Temperate Pines of Northern Mexico: Their Use, Abuse, and Regeneration

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Abstract.—The pines of northern Mexico contribute greatly to regional economies and biodiversity. This paper examines their distribution, ownership and principal uses. It also explores their present and future integrity in view of present and projected forest practices. In particular, the paper addresses the necessity for developing effective forest regeneration strategies which do not diminish genetic diversity. Some of these pines have a potential role in the genetic improvement of commercial, select gene pools maintained in the United States. Cooperative efforts to establish *ex situ* plantations for conserving germ plasm therefore deserve attention, especially in the case of endangered species.

INTRODUCTION

Mexico's geographic location, diverse topography and vast coastal areas have made its land rich in biological diversity (Bye, 1993; Rzedowski, 1993; WCMC, 1992). Its forests are especially rich in flora and fauna, with some groups having ancestral lines traceable to taxa existing today deep within South America or latitudes far to the north (Brown and Gibson, 1983) . Our aim is to examine the importance of Mexico's principal pine forests to its people and to describe some of the factors threatening their ecological integrity. We will also discuss efforts to regenerate deforested areas and how this work might be accelerated. We will see that the United States and Canada can indirectly exert both positive and negative influences on Mexico's biological resources. Opportunities for expanding positive U.S.-Mexico interactions should become obvious as we discuss Mexico's efforts to develop its resources without compromising ecological integrity.

Our focus will be two madrean regions (fig. 1), as recognized by Peet (1988), and three Mexican states. In a geological context , these regions are two of Mexico's 11 morphotectonic provinces, identified according to their physiographic and geologic-tectonic features (Ferrusquia-Villafranca, 1993). We will discuss the forests of two of these provinces, the Sierra Madre Occidental and Trans-Mexican Volcanic Belt. The Mexican states of Chihuahua and Durango have forests in the Sierra Madre whereas Michoacan has forests in the Volcanic Belt. The approach will be to describe the forest resources of each state followed by descriptions of their productivity and factors leading to deforestation. Forest regeneration needs and practices will be discussed with the issue of biodiversity in full view.

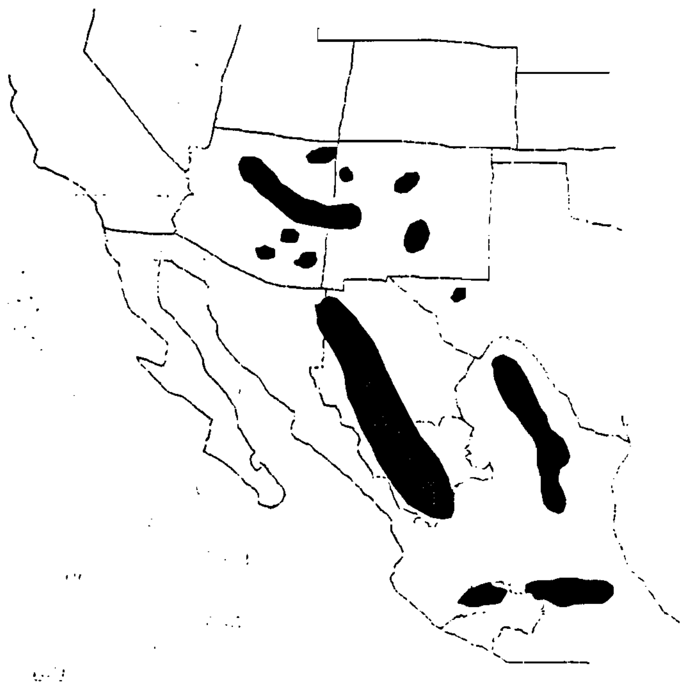

Figure 1.—Map of the Madrean regions within Mexico and southwestern United States.

Pines of these regions occur in pure stands, be they forests or woodlands, or mixed with oaks at

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lower elevations. Several species of *Abies* and *Picea* (Gordon, 1968) occur on the highest slopes but are increasingly threatened by human encroachment owing to their meager abundance. *Picea chihuahuana* occurring in the Creel, Mexico area is clearly an endangered species (National Research Council, 1991).

The forests of the Sierra Madre and Volcanic Belt are unusually rich in numbers of pine (Table 1, after Perry, 1991; Styles, 1993) and oak species and subspecies (Martinez, 1981; Nixon, 1993) . Numerous pine and oak species extend northward into the madrean regions of New Mexico, Arizona and western Texas. A reasonable estimate of oak species for the entire western Hemisphere is 200-225 species. About 135 *Quercus* species occur wholly or partly in Mexico and montane Mexico is recognized as the center of diversity for this genus in our hemisphere. The Sierra Madre Occidental is estimated to have 41 oak species and a species list is available for this area (Nixon, 1993).

The pine forests of the three states generally occur above 2000 m (Table 1) with extensive, uninterrupted areas of heavily stock stands being present in some areas of Chihuahua and Durango from 2200-2500 m. Compared to the neighboring forests of New Mexico and Arizona, forests of the Sierra Madre and the Volcanic Belt are more productive. Within Mexico, growth increases from north to south along the Sierra Madre Occidental range into the state of Michoacan. This can be attributed to several factors but is clearly related to increasing precipitation from 30 to 18 degrees latitude (Mosino-Aleman and Garcia, 1974). It must also be related to the briefer intervals of moisture deficit which are determined by the seasonal flow of monsoonal rains. Rains begin earlier and end later in the southern parts, nearer to the equator. A decisive point is that forests further south can be managed on shorter rotations which on better sites can be as brief as 12 years for pulpwood (Garcia Magana and Munoz Flores, 1993) production or more conventionally about 18-20 years. In northern Chihuahua, rotations require 80-100 years or longer depending on site factors (Arteaga Martinez, 1989).

