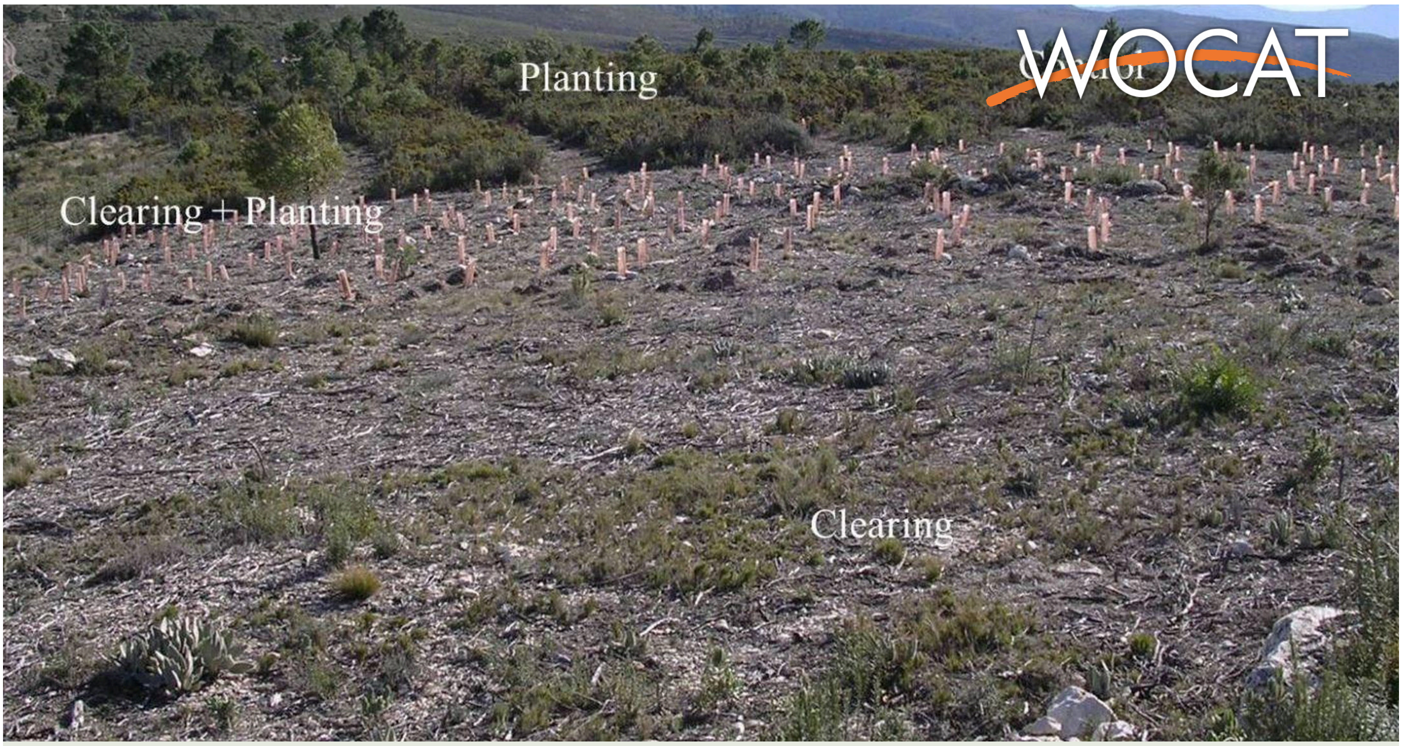


Different vegetation treatments were examined on four plots in three study sites. 1)Control (no action), 2)clearing, 3)clearing and planting, and 4)planting within the shrubland. (CEAM)

Selective clearing and planting experiment to promote shrubland fire resilience (Spain)

Experimento para aumentar la resiliencia del matorral contra incendios (Spanish)

DESCRIPTION

The combination of clearing of fire-prone seeder species and planting of more fire resistant resprouter species directs the vegetation to later successional stages which increases the resilience to fires.

