LIFE REFOREST LAYMAN´S REPORT

LIFE REFOREST - LIFE17 ENV/ES/000248
WITH THE CONTRIBUTION OF THE LIFE FINANCIAL INSTRUMENT
OF THE EUROPEAN COMMISSION

LIFE REFOREST
RECOVERING ECOSYSTEMS

Title of the project: Erosion prevention and flora REstauration of burnt FOREST areas through innovative fungal-technosol solution

Code: LIFE17 ENV/ES/000248

Duration: 01/07/2018 – 31/03/2022

Total budget: € 1,577,648

EU contribution: 937,037 €

1 EXECUTIVE SUMMARY

1. Executive summary

LIFE REFOREST is a project funded by the European Commission under the LIFE programme and led by the Multisectoral Research Technology Centre (Centro Tecnológico de Investigación Multisectorial - CETIM), whose main aim is to mitigate the impact caused by erosion and soil loss in areas affected by forest fires, through the application of a new system based on technosoils made from organic waste stabilized and inoculated with fungal species.

The project developed a system of tubular mycotechnosoil sleeves that were installed in 3 pilot areas (> 400m2) in Galicia and Portugal, two of the regions most affected by forest fires in the European Union.

The three pilot areas were assessed between 2019 and 2022, monitoring the erosion produced and the characteristics of both the eroded sediments and run-off water and the evolution of the affected areas. The results obtained showed a rapid regeneration of the vegetation cover, significantly reducing the run-off water generated and reducing erosion by 75%-80% compared to untreated areas.

2 THE PROBLEM

2. The problem

Forest fires annually affect more than 270,000 ha in the EU, of which more than 80% are concentrated in the Mediterranean region, causing a major economic and environmental impact[1].

Situation in Portugal and Spain

Portugal is the most affected country, with an annual average of more than 138,000 ha burned in the last decade, with 2017 being of particular mention, with a severity never recorded before in which more than 400,000 ha[2], were affected, due in part to large fires, one of the most important ones being in its central area, which devastated 53,000 ha and caused 66 deaths[3].Its cost was estimated at between €200 M and €1,000 M, which would represent between 20% and 80% of the economic benefit of forestry production. The loss and subsequent recovery was estimated at €3,500/ha[4].

In Spain, although forests account for 10% of the territory[5], there is an average affected area of 108,000 ha, with Galicia (North-west Spain) being one of the most relevant areas, where fires already cause average financial losses of €330,000/year, to which must be added the cost of post-fire work, estimated at €1,500-€2,000 /ha[6].

The frequency of large-scale forest fires is undermining the ability of ecosystems to regenerate naturally. Soil erosion, water scarcity and loss of biodiversity threaten the ecological stability of large areas. In addition, the effects of climate change are causing intense summer droughts, as well as extreme meteorological phenomena that increase the risk of fires.

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1 Viegas (2009). JRC Sci. Tech. Rep.

2 INPI 2022 Patentes e controlo de incêndios rurais

3 Alberti, B. M. (2018, 15 junio). Portugal's wildfire that broke a community. BBC News. https://www.bbc.com/news/world-europe-44438505

4 Mateu & Fernandes (2014). Forest fires in Portugal: dynamics, causes and policies.

5 Barreiro et al. (2016). Soil Biol. & Biochem. 97: 102-111.

6 Salas (2014). Aproximación a la consideración de los problemas ambientales más relevantes de la Península Ibérica: incendios forestales

Effects of fire on the soil

Erosión

Fire destroys or reduces organic matter, breaking the soil aggregates, which together with the disappearance of the vegetation cover, exposes the soil to erosion due to water and wind. In addition, it profoundly modifies the chemical and microbiological composition of the soil, affecting its properties.[7]

The effects depend largely on the severity of soil burning, topography and the occurrence of hydrological events[8].

