Participatory approaches to ecological restoration in Hidalgo, Mexico

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In the State of Hidalgo (Mexico), a participatory approach to forest restoration was launched with the objective of recovering the productive capacity of forests, which is essential for biodiversity conservation and for the economic well-being of local communities. The state of forest degradation, its causes and possible solutions were evaluated through regional and local community workshops. Criteria for selecting restoration techniques and plant species were based on the economic needs of the communities, known uses of the plants, seed availability, ecological function and site characteristics, amongst others. A total of 30 catalyst species and 23 rare species, all native, were selected for the four ecosystem types in the region. It was found that community members have a remarkable understanding of the state of local natural resources and that their participation was crucial to the success of restoration projects.

Degraded *Quercus* spp. forest in *Ejido* Zoquital, Atotonilco El Grande.
The natural oak forest has been cleared to provide space for agriculture.
Photo: A. Suárez Islas.

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RÉSUMÉ

APPROCHES PARTICIPATIVES POUR LA RESTAURATION ÉCOLOGIQUE DES MILIEUX À HIDALGO, MEXIQUE

Au Mexique, les taux élevés de déforestation et de dégradation forestière chez les communautés rurales augmentent la pauvreté et l'exode rural vers les villes et les pays étrangers. Les forêts de l'État de Hidalgo présentent une dégradation comparable à celle de nombreux autres États mexicains. Des projets de restauration forestière ont été menés dans deux régions de cet État, où tous les types de forêts sont représentés, dont bon nombre sont gérés par les communautés locales. La restauration des capacités productives de ces forêts est indispensable pour conserver la diversité biologique et assurer le bien-être économique des communautés. Une approche participative s'imposait pour parvenir à cet objectif. L'état de dégradation de la forêt, ainsi que ses causes et les solutions envisageables, ont été évalués par des ateliers mis en place au sein des communautés aux échelons régional et local. Les critères de sélection des techniques de restauration et des espèces ont été fondés, entre autres, sur les besoins économiques des communautés, les utilisations connues des plantes, leurs fonctions écologiques, la disponibilité des semences et les caractéristiques des sites. Les critères ont été déterminés au cours de réunions informelles et d'ateliers collectifs. La participation aux ateliers locaux était plus forte qu'aux ateliers régionaux, notamment à Huehuetla et dans les *ejidos* de Atotonilco El Grande, grâce aux capacités d'organisation des communautés concernées. Au total, 30 espèces catalytiques et 23 espèces rares, toutes indigènes, ont été choisies pour les quatre types d'écosystèmes de la région. Il s'est avéré que les membres des communautés ont une perception remarquablement fine de l'état des ressources naturelles locales, et leur participation est cruciale pour le succès des projets de restauration.

Mots-clés : espèce catalytique, sylviculture collective, déforestation, dégradation forestière, atelier participatif, reforestation.

ABSTRACT

PARTICIPATORY APPROACHES TO ECOLOGICAL RESTORATION IN HIDALGO, MEXICO

High rates of deforestation and forest degradation in Mexico's rural communities have increased poverty and are causing rural populations to migrate to cities and foreign countries. Forest degradation in the State of Hidalgo is typical of many other states in Mexico. Forest restoration projects have been carried out in two regions in Hidalgo that contain all major forest types. Many of these forests are community managed. Recovering the productive capacity of these forests is essential for biodiversity conservation and for the economic well-being of local communities. A participatory approach to restoration was necessary to achieve this objective. The state of degradation, its causes and possible solutions were evaluated through regional and local community workshops. Criteria for selecting restoration techniques and plant species were based on the economic needs of the communities, known uses of the plants, seed availability, ecological function and site characteristics, amongst others. These criteria were determined in formal and informal community meetings and workshops. There was more participation in community workshops that in regional ones, mainly in Huehuetla and the *ejidos* of Atotonilco El Grande, thanks to the organizational abilities of these communities. A total of 30 catalyst species and 23 rare species, all native, were selected for the four ecosystem types in the region. It was found that community members have a remarkable understanding of the state of local natural resources and that their participation was crucial to the success of restoration projects.

Keywords: catalyst species, community forestry, deforestation, forest degradation, participatory workshop, reforestation.

RESUMEN

ENFOQUES PARTICIPATIVOS PARA LA RESTAURACIÓN ECOLÓGICA DE ECOSISTEMAS DEGRADADOS EN HIDALGO, MÉXICO

Las elevadas tasas de deforestación y la degradación de bosques en comunidades rurales de México han incrementado los niveles de pobreza, provocando el éxodo de poblaciones rurales hacia las ciudades y al extranjero. El Estado de Hidalgo presenta situaciones de degradación forestal típicas de muchas otras regiones de México. Se llevaron a cabo proyectos de restauración en dos regiones de Hidalgo que contienen los principales tipos de bosque del país. Muchos de estos bosques son manejados por comunidades. La recuperación de la capacidad productiva de estos bosques es esencial para la conservación de la biodiversidad y el bienestar económico de las comunidades rurales. Fue necesario un enfoque participativo de la restauración para lograr este objetivo. La evaluación del estado de la degradación, sus causas y posibles soluciones fue realizada por medio de talleres regionales y con las comunidades. Los criterios para la selección de técnicas de restauración y especies de plantas se basaron en las necesidades económicas de las comunidades, usos conocidos de las plantas, disponibilidad de semillas, funciones ecológicas y características del sitio, entre otros factores. La determinación de los criterios se hizo en talleres y reuniones comunitarios formales e informales. Hubo mayor participación en los talleres comunitarios que en los regionales, principalmente en Huehuetla y en los *ejidos* de Atotonilco El Grande, debido a las habilidades organizativas de estas comunidades. Un total de 30 especies catalizadoras y 23 especies escasas, todas ellas nativas, fueron seleccionadas para los cuatro tipos de ecosistemas de la región. Los miembros de las comunidades tenían un conocimiento sustancial acerca de la stuación de los recursos naturales del estado, y su participación activa fue un factor principal en el logro de los objetivos de los proyectos de restauración.

Palabras clave: bosque comunitario, deforestación, degradación forestal, especie catalizadora, reforestación, taller participativo.

Introduction

The degradation of forested ecosystems is one of the major environmental problems in Mexico. It is estimated that the annual rate of deforestation in the period from 2000 to 2005 was 0.4%, equivalent to a loss of 260 000 ha, attributed principally to the expansion of agriculture and pasture lands and the increase in human population (Fao, 2006). For rural communities, which contain 80% of the forested land of Mexico, the forest degradation has brought negative socioeconomic consequences, such as increasing poverty and resulting migration to cities and foreign countries (Merino, Segura, 2002).

