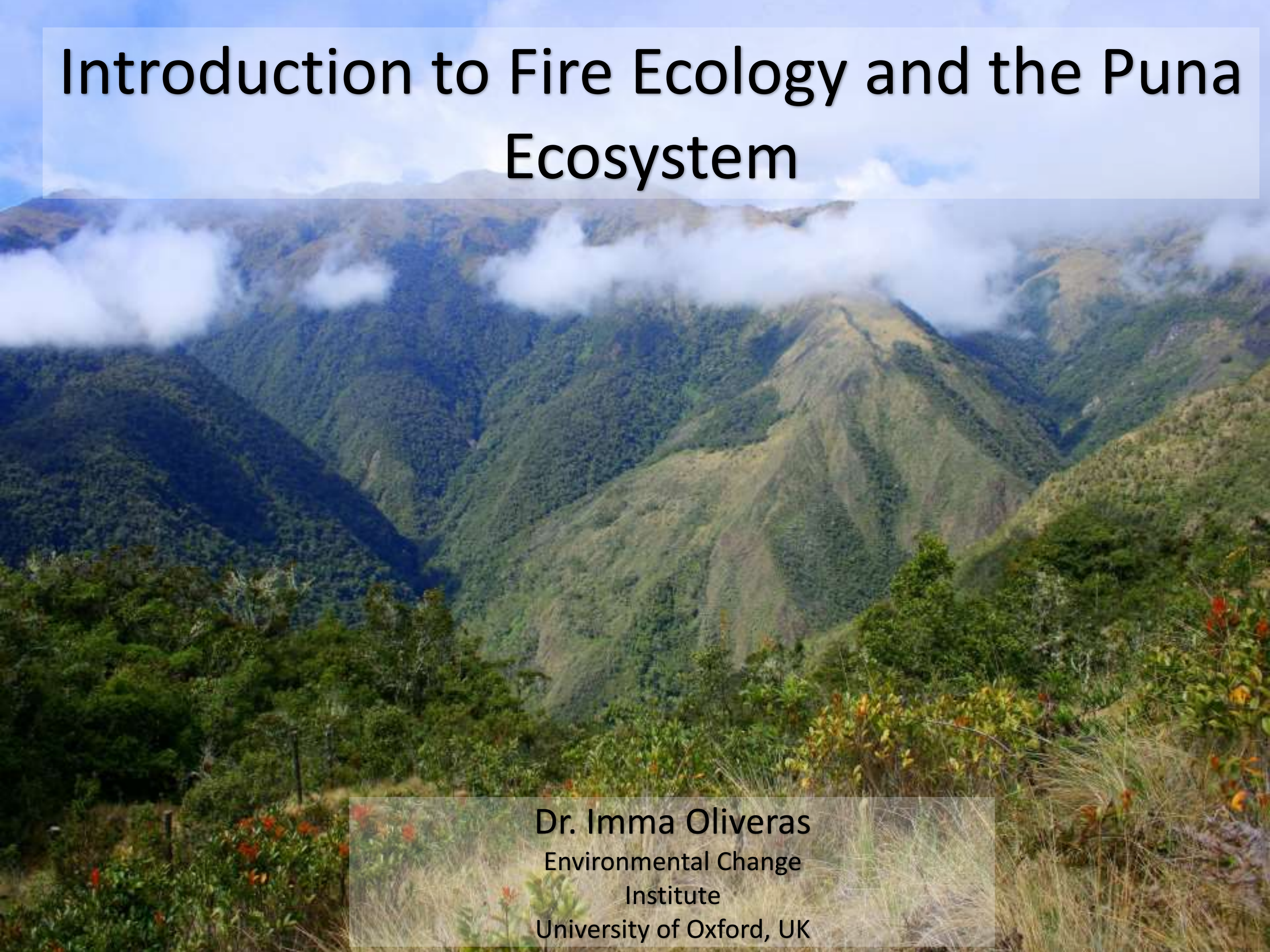
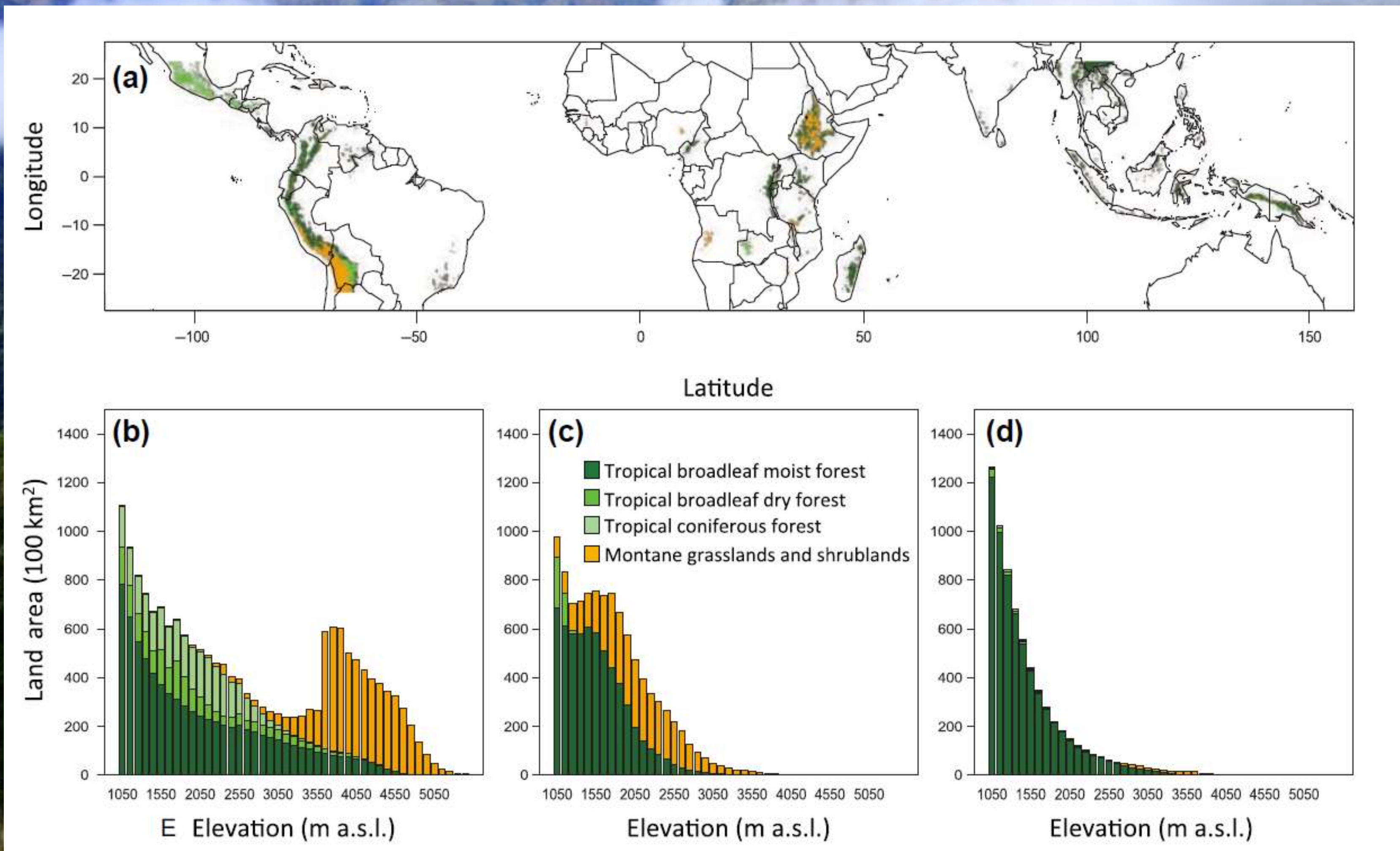
Introduction to Fire Ecology and the Puna Ecosystem



