climatic niche (red). The grey axis bars on the wind roses are scaled to represent 400 km in length (from 0, 0 to tip) [Colour figure can be viewed at wilevonlinelibrary.com]

Stressor	Increase	Decrease	No response
Temperature	Plant growth rates Altitudinal shift	Population densities Range size	Altitudinal distribution
Global Climate Change	Extinction rates Altitudinal distribution	Population densities	Extinction
Lower precipitation	Extinction	Population densities	
Glacier reduction	Changes in abundance Extinction	Regional diversity	Extinction
Higher altitudinal distrib.	Altitudinal distrib. (birds) Extinction	Seedling abundance Species richness (birds)	Extinction

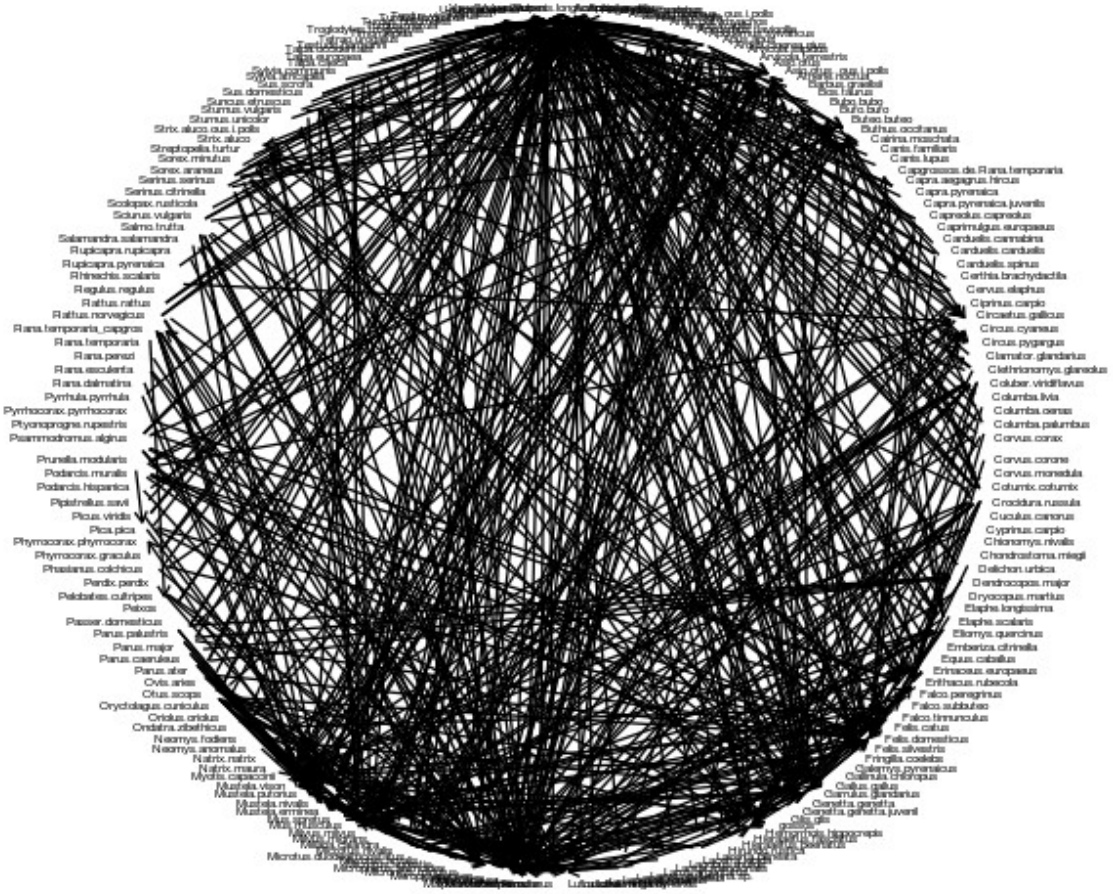
Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE

Wildlife in the Changing Andorran Pyrenees

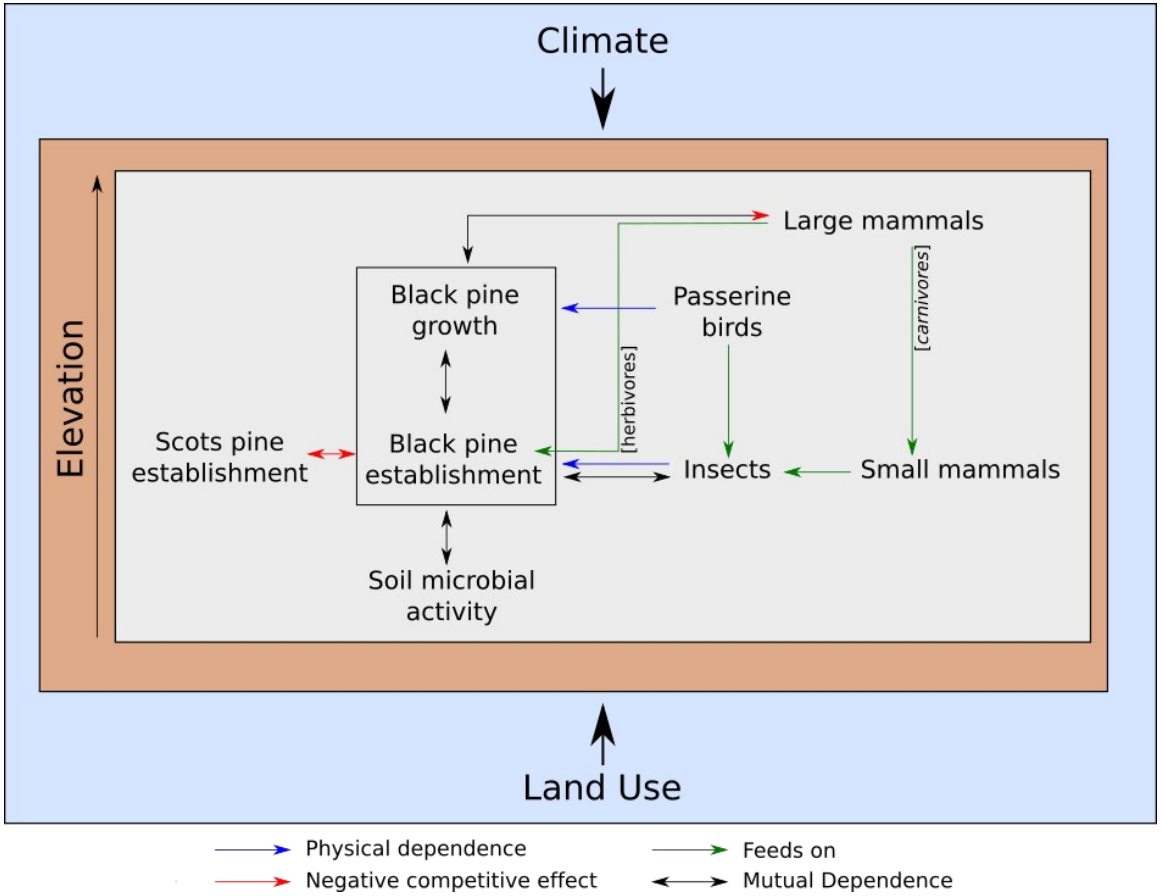
CREAF



Wildlife in the Changing Andorran Pyrenees

CREAF

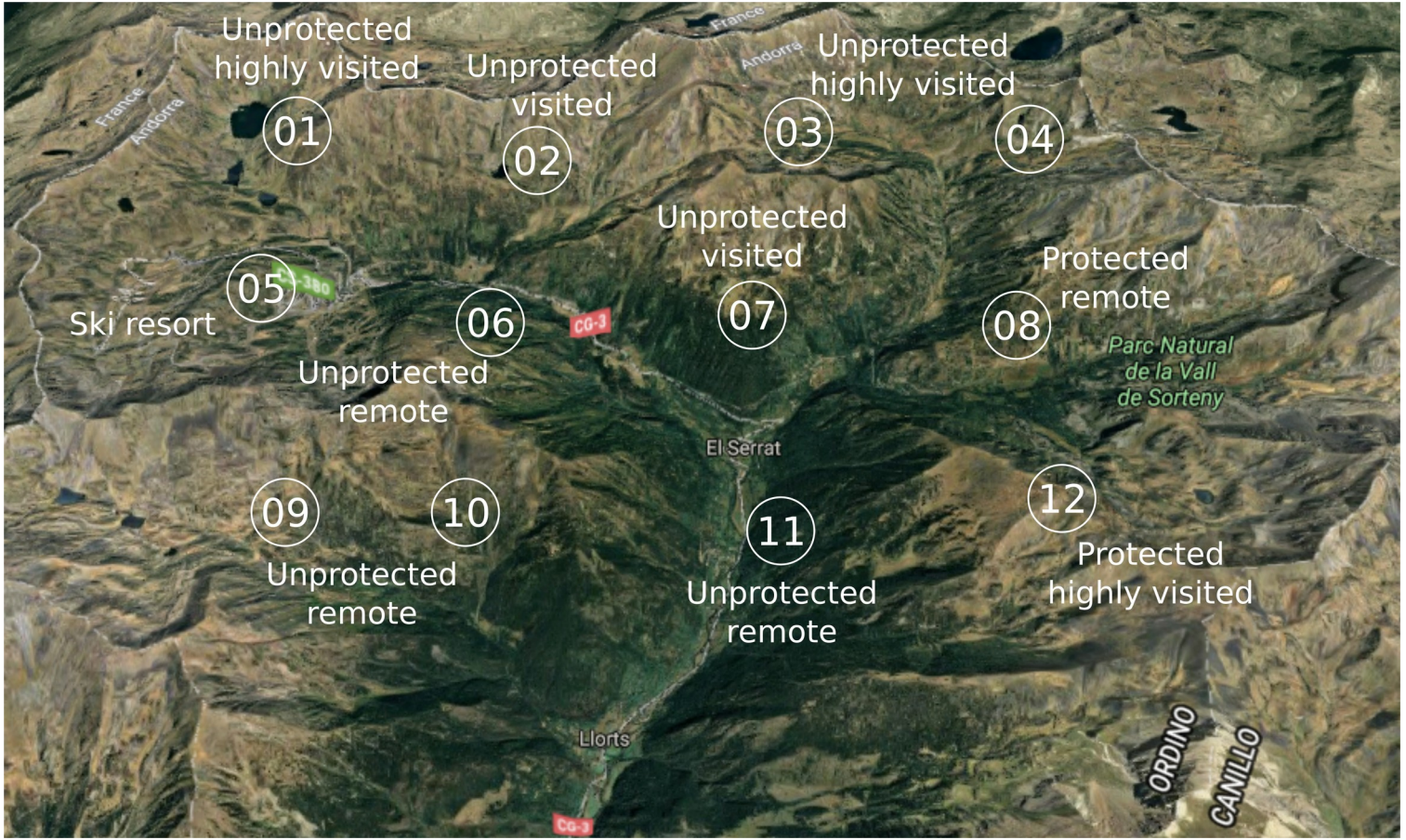
EARTHWATCH INSTITUTE



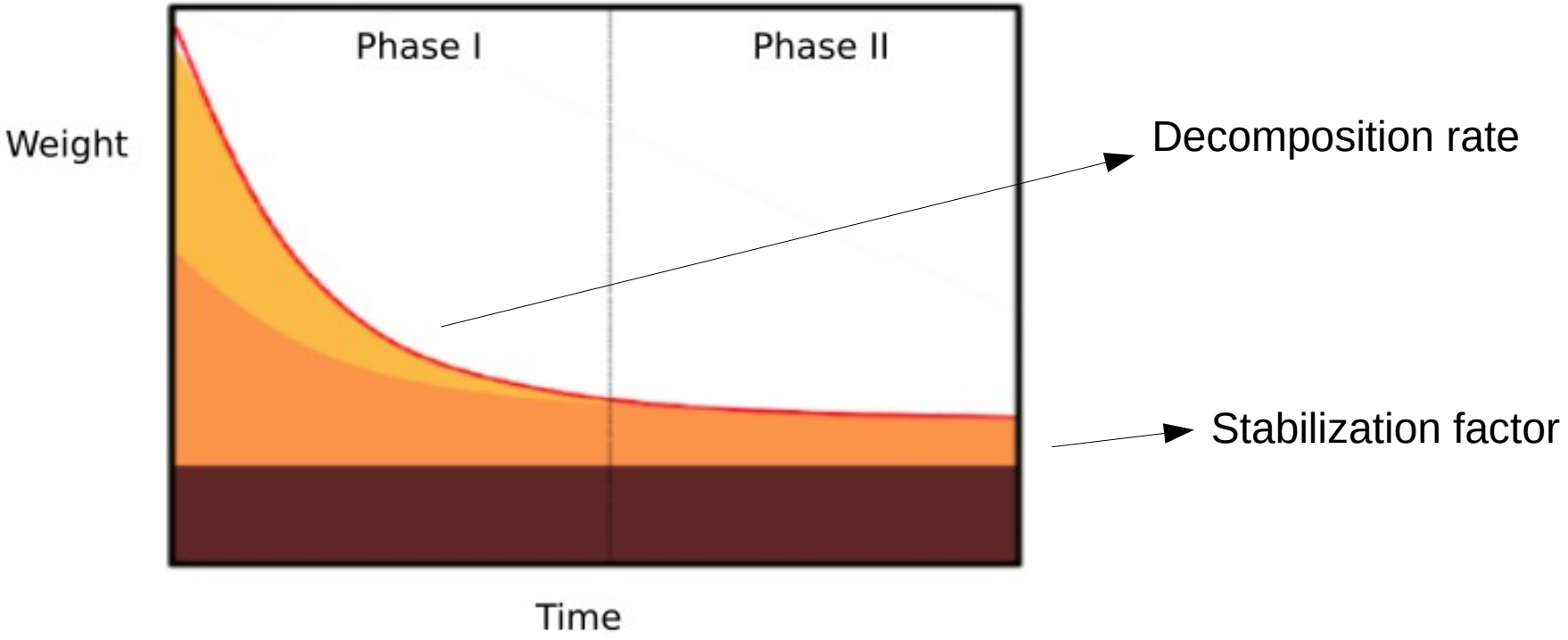
Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE



Soil organic matter decomposition



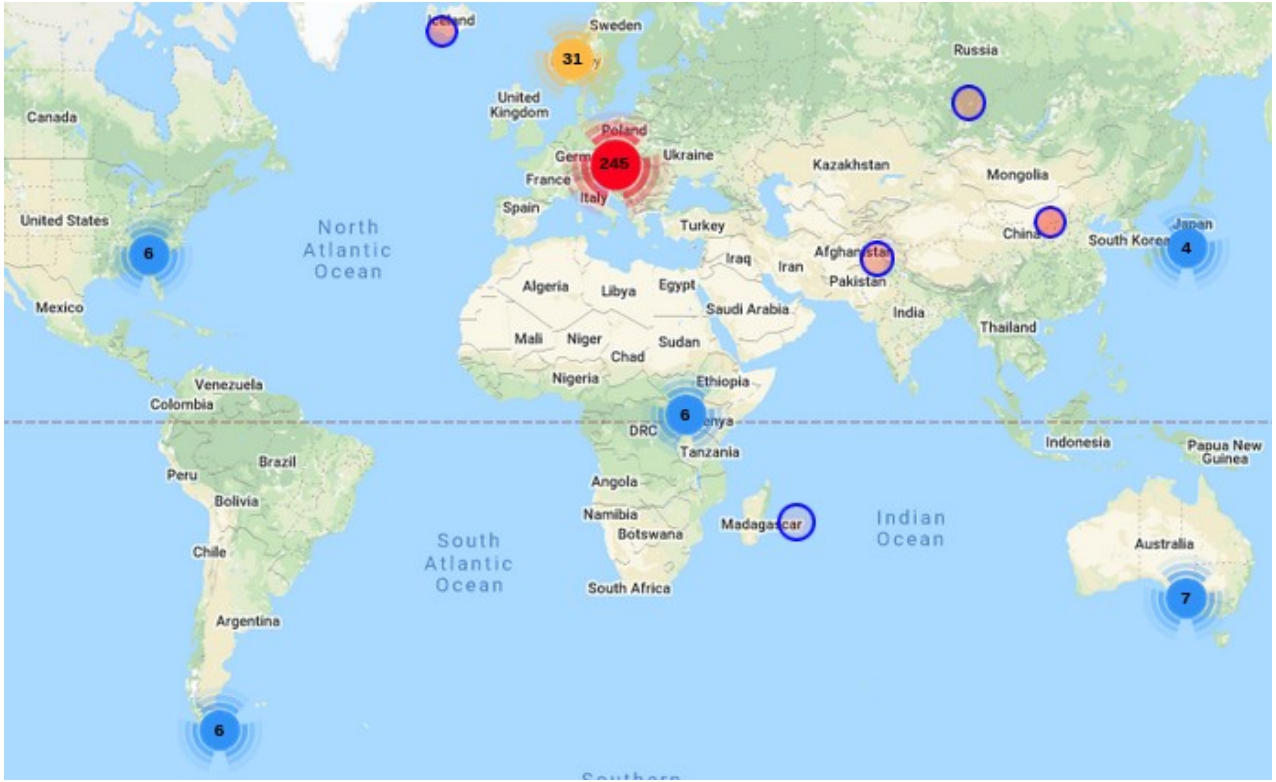
Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE

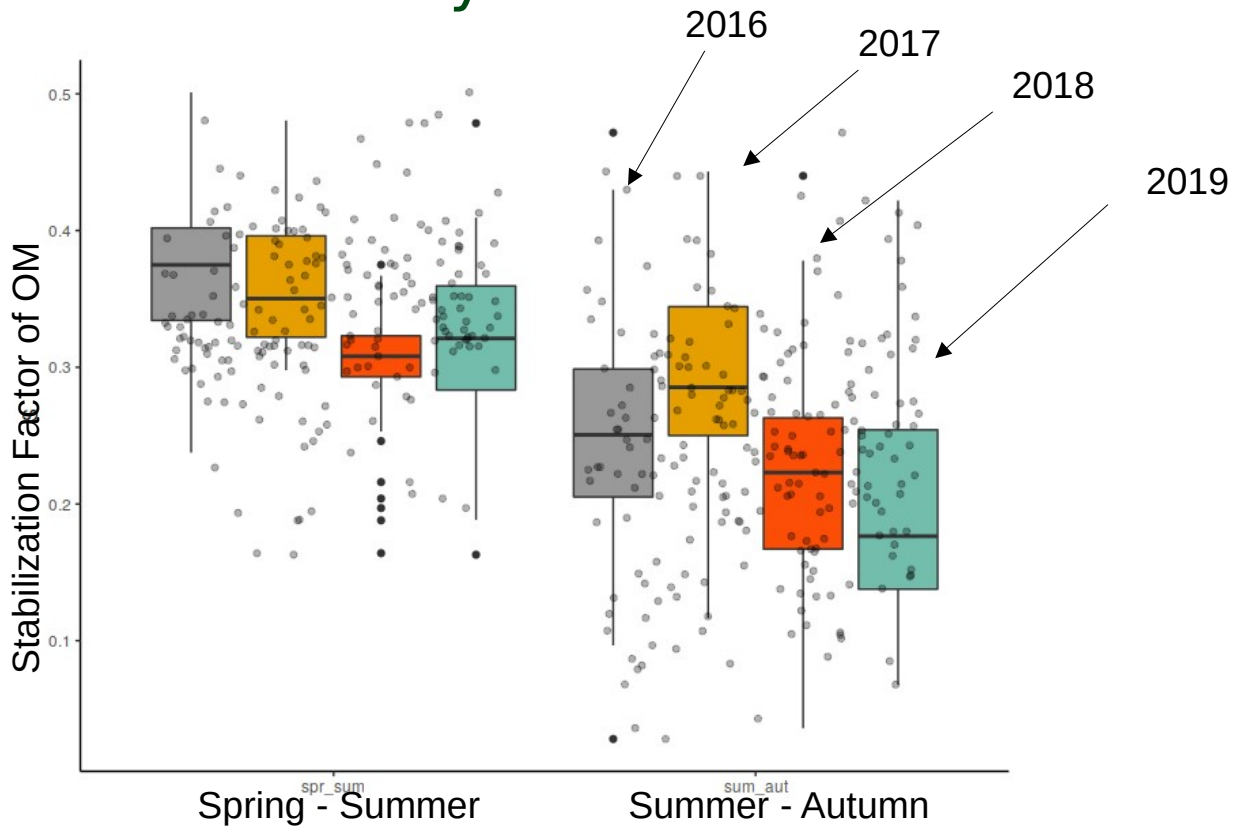
Soil microbial activity

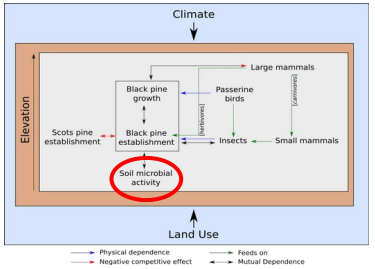
Tea bag index



Wildlife in the Changing Andorran Pyrenees

Soil microbial activity



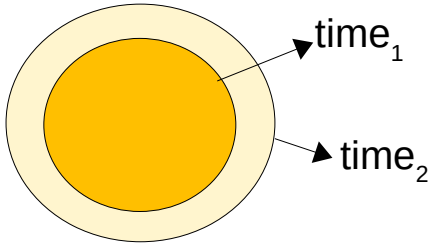


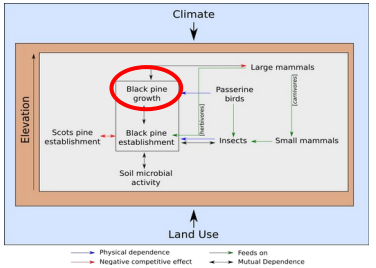
Wildlife in the Changing Andorran Pyrenees