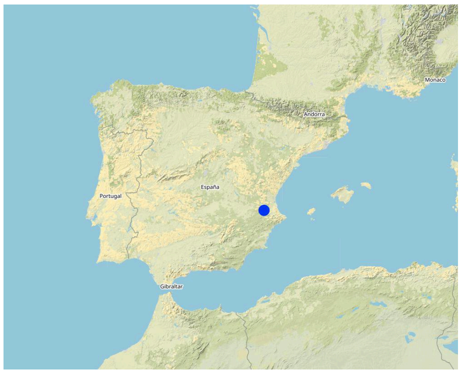
The forests and shrublands in Ayora experienced a series of disturbances in the past (such as deforestation and land use), which resulted in the degradation of the vegetation and the reduction of the resilience to fires. At present, there is a high fire incidence. Post-fire landscapes regenerated with a high and continuous fuel accumulation with few native resprouter species. Therefore appropriate vegetation management is crucial.
For management the major goals are to reduce the fuel load and its continuity and to increase the resilience of the vegetation to fires. Within this experiment carried out by CEAM (Centro de Estudios Ambientales del Mediterráneo, University of Valencia) different fuel management techniques were examined. They selected three study sites (Morera, Roñoso, Gachas) with a similar history of land use, vegetation composition, soil characteristics, and a typical post-fire scenario whith scarce occurrence of resprouter species. In each site, four plots were established to test the effect of the following management techniques: 1) control (no action), 2) clearing, 3) planting (within the shrubland) and 4) the combination of clearing and planting.

The main purpose of this experiment was to find out which management technique is the most appropriate to prevent fires and it was shown that the combination of selective clearing of fire-prone shrubs (fuel control) and planting of more resistant resprouter species can increase the resilience to fires and is therefore a suitable management practice. Compared to the other management techniques, there are some advantages. Clearing the vegetation (either by hand or mechanically) reduces the fire risk and enhances seedling establishment and growth. Furthermore, the cleared vegetation is chipped and applied in-situ as mulch, which protects the soil from erosion, reduces soil temperature and moisture loss, and enhances carbon conservation. Additionnally, selective clearing allows to preserve desired species and by planting resprouter species the natural processes can be accelerated. Once established, resprouter species persist for a long time which promotes an increase of the vegetation resilience.
In this documentation, only the combination of clearing and planting is evaluated since this action is considered as the most appropriate management practice.

In each study site, the experimental area covered about 5000m2 (3 plots of 1000m2 each, one plot of 2000m2). To test the effect of the combination of clearing and planting, a clearing machine was used to clear a plot of 1000 m2 in all three sites. The few resprouting individuals such as Juniperus oxycedrus and Quercus ilex and also some seeder trees such as Pinus halepensis and Pinus pinaster were left standing. The planting holes (0.35 m2) were created with a tractor using a backhoe. The slash and brush chips generated by the clearing were reused in the planting holes as mulch which resulted in ecological benefits.
In February 2003, native resprouters of late successional stages with a low amount of dead fuel were planted, such as Quercus ilex, Rhamnus alaternus and Pistacia lentiscus, all protected by a plastic tree shelter to prevent browsing.
The seedlings were grown for 8 months in a nursery in Santa Faz (Alicante) and then transferred to a nursery in La Hunde (Ayora) one month before planting. The Regional Forest Services of Valencia provided seeds as well.

The region of Ayora is mountainous with a dry subhumid climate (~380 mm annual rainfall). The risk of fire incidence is at its highest from June to September when there are adverse conditions like drought, high temperatures and strong winds (mainly the winds coming from central Spain, called “poniente”). The population density is very low and there are only few job

LOCATION



Location: Ayora, Spain, Valencia, Spain

No. of Technology sites analysed:

