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Article

Situación actual de la fauna silvestre en las cuencas de Nuevo León, México

Current situation of wildlife in the basins of *Nuevo León*, Mexico

Fernando N. González Saldívar[1]*, Cesar M. Cantú Ayala[1], José I. Uvalle Sauceda[1] y Bernal Herrera Fernández[2]

Resumen:

En el presente estudio se realizó una recopilación de los datos existentes sobre la riqueza de especies de vertebrados silvestres nativos, así como de taxones exóticos, además del endemismo y estado de conservación del primer grupo según la NOM-059-SEMARNAT-2010, en las 14 cuencas hidrográficas del estado de Nuevo León. Para analizar estos datos se usaron índices de aptitud de un área que se pueden construir a partir de la información de la historia de vida; o bien, mediante la modificación de los modelos existentes, basados en la importancia de las variables, a los cuales se les aplica normalización, ponderación y jerarquización de los valores de cada una de ellas. Las cuencas que presentaron los resultados positivos y mayores fueron: cuenca del Río Tamesí, cuenca Presa San José-Pilares y cuenca Sierra Madre Oriental (con índices de 19.65, 18.19 y 16.59 respectivamente) y las que registraron los valores negativos mayores fueron: cuenca Río Bravo-Nuevo Laredo, cuenca Río Bravo-Sosa y cuenca Río Bravo-Matamoros-Reynosa (con -22.07, -20.85 y -19.56 respectivamente). Se concluye que la cuenca Sierra Madre Oriental es la más importante en Nuevo León, por su mayor valor positivo y extensión territorial (13 % aproximadamente del total estatal) comparado con las primeras dos cuencas que sumadas ocupan menos de 1 % del territorio de Nuevo León.

Palabras clave: Biodiversidad, conservación, cuencas hidrográficas, índices ambientales, índices de jerarquización, vertebrados terrestres.

Abstract:

The present study was carried out through the analysis of the existing data on the richness of wildlife species, exotic species, endemic species and species at extinction risk according to NOM-059-SEMARNAT-2010, of the 14 hydrographic watershed of the *Nuevo León* state. To analyze these data, area aptitude indexes can be constructed from basic life history information or modifying existing models, based on the importance of the variables were used, applying normalization, weighting and hierarchization of the values of each of them. The highest positive values watershed were: *Tamesí* River, *Presa San José-Pilares* and others and *Sierra Madre Oriental* (with positive values of 19.65, 18.19 and 16.59 respectively). The highest negative values watershed were: *Cuenca Río Bravo-Nuevo Laredo, Cuenca Río Bravo-Sosa* and *Cuenca Río Bravo-Matamoros-Reynosa* (with negative values of -22.07, -20.85 and -19.56). It is concluded that the *Sierra Madre Oriental* watershed is the most important in *Nuevo León* for its greater positive value and the territorial extension it covers (almost 13 % of the total state) compared to the first two basins, which together account for barely one percent of the state territory.

Key words*:* Biodiversity, conservation, hydrographic watershed, environmental indexes, hierarchy indexes, terrestrial vertebrates.

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[1]Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León. México. Correo-e: fer1960_08_10@hotmail.com
[2]Instituto Internacional para la Conservación y Manejo de la Vida Silvestre, Universidad Nacional. Costa Rica.

Introduction

In Mexico, it is understood that wildlife constitutes a heritage of incalculable value, in fact, its immense diversity places Mexico as a mega-diverse region. And if that was not enough, the high degree of endemism that species present within national borders further increases the importance of concentrating efforts that result in their conservation (Sarukhán, 2017).

The objective of the national policy on wildlife and its habitat, is the protection and conservation through schemes of sustainable use. In this way, it is intended to increase the welfare of the population living in regions of high diversity while maintaining and promoting the restoration and integrity of ecosystems. In an effort to help reconcile and mutually reinforce the conservation of biodiversity with attention to the needs of production and socioeconomic development of the rural sector of Mexico, the government of the republic has implemented the Management Units for the Conservation of Wildlife since 1997 (Semarnap, 1997).

The UMA are properties or facilities that have a registry with the Department of Environment and Natural Resources, with the express purpose of conserving the natural habitat, through the management of populations and specimens of wild species. Thus, the tasks of an UMA include restoration, protection, maintenance, recovery, reproduction, repopulation, reintroduction, research, rescue, shelter, rehabilitation, exhibition, environmental education and sustainable use purposes (Semarnat, 2016).

The number and abundance of species of flora and wildlife of a place are considered as indicators of biodiversity, and also serve as indicators of quality and health of a site. An indicator can be defined as "a measure based on verifiable data that transmits information beyond itself"(Alianza sobre Indicadores de Biodiversidad, 2011).

The conservation of wild species faces the challenge of maintaining it against a reality characterized by anthropogenic pressure on terrestrial ecosystems, which threatens to degrade, diminish and even disappear remnants of still available native habitats. For this reason, natural systems and their biota must first be identified and quantified for their

understanding and preservation, with the additional problem of the lack of sufficient resources to catalog all the biodiversity to be protected in these ecosystems. The international scientific community has organized itself to discuss strategies for the conservation of biodiversity and has established criteria to determine its level of risk (Sarukhán, 2017).

The objective of the present study consisted in making a diagnosis of the conservation status of the wildlife of the 14 hydrological basins of *Nuevo León*, by means of the analysis of environmental variables to build aptitude indexes and with it, to rank the relative condition of the basins from the perspectives, biological and social. With this, proposals can be made to reduce the existing environmental gaps.

