DRYAD

Nature-based solutions for sustainable Mediterranean agrosilvopastoral ecosystems and landscapes

Nature-based Solutions (NbS) are actions to protect, manage and restore natural or modified ecosystems, addressing societal challenges and providing human well-being and biodiversity benefits. In the DRYAD project, we are developing and implementing real-life, climate-resilient NbS to improve the economic and environmental sustainability of Mediterranean agrosilvopastoral ecosystems in Europe, supporting the European Union's Mission on Adaptation to Climate Change. This document describes a selection of these solutions, aiming to address specific challenges relating to one or several of these themes: water, biological resources (biodiversity), and soil, and in all cases, enhancing climate resilience.

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1. Drainage and ditch systems

Contour ridge tillage (excavation along contour lines, with the ditches being able to be filled with vegetation residues from tree pruning and bush clearing) and/or keylines (deep digging of contour lines every 10-20 m in the cropland and grassland slopes). The Keyline system consists of a set of lines sloped 1% - 3% relative to the contour lines, allowing rainwater to naturally redistribute from the valleys to the ridges. These solutions especially help improve soil water retention, infiltration, and distribution along the watershed slopes, in addition to increasing soil carbon.

Source: Life Montado Adapt

Keylines and Yeomans (chisel) plow. Source: Life Montado Adapt

Keylines and plantation in contour ridge tillage. Source: Life Montado Adapt

2. Dry retention structures

Retention and storage infrastructures (dry dams, leaky dam systems, and infiltration swales) promote deep infiltration during periods of high rainfall. *Dry dams*, also known as a detention basin, retain and store water temporarily, mainly during periods of heavy rainfall, allowing it to gradually infiltrate into the ground. This infrastructure helps to manage storm water, prevent flooding, and replenish groundwater recharge. *Leaky dams*, mimic the natural obstruction caused by trees and branches falling into the river, following principles of natural flood management, to store water in the landscape, intercept rainfall and/or slow the rate of runoff. *Infiltration swales* are a shallow grassed or vegetated channel designed to capture, detain and treat stormwater and convey larger flows. It takes surface flows from adjacent slopes, clearings, or less permeable soils, holds the water behind weirs, and allows it to infiltrate through the soil bed into underlying soils. All these solutions especially help improve water retention, infiltration, and storage, decrease run-offs, soil erosion, and sediment loads; and improve soil quality.

Source: Life Montado Adapt

Dry dam. Source: Green Tec Irrigation

Leaky dams. Source: The Flood Hub

Infiltration swales. Source: Ferguson et al. (2020)

3. Artificial ponds

Artificial ponds, as opposed to dry dams, maintain a constant water level throughout the year because they are hydraulically connected to the groundwater table. This allows for the sustainable management of water resources, especially during dry periods, and supports local biodiversity by providing a stable aquatic habitat.

Source: Life Montado Adapt

Artificial pond. Source: Anastasia Pantera (AUA, Greece). Dryad Project

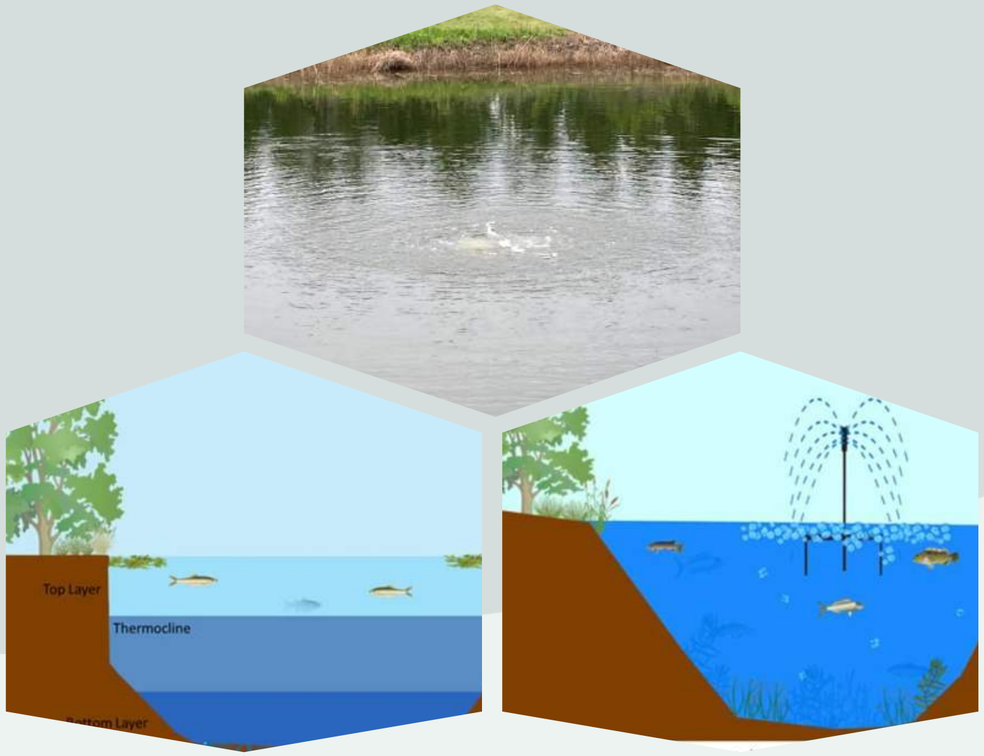
Artificial pond. Source: Herdade da Coitadinha (Portugal). Dryad Project

