INTECOL2022
Geneva, August 28 - September 2

Setting Restoration Priorities for Burned *Nothofagus* Forests in Tierra del Fuego, Argentina
Impact of Fire Severity on Soil Properties and Seedling Growth and Survival

MJ Ruggirello[a]*, RM Soler[a], P Rodriguez[a], GN Bustamante[a], MV Lencinas[a]

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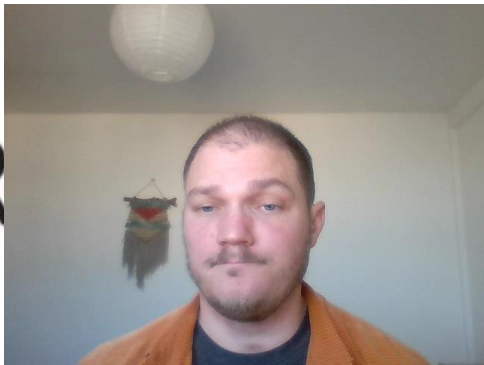
International Association of Wildland Fire

CONICET

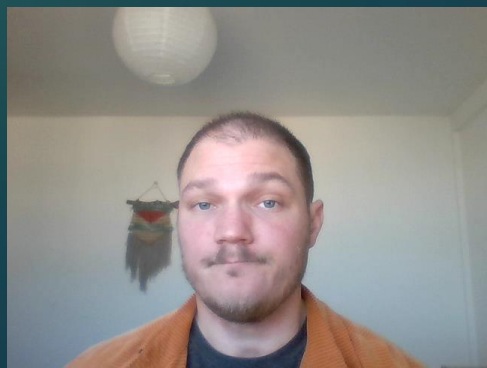
CADIC



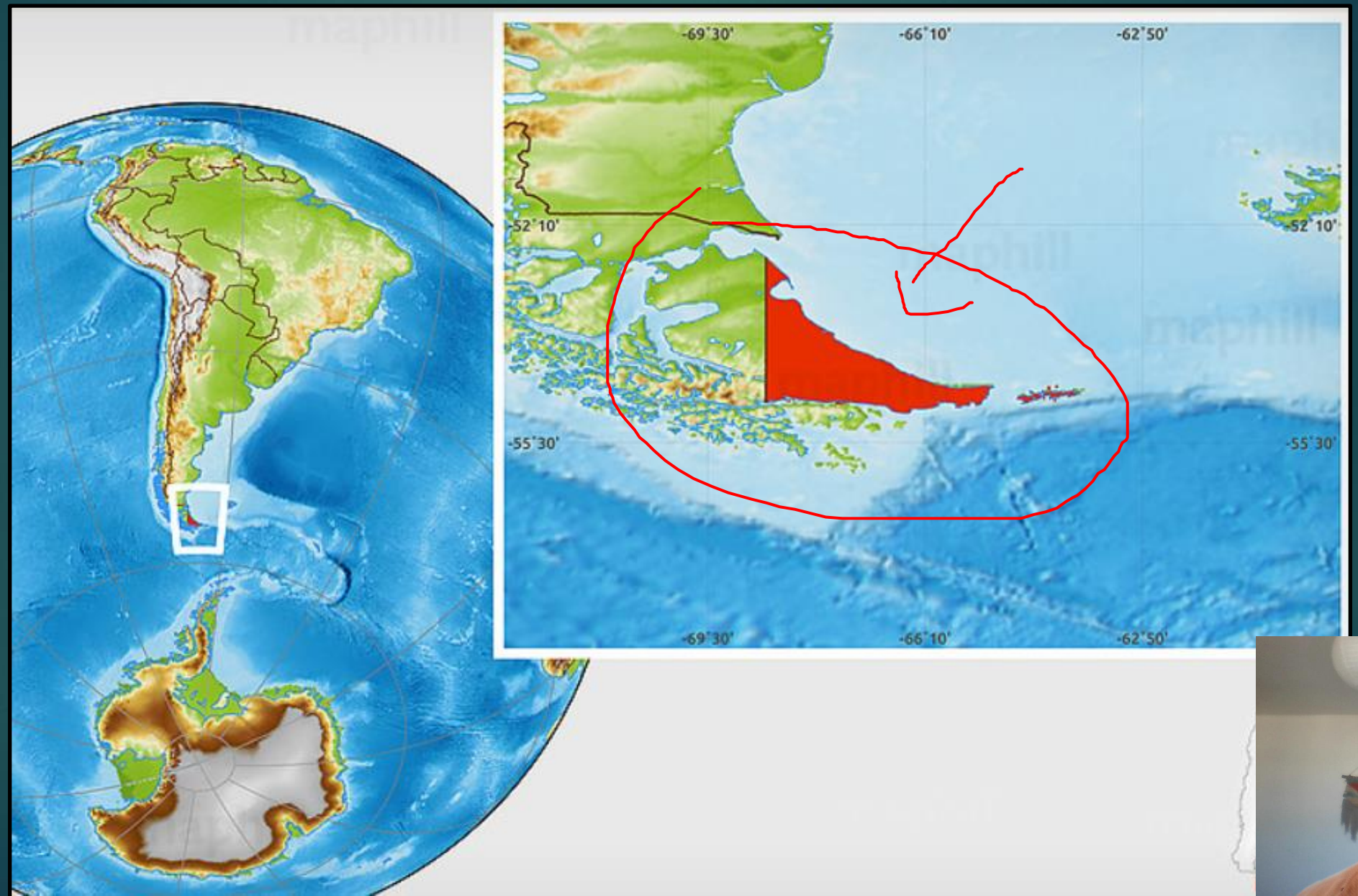
Fire in Southern Patagonia

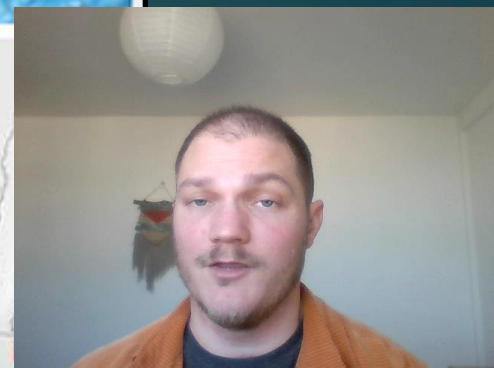
- In Tierra del Fuego, all fires are human-caused

- Wildfires appear to be severe and tree regeneration is often scarce post-fire



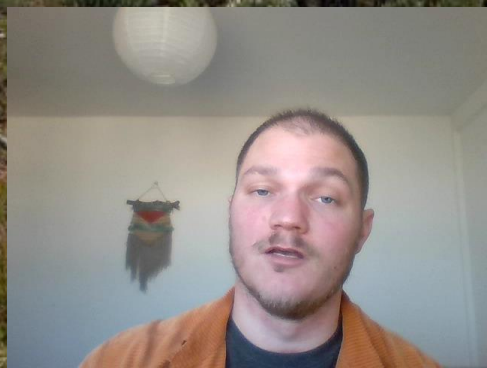
Study Location: Southern Tip of South America



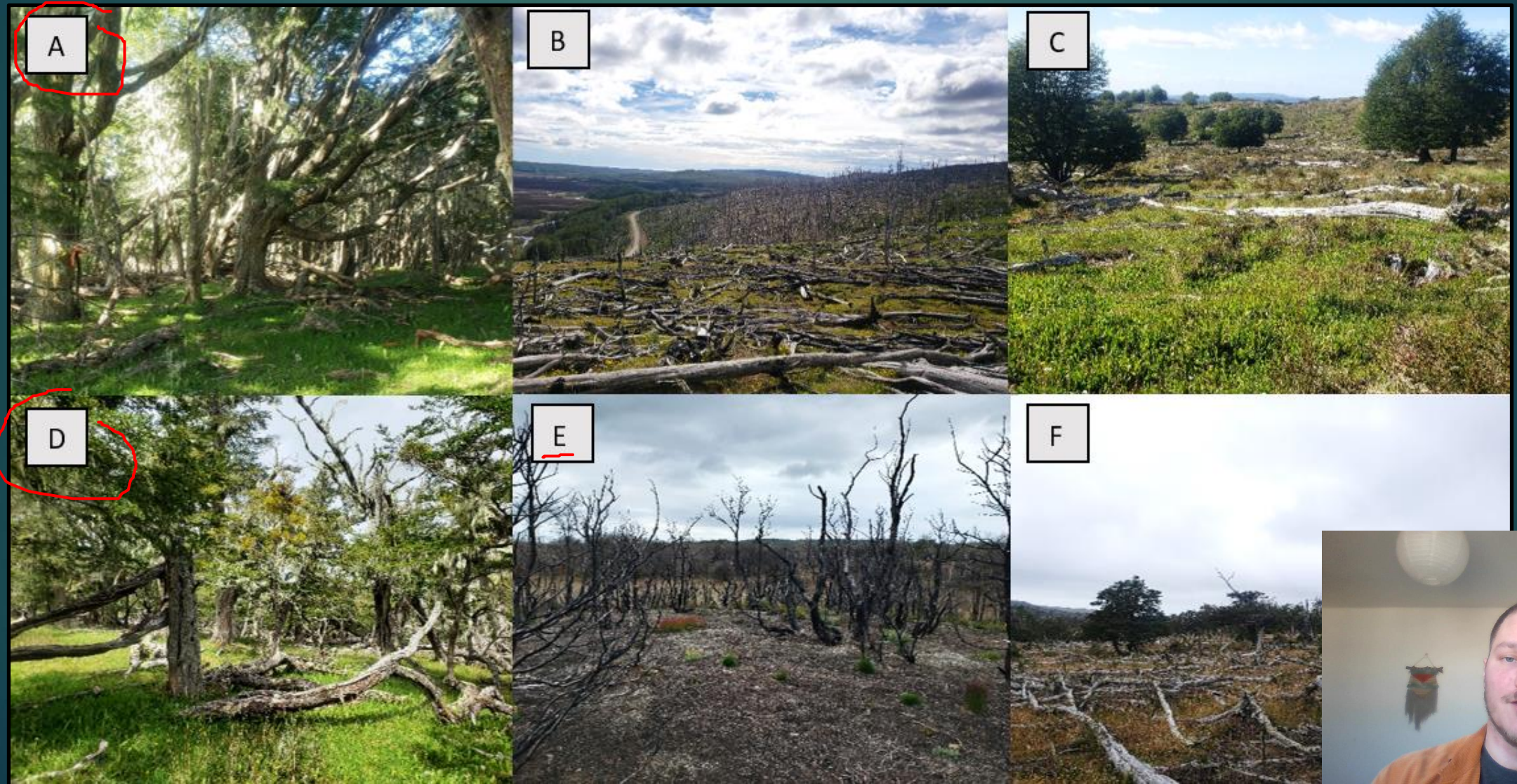


Objective

Determine the impact of fire severity on soil properties and seedling growth and survival in *Nothofagus pumilio* and *N. antarctica* forests



Soil Collection: Unburned, Recent (2019), and Old (1940s) Fires

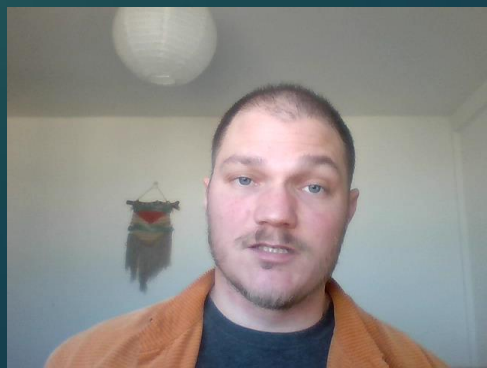


Soil collection

- Recent fire: from unburned, low-severity, and high-severity burn patches
- Old fire: from unburned and burned patches

Seedling Transplantation

- 200 seedlings of each species were transplanted and placed in different soil “treatments”



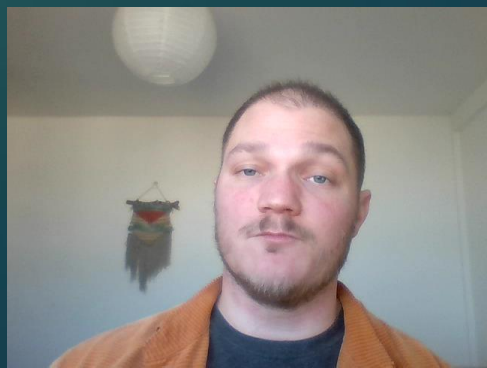
Experimental Design

Old Fire (1940s)

N. pumilio	*N. antarctica*
N = 20	N = 20
N = 20	N = 20

Unburned

Burned



Experimental Design

Old Fire (1940s)

