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An Evaluation of Forest Deterioration in the Disturbed Mountains of Western Mexico City

The present article addresses the deterioration of 12 forest geosystems located in a mountain range to the west of Mexico City. On the basis of identification of plant species that are indicators of environmental deterioration, as well as application of a Deterioration Index that considers these species in relation to the richness, vertical structure, and total cover of the climax forest facies—representing the most developed and stable evolutionary stage of each geosystem—forest geosystems are classified according to the present stage of deterioration that affects the best preserved forests in each case.

Keywords: *Forest geosystems; environmental deterioration; Mexico City; forest facies; Deterioration Index.*

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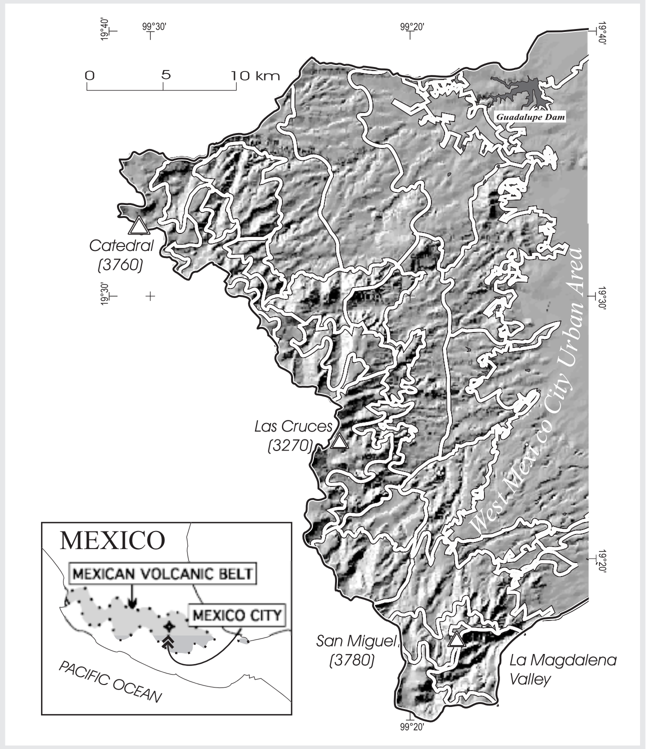


FIGURE 1 Location of the Las Cruces mountain range, west of Mexico City; the zones correspond to the geosystems described in the paper (see Figures 2, 3). (Map by author)

Introduction

The accelerated growth that characterizes several cities in the countries with transition economies leads to a rapid invasion of the agroforest fringes that limit them. Severe ecological degradation (including deterioration of the natural environment, air, water, and soil pollution, and hydrological and geomorphic imbalances) is reflected not only in the physical deterioration of forests but also in their capacity to mitigate future impacts (Berry et al 1994; Riebsame et al 1996). Mexico City's metropolitan area—comprising 22 million inhabitants—is a good example of this type of environmental dynamics. Its western border is located on the eastern slope of the Las Cruces mountain range (Figure 1). This slope, with an area of 832.8 km^2 ranging up to 1500 m in altitude, features the ecological heterogeneity of temperate mountains (Ferreras 1987; Buzhuo et al 1997; Price and Thompson 1997; Forsyth 1998) as well as the high occupation indexes and changes in land use, which result in contrasting rural–urban landscapes and imbalances that affect forest systems.

Twelve forest geosystems

Figures 2 and 3 show an overview of the environmental aspects of the slope, allowing classification into the 12 geosystems described below. The climate and water availability are subordinated to the slope's morphological features. In the mountain area (MA), between 2800 and 3580 m (Lugo 1990; García-Romero 1998), precipitation exceeds 1300 mm/y, and monthly average temperatures are below 10°C, favoring a maximum water surplus of 800 mm/y. Below 2800 m, on the connecting ramp (CR) that links the MA with the bottom of the Mexico basin, the lack of large topographic features mitigates orographic rainfall and promotes warming, which increases toward the ramp's base, where the mean annual temperature exceeds 18°C and precipitation is below 800 mm/y. The low moisture retention capacity in some soils and fractured pyroclastic materials reduces water availability, so that the annual average does not exceed 200 mm.