Dr. Imma Oliveras
Environmental Change
Institute
University of Oxford, UK

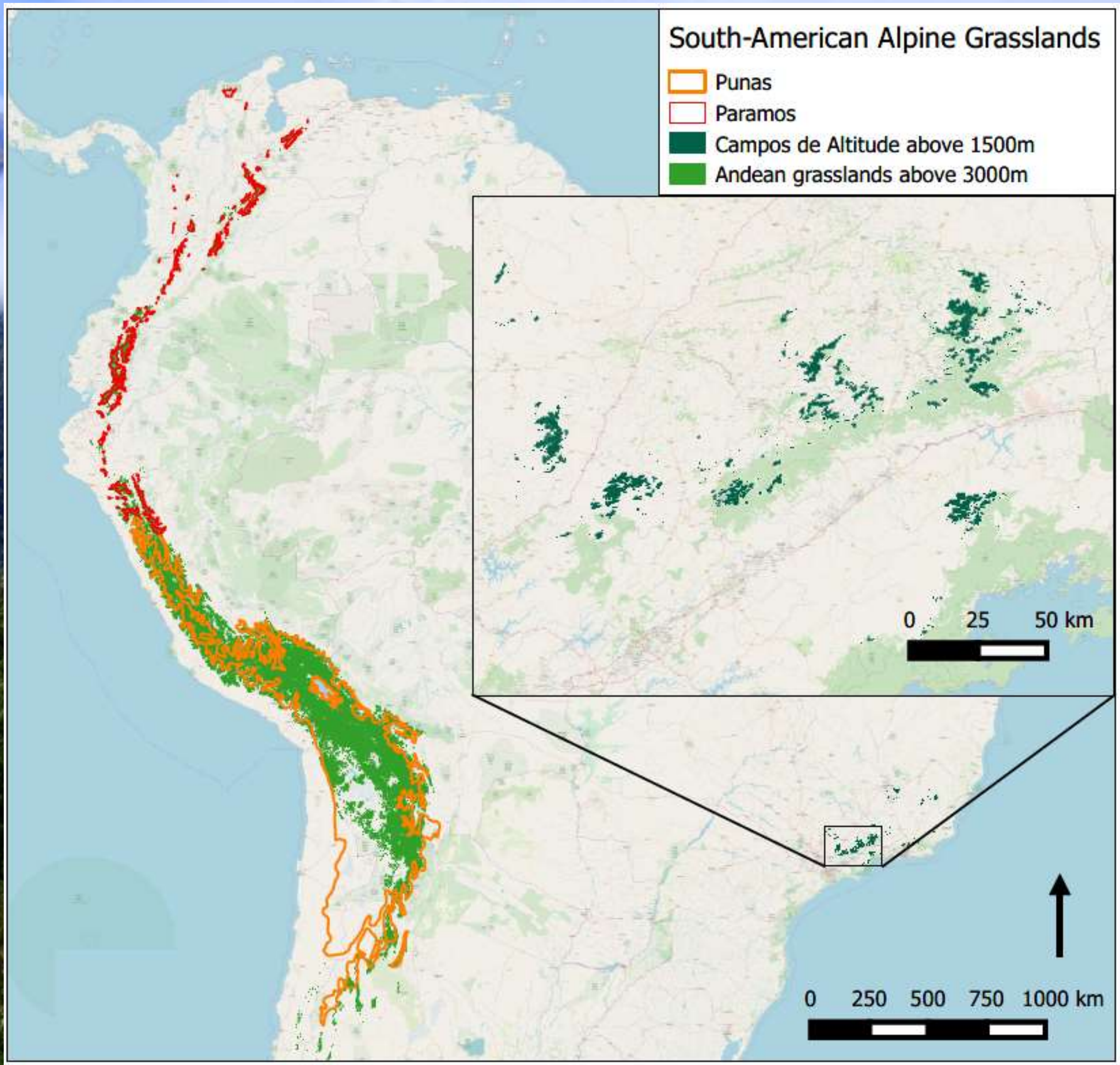
Worldwide elevation treelines

Found between 3000 – 4000 m asl, around 5C thermal isocline



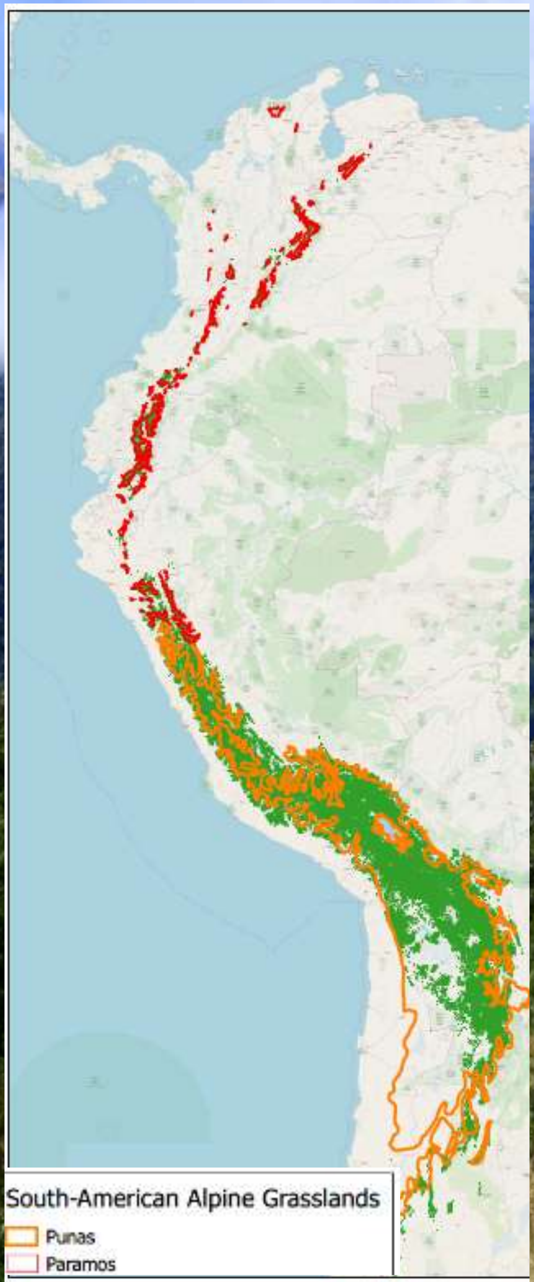
Rehm & Feeley (2015) Ecography

South American Alpine Grasslands



Christman and Oliveras *in press*

Puna and páramos



Páramo – ancient Spanish term for "elevated, barren treeless plateau"

Spans Northern Andes between Colombia, Venezuela, Ecuador and Northern Peru

Climate: large N-S and E-W variation. Drier than cloud forests, with increased seasonality as one moves south (2-4 months).

Soil: dark, acidic, rocky and poorly developed

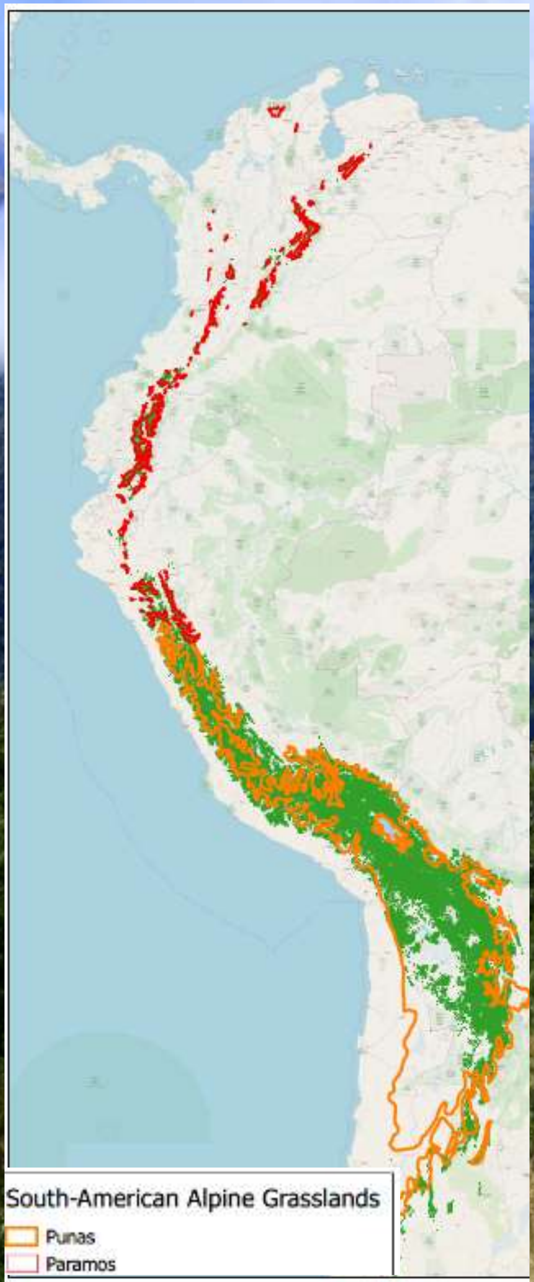
Vegetation types:

sub-páramo: 3500-4100 m asl, shrubby;
grass páramo: 3800-4100 m asl, tussocks;
supra-páramo: mat-forming cushion plants

Ancient vegetation formations, and usually recover well (resprout after fire)

Christman and Oliveras *in press*

Puna and páramos



Puna –

Spans Northern Peru to Northern Argentina – over more than 10 longitude and 300 km wide

Climate: precipitation 500-700 mm/y (250—500 in dry puna). Temperature 0-15 C

Soil: dark, acidic, often poorly developed. Sits on 6-8 million old bedrock.