Geo-reference of selected sites
- -0.89167, 39.03278

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

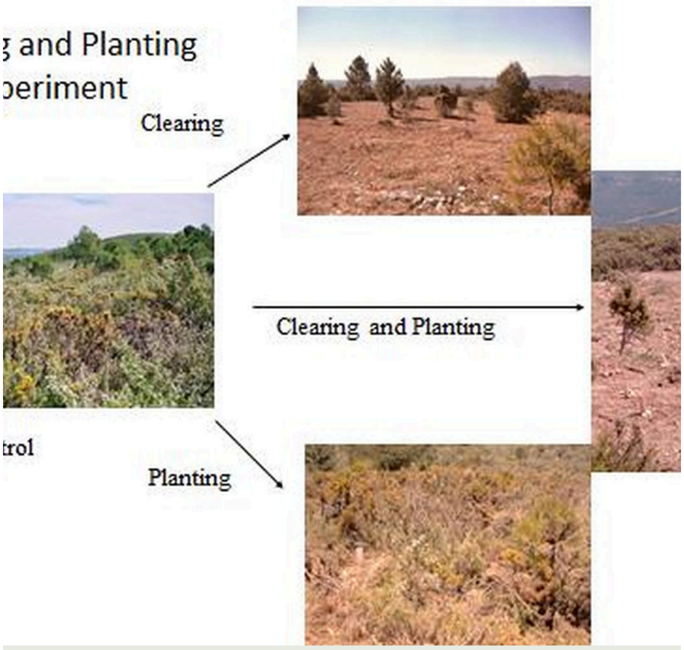
In a permanently protected area?:

Date of implementation: less than 10 years ago (recently)

Type of introduction
- ☐ through land users' innovation
- ☐ as part of a traditional system (> 50 years)
- ☑ during experiments/ research
- ☐ through projects/ external interventions

opportunities (e.g. marginal agriculture, grazing, hunting, beekeeping). Most of the inhabitants work in the nuclear power plant. Forest management could be a source for jobs.

Planted species are identified as shown in the picture. (Nina Lauterburg)



In each site, four plots were established to test the effect of the following management techniques: 1) control (no action), 2) clearing, 3) planting (within the shrubland) and 4) the combination of clearing and planting. (CEAM)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- [ ] improve production
- [x] reduce, prevent, restore land degradation
- [ ] conserve ecosystem
- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [ ] preserve/ improve biodiversity
- [x] reduce risk of disasters
- [ ] adapt to climate change/ extremes and its impacts
- [ ] mitigate climate change and its impacts
- [ ] create beneficial economic impact
- [ ] create beneficial social impact

Land use

Forest/ woodlands Products and services: Timber, Fuelwood, Fruits and nuts, Other forest products, Grazing/ browsing, Nature conservation/ protection, Recreation/ tourism, Protection against natural hazards, wind mill parc, hunting

Water supply

- [ ] rainfed
- [ ] mixed rainfed-irrigated
- [ ] full irrigation

Purpose related to land degradation

- [x] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

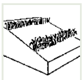
Degradation addressed

biological degradation - Bf: detrimental effects of fires, Bs: quality and species composition/ diversity decline

SLM group

- natural and semi-natural forest management
- forest plantation management

SLM measures

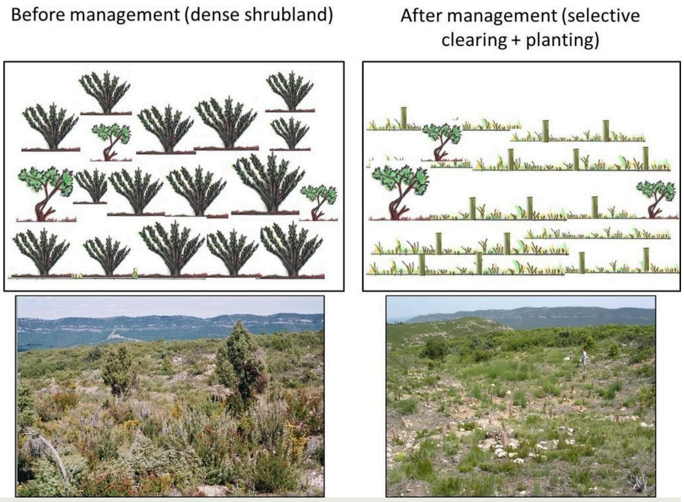


vegetative measures - V1: Tree and shrub cover, V3: Clearing of vegetation, V5: Others