Erosion especially affects rainy areas, as is the case in north-western Spain and Portugal. In Galicia, fires in autumn 2006 eroded some 34,000 tons of soil, of which 10% ended up in the sea[9]. This resulted in losses of around 14.5 tons of hectares, according to the Ministry of Agriculture and Fisheries, Food and Environment (Mapama).

Deterioration of water quality

In addition to changes in soil characteristics, another important effect of forest fires is the deterioration of water quality. Storm water following wildfires can contaminate watercourses and lakes with ash and other toxic elements. This ends up affecting the living beings in those areas, and may even threaten the supply of drinking water in the affected areas.

Mitigation techniques

Post-fire recovery time in the Mediterranean is estimated at 5 to 10 years[10]. At present, there is a lack of highly efficient solutions to cope with rainfall triggered ash entrainment, so mitigation techniques are the first line of defence against erosion. These should be applied urgently after the fire, since most losses occur during the first months after the fire.

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7 Barreiro (2016). PhD Thesis. University of Santiago de Compostela.

8 Robichaud et al. (2014). Int. J. Wildland Fire 23: 929–944

9 Carballas et al. (2009). Efecto de los incendios forestales sobre los suelos de Galicia

10 Inbar et al. (1998). Geomorphology 24: 17–33

The main mitigation techniques used are:

Sowing: This is the oldest and most common treatment. Aerial seeding of annual or perennial grasses is used to provide ground cover until native plants are re-established.

Mulching: Mulch is any organic material spread on the soil surface that increases soil cover and reduces the impact of raindrops and run-off. Both hydromulch and dry mulch (wheat straw, rice straw, wood strands, wood fibre, etc.) can be applied from the air or on the ground.

Erosion barriers: They can be made of straw, level felled logs or other natural barriers. Engineering structures are also used to provide mechanical barriers to overland flow, to promote infiltration and trap sediment on burned slopes.

Polyacrylamides (PAM): Mitigation technique in the form of dry granules[11] consisting of the use of flocculating agents.

11 Prats et al. (2014). CIG 40 (2): 403-427

3 THE SOLUTION

3. The solution

LIFE REFOREST aims to mitigate the impact caused by forest fires, reducing erosion, recovering organic matter and the ecosystem and, consequently, minimising the serious socio-economic and environmental impacts caused by fires.

The application of an artificial soil (technosoil) made from stabilized organic residues and by-products, inoculated with different species of fungi (mycotechnosoil), is proposed for the above, in order to mitigate soil loss and favour the natural regeneration of the burned areas.

This solution is applied in the form of biodegradable tubular net sleeves (approx. 1.5 m long) which are easy to transport and place in difficult to access terrain. They function as a bioactive barrier, slowing surface run-off and favouring infiltration and sedimentation of particles carried upstream. Meanwhile, the development of the mycelium of the fungus gives structure to the soil, recovering its environmental and productive functions.

In addition, the mycotechnosoil provides organic matter and nutrients, and includes seeds of local plants to encourage rapid development of vegetative cover, promoting water retention and minimising downstream contamination from ash entrainment.

4 CONSORTIUM

4. Consortium

The LIFE REFOREST consortium is composed of the Multisectoral Research Technology Centre (Centro Tecnológico de Investigación Multisectorial - CETIM) as coordinator, the Galician Forestry Association (AFG), the Portuguese Forestry Association (FORESTIS), the Galician companies TEN Tecnosuelos, Hifas da Terra (HdT), INDUTEC Ingenieros and the Environmental and Marine Research Centre (Centro de Investigación Medioambiental y Marina - CESAM) of the University of Aveiro (UAVR).

CETIM: In addition to leading the project, it carried out the characterisation of the flow of burned areas in Galicia and northern Portugal and collaborated with TEN in the formulation of technosoil at laboratory scale and in assessing the effectiveness of the mycotechnosoil. It also coordinated the transferability and replicability of the results, as well as the dissemination and monitoring of the project.

AFG and FORESTIS: They selected the burned areas, providing technical information on the managed forests, sampling and monitoring the fires. They also took the administrative steps to expedite the installation of pilots in Galicia and northern Portugal.