Vegetation types:

Wet-puna (3,700-4200 m asl), bunchgrass, small shrubs; *Carex, Juncus, Oreobolus* and *Scirpus*

Central puna: 4200-5000 m asl, grasses with prostrate and roseate growth forms; *Festuca*, *Stipa ichu*, and *Calamagrostis*

Dry puna: xerophytic vegetation and patchy distributions. *Calamagrostis, Agrostis* and *Festuca*

Puna

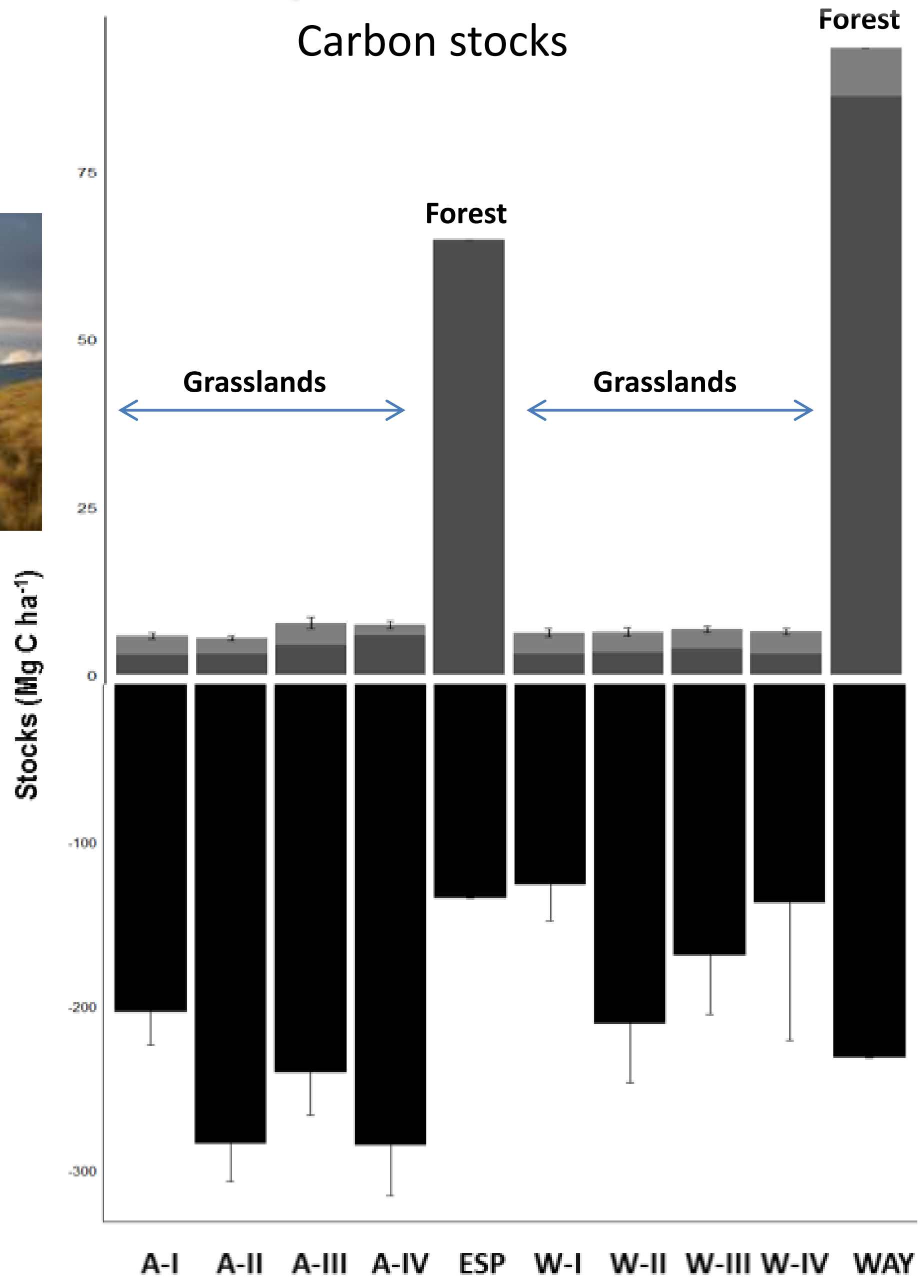
The treeline and the upper elevational range edges of most tropical cloud forest tree species are thought to be determined primarily by temperatures (Körner 1998, 2008).

Puna ecosystems dominated by C3 grasses

Why is puna important?

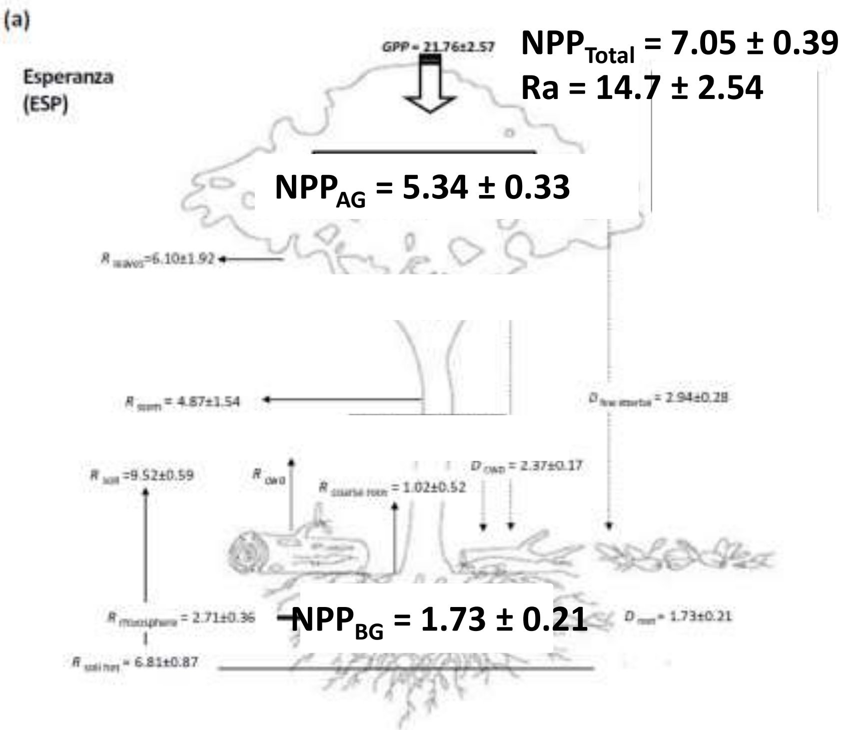
- Biodiversity hotspot
- C stocks (many seat above peatlands and high organic rich soils)
- Productivity

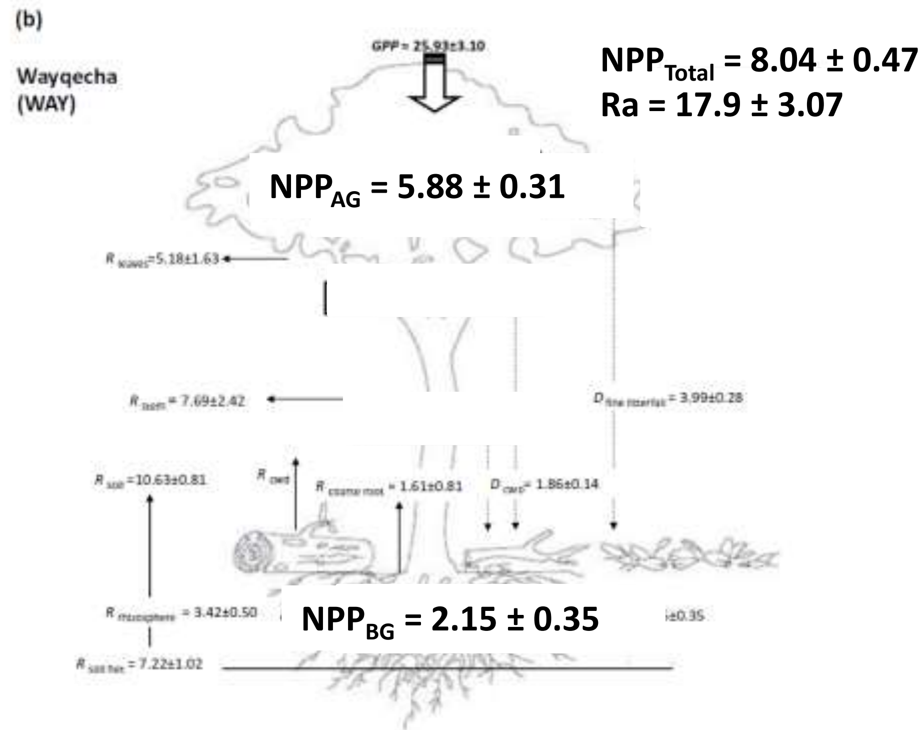
C stocks of Andean puna and montane forest



Oliveras et al (2014) ERL

Productivity of Andean puna

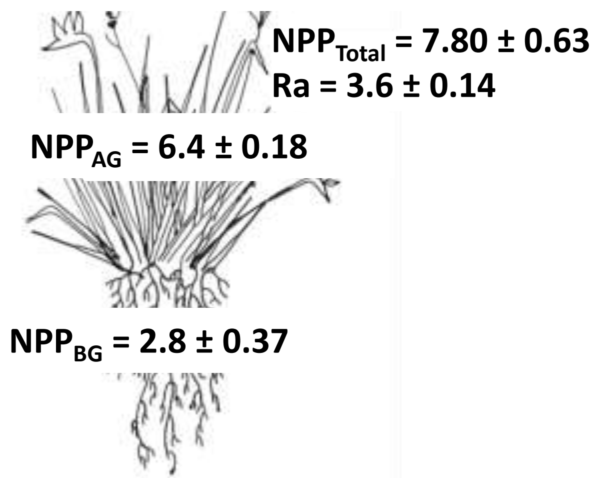




Girardin et al (2013) PED

Units: Mg C ha^{-1} y^{-1}

Grasslands have as much total, aboveground and belowground NPP as forests



Oliveras et al (2014) ERL

Threats to the puna and páramos

Global change

Rising cloud base and changes in cloud frequency (Halladay et al 2012)

Higher mean temperatures;

