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)

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.

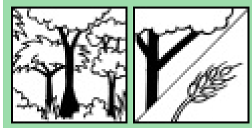
Location: Portugal
Region: Santarém / Mação
Technology area: 400 km^2
Conservation measure: structural
Stage of intervention: prevention of land degradation
Origin: Developed externally / introduced through project, recent (<10 years ago)
Land use type:
Forests / woodlands: Natural
Mixed: Agroforestry
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:

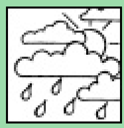
- Forest fires increase due to rural depopulation and to land management abandonment. (expert's point of view)

Land use



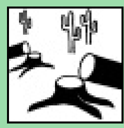
Natural
Agroforestry
rainfed
silvo-pastoralism
rainfed
selective felling of (semi-) natural forests, clear felling of (semi-)natural forests

Climate



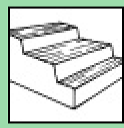
subhumid

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

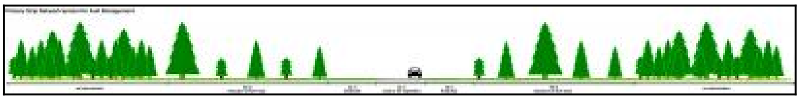
Human Environment

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.

Cleared strip network for fire prevention (firebreaks)

Spain - Área cortafuegos

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)

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.

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 Centre for Development and Environment
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

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

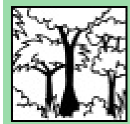
INSTITUTO UNIVERSITARIO CEAM CENTRO DE ESTUDIOS AMBIENTALES DEL MEDITERRÁNEO

Classification

Land use problems:

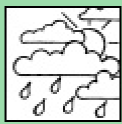
- In Ayora, the prevalent dense shrublands (dominated by seeder species), which resulted from past agricultural land use (changes of the vegetation composition, e.g. removal of key species), land abandonment/rural depopulation and fire occurrence, contain a high fire risk because of both the high fuel 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



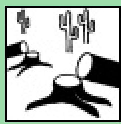

Natural
Plantations, afforestations
selective felling of (semi-) natural forests, plantation forestry

Climate



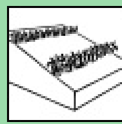
subhumid

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.

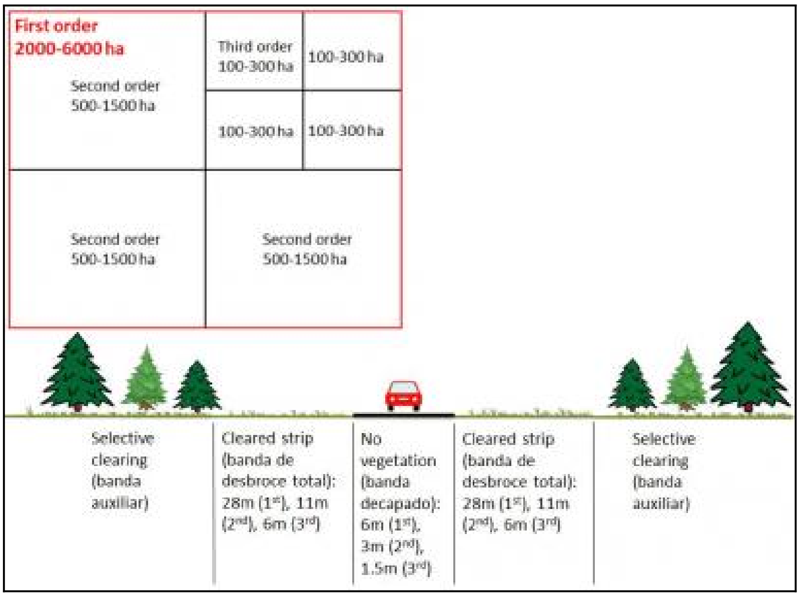
Human Environment

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.	


