CASCADE
Catastrophic shifts in drylands:
How can we prevent ecosystem degradation?

CASCADE REPORT series

Comprehensive guidelines for natural resource managers

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3	UNIVERSITA DEGLI STUDI DELLA BASILICATA	Unibas	Italy
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CASCADE Deliverable 7.3

Comprehensive guidelines for natural resource managers

Aim and introduction

The aim is to provide the stakeholders in the study sites with a practical instrument to learn about principles of dryland management and to potentially improve the long term sustainability/resilience of their land use and land management practices. The variety of promising measures within the CASCADE study sites and the information about their sustainability and resilience is used as the basis for guiding natural resource managers in improving the management of dryland ecosystems, in particular with regards to preventing disturbances, mitigating their negative impact and ensuring recovery. With this, land management takes an important role in avoiding ecosystem shifts to degraded states. We have thus developed principles of dryland ecology and recommendations for natural resource managers including best practices and upscaling approaches. The context - specific recommendations and principles consider the different ecological and socio-economic environments found within the CASCADE study sites. Due to the CASCADE study sites representing typical dryland ecosystems, the guidelines are useful and valid for other regions as well, especially in the Mediterranean.

Development of the guidelines

The idea to develop such guidelines was based on earlier experience of partner 9 (University of Bern, Switzerland) on deducting principles of sustainable land management (SLM) from documented SLM practices (technologies and approaches). The premise is that these SLM practices are actually applied in the field and thus reflect real life experience and innovative as well as traditional knowledge. Books containing such principles of SLM include the 'Desire for Greener Land' (Schwilch, Hessel and Verzandvoort, 2012) with a focus on global drylands, and other books from the WOCAT network, such as the Water Harvesting book (Mekdaschi Studer and Liniger, 2013), the 'SLM in Practice - Guidelines and Best Practices for Sub-Saharan Africa' (Liniger et al., 2011) and their forerunner 'where the land is greener' (Liniger and Critchley, 2007). However, in order to serve land managers, these books are too 'heavy', literally and as a matter of speech. We thus decided to choose a different approach and translate the findings from the documented practices (and other sources, see below) into recommendations understandable to land managers.

Our participatory assessment of the land management practices implemented in the study sites, together with a specific investigation on the resilience of the ecosystems, allowed us to identify key messages that we deemed important for stakeholders. The plan was to produce three booklets on three prevailing Mediterranean dryland contexts found in the CASCADE study sites, which represent three typical socio-environmental challenges: the forest fire context, the overgrazing context and the land abandonment context. The overall idea was presented to the CASCADE partners in May 2015 during the plenary meeting in Crete. In the following year, the data was collected from the different sources (see section 'source of knowledge' below) and the principles and recommendations were developed for the three contexts. A table with 3-7 principles for each context, their related recommendations as well as uncertainties regarding these issues was then presented to the CASCADE partners in May 16 during the plenary meeting in Ispra. Group work during the meeting served to accept, reject or modify each item of the table and to make sure all the project's expertise was brought together in a constructive manner. Additional input was sought from land management experts and colleagues within partner 9. Based on this improved version, draft guidelines were

elaborated with help from partner 7 (MEDES, Italy) regarding visualization and language. The results are three easy-to-read and visually attractive 8-12 page booklets.

Content of the guidelines

Each booklet has a number of ecological principles and related land management recommendations, which are subsequently explained in short and simple text and illustrated with photographs.

The principles should be understood as ecological principles: i.e. they explain or highlight a crucial ecological process that is relevant for the resilience of the ecosystem, and relate it with the socio-ecological dimension. The recommendations for management are derived from these principles and are presented in a bullet list of 1-5 recommendations.

Wherever possible, links are made to documented SLM technologies and approaches in order to explain the recommendation, illustrate it with an example or provide concrete options for land managers. At the end of each section (each principle), these management options are specifically listed. It has to be noted that these listed options for SLM practices are not meant to be complete, but only reflect the most interesting, practical or useful practices documented within the CASCADE project, which are, however, as representative for Mediterranean drylands as possible.

The last page of each booklet contains some information about the CASCADE project and the authors.

We decided to put the technical information and implementation approaches into an annex rather than in the main text of the booklets, in order not to overload the text. But all the practices are referred to in the booklets, even with hyperlinks to online WOCAT database in case of e-reading. Nevertheless, the printed version has annexes to each booklet with a standardized 4-page summary of the documented SLM technologies and approaches.

Sources of knowledge

The first source of knowledge for developing the guidelines was the documented SLM technologies and approaches from within the CASCADE project and study sites (see Deliverable 7.1). The 21 technologies and 4 approaches documented from the study sites can be accessed on https://qt.wocat.net/qt_search.php and https://qa.wocat.net/SelectApproach.php.

Secondly, the results from the resilience assessment tool developed for CASCADE and applied in all the case study sites, provided detailed knowledge about the socio-ecological system and the role of land management (see Deliverable 7.2). The assessment revealed important information to understand the resilience of the socio-ecological system at the scale at which management is implemented, highlighting strengths and weaknesses of the land management in coping with the disturbances that occur in the area. Scientific terms and concepts related with resilience are difficult to translate into non-specialist language, thus we chose to identify practical ecological principles and recommendations that exemplify how everyday land management can deal with disturbances. This way, we were able to ground resilience into land managers experience. We tried to show how land management practices can prevent shifts of ecosystems, what would be the threshold or early warning sign, and how land management can mitigate degradation or foster the recovery.

Thirdly, all the case study researchers provided written suggestions on how land users and land managers could improve the resilience of the land management system(s) that were assessed, using as much as possible the information they collected through the application of the resilience

assessment tool. Local case study and stakeholder knowledge was also included through extensive field work conducted for the participatory assessments of Del. 7.1 and Del. 7.2 Finally, the consulted local experts from the study sites all agreed to be acknowledged by name on the guidelines, which confirms their agreement with the results.

Fourthly, results of other CASCADE Workpackages were used, in particular deliverables and scientific papers. Deliverables were consulted e.g. for drivers, thresholds or early warning signals. These were namely Del. 2.1 (driver data), Del. 4.2 (thresholds of degradation) and Del. 5.2 (restoration options). The following scientific papers resulting from CASCADE or from related research of CASCADE partners were also included:

- Mayor, A., Valdecantos A., Vallejo V.R., Keizer J.J., Bloem, J., Baeza J., González-Pelayo O., Machado A.I., de Ruiter P.C. 2016. Fire-induced pine woodland to shrubland transitions in Southern Europe may promote shifts in soil fertility. Science of The Total Environment.
- Baeza, M. J. J., Valdecantos, A., Alloza, J. and Vallejo, V. R. R. 2007. Human disturbance and environmental factors as drivers of long-term post-fire regeneration patterns in Mediterranean forests. Journal of Vegetation Science, 18(2), 243
- Martins, M. a. S., Machado, A. I., Serpa, D., Prats, S. a., Faria, S. R., Varela, M. E. T., … Keizer, J. J. 2013. Runoff and inter-rill erosion in a Maritime Pine and a Eucalypt plantation following wildfire and terracing in north-central Portugal. Journal of Hydrology and Hydromechanics, 61(4), 261–268.

Outlook

All the booklets will be translated into the languages at the study sites (Spanish, Portuguese, Italian and Greek), and then distributed to the stakeholders through the local CASCADE researchers. In preparation for their final stakeholder workshop and policy event at the study site, the local researchers will prioritize the most relevant recommendations from the guidelines and then present and discuss these with the stakeholders.

The Deliverable 8.3 will finally describe the participatory multi-scale evaluation process used to evaluate scenarios and management options. It will also include information on stakeholder engagement and dissemination in each study site, their policy recommendations and upscaling approaches as developed in WP7.

The guidelines will also be presented at the international policy workshop planned to be held in Matera (Southern Italy) in February 2017, where policy stakeholders from the study site countries as well as from the European level will participate.

All the booklets including their annex will be made available on the CASCADE website as well as the CASCADis. On CASCADis, the key messages and recommendations will specifically be presented and be available beyond the project lifetime.

Guidelines for Land Managers

The FOREST FIRE context

Principles and recommendations from the CASCADE project, with contributions from land users and land managers

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Principle 1: Minimizing fuel load and connectivity reduces fire risk

- ✓ Reduce highly flammable biomass
- ✓ Create bare strips within forest to hinder spread of fire and ease fire-fighting operations

A forest can have very different fuel loads, fuel connectivity and flammability while remaining healthy and valuable*.

Reducing the fuel load means removing dead trees and decreasing the density of living trees in the canopy.

Reducing the fuel connectivity means increasing the patchiness of the forest**, increasing the size and number of open areas and also increasing the distance between canopy and understory by cutting the taller shrubs and removing smaller trees.

Land management options include **selective forest clearing** (1) and **fuel breaks** (2) and **preventive forest intervention** approaches (3).

*Managed (left) and unmanaged forest (right) with different fuel loads and consequent fire risk

**Cropland (top) and fuel breaks (right) decrease the connectivity of the forest, reducing the fire spread and facilitating access for fire fighters

Sources:
(1) Selective forest clearing to prevent large forest fires (SPA010), Selective cutting (ITA008)
(2) Fuel breaks (ITA007, SPA009, POR001)
(3) Preventive forest intervention approaches (A_POR001, A_SPA002)

CASCADE
Catastrophic shifts in drylands

Principle 2: Diversity of species reduces flammability, as well as outbreaks of pests, and thus leads to reduced fire hazards. In particular, promoting resprouters facilitates recovery after fire.

- ✓ Avoid afforestation with single or flammable species
- ✓ Sustain and increase diversity of endemic plants
- ✓ Avoid removing resprouters
- ✓ Plant resprouters in favourable places (northern slopes, humid spots)

Mediterranean forests in fire prone areas are at present dominated by seeder species (those regrowing from seeds after fire), especially where afforestation with Pines was implemented*. These are very flammable.

Resprouters (those regrowing from the roots after fire) are less resistant to drought and germinate with more difficulties than seeders. But they increase the capacity of the forest to recover after fire, especially if conditions in the first year are not favourable for seed germination.

*Typical seeder (left) and resprouter (right) species of the Mediterranean

Promoting a diversity of tree species and understory cover reduces forest flammability, because each reacts differently to fire. Increasing diversity of vegetation also reduces the impact of plant specific diseases that can in turn increase flammability, because sick and dead plant material are drier and thus more flammable.

Whenever removing vegetation (e.g. during logging, clearing, firebreak creation) beneficial species (e.g. resprouters) should be maintained (5, 6).

Land management options include **afforestation with diverse species** (4)** and **selective forest clearing** (1) ***

**Diverse afforestation area with Holm Oak and other resprouter species (left)

***Forest with reduced density of trees after selective clearing (right)

Sources:
(4) Selective clearing and planting experiment to promote shrubland fire resilience (SPA011)
(5) Shrubland under selective clearing and planting for fire risk reduction

Principle 3: Sufficient soil cover shortly after a fire reduces risk of soil erosion

✓ Keep or reach a minimum of 50-60% of soil cover

Vegetation has an important role in preventing soil erosion* thereby retaining nutrients and thus maintaining soil fertility (7). CASCADE studies have also highlighted that a reduction in vegetation promotes a long-term decrease in soil fertility (8). Avoiding soil and fertility loss is also important for recovery of vegetation after fire.

*Plant holding the soil through its root system

Soil cover can consist of living vegetation or dead plant residues**, (e.g. from logging) However, there is a risk that this material may spread plant and animal diseases and pests such as nematodes, and also increase the fuel load (9).

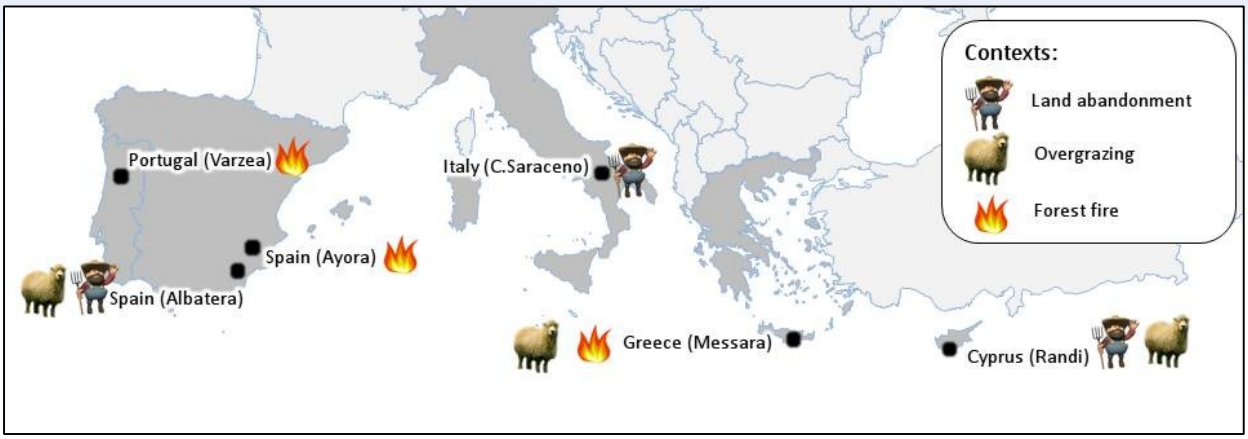
**Dead plant residues increase soil cover but also the risk of pest and fire

To simultaneously reduce the risk of fire and avoid soil erosion, a vegetation cover of 50-60% should be maintained, especially in fuel breaks or cleared areas.

Land management options include **mulching after fire** (10) and maintaining soil cover in **fuel breaks** (2)***.

***Forests managed to reduce density of vegetation (top) and connectivity (right) while keeping a minimum of soil cover

Sources:
(7) Afforestation with Pinus Halepensis after the fire of 1979 (La Molinera) (SPA012)
(8) Mayor A. G. et al. (2016). Fire-induced pine woodland to shrubland transitions in Southern Europe may promote shifts in soil fertility. Science of The Total Environment
(9) Traditional post-fire logging
(10) Mulching after fire (POR003, POR004)



The CASCADE Project study sites across southern Europe

These guidelines were developed within CASCADE Project WP7 with contributions from land users and managers in all the study sites

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Catastrophic shifts in drylands

Selective forest clearing to prevent large forest fires

Spain - Clareo selectivo para la prevención de incendios (tratamientos selvícolas) (Spanish)

Selective forest clearing aims in reducing the connectivity and the amount of (dead standing) fuel, as well as reducing the competition between regenerating pines, in order to prevent forest fires and to ensure the growth of a healthy forest.

The forests in the Ayora region experienced a huge disturbance in the past, such as deforestations, removal of key species, land abandonment, dense growth of fire-prone seeder species (high continuity of dead standing fuel), missing management, wildfires and dense afforestations. These disturbances resulted in the degradation of the vegetation, the reduction of the resilience of the ecosystem against fires and thus an increasing risk of wildfires. After fires, many landscapes regenerated with a high and continuous fuel accumulation with few native resprouter species, which made it extremely difficult to control forest fires. The dense growth not only increased the risk of wildfires but also the competition between different species (nutrients, light, space). Therefore appropriate vegetation management to increase the resilience of the ecosystem to fires and to reduce competition is crucial.
These problems are approached by selective forest clearing. The main purposes of thinning dense pine forests are the prevention of fires by reducing the fuel load and its continuity, and to improve pine regeneration by eliminating the competition between different species. As a result, the quality of the plants is improved and the amount of dead or sick plants is reduced, which is essential to ensure a healthy forest. This also leads to a higher resistance to pests which in turn again decreases the risk of fire (less dead plants). Vegetation removal produces fresh vegetation growth, therefore more diverse and nutritious fodder is provided to animals (game and livestock) in the cleared areas which is a benefit for herders. Also wild animals use this fodder supply which in turn hinders them to destroy cultivated fields of the farmers. Furthermore, honey producers make use of the enhanced growth of shrubs and the additional space created by selective clearing to place their beehives and to increase honey production. Especially during the current economic crisis forest management is an important source for jobs - most of the workers were unemployed before working in the selective clearing. Through the clearings, fuelwood is gained and offered to retired people for free for cooking and heating, allowing them to save money. Additionally, almost all villagers like to have a cleared forest due to its high aesthetic and recreational value.
In order to be selective and to preserve desired species, the clearing is done with small machines such as brushcutters and chainsaws. On average the forest is thinned until reaching a density of 800-1200 trees/ha. Species such as Juniperus, Rhamnus al., Quercus rotundifolia, Quercus faginea or Fraxinus ornus are not removed which increases the probability to have a more fire-resistant vegetation composition in future. Dead or sick plants and also a part of fire-prone shrubs such as Ulex parv. and Cistus alb. are removed. If there are both Pinus pinaster and Pinus halepensis. Pinus halepensis is cleared because they compete with each other. The roots are not removed which ensures the stability and productivity of the soil. The remaining species are pruned ("poda") until a maximum height of 2.5m to improve the conditions of the species. Around each tree they should clear an area of 2m. After felling trees and shrubs a part of the residues is chipped in-situ and covers the soil as mulch, which results in ecological benefits (e.g. increase in soil moisture, prevention from erosion, enhancement of nutrient cycling, reduction of the soil surface temperature). If the slope is steep, it takes more time to do the clearing and it might also increase the risk of erosion afterwards. Under the best conditions (e.g. good access and terrain), 0.8ha per day are cleared (calculated for a group of 9 persons working 7 hours). In this case the costs are paid by the municipal council, which receives a part of the money from the rental fee paid by the wind mill company. The cleared areas have to be maintained depending on the speed of the vegetation growth (which amongst others depends on the soil, slope and humidity). If the clearings are done regularly, it takes less time and it is cheaper than the first clearing. It should be noted that recurrent maintenance is crucial to ensure the effectiveness of the technology.
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 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.

left: Cleared forest with chipped material applied as mulch and fresh grasses providing fodder to animals. (Photo: Nina Lauterburg)
right: The residues generated by forest clearings are chipped in-situ using brushcutters (motodesbrozadoras). The chipped material protects the soil as a mulch layer. Forest management provides jobs - many forest workers were unemployed before. (Photo: Nina Lauterburg)

Location: Spain, Valencia
Region: Ayora/Jarafuel
Technology area: 0.5 km^2
Conservation measure: vegetative
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_SPA010en
Related approach:
Compiled by: Nina Lauterburg, CDE
Date: 2013-05-11
Contact person: Vicente Colomer, Forest Agent Generalitat Valenciana (Conselleria de infraestructura, territorio y medio ambiente). Phone: +34 669 819 522 E-mail: colomer.vju@gmail.com

Classification

Land use problems:

- The prevalent dense shrublands (dominated by seeder species), which resulted from past agricultural land use (changes of the vegetation composition, e.g. removal of key species), land abandonment/rural depopulation and fire occurrence, contain a high fire risk because of both the high fuel loads and their continuity. Also dense forests (either afforestations or natural regeneration) show a high risk for fires. Through the modifications of the vegetation composition in the past (removal of more fire resistant resprouter species, whereas fire-prone seeder species are abundant), the resilience of the ecosystem to fires has decreased. Today a higher fire recurrence can be observed which could still be worsen by future climate change impacts, undermining more and more the ecosystem's capacity to buffer such shocks. Furthermore, the high density of the forest results in a competition between different species which increases the amount of dead or thin material. (expert's point of view)

Land use

Natural
Plantations, afforestations selective felling of (semi-) natural forests, plantation forestry

Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires, quality and species composition /diversity decline

Conservation measure

Vegetative: Clearing of vegetation (eg fire breaks/reduced fuel)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user
- forest engineer

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: population pressure, poverty / wealth, labour availability

Main technical functions:

- control of fires
- reduction of dry material (fuel for wildfires)
- reduction of fire-prone species

Secondary technical functions:

- increase in nutrient availability (supply, recycling,...)
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil texture: fine / heavy (clay)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells
Sensitive to climatic extremes: seasonal rainfall increase
If sensitive, what modifications were made / are possible: The technology was not modified but it is important to add some notes to the above stated reactions to climatic extremes. The cleared areas are quite resistant against climate change or weather extremes. Only if there will be more rainfall the vegetation might grow faster and the maintenance costs could increase.

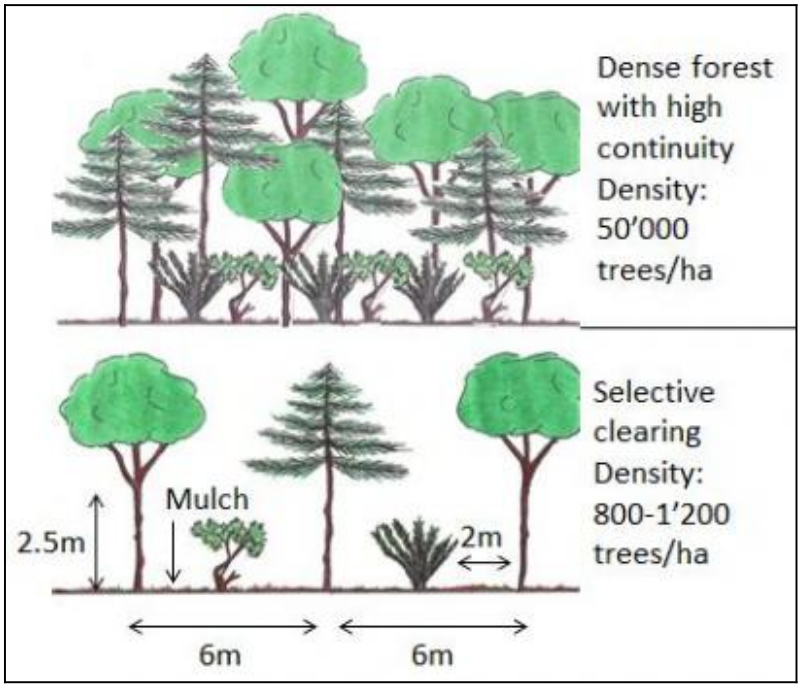
Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), common / average land users, mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: state, individual, titled
Land use rights: individual, public/open access but organised (e.g. wood, hunting) (There is some public land, controlled by the state. But there is also some private land. The access to the public land is open but organized. Permission is needed from the government to cut trees, to build a house or to hunt. There are some private hunting areas for which the hunting association has to pay a fee.)

Importance of off-farm income: : The forest brigade is only working when there is money and a project. If there is no money they have no work and need to look for another job.
Access to service and infrastructure:
Market orientation: mixed (subsistence and commercial)
Purpose of forest / woodland use: timber, other forest products / uses (honey, medical, etc.), recreation / tourism



Technical drawing

The main purposes of thinning dense forests (some 50'000 individuals per ha) are the prevention of fires by reducing the fuel load and its continuity (both vertical and horizontal), and to improve regeneration by eliminating the competition between different species. On average the forest is thinned until reaching a density of 800-1200 trees/ha. Species such as Juniperus, Rhamnus al., Quercus rotundifolia, Quercus faginea or Fraxinus ornus are not removed which increases the probability to have a more fire-resistant vegetation composition in future. Dead or sick plants and also a part of fire-prone shrubs such as Ulex parv. and Cistus alb. are removed. The remaining species are pruned ("poda") until a maximum height of 2.5m to improve the conditions of the species. Around each tree they should clear an area of at least 2m but ideally there should be a distance of 6m between different individuals. After felling trees and shrubs a part of the residues is chipped in-situ and covers the soil as mulch, which results in ecological benefits and provides fodder to livestock and game. (Nina Lauterburg)

Implementation activities, inputs and costs

Establishment activities

- Cutting and chipping (in-situ) of trees and shrubs (selective clearing)
- Transport of wood (fuel wood)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	404.00	0%
Equipment		
- machine use	2024.00	0%
TOTAL	**2428.00**	**0.00%**

Maintenance/recurrent activities

- Cutting and chipping (in-situ) of trees and shrubs (selective clearing)
- Transport of wood (fuelwood)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	446.00	0%
TOTAL	**446.00**	**0.00%**

Remarks:
The costs of selective forest clearing can be affected by numerous factors, such as slope (if the slope is steep, the work is much more difficult and takes more time), vegetation density (it takes more time to clear a dense area) and vegetation type (pine forest or shrubland), distance from a street (people can work less in a day if they have to walk far to clear). Important to note is that maintenance costs could increase with an increase in rainfall because the vegetation will grow faster.
The costs were calculated for the application of the technology (selective clearing) on one hectare. In this case, 9 people are working as a team. If the site is accessible and if the terrain is good for clearing work they can clear 0.8 ha per day. It should be noted that clearing with small machines such as brushcutters and chainsaws is much more expensive than clearing with tractors, but often it is only possible to clear with small machines (e.g. removal of trees is not possible with tractors). A tractor costs more or less 500 Euro per ha (674 Dollar per ha). A clearing of a pine forest with manual machines costs around 1800 Euro per ha (2428 Dollar per ha). The costs of the maintenance activities (e.g. second clearing) are much lower because the area was cleared already some years before. Therefore more ha per day can be cleared. In Jarafuel, a part of the costs are covered by the rental fee paid by the windmill company. The currency rate (Euro-Dollar) was calculated on November 16th, 2013.

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ increased wood production
+ increased fodder production
+ increased fodder quality
+ increased animal production
+ reduced expenses on agricultural inputs
+ increased farm income
+ increased production area
+ increased product diversification

Production and socio-economic disadvantages

++ high establishment and maintenance costs
+ reduced animal production
+ job uncertainty

Socio-cultural benefits

+++ improved cultural opportunities
+++ increased recreational opportunities
++ improved conservation / erosion knowledge
++ improved situation of disadvantaged groups
+ conflict mitigation
+ improved food security / self sufficiency

Socio-cultural disadvantages

Ecological benefits

+++ reduced fire risk
++ increased soil moisture
++ reduced hazard towards adverse events
++ increased biological pest / disease control
+ reduced evaporation
+ improved soil cover
+ increased biomass above ground C
+ increased nutrient cycling recharge
+ increased soil organic matter / below ground C
+ reduced emission of carbon and greenhouse gases
+ reduced soil crusting / sealing
+ increased animal diversity
+ reduction of soil surface temperature

Ecological disadvantages

+ increased soil erosion locally
+ increased habitat fragmentation

Off-site benefits

++ reduced risk of wildfires
+ reduced downstream flooding
+ reduced downstream siltation
+ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

+ Through the clearings it is easier to control fires and protect people. Furthermore it created jobs for the unemployed. In general forest management is not something people want to do, they work in this sector only if there are no other job opportunities. Forest management means a hard job and this kind of work is not well-respected in society.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	very positive	very positive
Maintenance / recurrent	very positive	very positive

Both the short-term and the long-term benefits are very positive assuming that maintenance is done. It contributes to prevent devastating fires and to guarantee a healthy forest. Together with the creation of jobs, directly after clearing there is firewood and timber available and a reduced risk of wildfires. But it should also be considered that the establishment costs are high. If maintenance is not done the long-term returns will be very negative because an increase in the risk of fire will occur again (without management, there will also be no firewood, no timber and no jobs). The maintenance costs increase the longer you wait because the vegetation will grow again densely.

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology. Clearings are only done when the state has money. Selective clearing is also applied in other countries/regions, e.g. in California.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Through selective forest clearing the fuel amount and connectivity (vertical/horizontal) is reduced which is crucial for preventing the occurrence and spread of large forest fires. → Recurrent maintenance is crucial to ensure the effectiveness of the technology. Especially the fire-prone seeder species (e.g. Ulex parviflorus, Cistus albidus) should be removed frequently. CEAM suggests to plant more fire-resistant species (late successional stages) within some spots to accelerate the natural succession and to increase the resilience of the ecosystem to fires. Green living plants have a higher humidity content which slows down a fire (oxygen is consumed). By planting late-successional species really densely you don't allow seeders to grow. This measure could also decrease management costs and create Jobs.	The establishment and the maintenance activities are expensive and labour-intensive. Without management the technology is not effective anymore. It would be necessary to extract biomass from the forest to decrease the continuity of the trees and shrubs. In case of a lack of management the risk of fires increases. → Management is crucial. Prevention measures are often less expensive than rehabilitation activities after a fire. The state should therefore invest more money in forest management and fire prevention. Managing the forest would not only decrease the risk of fire but also generate benefits (e.g. wood, biomass, fuelwood). Instead of getting unemployment pay people could get jobs in forest management. Stakeholders mentioned that it would be important to promote the forest as a sustainable economic resource and that the relation between the villagers and the forest should be enhanced. Furthermore it was mentioned that traditional activities (such as grazing, agriculture, wood gathering) should be reactivated and that the villagers should get economic compensation to maintain the forest in a good state. Especially the promotion of grazing was stressed many times. Also planting of more fire-resistant species (late successional stages) in some spots as suggested by CEAM could increase the resilience of the ecosystem and decrease management costs.
There is a reduction of competition between plants which is essential to ensure a healthy forest (more nutrients, light, space). This also leads to a higher resistance against pests which in turn again decreases the fire risk (less dead or sick plants). → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	The clearing of forests has potential to prevent fires and therefore degradation. But there are also a lot of highly connected shrublands with a high fuel load which are not addressed by this management practice. → Shrublands need to be cleared as well since they constitute a huge risk for wildfires.
Fuel management through vegetation clearing presents some positive aspects with respect to other techniques, e.g. the possibility of being selective in order to preserve desired species or individuals. Furthermore, after felling trees and shrubs a part of the vegetation is chipped in-situ and covers the soil as mulch. This results in ecological benefits (e.g. increase in soil moisture, prevention from erosion, enhancement of nutrient cycling, reduction of the soil surface temperature and evaporation loss). → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	If there is more space after clearing the first shrubs which will grow will be fire-prone early successional species, such as Cistus albidus and Ulex parviflorus. Without management, they will increase the risk of fires. → Recurrent maintenance is crucial to ensure the effectiveness of the technology. Management through grazing could be a simple way to reduce the costs and the risk. By planting resprouter species really densely seeders would not grow anymore in those spots which would also decrease the fire risk and the management costs.
The trees/shrubs are cut but the roots are not removed. This ensures the stability and productivity of the soil. →	When the clearing is done on extremely steep slopes there might be an increase in erosion. → Before clearing the soil erosion risk should be calculated.
Fewer fires result in a decrease of the destroyed area, less money will have to be invested in restoration or fire extinction. Furthermore, farmers, hunters and honey producers will experience fewer losses. → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	In some areas there will be less shade which could harm some species. →
There are both social and economic benefits for local people. The selective clearings provide jobs for rural people, which allows them to increase their livelihood conditions. People do not depend on unemployment pays and are therefore more accepted in society. A part of the extracted wood is used for biomass, fertilizers, pellets, or firewood. Furthermore there would be improved conditions for grazing. Therefore forest management contributes to rural development. → Actually there is still a lot of management required in the forest of this region which would provide jobs in the longer term. Furthermore, many local stakeholders mentioned the importance of reactivating traditional activities (such as grazing, agriculture, wood gathering) and that the villagers should get economic compensation to maintain the forest in a good state.	
There are also off-site benefits. Fewer fires will result in a reduction of downstream flooding, downstream siltation and damage on neighbours' fields. When fire removes less vegetation the soil is less vulnerable to erosion. → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	
In Jarafuel where most of the land is public retired people receive the firewood gained by forest clearings for free. They can use the wood for cooking and heating and save a lot of money. → People from the region (outside of Jarafuel) like this idea that villagers benefit from what is removed from the forest. More mechanisms like this should be developed so that people recognize that they also benefit from forest management, which in turn would ensure a sustainable forest management.	
Almost all villagers like to see a cleared forest. It has a high aesthetic and recreational value (it is possible to walk through the forest). They are also aware that the risk of wildfires is reduced through this technology. → Recurrent maintenance is crucial to ensure the effectiveness of the technology. Villagers and state need to work together to ensure a long-term forest management.	
Shepherds, hunters and farmers benefit from forest clearings. Vegetation removal produces fresh vegetation growth, therefore more diverse and nutritious fodder is available for animals (game and livestock) in the cleared areas. Game/wildlife and livestock are better because there is an increase in fodder quantity and quality. Wild animals benefit from this food source which in turn hinders them to destroy cultivated fields of the farmers. Also honey producers benefit from the cleared areas since bees can fly better and there is more place to put the beehives, furthermore the growth of shrubs is enhanced. → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	

SELECTIVE CUTTING

Italy

SELECTIVE CUTTING OF FOREST TREES TO PREVENT FIRES AND AVOID THE RISK OF DAMAGED TREES FALLING DOWN.

The technique consists of cutting down and removing damaged trees from the forest (for example those damaged by snow) or dried trees, which tend to fuel fires and increase their spread.
Protection of woods in case of fire and promoting the natural regeneration of forests.
Clearing activities carried out periodically.
The technique is applied in timber forests. The context of production is characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption.

Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: management
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, traditional (>50 years ago)
Land use type:
Forests / woodlands: Natural
Climate: subhumid
WOCAT database reference: T_ITA008en
Related approach: MUNICPAL FOREST MANAGEMNT PLAN (DECADE 2010-2019) (A_ITA001en)
Compiled by: Velia De Paola,
Date: 2014-05-27
Contact person: Giovanni Quaranta, University of Basilicata via dell'Ateneo Lucano 10, 85100 Potenza (IT)
giovanni.quaranta@unibas.it
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Classification

Land use problems:

- In the timber forests the presence of damaged trees promotes the spread of fires and the increase the risk of fallen trees. (expert's point of view)
Fire risk and risk of fallen trees. (land user's point of view)

Land use

Natural
clear felling of (semi-)natural forests

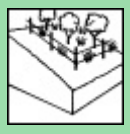
Climate

subhumid

Degradation

Biological degradation:
detrimental effects of fires

Conservation measure



Management: Others ()

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: traditional (>50 years ago)
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:

Main technical functions:
- control of fires
- reduction of dry material (fuel for wildfires)

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to august)
Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
Sensitive to climatic extremes: seasonal rainfall decrease

Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average, which represents 90% of the land users;

Importance of off-farm income: 10-50% of all income:
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: commercial / market
Purpose of forest / woodland use: fuelwood

Implementation activities, inputs and costs

Establishment activities

Maintenance/recurrent activities

- Cutting of trees damaged or dead by mechanical equipment (chainsaw).

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	270.27	100%
TOTAL	**270.27**	**100.00%**

Remarks:
Manual labour and fuel for chainsaw.

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ increased wood production
++ reduced risk of production failure

Production and socio-economic disadvantages

Socio-cultural benefits

+++ improved cultural opportunities

Socio-cultural disadvantages

Ecological benefits

+++ reduced hazard towards adverse events
+++ reduced fire risk
++ increased soil organic matter / below ground C

Ecological disadvantages

+ decreased soil organic matter

Off-site benefits

++ reduced damage on neighbours fields
++ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

+

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	slightly positive
Maintenance / recurrent	positive	positive

The value of the wood harvested is higher than the costs of felling

Acceptance / adoption:

50% of land user families have implemented the technology with external material support. Contributions through rural development measure (200 € per hectare)
50% of land user families have implemented the technology voluntary.
There is moderate trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Selective cutting of damaged trees is a useful tool in preventing the growing spread of wildfires and promotes a more homogenous and regular growth in the forest. → The resources forseen under the RDP to support this action have not led to the its spontaneous adoption.	There are no disadvantages to this technique. →
The technique is useful particularly in areas nearest public roads to prevention the spread of wildfires and to decrease risk of damaged trees falling. →	

Unvegetated strips to reduce fire expansion

Italy - Firebreaks

Firebreaks are stripes cleared of vegetation that divide a continuous forest in smaller patches to reduce spreading of wildfires and allow intervention.

The technology consists of creating gaps of vegetation of about 5 to 7 meters, every 50 to 75 meters distance contourline large forested areas. These clear strips are connected to main roads having varying length in relation to the size of the area.
Fire breaks act as a barrier to stop or slow the progress of fires and allow firefighters to better position themselves to operate.
Clearing activities which must be carried out annually by specialized workers using minor devices (hand and hedge cutter).
This technology is applied mostly in publicly owned woods (or very large private woods). The network of these fire strips is rather dense as the number of flammable species increases. So it creates patches of 2500 to 5000 meters according to the type of species. The context of production is characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption.

Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: management
Stage of intervention: prevention of land degradation
Origin: Developed through experiments / research, traditional (>50 years ago)
Land use type:
Forests / woodlands: Natural
Climate: subhumid
WOCAT database reference: T_ITA007en
Related approach: MUNICPAL FOREST MANAGEMNT PLAN (DECADE 2010-2019) (A_ITA001en)
Compiled by: Velia De Paola,
Date: 2014-05-27
Contact person: Giovanni Quaranta, University of Basilicata Via dell'Ateneo Lucano 10, 85100 POTENZA (IT)
giovanni.quaranta@unibas.it
+390971205411

Classification

Land use problems:

- In some wooded areas, especially nearest the roads, there is an excessive amount of undergrowth (with some shrubs reaching a height in excess of two metres) which leaves the area vulnerable to the start and spread of forest fires. (expert's point of view)
The increase in shrubs has increased fire risk. (land user's point of view)

Land use

Natural
clear felling of (semi-)natural forests

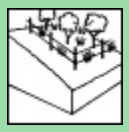
Climate

subhumid

Degradation

Biological degradation:
detrimental effects of fires

Conservation measure



Management: Waste Management: includes recycling, re-use or reduce

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research: traditional (>50 years ago)
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:

Main technical functions:
- control of fires

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to august)
Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period

Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average, which represents 90% of the land users;

Importance of off-farm income: 10-50% of all income: Most of the off farm income derives from public sector, i.e. Municipality, Mountain Community, Region and other public bodies. Very few farmer members run local shops or handcraft.
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: commercial / market
Purpose of forest / woodland use: fuelwood

Implementation activities, inputs and costs

Establishment activities

Maintenance/recurrent activities

- Cutting vegetation with the help of device (hedge cutters, usually owned by the specialized workers who are doing the job, and their cost is included in the salary) The hectare is intended to mean the area of cleared vegetation which is usually 5-7metres wide.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	1351.35	100%
TOTAL	**1351.35**	**100.00%**

Remarks:
Manual labour (including fuel for hedge cutter).

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ reduced risk of production failure

Production and socio-economic disadvantages

+ reduced wood production

Socio-cultural benefits

Socio-cultural disadvantages

Ecological benefits

+++ reduced hazard towards adverse events
+++ reduced fire risk

Ecological disadvantages

Off-site benefits

++ reduced damage on neighbours fields
++ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	slightly negative
Maintenance / recurrent	positive	positive

Acceptance / adoption:

100% of land user families have implemented the technology with external material support.
0% of land user families have implemented the technology voluntary.
There is moderate trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve

1) The creation of firebreaks is a very useful method to reduce the spread of fires. → Public funding is needed to ensure this method can continue.

the technique is an important tool in preventing the spread of fires, however, when winds are strong they can make little difference → some as before

Weaknesses and → how to overcome

Apart from the annual cost of clearing vegetation, it reduces the number of trees per hectare of wooded areas →

Cleared strip network for fire prevention (firebreaks)

Spain - Área cortafuegos

The basic principle of a firebreak network is to split continuous forest areas (where a lot of fuel is built up) into smaller patches separated by vegetation-free strips in order to prevent large forest fires.

In the forest law 3/1993 the declaration of special areas to “Zonas de Actuación Urgente (ZAU)” (zone of urgent actions) through the regional government of Valencia is defined. Objectives are the protection against natural hazards and the promotion of forest restoration within this area. Ayora was declared to a ZAU in 1997 due to its high risk of fires. In the “Plan de Selvicultura Preventiva de Incendios en los Sistemas Forestales de la Comunidad Valenciana” which became operative in 1996 and whose main objective is the reduction of the fire risk, the ZAU is practically addressed for the first time in the establishment of firebreaks (áreas cortafuegos). Based on this plan, the firebreaks were established within a pilot project “Proyecto Piloto de Selvicultura Preventiva” between 1998 and 2002, carried out by the company VAERSA (public company of the Generalitat Valenciana).
A firebreak is a strategically located strip on which the vegetation cover has been partially or totally removed down to mineral soil with the aim of controlling the spread of large forest fires. The main purposes are 1) to interrupt the continuity of hazardous fuels across a landscape to decrease the area affected by fires, 2) to provide areas where fire fighters are protected and can work more efficiently, 3) to slow down a fire, to reduce the fire intensity and caused damages, and 4) to provide strips where fuel management is facilitated. The total surface protected by the firebreaks is 33’851 ha while the management measures are executed on 1944,81 ha. This technology is also applied in other countries, e.g. Portugal, South Carolina or South Africa. The establishment and maintenance are labour-intensive and expensive. Firebreaks can range between a protected area of 2000-6000 ha (first order), 500-1500 ha (second order), and 100-300 ha (third order), together forming a system isolating separate areas by wide strips. This parcelling aims in limiting the burnt area to a maximum of 6000 ha. Each firebreak consists of a bare vegetation-free strip (banda decapado). The width of the bare area ranges between 6m (first order), 3m (second order) and 1.5m (third order). Existing vegetation-free areas (e.g. roads) are used to establish firebreaks to have less visual impact. If there is no road, trees and shrubs have to be cleared and chipped entirely using chainsaws and special tractors. On each side of the bare area there is a totally cleared strip (banda de desbroce total). The width depends on the climatic zone, the order and the hazard of fuel, therefore ranging between 28m (first order), 11m (second order) and 6m (third order). Almost all the existing vegetation is cleared, only some isolated mature trees are not cut if they do not contribute to the propagation of a fire. On both sides of these strips there are auxiliary strips (banda auxiliar) where selective clearing is applied until reaching a desired density. Sick trees are cleared with priority. Species of high ecologic value and low flammability level are not cleared, such as Juniperus phoenicea, Juniperus oxycedrus and Quercus ilex ssp. rotundifolia. The width of these elements can vary according to the prevalent conditions. A part of the wood generated by the clearings is used as fuelwood, the other part is chipped and distributed on the soil as mulch. Firebreaks are often located on mountain ridges and created with 45° to the dominant wind direction (west) to facilitate fire extinction. The maintenance of firebreaks is extremely important. Without clearing, fire-prone species will encroach which decreases the effectiveness of the firebreak. The maintenance is realized depending on the vegetation, usually in firebreaks of first order the maintenance is done every 2 years (“decapado” and “desbroce total”) or every 4 years (“banda auxiliar”) while firebreaks of second and third order are cleared every 4 years. In the here described project the maintenance was carried out in three phases (2001-2004, 2004-2008 and 2008-2012).
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 opportunities (e.g. marginal agriculture, grazing, hunting, beekeeping, artisanry, wind mill parc). Most of the inhabitants work in the nuclear power plant. Forest management could be a source for jobs.

left: Firebreaks are classified in first, second and third order, together forming a system isolating separate areas by wide strips. This parcelling aims in controlling the spread of large forest fires. (Photo: Nina Lauterburg)
right: Firebreaks are often located along existing roads to guarantee the access for fire-fighting vehicles and to keep the environmental impact limited. (Photo: Nina Lauterburg)

Location: Spain, Valencia
Region: Region of Ayora (including the municipalities Requena, Cofrentes, Jalance, Jarafuel, Zarra, Ayora)
Technology area: 338.5 km^2
Conservation measure: vegetative
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, 10-50 years ago
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_SPA009en
Related approach: Plan of preventive silviculture (PSP): implementation of firebreak network within a forest intervention area (ZAU) (A_SPA002en)
Compiled by: Nina Lauterburg, CDE
Date: 2013-05-06
Contact person: Jaime Baeza, Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Parque Tecnológico Paterna. C/ Charles Darwin 14, 46980 Valencia, Spain. E-Mail: jaime.baeza@ua.es

Classification

Land use problems:

- In Ayora, the prevalent dense shrublands (dominated by seeder species), which resulted from past agricultural land use (changes of the vegetation composition, e.g. removal of key species), land abandonment/rural depopulation and fire occurrence, contain a high fire risk because of both the high fuel loads and their continuity. Also dense forests (either afforestations or natural regeneration) show a high risk for fires. Through the modifications of the vegetation composition in the past (removal of more fire resistant resprouter species (mature forest), whereas fire-prone seeder species are now spreading), the resilience of the ecosystem to fires has decreased. Today a higher fire recurrence can be observed which could still be worsen by future climate change impacts, undermining more and more the ecosystem's capacity to buffer such shocks. Before the implementation of firebreaks, it was almost impossible to stop a fire and it was much more dangerous for fire fighters. There was also no access for fire-fighting vehicles. (expert's point of view)

Land use

Natural
Plantations, afforestations selective felling of (semi-) natural forests, plantation forestry

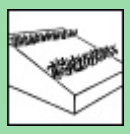
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires

Conservation measure



Vegetative: Clearing of vegetation (eg fire breaks/reduced fuel)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: traditional (>50 years ago)
- Experiments / Research
- Externally introduced: 10-50 years ago

Level of technical knowledge

- Agricultural advisor
- Land user
- Engineer

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: population pressure, poverty / wealth, labour availability

Main technical functions:
- control of fires

Secondary technical functions:
- reduction of dry material (fuel for wildfires)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: medium

Soil water storage capacity: high
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods
Sensitive to climatic extremes: seasonal rainfall increase, wind storms / dust storms, droughts / dry spells
If sensitive, what modifications were made / are possible: The technology was not modified. The firebreaks are quite resistant against climate change or weather extremes. Only if there will be more rainfall the vegetation might grow faster and the maintenance costs could increase. Furthermore, if there are heavy windstorms the effectiveness of firebreaks is undermined because strong winds result in faster spreading fires.

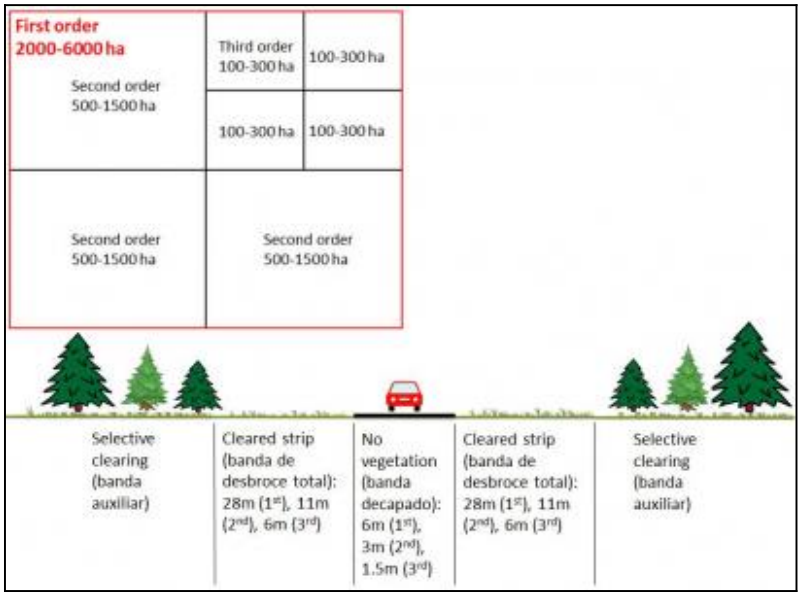
Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), common / average land users, mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: state, individual, titled
Land use rights: individual, open access but organised (e.g. wood, hunting)
(There is some public land, controlled by the state. But there is also some private land. The access to the public land is open but organized. Permission is needed from the government to cut trees, to build a house or to hunt. There are some private hunting areas for which the hunting association has to pay a fee.)

Importance of off-farm income: : The forest brigade is only working when there is money and a project. If there is no money they have no work and need to have a look for another job.
Access to service and infrastructure:
Market orientation: mixed (subsistence and commercial)
Purpose of forest / woodland use: timber, other forest products / uses (honey, medical, etc.), recreation / tourism



Technical drawing

Firebreaks can range between a protected area of 2000-6000 ha (first order), 500-1500 ha (second order), and 100-300 ha (third order), together forming a system isolating separate areas by wide strips. This parcelling aims in limiting the burnt area to a maximum of 6000 ha. Each firebreak consists of a bare strip (banda decapado) ranging between 6m (first order), 3m (second order) and 1.5m (third order). On both sides of the bare area there is a totally cleared strip (banda de desbroce total) whose width ranges between 28m (first order), 11m (second order) and 6m (third order). On both sides of these strips there are auxiliary strips (banda auxiliar) where selective clearing is applied. The width of these elements can vary according to the prevalent conditions. (Nina Lauterburg)

Implementation activities, inputs and costs

Establishment activities

- Project planning and design of firebreak system
- Adaption of the agricultural tractors with forest management machinery (wheels, protection of the machine against stones, clearing machinery with chains)
- Cutting and chipping (in-situ) of trees and shrubs (execution of firebreak network)
- Transport of wood (fuel wood)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1095.00	0%
Equipment		
- machine use	675.00	0%
TOTAL	**1770.00**	**0.00%**

Maintenance/recurrent activities

- Clearing of firebreaks of first order (every 2 years)
- Clearing of firebreaks of second and third order (every 4 years)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	557.00	0%
TOTAL	**557.00**	**0.00%**

Remarks:
The costs of the establishment of firebreaks can be affected by numerous factors, such as slope (if the slope is steep, the work is much more difficult and takes more time, because machines cannot be used on steep slopes), vegetation density (it takes more time to clear a dense area), stone content of the soil (if there are many stones the work is much more difficult for the machines and more dangerous for the workers), availability of a road (where a firebreak can be established, costs can be saved). Important to note is that maintenance costs could increase with an increase in rainfall because the vegetation will grow faster (otherwise firebreaks are quite resistant against climate change or weather extremes). Furthermore, modifying a normal tractor for forest management can be extremely expensive.
The total costs of the firebreaks (establishment and maintenance) were calculated for the application of the technology on one hectare, based on the indications given in the official project documents of the regional government (Generalitat Valenciana) and information from different stakeholders (e.g. forest agent, university staff, employee of VAERSA). The whole project costs were around 3 Mio Euro for the establishment and around 1.5 Mio Euro for the maintenance phase. The maintenance costs refer to the third maintenance phase taking place from 2008 to 2012. The costs of the execution of the project were 1312 Euro/ha (1770 Dollar) and the costs of the maintenance were 82.03 Euro/ha (110 Dollar, after 2 years) and 331.37 Euro/ha (446 Dollar, after 4 years). The currency rate (Euro-Dollar) was calculated on November 16th, 2013.

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ increased wood production
+ increased fodder production
+ increased fodder quality
+ increased animal production

Production and socio-economic disadvantages

++ high establishment and maintenance costs
+ loss of land
+ job uncertainty

Socio-cultural benefits

++ improved conservation / erosion knowledge
++ improved situation of disadvantaged groups
++ Increase of the security for fire fighters
+ conflict mitigation
+ improved food security / self sufficiency

Socio-cultural disadvantages

+ loss of recreational opportunities
+ socio cultural conflicts
+ increased health problems

Ecological benefits

++ reduced hazard towards adverse events
++ reduced fire risk
+ reduced emission of carbon and greenhouse gases

Ecological disadvantages

+ increased surface water runoff
+ decreased soil cover
+ decreased soil organic matter
+ increased soil erosion locally
+ increased habitat fragmentation

Off-site benefits

++ reduced risk of wildfires
+ reduced downstream flooding
+ reduced downstream siltation
+ reduced damage on neighbours fields
+ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

+ Through the establishment and the maintenance of firebreaks it is easier to control fires and protect people. Furthermore it created jobs for the unemployed. But it seems that in general forest management is not something people want to do, they work in this sector only if there are no other job opportunities. Forest management means a hard job and this kind of work is not well-respected in society

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	very positive	very positive
Maintenance / recurrent	very positive	very positive

Both the short-term and the long-term benefits are very positive assuming that maintenance is done. Together with the creation of jobs, directly after establishing the firebreaks there is firewood and timber available and a reduced risk of wildfires. But it should also be considered that the establishment costs are high. If maintenance is not done the long-term returns will be very negative because an increase in the risk of fire will occur again (without management, there will also be no firewood, no timber and no jobs). The maintenance costs increase the longer you wait because the vegetation will grow again densely.

Acceptance / adoption:

There is little trend towards (growing) spontaneous adoption of the technology. The existing firebreak network system was established within the pilot project. Other firebreaks were created afterwards by the regional government of Valencia or already existed before. Maybe the network is enlarged in some areas from time to time. This technology is also applied in other countries/regions, amongst others in Portugal, South Carolina and South Africa.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
There is a reduction of fuel load within the firebreaks and therefore they contribute to fire prevention. → The maintenance of firebreaks is crucial	Firebreaks are a strong disturbance of the natural environment. People often criticise the negative aesthetic/visual impact which results in a decline of the recreational value. → This problem is difficult to overcome, but the technology helps to prevent an even bigger disturbance of the forest caused by a fire. Even though criticising the firebreaks due to its visual impact people know about the importance of this measure and are also concerned with the devastating effects of a forest fire. There is always the question of what is better: to establish firebreaks and disturb nature, or to experience a large fire.
A firebreak does not stop a fire but facilitates the access for fire fighters (and vehicles) and guarantees a higher security for people, thus increasing the possibility to control/slow down a fire. By arranging the territory in different parcels (firebreaks of first, second and third order) the spread of large forest fires is less probable → The maintenance of firebreaks is crucial. Furthermore, there must be a good coordination and organisation within the fire fighter staff in case of an emergency.	The establishment and the maintenance activities are expensive and labour-intensive. Without management the firebreaks are not effective anymore. It would be necessary to extract biomass from the forest to decrease the continuity of the trees and shrubs. In case of a lack of management the risk of fires increases. → Management is crucial. It should be noted that prevention measures are often less expensive than rehabilitation activities after a fire. More investment in forest management and fire prevention is required. Managing the forest would not only decrease the risk of fire but also generate benefits (e.g. wood, biomass). Furthermore, jobs would be generated which is especially important during the current economy crisis in Spain. There are some good practices found in other regions to cover the maintenance costs: In Jarafuel (next to Ayora) a part of the rent paid by the wind mill company to the state is reinvested in forest management. Or in Andalucia, the government launched a project to invest subventions in maintenance of firebreaks through grazing and this was very successful. This could be a good alternative to expensive management measures. It was also mentioned by many stakeholders that traditional activities (such as grazing, agriculture, wood gathering) should be reactivated and that the villagers should get economic compensation to maintain the forest in a good state.
There are both social and economic benefits for local people. The establishment and the maintenance of firebreaks provide jobs for rural people which allows them to increase their livelihood conditions. A part of the extracted wood is used for biomass, fertilizers, pellets, or firewood. Furthermore there would be improved conditions for grazing. → More investment in forest management is required to sustain these benefits. Furthermore, many local stakeholders mentioned the importance of reactivating traditional activities (such as grazing, agriculture, wood gathering) and that the villagers should get economic compensation to maintain the forest in a good state.	Firebreaks are not that efficient because after clearing, the first plants which grow are Ulex parviflorus and Cistus albidus which are fire-prone species. Furthermore, if you cut them each 4 or 5 years there will only be grassland which is not natural in Mediterranean region. A fire could be caused more easily due to the high amount of thin and dead material. → CEAM suggests to plant more fire-resistant species (late successional stages) within some spots in the firebreaks to increase the resilience of the ecosystem. Green living plants have a higher humidity content which slows down a fire (oxygen is consumed). The issue is not to cover the whole firebreaks with plants but to establish some green spots. By planting late-successional species densely you don't allow seeders to grow. This measure could also decrease management costs. People keep in their minds the idea of having to clear all the vegetation in order to not have fires or to stop them, but it is not really the most sustainable one. The idea of green firebreaks is already common in some other countries but you need to ensure water availability for irrigation.
Vegetation removal produces fresh vegetation growth, therefore more diverse and nutritious fodder is available for animals (game and livestock) in the cleared areas. Game/wildlife and livestock are better because there is an increase in fodder quantity and quality. → The maintenance of firebreaks is crucial.	In some areas, the implementation of firebreaks can occupy productive land which means a loss of land → The main objective of this technology is to provide protection from forest fires instead of creating productive land.
Due to the high stone content of the soil, and due to mulching through in-situ brush-chipping of the cleared material, the firebreaks are not that prone to erosion as in other regions/countries (e.g. Portugal). →	The work is dangerous and there is a high risk to harm oneself when clearing and chipping the vegetation. It is also a physical stress due to the exhausting work →
Improvement and maintenance of the forest paths and streets to establish firebreaks and to guarantee access for fire fighter vehicles but also for recreational activities (rural tourism). → Establishment and maintenance of the firebreaks can improve the forest track network.	When there is a strong and dry wind from the inland (poniente) the smaller firebreaks are useless because the fire just passes over. It should also be noted that without human intervention the firebreaks do not stop a fire → Establish big firebreaks and ensure maintenance.
Fewer fires result in a decrease of the destroyed area, less money will have to be invested in restoration or fire extinction. Furthermore, farmers, hunters and honey producers will experience fewer losses. → The maintenance of firebreaks is crucial.	
In Jarafuel where most of the land is public retired people receive the firewood gained by forest clearings for free. They can use the wood for cooking and heating and save a lot of money. → People from the region (outside of Jarafuel) like this idea that villagers benefit from what is removed from the forest. More mechanisms like this should be developed so that people recognize that they also benefit from forest management, which in turn would ensure a sustainable forest management.	
There are also off-site benefits. Fewer fires will result in a reduction of downstream flooding, downstream siltation and damage on neighbours' fields. When fire removes less vegetation the soil is less vulnerable to erosion → The maintenance of firebreaks is crucial.	

Primary strip network system for fuel management

Portugal - Primary strip network system for fuel management

Linear strips are strategically located in areas where total or partial removal of the forest biomass is possible. This technology contributes towards preventing the occurrence and spread of large forest fires and reducing their consequences for the environment, people, infrastructures, etc.

There are three types of strip for fuel management in forest areas: primary, secondary and tertiary, defined by the Law 17/2009. The most important differences between them are in terms of size (primary being the widest and the tertiary the narrowest) and scale (primary referring to the district level, secondary to the municipal level and tertiary to the parish level). The primary strip network system for fuel management (RPFGC) is integrated in the National System to Prevent and Protect Forest against Fires and it is defined by the National Forest Authority (AFN).
The RPFGC aims to re-arrange landscape elements, through the establishment of discontinuities in the vegetation cover, in forest areas and in the rural landscape (for example using water bodies, agricultural land, pasture, rocky outcrops, shrubland and valuable forest stands). Land tenure is private in most of the areas covered by the RPFGC. The main objectives of this technology are: to decrease the area affected by large fires; to enable direct access by fire fighters; to reduce fire effects and protect roads, infrastructures and social equipment, urban areas and forest areas of special value; and to isolate potential fire ignition sources.
These primary strips are ≥ 125 metres wide and preferably between 500 and 10,000 ha in area. The tree cover should be less than 50% of the area and the base of the tree canopy should not be lower than 3 metres. The RPFGC concept should include the adoption of a maintenance programme. The implementation and maintenance operations can be performed through different agro-forest technologies, such as clearance of bushes and trees, pruning, prescribed fire, harrowing and cultivation of the ground beneath the trees. Timber products can be sold and the removed litter can be used in a biomass power plant or applied to the fields to improve soil fertility, using mulching technology.
This SWC Technology needs considerable financial resources in terms of labour and equipment at the implementation phase. Costs, however, undergo considerable reduction thereafter. The implementation of this infrastructure to prevent and protect the land from forest fire is entirely funded by the government and implemented by the forest municipal services.

left: Reduction of the density of trees and or vegetation removal using machinery (Photo: João Soares)
right: Primary strip network system for fuel management. (Photo: João Soares)

Location: Portugal
Region: Santarém / Mação
Technology area: 400 km^2
Conservation measure: structural
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Mixed: Agroforestry
Climate: subhumid, temperate
WOCAT database reference: T_POR001en
Related approach: Forest Intervention Area (QA | POR01)
Compiled by: Celeste Coelho, University of Aveiro
Date: 2011-10-16
Contact person: Celeste Coelho, Centre for Environmental and Marine Studies University of Aveiro 3810 - 193 Aveiro Portugal Tel.: +351 234 370 349 Fax: +351 234 370 309 E-mail: coelho@ua.pt

Classification

Land use problems:

- Forest fires increase due to rural depopulation and to land management abandonment. (expert's point of view)

Land use

Natural
Agroforestry
rainfed
silvo-pastoralism
rainfed
selective felling of (semi-) natural forests, clear felling of (semi-)natural forests

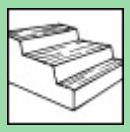
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires

Conservation measure



Structural: Others ()

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: Property size

Main technical functions:
- control of fires

Secondary technical functions:
- reduction of dry material (fuel for wildfires)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 1 days(1 per year)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, decreasing length of growing period
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells

Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: groups / community, Small scale land users, common / average land users, men and women
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, not titled
Land use rights: individual
Water use rights: open access (unorganised)
(Individual, not titled: Usually, legal documents for the property are missing.)
Relative level of wealth: average, which represents 50% of the land users; 50% of the total area is owned by average land users
poor, which represents 50% of the land users; 50% of the total area is owned by poor land users

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: low: employment (eg off-farm); moderate: education, technical assistance, telecommunications; high: health, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: mixed (subsistence and commercial)

Technical drawing

This technical drawing indicates the technical specifications, dimensions and spacing for the Primary Strip Network System for Fuel Management. The figure shows a road as the axis of the RPFGC, but it can also be a river or a ridge, amongst other breaks in the forest cover. (João Soares)

Implementation activities, inputs and costs

Establishment activities

- Primary System design
- Shrubs cleaning + Thinning (reduction of fuel load) + Pruning
- Removing the cut waste material
- Litter Shredding
- Transport to the Biomass Plant

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1076.00	0%
Equipment		
- machine use	568.00	0%
- Transport	100.00	0%
TOTAL	**1744.00**	**0.00%**

Maintenance/recurrent activities

Remarks:
The costs include the activities to ensure the vertical and horizontal discontinuity of the fuel load and also the activities needed to manage the waste produced from the shrubs cleaning and thinning.
The costs calculation was made for the implementation of the first section of the RPFGC. The implementation phase lasted for 2 or 3 months during the dry season. This section included 28 ha and 4 teams of forest sappers were involved.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ reduced risk towards adverse events (droughts, floods and storms)
++ increased fodder production
++ increased fodder quality
++ increased animal production
+ increased energy production: biomass

Production and socio-economic disadvantages

++ costs of implementation
+ reduced wood production
+ increased maintenance costs

Socio-cultural benefits

++ community institution strengthening
+ national institution strengthening
+ conflict mitigation
+ improved conservation / erosion knowledge

Socio-cultural disadvantages

+ socio cultural conflicts

Ecological benefits

+++ reduced hazard towards adverse events
+++ reduced fire risk
+ improved soil cover

Ecological disadvantages

++ decreased soil cover
+ increased surface water runoff
+ decreased soil organic matter
+ increased soil erosion locally
+ increased habitat fragmentation

Off-site benefits

+++ reduced damage on public / private infrastructure
++ reduced damage on neighbours fields

Off-site disadvantages

Contribution to human well-being / livelihoods

+ reduced risk of wildfire

Benefits /costs according to land user

Benefits compared with costs	**short-term:**	**long-term:**
Establishment	neutral / balanced	positive
Maintenance / recurrent	neutral / balanced	positive

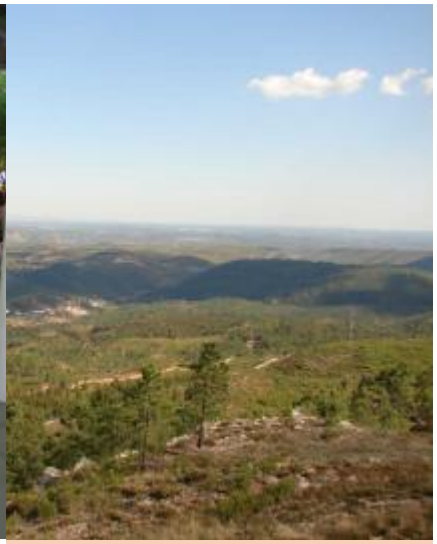
The maintenance will only start 2 or 3 years after the technology implementation, so no returns are expected at short-term.

Acceptance / adoption:

There is strong trend towards (growing) spontaneous adoption of the technology. After the implementation period there was a high local acceptance of the technology. It is also expected that grazing activities contribute to the technology maintenance

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Fuel load reduction → This will be achieved using prescribed fire and specialised machinery. The efficacy of prescribed fire depends on the collaboration of technicians and forest sapper teams. To guarantee the effectiveness of RPFGC implementation, long-term maintenance has to be ensured.	Soil erosion increase → Forestry good practices should be used in the RPFGC implementation, especially concerning the use of machinery and avoiding disturbance of soil at depth. Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture).
Reinforcement of the forest path system → Clearing the strips of the RPFGC can enhance the forest track network.	Soil cover reduction → Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture).
Forest fire prevention and fighting → The know-how of the local stakeholders and communities will contribute to the design of the RPFGC . This information should be integrated into the Municipal Plans to Prevent and Protect Forest Against Fires (PMDFCI). Any further information should be provided to the Civil Protection Agencies and to the Forest Technical Office and also to the local fire-brigade team.	Runoff increase → Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture). Excessive vegetation removal should be avoid, especially near water courses where the removal should be nil or minimum.
Increase in landscape resilience → This will only be effective if the RPFGC is continuous and without gaps. The acceptance of the RPFGC by the landowners is fundamental to widespread the use of this technology. Information and awareness about the need to change vegetation cover is also very important, in order to avoid extensive areas of monoculture.	Budget for implementation and maintenance → European and national funds. Collaboration of the local government providing equipment and labour force. Information and awareness to the landowners about the importance of this technology. Campaigns of national awareness and definition of this technology as 'public use' to overcome some potential social conflicts concerning the land rights.



Forest Intervention Area (ZIF)

Portugal - Zona de Intervenção Florestal (Portuguese)

Forest Intervention Area (ZIF) is a territorial unit, where the main land use is forestry. This approach assembles and organizes small forest holders and defines a joint intervention for forest management and protection. Defined by law in 2005, and revised in 2009, each ZIF of private forest has to include at least a contiguous area of 750 ha, 50 landowners and 100 forest plots, and has to be managed by a single body, defined by ZIF members.