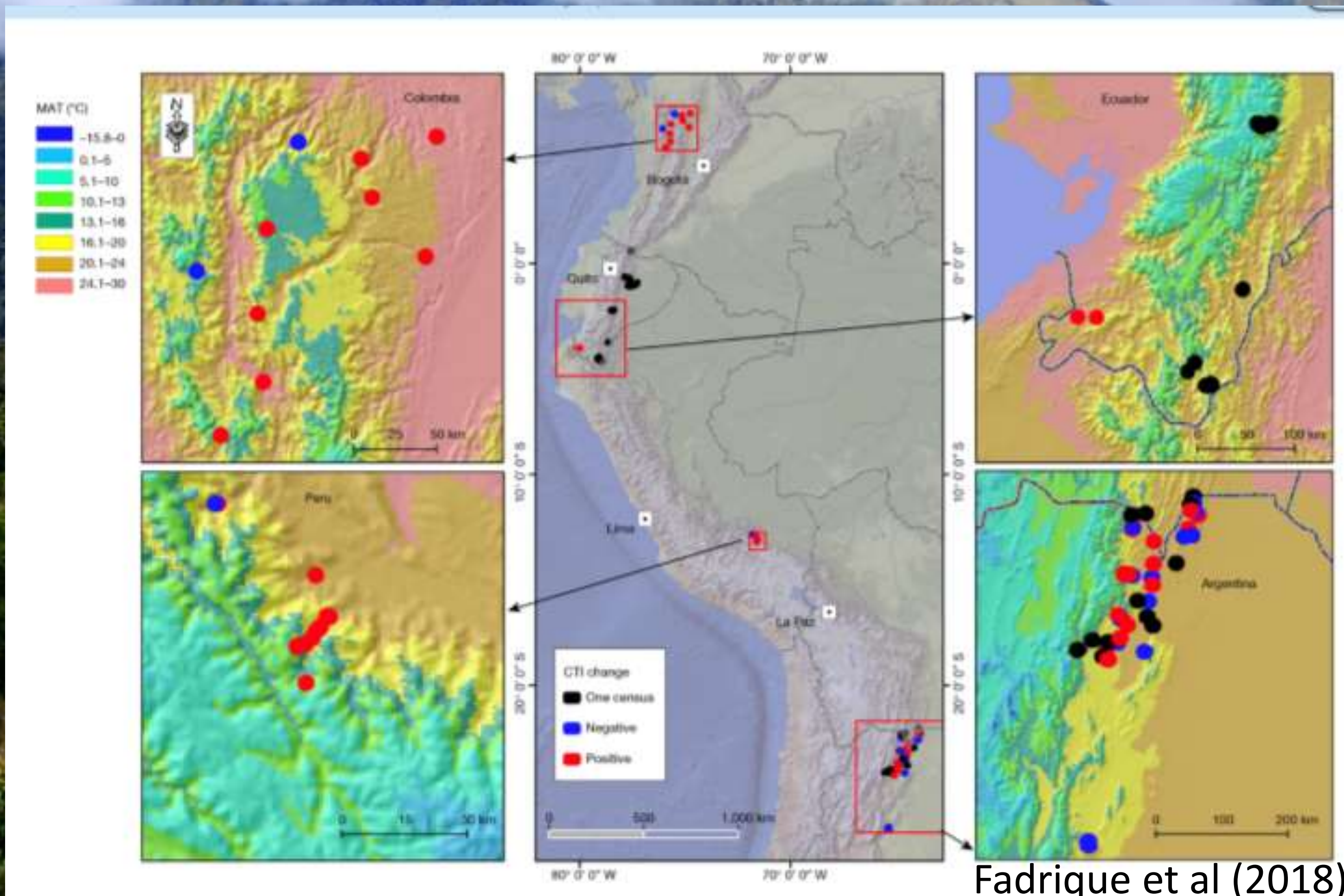
Longer dry seasons

Anthropogenic pressures (cattle & fire) (Sarmiento and Frolich 1990, Oliveras et al 2014)

Responses to climate change

Rising cloud base and mean temperatures is resulting in a **upslope tree migration** (Feeley et al (2011)

Main reason is **thermofilization** (Fadrique et al., 2018)



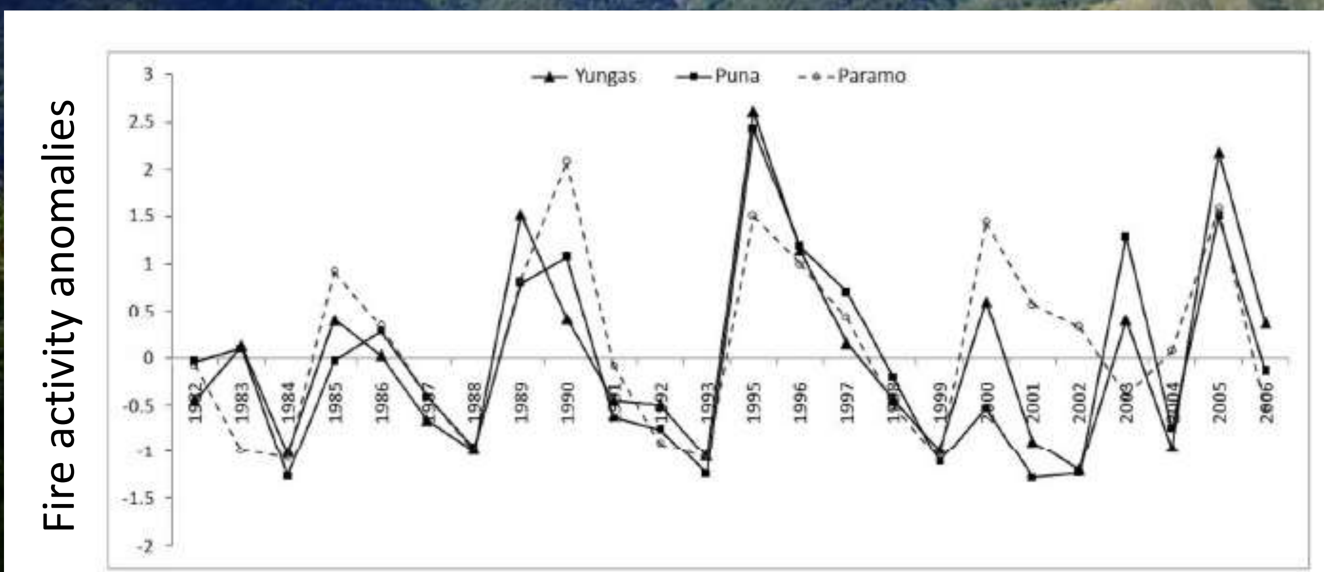
Fadrique et al (2018)

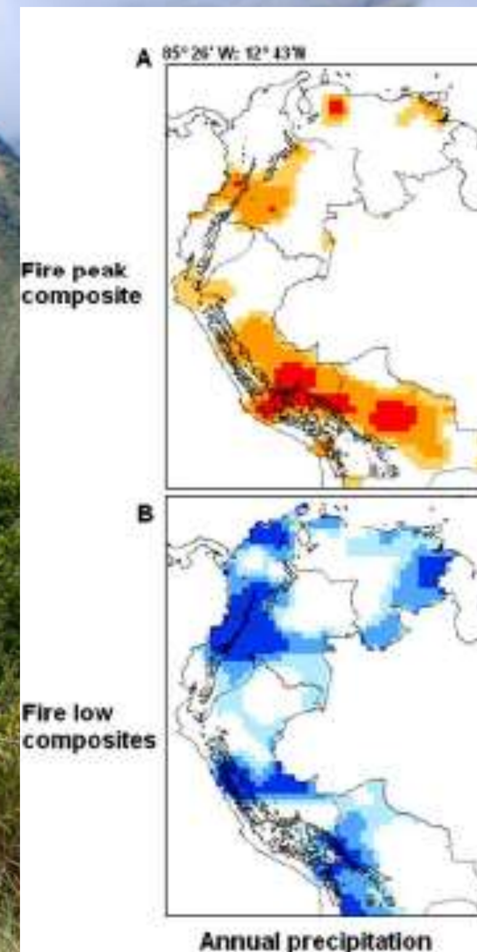
But FIRES are increasingly penetrating into the forests

Being a key factor on stopping upslope migration, and killing fire-sensitive TMCF

Fire regimes in the Andean grasslands

Fires are becoming increasingly frequent in the region, associated with rainfall patterns