Unvegetated strips to reduce fire expansion
Italy - Firebreaks

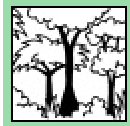
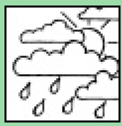
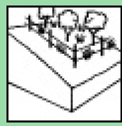
Firebreaks are stripes cleared of vegetation that divide a continuous forest in smaller patches to reduce spreading of wildfires and allow intervention.

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	Climate	Degradation	Conservation measure
			
Natural clear felling of (semi-)natural forests	subhumid	Biological degradation: detrimental effects of fires	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 →


Prescribed fire
Portugal - Fogo Controlado

left: fire fighter monitoring the spread of a prescribed fire
right: : a fire torch being prepared in order to start a prescribed fire (Photos: Portuguese

Use of prescribed fire (or ‘controlled burn’) to reduce the fuel load in the form of live and dead plant material and thus to prevent the likelihood of more damaging wildfire.

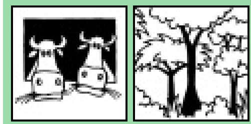
This technique is an essential management tool that applies fire to control the quantity of forest or scrubland fuels. The type of fire depends on the specific goals and on the weather conditions. Firstly, it is important to consider slope angle and the kind of fuels to be burned. Weather conditions include temperature, wind direction and air humidity. Another important aspect is the ability to control the speed of flame spread. In order to carry out the controlled fire, a plan has to be drawn up and approved and a fully-trained, authorised technician must be present in addition to the appropriate support teams (fire fighters, forest management teams). These teams use water or other means of combating the fire in the event of it possibly getting out of control and are in charge of the burning process.
The main purposes are enhancement of grazing areas and the creation of the so-called primary network for wildfire defence, which is a national network to limit the spread of wildfire. It involves strategically burning key sites (e.g. mountain ridges) to restrict the spread of the wildfire.
An analysis of weather conditions is made prior to carry out the prescribed fire. On the day of the prescribed fire itself, safety checks are made and the specific tasks of all the team members are defined. Wind direction and strength need to be minimal and are strictly controlled during burning. The size of the team depends on the specific problems of the area to be treated. Team size needed for about 10 ha is around 10 persons. The team members start along a line working from the top on the mountain along the contour and move downwards. Gentle breeze should be against the direction of the spreading of the fire. Workers use a drip-feed fuel can. There is also a strategy for prescribed fires by burning a strip along ridges of the mountains to avoid spreading of accidental wildfires and to burn in catchments the lowest point from which fire can spread to different areas and spread in different directions on the slopes.
Improved grazing management might also reduce the fuel load. Abandoning grazing in the forest can increase the fuel load and aggravate the occurrence and impact of wildfires. The creation or maintenance of grazing areas is determined by the size of the herd. Prescribed fire used as a means of improving grazing enables the local population needs to be addressed while considering environmental concerns. The prescribed fire also helps to protect the local population and their property by reducing the likelihood of devastating wildfire.

Location: Castanheira de Pêra
Region: Leiria
Technology area: 0.57 km^2
Conservation measure: management
Stage of intervention: mitigation / reduction of land degradation
Origin: Developed through land user`s initiative, traditional (>50 years ago)
Land use type:
Grazing land: Intensive grazing/ fodder production
Forests / woodlands: Natural
Climate: subhumid, temperate
WOCAT database reference: T_POR002en
Related approach: Forest Intervention Area (QA POR01)
Compiled by: António Dinis Ferreira, Escola Superior Agraria de Coimbra
Date: 2011-12-09
Contact person: António Dinis Ferreira, CERNAS, IPC/ESAC, Bencanta, 3040-316 Coimbra, Portugal

Classification

Land use problems:
- The problem is linked to the loss of traditional natural pasture use. Since there is nowadays no grazing/pasture use of forests, the fuel load remains uncontrolled. It is also linked to minimising wildfire impacts and the creation of grazing land. As more people visit forest areas for leisure and accidentally set fire. Another problem is vandalism and arson. (expert's point of view)

Land use



Intensive grazing/ fodder production
Natural
extensive grazing land
rainfed
Shrublands/pasture

