Technical Specification FOR-REST-SUBT1

System: Forest Restoration (reforestation and regeneration)
Variation: *Pinus oocarpa, Juniperus lusitanica, Quercus sp.*

Summary[1]

This system involves the restoration of open pine forest that has been degraded in the past through harvesting, fire and grazing in order to increase the stocking of commercial species. Restoration can either involve enrichment planting, where open areas are planted with pine (*Pinus oocarpa*) and cipres (*Juniperus lusitanica*), or through encouraging natural regeneration by fencing off the area to prevent grazing.

Ecology[2,3,4]

Pine forest occurs in temperate to sub-tropical highland regions of Central America. Pine is associated with a number of species including oak (notably *Quercus segouiensis* and *Q.crispipilis*) and cipres (*Juniperus lusitanica*). *P. oocarpa* is the most important commercial species and many of the associated species have local uses. Much of the pine forest in the Chiapas highlands has been degraded through years of timber extraction.

P.oocarpa is a light demanding species that occurs over a wide range of altitude, 250-2500 masl, and rainfall, 700-3000 mm/yr. It grows best between 700 and 2000 masl and with 1000-1500 mm rain /yr on free draining soils[2] and will tolerate shallow or infertile soils and steep slopes. The mean annual temperature in its natural range is 13-21ºC.

Classification of climate and site productivity

Climate is classed as optimal and sub-optimal based on the conditions where the species exhibits best performance[2].This system is implemented in areas where pine forests occur naturally, and hence the use of this system in areas classified as sub-optimal for climatic conditions should not occur.

Optimal	Subtropical/temperate, sub-humid 700 - 2000 masl 1000 - 2000 mm/yr
Sub-optimal	Tropical, humid <700 or >2000 masl <1000 mm/yr

Site productivity is classification is still in development

Management objectives

The main production objective is for timber for local use and sale. *P.oocarpa* produces good quality timber, there is a ready market for both round and sawn wood, it is also used locally for house construction. *J.lusitanica* produces good timber and is commonly used for house construction. Oak is the preferred species for fuelwood, but trees of good form can produce high value timber. Other native pine forest species are used for various purposes including poles, stakes, fruits and flowers. Thinning should aim to liberate both the planted pine and oak trees of good form. Regenerating pine forest has a high biodiversity value due to the variety of tree species and other flora and fauna present.

Potential income – assuming a net value of timber of US$20 /m3 (accounting for harvesting and transportation costs) 300 m3 pine timber /ha would produce a total net income of US$6,000 /ha at the end of the rotation plus additional benefits from fuelwood and other products. (Volume estimated from average reported yield).

Costs of implementation[5]- Estimated costs per ha over the rotation are:

- regeneration: establishment US$70, maintenance US$510 and opportunity cost (lost income from increased harvest control) US$0-720
- reforestation: establishment US$360, maintenance US$585 and opportunity cost US$0-720

Management operations

The selection of the most appropriate system will depend on the condition of the forest and the cause of past degradation. Where there are insufficient seed trees to facilitate natural regeneration or where seed trees are of poor form due to genetic degradation it will be necessary to plant seedlings into open areas. If seed trees are present it may be sufficient to control the factors that have prevented natural regeneration to date for example through fences and fire breaks.

Establishment

1. Regeneration - Where forest degradation is the result of and over grazing in forest areas, the stocking of pine trees can be increased through promoting natural regeneration by excluding stock and stopping grazing in the forest. Where fire is a primary cause of degradation the creation of fire beaks will be essential in achieving forest regeneration. Community level commitment to controlling over harvesting and other causal factors of degradation will also be necessary.

2. Reforestation
    - 2.1. Reforestation involves the planting of pine and cipres seedlings in open areas of forest. Planting density will depend on initial tree stocking density and the occurance of regeneration. Open areas should have a planting spacing of 3x3m.
    - 2.2. Holes for seedlings should be 30cm depth and 30cm diameter – large holes produce better conditions for root development. The topsoil is more fertile and should be placed in the bottom of the hole for better rooting. Very compact soils holes may be dug after the start of the rains.
    - 2.3. It is important to obtain good quality planting stock, which should be ready for planting at the beginning of the rainy season. The roots of seedlings should be pruned just prior to planting to help root development.