The situation of forest degradation in the State of Hidalgo is common in much of Mexico. Hidalgo, with a population of 2 354 885 inhabitants, covers an area of 20 987 km^2 in the centre of the country (Inegi, 2005). It has a wide variety of ecosystems in tropical, temperate and semi-arid climates. Poor management of natural resources has caused various degrees of disturbance in 292 000 ha of forested areas, resulting in 22 000 ha of fragmented rainforest and 31 000 ha of fragmented temperate and semi-arid forest (Semarnat, 2001). The consequences of degradation for these ecosystems include alteration of the hydrological cycle, loss of biodiversity, declining soil productivity and soil erosion. In response to this situation and to produce information that contributes to resolving these environmental problems, the Centre for Forest Research (CIF) at the University of the State of Hidalgo (UAEH) has initiated a project for the Restoration of Forested Ecosystems.

The project was initiated in order to gain a better understanding of the root causes of forest ecosystem degradation in the region, directly from the people involved in the problem. This was done by listening to the opinions of people from both communities and local authorities in Hidalgo. The objectives of the project were to:

- Identify the causes of destructive activities in the ecosystem, their repercussions for local communities and possible solutions.
- Select woody species with the greatest potential for use in restoring these forest ecosystems, based on traditional knowledge and the experience of local technicians and project researchers.

The information generated by this research is to form the basis for implementing research and disseminating restoration projects in the State of Hidalgo.

Juniperus flaccida is seen here growing in association with *maguey* in an agroforestry system. A nutritious drink called "*pulque*" is prepared with the fermented sap of the maguey.
Photo: F. Montagnini.

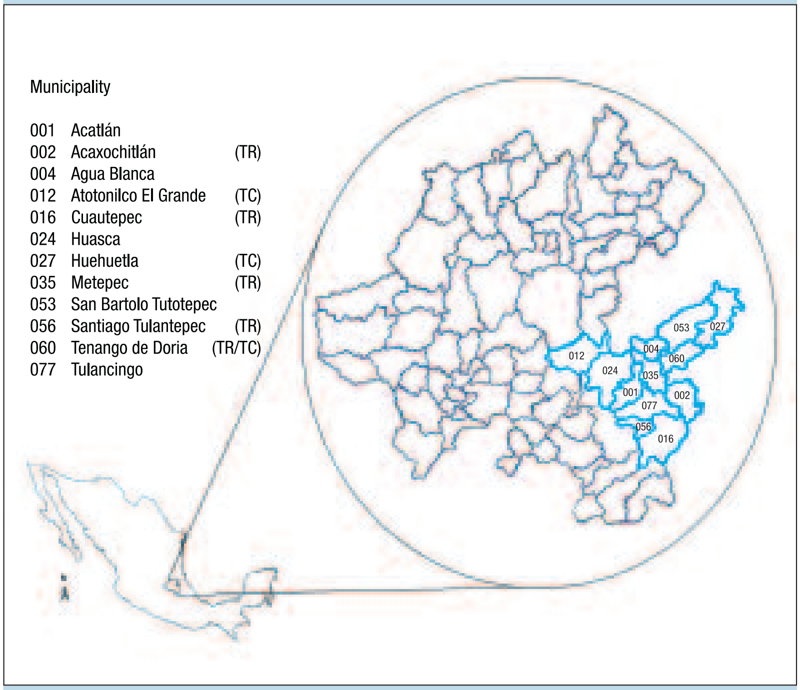

Figure 1.
Municipalities of the State of Hidalgo where participatory workshops were held.
TR: regional workshop; TC: community workshop.

Plantations of *Cupressus benthami* on a small farmer's land in the Sierra Otomí Tepehua, where a temperate humid montane forest predominates.
Photo: A. Suárez Islas.

Table I.
Main forest ecosystem types in south-eastern Hidalgo.

Ecosystem type	Altitude (m)	Annual precipitation (mm)	Mean annual temperature (ºC)
Pine-oak forest	2 100 to 2 800	900 to 1 500	13 to 15
Oak forest	2 000 to 2 500	600 to 800	14 to 17
Humid montane forest	800 to 2 100	1 500 to 2 500	14 to 20
Tall perennial rainforest	250 to 800	2 000 to 2 500	20 to 24

Source: INEGI (1999 and 2003).

The state of Hidalgo

The State of Hidalgo lies 60 km north of Mexico City. The project was carried out in the south-eastern part of the state (figure 1). The project covers two geocultural regions: the Valley of Tulancingo (municipalities of Tulancingo, Santiago Tulantepec, Cuautepec, Atotonilco El Grande and Metepec) and the Sierra Otomí Tepehua (municipalities of Acaxochitlán, Tenango de Doria and Huehuetla). The project study region covers a total area of 2 896,08 km^2.

These municipalities represent most of the forested ecosystems in Hidalgo state. Temperate, semi-dry oak forests predominate in a transect running southeast to northeast; sub-humid and humid temperate pine oak forests are located more to the east; temperate humid montane forests flourish at higher elevations and small fragments of secondary vegetation derived from perennial rain forest are observed at lower altitudes (table I).

The ethnic composition of the municipalities is predominantly mixed Indigenous-European (mestiza), with a large segment of indigenous Otomí, Tepehua and Náhuatl groups in the municipalities of Huehuetla, Tenango de Doria and Acaxochitlán. The primary economic activities of these communities are agricultural (corn, beans, coffee and barley), cattle and goat ranching, and forestry, primarily with the following timber species: *Pinus* spp., *Quercus* spp., *Liquidambar styraciflua* and *Cedrela odorata* (INEGI, 2000).

There are two types of property ownership in the study region: *ejidos* (collectively owned and managed lands in Mexico) and private ownership. *Ejidos* cover 300-500 ha. The average parcel of land managed by each family in the *ejidos* is 2.04 ha (COEDE, 2001). The political organization of the municipalities is represented by a mayor and municipal secretary. Agrarian governance systems consist of the *ejido* commission and rural producer organizations, which represent a form of authority in specific branches of agricultural production (COEDE, 2001).

