



EVALUATION OF THE HABITAT OF THE WHITE TAIL DEER (*ODOCOILEUS VIRGINIANUS*) IN THE PROTECTED NATURAL AREA, STATE PARK "FLOR DEL BOSQUE", PUEBLA, MEXICO

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**ABSTRACT:** The conditions of the white tail deer's habitat (*Odocoileus virginianus*) were evaluated in the Protected Natural Area (PNA), State Park Lázaro Cárdenas del Rio General "Flor del Bosque" (SPFB), by means of the methodology of Transecto Steps along Direct and Indirect Points, in transect of 500 meters of length for type of vegetation. The types of predominant vegetation in the SPFB are oak forest, mixed forest and scrub-grassland. The oak forest presents the major extension with 59 % in the PNA followed of the scrub-grassland and the mixed forest, 30 % and 11 % respectively. The oak forest presented the best conditions of habitat that other vegetative types, it presents the major percentage of basal coverage in both epochs of the year, low water and rains respectively (52.03 % and 53.06 %). In addition it presents the minor percentage of bare soil in the epoch of rain with 5.07 %, and percentages of organic humus of 39.43 % and 41.87 % in epochs of low water and rains respectively. It is recommended a vegetable gradual alteration of damaged or eroded areas in the mixed forest of the SPFB, across the implantation of native species to assure the conservation of the habitat of the cervid.

**Key words:** PNA, SPFB, vegetation, oak, cervid.

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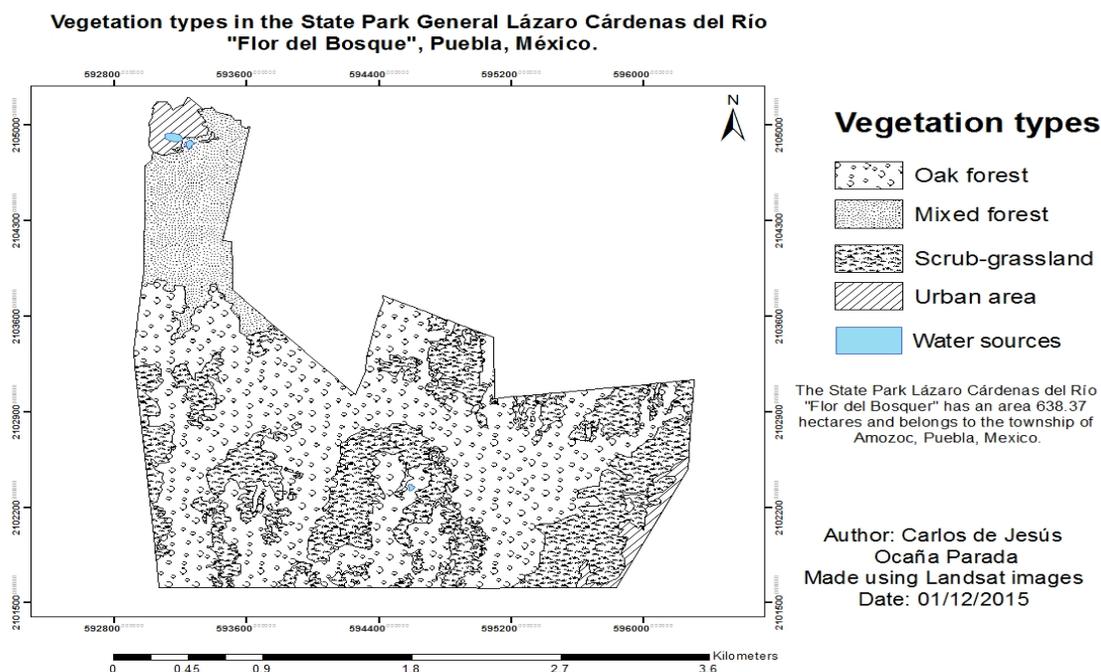
## INTRODUCTION

The white tailed deer (*Odocoileus virginianus*: Zimmerman, 1780) is one of the most important and charismatic species of wild, due to its hunting potential [1]. This species is the animal of big game hunting most harvested in the game in Mexico and North America [2, 3, 4]. The habitat for the white tail deer must be a site that provides the essential elements for the survival of the species, such as water, food, coverage and space [5, 6]. The space considers to the first three requirements, since a sufficient space allows the access to the necessary water, the supply and the coverage. The quantity of space is determined by the patterns of distribution and use of the habitat by the deer [5, 6]. The availability of the basic requirements of the habitat defines the presence or absence of this and other species of wild fauna in a particular habitat [7, 8]. The evaluations of the habitat imply knowing the characteristics that present the area that habit a certain species; it comprises a series of components that influence in a direct way the number and distribution of the animals.