Materials and Methods

Study area

The state of *Nuevo León*, with 63 556 km^2, is located in a transition zone between the Neartic and Neotropical biogeographic regions, which determines the existence of a rich and complex biodiversity. Extreme semi-arid climates predominate in its territory, in whose ecosystems various xerophilous thickets thrive. Only 11 % of its territory is covered by temperate forests (mainly conifers and oaks), which contributes to the fact that agricultural activities occupy a place that is not very relevant with respect to other sectors of the economy. The state has great climatic, orographic and geological contrasts, with 14 hydrological basins distributed in four hydrological regions (RH): RH24 *Bravo-Conchos*, RH25 *San Fernando-Soto la Marina*, RH26 *Pánuco* and RH37 *El Salado*; whose total extension is 234 442 km^2, that is, 3.7 times the territory of *Nuevo León*, and includes the states of *Coahuila*, *Tamaulipas, San Luis Potosí, Zacatecas* and *Veracruz* (Figure 1) (INEGI, 1986).

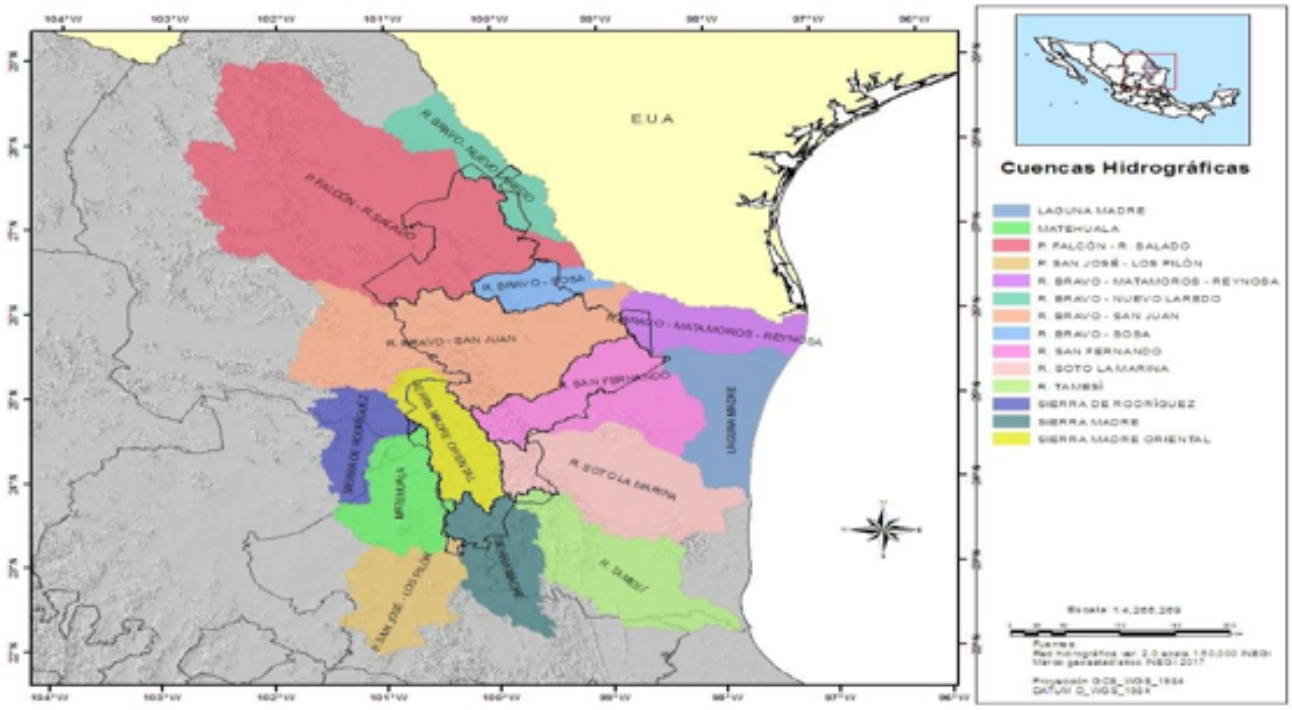

Figure 1. Hydrological basins of the state of *Nuevo León.*

Methodology

Geographic Information System

A Geographic Information System (GIS) was built with the digital maps available on the websites of the *Comisión Nacional para el Conocimiento y Uso de la Biodiversidad* (Conabio, 2012) (National Commission for the Knowledge and Use of Biodiversity), of the *Instituto Nacional de Geografía y Estadística* (National Institute of Geography and Statistics) (Inegi, 2017), of the *Secretaría de Desarrollo Urbano y Ecología del estado de Nuevo León* (Sedue) (Ministry of Development Urban and Ecology of the State of *Nuevo León*) (Sedesu, 2017), of the *Dirección Técnica de la Cuenca Río Bravo de la Comisión Nacional del Agua* (Technical Direction of the Rio Bravo Basin of the National Water Commission) (Conagua, 2017), of the *Fondo de Agua del Área Metropolitana de Monterrey* (FAMM) (Water Fund of the Metropolitan Area of Monterrey) (FAMM,

2017) and of the *Secretaría de Medio Ambiente y Recursos Naturales* (Department of the Environment and Natural Resources) (Semarnat, 2017).