Table 1.—Key features of the pine forests of Mexico's three principal pine wood producing states. Demographic data from INEGI (1991a, 1991b and 1992; production data from FAO (1992); information on pines from Perry (1991).

	Chihuahua	Durango	Michoacan
Total area (Km^2)	244,938	123,181	59,928
Forested Area (Ha)	464,100	407,300	129,200
Elevational band of pine forest (masl)	2000 - 3500	2000 - 3500	2000 - 3700
Pine roundwood production in 1993 (m^3)	1,049,000	1,695,000	634,000
Minimum and maximum temperatures (C°)	5 - 30	10 - 25	15 - 25
No. of pine species	15	21	21
No. of pine subspecies	1	5	6

FOREST PRODUCTS AND UTILIZATION

According to Camara Nacional de la Industria Forestal (CNF, 1994), Mexico produces almost 25 million cubic meters of roundwood each year and production was rather steady from 1982-1992 (fig. 2). The three states of interest contribute greatly to pine roundwood production (Table 1), accounting for 68.2% of Mexico's total pine wood production. Durango leads production (33.5%) followed by Chihuahua (20.7%) and Michoacan (12.6%) (CNF, 1994). The products obtained from these forests are numerous and reflect both industrial and communal uses (Gonzalez Hernandez, 1986). In each of the three states conventional industrial products are obtained as shown for the state of Durango (fig. 3).

Most of the volume (60.5%) is utilized in the production of lumber for local, national and export consumption. Pulp and paper production consumes 29% followed by plywood production (5.9%), pressure treated products (4.1%) and chipped products (0.5%) (CNF, 1994). Forests also provide commercially important resins (Moncayo Ruiz and Gonzalez Lopez, 1979) fuelwood for mountain communities and a host of products needed for furniture manufacturing and artist guilds. Michoacan is especially well known for its artistic use of wood in carved furniture.

Pulp mills consume mostly pines but also utilize oaks where they are abundant. (e.g., Michoacan). Pulp and paper mills tend to be few in number in each of the states owing to infrastructure requirements and wood supply. Sawmills can be found throughout the intensely forested areas in Michoacan , for example, and closely follow the east to west belt of forests in the upper third of the state (Moncayo Ruiz and Gonzalez Lopez. 1979). Each state has centers of more intense utilization as shown for the state of Chihuahua (fig. 4). Utilization is particularly intense in the municipios of Guachochi, Guerrero andUrique (Gonzalez Hernandez, 1986; INEGI, 1991b).

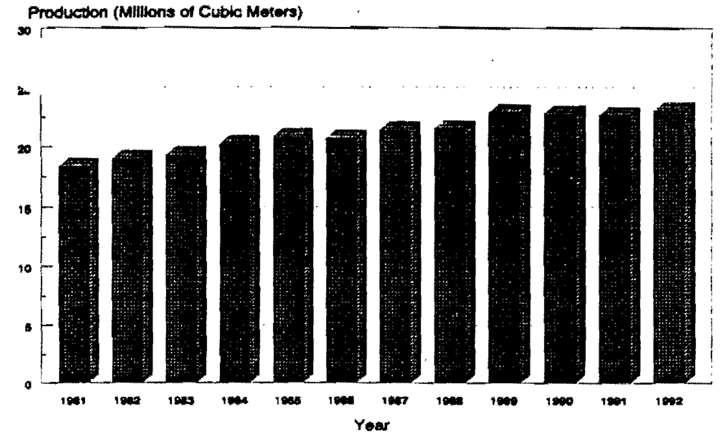

Figure 2.—Total roundwood production for Mexico from 1981 through 1992 (Source: FAO).

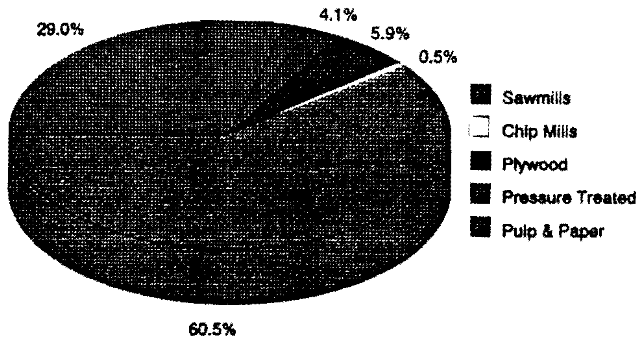

Figure 3.—Product utilization by industry for the state of Durango.