Alternatives for the restoration of forest ecosystems

The first step in the implementation of a restoration project is to determine the type and severity of degradation of each site. The second step is to determine the specific objectives of restoration, which will in turn determine the course of action. In a participatory approach to restoration, interaction with farmers is necessary to identify the causes of degradation, the farmer's goals and objectives, and practical possibilities for project implementation.

This project aims to rehabilitate lands that have suffered from deforestation and have been abandoned after intensive agriculture and ranching. The purpose of rehabilitation is to recover productive capacity by implementing land use systems that are suited to the region, and to include, whenever possible, economically valuable native woody species. Furthermore, in all of these objectives, the idea of harmonizing the rehabilitation of land productivity with environmental services is emphasized, with particular reference to the recovery of biodiversity.

Systems for the recovery forest ecosystems

Systems that can be implemented include tree planting, in lines or groups or in combination with agricultural crops (agroforestry systems). Research on the recovery of degraded lands in tropical rainforest regions in Brazil, Argentina and Costa Rica suggest that forest plantations with native species can fulfil a socioeconomic function, providing tree products and contributing to the rehabilitation of degraded areas, the absorption of atmospheric carbon, and the recovery of biodiversity (Montagnini, 2001). Furthermore, tree regeneration in the understory was more successful beneath plantations than in abandoned lands. This indicates that plantation forests can act as accelerators or catalysts of forest succession (Parrotta *et al.*, 1997).

In many cases, the possibility of inter-planting crops amongst the trees during the first few years of establishment of the forest system facilitates its adoption by farmers, by providing a financial return in the short term (Montagnini *et al.*, 2006). In agroforestry systems, planting tree and crop species in combination means that light, water and nutrient resources must be considered. Experiences in forest ecosystem restoration in the subtropical forest region of Misiones, Argentina, where nitrogen-fixing trees (*Enterolobium contortisiliquum*) were planted along with valuable timber species (*Tabebuia heptaphilla, Balforuroden-dron riedelianum*) and inter-planted with rows of yerba mate (*Ilex paraguariensis*) and annual crops, have demonstrated that it is possible to combat invasive grasses, recover soils and produce economic benefits in the short and long term (Montagnini *et al.*, 2006).

Criteria for the selection of tree species for restoration projects

Recovering the productivity of degraded lands is frequently expensive. Therefore, the techniques selected for a project should produce a net financial return that encourages local producers to adopt them. Availability of seeds, seedlings, and information about the silvicultural characteristics and management of selected species are also important. The following criteria are important in the selection of plant species for the restoration of degraded ecosystems:

- Growth rate.
- Uses (e.g., timber, food, medicine, ornamental, environmental services, etc.).
- Form (in the case of timber and ornamental species).
- Availability of seeds (certified seeds of verifiable origin or gathered in the field).
- Possibility of vegetative propagation (this can accelerate establishment time and help to ensure genetic composition).
- Nursery production options.
- Site characteristics (conditions where the species will be placed).
- Site requirements (or treatments to aid species growth, such as mycorrhizae inoculation).
- Tolerance to disturbance (e.g., pests, disease, drought, wind, fire, etc.).
- Age and time of flowering (for fruit production if this is the desired product, or for seeds for reproduction).
- Quality of wood and other products.
- Laws and regulations concerning the species (e.g., threatened, scarce or protected).

In addition to these criteria, it is also important to know and understand the ecological function of each species, such as whether it can provide shade for other seedlings, nutrient recycling, and serve as habitat for birds and other animals. These characteristics determine whether a species is a catalyst of succession. In other words, such a species can be important in accelerating the processes of restoration of degraded forest ecosystems.

A group of women engaged in growing medicinal plants is advised by project researchers. Photo: A. Suárez Islas.

Community evaluation for forest ecosystem restoration

Community participation allows exchanges of knowledge between rural populations and forest scientists and technicians. This process is an opportunity for mutual learning that guarantees the use and dissemination of evaluated practices, which in turn enhances local capacity. Participation is a functional process that allows metagroups to identify with the project. It provides incentives for them to express their perceptions and experiences, giving more substance to the evaluation and promoting the application of their traditional knowledge and techniques. Tools commonly used in participatory approaches include round-table discussions, rapid ecological assessments, and participatory community evaluations (Van Dam, 2001).

Participatory workshops

The state of degradation, its causes and possible solutions in the communities were evaluated with the following methods: participatory rural evaluation, interviews with key informants, and "focal groups" (Geilfus, 1998), in addition to periodic meetings with interested groups and training workshops.

Methods were focused on two levels of participation: a) regional – regional workshops and b) local – local community workshops. The regional workshops were conducted in a town that was chosen to represent each of the regions studied, with the participation of municipal authorities and government institutions. The local workshops were held in communities or *ejidos* with the participation of local farmers and municipal authorities. Concepts relating to forest ecosystems and their degradation and restoration were presented in these workshops. An analysis of the causes, effects, and possible solutions to alleviate degradation of regional and local ecosystems was compiled after participants filled out a questionnaire.

Participatory selection of species for restoration: a local community workshop in *Ejido* Zoquital, Atotonilco El Grande, where the natural vegetation type is semi-dry oak forest and xerophyllous scrubland.
Photo: C. Palacios.

A workshop was held in each of the study regions, in which local authorities in rural development, forest ecology, and public protection participated. Communities with the most forest degradation were identified in these workshops, in order to select communities where the local workshops would be held.

Regional workshops

Two regional workshops were conducted, with the participation of representatives from five municipalities of the Valle de Tulancingo and Otomí Tepehua regions: Santiago Tulantepec, Cuautepec, Acaxochitlán, Metepec and Tenango de Doria. The first regional workshop was conducted in Tenango de Doria with a total of 25 people, including municipal authorities, representatives of the National Forestry Commission (CONAFOR), the Secretary of the Environment, and the Association of Providers of Forest Services, as well as students and professors of the Centre for Forest Research (CIF) at the University of the State of Hidalgo (UAEH). The participants formed two groups to discuss the causes of forest degradation and to suggest potential solutions. Both groups presented their results in a plenary session and solutions were proposed. The second regional workshop was conducted in the Valle de Tulancingo with a total of 8 people including municipal authority representatives and CIF students and professors of CIF. Despite the smaller number of participants, there were lively discussions of the restoration issues and solutions, both at the group level and during the plenary session.

Results from the two regional workshops showed that according to the municipal authorities, the principal causes of forest degradation are land use changes leading to soil degradation, overgrazing, forest fires, illegal logging and forest pests and diseases. This reflects the lack of zoning laws, forest stewardship and economic alternatives for the people of these areas.