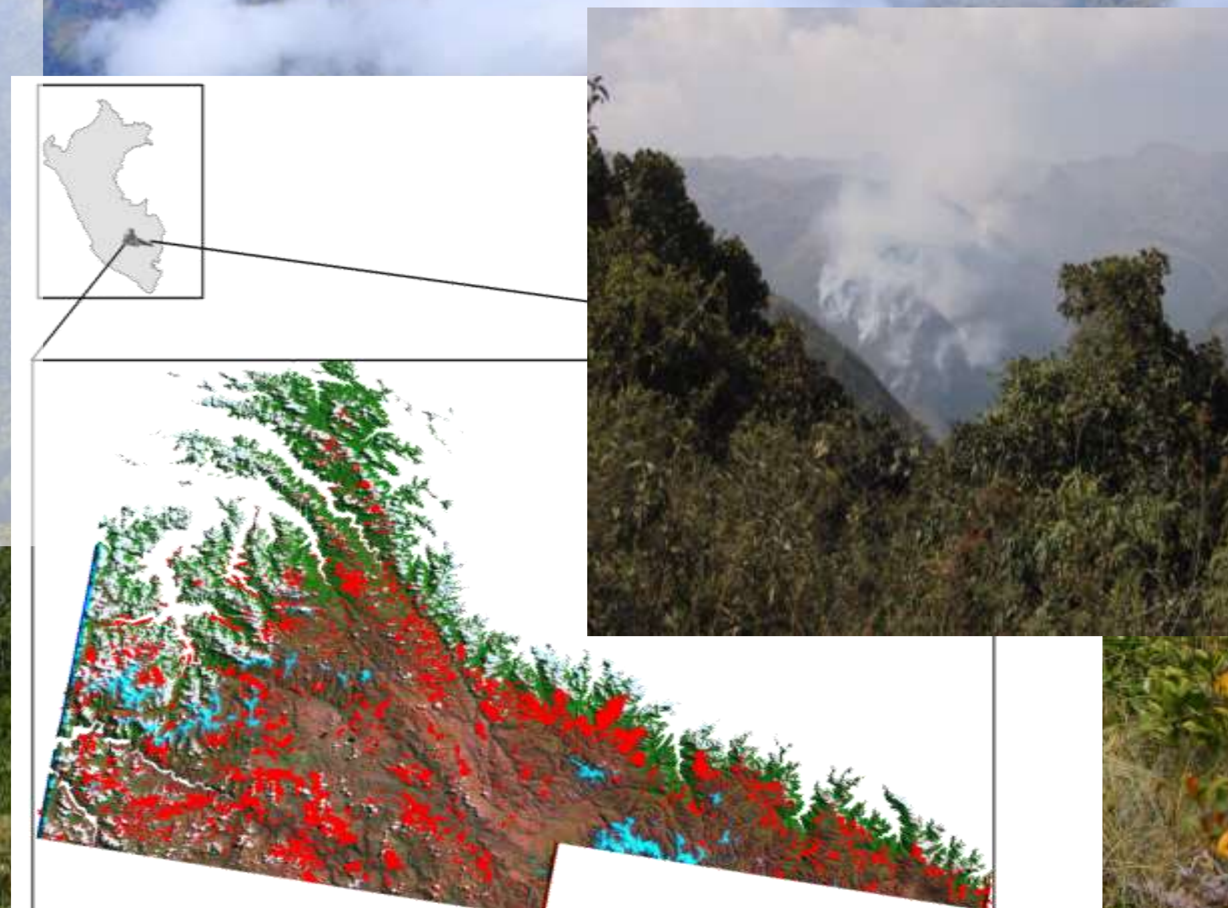
Román-Cuesta et al (2014) GCB

Fire regimes in Andean grasslands

In a 12-y period, almost 10% of the study area had burned at least once

Fire return interval was of 35 years (it is of 74 years in the lowlands)

Every year, 10-25% of the fires occurred in forests



Oliveras et al (2014) GBC

Fire regimes in Andean grasslands

We still know very little about impacts of fires in Andean ecosystems

95% published by our team

Only two articles on impacts of fire in puna grasslands since 2015

Biodiversity and Conservation (2019) 28:885–908
https://doi.org/10.1007/s10531-019-01700-3

ORIGINAL PAPER

Check for updates

Biodiversity outcomes of payment for ecosystem services: lessons from páramo grasslands

Leah L. Bremer[1,2] · Kathleen A. Farley[3] · Nathan DeMaagd[1,4] · Esteban Suárez[5] · Daisy Cárate Tandalla[6,7] · Sebastián Vasco Tapia[8] · Patricio Mena Vásconez[9]

Plant Ecol (2018) 219:79–88
https://doi.org/10.1007/s11258-017-0779-x

CrossMark

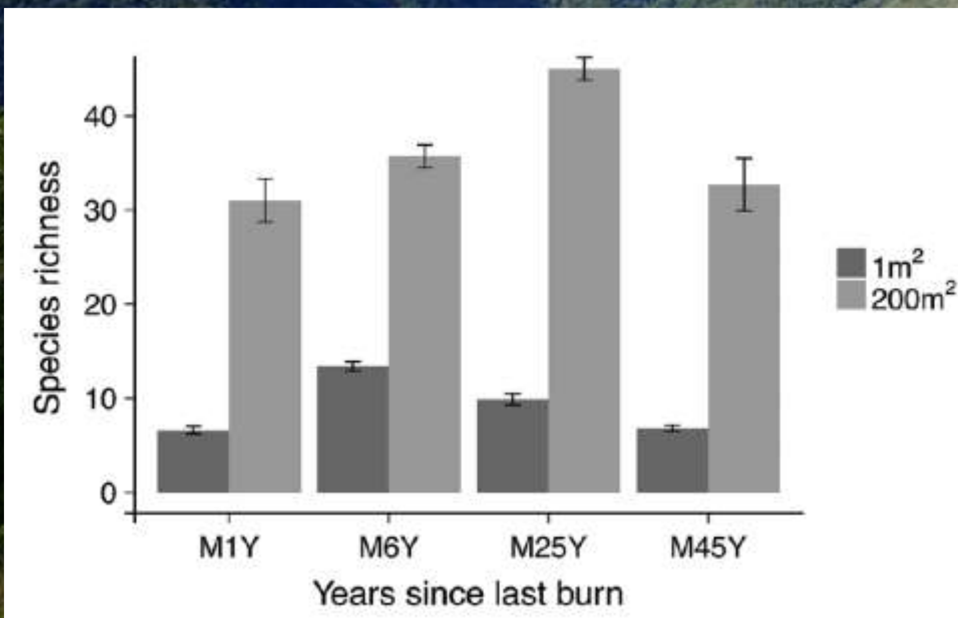
***Espeletia* giant rosette plants are reliable biological indicators of time since fire in Andean grasslands**

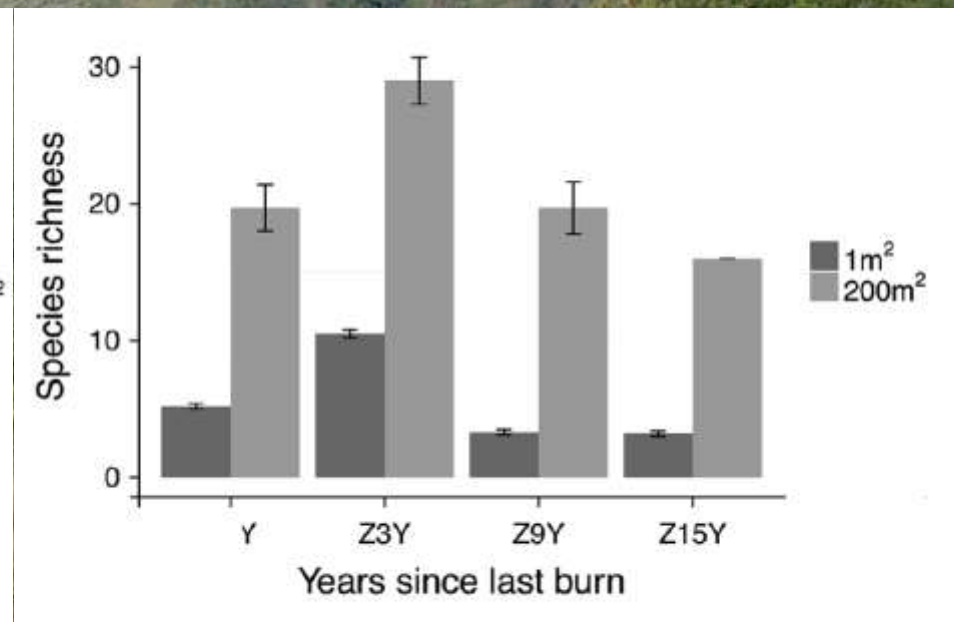
Maya A. Zomer · Paul M. Ramsay

Fire regimes in Andean grasslands

Table 1 Sampling sites in Mazar Wildlife Reserve (M) and Zuleta (Z)

Sites	Elevation (m)	Slope (°)	Land use
M1Y	3449	21	Burned twice in year prior to sampling (one experimental and one accidental burn); occasional alpaca grazing
M6Y	3428	20	Burned 6.5 years prior to sampling; occasional alpaca grazing
M25Y	3453	13.5	Last burned approximately 25 years ago prior to sampling
M45Y	3351	22	Had not been burned in at least 45 years prior to sampling
Z1Y	3654	15.5	Recent burn (< 1 year); occasional alpaca grazing
Z3Y	3626	20	Recent burn (2.5 years); saplings of *P. racemosa* (40–120 cm)
Z9Y	3655	13	Intermediate burn (10 years); occasional alpaca grazing
Z15Y	3645	12.5	Burn exclusion (16 years)