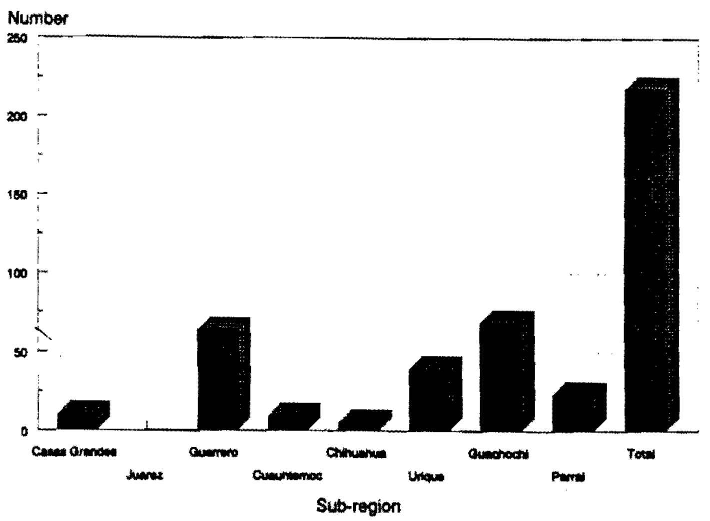

Figure 4.—Sawmill distribution by sub-region within the state of Chihuahua (Source:SARH).

Table 2.—Forestry related employment for the states of Chihuahua, Durango, and Michoacan.

	Chihuahua	Durango	Michoacan
People employed	17,854	15,229	10,133
Percent of total population	1.00%	1.10%	0.30%
Total population	2,238,542	1,384,518	3,377,732

Owing to Mexico's historical dependence on rural-based agriculture economies, forestry employment plays a critical role in the livelihood of communities existing outside the economic mainstream of the larger cities (table 2). No where is this more obvious than in the state of Durango where no less than 1% of the population is employed in forestry-related activities (Hernandez Diaz et al, 1991). In Chihuahua, ranching gives way to forestry as one moves from the natural pastures of the plains into the sierras. Forest land use increases from 15.2% to 47.7% from plains to sierras (INEGI, 1991a) and the importance of forestry employment becomes outwardly obvious. In areas such as Creel, forest industry employs a member of one of every third or fourth household.

DEFORESTATION

Numerous factors threaten the forests serving Mexico's forest-based communities. On a local scale, fire takes a heavy toll on forests. From 1983-1988, as much as 125,000 Ha of Mexico's forest have been lost in a given year with rangeland fires covering twice that amount (e.g., 1988) (fig. 5).

Fire is particularly destructive in Durango(fig. 6 (Hernandez Diaz et al., 1991) and Chihuahua (fig. 7 (INEGI, 1991b) where pine growth is less rapid. Owing to the concentration of forests in these states, forested lands often exceed rangelands in total areas burned. Figure 7 also illustrates one of the underlying reasons for Mexico's steady decline in forest cover.; regeneration simply falls woefully short of replacing forests lost to fire.

We see a similar pattern in Chihuahua which also shows a fire-regeneration mismatch but also that fire consumes as much timber as harvest.

For the entire country the net rate of deforestation from 1980-1992 has shown a steady increase and in 1992 exceeded 1 million hectares. Fire and an inability to regenerate forests therefore does not fully explain Mexico's forest decline. Here, the issues become exceedingly complex with opinions differing among economists and sociologists as to root causes.

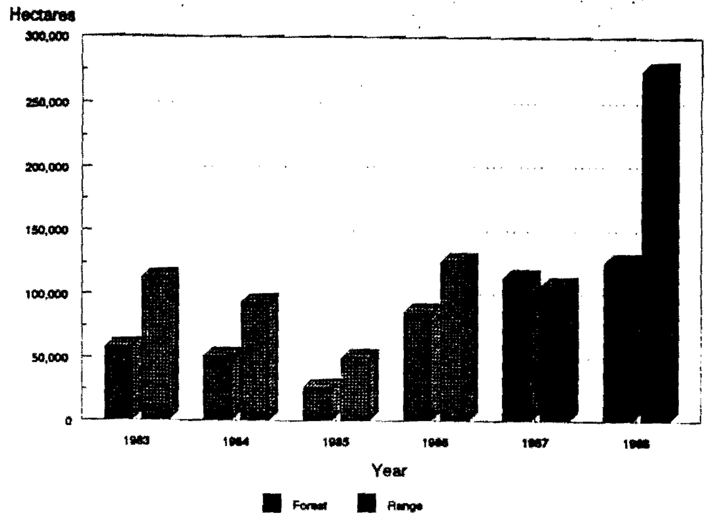

Figure 5.—Mexican forest and range area lost to fire.

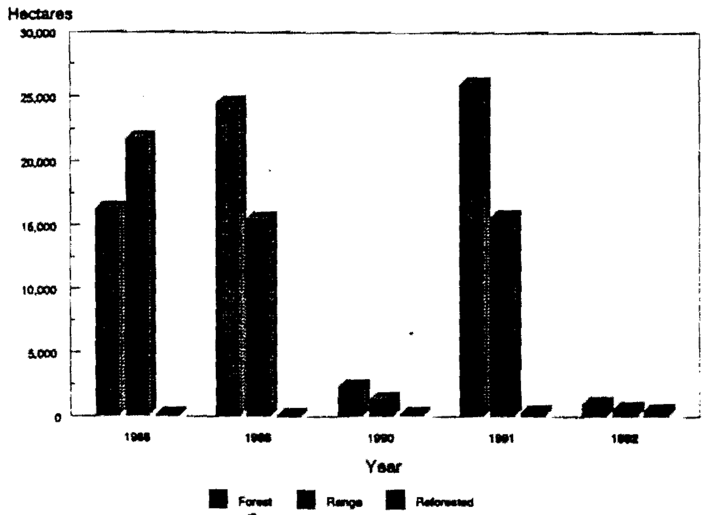

Figure 6.—Fire and reforestation areas for the state of Durango.