TECHNICAL DRAWING

Technical specifications

On the left, the situation before management is illustrated. Dense shrublands contain a high fire risk due to their high fuel amount and continuity. On the right, the situation after management is shown. The combination of selective clearing of fire-prone seeder species and planting of more fire resistant resprouter species (illustrated by tree shelters in the drawing) promotes shrubland resilience to fires.
Location: Ayora. Valencia, Spain
Date: 13-12-2013



Author: Nina Lauterburg

Technical knowledge required for field staff / advisors: high (The experiment was carried out by scientists (biologists) with a high technical knowledge.)
Technical knowledge required for land users: low (In case of upscaling this experiment to a local or regional level, the work could be carried out by land users with a low technical knowledge, with technical support of scientists and forest agents)

Main technical functions: control of fires, reduction of dry material (fuel for wildfires), Promotion of vegetation species and varieties (more fire resistant vegetation composition)
Secondary technical functions: control of raindrop splash, increase in nutrient availability (supply, recycling,…), increase / maintain water stored in soil

Aligned: -linear
Vegetative material: T : trees / shrubs
Number of plants per (ha): 1000
Vertical interval between rows / strips / blocks (m): <2m
Spacing between rows / strips / blocks (m): <2m
Vertical interval within rows / strips / blocks (m): <2m
Width within rows / strips / blocks (m): <2m

Vegetative measure: Selective vegetation clearing
Vegetative material: T : trees / shrubs
Trees/ shrubs species: Planted species: Pistacia lentiscus, Quercus ilex and Rhamnus alaternus.
Other species: Removed species: Ulex parviflorus, Rosmarinus officinalis, Cistus albidus

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated:
- Currency used for cost calculation: **Euro**
- Exchange rate (to USD): 1 USD = 0.74 Euro
- Average wage cost of hired labour per day: 47.00

Most important factors affecting the costs

Slope (if the slope is steep, the work is much more difficult and takes more time), distance from a street (people can work less in a day if they have to walk far to clear/plant), vegetation density (it takes more time to clear a densely vegetated area).

Establishment activities

1. Cutting and chipping (in-situ) trees and shrubs (removed species: ulex parviflorus, rosmarinus officinalis, cistus albidus. Natural regenerated species which are not cleared: pinus halepensis, pinus pinaster, quercus ilex, juniperus oxycedrus) (Timing/ frequency: autumn/winter (when the vegetation activity is slowed down))
2. Planting (planted species: pistacia lentiscus, quercus ilex, rhamnus alaternus) (Timing/ frequency: autumn/winter (february 2003))

Establishment inputs and costs

Specify input	Unit	Quantity	Costs per Unit (Euro)	Total costs per input (Euro)	% of costs borne by land users
Equipment					
machine use	ha	1.0	3089.0	3089.0	
tree shelters	ha	1.0	945.0	945.0	
Plant material					
seedlings	ha	1.0	4587.0	4587.0	
Total costs for establishment of the Technology				**8'621.0**	
Total costs for establishment of the Technology in USD				*11'650.0*	

Maintenance activities

1. There is no maintenance, but in case of maintenance they would do selective clearings (using machines) (Timing/ frequency: all 5-7 years in autumn/winter)

Maintenance inputs and costs

Specify input	Unit	Quantity	Costs per Unit (Euro)	Total costs per input (Euro)	% of costs borne by land users
Equipment					

machine use	ha	1.0	446.0	446.0	
Total costs for maintenance of the Technology				**446.0**	
Total costs for maintenance of the Technology in USD				*602.7*	

NATURAL ENVIRONMENT

Average annual rainfall
- < 250 mm
- ✓ 251-500 mm
- ✓ 501-750 mm
- 751-1,000 mm
- 1,001-1,500 mm
- 1,501-2,000 mm
- 2,001-3,000 mm
- 3,001-4,000 mm
- > 4,000 mm

