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GRINDELIA CHILOENSIS AS A SOIL RESTORATION TOOL: EVALUATION IN A DEGRADED SECTOR OF PARQUE NORTE (NEUQUÉN)

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Abstract

This paper analyzes the potential of *Grindelia chiloensis* a native species of arid environments, which was studied as a tool for mitigating erosion and desertification in degraded soils. The research was conducted in a sector of Parque Norte (Neuquén) with characteristics similar to those of areas affected by small-scale fires. Soil samples were collected, physicochemical parameters (pH, moisture, electrical conductivity, N, P, and K) were measured, and a germination test was performed under controlled conditions. The results show that the soil, despite its loss of vegetation cover, maintains adequate levels of fertility and stability. Germination reached 50%, confirming the adaptation of the species.*G. chiloensis* clay soils. The findings suggest that revegetation with native species represents an effective strategy to restore degraded soils and reduce erosion in arid and semi-arid environments.

Keywords: Soil, erosion, native plants, vegetation cover.

1. INTRODUCTION

In recent decades, the occurrence and severity of wildfires have increased significantly in various regions of the world, generating direct impacts on ecosystems and water resources (Cole, Bladon, Wagenbrenner, & Coe, 2020). These events modify fundamental soil properties, such as infiltration, structure, fertility, and aggregate stability, increasing runoff, erosion, and nutrient loss (Vieira et al., 2023). These effects compromise vegetation recovery and ecosystem balance, whose vulnerability is intensified in the context of climate change, where an increase in the frequency and magnitude of fires is predicted (Bednar-Friedl et al., 2022, cited in Vieira et al., 2023).

While the literature has extensively documented the immediate impacts of fires on soil and water (Ebel & Moody, 2017; Robichaud et al., 2016, cited in Cole et al., 2020), gaps remain regarding the effectiveness of post-fire management strategies and their contribution to ecosystem regeneration. Studies such as that by Cole et al. (2020) indicate that post-fire management practices—such as salvage logging or subsoiling—influence erosion dynamics, although their advantages and limitations remain under debate. At a continental scale, Vieira et al. (2023) highlighted that the most widely used models for predicting erosion do not adequately account for the effects of fire or vegetation recovery processes, underscoring the need to integrate knowledge about soil degradation, vegetation restoration, and mitigation measures adapted to each geographic context.

Within this framework, the present study aims to analyze strategies for mitigating erosion and desertification through the use of native plant species. Although the soil samples used do not come from burned areas, the observation of degradation and loss of cover in fire-affected environments—such as the planted forest of Parque Norte (Neuquén)—constituted the starting point that motivated this research. In particular, it proposes to evaluate the potential of*Grindelia chiloensis*A native species adapted to arid environments is being studied as a tool to improve soil stability and resilience against degradation processes. In this way, the work seeks to generate evidence on restoration practices that contribute to soil conservation and ecosystem recovery in contexts of erosion and desertification.

2. METHODOLOGY

The present study adopted an exploratory-descriptive approach, aimed at evaluating soil properties under conditions of vegetation cover loss and analyzing the potential of *Grindelia chiloensis, a strategy* for mitigating erosion and desertification.

2.1 Data collection

Sampling was carried out in a section of Parque Norte (Neuquén) ceded to the National University of Comahue, where restoration activities with native species are currently being carried out by the university nursery (Fig. 1a and b). Although this area had not been directly affected by fires, it was selected because it presents the same soil characteristics as the burned sections of the park and because it constitutes a representative environment of soils with degradation processes linked to the loss of vegetation cover.

Figure 1. Soil sampling procedure: (a) delineation of the extraction area, (b) start of excavation and sample collection, (c) depth measurement to ensure sampling of the upper 5 cm of the soil profile.

With authorization from the site authorities, four bags of soil were extracted from different points within the selected area (Fig 1a and b). Each sample was labeled and transported to the university nursery, where it was kept under refrigeration for later use.

During fieldwork, in situ measurements were also taken: soil temperature in areas with and without vegetation cover, relative humidity, electrical conductivity, nitrogen, phosphorus, and potassium content, and pH (5 cm depth) (Fig. 1c). It is worth noting that data collection took place the day after rainfall, which facilitated pH determination due to the greater availability of ions in solution. Values for moisture (36.14%), conductivity (0.308 dS/m), nitrogen (7.0 ppm), phosphorus (42.0 ppm), potassium (51.0 ppm), and pH (4.13) were also recorded. These observations were supplemented with photographic records (Fig. 2).

