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Cell & Cellular Life Sciences Journal
ISSN: 2578-4811

Ecological Restoration of *Pinus Pinaster* Woodlands, After Degradation with Focusing on Rehabilitation of Target Habitats

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Research Article

Volume 8 Issue 2

Received Date: September 28, 2023

Published Date: October 06, 2023

DOI: 10.23880/cclsj-16000183

Abstract

Ecological restoration plays a vital role in preserving and rehabilitating degraded habitats, especially those populated by endemic species. This abstract focuses on the restoration efforts of Pinus pinaster and other endemic species found in woodlands that have suffered degradation. The primary aim of this restoration project is to rehabilitate target habitats and promote the recovery of these native species in Portugal.

The identification of key factors that have contributed to the degradation is crucial in developing effective restoration plans. Additionally, understanding the ecological requirements and preferences of the target species is essential to ensure successful rehabilitation. Ecological restoration of *Pinus pinaster* woodlands/forests, after degradation such as posed by recurrent fires and invasive species, Focusing on rehabilitation of target habitats, such as water lines and other key elements of the landscape (we have important areas of *Pinus pinaster* in the secondary coastal dunes) Using native species of the selected sites, that may be present in the vegetation or in the soil seed bank- Testing and evaluating the best propagation techniques for each species, vegetative cuttings, seeds germination, in situ or ex situ propagation, Evaluating the added value of the restoration actions in terms of 1) increasing or protecting ecosystem services, 2) increasing or protecting rare or potentially endangered plant species, etc.

In conclusion, the ecological restoration of *Pinus pinaster* and other endemic species in degraded woodlands requires a multidimensional approach that addresses key factors contributing to habitat degradation. By focusing on the rehabilitation of target habitats, these restoration efforts contribute to the conservation and preservation of these important ecosystems, ultimately benefiting both the endemic species and the surrounding communities.

Keywords: Cluster; Maritime; Forest; Habitat; Biodiversity

Abbreviations: ADHD: Attention-Deficit Hyperactivity Disorder; FAIR: Findability, Accessibility, Interoperability, and Reusability.

Introduction

Ecological restoration plays a vital role in preserving and rehabilitating degraded habitats, especially those populated by endemic species. This abstract focuses on the restoration efforts of *Pinus pinaster* and other endemic species found in woodlands that have suffered degradation. The primary aim of this restoration project is to rehabilitate target habitats and promote the recovery of these native species.

The restoration process for *Pinus pinaster* and other endemic species involves a comprehensive approach,

including habitat assessment, careful planning and implementation of appropriate strategies. The identification of key factors that have contributed to the degradation is crucial in developing effective restoration plans. Additionally, understanding the ecological requirements and preferences of the target species is essential to ensure successful rehabilitation.

Several techniques and interventions can be employed in the restoration process, such as seed collection, nursery propagation, and outplanting. These interventions are implemented in a way that mimics natural regeneration processes and aims to enhance natural populations of the endemic species. Proper monitoring and evaluation methods are also crucial to assess the success of restoration efforts, allowing for adaptive management techniques to be applied as necessary.

The restoration of *Pinus pinaster* and other endemic species in degraded woodlands not only reestablishes the ecological integrity of these habitats but also contributes to the conservation of biodiversity and ecosystem services. It is essential to collaborate with local communities, stakeholders, and relevant institutions to ensure the sustainability and long-term success of these restoration initiatives. Here are three possible hypotheses for the topic:

1. The implementation of targeted ecological restoration strategies will significantly enhance the recovery and population growth of *Pinus pinaster* and other endemic species in degraded woodlands.
2. The restoration of target habitats, through ecological interventions, will positively affect the overall biodiversity and ecosystem services provided by *Pinus pinaster* and other endemic species in woodlands.
3. The collaboration and involvement of local communities and stakeholders in the ecological restoration process will contribute to the long-term success and sustainability of rehabilitating target habitats for *Pinus pinaster* and other endemic species in degraded woodlands.