Agro-climatic zone
- humid
- ✓ sub-humid
- semi-arid
- arid

Specifications on climate
Thermal climate class: temperate

Slope
- flat (0-2%)
- gentle (3-5%)
- ✓ moderate (6-10%)
- rolling (11-15%)
- ✓ hilly (16-30%)
- steep (31-60%)
- very steep (>60%)

Landforms
- plateau/plains
- ✓ ridges
- ✓ mountain slopes
- hill slopes
- footslopes
- valley floors

Altitude
- 0-100 m a.s.l.
- 101-500 m a.s.l.
- ✓ 501-1,000 m a.s.l.
- ✓ 1,001-1,500 m a.s.l.
- 1,501-2,000 m a.s.l.
- 2,001-2,500 m a.s.l.
- 2,501-3,000 m a.s.l.
- 3,001-4,000 m a.s.l.
- > 4,000 m a.s.l.

Technology is applied in
- convex situations
- concave situations
- not relevant

Soil depth
- very shallow (0-20 cm)
- ✓ shallow (21-50 cm)
- moderately deep (51-80 cm)
- deep (81-120 cm)
- very deep (> 120 cm)

Soil texture (topsoil)
- coarse/ light (sandy)
- medium (loamy, silty)
- ✓ fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- coarse/ light (sandy)
- medium (loamy, silty)
- fine/ heavy (clay)

Topsoil organic matter content
- high (>3%)
- ✓ medium (1-3%)
- low (<1%)

Groundwater table
- on surface
- < 5 m
- ✓ 5-50 m
- > 50 m

Availability of surface water
- excess
- good
- medium
- ✓ poor/ none

Water quality (untreated)
- ✓ good drinking water
- poor drinking water (treatment required)
- for agricultural use only (irrigation)
- unusable

Water quality refers to:

Is salinity a problem?
- Yes
- No

Occurrence of flooding
- Yes
- No

Species diversity
- high
- ✓ medium
- low

Habitat diversity
- high
- medium
- low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- subsistence (self-supply)
- ✓ mixed (subsistence/ commercial)
- commercial/ market

Off-farm income
- less than 10% of all income
- 10-50% of all income
- > 50% of all income

Relative level of wealth
- very poor
- poor
- average
- rich
- very rich

Level of mechanization
- manual work
- animal traction
- mechanized/ motorized

Sedentary or nomadic
- Sedentary
- Semi-nomadic
- Nomadic

Individuals or groups
- individual/ household
- groups/ community
- cooperative
- ✓ employee (company, government)

Gender
- women
- ✓ men

Age
- children
- youth
- middle-aged
- elderly

Area used per household
- < 0.5 ha
- 0.5-1 ha
- 1-2 ha
- 2-5 ha
- 5-15 ha
- 15-50 ha
- 50-100 ha
- 100-500 ha
- 500-1,000 ha
- 1,000-10,000 ha
- > 10,000 ha

Scale
- small-scale
- medium-scale
- large-scale

Land ownership
- ✓ state
- company
- communal/ village
- group
- individual, not titled
- ✓ individual, titled

Land use rights
- open access (unorganized)
- communal (organized)
- leased
- ✓ individual
- ✓ public/open access but organised (e.g. wood, hunting)

Water use rights
- open access (unorganized)
- communal (organized)
- leased

- [ ] individual
- [x] public/open access but organised (e.g. wood, hunting)

Access to services and infrastructure

IMPACTS

Socio-economic impacts

fodder production	decreased ☐☐☐☐✓☐☐ increased	More grasses for animals (game and livestock) in the cleared areas
fodder quality	decreased ☐☐☐☐✓☐☐ increased	Animals (especially goats) eat everything but they like more young grasses than shrubs
animal production	decreased ☐☐☐☐✓☐☐ increased	Game/wildlife and livestock are better because there is an increase in fodder quantity and quality
wood production	decreased ☐☐☐☐✓☐☐ increased	Production increases because there is less competition between species and more species planted. The wood/timber generated by the clearing can be used for biomass, fertilizers, pellets, firewood. A part of the wood is chipped in-situ and applied as mulch
energy generation (e.g. hydro, bio)	decreased ☐☐☐☐✓☐☐ increased	Bioenergy (biomass)
expenses on agricultural inputs	increased ☐☐☐✓☐☐☐ decreased	Less damage on the cultivated fields because the wild animals do not destroy the fields anymore and stay in the forest (because there is more grass available due to clearings).