N. pumilio

N = 20

N = 20

N. antarctica

N = 20

N = 20

Recent Fire (2019)

N. pumilio

N = 20

N = 20

N = 20

N. antarctica

N = 20

N = 20

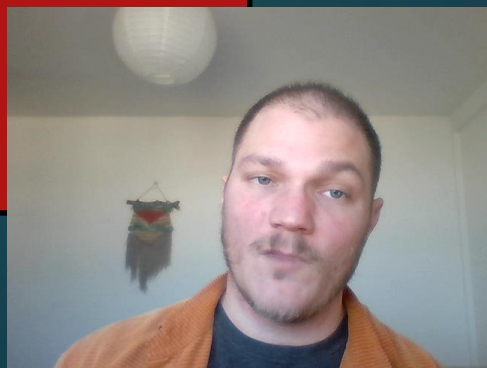
Unburned

Burned

Unburned

Low severity

High severity

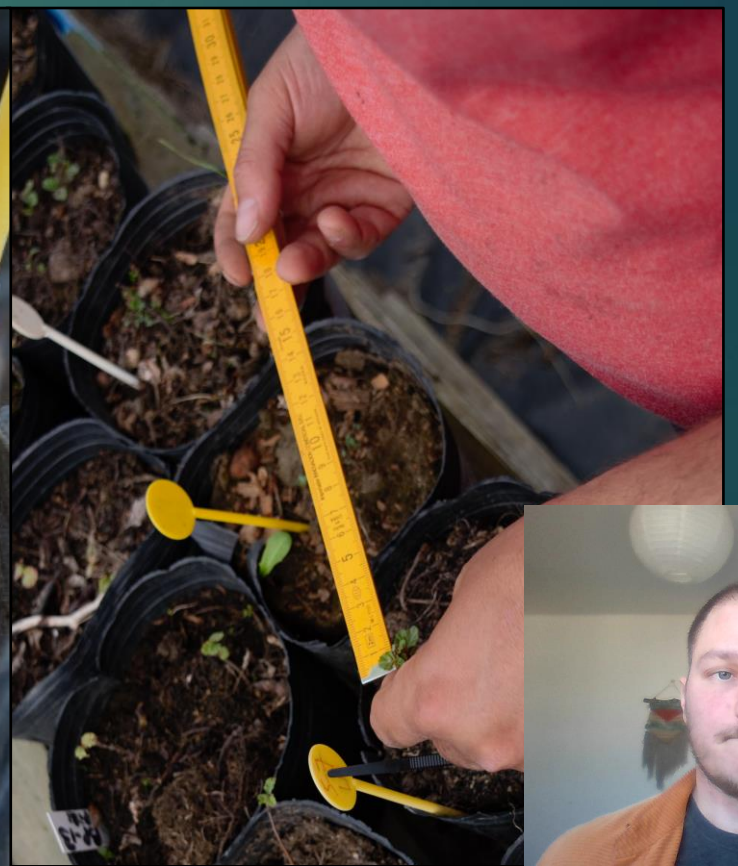


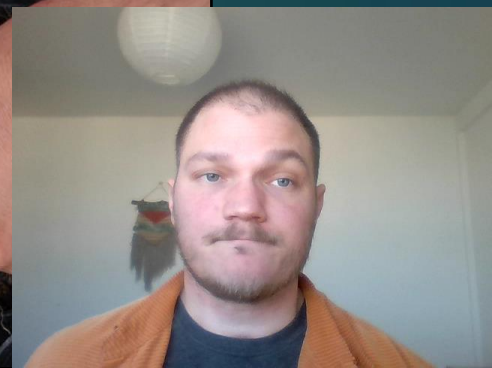
Seedling Location #1: Shade Tunnel

Seedling Location #2: Experimental Garden

Initial Measurements

- October 2021 and April 2022
- Survival and seedling length
- Diameter at root collar, leaf area, and number of branches

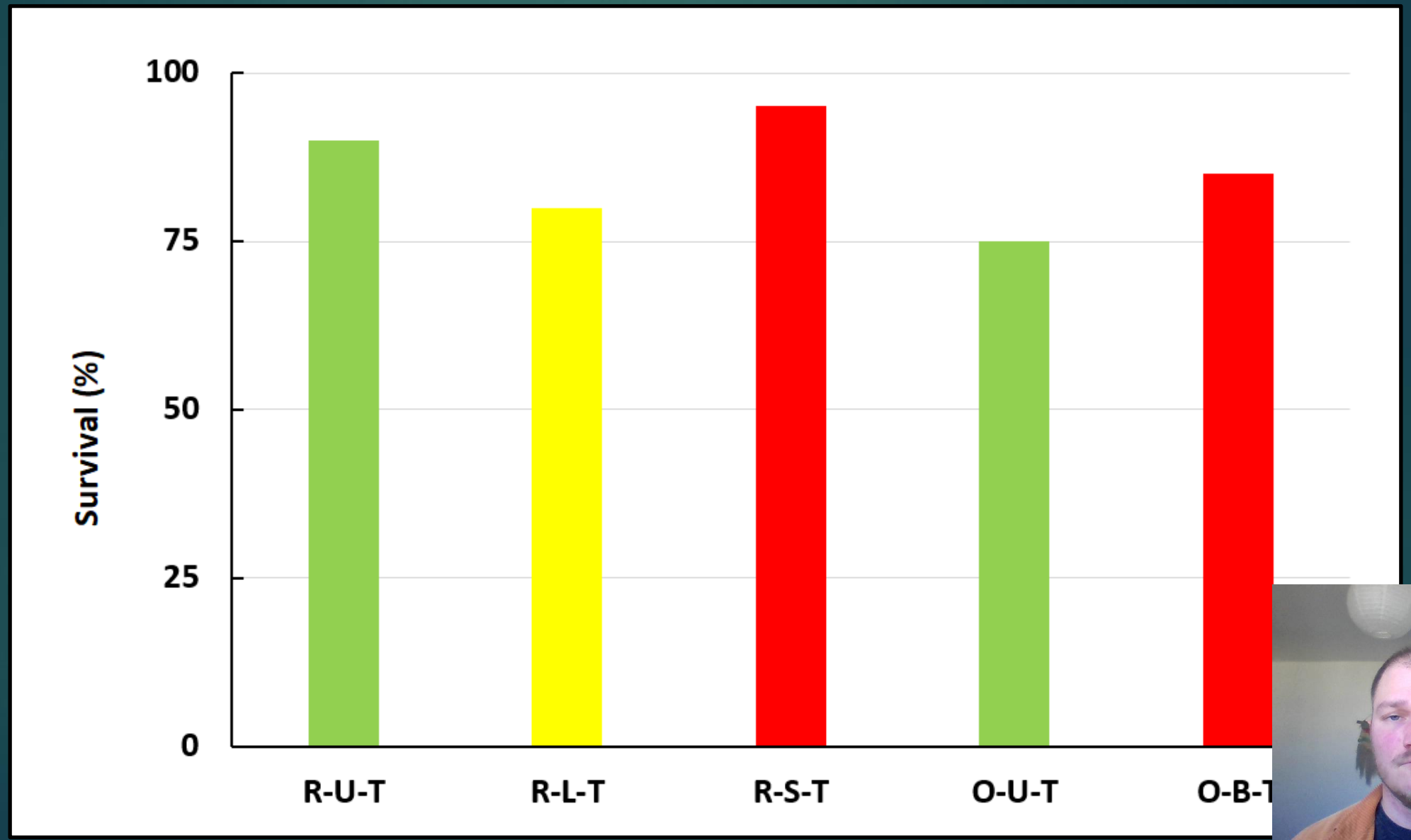




Initial Measurements

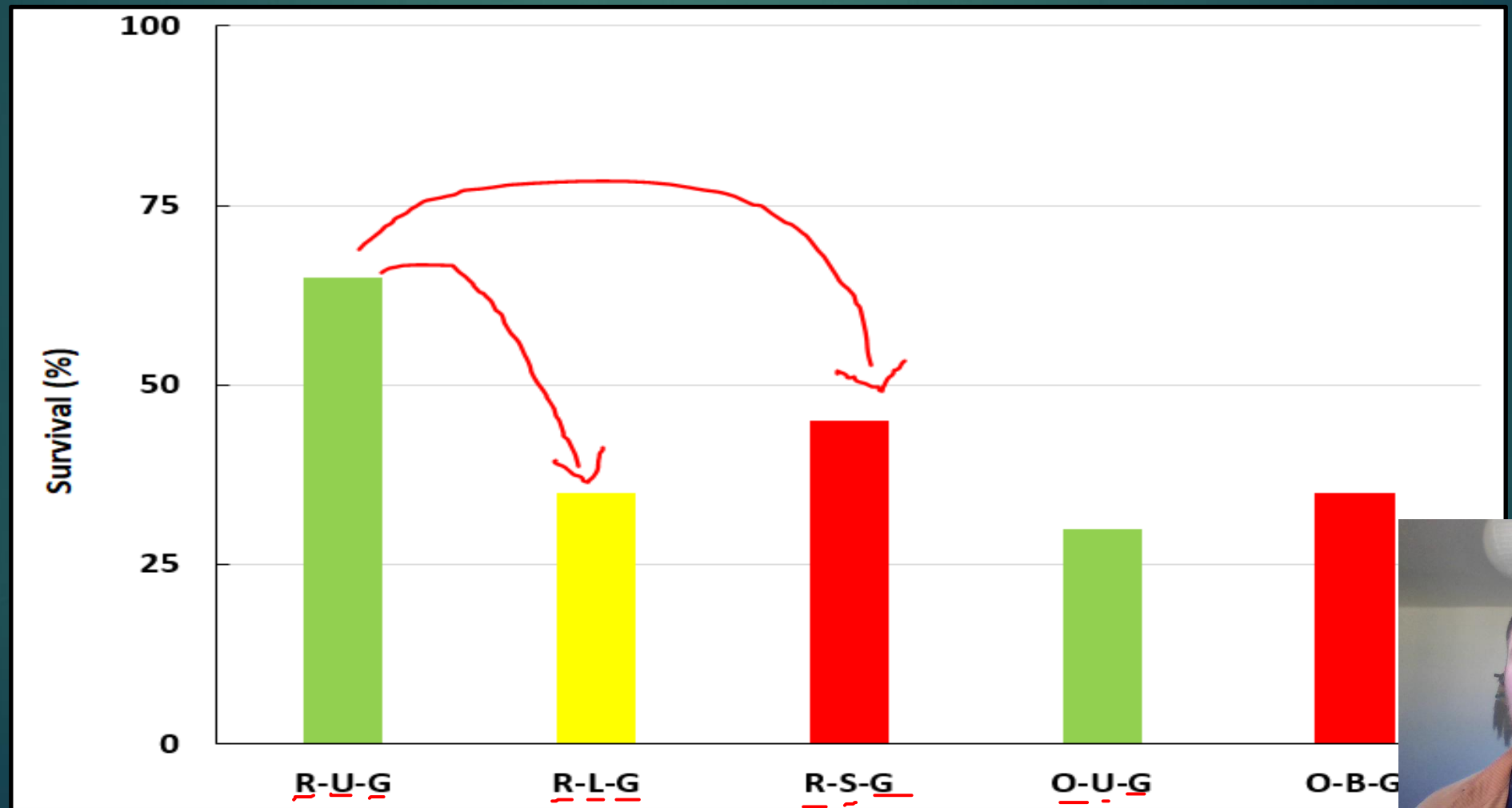
- Soil pH, organic material, and moisture content (awaiting results for N and P)

Results: *N. pumilio* Survival – Shade Tunnel



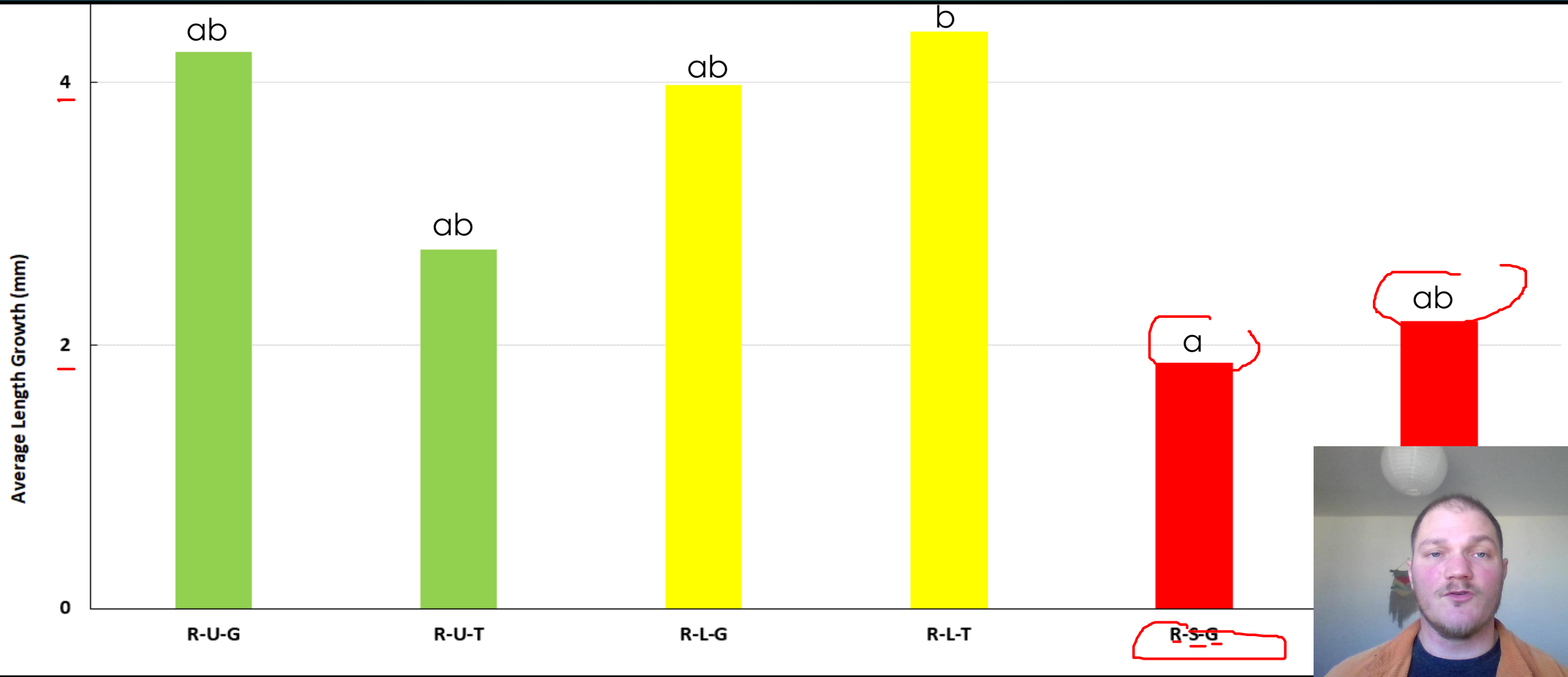
Results: *N. pumilio* Survival – Exp. Garden

- Outdoor survival in recently burned soils was lowest for lightly (35%) and severely (45%) burned versus unburned treatments (p > 0.05)



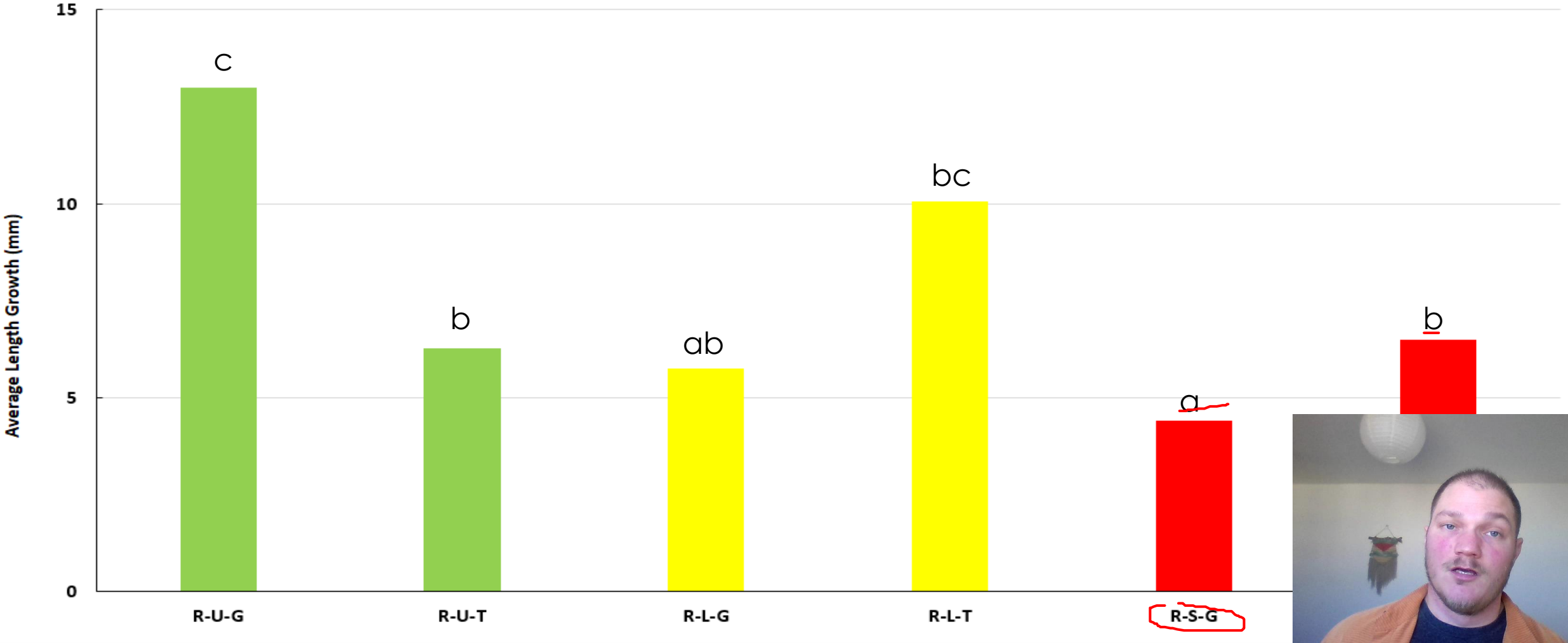
Results: *N. pumilio* Length

- Mean length growth was lowest in severely burned soils from the 2019 wildfire ($F = 5.31$; $p = 0.0003$)



Results: *N. antarctica* Length

- Mean length growth was lowest in severely-burned soils located from the 2019 wildfire located in the experimental garden (F=13.81; p<0.0001)



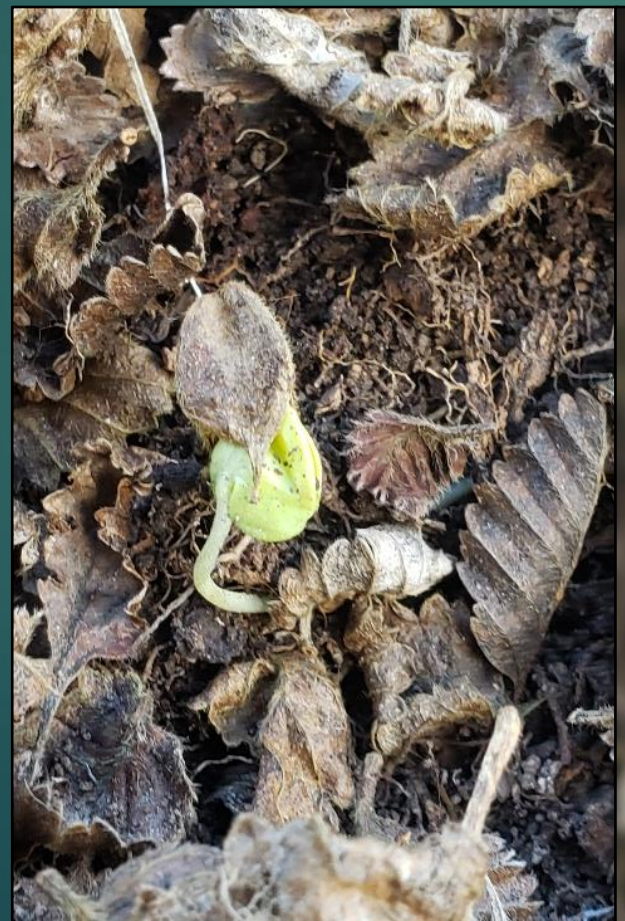
Results: Soil pH

- Acidity ($F=15.38$; $p<0.0001$) was also highest in recently, severely-burned soils.

Treatment	Soil Ph
R-U	4.5
R-L	4.6
R-S*	**4.0***
O-U	4.7
O-B	4.6

Early Conclusions: High-severity Fire Produces Short-term Soil Changes

- Chemical and physical changes to severely-burned soils likely negatively impact seedling growth and may increase mortality, particularly for *N. pumilio*



Implications for Restoration

- Develop a clear field guide for classifying fire severity
- Reduce stress on seedlings planted in recently, severely-burned soils

Thank You

INCENDIOS FORESTALES: UN RESUMEN EN TIERRA DEL FUEGO

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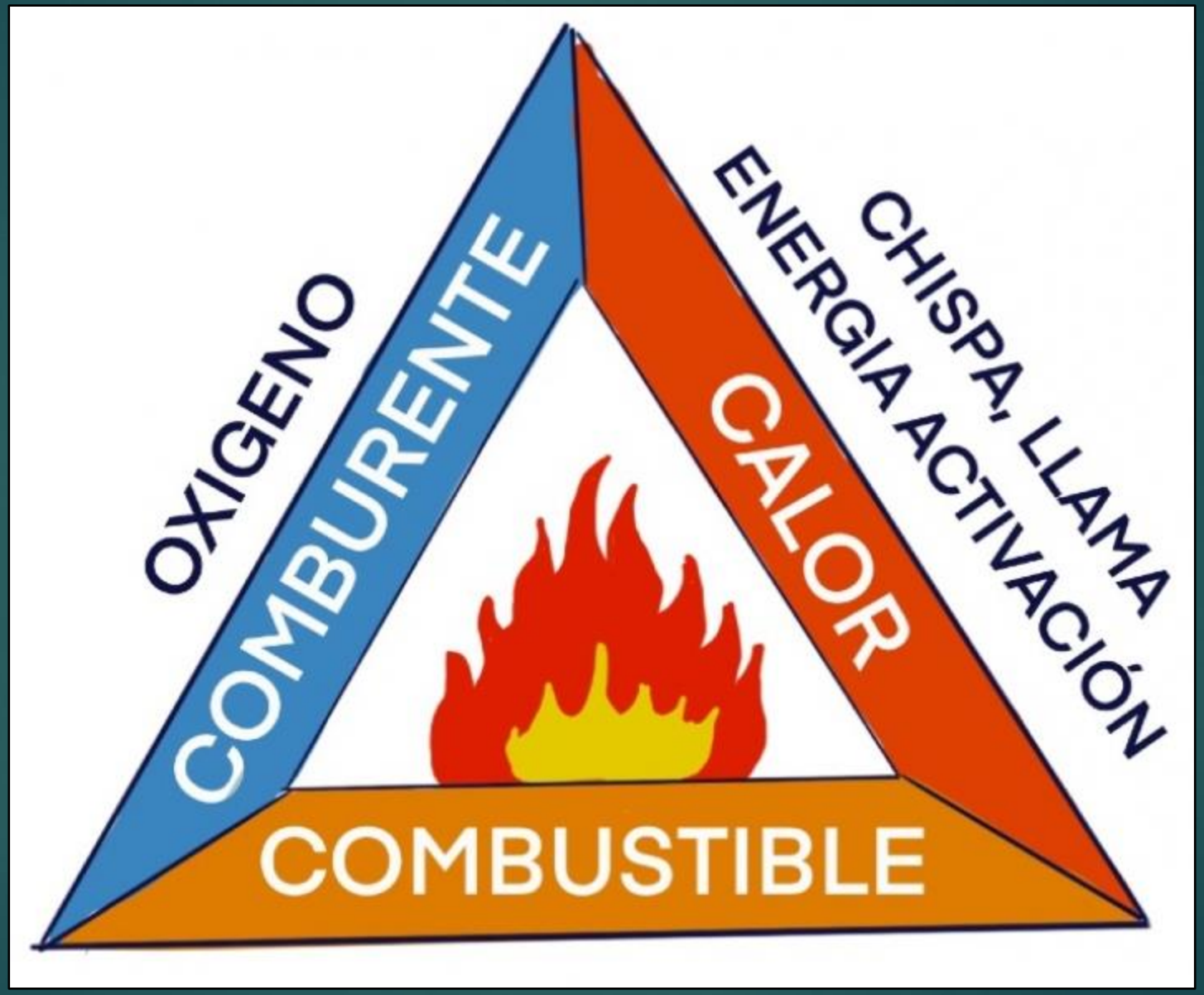
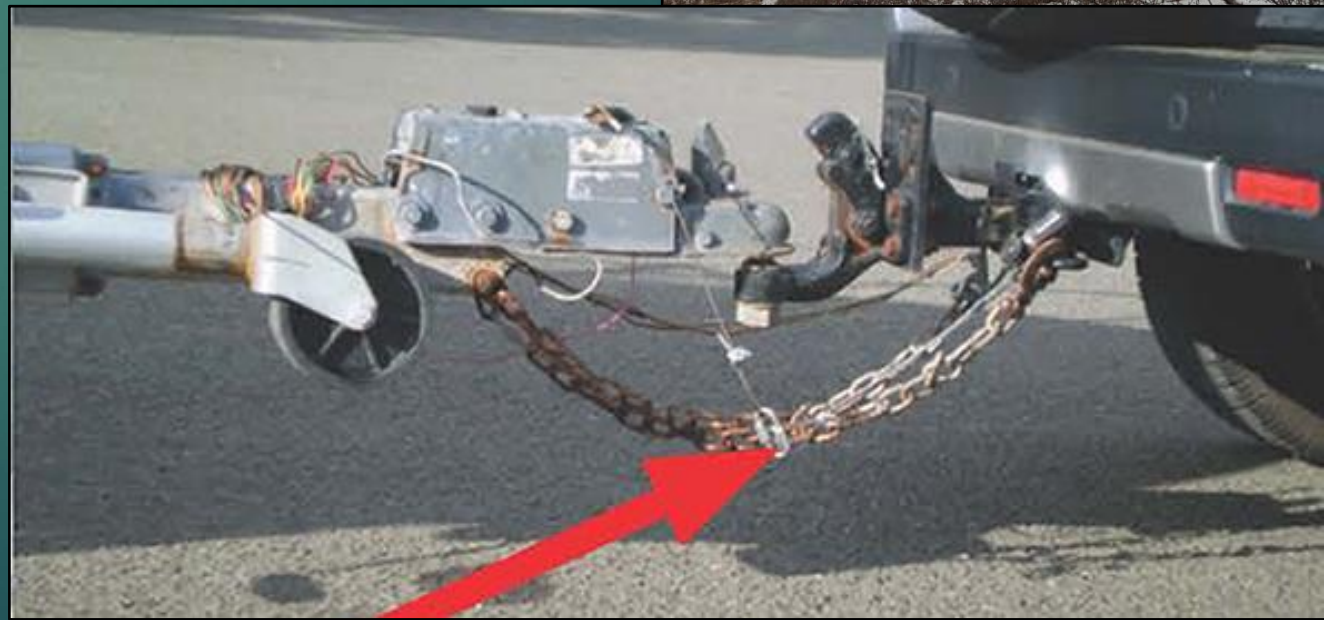
Matt Ruggirello (MF) mag. ingeniería forestal


OXIGENO
COMBURENTE
CHISPA, LLAMA
ENERGIA ACTIVACIÓN
CALOR
COMBUSTIBLE

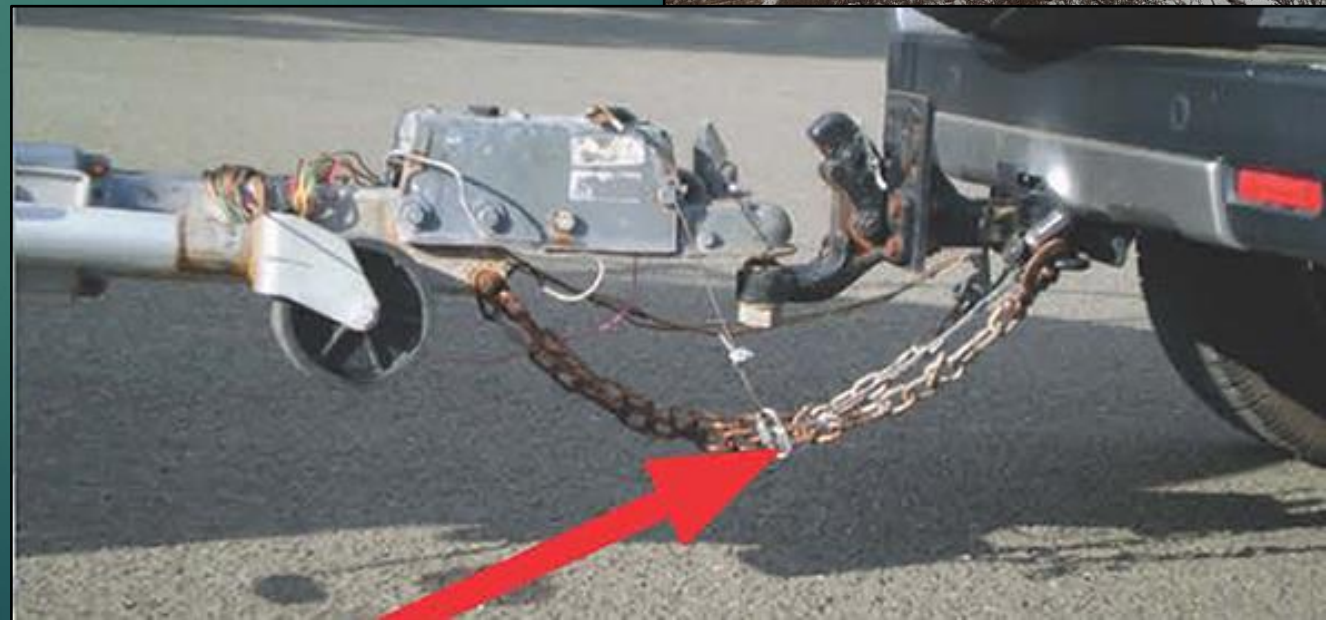
Fuentes de ignición

Fuentes de ignición

Fuentes de ignición



Fuentes de ignición



Fuentes de ignición

Reducción de combustible: la línea de cortafuegos hecha por una maquina

Reducción de combustible: la línea de cortafuegos hecha a mano

Tenemos una historia de incendios en T.D.F.

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Tenemos una historia de incendios en T.D.F.

"Incendios de bosques hubo muchísimos, a veces dejaban algún fueguito y se quemaba todo, pero mas bien eran los pastos, siempre se alcazaba a llegar. En una ocasión, yo tenía 6 o 7 años, vi fuego y pensé si no se quemaría la ciudad entera; tenía miedo. Una vez se prendió fuego donde hacían los rajones. Fue impresionante..." rememora Victoria Padín.

El combate de un incendio: apagar vs. contener

El combate de un incendio: las técnicas para contenerlo (ya vimos la dos más comunes)

El combate de un incendio: el mito del hidroavión

El combate de un incendio: el mito del hidroavión

El combate de un incendio: la “limpieza”

Post-fuego: la regeneración de arboles

Post-fuego: el ñire

Nothofagus antarctica rebrotando post-incendio

Post-fuego: la lenga

Nothofagus pumilio
germinando de semilla

Conclusiones: es necesario restaurar el bosque post-fuego

Conclusiones: en comunidades de interfase siempre hay riesgo de incendios

Una revisión de la recuperación forestal post-incendio en sitios de altas latitudes

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[2]FACULTAD DE CIENCIAS BIOLÓGICAS, UNIVERSIDAD COMPLUTENSE DE MADRID, MADRID, SPAIN

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Introducción: Latitudes Altas

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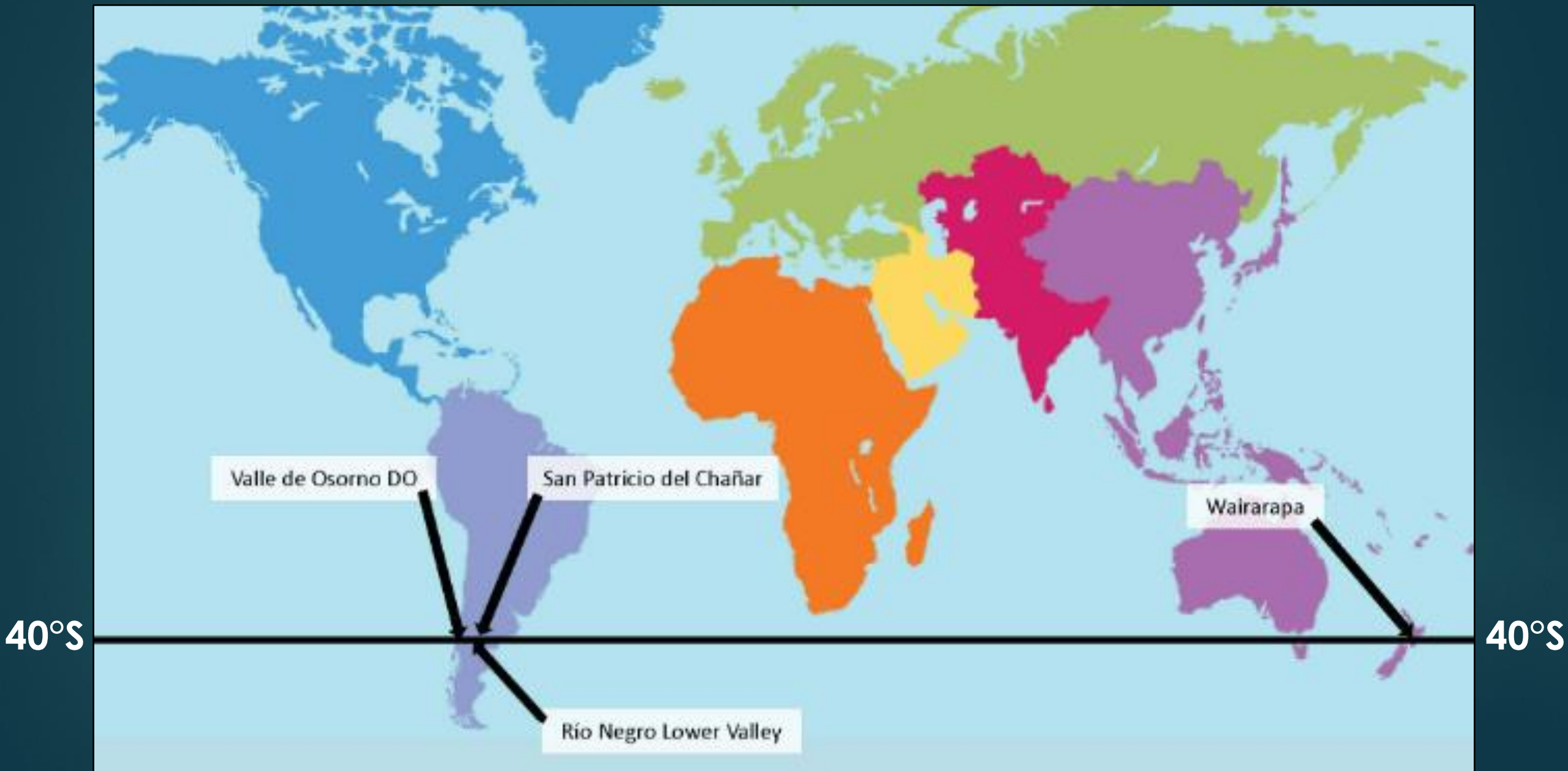
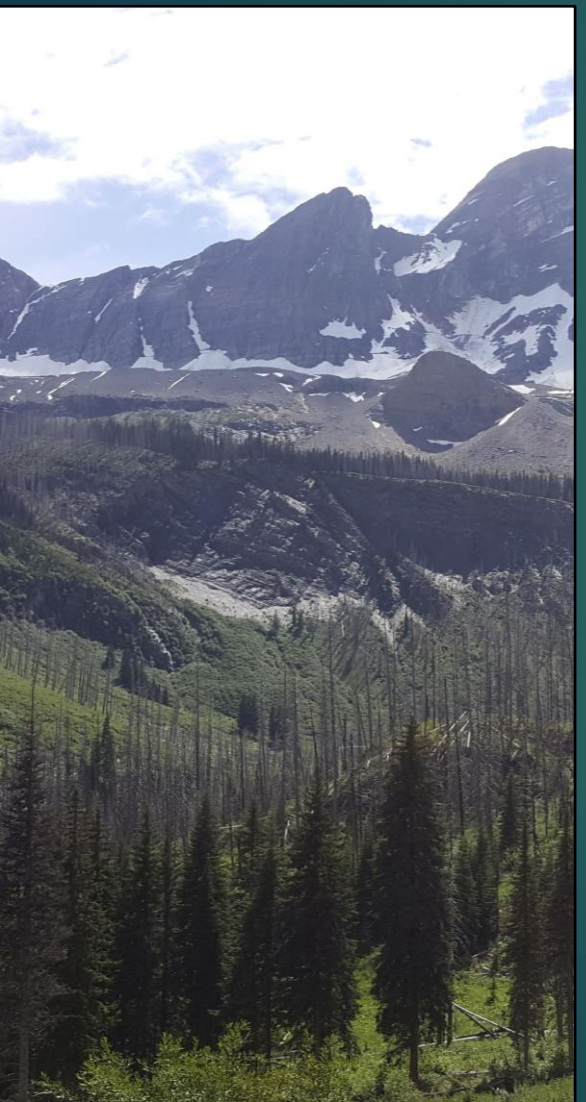


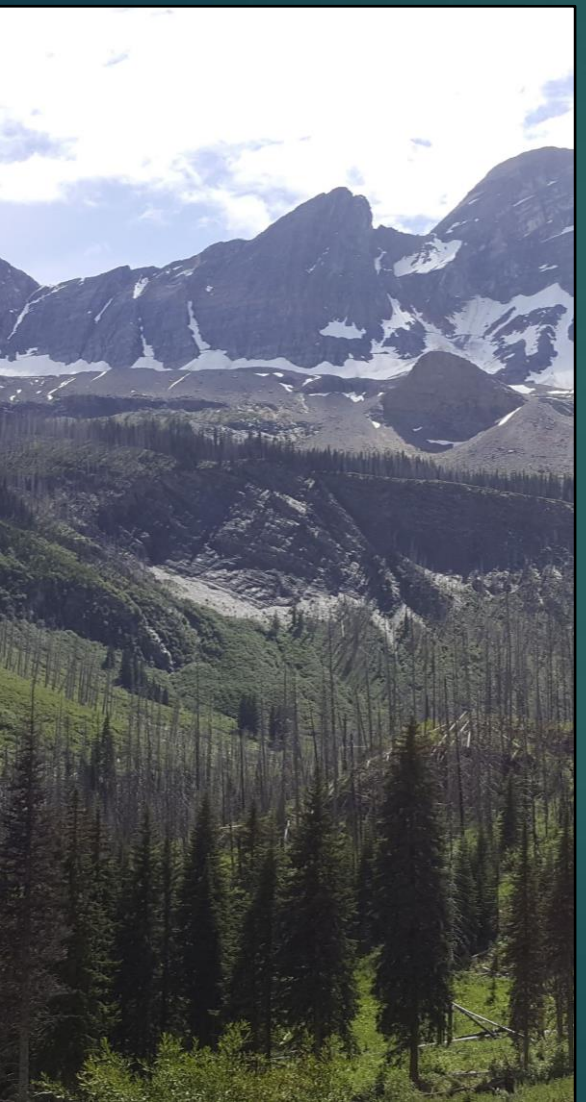
Biomas (Olsen et al. 2001)

Coníferas



Biomas (Olsen et al. 2001)

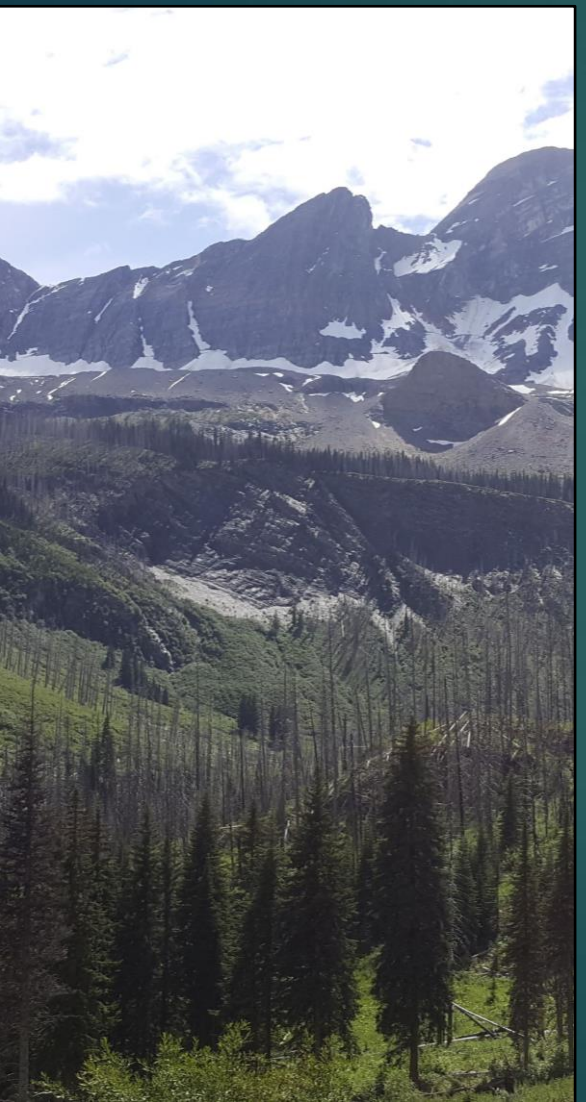
Coníferas



Caducifolio

Biomas (Olsen et al. 2001)

Coníferas



Caducifolio

Mixto

Metodología: Búsqueda y selección de artículos

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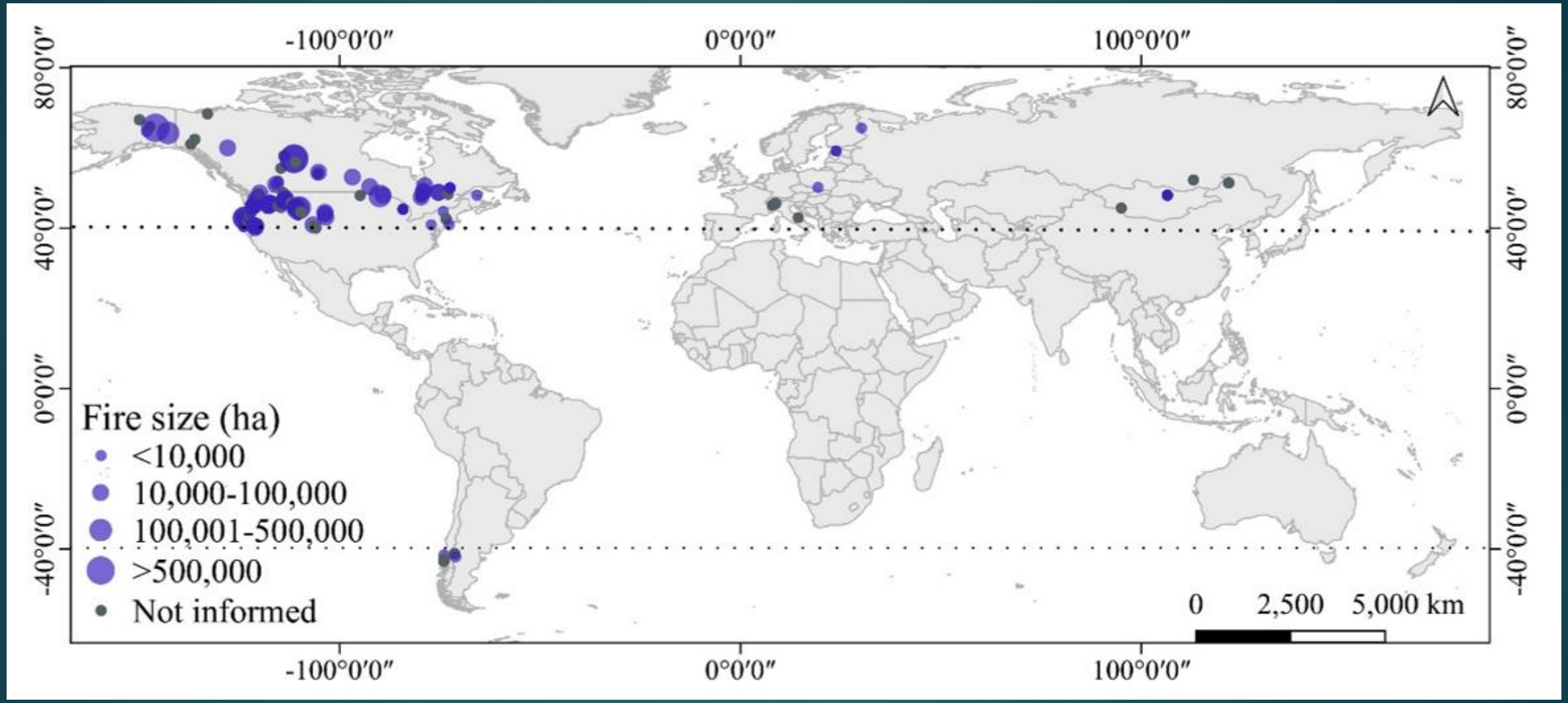
Elimination criteria	**Nº eliminated articles**
Fauna	508
Below 30	398
Generally irrelevant	256
Prescribed/intentional fire	251
Historical	244
Modelling/simulation	222
Soils	214
No fire	194
Non-forest/non-trees	186
Hydrology	171
Wrong variables	132
Carbon	122
Social	115
Remote sensing/no direct measurements	108

Metodología: Eliminación de artículos y extracción de datos

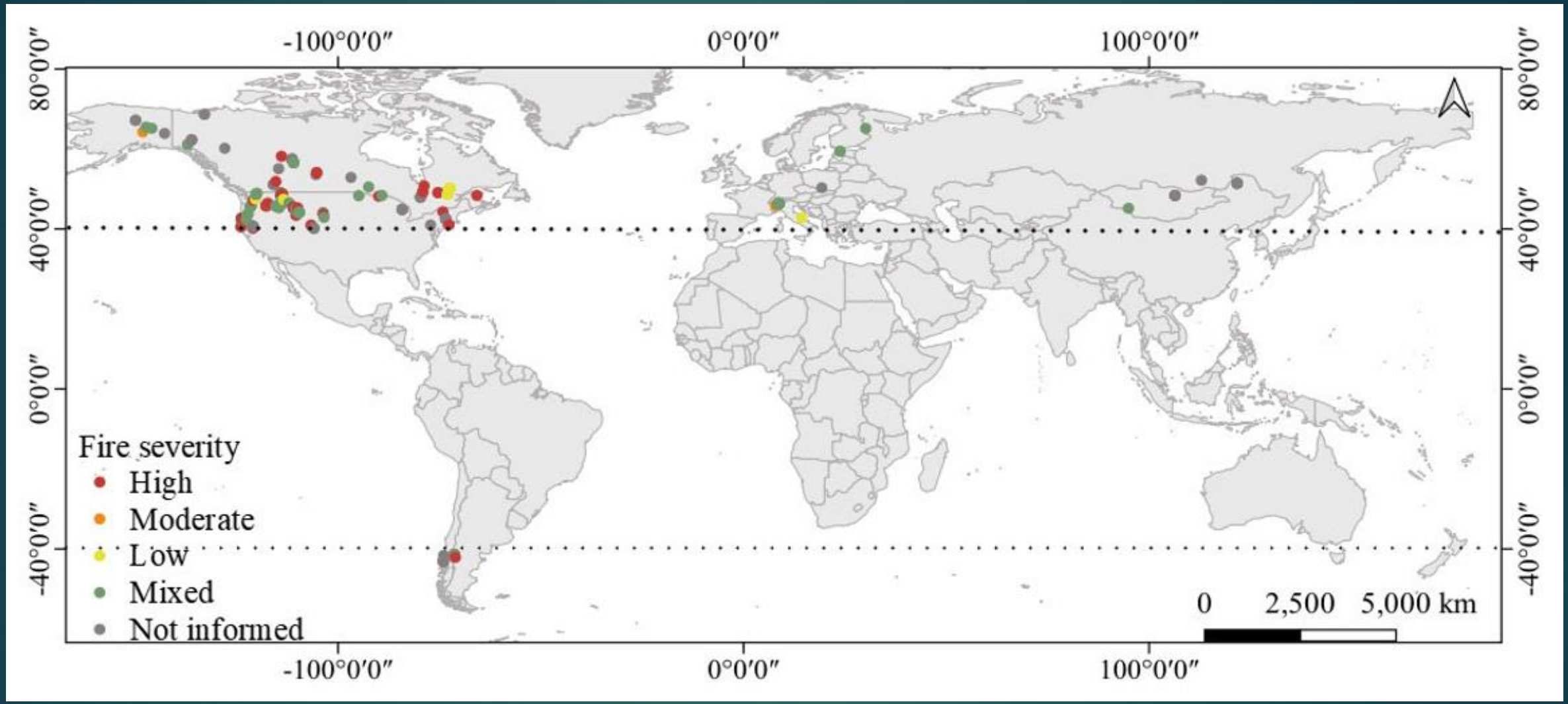
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Case	DOI	Article numb	Authors	Title	Pub. year	Journal	Asigned to	Study area	Country	Long	Lat	Altitude	Biome	Forest stage	Year of fire	Size of Fire	Time betwee	Intensity	Sev
2	Tsuga heterophylla,	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
3	All species, short-int	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young	2018	6000	2	not informed	hig
4	All species, long-int	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	mature	2017	7000	2	not informed	hig
5	Abies lasiocarpa	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
6	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
7	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
8	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
9	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
10	Abies lasiocarpa	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
11	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
12	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
13	Abies lasiocarpa	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
14	Pinus contorta	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
15	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
16	Pinus contorta	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
17	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
18	Pinus contorta	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
19	Abies lasiocarpa	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
20	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
21	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
22	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
23	Pinus contorta	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
24	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
25	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
26	Larix occidentalis	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
27	Pinus contorta	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
28	Pseudotsuga menzie	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
29	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
30	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
31	Abies lasiocarpa	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig
32	Picea engelmannii	10.1016/j.for	2	Hoecker, T.J.,	A short-inter	2022	Forest Ecolog	Matt	Northern US	USA	-113.91	48.60	1,325.00	temperate co	young and m	2017, 2018		2	not informed	hig

WorkingDB | FiresDB | Plot data | CompositionDB | CompSummary | CompRegressions | CompGLMM | RegenDB | RegenSummary

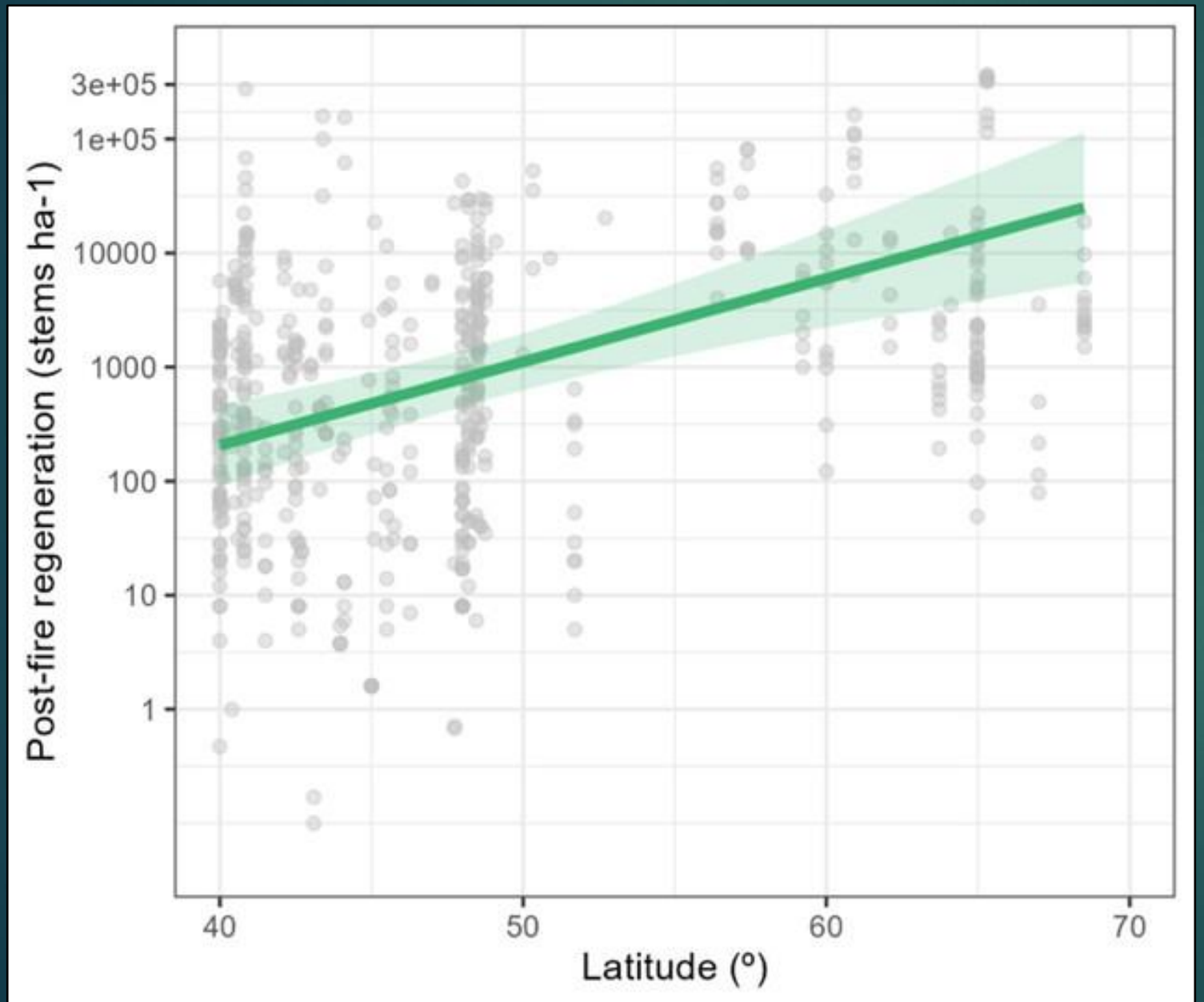
Resultados


-100°0′0″
0°0′0″
100°0′0″
80°0′0″
40°0′0″
0°0′0″
-40°0′0″
Fire size (ha)
<10,000
10,000-100,000
100,001-500,000
>500,000
Not informed
0
2,500
5,000 km

Resultados


-100°0′0″
0°0′0″
100°0′0″
80°0′0″
40°0′0″
0°0′0″
-40°0′0″
Fire severity
High
Moderate
Low
Mixed
Not informed
0
2,500
5,000 km

Resultados



La regeneración aumenta con la latitud

Resultados

Variabilidad de la densidad de regeneración post-fuego por bioma

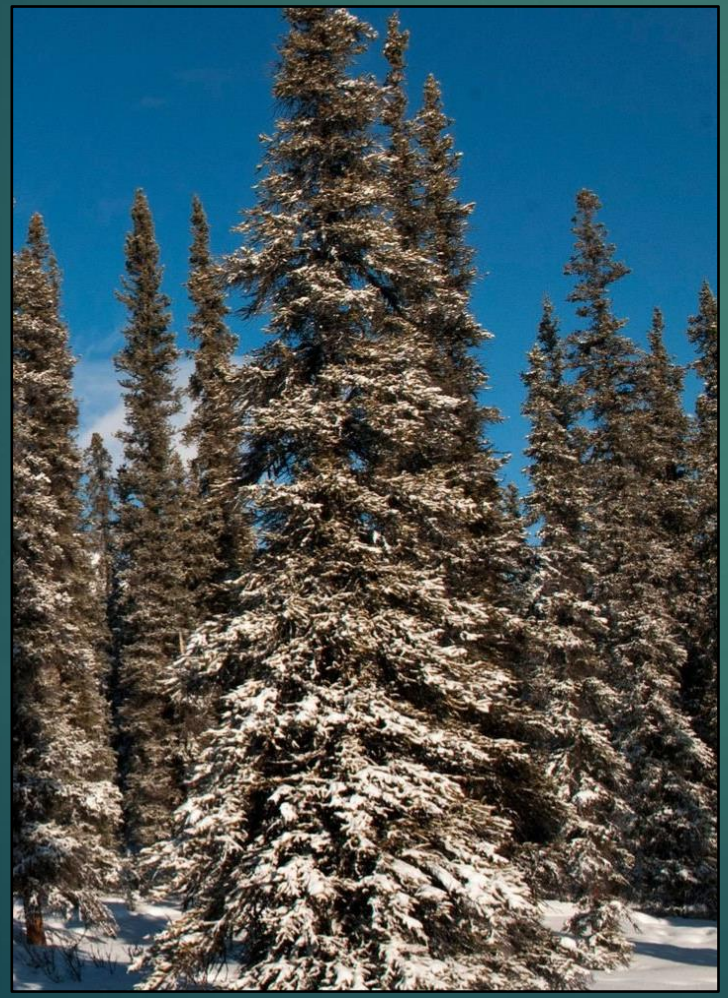
	Sin fuego (tallos ha^{-1})	Con fuego (tallos ha^{-1})	Diferencia
Coníferas	1,488 ± 285	1,994 ± 290	+506
Caducifolio	5,028 ± 1,478	9,291 ± 2,838	+4,263
Boreal	6,634 ± 1,671	21,124 ± 4,028	+14,490

Conclusiones

- Latitudes cercanas a los 40° muestran menos recuperación forestal (ej., en ecotonos y hábitats marginales).

Conclusiones

- Los bosques boreales demuestran mejor recuperación, pero con cambios en su composición forestal.



Conclusiones

- **A pesar de nuestras búsqueda bibliográfica a nivel mundial, el estudio principalmente informa sobre patrones en Norteamérica.**

Conclusiones

- Los patrones de recuperación podrían ser muy distintos en otras regiones, particularmente en el hemisferio sur.


Gracias

Exploring alternative techniques for restoring burned *Nothofagus* forests in Tierra del Fuego, Argentina: analyzing the viability of restoration from seed

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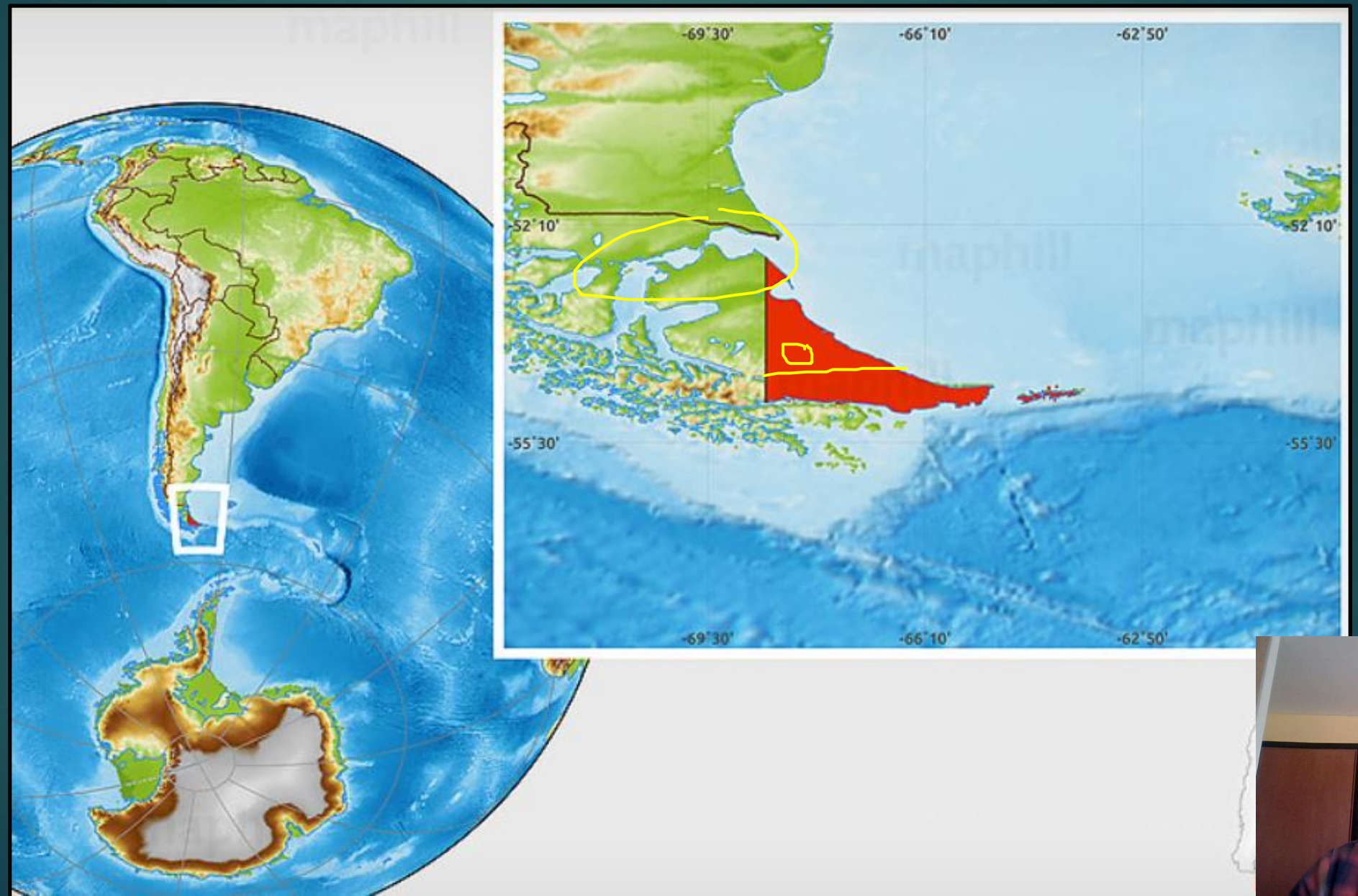
Study Location: Southern Tip of South America



Context: Fire in Southern Patagonia

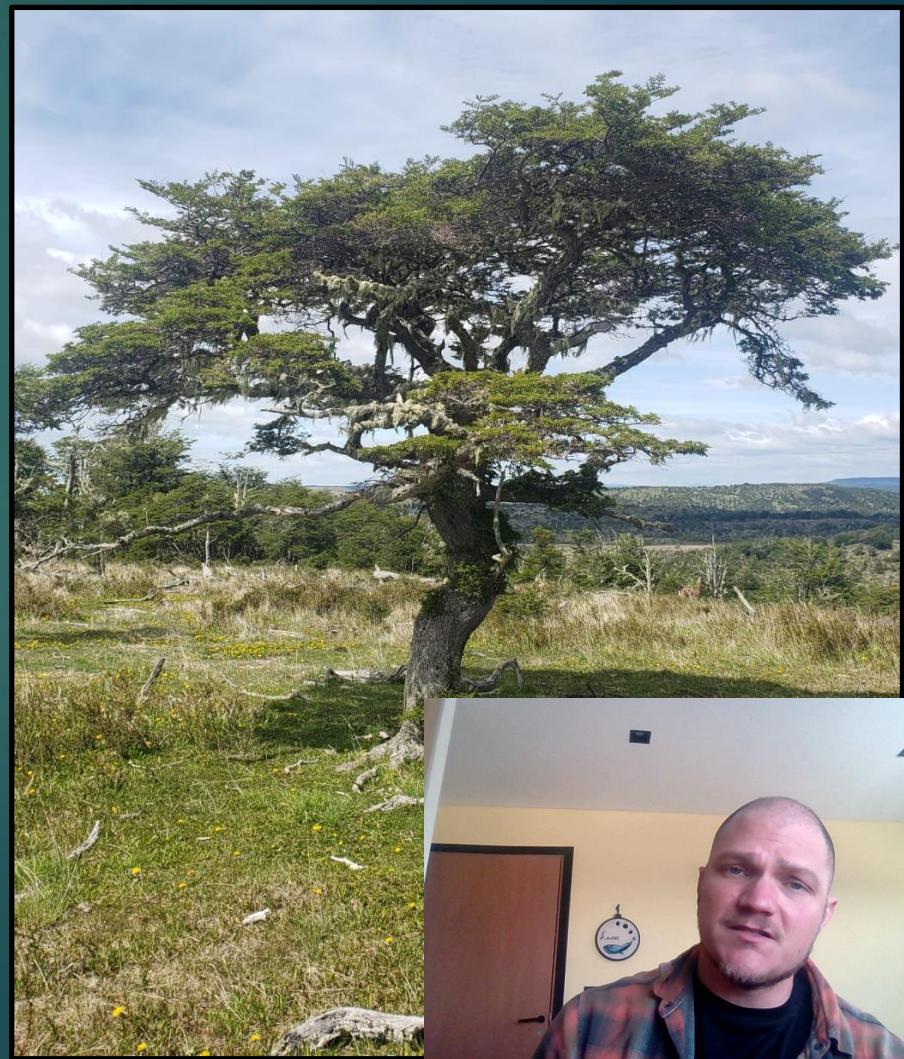
- In Tierra del Fuego, all fires are human-caused
- Tree regeneration is often scarce post-fire

Species of Interest

Nothofagus pumilio germinating from seed post-fire

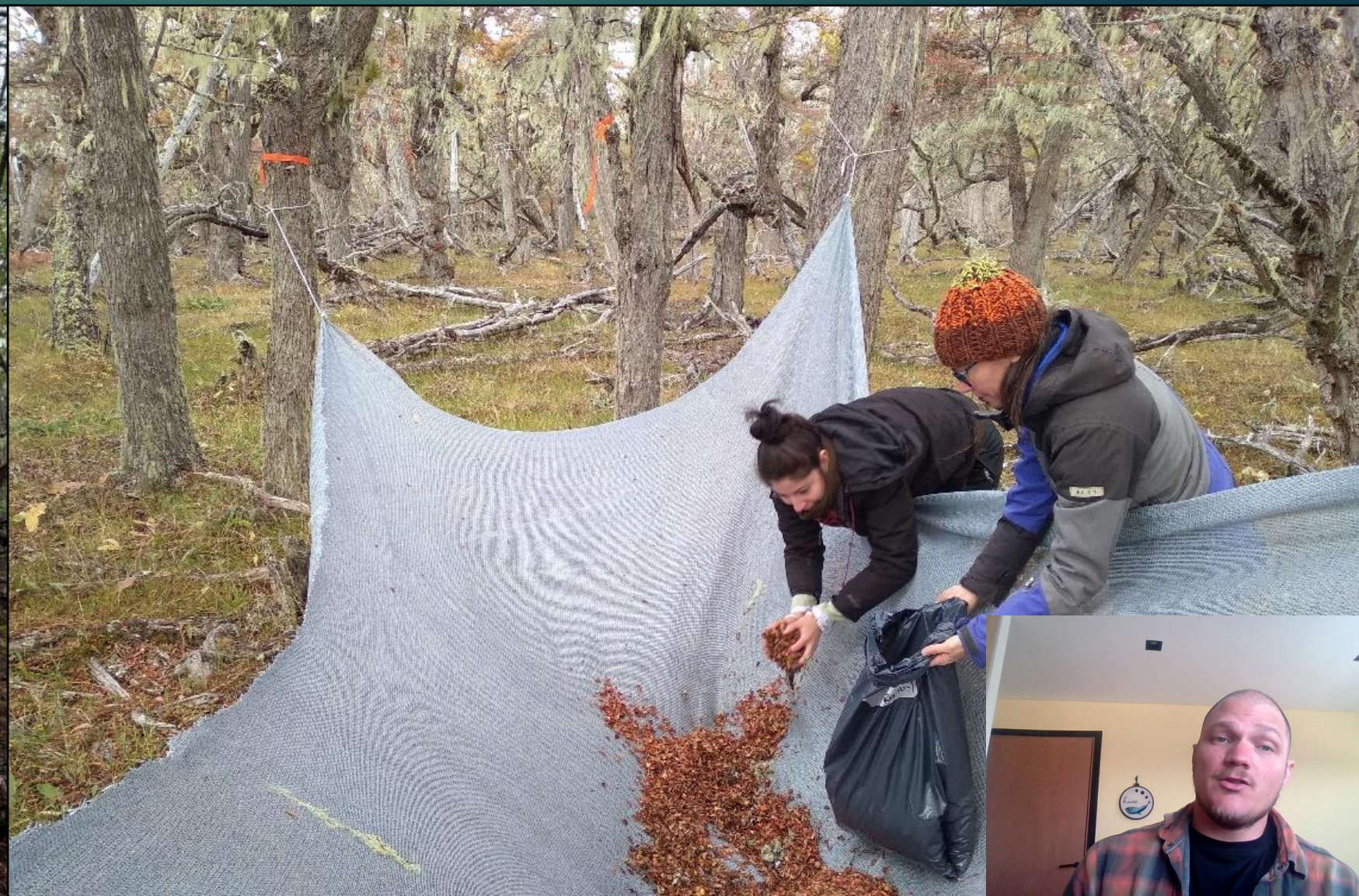
Species of Interest

Nothofagus antarctica resprouting post-fire



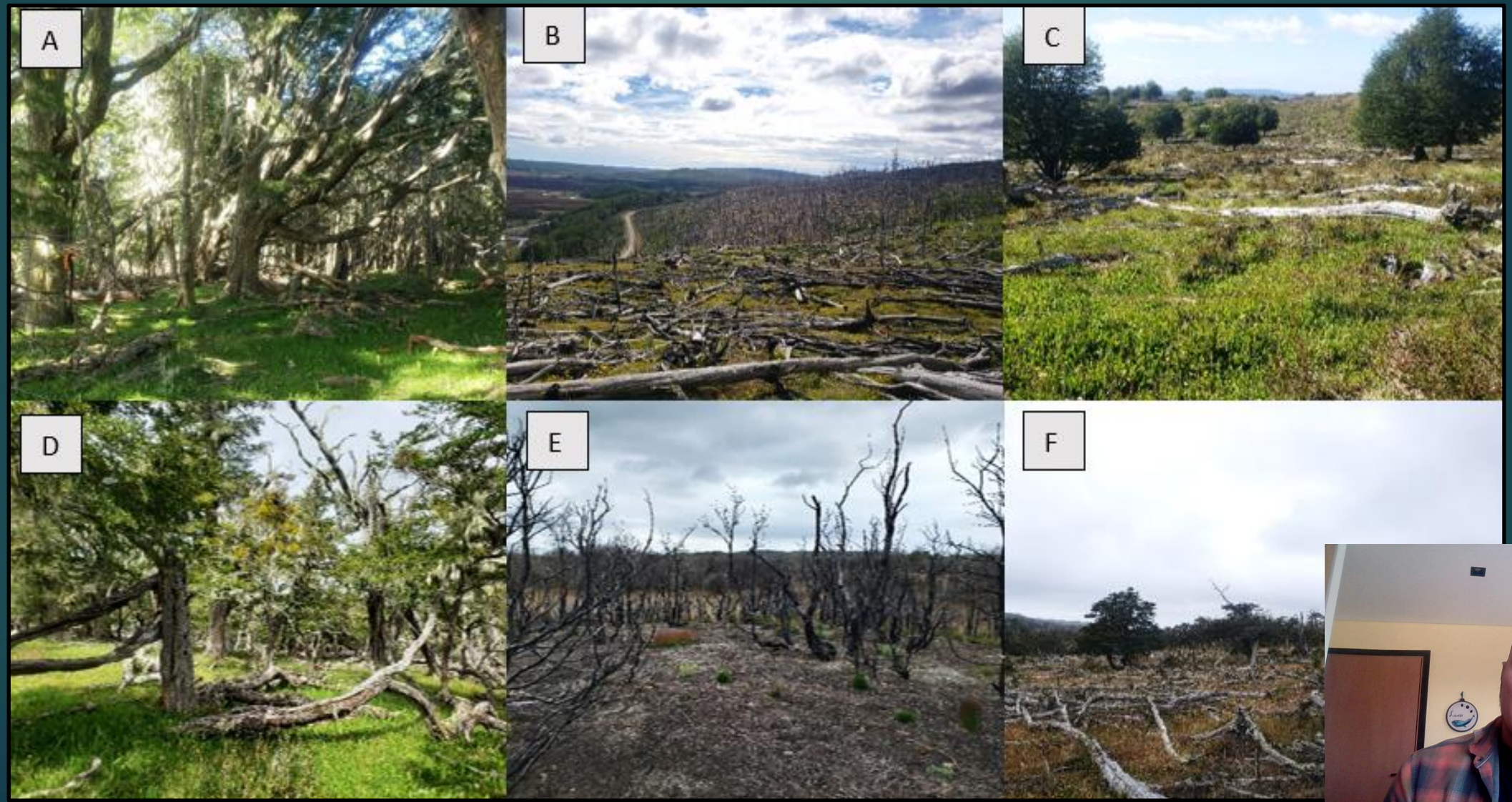
Objective: to evaluate the efficacy of *Nothofagus pumilio* (lenga) and *N. antarctica* (ñire) seed collection traps, and seed fullness and germination in the context of post-fire forest restoration.

Seed Collection: Coast versus Inland

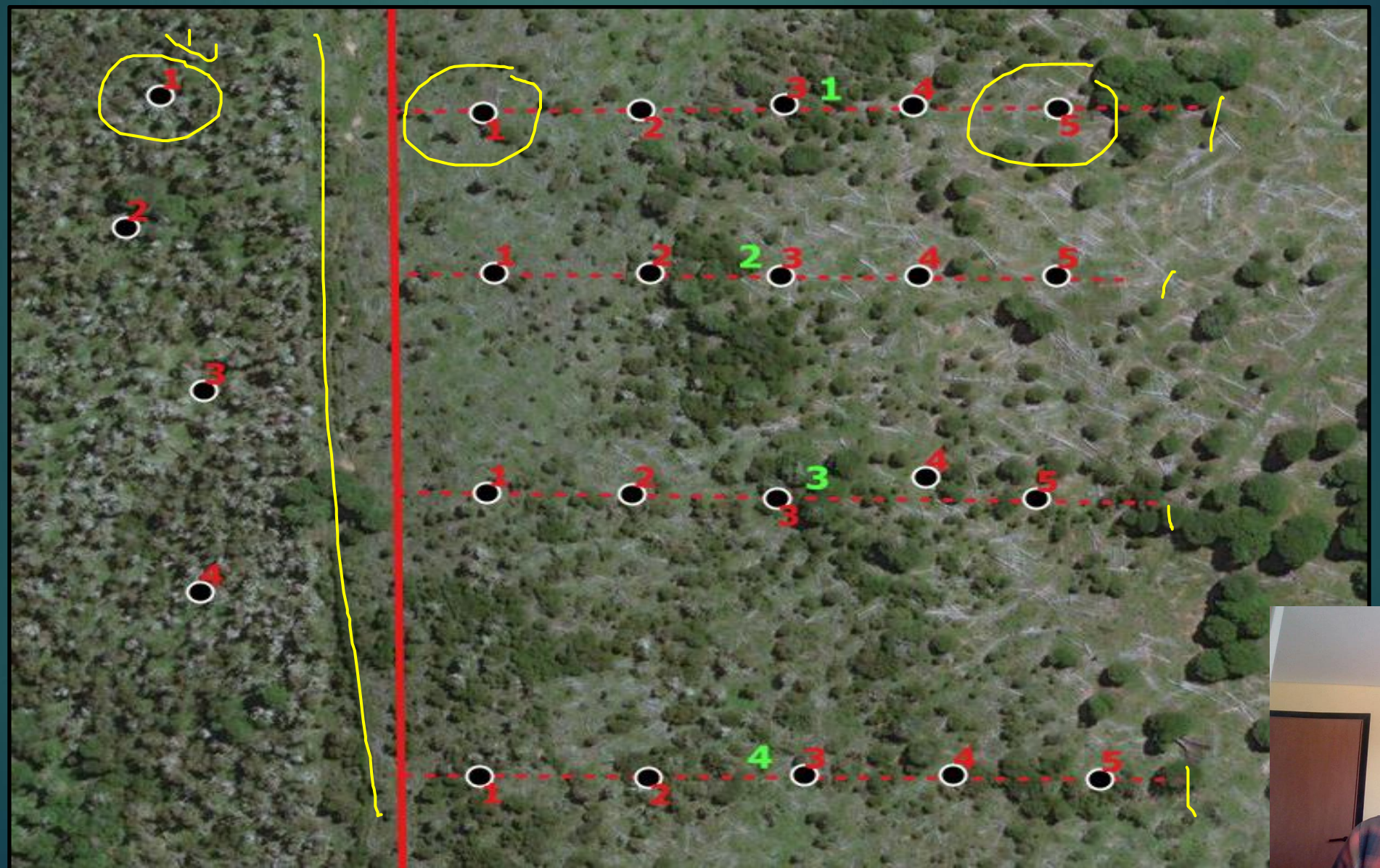


Seed Selection

Study Sites: New and Old Fires in *Nothofagus pumilio* and *Nothofagus antarctica* forests



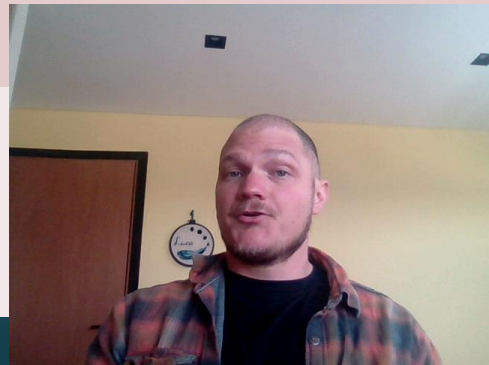
Installation



Installation

Results: Production (Seeds/m²)

Species	Source	Mean (Seeds/m²)	H	p
Lenga	Inland	128	5.33	0.029
Lenga	Coast	271		
Ñire	Inland	320	6.82	0.008
Ñire	Coast	289		

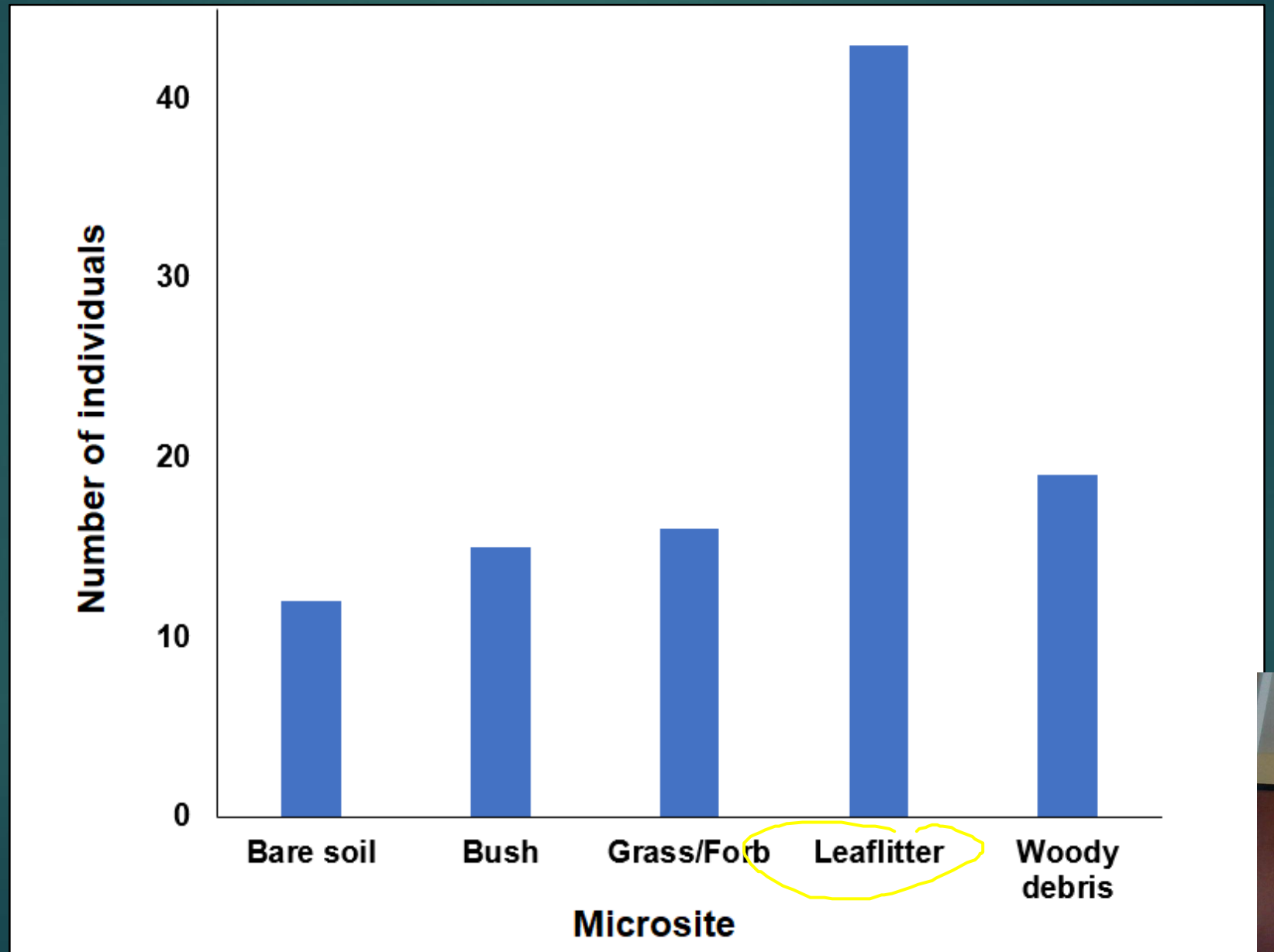


Results: Fullness (%)

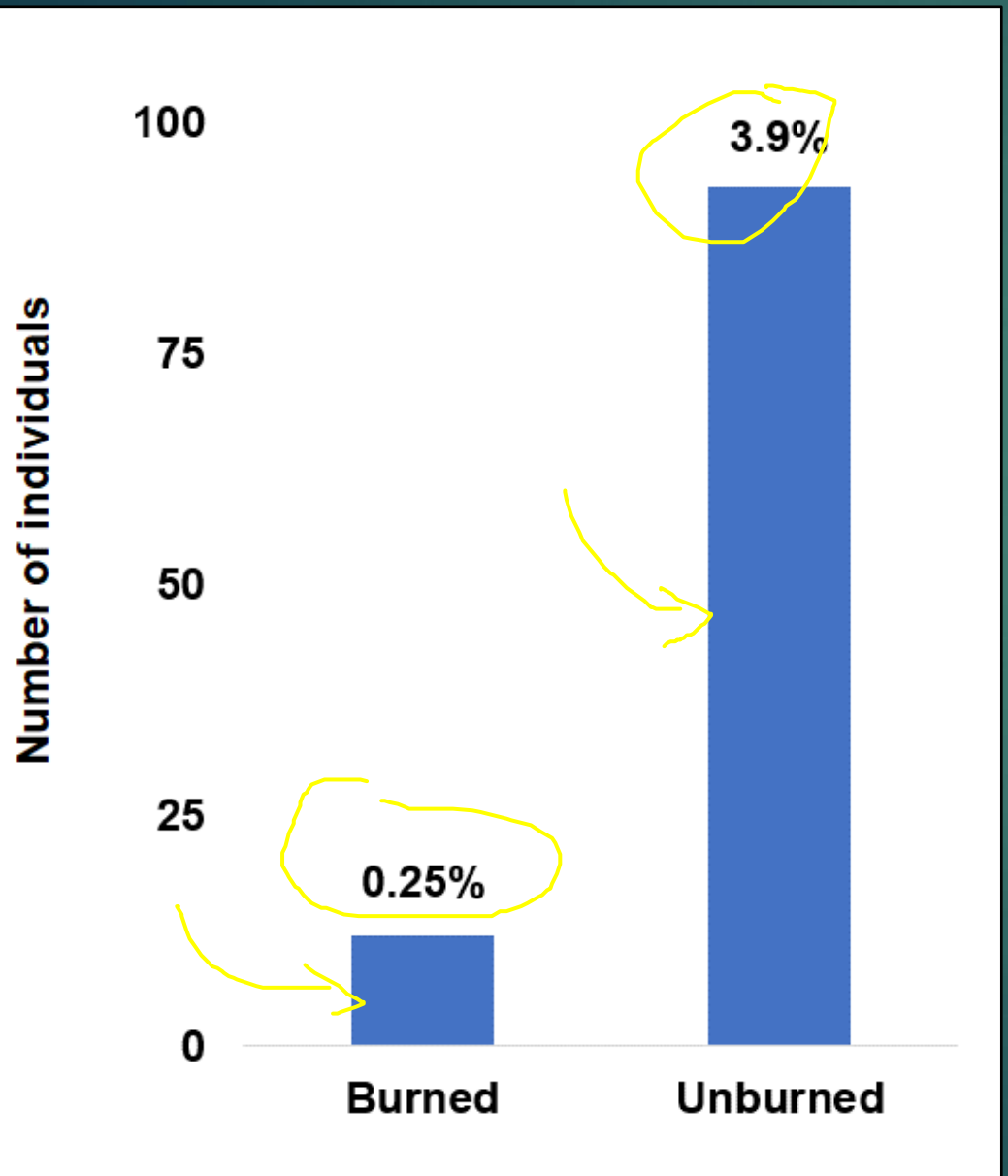
Species	Source	Filled seeds (%)
Lenga	Inland	40
Lenga	Coast	57
Ñire	Inland	31
Ñire	Coast	31

Results: Germination

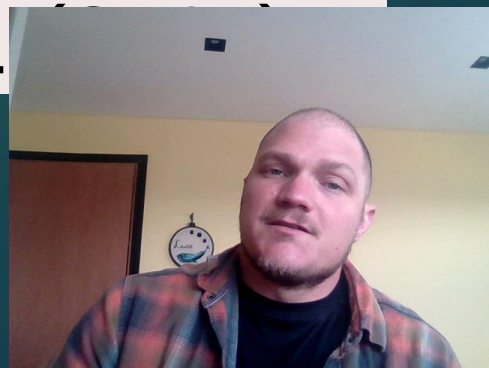
Results: Germination Lenga



Results: Germination Lenga



Source	Total	Burned
Coast	61	1 (2%)
Inland	44	11



Conclusions: Implications for Seed Collection

Antarctic beech
(Nothofagus antarctica)

Conclusions: Implications for Restoration

Thank you