INDUTEC: Analysed the data provided by the other partners, evaluated the environmental impact of the new solution, prepared the life cycle analysis (LCA) and was responsible for analysing the associated economic costs (LCC).

HdT: Conducted the laboratory-scale study and selection of fungal strains, as well as producing fungal cultures for inclusion in the final mycotechnosoil formulation.

TEN: Was in charge of formulating different technosoils and selecting, together with HdT, the mycotechnosoils that were applied as a solution.

UAVR-CESAM: Carried out the characterisation of the burned areas in the sites where the pilots were implemented and together with TEN, HdT and CETIM validated the effectiveness of the LIFE REFOREST system on soil erosion and run-off water pollution, assessing its future replicability in other areas affected by fire in Europe.

5 PROJECT RESULTS

5. Project Results

Life Reforest Pilots

The LIFE REFOREST project has three pilots installed in Galicia and Northern Portugal.

	Pilot 1	Pilot 2	Pilot 3
Location	Nespereira, in Pazos de Borbén (Pontevedra, Galicia, Spain)	Albergaria (Aveiro, Portugal)	Penouços (Sever do Vouga - Aveiro, Portugal)
Characteristics of the area	Granite-derived soil, Pine forest stand	Shale soil, eucalyptus forest stand	Shale soil, young pine forest stand (previous fire in 2015)
Fire	14-15/09/2019 10 ha	5-7/09/2019 1492 ha	7-15/09/2020 2149 ha
Description of the pilot	2x8 m plots 3 plots with Geotubes 4 m apart 3 plots with Mulch of pine needles 3 plots without treatment	2x8 m plots 3 plots with Geotubes 4 m apart 3 plots with Eucalyptus bark mulch 3 plots without treatment	2x8 m plots 3 plots with Geotubes 8 m apart 3 plots with acacia waste mulch 3 plots without treatment

Following the monitoring of the 2019 fires and in order to select areas at risk of erosion due to fire intensity, lack of vegetation and moderate slope, two areas were selected, one in Galicia and the other in Portugal. These were continuously monitored to assess the amount of soil mobilised during rainy periods, as well as to study the characteristics of the run-off water produced during these episodes (suspended solids, nutrients, metals, etc.)

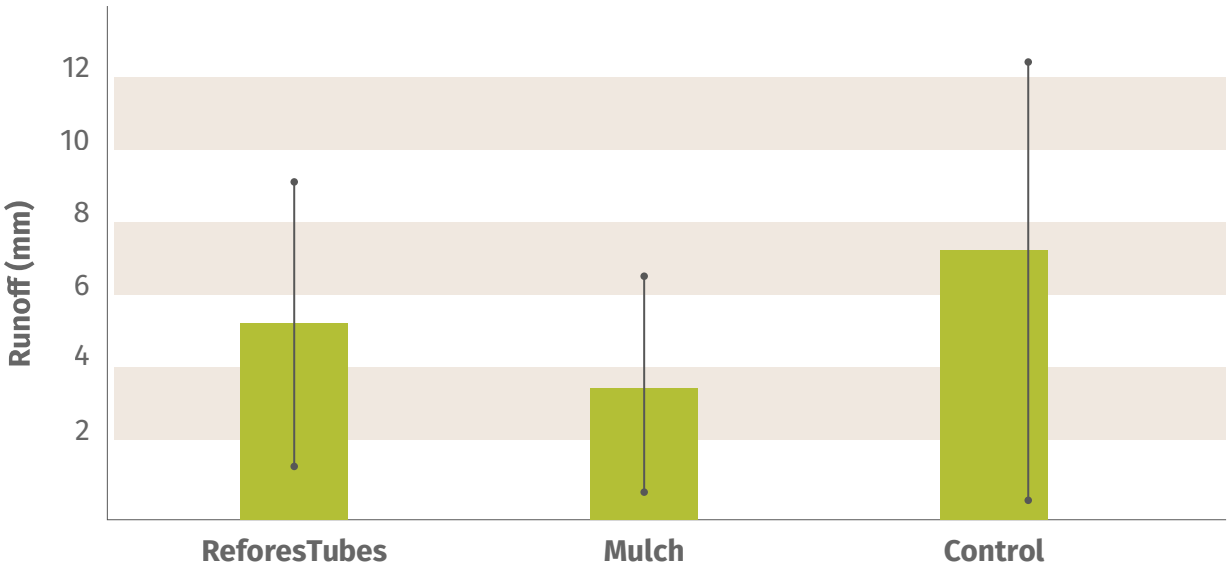
The aim of the third pilot was to validate the system under conditions different from those of the first two cases. The Penouços area, in Aveiro, has the peculiarity that in addition to the 2020 fire, it had already suffered the effects of fire in 2016. This meant a scenario in which the planted pines were still very young and spontaneous recovery of the area was practically impossible.