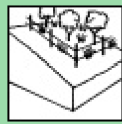
Climate

subhumid

Degradation

Biological degradation: detrimental effects of fires

Conservation measure



Management: Control / change of species composition

Stage of intervention

Prevention
Mitigation / Reduction
Rehabilitation

Origin

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

Level of technical knowledge

Agricultural advisor
Land user
Fire men

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

Main technical functions:
- control of fires
- reduction of dry material (fuel for wildfires)
- spatial arrangement and diversification of land use

Secondary technical functions:
- control of dispersed runoff: impede / retard
- increase of infiltration

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: coarse / light (sandy), medium (loam)
Soil fertility: low
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: medium

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

Tolerant of climatic extremes: droughts / dry spells
Sensitive to climatic extremes: wheather conditions
If sensitive, what modifications were made / are possible: As a result of the characteristics of the technique, it is not possible to make modifications except to select the right weather conditions and the fuel load.

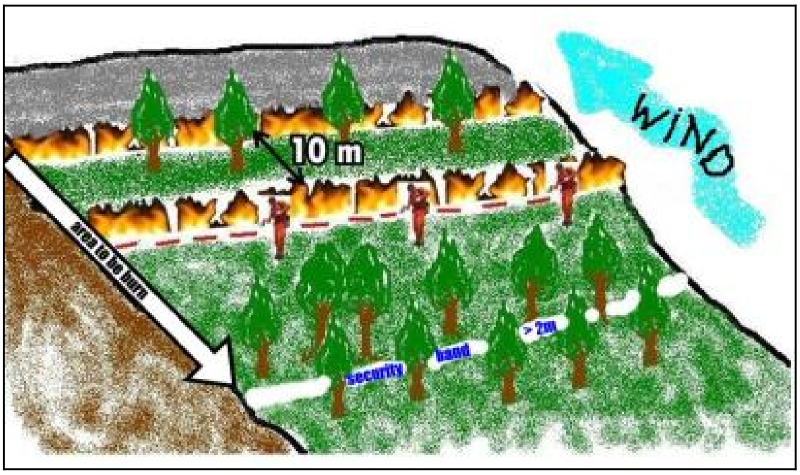
Human Environment

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: employee (company, government)
Population density: < 10 persons/km2
Annual population growth: negative
Land ownership: communal / village
Land use rights: communal (organised)
Water use rights: open access (unorganised)
Relative level of wealth: poor, which represents 75% of the land users;

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



Technical drawing

Prescribed fire is a practice used to manage vegetation in wildfire-prone areas. It consists of slowly burning strategic areas in the wet season, under specific weather and ground conditions and procedures: the soil should be moist, burning typically carried out in thin strips (normally 10m distance between two fire lines) from the top to the bottom of the slope, there should be only a gentle breeze blowing upslope and the ignition points should be 2m apart along the contour. The fire is allowed to progress downslope against the wind, which therefore provides some control. Burning is achieved by a number of the team who are prepared to dowse the flames if the fire gets out of hand. This degree of control is only possible when burning small areas with the same slope angle. (Adapted from Pedro Palheiro)

Implementation activities, inputs and costs

Establishment activities

- Planning and implementation
- Fire control equipment
- Monitoring prescribed fire

Establishment inputs and costs per unit

Inputs	Costs (US$)	% met by land user
Labour	100.00	%
Equipment		
- machine use	100.00	%
TOTAL	**200.00**	**0.00%**

Maintenance/recurrent activities

- No maintenance is necessary. Every 3 to 5 years, prescribed fire is carried out again, repeating the process described abovet.

Remarks:
Prescribed fire costs: timing, the right number in the team, fuel type and specific local conditions (slope and vegetation) are the most important determining factors affecting the costs.
Calculation of costs has been made based on the prescribed fire conducted for the DESIRE project. They represent the costs to burn 3-4ha, during a morning and including human resources (12 people), equipment (fire torch, fuel, special fire protection clothing, scythes, and hoses) and specialized fire fighting vehicles.

