Project Update: August 2023

This study has been carried out, with the support of The Rufford Foundation, since September 2022 in the Lanín National Park (PNL) and neighbouring areas, province of Neuquén, Argentina. We made significant progress with the proposed objectives and managed to generate a collaborative link with the PNL Management and Conservation Department, the NGO Asociación Amigos of Patagonia (AAP) and the Ñorquinco community. More than 30 education students (biology and management of natural areas technician) from the nearby town of Aluminé, also participated in our activities. Our advances were:

Objective 1. Evaluate the influence of the mortality of seed trees after the fire on the reduction of regeneration (activity that began in the austral summer of 2021).

Performed activities. To assess the influence of seed tree mortality on the abundance of natural regeneration 7 years after the fire, we conducted a forest inventory at the Ñorquinco fire and Rucachoroy fire sites, located in the PNL. We surveyed 117 circular plots of 700 m^2, which included burned areas with different severities. We considered two severity classes based on values of the Normalized Burn Ratio delta spectral index: low (dNBR < 300) and high (dNBR > 500). On the other hand, we chose two types of vegetation in each fire: forests of *A. araucana* and *N. obliqua* in Ñorquinco, and forests of *A. araucana* and *N. pumilio* in Rucachoroy. In these plots, we counted the seed trees, recorded their status (alive or dead) and counted natural regeneration (plants with a diameter at breast height of less than 4 cm) made up of seedlings (sexual origin) and resprouts (sexual origin).

Results obtained. The abundance of seedlings of the three species was positively correlated to the density of living trees. In areas burned with high severity (dNBR > 500), the abundance of *A. araucana* and *N. obliqua* seedlings was low, while the abundance of *N. pumilio* seedlings was completely null. In areas burned with low severity (dNBR < 300), the abundance of seedlings was highly variable in the three species. We found that *A. araucana* resprouts were more abundant in low-severity burned areas, while *N. obliqua* resprouts were more abundant in high-severity burned areas. We found that 10,2 % of the living trees and 2 % of the standing dead trees of *A. araucana* had at least one resprout (between 1 and 6, both in living and standing dead trees), while in *N obliqua*, 15,4 % and 55 % of the living and dead standing trees, respectively, had at least one resprout (between 1 and 12 resprouts on dead trees).

These results allowed us to identify the areas and forests that were most degraded by the fires in terms of deficiency in the availability of seed trees and scarcity of natural regeneration. In this way, we found that the highly severely burned areas of the *A. araucana* and *N. pumilio* forests are the most vulnerable due to their low regeneration and require differential management for their recovery. This information was shared with Dr. Javier Sanguinetti from PNL, and together with the AAP and volunteers we began the sowing and planting studies described in objective 2.

Communication of results. Castro M, Holz A, Veblen T, Paritsis J. 2023. Estrategias de regeneración de *Araucaria araucana* y *Nothofagus* según la severidad del fuego en el noroeste de la Patagonia Argentina. *VIII Congreso Forestal Latinoamericano y V Congreso Forestal Argentino*, Mendoza 2023. https://congresoforestal2023.org.ar/papers/

Objective 2. Evaluate the effects of post-fire microsite conditions, at different spatial scales, on the emergence, predation, and establishment of *A. araucana* propagules.

Performed activities. To determine if seed predation, seedling emergence and survival differs at the landscape scale, between burning severities, we installed 60 planting plots in *A. araucana* forests burned with low and high severity, and without burning (20 plots per site condition) in Ñorquinco fire. The plots are rectangular, 1 m wide (0,5 m per side of the median line) and 2 m long and originate from a fallen trunk (photograph 3). To determine if the aforementioned variables vary between microsites close to or far from a fallen trunk, regardless of the severity of the burn, in each plot we placed 10 *A. araucana* seeds at 0,1 m (near) and 10 at 2 m (far) of each trunk. Of these seeds, five from each distance range were placed in cages against seed predators. To evaluate the effect of the planting season, we carried out a first planting in spring 2021 and a second in autumn 2022 (austral seasons). In total we sowed 2400 *A. araucana* seeds that will remain in the field as part of the restoration efforts.