CREAF

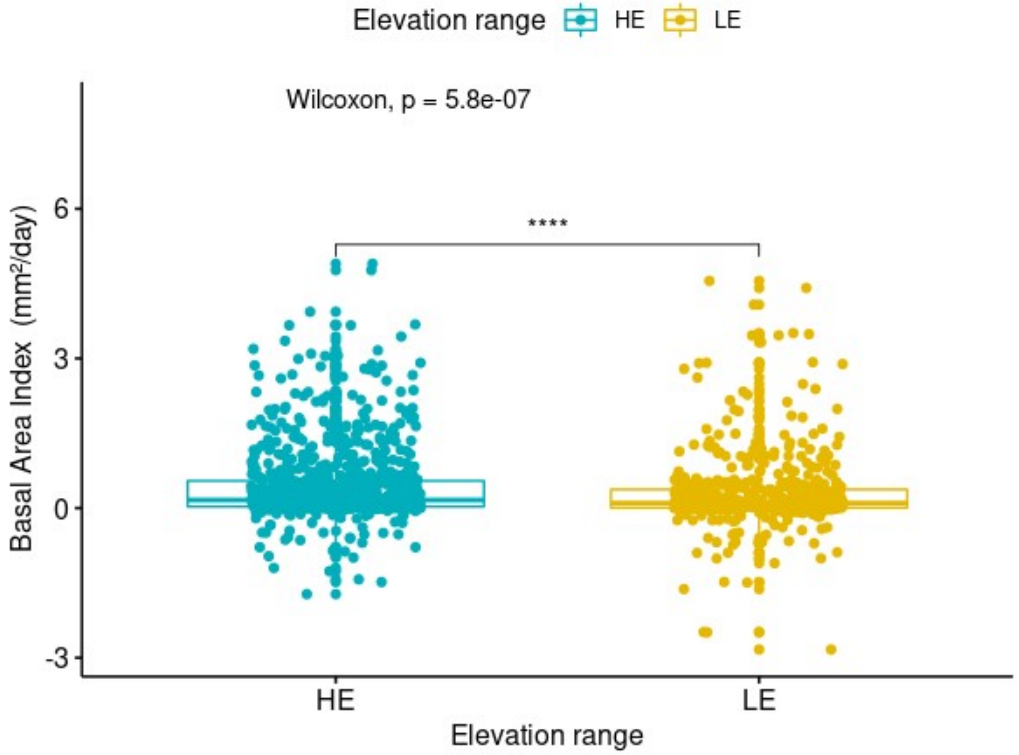
EARTHWATCH INSTITUTE

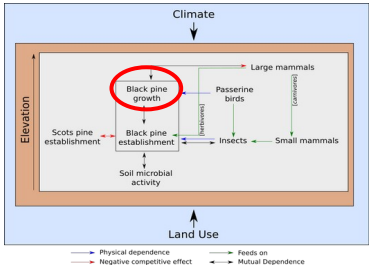
Black pine growth





Black pine growth

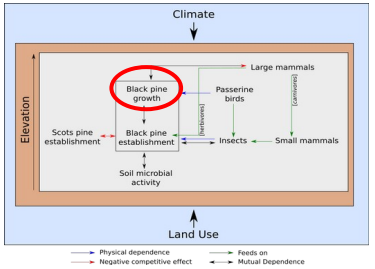




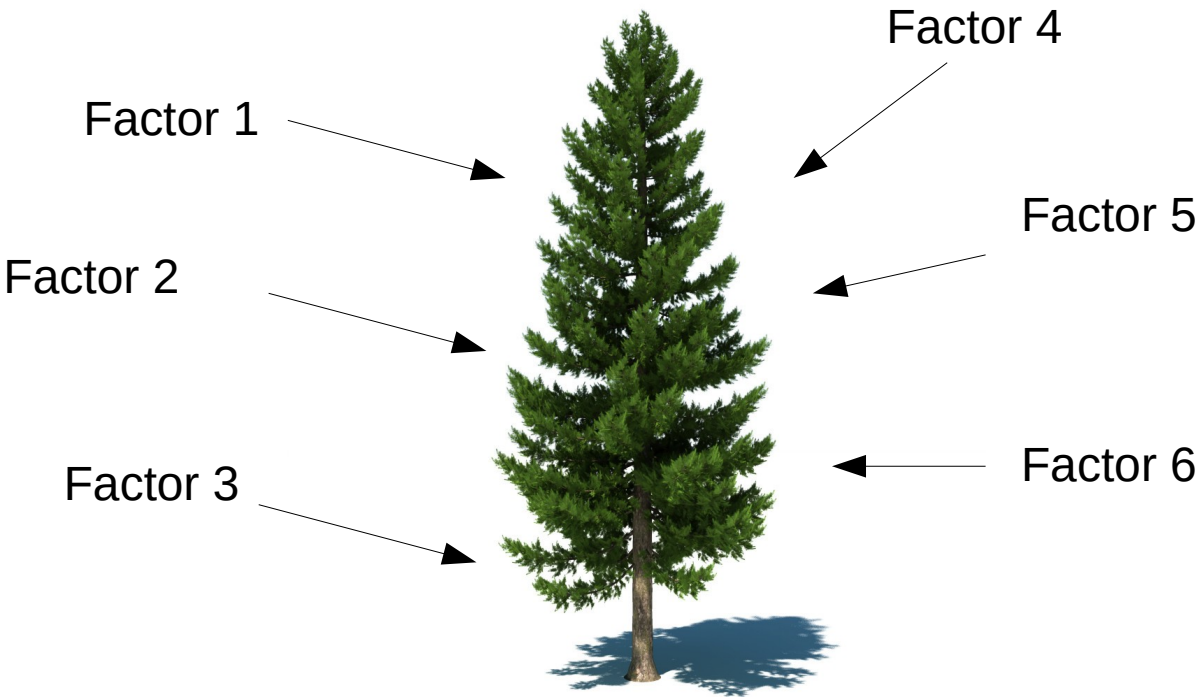
Black pine growth

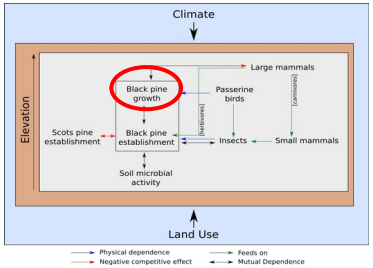
And now what ??

→ which factors can explain this difference?