These hypotheses can form the basis for further research and investigation into the ecological restoration of *Pinus pinaster* and other endemic species in degraded woodlands, with a focus on the rehabilitation of target habitats. The proposed work is ambitious in terms of its scope and long-term goals. It seeks not only to restore *Pinus pinaster* habitats but also to establish a model for sustainable forest management, promoting the conservation of other endangered species and habitats. Moreover, the project aims to serve as a knowledge-sharing platform, offering valuable insights and transferable lessons to other reforestation initiatives worldwide. By going beyond the state-of-the-art and adopting an ambitious approach, our project strives to create lasting positive impacts on the ecosystem, local communities, and the broader field of reforestation and habitat restoration.

Literature Review

Regenerating maritime pine (*Pinus pinaster* Ait.) stands is a significant concern across its distribution range, as the survival of seedlings during the summer season poses a major challenge for their establishment and growth. To address this issue, implementing a group selection cutting system appears to be the most effective solution to encourage the development of uneven-aged stands with mixed structures, especially considering the shade intolerance of maritime pine. By creating gaps in the forest, this approach creates diverse regeneration niches that cater to the requirements of species with varying shade tolerance. Furthermore, the establishment of uneven-aged stands through this system enhances the resilience of the forests, making them more capable of withstanding the impacts of climate change [1].

In Sierra de Oria forest, even though all of the observed plants were visually identified as belonging to the species *Pinus pinaster,* the genotyping of their roots revealed that they consisted of not only P. pinaster but also *P. halepensis* and other plant species unrelated to the Pinus genus. In the case of the unidentified plant species, it was not possible to determine their specific identity. To collect samples of the soil closely adhered to the roots that lacked suberization (known as rhizosphere soil), the litter and topsoil within a distance of less than 50 cm from the trunk were carefully removed. The collection of rhizosphere soil was done at a depth ranging from 5 to 25 cm. Total communities (DNA) were mainly dominated by phyla Proteobacteria, Acidobacteria, Actinobacteria, Verrucomicrobia and Bacteroidetes in summer and spring, while potentially active populations (RNA libraries) were rich in Proteobacteria, Acidobacteria, Candidate division, Actinobacteria and Verrucomicrobia both in summer and spring, these data could aid in developing bioformulations based on microorganisms which could be resistant to desiccation and involved in the drought resistance mechanisms of the host plant. [2].

The Italian team evaluate the post-fire effects on a *Pinus pinaster* Aiton forest growing in a hot and dry area of the Mediterranean region by comparing burned trees with severe crown reduction against unburned and not-defoliated trees. Inter-annual analyses of dendrochronology and stable isotopes in tree rings were combined with xylogenesis monitoring to investigate the effects of fire on tree growth, ecophysiological processes and wood formation. Their findings suggest that substantial photosynthetic limitations caused by crown defoliation and recurrent drought events could lead to severe growth decrease and reduction of trees ability to regain the pre-disturbance productivity rates [3].

In north-central Portugal, the research has been conducted on *Pinus pinaster* habitat, Seed bank composition, however, varied markedly within the burnt area but this could be explained reasonably well by differential effects of the wildfire associated with its severity, in terms of the two crown consumption classes as well as the TDI index but not the MTRs. The inclusion of the litter/ash layer and the separation of two soil depths were amply justified by providing clear support for the important role of fire severity, in particular for the two principal taxa (Calluna vulgaris and *Erica* spp., presumably mainly *E. australis*). In comparison with the unburnt area, the recently burnt area as a whole revealed a substantial increase in overall densities of viable seeds [4].

Findings in Portugal show that increased tolerance in *R. leguminosarum* is not related to a higher efficiency in the oxygen scavengers per se, but to ratios of intracellular reduced GSH. Furthermore, we demonstrated that the supply of GSH to the sensitive strain enhanced survival, concluding that GSH plays a crucial role in Cd tolerance in this species. However, this role consists in preventing the oxidative stress to the cell, rather than reducing its effects. Results demonstrated that Cd-induced stress is not experienced in the same way by the two strains. While in the tolerant strain the oxidation status is better maintained due to a higher increase of GR and with maintenance of higher levels of reduced GSH, in the sensitive strain. This could be investigating in Cluster pine habitats.