As shown in Figure 3, the distribution of forests reflects an altitudinal pattern resembling "steps" or floors on a series of soils that are similar to the parental materials both in structure and chemical features (Wright 1972; FAO-UNESCO 1981, 1991):

1. *Peak floor (>3400 m)*. Dominated by peak pine forest, situated near the timberline located at 4000 m (Troll 1971). These forests grow above intercalated humic Andosols and lithic Leptosols.
2. *Montane floor (3200–3400 m)*. Dominated by fir and

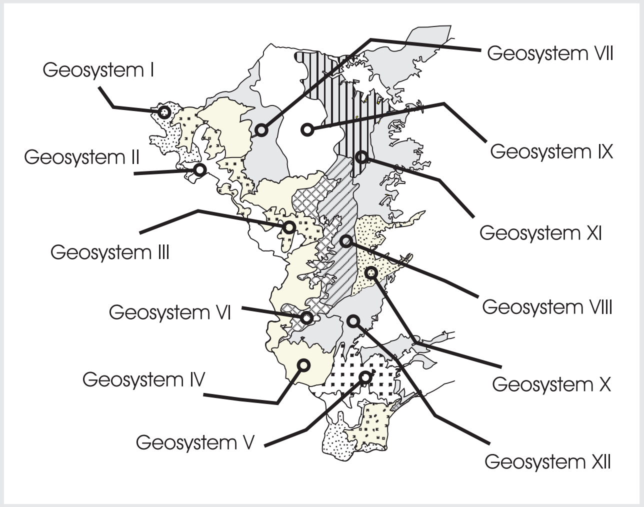


FIGURE 2 Distribution of the forest geosystems. (Map by author)

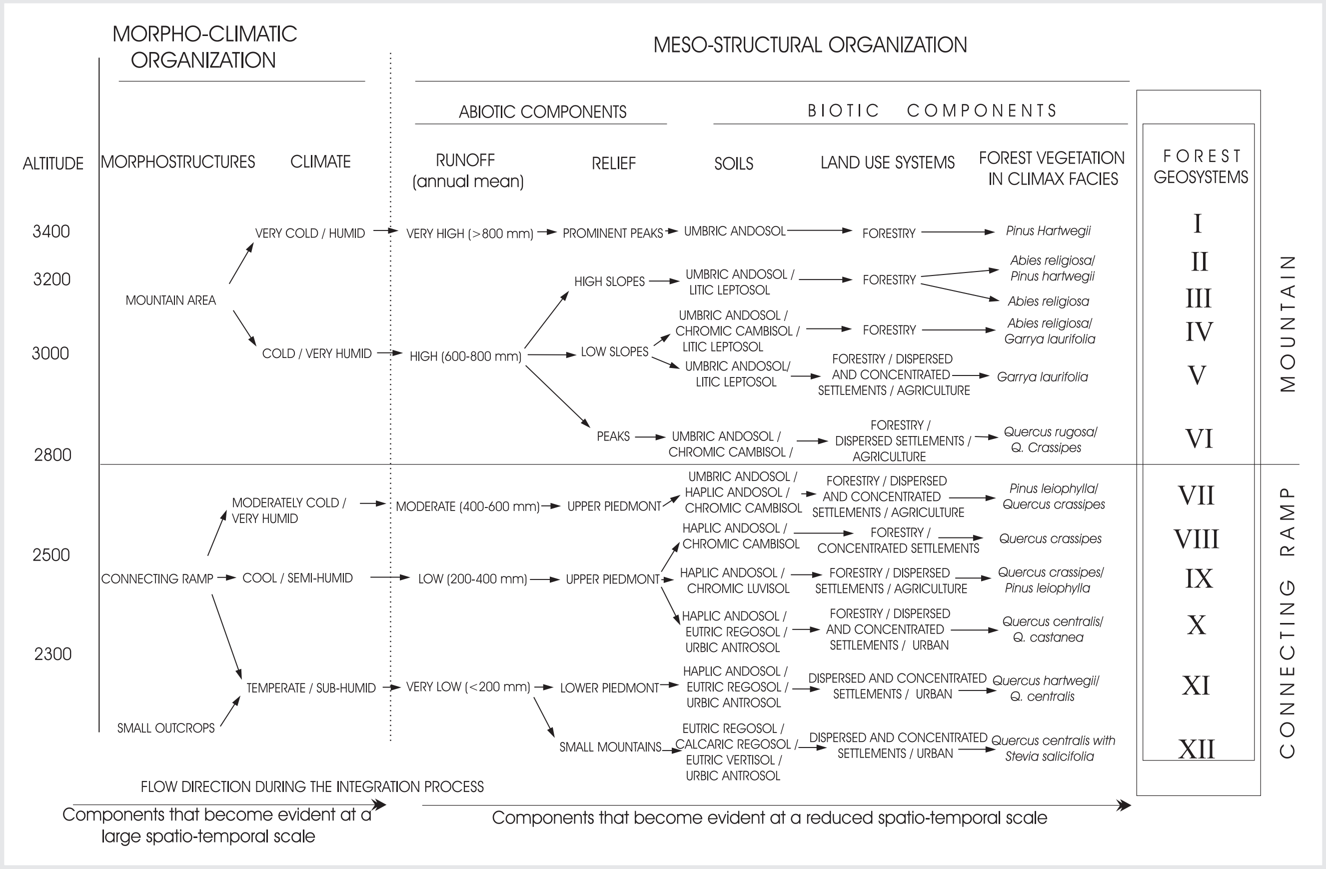
fir–pine forests that grow on sequences of humic Andosols and lithic Leptosols that are frequent in rocky scarps at the mountain border.