Pilot area monitored by AFG in Nespereira (Pazos de Borbén - Pontevedra) and by FORESTIS in Albergaria-a-Velha (Aveiro, Portugal)

FORESTIS pilot area in Albergaria-a-Velha (Aveiro, Portugal)

Photographs of the Nespereira pilot in October 2019. (On the left the geotubes; in the middle the mulch and on the right without treatment)

Photographs: of the Albergaria-a-Velha pilot: left - October 2019; right - February 2020.

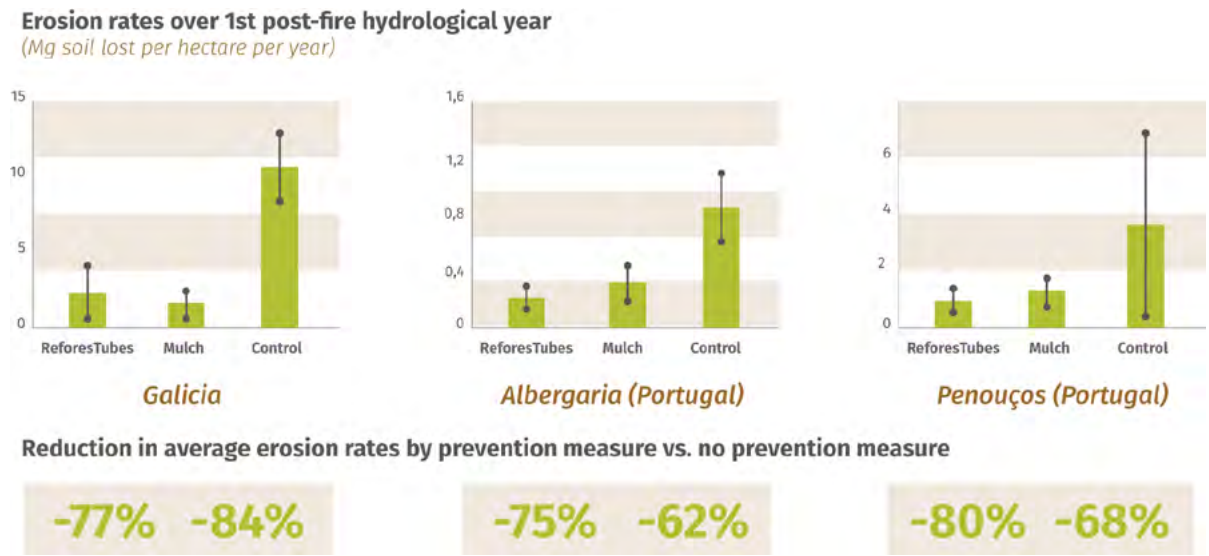


Mean value of run-off on the plot with the LIFE-REFOREST treatment mycotechnosoils (ReforesTubes), shredded eucalyptus bark mulch (Mulch) and untreated (control), after the first post-fire year in the Albergaria-a-Velha pilot.