Assessment

Impacts of the Technology

Production and socio-economic benefits	Production and socio-economic disadvantages
+++ increased fodder production +++ increased fodder quality +++ reduced risk of production failure +++ avoid extreme/catastrophic events of hot fires	

Socio-cultural benefits	Socio-cultural disadvantages
+++ community institution strengthening + national institution strengthening + improved food security / self sufficiency	

Ecological benefits	Ecological disadvantages
+++ reduced invasive alien species +++ increased / maintained habitat diversity +++ reduced wild fire risk + increased biological pest / disease control	+ decreased soil moisture + decreased soil cover

Off-site benefits	Off-site disadvantages
+++ reduced downstream flooding +++ improved buffering / filtering capacity ++ reduced downstream siltation ++ reduced wind transported sediments + increased stream flow in dry season	+ Risk of damage to life and property

Contribution to human well-being / livelihoods

++ There are not direct improves on livelihoods, they are the results of the prevention of forest fires.

Benefits /costs according to land user

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

The major benefit it is to prevent fores fires by reducing fuel quantities. A second benefit it is the increase of pasture on the next years that will be available to animals.

Acceptance / adoption:

There is strong trend towards (growing) spontaneous adoption of the technology. In vulnerable areas, there is a need for reduction of the fuel load, removal of the vegetative cover or promotion of new plant growth.

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
The vegetation is adapted to the fire – impact minimization. → ore use of controlled fires.	Air pollution → ensure that the wind direction does not carry smoke over settlements. However, it is not possible to eliminate the smoke problem. In particular, a certain degree of moisture is required in the fuel load to enable the fire to be controlled, in order that the burning temperature is low and this tends to produce smoke.
With prescribed burning, larger areas can be treated compared to other fire control techniques, limited to strips in strategic areas, which are so difficult and expensive, whereas with prescribed burning, there is effective control of the vegetation over a large area”.□ → continue the use of controlled burning.	Lack of knowledge of people living near the burnt areas → improved education via schools, community meetings and in pamphlets.
Difficult operating conditions and high costs make the technology unsuitable for certain areas costs → continued use of the controlled fire technique instead of other techniques.	Possibility of the control loss of the prescribed fire → care needed to prevent this happening.
It is cheaper than other control measures, for instance mechanical ones →	Safety of the personnel carrying out the burn → conduct risk assessment exercises, carry out detailed planning and only apply the technology under the right weather conditions
In comparison with other techniques that manage biomass, this technique is more conservational, and it is culturally embedded in the local population way of life. It contributes to landscape diversification and the development of the local economy. It introduces fire as an essential feature of the Mediterranean landscape in a controlled manner. →	

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 Centre for Development and Environment
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

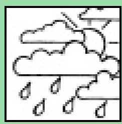
Land use problems:

- 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

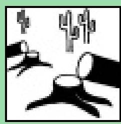
Natural
Plantations, afforestations
selective felling of (semi-) natural forests, plantation forestry

Climate



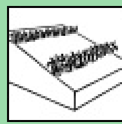
subhumid

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.