4. Practices to improve water quality

Practices to prevent deterioration of the quality of water bodies include vegetation buffer strips to filter and reduce pollutants in runoff areas, the installation of perimeter fences to protect riverways and ponds from cattle, the provision of watering troughs, and the placement of artificial fountains to increase the dissolved oxygen contents in the ponds.

Source: Life Montado Adapt

Natural fences. Source: Anastasia Pantera (AUA, Greece). Dryad Project



Artificial fountains. Source: Howley et al.

5. Natural habitat islands and landscape elements

Creation and maintenance of natural habitat islands (shrubs, wet areas, wooded areas) or other elements that serve as a refuge for wild animals and increase biodiversity, acting as safe havens for wildlife, offering shelter, food sources, and breeding grounds, particularly in areas where natural habitats may be fragmented or under threat.

Source: Life Montado Adapt

Natural islands after grazing exclusion. Source: Adriana Silva (LTsER – Companhia das Lezírias, Portugal). Dryad Project

Natural islands. Source: Anastasia Pantera (AUA, Greece). Dryad Project

6. Tree and shrub planting in grasslands and arable land

Planting of trees and shrubs in open areas (on agricultural land and non-wooded pastures). Planting trees and shrubs in open areas of agricultural land and pastures increase soil carbon content and has positive effects on the water cycle and biodiversity. By capturing carbon from the atmosphere, they contribute to climate change mitigation, while their root systems improve soil structure and water infiltration. Additionally, they can create microclimates that benefit surrounding crops and livestock, leading to more resilient and sustainable farming systems.

Source: Life Montado Adapt

Planting quercus tree. Source: Fco. Bruno Navarro (IFAPA, Spain). Dryad Project

Planting of Tagasaste *as fodder bank in agricultural lands. Source: Víctor Rolo (UEx, Spain)*

7. Protection of regenerated trees and shrubs

Reconcile grazing with tree protection through tree shelters and temporary fences. This helps prevent damage to young trees and plants caused by herbivores while allowing for sustainable grazing practices. The shelters and fences provide a protective barrier, ensuring that plant growth is not hindered, which supports both biodiversity conservation and the sustainable use of land.

Source: Life Montado Adapt

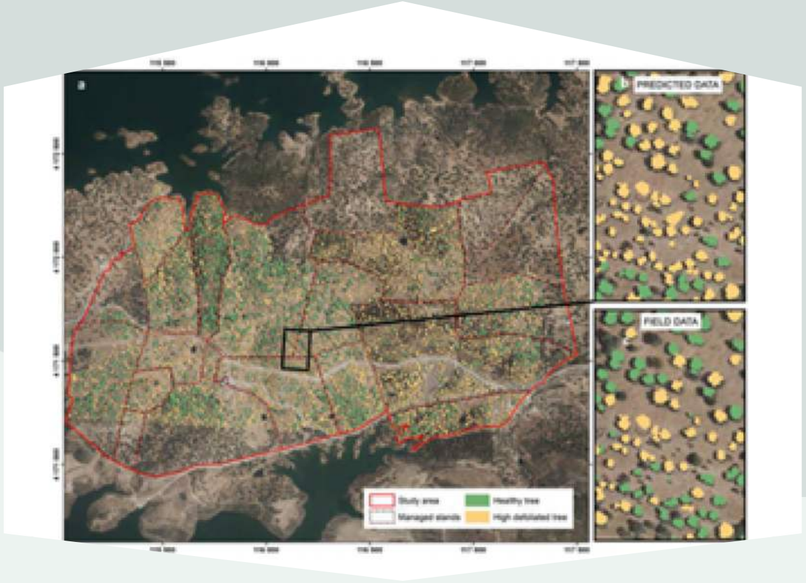
Protected regenerated Quercus spp. tree.
Source: J.R. Ramos (Valle de Alcudia Natural Park, Spain)

Protected oak seedling under a shrub. Source: Víctor Rolo (UEx, Spain)