Installation area of the LIFE REFOREST pilot in Nespereira (Pontevedra, Galicia)

LIFE REFOREST pilot installation area in Albergaria (Portugal)

Installation area of the third LIFE REFOREST pilot in Oliveira de Frades, Portugal (above) and detail of the installation on the selected hillside (below).



Project Results

The REFOREST solution has been able to reduce soil losses during the first post-fire year by 75%-85%, in addition to obtaining efficiency similar to that of traditional total surface cover treatments, with pine needles or wood debris (mulch).

Soil losses during the first post-fire year in the untreated areas ranged from an average of 1 Mg ha-1 in Albergaria to 11 Mg ha-1 in Nespereira, reducing in the following year to 0.7 Mg ha-1, while both treatments proved to maintain their efficiency in the second year.

Importantly, the reduction in the rate of geotube application in Penouços proved to be as effective as in the other two pilots. The technosoils also proved to be effective obstacles in controlling surface run-off, reducing it by 25% to 90%, which is especially relevant to promote the sedimentation of eroded soil on the top slopes.

In terms of water quality, a significant improvement was achieved with respect to untreated plots, reducing turbidity levels (21%-24%), total solids (10%-38%) and suspended solids (22%-54%) and organic matter content (25%-41%).

Another aspect to highlight is that the composition of the technosoil and the inclusion of seeds have facilitated the development of vegetation cover in its areas of application.

Other tasks performed

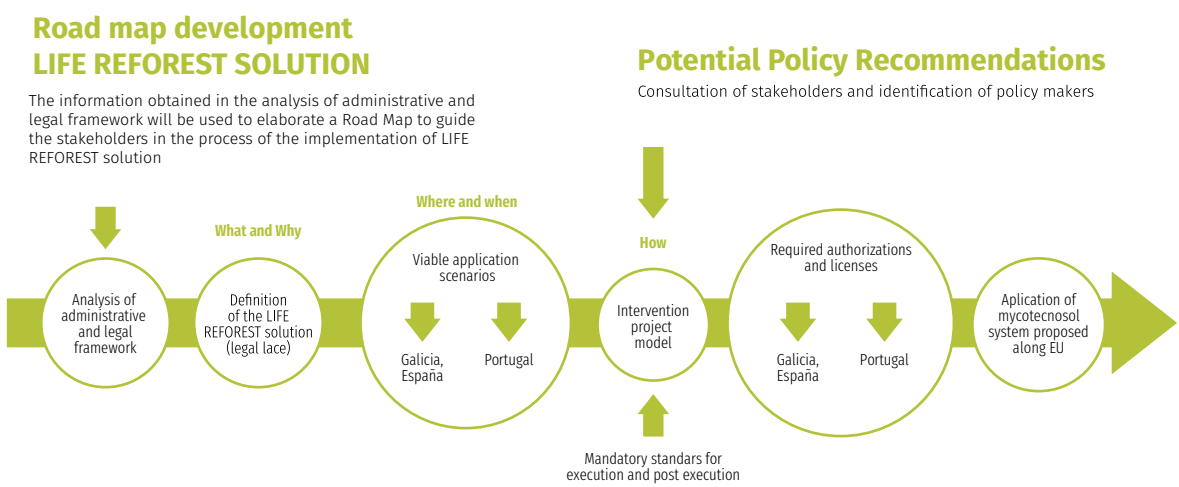
Analysis of the environmental and economic impact of the solution:

In parallel to the technical validation of the solution, a life cycle analysis was carried out to assess the environmental impact and analyse the economic costs associated with the implementation of the new solution.

Application and transfer guides:

The project consortium has produced different guides that help to replicate and transfer the system to other burned geographical areas in Europe, and that facilitate their immediate post-fire application. In addition, the regulatory and administrative framework at regional, national and European level for the commercialisation and field installation of the final product has been analysed.

In this sense, except in protected areas or areas affected by heritage, it will not be necessary to request authorisation for the application of REFOREST Solution, if it is considered a fertilizer product.