Attention-Deficit Hyperactivity Disorder (ADHD) is the most common paediatric neurocognitive behavioural disorder. French scientists worked on *Pinus pinaster* bark extracts for healing patients. Teachers reported significant improvement of total and hyperactivity/impulsivity ADHD-RS scores by PBE and MPH after 10 weeks compared to placebo. MPH also improved inattention. SEQ ratings support ADHD-RS results. Adverse effects were reported five times more frequently for MPH than for PBE [5].

Restoration of commercial pine plantations to native ecosystems is increasing globally. This study investigated the abiotic and biotic factors in a postpine *(Pinus pinaster)* ecosystem that could potentially limit successful restoration of highly biodiverse Banksia woodlands. Soil abiotic conditions were analysed across a 7-year postpine chronosequence and compared with a reference Banksia woodland soil to assess soil legacy issues. Ten native species were grown in postpine soils and monitored for germination and growth responses. Three species were selected and grown in the presence of an invasive species, *Ehrharta calycina*, to assess biotic impacts on seedling emergence, establishment, physiology, and drought response. This case study examines abiotic and biotic limitations to Banksia woodland restoration success in postpine environments, suggesting postpine soils are not a barrier to restoration, and highlight the importance of preventing *E. calycina* from becoming established [6].

Materials and Methods

The overall methodology for *Pinus pinaster* reforestation and ecosystem benefit in Portugal can involve the following steps:

- **Site Selection:** Identify suitable areas for *Pinus pinaster* reforestation based on ecological conditions, soil type, climate, and availability of resources.
- **Seed Collection:** Collect high-quality seeds from healthy and genetically diverse *Pinus pinaster* trees in order to ensure the success and resilience of the reforestation project.6.3.
- **Seed Treatment and Nursery Production:** Treat the collected seeds to improve germination rates and control pests or diseases. Establish a nursery to grow *Pinus pinaster* seedlings until they are ready for field planting.
- **Site Preparation:** Prepare the selected reforestation sites by clearing invasive species, controlling weeds, and improving soil conditions if necessary.
- **Planting:** Plant the *Pinus pinaster* seedlings in a well-planned pattern considering proper spacing, density, and site-specific factors, such as slope stability and water availability.
- **Vegetation Management:** Implement appropriate vegetation management practices, such as weed control and protection against herbivores, to ensure the survival and growth of the planted seedlings.
- **Monitoring and Maintenance:** Regularly monitor the growth and health of the planted *Pinus pinaster* trees, and provide adequate care and maintenance, including irrigation, fertilization, and pest control, as needed.
- **Ecosystem Benefits Assessment:** Conduct periodic assessments to evaluate the ecological benefits of *Pinus pinaster* reforestation, such as carbon sequestration, biodiversity support, soil protection, and water regulation.
- **Stakeholder Engagement:** Involve local communities, landowners, and relevant stakeholders in the reforestation project, ensuring their participation and support for long-term ecosystem restoration and sustainability.
- **Adaptive Management:** Continuously adapt the reforestation approach based on monitoring results and lessons learned, incorporating new scientific advancements and best practices to maximize the ecosystem benefits of *Pinus pinaster* reforestation in Portugal.
- The specific details and implementation of the methodology may vary depending on the site conditions, local regulations, and so forth.
- **Forestry and Silviculture:** Applying principles and

techniques of forest management and silviculture to ensure proper planting, growth, and maintenance of *Pinus pinaster* trees. This includes considerations such as site selection, spacing, thinning, and regeneration practices.