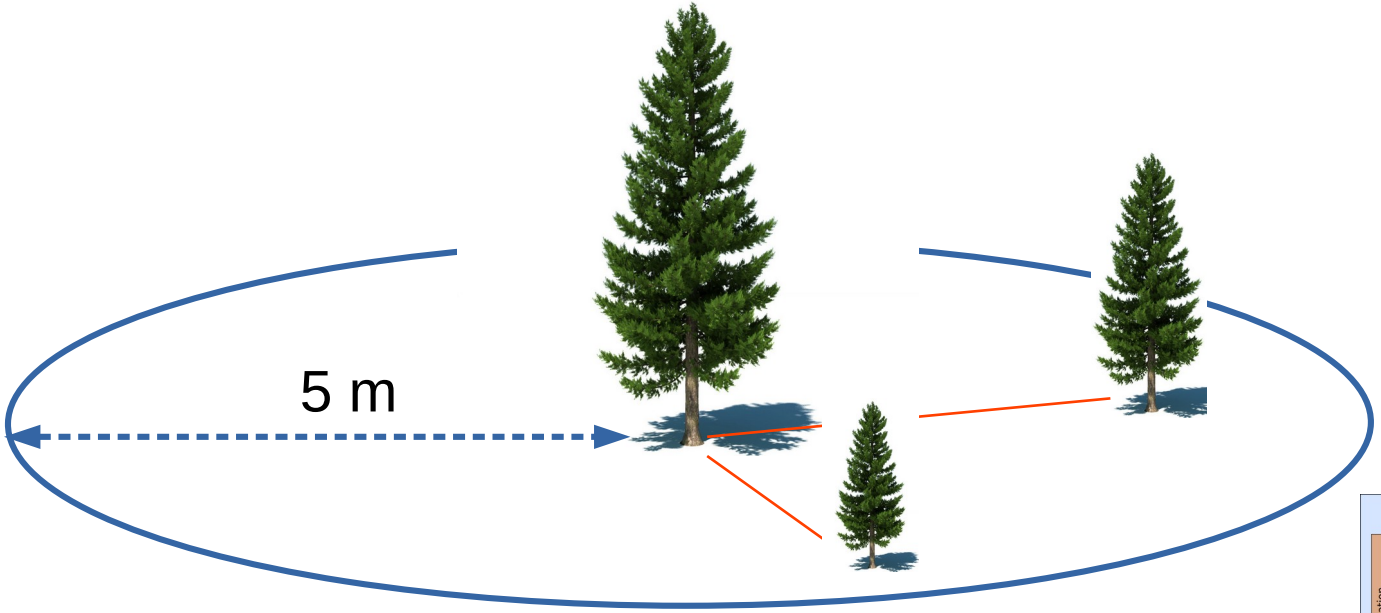


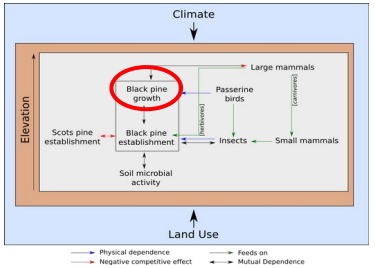
Black pine growth





Black pine growth - competition



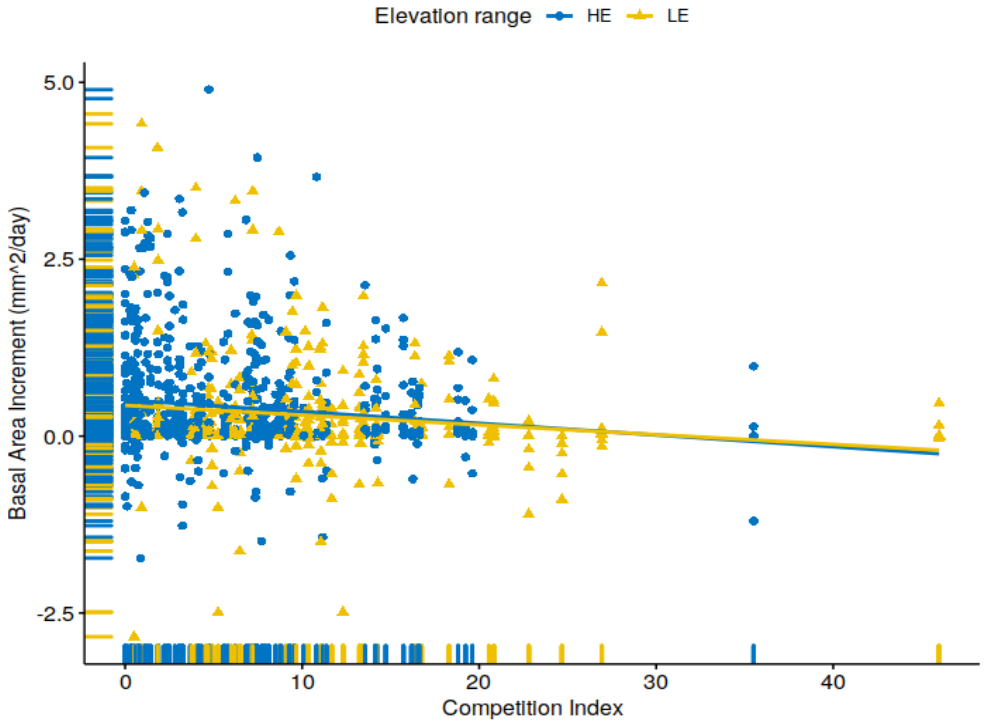


Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE

Black pine growth



Competition >> Elevation

Wildlife in the Changing Andorran Pyrenees

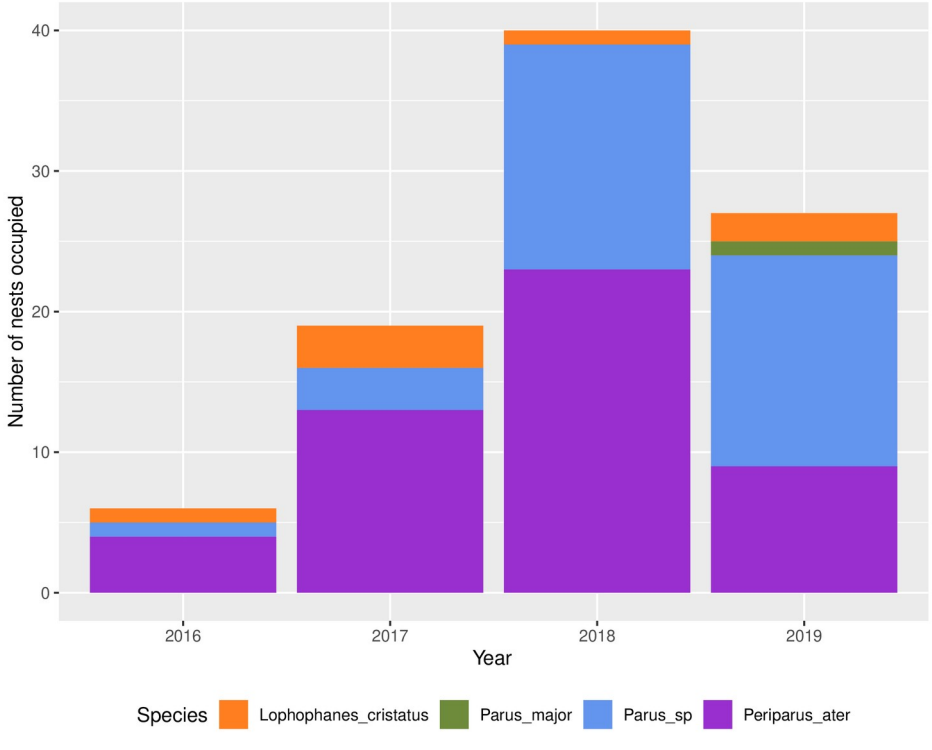
Passerine birds

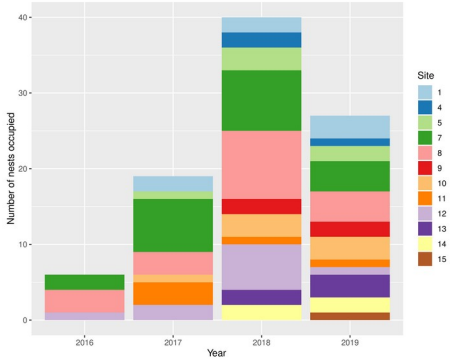
Wildlife in the Changing Andorran Pyrenees