Aim/objectives: The ZIF overall objective is to promote the efficient management of forest and to mitigate current constraints of forest intervention (e.g. land size and tenure). Other objectives are to develop structural measures for fire prevention, to integrate local and central administration actions and to implement the national and regional forest management policy at the local level. The final purpose of ZIF areas is to improve productivity in rural forest areas, contributing to rural development

Methods: The idea emerged after the catastrophic wildfires of 2003 and was developed and presented by a group of stakeholders (landowners, forest associations, City Council, among others) to the Ministry of Agriculture, Rural Development and Fisheries. The ZIF approach was legislated by Law 127/2005, and revised under Law 15/2009. Each ZIF assembles small properties, which will be jointly managed by a single entity, which can be a non-profit-making and voluntary organization or some other group of people approved by the forest owners. Each ZIF will have a Forest Management Plan (PGF), where the forestry operations and activities for ZIF area are defined accordingly to the guidelines of the Regional Plan for Forestry Management and Planning (PROF), and a Specific Plan to Forest Protection (PEIF), which includes actions to protect forest against biotic and abiotic risks. The management entity should have a team with qualifications and experience in forestry and with technical ability to design these plans.

Stages of implementation: The legal constitution of ZIF includes six mandatory steps, namely the constitution of the founding group (group of landowners with at least 5% of a continuous area inside the ZIF), the prior consultation meeting, the public consultation, the final audience meeting, the proposal submission to the National Forest Authority (AFN) and legal publication of each ZIF (already done). After these procedures, the PGF and PEIF of each ZIF will be designed by the management entity and evaluated and approved by AFN. The implementation activities can then be implemented by the management entity or by individual landowners following the rules described on the plans. PEIF validity is five years and PGF validity is 25 years (still in preparation). [See figure below].

Role of stakeholders: The founding group is mainly composed of forest owners and producers and is the starting point for creating a ZIF. The management entity administers the ZIF in order to achieve their main purposes and the aims defined on the plans. AFN will support and monitor ZIF activities. ZIF non-supporting landowners are obliged to have a PGF for their land, as well as to accomplish the PEIF of the ZIF.

The landowners inside the ZIF who are non-supporters do not have a clear role. Based on PROF - Plano Regional de Ordenamento Florestal (Regional Plan for Forestry Management and Planning), for ownerships of > 25 ha, the owners are obliged to have a PGF - Plano de Gestão Florestal (Plan for Forestry Management) for their property.

left: ZIF Information Session (Photo: AFLOMAÇÃO)

right: Forest Intervention Areas in Mação Municipality (Photo: João Soares)

Location: Santarém, Mação
Approach area: 400.00 km^2
Type of Approach: project/programme based
Focus: mainly on other activities
WOCAT database reference: A_POR001en
Related technology(ies): Prescribed Fire (POR02), Primary Strip Network System for Fuel Management (POR01)
Compiled by: Celeste Coelho, University of Aveiro
Date: 2009-02-01
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Problem, objectives and constraints

Problems

- lack of forest planning and management, forest fires, land structure and tenure, land abandonment, rural depopulation and ageing.

Aims/Objectives

- To promote the sustainable management of forest; - To coordinate the protection of forest and natural areas; - To reduce the conditions to fire ignition and spread; - To coordinate the recovery of forest and natural areas affected by forest fires; - To give territorial coherence and effectiveness to the action of local administration and others actors.

Constraints addressed

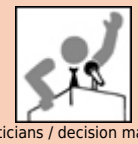
	Constraint	Treatment
social / cultural / religious	Social resistance to this approach. Landowners fear to lose tenure rights. Difficult to reach and find owners due to inheritance and out-migration. Rural depopulation occurred in the last decades.	Financial support, creation of new job opportunities in rural areas.
institutional	Scepticism about the practical effects of this approach. Very high costs for implementation and lack of private investment	ZIF pilot areas will motivate implementation and investment into other ZIFs.
financial	High implementation cost.	Governmental incentives
legal / land use and / water rights	Land structure and tenure (private holdings)	Minimum area to constitute a ZIF is 750 ha

Participation and decision making

Stakeholders / target groups


land users, individual


SLM specialists / agricultural advisors


politicians / decision makers

Approach costs met by:

government (Permanent Forest Fund)	100%
local community / land user(s) (ZIF implementation activities: National Strategic Reference Framework (60%), Land users (40%))	0%
Total	**100%**

Annual budget for SLM component: US$ > 1,000,000

Decisions on choice of the Technology(ies) mainly by SLM specialists with consultation of land users

Decisions on method of implementing the Technology(ies): by SLM specialists alone (top-down)

Approach designed by: national specialists

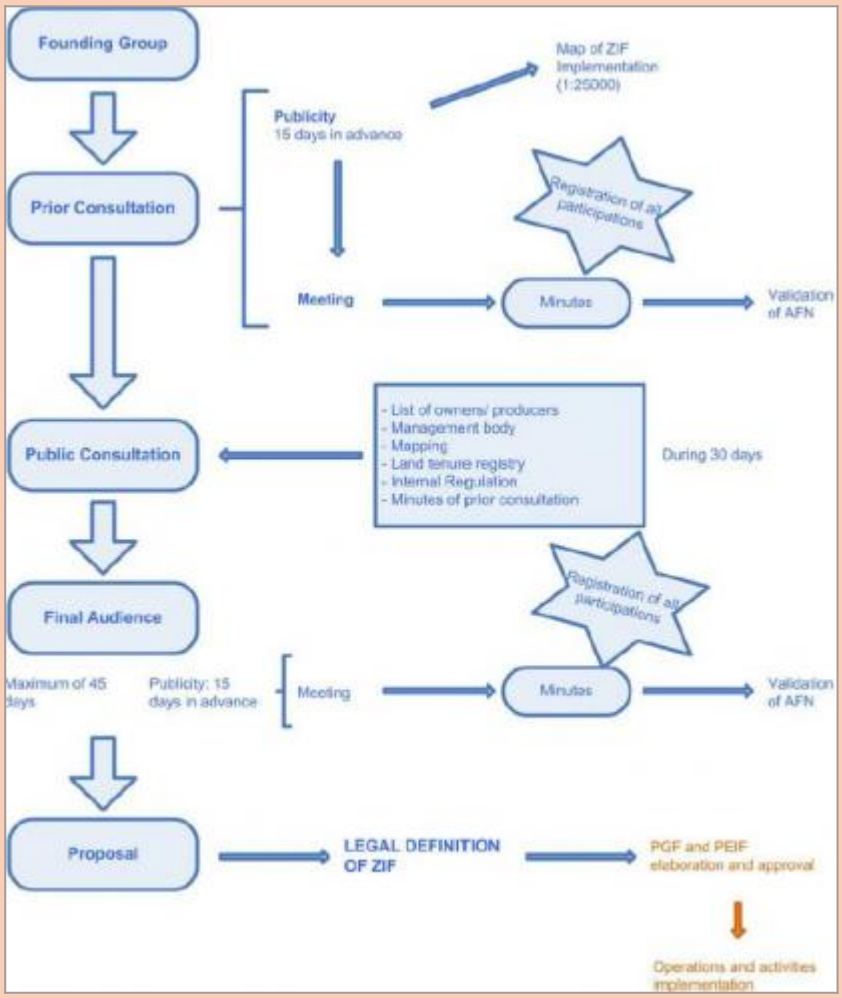
Implementing bodies: other (Private organizations), local community / land users, local government (district, county, municipality, village etc)

Land user involvement

Phase	Involvement	Activities
Initiation/motivation	Interactive	Balance alternatives and take decision to test the agave forestry information sessions about ZIF approach; informal contacts, door-to-door approaches and formal agreement of the landowners to become ZIF members.
Planning	Passive	information sessions to present the ZIF plans (PGF and PEIF).
Implementation	Interactive	management activities can be made by the land owners or by the ZIF management entity. Regular meetings with ZIF members
Monitoring/evaluation	Interactive	not defined yet
Research	Interactive	on-farm research, good practice demonstration and collaboration with research projects.

Differences between participation of men and women: No

Involvement of disadvantaged groups: Yes, moderate
Yes (in the sense that the majority of forest owners are usually pensioners, with low incomes)



Organogram: Legal process related with the ZIF constitution (blue) Elaboration and approval of the ZIF plans (orange) Implementation of the plans (orange)

Technical support

Training / awareness raising:
Training provided for opinion leaders
Training focused on information sessions and individual contacts with opinion leaders

Advisory service:
Name: Information sessions
Key elements:
1. ZIF process
2. Explaining rational of ZIF for specific municipality and its conditions like depopulation, forest fires, etc
3. Elaboration of the ZIF plans

The extension system is well set up to ensure follow-up activities
The extension system is very adequate to ensure continuation of activities.

Research:
Yes, great research. Topics covered include sociology, economics / marketing, forestry, politics, ecology
Mostly on station and on-farm research.
The approach includes technical and local knowledge. The idea was prepared and presented by a group of stakeholders (landowners, forest associations, among others) to the Ministry of Agriculture, Rural Development and Fisheries and legislated by the Law n. º 127/2005, 5 August.

External material support / subsidies

Contribution per area (state/private sector): Yes. through FFP (Permanent Forest Fund) and QREN (National Strategic Reference Framework).

Labour: Voluntary. landowners can work on their properties or can be substituted by the ZIF management entity. Some activities, such as the implementation of the Primary Strips Network System for Fuel Management can be supported by the municipality services.

Inputs:
- Equipment (machinery, tools, etc): Printer, toners, map production.. Fully financed

Credit: n. a.

Support to local institutions: Yes, great support with
City council supports the forest association activities.

Monitoring and evaluation

Monitored aspects	Methods and indicators

Changes as result of monitoring and evaluation:
(* The monitoring procedures are not structured yet) (* The monitoring procedures are not structured yet)

Impacts of the Approach

Improved sustainable land management: Yes, great; Reduction of the number and likelihood of forest fires.

Adoption by other land users / projects: Yes, many; The initial social resistance to the approach will diminish through the existence of a successful ZIF.

Improved livelihoods / human well-being: Yes, moderate

Improved situation of disadvantaged groups: Yes, moderate; It is expected that the increase in land productivity through the implemented technologies will help to improve the socio-economic situation of these rural groups.

Poverty alleviation: Yes, moderate; It is expected that the implementation of this approach will contribute to the improvement of rural socio-economic conditions through productivity increase, creation of employment and promotion of local products.

Training, advisory service and research:

- Training effectiveness
  SLM specialists: good
- Advisory service effectiveness
  Land users*: good
  Information sessions; Dissemination

Land/water use rights:
Hinder - greatly in the implementation of the approach. The ZIF join small properties and their management is undertaken as a single property, guide by a forest management plan. This entity can be a non-profit and voluntary organization or an other group of people approved by the forest owners and/or producers.
The approach did reduce the land/water use rights problem (greatly).

Long-term impact of subsidies:
Positive long-term impact: Greatly

Concluding statements

Main motivation of land users to implement SLM:

Rules and regulations (fines) / enforcement

Affiliation to movement / project / group / networks

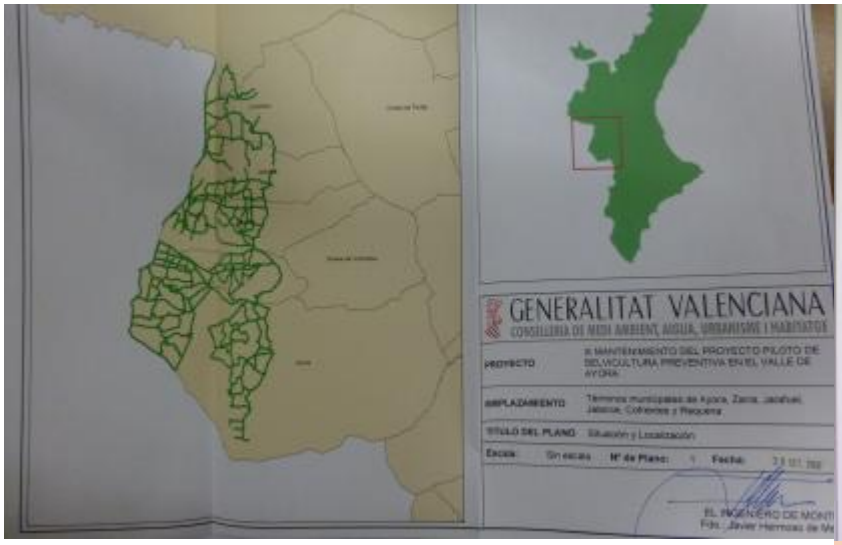
Aesthetic

Forest fires

Sustainability of activities:

No the land users can`t sustain the approach activities without support.
The forest owners do not have the financial capacity to apply and support these activities by themselves.

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Social conscience → through awareness campaigns and information sessions provided at national and local level.	Unattractive investment (low public support and lack of private support) → the need to review and reform the existing QREN or provide others means of support. Incentives to private initiative or donors should be found.
Prevention of forest fires → the increase of forest management will contribute to the decrease of large forest fires. The implementation of integrated and global measures to fire prevention will be suitable within the ZIF approach.	Highly bureaucratic nature of the ZIF approach → simplification of the bureaucratic process
Restoration of burnt areas → The use of forest species to enable the protection and recovery of degraded soils or soils with high erosion risk has a very positive influence on the rehabilitation of burnt areas. However, many of these species are not economically attractive at short or medium term. The management of the land using ZIF model will allow the definition of the most affected areas for an urgent intervention.	Rather complex process: unclear role for the non-adherent landowners within the ZIF; ZIF has to follow many laws and plans; control and monitoring activities still not defined → clarification and simplification of the bureaucratic process of the ZIF
Increase productivity → present land tenure and structure of forest holdings constitute a bottleneck for forest productivity. The integrated management of the ZIF will allow a better management and use of the land, increasing the exploitation of timber and non-timber products and also increasing the resilience to wildfires.	Costs related to the approach → major financial support from the government needs to be provided.
Improve forest management → promotion of the planting of more fire-resilient species which are better adapted to the local conditions. AFN should: (i) provide information about the guidelines; (ii) develop new policies and tools, which are more suitable to the local level; (iii) support and implement public awareness campaigns about forest values and services, and (iv) provide financial support to ZIF constitution and implementation activities.	



Plan of preventive silviculture (PSP): implementation of firebreak network within a forest intervention area (ZAU)

Spain - Plan de selvicultura preventiva de incendios en los sistemas forestales de la Comunidad Valenciana (Spanish)

Through the declaration of Ayora to a forest intervention area (ZAU) and the implementation of the pilot project of the PSP, a preventive silviculture was promoted through the establishment of a firebreak network.

Aim/objectives: Forest fire is the main degradation driver in Ayora. In the article 24 of the forest law 3/1993 the declaration of special areas to forest intervention areas, so-called "Zonas de Actuación Urgente (ZAU)" through the regional government of Valencia is defined. Objectives are the protection against natural hazards and the promotion of conservation/restoration within a area which is degraded, affected by a forest fire (and natural regeneration is not probable), adverse climatic conditions, pests, severe ecological change, or fauna or flora of special value. If the use of the resources is not compatible with the conservation objectives within a ZAU, the administration has the right to enforce restrictions. The Ayora region was declared to a ZAU in 1997 due to its high risk of fires. In the "Plan de Selvicultura Preventiva de Incendios en los Sistemas Forestales (PSP)" ("plan of preventive silviculture to prevent forest fires") which became operative in 1996 and whose main objective is the reduction of the fire risk, the ZAU was practically addressed for the first time in the establishment of a firebreak network (áreas cortafuegos). The PSP constitutes an important part of the "plan de protección contra incendios forestales" ("plan of protection against forest fires") and has the following main objectives: The analysis/mapping of historic forest fires in Valencia (1984-1994) to support decision-making in silvicultural issues, the classification of the forest by quality and fire risk to establish local/regional plans to prevent fires (through silvicultural actions), selection of areas (province level) for the establishment of pilot projects (to apply silvicultural actions), decision on periodic investment and level of employment.

Methods: Within the PSP, 4 pilot projects were initiated in Los Serranos (17'470 ha), Utiel-Requena (20'966 ha), Valle de Ayora-Cofrentes (33'851 ha) and Sierra de Mariola (11'574 ha) to promote a preventive silviculture which aims in modifying the amount of fuel in the forest through the establishment of a firebreak network and to limit the burnt area. The pilot areas were selected (in collaboration with the forest administration of Valencia) by the following criteria: representativity for the whole province, high value for the population, high potential risk of fire. In T_SPA009en the pilot project of Ayora-Cofrentes (Cofrentes, Jalance, Jarafuel, Zarra, Ayora) is described in detail and this approach focuses on the Ayora site as well. The firebreak network was established between 1998 and 2002, carried out by the company VAERSA and executed on both public and private land. Since the old firebreaks (established before the project) had a strong visual and ecological impact, the PSP designed a new type called "área cortafuego". The continuous maintenance of the firebreaks is required which is also included in the pilot project. The total area protected by the firebreak network amounts to 33'851 ha while the management measures were executed on 1944,81 ha. The costs of the execution were 1312 Euro per ha, the maintenance 82.03 Euro per ha (all 2 years) and 31.37 Euro per ha (all 4 years).

Stages of implementation: After the establishment of the PSP (1996) and the declaration of Ayora to a ZAU (1997) the implementation of the pilot project was realized in the following phases: 1) splitting up of the territory based on the quality and the potential risk (using maps and aerial pictures), 2) field work (to examine the first draft of the firebreak network elaborated in the office), 3) office work (digitizing), 4) final map, 5) estimation of costs, 6) combination of firebreak plan with the cadastral land register.

Role of stakeholders: The PSP, the ZAU and the pilot projects were set up by the regional government of Valencia, in collaboration with the forest services. The PSP is put into operation each year by the forest services to plan the maintenance of the firebreak network. The effect on the local population is the creation of jobs in forest management.

left: Third maintenance of the firebreaks established through the pilot project of the plan of preventive silviculture (Photo: Generalitat Valenciana)

right: Project documents of the plan of preventive silviculture (Photo: Generalitat Valenciana)

Location: Spain, Valencia, Los Serranos, Utiel-Requena, Valle de Ayora-Cofrentes, Sierra de Mariola
Approach area: 838.61 km^2
Type of Approach: project/programme based
Focus: mainly on conservation with other activities
WOCAT database reference: A_SPA002en
Related technology(ies): Cleared strip network for fire prevention (firebreaks) (T_SPA009en)
Compiled by: Nina Lauterburg, CDE
Date: 2013-05-06
Contact person: Jaime Baeza, Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Parque Tecnológico Paterna. C/ Charles Darwin 14, 46980 Valencia, Spain. / Departamento de Ecología, Universidad de Alicante, Ap. 99, 03080 Alicante, Spain.
jaime.baeza@ua.es

Problem, objectives and constraints

Problems

High amount of continuous fuel due to lack of management which increases the risk of vast and devastating fires, lack of fire prevention and extinction measures, ecological and visual impact of old firebreaks.

Aims/Objectives

Research on historic fires to support decision-making in silvicultural practices, fire risk reduction, reducing the burnt area through splitting up the forest, improvement of fire prevention and extinction measures (e.g. improvement of access for fire-fighting vehicles and protection of fire fighters), establish local/regional plans to prevent fires (through silvicultural actions), promote conservation of the forest on a large scale

Constraints addressed

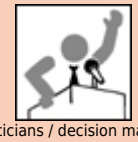
	Constraint	Treatment
institutional	Laws on forest management existed already before the implementation of the PSP but the idea of establishing a firebreak network was not available	With the pilot project of the PSP the firebreak network was carefully assessed and implemented
financial	There was a lack of money to implement silvicultural measures	The pilot project of the PSP was fully financed by the government

Participation and decision making

Stakeholders / target groups


planners


SLM specialists / agricultural advisors


politicians / decision makers


land users, groups

Approach costs met by:

government (government of Valencia)	100%
Total	**100%**

Annual budget for SLM component: US$ 100,000-1,000,000

Decisions on choice of the Technology(ies) Politicians in collaboration with SLM specialists

Decisions on method of implementing the Technology(ies): Politicians in collaboration with SLM specialists

Approach designed by: national specialists

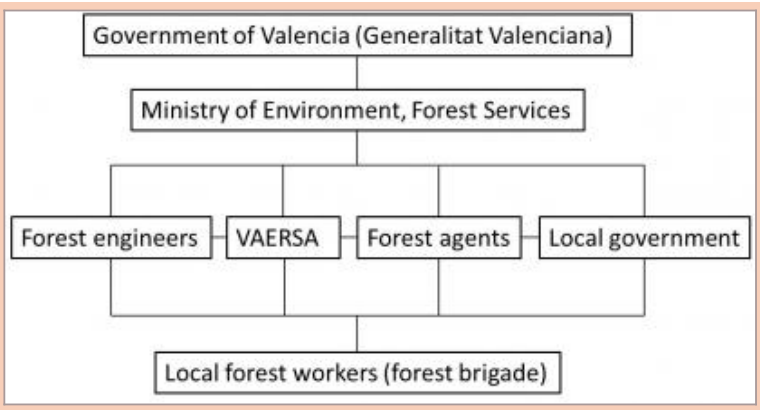
Implementing bodies: government (Regional government of Valencia (Generalitat Valenciana), forest services), local government (district, county, municipality, village etc) (Probably the local governments helped in the implementation of the pilot projects, e.g. provision of maps.)

Land user involvement

Phase	Involvement	Activities
Initiation/motivation	None	By government of Valencia
Planning	None	By government of Valencia
Implementation	Payment/external support	local people working in the execution and maintenance of the firebreak network, led by forest agents and forest engineers of the government of Valencia
Monitoring/evaluation	None	By government of Valencia
Research	None	By government of Valencia

Differences between participation of men and women: Yes, moderate
Usually men are involved in the forest sector

Involvement of disadvantaged groups: Yes, little
In the execution and the maintenance of the firebreak network unemployed local people were/are included. But in the development of the PSP this was not the case.



Organogram: The PSP and the pilot projects were set up by the regional government of Valencia in collaboration with the forest services. Forest engineers and forest agents are employed at the forest services and helped to design the projects. VAERSA, a public company of the Generalitat Valenciana, executed the pilot projects and was supported by forest engineers, forest agents and the local governments. Local forest workers were contracted (by VAERSA) for execution and maintenance work and controlled by forest agents. (Nina Lauterburg)

Technical support

Training / awareness raising:
Training provided for land user
Training was on-the-job
Training focused on Training of local people in the use of machinery in forest management (execution and maintenance of firebreaks)

Advisory service:

The extension system is quite adequate to ensure continuation of activities. The maintenance of the pilot projects is included in the PSP and is planned and executed by the government of Valencia. Already three maintenance projects followed after the execution of the pilot projects (2000-2004, 2004-2008, 2008-2012). Future funding of activities is not clear.

Research:
Yes, moderate research. Topics covered include technology, economics / marketing, ecology
Mostly on station and on-farm research.
analysis/mapping of historic forest fires in Valencia (1984-1994) to support decision-making in silvicultural practices, classification of the forest by quality and fire risk, research on causes of forest fires

External material support / subsidies

Contribution per area (state/private sector): Yes. state (government of Valencia)

Labour: Paid in cash. execution and maintenance of firebreak network (forest management)

Inputs:
- Equipment (machinery, tools, etc): machinery for forest management. Fully financed
- Infrastructure (roads, schools, etc): roads . Fully financed

Credit: Credit was not available

Support to local institutions: No

Monitoring and evaluation

Monitored aspects	Methods and indicators
technical	Regular observations by project staff, government: Observations of built-up of fuel to decide when and where maintenance is required

Changes as result of monitoring and evaluation:
There were no changes in the approach.

There were few changes in the technology. The technology is the same since the execution of the project but maintenance (e.g. clearing of firebreaks) is applied. Some more firebreaks were established where it was still required and not covered by the pilot project.

Impacts of the Approach

Improved sustainable land management: Yes, moderate; Improvement of fire extinction and prevention

Adoption by other land users / projects: Yes, few; Within the PSP they carried out 4 pilot projects, and after the projects more firebreaks were established

Improved livelihoods / human well-being: Yes, little; Reduction of the risk of fire and the loss of land through fires. Furthermore jobs were created by this project.

Improved situation of disadvantaged groups: Yes, little; More jobs provided through this approach of forest management

Poverty alleviation: Yes, little; More jobs provided through this approach of forest management

Training, advisory service and research:

- Training effectiveness
  Land users*: good
- Research contributing to the approach`s effectiveness: Moderately
  The development of the firebreak network is a complex process and was planned in detail.

Land/water use rights:
None of the above in the implementation of the approach. The firebreak network was implemented on both public and private land and the government of Valencia is allowed to establish a ZAU by law.

Long-term impact of subsidies:
Once the government will not be able to continue paying the maintenance of the firebreaks the technology will probably not be managed anymore

Concluding statements

Main motivation of land users to implement SLM:

Fire prevention and extinction

Sustainability of activities:

No the land users can`t sustain the approach activities without support.
The maintenance is expensive and has to be financed by the state. Furthermore, forest services need to provide technical assistance.

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
There are both social and economic benefits for local people. The establishment and the maintenance of firebreaks provide jobs for rural people, which allows them to increase their livelihood conditions. People do not depend on unemployment payments and are therefore more accepted in society. → The government should sustain its investment in forest management and include the local population	Land users cannot continue the SLM approach/ technology on their own. The maintenance is expensive and has to be financed by the state. Once the government will not continue paying the maintenance of the firebreaks the technology will probably not be managed anymore. Furthermore, forest services need to provide technical assistance → The government should sustain its investment in forest management. More trainings could be provided to local land users by the government of Valencia
There are also firebreaks which were not established within the pilot project but due to a request of forest agents. The project was important to upscale this technology and to get people's attention for the problem of forest fires. → Public awareness raising.	Little involvement of the local population. The projects were designed by the government without including local land users → Include local land users in the planning of forest management. Work in a transdisciplinary way.
The firebreak network facilitates the access for fire fighters (and vehicles) and guarantees a higher security for people, thus increasing the possibility to control/slow down a fire. By arranging the territory in different parcels (firebreaks of first, second and third order) the spread of large forest fires is less probable → The maintenance of firebreaks is crucial. Furthermore, there must be a good coordination and organisation within the fire fighter staff in case of an emergency	Firebreaks do mainly work in fire extinction and less in fire prevention → Investigation of other management practices and approaches. An integrative way of forest management could be the clearing of fire-prone species and the planting of more fire-resistant species as suggested by CEAM.
The maintenance of the firebreak network is included in the PSP. → The government should sustain its investment in forest management.	
Before the implementation of the pilot projects of the PSP there was a lack of money and no institutional base. The pilot project allowed to establish a firebreak network (fully financed by the government of Valencia) → The government should sustain its investment in forest management.	

Selective clearing and planting experiment to promote shrubland fire resilience

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

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 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.

left: 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. (Photo: CEAM)
right: The combination of clearing fire-prone and planting more fire resistant species is an appropriate management practice of fire-prone shrubland. (Photo: CEAM)

Location: Spain, Valencia
Region: Ayora
Technology area: 0.015 km^2
Conservation measure: vegetative
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: Developed through experiments / research, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_SPA011en
Related approach:
Compiled by: Nina Lauterburg, CDE
Date: 2013-04-26
Contact person: Alejandro Valdecantos, Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Parque Tecnológico Paterna. C/ Charles Darwin 14, 46980 Valencia, Spain. Phone: +34 609 183 599 E-Mail: a.valdecantos@ua.es

Classification

Land use problems:

- In Spain the prevalent dense shrublands (dominated by seeder species), which resulted from agricultural land abandonment and fire occurrence, contain a high fire risk because of both the high fuel loads and their continuity. Resprouter species have been removed in the past and are therefore scarce, whereas seeder species are abundant and increase the risk of fires. (expert's point of view)

Land use

Natural
Plantations, afforestations selective felling of (semi-) natural forests, plantation forestry

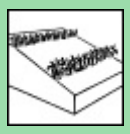
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires, quality and species composition /diversity decline

Conservation measure



Vegetative: Tree and shrub cover
Vegetative: Clearing of vegetation (eg fire breaks/reduced fuel)
Vegetative: Others (Introduction of fire resistant species)

Stage of intervention

Prevention
Mitigation / Reduction
Rehabilitation

Origin

Land users initiative
Experiments / Research: recent (<10 years ago)
Externally introduced

Level of technical knowledge

Agricultural advisor
Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires), other human induced causes, change of vegetation composition to fire-prone shrubland
Indirect causes: population pressure, poverty / wealth, labour availability

Main technical functions:

- control of fires
- reduction of dry material (fuel for wildfires)
- Promotion of vegetation species and varieties (more fire resistant vegetation composition)

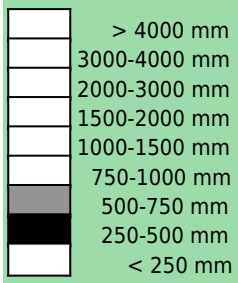
Secondary technical functions:

- increase / maintain water stored in soil

Environment

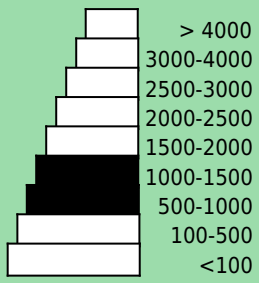
Natural Environment

Average annual rainfall (mm)



> 4000 mm
3000-4000 mm
2000-3000 mm
1500-2000 mm
1000-1500 mm
750-1000 mm
500-750 mm
250-500 mm
< 250 mm

Altitude (m a.s.l.)



> 4000
3000-4000
2500-3000
2000-2500
1500-2000
1000-1500
500-1000
100-500
<100

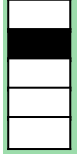
Landform

plateau / plains
ridges
mountain slopes
hill slopes
footslopes
valley floors

Slope (%)

flat
gentle
moderate
rolling
hilly
steep
very steep

Soil depth (cm)



0-20
20-50
50-80
80-120
>120

Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: seasonal rainfall decrease, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells
Sensitive to climatic extremes: temperature increase, seasonal rainfall increase, temperature decrease, snow, frost

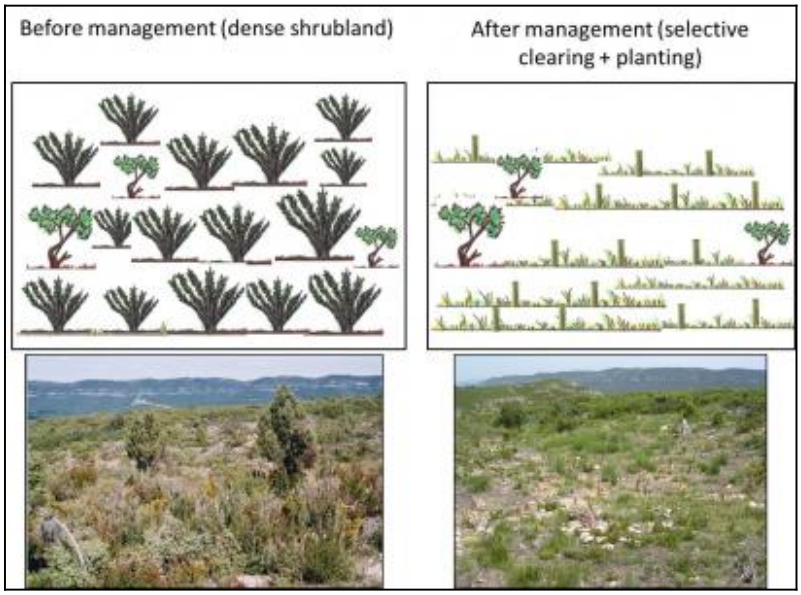
Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: state, individual, titled
Land use rights: individual, public/open access but organised (e.g. wood, hunting)
(There is some public land, controlled by the state. But there is also some private land. The access to the public land is open but organized. Permission is needed from the government to cut trees, to build a house or to hunt. There are some private hunting areas for which the hunting association has to pay a fee.)

Importance of off-farm income: :
Access to service and infrastructure:
Market orientation: mixed (subsistence and commercial)
Purpose of forest / woodland use: timber, other forest products / uses (honey, medical, etc.), recreation / tourism



Technical drawing

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. (Nina Lauterburg)

Implementation activities, inputs and costs

Establishment activities

- 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)
- Planting (planted species: pistacia lentiscus, quercus ilex, rhamnus alaternus)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	3089.00	0%
- tree shelters	945.00	0%
Agricultural		
- seedlings	4587.00	0%
TOTAL	**8621.00**	**0.00%**

Maintenance/recurrent activities

- There is no maintenance, but in case of maintenance they would do selective clearings (using machines)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	446.00	0%
TOTAL	**446.00**	**0.00%**

Remarks:
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). The costs were calculated for the application of the technology (combination of clearing and planting) on one hectare. The costs can vary depending on the amount of vegetation which has to be cleared (site specific). The costs of the clearing amount to 1090 Euro per ha (1470 Dollar). The costs of the plantation (both labour and machines) are approximately 5300 Euro per hectare (7150 Dollar). But it should also be noted that the application of the selective clearing and planting on a vast continuous area is not the aim of this technology, but rather to apply the treatments on some selected spots to reduce the continuity of fire-prone seeder species and to increase the probability of dispersal of resprouter species (e.g. by birds). Therefore the costs would be lower than indicated here. The currency rate (Euro-Dollar) was calculated on November 16th, 2013.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+ increased fodder production
+ increased fodder quality
+ increased animal production
+ increased wood production

Production and socio-economic disadvantages

+ reduced animal production

Socio-cultural benefits

++ improved cultural opportunities
++ increased recreational opportunities
++ improved conservation / erosion knowledge
++ improved situation of disadvantaged groups
+ conflict mitigation

Socio-cultural disadvantages

Ecological benefits

+++ reduced fire risk
++ increased soil moisture
++ increased plant diversity
++ increased biological pest / disease control
++ reduction of germination of competing seeds
++ reduction of soil surface temperature
+ reduced evaporation
+ improved soil cover
+ increased biomass above ground C
+ increased nutrient cycling recharge
+ increased soil organic matter / below ground C
+ reduced emission of carbon and greenhouse gases
+ reduced soil loss
+ reduced soil crusting / sealing
+ increased animal diversity

Ecological disadvantages

Off-site benefits

++ reduced risk of wildfires and damage of villages

Off-site disadvantages

Contribution to human well-being / livelihoods

Not applicable since it was only an experiment, but for sure it would contribute to improve livelihoods and human well-being, forest and shrubland management could provide jobs and would also decrease the risk of fires.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	very positive
Maintenance / recurrent	very positive	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.

