Degradación de Suelos en los parques Las Peñas-Los Ocotillo, de Ciudad Guzmán, Jal.

Degradation of soils in Las Peñas – Los Ocotillos parks of Guzman City, Jalisco

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Resumen

Los parques Las Peñas y Ocotillos se encuentran al sur del estado de Jalisco, al este de Ciudad Guzmán en la "Sierra del Tigre". El objetivo del trabajo es describir las características de los suelos y analizar el efecto de la pendiente y la materia orgánica en su degradación, en especial la erosión; destaca la importancia de la vegetación de bosque de pino-encino en este proceso. También se establecen las consecuencias ambientales que se tendrían si desapareciera la vegetación actual como resultado de un cambio de uso del suelo. Para lograr el objetivo, se levantó información del medio ambiente natural, para valorar la degradación y estimar la erosión con la Ecuación Universal de Pérdida de Suelo; puntualizando sus efectos en el futuro en el Valle de Zapotlán como zona de sedimentación. También se infieren las secuelas en la Microcuenca "Arroyo el Guayabo" y en la Sierra del Tigre si desapareciera el bosque de pino-encino.

Palabras clave: degradación, erosión, erosividad, erodabilidad, Ecuación Universal de Pérdida de Suelo.

Abstract

The parks Las Peñas and Ocotillos are located in the south of the state of Jalisco, at the east of Ciudad Guzman in "Sierra del Tigre". The target of this study is to describe the characteristics of the soil and analyze the effect of the slope and organic matter degradation, particularly erosion; it's important to stand out the relevance of the pine-oak forest vegetation in this process. It's also set the environmental consequences if the current vegetation disappears as a result of a change in land use. To achieve this target, it was picked information of the natural environment, to assess degradation and erosion estimated with the Universal Soil Loss Equation; emphasizing their effects in the future in the Valley of Zapotlán as a settling zone. It's also inferred the consequences in the watershed "Arroyo Guayabo" and in the Sierra del Tigre, if the pine-oak forest disappears.

Key words: erosion, erosivity, erodability, Universal Soil Loss Ecuation (USLE).

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Introduction

This research is about the degradation of the soil of the parks Las Peñas – Los Ocotillos, and was carried out to support the Declaration of the parks as conservation areas, although it may be useful to understand the dynamics of the environment in the region. An important part of the parks Las Peñas – Los Ocotillos is occupied by a vegetation of pine-oak and pine in the higher portions; It's the vegetation that prevailed in the Sierra del Tigre. The places where there was a relatively recent deforestation are covered by a secondary vegetation either were reforested with eucalyptus and casuarinas. Degradation is characterized in each of these environmental conditions, as well as the environmental effects that are both in the study area and in the area of sedimentation. Likewise, the environmental conditions that would be as a result of the disappearance of the vegetation are inferred. Work serves to justify to the parks as conservation areas, but may also be useful to illustrate the process whereby Los Guayabos watershed and Sierra del Tigre are located, where there is a logging and the original vegetation is being replaced by the cultivation of avocado**.**

Materials and methods

To analyze the degradation of the soil of the parks Las Peñas – Los Ocotillos was designed a field format with the variable strategic work, lifted on previously established and representative of the main areas of degradation of the parks environmental units. Sampling was recorded according to the *Soil Survey Manual* (1998) and the Guide for the description of profiles of FAO (2002). During the uprising were also made measurements with the torque wrench Torvane and the penetrometer (Pocket Penetrometer) to characterize the mechanical properties of soils. This description was supplemented with sampling in the surface horizon.

Samples were dried in the shade and then a part served to establish the grading curve, consistency limits, and the percentage of very fine sand. The other part was used to determine the texture with the method Bouyucos, the organic matter with Black procedure. For his part, bulk density was estimated with triangles of the Soil Survey Manual procedure, insofar as the percentage of water was estimated at capacity (CC) field and the (PMP) permanent wilting point, by means of tables (Juarez, 2011). During this stage was also established the water stability of agreement to *Motitorig Manual for Grasslands, Shrubland and Savanna Ecosystems*, the degree with which the soil repels water with the procedure of *Water Repellence* (Mackenzie N., Coughland K. & H. Cresswell, 2002).