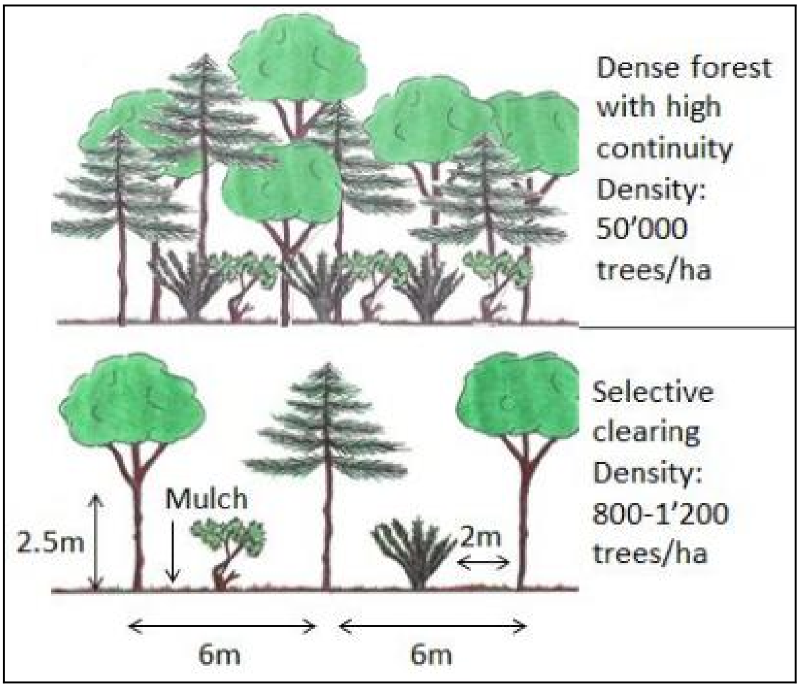
Human Environment

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.

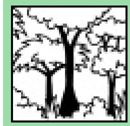
Location: Basilicata
Region: Castelsaraceno
Technology area: 0.1 - 1 km2
Conservation measure: management
Stage of intervention: prevention of land degradation
Origin: Developed through land user`s initiative, traditional (>50 years ago)
Land use type:
Forests / woodlands: Natural
Climate: subhumid
WOCAT 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
+390971205411

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

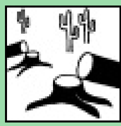


Natural
clear felling of (semi-)natural forests

Climate

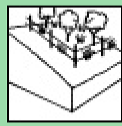
subhumid

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. →	

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 Centre for Development and Environment
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

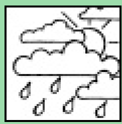
Classification

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

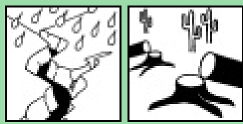
Natural
Plantations, afforestations
Other: Other: wastelands, deserts, glaciers, swamps, recreation areas, etc (before)
Forests / woodlandsrests / woodlands: Plantations, afforestations (after)
plantation forestry

Climate



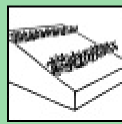
subhumid

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 (marked)
- 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.

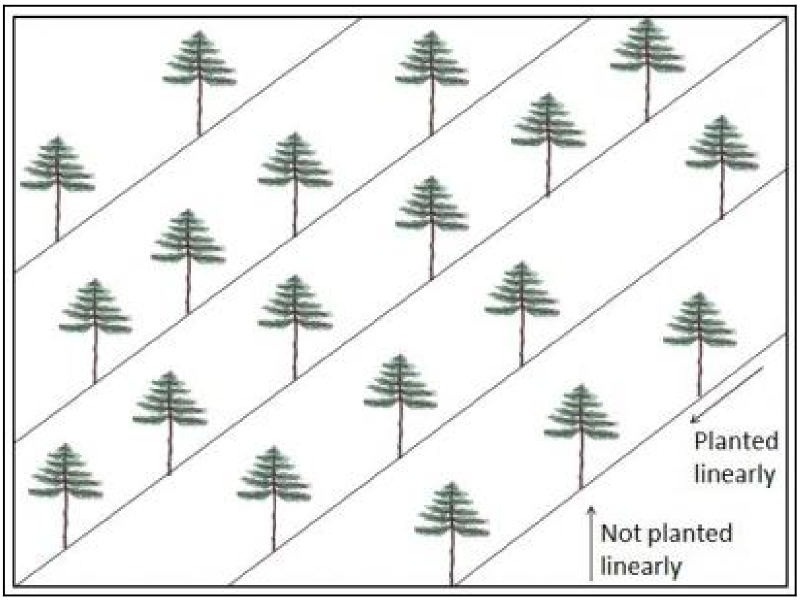
Human Environment

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

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

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

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

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.

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 afforestation contributed to rural development →

Weaknesses and → how to overcome

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.

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

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.