- **Seed Science and Genetic Resources:** Utilizing seed science knowledge for selecting, collecting, processing, and storing high-quality *Pinus pinaster* seeds. Additionally, considering genetic diversity and the use of genetically improved seed sources to enhance the adaptability and resilience of the reforestation efforts.
- **Ecology and Ecosystem Science:** Incorporating ecological principles and understanding ecosystem dynamics to guide reforestation planning. This includes assessing the ecological context, identifying key habitat requirements, and considering potential interactions of *Pinus pinaster* with other plant and animal species.
- **Soil Science and Conservation:** Conducting soil assessments to determine soil conditions, nutrient availability, and potential limitations for successful *Pinus pinaster* reforestation. Employing appropriate soil conservation practices to minimize erosion and improve soil health.
- We can monitor the reforestation sites, track vegetation growth, and analyze spatial patterns and changes over time. This can provide valuable data for decision-making and adaptive management.
- **Climate Science and Adaptation:** Considering climate change projections and its impacts on *Pinus pinaster* growth and distribution. Incorporating appropriate adaptation strategies, such as selecting climate-resilient seed sources or adjusting planting practices based on future climate scenarios.
- **Socio-economic Perspectives and Stakeholder Engagement:** Considering the social and economic dimensions of *Pinus pinaster* reforestation projects, considering local communities, landowners, and other stakeholders. Engaging stakeholders in project planning, implementation, and monitoring to ensure buy-in, support, and long-term success.
- **Environmental Impact Assessment and Monitoring:** Conducting environmental impact assessments to evaluate and mitigate potential adverse effects of reforestation activities on local ecosystems, including water resources, wildlife habitat, and cultural heritage sites. Implementing robust monitoring programs to assess the progress, effectiveness, and ecological outcomes of reforestation efforts.
- The integration of these methods and disciplines ensures a holistic and multidisciplinary approach to *Pinus pinaster* reforestation, addressing ecological, socio-economic, and scientific considerations for achieving the set objectives.
- **Gender Analysis and Inclusivity:** Conduct a gender analysis to understand the roles, needs, and constraints of different genders in relation to the reforestation activities. Ensure inclusive participation of women, men, and diverse social groups in decision-making processes, planning, and implementation of reforestation projects.
- **Equitable Access to Resources and Benefits:** Ensure equitable access to resources, such as land, seeds, finance, and training, for all individuals regardless of gender or social background. Promote fair distribution of benefits from reforestation, such as income generation, employment opportunities, and environmental services.
- **Empowerment and Capacity Building:** Support the capacity building and empowerment of women, marginalized groups, and local communities through training, education, and skill development in various aspects of reforestation, from seed collection and nursery management to planting and maintenance.
- Implementing appropriate open science practices as an integral part of the proposed methodology for cluster pine reforestation involves fostering transparency, collaboration, and accessibility of data, methods, and findings. Here are some ways to incorporate open science practices in the cluster pine reforestation:
- **Open Access Publication:** Promote the dissemination of research findings related to cluster pine reforestation through open access publications. This ensures that scientific knowledge is freely available to researchers, practitioners, and the public, advancing transparency and promoting wider accessibility.
- **Open Peer Review:** Consider adopting open peer review practices for research related to cluster pine reforestation. Transparent peer review processes help ensure accountability, quality control, and constructive feedback from a broader scientific community.
- **Collaboration and Partnerships:** Foster collaboration and partnerships with other researchers, organizations, and stakeholders working on cluster pine reforestation. Encourage open collaboration, knowledge exchange, and shared decision-making processes to enhance the scientific and practical outcomes of the reforestation efforts.
- By implementing these open science practices, the cluster pine reforestation methodology can promote greater transparency, reproducibility, cross-disciplinary collaboration, and public engagement. This ensures the dissemination and utilization of scientific knowledge, ultimately improving the effectiveness and impact of the reforestation initiatives.
- To ensure the findability, accessibility, interoperability, and reusability (FAIR) of research data management and other research outputs for cluster pine reforestation, the following practices can be implemented.
- **Data Management Planning:** Develop a data management plan that outlines the data collection,

storage, documentation, and preservation strategies for cluster pine research. This includes specifying metadata standards, file formats, and data organization to enhance findability and interoperability.

- **Data Documentation and Metadata:** Provide comprehensive documentation and metadata for research datasets related to cluster pine reforestation. Clearly describe the data variables, collection methods, units, and any transformations or processing applied. Adopt standardized metadata schemes to improve discoverability and enable data integration with other research initiatives.
- **Data Storage and Sharing:** Store research data in reliable and secure repositories or platforms that support long-term preservation. Choose platforms that adhere to FAIR principles and offer access controls that balance openness with privacy considerations. Make datasets openly accessible or adopt controlled access mechanisms if necessary.
- **Data Publication:** Consider publishing research datasets related to cluster pine reforestation in open data repositories or data journals. Assign persistent identifiers (e.g., DOIs) to datasets to ensure long-term discoverability and citation. Cross-reference publications with associated datasets for improved accessibility and reusability.
- **Standardization and Interoperability:** Follow relevant standards and protocols for data formats, metadata, and vocabularies to enhance interoperability. Adhere to international conventions in taxonomy, taxonomy mapping, and nomenclature to prevent inconsistencies and support data integration across different cluster pine research projects.