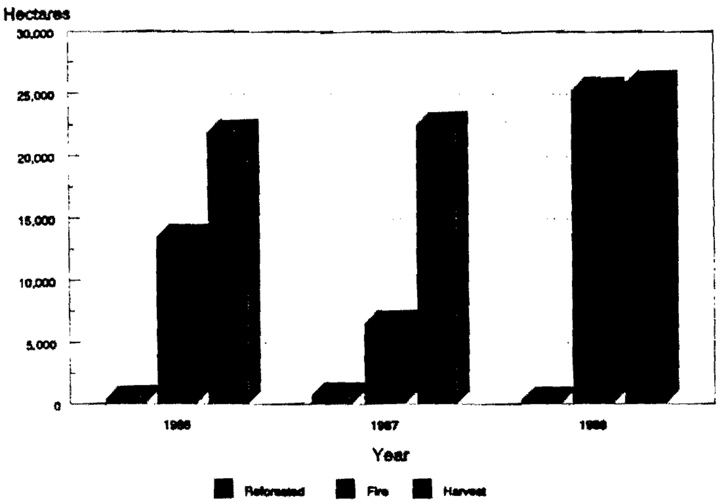

Figure 7.—Harvest, fire and reforestation areas for the state of Chihuahua. (Assumption of 100% loss due to fire.)

One approach toward understanding Mexico's forest-related dilemmas is to examine the broader issue of ecosystem health. As we identify threatened resources and why they are being challenged, we will see that many problems , including deforestation, have similar root causes. We will also be better able to understand why Mexico's land management priorities are gradually changing.

One economist (Mumme, 1992) characterized Mexico's ecosystem health as undergoing steady degradation. He listed as symptoms of decline:

- Loss of biodiversity
- Damaged aquatic ecosystems
- Decline in sustainable agricultural practices
- Deforestation

Economists have attributed ecosysten degradation primarily to political, economic and social factors (Barkin, 1990; Mumme, 1992; Nuccio et al., 1990; Nuccio, 1991). Political factors are largely associated with the need to stress economic recovery to the electorate with other causes and reforms remaining secondary to this chief aim. This is understandable in view of the financial stresses imposed on Mexico since the oil bust of the 1980s. Economic recovery would mean an increase in real wage earnings. It would also mean that finances needed for public works and the environment would become available. In particular, Mexico's industrial plants are severely lacking in environmental control equipment (Herrera Toledano, 1992).

Economic strategies dating back to the 1950s are often cited as creating Mexico's financial crisis, and as indirectly creating social pressures leading to environmental decline. In particular, rural areas are said to have suffered at the hands of policies lacking economic incentives for the production of basic foods. As farmers abandoned the production of basic foods such as corn and beans due to price controls, they moved to urban areas to seek higher wages. Cd. Mexico now has more than 20% of the country's population (Wilkie, 1993). Unable to keep pace with an inflation economy, peasants remaining in rural areas progressively cleared land for agriculture or cattle. Southern Mexico has been heavily impacted by cattle.

Hoping to balance its trade deficits, Mexico poured large subsidies into intensive irrigated agriculture for the purpose of bolstering its exports of high value crops. Unsubsidized rain-fed lands cultivated and cropped continuously lost their productivity owing to nutrient decline and erosion. In Oaxaca, some areas (e.g., Mexteca) arable l–d has been reduced 70%. The removal of trees .ı watersheds to make room for crops and cattle has been blamed for erosion, flooding and the loss of biodiversity. One concern is that peasant migration could erase the existence of endemic forest species occurring at lower elevations where mountains join farming valleys. Forests at these locations are at high risk in terms of intentional burning. Deforestation has led to further desertification in the drier areas, and in the humid subtropical areas extensive biologically diverse forests have been lost. For example, the Lacandon jungle area has been reduced 70% over the past 40 years. The overall loss of Mexico's forested areas has been estimated to be 66%.

The net result of migration from rural to urban areas has intensified the need for industrialization to create employment. Effects associated with urbanization and industrialization have combined to create problems of waste management, air pollution, coastal oil spills and sanitation handling. More than 60% of Mexico's rivers and streams and many of its largest and best known lakes (*e.g.* Chapal & Patzcuaro) are reported to be contaminated (Mumme, 1992) by pollution from concentrated populations and industry.

These issues received considerable debate during the NAFTA debates which directed attention to Mexico's lax enforcement of environmental laws, transborder pollution from maquiladoras, and potentially negative effects of the trade agreement on Mexico's environmental quality.

Mexico's response to these issues has been to overhaul its environmental oversight agency (SEDESOL). It stiffened enforcement and now requires environmental impact statements for all construction projects. Mexico has also declared its commitment to sustainable development (Manzanilla, 1992) and has entered numerous multi-lateral agreements to protect biodiversity. One of Mexico's immediate aims is to develop a thorough inventory of its biotic resources and to put risk assessment at the top of its development criteria.