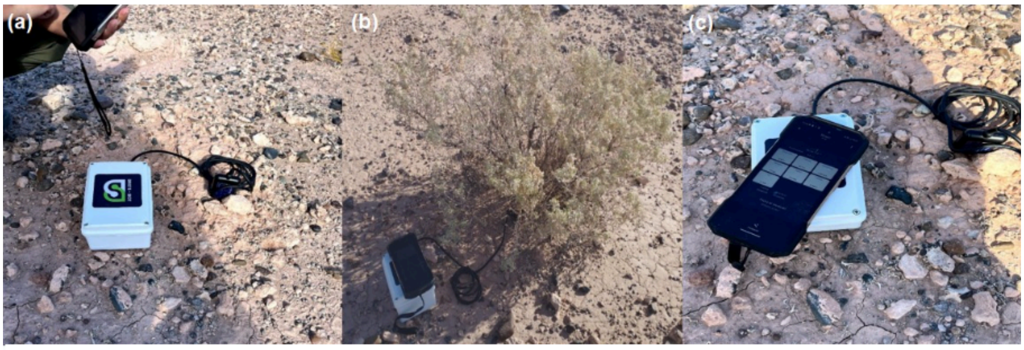


Figure 2. Measurement of field parameters: (a) bare soil, (b) soil with vegetation cover, (c) recording of the collected data.

2.2 Experimental procedure

A germination trial was implemented in the university nursery using the collected soil. Six pots were prepared, and five seeds were sown in each one. *Grindelia chiloensis* The native species was selected for its adaptation to arid environments and its potential to promote soil stability. The pots were maintained under controlled nursery conditions, and the germination and seedling development process was recorded periodically.

Figure 3. *Grindelia chiloensis* planting process: (a) disinfection of tools and pots, (b) partial filling of pots with soil, (c) seed selection, (d) placement and covering of seeds in the pots.

This procedure aimed to test the capacity for plant growth in soils devoid of cover, in an area whose degradation conditions resemble those of land affected by low-intensity forest fires, where surface vegetation is damaged but the internal properties of the soil remain largely preserved.

2.3 Data Analysis

The analysis of the results was based on a comparison between the values obtained in the field and the theoretical values reported in the literature for soils with fertility limitations or acidity that impede the growth of plant species. In particular, the pH, moisture, conductivity, and nutrient content (N, P, K) readings were evaluated to determine if the conditions of the sampled soil are suitable for the establishment of [plants/plants].*Grindelia chiloensis*.

Thermal images and temperature readings taken in areas with vegetation cover and in areas devoid of vegetation were also analyzed comparatively. This comparison will demonstrate the effect of vegetation cover on soil temperature regulation and its importance as a protective factor against direct solar radiation.

The results of these comparisons will be interpreted descriptively and discussed in relation to the central objective of the study: to assess the potential of *Grindelia chiloensis as* a tool for mitigating erosion and desertification in soils with loss of vegetation cover due to fires.

2.4 Participants

The research was conducted by two geology students from the National University of Comahue, Natalia Rojas and Rocío Mardones. Both participated in all stages: planning, sample collection, field measurements, and nursery experimentation. They also had the collaboration of Professor Juana, head of the university nursery, who provided technical assistance during data collection and seed sowing..

3. RESULTS

The results obtained allow us to characterize the physical and chemical properties of the soil studied and evaluate its potential for plant recovery through the use of*Grindelia chiloensis*The samples analyzed come from a sector of Parque Norte (Neuquén) with characteristics similar to those of soils affected by small-scale fires. Although the selected area was not directly burned, its composition and degree of degradation make it a suitable model for analyzing erosion and desertification processes associated with the loss of vegetation cover.

3.1 Soil properties

The values recorded in the field show differences between the areas with and without vegetation. In soils with vegetation cover, the following values were obtained: pH 4.83, moisture 23.62%, electrical conductivity 0.157 dS/m, nitrogen 8.0 ppm, phosphorus 24.0 ppm, and potassium 28.0 ppm. In soils without vegetation cover, the values were: pH 4.13, moisture 36.14%, conductivity 0.308 dS/m, nitrogen 7.0 ppm, phosphorus 42.0 ppm, and potassium 51.0 ppm.

Comparing these results with theoretical values reported for soils affected by fires, it is observed that the pH of the analyzed samples remains within an acidic range, contrary to what is expected in post-fire soils, where the pH tends to become more alkaline due to the addition of ash. This result suggests that the soil still retains a significant fraction of organic matter and that it was not subjected to high temperatures, which is consistent with the low magnitude of the fire in the area.

On the other hand, electrical conductivity values remained low compared to soils heavily affected by fire, where they typically increase due to the accumulation of mineral salts. Phosphorus and potassium levels were relatively high, indicating good nutrient availability for plant growth. As for nitrogen, moderate values (7–8 ppm) were recorded, significantly higher than what would be expected in soils.set on fire, where this nutrient usually volatilizes almost completely.

3.2 Temperature and vegetation cover

Soil temperature measurements reflect the direct influence of vegetation cover on thermal regulation. In areas without vegetation, temperatures ranged from 35 °C to 37.9 °C, while in areas with vegetation they ranged from 25 °C to 28.2 °C (Fig. 4). These differences confirm the protective role of vegetation against solar radiation, reducing surface soil heating and preserving its moisture. Comparing thermal images clearly visualized this contrast, demonstrating that vegetation cover acts as a thermal regulator and a barrier against water loss and erosion.

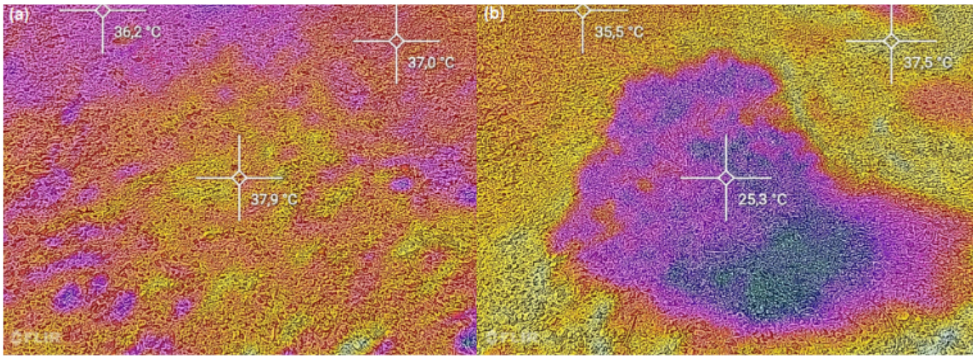


Figure 4. Surface temperature measurement using an infrared sensor: thermal difference observed between (a) bare soil and (b) soil with vegetation cover.

3.3 Germination test

The planting of plants took place in the university nursery *Grindelia chiloensis* using soil samples collected in the North Park area.

Three observation records were made, with a ten-day interval between each, to evaluate the germination and initial development of the species in six machetes each containing five seeds (30 seeds in total). In each instance, the number of visible sprouts was counted and growth was recorded by means of photographs (Figure 5).

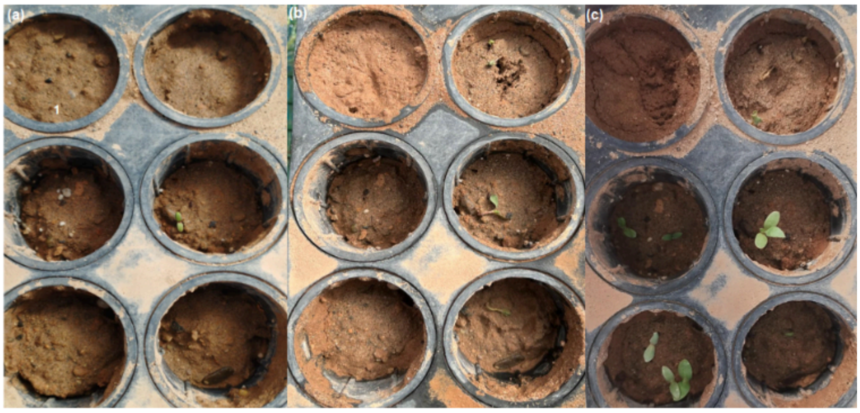


Figure 5. Early growth development of *Grindelia chiloensis* under controlled nursery conditions: (a) after 10 days, a single shoot is observed, (b) after 20 days, new shoots appear, although some seedlings begin to show signs of wilting, (c) after 30 days, a noticeable growth of leaves and the presence of new shoots are observed.

In the first observation, a single shoot was recorded in pot 3. During the second observation, four shoots were counted, distributed in pots 1 (two shoots), 3 (one), and 6 (one). In the third observation, corresponding to the last record, eight active shoots were identified, distributed as follows: pot 1 (one surviving shoot), 2 (no shoots), 3 (one), 4 (two), 5 (one), and 6 (three shoots) (Table 1).

Overall, a progressive increase in the number of outbreaks was observed throughout the monitoring period, although with the loss of one specimen in pot 1.

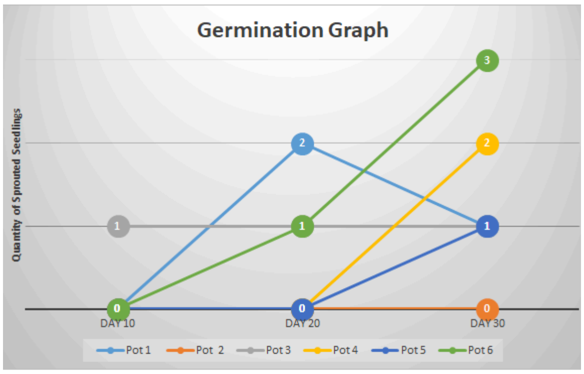
Pot	Day 10	Day 20	Day 30
1	0	2	1
2	0	0	0
3	1	1	1
4	0	0	2
5	0	0	1
6	0	1	3

Table 1. Number of shoots recorded in each pot during the three observations corresponding to days 10, 20, and 30 of the experiment.

In total, germination was obtained in three of the six pots (50% of the total). (Fig 6), which demonstrates that the soil, despite its degraded appearance and low vegetation cover, retains sufficient fertility conditions to allow the establishment of native species.

The low germination rate is mainly attributed to the high clay content of the soil, which results in poor aeration and excessive water retention, affecting the development of some seeds. This limitation could be mitigated by incorporating sandy material into the substrate, which improves filtration and drainage. This material could come from Parque Norte itself or be sand authorized and provided by the municipality, since the area's regulations only permit the use of natural components from the surrounding environment and do not authorize the addition of fertilizers or other external compounds.

Despite these limitations, the results demonstrate that the soil maintains suitable properties for plant recovery. Under controlled nursery conditions,*Grindelia chiloensis showed* adaptability and growth capacity, which supports its potential as a suitable species for restoration strategies and mitigation of erosion and desertification in soils with similar characteristics.



Graph showing the evolution process of Grindelia Chiloensis' growth studied on 6 pots during three varied periods of observation (days 10, 20, 30)

3.4 General interpretation

Overall, the results show that the soil in the analyzed sector presents chemical and physical conditions favorable for plant development, despite its low surface cover.

pH, conductivity, and nutrient levels remain within ranges compatible with plant life, and the temperature difference between areas with and without vegetation confirms the importance of cover in conserving moisture and soil stability.

These findings support the initial hypothesis of the work: degraded soils, analogous to those affected by low-magnitude fires, can maintain their recovery potential if revegetation with native species adapted to the local environment is favored. *Grindelia chiloensis*In this sense, it represents a viable alternative to promote soil stabilization, reduce erosion and contribute to mitigating desertification processes in arid and semi-arid environments.

4. DISCUSSION

The results obtained made it possible to analyze the behavior of a soil with characteristics similar to those of a terrain slightly affected by fires, in relation to its capacity to support vegetation and resist erosion and desertification processes.

The pH range (between 4.13 and 4.83) remained within acidic values, indicating that the soil did not undergo significant heat alteration and retains its original mineral composition. This suggests that the properties of the parent material, likely with a good proportion of fine minerals and clays, continue to contribute to water and nutrient retention, fundamental aspects for plant growth. Similar results were reported by studies conducted on soils in northern Patagonia with a low degree of thermal alteration after small-scale fires. Ravetta, D. A., Bertiller, M. B., & Sain, C. L. (2019).

The low electrical conductivity observed indicates no salt accumulation, which is generally favorable for vegetation growth. From a geological perspective, this soil type may correspond to fine sedimentary materials with some cohesion, which limit water erosion but also reduce soil aeration, as evidenced in the germination test.

The temperature differences between areas with and without vegetation reflect the importance of plant cover in regulating soil temperature. Geologically, this protection helps maintain soil structure and prevents soil erosion, contributing to soil stability.

Germination trials with *Grindelia chiloensis confirmed* that this species can thrive in clay soils with low permeability, conditions common in arid or semi-arid environments of northern Patagonia. Its adaptability makes it a suitable option for revegetation and erosion control strategies.

Overall, the results indicate that degraded soils, even those not severely affected by fire, retain their recovery potential if vegetation cover with native species is promoted. This has not only ecological but also geological relevance, as vegetation restoration helps stabilize surface processes and prevent desertification.

5. CONCLUSION

The study allowed the evaluation of soil conditions with characteristics similar to those of land slightly affected by fires and its capacity for revegetation with *Grindelia chiloensis* the results showed that, despite the loss of vegetation cover, the soil maintains an adequate level of fertility and stability, which allows for the growth of native species.

Analysis of pH and temperature parameters confirmed that the soil maintains a favorable chemical balance, and that the presence of vegetation helps regulate temperature and conserve moisture. Germination trials yielded a 50% success rate, demonstrating the adaptation of the plants. *Grindelia chiloensis* to clay soils, although it is recommended to incorporate sand from the surrounding area or provided by the municipality to improve aeration and drainage.

Overall, the results indicate that soils little affected by fires have a high recovery potential, and that revegetation with native species is an effective alternative to reduce erosion and promote the restoration of degraded environments, contributing to the ecological and geological balance of the study area.

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