Changes in land use patterns and subsequent soil degradation are caused primarily by shifting agriculture practices (grazing followed by slash and burn) and the opening of kaolin and sand mines in the Otomí Tepehua region. In the Tulancingo region, soil degradation is due to permanent agriculture.

Uncontrolled invasion of forest areas by cattle herds leads to overgrazing. The cattle browse and trample seedlings, which also causes soil compaction and erosion. Moreover, forest fires that are used in agricultural and pastoral management are often not controlled.

Illegal logging of trees for domestic use and sale is a common practice in the majority of communities living near forested areas. In the Otomí-Tepehua region, there is high demand for firewood for use in local bakeries. The wood is also used for making fences, houses, and furniture.

Problems arising from forest degradation are primarily soil erosion, a reduction in forested areas used to capture rain water, and the loss of biodiversity. This is a trend experienced in other regions of Mexico as well (Merino, Segura, 2002). The participating authorities identified 29 communities with serious forest degradation problems, as well as the causes of their deterioration (table II).

Existing measures for restoration at the regional level

Some municipalities, in coordination with the rural communities, have developed action plans to restore their degraded areas, thereby also creating a source of jobs. The Municipality of Santiago Tulantepec has carried out environmental education programs in their primary schools, as well as taking part in conferences with the National Forestry Commission (CONAFOR) and the Secretary for Environment and Natural Resources (SEMARNAT). Degraded areas have been reforested with native species in the municipalities of Acaxochitlán, Metepec, Tenango de Doria, Santiago Tulantepec and Cuautepec. Two of these municipalities also have nurseries (Metepec and Cuautepec). Municipal police and the Federal Environmental Protection Agency (PROFEPA) have set up permanent fire prevention and control operations in the municipalities of Acaxochitlán, Metepec, Cuautepec and Santiago Tulantepec, where a forest fire fighting brigade was formed in coordination with CONAFOR.

Despite these measures, the authorities realize that the government's plans for environmental improvement have not taken community participation into account, have been short-term in scope, and have not transcended political change in the communities, all of which has led to people's disinterest in participating in these projects. This is why it is necessary for future projects to involve governmental and research institutions with rural communities.

Local community workshops

Six local community workshops were conducted: one in the Municipality of Tenango de Doria (Ejido Santa Mónica), three in communities in Huehuetla (San Guillermo, Cantarranas, El Paraíso), and two in Atotonilco El Grande (Ejido Zoquital, Ejido Sauz Xhate) (table III). The number of participants in each workshop was 17-42 people, with a total of 159 for the six workshops. Overall, the participants were 59% male and 41% female. Indigenous and mestizo people participated in all the workshops: Otomí people participated in the workshops at *ejidos* Zoquital and Sauz Xhate of Atotonilco el Grande, and Tepehuas participated in the workshops conducted in Cantarranas, El Paraíso and San Guillermo of Huehuetla.

Table II.
Communities with the most forest degradation and its principal causes.

Municipality	Communities with the most forest degradation	Primary causes of degradation
Tenango de Doria	La Cruz de Tenango, El Texmé, El Dequeña, El Casiú, El Desdavi and El Xuthi.	Illegal logging (for firewood, charcoal and fence posts), and opening of kaolin mines.
Acaxochitlán	Santiago Tepepa, Los Reyes, Apapaxtla, San Miguel de Rescate, La Mesa and Tlamimilolpan.	Illegal logging.
Metepec	Cañada de Flores, San Diego, Temascalillos, Estación de Apulco, Ferrería de Apulco, San José and La Victoria.	Illegal logging, overgrazing and lack of forest management plans.
Santiago Tulantepec	Ejido Santiago Tulantepec, Ejido Tilhuacán, Paxtepec and Los Romeros.	Forest fires, illegal logging.
Cuautepec	El Aserradero, Cuatzezengo, Las Puentes, Ojo de Agua, Hueyapita, Cima de Togo and Ventorrillo.	Forest fires and overgrazing.

Table III.
General characteristics of the communities/*ejidos* studied.

Municipality	Community/Ejido	Inhabitants (number)	Predominant vegetation type	Environmental problems
Tenango de Doria	Santa Mónica	1 476	Humid montane forest	Land use changes Wood extraction Forest fires
Huehuetla	El Paraíso Cantarranas San Guillermo Dos Caminos Los Planes	220 335 543 329 309	Tall and medium perennial rainforest	Excessive logging Logging for firewood Extraction of woody debris for firewood
Atotonilco El Grande	Ejido Zoquital Ejido Sauz Xathe San Nicolás Xathe	490 320 355	Xerophillous scrubland	Deforestation Grazing Lack of forest culture among local people
Total	9	4 377		

There was more participation in community workshops than in the regional ones, mainly in the communities of Huehuetla and the *ejidos* of Atotonilco El Grande, thanks to the organizational abilities of their local authorities (table III). In the communities of the Municipality of Huehuetla, family relationships facilitated the participation of community members in workshops. Relationships also exist that make production processes much easier, such as sharecropping (a system in which each person shares a proportion of the inputs, land, labour, and benefits), the *mano-vuelta* (“hand return”, or group work in which each member provides uncompensated labour for the others and vice versa), and the *faena* (“team”, which carries out cooperative work for the common good) (Coede, 2001). On the other hand, in the communities of Atotonilco El Grande, the organization of the *ejidos* makes decision-making and reaching agreement very difficult because of the large number of members.

In the local communities, especially in the *ejidos*, the participation of men and women in the workshops might have been influenced by power relationships as well as by the emigration problem. It is interesting to note that *ejido* authorities exercise a certain amount of power over community members. *Ejido* leaders invited community members to participate in the workshops and in a couple of cases, as in the *Ejido* Santa Mónica in Tenango de Doria, a roll call was taken during the workshop, giving the names of community members, to encourage attendance. The workshop conducted in the Ejido Santa Mónica had the largest participation with a total of 42 people. In this particular case, due to the large number of participants, five groups were formed to discuss restoration issues. Only a small fraction of the participants spoke Spanish, and an interpreter who spoke the Otomi language was therefore assigned to each discussion group.

In several cases, women participated in the workshops because of their own interest in restoration. In other cases, their participation was also influenced by the fact that their husbands were away, having migrated to the USA in search of other jobs.

Participatory selection of species for restoration: field walk with farmers in the Sierra Otomí Tepehua.
Photo: C. Palacios.