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))

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 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.

left: Example of a 10 year old forest regenerated by assisted re-afforestation technology (Photo: Chaker Miloud)
right: Degraded cork oak forest lacking young trees and with a weak cover of unpalatable herbs (Photo: Abdellah Laouina)

Assisted cork oak regeneration

Morocco - Takhlif Madoum Elghaba (arabic)

Assisted cork oak regeneration in the Sehoul forest, by acorn seeding and seedling plantation (derived from a plant nursery), involving careful husbandry and protection from grazing

Because of the accelerated degradation of the Sehoul forest and the difficulties with natural regeneration, the Moroccan State has planned and adopted a policy, based on a global and integrated view. The preservation of forests is an important topic for socio-economic development. The National Plan for Reforestation defines the main lines of the national reforestation strategy and is the framework for the implementation of this technology.
The goal of this technology is to prepare plots where acorns should be sown or cork oak seedlings from plant nurseries planted. These test plots are guarded, maintained and watered to allow young plants to grow. Thus, cork oak regeneration ensures the continued existence and development of the forest. It conserves soil and water and fights against desertification. There are several benefits such as cork production, wood production, fodder production and better soil cover. Furthermore this technology positively impacts the socio-economic development of local populations, and services production (landscape, welfare and recreation) for urban populations.
The implementation of this technology needs the following activities: in general, good quality acorns and seedlings are required. Seedlings should come from the same region where they are planted and be certified by the authorities. An initial step in implementation is the clearing and shredding of small, woody plants. Soil preparation consists of 30 cm deep ploughing to loosen the topsoil, and to allow easier root growth. Then rows of pits are dug. Generally, it is crucial to apply correct plantation and seedling according to the season (winter), to ensure a depth of 50 cm in the planting hole, and to water copiously after planting to ensure a good contact between the soil and roots. A fence installed to protect areas from grazing is temporarily required until the trees are robust enough to cope with browsing cattle. The enclosure period usually lasts a minimum of 6 years.
The natural condition is semi-arid with precipitation ranging from 350 to 450 mm per year. The underlying geology consists of quartzite and sandstone, covered by marl. Soils are varied, but the main types are hydromorph and ferrous. Socially, the Sehoul forest is populated by poor farmers, strongly dependent on forest resources (fodder and firewood). The forest is owned by the government, but managed by local communities, who benefit from its use (marketing of cork, pharmaceutical products, charcoal, etc.). The rights of free forest exploitation for the local population are a political problem which needs to be resolved in order to achieve good forest management. Economically, the contribution of forestry to the GDP is low, but its environmental role is essential.

Location: Salé
Region: Sehoul
Technology area: 0.2 km^2
Conservation measure: vegetative
Stage of intervention: mitigation / reduction of land degradation
Origin: Developed through experiments / research, traditional (>50 years ago)
Land use type:
Forests / woodlands: Natural
Forests / woodlands: Plantations, afforestations
Climate: semi-arid, subtropics
WOCAT database reference: T_MOR013en
Related approach: Development of rainfed agriculture (A_MOR014e)
Compiled by: Miloud Chaker, Faculté des Lettres et Sciences Humaines, Départ
Date: 2008-08-19
Contact person: Miloud Chaker, Université Mohamed V, Départment de Géographie, Rabat, Morocco, chaker.m@gmail.com

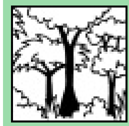
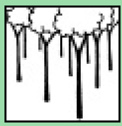
Classification

Land use problems:

- Forest ageing and degradation processes can lead to desertification (expert's point of view)

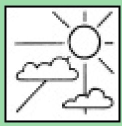
Reforesting is positive, but resting areas are seen as negative because land users cannot access the resources during 5 to 6 years. (land user's point of view)

Land use

Natural
Plantations, afforestations
extensive grazing land
rainfed
plantation forestry

Climate

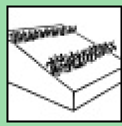


semi-arid

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: traditional (>50 years ago)
- Externally introduced