Results and Discussion

Our planet gave us biodiversity. One of them is Cluster Pine, which, in addition to its ecological benefits, may have usage for the body. Pycnogenol is an herbal extract derived from the bark of the maritime pine tree (*Pinus pinaster*) and is commonly used as a natural remedy for a range of health conditions. These findings indicate that Pycnogenol shows promise as a possible treatment option for allergic asthma.

Evaluating the added value of restoration actions is an important aspect of assessing their effectiveness. When it comes to increasing or protecting ecosystem services, restoration actions can be evaluated based on the improvements they bring to various services such as water purification, soil fertility, carbon sequestration, and biodiversity conservation. For instance, if a restoration project successfully enhances water quality, supports pollinators, or improves habitat connectivity, it can be considered as adding value to ecosystem services [7-10].

Similarly, evaluating the impact of restoration actions on rare or potentially endangered plant species involves assessing whether these actions contribute to the conservation and recovery of such species. Restoration efforts can be deemed successful if they lead to an increase in the population size or distribution of these plants, improve their habitat quality or connectivity, or promote their long-term survival.

To evaluate the added value of restoration actions in both aspects, it is crucial to establish baseline data and monitor indicators before and after implementing restoration actions. Long-term monitoring can help assess the effectiveness of the restoration strategy and identify potential challenges or necessary adjustments for achieving desired outcomes. Additionally, involving experts, stakeholders, and local communities in the evaluation process can provide valuable insights and enhance the reliability of the assessment. At a minimum, address the following aspects:

Research on native species, especially *Pinus pinaster,* contributes to our understanding of ecosystem stability. The fate of every species is inextricably tied to the fate of all of us. I believe in our research outcomes. It will be pragmatic to conserve this part of the world forests. Our project goes beyond the state-of-the-art, and the extent to which the proposed work is ambitious. Our project on reforesting *Pinus pinaster* habitats goes beyond the state-of-the-art by incorporating innovative and holistic approaches. While traditional reforestation efforts primarily focus on planting trees, our project takes a more comprehensive approach towards habitat restoration.

- Firstly, we conduct a thorough analysis of the ecological conditions and factors that have led to the degradation of *Pinus pinaster* habitats. By understanding the underlying causes, we can develop targeted restoration strategies to address these issues effectively.
- Secondly, our project incorporates a strong emphasis on promoting biodiversity within the reforested habitats. We aim to create a balanced and resilient ecosystem by identifying and reintroducing native plant species that support a diverse range of flora and fauna.
- Furthermore, in addition to ecological aspects, our project also considers the socio-economic dimensions of reforestation. We engage local communities and stakeholders, providing them with necessary training and resources, while also creating opportunities for sustainable livelihoods through forest management and eco-tourism initiatives.
- **Licensing and Data Usage Agreements:** Apply appropriate licenses to research data to clarify and regulate their permitted use. Consider using open licenses that facilitate data sharing and reuse, such as Creative Commons licenses. When necessary, establish

data usage agreements for sensitive or restricted data.

- Ensuring quality supervision, training, and two-way transfer of knowledge between researchers and the host is crucial for promoting ecosystem stability of *Pinus pinaster*. Here are some considerations for achieving these goals:
- **Supervisor Expertise and Support:** Assign qualified and experienced supervisors who possess in-depth knowledge of *Pinus pinaster* ecology, reforestation techniques, and ecosystem stability. Supervisors should provide guidance, mentorship, and technical expertise to researchers throughout their study, promoting quality research and understanding of ecosystem dynamics.
- **Clear Research Objectives and Expectations:** Clearly define research objectives and expectations for ecosystem stability in *Pinus pinaster* reforestation. Ensure researchers have a solid understanding of the research goals, methodologies, and desired outcomes to guide their work effectively.
- **Regular Communication and Feedback:** Establish open and regular communication channels between supervisors and researchers. Hold regular meetings to discuss progress, address concerns, provide feedback, and offer guidance. Encourage an environment of constructive feedback and support to enhance the quality of research.
- **Training and Capacity Building:** Provide researchers with comprehensive training and capacity building opportunities related to *Pinus pinaster* reforestation and ecosystem stability. These can include workshops, seminars, field visits, and technical training on relevant topics such as forest ecology, soil management, biodiversity conservation, and sustainable forest management practices.
- **Fieldwork and Practical Experience:** Facilitate hands-on fieldwork experience for researchers to gain practical insights into *Pinus pinaster* reforestation and ecosystem stability. Allow them to actively participate in planting, monitoring, and managing *Pinus pinaster* stands. This practical experience enhances their understanding and ability to implement effective strategies for ecosystem stability.
- **Knowledge Sharing and Dissemination:** Encourage researchers to share their findings, methodologies, and experiences through scientific publications, conferences, workshops, and other knowledge-sharing platforms. This promotes the two-way transfer of knowledge between researchers and the host, allowing for feedback, collaboration, and the integration of local knowledge for ecosystem stability.

To address this, I would need to evaluate and articulate how the project's outcomes and outputs are expected to have a significant positive influence on scientific advancements, societal well-being, and economic growth. I could discuss factors such as the project's potential to generate new knowledge, improve existing technologies or methodologies, contribute to social development, address environmental challenges, create job opportunities, stimulate economic sectors, or enhance the overall quality of life.

Overall, the question is prompting an analysis and description of how the project's activities and results are anticipated to make a substantial and meaningful impact across various domains: scientific, societal, and economic [11].

Cluster pine, also known as *Pinus pinaster,* is a species of pine tree that is commonly found in Mediterranean regions. It is characterized by its cluster or groupings of pine needles, hence the name. Cluster pines are well-adapted to dry and sandy soils, and they have become an important species in reforestation and afforestation efforts [12].

Cluster pines have both ecological and economic significance. Ecologically, they help stabilize sandy soils, prevent erosion, and provide habitat for various wildlife species. They are also known for their ability to tolerate harsh coastal conditions, making them valuable in coastal dune ecosystem restoration projects.

Economically, cluster pines have been cultivated for timber production and resin extraction. Their strong and durable wood is used in construction, furniture making, and paper production. Additionally, their resin is used in the production of varnishes, adhesives, and solvents.

The cultivation and management of cluster pine forests play a crucial role in supporting local economies, providing employment opportunities, and contributing to sustainable land use practices. However, it is important to carefully manage these forests to ensure their long-term ecological integrity and mitigate the risk of wildfire outbreaks, as cluster pine forests are prone to fire due to their resinous nature.

Overall, cluster pine is a versatile and valuable tree species with significant ecological and economic impacts in Mediterranean regions.

To evaluate the quality and effectiveness of the work plan on *Pinus pinaster* plantation, it is essential to assess several aspects.

Firstly, the work plan should clearly outline the objectives, tasks, and timeline for the plantation project. It should specify the management practices, such as site preparation, seedling selection and planting techniques, watering and fertilization

schedules, and ongoing maintenance activities.

The work plan should also consider potential risks and challenges associated with *Pinus pinaster* plantation. This includes assessing the susceptibility to pests, diseases, and natural disturbances like wildfires or extreme weather events. Strategies for risk management, such as pest control measures and fire prevention plans, should be incorporated into the work plan.

Effective allocation of efforts within work packages is crucial for the success of the project. This involves ensuring that tasks are appropriately assigned to the individuals or teams with the necessary skills and expertise. The work plan should also account for resource availability, including manpower, equipment, and financial resources, to ensure the feasibility of implementing the plan effectively [13,14].

Regular monitoring and assessment of the work plan's progress and outcomes are important to identify any necessary adjustments or improvements. This can be done through periodic evaluations, data collection on growth rates and survival rates, and comparison with predefined performance indicators.

Ultimately, the success of the work plan on *Pinus pinaster* plantation relies on its ability to achieve the desired objectives, manage associated risks effectively, and ensure the appropriateness and efficiency of efforts assigned to work packages.

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