Local community perspectives and proposed methodology for restoration planning

Community members consider the principal causes of forest degradation to be illegal logging, forest fires, overgrazing and the presence of pests in the forests. However, they do not consider changes in land use as a factor in degradation. The perception of the population is that forest degradation began to increase during the 1980s with a decrease in the diversity and abundance of plants and animals, as well as in the number and volume of natural springs and water wells.

Community members showed interest in participating in a planning exercise for the restoration of their degraded areas. The people represented their expectations for forest ecosystem restoration graphically. A planning proposal was drafted in these workshops, adapted from GEILFUS (1997) and consisting of three steps:

- enumerating the necessary actions for restoration;
- organizing them in a logical fashion;
- justifying the proposed actions.

Existing actions for restoration at the local community level

Despite the fact that the concept of forest ecosystem restoration was not commonly known among members of the communities, some had already carried out reforestation projects, mainly under institutional programs where they did not take part in the planning and selection of species of interest. These programs have not fulfilled the expectations of local participants, nor have they generated benefits or significant increases in plantation productivity. Therefore, it is necessary to consider the uses of native species in the different forest plantation systems.

Guitars made of *Platymiscium yucatanum* wood, one of the rare species of tall perennial rain forests identified during the participatory workshops.
Photo: A. Suárez Islas.

Selection of woody species for restoration

In the study region, plantations with ecological restoration goals were established in the 1970s with the support of government. Only a few species were used, some of them exotic. The most commonly used species in the temperate zone were the exotic *Eucalyptus camaldulensis* and *Casuarina* sp., and the native *Cupressus lusitanica*. In the tropical zones, the native *Cedrela odorata* and the exotic *Grevillea robusta* and *Melia azederach* were encouraged. The variety of species has increased in the past few years, and now includes native conifers, such as *Pinus greggii* and *P. patula*. These species are preferred because the seeds are readily available and easy to propagate in nursery.

When the plantations were established in the 1970s, the species were selected without taking local knowledge and local species uses into consideration. Farmers in many communities feel that plantations with exotic species have fulfilled restoration objectives if they prevent soil erosion, even though these species have not allowed native plants and animals that were previously present in these ecosystems to recover. In some cases, farmers do not know how to use these exotic species.

Due to the above-mentioned factors in previous restoration attempts, the following fundamental premises were taken into account in this project:

- The most important decision in the planning of any plantation forest, whether the objectives are industrial, social or environmental, is the selection of the appropriate available species that will grow well in the site.
- The knowledge of rural populations is often an untapped mine of experience and wisdom on the management and use of natural resources. This knowledge should be incorporated into the technology used to resolve the current ecological crisis (TOLEDO, 1991).

A preliminary selection of woody species with potential for the restoration of forest ecosystems was made, incorporating the participation of farmers and local forestry and agricultural professionals. The purpose was to document traditional knowledge and experience in the management of these species, in order to have a reference for future restoration projects.

Areas in need of restoration, community groups, and technical personnel willing to participate were identified at the beginning of the project. Key informants with ample knowledge about the management and use of woody species were also identified. Participatory workshops were organized with input from these key informants. Basic concepts of forest ecosystem restoration were then presented by the researchers in workshops. In addition, a dynamic brainstorming session was held to come up with a list of species with potential for restoration, which were then classified into two groups:

a) Catalyst species: species that rapidly create favourable conditions for the establishment or regeneration of intermediate or advanced stages of succession and/or seed dispersal agents that can transport seeds from local sources.

b) Rare or endangered species: species with reduced populations, at risk of extinction or having protected status according to SEMARNAT (2001). Factors that place the viability of rare species at risk are: changes in land use, overexploitation, overgrazing, pests and disease, and forest fires.

A home garden in El Paraiso, Huehuetla, a medium-altitude rain forest region in Hidalgo (Table III). In this type of agroforestry system, the farmers associated with the restoration projects are planting several of the species recommended for restoration in association with crops and fruit trees such as papaya. Photo: F. Montagnini.

Information on the most frequently mentioned and well-known species was obtained in workshops and field walks: common names, method of propagation, rate of growth, tolerance to adverse conditions, animal habitat, their restorative effects on the ecosystem, management practices, uses and factors that place the species at risk. Information gathered during the field walks corroborated and complemented the information gathered in the workshops. Botanical specimens were collected and photos were taken.

Information obtained with key informants in the field was complemented by references in the literature on woody species of the Mexico's central region (ZAVALA CHÁVEZ, 1995; PÉREZ-RODRÍGUEZ, 1999; VÁZQUEZ-YANES *et al.*, 1999; BENÍTEZ *et al.*, 2004; NIEMBRO-ROCAS *et al.*, 2004; TERRONES *et al.*, 2004; VILLAVICENCIO, PÉREZ, 2005). These two types of information suggested potential systems to use for restoration: management of natural regeneration, forest plantations, enrichment plantings, stream restoration, and agroforestry systems.

A preliminary selection of 30 catalyst species and 23 rare species was made for the four forest ecosystem types found in the study region (tables IV and V). All of the selected species are native. Catalyst species pertain to early and intermediate successional stages, while rare species are from intermediate and advances stages. With respect to the use of each of the selected species, most have multiple uses: firewood, construction, medicine, honey and timber for the catalysts; timber, ornamental uses, medicine, firewood and construction for the rare species.

The most frequent attributes of the catalyst species were: erosion control, litter accumulation, rapid growth and habitat and food for wildlife. In the case of rare species, two species at risk of extinction and two with special protection were selected, in accordance with the national law regarding the protection of endangered species (SEMARNAT, 2001).

Several of the communities employed various methods to initiate forest restoration. Public and private lands were used in the efforts, although only local municipalities chose to set up plant nurseries. Measures to prevent illegal logging and fire were taken by implementing various forms of observation and reporting systems.

A multi-pronged strategy was implemented to accomplish restoration goals. A seed collection program was established for the nurseries in cooperation with producers and project collaborators, in order to obtain seeds from high-value trees, such as cedar (*Cedrela odorata*) and walnut (*Juglans mollis*). Project collaborators were trained in nursery techniques and care so that they in turn could educate members of their communities on how to operate the nursery. Where possible, natural regeneration of the forests was encouraged. Project collaborators helped land owners and communities to identify important areas of natural regeneration.