Level of technical knowledge

- Agricultural advisor
- Land user

Main causes of land degradation:
Direct causes - Human induced: over-exploitation of vegetation for domestic use
Indirect causes: urban capital invested in excessive livestock, roads, unorganized tourism and leisure

Main technical functions:
- improvement of ground cover
- increase in organic matter
- increase of biomass (quantity)
- promotion of vegetation species and varieties (quality, eg palatable fodder)

Secondary technical functions:
- increase of surface roughness
- stabilisation of soil (eg by tree roots against land slides)
- 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: coarse / light (sandy)
Soil fertility: low
Topsoil organic matter: high (>3%)
Soil drainage/infiltration: medium

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

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

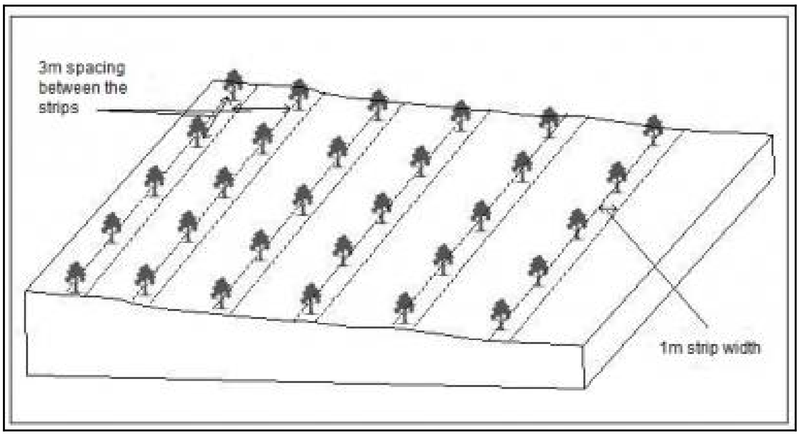
Human Environment

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)
Population density: 10-50 persons/km2
Annual population growth: < 0.5%
Land ownership: state
Land use rights: communal (organised)
Water use rights: open access (unorganised)
(In Morocco, forest belongs to the State but the population has the right to perform pastoral activities, to gather wood, to collect aromatic and medicinal plants, acorns, etc.))
Relative level of wealth: average, which represents 80% of the land users; 80% of the total area is owned by average land users

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



Technical drawing

Contour planting in strips where Cistus has been removed (in order to allow more light and avoid competition for moisture) (Chaker Miloud)

Implementation activities, inputs and costs

Establishment activities

- Soil preparation, weeding
- Ploughing and digging planting pits
- Plantation and watering
- Fencing
- Reduction of density, replacement of weak / dead plants

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour	435.00	0%
Agricultural		
- seeds	208.25	0%
- Cultivation and weeding (2x)	125.00	0%
TOTAL	**768.25**	**0.00%**

Maintenance/recurrent activities

- Weeding and ploughing
- Watering (first two years)
- Guarding

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour	35.00	%
Agricultural		
- Cultivation and weeding (2x)	125.00	%
TOTAL	**160.00**	**0.00%**

Remarks:
If planting coincides with a dry season, it takes watering on several occasions, which makes applying the technology more expensive - Stronger fences and more supervising are required if near to habitation.

Assessment

Impacts of the Technology

Production and socio-economic benefits		Production and socio-economic disadvantages	
+++	increased fodder production	++	reduction of forest pastoral area
+	increased animal production		
+	increased wood production		

Socio-cultural benefits		Socio-cultural disadvantages	
++	improved conservation / erosion knowledge	++	socio cultural conflicts
++	Conflict resolution and reduction		
+	community institution strengthening		
+	national institution strengthening		
+	improved health		

Ecological benefits		Ecological disadvantages	
+++	increased soil moisture		
+++	reduced surface runoff		
+++	reduced soil loss		
++	increased biomass above ground C		
++	increased soil organic matter / below ground C		
++	reduced soil crusting / sealing		
++	increased animal diversity		
+	recharge of groundwater table / aquifer		

Off-site benefits		Off-site disadvantages	
+	reduced downstream flooding	+	Increased grazing pressure on neighbouring areas
+	reduced downstream siltation		
+	reduced wind transported sediments		
+	reduced damage on neighbours fields		

Contribution to human well-being / livelihoods

+ In the long term. It is too early to assess the technology impacts on the livelihood.