Acceptance / adoption:

There is no adoption trend since this was only an experiment, but maybe there will be the possibility to upscale this technology in a regional project.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
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). → Clearing of fire-prone species and planting of late-successional species. The management of these areas is crucial – the clearings must be repeated from time to time.	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.
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 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.
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. → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	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.
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. → Recurrent maintenance is crucial to ensure the effectiveness of the technology.	After clearing, an increase in wind velocity might occur. → The planted trees will grow which will again result in the reduction of this problem.
Social and economic benefits for the locals. Especially during the economic crisis the forest management is an important source for jobs. → Actually there is still a lot of management required in the forest of this region which would provide jobs in the longer term.	
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. → Recurrent maintenance is crucial to ensure the effectiveness of the technology. Villagers and state need to work together and ensure a long-term forest management.	
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. → Recurrent maintenance is crucial to ensure the effectiveness of the Technology.	

Resilience analysis Tool

Result summary

About this Resilience Assessment
Authors:
Baeza, Jaime

Date of Submission:
11/01/2016

Main sources of information:
scientific knowledge

References in the WOCAT database:
SPA 11;

Spain
Spa_3

Shrubland under selective clearing and planting for fire risk reduction and resilience increase

Disturbances affecting the land management system:

The following disturbances affect the land management system, and could change dramatically the environment making it unusable for land users:

Type of disturbance:	 fires	 droughts
Frequency:	**Between 1 and 5 years**	**Between 5 and 10 years**
Risk of permanent changes to the environment after a disturbance:	**High**	**High**

Impact of land management on resilience to disturbances:

This is the impact that the land management practices have in preventing, mitigating and fostering recovery after. All together they indicate which effect the land management has on the resilience of the system to disturbances:

Land Management practice 1: ***Clearing of fire-prone seeder species.***	++	++
Land Management Practice 2: ***Planting of fire resistant resprouter shrubs and trees***	++	0
Overall impact of land management on resilience to disturbances	Very positive	Very positive

*Legend: ++ Very positive; + Positive; 0 Neutral; - Negative; -- Very negative

Human and natural environment of the land management system:

A brief description of the features of the land management system assessed

Land use type		Environment		Management	
	Present land use(s): ***Fo: Other; Fp: Plantations;***		Climate: ***subhumid***		Main measure: ***Vegetative***
	Past land use(s): ***Ca: Annual cropping; Fn: Natural forests; Ca: Annual cropping***		Land forms: ***plateau / plains, valley floors***		Land managers: ***employee (company, government), , ,***

Current state of the land management system:

We have asked ***Land users, Land managers, and local experts*** to assess the provision of benefits and the state of the environment in the land management system. These are the most important benefits / services that the environment should provide:

(P1) Animal and plant productivity

(E6) greenhouse gas absorption
(E8) Protection from extreme events

And these are the most important environmental properties that allow the land management system to remain valuable:

Category ***Soil and Water:***

Availability/protection of springs / water sources

Low soil erosion

Category ***Fauna:***

High number of wild grazers

High number of domestic grazers

Category ***Vegetation:***

Low presence of alien/ dangerous species (specify)

Presence of a specific plant or group(e.g resprouters, palatables)

Category ***Landscape:***

Presence of one specific habitat/land use/land cover

Presence of different landscape elements and vegetation patterns

Land users, Land managers, and local experts have provided the following evaluation of the state of the environment and the provision of benefits/services:

State of the environment:		Provision of benefits /Services:	
Category	Evaluation	Category	Evaluation
Soil and Water:	**Healthy**		
Fauna:	**Degraded**	Productive benefits /services:	**Insufficient**
Vegetation:	**Degraded**	Ecological benefits/Services:	**Insufficient**
Landscape:	**Healthy**	Socio-cultural benefits /Services:	**Undecided**

Concluding remarks

External factors affecting the resilience of land management system:

What external factors ***increase the pressure*** on the environment of the land management system? How they are likely to evolve in the future?*	What external factors *enable sustainable land management* ? How they are going to evolve in the future?*
Removal of natural vegetation (-)	**Subsidies for land use activity (-)**
	Land tenure(=)
	Laws and regulations prescribing land management(=)

*Forecasted evolution of ext. Factors in the next 10 years: (+) increase, (=) Stable, (-) Decrease

Under what conditions can the disturbances induce a permanent change to the land management system?

Fire:
If more than 2 fires occur within 20 years woodland to shrubland transitions are expected. Higher recurrences can drive the system to non-return stable states

Drought:
If severity of drought is higher than tolerance limit for most shrub species re-established in the area, general dieback could be expected, with consequences on ecosystem functioning.

What are the conditions for a positive evolution of the land management system?

I further maintenance is applied and other treatments of preventive silviculture are applied to reduce fire risk with these land management practices

Sources used to compile the questionnaire:

M.J. Baeza , J. Raventos , A. Escarre and V.R. Vallejo. Fire risk and vegetation structural dynamics in Mediterranean shrubland. Plant Ecology, 187:189–201. ;

A. Valdecantos,M. J. Baeza,and V. R. Vallejo. Vegetation Management for Promoting Ecosystem Resilience in Fire-Prone Mediterranean Shrublands. Restoration Ecology 17:414–421;

M. Jaime Baeza, Alejandro Valdecantos and V. Ramón Vallejo. Management of Mediterranean Shrublands for Forest Fire Prevention. In: New research on Forest Ecosystems A.R. Burk (Ed.) Nova Science Publishers. New York

Afforestation with Pinus Halepensis after the fire of 1979 (La Molinera)

Spain - Repoblación “La Molinera” con Pino Halepensis después del incendio del año 1979 (Spanish)

Post-fire afforestation with Pinus Halepensis to reduce soil erosion and to enhance forest growth.

As a consequence of the devastating fire of the year 1979 which destroyed 33’000 ha of forest, strong erosion processes occurred on the bare soil and hindered the vegetation to regrow. Furthermore, this region was already abandoned (rural exodus) and missing management practices increased the problem of erosion. Therefore the government mandated to afforest the burnt areas in 1985.
The main purpose of the afforestation was to reduce the soil erosion (which was severe at that time) by planting trees, which increases soil stability and enables forest growth again. But the state also wanted to ensure wood extraction in the future. Furthermore, the visual impact was an important driver for afforesting this area.
The afforestation was executed in the winter of 1985 (November-February/March) by the regional forest services (Conselleria de agricultura). Forest engineers, who worked for the state and planned the project, collaborated with forest agents whereas the involved forest agents contracted local villagers to help afforesting these areas. The forest agent acted as a link between engineer and forest brigade and controlled if the brigade executed what the engineer proposed. He also provided assistance to the workers. The forest brigade was paid by day-if it was raining, people did not work and did not get any salary. Nobody could provide direct information on the afforestation process in 1985 but there are not many differences of how they did it in the past and how it works today. The planting holes (60cm x 60cm x 60cm) were created with a machine (Caterpillar) using a “spoon” to open a hole and cover it again. This process loosens the soil (only possible in soils which are free from big stones). It should be noted that they did not use a ripper, they knew that the soil is destroyed using this technique. The seedlings were planted manually by the forest workers and arranged linearly because this facilitated the handling of the machines. Since the soil had a low stone content, it was suitable for the establishment of a forest. The afforested area covered around 100 ha (not continuously). Today, the costs of an afforestation are around 1500 Euro per ha, but in the past it was less expensive. They only planted Pinus Halepensis. Today, a seedling of this tree species costs between 20 and 60 Cents. If the regional forest services have their own nurseries, they do not need to spend money to buy seedlings. The success of an afforestation depends on numerous factors such as aspect and humidity (better on north-facing slopes), soil amount/fertility (better conditions on former cultivated fields), origin of the seedlings (adapted to the local climatic conditions), variability/uncertainty of the weather conditions (e.g. droughts, freezing). Usually a plantation is done in October/November and therefore especially the first summer determines the success. If it is too dry the plant will not grow (roots are too short to reach the humidity deeper in the ground). Further, the availability of trained people and the selection of appropriate machines are crucial. The documented afforestation is one of a few examples of afforestation trials which succeeded. Today there is a forest where young pines are growing naturally ("children" of the planted ones), but also resprouter species (e.g. Quercus) can be found, which regenerated without having been planted and apparently were dispersed by birds. But there are also some problems related to this afforestation. The forest agent explained that there is a high pest risk since monoplantations are less resilient to diseases (sick or dead plants in turn increase the fire risk). Another problem is that the trees were planted too densely (800-1000 plants per ha with a spacing of 5-10m) which requires recurrent management of the forest. Knowing about this problem, around the year 2003 they managed the area doing a selective clearing to reduce both the continuity and the competition between the species and thus also reduced the fire risk (“ayuda regeneración”). But the forest has become extremely dense again, thus increasing the risk of fires. There is a need to manage this area again and to extract biomass (selective clearing), but unfortunately no management project is planned for the near future.
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 opportunities (e.g. marginal agriculture, grazing, hunting, beekeeping). The plantation provided jobs for rural people. Also today forest management could be a source for jobs.

left: The Pinus Halepensis seedlings were planted linearly which is still visible from the distance. (Photo: Nina Lauterburg)
right: The success of this Pinus Halepensis afforestation is not only proved by the occurence of healthy old pines, but also by the growth of young pines and resprouter species such as Quercus which have not been planted. (Photo: Nina Lauterburg)

Location: Spain, Valencia
Region: Ayora, La Molinera
Technology area: 1 km^2
Conservation measure: vegetative
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed externally / introduced through project, 10-50 years ago
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Land use:
Other: Other: wastelands, deserts, glaciers, swamps, recreation areas, etc (before), Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
Climate: subhumid, temperate
WOCAT database reference: T_SPA012en
Related approach:
Compiled by: Nina Lauterburg, CDE
Date: 2013-06-01
Contact person: Vicente Colomer, Forest Agent Generalitat Valenciana (Conselleria de infraestructura, territorio y medio ambiente). Phone: +34 669 819 522 E-mail: colomer.vju@gmail.com

CASCADE
Catastrophic shifts in drylands: How can we prevent ecosystem degradation?

INSTITUTO UNIVERSITARIO CEAM
CENTRO DE ESTUDIOS AMBIENTALES DEL MEDITERRÁNEO

Classification

Land use problems:

- The past land use resulted in a change of the vegetation composition (e.g. through removal of resprouter species). Due to rural exodus and land abandonment, the natural succession took place and fire-prone early-successional species colonized the abandoned fields. The vegetation grew without any control which seems to have caused the devastating fire of the year 1979 which destroyed 33’000 ha of forest. As a consequence of this fire, strong erosion processes occurred on the bare soil and hindered the vegetation to regrow. Furthermore, people which still lived there lost their properties after the fire and moved away as well. A consequence of the depopulation was a lack of management practices which increased the problem of post-fire erosion. (expert's point of view)

Land use

Natural
Plantations, afforestations
Other: Other: wastelands, deserts, glaciers, swamps, recreation areas, etc (before)
Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
plantation forestry

Climate

subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion,
Biological degradation: detrimental effects of fires

Conservation measure

Vegetative: Tree and shrub cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: 10-50 years ago

Level of technical knowledge

- Agricultural advisor
- Land user
- Engineer

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: population pressure, land tenure, labour availability, inputs and infrastructure

Main technical functions:

- control of raindrop splash
- control of dispersed runoff: retain / trap
- control of dispersed runoff: impede / retard
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- improvement of ground cover
- stabilisation of soil (eg by tree roots against land slides)
- sediment retention / trapping, sediment harvesting
- increase of biomass (quantity)

Secondary technical functions:

- increase of surface roughness
- increase in organic matter
- increase in nutrient availability (supply, recycling,...)
- increase of infiltration
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil texture: fine / heavy (clay)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: medium

Soil water storage capacity: medium
Ground water table: 5 - 50 m, > 50 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount)
Sensitive to climatic extremes: seasonal rainfall decrease, droughts / dry spells, decreasing length of growing period, fires, temperature decrease, hail/snow
If sensitive, what modifications were made / are possible: The technology was not modified but it is important to add some notes to the above stated reactions to climatic extremes. If the temperature is decreasing to -15°C the pines are sensitive because they freeze. But they are tolerant against temperature increase always when there is water available (Pinus Hal. is more tolerant to temperature increase than Pinus Pinaster). Afforestations are more sensitive to droughts than natural forests because the afforested trees are not used to these hard conditions. If the pines are mature, they are more tolerant than young pines because their roots are longer and reach deeper into the ground. If there is a drought when pines are still young it can increase the risk of a fire. The pines are also sensitive to hail and snow.

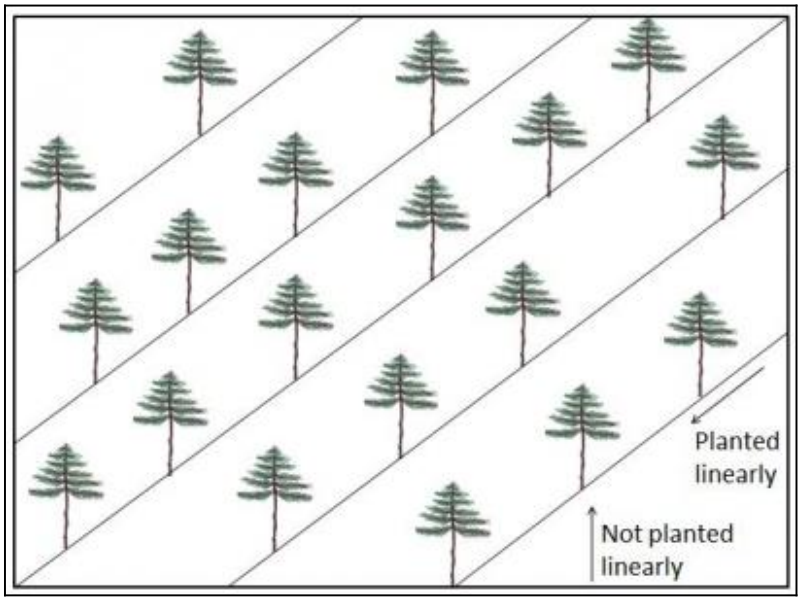
Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: employee (company, government), common / average land users, mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: state, individual, titled
Land use rights: individual, public/open access but organised (e.g. hunting)
(In the region, there is some public land, controlled by the state. But there is also some private land. The access to the public land is open but organized. Permission is needed from the government to cut trees, to build a house or to hunt. There are some private hunting areas for which the hunting association has to pay a fee.)

Importance of off-farm income: :
Access to service and infrastructure:
Market orientation: mixed (subsistence and commercial)
Purpose of forest / woodland use: nature conservation / protection, protection against natural hazards



Technical drawing

The Pinus Halepensis seedlings were planted on a line in order to facilitate the operation of machines. The linear arrangement is still visible when observing the plantation from the distance, but when finding oneself within the forest this alignment is not visible anymore since the forest grew very densely. A part of today's forest grew naturally after planting the trees - some young pines but also some resprouters (e.g. Quercus) can be found which is pleasant and shows the success of this plantation effort. However, it would have been better to plant less trees with a bigger distance between the individuals. To reduce the high density and continuity of the forest (and thus to reduce the fire risk) a selective clearing would be required but currently the state does not invest money in forest management practices. Without extraction of biomass this dense forest contains a high risk of fire. (Nina Lauterburg)

Implementation activities, inputs and costs

Establishment activities

- Digging holes (60cm x 60cm x 60cm)
- Plantation of the seedlings (pinus halepensis)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	4857.00	0%
TOTAL	**4857.00**	**0.00%**

Maintenance/recurrent activities

- Selective clearing "ayuda regeneración" (only done once in 2003 but should be done again to decrease the risk of fires and competition between species)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	2428.00	0%
TOTAL	**2428.00**	**0.00%**

Remarks:
The costs of a plantation can be affected by numerous factors, such as slope (if the slope is steep, the work is much more difficult and takes more time, also because machines cannot be used on steep slopes), distance from a street (people can work less in a day if they have to walk far to plant), stone content of the soil (if there are many stones the work is much more difficult for the machines), soil type (plantations work much better on previous cropland because the soil is more fertile), origin of the seedlings (adapted to the local climatic conditions), variability/uncertainty of the weather conditions (e.g. droughts, freezing). If there are adverse climatic conditions or other negative circumstances the afforestation will not work well and this might cause higher costs.
The costs were calculated for the application of the technology on one hectare. Furthermore, the total costs of the afforestation were calculated with today's costs because the costs at the time it was implemented are not known. The currency rate (Euro-Dollar) was calculated on November 16th, 2013.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased wood production
++ increased product diversification

Production and socio-economic disadvantages

++ loss of land
+ reduced animal production

Socio-cultural benefits

++ improved conservation / erosion knowledge
++ improved situation of disadvantaged groups
+ increased recreational opportunities

Socio-cultural disadvantages

Ecological benefits

++ improved harvesting / collection of water
++ increased soil moisture
++ reduced surface runoff
++ improved excess water drainage
++ improved soil cover
++ increased biomass above ground C
++ increased nutrient cycling recharge
++ increased soil organic matter / below ground C
++ reduced soil loss
++ Reduction of soil surface temperature
+ reduced evaporation
+ recharge of groundwater table / aquifer
+ reduced wind velocity
+ reduced soil crusting / sealing
+ increased animal diversity
+ increased plant diversity
+ Increase in shade

Ecological disadvantages

++ increased fire risk
++ increased niches for pests

Off-site benefits

+ reduced downstream flooding
+ reduced damage on neighbours fields
+ reduced damage on public / private infrastructure
+ Reduced amount of sediments in the water ponds for fire extinction

Off-site disadvantages

Contribution to human well-being / livelihoods

+ In the year 1985 the afforestation created jobs for the unemployed. But it seems that in general forest management is not something people want to do, they work in this sector only if there are no other job opportunities. Until today this attitude did not change much. Forest management means a hard job and this kind of work is not well-respected in society.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	negative	positive
Maintenance / recurrent	neutral / balanced	neutral / balanced

Short-term returns are 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 shows a positive result because compared to bare soil or shrubland it has ecological benefits such as the reduction of soil erosion, and it also provides wood and biomass which could be extracted. Currently there is no management project because the state does not invest money but it would actually be required in order to maintain the healthy state of this forest patch and to control the fire risk. If there is money invested by the state they can do a selective clearing which will result in short-term returns, e.g. wood (but also in the long-term they will be able to extract wood).

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology. In Spain a lot of afforestation trials have been realized in the past but only a few of them succeeded.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The afforestation allowed the rehabilitation of an area affected by a devastating wildfire. It is an example out of many afforestation trials which succeeded. The success of this Pinus Halepensis afforestation is not only shown by the occurrence of healthy old pines, but also by the growth of young pines and resprouter species such as Quercus which were not planted. → Recurrent management, e.g. selective clearing, is crucial to ensure a healthy forest	It would be necessary to extract biomass from the forest to decrease the continuity of the trees and shrubs. Due to the lack of forest management (the management activities are expensive and labour-intensive) there is an increased risk of fires. → More investments in forest management such as selective forest clearings are required. Managing the forest would not only decrease the risk of fire and the competition between the species but also generate benefits such as timber or biomass for bioenergy production. Furthermore, jobs would be generated. In general, after afforestations, it would be required that people manage the forest. Nowadays, there is only limited use of the forest – in the past people lived of the land, but today this is not the case anymore. E.g. grazing is almost not existing anymore but in fact this would be really important for the reduction of the fire risk.
Through the plantation of pines, the soil cover and stability was improved which in turn led to a decrease of soil erosion. The reduction in soil erosion (less transported sediments) also resulted in a decrease of damages of the infrastructure (such as streets or water ponds for fire extinction). → There is no need to plant more trees or shrubs because the ecosystem regenerated well. But recurrent management, e.g. selective clearing, is crucial to ensure a healthy forest	It is not fully clear whether Pinus Halepensis plantations are a useful tool for restoration and it is also questioned whether it is sustainable to plant only Pinus Halepensis. Monoplantations result in the simplification of the landscape and alterations of habitats. One of the reasons why they used this species is that planting pines is kind of a tradition: it was always used for economic purposes because in earlier times the wood had a higher value. Furthermore, Pinus Halepensis seedlings grow faster and show a higher survival rate than other species, and since the aim of the afforestations was to have forest again in a short period of time, this species seemed to be the most suitable. But often in Pinus Halepensis Monoplantations other species do not grow (which is not the case in the documented afforestation). → Research carried out on this topic showed that it would be good to increase the diversity (e.g. with carrasca, sabina, enebros, madroños), to combine the plantation of pines with the plantation of broad-leaved resprouting species (such as holm oak), in order to take advantage of both the fast-growth features of pines and the high resilience of oaks. This also provides higher diversity and landscape heterogeneity
There are also economic benefits for local people. The afforestation provided jobs for rural people. Furthermore, Pinus Halepensis seedlings grow faster and show a higher survival rate than other species, therefore the natural process of forest growth is increased which in turn results in the possibility to use the forest after some years again, e.g. extraction of wood/biomass for bioenergy or timber. But unfortunately this is not done frequently because it is expensive to clear the forest (located in a remote area). → Also today forest management could be a source for jobs. It was also mentioned by many stakeholders that traditional activities (such as grazing, agriculture, wood gathering, selective clearings) should be reactivated and that the villagers should get economic compensation to maintain the forest in a good state	Monoplantations are more vulnerable to perturbations such as forest fires or pests. If there is a high amount of one specific species the spread of a pest is facilitated. Sick or dead trees in turn increase the fire risk. → It would be good to increase the diversity (e.g. with carrasca, sabina, enebros, madroños), to combine the plantation of pines with the plantation of broad-leaved resprouting species (such as holm oak), in order to take advantage of both the fast-growth features of pines and the high resilience of oaks.
Many stakeholders mentioned the positive visual impact. They prefer to have a forest instead of bare soil or shrubland, and it reminds them of how the state of the forest was before the fire. Trees have a higher value for them than shrubs. They supported the fact that the afforestation helped the environment to regenerate. → Recurrent management, e.g. selective clearing, is crucial to ensure a healthy forest.	Additional information: The here documented afforestation was successful, but usually many plantations of Pinus Halepensis failed (low seedling survival rate) → Seedling survival can in some cases (has also be questioned) be enhanced through preconditioning, water harvesting techniques (micro-catchments), tree-shelters (protective tubes), fertilisation, application of mulch, using facilitating effects (planting close to a resource island or a nurse plant, to benefit from shade, change in soil properties, retention of soil and nutrients, protection from grazers), perch effect (providing bird perches e.g. dead trees, artificial woody structures, in old fields to accelerate colonisation rates (bird-mediated restoration))
Compared to the situation after the fire there is a higher biodiversity due to the afforestation. → Recurrent management, e.g. selective clearing, is crucial to ensure a healthy forest.	The area which was afforested is now not available anymore for agriculture. There is therefore a loss of agricultural land, but it is not sure either whether there would be a farmer using this land since it is located in a remote area. →
The afforestation contributed to rural development →	The area is now less accessible for hunters because of the density of the forest which allows animals to hide themselves → Local hunters are cultivating cereals next to the forest to attract the animals. This is also important for the animals because without these fields, they would probably have to leave this area due to the scarce fodder supply
	Some stakeholders criticized the linear planting. This is not like nature “would do it”. →
	There are many stakeholder who said that it was an error to do so many afforestations with Pinus Halepensis because in many regions nature would have regenerated by itself. It would have been possible to save a lot of money. A plantation causes high costs. →
	Due to the lack of management and because there is almost no use of the forest by the local population, there is a high amount of shrubs which increases the fire risk and hinders from walking through the forest → In the opinion of the villagers it would be important to promote the relationship between humans and nature and to find a balance between forest use and natural processes. The consciousness of the patrimonial value of the forest should also be promoted.

Resilience analysis Tool

Result summary

About this Resilience Assessment Authors:
Keizer, Jan Jacob
Cristina Ribeiro, Sandra Valente, Oscar González-Pelayo, Victor Santana

Date of Submission:
01-11-2015

Main sources of information:
other knowledge

Portugal
Por_2

Recently burnt maritime pine plantation subjected to traditional logging following the fire, with extraction of all the woody material and use of heavy machinery

Disturbances affecting the land management system:

The following disturbances affect the land management system, and could change dramatically the environment making it unusable for land users:

Type of disturbance:	 fires	 pests / diseases
Frequency:	**Between 5 and 10 years**	**Once per year or less**
Risk of permanent changes to the environment after a disturbance:	**High**	**Low**

Impact of land management on resilience to disturbances:

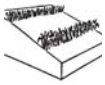
This is the impact that the land management practices have in preventing, mitigating and fostering recovery after. All together they indicate which effect the land management has on the resilience of the system to disturbances:

Land Management practice 1: ***Traditional logging using heavy machinery for extraction all woody material***	**0**	**+**
Overall impact of land management on resilience to disturbances	**Neutral**	**Positive**

*Legend: ++ Very positive; + Positive; 0 Neutral; - Negative; -- Very negative

Human and natural environment of the land management system:

A brief description of the features of the land management system assessed

Land use type		Environment		Management	
	Present land use(s): ***Fp: Plantations;***		Climate: ***subhumid***		Main measure: ***Vegetative***
	Past land use(s): ***Ge: Extensive grazing land;***		Land forms: ***hill slopes***		Land managers: ***employee (company, government), Small scale land users, Leaders / privileged, mainly men***

Current state of the land management system:

We have asked ***Land users, Land managers, and local experts*** to assess the provision of benefits and the state of the environment in the land management system. These are the most important benefits / services that the environment should provide:

(P1) Animal and plant productivity

(S2) Cultural services (e.g maintaining traditional landscape)

And these are the most important environmental properties that allow the land management system to remain valuable:

Category ***Soil and Water:***

Low soil erosion

High soil cover (including vegetation, litter, rocks and mosses)

Category ***Vegetation:***

Presence of a mixture of grasses, shrubs and trees (complex vegetation structure)

High number of different species (vegetation diversity)

Category ***Landscape:***

Presence of different landscape elements and vegetation patterns

Connectivity between healthy areas

Category ***Fauna:***

High soil fauna

High number of birds

Land users, Land managers, and local experts have provided the following evaluation of the state of the environment and the provision of benefits/services:

State of the environment:		Provision of benefits /Services:	
Category	Evaluation	Category	Evaluation
Soil and Water:	**Degraded**		
Vegetation:	**Degraded**	Productive benefits /services:	**Undecided**
Landscape:	**Healthy**	Ecological benefits/Services:	**Insufficient**
Fauna:	**Degraded**	Socio-cultural benefits /Services:	**Sufficient**

Concluding remarks

External factors affecting the resilience of land management system:

What external factors ***increase the pressure*** on the environment of the land management system? How they are likely to evolve in the future?*	What external factors *enable sustainable land management* ? How they are going to evolve in the future?*
Removal of natural vegetation (+)	**Subsidies for land management or nature conservation(=)**
Unsustainable soil management(+)	**Market prices of goods produced from the land (-)**
disturbance of water cycle (+)	**Land tenure(=)**

*Forecasted evolution of ext. Factors in the next 10 years: (+) increase, (=) Stable, (-) Decrease

Under what conditions can the disturbances induce a permanent change to the land management system?

Fire:
If recurrent fires occur before the pine stand has been able to create a viable seed bank (typically 10-15 years).
If the influx of pine seeds from neighboring unburnt areas is limited
If post-fire logging produces massive mortality of the pine seedlings.

Pests / diseases:
Not possible to define--

What are the conditions for a positive evolution of the land management system?

Ecosystem regeneration, and in particular natural pine recruitment is sufficient. Ecosystem regeneration can be reduced by soil degradation, which is caused by fire and the following soil erosion, and can also be increased by post-fire logging with machinery . Pine recruitment can be reduced by the lack of a viable seed bank, at the time of the fire or elevated rates of mortality of pine seeds and seedlings due to high fire severity, post-fire forestry operations and, possibly, post-fire drought and phytosanitary problems (especially pine nematode);
If fire events are avoided for 15 years

Sources used to compile the questionnaire:

Prats S.A., MacDonald L.H., Monteiro M., Ferreira A.J.D., Coelho C.O.A., Keizer J.J., 2012. Effectiveness of forest residue mulching in reducing post-fire runoff and erosion in a pine and a eucalypt plantation in north-central Portugal. Geoderma 191, 115-125;

Maia P., Pausas J., Vasques A., Keizer J.J., 2012. Fire severity as a key factor in post-fire regeneration of Pinus pinaster (Ait.) in Central Portugal. Annals of Forest Science 69, 4, 489-498;

Prats S.A., Malvar, M.C., Vieira, D.C.S, MacDonald L.H., Keizer J.J., 2013. Effectiveness of hydro-mulching to reduce runoff and erosion in a recently burnt pine plantation in central Portugal. Land Degradation & Development (doi: 10.1002/ldr.2236)

Post-fire Forest Residue Mulch

Portugal - acolchoado, aplicação de restos vegetais

Forest residue mulch is spread immediately after a wildfire in order to prevent soil erosion and reduce overland flow.

In two areas of eucalypt plantations affected by wildfires in central Portugal in 2007 and 2010, the research team of the University of Aveiro set up two experiments in order to test the effect of forest residue mulching as a soil erosion mitigation technique. Forest residues such as chopped eucalypt bark mulch was spread over a group of erosion plots, and was compared to an untreated group of plots. The mulching was applied at ratios of 8.7 and 10.8 Mg ha-1 provided an initial ground cover of 70 to 80%, and was found to reduce post-fire runoff by 40-50% and soil erosion by 85-90%, respectively.
The increase in ground cover will decrease post-fire soil erosion by reducing raindrop impact over the ashes and bare soil, and decrease the runoff amount by increasing water surface storage, decreasing runoff velocity, and increase infiltration. Ideally, post-fire mulching must be carried out immediately after the fire, in order to prevent that the first autumn rainfall events fall over the bare and unprotected burnt soils. It is intended for places in which burnt severity was moderate to high and where there are important values at risk, such as water reservoirs, populations, industries, human and wild life.
The chopped bark mulch was obtained at a depot 20 km from the burnt area, where eucalypt logs are debarked and then transported to a paper pulp factory. The bark is chopped into fibers and are typically transported to a biomass energy plant. We used these 10–15 cm wide 2–5 cm long bark fibers as the source for our mulching experiment. The chopped bark mulch decays very slowly (around 20% less ground cover per year) which was very useful in cases of low re-growth of natural vegetation.
The eucalypt trees in the region are typically planted as monocultures for paper pulp production, and harvested every 7-14 years. The landscape reflects a long history of intense land management, with a mosaic of (semi-)natural and man-made agricultural and afforested lands. Since the 1980´s, however, wildfires have increased dramatically in frequency and extent, aided by a general warming and drying trend but driven primarily by socio-economic changes.

left: Forest residue mulch being scattered in a recently burnt area.
right: Detail of a forest residue mulch composed by eucalypt chopped bark mulch.

Location: Portugal/Beira Litoral
Region: Sever do vouga/ Pessegueiro do Vouga, Ermida
Technology area: 1.0E-5 km^2
Conservation measure: agronomic
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: Developed through experiments / research, recent (<10 years ago)
Land use type:
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_POR003en
Related approach: not applicable ()
Compiled by: Sergio Prats Alegre Prats, Universidad de Aveiro
Date: 2013-04-25
Contact person: Jan Jacob Keizer /Jacob, Assisstant Researcher CESAM –Centro de Estudos do Ambiente e do Mar, Universidade de Aveiro. Phone: + 351 234 370200 ext. 22612. e-mail: jjkeizer@ua.pt.

Classification

Land use problems:

- Increased runoff and soil erosion, resulting in a decrease of on-site fertility and derived off-site effects such as loss of water quality, reservoirs water volume storage, higher risk of flooding and human beings damage. (expert's point of view)
Loss of wood resources and productivity. (land user's point of view)

Land use

Plantations, afforestations
plantation forestry

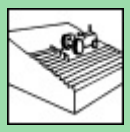
Climate

subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion,
Water degradation: change in quantity of surface water, decline of surface water quality

Conservation measure



Agronomic: Vegetation/soil cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research: recent (<10 years ago)
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: crop management (annual, perennial, tree/shrub), deforestation / removal of natural vegetation (incl. forest fires), disturbance of water cycle (infiltration / runoff)
Direct causes - Natural: Heavy / extreme rainfall (intensity/amounts), other natural causes, Sediment deposition can decrease the storage volume of reservoirs.