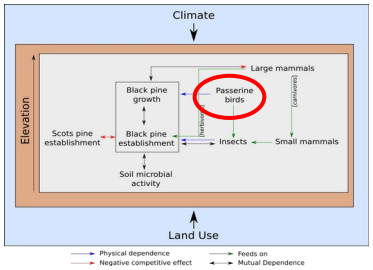
CREAF

EARTHWATCH INSTITUTE

Passerine birds – Nest boxes

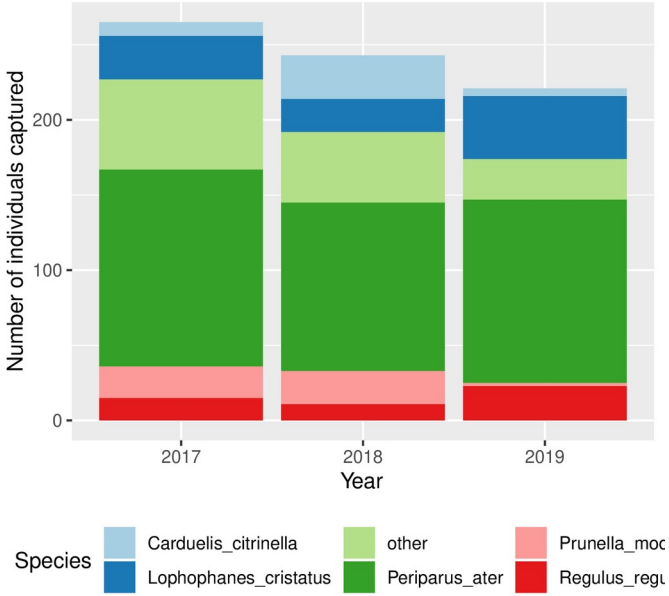


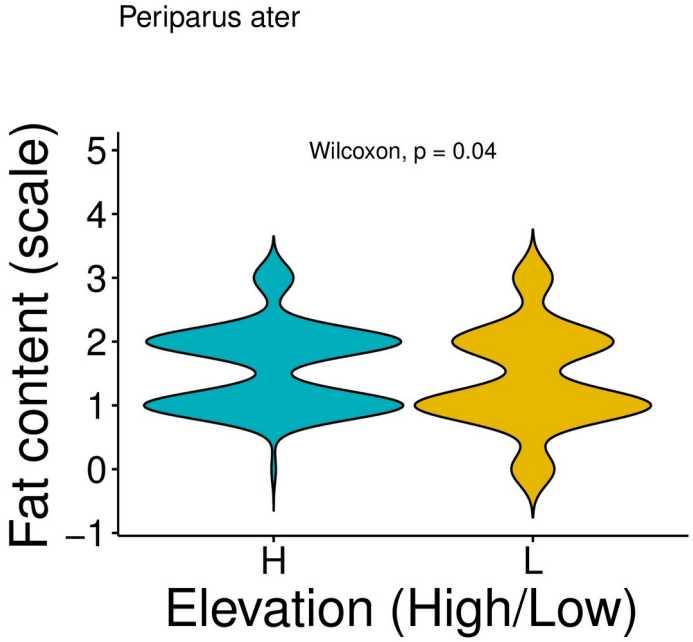


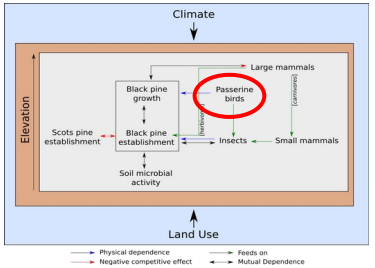


Wildlife in the Changing Andorran Pyrenees

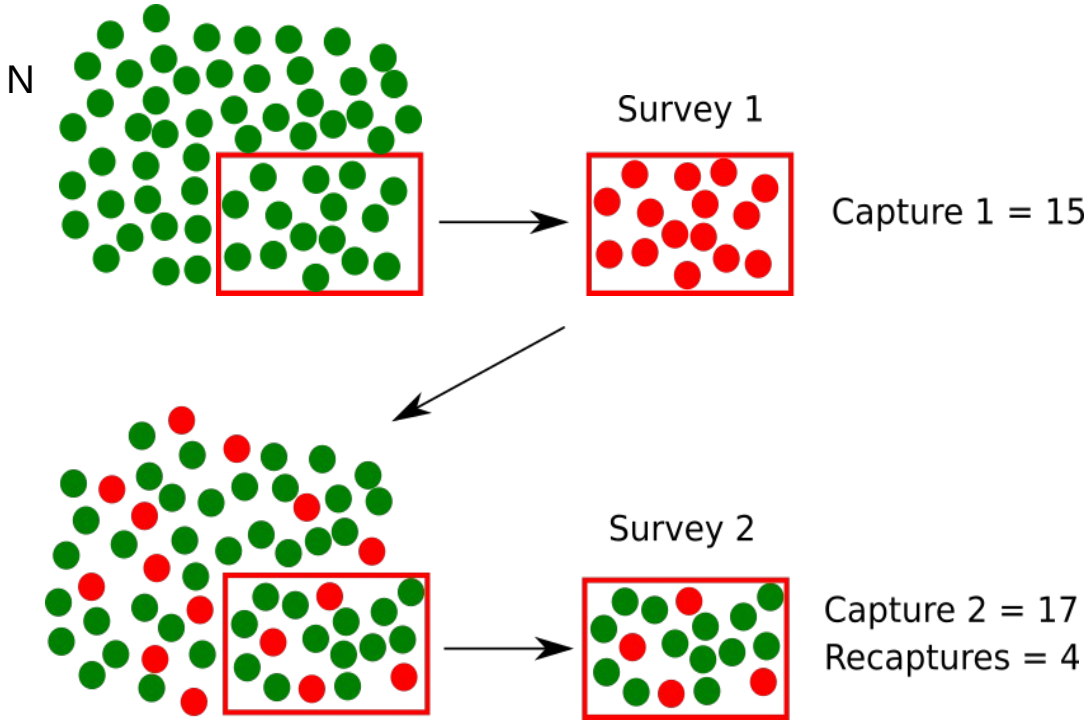
Passerine birds – Captures







Passerine birds – Captures → Demography



Survey 1 **Survey 2**

$$\frac{\text{Capt. 1}}{N} = \frac{\text{Recapt.}}{\text{Capt. 2}}$$

$$N = \frac{\text{Capt. 1} * \text{Capt. 2}}{\text{Recapt.}}$$

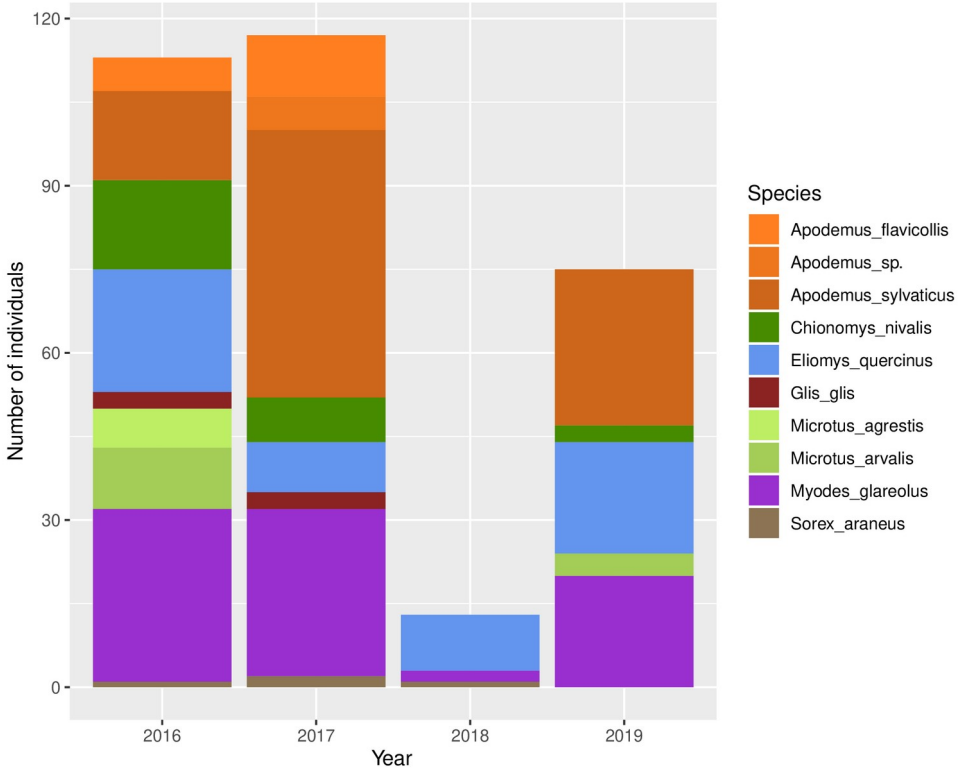
$$N = \frac{15 * 17}{4} = 63.75$$

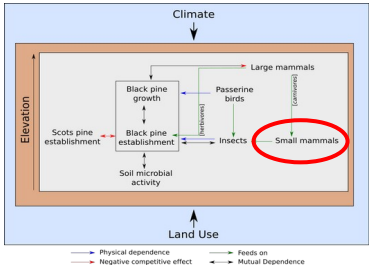
Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE

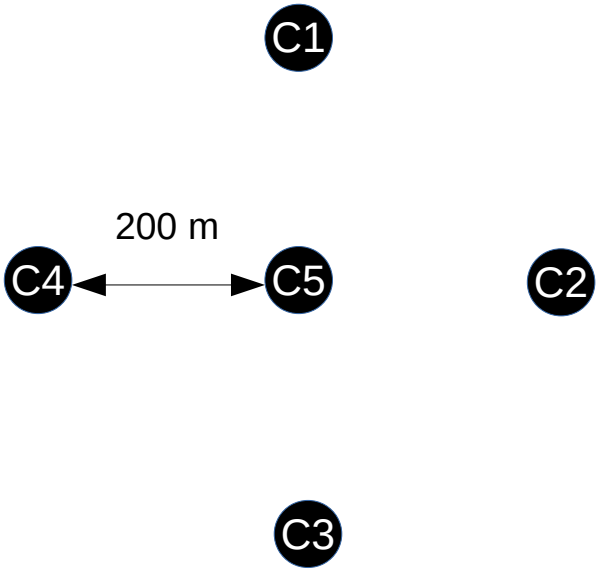
Small mammals





Wildlife in the Changing Andorran Pyrenees

Large mammals



Wildlife in the Changing Andorran Pyrenees

	Time 1	*Time 2*	*Time 3*	*Time 4*	*…*	*Time 2*
Cam 1	1	1	0	1	…	0
Cam 2	0	0	0	0	…	1
Cam 3	1	0	1	0	…	0
…	…	…	…	…	…	…
Cam 60	0	0	1	1	…	0

seen

Species “X” has been present in “Cam 1 site” 75% of the times

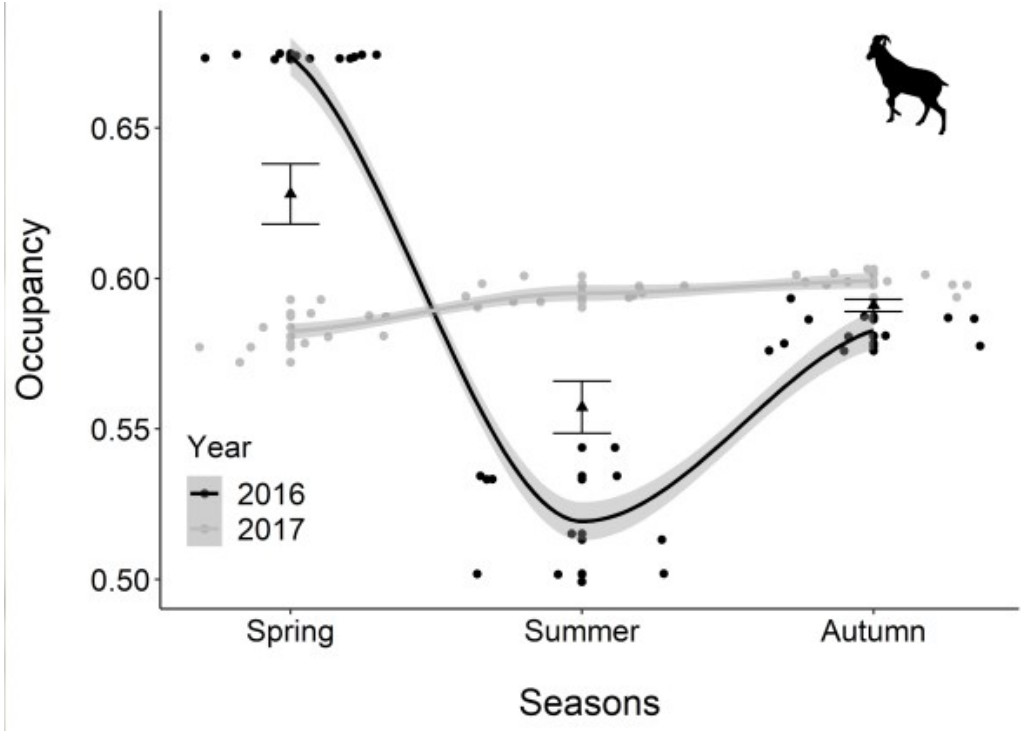
?

Wildlife in the Changing Andorran Pyrenees

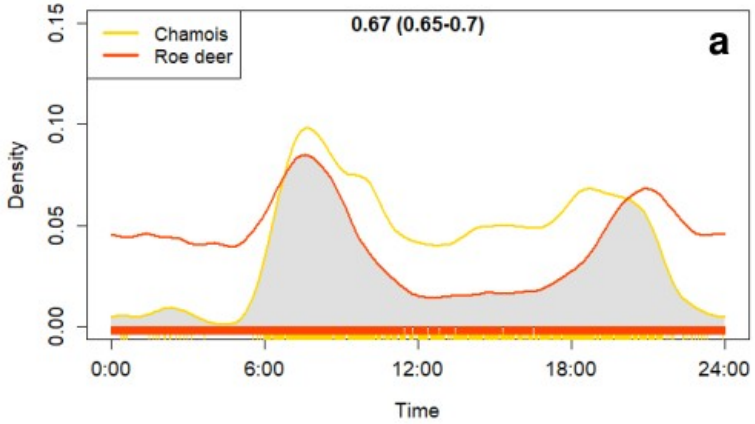
CREAF

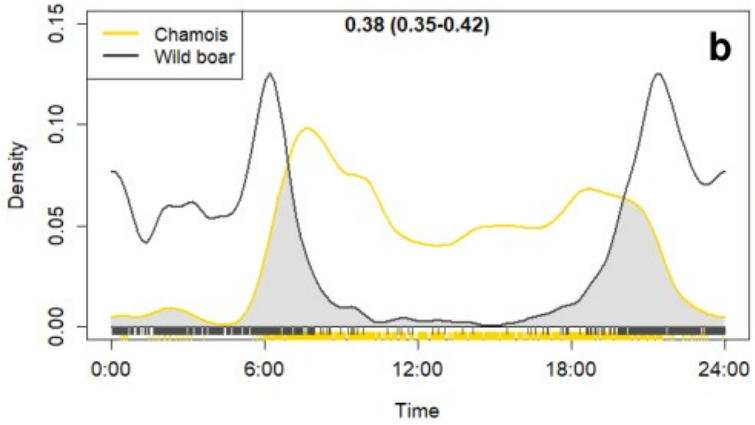
EARTHWATCH INSTITUTE

Large mammals



Wildlife in the Changing Andorran Pyrenees





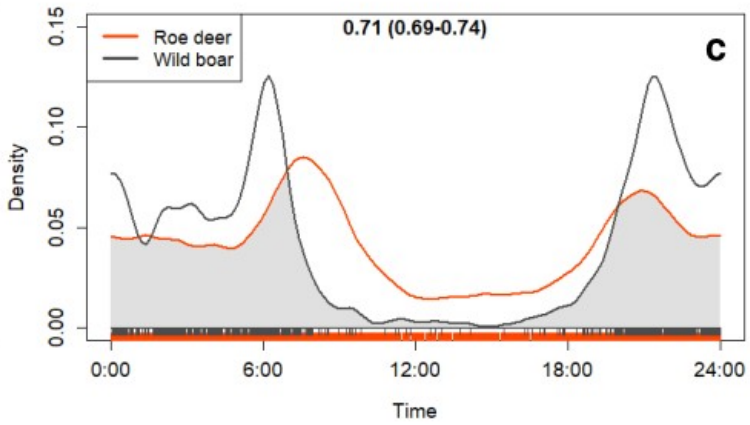


Fig. 2 Daily activity patterns of the studied wild ungulates and temporal overlap between them: chamois vs. roe deer (a), chamois vs. wild boar (b) and roe deer vs. wild boar (c). In bold, coefficients of overlap (Δ_4) and its confidence intervals.