To evaluate the survival and mortality of saplings (4 years old and 30 cm tall, grown in a nursery), we placed six saplings in each plot, three of which were placed near the fallen trunk and three far from it. In unburned areas, 14 plots (84 saplings) were planted, in low severity 17 plots (102 saplings), and in high severity 17 plots (102 saplings), 288 saplings in total. Planting took place in September 2022 and saplings were purchased from a local community nursery.

Results obtained. In the spring sowing, the emergence of seedlings was double and the predation half of that in the autumn sowing, for all severities. Seedling emergence was lower near the trunk in autumn sowing, while in spring it did not differ with distance from the trunk. Seed predation was higher near the trunk in unburned areas. Seedling survival was higher near than far from the trunks.

Until now, only one survey of the saplings was carried out (6 months after planting), in March 2023, and we found that the survival of saplings, at the landscape scale, was between 60 and 80 % in the three site conditions. At the microsite scale, sapling survival near trunks in high severity doubled the survival, documented far from them.

These preliminary results indicate that the fallen trunks create suitable microsites for the initial establishment of *A. araucana* seeds and seedlings. We advise decision makers that seeding in spring is an excellent option for starting restoration efforts from seed. Spring sowing increases the chances of success in the emergence of seedlings and considerably decreases the percentage of predation by rodents. Likewise, we recommend compensating the high rates of seed predation in the fall with the placement of saplings.

Additional project goal.
We observed high mortality of *A. araucana* saplings after being transplanted in the field for restoring the purposes. Forest nurseries (saplings producers) use traditional production techniques in which *A. araucana* plants are in the nursery for relatively long periods of time (not less than 4 years). We decided to evaluate different *A. araucana* seed sowing techniques and produce young plants suitable for the field. For this we produced 168 saplings in the greenhouse of the Institute for Research in Biodiversity and Environment (INIBIOMA). In November 2022, we germinated *A.*

araucana seeds and took the opportunity to test the influence of leaf litter cover and the position of the seed at the time of sowing, on their emergence. We consider the following six conditions: seeds in a vertical position (with the radicle downwards) and upside down (with the radicle upwards), completely buried, covered with and without leaf litter; plus, two controls that consisted of seeds located horizontally on the surface with and without litter. Litter is composed of *A. araucana* leaves, remains of male catkins, and seed bracts. The sowing design consisted of sowing one seed in a polyethylene bag of approximately 300 g of substrate, the treatments that required litter were covered with 1 cm of it. We have 28 replicates for all cases. The environmental conditions of the greenhouse, relative humidity, air temperature and irrigation, were the same for all. Saplings emergence was counted once a month for 3 months.