3. *Transition floor (2700–3200 m)*. Dominated by mixed pine–oak forests growing on umbric Andosols, chromic Cambisols, and eutric Regosols, which evolve on compact lava and cemented pyroclastic flows.
4. *Piedmont floor (<2700 m)*. Dominated by oak forests growing on sequences of umbric Andosols and eutric Regosols. Chromic Luvisols and eutric Vertisols coincide with loose and altered pyroclast deposits under seasonal but abundant pluviometric conditions that favor percolations and wash-away processes.

During the mid-19th century Mexico City's western border reached the base of the Las Cruces mountain range. The population increased from 70,000 inhabitants in 1940 to 1,700,000 in 1980 and 3,000,000 in 1990 (García-Romero 1998). Although the urban area had not reached the 2300 m altitudinal zone by 1960, it had invaded the inner portion of ravines by 1980 without a single efficient control measure. Since then, changes in land use have mostly consisted in the replacement of agricultural and forest uses by several kinds of residential uses—dispersed settlement, concentrated (village) settlement, and urban settlement—as well as commercial establishments and services, offices, and transport infrastructure.

The forest geosystems classification presented in previous studies (García-Romero 1998, 2001) is based on the analysis and cartographical synthesis (1:50,000) of a series of natural and cultural variables covering several aspects: morphostructures, climate, runoff, landform dynamics, soil types, plant formations, and land

FIGURE 3 Overview of the environmental aspects of the 12 forest geosystems west of Mexico City.



use (Steedman and Haider 1993). This classification allows the identification of 12 forest geosystems in the study area (Figures 1–3).

Mountain area

I. Cold and humid geosystem located on the Catedral and San Miguel mountain peaks, covered by mountain pine forests (*Pinus hartwegii*); land use: silviculture and herding.
II. Cold and very humid geosystem on the Catedral, Las Cruces, and San Miguel upper slopes, covered by dense *Abies religiosa* and *P. hartwegii* forests; land use: silviculture.
III. Cold and very humid geosystem on the Catedral, Las Cruces, and San Miguel middle slopes, covered by *A. religiosa* forests; land use: silviculture.
IV. Cold and very humid geosystem on the Las Cruces mountain peaks and the Catedral and San Miguel lower slopes, covered by *A. religiosa* and *Garrya laurifolia* mixed forests; land use: silviculture and herding.
V. Cold and very humid geosystem on the San Miguel lower slopes, covered by *G. laurifolia* forest; land use: agriculture, recreation, and dispersed and concentrated settlements.
VI. Cold and very humid geosystem on the Las Cruces lower slopes and the La Magdalena river valley, covered by *Quercus rugosa* and *Q. crassipes* forests; land use: agriculture and concentrated settlements.

Connecting ramp

VII. Moderately cold and humid geosystem on the ramp's northern sector, covered by *P. leiophylla* and *Q. crassipes* mixed forests; land use: agriculture, silviculture, herding, and concentrated residential land.
VIII. Cool and semihumid geosystem on the ramp's central sector upper slopes, covered by *Q. crassipes* forests; land use: agriculture, silviculture, and concentrated residential land.
IX. Cool and semihumid geosystem on the ramp's northern sector upper slopes, covered by *Q. crassipes* and *P. leiophylla* forests; land use: agriculture, silviculture, herding, and concentrated residential and urban land.
X. Cool and semihumid geosystem on the ramp's central and northern sector lower slopes, covered by *Q. centralis* and *Q. castanea* forests, where agriculture, silviculture, and herding have been abandoned in favor of dispersed residential land use.
XI. Temperate and subhumid geosystem on the ramp's lower slopes in the central and northern sectors, covered by low *Q. hartwegii* and *Q. centralis* forests, where agriculture, silviculture, and herding have been abandoned in favor of dispersed and concentrated settlements.
XII. Temperate and subhumid geosystem on the ramp's southern sector, covered by *Q. centralis* and *Stevia salicifolia* forests, where agriculture has been abandoned in favor of dispersed and concentrated settlements.

Lack of research

Despite the problems associated with reduction of the forest area to one third of its original surface (5% in the last decade) and forest fragmentation into disconnected and exposed patches prone to physical damage and pollution, published studies on environmental effects are rare. Existing studies include the work of Pezzoli (1998), who warns against the severe environmental degradation associated with the urban dynamics of southern and western Mexico City, and that of García-Romero (1998), who offers the classification system of mountain range forest geosystems mentioned above.

Although it is of considerable geographical interest, the ecological meaning of flora—especially herbs and shrubs—in forest communities is poorly understood because it is often barely obvious in the landscape. The present study assesses the extent of deterioration currently affecting woodlands on the slope that was studied, on the basis of identification of plant species that function as indicators of deterioration and of their participation in the communities' richness, vertical structure, and total cover.

Materials and methods

Given the numerous potential combinations between a fragile and diverse natural environment and a dynamic and unstable society (Pezzoli 1998), the concept of the geosystem's *elementary facies*—referring to plant communities that systematically synthesize and express several dynamic (ie, progressive or regressive) "stages" of the geosystem to which they belong (Bertrand 1968; Beroutchachvili and Bertrand 1978; Steedman and Haider 1993; Muñoz 1998)—is used as the minimum synthetic information unit.

This concept relies on the assumption that, currently and in the light of human-induced environmental deterioration, each geosystem on the slope consists of several elementary facies. The geosystem's functioning is determined by the interaction of multiple facies that succeed one another, so that within the geosystem there is only 1 highly evolved and specific facies that is dynamically stable, in this case the *climax forest facies* (Regier 1993; Price and Thompson 1997; Muñoz 1998).

The analysis of facies derives from the interpretation of their plant communities, which are considered important ecological and environmental synthesizers

(Bertrand 1966; Matteucci and Colma 1982; Bugmann and Solomon 1995). Because the shift from one elementary facies to another not only has physiognomic implications but also involves the responses of communities to levels of human disturbance, the distribution of plant species within the different geosystem facies contains highly relevant ecological information.

To appreciate and assess the participation of alien plants in the physical structure of climax forest facies in each geosystem, the Landscape Integrated Analysis developed by Bertrand (1966, 1968, 1978) was taken as a point of reference and adapted to Mexican conditions by García-Romero (1998). The procedure consisted of the following sequential steps:

- The elementary facies of the geosystems' evolutionary series were identified through direct observation, photographs taken in situ, and photointerpretation of their plant communities.
- Inventories of floristic content, structured in vertical horizons, were conducted for each facies. The results were graphically depicted according to Bertrand's (1966, 1968) Vegetation Pyramids Method, as adapted by García-Romero (1998), to show results in a clear, immediate, and objective way.
- A qualitative and integral analysis of all samples, supported by field work and the literature, made it possible to determine each of the facies in the series of phases included in the evolution of the geosystem to which they belong. The climax forest facies was identified among them, representing the most evolved, natural, and stable stage under the present conditions of deterioration affecting each geosystem.
- Sixty plant species found in the climax forest facies were studied. Their frequency was determined, not only in climax facies but in all secondary facies of the 12 geosystems, which in turn allowed identification of the most frequent species among them in highly deteriorated and unstable environments, coinciding with the areas of most intense human activity. These were, therefore, considered as indicators of environmental deterioration.
- Analysis of the participation of these phytoindicator plants in the richness of climax forests, their vertical structure, and their total cover made it possible to develop a Deterioration Index (DI):

  $$DI = \frac{Ct}{Rr + S + CT}$$

  where

  Ct = total cover of deterioration indicator plants (DIPs) in the community;
  Rr = relative richness in the plant community (this variable is obtained by dividing the richness in the sampling unit [R] by the total richness of the total number of species in the sample [RT]: Rr = R/RT)
  S = vertical structure (this shows the number of vegetal strata in the community);
  CT = total cover (this is the sum total of the cover data for all the community strata).

  All parameters were adjusted to fit a scale of 1–100 to facilitate comparison of results (Figure 4).

  The participation of DIPs is expressed only through cover because the low values obtained for these plants in richness and complexity tend to minimize their importance. Furthermore, the characterization of communities is supported by 3 parameters—relative richness, vertical structure, and total cover—with the aim of balancing the trends that emerge when only 1 of these parameters is considered.
- The responses of forests to human activities, as well as global deterioration levels, were obtained from the comparative analysis of results by geosystem, supported by visual interpretations made during field work.

Results and discussion

The floristic stock of the 12 climax forest facies includes 60 species. They were classified according to their preference for natural or perturbed environments. Figure 5 shows the frequencies obtained for each species in the different successional facies (from A to I) of the 12 geosystems. A noticeable decrease was observed in frequency between climax forest facies (A) and those facies differing most importantly from it (I), in which the level of environmental deterioration is high and is tolerated only by certain species such as *Baccharis conferta, Festuca amplissima, Penstemon gentianoides, Senecio salignus,* and *Verbesina virgata,* which were therefore considered as indicators of environmental deterioration and instability.

Figure 5 also shows a fundamental difference between the most frequent species in columns A and B, which are indicative of the most evolved, stable, and natural facies (NF), and the most frequent species in columns C to I, indicative of facies distanced from the climax, tolerant of deterioration and instability (DF). The physiotype of the latter is mostly shrubby and herbaceous, coinciding with shrublands and grasslands that represent the first phases of recovery of abandoned agricultural parcels or those that are subjected to poor treatment and high pollution levels.

DIPs were determined by calculating the difference between frequencies for the different species in NF and DF facies. Twenty species were obtained this way, with a DIP value less than -2: *Acaena elongata, Agave ferox, Arbutus xalapensis, Arctostaphylos arguta, Aristida* spp, *B. confer-*

Geosystem	Ct	Rr	S	CT	Ct'	Rr'	S'	CT'	DI	DI'
I	3.0	0.15	4.0	9.5	42.86	42.86	66.67	50.00	**80.60**	**72.11**
II	2.5	0.16	6.0	19.0	35.71	45.71	100.00	100.00	**43.60**	**39.01**
III	4.5	0.25	5.0	14.0	64.29	71.43	83.33	73.68	**84.42**	**75.53**
IV	5.5	0.20	5.0	15.0	78.57	57.14	83.33	78.95	**107.42**	**96.12**
V	0.0	0.06	3.0	8.0	0.00	17.14	50.00	42.11	**0.00**	**0.00**
VI	0.0	0.16	6.0	11.0	0.00	45.71	100.00	57.89	**0.00**	**0.00**
VII	7.0	0.35	6.0	13.0	100.00	100.00	100.00	68.42	**111.76**	**100.00**
VIII	6.0	0.25	6.0	15.0	85.71	71.43	100.00	78.95	**102.70**	**91.89**
IX	3.5	0.28	6.0	14.0	50.00	80.00	100.00	73.68	**59.13**	**52.90**
X	1.5	0.20	4.0	10.0	21.43	57.14	66.67	52.63	**36.43**	**32.60**
XI	2.5	0.20	4.0	7.5	35.71	57.14	66.67	39.47	**65.62**	**58.71**
XII	4.5	0.21	4.0	12.0	64.29	60.00	66.67	63.16	**101.60**	**90.90**

Key:

Ct = Total cover of Deterioration Indicator plants in the community.

Rr = Relative richness in the plant community. This variable is obtained by dividing the richness in the sampling unit R by the total richness of the total number of species in the sample (RT): Rr = R/RT.

S = Vertical structure. This shows the number of vegetal strata in the community.

CT = Total cover. This is the sum total of the cover data for all the community strata.

Ct', Rr', S' and CT' = Data on a scale of 1 to 100.

DI = Deterioration Index. This analyzes the contribution of phytoindicator plants to the richness of climax forests, their vertical structure, and their total cover: DI=Ct'/(Rr'+S'+CT'/3).

DI' = Deterioration Index on a scale of 1 to 100.

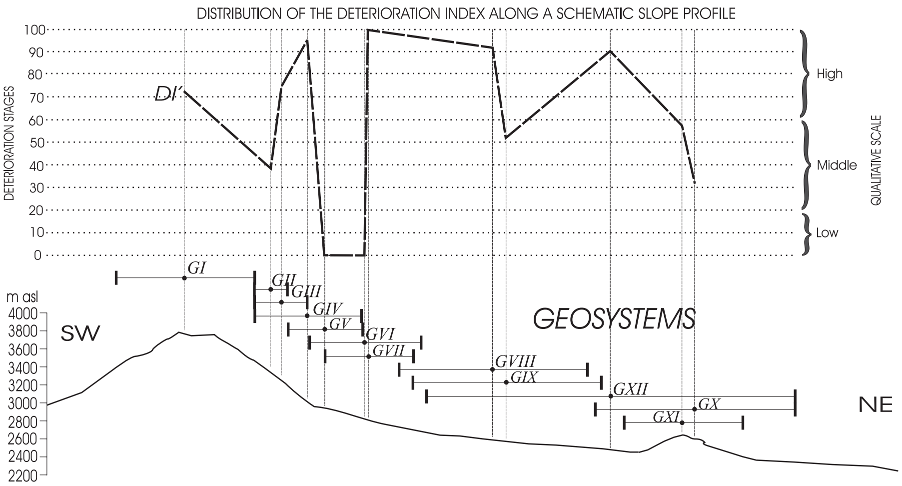


FIGURE 4 Proportion of DIPs in relation to richness, vertical structure, and total cover of climax forest facies.

ta, B. ramulosa, Bouteloua spp, *Eupatorium glabratum, F. amplissima, Geranium mexicanum, Hilaria cenchroides, Penstemon gentianoides, P. leiophylla, Prunus capuli, Q. conglomerata, S. roldana, S. salignus, Thelypodium pallidum,* and *V. virgata*. These are plants that either have been introduced with crops (*Agave ferox)* to tolerate certain disturbance environments (*P. leiophylla* cones tolerate fire) or are native but are favored by their competition abilities under the new conditions.

The DI, which considers the participation of these plant species in richness, vertical structure, and total cover of the climax forest facies, makes it possible to classify forest geosystems according to the present deterioration stage that affects the best preserved forests in each case.

Although an increase in deterioration with greater proximity to Mexico City might be expected, the DI curve shows intercalated high and low values along the slope, which can be explained by the local changes in land use intensity and the response of the different geosystems to damage. The most representative cases are described in the following paragraphs (see also Figure 4).

Forest geosystems of the MA (2800–3580 m)

Human interventions are conditioned by difficulty of access in these mountain areas, whereas forests have a low or medium deterioration stage—DI < 60 in geosystem II (G. II), G. V, and G. VI—and richness, including more than 30 species per geosystem, with most plants that require cold and humid climates belonging to the pine family (*A. religiosa* and *Pinus* spp). Only the *P. hartwegii* (G. I) covering peaks above 3200 m and the *G. laurifolia* forest (G. V) in the large intermontane valleys are geosystems where thermal limitations and agricultural and cattle-raising practices become evident in a simple vegetal structure, with peaks in the DI curve (Figures 4, 6).

On the lower slopes of the mountain border (G. V and G. VI), proximity to the city increases direct physical interventions and, consequently, soil compaction, runoff, modeling, and erosion, all of which are reflect-

Species	A	B	C	D	E	F	G	H	I	NF	DF	DIPv
Abies religiosa	4	4	4	1	2			2		8	9	-1
Acaena elongata	2	2	3	2	2	1	1	2	1	4	12	-8
Adiantum andicola	1	1			1					2	1	1
Agave ferox	1		1	2			1	2		1	6	-5
Alchemilla procumbens	2									2	0	2
Arbutus xalapensis	3	2	2	1	4	1		1		5	9	-4
Arctostaphylos arguta	1	2	2	1	1		2			3	6	-3
Aristida spp	1		1			1	1			1	3	-2
Arracacia atropurpurea	3		1		1					3	2	1
Baccharis conferta	2	2	4		3	1	2	2	3	4	15	-11
Baccharis ramulosa	1							2	1	1	3	-2
Bouteloua spp	2			1			1	1	1	2	4	-2
Buddleja americana	4				1	2	2			4	5	-1
Clethra mexicana	2	1				1				3	1	2
Crataegus mexicana	1	1								2	0	2
Cunila lythrifolia	1		1				1			1	2	-1
Deschampsia pringlei	1							1	1	1	2	-1
Eryngium ranunculoides	1									1	0	1
Eupatorium aschembornianum	1									1	0	1
Eupatorium deltoideum	1							1	1	1	2	-1
Eupatorium glabratum	3	2	5	3	2	1	1	2		5	14	-9
Eupatorium petiolare	2				1		2			2	3	-1
Festuca amplissima	1		1		1			1	2	1	5	-4
Festuca rosei	1									1	0	1
Garrya laurifolia	5	3	3	2	2	2				8	9	-1
Geranium mexicanum	1		2	1	1	1				1	5	-4
Hilaria cenchroides	1			1			1		1	1	3	-2
Malvastrum lacteum	1	1								2	0	2
Mentha canadensis	1									1	0	1
Muhlenbergia robusta	1			1					1	1	2	-1
Penstemon gentianoides	1							1	3	1	4	-3
Phaseolus spp	1									1	0	1
Pinus hartwegii	1		1						1	1	2	-1
Pinus leiophylla	2					1		3		2	4	-2
Potentilla heterophylla	1		1							1	1	0
Prunus capuli	2	2	2	1	2	2	1	2		4	10	-6
Quercus Bourgaei	1		1		1					1	2	-1
Quercus castanea	1	1	1			1			1	2	3	-1
Quercus centralis	3		1	1					1	3	3	0
Quercus conglomerata	1				2	1				1	3	-2
Quercus crassipes	5	1		1	1					6	2	4
Quercus hartwegii	1									1	0	1
Quercus magnoliaefolia	1						1			1	1	0
Quercus mexicana	1	1	1		1			1		2	3	-1
Quercus rugosa	3	2	1	1	1	2		1		5	6	-1
Quercus rugulosa	1	1			1					2	1	1
Ribes rugosum	1		1							1	1	0
Rosa montezumae	1	1							1	2	1	1
Senecio actinella	1		1		1					1	2	-1
Senecio andreuxii	2									2	0	2
Senecio barba-Johannis	6	1	3	1	2	1				7	7	0
Senecio platanifolius	1		1							1	1	0
Senecio roldana	3	2	1	2	3	1				5	7	-2
Senecio salignus	2					1	3	1	3	2	8	-6
Stevia salicifolia	3		2		1	1				3	4	-1
Thelypodium pallidum	1					1	2		1	1	4	-3
Verbesina virgata	1					1			2	1	3	-2
Veronica americana	1							1	1	1	2	-1
Viburnum stellatum	1	1								2	0	2
Viola flageliformis	1									1	0	1

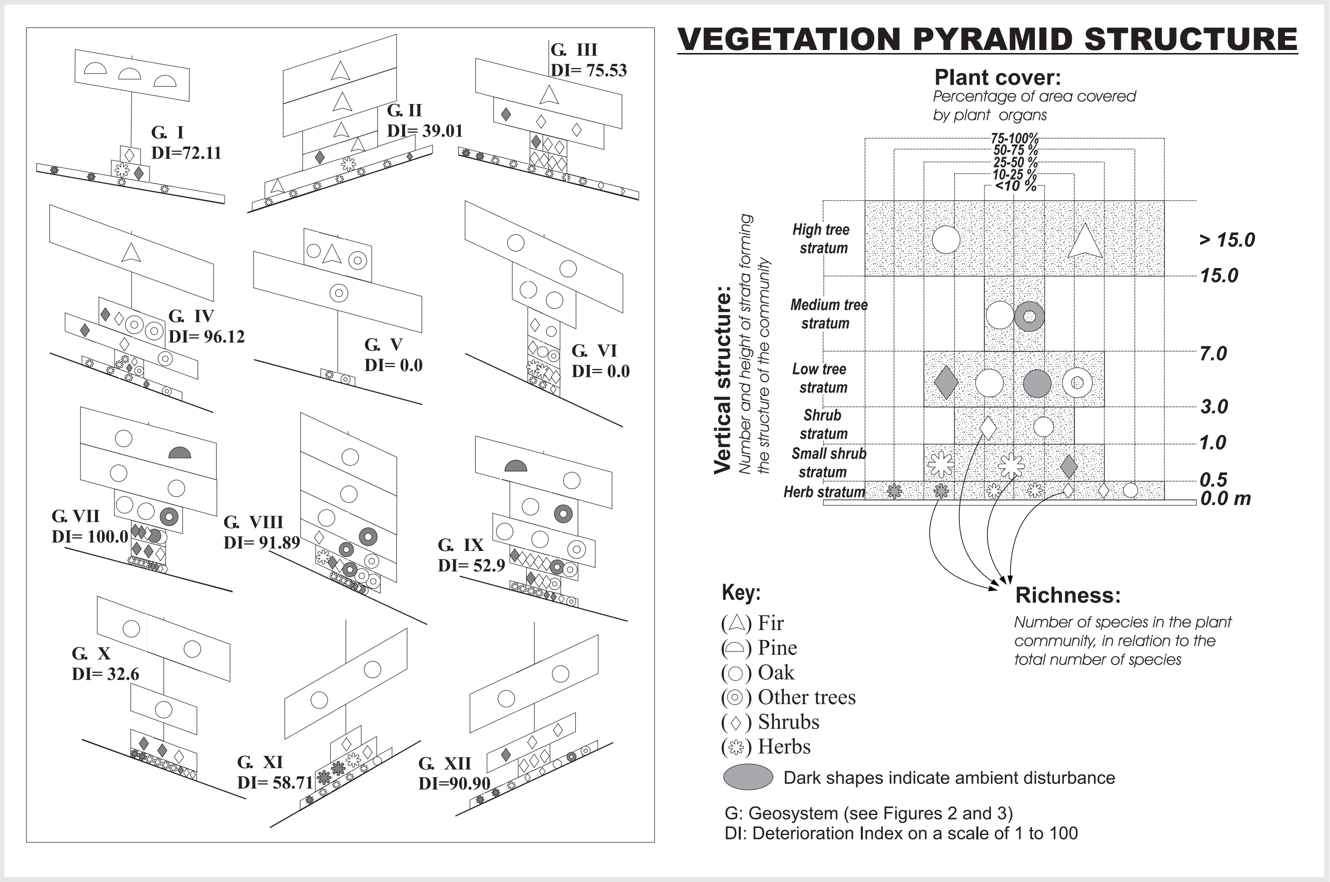
Key:
A-I = Internal facies for the 12 forest geosystems.
A = Climax forest facies.
B-I = Secondary facies in progressive order, as they move away from the climax.
NF = Sum of frequencies for the two facies closest to the climax (A+B).
DF = Sum of frequencies for the facies that are farthest away from the climax, usually shrubs and grassland (C+D+…I).
DIPv = Value obtained by subtracting the frequencies in a deteriorated environment from the frequencies in a stable environment (NF-DF).

▨ Deterioration Indicator Plants (if DIPv = or < -2).

FIGURE 5 Plant frequency obtained for the different internal facies (trees, shrubs, and grasslands) of the 12 forest geosystems and the resulting DIP values (DIPv).

ed in the disappearance of the original "climax stages," as is the case for the subclimax oakwood of G. VI. Nevertheless, this geosystem admits zero participation values for disturbance indicator species (DI = 0.0), reflected as depressions in the DI curve, which can be explained by the high resistance of some oakwood forests to situations of severe disturbance (Figures 4, 6). The most frequent disturbing species in the mountain environment are *Acaena elongata*, *Arbutus xalapensis*, *Arctostaphylos arguta*, *B. conferta*, *E. glabratum*, *F. amplissima*, *Geranium mexicanum*, *Penstemon gentianoides*, *P. leiophylla*, *Prunus capuli*, *S. roldana*, and *S. salignus* (Figure 5).

FIGURE 6 Plant pyramids representing the climax forest facies in the 12 forest geosystems. Species, richness, plant cover, and vertical structure of the plant communities are indicated.



Forest geosystems of the CR (2240–2800 m)

Despite the floristic richness that characterizes temperate oakwood forests, some deterioration is evident—with less than 30 species per community—in most geosystems. The DI in the forest structure and physiognomy is medium or high: DI = 58.71 in low *Q. hartwegii* and *Q. centralis* low oakwood forests (G. XI), and DI = 90.9 in *Q. centralis* with *Stevia salicifolia* forests (G. XII). The peaks in the DI curve have been correlated with proximity to the urban area and mainly with areas of intense urban growth. Consequently, new degradation dynamics appear, such as intense land use change processes and environmental deterioration, that together result in fragmented, pest-infested, unhealthy forests (Figures 4, 6).

The *P. leiophylla* and *Q. crassipes* mixed forest (G. VII) constituted an exceptional case because despite its high location on the slope, it marks the highest point on the DI curve (100.0), interpreted as being a consequence of extensive cover by *P. leiophylla*, whose cones are resistant to fires provoked by agricultural and cattle-raising activities (Figures 4, 6). The remaining geosystems are subjected to the frequent presence of human beings, who favor the incorporation of new species including *Agave ferox, Arbutus xalapensis, Artostaphylos arguta, Aristida* spp, *B. conferta, B. ramulosa, Bouteloua* spp, *E. glabratum, F. amplissima, H. cenchroides, P. leiophylla, Prunus capuli, S. roldana, S. salignus, T. pallidum,* and *V. virgata* (Figure 5).

Conclusions

The identification of disturbance indicator species and their influence on floristic composition and plant community structure is an adequate method for evaluating the environmental degradation that affects the climax facies of forests in disturbed mountains, such as those in western Mexico City, given the high ecological and impact gradients that occur there. The most important results of the present study can be summarized as follows:

- Better knowledge of flora, in this case better knowledge of the ecological significance of some species in central Mexico's temperate forests, is particularly valuable in regions of the world where evaluation and protection of forest areas are lacking.
- Twenty plant species were identified that showed a high degree of correlation with secondary facies removed from the climax and were, hence, linked to human-related dynamics at least under the environmental conditions of the slope studied.

- Forest geosystems in which sufficiently intense degradation mechanisms operate to affect the forests' plant structure were detected (DI = >60 in G. I, G. II, G. III, G. VII, G. VIII, G. IX, G. X, G. XI, and G. XII). Damage varied and became evident in (1) the reduction of plant quality and diversity, (2) greater complexity in the spatial organization of the landscape, (3) new degradation dynamics that exert an excluding effect on numerous plant elements and give rise to changes in the evolution of climax structures, and (4) loss or risk of destruction of some oakwood forests and other valuable (eg, coniferous) forests, which are frequently highly sensitive to environmental changes.
- Comparative analysis of the results obtained in the 12 forest geosystems made it possible to identify the advance of the urban front and the permanence of agricultural and cattle-raising activities as factors that condition the invasion of foreign species and the expansion of other natural species that tolerate the incidence of human activities. Variations in the floristic stock of climax communities are mostly related not to the type of human intervention but to the degree to which intervention modifies the natural system.
- The DI, which measures the participation of deterioration indicator species in richness, vertical structure, and total cover of climax forest facies, and the positive results of which open up the possibility of its application in other areas, was applied for the purpose of evaluating the significance of the presence of certain species within the plant community. The DI adjusted on a scale of 1–100 is a simple but very useful tool that facilitates comparison of results.

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