Maintenance

1. Weeding should be carried twice per year – until canopy closure.
2. Pruning should be carried out when necessary to prevent forking and reduce lateral branching
3. All activities must be carried out together with actions that will prevent a continued degradation of the forest resource. Depending on the land use patterns in the community this may require maintenance of fences and fire breaks and ensuring community controls over the use of the forest are in place.

Thinning and Harvesting

1. Thinning should take place in year 15, trees of good form should be retained those of poorer form being removed to leave final spacing of 6x6m.
2. The harvest should take place in year 40 when the trees have a diameter of 40cm

Re-establishment

Shelterwood: 25 to 30 trees per ha (approx. 20x20m) may be retained as seed trees when the main crop is felled to provide seed for the new crop. Regeneration should be maintained by regular weeding.

Carbon sequestration potential[6,7]

Carbon sequestration potential over 150 years with a crop rotation of 40 years on an average quality site with optimal climatic conditions is 44.7 tonnes of carbon per ha above an initial soil and vegetation carbon baseline of 210 tC/ha.

This includes above and below ground biomass, soil carbon and carbon in products and is based on an assumed annual timber production of 8m3/ha for planted pine trees and 3m3/ha for existing oak vegetation. The baseline is the carbon stock in typical open forest based on the assumption that current land use would continue unchanged and that the long term average carbon storage would be the same as current carbon stock.

Details of the modelling approach and parameters used (initial biomass, maximum potential biomass per ha; species distribution; maximum growth; biomass allocation relative to stem; average annual mortality; wood carbon content; turnover and decomposition factors; product allocation and lifetime) are given in de Jong *et al* 1998. Details of the productivity data are given in de Jong *et al* 1995.

Monitoring[7]

Monitoring indicators depend on the method used to assist regeneration but in either case are based on establishment in the first few years thereafter using the diameter increment of regenerating trees.

Year	Regeneration	Restoration
1	Fences erected, stock excluded	33% area planted
2	Evidence of natural regeneration	66% area planted
3	Natural regeneration abundant (at least 2500 stem/ha)	All area planted (at least 1111 stems/ha), Survival at least 85%
5	Saplings at least 2m in height	Survival at least 85%
10	Average DBC not less than 13cm	Average DBC not less than 13cm
15	Average DBH not less than 19.5cm	Average DBH not less than 19.5cm

Additional Information

(Under development)

References

1 This specification is based on a system used in Chiapas, Mexico

2 Greaves A. (1982) Pinus oocarpa. [Review Article]. Forestry Abstracts 43(9) 503-526

3 Webb D.B., Wood P.J., Smith J.P. and Henman G.S. (1984) *A Guide to Species Selection for Tropical and Subtropical Plantations*. Tropical Forestry Paper 15, Oxford, UK

4 CABI Forestry Compendium

5 Data adapted from Tipper R., de Jong B., Ochoa-Gaona S., Soto-Pinto M., Castillo-Santiago M., Montoya-Gomez G. and March-Mifsut I. (1999) Assessment of the cost of large scale forestry for CO2 sequestration: evidence from Chiapas, Mexico. IEA Greenhouse Gas R&D Programme

6 de Jong B., Ochoa-Gaona S., Castillo-Santago M., Montoya-Gomez G., March-Mifsut I. And Tipper R. 1998. Modelling forestry and agroforestry opportunities for carbon mitigation at the landscape level. In Nabuurs G., Nuutinen T., Bartelik H. and Korhonen (eds) *Forest Scenario Modelling for Ecosystem Management at Landscape Level*. EFI Proceedings No. 19. pp. 221-238

7 de Jong B., Montoya-Gomez G., Nelson K., Soto-Pinto L., Taylor J. and Tipper R. (1995) Community forest management and carbon sequestration: a feasibility study from Chiapas, Mexico. *Interciencia* 20(6):409-416