Wildlife in the Changing Andorran Pyrenees

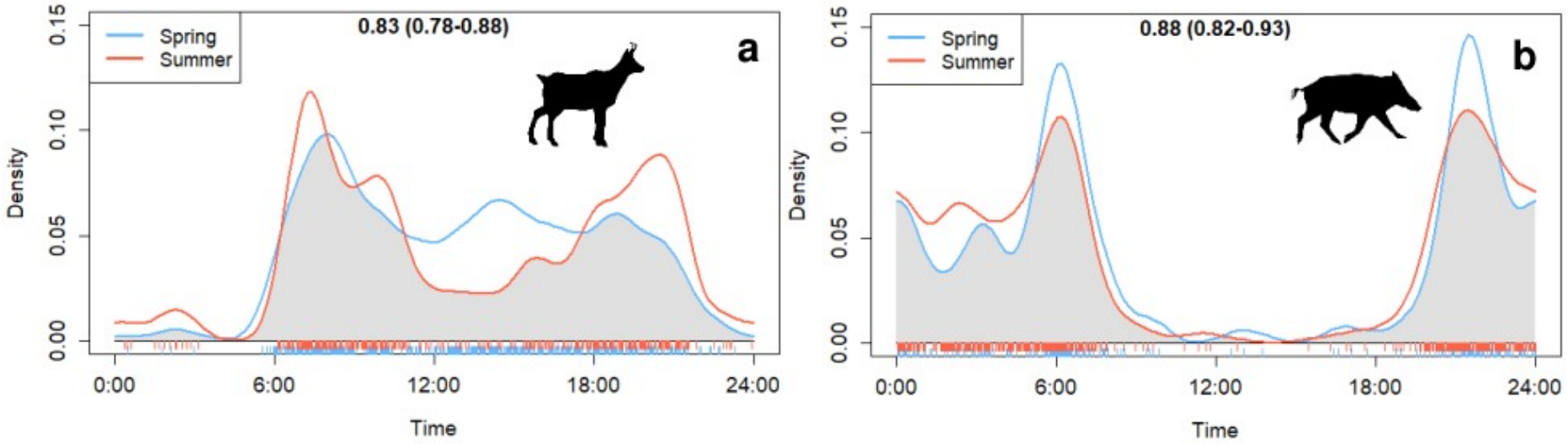


Fig. 4 Daily activity patterns and temporal overlap between spring and summer in chamois (a) and wild boar (b). In bold, coefficients of overlap (Δ_4) and its confidence intervals.

Wildlife in the Changing Andorran Pyrenees

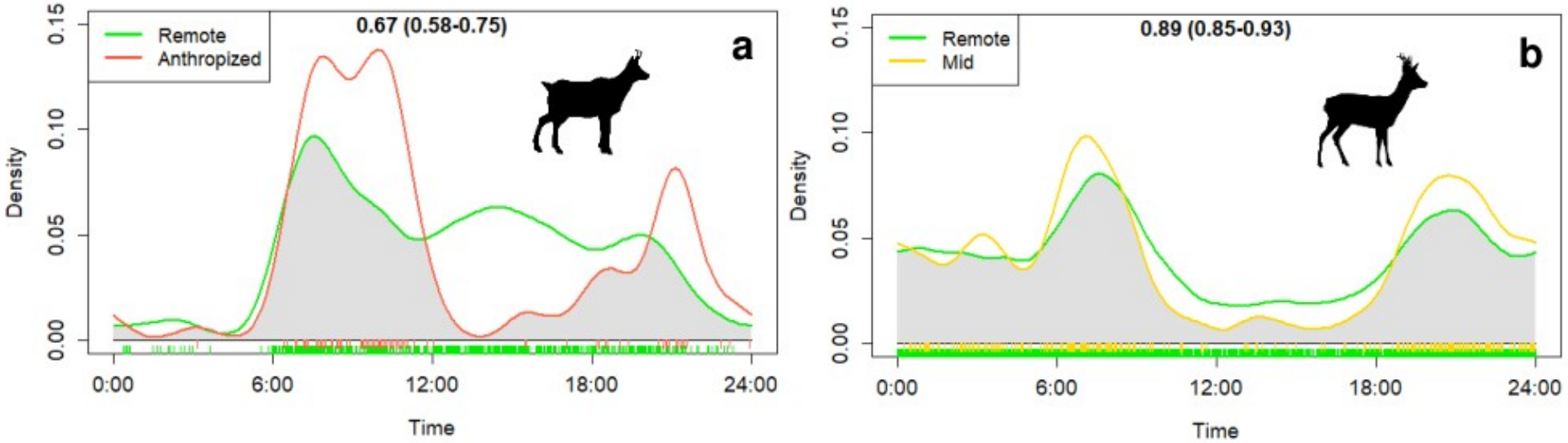


Fig. 5 Daily activity patterns and temporal overlap between levels of anthropization in chamois (a) and roe deer (b). In bold, coefficients of overlap (Δ_4) and its confidence intervals.

Wildlife in the Changing Andorran Pyrenees

CREAF

EARTHWATCH INSTITUTE

Insect biodiversity (and bird's diet!)

+

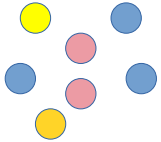
?

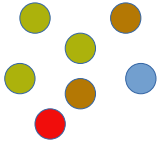
Wildlife in the Changing Andorran Pyrenees

Insect biodiversity (and bird's diet!)

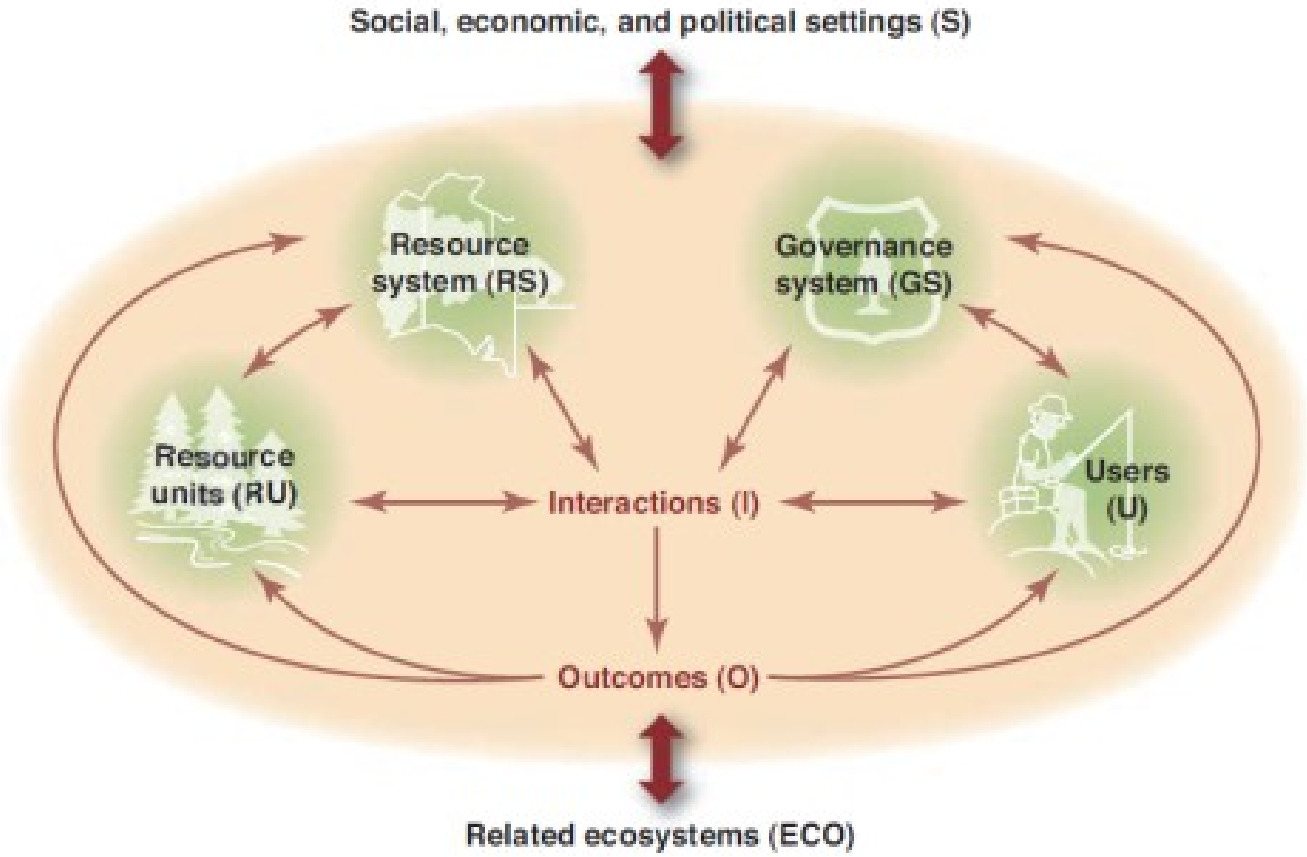
Similar richness (number of species), but...

...very different composition!!!