Socio-cultural impacts

cultural opportunities (eg spiritual, aesthetic, others)	reduced ☐☐☐☐☐✓☐ improved	People appreciate the visual impact of a cleared forest with a high species richness. It has a high aesthetic value and offers recreational opportunities. Since the planted species are more fire-resistant this value can be sustained.
recreational opportunities	reduced ☐☐☐☐☐✓☐ improved	People appreciate the visual impact of a cleared forest with a high species richness. It has a high aesthetic value and offers recreational opportunities. Since the planted species are more fire-resistant this value can be sustained.
SLM/ land degradation knowledge	reduced ☐☐☐☐✓☐☐ improved	Local people know about the importance of conservation of the area and really like to have the forest protected of wildfires. They will learn about the relationship of planting later-successional species and the reduction of the fire hazard.
conflict mitigation	worsened ☐☐☐☐☐✓☐ improved	Less fires result in a decrease of the destroyed area, less money will have to be invested in restoration or fire extinction. Farmers, hunters,honey producers will experience fewer losses. Wild animals remain in the forest (more grasses after clearing).
situation of socially and economically disadvantaged groups (gender, age, status, ehtnicity etc.)	worsened ☐☐☐☐☐✓☐ improved	The clearing and planting could create more job opportunities for unemployed people. This is especially important during the current economic crisis.

Ecological impacts

evaporation	increased ☐☐☐☐✓☐☐ decreased	Due to the mulch layer more moisture is stored in the soil and less water is lost by evaporation (the soil is covered).
soil moisture	decreased ☐☐☐☐☐✓☐ increased	More soil moisture because of less dense shrubland and mulch cover after clearing

soil cover	reduced	✓ (5 of 7)	improved	Mulch layer
soil loss	increased	✓ (5 of 7)	decreased	Less erosion because the soil is protected by a mulch layer.
soil crusting/ sealing	increased	✓ (5 of 7)	reduced	Mulch layer protects the soil from crusting.
nutrient cycling/ recharge	decreased	✓ (5 of 7)	increased	
soil organic matter/ below ground C	decreased	✓ (5 of 7)	increased	
biomass/ above ground C	decreased	✓ (5 of 7)	increased	
plant diversity	decreased	✓ (6 of 7)	increased	Reintroduction of native species which disappeared due to removal by humans in the past.
animal diversity	decreased	✓ (5 of 7)	increased	There might be more animals because of the fodder supply. Further, different species (e.g. birds) might be attracted by the reintroduced plant species.
pest/ disease control	decreased	✓ (6 of 7)	increased	Mono-plantations are bad for the propagation of a pest. After clearing there is a decrease in competition, plants are in healthier conditions,less prone to diseases.Weak plants are eliminated which reduces the risk of pests (always weak plants affected).
emission of carbon and greenhouse gases	increased	✓ (5 of 7)	decreased	Carbon sequestration, and less fires because the fire-prone shrubs are removed and more fire-resistant trees and shrubs are prevalent
fire risk	increased	✓ (7 of 7)	decreased	The fire risk is reduced in the long term because by clearing fire-prone and planting more fire-resistant species the vegetation is redirected towards later successional stages (ecosystem more resilient against fires).
wind velocity	increased	✓ (4 of 7)	decreased	
germination of competing seeds	increased	✓ (6 of 7)	reduced	
soil surface temperature	increased	✓ (6 of 7)	reduced	Mulch layer

Off-site impacts

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	✓ (3 of 7)	very positive
Long-term returns	very negative	✓ (7 of 7)	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	✓ (7 of 7)	very positive
Long-term returns	very negative	✓ (7 of 7)	very positive