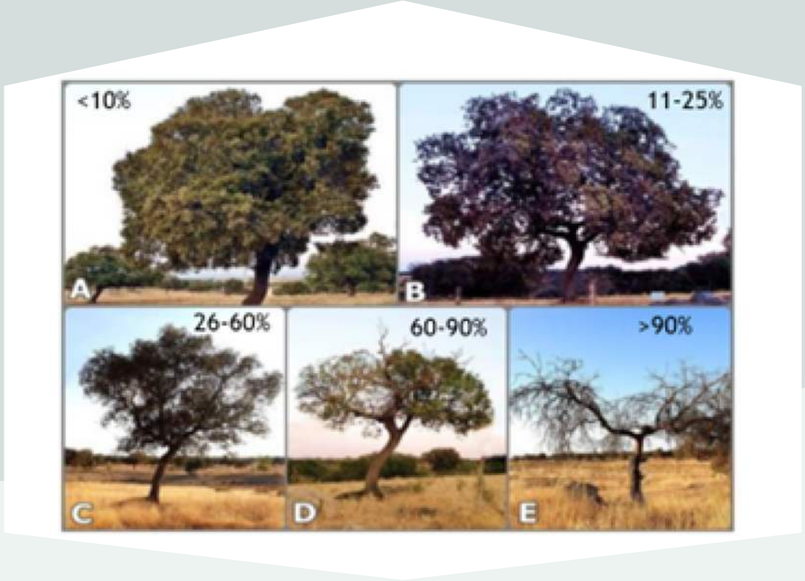
8. Early detection of tree mortality

Assessment of tree health and mortality using specific sensors, satellite images, multispectral images captured by drones, ecological models, and composite risk indices. These methods enable the early identification of tree stress and disease, allowing for timely intervention and management. By monitoring key indicators of tree health, such as changes in foliage, water stress, and environmental factors, it is possible to detect issues before they lead to widespread mortality, helping to protect forest ecosystems and improve forest management strategies.

Source: Life Montado Adapt



Early detection of tree mortality. Source: Navarro-Cerrillo et al. 2019



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9. Real-time livestock monitoring

Use of collars with sensors to monitor livestock in real-time. These collars, equipped with LoRaWAN technology, allow for the continuous tracking of the animals' location, health, and behaviour. This system enables farmers to gather data on the livestock’s movements and well-being, improving herd management, preventing loss, and ensuring better animal welfare. The real-time monitoring also helps optimize grazing practices and detect potential health issues early.

Source: Dryad working group

Detail of radio collars and related app. Source: Digitanimal

10. Fire prevention

Fuel load (biomass) management in fire-prone areas involves the strategic reduction of combustible vegetation through techniques such as selective pruning, thinning, aeration, and controlled grazing. These interventions are part of fuel management strip strategies aimed at disrupting the horizontal and vertical continuity of combustible materials by altering the structure and composition of vegetation. In doing so, landscape resilience to wildfire is enhanced, reducing fire intensity and spread. Fuel treatments include mechanical or manual biomass removal, as well as targeted herbivores, such as grazing, to limit the accumulation of flammable material.

Source: Dryad working group

Thining and pruning of trees in Mediterranean agroforestry systems. Source: UNISS (Italy). Dryad Project

11. Regenerative rotational grazing

Rotational grazing practices designed to improve soil health and plant diversity. In this system, animals are moved between pastures (paddocks) on a regular basis, seeking to mimic natural grazing dynamics and allowing each area to rest and regrow, which improves soil health, pasture productivity, animal health and enhances biodiversity.

Source: Life Montado Adapt

Rotational grazing. Source: Gonzalo Palomo (INDEHESA-UEX, Spain). Dryad Project

12. Biochar

Use of biochar (charcoal obtained by the pyrolysis of biomass) to increase water retention in the soil. Biochar improves soil structure by increasing porosity, which helps retain moisture and nutrients. It also enhances soil fertility, promotes beneficial microbial activity, and reduces soil acidity. By retaining water in the soil, biochar reduces the need for frequent water addition, making it particularly useful in drought-prone areas. Moreover, it sequesters carbon in the soil, contributing to climate change mitigation.

Source: Life Montado Adapt

Biochar at the dehesa farm gate. Source: LIFE Regenerate

Pile of biochar mixed with manure. Source: Víctor Rolo (UEx, Spain)

13. Biodiverse grass seed sowing

Sowing of diverse grass seeds in grasslands rich in legumes to improve vegetation cover without tillage. By using a mixture of various species and plant varieties, it is possible to create pastures that are more resilient to weather variations, such as drought and extreme temperatures. These pastures are also better adapted to different soil types, even within the same plot of land. The diversity of plant species enhances soil health, improves water retention, and promotes biodiversity. This approach reduces the need for external inputs, such as fertilizers and pesticides, while supporting sustainable grazing and improving overall pasture productivity and resilience.

Source: Life Montado Adapt

Biodiverse grassland sowing. Source: Ana Hernández Esteban (UEX, Spain). Dryad Project

14. Restore natural water courses

Restore natural water courses, water bodies, riparian zones and their connectivity for the better functioning of water cycle to provide habitat for aquatic species and improve water quality. Additionally, the use of riparian species to protect wetland areas and conserve watercourses has a positive effect on the overall improvement of the soil and its water flows, allowing larger areas of land to fulfil their productive role and act as carbon sinks.

Source: Life Montado Adapt

Natural water courses restauration. Source: Cañada Real de la Plata (Spain). Dehesa de la Luz (Spain)

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