The most frequent systems employed in restoration with catalyst species were agroforestry systems, plantation forestry and natural regeneration. Those used with rare species were enrichment plantings, agroforestry systems and plantation forests. It is still too early to anticipate the success of these systems in achieving the objectives that were established by the researchers and the farmers. In addition, this is a dynamic process through which other species and restoration systems may later be identified.

During the workshops and field walks, it was recognized that producers needed training. Therefore, two courses in community nursery management were held and a small nursery with native species from oak forests was constructed. It was also observed that the exercise in methodology with participation from the people has a role in developing their self-esteem, because it gives value to their experience and knowledge. For this reason, the use and pursuit of this knowledge by researchers is of fundamental importance in identifying the course of action to be taken in the field.

Conclusions

The use of participatory methods brought an understanding of the relationship between rural communities and the degradation of forested ecosystems. Local farmers and forestry and agricultural personnel possess a huge amount of knowledge about local woody species that can be utilized in forest ecosystem restoration projects. Community members know and understand the state of their natural resource base and are therefore seeking enduring solutions for future generations. However, the integration of municipal authorities is complex due to the lack of a long-term work plan for the protection and restoration of forest resources.

The experience gained in this research demonstrated that community participation is an essential condition for planning research projects so that communities have a base of objective information. On the other hand, researchers also need to interact more closely with communities in order to help resolve environmental problems. It is suggested that researchers take a more active role in community development while remaining sources of objective information. Once researchers establish a relationship with the communities, there may be opportunities for them to carry out long-term research projects in cooperation with those communities, which could be beneficial for both parties.

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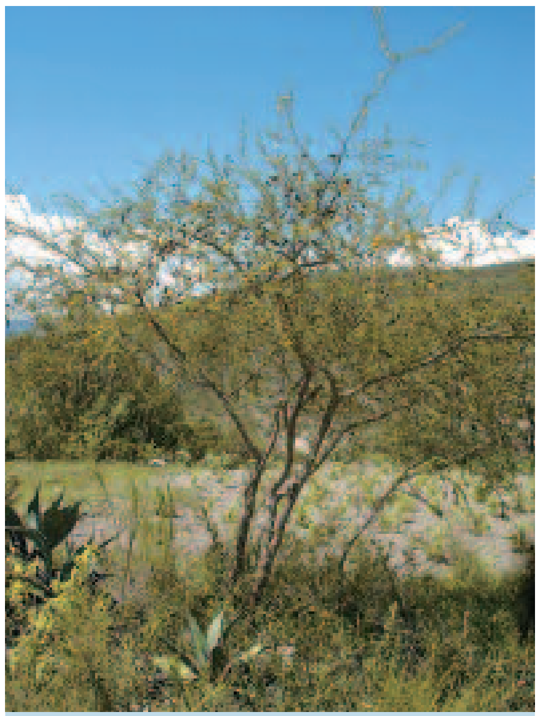

Mimosa biuncifera (“Uña de gato”), a nitrogen-fixing pioneer species that acts as a catalyst for the restoration of oak forest ecosystems in south-eastern Hidalgo (Table IV). These trees were planted as live fences in a farm in Atotonilco El Grande. Photo: F. Montagnini.

Table IV.
Catalyst species with potential for restoration of forested ecosystems in south-eastern Hidalgo.

Ecosystem type/ species	Common name	Family	Form[1]	Successional stage[2]	Uses[3]	Propagation[4]	Restoration attributes[5]	Potential use in restoration[6]
A. Tall perennial rainforest (selva alta perennifolia)								
Bursera simaruba (L.) Sarg.	Chaca	Burseraceae	T	Pioneer - Intermediate	Co, W, Me, O, SH	S, Se	F, Ec, D, Ss, Rg, St, Td	FP, NR, AFS (lf,hg)
Cecropia obtusifolia Bertol.	Hormiguillo	Cecropiaceae	T	Pioneer	Fl, Me, SH	Se	F, Ec, Ll, Rg	FP, NR
Croton draco Schltdl.	Sangre de grado	Euphorbiaceae	T	Pioneer	Fl, Me, H, SH	Se	Ec, Ll, Rg	FP, NR, AFS (lf, sp)
Dendropanax arboreus (L) Planch. et Decne.	Palo de agua	Araliaceae	T	Pioneer	Co, Fl, W, H, SH	Se	F, Ec, Ha	FP, FR, AFS (wb, pbm, ta, sc)
Guazuma ulmifolia Lam.	Guásima	Sterculiaceae	T	Pioneer	Ch, Co, F, Fl, Me, H, P	Se	F, Ec, Rg, St	FP, AFS (ifa, fb, lf, sp)
Heliocarpus tigrinus Hochr	Jonote blanco	Tiliaceae	T	Pioneer	Cr, Co, Fl, P	?	Ec, Ll, Rg	FP, NR, AFS (ifa, pbm, sp)
Inga vera Willd.	Chalahuite	Mimosaceae	T		Co, F, Fr, Fl, H, P, SH	Se	F, Ec, Ll, Ha, N, Rg	FR, AFS (wb, hg, sc, sp)
Leucaena leucocephala (Lam.) de Wit	Huaxe	Mimosaceae	T	Pioneer	Co, F, Fl, O, Me, H, P, Se	Se	Ec, N, Ll, Rg, St, Td	FP, AFS (ifa, fb, hg, sc)
Psidium guajava L.	Guayabo	Myrtaceae	T, s	Pioneer	Ch, Fr, Fl, Me, H, O	G, c, Se	F, Ec, Rg, St, Td	NR, AFS (wb, lf, hg)
Lippia umbellata Cav.	Tabaquillo	Verbenaceae	T	Pioneer	Co, Fl, Me	Se	Ec, Ll, Ha, Rg	FP, NR, AFS (sc)
Trema micrantha (L.) Blume	Jonote rojo	Ulmaceae	T	Pioneer	Cr, Co, F, Fl	Se	F, Ec, Ll, Rg, St	FP, NR, AFS (ifa, fb, lf)
B. Humid montane forest								
Acer negundo L.	Denshe	Aceraceae	T	Intermediate	Co, O, W, H	Se	F, Ec, Ha, Rg, Td	FP, NR, FR, AFS (lf, wb, sp)
Alnus acuminata ssp. *arguta* (Schltdl.) Furlow	Aile	Betulaceae	T	Pioneer	Cr, Co, F, Fl, W, Me, O	Se	Ec, Ll, N, Pf, Rg, St	FP, NR, FR, AFS (ifa, wb, lf, pbm, sc, sp, ta)
Clethra mexicana DC.	Pahuilla	Clethraceae	T	Pioneer	Ch, Co, Fl, H, O	Se	F, Ec, Ll, Ha	FP, AFS (wb, lf, sp)
Pinus greggii Engelm. ex Parl.	Ocote	Pinaceae	T		Co, W, Fl, O	Se	Ec, Ll, Ha, Tf, Pf	FP, EP, AFS (pbm, sc, ta)
Liquidambar macrophylla Oerts.	Copal	Hamamelidaceae	T	Pioneer	Ce, Co, I, W, Me, O, SH, R	Se	Ec, Ss, Ll, Ha, Rg, St	FP, EP, NR, AFS (wb, pbm, sc, ta)
Platanus mexicana Moric.	Alamo	Platanaceae	T		Co, W, Me, O	c, Se	Ss, Ll, Rg	FP, EP, FR, AFS (pbm)
C. Oak forest								
Acacia farnesiana (L.) Willd.	Huizache	Mimosaceae	S	Pioneer	Co, F, Fl, Me, H, P	Se	Ec, Ll, Ha, Tf, N, Td	FP, NR, AFS (fb, lf, wb)
Juniperus flaccida Schltdl.	Tlaxcal	Cupressaceae	T, s		Fl, W, Me, P	Se	F, Ec, Ha, Tf, Td	FP, NR, AFS (wb, pbm, ta)
Lindleyella mespiloides (H.B.K.) Rydb.	Rosa blanca	Rosaceae	S		F, Fl	Se	Ec, Ll, Nu, Td	NR, AFS (fb)
Mimosa biuncifera Benth.	Uña de gato	Mimosaceae	S	Pioneer	Fl, F, Me, H	Se	Ec, Ll, Tf, N, Nu, Td	NR, AFS (ifa, lf)
Prosopis laevigata (Humb. & Bonpl. ex Willd.) M.C. Johnst.	Mezquite	Mimosaceae	T, s		Ch, Co, F, Fr, Fl, W, Me, H,	Se	F, Ec, Ss, Ll, N	FP, NR, AFS (fb, wb, lf, sp, ta)
Quercus deserticola Trel.	Encino toronja	Fagaceae	T		Ch, Co, Fl, P	Se	F, Ec, Ll, Ha, Tf, St, Td	FP, EP