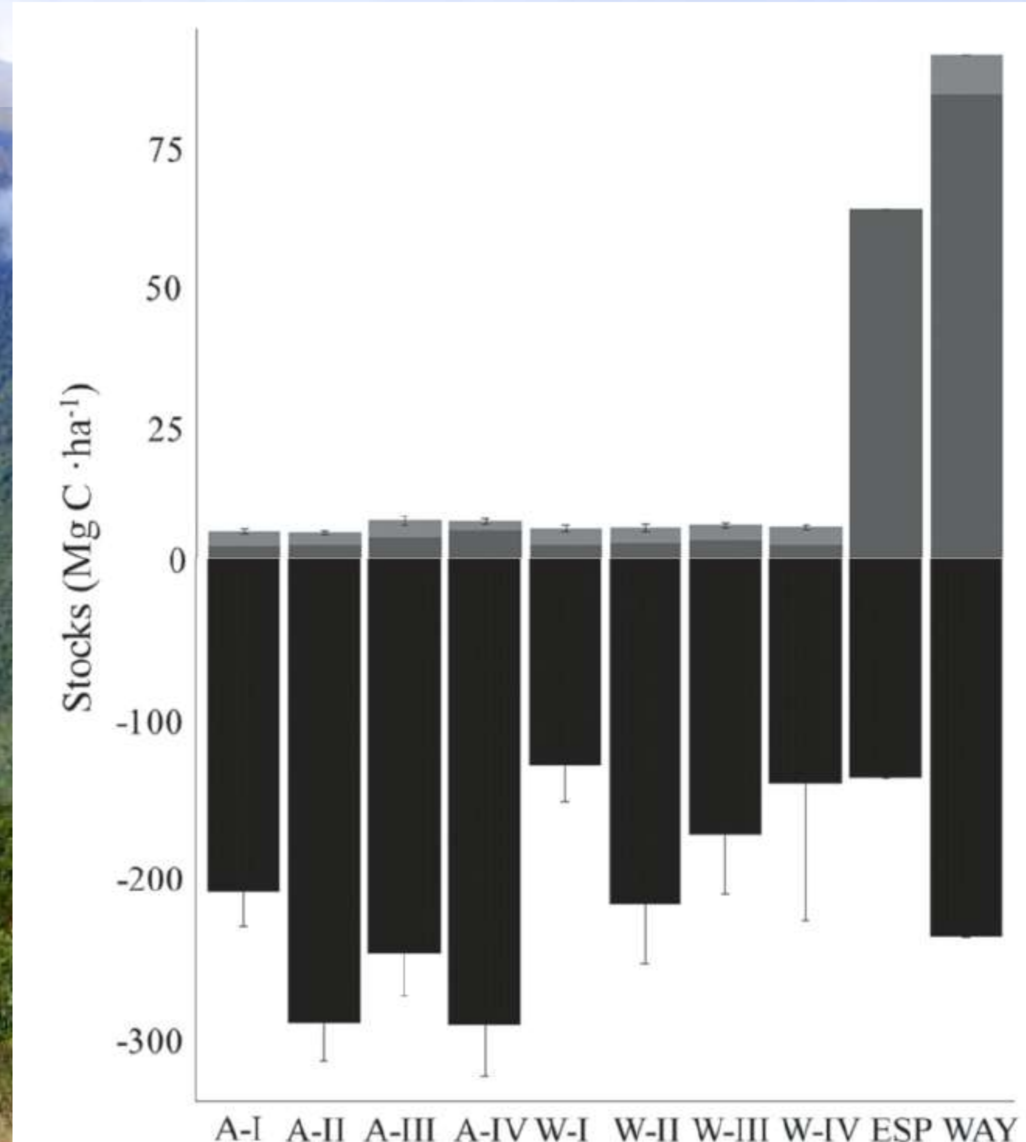




Bremer et al (2019)

Fire regimes in Andean grasslands

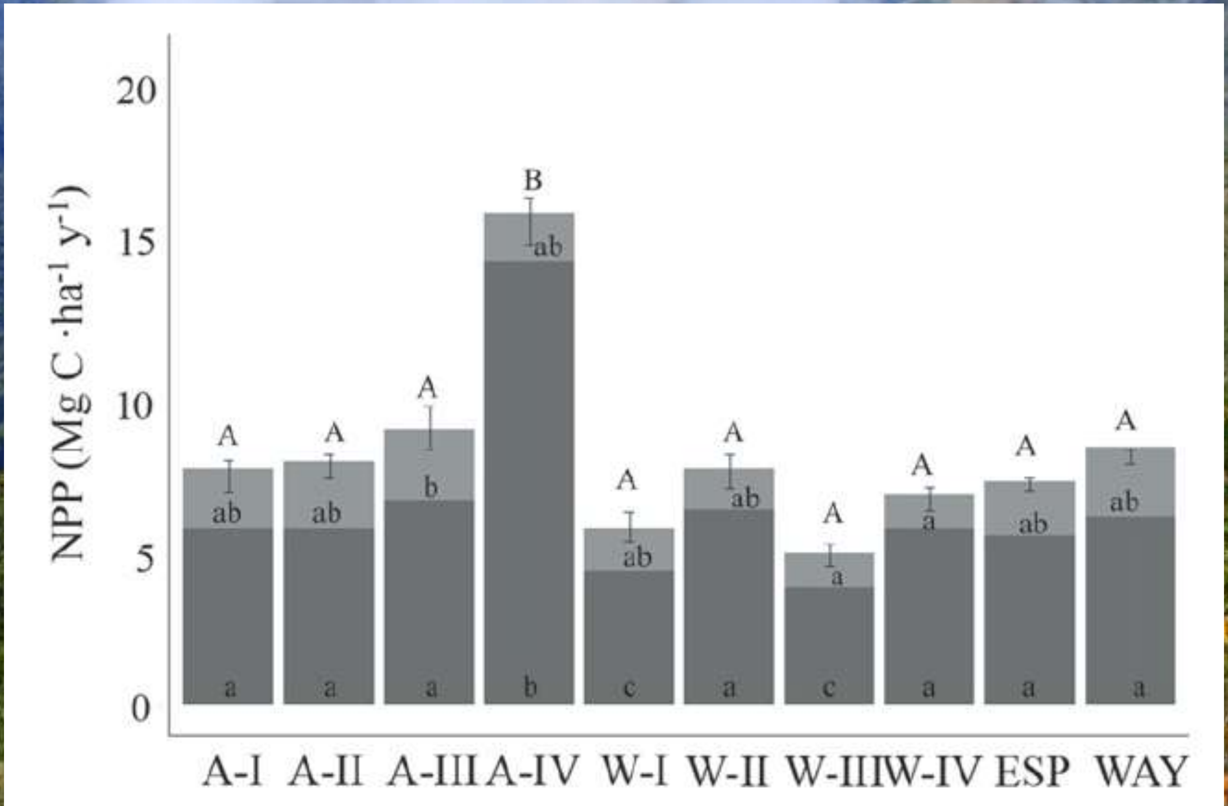
Area	Site	Fire	Grazing
A-I	A	2005	Low
A-II	A	2005	No
A-III	A	No	Low
A-IV	A	No	No
W-I	Way	2003	Moderate
W-II	Way	2003	No
W-III	Way	No	Moderate
W-IV	Way	No	No
WAY	Way 3025 m	No	No
ESP	Esp 2028 m	No	No



Oliveras et al 2014

Fire regimes along the Andean treeline

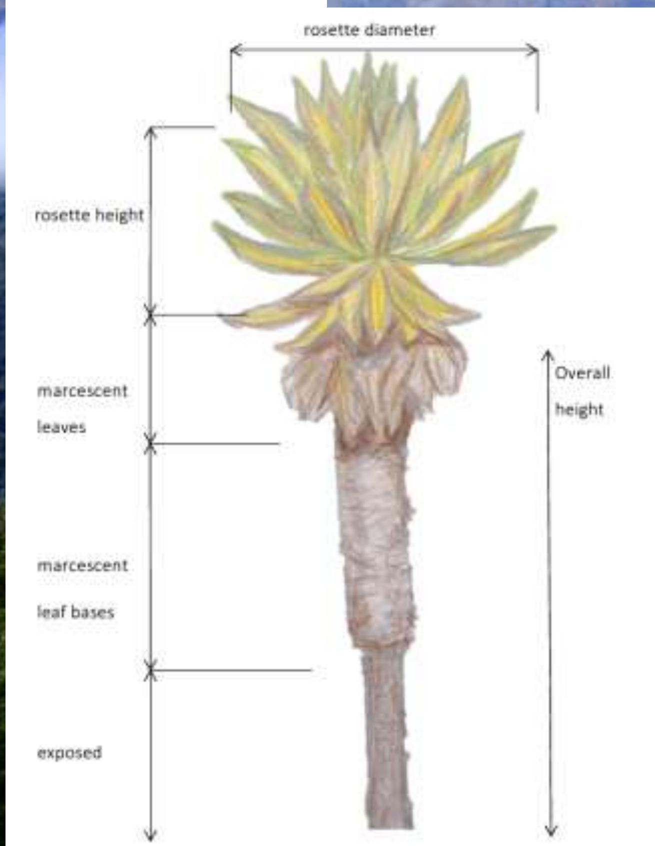
Area	Site	Fire	Grazing
A-I	A	2005	Low
A-II	A	2005	No
A-III	A	No	Low
A-IV	A	No	No
W-I	Way	2003	Moderate
W-II	Way	2003	No
W-III	Way	No	Moderate
W-IV	Way	No	No
WAY	Way 3025 m	No	No
ESP	Esp 2028 m	No	No