Rural economic development has been dealt with by a massive restructuring of the ejido system (Kuenzler, 1992) through which the majority of agricultural and forest lands were previously managed. Reorganization will encourage further intensification of agriculture under varying types of land ownership. The goal is to connect capital investment, domestic or foreign, with land and labor previously managed exclusively under ejido domain. For example, foreign capital has enabled Mexico to expand production of winter export vegetables and fruit crops offering comparative advantage. Forestry may also prove attractive to foreign companies.

Effects of Mexico's polices and NAFTA on timber harvest *per se* have received minor attention compared to the staggering environmental problems of the Federal District and border towns. In domestic terms, Mexico clearly will have to harvest or import more trees to meet the needs of its expanding population (fig. 8) . Anticipating this need, the American Plywood Association and the Forest Products Association both voiced support for NAFTA. According to one economic model, both U.S. and Mexican consumers of softwood lumber will benefit (Boyd, et al., 1993).

The attention given trade negotiations and global ecology clearly intensified cooperation among the NAFTA participants. The U.S. Forest Service has worked closely with the Mexican government to meet needs for reforestation training while continuing efforts to provide assistance in fire management (Gonzalez-Caban and Sandberg, 1989). New Mexico State University has worked with the Forest Service to deliver nursery management training over the past four years. Canada is currently extending its "model forest" concept (Brand and LeClaire, 1994) to a project near Creel, Mexico. Creel is a somewhat remote forest-dependent community with an unresolved future owing to the growing needs of the community for potable water, sanitation facilities and transportation. Responding to concerns that road development would adversely affect the area, the World Bank apparently is not going forward with road construction assistance. Development impacts on the future of the Tarahumarans, numbering in excess of 40,000., and maintaining the scenic value of Copper Canyon were among the principal concerns. Forest Guardians, a conservation group based in Santa Fe, New Mexico , is providing financial assistance for developing Tarahumaran community nature reserves and agro-ecology training centers. Clearly This region clearly is attracting international attention and resource management case studies addressing its complex problems should be greatly rewarded.

Forest Regeneration

With a fuller understanding of issues impacting the pine forests of Mexico, we return to the need to close the gap between forest loss and reforestation. Mexico's commitment to reforestation is most evident in the work being done by nursery specialists at community, state and national levels. It is also apparent in the cooperation among these groups in finding solutions to difficult technical problems. The fact remains, however, that reforestation must become increasingly efficient and this can be achieved more rapidly by overcoming existing limitations. Factors constraining reforestation include available finances, technical services and the shortage of professionals capable of handling the diverse problems encountered in nursery operations. The technical problems encountered would tax the capabilities of the most advanced nursery research centers in the U.S. owing to the absence of published information about Mexico's diverse tree species. The absence of soil, plant and water testing laboratories with advanced testing equipment poses another limitation. Tree seed testing facilities are especially needed.

Although some Mexican nurseries have greenhouse facilities, most grow seedlings in containers outdoors. Bare root nurseries are rare. The nurseries observed thus far frequently have problems associated with crop salinity caused directly by water supplies or soil media, or indirectly by crop management. Probably the most frequent cause of poor seedling growth is the container medium used. Media frequently have poor physical properties owing to the large amounts of soil used in them. Reliable substitutes for unaffordable Canadian peat are needed. Severe labor problems are created by the large number of blank containers caused by poor seed germination. Most nurseries avoid this problem by investing considerable labor in transplanting germinants. This practice is

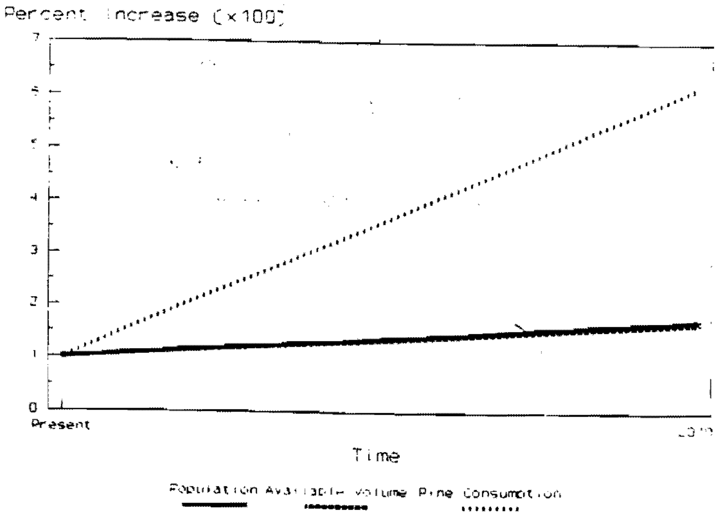

Figure 8.—Projected trends for population growth, pine volume consumption and available pine volume for the state of Michoacan.

even used in bare root nurseries where transplanting is back breaking. Fertility management problems are severe in some nurseries with deficiencies in nitrogen, phosphorus and iron being most common. Sometimes bareroot crops show striking growth reductions as fertility declines. Green manure rotation practices could alleviate many fertility and disease related problems. Production can also be accelerated by using pest and weed control chemicals within integrated management schemes recognizing the need for safe application.