Table IV (continued).
Catalyst species with potential for restoration of forested ecosystems in south-eastern Hidalgo.

Ecosystem type/ species	Common name	Family	Form[1]	Successional stage[2]	Uses[3]	Propagation[4]	Restoration attributes[5]	Potential use in restoration[6]
D. Pine-oak forest								
Baccharis conferta H.B.K.	Escoba	Asteraceae	S	Pioneer	Me, Fl	Se	Ec, Ha, Tf, Nu, Rg, St, Td	NR
Buddleja cordata (H.B.K.) ssp. *cordata*	Tepozán	Loganiaceae	T, s	Pioneer	Fl, Me, H, P	Se, c	Ec, Ll, Tf, Nu, Rg, St, Td	NR, AFS (ifa, lf, wb)
Prunus serotina Ehrh. ssp. Capuli (Cav.) Mc Vaugh	Capulín	Rosaceae	T, s	Pioneer	Fr, Fl, W, Me, H, O, P, SH	Se, c	F, Ec, Ha, Tf, Rg, St	NR, AFS (lf, wb, hg)
Pinus patula Schltdl. & Cham.	Ocote colorado	Pinaceae	T	Intermediate	Co, Fl, W, O, P	Se	Ec, Ll, Tf, Pf, Rg	NR, FP, EP, AFS (pbm, ta)
Pinus teocote Schltdl. & Cham.	Ocote	Pinaceae	T	Intermediate	Co, Fl, W, P, R	Se	Ec, Ll, Ha, Tf, Td	NR, FP, EP, AFS (pbm, ta)
Quercus microphylla Née	Encino rastrero	Fagaceae	S	Pioneer	F, Fl	Se	F, Ec, Ll, Ha, Tf, Td	NR, FP
Senecio salignus DC.	Jarilla	Asteraceae	S	Pioneer	Ce, F, I, Me, H	Se	Ec, Ha, Rg, St	NR, AFS (hg)

[1] T: tree, s: shrub; [2] pioneer, intermediate; [3] Ce: ceremonial, Ch: charcoal, Co: rural construction, Cr: crafts, F: forage, Fr: fruit, Fi: firewood, H: honey, I: insecticide, Me: medicinal, O: ornamental, P: posts, R: resin, Sh: shade, Se: edible seed, W: wood; [4] c: cutting, G: graft, R: root graft, S: season, Se: seed; [5] F: food for wildlife, Ec: erosion control, D: drainage of inundated lands, Ss: stabilizes sand banks, Ll: leaf-litter input, Ha: habitat for wildlife, Tf: tolerates frost, N: biological fixation of Nitrogen, Nu: nurse plant, Pf: precipitates fog, Rg: rapid growth, St: stump sprouting ability, Td: tolerates drought; [6] FP: forest plantations, EP: enrichment plantations, NR: natural regeneration management, FR: floodplain restoration, AFS: agroforestry systems (fb: forage banks, ifa: improved fallow areas, lf: living fences, wb: windbreaks, hg: home gardens, pbm: property boundary markers, sc: shade for coffee, sp: shade in plots, ta: Taungya).

Table V.
Scarce species with potential for restoration of forested ecosystems in south-eastern Hidalgo.