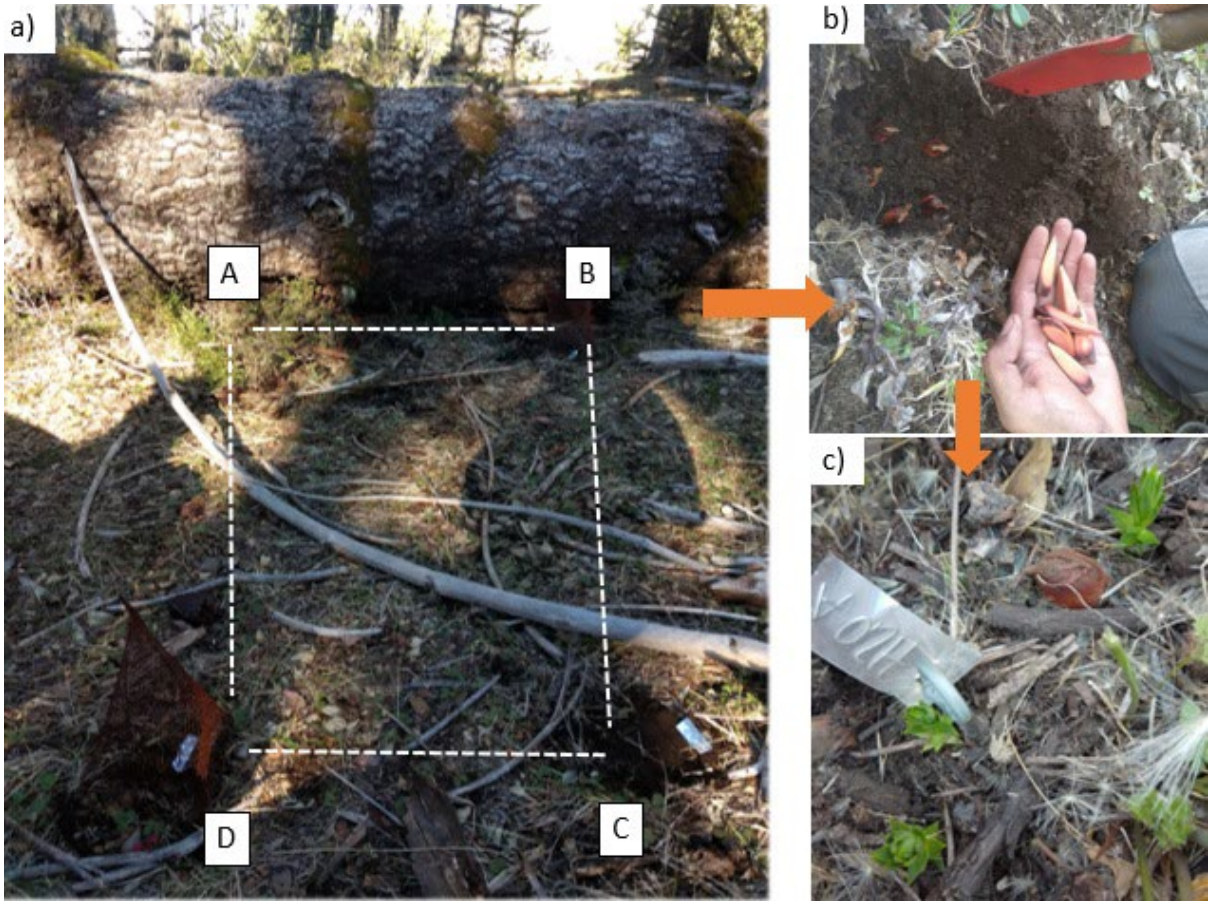
After 3 months, the saplings that emerged went to an area for their fortify, where they were exposed to external climate conditions, that is, without temperature or controlled irrigation. The fortify time was 3 months from February to April 2023. In May 2023, 6 months after sowing, the saplings were transferred and planted by the AAP and the PNL in an affected area with high severity of Ñorquinco fire. The plantation design consisted of grouping saplings (15 saplings) in microsites identified as suitable (with the presence of nurse plants, fallen trunks, repair areas) within the severely burned area and with little natural regeneration. We plan to monitor the survival of these saplings during the austral spring 2023 and summer 2024.

We believe that this additional study will provide key information regarding cultivation techniques of the species, and we will obtain information of the optimal age at which the sapling should be placed in the field. At the same time, it will serve to compare survival versus the oldest saplings (4 years old) and the way the seed should be planted.

A large part of the proposed work has been carried out, all the experiments are in progress in the field, and we already have data that provides us with preliminary results.

We are currently writing a manuscript that we plan to submit to an international journal. We are also processing data that correspond to objective 2, the results will be disclosed at the XXX Argentine Ecology Meeting (RAE) to be held in the city of San Carlos de Bariloche from October 17 to 20, 2023. During the next field season (austral spring-summer) we will monitor and collect data from all the experiments. We are constantly in contact with Dr. Javier Sanguinetti (PNL administrator) and the AAP, with whom we share results and with whom we maintain collaborative work. In May 2023, we actively participated in a day to plant 3,500 *A. araucana* seedlings in Ñorquinco fire, organized by the PNL "Pewen" programme, with the aim of restoring degraded *A. araucana* forests.

Communication of results © Vanesa Lencinas.



a) Sowing method: sowing points A, B, C and D (B and D with cages). b) placement of A. araucana seeds. c) Seedling emergence. © Marcelo Castro.

AAP volunteers planting an A. araucana © Javier Sanguinetti.

Planting method: AAP volunteer planting 4-year-old A. araucana saplings © Marcelo Castro.