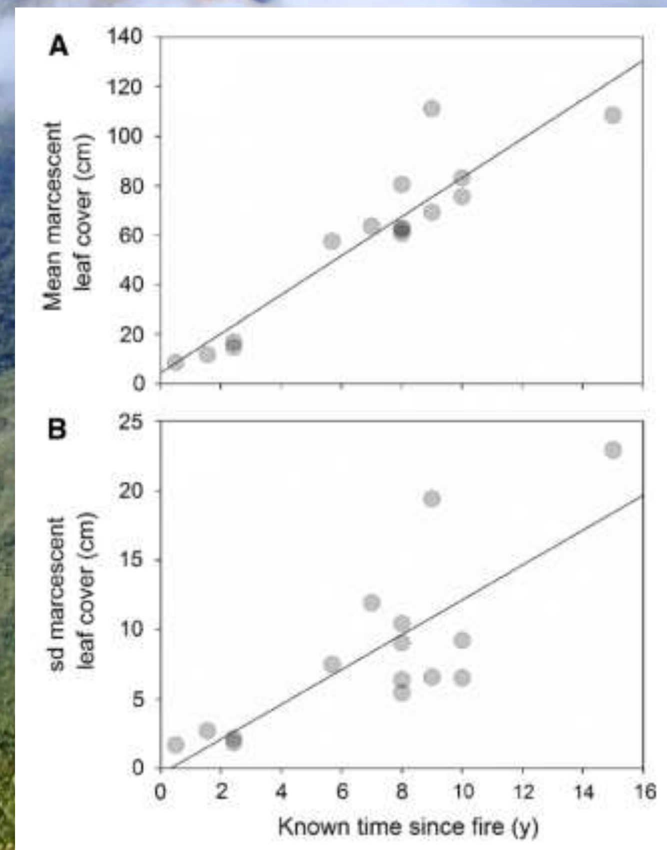


Oliveras et al 2014

Fire regimes along the Andean treeline

Espeletia pycnophylla





Zomer & Ramsay 2016

Effects of fires on the puna soils

The soils in puna are very organic rich, with potential for smouldering, which a flameless combustion in anoxic conditions

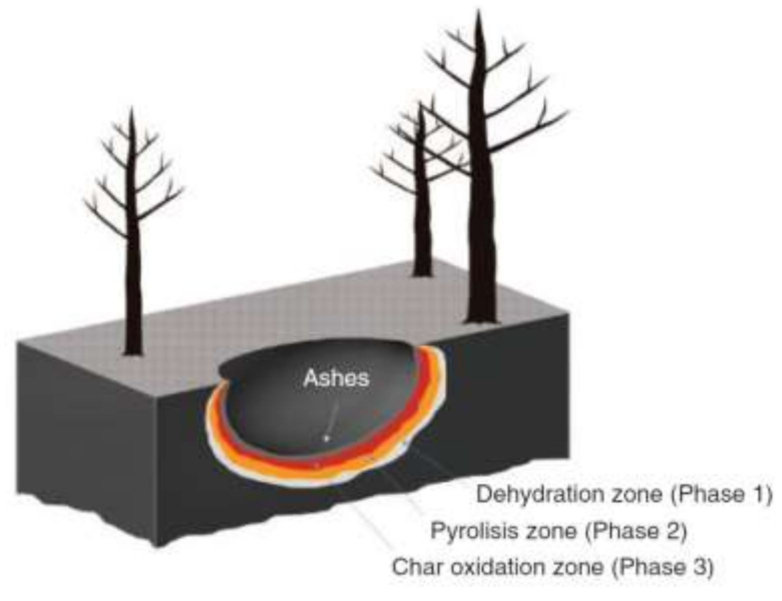
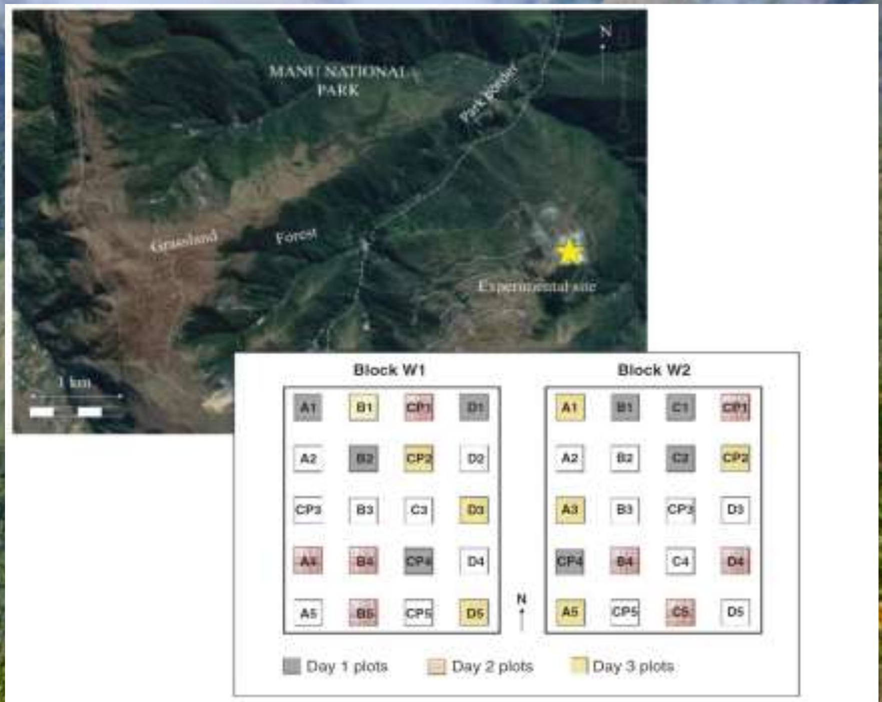
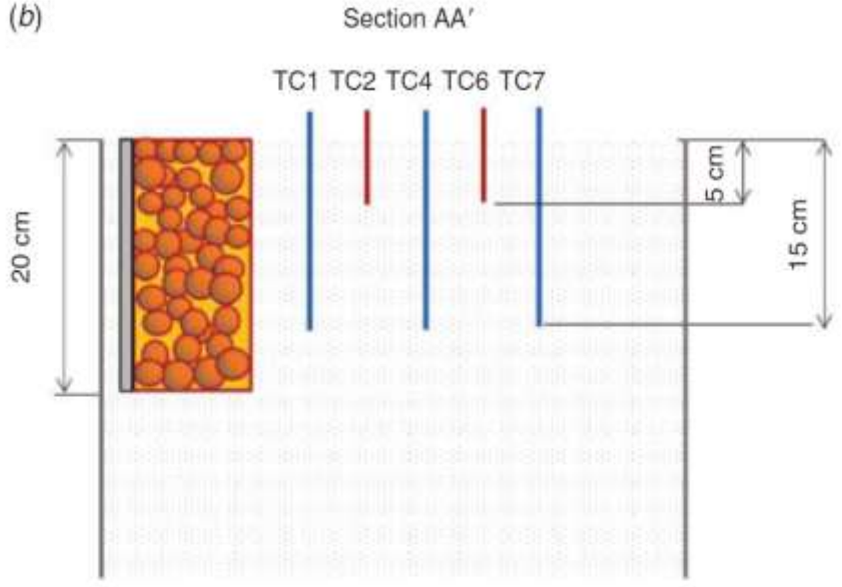


Fig. 1. Smouldering stages.