More needs to be known about basic growth patterns of Mexican forest species as related to nursery production and outplanting success. The diversity of Mexican species magnifies the need for such information while representing a conservation issue deserving separate attention. In view of Mexico's biodiversity, a rich store of tree genotypes can be lost as nursery and reforestation practices inadvertently deselect them. Practices should therefore be examined to identify steps where potentially valuable genotypes are being lost (Jasso, 1970; Kleinschmidt, 1979; Ledig, 1986). In particular, reductions in seed and seedling mortality would promote gene conservation. Some of Mexico's temperate tree species may deserve germ plasm preservation efforts similar to those presently directed toward its tropical conifer species (Dvorak and Laarman, 1986). Pine seed production appears to be quite reliable for some species and areas (e.g., Michoacan (Guzman et al, 1979). Mexican forest researchers are testing methods for improving long term storage for species offering only rare collection opportunities. They are also discussing provisional seed zones as a means of protecting pine diversity. Oaks and other endemic hardwoods should receive attention as well as pines and other conifers.

Mexican nurseries could operate at higher efficiency levels through the centralization of facilities. Also, fixed geometry container systems permitting mechanized precision sowing could be used, and bare root nurseries could be developed to reduce seedling costs (Carrillo Sanchez, 1980). At present, the few bareroot nurseries existing in Mexico struggle with a brief lifting window created by mild climate, and presently do not offer much of a cost advantage, if any. Compared to the USA, Mexico presently has fewer options for safely transporting and storing bare root stock owing to its infrastructure limitations.

There clearly is a need to view issues such as production centralization and mechanization within social and environmental contexts. Because

Mexico must provide 300,000 new jobs in agriculture each year to stay even with population growth, rural employment cannot be neglected. Also, one dollar earned in a rural community translates to almost four dollars of benefit to the local economy. Steps toward production centralization and mechanization therefore must be taken in a responsible manner. However, these steps may provide the only means of accelerating seedling production to achieve specific goals. Proper treatment of these issues, belongs in our opinion, in the hands of managers having thorough knowledge of rural economics and Mexico's infrastructure.

With its nurseries working at a high level of efficiency, intensively managed plantations could be developed rapidly for the purpose of sparing, not replacing, its natural forests . Strategically located plantations could provide a more steady flow of supply to Mexico's forest industry. In the past, industry has been plagued with flow interruptions created by difficult harvest access, lack of machinery and transportation net works. NAFTA could play major role in developing such plantations by providing the capital and technology needed. Research is needed to identify plantation approaches featuring contributions to genetic, ecological, and landscape diversity as discussed by Kanowski et al., (1992). In some areas (e.g., Michoacan (Esparza and Trujillo, 1986), extensive surveys are available for matching species and forest types with soils, topography and land uses.

We will conclude our topics by asking what importance do the forests of Mexico have for the U.S. beyond the immediate issues. As we asked this question it became apparent that global warming could make us directly dependent on some Mexican forest species sometime in the future.

Global climatic models (GCMs) enable us to predict how global warming could increase the United State's dependency upon Mexican forest species. Under the assumption that the concentration of atmospheric CO_2 is doubled from 0.03% (Sagan and Turco, 1990) the effects on forest communities might include:

- A 200 - 1,500 km shift to the northwest of some tree species,
- A 1 - 5 degree Celsius rise in mean annual temperature,
- Increased plant stress,
- Species composition changes,
- Decrease in productive areas (Andrasko, 1990; Ledig and Kitzmiller 1992).

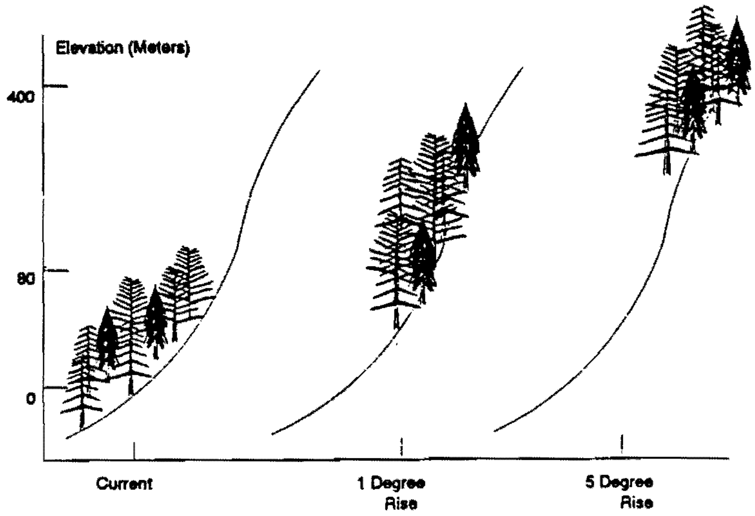

Figure 9.—Elevational and spatial change in forest community with global warming.

The easiest transition for a forest community to make is elevationally (Ledig and Kitzmiller 1992). Figure 9 illustrates the outcome of a forest community adapting to increased temperatures elevationally. The relatively small distances in elevation that need to be traversed are within the capability of the natural transport vectors (e.g., animal and wind). However, elevational transition is limited by the narrow range existing between the current timberline and the apex of the mountain. At many locations more than a 2° to 3° C rise in temperature would cause the upper boundary of the forest to shift upward beyond the top of the mountain it occupied.

Unlike elevational transition, however, latitudinal movement is hampered by geography, habitat and territory conflicts (Ledig and Kitzmiller 1992). The migration rate utilizing natural dispersion vectors will be incapable of keeping pace with the expected displacement of isotherms (Table 3). Forest ecosystems in the Madrean archipelago and the southwestern United States are faced with an extreme challenge in adapting to climatic change. Because of the isolation of the range peaks, latitudinal migration is improbable without intervention by man.

Table 3.—Expected migration rates and isotherm displacement under assumptions of global warming.

Vector Class	
Anemophilous	25 kilometers per century
Zoophilous	12 kilometers per century
Mean Temperature Increase (Celsius)	
1 degree rise	200 kilometers northwest
5 degree rise	1,000 kilometers northwest

What this portends for the Madrean region as a whole and the United States in particular is the 'oss of forest species that are commercially valuable as those species migrate northward to adapt to changing climatic conditions. The forest species that occupy the lower latitudes (18° -30°) can be used to replace those species lost in the southwestern United States as the dominant commercial species.

Global climatic change is an ongoing process. Changes that would be considered catastrophic to a forest ecosystem are not going to occur "overnight", however, the effects are cumulative and accrue rapidly relative to a systems ability to respond. Utilizing available technology in conjunction with foresight, proper planning, and the inherent adaptability of forest species, man can mitigate the consequences of global climatic change through forest regeneration efforts.

CONCLUSIONS AND RECOMMENDATIONS

The information presented shows that the madrean forests in the states of Chihuahua, Durango and Michoacan are major contributors to Mexico's people, economy and biodiversity. However, Mexico's national rate of deforestation threatens the livelihood of rural communities and industries, while posing a serious threat to Mexico's rich biodiversity. Impacts on Mexico's biodiversity will be felt much beyond its borders. Effective regeneration practices, as discussed, can reverse current trends in deforestation, thereby preserving ecological integrity and sustainable economic development.

Our recommendation is for North American countries to continue building cooperative strengths to overcome factors threatening the biota of this hemisphere. The assistance being provided to Mexico by the U.S. Forest Service and Canada is commendable and represents several productive approaches. Non-governmental organizations on both sides of the border are also becoming increasingly involved. Mexico's most pressing problem obviously centers on its ability to develop its resources without damaging its environment. In this context, there have been too few studies on the economic values derived from its natural ecosystems, particularly its forests. More effort should be directed to this area. Finally, it is clearly in the best interest of the U.S. to foster ecological, economical and political stability in Mexico. Our lives are not separate, now or in the future.

LITERATURE CITED

Andrasko, K. 1990. Global warming and forests: an overview of current knowledge. Unasylva 163:41:3-10.

Arteaga Martinez, B. 1989. Evaluacion de la productividad de sitios forestales. Universidad Autonoma Chapingo, Division de Ciencias Forestales, 75 pp.

Barkin, David. 1990. Distorted Development: Mexico in the World Economy. Westview Press, Boulder, CO.

Boyd, R. , K. Doroodian and S. Abdul-Latif. 1993. The effects of tariff removals on the North American lumber trade. Canadian Jour. Agric. Econ. 41:311-328.

Brand, D.G. and A.M. LeClaire. 1994. The model forests programme: international cooperation to define sustainable management. Unasylva 45:51-58.

Brown, J.H. and A.C. Gibson. 1983. Biogeography. C.V. Mosby Co. St. Louis, 643 pp.

Bye, R. 1993. The role of humans in the diversification of plants in Mexico, pp. 707-731. In M. Ramamoorthy, et al., Biological Diversity of Mexico: Origins and Distribution. Oxford Univ. Press, New York, 812 pp.

Carrillo Sanchez, Arturo. 1980. Plantacion a raiz desnuda de *Pinus pseudostrobus* Var. *oaxacana* Mtz. y *Pinus montezumae* Lamb. Serie Technica, Epoca 3a, No. 1. Comision Forestal del Estado de Michoacan.

Committee on Managing Global Genetic Resources, National Research Council. 1991.

Managing Global Genetic Resources: Forest Trees. National Academy Press, Wash. D.C., 229 pp.

Dvorak, W.S. and J.G. Laarman. 1986. Conserving the genes of tropical conifers. J. Forestry 43-45.

Esparza Luevano, J.A. and M.P Trujillo Garcia. 1986. Algunos aspectos ecologicos basicos para manejo integral de la cuenca hidrografica "Presa de Cointzio", Estado de Michoacan.

Food and Agriculture Organization of the United Nations. 1992. Forest Products 1981-1992. FAO, Rome, 336 pp.

Ferrosquia-Villafranca, I. 1993. Geology of Mexico: A synopsis, pp. 3-107. In M. Ramamoorthy, et al., Biological Diversity of Mexico: Origins and Distribution. Oxford Univ. Press, New York, 812 pp.

Garcia Magana, J. Jesus, and H.J. Munoz Flores. 1993. Guia tecnica para el establecimiento y manejo de plantaciones forestales en la Cuenca del Lago de Patzcuaro. Guia Tecnica Num. 2. Instituto Nacional ede Investigaciones Forestales y Agropecuarias, Centro Investigaciones del Pacifico Centro Michoacan, Morelia, Michoacan, Mexico, 22 pp.

Gonzalez-Caban, A and D.V. Sandberg. 1989. Fire management and research needs in Mexico: Opportunities for U.S.-Mexican cooperation in fire research and technology transfer. J. Forestry 87:20-26.