The maps served as the basis for calculating the conservation rates of species richness and ecosystem conservation. All digital covers were combined and analyzed based on the ArcGis® version 10.4 programs; Vector and raster maps were used with the conical projection of Lambert and the Datum WGS 84.

The biodiversity indices for wildlife species were constructed with data from the five groups of vertebrates (freshwater fish, amphibians, reptiles, birds and mammals), obtained from databases of the *Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (Conabio) (*National Commision on Biological Diversity), of the *Instituto Nacional de Ecología de la UNAM* (National Institute of Ecology of the UNAM),, of the of the wildlife collections of the *Facultad de Ciencias Biológicas de la Universidad Autónoma de Nuevo León* (School of Biological Sciences of the Autonomous University of *Nuevo Leon*), and of data from specialized literature.

Data normalization

The data were normalized for each variable, and those of each of the variables were divided by the maximum value of it, so that they all fluctuated between 0 and 1 (Inhabert, 1976) using the formula:

$$Vn = \frac{Vvar}{Vmax\ Var}$$

Where:

Vn = Normalized value

Vvar = Value of each variable

VmaxVar = Maximum value of the variable

Data weighing

Once they were normalized, the data were weighted based on the following values:

2 = Very Low

4 = Low

6 = Medium

8 = High

10 = Very high

Each normalized variable was multiplied by the weighting value that was assigned, from which came the final value that varied from 0 to 10 (Inhabert, 1976). The formula that was used for the weighting of each variable was the following:

$$Vp = Vn * kp$$

Where:

Vp = Weighted value

Vn = Normalized value

Kp = Constant of the assigned weighing to the variable (between 0 and 10)

In order for the value of each zone to be adjusted between the values 0 and 100, the data was normalized by multiplying the total number of variables by the maximum weight value to obtain the index. To equalize the weight of all the variables, 100 was divided by the result of normalization, of which a constant was obtained; this number was multiplied by the weighted value of each zone, and the Infrastructure Index resulted, according to the following formula:

$$II = \sum((VpV1 * Ki) + (VpV2 * Ki) + (VpV3 * Ki) \ldots\ldots + (VpVn * Ki)$$

Where:

II = Index of interest

VpV1 = Weighted value of variable 1

VpV2 = Weighted value of variable 2

VpV3 = Weighted value of variable 3

VpVn = Up to the weighted value of variable n

Ki= Constant of interest

Analized indexes

The indexes analyzed were: Index of wildlife richness of species (fauna), Index of wildlife endemisms (fauna), Index of wildlife at risk of extinction and Index of invasive or exotic wildlife.

Goal: analysis of the indexes

The models of the Fitness Indexes of an area can be constructed from the information of the basic life history or the modification of the existing models. The Aptitude Index of an area is defined as a numerical index that represents the capacity of a given habitat to support and conserve biodiversity in aquatic and terrestrial ecosystems, taking into account physical, chemical and biological variables. As defined by Inhabert (1976), an index is the ratio of an interest value divided by a comparison standard. For purposes of this Area Assessment Procedure, the value of interest is an estimate of the extent of the ecosystem conditions in the study area, and the comparison standard is the optimal condition of the habitat for the same assessment area.

Thus,

$$Value\ of\ the\ index = \frac{Value\ of\ \ interest}{Comparison\ standard} \quad or$$

$$Aptitude\ Index\ of\ an\ area = \frac{State\ of\ the\ study\ area}{State\ of\ the\ optimal\ area}$$

This index has a minimum value of 0.0, which represents a totally inadequate habitat and a maximum value of 1.0, under the assumption that there is a direct linear relationship between the index value of aptitude of an area and the carrying capacity. Specifically, the use of this procedure is based on the fact that, for any evaluation of ecosystems, a unit change in the index will always have the same meaning (that is, it will always correspond to the same change in load capacity units) (Inhabert, 1976).

Results and Discussion

Index of Wildlife Species Richness

For the construction of this index, five variables were used, among which are: the richness of freshwater fish species and amphibians, since for these two groups the presence, availability and quality of water is the most important vital requirement for their survival, permanence and reproduction. It is obvious that, for all groups of vertebrates, water is a crucial variable, but the scarcity of this resource does not have as much effect on fish and amphibians.

It is important to mention that, for the state, there is a total of 713 species of vertebrates (fish, amphibians, reptiles, birds and mammals), a figure that places it in the first place in diversity of species, and of the group of birds in particular, 339, which represents 47.5 %. For the list of birds, only resident species were taken into account, and winter, summer, migratory and occasional species were excluded. The second place corresponds to mammals with 176 species, which is equivalent to 24.7

%. In third place are the reptiles, with 102 species and 14.3 % of the vertebrate diversity of *Nuevo León.* Finally, freshwater fish and amphibians are the least numerous groups with 74 and 25 species, respectively, accounting for 10.4 % and 3.5 % of all vertebrates (Table 1).

Table 1. Variables used for the construction of the different indexes in the hydrographic basins of the state of *Nuevo León.*

Num.	Variables	a	b	c	d
1	Freshwater fish	74	15	11	18
2	Amphibians	25	01	03	07
3	Reptiles	102	03	09	36
4	Birds	337	12	04	33
5	Mammals	176	49	04	30
	Total number of species	713	80	31	124

a = wildlife species richness; b = exotic wildlife; c) endemic wildlife; d) wildlife at risk of extinction.

The basins with the highest positive index values of richness of wild wildlife species are: the *Río Bravo-San Juan* basin, with a value of 94.6; second, the *San Fernando* River basin with an index of 86.5, followed by the *Presa Falcón-Río Salado* basin with 83.9 points. On the contrary, the *Río Soto la Marina, Sierra Madre Oriental* and *Sierra Madre* basins obtained values of 70, 53.5 and 49 points, respectively. In the Figure 2, the indices of species richness of the *Nuevo Leon* basins are shown in green colors; the most intense green tones refer to the basins with the richest species and the faintest ones, the lowest values.

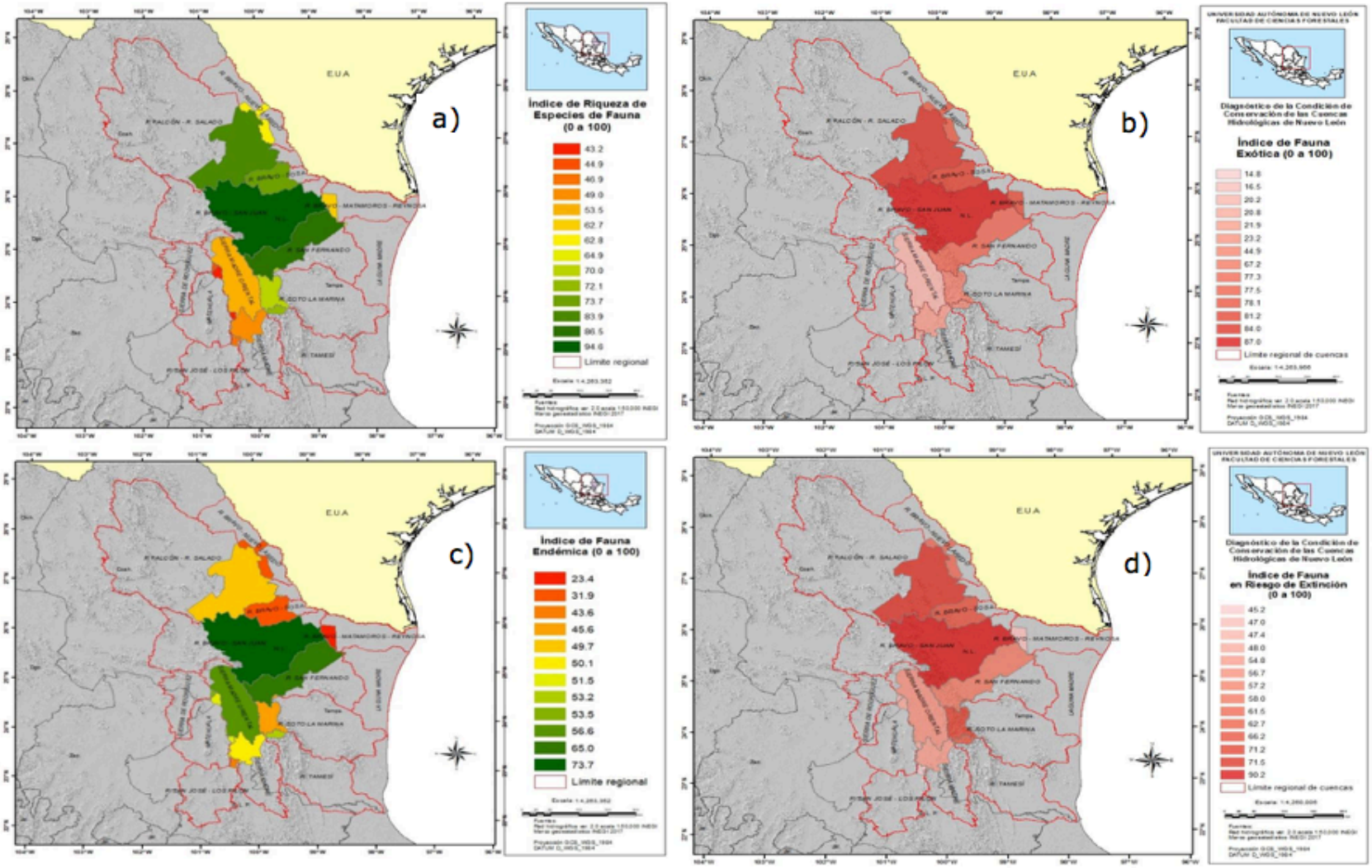

Figure 2 Basins with values of the different indices: a) index of species richness, b) index of exotic wildlife, c) endemic wildlife index and d) index of wildlife at risk of extinction, showing in shades of green those with positive values and in shades of red the negative values.

From the great territorial extension of the country and especially of the state of *Nuevo León*, it is not surprising that many of the species have a considerable genetic variability, and others do not and that, therefore, demand special care.

The best known groups are terrestrial vertebrates. With regard to mammals, there are 535 species in Mexico, of which 488 are terrestrial and 47 are marine (Ramírez *et al.,* 2005, 2008); for 2014, Ramirez *et al.* (2014) recognizes 496 species for Mexico. Ceballos *et al.* (2005) supposes a total of 525 mammals, of which 485 are terrestrial and 40 marine. In the state of *Nuevo León*, a total of 176 taxa are recorded (a little over 30 % of the total recorded for Mexico), but 49 of them correspond to exotic species, mainly species of game mammals (Contreras *et al.,* 1995).

The birds registered for *Nuevo León* according to Avibase-List of Birds of the World, Country or Region: *Nuevo León*, a total of 490 species is collected, but all types of birds are included, both migratory, summer, winter, etc. (Avibase-list of birds of the world, 2008). Navarro *et al.* (2014) explain that Mexico has around 1 123 to 1 150 species of birds, about 11 % of the world's birds. *Nuevo León* has 337 species of resident birds, approximately, which is equivalent to 30 % of the birds of Mexico.

For the state of *Nuevo León*, according to Lazcano *et al.* (2017), there are 126 species of reptiles and amphibians, of which 24 are amphibians and 102 reptiles; compared to the present study (25 species) there is only one amphibian species of difference, but in reptiles, the authors consider the same species. With regard to the contribution of Lemos-Espinal (2015) recognizes 132 species (23 amphibians and 109 reptiles), Nevárez *et al.* (2016) describes the herpetofauna for the state of *Nuevo León*, which consists of 139 species; 22 anurans, four salamanders, 106 squamatos, and seven turtles.

Lack of information this is because in these studies there are records up to the ancestor century (1852 the oldest) and for this occasion only the last 50 years have been recorded.

In the first published official list of fish from *Nuevo León* by Contreras (1967), it included 54 species; followed by later contributions (Contreras *et al.,* 1995), in which they gathered 83 species distributed in 46 genera and 18 families. Likewise, Lozano *et al.* (2013) report 28 species distributed in 21 genera and 11 families, with nine

non-native species in the *Cumbres de Monterrey* National Park Protected Natural Area, NL (Fish section). For this study, a diversity of 74 species was calculated. of freshwater fish.

Exotic Wildlife Index

80 species of exotic and invasive vertebrates were counted; first of all there are the mammals, with 49 species, which comprise more than half of the total of the exotic wildlife species of *Nuevo León* (61.3 %). This group stands out because in many UMA has been a fashion the introduction of exotic mammals of African and Asian origin mainly, which are used by hunters who want to obtain trophies of these species.

Freshwater fish with 15 and birds with 12 exotic species occupy the second and third place, respectively. Fish and birds are bought as pets and subsequently released so they can become invasive.

Finally, reptiles and amphibians are the least numerous groups with three and one species, respectively, representing 3.8 % and 1.3 % of the total number of exotic vertebrates in the state (Table 1). These species can cause great negative effects due to interspecific competition and predation on native species.

The basins that present the highest rates of exotic wildlife are: the *Río Bravo-San Juan* basin, with a value of 87.0, in second place, the *Falcón-Río Salad*o dam basin obtained an index of 84.0, followed by the *Río Bravo –Sosa* basin with 81.2 points. On the contrary, the *Río Bravo-Matamoros-Reynosa, Río Grande-Nuevo Laredo* and *Río San Fernando* basins recorded values of 78.1, 77.5 and 77.3 points, respectively (Figure 2b). The exotic wildlife indexes of the *Nuevo León* basins are shown in red colors, the colors in higher red tones, show the basins with the largest number of exotic species and the lowest tenuous values.

The panorama is critical for fish since, of the 510 species of fresh water, in the NOM-059-SEMARNAT-2010 (DOF, 2010), 31 % of these species are stated in some conservation status, which responds to the presence of exotic-invasive species. The relative importance of the species introduced in this case is understandable

considering that the number of exotic species of fish in Mexico, up to 2004, was 115 (Contreras *et al.,* 2003).

The case of freshwater bodies is impressive; lakes and rivers are particularly vulnerable to the introduction of exotic species. These ecosystems harbor a high number of endemic species (Contreras-Balderas *et al.,* 2008). *Nuevo León* is not the exception and after mammals (with 49 species), fish occupy the second place in number of exotic species (15 species), and compete with native species.

In a very short time, extinction can be provoked by depredation or complete degradation of a habitat, due to overgrazing. This problem is has become even worse by the amplitude and intensity of the process of mobilization of species by humans, which is unprecedented in the geological scale. The introductions, both intentional and accidental, that modern civilization has made, are huge. The most intense moments have occurred, first, during the discovery and colonization of America and, most recently, with the underway globalization (Manson *et al.,* 2009).

Endemic Wildlife Index

In the state, 31 species of endemic vertebrates were identified, of which freshwater fish, with 11 species, comprise more than a third of all endemics (35.48 %). This group stands out because many of them have specific requirements and characteristics of their habitats, which means that outside of where they live it is almost impossible to find them, because they live isolated and restricted to very small areas; most of its populations are listed as endangered (Table 1).

The second place is occupied by reptiles with nine species in the state, representing 29 % of the total vertebrate species of the entity. Third, there are birds and mammals with four species each, equivalent to 12.9 % of all the endemic wildlife species described for the state; finally, amphibians are the least numerous groups with three species, representing 9.7 % of the total endemic vertebrates of the state.

The basins with the highest indexes of endemic wildlife in *Nuevo León* are: the *Río Bravo-San Juan* (73.7); second, the *San Fernando River* (65) and third, the *Sierra*

Madre Oriental (56.6) (Figure 2c). The indices of endemic wildlife in the river basins of *Nuevo León* are shown in colors of green tones of high values and with shades of red those of lower index.

In 1961 there were 11 species of fish in danger of extinction and seven extinct in the country. Four decades later, these figures amounted to 83 and 25 species, respectively (Contreras *et al.,* 2003). Consequently, Mexico today occupies one of the first places in the world as a region of high risk or vulnerability for freshwater fish (Torres-Orozco y Pérez-Hernández, 2011). *Nuevo León* is not the exception and is the group most affected in terms of the loss of endemic species from its territory.

Lazcano and Contreras (1995) reported a preliminary list of the state herpetowildlife, in which they relate 131 reptile species of which 12 are endemic and 27 amphibian species, of which only two are mentioned as endemic to the entity. In the present study, nine reptiles and three amphibians were recorded as endemic to the site.

Ceballos and Oliva (2005) consigned 525 mammals to Mexico, of which 161 are endemic and for the state of *Nuevo León*, 91 species. Jiménez-Guzmán (1966) determined 103 species for this same state and González and Moreno (1995) elaborated a list of 116 species of mammals, including exotic and introduced species, of which four endemic species (mainly rodents and bats) are also mentioned than those presented in this work.

In the context of the National Strategy for Wildlife (INE, 2000b), Semarnat has designed strategic plans for various groups of flora and wildlife that, not only contemplate their conservation and management in protected areas, but in the context of all the national territory. Among the instruments developed by the Mexican government can be mentioned the recovery projects of priority species known as PREP, and the UMAS or Management Units for the Conservation of Wildlife; Currently CONANP manages the so-called action programs for the conservation of species at risk (PACE, for its acronym in Spanish), focused on the conservation of so-called "priority species".

Index of Wildlife at Risk of Extinction

A total of 124 species of vertebrates at some risk of extinction were counted, belonging to the five groups (fish, amphibians, reptiles, birds and mammals); the first place in diversity corresponds to reptiles, with 36 species (29 %); the second, to the birds with 33 species in some status registered in the state (27 %); the third place to mammals with 30 species (24 %), and, finally, freshwater fish and amphibians as the groups with the lowest number of species at some risk of extinction, the first with 18 (14 %) and the second with 7 (6 %) (Table 1).

The basins with the highest rates of exotic wildlife are: the *Río Bravo-San Juan* basin, with a value of 90.2; secondly, the *Presa Falcón-Río Salado* basin with 71.5, followed by the *Soto la Marina* basin with 71.2 points. On the other hand, the basins *Río Bravo-Sosa, Río Tamesí* and *Río Bravo-Nuevo Laredo* had 66.2, 62.7 and 61.5 points, respectively. Wildlife indexes at some risk of extinction of the *Nuevo León* basins are shown in red colors, colors in higher red tones, basins with a greater number of exotic species and the lowest tenuous values (Figure 2d).

In NOM-059-SEMARNAT-2010 (DOF, 2010), 221 animals in danger of extinction are mentioned. Among them are 43 species of mammals, 72 of birds, 14 of reptiles, six of amphibians, 70 of fish and 16 of invertebrates. It should be noted that the list is an attempt to approach reality, since there is a continuous review in accordance with a greater and better knowledge of the flora and wildlife of Mexico (Naranjo *et al.,* 2009).

The 124 species of vertebrates at some risk of extinction for the entity are explained, mainly, by the changes in land use that cause the strong fragmentation of ecosystems. Another key factor is the excessive use of natural resources, which affects these species directly and indirectly, by modifying their habitats (Santos y Tellería, 2006).

On the other hand, the environmental contamination of water bodies by domestic and industrial waste, has impacted the populations of these species to a large extent. This has been recorded by monitoring thousands of populations of thousands of wildlife species, in which it has been recognized that in the last decade their densities have

been reduced by 50 %, on average, of terrestrial species and 80 % the aquatic ones (WWF, 2016).

Goal: Analysis of the Indexes

Indexes of positive and negative percentages of the watersheds

Positive diversity indexes for wildlife in watersheds were established by comparing the following two variables: species richness index and endemic wildlife index. The basins with the highest average values of positive indexes obtained by the mean of these two variables were, first, the *Bravo-San Juan* River Basin (84.15); second, the *San Fernando* River Basin (75.78) and third, the *Soto la Marina* River Basin (57.77) (Table 2).

Table 2. Ecosystems and species indexes with positive values of the watersheds of *Nuevo León.*

Hidrologic Region Key	Hidrologic Region's Name	Basin's ID	Basin's key	Name of the Basin	Surface area of each basin/ Region (ha)	Wildlife species richness index	Wildlife endemism index	Average value of Index total
RH24	*Bravo-Conchos*	1	RH24A	*Río Bravo-Matamoros-Reynosa*	100 159.9	62.7	23.4	43.01
		2	RH24B	*Río Bravo-San Juan*	1 967 347.3	94.6	73.7	84.15
		3	RH24C	*Río Bravo-Sosa*	374 743.1	73.7	31.9	52.84
		4	RH24D	*Presa Falcón-R. Salado*	1 328 504.4	83.9	49.7	66.83
		5	RH24E	*Río Bravo-Nuevo Laredo*	156 378.6	62.8	31.9	47.39
RH25	*San Fernando*	6	RH25B	*Río Soto La Marina*	255 413.1	70.0	45.6	57.77
		7	RH25C	*Laguna Madre*	2 975.1	64.9	23.4	44.15
		8	RH25D	*Río San Fernando*	883 886.8	86.5	65.0	75.78
RH26	*Pánuco*	9	RH26B	*Río Tamesí*	46 977.2	72.1	53.2	62.62
RH37	*El Salado*	10	RH37A	*Sierra Madre Oriental*	860 138.1	53.5	56.6	55.03
		11	RH37B	*Matehuala*	60 484.7	43.2	51.5	47.37
		12	RH37C	*Sierra de Rodríguez*	12 340.9	44.9	53.5	49.21
		13	RH37G	*Presa San José-Los Pilares y otras*	26 210.0	46.9	43.6	45.25
		14	RH37H	*Sierra Madre*	280 326.5	49.0	50.1	49.57

As the indexes of diversity of species and positive ecosystems, the indexes of diversity of species and negative ecosystems resulted from the comparison of the two following variables: the index of wildlife at risk of extinction and the index of exotic wildlife. The basins that presented the highest average values of negative indices were: first, the *Bravo-San Juan* River Basin (88.60), secondly, the *Falcón Río Salado* Dam Basin (77.74) and third, the *Bravo-Sosa* River Basin (73.69) (Table 3).

Table 3. Ecosystems and species indexes with negative values of the watersheds of *Nuevo León.*

Hidrologic Region Key	Hidrologic Region's Name	Basin's ID	Basin's key	Name of the Basin	Surface area of each basin/ Region (ha)	Index of wildlife at risk of extinction	Index of invasive-exotic wildlife	Average value of Index total
RH24	*Bravo-Conchos*	1	RH24A	*Río Bravo-Matamoros-Reynosa*	100 159.9	47.0	78.1	62.57
		2	RH24B	*Río Bravo-San Juan*	1 967 347.3	90.2	87.0	88.60
		3	RH24C	*Río Bravo-Sosa*	374 743.1	66.2	81.2	73.69
		4	RH24D	*Presa Falcón-R. Salado*	1 328 504.4	71.5	84.0	77.74
		5	RH24E	*Río Bravo-Nuevo Laredo*	156 378.6	61.5	77.5	69.46
RH25	*San Fernando*	6	RH25B	*Río Soto La Marina*	255 413.1	71.2	44.9	58.08
		7	RH25C	*Laguna Madre*	2 975.1	57.2	67.2	62.24
		8	RH25D	*Río San Fernando*	883 886.8	58.0	77.3	67.64
RH26	*Pánuco*	9	RH26B	*Río Tamesí*	46 977.2	62.7	23.2	42.97
RH37	*El Salado*	10	RH37A	*Sierra Madre Oriental*	860 138.1	56.7	20.2	38.44
		11	RH37B	*Matehuala*	60 484.7	48.0	16.5	32.27
		12	RH37C	*Sierra de Rodríguez*	12 340.9	47.4	14.8	31.07
		13	RH37G	*Presa San José-Los Pilares y otras*	26 210.0	45.2	20.8	32.99
		14	RH37H	*Sierra Madre*	280 326.5	54.8	21.9	38.36

Comparison of Positive Values against Negatives

The percentages of positive and negative values were contrasted in order to rank the basins regarding the degree of conservation of their resources. As a result, the *Río Tamesí* and *Sierra de Rodríguez* basins (with positive values of 19.65 and 18.14), showed, as a result, the highest positive numbers of the 14 basins, but with their extensions in the state of *Nuevo León* so restricted (> 1 % of the extension between the two, in the state), its high values do not have any impact on the conservation of wildlife.

The third place occupied by the *Sierra Madre Oriental* Basin (with a value of 16.59), recorded the highest degree of conservation with respect to the negative values it presents, and as it represents 14 % of the territory of the state, its positive values High impacts have a large impact on the conservation of the state's wildlife (Table 4 and Figure 3).

Although the *Bravo-San Juan* River Basin has the highest conservation values of the 14 basins (84.15 of a maximum of 100 points that could be obtained), the negative values for its conservation are even higher (88.60 of a maximum of 100 points); this leads to negative values of -4.45 points, which means that the basin experiences low but continuous degradation of the wildlife resource.

On the other hand, after confronting the percentages of positive and negative values to rank basins, regarding the degree of conservation of wildlife, it was found that the basins with the highest negative values were the following: first, with the highest negative value is the *Río Bravo-Nuevo Laredo* basin (-22.07), followed by the Río Bravo-Sosa basin (-20.85) and finally the *Río Bravo-Matamoros-Reynosa* basin (-19.56) (Table 4, Figure 3).

Table 4. Positive and negative values of the indices (%) to determine the value of the Hierarchy Index for the hydrographic basins of *Nuevo León*.

Hidrologic Region Key	Hidrologic Region's Name	Basin's ID	Basin's key	Name of the Basin	Surface area of each basin/ Region (ha)	Positive values	Negative values	Comparison of positive and negative values
RH24	*Bravo-Conchos*	1	RH24A	*Río Bravo-Matamoros-Reynosa*	100 159.9	43.01	62.57	-19.56
		2	RH24B	*Río Bravo-San Juan*	1 967 347.3	84.15	88.60	-4.45
		3	RH24C	*Río Bravo-Sosa*	374 743.1	52.84	73.69	-20.85
		4	RH24D	*Presa Falcón-R. Salado*	1 328 504.4	66.83	77.74	-10.91
		5	RH24E	*Río Bravo-Nuevo Laredo*	156 378.6	47.39	69.46	-22.07
RH25	*San Fernando*	6	RH25B	*Río Soto La Marina*	255 413.1	57.77	58.08	-0.31
		7	RH25C	*Laguna Madre*	2 975.1	44.15	62.24	-18.08
		8	RH25D	*Río San Fernando*	883 886.8	75.78	67.64	8.14
RH26	*Pánuco*	9	RH26B	*Río Tamesí*	46 977.2	62.62	42.97	19.65
RH37	*El Salado*	10	RH37A	*Sierra Madre Oriental*	860 138.1	55.03	38.44	16.59
		11	RH37B	*Matehuala*	60 484.7	47.37	32.27	15.10
		12	RH37C	*Sierra de Rodríguez*	12 340.9	49.21	31.07	18.14
		13	RH37G	*Presa San José-Los Pilares y otras*	26 210.0	45.25	32.99	12.26
		14	RH37H	*Sierra Madre*	280 326.5	49.57	38.36	11.22

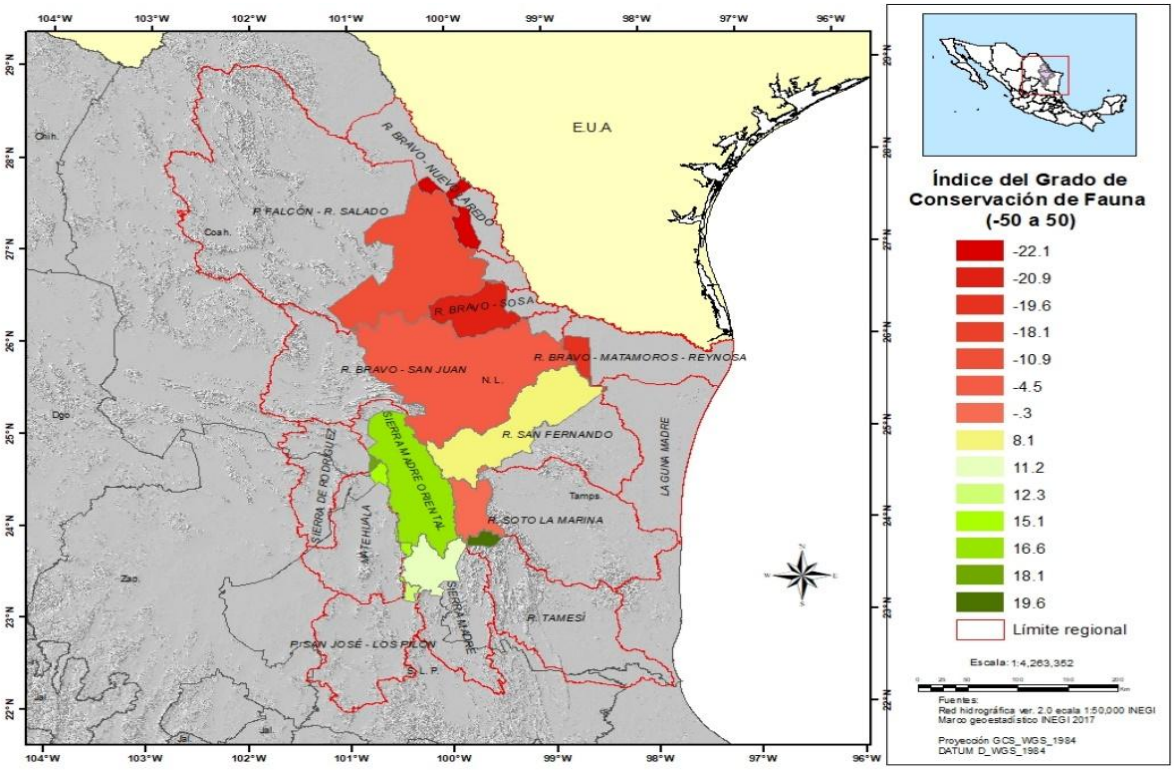

Figure 3. Mapa con los valores del Índice de Jerarquización de conservación de wildlife silvestre en las cuencas de Nuevo León.

Conclusions

Of the 14 basins in *Nuevo León*, the highest positive values were those of the *Río Tamesí* and *Sierra de Rodríguez* basins, but these two basins together do not add up to 1 % of the total of the state, so the effect for the Conservation of wildlife resources is insignificant.

However, as the *Río Bravo-San Juan* basin was always the most outstanding positive values, they were contrasted with the negatives of its site quality: Thus, the largest basin that obtained the greatest positive value was the basin of the *Sierra Madre Oriental*; even though he has the third place overall. It occupies almost 13 % of the state and is the most important watershed for the capture of water and for the conservation of the natural resources (wild wildlife) of the entity.

The *Falcón-Río Salado* Dam, the *Bravo-Sosa* River and the *Río Bravo-Nuevo Laredo* basin are the main basins in terms of their extension, which show more negative than positive values, with which it can be concluded that most of the projects of recovery of the areas for greater water harvesting and conservation of natural resources, should be targeted primarily to these basins.

If the state is divided into north and south, it can be observed that the northern part is the section with the highest negative values, due to the greater presence of human populations and, therefore, with more activities that cause degradation of both the habitat as of wildlife; they emphasize the increase of the agricultural frontier, the fragmentation, the changes of land use, the environmental contamination and the overexploitation of the resources, for example.

These basins can recover their level of quality or, at least, achieve that the positive attributes are greater than the negative ones, and with this, have a greater catchment and water quality and a better state of conservation of resources in the state of *Nuevo León*. Based on the Hierarchy Index, the prioritization criteria for the implementation of the actions in the Nuevo Leon basins can be established.

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Conflict of interests

The authors declare no conflicts of interest with the *Fondo del Agua Metropolitano de Monterrey,* sponsor of the investigation; in addition, none of the authors works for such organization. