Project Update: May 2023

Remeasurement of field and research station experiments

Over the last 2 years, we have established two experiments as part of this project. In the first, we transplanted over 400 lenga and ñire seedlings to our research station in Ushuaia and planted them in pots filled with severely burned, lightly burned, and unburned soils. In February 2023, we re-measured these plants. Only three lenga seedlings remain alive, whereas 74 ñire seedlings have survived up until this point. Ñire has shown itself to be significantly more resilient to burned conditions both in this experiment and in the field. All indications are that lenga will need help to reestablish after fire (restoration). Though burn severity does not appear to be impacting survival, it does slow height growth, which in the field could potentially slow forest recovery.

The original cohort of seedlings soon after transplantation to our research station (top) and the remaining survivors (bottom).

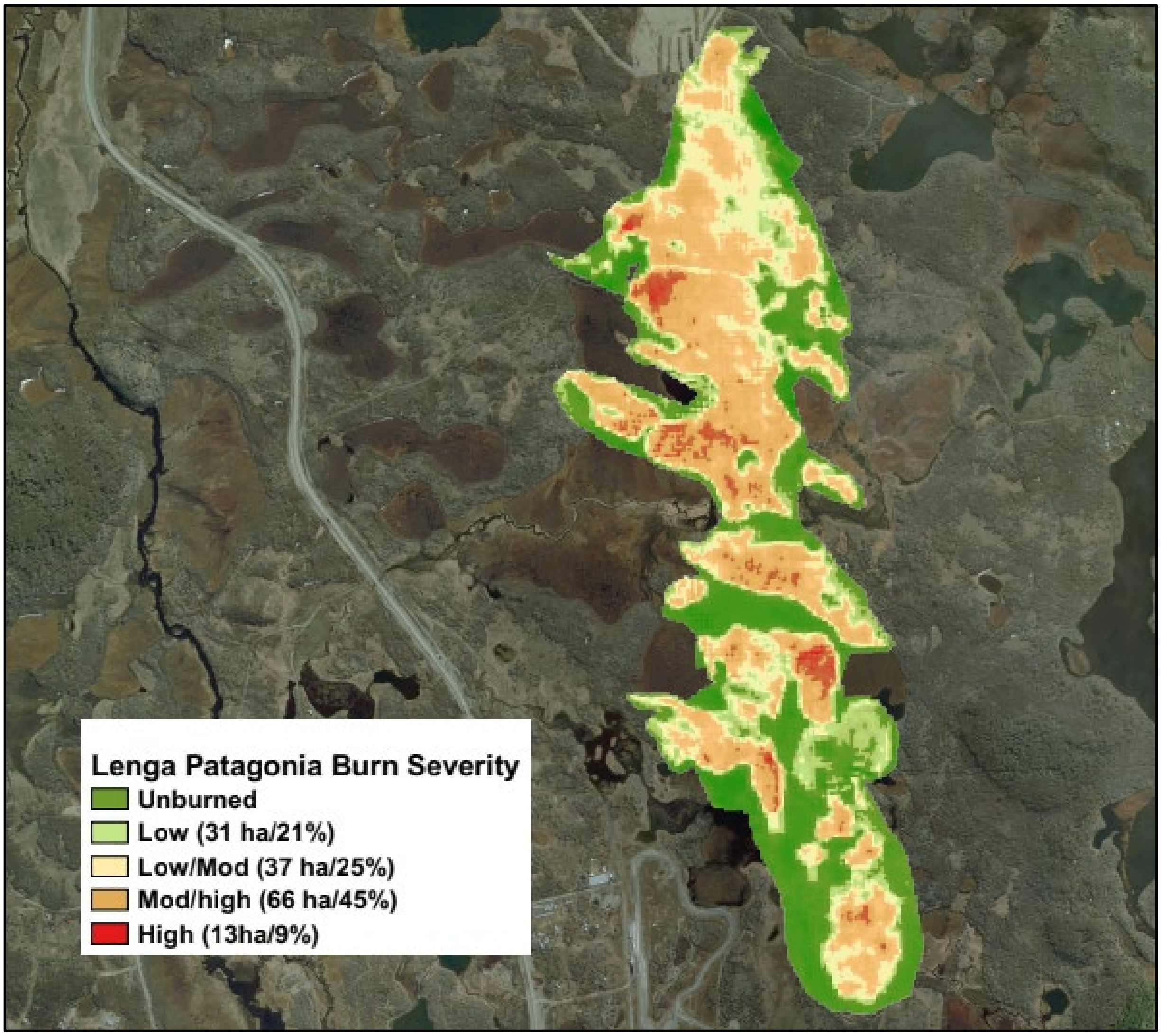
In March 2023, we re-measured a seed germination experiment we established in burned areas and in neighbouring unburned controls. Of the over 7,000 ñire seeds we sowed for this experiment, not a single one germinated. Due to their light weight, seeds may have blown outside of the study area. Still, ñire is known to have poor seed viability and potency and principally recovers post-fire via resprouting from top-killed individuals. The results of this experiment reinforce this understanding. Of the 105 lenga seeds that germinated in the spring, 54 seedlings survived through the summer. Seedling mortality was actually higher in control than burn plots, and grasses had a strong negative impact on both survival and height growth, whereas the protection of downed logs positively impacted survival and growth. This experiment provides valuable information on where restoration of *Nothofagus* sp. in Tierra del Fuego is likely to be most necessary. Rufford funds were used to purchase calipers to measure seedlings and were also essential to conduct trips to the field over many weeks to measure seedlings. We presented a poster detailing this work at the 8th International Wildland Fire Conference in Portugal.

A lenga seedling that germinated and survived the summer in a burned area of the Lote 93 fire. We would check on it in the spring to see if it survived the winter.

Determining burn severity

Last summer, we collected many field variables essential to determining the severity at which different fires burned; burn severity refers to the damage a fire induces and is usually based on a combination of tree mortality and ground layer consumption. Our field estimates of burn severity correlated high-severity fire with lower tree regeneration densities. Field surveying a burned area in its entirety to determine severity across a complete burn scar, however, is not possible for most fires. Instead, remote sensing is used to map burn severity. However, in Tierra del Fuego, the parameters that delineate low, medium, and high severity bands are not defined. Overlaying remote sensing data with field data should allow for an initial calibration of these bands based on local conditions. This may eventually allow land managers to quickly and reliably assess burn severity through satellite imagery and prioritise high severity burn patches in large fires. Rufford funds were essential to completing the field determinations of burn severity. We presented a poster detailing this work at the 8th International Wildland Fire Conference in Portugal.

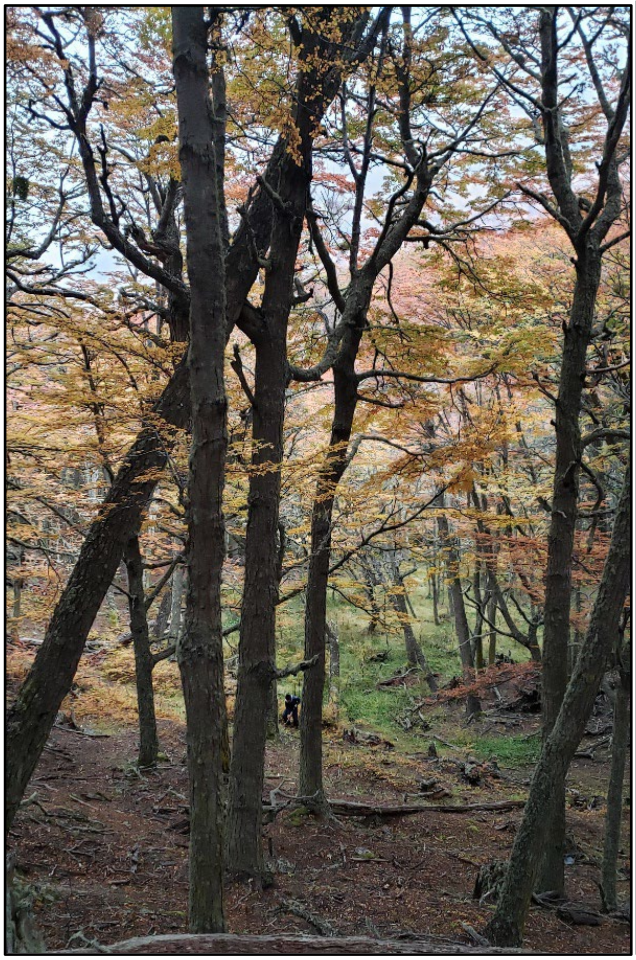
In the field, burn scars as seen above in lenga (left) and ñire (right) actually indicate lower severity fire, as the fire did not inflict enough damage to kill the tree, simply wounding it instead.



Field calibration of the normalized burn ratio (NBR) fire severity bands will allow for more accurate mapping of fire severity across large, burned areas in Tierra del Fuego. Uncalibrated image above.

Implementing restoration project with local collaborator
The Arakur hotel in Ushuaia owns several hundred acres of land, a significant portion of which was lenga forest that burned in the early 1900s. Much of this burned area has not returned to forest approximately 100 years after it burned and is instead a grass/shrubland. The hotel's owners agreed to support a restoration project in this burn scar that implements lessons learned from my thesis and related projects. We transplanted half of approximately 2,000 tree seedlings selected from healthy adjacent forests with abundant regeneration to the burned area. The other half will be transplanted in the spring to compare survival rates between these two common planting seasons. We utilised a variety of planting techniques and sites when transplanting groups of individuals (with/without herbivore protection and with/without protection via downed logs, for example). Volunteers from the local community assisted in the planting event. Not only will this project result in the restoration of approximately

eight acres of forest that would otherwise likely be permanently lost, but it will also provide concrete validation of the effectiveness of different restoration strategies developed based off my thesis results. Rufford funds were used to buy stakes to mark planting sites, fencing and rebar to construct metal plant protective structures, tags to mark planting sites, metal wiring, meals for volunteers, and for fuel to go to and from the project site.






Collecting plants from healthy forest (top left) for transplantation to the burn scar above the city of Ushuaia (top right). Constructing herbivore protection structures (middle) and using natural protection (bottom) to increase transplant survival.

Community outreach

I recently published an article in a magazine dedicated to bringing science to the local community in Ushuaia and was invited to present a summary of my research to the local community (left). A group of approximately 50 adults and children attended the event and took away valuable lessons on the impacts of forest fires on the island and implications for forest conservation. I was also interviewed on local television where I described our restoration work around the city and a colleague was able to present two posters describing our work at the 8th International Wildland Fire Conference in Porto, Portugal.


VIVO
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PLAN DE REFORESTACIÓN DE UN ÁREA QUE SE QUEMÓ EN 1917
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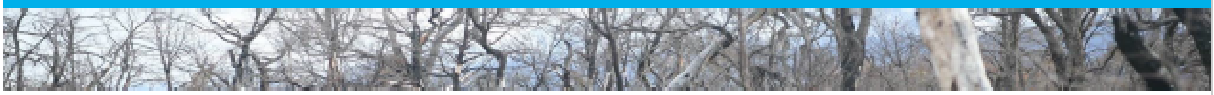
8TH INTERNATIONAL WILDLAND FIRE CONFERENCE
GOVERNANCE PRINCIPLES: Towards an International Framework
www.wildfire2023.pt
Porto-Portugal
May 16-19th
2023

Determining burn severity and its impact on post-fire regeneration in the *Nothofagus* forests of Tierra del Fuego, Argentina

MJ Ruggirello[a], GN Bustamante[a], PZ Fulé[b]*, RM Soler[a]
[a]Centro Austral de Investigaciones Científicas (CADIC - CONICET), Ushuaia, Tierra del Fuego, Argentina.
[b]Northern Arizona University (NAU), Flagstaff, Arizona, United States.
*presenting author



Background

In southern Argentina, recent wildfires in *Nothofagus* forests have produced post-fire conditions commonly associated with high burn severity. Still, fire severity has not been systematically categorized in the region. We sought to test the relationship between simple field methods for determining burn severity and seedling regeneration densities.

Methods

- In two wildfires (2008 - "Lote 93" and 2019 - "Lenga Patagonia"), we established 80 burned and 16 unburned plots in *N. pumilio* (lenga) and *N. antarctica* (ñire) forests (fig. 2). We estimated burn severity, measured live tree basal area, estimated bare-ground cover, and tallied seedlings. The "Lote 93" fire was lenga-dominated and "Lenga Patagonia" was ñire-dominated.
- Plots were classified as high severity (>90% overstory mortality, >50% bare ground), not high severity (<90% overstory mortality, <50% bare ground, presence of fire scars on live trees (fig. 1)), or as unburned. Bare-ground criteria were only used in the 2019 fire.
- Seedling density was correlated to burn severity, bare-ground cover, and live basal area using Pearson's correlation coefficient (r). We fit GLMM to determine the effect of burn severity on seedling density.

Figure 1. Fire scars in lenga (left) and ñire (right).

Figure 2. High-severity burn patches in ñire (top) and lenga (bottom) forests.

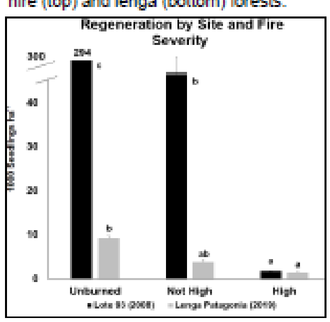


Figure 3. Seedling regeneration by site and burn severity; bars = S.E.

Results

- Of burned plots, 71% burned at high severity and 29% did not.
- Live basal area increased from 0 m^2ha^{-1} in high-severity plots, to 5 m^2ha^{-1} in not high severity plots, to 41 m^2ha^{-1} in controls.
- Bare-ground covered 57% of high-severity plots, 27% of not high-severity plots, and 0.5% of controls (2019 fire only).
- Seedling density was negatively correlated with visual estimates of burn severity ($r = -0.43$, $p < 0.0001$) (fig. 3) and bare-ground cover ($r = -0.19$, $p = 0.06$), and was positively associated with live basal area ($r = 0.48$, $p < 0.0001$).

Conclusions

Burn-severity classifications will be recategorized using the Composite Burn Index (CBI) for comparison and to incorporate moderate-severity fire. Field date will also be used to calibrate burn severity band ranges for the Normalized Burn Ratio (NBR). Still, simple field delineation of plots into high severity and not high severity categories correlated well with seedling regeneration. To maximize limited restoration resources, field estimates of burn severity should be used to inform planting decisions. Areas with high overstory mortality, dominated by bare ground should be prioritized in post-fire restoration efforts.

8[TH] INTERNATIONAL WILDLAND FIRE CONFERENCE

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Porto-Portugal May 16-19[th] 2023

Experimental post-fire restoration of *Nothofagus pumilio* and *N. antarctica* forests in Tierra del Fuego, Argentina

MJ Ruggirello[a], GN Bustamante[a], PZ Fulé[b*], RM Soler[a]
[a]Centro Austral de Investigaciones Científicas (CADIC - CONICET), Ushuaia, Tierra del Fuego, Argentina.
[b]Northern Arizona University (NAU), Flagstaff, Arizona, United States
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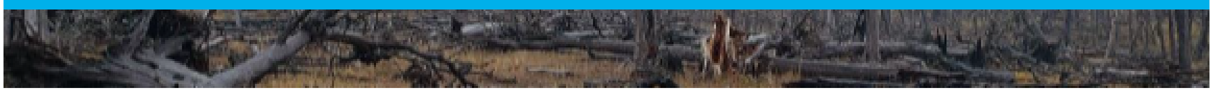

Background

Wildfires in the native *Nothofagus* forests of Tierra del Fuego, southern Argentina, impede post-fire regeneration of *N. pumilio* (lenga) and *N. antarctica* (ñire). Densities are lowest in the interior of burned areas where microsites are dominated by grasses and forbs rather than leaflitter.

Objective and Methods

- Objective: test strategies to restore forest in burned areas.
- We collected 19,000 lenga and 36,000 ñire seeds from different provenance sources (fig. 1). We tested the viability of these seeds and selected the fullest individuals.
- In burned plots 30 and 270 m from the unburned forest edge and in unburned controls ($n = 96$), we selected five microsites per plot (bare soil, bush, grass/forb, leaflitter, woody-debris), and within a 20 cm^2 subplot at each microsite we removed naturally-deposited seeds and sowed 30 pre-selected ones.
- Seed germination was recorded in December, 2022, and survival was measured in March, 2023 (fig. 1). Germination differences between plot locations were analyzed using Fishers LSD Test. Total seedling mortality was correlated to mortality by microsite using the Pearson correlation coefficient (r).

Figure 1. Collecting ñire seeds (top), and a lenga seedling that survived the summer in the foreground of a burn scar (bottom).

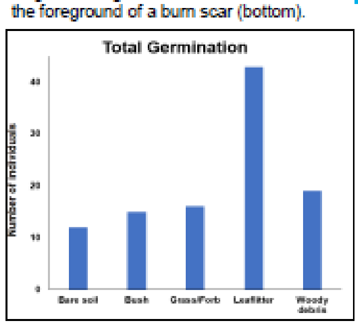

Figure 2. Total number (burned and unburned) of lenga seeds that germinated in different microsites by December, 2022.

Results

- 105 lenga seeds germinated (1.5%), 93 (3.9%) in unburned plots and 12 in burned plots (0.25%). No ñire seeds germinated.
- No seedlings in burned plots germinated in grass/forb microsites common post-fire. Nearly half of seedlings that germinated in control plots did so in leaflitter (fig. 2).
- Distance to fire boundary did not impact seedling germination, but total germination was significantly higher in control plots than burned plots ($F = 12.61$, $p < 0.001$).
- 54 seedlings survived through the summer. Total seedling mortality was most closely tied to mortality in grass/forb microsites ($r = 0.97$, $p = 0.001$). This correlation was weakest between mortality in leaflitter and total mortality ($r = 0.43$, $p = 0.2$)

Conclusions

Post-fire conditions are harsh for seedling germination and survival due in part to the ubiquity of grass- and forb-dominated microsites post-fire. This cannot be mitigated by sowing seeds in leaflitter, bare soil, or protected by bushes or logs. Restoration via seed sowing is likely a poor strategy. Continuing research should be directed at improving techniques for seedling transplantation or planting of greenhouse stock.