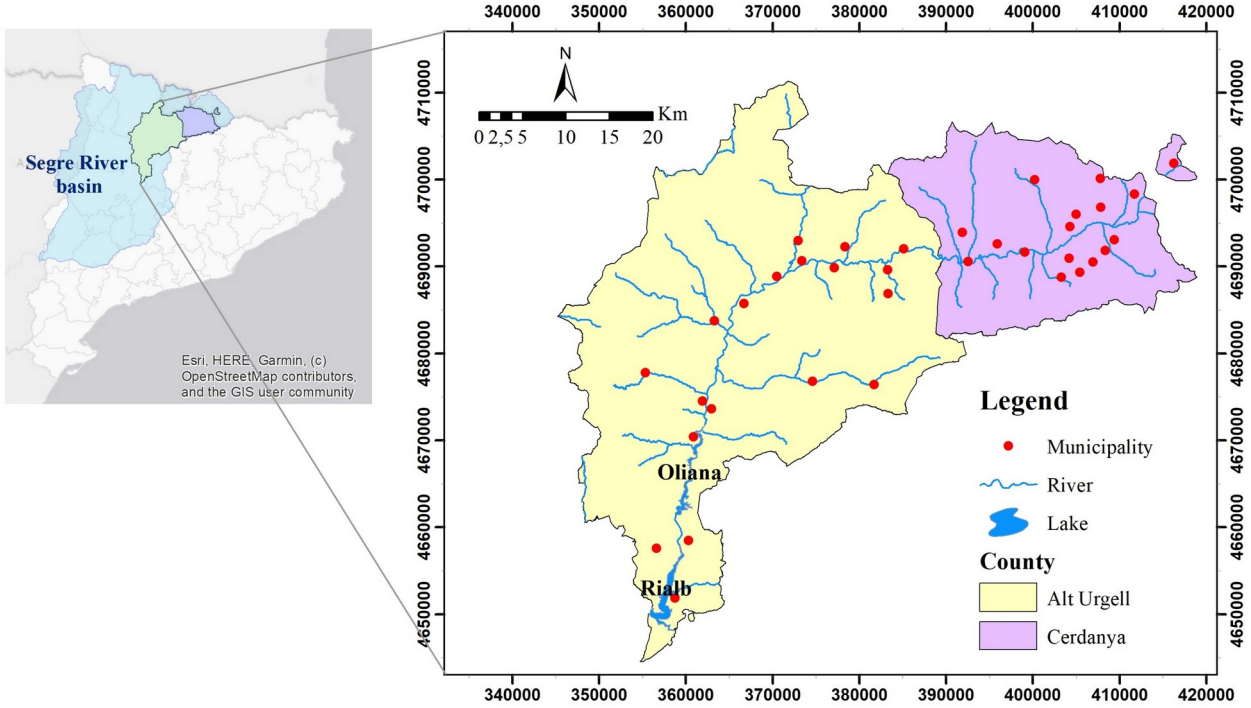




Beyond Wildlife



Study Area


Segre River basin
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
N
Km
0 2,5 5 10 15 20
340000 350000 360000 370000 380000 390000 400000 410000 420000
4710000 4700000 4690000 4680000 4670000 4660000 4650000
Oliana
Rialb
Legend
Municipality
River
Lake
County
Alt Urgell
Cerdanya

Study Area

Data analysis

Data (2000-2020)

- Hydrological
- Climatic
- Remote-sensing (environ.l)
- Socioeconomic

Missing data assessment: data imputation, estimation and forecasting

Data **averaged** to the scale of the Alt Urgell and Cerdanya when possible

CONFEDERACIÓN HIDROGRÁFICA EBRO

meteo.cat Servei Meteorològic de Catalunya

NASA

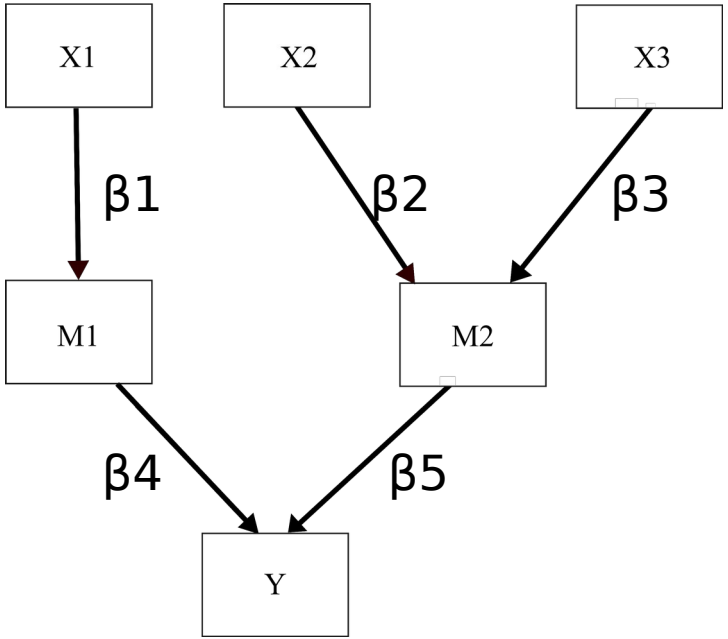
Generalitat de Catalunya Institut d'Estadística de Catalunya

INE Instituto Nacional de Estadística

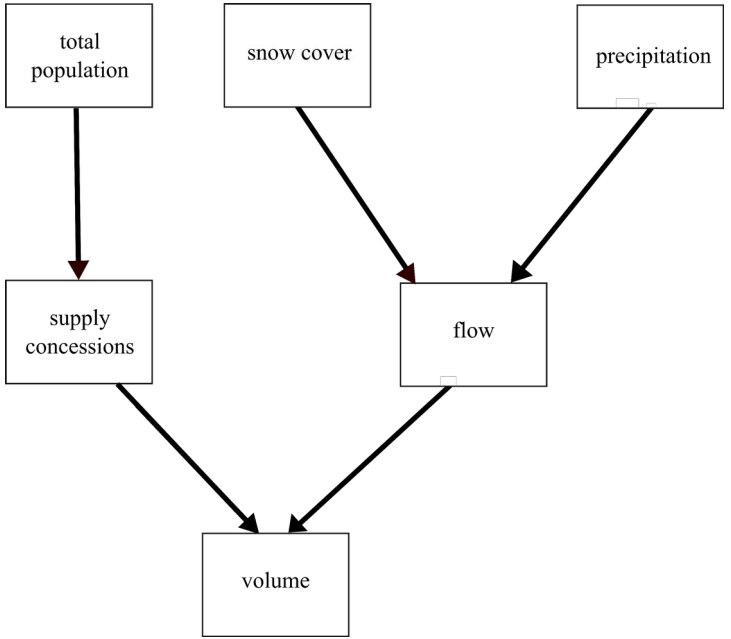
Path Analysis

Independent \ Dependent	*flow*	*volume*	*NDVI*	*ET*	*snow cover*	*agriculture concessions*	*supply concessions*	*seasonal population*	*rural tourism establishments*	*occupation services*	*occupation agriculture*	*GDP services*	*GDP total*
flow		+										+	
mean T					-			+					
min T			+		-								
max T				+	-								
precipitation	+	+	+	+	-								
NDVI				+	-			+					
ET	-												
snow cover	-		-					+				+	
supply concessions	-	-											
agriculture concessions	-	-											
total population	-	-				+	+	+		+	-	+	

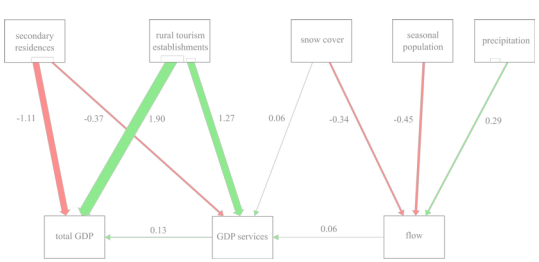
Path Analysis

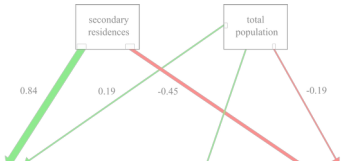


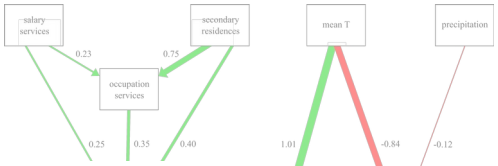
Reading a path diagram



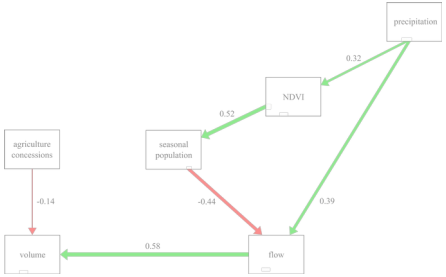
e.g. Model 10

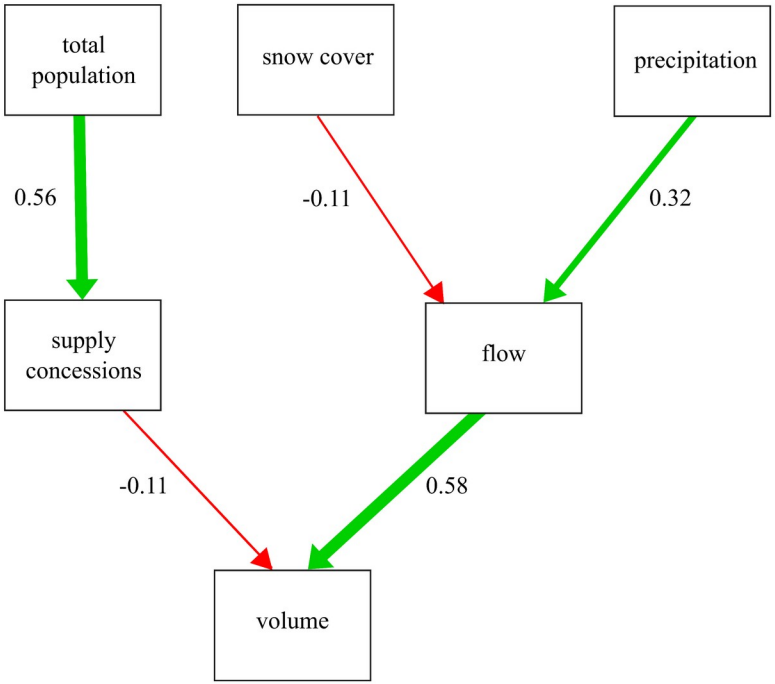

secondary residences
rural tourism establishments
snow cover
seasonal population
precipitation
-1.11
-0.37
1.90
1.27
0.06
-0.34
-0.45
0.29
total GDP
0.13
GDP services
0.06
flow