With the results estimated the loss of erosion with the Universal Soil Loss Equation. Classification of erosion was established through the System of Codes to assess Erosion in the field, as proposed by Morgan (1997).

Results

The floors of the Rocks-Ocotillo parks have features that are related to the different elements of the landscape or the environment, such as relief, climate, geological material and organisms; the latter emphasizes the vegetation, which is dependent on soil as this is supported, water and nutrients necessary for their development; but, in turn, the floor has a granular structure characteristics, low density, high porosity, good aeration, etc., depending on the vegetation; even it protects against degradation, especially water erosion, as well as processes landslides and rapid mudslides or landslides.

Most soils in the area have a sandy clay loam texture, which are classified as cohesive soils because they have more than 15% clay, ie, are more or less stable; However, this feature does not protect the rapid landslides that may occur during times of saturation (Figure 1).

Therefore, care must be taken with the cuts that are made during the construction of roads, which should always consider the appropriate infrastructure to protect conservation practices slopes.

Figure. 1. Example of detachment in a vertical section of a sidewalk at the top of Parque las Peñas

According to the tests without settling dispersant that most of the samples of surface horizons were performed, the clay soil of the study area is very active, suggesting, according to Brady (2002) and Hillel (2008), the inorganic colloid prevailing in the study area is kaolinite. However, this colloid is important in soil behavior and that gives cohesion.

According to the particle size, are coarse soils because of a representative sample, only 28.8% passed through 200 mesh (0.074 mm); in a more specific manner, they are gritty and that over 99% of the sample passes through 4 mesh (4.76 mm). According to the grading curve, the floor has a D10 of 0.025 a 0.062 D30 and D60 0.23[1], So that the uniformity coefficient is 9.2 and its curvature coefficient is 0.66, while its effective size is 0.025 mm. According to these data, the soil is classified as well graded, ie, has a wide range of particle size classes, with appreciable amounts of each size class in the intermediate categories. Such soils have an acceptable mechanical behavior (Figure 2).

[1] D_{10} es el diámetro máximo del 10 % más pequeño de la muestra. D_{30} y D_{60} se definen con los mismos términos.

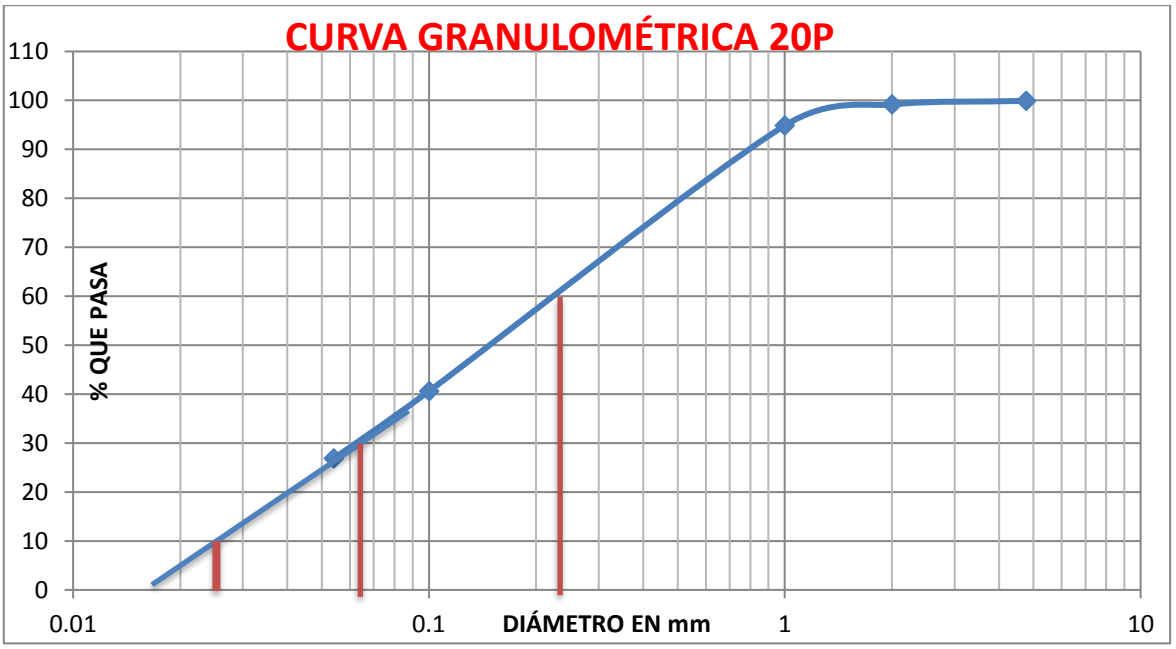

Figure 2. Curva *granulométrica* del pozo 3 del Parque las Peñas.

Thanks to the natural vegetation most soils have a fine grain structure of a moderate size and development, with a strong development in the least degraded sites. Its tensile strength is very friable wet, but is friable in places where the forest is better preserved. Because of these characteristics it shows that the least degraded soils have a density of 1.19 g / cm3 and 1.22 g / cm3 the most degraded, which correspond to the Ocotillos Park. Considering this density, the estimated porosity is 55% in most of the soils of Parque las Peñas and 51% in the Park Ocotillos. According to these characteristics, we can say that the soils of the study area have excellent ventilation, so it is important for all organisms living in the soil.

According to the texture and organic carbon content, the water content in the field capacity (CC) ranges from 26.53% to 18.27%; the wilting point (PMP) of 15.79% to 10.87%; as long as the available water goes from 10.73% to 7.40%. That is, more or less correspond to the upper range of loam (Table I).

Table I. Results of topsoil wells parks penalties and Ocotillos.

POZOS	TEXTURA	% ARCILLA	% C.	C.C.	P.M.P.	A.A.
1	FA	18.72	3.65	26.49	15.76	10.73
2	FRA	31.44	5.79	26.53	15.79	10.46
3	FRA	24.72	2.55	25.15	14.96	10.18
4	FA	19.44	3.01	19.21	11.43	7.78
5	FRA	25.44	4.82	25.81	15.36	10.45
6	FRA	22.0	2.65	18.48	16.61	11.30
7	FRA	19.28	3.9	18.48	11.00	7.48
8	FA	16.0	4.15	23.40	13.92	9.48
Litosol	FAR	31.44	3.03	18.27	10.87	7.40

Nota: C. = Carbono Orgánico: C.C. = capacidad de campo; P.M.P. = punto de marchitez permanente; A.A. = agua aprovechable.

The presence of the forest causes the organic matter content is high; indeed, the amount of organic carbon is 4.82% to 2.55%. The most important values are in places where the natural vegetation is better preserved, ie, in the well 2 is also high in the structural terrace where the vegetation has further degradation, even has been replaced by a tropical deciduous forest; but being a convergence zone of the adjacent uplands provide funding through the side illuviation colloidal materials, among which is humified organic matter (well 5). It is also substantial in the lower third of the slope of the park Ocotillos. In this case, the high organic matter content may be due to the lateral component eluviation this soil.

Figure 3. Capa de *litter* de un espesor de 5 cm en el pozo 4.

Forest vegetation that promotes the study area is presented litter layer or horizon O (Figure 3). The thickness of this layer is related to forest conditions; which is better preserved thickness of the organic layer is higher. This layer, with the undergrowth called not only protects the soil from erosion, but also prevents direct solar radiation to reach the ground and avoid heating it, resulting in a cooling effect that fosters an attenuated weathering of minerals and low mineralization of organic matter; the latter explains the relatively high amount of organic matter with the soil of the parks the pains and Ocotillos. The presence of the layer of litter with the granular structure of the minerals horizons and to infiltration high, much higher than rainfall intensities that occur in the region. Obviously, this process contributes to feeding the aquifers and springs expenses that occur in the lower parts of the forest.

Effects on the floor deforestation

If the forest disappears the granular structure of the surface layers is transformed into a block structure or a compact layer accompanied with a crust on the surface; this amendment would cause a decrease in infiltration and, therefore, a leeway in the aquifer storage, which would result in a decline in spending from the springs of the area or even their disappearance. The decrease in infiltration would also bring an increase in runoff, which would favor an acceleration of erosion at the site imply a decrease in the horizon, which is one of the most important soil; this reduction of topsoil would be accompanied by the loss of a large amount of organic matter and nutrients. Meanwhile, in the lower parts increased sediment would cause plugging problems in the hydraulic infrastructure of the urban area or clogging of the channels, which could result in storms possible overflows in the beds of the lower parts it would, resulting in increased flooding of areas adjacent to the runways. In addition, the bodies of water in low-lying areas further accumulation of nutrients washed away by runoff would be reflected in eutrophication problems that could affect the availability of oxygen for aquatic life in water bodies of the lowlands it would.

The disappearance of the forest would mean the disappearance of litter layer, which would result in the reduction of organic waste that protect the soil from water erosion, mainly rain, the laminar of spills and concentrated. The latter would cause the appearance of gullies which eventually would lead to a modeling badlands (bad lands). Fading litter layer also favor an increase in the average temperature of the soil, which would lead to increased weatherability and mineralization of organic matter, which, in turn, would facilitate a decrease in organic matter. This rise in breakdown contribute to a greater contribution of carbon dioxide and

methane into the atmosphere, compounds would be formed from the liberated carbon is sequestered in the organic matter in the soil with vegetation. Thus, forest destruction contribute to global warming.

As already mentioned, the disappearance of the forest would also imply a decrease in soil organic matter would be reflected in an increase in bulk density, which is manifested in a decrease in porosity, which would be below 50%. This reduction in porosity, together with the presence of a crust on the soil surface would produce a loss of aeration, which would enable the emergence soil in the study area of unfavorable conditions for the development of organisms, especially for the roots of the vegetation.

Without the forest they would cease to exist many environments found in the soil, which would imply the disappearance of many bodies which have a role in the environment. Moreover, the lack of vegetation cover would be accompanied by the dissipation of the root system that keeps the soil on steep slopes that are prevalent in the parks; so the erosion and landslide processes would increase, as shown in degraded areas surrounding the parks studied (Figure 4). According to the data of Tables 2 and 3, it should be emphasized that the steep slopes that characterize the study area, deforestation can increase erosion of 11 to 14 500 times with respect to the unchanged areas with vegetation (Tables III and IV).

Figure 4. Traces of translational landslides known as pickets in a village close to the parks penalties and Ocotillo.

In short, if it disappeared vegetation degradation is greatly increased, mainly erosion; in soil productivity and the ability of the soil to support vegetation is reduced. The site called topsoil lose and what would be the underlying strata who lack the necessary for optimal development of vegetation characteristics. As already explained, a depletion of nutrients, loss of organic matter on the surface appear phenomena such as crusting that would prevent the emergence of roots also decrease the soil's ability to store carbon would occur. To make matters worse, the disappearance of vegetation cover and litter that comes in forests, would cause an increase in the average temperature of the soil, which would accelerate mineralization and the subsequent production of carbon dioxide and methane.

Characterization of degradation

In the study area dominated by steep slopes, so the risk of erosion it is very large; For this reason, the land more than 19 °, which are predominant in the parks analyzed, should not be touched; the implementation of conservation practices even suggested to guarantee the permanence of soil (Figure 5).

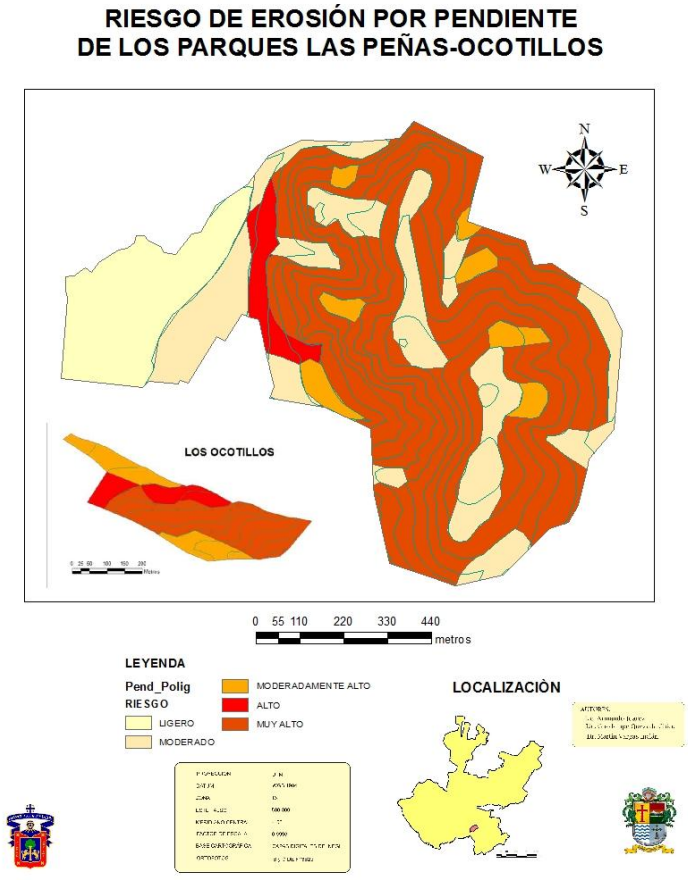

Figure 5. Susceptibility to erosion Slope study area.

According to the National Meteorological Service (SMN), in the region where the study area falls an average annual rainfall of 717.8 mm, so that when applying the formula Forunier a rainfall erosivity of 118.6 was had. According to Morgan (1997), this estimator undervalues erosivity, so estimator Rosse, which resulted in 620,897 was applied. In applying the estimator Morgan a score of 498.92 was taken. According to the author cited above, these formulas generate closest to reality results, so when handling an average of these estimators 559.9 was obtained, which is handled in this study.

Table II. Features necessary to estimate soil erosion in the study area.

PERFIL	% AF	% L	% A	MO	ESTR.	PER.	PEND	LONG.	USO	PRAC
1	13.13	7.28	74	6.3	Granular	Rápida	15.8	20	Bos.Med.Per	-
2	9.95	16	61.3	9.9	Granular	Rápida	52	15	Bos.Poc.Per	-
3	19.7	18	62.7	4.4	Granular	Rápida	28	15	Bos.Alt.Per	-
4	11.1	18	66	5.2	Granular	Rápida	40	20	Bos.Alt.Per.	-
5	10.0	8	84	8.8	Granular	Moderada	4	40	Matorral	-
6	11.4	8	84	4.7	Granular	Rápida	57	20	Bos.Alt.Per.	-
7	10.4	12	63.3	6.7	Granular	Rápida	60	15	Bos.Alt.Per.	-
8	15.3	2	76	7.2	Granular	Rápida	57	30	Bos.Alt.Per.	-
Litosol	11	10	58.7	5.2	Granular	Rápida	10	10	Selva Baja	-

Nota: % AF = Porcentaje de arena muy fina; % L = Porcentaje de Limo; % A = Porcentaje de Arena; MO = Porcentaje de materia orgánica; ESTR = Estructura; PER = Permeabilidad; PEND = pendiente en %; LONG = Longitud de la pendiente en metros PRAC = Práctica de conservación. **En los datos**: Bos.Med.Per. = Bosque medianamente perturbado; Bos.Poc.Per. = Bosque poco perturbado; Bos.Alt.Per. = Bosque altamente perturbado.

To estimate the erosion in each of the environmental units Universal Soil Loss Equation was used. The data used in this procedure are shown in Table II. These data highlight the presence of natural vegetation, which explains the high percentage of organic matter and the granular structure presented on the floor. As it is an area where the natural landscape dominates no apparent conservation practices are observed, although the implementation of these is desirable to preserve the main resources of the park, which are the vegetation and soil.

According to Table III, the current soil erodibility Park Ocotillos penalties and was classified as very low, since all are below 0.1. Meanwhile, the LS (slope length) factor found is from 0.8 to 20, with the lowest values in the structural terraces low slope (points 3, 5 and Litosol) and the highest values in the portions of the slopes known as slope with gravel (points 1, 4, 6, 7 and 8) and in the part of the slope known as shoulder (convex projection). On the other hand, use the management factor, vegetation cover that predominated in the study area ranged between 0.001 and 0.9; with the lowest values in areas where the natural vegetation is better preserved, as in the well 2. According to the results, soil parks Las Peñas are better preserved than those corresponding to the Ocotillos Park. In the Parque las Peñas, only about 5 presents

relatively high values, however, this is a structural terrace slope, so its effect on the overall erosion is relatively low.

The average annual erosion found in almost every corner of the Parque las Peñas is from 0.11198 to 1.3771755 t / ha / year, so it was classified as none or mild, since it is less than 10 tons / ha / year. Just point 5 amounted to 8.651612 ton / ha / year, however, erosion on this site was also ranked as none or mild. The highest values were found in the Park Ocotillos, where the average annual soil loss was estimated 25.1955 ton / ha / year to 55.99 tons / ha / year. Compared to soil the Parque las Peñas, these values are a reflection of the greater degradation of the Park vegetation presents the Ocotillos, which, in turn, leads to greater degradation in soils that support it.

Table III. Parameters found for calculating the current soil erosion in the area.

POZO	*Ri*	*Kf*	*Kw*	*LS*	*C*	*P*	*EROSIÓN*
1	559.9	0.02		2	0.005	1	0.11198
2	559.9	0.02		13	0.001	1	0.145574
3	559.9	0.07		5	0.007	1	1.371755
4	559.9	0.05		10	0.003	1	1.39974
5	559.9	0.03		4.4	.0.09	1	8.651612
6	559.9	0.02		17	0.003	1	28.5549
7	559.9	0.02		15	0.003	1	25.1955
8	559.9	0.02		20	0.005	1	55.99
Litosol	559.9	0.01	0.02	0.08	0.09	1	4.03128

Nota: Ri = Erosividad de la lluvia; Kf = Erodabilidad de la tierra fina; Kw = Erodabilidad tomando en cuenta la pedregosidad; LS = Factor pendiente y longitud; C = Factor uso y manejo; P = Factor prácticas de conservación. Los datos de la erosión se presentan en ton/ha/año.

If vegetation disappear abruptly decreases the amount of organic matter, possibly to values below 1%; without supplying source of organic matter, the granular structure to change subangular blocky or, in the worst cases, a crusting be generated on the surface. These changes would favor a decrease in infiltration and, therefore, a significant increase in the erosion. The changes would be reflected in erodibility, which would reach values of 0.26 to 0.35, which would be classified as moderate.

Obviously, the rainfall erosivity and LS factor would remain the same; but use the management factor, the low values you have, come to 1. Therefore, the loss of soil by water erosion would reach values ranging between 44,792 ton / ha / year and 8398.5 ton / ha / year. According to these results, most of the points loss by water erosion would be classified as very high and only one of the points corresponding to Litosol, would be classified as moderate. Indeed, the sites are on slopes with gravel losses would have extremely high erosion higher than 1000 t / ha / year values. For its part, the sites classified as structural

terraces, points 5 and the site where the Leptosol Lítico (Litosol) have values ranging between 44.79 ton / ha / year and 640.26 ton / ha / year (Table IV).

Table IV. Parameters for the calculation of erosion disappear if the natural vegetation in the study area.

POZO	*Ri*	*Kf*	*Kw*	*LS*	*C*	*P*	*EROSIÓN*
1	559.9	0.28		2	1	1	303.544
2	559.9	0.29		13	1	1	2110.823
3	559.9	0.35		5	1	1	979.825
4	559.9	0.26		10	1	1	1903.66
5	559.9	0.26		4.4	.1	1	640.2556
6	559.9	0.27		17	1	1	9518.3
7	559.9	0.26		15	1	1	8398.5
8	559.9	0.26		20	1	1	11198
Litosol	559.9	0.28	0.30	0.08	1	1	44.792

Nota: Ri = Erosividad de la lluvia; Kf = Erodabilidad de la tierra fina; Kw = Erodabilidad tomando en cuenta la pedregosidad; LS = Factor pendiente y longitud; C = Factor uso y manejo; P = Factor prácticas de conservación.

Conclusions

In the study area is dominated by greater than 19 ° slopes, therefore, it is an area very susceptible to water erosion processes and landslides. For this reason, soils parks penalties and Ocotillos are fragile and constantly being rejuvenated; Still, it took hundreds of years to form. However, by their nature may be degraded or disappear rapidly through carelessness or improper soil management.

The vegetation is important, especially the tree, with its deep roots are constantly recycling nutrients, sucking them horizons and deep layers of the profile and returning them to the surface. In addition, vegetation not only acts as a shield against erosion, but works like a blanket that holds the soil in place; thus the deep roots act as anchors to prevent displacement of the downslope soil.

Today the forest floor has several functions in the environment; therefore disappear if the forest soil-aquifer system would be lowered soil-related parks and therefore diminish spending springs; sediment and nutrients that carry runoff would accrue, which are deposited in the lower parts of the relief, especially in urban areas, where technicians would cause environmental problems and water infrastructure by increasing sediments; also it increases the runoff, with a consequent increase in flooding in the urbanized part; the supply of soil carbon dioxide and methane would also increase as the carbon sequestered by the soil of the parks would be released; thus the destruction of forest vegetation contribute to global warming.

Hence the importance of preserving the forest-soil system as it is vital and essential for the population receiving the aforementioned environmental services.

As in most of the surface of the earth, the degradation is most striking in the study area is water erosion; ie erosion caused by the impact of raindrops on the runoff in sheet form and small streams of water flowing downhill. Therefore, if the forest was struck, runoff, which would result in accelerated erosion could leave as trace modeling of badlands (bad lands) is significantly increased, where the concentrate drain lines turned into gullies flow transported thousands of tons of soil downslope.

The present study is an example of the processes taking place in the forest and those that would be generated if a change in land use was given, especially if forest areas were transformed into agricultural or urban areas. This is happening in the watershed the Guayabos where the study area is located, but also throughout the Sierra del Tigre where there is deforestation by logging out of control and the introduction of the cultivation of avocado.

As elsewhere, soil degradation is related to the degradation of vegetation; and according to the results, the sites where the forest is more deteriorated as the Parque Los Ocotillos are also the places where the highest rates of soil degradation are presented. All layers of the profiles, the most critical are the surface as the litter and the horizon, they are where they enter the water and nutrients to the soil; but also it takes place where gas exchange between the outside atmosphere and the soil atmosphere. Due to its characteristics, in the horizon the seeds germinate; It is also the horizon where organic matter originating from the decomposition of the remains of organisms, or where this is lost accumulates mineralization. These layers play a strategic role in the ecosystem are the most vulnerable, especially litter layer that may cease to exist if the forest is removed; meanwhile, the horizon is would compact and scabs form on its surface or disappear entirely by erosion, with all the environmental implications involved.

According to the above, it is not only essential to preserve the forest, but also accompany this action effective conservation practices that can eliminate or reduce the degradation processes affecting parks.

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