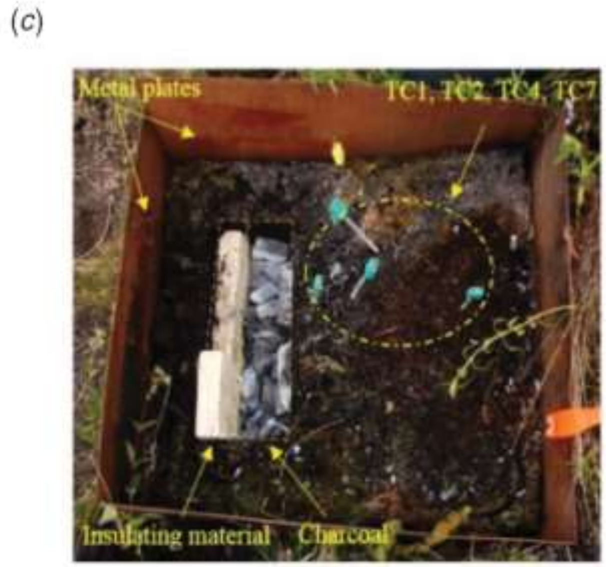


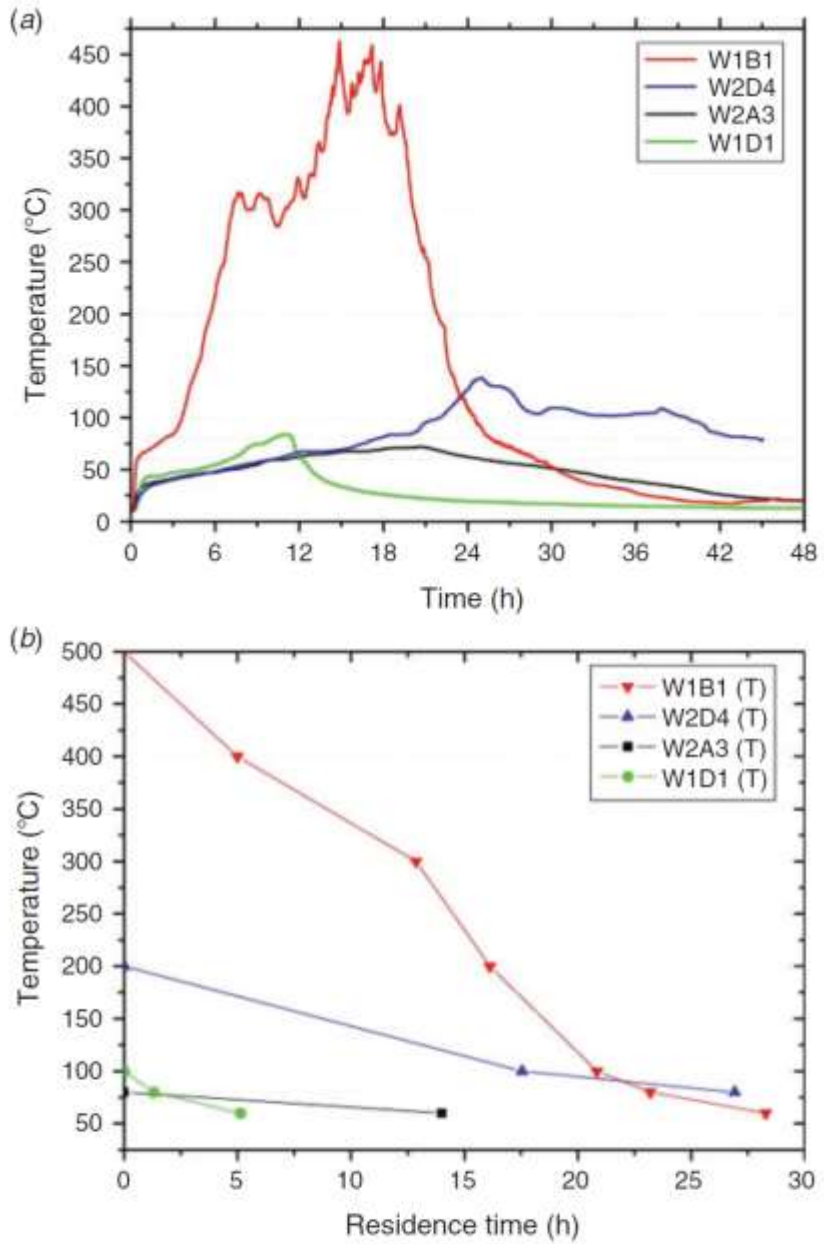
Pastor et al (2017) IJWF

Effects of fires on the puna soils



plates





Effects of fires on the puna soils

However, our results showed no effect of fire 5-7 years after the last fire, nor in the biomass (Oliveras et al 2014) nor soil carbon stocks (Oliver et al 2017)

Site	Land use	Bulk C ($Mg\,C\,ha^{-1}$)				Total C stock ($Mg\,C\,ha^{-1}$)	
		0–5 cm	5–10 cm	10–20 cm	20–30 cm	0–30 cm	0–20 cm
Acjanaco	Grazed–burnt	40.9 ± 6.5^{a}	31.7 ± 4.4^{a}	43.1 ± 13.4^{a}	$57.6 \pm$	136 ± 30^{a}	117 ± 17^{a}
	Not grazed–burnt	53.5 ± 4.5^{a}	40.9 ± 4.7^{a}	76 ± 3.7^{a}	$35.4 \pm$	182 ± 24^{a}	170 ± 12^{a}
	Grazed–not burnt	41.4 ± 3.2^{a}	34.7 ± 6.6^{a}	53.7 ± 16^{a}	$44.2 \pm$	144 ± 16^{a}	130 ± 8^{a}
	Not grazed–not burnt	40.7 ± 8.3^{a}	44.4 ± 5.4^{a}	81.4 ± 24^{a}	71.6 ± 13.4	238 ± 33^{a}	166 ± 22^{a}
	Average					175 ± 17^{a}	146 ± 10^{a}
Wayqecha	Grazed–burnt	40 ± 1.7^{a}	26.6 ± 1.6^{a}	40.8 ± 5^{a}	16 ± 3.2	123 ± 10^{a}	107 ± 8^{a}
	Not grazed–burnt	40.3 ± 3.3^{a}	16 ± 5.7^{a}	63.4 ± 21.1^{a}	44.4 ± 29.5	175 ± 47^{a}	131 ± 18^{a}
	Grazed–not burnt	41.3 ± 11.5^{a}	41.3 ± 9.8^{a}	42 ± 5.1^{a}	$3 \pm$	126 ± 24^{a}	125 ± 25^{a}
	Not grazed–not burnt	38.7 ± 5.3	31 ± 3.6^{a}	55.4 ± 17.3^{a}	14.8 ± 4.4	140 ± 31^{a}	125 ± 26^{a}
	Average					150 ± 15^{a}	122 ± 9^{a}
Acjanaco + Wayqecha	Grazed–burnt	40 ± 3^{a}	30 ± 2^{a}	42 ± 6^{a}	26 ± 11^{a}	130 ± 20^{a}	112 ± 12^{a}
	Not grazed–burnt	47 ± 4^{a}	34 ± 5^{a}	70 ± 10^{a}	42 ± 21^{a}	179 ± 36^{a}	151 ± 15^{a}
	Grazed–not burnt	41 ± 5^{a}	38 ± 5^{a}	48 ± 8^{a}	24 ± 21^{a}	135 ± 20^{a}	127 ± 16^{a}
	Not grazed–not burnt	40 ± 4^{a}	38 ± 4^{a}	68 ± 14^{a}	43 ± 14^{a}	189 ± 32^{a}	146 ± 24^{a}

Oliver et al (2017) Biogeosciences

Thank you!!! Gracias!!! Obrigada!!!

PERGUNTAS ?

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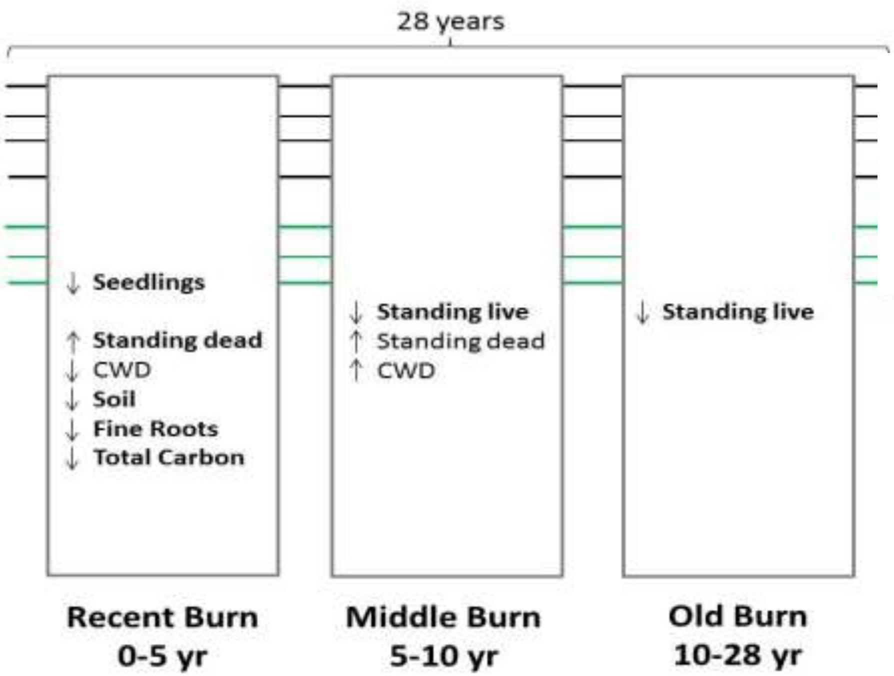
Effects of fires on the Andean cloud forests



Carbon pools Mg.ha^{-1}	RB	MB	OB
Trees < 10 cm – Burned	3.8 (2.2-5.4)	5.8 (3.2-8.4)	3.56 (0.85-6.3)
Trees < 10cm Control	6.9 (3.9-9.9)	6.5 (2.7-10.3)	6 (1.3-10.7)
Trees > 10 cm- Burned	37.3 (15.3-59.3)	37.7 (24.7-50.7)	39.9 (0-91.1)
Trees > 10 cm- Control	63.5 (27.8-99.2)	70.4 (45.7-95.1)	118.1 (34.7-201.5)
Standing dead trees- Burned	15.3 (0-30.6)	13.2 (0.7-25.7)	13 (0-34.1)
Standing dead trees-Control	3.4 (0.7-6)	3.4 (1.5-5.2)	1.9 (0.4-3.4)
CWD-Burned	1.5 (0.13-2.9)	14.5 (0-30.5)	13.9 (0-34.4)
CWD – Control	3.3 (0-7.6)	8.1 (3.5-12.8)	4.8 (0-10.6)
Litter- Burned	6.3(4.6-8.0)	7.4(4.3-10.6)	5.0(4.7-5.2)
Litter- Control	8.2(4.1-12.3)	7.3(4.3-10.1)	10.4(0-40)
Soil – Burned	52.6 (21.9-83.2)	60.5 (36.7-84.4)	95.1 (49.1-141.1)
Soil- Control	104.8 (70.6-138.9)	72.4 (49.1-95.6)	124.4 (25.6-223.2)
Fine roots Burned	2.2 (0.4-4)	8.5 (2-15)	5.2 (1.1-9.2)
Fine Roots Control	6.1 (1.3-10.9)	3.7 (1.6-5.7)	9.7 (2.2-17.2)
Total C Burned	127.0 (76.6-177.4)	160.6 (120.6-200.5)	327.4 (271.8-382.9)
Total C Control	200.7 (142.9-258.4)	161.7 (116.9-206.4)	314.7 (214.9-321.9)

Oliveras et al (2014) PED

Oliveras et al 2018 GCB

Effects of fires on the Andean cloud forest

Fire increases alpha and beta diversity