Main technical functions:

- control of raindrop splash
- control of dispersed runoff: retain / trap
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- control of concentrated runoff: drain / divert
- improvement of ground cover
- improvement of water quality, buffering / filtering water
- sediment retention / trapping, sediment harvesting

Secondary technical functions:

- control of dispersed runoff: impede / retard
- increase of infiltration
- increase / maintain water stored in soil

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil texture: medium (loam)
Soil fertility: high
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium

Ground water table: 5 - 50 m
Availability of surface water: good
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), wind storms / dust storms, droughts / dry spells
Sensitive to climatic extremes: floods

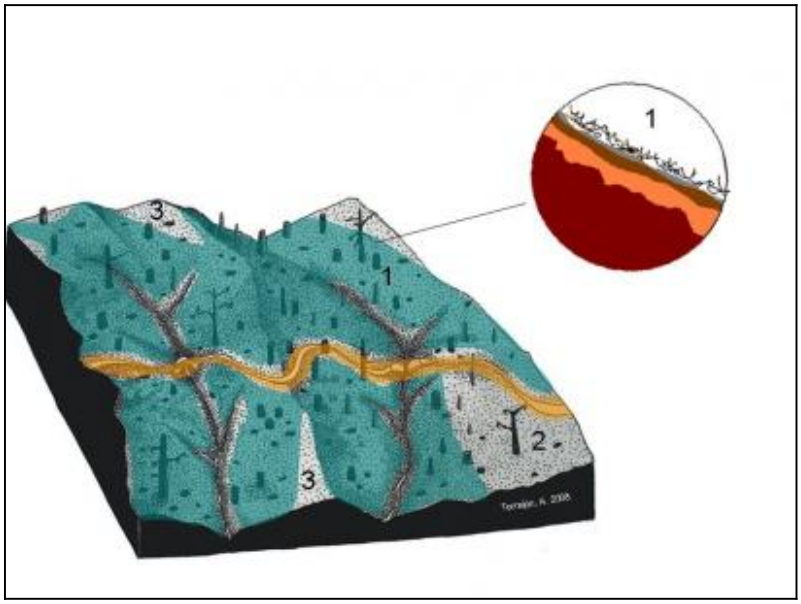
Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), Small scale land users, common / average land users, men and women
Population density: 50-100 persons/km2
Annual population growth: negative
Land ownership: communal / village
Relative level of wealth: average, which represents 50% of the land users;

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low: employment (eg off-farm), market, energy; moderate: health, education, technical assistance, roads & transport, drinking water and sanitation, financial services
Market orientation: commercial / market
Purpose of forest / woodland use: timber



Technical drawing

Forest residue mulch is spread as homogeneous as possible over steep areas (steeper than 15º) burnt at high fire severity (represented in green and 1). Other areas which are flat (2) and burnt at low severity or only partially burnt (3) must be avoided.

Implementation activities, inputs and costs

Establishment activities

- Manpower
- Transportation (small truck for carrying persons and material)
- Eucalypt chopped bark mulch
- Others

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	192.00	100%
Equipment		
- machine use	51.20	100%
Agricultural		
- forest residue mulch	307.60	100%
Other		
-	64.10	100%
TOTAL	**614.90**	**100.00%**

Maintenance/recurrent activities

-

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	0.00	0%
Equipment		
- machine use	0.00	0%
TOTAL	**0.00**	**NaN%**

Remarks:
Accessibility and steepness will raise the costs, but selecting forest residues with lower densities as well as applying them in horizontal strips along the slope can reduce the application rates and the costs. For large and inaccessible areas some researchers indicated that helicopters can reduce the costs.
The prices were determined in winter 2012 for central Portugal. It is intended that mulch is applied only once, and thus maintenance is not needed. In other regions other forest residues can have a higher availability. Straw, needles, deciduous leaves or chopped shrubs are lighter compared to eucalypt chopped bark, slash stems or wood chips, and thus, can be easier to apply and transport. However, the lighter the material, the easier it can be blown away in windy areas.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
++□ increased irrigation water availability quality	+□□ increased expenses on agricultural inputs
+□□ reduced demand for irrigation water	

Socio-cultural benefits	Socio-cultural disadvantages
+++ improved conservation / erosion knowledge	
+□□ conflict mitigation	

Ecological benefits	Ecological disadvantages
+++ improved soil cover	
+++ reduced soil loss	
++□ increased water quality	
++□ reduced surface runoff	
+□□ increased soil moisture	
+□□ reduced evaporation	
+□□ recharge of groundwater table / aquifer	
+□□ reduced hazard towards adverse events	
+□□ increased soil organic matter / below ground C	
+□□ increased beneficial species	

Off-site benefits	Off-site disadvantages
++□ reduced downstream siltation	
++□ reduced groundwater river pollution	
++□ improved buffering / filtering capacity	
++□ reduced wind transported sediments	
++□ reduced damage on neighbours fields	
++□ reduced damage on public / private infrastructure	
+□□ increased water availability	
+□□ reduced downstream flooding	

Contribution to human well-being / livelihoods

Public awareness of the technology is very limited. It is necessary to show it to landowners and stakeholders and increase dissemination.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	positive	neutral / balanced
Maintenance / recurrent	slightly positive	slightly positive

Acceptance / adoption:

0% of land user families (0 families; 0% of area) have implemented the technology with external material support. The technology has been tested by scientific researchers and it is very effective, but not broadly implemented.
0% of land user families (0 families; 0% of area) have implemented the technology voluntary. The technology has been tested by scientific researchers researchers and it is very effective, but not broadly implemented.
There is no trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
It is a technology very easy to apply, with low failure possibilities and a strong soil erosion control → Some researchers found better performance by grinding the mulch and selecting only the longest fibres.	When applying high density mulches the application labour requirements and costs will be higher → Distribute the mulch in strips, use lighter mulches, grind to remove the fine fibres or maybe try to reduce the application rate. It is also possible to use in-situ chopping tree machines or to use aerial application methods, such as helicopters to reduce the application costs.
The material is readily available (residues from the main forest specie affected by the wildfire) →	The costs are not very high, but enough to discourage the landowners to cover the expenses. → Look for Government funding, educate land owners about soil erosion conservation techniques.
It will prevent sediment movement and accumulation over roads and downslope properties →	

Post-fire Natural Mulching

Portugal - No intervention, needle carpet, caruma (Portuguese)

In certain situations, the leaves from the burnt trees created a natural carpet that protect the soil from being eroded.

In the 2007 summer a wildfire affected the locality of Pessegueiro do Vouga, municipality of Sever do Vouga, north-central Portugal. The area was afforested with eucalypt and pine plantations. The research team of the University of Aveiro checked that in some burnt areas the crown damage was very small, despite the litter and underground vegetation were totally consumed by fire. The pine site presented a markedly lower fire severity, with the canopies only partially consumed by the fire, so it allow to study the effect of fire severity on soil erosion by comparison with adjacent slopes burned a high severity.
In a wildfire that affected a pine plantation in central Portugal in 2007, the research team of the University of Aveiro set up an experiment in order to test the effect of forest residue mulching as a soil erosion mitigation treatment. However, the low fire severity resulted in an elevated litter cover prior any technique was applied. The objective is to determine were “no action” in post-fire management will still result in low soil erosion values.
The high litter cover will decrease post-fire soil erosion by reducing raindrop impact over the ashes and the bare soil, and decrease the runoff amount by increasing water surface storage, decrease of runoff velocity, and increase infiltration. As the needle litter cover was natural, no action was needed. After a simple assessment of the remaining ground cover in the burnt area, the "no intervention" option should be selected if the soil is covered by litter, leaves or needles. The benefits of this are not only the mitigation of soil erosion (and associated soil fertility losses) immediately after forest fires, but also the long-term conservation of the soil resources without additional costs.
The landscape reflects a long history of intense land management, with a mosaic of (semi-)natural and man-made agricultural and afforested lands. Since the 1980´s, however, wildfires have increased dramatically in frequency and extent, aided by a general warming and drying trend but driven primarily by socio-economic changes.

left: Natural needle carper protecting the soil from soil erosion (Photo: Sergio Prats Alegre)
right: Leaves protecting the soil in a burned slope

Location: Portugal, Aveiro
Region: Sever do Vouga, Pessegueiro de Vouga
Technology area: 1.0E-5 km²
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: Developed through experiments / research, recent (<10 years ago)
Land use type:
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_POR004en
Related approach:
Compiled by: Sergio Prats Alegre Prats, Universidad de Aveiro
Date: 2007-10-04
Contact person: Sergio Prats Alegre- Post-doc fellow, Centre for Environmental and Marine Studies (CESAM) - Department of Environment and Planning-University of Aveiro, Campus de Santiago, 3810-193 Aveiro, Portugal Phone: + 351 234 370200 e-mail: sergio.alegre@ua.pt

Classification

Land use problems:

- Strong increases in runoff and erosion should be a main land management concern following wildfires, as they constitute a serious threat to land-use sustainability and downstream aquatic habitats and human infrastructures. The forest owners and managers need to establish target areas to apply cost-effective post-fire soil erosion mitigation treatments, included the “no action” option. (expert's point of view)
Loss of wood resources and productivity. (land user's point of view)

Land use

Plantations, afforestations
plantation forestry

Climate

subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion

Conservation measure

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: recent (<10 years ago)
- Experiments / Research: recent (<10 years ago)
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: soil management, deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: population pressure

Main technical functions:

- control of raindrop splash
- control of dispersed runoff: retain / trap
- control of concentrated runoff: retain / trap
- improvement of ground cover
- increase of surface roughness
- increase of infiltration
- sediment retention / trapping, sediment harvesting
- increase of biomass (quantity)

Secondary technical functions:

- control of dispersed runoff: impede / retard
- control of concentrated runoff: impede / retard
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- increase in organic matter
- increase in nutrient availability (supply, recycling,...)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 270 days(September to May)
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium, poor (eg sealing /crusting)

Soil water storage capacity: low
Ground water table: > 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, wind storms / dust storms
Sensitive to climatic extremes: heavy rainfall events (intensities and amount)

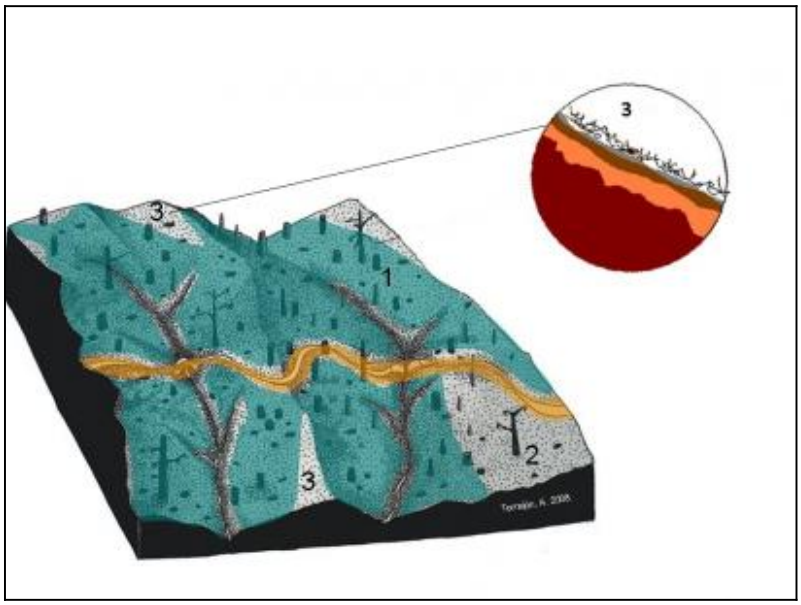
Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: groups / community, Small scale land users, common / average land users, men and women
Population density: 50-100 persons/km2
Land ownership: individual, not titled
Relative level of wealth: poor, which represents 60% of the land users; 70% of the total area is owned by poor land users

Importance of off-farm income: 10-50% of all income:
Access to service and infrastructure: moderate: health, technical assistance, employment (eg off-farm), financial services; high: education, market, energy, roads & transport, drinking water and sanitation
Market orientation: commercial / market
Purpose of forest / woodland use: timber



Technical drawing

Natural mulch is often present in areas burnt at low severity or only partially burnt (3). This areas as well as planar areas (2) must be areas for no mitigation treatment or “no action” after forest fires.

Implementation activities, inputs and costs

Establishment activities

- Natural cover

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	0.00	%
Equipment		
- machine use	0.00	%
- animal traction	0.00	%
- tools	0.00	%
Construction material		
- stone	0.00	%
- wood	0.00	%
- earth	0.00	%
Agricultural		
- seeds	0.00	%
- seedlings	0.00	%
- fertilizer	0.00	%
- biocides	0.00	%
- compost/manure	0.00	%
Other		
-	0.00	%
-	0.00	%
-	0.00	%
-	0.00	%
TOTAL	**0.00**	**0.00%**

Maintenance/recurrent activities

Remarks:
No cost are envisaged for this technology. Visual assessment of the soil cover can be susceptible for costs, for example consulting, but we think it is not eligible.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
	+ reduced wood production
Socio-cultural benefits	**Socio-cultural disadvantages**
+ + + improved conservation / erosion knowledge	
Ecological benefits	**Ecological disadvantages**
+ + + improved soil cover	
+ + + reduced soil loss	
+ + reduced surface runoff	
+ + reduced soil crusting / sealing	
+ + reduced soil compaction	
+ increased soil moisture	
+ reduced evaporation	
Off-site benefits	**Off-site disadvantages**
+ + reduced damage on public / private infrastructure	
+ reduced downstream flooding	
+ reduced damage on neighbours fields	
Contribution to human well-being / livelihoods	

Benefits /costs according to land user

	Benefits compared with costs	short-term:	long-term:
	Establishment	very positive	very positive
	Maintenance / recurrent	very positive	very positive

As natural mulching has no cost, any benefit is always very positive

Acceptance / adoption:

0% of land user families (0 families; 0% of area) have implemented the technology voluntary. The land users are not aware about the advantages of natural mulching, but in fact they apply it when they have not economic resources.
There is moderate trend towards (growing) spontaneous adoption of the technology. Some times logging after fire reduces the natural mulching capacity to prevent post-fire erosion

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
It is a technology with no associated cost and with low failure possibilities and a strong soil erosion control. → Inform land owners and forest managers to avoid post-fire logging in areas with natural mulching and therefore avoid the decrease in the technology effeciency. Some times logging after fire reduces the natural mulching capacity to prevent post-fire erosion.	Some people argue that can increase fire risk → Fire risk will not be probably increase as the surrounded areas were frequently also burned
No cost →	No possible to harvest the logs during the first period after the fire → Assume the cost of selective felling

Guidelines for Land Managers

The OVERGRAZING context

Principles and recommendations from the CASCADE project with contributions from land users and land managers

CASCADE
Catastrophic shifts in drylands

Principle 1: Reduction of vegetation increases soil erosion, leading to less fertile soil and less productive pastures

- ✓ Keep a minimum of 30-40% soil cover
- ✓ Rotate grazing areas and control the amount of animals
- ✓ Use stall feeding, especially during the dry season

Vegetation cover is important to protect soil against erosion and to maintain soil nutrients and soil water content*, which in turn guarantee that plants remain healthy and continue growing (1). If the surface cover falls below 30-40%, soil erosion increases sharply. At such low cover, connectivity of bare patches facilitate loss of water and nutrient resources, resulting in possibly irreversible changes**.

*Healthy (darker) soil from a vegetated area placed on a degraded (white) soil from an overgrazed area

**Temporary (right) and permanent degradation (bottom) caused by overgrazing

CASCADE
Catastrophic shifts in drylands

If grazing is too intense, the proportion of bare soil increases and hence permanently degrades the pasture (2). This is particularly relevant during droughts (2) or in summer, where the vegetation is most under pressure. During these periods, alternative sources of fodder** should be provided to animals (3), and care should be taken to maintain a vegetation cover of at least 40 % (1,4).

Land management options include **fodder provision** (3), rotational grazing and area closure.

** Cultivating and storing fodder, hay making, cut and carry systems, and excluding some areas from grazing can help maintain the environment even during the driest periods

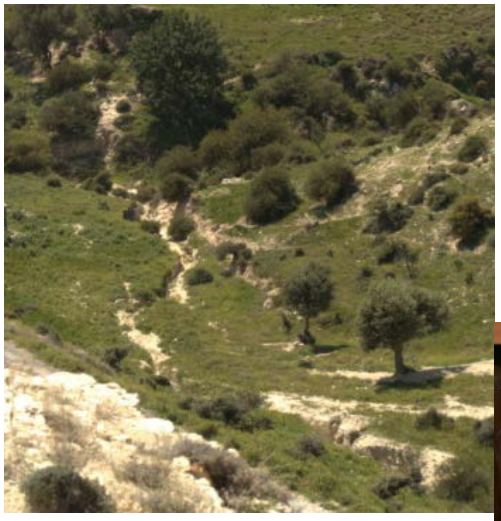
Sources:
(1) CASCADE Deliverable 4.2
(2) CASCADE Deliverable 6.1 page 3
(3) Fodder provision to reduce grazing pressure on natural vegetation (CYP001)
(4) Mayor A. G. et al. (2016). Fire-induced pine woodland to shrubland transitions in Southern Europe may promote shifts in soil fertility. Science of The Total Environment

Principle 2: Integrating trees and pastures has ecological and socio-economic benefits

- ✓ Protect existing trees
- ✓ Plant fruit and fodder trees such as carob
- ✓ Diversify pasture land products to explore new market opportunities

Livestock production allows only relatively low gains, especially if competition from markets elsewhere is high and the productivity of pastures is low. Introducing fruit trees in pastoral lands can improve pastures*, provide additional fodder and shade for the animals, decrease soil erosion and improve soil fertility. Products from olive or carob trees can create additional income from alternative markets** (4, 5).

Land management options include **planting carob trees on grazing land** (5).



*Trees in pastures help retain the soil and provide shade

**Carob trees are particularly adapted to dryland pastures and provide valuable products

Source:
(5) Planting *Carob trees* in degraded grazing land (GRE008)

Principle 3: Pest management requires an integrated ecosystem approach to promote natural predators

- ✓ Protect ecosystem floral and faunal diversity
- ✓ Avoid killing all snakes, wolves or other predators
- ✓ Protect trees against rats
- ✓ Install fences and traps
- ✓ Provide nest boxes for birds of prey

Animal pests such as rats and boars, beyond a certain number, can damage the vegetation, increase soil erosion and thus reduce the value of pastures. Long term improvement has to consider the ecosystem as a whole, in order to increase the number of wolves, snakes, and eagles.

Short term land management options include **tree protection from rats*** (6) and **fences to prevent damage from wild boars** ** (7).

**Fence to keep wild boars out

*Measures to protect trees and pastures from pests

Sources:
(6) Carob tree protection from rats (CYP003)
(7) Metallic fences to prevent damages to pastures from wild boars (ITA005)

Principle 4: Animal types and herd composition influence plant diversity and health. Overgrazing by uniform livestock species can lead to the spread of invasive/unpalatable species

- ✓ Plan resting periods for pastures
- ✓ Selectively remove unwanted species, while keeping some for soil protection if necessary
- ✓ Diversify animal types
- ✓ Increase health and productivity of individual animals instead of increasing the size of the herds

Animals tend to eat the plants that they prefer (e.g. annual grasses or large-leafed plants) and avoid the unpalatable or less tasty species* (e.g. perennial grasses or thorny shrubs).

*Unpalatable species colonize overgrazed areas, reducing productivity and changing the ecosystem



*Shift (from left to right) from annual grasses To perennials caused by prolonged grazing

Continued and heavy grazing changes the vegetation and can decrease pasture productivity*. If the unpalatable species have a competitive advantage over the more palatable ones, this process can lead to a permanent change in the ecosystem.


*Fencing to exclude livestock temporarily helps the “good” plants to recover

**Unpalatable species like ferns (left) can be cut and used as litter for stables, and the fields can be ploughed and seeded (top) to restore them

Pasture degradation can be prevented by allowing the pastures to rest, especially during the growing season, favouring the recovery of more palatable species*.

Land management options include having different types of livestock (e.g cows, sheep and goats), **manuring pastures** (8) and **ploughing and seeding of fodder species to recover degraded pastures** (9).

Sources:
(8) Pasture manuring (ITA003)
(9) Ploughing and seeding of fodder species to recover degraded grazing areas (ITA004)

Principle 5: Controlled grazing reduces risk of fires, and maintains grass species and productivity of pastures

- ✓ Avoid completely abandoning an area for a long period
- ✓ Limit grazing during the dry season as much as possible
- ✓ Remove woody/thorny bushes mechanically once they are abundant
- ✓ Install fuel breaks or reduce bush cover into hedge rows to (re-)allow grazing and thus decrease fire risk

*Abandoned agricultural terraces and pastures in Cyprus

In dry areas, wildfires can occur whenever there is sufficient vegetation to burn*. Grazing reduces the amount of fuel, and has an important effect in reducing the occurrence of fire (4).

If pastures are not grazed anymore, they can become much more vulnerable to fire. If the vegetation includes thorny shrubs, once it is too thick, animals will not be able to enter it, generating a vicious circle that leads to loss of productive pastures and increased fire risk.

Thus pastures should not be completely abandoned for long periods, but should be grazed at moderate intensity and rested occasionally.

Land management options include controlled and rotational grazing.

*Abandoned pastures with too great a bulk of vegetation can easily catch fire

Sources:
(10) Carrob afforestation on grazing land

Principle 6: After a fire or drought continued grazing could lead to a permanent change in pasture productivity and quality

- ✓ Reconsider management immediately after a fire or during a drought by reducing grazing, allowing a minimum of 2 years for resting, and providing supplementary fodder
- ✓ In case of a permanent loss of vegetation cover or quality, actively revegetate/regenerate/restore

Even if grazing is sustainable during “normal” periods, it can degrade the land irreversibly during or immediately after a disturbance, such as a drought or a fire*.

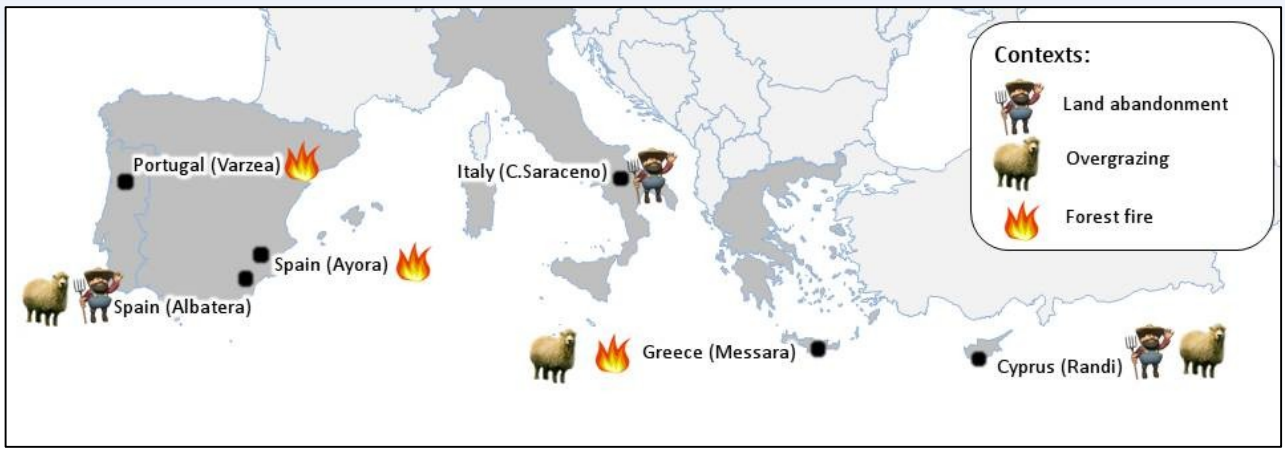
*Allowing grazing after a fire prevents regrowth of palatable vegetation (left) and increases the presence of invasive species (right)

To ensure that the land recovers from disturbance and returns to productivity rapidly, it is important to modify the land management immediately after a disturbance and not to wait until it is evident that it is not recovering**.

Land management options include grazing exclusion, irrigation, **revegetation** (11, 12).

*Examples of grazing exclusion (left) and revegetation (right) in arid rangelands

Sources:
(11) Restoration options CASCADE Deliverable 5.2
(12) Multi-specific plantation of semiarid woody species (SPA013)



The CASCADE Project study sites across southern Europe

These guidelines were developed within CASCADE Project WP7 with contributions from land users and managers in all the study sites
***Authors**: Matteo Jucker Riva, Hanspeter Liniger, Gudrun Schwilch, (Centre for Development and Environment CDE, University of Bern, Switzerland); with contribution from CASCADE study site researchers and collaborators*
***Photos**: Matteo Jucker Riva*
***Layout**: Nichola Geeson, (MEDES Foundation, Italy)*

We thank Andreas and Dimitrious Siaxinos, Marcos Foutas (Cyprus), Giorgos Karatzis, Marinos Kritsotakis (Greece) for their contributions

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left: Stainless Steel Fodder Silo (Photo: Michalakis Christoforou)

Fodder provision to goats and sheep to reduce grazing pressure on natural vegetation

Cyprus - Παροχή σιτηρεσίου στα αιγοπρόβατα ως εναλλακτική τροφή με σκοπό τη μείωση της υπερβόσκησης στα φυσικά οικοσυστήμα(greek)

Use of different types of fodder in order to reduce grazing impact on natural vegetation

Goats graze on almost all plants even on thorny shrubs. The pastoralist in the past (some still do now a days) use to spread seeds on the grazing area in order to provide fodder for the animals. Another method is to provide fodder within the farm using dry seeds of wheat, barley, soya etc which can be stored in big silos.
The purpose of this technology is to provide to the animals with the food they need in order to minimize or even stop them from grazing on the wild flora such as shrubs, trees and annual plants. Within the study area, most of the vegetation is vanished and only traces of plant species can be found. Even the thorny shrubs like Callicotome villosa and Rhamnus oleiodes are suffering from overgrazing.
Fodder can be provided in-farm and out-farm. In-farm fodder is provided using a silo in which dry fodder can be store, mixed and deliver to the animals mechanically. Out-farm fodder is provided seasonally since the seeds should be seeded and plants must grow up before eaten by the animals
By providing fodder to the animals in-farm, grazing is avoided since the animals remain within the farm. This way, animal diseases transmission from one farm to another can be minimized. Also, animals may travel a long distance to find food whose energy miight be less than the energy they use. Seeding on the hills will attract the goats and stop them from grazing on other wild plant species. Minimizing grazing will allow to the vegetation to recover and grow up providing good aesthetic view and also shelter for the wild animals. Furthermore, vegetation increase will contribute to the decrease of soil erosion and the increase of organic matter.

Location: Limassol
Region: Pissouri
Technology area: 10 - 100 km2
Conservation measure: agronomic, structural
Stage of intervention: mitigation / reduction of land degradation
Origin: Developed through land user`s initiative, recent (<10 years ago)
Land use type:
Grazing land: Extensive grazing land
Land use:
Grazing land: Extensive grazing land (before), Cropland: Annual cropping (after)
Climate: semi-arid, arid, tropics
WOCAT database reference: T_CYP001en
Related approach:
Compiled by: Michalakis Christoforou, Cyprus University of Technology
Date: 2014-05-15

Classification

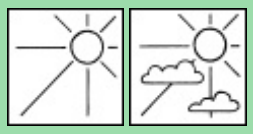
Land use problems:

- overgrazing due to a large amount of animals, drought, erosion (expert's point of view)
drought, poor calcareous soils, incomes are not enough to buy food (land user's point of view)

Land use

Extensive grazing land
Grazing land: Extensive grazing land (before)
Cropland: Annual cropping (after)
rainfed
extensive grazing land
rainfed

Climate

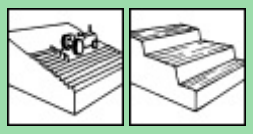


semi-arid
arid

Degradation

Biological degradation: reduction of vegetation cover

Conservation measure



Agronomic: Vegetation/soil cover
Structural: Others (Use of Silos in order to provide fodder to the animals)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: recent (<10 years ago)
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing
Direct causes - Natural: change in temperature, change of seasonal rainfall, droughts
Indirect causes: poverty / wealth

Main technical functions:

- increase of biomass (quantity)
- promotion of vegetation species and varieties (quality, eg palatable fodder)
- control of animal feeding on natural vegetation

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to June), 100 days(September to December)
Soil texture: coarse / light (sandy)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Availability of surface water: poor / none
Biodiversity: low

Tolerant of climatic extremes: seasonal rainfall increase, heavy rainfall events (intensities and amount)
Sensitive to climatic extremes: temperature increase, seasonal rainfall decrease, droughts / dry spells

Human Environment

Grazing land per household (ha)

<0.5
0.5-1
1-2
2-5
5-15
15-50
50-100
100-500
500-1,000
1,000-10,000
>10,000

Land user: Individual / household, large scale land users, Leaders / privileged, men and women
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: state
Land use rights: open access (unorganised), individual
(More than 70% of the land belongs to the government (forestry department) and the land is open to everybody. The pastoralists do not pay rent for using the land. The land which belongs to individuals is used by the owners or is been rented to the pastoralists)
Relative level of wealth: average, which represents 10% of the land users; 10% of the total area is owned by average land users

Importance of off-farm income: 10-50% of all income: Some of the pastoralists who apply the SLM technology, have apartments which they rent to tourists during the summer season
Access to service and infrastructure: low: health, employment (eg off-farm), financial services; moderate: education, technical assistance, market; high: energy, roads & transport, drinking water and sanitation
Market orientation: mixed (subsistence and commercial), Equipment and structure subsidy
Livestock density: > 100 LU /km2

Implementation activities, inputs and costs

Establishment activities

- Cereal seeds
- legume seeds
- Buy or make a Silo

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	116.00	100%
Construction material		
- stainless steel Silo	2589.00	100%
Agricultural		
- seeds	427.00	100%
Other		
- fodder transfer tubes	1000.00	100%
TOTAL	**4132.00**	**100.00%**

Maintenance/recurrent activities

- spreading seeds

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	233.00	100%
Agricultural		
- seeds	427.00	100%
TOTAL	**660.00**	**100.00%**

Remarks:
Cost for applying fodder is affected by 3 factors: a) the price of the Silo which is applied only once, b) the cost of the seeds and c) the labor needed for spreading the seeds. The slope in the area where the technology is applied is steep and makes the seeding difficult.
Cost were calculated according to the farmers opinion which was confirmed by the agricultural department. Seeds and labor are calculated as units per ha and the silo per unit (farm)

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased fodder production
+++ increased animal production
+++ reduced risk of production failure
+++ increased farm income
+++ simplified farm operations
++ decreased workload
++ increased product diversification
+ decreased labour constraints

Production and socio-economic disadvantages

+ increased expenses on agricultural inputs

Socio-cultural benefits

+++ conflict mitigation
+++ improved conservation / erosion knowledge
++ improved food security / self sufficiency

Socio-cultural disadvantages

Ecological benefits

+++ reduced surface runoff
+++ improved soil cover
+++ reduced soil loss
+++ increased animal diversity
++ increased soil moisture
+ reduced evaporation

Ecological disadvantages

Off-site benefits

+++ reduced damage on neighbours fields
+++ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

++ Shepherds who provide fodder and/or are seeding cereals and legumes on grazing land, produce more milk and meat. Therefore, they have higher incomes and a better life. They are able to send their children to school and provide a health care insurance to their families.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	very negative	slightly positive
Maintenance / recurrent	neutral / balanced	slightly positive

Shepherds who apply the technology and are in a better socio-economical status are satisfied with their incomes but they believe that things could get better. Shepherds who don't apply the technology are poor, not satisfied with the incomes they receive and at the same time they are negative in applying the technology although they see other shepherds being in a better socio-economic status than them.