Gonzalez Hernandez, J.J. 1986. Analisis y perspectivas de la actividad forestal en El Estado de Chihuahua. M.S. Thesis, Universidad Autonoma Chapingo, Division de Ciencias Forestales. Chapingo, Mexico.

Gordon, A.G. 1968. Ecology of *Picea chihuahuana* Martinez. Ecology 49:880-896.

Guzman M., A., M. Barrera O. and F. Moncayo R. 1979. Manejo de semillas de pino (*Pinus* spp) en la Comision

Forestal del Estado de Michoacan. Comision Forestal del Estado Michoacan Serie Epoca 2a, Tecnica Reforestacion No. 19.

Hernandez Diaz, Jose, J. Prieto Ruiz and A. Barretero Jaquez. 1991. La actividad forestal de Durango en CIFRAS. Centro de Investigacion Region al del Norte Centro Campo Experimental "Valle del Guadiana", INIFAP, Durango, Dgo. Mexico.

Herrera Toledano, S. 1992. The ecological factor in the NAFTA. Business Mexico 2:28-31.

Instituto Nacional de Estadistica Geografia e Informatica. 1991a. Atlas Ejidal del Estado de Chihuahua.CD, Juarez, Chih., 47 pp.

Instituto Nacional de Estadistica Geografia e Informatica. 1991a. Atlas Ejidal del Estado de Chihuahua.CD, Juarez, Chih., 47 pp.

Instituto Nacional de Estadistica Geografia e Informatica. 1992. Anuario Estadistico Del Estado De Durango. Gobierno del Estado de Durango.

Jasso, M., J. 1970. Impact of silviculture on forest gene resources. Unasylva 24:70-75.

Kanowski, P.J. and P.S. Savill with P.G. Adlard, J. Burley, J. Evans, J.R. Palmer and P.J. Wood. 1992. Plantation forestry, pp. 375-401. IN N.P Sharma (ed.), Managing the World's Forests: Looking for Balance Between Conservation and Development. Kendall/ Hunt Pub. Co., Dubuque, Iowa, 535 pp.

Kleinschmidt, J. 1979. Limitations for restriction of the genetic variation. Silvae Genetica 28:61-67.

Kuenzler, L.T. 1992. Foreign investment opportunities in the Mexican agricultural sector. Business Mexico: 2:44.

Ledig, F.T. 1986. Conservation strategies for forest gene resources. For. Ecol. Manage., 14:77-90.

Ledig, F.T. and J.H. Kitzmiller. 1992. Genetic strategies for reforestation in the face of global climate change. Forest Ecology and Management 50:153-169.

Manzanilla, E. 1992. Border environment and NAFTA: A commentary, pp. 80-82. In P. Ganster and E.O. Valenciano The Mexican-U.S. Border Region and the Free Trade Agreement. Inst. Regional Studies of the Californias, San Diego State Univ, San Diego, CA.

Martinez, M. 1981. Los Encinos de Mexico, 2nd Ed. Comision Forestal

Moncayo Ruiz, F and C. Gonzalez Lopez. 1979. Michoacan forestal: Datoa y cifras. Comision Forestal del Estado Michoacan Serie Epoca 2a, Tecnica Informacion 20.

Mosino Aleman, P.A. and E. Garcia. The climate of Mexico, pp. 305-404. In R.A. Bryson and F.K. Hare (eds.), Climates of North America, World Survey of Climatology Vol 11. Elsevier Sci. Pub. Co., New York, 420 pp.

Mumme, S.P. 1992. System maintenance and environmental reform in Mexico. Latin American Perspectives 19:123-143.

Nuccio, R.A. 1991. The possibilities and limits of environmental protection in Mexico, pp. 109-122. In J.S. Tulchin (ed.) Economic Development and Environmental Protection in Latin America. Lynne Rienner Publishers, Boulder, CO, 143 pp.

Nuccio, R.A. and A.M. Ornelas and I. Restrepo. 1990. Mexico's environment and the United States, pp. 19-58. In J.W. Brown (Ed.) In the U.S. Interest. Westview Press, Inc., Boulder, Colorado.

Peet, R.K. 1988. Forests of the Rocky Mountains, pp. 64-101. In M.G. Barbour and W.D. Billings (Eds.) North American Terrestrial Vegetation. Cambridge Univ. Press, New York, 434 pp.

Perry, J.P. 1991. The Pines of Mexico and Central America. Timber Press. Portland, Oregon, 231 pp.

Rzedowski, J. 1993. Diversity and origins of the phanerogamic flora of Mexico, pp. 129-144. In M. Ramamoorthy, et al., Biological Diversity of Mexico: Origins and Distribution. Oxford Univ. Press, New York, 812 pp.

Sagan, C. and R. Turco. 1990. A Path Where No Man Thought. Random House. New York. pp. 499.

Styles, B.T. 1993. Genus Pinus: A Mexican purview, pp. 397-420. In M. Ramamoorthy, et al., Biological Diversity of Mexico: Origins and Distribution. Oxford Univ. Press, New York, 812 pp.

Wilkie, J.W. 1993. Statistical Abstract of Latin America Vol 30. Part I. UCLA Latin American Center Publications, Univ. of California, Los Angeles.

World Conservation Monitoring Center. 1992. Global Biodiversity: Status of the Earth's Living Resources. Chapman and Hill, New York, 585 pp.