Short term returns are slightly negative because the management practice is expensive and until the trees reach a mature state, there are not many returns (in terms of wood and biomass). In the long term this management practice has very positive results because it increases the resilience to fires and can be seen as a sustainable management of fire-prone areas. Additionally, wood and biomass can be extracted. The idea is not to apply any maintenance in the first 10 years after the establishment.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	✓ (2 of 5)	very well

Climate-related extremes (disasters)

local rainstorm	not well at all	✓ (4 of 5)	very well
local windstorm	not well at all	✓ (4 of 5)	very well
drought	not well at all	✓ (4 of 5)	very well
general (river) flood	not well at all	✓ (4 of 5)	very well

Other climate-related consequences

temperature decrease, snow, frost	not well at all	✓ (2 of 5)	very well

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- single cases/ experimental

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- 0-10%

- 1-10%
- 11-50%
- > 50%

- 11-50%
- 51-90%
- 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- Yes
- No

To which changing conditions?

- climatic change/ extremes
- changing markets
- labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Almost all villagers prefer a managed forest. It has a high aesthetic and recreational value. Through the application of this technology the awareness of the risk of wildfires would probably increase.
- Shepherds and farmers benefit from forest clearings. There are more young grasses in the forest which provides fodder for livestock. Also wild animals benefit from this food supply which in turn hinders them to destroy cultivated fields of the farmers.

Strengths: compiler’s or other key resource person’s view

- After fires, the natural landscape regenerated with a high and continuous fuel amount and a scarce occurrence of native resprouter species. It is crucial to apply management actions to reduce the fire hazard. The experiment demonstrated that it is possible to accelerate the post-fire vegetation response (which promotes ecosystem resilience).
- Planting of resprouting species in post-fire areas can accelerate the natural process. Clearing of the vegetation reduces the fire risk, but this treatment may also enhance seedling establishment and growth.
- The slash and brush chips generated by the clearings can be reused in the planting holes. This mulch layer protects the soil surface and reduces both the soil surface temperature and the germination of competing seeds while increasing the soil moisture content, especially in the driest periods.
- The combination of clearing and planting resprouting species seems to be an appropriate option for managing these areas because, once established, the resprouting species persist for a long time and lead to an increase of the ecosystem resilience.
- Social and economic benefits for the locals. Especially during the economic crisis the forest management is an important source for jobs.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

Weaknesses/ disadvantages/ risks: compiler’s or other key resource person’s viewhow to overcome

- The management activities are expensive and labour-intensive. The state does not invest much money in prevention of forest fires but focuses more on fire extinction. More investment in prevention of forest fires is required and this management practice could increase the ecosystem resilience against fires in the long term in a sustainable way. This would also generate jobs. This technology implies a combination of techniques (selective clearing and planting). Costs may be reduced by implementing individual techniques but positive results may also be reduced.
- The technology could result in a reduction of the animal production because grazing should be restricted after planting to ensure the growth of the planted seedlings. Since the technology would not be applied over vast areas but only locally on some plots, the fodder supply would probably still cover the needs of the animals.
- Depending on the site, some soil may be exposed to erosion due to mechanical clearing. Mulching with brush chipping can minimize or even solve this problem.
- After clearing, an increase in wind velocity might occur. The planted trees will grow which will again result in the reduction of this problem.

REFERENCES

Compiler
Nina Lauterburg

Editors

Reviewer
Alexandra Gavilano
Deborah Niggli
Hanspeter Liniger

Date of documentation: Aug. 6, 2013

Last update: Dec. 1, 2021

Resource persons
Nina Lauterburg - SLM specialist
Alejandro Valdecantos - SLM specialist
Jaime Baeza - SLM specialist

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_1579/

Linked SLM data
n.a.

Documentation was faciliated by

Institution
- Centro de Estudios Ambientales del Mediterraneo (CEAM) - Spain

Project
- Catastrophic shifts in drylands (EU-CASCADE)

Key references

- Valdecantos, A., Baeza, M.J., Vallejo, V.R. (2009): Vegetation management for promoting ecosystem resilience in fire-prone Mediterranean shrublands. Restoration Ecology 17, 3: 414-421.: