Final Evaluation Report

Your Details	
Full Name	María Florencia Spalazzi
Project Title	Douglas-fir tree invasion in Patagonian forests: sustainable ecological restoration from the bottom up
Application ID	30162-1
Date of this Report	05/21/2024

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Remove adult Douglas-fir individuals chemically and mechanically.			■	In the original objective we proposed to remove the trees with both methods in the same experimental site with a split-plot design. We then decided to carry them out in different experimental sites (within Isla Victoria).
Combine the removal of invasive trees with trenching treatments to cut fungal connections.			■	
Quantify the regeneration of native and exotic seedlings after applying the aforementioned treatments.			■	In the original experiment we proposed to sow exotic and native seeds. We then decided to analyse the regeneration of seedlings (between 1 and 2 years old) that were already growing in the forest.
Identify the profitability and effectiveness of each methodology to diagram a potential control plan for invasive exotic species.			■	

2. Describe the three most important outcomes of your project.

a). Herbicide administered by the drill and fill method is a very effective technique for removing medium to large invasive Douglas fir trees in a short period of time.

b). The application of the drill and fill method reduces removal costs by 98%. This is because with chemical removal the trees are left standing dead and there are no costs associated with waste treatment.

c). Regeneration of exotic and native species (growth and survival) does not change after removing invasive adult trees or after limiting the access to ectomycorrhizal fungi.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

The main difficulty encountered was related to the experimental design proposed in the original project and the feasible action times. Due to the SARS-CoV-2 pandemic, we were denied access to the study sites (*Nahuel Huapi* National Park) for about 20 months. Around this date (beginning of 2022) my PhD programme was closer to its end. For this reason, I had to adapt the original proposal to an alternative that would minimise potential failures and allow me to collect consistent results in the short term without modifying the original question. Consequently, the original experiment was divided into two different trials and therefore, two different experimental sites. One trial involved testing the efficacy of chemical control by injecting two different herbicides into the target invasive trees. We then compared the cost-benefit ratio of applying chemical methods with mechanical removal, which is the current technique used in the park to control woody invasion. The other trial consisted of removing large Douglas fir trees with herbicide applying a fungal hyphal restriction treatment (trenching). We then analysed the effect of those combined treatments on the regeneration of native and exotic seedlings (between 1 and 2 years old) that were already growing in the forest. In this way, we save the time of waiting for spring (September 2022 in the Southern Hemisphere) to sow the seeds of the species under study. From previous personal experience, germination success can be significantly low if climate conditions are suboptimal. Thus, after 2 years and seven field trips, we succeeded in gathering conclusive results. These results are now published in a scientific journal (*Invasive Plant Science and Management*) and presented at conferences and scientific meetings as mentioned in questions 6 and 8.

4. Describe the involvement of local communities and how they have benefitted from the project.

During the period in which this project was developed, we strengthened our ties with the staff working for Argentina's National Parks department. We had several meetings to brainstorm about how to improve and continue this applied conservation work. They were involved both in field work and in communicating our results at local scientific meetings and publications. Students from courses related to conservation participated in some field campaigns, an activity that has enriched their knowledge about the ecological mechanisms that operate during the invasion of Pinaceae while they gained experience in field tasks. Together with the park

rangers, we gave talks and field trips to students from the local universities who visited the national park (Nahuel Huapi and Isla Victoria) were we conducted most of our research. We visited a kindergarten in Bariloche (the main city near the national park), where we went out to collect fungi and learned to recognise them according to their characteristics. The children talked about their experiences with the mushrooms they find in their gardens and expressed a lot of interest as they asked many questions!

5. Are there any plans to continue this work?

Yes, we plan to continue this work if further funding is found. The results obtained so far have left unanswered research questions concerning the conservation of these native forests, and has brought on new challenges that could be addressed in the short to medium term, for example:

1. Mortality of large Douglas fir trees by stem injection (or drill and fill method) was very high. However, in future work we intend to test a range of concentrations at different volumes to obtain a more accurate dose and avoid the overuse of the product as well as the costs associated to the herbicide and its application.
2. Due to the great practicality of this technique, we plan to extend the experiments to other exotic woody species (some invasive) of the *Nahuel Huapi* National Park. This would allow us to cover a larger spatial area that includes other phyto-regions, such as the Patagonian steppe (which is also part of *Nahuel Huapi* NP). In this way we could describe the effectiveness and behaviour of herbicides under different climates (temperature and precipitation) and elevations.
3. Although it is already being studied in other parts of the world, we consider that it would be important for local knowledge to address chemical analysis of possible herbicide residues in the soil, litter and watercourses near the treated individuals or their effects on non-target vegetation.
4. Native forest regeneration is another of our main challenges. So far, we have seen that the removal of adult trees and limiting access to fungal connections does not affect the survival and growth of exotic or native seedlings. However, we observed that herbivory pressure by invasive exotic mammals on these species is enormous. As soon as the seedlings exceeded the height of the enclosures, they showed evidence of animal bites. Therefore, active restoration efforts cannot be planned without strict plans to control exotic mammals. It is a great challenge ahead.

6. How do you plan to share the results of your work with others?

So far, our results have been communicated mainly to the scientific community. The results were presented at an institutional conference, at a scientific meeting and in a publication in the journal *Invasive Plant Science and Management* (Spalazzi et al., *in*

press) The next steps will be to continue researching and looking for strategies to communicate the value of this tool to local communities. This must be carefully planned because there is much resistance to herbicide application within local communities.

7. Looking ahead, what do you feel are the important next steps?

We have two great challenges ahead that we are already working on. First, as we mentioned in question 5, we are very interested in further testing stem injection on other woody invasive species with an experimental design that covers a larger spatial area. Our idea is to generate a dose-response curve for other exotic woody species invading the *Nahuel Huapi* National Park. Our goal is to be able to generate an integrated management plan with highly efficient, cost-effective methodologies applicable to priority conservation areas. Second, we believe it is vitally important to bring our results closer to the local community, especially regarding the proper use of herbicides. In this process we have learned that herbicides are very effective tools but that society has a great rejection towards them. We believe that it is our duty, not only to inform about good practices for the use of herbicides, but also to advise on how and when to use them.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

Indeed, we used the Rufford Foundation logo during the presentation of our results at an institutional conference in November 2023. Additionally, the logo was used on a poster presented at a scientific meeting organised by the Argentine Society of Ecology (AsAE), held in the Patagonian city of Bariloche in October 2023. And finally, we mentioned and acknowledged the Rufford Foundation as the main source of funding for our scientific publication (Spalazzi et al., in press)

9. Provide a full list of all the members of your team and their role in the project.

Tomas Milani. PhD, was part of my work team. He actively participated in the design of the experiments, field work and logistics. In addition, he collaborated with the writing of the publication so he is one of the co-authors.

Cecilia Nuñez. She was our main connection with the National Park Administration. She helped us to adapt our project to the needs of the *Nahuel Huapi* National Park and provided us with unpublished internal reports that helped us define the knowledge gap on this subject specific subject. She encouraged us to publish our results (in conferences and journals), and took an active role in the writing of our publication so she is also one of the co-authors.

Martin Nuñez is my PhD co-advisor. He contributed with ideas in the preparation and writing of the project. Being a native of the study area, he introduced us to key people who somehow ended up engaging with the project. He is one of the co-authors of our publication.

François Teste is my PhD advisor. He made sustained intellectual contributions throughout, and helped prepare and draft parts of the project, and participated in the writing of the publication so he is one of the co-authors.

Facundo Merker is a National Park ranger of the Isla Victoria (study site). He participated in most of the field measurements and collaborated with the field campaign logistics.

I would also like to mention the field assistants and suppliers of field inputs, **Ricardo Paez**, **Matías Almonacid**, **Luciana Ebrecht** and **Ana Laura Llanes.**

10. Any other comments?

We have no other comments.