Benefits /costs according to land user

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

Acceptance / adoption:

Concluding statements

Strengths and → how to sustain/improve	Weaknesses and → how to overcome
Natural resources conservation and fight against desertification → Involve local populations in the forest management	Problems because of the high cost of this technology (about 8000 dh/ha, 1000 US$) → Costs can be reduced if population commit to respect the converted plots, even without fences and guards.
Cork oak regeneration in order to ensure the existence of cork oak forests → Review the forest exploitation modalities by local populations (beneficiaries)	Forest users ask for subsidies in case of resting processes → Define the beneficiaries for the forest exploitation and its rules, its calendar and its rest areas by founding associations and unions
Improve sylvo-pastoral activities → Participative management for the population	For land users, the forest potential by pastoral activities needs to be improved by seeding of palatable species → farmers must be included in the choice of implemented species
Cork production enhancement → Improve cork extraction techniques	
Improved fodder production in the long term → provide compensation for enclosure time	

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.

CESAM

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

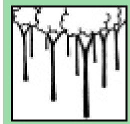
RECARE

Classification

Land use problems:

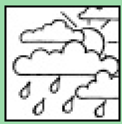
- Increased runoff and soil erosion, resulting in a decrease of on-site fertility and derived off-site effects such as loss of water quality, reservoirs water volume storage, higher risk of flooding and human beings damage. (expert's point of view)
Loss of wood resources and productivity. (land user's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

Land use



Plantations, afforestations plantation forestry

Climate

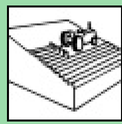


subhumid

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

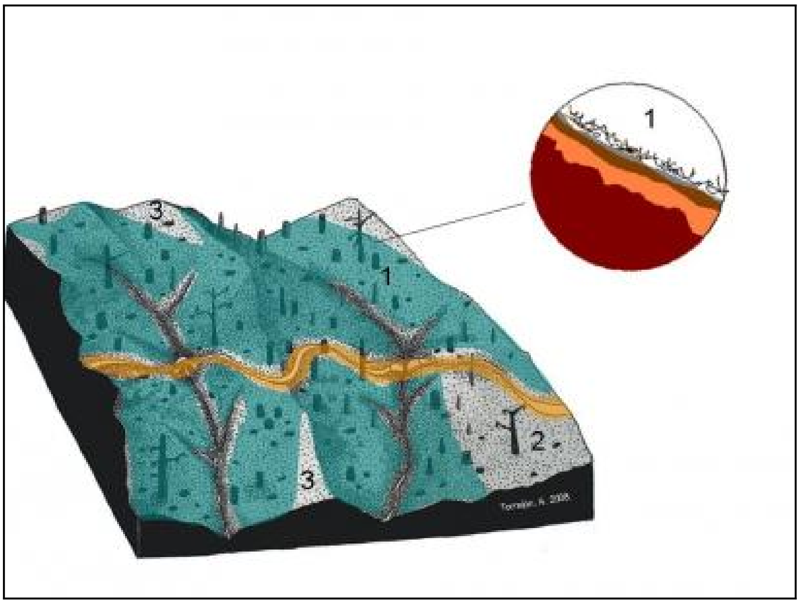
Human Environment

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

- ++ increased irrigation water availability quality
- + reduced demand for irrigation water

Production and socio-economic disadvantages

- + increased expenses on agricultural inputs

Socio-cultural benefits

- +++ improved conservation / erosion knowledge
- + conflict mitigation

Socio-cultural disadvantages

Ecological benefits

- +++ 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

Ecological disadvantages

Off-site benefits

- ++ 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

Off-site disadvantages

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 →	