Likewise, in case of the conservation and sustainable utilization of the white tail deer, the study of habitat is priority for the managing and must include the knowledge of the basic needs of the species. The fundamental objective of the Protected Natural Area (PNA) State Park General Lázaro Cárdenas "Flor del Bosque" (SPFB), is to support a viable population of white tailed deer of the "*mexicanus*" subspecies, as well as the conservation of the habitat, the natural resources and the ecotourism. It comprises a population absolute density of deer between 36.03 and 40.6 animals, in dry epoch and rains, which corresponds to relative population densities of 5.64 and 6.35 deer /km<sup>2</sup>, or 17.73 and 15.74 ha / deer respectively [9]. The objective of this study is to characterized the habitat of the PNA of the SPFB, to establish recommendations that allow to improve its conditions of conservation and managing; as well as to present a list of the principal species of wildlife of the site.

### Zone of study

The study was realized in the Unit for the Management and Wildlife Conservation (UMA) of the SPFB, which is PNA of category of State Park, with a surface of 638.37 has. of available habitat [10, 9]. This PNA, is located in the following geographical coordinates: 19 ° 00 ' 00 " and 19 ° 01 ' 50 " of north latitude; with 98 ° 20 ' 35 " and 98 ° 20 ' 53 " of westlongitude; and it is placed to 11 km from the Puebla city and belongs to Amozoc's township, Puebla state, Mexico [11]. It presents a moderate sub-humid climate with rains in summer, the average annual temperature is of 18 °C and the average annual rainfall is 800 mm, and it possesses an altitude from 2200 to 2470 masl [10]. Its vegetative types are [9]: oak forest, mixed forest and scrub-grassland (figure 1). The oak forest presents a total surface of 362.39 has., with an altitude from 2200 to 2470 masl, the species of oaks *Quercus rugose*, *Quercus obtusata*, besides *Juniperus deppeana* among other species [12]. The mixed forest has a surface of 69.10 has., with an altitude from 2267 to 2298 masl., with a composition of vegetation of eucalyptus (*Eucalyptus resinifera*) and oak (*Quercus rugose*). Finally, the scrub-grassland has a surface of 185.1 ha. Its altitude changes between 2308 and 2324 masl., where there are a lot of very adapted families and genres to the drought, such as leguminous, cactus, agaves, euphobiaceae and graminaceous plants among other [13].



**Figure 1. Types of vegetation in the UMA State Park General Lázaro Cárdenas del Río "Flor del Bosque", Puebla, México**

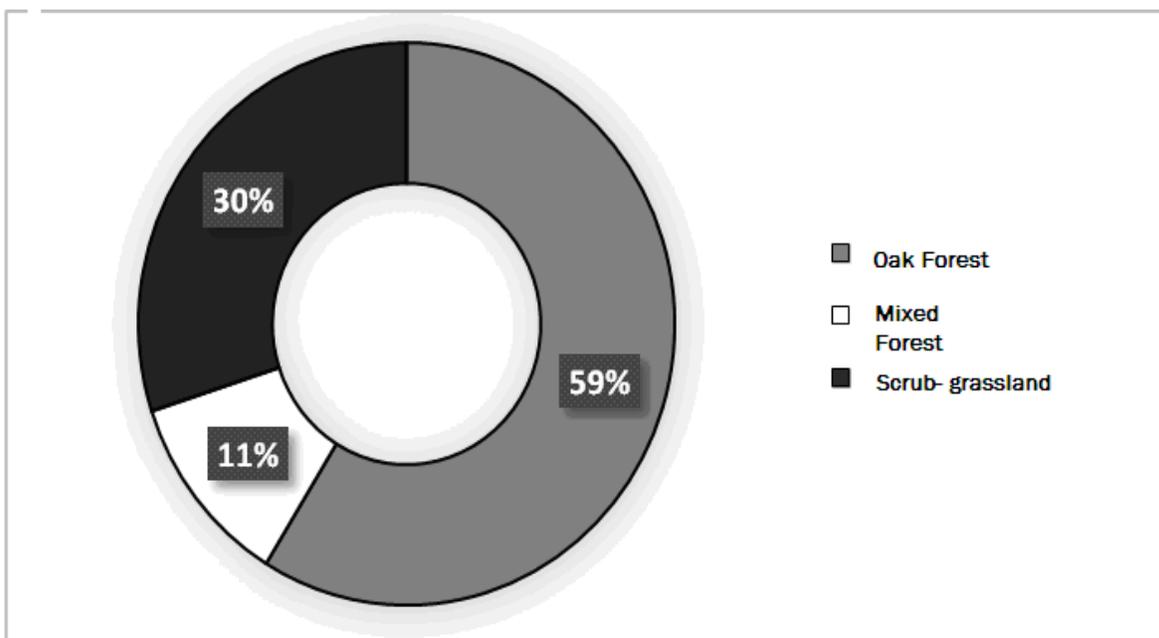
### MATERIALS AND METHODS.

The used methodology was the transect to Steps by Direct and Indirect Points with Cane, modified [14, 15]. This methodology has been used by the COTECOCA (Commission Technician Consultative for the Regional Determination of the Coefficients of Summer Pasture) [16, 17] [16, 17], due to the fact that it is applicable to all the types of vegetation, including the tropical, subtropical and desert areas [18, 15].

First, the points of sampling inside the habitat where the species is distributed in natural form were identified, six transects were realized (two transect for every type of vegetation) of 500 meters long. At the beginning, a record in a field sheet with the annotations of plant's species that were found below or immediately to the top of the cane, after every two steps was used. The species located below the cane were annotated like direct, if none was found, it was considered like of indirect type, the first plant located in an angle of 180 ° immediately at the head of the cane. When one was found under the cane bare soil, stone or organic humus, they were annotated as direct points. The total of direct points of the species of considered plants, determined the percentage of vegetable basal coverage of the sampled area. The sum of the indirect points of soil and stone provided the bare area. From the organic humus, there was obtained a value considered as percentage of coverage of the soil to anticipate the erosion. The evaluation was realized two times a year, during the season of low water, and during that of rains at the end of the growth of plants. In addition with the direct and indirect points, there was decided the average height of every vegetable stratum: pastureland, herbaceous, shrubby and arboreal. Finally, there was obtained a list of the more important species of flora and fauna inside the SPFB. The program IBM SPSS Statistic, by means of a test of Tukey and ANOVA, using non-parametric variables, analyzed the results statistically.

## RESULTS

In relation to the vegetative types, the oak forest presents the major percentage of vegetation (59 %) (Figure 2), followed by the scrub-grassland and the mixed forest, respectively.



**Figure 2. Percentages of vegetative types in the SPFB, Puebla, México**

By the characterization of the habitat six transects were planned in the total surface of the PNA, two for every type of vegetation in the epoch of low water and of rains respectively, representing a total of 4.320 points of sampling. The characterization of habitat for type of vegetation in the epoch of low water appears in Table 1, obtaining that by means of Tukey's statistical test exist significant differences ( $P < 0,05$ ) among the characteristics of the habitat (percentages of soil, rock, humus and basal coverage) in the different types of vegetation. In case of the mixed forest showed major % of bare soil (31.05 %) in relation with the oak forest and scrub-grassland, this might be to the high concentration of eucalyptus (*Eucalyptus resinifera*) and its process of intensive growth and superficial runoff that tend to reduce the quality of the water and the nutritional quality of the soils [19]. The major percentage of humus appeared in the scrub-grassland (45.04 %) in comparison of other types of vegetation, and in relation to the percentage of basal coverage the oak forest resulted to be the major one with 52.03 %.

**Table 1. Characterization of the habitat for type of vegetation in the SPFB in epoch of low water**

Type of vegetation	% Soil	% Rock	% Bare Soil	% Humus	% Basal coverage
Oak forest	4,87 a (.011)	3,65 b (.011)	8,52 b (.011)	39,43 b (.011)	52,03 c (.011)
Mixed forest	22,00 c (.014)	9,05 c (.008)	31,05 c (.014)	20,25 a (.008)	48,27 b (.008)
Scrub-rassland	5,37 b (.014)	2,89 a (.011)	8,26 a (.014)	45,04 c (.008)	46,69 a (.011)

Literal column (a, b, c) they indicate significant differences P <0.05 in Tukey's test. Bare soil =? Soil and rock. Standard mistake (E.S).

In the Table 2 the characterization of the habitat appears for type of vegetation in the epoch of rains, obtaining significant differences (P <0,05) among the characteristics of the habitat (percentages of soil, rock, humus and basal coverage) with the types of vegetation. Likewise the percentage of bare soil is major in the mixed forest (29,04 %), the percentage of higher humus in the scrub-grassland (46,9 %) and the percentage of basal coverage in the forest of the oak forest (53,06 %).

**Tabla-1. Characterization of habitat by type of vegetation in the SPFB in epoch of rain**

Type of Vegetation	% Soil	% Rock	% Bare Soil	% Humus	% Basal Coverage
Oak forest	3,19 a (.011)	1,88 a (.014)	5,07 a (.008)	41,87 b (.008)	53,06 c (.017)
Mixed forest	20,91 c (.014)	8,13 c (.011)	29,04 c (.014)	22,03 a (.011)	48,90 b (.011)
Scrub-grassland	4,32 b (.012)	2,07 b (.011)	6,39 b (.011)	46,9 c (.014)	46,71 a (.014)

Literal column (a, b, c) indicates significant differences P <0,05 in Tukey's test. Naked soil= Soil and rock. Standard mistake (E.S).

In relation to the average height of every vegetative stratum (pastureland, herbaceous, shrubby and arboreal) for the dry season (Table 3), the ranges of average height go from 0,17 meters in the stratum pastureland to 12,13 meters in the arboreal stratum of the oak forest. It is necessary to indicate that statistically significant differences were observed (P <0,05) between the heights of the vegetative stratum and the types of vegetation, with exception of the arboreal stratum in the oak forest and the mixed forest; similarly in the bush stratum in the mixed forest and the scrub-grassland. For the case of the average height of the vegetative stratum rain season (Table 4) the ranges of average of height ranges from 0,24 meters of the stratum pasture pastureland until to 12,15 meters in the arboreal stratum in the oak forest, presenting a small variation due to the growth of the same ones. In addition, significant differences were presented (P <0,05), between the oak forest and the scrub-grassland.

**Table-3. Average height of the vegetative stratum (meters) in every type of vegetation of the SPFB in the dry season**

Type of vegetation	Grassland	Herbaceous	Shrubby	Arboreal
Oak Forest	0,17 a (.008)	0,83 a (.017)	1,8a (.145)	12,13 b (3.31)
Mixed Forest	0,21b (.011)	1,12b (.011)	2,03 b (.011)	10,63 b (.017)
Scrub-grassland	0,24c (.014)	1,15c (.014)	1,93b (.017)	3,53 a (.017)

Literal column (a, b, c) indicate significant differences P <0.05 in Tukey's test. Standard mistake (E.S).

**Table-4. Average height of the vegetative stratum (meters) in every type of vegetation of the SPFB in the rain season**

Type of vegetation	Grassland	Herbaceous	Shrubby	Arboreal
Oak Forest	0,24 a (.008)	1,08 a (.008)	1,93 a (.005)	12,15 c (.014)
Mixed forest	0,28 b (.008)	1,17 b (.011)	2,11 c (.011)	11,0 b (.011)
Scrub-grassland	0,30 b (.008)	1,20 b (.011)	2,07 b (.008)	4,03 a (.014)

Literal column (a, b, c) indicate significant differences P <0.05 in Tukey.'s test standard mistake (E.S).

The scrub-grassland presents the main height of vegetative strata with the exception of the arboreal and bush ones, so much in epoch of low water and of rains. The main arboreal height is in the oak forest, and the main bush height appears in the mixed forest in both epochs (Figures 3 and 4).

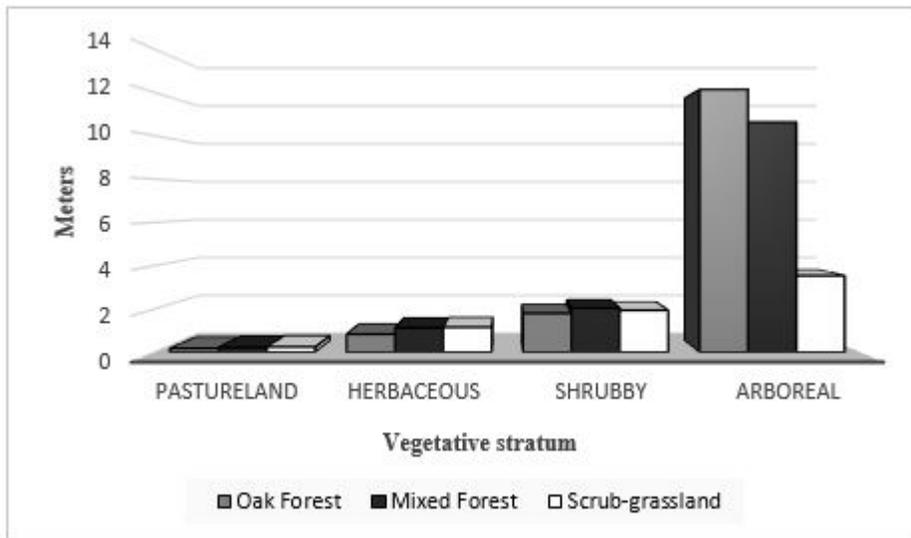


Figure-3. Average Height vegetative stratum in the dry season in the SPFB

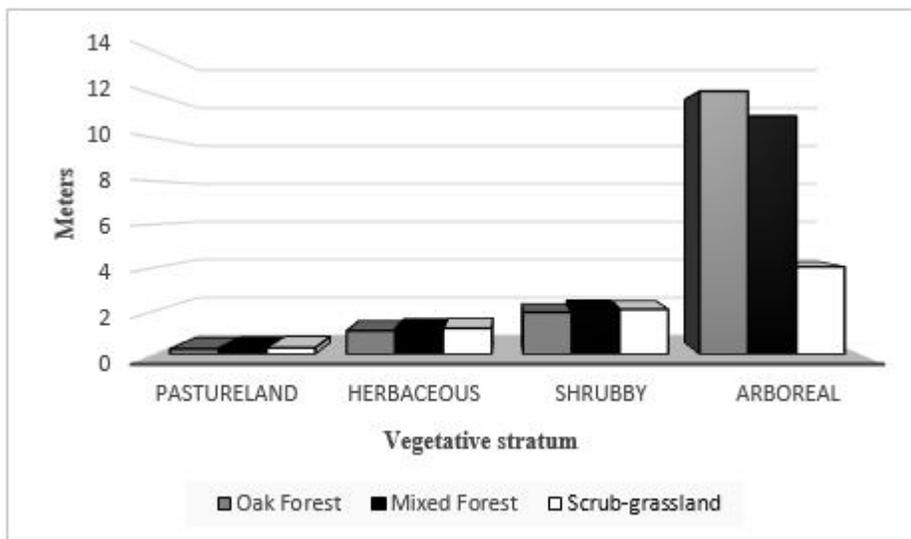


Figure-4. Average Height vegetative stratum, in the rain season in the PFBS

During the establishment of the transects and during the location of the direct and indirect points, were identified by means of the direct sighting report, some of the most important vegetable and animal species that are found in the different types of vegetation. Twenty-six vegetable species, three species of reptiles, six of birds and five of mammals were identified, the most important are Mexican pygmy rattlesnake (*Crotalus ravus*), the Boucard's wren (*Campylorhynchus jocosus*), cottontail rabbit (*Sylvilagus floridanus*) and coyote (*Canis latrans*) among other species. From the 26 vegetable identified species in SPFB, six (*Agave lechuguilla*, *Agave spp*, *Tecoma stans*, *Ipomea spp*, *Euphorbia antisiphilitica* and *Quercus castanea*) are inside 44 species that contribute the major percentage of dry matter (MS) in the diet of the white tailed deer, in the region of the Mixteca Poblana, México [21, 18, 22, 23]. There is a taxonomic classification in the tables 5, 6 and 7.

Table-5. Species identified in the oak forest of present in the SPFB

Family	Specie	Common name
Cupressaceae	<i>Juniperus deppeana</i>	Alligator juniper or checkerbark
Pinaceae	<i>Pinus montezumae</i>	Ocote
	<i>Pinus pseudostrobus</i>	Mexican pine
Buddlejaceae	<i>Buddleia cordata</i>	Buddleia
Cornaceae	<i>Cornus disciflora</i>	Palo canelo
Fabaceae	<i>Eysenhardtia polystachya</i>	Mexican Kidneywood
Fabaceae	<i>Quercus castanea</i>	Castanea oak
	<i>Quercus laurina</i>	White oak
	<i>Quercus rugosa</i>	Netleaf oak
Rosaceae	<i>Prunus serotina</i>	Wild black cherry

Table-6. Species identified in the mixed forest present in the SPFB

Family	Specie	Common name
Pinaceae	<i>Pinus montezumae</i>	Ocote
	<i>Pinus pseudostrobus</i>	Mexican pine
Fagaceae	<i>Quercus laurina</i>	Mexican whithe oak
	<i>Quercus rugosa</i>	Mexican netleaf oak
Myrtaceae	<i>Eucalyptus resinifera</i>	Red mahogany
Poaceae	<i>Andropogon sp.</i>	Bluestem
	<i>Bouteloua spp.</i>	Brassgrama grass
	<i>Buchloe dactyloides</i>	Buffalo grass
	<i>Eragrostis intermedia</i>	Plains lovegrass

Table-7. Species in the scrub-grassland present in the SPFB

Family	Specie	Common name
Agavaceae	<i>Agave spp.</i>	Maguey
	<i>Agave lechuguilla</i>	Lechuguilla
Bignoniaceae	<i>Tecoma stans</i>	Tecoma
Convolvulaceae	<i>Ipomea spp.</i>	<u>Morning glory</u>
Euphobiaceae	<i>Euphorbia antisiphilitica</i>	Candelilla or wax plant
Fabaceae	<i>Acacia spp.</i>	Whistling thorn
	<i>Eysenhardtia polystachya</i>	Mexican Kidneywood
	<i>Prosopis glandulosa</i>	Honey mezquite
Fouquieriaceae	<i>Fouquieria splendens</i>	Ocotillo
Poaceae	<i>Andropogon sp.</i>	Bluestem
	<i>Bouteloua spp.</i>	Grassgrama grass
	<i>Buchloe dactyloides</i>	Buffalo grass
	<i>Eragrostis intermedia</i>	Plains lovegrass
Sapindaceae	<i>Dodonaea viscosa</i>	Hopbush
Tiliaceae	<i>Heliocarpus sp.</i>	Mastate

## DISCUSSION

The oak forest presents better conditions of habitat than other types of vegetation, it presents the major percentage of basal coverage in both epochs of the year, low water and rains respectively. Likewise, it presents the minor percentage of bare soil in the ideal epoch of rain, and percentages of organic humus in epochs of low water and rains respectively. The previous coincides with the preference of habitat of the white tail deer (*Odocoileus virginianus*) with the SPFB, that resulted to be the oak forest, supporting an absolute population density of these deer of 17,6 and 19,4 individuals in epoch of low water and of rains (respectively [9]).

The scrub grassland presented similar percentages of arboreal coverage with the oak forest, besides it supports five of six vegetable identified species that belong to the diet of the deer, in the Mixteca Poblana region, México; with this, an emphasis is done in the importance of this type of vegetation as zone of feeding source of this cervid inside the SPFB. Nevertheless; holding similar percentages of arboreal coverage as the oak forest; the average of height of this stratum is the lowest (Table 3 and 4) in epoch of low water and of rains respectively. This indicates hypothetically that there does not exist a coverage of suitable protection for the white tail deer, and fits with the lowest absolute population density reported by [9] from 5,5 and 7,14 individuals in epoch of low water and of rains respectively; confirming, the excellent adaptability of this species of countering the availability of its basic requirements in different conditions and structures of habitat. Finally, the mixed forest supports opposite conditions to the oak forest and to the scrub-grassland, since it presents the major percentage of bare soil in epochs of low water and rain, existing wide eroded zones.

Nevertheless in agreement with [9] the absolute population density of this deer in this type of vegetation is 6,3 and 6,8 individuals in epoch of low water and of rains, which supposes a preference to this type of vegetation still with the presence of eroded zones, however; it can be supposed that for the forest combination of the mixed forest (oak, eucalyptus, bushes and pastures) there is a certain coverage of protection for the deer. Each of the types of predominant vegetation in the SPFB supports different conditions that allow the development of the white tail deer and of other species of wildlife. The presence of four types of vegetative strata in each of these types of vegetation guarantees a major capacity of balance in the biotic community, providing stability before possible climatic or environmental variations for the development of the deer. Likewise, they provide food for the white tail deer and other species of wildlife, to this hoofed for being a ruminant considered as a browser species of concentrates [20]. The vegetable species identified in the SPFB as part of the diet of the cervid, also performs a double function, beside supplying food, are a way of coverage that gives protection, refuge and places for breeding; that form a part of the managing of the habitat of this species [15].

## CONCLUSION AND RECOMMENDATIONS

In addition, the oak forest presents the major extension of vegetation in the PNA, presented the best conditions of habitat that other vegetative types. The preference of habitat of the white tail deer (*Odocoileus virginianus*) in the SPFB, coincides with the oak forest, with an absolute population density of this deer of 17,6 and 19,4 individuals in two epochs of the year [9]. It must be pointed out to indicate the importance of the conservation of the habitat of this PNA and the improvement of its conditions, to support and to increase the food chains of the different species in the SPFB. It is recommended to realize some actions of habitat's improvement of the Park, to increase the population of white wild tailed deer and other wild animals. At the same time, it is necessary to realize a vegetable gradual alteration in the mixed forest, since it presents the major percentage of bare soil, provoking in the site large eroded areas. This can be realized by means of the implantation of native species inside the SPFB to assure the conservation of the habitat (flora, fauna, soil, water, among others) and to support its ideal conditions. The elimination of exotic species like the eucalyptus (*Eucalyptus resinifera*) is a viable strategy to avoid the eroded zones and to support the biodiversity. This will help to recover the biotic conditions of the ecosystem, which would accompany on the increase of species of wildlife and which protection and refuge would find in these vegetable species for their development.

Each of the types of present vegetation in the SPFB supports diverse conditions for the development of the white tailed deer and this one is considered to be a browser species of concentrates. The browse of leaves from the woody plants (trees and shrubby), the consumption of grasses and native cactus, yolks in growth, tender stems, seeds and fleshy fruits and of hard-shelled fruit (acorns and nuts) and some flowers are the principal component of the diet of this cervid. Due to this it is necessary to realize a study of the botanical composition for the diet of the white tailed deer inside this PNA, which will serve as reference to other similar regions of the Mexican plateau. In conjunction the variations of rain, droughts (seasonal and annual) and the frosts or important falls of temperature, do that the production of forage (quantity and quality) of a natural habitat changes and for this reason, change also its capacity of load. For such motive, it is recommended to realize a study of the capacity of load (K) from the habitat and its feed balance [24, 25, 15]. This study will serve to indicate if a major utilization of the habitat is possible for the rational management of the deer; similarity to improve the habitat and to establish recommendations of managing of its most fundamental components. One of them is the water, which is an important factor for the improvement and maintenance of the habitat, and that will allow the increase of wild populations of white tailed deer and other animals. The SPFB presents three jagüeyes or artificial bodies of water (Figure 1), nevertheless, it is recommended to renovate them in critical epochs, beside distributing drinking-troughs of a homogeneous way in the available habitat. This could be realized with a study on radical distance to the water and coverage of leak, to improve and establish in an optimal way some additional sources of water.

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