Ecosystem type/ species	Common name	Family	Form[1]	Successional stage[2]	Uses[3]	Propagation[4]	Restoration attributes[5]	Factors placing species at risk[6]	Potential use in restoration[7]
A. Tall perennial rainforest (selva alta perennifolia)									
Cedrela odorata L.	Cedro rojo	Meliaceae	T	Intermediate	Cr, I, W, Me, H, O, Sh	c, Se	Ec, Ll, Ha, Rg	Ch, Oe, Og	NR, FP, EP, AFS (hg, pbm, sp, sc, ta)
Ceiba pentandra (L.) Gaernt.	Ceiba	Bombacaceae	T	Intermediate	F, W, Me, O, Sh	Se	Ec, Rg	Ch, Oe	FP, EP, AFS (hg, sc, sp)
Diphysa sennoides Benth.	Camarón	Fabaceae	T, s		Co, Fi, Me, O, P, Sh		Ec, Ll, N	Ch, PD, Oe, Og	FP, NR, AFS (lf, pbm, sp)
Persea schiediana Nees	Pagua	Lauraceae	T	Late?	Fr, I, Fi, W, Me	Se	F, Ec, Ll, Ha	Ch	EP, AFS (hg, sc)
Platymiscium yucatanum Standl.	Tlacuilo	Fabaceae	T		Cr, W, Sh		Ec, Ll, N, St	Ch, PD, Oe, Og	FP, EP, AFS (hg, pbm, sc, sp)
Pouteria campechiana (Kunth) Baheni	Zapote amarillo	Sapotaceae	T	Late?	Fr, W, Me	G, R, Se	F, Ec, Ll	Ch, PD	EP, AFS (hg, sc)
Pouteria sapota (Jacquin) H.E. Moore & Stearn	Mamey	Sapotaceae	T	Late?	Co, Fr, Fi, W, Me, H	R, Se	F, Ec, Ll	Ch	FP, EP, AFS (hg, sc)
Tapirira mexicana Marchand	Bienvenido	Anacardiaceae	T	Late?	Fr, Fi, W, O, P	Se	F, Ec, Ll	Ch, Oe	EP, AFS (hg, sc)
B. Humid montane forest									
Fagus grandifolia Ehrh. var. *mexicana* (Martinez) Little	Haya	Fagaceae	T	Late	Ch, Fi, W, O, Se	Se	Ec, Ll, Pe, Pf, St	Ch, Oe	EP
Juglans pyriformis Liebm.	Nogal	Juglandaceae	T	Late?	Cr, W, Sh, Se	Se	F, Am, Ec, Ll	Ch, PD, Oe	FP, EP, AFS (pbm, sc, ta)
Meliosma alba (Schltdl.) Walp.	Fresno blanco	Sabiaceae	T	Pioneer	Cr, Co, Fi, O, Sh	Se	F, Ec, Ll, Ha	Ch	FP, AFS (wb)
Morus celtidifolia H.B.K.	Mora	Moraceae	T		Cr, F, Fr, W, O	Se	F, Ec, Ll, Ha, St, Td	Ch, Oe, Og	FP, AFS (fb, hg, sc, sp)
Tilia houghi Rose	Jonote de tierra fría	Tiliaceae	T	Late?	Cr, Co, W, Me		Ec, Ll, St	Ch	EP, FR
Ulmus mexicana (Liebm.) Planch	Petatillo	Ulmaceae	T	Late?	Co, F, W, Me, O, Sh	c, Se	Ec, Ll	Ch, Oe	FP, EP
C. Oak forest									
Casimiroa edulis La llave & Lex	Zapote blanco	Rutaceae	T		Co, Fr, Fi, Me, H, O, Sh	R, Se	F, Ec, Ll, Ha, Td	Ch	EP, AFS (wb, lf, hg, sc, sp)
Juglans mollis Engelm.	Nogal cimarrón	Juglandaceae	T		Co, Fi, W, Me, H, Se	Se	F, Ec, Ll, Ha, St, Td	Ch, Oe	FP, EP, AFS (wb, hg, ta, sp)
Litsea glaucescens H.B.K.	Laurel	Lauraceae	T, s		Cd, Me, O		F, Pe	Ch, Oe, Og	EP, AFS (hg)
Quercus obtusata Humb. & Bonpl.	Encino hoja ancha	Fagaceae	T, s	Late	Ch, Co, F, Fi, P	Se	F, Ec, Ll, Ha, Tf, St	Ch, Oe, Og	FP, EP, AFS (lf, sp)

Table V (continued).
Scarce species with potential for restoration of forested ecosystems in south-eastern Hidalgo.

Ecosystem type/ species	Common name	Family	Form[1]	Successional stage[2]	Uses[3]	Propagation[4]	Restoration attributes[5]	Factors placing species at risk[6]	Potential use in restoration[7]
D. Pine-oak forest									
Abies religiosa (Kunth) Schltdl. & Cham.	Oyamel	Pinaceae	T	Late	Co, Fi, W, Me, O, R	Se	F, Ec, Ll, Ha, Tf	Ch, PD, Ff, Oe	NR, FP, EP
Cupressus benthamii Endl.	Sabino	Cupressaceae	T	Intermediate?	Co, Fi, W, O	c, Se	Ec, Ll, Ha, Tf, Pf, Pr	Ch, Ff, Oe, Og	NR, FP, EP, AFS (wb, pbm, ta)
Pinus ayacahuite C. Ehrenb. ex Schltdl.	Ayacahuite	Pinaceae	T	Intermediate?	Cr, Fi, W, Me, O	Se	Ec, Ll, Ha, Tf, Pf	Ch, Ff, Oe	FP, EP, AFS (pbm, ta)
Pseudotsuga macrolepis Flous	Romerillo	Pinaceae	T	Intermediate?	Fi, W, O	Se	Ec, Ll, Ha, Tf, Pr	Ch, Ff, PD	FP, EP
Quercus laurina Humb. & Bonpl.	Encino laurelillo	Fagaceae	T	Late	Ch, Co, Fi, W, P	Se	F, Ec, Ll, Ha, Tf, Pf, St	Ch, Ff, Oe	FP, EP, FR

[1] T: tree, s: shrub; [2] pioneer, intermediate; [3] Ce: ceremonial, Ch: charcoal, Cd: Condiment, Co: construction, Cr: crafts, F: forage, Fr: fruit, Fi: firewood, H: honey, I: insecticide, Me: medicinal, O: ornamental, P: posts, R: resin, Sh: shade, Se: edible seed, W: wood; [4] c: cutting, G: graft, R: root graft, S: season, Se: seed; [5] F: food for wildlife, Ec: erosion control, D: drainage of inundated lands, Ss: stabilizes sand banks, Ll: leaf-litter input, Ha: habitat for wildlife, Tf: tolerates frost, N: biological fixation of Nitrogen, Nu: nurse plant, Pf: precipitates fog, Rg: rapid growth, St: stump sprouting ability, Td: tolerates drought; [6] Ch: change in land use, Ff: forest fires, PD: pests and disease, Oe: Overexploitation, Og: Overgrazing; [7] FP: forest plantations, EP: enrichment plantations, NR: natural regeneration management, FR: floodplain restoration, AFS: agroforestry systems (fb: forage banks, ifa: improved fallow areas, lf: living fences, wb: windbreaks, hg: home gardens, pbm: property boundary markers, sc: shade for coffee, sp: shade in plots, ta: Taungya).

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