Acceptance / adoption:

100% of land user families (2 families; 100% of area) have implemented the technology with external material support. New farmers-shepherds can have up to 60% funding from EU and government funds for construction and equipment
0% of land user families (0 families; 0% of area) have implemented the technology voluntary.
There is no trend towards (growing) spontaneous adoption of the technology. The cost of buying fodder is extremely high. Also the equipments (silo) is considered to be expensive.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
By providing fodder in and out of the farm the animals receive a better quality of fodder and the right quantities of fodder they need. → experts can give advices to the shepherds about the type of fodder, and the quantity during different seasons	Not all shepherd are able to buy the Silo and large amounts of fodder to store in the silo → Government funding can cover the cost of the silo
Through grazing in a specific area marked and seeded by the shepherd, the animals avoid direct contact with other animals. This minimizes the spread of diseases between animals of different farms. → Shepherds should come to an agreement about the area their animals graze and create borders	The Randi forest area is suffering from prolonged droughts. Seeding cereals in the grazing land will not be achieved without rain. →
Seeding cereals and legumes within the grazing areas decreases overgrazing on shrubs and annual plants → in the case where the shepherd is leading the animals, he should not allow the animals to graze on shrubs	It is difficult to spread seeds on the rocky hills →
The presence of a Silo in a farm makes fodder provision easier and therefore less work is required → Government funding can cover the cost of the silo	Buying fodder is expensive →
seeding in the grazing area leads to improved soil cover which minimizes soil erosion →	
Using the Silo for providing fodder, they spend less hours in the farm. →	
By providing fodder, the quality and quantity of milk and meat is better →	
By keeping the animals in the farm, they save work hours and also the threat of animal poisoning is minimized →	

Graze land forestation with Ceratonia siliqua (carob trees) in the Mediterranean

Greece - Φύτευση βοσκότοπου με Ceratonia siliqua (χαρουπιές) στη Μεσόγειο (EL)

Graze land forestation with Ceratonia siliqua (carob trees)

A stand of Ceratonia siliqua (carob trees) is established within an area used for grazing. Tree density is average (6 m grid configuration) and the majority of maintenance input is limited to the first 3 years. Once established, grazing can continue with few limitations. Ceratonia siliqua (carob tree) is very characteristic of the Mediterranean region, thus blending in very well with the local landscape, especially in the rugged agro-pastoral areas of the Mediterranean islands. After the successful establishment of the plantation, intense irrigation is no longer required and livestock can be allowed in the afforested area which has been upgraded to an improved agro-pastoral or agroforestry land. This improvement facilitates a healthier ecosystem that mitigates land degradation by stabilizing soil, increasing infiltration and organic matter and promoting flora and fauna. In addition to those traits, Ceratonia siliqua is fire resistant and can promote market diversification for the farmer. The main drawback of this technology is the reduction in livestock and other crop production during the first decade of application until trees are mature.
The purpose of this technology is multifold. The primary goal is to increase ecosystem services provided by the treated area, especially for grazing. The farmer takes advantage of the qualities of carob trees for providing: (a) Fodder to the livestock from the carob pods as well as leaves from cuttings; (b) Shade to the livestock during the summer months; (c) Better soil retention, water infiltration etc. A secondary goal is to increase market diversification with the direct exploitation of carob beans for various products, such as carob honey and carob flour. These products give added value to the land and allow the farmer to increase his income in a more sustainable way. At the same time much is gained from various other ecosystem services relevant to habitat and supporting services for the fauna of the area, such as birds and honey-bees. The aesthetic value of the landscape which strongly linked with Cretan traditions and pastoralism lifestyle is enhanced. The touristic attraction of the area is greatly improved providing new options for recreational activities and exploitation through actions such as agro-tourism.
Initially, few structural measures are required, mostly related to preparing slopes and soil for sapling planting and establishing irrigation infrastructure. A palisade that will effectively prevent livestock from damaging young trees needs to be maintained during the first 10 years of application of the technology. 2-year-old saplings are planted in a grid configuration with spacing of 6 m and actively managed for at least 3 years. Management includes watering, fertilization and replacement of dead or weak saplings.
The average annual precipitation in the area is 690 mm and the climate is classified as subhumid. Average annual temperature is 17.5 oC with 7 months below 18 °C but above 5 °C, thus classifying the area as subtropical. In the location where the technology is applied, land is mostly individually owned and distributed among a few families of a community of about 100 inhabitants. Although the financial means of the land user who applies this technology are more or less on par with those of the rest of the community, he has a wider empirical education and relatively higher social status acquired thought his involvement with the commons.

left: Mature plantation of Ceratonia siliqua (Photo: I. Daliakopoulos)
right: Pruned stand of Ceratonia siliqua (Photo: I. Daliakopoulos)

Location: Heraklion
Region: Melidochorion/Kastriotis
Technology area: 0.05 km^2
Conservation measure: vegetative
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, 10-50 years ago
Land use type:
Mixed: Agro-pastoralism
Mixed: Agro-silvopastoralism
Land use:
Mixed: Agro-pastoralism (before),
Mixed: Silvo-pastoralism (after)
Climate: subhumid, subtropics
WOCAT database reference: T_GRE008en
Related approach:
Compiled by: Ioannis Daliakopoulos, Technical University of Crete
Date: 2013-12-06
Contact person: Ioannis Tsanis, Technical University of Crete, Greece, tsanis@hydromech.gr

Classification

Land use problems:

- The main problems are reduced land cover that progressively leads to soil erosion, combined with the lack of sufficient water resources in the wider area. (expert's point of view)
Land users perceive a problem of reduced pasture fodder availability thus residing to more expensive solutions (land user's point of view)

Land use

Agro-pastoralism
Agro-silvopastoralism
Mixed: Agro-pastoralism (before)
Mixed: Silvo-pastoralism (after)
extensive grazing land
mixed rainfed - irrigated

Climate

subhumid

Degradation

Biological degradation: reduction of vegetation cover

Conservation measure

Vegetative: Tree and shrub cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: 10-50 years ago

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: overgrazing

Main technical functions:
- improvement of ground cover

Secondary technical functions:
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: high

Sensitive to climatic extremes: seasonal rainfall decrease, droughts / dry spells for the first 3 years

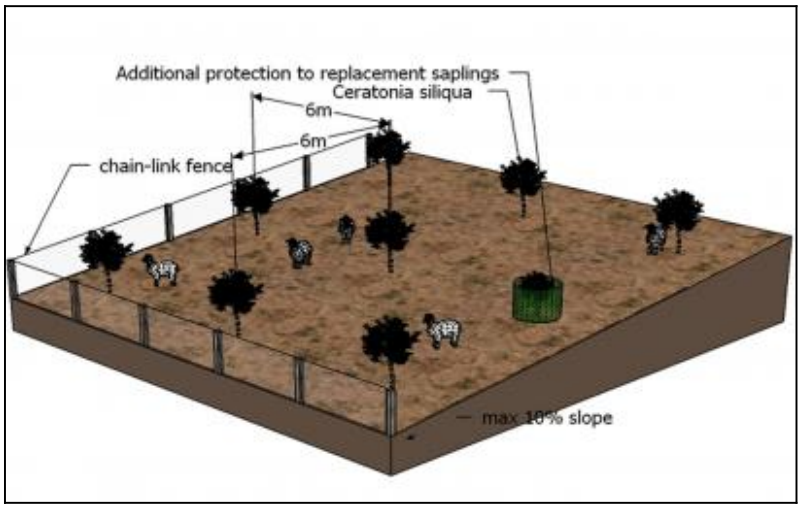
Human Environment

Mixed per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, medium scale land users, Leaders / privileged, mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Water use rights: communal (organised)
Relative level of wealth: average

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: low: employment (eg off-farm), roads & transport, financial services; moderate: health, technical assistance, market, energy, drinking water and sanitation; high: education
Market orientation:



Technical drawing

A stand of Ceratonia siliqua (carob trees) is established within an area used for grazing. For at least 10 years the area is fenced adequately to exclude livestock; once trees are mature sheep can return to graze. If a tree needs to be replaced after establishment, it can be individually fenced. (I. Daliakopoulos)

Implementation activities, inputs and costs

Establishment activities

- Planting saplings
- Grafting
- Slope/soil preparation
- Chain-link fencing
- Irrigation piping

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	3760.00	0%
Equipment		
- machine use	3020.00	0%
Construction material		
- Chain-link fence	1900.00	0%
- Pipes	270.00	0%
Agricultural		
- seedlings	820.00	0%
TOTAL	**9770.00**	**0.00%**

Maintenance/recurrent activities

- Fertilization
- Replacing dead or weak trees
- Pruning
- Watering

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	350.00	0%
Agricultural		
- seedlings	280.00	0%
- fertilizer	160.00	0%
- water	6.00	0%
TOTAL	**796.00**	**0.00%**

Remarks:

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased fodder production
+++ increased fodder quality
+++ diversification of income sources
++ reduced expenses on agricultural inputs
++ increased product diversification
+ increased wood production
+ increased farm income

Production and socio-economic disadvantages

+++ reduced animal production
++ increased risk of crop failure
++ increased expenses on agricultural inputs
++ decreased farm income

Socio-cultural benefits

+++ increased recreational opportunities
++ improved cultural opportunities
+ improved conservation / erosion knowledge

Socio-cultural disadvantages

Ecological benefits

+++ reduced fire risk
+++ increased plant diversity
+++ increased beneficial species
+++ increased / maintained habitat diversity
++ improved soil cover
++ increased nutrient cycling recharge
++ reduced soil loss
++ increased animal diversity
++ increased biological pest / disease control
+ increased soil moisture
+ reduced surface runoff
+ increased biomass above ground C

Ecological disadvantages

Off-site benefits

Off-site disadvantages

Contribution to human well-being / livelihoods

Benefits /costs according to land user

	Benefits compared with costs	short-term:	long-term:
	Establishment	negative	positive
	Maintenance / recurrent	slightly negative	positive

Acceptance / adoption:

There is no trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Restoration and protection of pastureland from further degradation. → Maintain the vegetation cover and infrastructure as much as possible, retain a sustainable livestock density.	Decreased income though the reduction of livestock density (exclusion) for at least 10 years. → Receive financial assistance (subsidies) per excluded animal.
Provision of additional market opportunities to the land user. → Provide incentives for exporting, education on small business logistics, online marketing, etc.	Cannot implement in higher altitude pastureland due to the nature of the carob tree. → Perform afforestation with Mulberries (Morus nigra)
Increased income through the provision of free fodder for the livestock. → Maintain the vegetation cover and infrastructure as much as possible.	Decreased income though the reduction of livestock density (exclusion) for at least 10 years. → Receive financial assistance (subsidies) per excluded animal. Voluntary contribution of local farmers to benefit from economies of scale (for unions).
Restoration and protection of pastureland from further degradation. → Maintain the vegetation cover and infrastructure as much as possible.	Decrease of vegetation under the tree canopy. → Reduce carob tree density.
Provision of additional market opportunities to the land user. → Succeed in marketing alternative products. Secure a sustainable income from the alternative production sources.	

Carob tree protection from rats

Cyprus - Προστασία χαρουπόδενδρων απο προσβολές αρουραίων και ποντικών

Carrob tree protection from rat attacks include protection of trees directly by using aluminium layers as rings on the neck of the carob trees in order to keep rats away from climbing on the threes and thus causing problens on fruits and new branches. Furthermore, poisonus rat baits are attached on the trees in case the aluminium layers can not be used.

Carob trees are attacked every year by rats who nibble the trunk stem of the tree, remove the bark of the trunk and the branches sucking the juice and eat the mature fruits. Rats nibble the bark of the tree in order to reduce their teeth size which tends to enlarge year by year. This results in the death of the tree branch or even of the entire tree. The tree may also show symptoms of hemiplegia. Rats run on the tree through the trunk. Apart from the direct effect of rat attacks on carob trees, rats also cause other problems to humans and animals. Rats are vectors for serious pest and diseases
The rat population increases rapidly when there is enough food (such as carobs) available, and the population grows even faster in the absence of natural enemies. .
Through interrupting the access from the ground to the tree trunk, or by pruning the branches which are connected to the ground, the rats are hindered from climbing the trees. Rats can also be controlled through the use of chemical baits. However, these baits should only be used by experts who know where and how to place them in order to avoid that other animals come in contact with the baits. Natural enemies such as cats, snakes and birds (e.g. Bam owl (Tyto alba)) should be breeded and established on the carob trees, and farmers, hunters and locals should be informed not to kill the natural enemies of rats.
The carob trees can be protected from rats by covering the tree neck and trunk from the ground up to 1 meter with a hard material such as aluminium with a slippery surface. This way the rats are not able to climb the trees since they will slither on the ring layer.
The carob tree protection will increase the production of carobs and therefore the income of the growers. Already established carob trees could provide a good income to growers with low production cost. The population of rats will decrease since the major source of food will not be provided anymore. Educating farmers, hunters and the local population about the benefits of natural enemies will allow that the environment regulates the rat population by itself.

left: Aluminium frame instalation on carob tree trunk (Photo: Costas Michael)
right: Instalation of Plastic tube bait traps in the field (Photo: Costas Michael)

Location: Limassol
Region: Pissouri
Technology area: 50 km²
Conservation measure: structural
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Cropland: Tree and shrub cropping
Climate: semi-arid, subtropics
WOCAT database reference: T_CYP003en
Related approach:
Compiled by: Michalakis Christoforou, Cyprus University of Technology
Date: 2014-06-01
Contact person: Costas Michael, Department of Agriculture, Tel: +357-26-804567 Fax: +357-26-306320 email: costasmichael@ymail.com

Classification

Land use problems:

- Rat attacks on carob trees cause severe problems for plants health and the fruit quality and production. (expert's point of view)
Carob growers: Rats are attacking the carob trees causing the death of the trees and damage of fruits. Locals: The rat population increased during the last 30 years especially in areas where carobs are grown. Agricultural officer: Rat population increased rapidly causing serious problems in carob production due to heavy rainfall in 2012 and to the hunting and killing of the natural enemies such as snakes and birds by the locals and the farmers. (land user's point of view)

Land use

Tree and shrub cropping

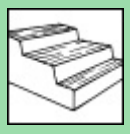
Climate

semi-arid

Degradation

Biological degradation: increase of pests / diseases, loss of predators

Conservation measure



Structural: Others (covering the tree trunk with aluminium layer)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: 10-50 years ago
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: other human induced causes, Hunting and killing the natural enemies such as snakes and birds

Main technical functions:
- reduction of rat population
- protection of carob trees and fruits

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 210 days(mid October to mid May)
Soil texture: medium (loam)
Soil fertility: medium
Topsoil organic matter: medium (1-3%), low (<1%)
Soil drainage/infiltration: good

Soil water storage capacity: low
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
If sensitive, what modifications were made / are possible: The use of aluminium layers covering the trunk of carob trees is not affected by the climatic conditions. Climatic conditions such as heavy rain could affect the use of plastic tubes which include poisonous bait or the direct poisonous cubes placed on the tree branches.

Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, men and women
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, not titled, individual, titled
Land use rights: individual
Relative level of wealth: poor, which represents 80% of the land users; 50% of the total area is owned by poor land users

Importance of off-farm income: > 50% of all income: Since rat attack is the most damaging factor affecting the growth of carob trees and the quality of the product, the land users who apply the technology have more income with unsignificant yield losses caused by other factors
Access to service and infrastructure: low: health, employment (eg off-farm), financial services; moderate: education, technical assistance, market; high: energy, roads & transport, drinking water and sanitation
Market orientation: mixed (subsistence and commercial)
Mechanization: manual labour
Livestock grazing on cropland: yes

Technical drawing

Aluminium layers are placed aroud the bark of carob trees as a ring. The aluminium is thin and light thus does not affect the growth of the tree. The hight of the aluminium is more than 50cm so that the rats can not climb or jumb on the bark of the tree (Costas Michael)

Implementation activities, inputs and costs

Establishment activities

- covering the tree trunk with an aluminium layer

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	265.00	100%
Equipment		
- tools	1.00	100%
Construction material		
- aluminium layer	1116.00	100%
- iron nails	11.00	100%
TOTAL	**1393.00**	**100.00%**

Maintenance/recurrent activities

- Control of aluminium layers

Remarks:
The costs are affected by the trunk diameter and the plant height
The costs were calculated for 8 persons working 8 hours per day and per ha. The costs were calculated on the 28th of August 2015.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
+ increased crop yield	
+ reduced risk of production failure	
+ reduced expenses on agricultural inputs	
+ decreased labour constraints	

Socio-cultural benefits	Socio-cultural disadvantages
++ improved food security / self sufficiency	
+ improved health	

Ecological benefits	Ecological disadvantages
+++ Control of rat population	
+++ Improved quality of carob trees and fruits	

Off-site benefits	Off-site disadvantages
++ reduced damage on neighbours fields	

Contribution to human well-being / livelihoods

++ The technology improved both livelihoods and human health. The growers income has increased more than 10-20% due to the reduction of the damage caused by rats every year. The reduction of the number of rats minimized the risk of human pathogens such as typhus which was very common in these areas.

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	very positive
Maintenance / recurrent	very positive	positive

Due to the damage caused on the carob trees by rats already, the trees will need some time (2-3 years) to create new branches able to produce fruits. Furthermore no new damages occur on trees. During the first 3-5 years the aluminium layer can remain on the trees. After this period the aluminium should be replaced with a larger one due to the enlargement of the tree trunk.

Acceptance / adoption:

100% of land user families (10 families; 100% of area) have implemented the technology voluntary. Due to the lack of effective and cheap ways for controlling rat attack on carob trees the land users are adopting the technology, and so far they get positive results.
There is little trend towards (growing) spontaneous adoption of the technology. Few other land user are interested in adopting the technology. Many other land users are not adopting the technology because they inherited the land and they are not actually working on the land in order to make profit.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
the technology can be used over a long time → use of non-oxidizing material	the aluminium layer should be replaced in time because the trees are growing in size → install larger aluminium layers and lold it with spring
the aluminium layer can be bent easily → both vertical edges should be hold each other by the use of a spur	The aluminium (metal) can overheat during summer time → Spray the layer with white paint
low cost →	the aluminium layer can be a target for thieves who steal metal →
easy installation →	
easy to install →	
the technology can be used over a long time →	

Metallic fences to prevent damages to pastures from wild boars

Italy

CONSTRUCTION OF FENCES TO KEEP WILD BOAR OFF PASTURE LAND

the regulations implemented by the Pollino national park to protect the wild fauna have led to large numbers of wild boar in the local area. Numbers of wild boar have also increased because of breeding with non-native species (a Hungarian strain) on the part of hunting associations. Numbers have increased so much that currently these animals have even reached rural areas destined for pasture, livestock farming and cultivation. To protect crops and pastures more fences have been built. Typically these fences are constructed out of pales made from local wood and galvanised iron netting.
Protection of pasture land and cropland
The construction of fences requires an initial investment in order to buy the wooden pales and iron netting. Generally the pales come from local woods, often from the farm itself, and are felled and prepared by local farmers who also usually construct the fences themselves. The height of the fences ranges from 1m to 1.20
Production methods are characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption. The area is partially included in two bordered national parks, i.e. Pollino national park and val d'agri national park. This peculiar situation creates a very natural environment allowing the presence of many wild species.

left: Metallic fence (Photo: Giovanni Quaranta)
right: Metallic fence (Photo: Giovanni Quaranta)

Location: Basilicata
Region: CASTELSARACENO
Technology area: 0.1 - 1 km2
Conservation measure: structural
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, 10-50 years ago
Land use type:
Cropland: Annual cropping
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_ITA005en
Related approach:
Compiled by: Velia De Paola,
Date: 2014-06-27
Contact person: Giovanni Quaranta, University of Basilicata

Classification

Land use problems:

- The wild boar tend to dig into the ground in search of food and, in doing so, leave soil open to processes of erosion and permanently degrade grass cover. (expert's point of view)
Severe damage to grass cover and crops (land user's point of view)

Land use

Annual cropping
Extensive grazing land
extensive grazing land
rainfed

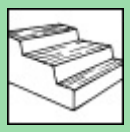
Climate

subhumid

Degradation

Soil erosion by water: loss of topsoil / surface erosion,
Biological degradation: reduction of vegetation cover, quantity / biomass decline, quality and species composition /diversity decline

Conservation measure



Structural: Walls / barriers / palisades

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: 10-50 years ago
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Indirect causes: increase and spreading of wild boars

Main technical functions:

Secondary technical functions:
- improvement of ground cover
- increase of biomass (quantity)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(march to august)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
Sensitive to climatic extremes: seasonal rainfall decrease

Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average 90% of the total area is owned by average land users

Importance of off-farm income: 10-50% of all income: Most of the off farm income derives from public sector, i.e. Municipality, Mountain Community, Region and other public bodies. Very few farmer members run local shops or handcraft.
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation:

Implementation activities, inputs and costs

Establishment activities

- Wood pales and network
- wood pales
- Iron net

Establishment inputs and costs per unit

Inputs	Costs (US$)	% met by land user
Labour	5000.00	100%
Construction material		
- wood	3310.80	100%
- iron net	5405.40	100%
TOTAL	**13716.30**	**100.00%**

Maintenance/recurrent activities

- Checking fence for repairs

Maintenance/recurrent inputs and costs per unit per year

Inputs	Costs (US$)	% met by land user
Labour	81.08	100%
TOTAL	**81.08**	**100.00%**

Remarks:
The total cost for the construction of 1,000 metres of fencing is spread over a period of 20 years on the basis of the duration of the structure

Assessment

Impacts of the Technology

Production and socio-economic benefits

+ increased fodder production
+ reduced risk of production failure
+ increased farm income

Production and socio-economic disadvantages

+ increased expenses on agricultural inputs

Socio-cultural benefits

++ improved conservation / erosion knowledge

Socio-cultural disadvantages

Ecological benefits

++ reduced soil loss
++ reduced soil compaction
++ increased / maintained habitat diversity
+ reduced surface runoff
+ increased biomass above ground C
+ increased beneficial species

Ecological disadvantages

Off-site benefits

+ reduced damage on neighbours fields
+ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

+

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	slightly positive
Maintenance / recurrent	slightly positive	slightly positive

Acceptance / adoption:

100% of land user families have implemented the technology with external material support. support by the national park
0% of land user families have implemented the technology voluntary.
There is little trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The technology helps preserve pastures and protects against damage to crops → If the National Park of Pollino would also support activities to prevent damage caused by wild boar instead of focusing solely on the conservation of wild local species (boar).	The only disadvantage is the high initial cost of building fences which is, however, partly mitigated by the possibility to use the fences also as boundary marker dividing one property from another. →
If the National Park of Pollino would also support activities to prevent damage caused by wild boar instead of focusing solely on the conservation of wild local species (boar). → Greater economic support for the building of fences.	Disadvantage solely related to high cost of construction. → More subsidies

Pasture manuring (application of manure from shelter)

Italy

Application of manure in valuable pastures to increase grass recover and reduce shrub encroachment

This is a technique used on animal husbandry farms with either deep litter housing systems (sheep and goat manure) or manure heaps (cattle manure). Manure spreading is carried out twice a year but on different land. In the case of deep litter housing systems fresh straw is continuously spread over soiled litter in layers. After around six months the deep litter bedding is removed and mechanically spread on pasture lands or arable land. In the case of cattle farms animal waste is transferred daily to the farm's manure heap where it is left to decompose for at least a year. Also in this case straw is added for the animals' comfort and hygiene and is added to the manure heap together with faeces. Once the manure is ready it is spread on areas of land which can be farmed using mechanical means In the case of arable cropland manure is immediately buried by ploughing, in the case of pasture land it is spread at the beginning of autumn and left on the surface without ploughing (if not occasionally a harrow might be used to break down the manure to increase even distribution and penetration).
Increase growth of palatable species, increase value of grazing area
The technique is an agronomic measure which is applied on meadows, pastures and cropland in an area with a sub-humid climate, moderate scope and shallow clayey soil. As to the context of production, it is characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption.

Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: agronomic
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, traditional (>50 years ago)
Land use type:
Cropland: Annual cropping
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_ITA003en
Related approach:
Compiled by: Velia De Paola,
Date: Before 1992
Contact person: Giovanni Quaranta, University of Basilicata

Classification

Land use problems:

- Decrease of value of pastures due to under grazing and shrub encroachment (expert's point of view)
Decrease of value of pastures due to under grazing and shrub encroachment (land user's point of view)

Land use

Annual cropping
Extensive grazing land
extensive grazing land
rainfed

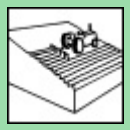
Climate

subhumid

Degradation

Biological degradation: quality and species composition /diversity decline

Conservation measure



Agronomic: Organic matter / soil fertility

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: traditional (>50 years ago)
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: other human induced causes, Undergrazing, decrease in land use and land management
Indirect causes: labour availability

Main technical functions:

Secondary technical functions:
- increase in organic matter
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to august)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
Sensitive to climatic extremes: seasonal rainfall decrease

Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average, which represents 90% of the land users;

Importance of off-farm income: > 50% of all income: Most of the off farm income derives from public sector, i.e. Municipality, Mountain Community, Region and other public bodies. Very few farmer members run local shops or handcraft.
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation:

Implementation activities, inputs and costs

Establishment activities

-

Maintenance/recurrent activities

- Emptying of deep litter bedding or manure hap
- Spreading of manure on 3 hectares of pasture land
- Hire of manure spreader

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	932.38	100%
TOTAL	**932.38**	**100.00%**

Remarks:
Assuming that the production of manure (as described above) happens on farm, the critical point of the application of the technique is the availability of equipment for spreading. The largest farms buy the equipment spending from 35,000 to 40,000 euro depending on the machines' working capacities. The smaller farms (which represent the vast majority) rent this equipment (from third parties) twice a year at an overall cost of around €70 an hour.

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ increased fodder production
\+ increased fodder quality
\+ increased farm income

Production and socio-economic disadvantages

\+ increased demand for irrigation water

Socio-cultural benefits

Socio-cultural disadvantages

Ecological benefits

++ increased soil moisture
++ increased biomass above ground C
++ increased nutrient cycling recharge
++ increased soil organic matter / below ground C
\+ reduced surface runoff
\+ increased plant diversity
\+ reduced invasive alien species
\+ increased beneficial species
\+ increased / maintained habitat diversity

Ecological disadvantages

Off-site benefits

Off-site disadvantages

Contribution to human well-being / livelihoods

\+

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	not specified	not specified
Maintenance / recurrent	neutral / balanced	neutral / balanced

Acceptance / adoption:

10% of land user families have implemented the technology with external material support. Part of the implementing farms have adopted the technology thanks to support in buying ad hoc machinery
90% of land user families have implemented the technology voluntary.
There is little trend towards (growing) spontaneous adoption of the technology. High cost of fuel are reducing the rate of adoption given the high machinery requirements

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The farms try to concentrate their activities and so they try to improve local (close by) pastureland. The technology increases the grass productivity and so helping farms to reduce time of grazing. → Supporting ad hoc machinery and equipment.	The technology is difficult to apply on very steep slope lands → No way
It's the only natural way to fertilize pasture and croplands. This avoids the use of chemical fertilizers and external inputs. This also provides great beneficial effects on the milk/meat quality through better grass. → Providing subsides both to machinery and organic production	This is considered as a heavy work (mainly dirty). The use of machinery is the only way to implement it → No way

Ploughing and seeding of fodder species to recover degraded grazing areas

Italy

left: Ploughed and seeded pasture (Photo: Matteo Jucker Riva)
right: improvement of grass cover in managed field as compared to unmanaged (Photo: Matteo Jucker Riva)

Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: agronomic
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed through land user`s initiative, traditional (>50 years ago)
Land use type:
Grazing land: Extensive grazing land
Climate: subhumid, temperate
WOCAT database reference: T_ITA004en
Related approach:
Compiled by: Velia De Paola,
Date: 2014-06-26
Contact person: Giovanni Quaranta, University of Basilicata

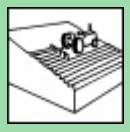
Ploughing and seeding of fodder species to recover old degraded grazing areas and maintain valuable pastures against shrub encroachment and decrease of palatable species

The technology consists of seeding pastureland with high palatable species whenever they are purely represented. In order to ensure a quality grass cover for grazing areas, pastures are ploughed (removing non-palatable shrubs) and planted with a variety of grains: i.e. oats, barley, alfalfa. This operation is periodically repeated (every tree-four years) according to the state of the grasses.
Regeneration of degraded pastures
The technique is an agronomic measure which is applied to degraded pastures (often modest areas of pasture land closest to farm sheds and stables). As to the context of production, it is characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption.

Classification

Land use problems:

- Change of vegetation in pastures: encroachment of unpalatable species (expert's point of view)
The problem is degraded pastures (presence of non-palatable shrubs). (land user's point of view)

Land use	Climate	Degradation	Conservation measure
			
Extensive grazing land extensive grazing land rainfed	subhumid	Biological degradation: quality and species composition /diversity decline	Agronomic: Vegetation/soil cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: traditional (>50 years ago)
- Experiments / Research
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: other human induced causes, Undergrazing

Main technical functions:
- increase of biomass (quantity)
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Secondary technical functions:
- increase of infiltration
- increase / maintain water stored in soil

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

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Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to august)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period
Sensitive to climatic extremes: seasonal rainfall decrease

Human Environment

Grazing land per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average, which represents 90% of the land users;

Importance of off-farm income: 10-50% of all income: Most of the off farm income derives from public sector, i.e. Municipality, Mountain Community, Region and other public bodies. Very few farmer members run local shops or handcraft.
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: mixed (subsistence and commercial)
Livestock density: > 100 LU /km2

Implementation activities, inputs and costs

Establishment activities

-

Maintenance/recurrent activities

- Ploughing with machinery and add fertilizer if needed
- Seeding

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	54.04	100%
Equipment		
- machine use	270.27	100%
Agricultural		
- seeds	202.70	100%
TOTAL	**527.01**	**100.00%**

Remarks:
The most determinate factor affecting costs of the technique is the availability of equipment for spreading. The largest farms buy the equipment spending from 35,000 to 40,000 euro depending on the machines' working capacities. The smaller farms (which represent the vast majority) rent this equipment at a cost of around €50 an hour.
The above costs have been calculated according to the average of small farm's records.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ increased fodder production
++ increased fodder quality
+ reduced risk of production failure
+ increased farm income

Production and socio-economic disadvantages

++ increased expenses on agricultural inputs

Socio-cultural benefits

Socio-cultural disadvantages

Ecological benefits

++ improved soil cover
++ increased biomass above ground C
++ increased beneficial species
+ improved excess water drainage
+ recharge of groundwater table / aquifer
+ reduced hazard towards adverse events
+ increased nutrient cycling recharge
+ reduced soil compaction

Ecological disadvantages

+ increased surface water runoff
+ decreased soil organic matter
+ increased soil sealing / compaction
+ increased soil erosion locally
+ reduced biodiversity / crop diversity
+ increased habitat fragmentation
+ increased niches for pests

Off-site benefits

Off-site disadvantages

+ decreased buffering / filtering capacity

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	slightly positive
Maintenance / recurrent	slightly negative	slightly negative

Acceptance / adoption:

90% of land user families have implemented the technology with external material support. The activities were initially supported by a regional program with a subside equal to 50% of the total cost. However the technology proved not very efficient from the economic point of view, hence the subsidies where suspended.
10% of land user families have implemented the technology voluntary.
There is no trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The technology can improve productivity and help restore the most valuable pastures, especially those situated near the animal housing structures → Subsidies where available in the past but didn't prove effective or beneficial.	Removing soil surfaces in order to seed the lands can create condition for soil degradation if not performed adequately → Increasing farmers awareness and skills for good agricultural practices
The technology can improve very degraded pastureland but is not very useful when the pasture is only partly degraded → In order to increase the technology supports to machinery use should be provided, since they are the main relevant cost/barrier to adopt the technology.	High cost of machinery/equipment and their difficult use in tough environmental conditions (stony lands and steep slopes). →

Resilience analysis Tool

Result summary

About this Resilience Assessment
Authors:
Panagea, Ioanna
Ioannis Daliakopoulos, Technical University of Crete, Greece

Date of Submission:
05-01-2016

Main sources of information:
local knowledge
local knowledge

References in the WOCAT database:
GRE 08; ;

Greece
Gre_1

Carob afforestation on grazing land for land restoration and income diversificatio

Disturbances affecting the land management system:

The following disturbances affect the land management system, and could change dramatically the environment making it unusable for land users:

Type of disturbance:	 fires	 droughts	 pests / diseases
Frequency:	**Between 1 and 5 years**	**Between 1 and 5 years**	**Between 5 and 10 years**
Risk of permanent changes to the environment after a disturbance:	**Medium**	**Low**	**Low**

Impact of land management on resilience to disturbances:

This is the impact that the land management practices have in preventing, mitigating and fostering recovery after. All together they indicate which effect the land management has on the resilience of the system to disturbances:

Land Management practice 1: ***Grazing land afforestation with carob trees***	++	0	++
Land Management Practice 2: ***Controlled grazing in spring months and tree protection***	++	-	++
Overall impact of land management on resilience to disturbances	Very positive	**Negative**	Very positive

*Legend: ++ Very positive; + Positive; 0 Neutral; - Negative; -- Very negative

Human and natural environment of the land management system:

A brief description of the features of the land management system assessed

Land use type		Environment		Management	
	Present land use(s): ***Fp: Plantations; Ms: Silvo-pastoralism;***		Climate: ***subhumid***		Main measure: ***Vegetative; Management***
	Past land use(s): ***Gi: Intensive grazing/ fodder production; Mp: Agro-pastoralism;***		Land forms: ***hill slopes***		Land managers: ***Individual/household, , Leaders / privileged, mainly men***

Current state of the land management system:

We have asked ***Land users, Land managers, and local experts*** to assess the provision of benefits and the state of the environment in the land management system. These are the most important benefits / services that the environment should provide:

(P1) Animal and plant productivity
(P3) land available for production
(E3) reduced erosion
(E5) above ground biodiversity
(S2) Cultural services(e.g maintaining traditional landscape)

And these are the most important environmental properties that allow the land management system to remain valuable:

Category ***Fauna:***

Low number of wild / domestic grazers

High number of predators

Category ***Soil and Water:***

Favourable soil structure

Low soil erosion

Category ***Landscape:***

Presence of different landscape elements and vegetation patterns

Connectivity between healthy areas

Category ***Vegetation:***

Presence of a mixture of grasses, shrubs and trees (complex vegetation structure)

Continuity of vegetation canopy/cover

Land users, Land managers, and local experts have provided the following evaluation of the state of the environment and the provision of benefits/services:

State of the environment:		Provision of benefits /Services:	
Category	Evaluation	Category	Evaluation
Fauna:	**Healthy**		
Soil and Water:	**Healthy**	Productive benefits /services:	**Undecided**
Landscape:	**Degraded**	Ecological benefits/Services:	**Insufficient**
Vegetation:	**Healthy**	Socio-cultural benefits /Services:	**Sufficient**

Concluding remarks

External factors affecting the resilience of land management system:

What external factors ***increase the pressure*** on the environment of the land management system? How they are likely to evolve in the future?*	What external factors *enable sustainable land management* ? How they are going to evolve in the future?*
Overgrazing(-)	**Subsidies for land use activity (=)**
Removal of natural vegetation (=)	**Subsidies for land management or nature conservation(=)**
	A specific land use activity:(=)

*Forecasted evolution of ext. Factors in the next 10 years: (+) increase, (=) Stable, (-) Decrease

Under what conditions can the disturbances induce a permanent change to the land management system?

Fire:
If there is no restriction of grazing after the fire for many years in order the carob trees to regrow.

Drought:
If the trees are new (less than 3-5 years) and there is no sufficient irrigation in case of a drought

Pests / diseases:
not possible to define

What are the conditions for a positive evolution of the land management system?

If pruning and managed grazing is maintained;
If Carrob fruit value remains high
If the land avoids frequent wildfires
If land is not abandoned due to other financial reasons.

Sources used to compile the questionnaire:

Bottema, S., 1980. Palynological investigations on Crete. Review of Palaeobotany and Palynology 31, 193–217.

Briassoulis, H., 2003. Crete: Endowed by nature, privileged by geography, threatened by tourism? Journal of Sustainable Tourism 11, 97–115.

Chartzoulakis, K.S., Paranychianakis, N.V., Angelakis, A.N., 2001. Water resources management in the island of Crete, Greece, with emphasis on the agricultural use. Water Policy 3, 193–205.;

Multi-specific plantation of semiarid woody species on slopes

Spain - Plantación pluriespecífica de especies leñosas de ambiente semiárido en laderas

Plantation of native woody species using planting holes on slopes

This technology is a restauration technology implemented on degraded south-facing slopes of a semiarid mountain range. The restoration technology consisted of a plantation of seedlings of a variety of native woody species, mostly shrubs, using deep (60cm depth) planting holes. Microcatchments were established upslope the planting hole in suitable areas. Seedlings were protected from extreme radiation and predation by biodegradable seedling shelters. The target area was highly degraded due to long-term overexploitation of resources under harsh environmental conditions. Failed previous reforestation actions on bench terraces led to further degradation in some areas. Degradation resulted in low plant cover, decreased plant biodiversity, lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. To address this problem, the Forest Administration implemented a restoration program on the south-facing slopes of the Albatera-Crevillente mountain range. The program was implemented in 2006-07.
The purpose of the plantation is the restoration of diversity and cover of vegetation on degraded south-facing slopes of a semiarid mountain range, erosion control, and flood prevention.
The target area is the south-facing side of a mountain range in a semiarid area of Southeast Spain. Exploitation of resources over centuries, mostly grazing and wood gathering, under harsh environmental conditions, led to very low plant cover, mostly consisting of dwarf shrubs sparsed in a matrix of bare soil, lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. The exploitation of the land was drastically reduced during the second half of the 20th century due to the general rural land abandonment trend that started in Spain around the 1950's driven by critical socio-economic changes such as the use of fossil fuels and the sharp increase in activity in the tourism and services business sectors, mostly in the coast land. However, despite the reduction, or even complete abandonment, of rural activity on the mountain range area, there was no sign of spontaneous recovery from degradation. Soil erosion and floods were of major concern for the resource managers in the area (Public Forest Administration), and a number of reforestation and restoration programs have been implemented in the area, with varying degree of success. In more recent decades, new pressures appeared in the mountain area, such as agricultural expansion into the range area (1970s), mining activities (late 1990's - early 2000's), and urbanization (2000s). Rural tourism and recreation are new activities in the mountain range area. For the time being, the intensity of these activities is low to moderate. However there is already some evidence of incipient degradation associated to recreation, and some regulation is being demanded by environmental NGOs.

left: Walking excavator preparing planting holes (Photo: S.Bautista)
right: Detail of a planted seedling showing one of the applied planting treatments: microcatchment and seedling shelter (Photo: S.Bautista)

Location: Spain/Alicante
Region: Albatera
Technology area: 5.7 km^2
Conservation measure: vegetative
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Land use:
Forests / woodlandsrests / woodlands: Natural (before), Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
Climate: semi-arid, subtropics
WOCAT database reference: T_SPA013en
Related approach:
Compiled by: Susana Bautista, Universidad de Alicante
Date: 2014-07-01

Classification

Land use problems:

- Erosion, water scarcity, low productivity, loss of soil functions (water infiltration, nutrient cycling), low biodiversity, loss of landscape structure (expert's point of view)
Low productivity, aridity, erosion (land user's point of view)

Land use

Natural
Forests / woodlandsrests / woodlands: Natural (before)
Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
plantation forestry

Climate

semi-arid

Degradation

Soil erosion by water: loss of topsoil / surface erosion, offsite degradation effects, Biological degradation: reduction of vegetation cover, quantity / biomass decline, quality and species composition /diversity decline

Conservation measure

Vegetative: Tree and shrub cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires), over-exploitation of vegetation for domestic use
Indirect causes: poverty / wealth

Main technical functions:

- control of dispersed runoff: retain / trap
- improvement of ground cover
- increase in nutrient availability (supply, recycling,...)

Secondary technical functions:

- control of dispersed runoff: impede / retard
- control of concentrated runoff: retain / trap
- increase of surface roughness
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase of infiltration
- increase / maintain water stored in soil
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 240 days(November-June)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, decreasing length of growing period
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), droughts / dry spells

Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
■	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), large scale land users, Leaders / privileged, men and women
Population density: 100-200 persons/km2
Annual population growth: 2% - 3%
Land ownership: state
Land use rights: open access (unorganised)

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: moderate: employment (eg off-farm), financial services; high: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation
Market orientation: No forestry production
Purpose of forest / woodland use: nature conservation / protection, recreation / tourism

Technical drawing

Test (Test)

Implementation activities, inputs and costs

Establishment activities

- Soil preparation and planting holes
- Soil and microcatchment preparation
- Fertilization plantation (holes)
- Fertilization microcatchment
- Plantation
- Plantation (microcatchments)
- Tree shelter placement
- tree shelter placement (Microcatchments)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1343.00	100%
Equipment		
- machine use	853.00	100%
Agricultural		
- seedlings	252.00	100%
- biocides	154.00	100%
- Tree shelters	424.00	100%
TOTAL	**3026.00**	**100.00%**

Maintenance/recurrent activities

Remarks:

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages

Socio-cultural benefits	Socio-cultural disadvantages
+ increased recreational opportunities	
+ improved conservation / erosion knowledge	

Ecological benefits	Ecological disadvantages
++ improved harvesting / collection of water	
++ reduced evaporation	
++ reduced surface runoff	
++ improved soil cover	
++ increased biomass above ground C	
++ increased nutrient cycling recharge	
++ increased soil organic matter / below ground C	
++ reduced soil loss	
++ increased plant diversity	
++ increased / maintained habitat diversity	
+ increased soil moisture	
+ increased animal diversity	
+ increased beneficial species	

Off-site benefits	Off-site disadvantages
+ reduced downstream flooding	

Contribution to human well-being / livelihoods
+ Recreational use

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	positive
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome

Guidelines for Land Managers

The LAND ABANDONMENT context

Principles and recommendations from the CASCADE project with contributions from land users and land managers

CASCADE
Catastrophic shifts in drylands

Principle 1: The environment of abandoned land can change in unexpected and diverse ways: it might not continue to provide the same services, and degraded land might not recover spontaneously

- ✓ Adapt to the changes in the environment to exploit new ecosystem services
- ✓ Maintain a certain level of use of the land if you want to avoid radical changes to the landscape and a decrease of productivity

The environment of abandoned land can evolve following diverse pathways depending on the limiting conditions (e.g. soil type, water availability, topography).

The vegetation can shift to a different type of community (e.g. from grassland to shrubland or to forest)*(1).

* Cropland and pastures turned into shrubland (left) and forest (right) after abandonment

If the land was particularly degraded before the abandonment, or if the environmental conditions are limiting spontaneous recovery, the land degradation might increase even after the land use has stopped.**

This means that the services provided by the land will change, and without substantial investment it might not be possible to revert back to using the land as it was before abandonment.

Thus it might be more desirable to plan for some areas to adapt the land use*** and for others to maintain the previous use (e.g. rotational grazing to maintain pasture, cultivating with longer fallow periods).

Abandoned land can also be specifically managed for its biodiversity.

Land management options include **revegetation of abandoned land** (2), rotational grazing, or some alternative use of the land.

**Land abandonment does not always increase the bulk of vegetation. Lack of management can sometimes lead to severe land degradation

***Bee-keeping, tourism and wind energy are possible alternative uses of abandoned land

Sources:
(1) CASCADE Deliverable 2.1 Italian study site
(2) Multi-specific plantation of semiarid woody species (SPA013, SPA016)

CASCADE
Catastrophic shifts in drylands

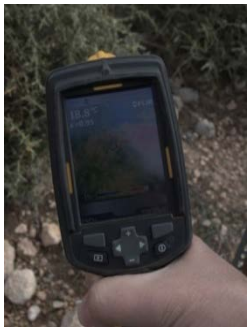
Principle 2: Environmental changes regarding vegetation, soil and water after land abandonment can lead to new risks that require specific management

- ✓ Monitor the environment and adapt management to new risks
- ✓ Actively regenerate and revegetate abandoned areas to prevent soil erosion, flooding or further land degradation

Environmental changes on abandoned land, combined with an interruption in the management of the area, can produce new disturbances like fire, soil erosion or floods with relevant on-site as well as offsite impacts.

Observing and monitoring the environment* should continue despite land abandonment, and management should consider new risks such as fire (related to increased biomass), landslides (related to abandonment of terraces and roads) or increased flooding and erosion.

Land management options include **fuel breaks** (3) and **revegetation of abandoned land** (2), especially in case of heavy degradation to re-naturalize the area and prevent further negative impact.



*Examples of revegetation and monitoring of vegetation growth

Sources:
(3) Fuel breaks (ITA007, SPA009, POR001), Forest Management Plan (A_ITA001)

Principle 3: Land that is not used or economically valuable at present can be used in the future

Recommendations:

- ✓ Maintain infrastructure (e.g. roads, terraces, irrigation networks)
- ✓ Maintain knowledge for future generations
- ✓ Explore new emerging market opportunities

Even if the land is not economically valuable or productive at the moment, it might still be culturally important. Changes in subsidies, market or in the environment may change the situation and increase the demand for land, previous land uses or new ones.

Infrastructure such as roads, irrigation networks and terraces should be maintained at a basic level, as they are essential to allow future access and use of the land*. Also, their destruction could lead to enhanced risks of landslides, flooding and erosion.

Knowledge related to the land and the former land uses should also be maintained, as a basis for a sustainable use of the land in the future.

* Unused infrastructure such as terraces and waterpoints should be maintained

Principle 4: Labour availability is a constraint in abandonment-prone areas

- ✓ Focus on activities requiring low labour for land management / maintenance
- ✓ Promote cooperation and participation among land users, to make the most of current use and management

In areas where there is outmigration or land abandonment, the former land management or land use may become difficult to maintain because of the lack of labour.

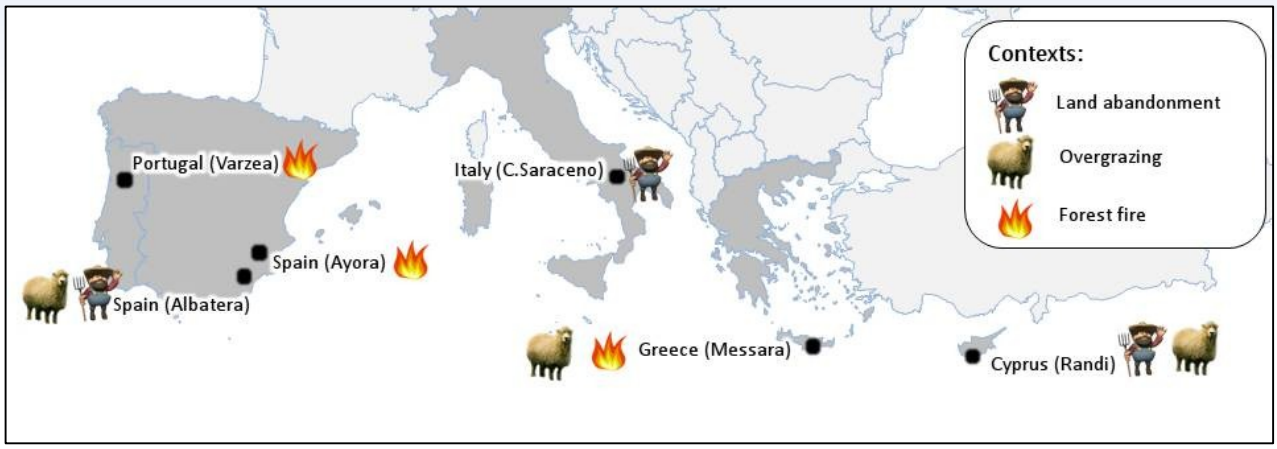
In order to preserve the land and to keep the possibility to return back to former land uses, management should concentrate on activities that are not labour intensive (e.g. from agriculture to silviculture; from sheep to cattle farming)*.

*Examples of fodder cultivation on former cropland (left) and silviculture (right)

Labour requirements for land management can also be reduced by increasing cooperation among the remaining land users. They can reduce costs , inputs and labour requirements by sharing tools and machinery, and cooperating for major works such as restoring land or increasing access to land.

Participation of land users in management decisions, and exchange between land users, local administrators and land managers * can lead to new land uses and adaptation measures, requiring less labour, such as golf or hiking areas.

*Cooperation and exchange of knowledge with land users



The CASCADE Project study sites across southern Europe

These guidelines were developed within CASCADE Project WP7 with contributions from land users and managers in all the study sites

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***Photos**: Matteo Jucker Riva*

***Layout**: Nichola Geeson, (MEDES Foundation, Italy)*

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Multi-specific plantation of semiarid woody species on slopes

Spain - Plantación pluriespecífica de especies leñosas de ambiente semiárido en laderas

Plantation of native woody species using planting holes on slopes

This technology is a restauration technology implemented on degraded south-facing slopes of a semiarid mountain range. The restoration technology consisted of a plantation of seedlings of a variety of native woody species, mostly shrubs, using deep (60cm depth) planting holes. Microcatchments were established upslope the planting hole in suitable areas. Seedlings were protected from extreme radiation and predation by biodegradable seedling shelters. The target area was highly degraded due to long-term overexploitation of resources under harsh environmental conditions. Failed previous reforestation actions on bench terraces led to further degradation in some areas. Degradation resulted in low plant cover, decreased plant biodiversity, lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. To address this problem, the Forest Administration implemented a restoration program on the south-facing slopes of the Albatera-Crevillente mountain range. The program was implemented in 2006-07.
The purpose of the plantation is the restoration of diversity and cover of vegetation on degraded south-facing slopes of a semiarid mountain range, erosion control, and flood prevention.
The target area is the south-facing side of a mountain range in a semiarid area of Southeast Spain. Exploitation of resources over centuries, mostly grazing and wood gathering, under harsh environmental conditions, led to very low plant cover, mostly consisting of dwarf shrubs sparsed in a matrix of bare soil, lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. The exploitation of the land was drastically reduced during the second half of the 20th century due to the general rural land abandonment trend that started in Spain around the 1950's driven by critical socio-economic changes such as the use of fossil fuels and the sharp increase in activity in the tourism and services business sectors, mostly in the coast land. However, despite the reduction, or even complete abandonment, of rural activity on the mountain range area, there was no sign of spontaneous recovery from degradation. Soil erosion and floods were of major concern for the resource managers in the area (Public Forest Administration), and a number of reforestation and restoration programs have been implemented in the area, with varying degree of success. In more recent decades, new pressures appeared in the mountain area, such as agricultural expansion into the range area (1970s), mining activities (late 1990's - early 2000's), and urbanization (2000s). Rural tourism and recreation are new activities in the mountain range area. For the time being, the intensity of these activities is low to moderate. However there is already some evidence of incipient degradation associated to recreation, and some regulation is being demanded by environmental NGOs.

left: Walking excavator preparing planting holes (Photo: S.Bautista)
right: Detail of a planted seedling showing one of the applied planting treatments: microcatchment and seedling shelter (Photo: S.Bautista)

Location: Spain/Alicante
Region: Albatera
Technology area: 5.7 km^2
Conservation measure: vegetative
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Land use:
Forests / woodlandsrests / woodlands: Natural (before), Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
Climate: semi-arid, subtropics
WOCAT database reference: T_SPA013en
Related approach:
Compiled by: Susana Bautista, Universidad de Alicante
Date: 2014-07-01

Classification

Land use problems:

- Erosion, water scarcity, low productivity, loss of soil functions (water infiltration, nutrient cycling), low biodiversity, loss of landscape structure (expert's point of view)
Low productivity, aridity, erosion (land user's point of view)

Land use

Natural
Forests / woodlandsrests / woodlands: Natural (before)
Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
plantation forestry

Climate

semi-arid

Degradation

Soil erosion by water: loss of topsoil / surface erosion, offsite degradation effects, Biological degradation: reduction of vegetation cover, quantity / biomass decline, quality and species composition /diversity decline

Conservation measure

Vegetative: Tree and shrub cover

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires), over-exploitation of vegetation for domestic use
Indirect causes: poverty / wealth

Main technical functions:

- control of dispersed runoff: retain / trap
- improvement of ground cover
- increase in nutrient availability (supply, recycling,...)

Secondary technical functions:

- control of dispersed runoff: impede / retard
- control of concentrated runoff: retain / trap
- increase of surface roughness
- improvement of surface structure (crusting, sealing)
- improvement of topsoil structure (compaction)
- stabilisation of soil (eg by tree roots against land slides)
- increase in organic matter
- increase of infiltration
- increase / maintain water stored in soil
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 240 days(November-June)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, decreasing length of growing period
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), droughts / dry spells

Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
■	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), large scale land users, Leaders / privileged, men and women
Population density: 100-200 persons/km2
Annual population growth: 2% - 3%
Land ownership: state
Land use rights: open access (unorganised)

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: moderate: employment (eg off-farm), financial services; high: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation
Market orientation: No forestry production
Purpose of forest / woodland use: nature conservation / protection, recreation / tourism

Technical drawing

Test (Test)

Implementation activities, inputs and costs

Establishment activities

- Soil preparation and planting holes
- Soil and microcatchment preparation
- Fertilization plantation (holes)
- Fertilization microcatchment
- Plantation
- Plantation (microcatchments)
- Tree shelter placement
- tree shelter placement (Microcatchments)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1343.00	100%
Equipment		
- machine use	853.00	100%
Agricultural		
- seedlings	252.00	100%
- biocides	154.00	100%
- Tree shelters	424.00	100%
TOTAL	**3026.00**	**100.00%**

Maintenance/recurrent activities

Remarks:

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages

Socio-cultural benefits	Socio-cultural disadvantages
+ increased recreational opportunities	
+ improved conservation / erosion knowledge	

Ecological benefits	Ecological disadvantages
++ improved harvesting / collection of water	
++ reduced evaporation	
++ reduced surface runoff	
++ improved soil cover	
++ increased biomass above ground C	
++ increased nutrient cycling recharge	
++ increased soil organic matter / below ground C	
++ reduced soil loss	
++ increased plant diversity	
++ increased / maintained habitat diversity	
+ increased soil moisture	
+ increased animal diversity	
+ increased beneficial species	

Off-site benefits	Off-site disadvantages
+ reduced downstream flooding	

Contribution to human well-being / livelihoods
+ Recreational use

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	positive
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome

Multi-specific plantation of semiarid woody species on terraces with stone walls in ravines and gullies

Spain - Plantación pluriespecífica de especies leñosas de ambiente semiárido en terrazas con pared de piedra sobre barrancos y c

Plantation of native semiarid woody species on small terraces with stone walls on ravines and gullies

This technology is a restoration technology implemented on ravines and gullies in a degraded semiarid mountain range. The restoration technology consisted of a plantation of seedlings of a variety of native woody species, mostly shrubs, on terraces with stone walls. Using planting holes, one or two rows of seedlings were established on each terrace; Seedlings were protected from extreme radiation and predation by biodegradable seedling shelters. The target area was highly degraded due to long-term overexploitation of resources under harsh environmental conditions. Failed previous reforestation actions on bench terraces led to further degradation in some areas. Degradation resulted in lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. To address this problem, the Forest Administration implemented a restoration program on the ravines and gullies of the south-facing side of the Albatera-Crevillente mountain range. The program was implemented in 2006-07.
The purpose of the restoration was control of concentrated erosion in gullies and ravines; mitigation of landscape degradation; flood prevention; restoration of diversity and cover of vegetation on a degraded semiarid mountain range.
The target area is the south-facing side of a mountain range in a semiarid area of Southeast Spain. Exploitation of resources over centuries, mostly grazing and wood gathering, under harsh environmental conditions, led to very low plant cover, mostly consisting of dwarf shrubs sparsed in a matrix of bare soil, lack of riparian vegetation on the ramblas (ravines with intermittent flow), soil erosion, development of gullies, and frequent floods. The exploitation of the land was drastically reduced during the second half of the XXth century due to the general rural land abandonment trend that started in Spain around the 1950's driven by critical socio-economic changes such as the use of fossil fuels and the sharp increase in activity in the tourism and services business sectors, mostly in the coast land. However, despite the reduction, or even complete abandonment, of rural activity on the mountain range area, there was no sign of spontaneous recovery from degradation. Soil erosion and floods were of major concern for the resource managers in the area (Public Forest Administration), and a number of reforestation and restoration programs have been implemented in the area, with varying degree of success. In more recent decades, new pressures appeared in the mountain area, such as agricultural expansion into the range area (1970s), mining activities (late 1990's - early 2000's), and urbanization (2000s). Rural tourism and recreation are new activities in the mountain range area. For the time being, the intensity of these activities is low to moderate. However there is already some evidence of incipient degradation associated to recreation, and some regulation is being demanded by environmental NGOs

left: Multi-specific plantation on a ravine area "barranco": Example of a restored ravine. Terrace with stone wall and planted seedlings. (Photo: S.Bautista)

Location: Spain/Alicante
Region: Albatera
Technology area: 5.7 km²
Conservation measure: vegetative, structural
Stage of intervention: rehabilitation / reclamation of denuded land
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Land use:
Forests / woodlandsrests / woodlands: Natural (before), Forests / woodlandsrests / woodlands: Natural (after)
Climate: semi-arid, subtropics
WOCAT database reference: T_SPA016en
Related approach:
Compiled by: Susana Bautista, Universidad de Alicante
Date: 2014-07-01

Classification

Land use problems:

- Erosion, water scarcity, low productivity, loss of soil functions (water infiltration, nutrient cycling), low biodiversity, loss of landscape structure, flood risk (expert's point of view)
Low productivity, aridity, limiting conditions for tree cover, erosion (land user's point of view)

Land use

Natural
Forests / woodlandsrests / woodlands: Natural (before)
Forests / woodlandsrests / woodlands: Natural (after)
plantation forestry

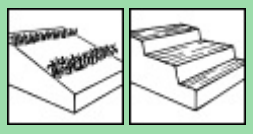
Climate

semi-arid

Degradation

Soil erosion by water: gully erosion / gullying, offsite degradation effects

Conservation measure



Vegetative: Tree and shrub cover
Structural: Bench terraces (slope of terrace bed <6%)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires), over-exploitation of vegetation for domestic use
Indirect causes: poverty / wealth

Main technical functions:

- control of dispersed runoff: retain / trap
- control of dispersed runoff: impede / retard
- control of concentrated runoff: retain / trap
- control of concentrated runoff: impede / retard
- reduction of slope angle

Secondary technical functions:

- reduction of slope length
- improvement of ground cover
- increase in nutrient availability (supply, recycling,...)
- increase of infiltration
- increase / maintain water stored in soil
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 240 days(from November till June)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: for agricultural use only
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, decreasing length of growing period
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), droughts / dry spells

Human Environment

Forests / woodlands per household (ha)

Land user: employee (company, government), large scale land users, Leaders / privileged, men and women
Population density: 100-200 persons/km2
Annual population growth: 2% - 3%
Land ownership: state
Land use rights: open access (unorganised)

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: moderate: employment (eg off-farm), financial services; high: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation
Market orientation: No forestry production
Purpose of forest / woodland use: nature conservation / protection

Implementation activities, inputs and costs

Establishment activities

- Building small walls and terraces in ravines and gullies
- Soil and microcatchment preparation
- Soil preparation and planting holes
- Fertilization microcatchment
- Fertilization plantation (holes)
- Plantation (microcatchments)
- Plantation (in holes)
- Tree shelter placement
- tree shelter placement (Microcatchments)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1796.00	100%
Equipment		
- machine use	853.00	100%
Agricultural		
- seedlings	252.00	100%
- compost/manure	154.00	100%
- Tree shelters	424.00	100%
TOTAL	**3479.00**	**100.00%**

Maintenance/recurrent activities

Remarks:

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages

Socio-cultural benefits	Socio-cultural disadvantages
+ increased recreational opportunities	
+ improved conservation / erosion knowledge	

Ecological benefits	Ecological disadvantages
+ + reduced surface runoff	
+ + improved soil cover	
+ + increased biomass above ground C	
+ + increased nutrient cycling recharge	
+ + increased soil organic matter / below ground C	
+ + reduced soil loss	
+ + increased plant diversity	
+ + increased beneficial species	
+ + increased / maintained habitat diversity	
+ improved harvesting / collection of water	
+ increased soil moisture	
+ reduced evaporation	
+ increased animal diversity	

Off-site benefits	Off-site disadvantages
+ reduced downstream flooding	

Contribution to human well-being / livelihoods

+ Recreational use

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly negative	positive
Maintenance / recurrent	not specified	not specified

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome

Unvegetated strips to reduce fire expansion

Italy - Firebreaks

Firebreaks are stripes cleared of vegetation that divide a continuous forest in smaller patches to reduce spreading of wildfires and allow intervention.

The technology consists of creating gaps of vegetation of about 5 to 7 meters, every 50 to 75 meters distance contourline large forested areas. These clear strips are connected to main roads having varying length in relation to the size of the area.
Fire breaks act as a barrier to stop or slow the progress of fires and allow firefighters to better position themselves to operate.
Clearing activities which must be carried out annually by specialized workers using minor devices (hand and hedge cutter).
This technology is applied mostly in publicly owned woods (or very large private woods). The network of these fire strips is rather dense as the number of flammable species increases. So it creates patches of 2500 to 5000 meters according to the type of species. The context of production is characterised by a medium level of mechanisation (only the most demanding operations are carried out using mechanical means), the production system is essentially mixed, a small part is destined for personal consumption whilst the bulk of production is destined for local markets. The property is predominantly privately owned but also includes some public land, especially in the case of pasture land. Most farms in the area are livestock farms whilst the agricultural component is destined exclusively for private consumption.

Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: management
Stage of intervention: prevention of land degradation
Origin: Developed through experiments / research, traditional (>50 years ago)
Land use type:
Forests / woodlands: Natural
Climate: subhumid
WOCAT database reference: T_ITA007en
Related approach: MUNICPAL FOREST MANAGEMNT PLAN (DECADE 2010-2019) (A_ITA001en)
Compiled by: Velia De Paola,
Date: 2014-05-27
Contact person: Giovanni Quaranta, University of Basilicata Via dell'Ateneo Lucano 10, 85100 POTENZA (IT)
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+390971205411

Classification

Land use problems:

- In some wooded areas, especially nearest the roads, there is an excessive amount of undergrowth (with some shrubs reaching a height in excess of two metres) which leaves the area vulnerable to the start and spread of forest fires. (expert's point of view)
The increase in shrubs has increased fire risk. (land user's point of view)

Land use

Natural
clear felling of (semi-)natural forests

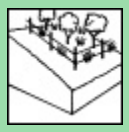
Climate

subhumid

Degradation

Biological degradation:
detrimental effects of fires

Conservation measure



Management: Waste Management: includes recycling, re-use or reduce

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research: traditional (>50 years ago)
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:

Main technical functions:
- control of fires

Secondary technical functions:

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 120 days(March to august)
Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: medium (1-3%)
Soil drainage/infiltration: good

Soil water storage capacity: medium
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells, decreasing length of growing period

Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, Small scale land users, common / average land users, mainly men
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, titled
Land use rights: individual
Relative level of wealth: average, which represents 90% of the land users;

Importance of off-farm income: 10-50% of all income: Most of the off farm income derives from public sector, i.e. Municipality, Mountain Community, Region and other public bodies. Very few farmer members run local shops or handcraft.
Access to service and infrastructure: low: employment (eg off-farm); moderate: health, education, technical assistance, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: commercial / market
Purpose of forest / woodland use: fuelwood

Implementation activities, inputs and costs

Establishment activities

Maintenance/recurrent activities

- Cutting vegetation with the help of device (hedge cutters, usually owned by the specialized workers who are doing the job, and their cost is included in the salary) The hectare is intended to mean the area of cleared vegetation which is usually 5-7metres wide.

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	1351.35	100%
TOTAL	**1351.35**	**100.00%**

Remarks:
Manual labour (including fuel for hedge cutter).

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ reduced risk of production failure

Production and socio-economic disadvantages

+ reduced wood production

Socio-cultural benefits

Socio-cultural disadvantages

Ecological benefits

+++ reduced hazard towards adverse events
+++ reduced fire risk

Ecological disadvantages

Off-site benefits

++ reduced damage on neighbours fields
++ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	slightly positive	slightly negative
Maintenance / recurrent	positive	positive

Acceptance / adoption:

100% of land user families have implemented the technology with external material support.
0% of land user families have implemented the technology voluntary.
There is moderate trend towards (growing) spontaneous adoption of the technology.

Concluding statements

Strengths and → how to sustain/improve

1) The creation of firebreaks is a very useful method to reduce the spread of fires. → Public funding is needed to ensure this method can continue.

the technique is an important tool in preventing the spread of fires, however, when winds are strong they can make little difference → some as before

Weaknesses and → how to overcome

Apart from the annual cost of clearing vegetation, it reduces the number of trees per hectare of wooded areas →

Cleared strip network for fire prevention (firebreaks)

Spain - Área cortafuegos

The basic principle of a firebreak network is to split continuous forest areas (where a lot of fuel is built up) into smaller patches separated by vegetation-free strips in order to prevent large forest fires.

In the forest law 3/1993 the declaration of special areas to “Zonas de Actuación Urgente (ZAU)” (zone of urgent actions) through the regional government of Valencia is defined. Objectives are the protection against natural hazards and the promotion of forest restoration within this area. Ayora was declared to a ZAU in 1997 due to its high risk of fires. In the “Plan de Selvicultura Preventiva de Incendios en los Sistemas Forestales de la Comunidad Valenciana” which became operative in 1996 and whose main objective is the reduction of the fire risk, the ZAU is practically addressed for the first time in the establishment of firebreaks (áreas cortafuegos). Based on this plan, the firebreaks were established within a pilot project “Proyecto Piloto de Selvicultura Preventiva” between 1998 and 2002, carried out by the company VAERSA (public company of the Generalitat Valenciana).
A firebreak is a strategically located strip on which the vegetation cover has been partially or totally removed down to mineral soil with the aim of controlling the spread of large forest fires. The main purposes are 1) to interrupt the continuity of hazardous fuels across a landscape to decrease the area affected by fires, 2) to provide areas where fire fighters are protected and can work more efficiently, 3) to slow down a fire, to reduce the fire intensity and caused damages, and 4) to provide strips where fuel management is facilitated. The total surface protected by the firebreaks is 33’851 ha while the management measures are executed on 1944,81 ha. This technology is also applied in other countries, e.g. Portugal, South Carolina or South Africa. The establishment and maintenance are labour-intensive and expensive. Firebreaks can range between a protected area of 2000-6000 ha (first order), 500-1500 ha (second order), and 100-300 ha (third order), together forming a system isolating separate areas by wide strips. This parcelling aims in limiting the burnt area to a maximum of 6000 ha. Each firebreak consists of a bare vegetation-free strip (banda decapado). The width of the bare area ranges between 6m (first order), 3m (second order) and 1.5m (third order). Existing vegetation-free areas (e.g. roads) are used to establish firebreaks to have less visual impact. If there is no road, trees and shrubs have to be cleared and chipped entirely using chainsaws and special tractors. On each side of the bare area there is a totally cleared strip (banda de desbroce total). The width depends on the climatic zone, the order and the hazard of fuel, therefore ranging between 28m (first order), 11m (second order) and 6m (third order). Almost all the existing vegetation is cleared, only some isolated mature trees are not cut if they do not contribute to the propagation of a fire. On both sides of these strips there are auxiliary strips (banda auxiliar) where selective clearing is applied until reaching a desired density. Sick trees are cleared with priority. Species of high ecologic value and low flammability level are not cleared, such as Juniperus phoenicea, Juniperus oxycedrus and Quercus ilex ssp. rotundifolia. The width of these elements can vary according to the prevalent conditions. A part of the wood generated by the clearings is used as fuelwood, the other part is chipped and distributed on the soil as mulch. Firebreaks are often located on mountain ridges and created with 45° to the dominant wind direction (west) to facilitate fire extinction. The maintenance of firebreaks is extremely important. Without clearing, fire-prone species will encroach which decreases the effectiveness of the firebreak. The maintenance is realized depending on the vegetation, usually in firebreaks of first order the maintenance is done every 2 years (“decapado” and “desbroce total”) or every 4 years (“banda auxiliar”) while firebreaks of second and third order are cleared every 4 years. In the here described project the maintenance was carried out in three phases (2001-2004, 2004-2008 and 2008-2012).
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 opportunities (e.g. marginal agriculture, grazing, hunting, beekeeping, artisanry, wind mill parc). Most of the inhabitants work in the nuclear power plant. Forest management could be a source for jobs.

left: Firebreaks are classified in first, second and third order, together forming a system isolating separate areas by wide strips. This parcelling aims in controlling the spread of large forest fires. (Photo: Nina Lauterburg)
right: Firebreaks are often located along existing roads to guarantee the access for fire-fighting vehicles and to keep the environmental impact limited. (Photo: Nina Lauterburg)

Location: Spain, Valencia
Region: Region of Ayora (including the municipalities Requena, Cofrentes, Jalance, Jarafuel, Zarra, Ayora)
Technology area: 338.5 km^2
Conservation measure: vegetative
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, 10-50 years ago
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Climate: subhumid, temperate
WOCAT database reference: T_SPA009en
Related approach: Plan of preventive silviculture (PSP): implementation of firebreak network within a forest intervention area (ZAU) (A_SPA002en)
Compiled by: Nina Lauterburg, CDE
Date: 2013-05-06
Contact person: Jaime Baeza, Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Parque Tecnológico Paterna. C/ Charles Darwin 14, 46980 Valencia, Spain. E-Mail: jaime.baeza@ua.es

Classification

Land use problems:

- In Ayora, the prevalent dense shrublands (dominated by seeder species), which resulted from past agricultural land use (changes of the vegetation composition, e.g. removal of key species), land abandonment/rural depopulation and fire occurrence, contain a high fire risk because of both the high fuel loads and their continuity. Also dense forests (either afforestations or natural regeneration) show a high risk for fires. Through the modifications of the vegetation composition in the past (removal of more fire resistant resprouter species (mature forest), whereas fire-prone seeder species are now spreading), the resilience of the ecosystem to fires has decreased. Today a higher fire recurrence can be observed which could still be worsen by future climate change impacts, undermining more and more the ecosystem's capacity to buffer such shocks. Before the implementation of firebreaks, it was almost impossible to stop a fire and it was much more dangerous for fire fighters. There was also no access for fire-fighting vehicles. (expert's point of view)

Land use

Natural
Plantations, afforestations selective felling of (semi-) natural forests, plantation forestry

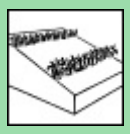
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires

Conservation measure



Vegetative: Clearing of vegetation (eg fire breaks/reduced fuel)

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative: traditional (>50 years ago)
- Experiments / Research
- Externally introduced: 10-50 years ago

Level of technical knowledge

- Agricultural advisor
- Land user
- Engineer

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: population pressure, poverty / wealth, labour availability

Main technical functions:
- control of fires

Secondary technical functions:
- reduction of dry material (fuel for wildfires)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Soil texture: fine / heavy (clay)
Soil fertility: medium
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: medium

Soil water storage capacity: high
Ground water table: 5 - 50 m
Availability of surface water: poor / none
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall decrease, heavy rainfall events (intensities and amount), floods
Sensitive to climatic extremes: seasonal rainfall increase, wind storms / dust storms, droughts / dry spells
If sensitive, what modifications were made / are possible: The technology was not modified. The firebreaks are quite resistant against climate change or weather extremes. Only if there will be more rainfall the vegetation might grow faster and the maintenance costs could increase. Furthermore, if there are heavy windstorms the effectiveness of firebreaks is undermined because strong winds result in faster spreading fires.

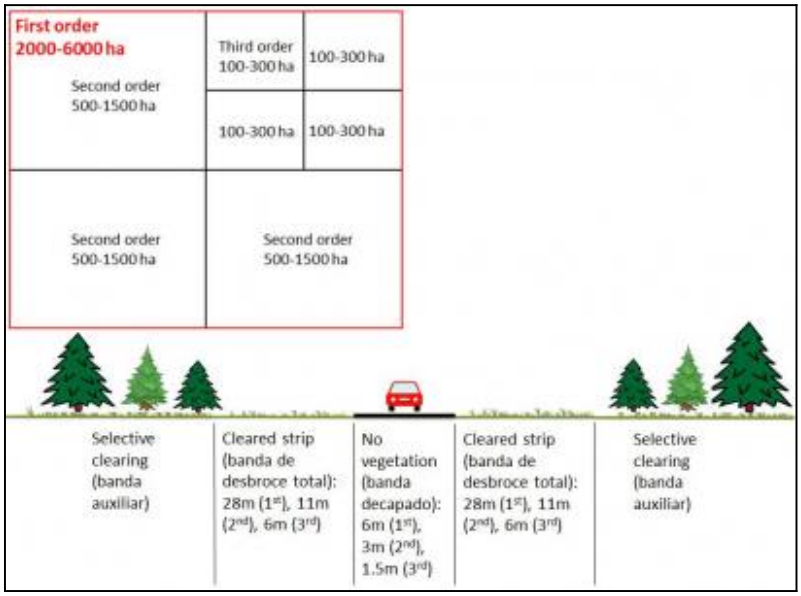
Human Environment

Forests / woodlands per household (ha)

	<0.5
	0.5-1
	1-2
	2-5
	5-15
	15-50
	50-100
	100-500
	500-1,000
	1,000-10,000
	>10,000

Land user: employee (company, government), common / average land users, mainly men
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: state, individual, titled
Land use rights: individual, open access but organised (e.g. wood, hunting)
(There is some public land, controlled by the state. But there is also some private land. The access to the public land is open but organized. Permission is needed from the government to cut trees, to build a house or to hunt. There are some private hunting areas for which the hunting association has to pay a fee.)

Importance of off-farm income: : The forest brigade is only working when there is money and a project. If there is no money they have no work and need to have a look for another job.
Access to service and infrastructure:
Market orientation: mixed (subsistence and commercial)
Purpose of forest / woodland use: timber, other forest products / uses (honey, medical, etc.), recreation / tourism



Technical drawing

Firebreaks can range between a protected area of 2000-6000 ha (first order), 500-1500 ha (second order), and 100-300 ha (third order), together forming a system isolating separate areas by wide strips. This parcelling aims in limiting the burnt area to a maximum of 6000 ha. Each firebreak consists of a bare strip (banda decapado) ranging between 6m (first order), 3m (second order) and 1.5m (third order). On both sides of the bare area there is a totally cleared strip (banda de desbroce total) whose width ranges between 28m (first order), 11m (second order) and 6m (third order). On both sides of these strips there are auxiliary strips (banda auxiliar) where selective clearing is applied. The width of these elements can vary according to the prevalent conditions. (Nina Lauterburg)

Implementation activities, inputs and costs

Establishment activities

- Project planning and design of firebreak system
- Adaption of the agricultural tractors with forest management machinery (wheels, protection of the machine against stones, clearing machinery with chains)
- Cutting and chipping (in-situ) of trees and shrubs (execution of firebreak network)
- Transport of wood (fuel wood)

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1095.00	0%
Equipment		
- machine use	675.00	0%
TOTAL	**1770.00**	**0.00%**

Maintenance/recurrent activities

- Clearing of firebreaks of first order (every 2 years)
- Clearing of firebreaks of second and third order (every 4 years)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Equipment		
- machine use	557.00	0%
TOTAL	**557.00**	**0.00%**

Remarks:
The costs of the establishment of firebreaks can be affected by numerous factors, such as slope (if the slope is steep, the work is much more difficult and takes more time, because machines cannot be used on steep slopes), vegetation density (it takes more time to clear a dense area), stone content of the soil (if there are many stones the work is much more difficult for the machines and more dangerous for the workers), availability of a road (where a firebreak can be established, costs can be saved). Important to note is that maintenance costs could increase with an increase in rainfall because the vegetation will grow faster (otherwise firebreaks are quite resistant against climate change or weather extremes). Furthermore, modifying a normal tractor for forest management can be extremely expensive.
The total costs of the firebreaks (establishment and maintenance) were calculated for the application of the technology on one hectare, based on the indications given in the official project documents of the regional government (Generalitat Valenciana) and information from different stakeholders (e.g. forest agent, university staff, employee of VAERSA). The whole project costs were around 3 Mio Euro for the establishment and around 1.5 Mio Euro for the maintenance phase. The maintenance costs refer to the third maintenance phase taking place from 2008 to 2012. The costs of the execution of the project were 1312 Euro/ha (1770 Dollar) and the costs of the maintenance were 82.03 Euro/ha (110 Dollar, after 2 years) and 331.37 Euro/ha (446 Dollar, after 4 years). The currency rate (Euro-Dollar) was calculated on November 16th, 2013.

Assessment

Impacts of the Technology

Production and socio-economic benefits

++ increased wood production
+ increased fodder production
+ increased fodder quality
+ increased animal production

Production and socio-economic disadvantages

++ high establishment and maintenance costs
+ loss of land
+ job uncertainty

Socio-cultural benefits

++ improved conservation / erosion knowledge
++ improved situation of disadvantaged groups
++ Increase of the security for fire fighters
+ conflict mitigation
+ improved food security / self sufficiency

Socio-cultural disadvantages

+ loss of recreational opportunities
+ socio cultural conflicts
+ increased health problems

Ecological benefits

++ reduced hazard towards adverse events
++ reduced fire risk
+ reduced emission of carbon and greenhouse gases

Ecological disadvantages

+ increased surface water runoff
+ decreased soil cover
+ decreased soil organic matter
+ increased soil erosion locally
+ increased habitat fragmentation

Off-site benefits

++ reduced risk of wildfires
+ reduced downstream flooding
+ reduced downstream siltation
+ reduced damage on neighbours fields
+ reduced damage on public / private infrastructure

Off-site disadvantages

Contribution to human well-being / livelihoods

+ Through the establishment and the maintenance of firebreaks it is easier to control fires and protect people. Furthermore it created jobs for the unemployed. But it seems that in general forest management is not something people want to do, they work in this sector only if there are no other job opportunities. Forest management means a hard job and this kind of work is not well-respected in society

Benefits /costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	very positive	very positive
Maintenance / recurrent	very positive	very positive

Both the short-term and the long-term benefits are very positive assuming that maintenance is done. Together with the creation of jobs, directly after establishing the firebreaks there is firewood and timber available and a reduced risk of wildfires. But it should also be considered that the establishment costs are high. If maintenance is not done the long-term returns will be very negative because an increase in the risk of fire will occur again (without management, there will also be no firewood, no timber and no jobs). The maintenance costs increase the longer you wait because the vegetation will grow again densely.

Acceptance / adoption:

There is little trend towards (growing) spontaneous adoption of the technology. The existing firebreak network system was established within the pilot project. Other firebreaks were created afterwards by the regional government of Valencia or already existed before. Maybe the network is enlarged in some areas from time to time. This technology is also applied in other countries/regions, amongst others in Portugal, South Carolina and South Africa.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
There is a reduction of fuel load within the firebreaks and therefore they contribute to fire prevention. → The maintenance of firebreaks is crucial	Firebreaks are a strong disturbance of the natural environment. People often criticise the negative aesthetic/visual impact which results in a decline of the recreational value. → This problem is difficult to overcome, but the technology helps to prevent an even bigger disturbance of the forest caused by a fire. Even though criticising the firebreaks due to its visual impact people know about the importance of this measure and are also concerned with the devastating effects of a forest fire. There is always the question of what is better: to establish firebreaks and disturb nature, or to experience a large fire.
A firebreak does not stop a fire but facilitates the access for fire fighters (and vehicles) and guarantees a higher security for people, thus increasing the possibility to control/slow down a fire. By arranging the territory in different parcels (firebreaks of first, second and third order) the spread of large forest fires is less probable → The maintenance of firebreaks is crucial. Furthermore, there must be a good coordination and organisation within the fire fighter staff in case of an emergency.	The establishment and the maintenance activities are expensive and labour-intensive. Without management the firebreaks are not effective anymore. It would be necessary to extract biomass from the forest to decrease the continuity of the trees and shrubs. In case of a lack of management the risk of fires increases. → Management is crucial. It should be noted that prevention measures are often less expensive than rehabilitation activities after a fire. More investment in forest management and fire prevention is required. Managing the forest would not only decrease the risk of fire but also generate benefits (e.g. wood, biomass). Furthermore, jobs would be generated which is especially important during the current economy crisis in Spain. There are some good practices found in other regions to cover the maintenance costs: In Jarafuel (next to Ayora) a part of the rent paid by the wind mill company to the state is reinvested in forest management. Or in Andalucia, the government launched a project to invest subventions in maintenance of firebreaks through grazing and this was very successful. This could be a good alternative to expensive management measures. It was also mentioned by many stakeholders that traditional activities (such as grazing, agriculture, wood gathering) should be reactivated and that the villagers should get economic compensation to maintain the forest in a good state.
There are both social and economic benefits for local people. The establishment and the maintenance of firebreaks provide jobs for rural people which allows them to increase their livelihood conditions. A part of the extracted wood is used for biomass, fertilizers, pellets, or firewood. Furthermore there would be improved conditions for grazing. → More investment in forest management is required to sustain these benefits. Furthermore, many local stakeholders mentioned the importance of reactivating traditional activities (such as grazing, agriculture, wood gathering) and that the villagers should get economic compensation to maintain the forest in a good state.	Firebreaks are not that efficient because after clearing, the first plants which grow are Ulex parviflorus and Cistus albidus which are fire-prone species. Furthermore, if you cut them each 4 or 5 years there will only be grassland which is not natural in Mediterranean region. A fire could be caused more easily due to the high amount of thin and dead material. → CEAM suggests to plant more fire-resistant species (late successional stages) within some spots in the firebreaks to increase the resilience of the ecosystem. Green living plants have a higher humidity content which slows down a fire (oxygen is consumed). The issue is not to cover the whole firebreaks with plants but to establish some green spots. By planting late-successional species densely you don't allow seeders to grow. This measure could also decrease management costs. People keep in their minds the idea of having to clear all the vegetation in order to not have fires or to stop them, but it is not really the most sustainable one. The idea of green firebreaks is already common in some other countries but you need to ensure water availability for irrigation.
Vegetation removal produces fresh vegetation growth, therefore more diverse and nutritious fodder is available for animals (game and livestock) in the cleared areas. Game/wildlife and livestock are better because there is an increase in fodder quantity and quality. → The maintenance of firebreaks is crucial.	In some areas, the implementation of firebreaks can occupy productive land which means a loss of land → The main objective of this technology is to provide protection from forest fires instead of creating productive land.
Due to the high stone content of the soil, and due to mulching through in-situ brush-chipping of the cleared material, the firebreaks are not that prone to erosion as in other regions/countries (e.g. Portugal). →	The work is dangerous and there is a high risk to harm oneself when clearing and chipping the vegetation. It is also a physical stress due to the exhausting work →
Improvement and maintenance of the forest paths and streets to establish firebreaks and to guarantee access for fire fighter vehicles but also for recreational activities (rural tourism). → Establishment and maintenance of the firebreaks can improve the forest track network.	When there is a strong and dry wind from the inland (poniente) the smaller firebreaks are useless because the fire just passes over. It should also be noted that without human intervention the firebreaks do not stop a fire → Establish big firebreaks and ensure maintenance.
Fewer fires result in a decrease of the destroyed area, less money will have to be invested in restoration or fire extinction. Furthermore, farmers, hunters and honey producers will experience fewer losses. → The maintenance of firebreaks is crucial.	
In Jarafuel where most of the land is public retired people receive the firewood gained by forest clearings for free. They can use the wood for cooking and heating and save a lot of money. → People from the region (outside of Jarafuel) like this idea that villagers benefit from what is removed from the forest. More mechanisms like this should be developed so that people recognize that they also benefit from forest management, which in turn would ensure a sustainable forest management.	
There are also off-site benefits. Fewer fires will result in a reduction of downstream flooding, downstream siltation and damage on neighbours' fields. When fire removes less vegetation the soil is less vulnerable to erosion → The maintenance of firebreaks is crucial.	

Primary strip network system for fuel management

Portugal - Primary strip network system for fuel management

Linear strips are strategically located in areas where total or partial removal of the forest biomass is possible. This technology contributes towards preventing the occurrence and spread of large forest fires and reducing their consequences for the environment, people, infrastructures, etc.

There are three types of strip for fuel management in forest areas: primary, secondary and tertiary, defined by the Law 17/2009. The most important differences between them are in terms of size (primary being the widest and the tertiary the narrowest) and scale (primary referring to the district level, secondary to the municipal level and tertiary to the parish level). The primary strip network system for fuel management (RPFGC) is integrated in the National System to Prevent and Protect Forest against Fires and it is defined by the National Forest Authority (AFN).
The RPFGC aims to re-arrange landscape elements, through the establishment of discontinuities in the vegetation cover, in forest areas and in the rural landscape (for example using water bodies, agricultural land, pasture, rocky outcrops, shrubland and valuable forest stands). Land tenure is private in most of the areas covered by the RPFGC. The main objectives of this technology are: to decrease the area affected by large fires; to enable direct access by fire fighters; to reduce fire effects and protect roads, infrastructures and social equipment, urban areas and forest areas of special value; and to isolate potential fire ignition sources.
These primary strips are ≥ 125 metres wide and preferably between 500 and 10,000 ha in area. The tree cover should be less than 50% of the area and the base of the tree canopy should not be lower than 3 metres. The RPFGC concept should include the adoption of a maintenance programme. The implementation and maintenance operations can be performed through different agro-forest technologies, such as clearance of bushes and trees, pruning, prescribed fire, harrowing and cultivation of the ground beneath the trees. Timber products can be sold and the removed litter can be used in a biomass power plant or applied to the fields to improve soil fertility, using mulching technology.
This SWC Technology needs considerable financial resources in terms of labour and equipment at the implementation phase. Costs, however, undergo considerable reduction thereafter. The implementation of this infrastructure to prevent and protect the land from forest fire is entirely funded by the government and implemented by the forest municipal services.

left: Reduction of the density of trees and or vegetation removal using machinery (Photo: João Soares)
right: Primary strip network system for fuel management. (Photo: João Soares)

Location: Portugal
Region: Santarém / Mação
Technology area: 400 km^2
Conservation measure: structural
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Mixed: Agroforestry
Climate: subhumid, temperate
WOCAT database reference: T_POR001en
Related approach: Forest Intervention Area (QA | POR01)
Compiled by: Celeste Coelho, University of Aveiro
Date: 2011-10-16
Contact person: Celeste Coelho, Centre for Environmental and Marine Studies University of Aveiro 3810 - 193 Aveiro Portugal Tel.: +351 234 370 349 Fax: +351 234 370 309 E-mail: coelho@ua.pt

Classification

Land use problems:

- Forest fires increase due to rural depopulation and to land management abandonment. (expert's point of view)

Land use

Natural
Agroforestry
rainfed
silvo-pastoralism
rainfed
selective felling of (semi-) natural forests, clear felling of (semi-)natural forests

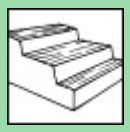
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires

Conservation measure



Structural: Others ()

Stage of intervention

- Prevention
- Mitigation / Reduction
- Rehabilitation

Origin

- Land users initiative
- Experiments / Research
- Externally introduced: recent (<10 years ago)

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: deforestation / removal of natural vegetation (incl. forest fires)
Indirect causes: Property size

Main technical functions:
- control of fires

Secondary technical functions:
- reduction of dry material (fuel for wildfires)

Environment

Natural Environment

Average annual rainfall (mm)

- > 4000 mm
- 3000-4000 mm
- 2000-3000 mm
- 1500-2000 mm
- 1000-1500 mm
- 750-1000 mm
- 500-750 mm
- 250-500 mm
- < 250 mm

Altitude (m a.s.l.)

- > 4000
- 3000-4000
- 2500-3000
- 2000-2500
- 1500-2000
- 1000-1500
- 500-1000
- 100-500
- <100

Landform

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

Slope (%)

- flat
- gentle
- moderate
- rolling
- hilly
- steep
- very steep

Soil depth (cm)

- 0-20
- 20-50
- 50-80
- 80-120
- >120

Growing season(s): 1 days(1 per year)
Soil texture: medium (loam)
Soil fertility: low
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: poor (eg sealing /crusting)

Soil water storage capacity: low
Ground water table: 5 - 50 m
Availability of surface water: medium
Water quality: good drinking water
Biodiversity: medium

Tolerant of climatic extremes: temperature increase, seasonal rainfall increase, seasonal rainfall decrease, decreasing length of growing period
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), wind storms / dust storms, floods, droughts / dry spells

Human Environment

Forests / woodlands per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: groups / community, Small scale land users, common / average land users, men and women
Population density: 10-50 persons/km2
Annual population growth: negative
Land ownership: individual, not titled
Land use rights: individual
Water use rights: open access (unorganised)
(Individual, not titled: Usually, legal documents for the property are missing.)
Relative level of wealth: average, which represents 50% of the land users; 50% of the total area is owned by average land users
poor, which represents 50% of the land users; 50% of the total area is owned by poor land users

Importance of off-farm income: > 50% of all income:
Access to service and infrastructure: low: employment (eg off-farm); moderate: education, technical assistance, telecommunications; high: health, market, energy, roads & transport, drinking water and sanitation, financial services
Market orientation: mixed (subsistence and commercial)

Technical drawing

This technical drawing indicates the technical specifications, dimensions and spacing for the Primary Strip Network System for Fuel Management. The figure shows a road as the axis of the RPFGC, but it can also be a river or a ridge, amongst other breaks in the forest cover. (João Soares)

Implementation activities, inputs and costs

Establishment activities

- Primary System design
- Shrubs cleaning + Thinning (reduction of fuel load) + Pruning
- Removing the cut waste material
- Litter Shredding
- Transport to the Biomass Plant

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	1076.00	0%
Equipment		
- machine use	568.00	0%
- Transport	100.00	0%
TOTAL	**1744.00**	**0.00%**

Maintenance/recurrent activities

Remarks:
The costs include the activities to ensure the vertical and horizontal discontinuity of the fuel load and also the activities needed to manage the waste produced from the shrubs cleaning and thinning.
The costs calculation was made for the implementation of the first section of the RPFGC. The implementation phase lasted for 2 or 3 months during the dry season. This section included 28 ha and 4 teams of forest sappers were involved.

Assessment

Impacts of the Technology

Production and socio-economic benefits

+++ reduced risk towards adverse events (droughts, floods and storms)
++ increased fodder production
++ increased fodder quality
++ increased animal production
+ increased energy production: biomass

Production and socio-economic disadvantages

++ costs of implementation
+ reduced wood production
+ increased maintenance costs

Socio-cultural benefits

++ community institution strengthening
+ national institution strengthening
+ conflict mitigation
+ improved conservation / erosion knowledge

Socio-cultural disadvantages

+ socio cultural conflicts

Ecological benefits

+++ reduced hazard towards adverse events
+++ reduced fire risk
+ improved soil cover

Ecological disadvantages

++ decreased soil cover
+ increased surface water runoff
+ decreased soil organic matter
+ increased soil erosion locally
+ increased habitat fragmentation

Off-site benefits

+++ reduced damage on public / private infrastructure
++ reduced damage on neighbours fields

Off-site disadvantages

Contribution to human well-being / livelihoods

+ reduced risk of wildfire

Benefits /costs according to land user

Benefits compared with costs	**short-term:**	**long-term:**
Establishment	neutral / balanced	positive
Maintenance / recurrent	neutral / balanced	positive

The maintenance will only start 2 or 3 years after the technology implementation, so no returns are expected at short-term.

Acceptance / adoption:

There is strong trend towards (growing) spontaneous adoption of the technology. After the implementation period there was a high local acceptance of the technology. It is also expected that grazing activities contribute to the technology maintenance

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Fuel load reduction → This will be achieved using prescribed fire and specialised machinery. The efficacy of prescribed fire depends on the collaboration of technicians and forest sapper teams. To guarantee the effectiveness of RPFGC implementation, long-term maintenance has to be ensured.	Soil erosion increase → Forestry good practices should be used in the RPFGC implementation, especially concerning the use of machinery and avoiding disturbance of soil at depth. Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture).
Reinforcement of the forest path system → Clearing the strips of the RPFGC can enhance the forest track network.	Soil cover reduction → Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture).
Forest fire prevention and fighting → The know-how of the local stakeholders and communities will contribute to the design of the RPFGC . This information should be integrated into the Municipal Plans to Prevent and Protect Forest Against Fires (PMDFCI). Any further information should be provided to the Civil Protection Agencies and to the Forest Technical Office and also to the local fire-brigade team.	Runoff increase → Soil cover after the removal of the existing vegetation should be promoted (by seeding, mulching or creating a low intensity pasture). Excessive vegetation removal should be avoid, especially near water courses where the removal should be nil or minimum.
Increase in landscape resilience → This will only be effective if the RPFGC is continuous and without gaps. The acceptance of the RPFGC by the landowners is fundamental to widespread the use of this technology. Information and awareness about the need to change vegetation cover is also very important, in order to avoid extensive areas of monoculture.	Budget for implementation and maintenance → European and national funds. Collaboration of the local government providing equipment and labour force. Information and awareness to the landowners about the importance of this technology. Campaigns of national awareness and definition of this technology as 'public use' to overcome some potential social conflicts concerning the land rights.

Municipal forest management plan -MFMP (decade 2010-2019)

Italy - PAF

Management plan for silvopastoral areas with a ten year intervention plan

Aim/objectives: The management plan is a legally binding document which outlines an analysis of the current situation of the forest and pastures and gives indications on the best future interventions to ensure their sustainable future management. The MFMP provides prescription to: cutting periods and tree ages, forest cultivation care, opening of firebreaks and their maintenance, allowance of grazing animals in the forest area, etc.

Methods: This legislative instrument, provides provisions and directions wich have to be followed and wich are legally binding in the local territory the plan covers. Any violations of the plan will result in sanctions.

Stages of implementation: The MFMP is a commitment of the municipality imposed by the Region. The Region provides funds to both to build and implement it when it has been approved. A specific forestry committee is appointed by the Region who provides the technical support to approve the MFMP presented by the municipalities.

Role of stakeholders: Stakeholders participate in drawing up the plan (at a municipal level) which is then approved at a regional level.

Location: Basilicata, Castelsaraceno
Approach area: 1 - 10 km^2
Type of Approach: recent local initiative / innovative
Focus: mainly on conservation with other activities
WOCAT database reference: A_ITA001en
Related technology(ies): Selective cutting (T_ITA008en), Unvegetated firebreaks (T_ITA007en)
Compiled by: Velia De Paola,
Date: 2014-05-28
Contact person: Giovanni Quaranta, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 POtenza.
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Problem, objectives and constraints

Problems

The management plan aims at a correct, rational and sustainable management of woods and silvo-pastoral areas.

Aims/Objectives

The land-use plan has the general objective of managing public forests and rangelands.

Constraints addressed

	Constraint	Treatment
technical	The technologies aim at preventing fires. However, in public woodland, which makes up the majority of the territory, no-one has a “vested interest” in carried out fire prevention actions and, as such, interventions must be made compulsory under law.	The management plan, being legally binding, forces the implementation of the two technologies associated with this approach.

Participation and decision making

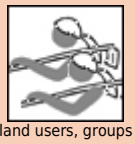
Stakeholders / target groups


planners


land users, individual


SLM specialists / agricultural advisors


politicians / decision makers


land users, groups

Approach costs met by:

local government (district, county, municipality, village etc) (70% region, 30% municipality)	100%
Total	**100%**

Annual budget for SLM component: US$ 2,000-10,000

Decisions on choice of the Technology(ies) mainly by SLM specialists with consultation of land users

Decisions on method of implementing the Technology(ies): mainly by land users supported by SLM specialists

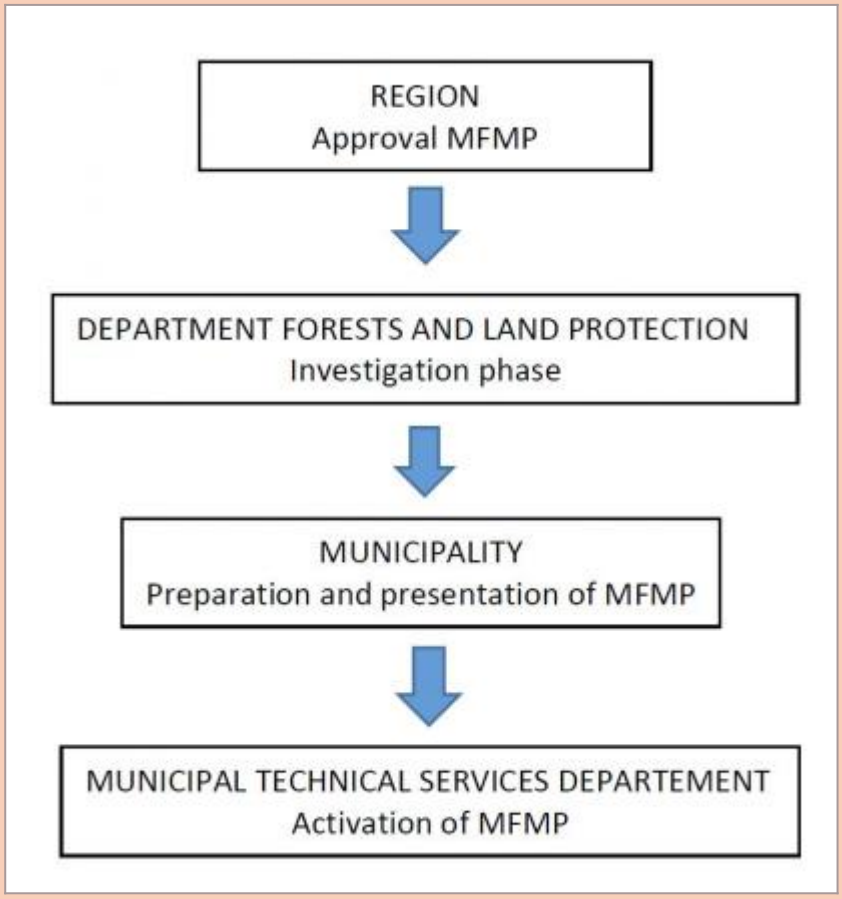
Approach designed by: national specialists

Implementing bodies: local government (district, county, municipality, village etc) (Region), other (Municipality)

Land user involvement		
Phase	**Involvement**	**Activities**
Initiation/motivation	Passive	Municipality, region, relative associations
Planning	Interactive	During the planning phase local land users help the specialists in identifying the problems facing the territory and in the choice of best technologies to improve land mangement
Implementation	Interactive	
Monitoring/evaluation	None	State forest service
Research	None	

Differences between participation of men and women: No
there is minimal participation of women because of the nature of the implementation work.

Involvement of disadvantaged groups: No



Organogram: Organization chart of MFMP (Velia De Paola)

Technical support

Training / awareness raising:
No

Advisory service:
Name: Publication in the Regional Official Gazette.
Key elements:
1. Local stakeholders presentation
2. Distribution of MFMP copies to whum is concerned

When approved, the MFMP is published on Regional Official Gazette. Implementation responsible is the Municipal thought its technical department and forestry services who is also responsible for updating and upgrading it periodically. The extension system is quite adequate to ensure continuation of activities. the forest service constantly monitors the implementation of the management plan and in cases of violations applies sanctions

Research:
No research.

External material support / subsidies

Contribution per area (state/private sector): No.

Labour: Paid in cash.

Inputs:

Credit: Credit was not available

Support to local institutions: Yes, little support with dissemination of paf

Monitoring and evaluation

Monitored aspects	Methods and indicators
area treated	Regular observations by other: State forest service

Changes as result of monitoring and evaluation:
There were no changes in the approach.

There were no changes in the technology.

Impacts of the Approach

Improved sustainable land management: Yes, moderate; Since the region adopted the Forest Management Plan for each municipality the management of woods and silvo-pastoral areas has been much more sustainable compared to the past.

Adoption by other land users / projects: Yes, few; Larger owners adopted some measures of the path although they were not obliged.

Improved livelihoods / human well-being: Yes, little; With the Forest Management Plan the income from the sale of woods is much more stable and constant over the years.

Improved situation of disadvantaged groups: No

Poverty alleviation: No

Training, advisory service and research:

- Advisory service effectiveness

  Land users*: good

  During the presentation of the management plan to the land users, the proposed technologies were fully explained and land users were given instructions on their implementation.

- Research contributing to the approach`s effectiveness: Moderately
  Research activities are not foreseen under the Forest Management Plan but play a role in giving general support

Land/water use rights:
None of the above in the implementation of the approach. The Forest Management Plan applies exclusively to public lands and so does not affect private property in any way.

Long-term impact of subsidies:

Concluding statements

Main motivation of land users to implement SLM:

Rules and regulations (fines) / enforcement

Well-being and livelihoods improvement

Sustainability of activities:

No the land users can`t sustain the approach activities without support.

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The Forest Management Plan plays a vital role in local land management. It is revised and renewed every ten years which allows for a periodic re-assessment of changes to economic and environmental conditions. → Public funding must be guaranteed for actions as interventions aim at protecting public resources.	The only disadvantage is the high initial costs to draft the plan. After the first 10 years the costs for updating the plan are greatly reduced so that costs are ultimately spread out over the long term. → The only thing which garantees the adoption of the plan is public funding.
The Forest Management Plan was first viewed with suspicion as another example of red tape but then during its implementation land users saw the benefits it brought and even private land owners began implementing the same technologies on their own land. → They rely on public funding for implementation.	