6 LIFE REFOREST EVENTS

6. Life Reforest Events

Tipe of event	Date	Title	Organising partner	Venue	Number of attendees
Seminar	16/01/2019	Post-fire management and soil erosion mitigation in Portugal.	UAVR	Aveiro	82
Seminar	05/03/2020	LIFE REFOREST Seminar	TEN	A Coruña	43
Workshop	14/07/2021	LIFE REFOREST solution: Erosion Prevention and Restoration of Burned Areas	FORESTIS	Sever do Vouga	11
Seminar	03/12/2021	World Soil Day	UAVR	Online	66
Workshop	09/12/2021	LIFE REFOREST Workshop - Nespereira	AFG	Ponteareas	26
Final Event & Seminar	30/03/2022	Final project event // The new EU forestry strategy	CETIM	Santiago de Compostela	37 on-site 41 online 78 total

7 PROJECT PUBLICATIONS

7. Project publications

Serpa, D., J. Keizer, J., I. Machado, A., Santos, M., R. F. Oliveira, B., Gholamahmadi, B., Martins, M., González-Pelayo, O., & Consortium, L. R. (2020). Testing a novel technique, geotubes with mycotechnosoil, to mitigate post-fire erosion and enhance ecosystem recovery. EGU General Assembly 2020. https://doi.org/10.5194/egusphere-egu2020-20618

Serpa, D., I. Machado, A., Santos, M., Campos, I., R. F. Oliveira, B., Gholamahmadi, B., Martins, M., González-Pelayo, O., Jesus, F., Keizer, J., Abrantes, N., & Consortium, L. R. (2020). Post-fire mobilization of metals and polycyclic aromatic hydrocarbons in a recently burnt eucalypt stand in North-Central Portugal. EGU General Assembly 2020. https://doi.org/10.5194/egusphere-egu2020-19102

Serpa, D., Machado, A., Santos, M., Campos, I., Jesus, F., Oliveira, B., Gholamahmadi, B., Martins, M., González-Pelayo, O., Jacob Keizer, J., Abrantes, N., & Consortium, L. R. (2021). Post-fire mobilization of metals in a recently burnt area in North-Central Portugal: a contamination risk for waterbodies? EGU General Assembly 2021. https://doi.org/10.5194/egusphere-egu21-4929

Machado, A. I., Oliveira, B., Serpa, D., Santos, M., Jesus, F., Xavier, A., Gholamahmadi, B., Martins, M., González-Pelayo, O., Keizer, J. J., & Consortium, L. R. (2021). Geotubes vs. mulching for post-fire erosion mitigation in eucalypt vs. pine plantations in Central Portugal vs. Galicia. EGU General Assembly 2021. https://doi.org/10.5194/egusphere-egu21-12454

Asociación Forestal de Galicia. (2019). Proxecto Europeo Life Reforest. O Monte, 61 (Ano XXXII), 41. https://asociacionforestal.gal/novidades/revista-o-monte/

Asociación Forestal de Galicia. (2019). Life Reforest comienza la validación de sus pilotos. O Monte, 62 (Ano XXXII), 42. https://asociacionforestal.gal/novidades/revista-o-monte/

8 ACKNOWLEDGMENT TO THE COLLABORATING ENTITIES

8. Acknowledgment to the collaborating entities

Government representatives and public authorities. Dialogue and commitment were established to disseminate the results of the LIFE REFOREST solution and to inform them of the public recommendations resulting from the LIFE REFOREST project.

Forestry associations and groups, private forest owners and community forestry

The Research, Scientific and Technological Community specialised in soil, territory, forestry and ecology. LIFE REFOREST has promoted technical and scientific discussions at the events. Researchers and engineers from different organisations have actively participated.

Other projects. LIFE REFOREST partners have identified other initiatives both nationally and internationally. The organisations behind these projects were invited to participate in the project's various seminars and workshops.