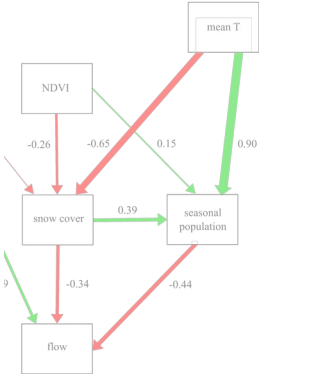

secondary residences
total population
0.84
0.19
-0.45
-0.19

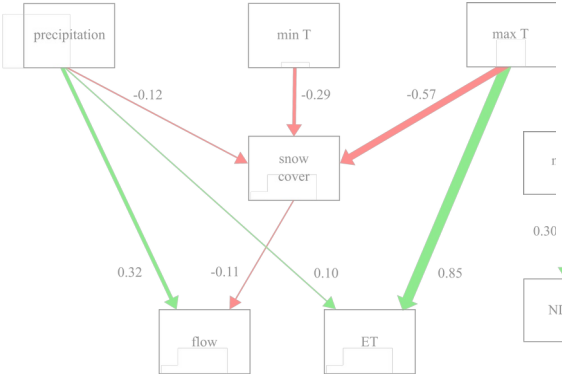

salary services
secondary residences
occupation services
0.23
0.75
0.25
0.35
0.40

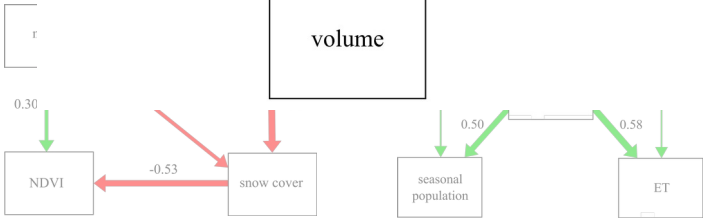
mean T
precipitation
snow cover
seasonal population
1.01
-0.84
-0.12
0.37

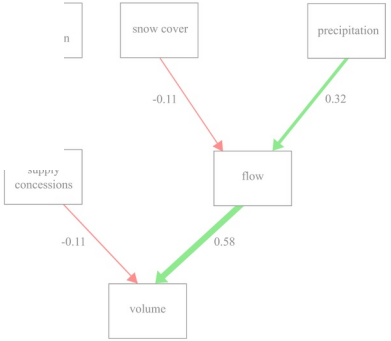

precipitation
NDVI
agriculture concessions
seasonal population
volume
flow
0.32
0.52
-0.14
-0.44
0.39
0.58


total population
snow cover
precipitation
0.56
-0.11
0.32
supply concessions
flow
-0.11
0.58
volume


mean T
NDVI
snow cover
seasonal population
flow
-0.26
-0.65
0.15
0.90
0.39
-0.34
-0.44

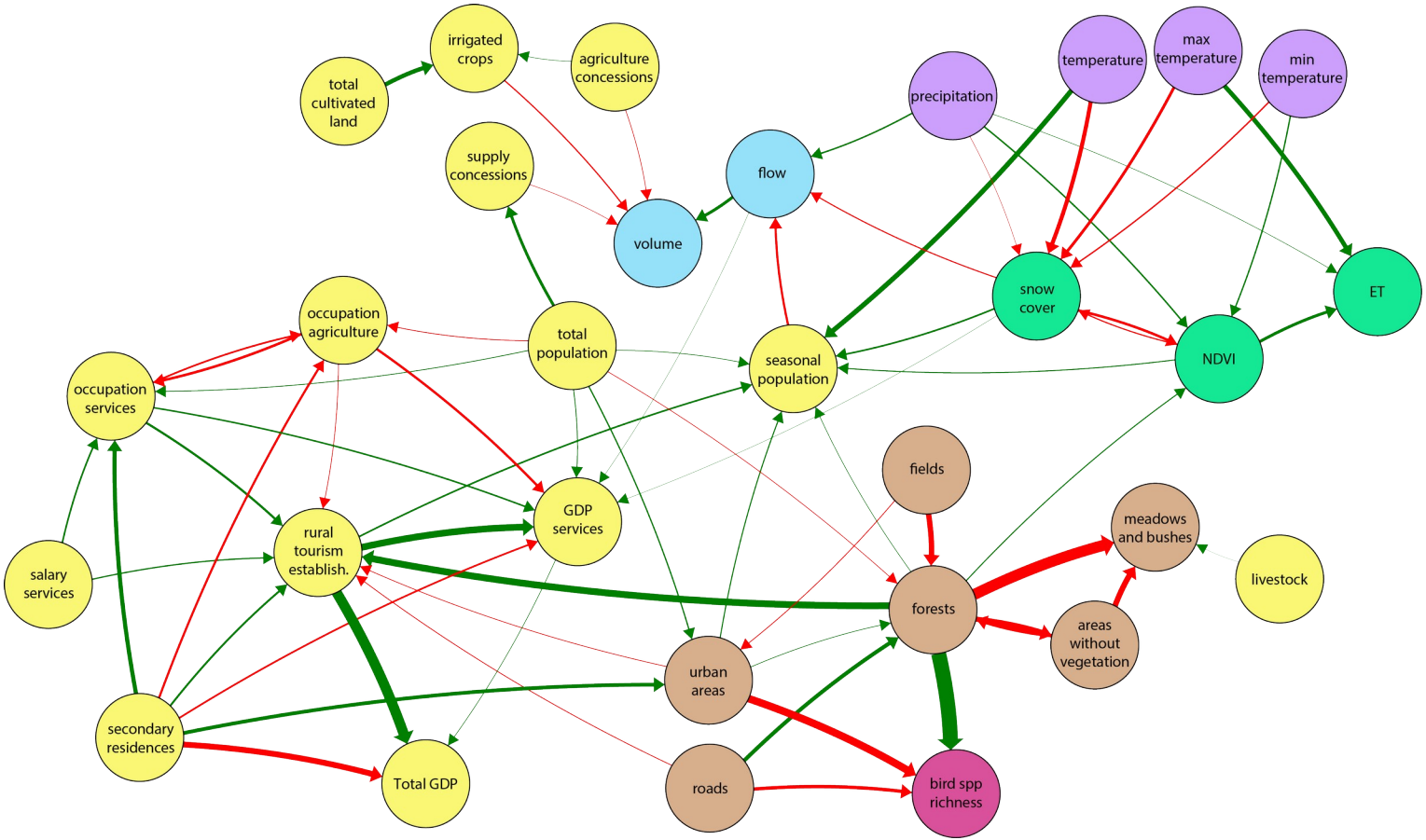

precipitation
min T
max T
snow cover
flow
ET
-0.12
-0.29
-0.57
0.32
-0.11
0.10
0.85


0.30
NDVI
-0.53
snow cover
seasonal population
0.50
0.58
ET

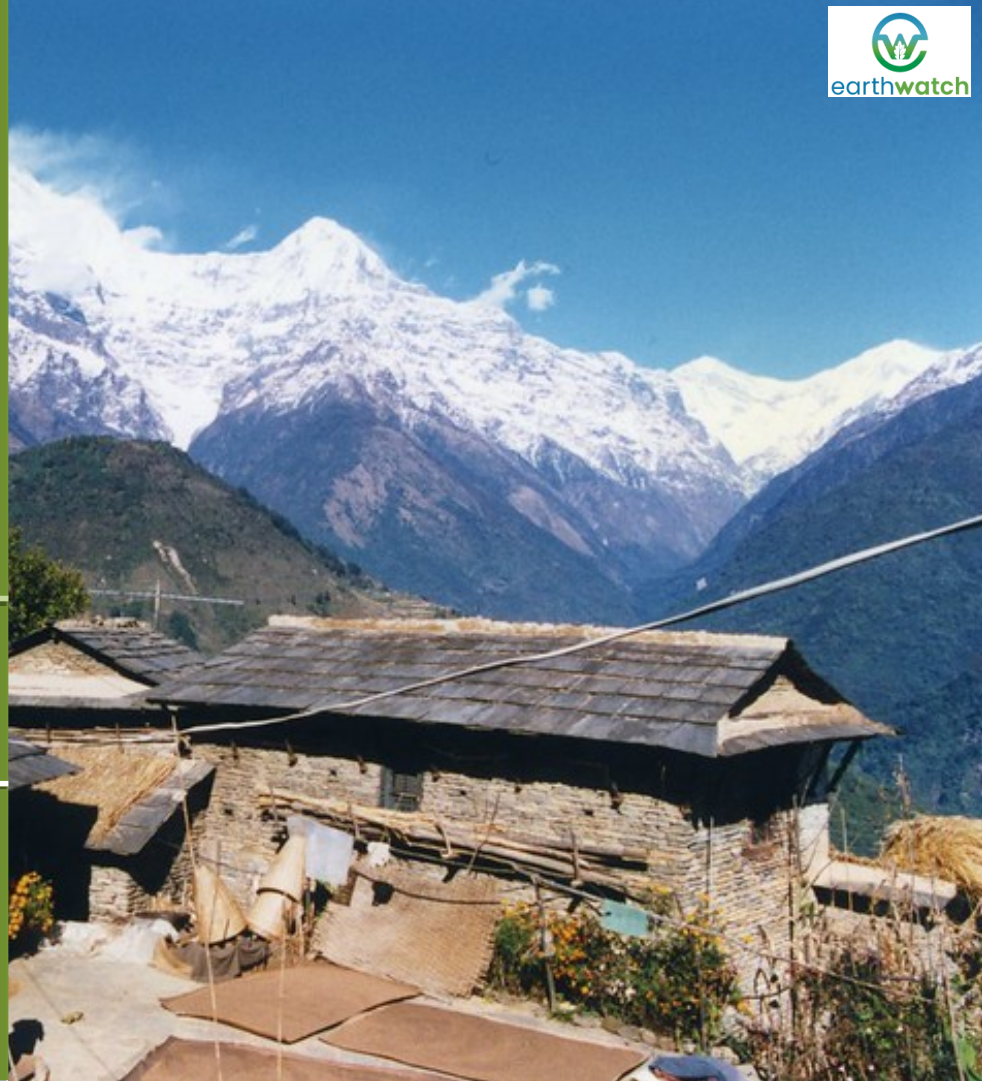

snow cover
precipitation
-0.11
0.32
flow
supply concessions
-0.11
0.58
volume

Water management in the Catalan Pyrenees

CREAF



The effects of climate change on mountain ecosystems

Bernat Claramunt-López
Researcher

October 26th, 2021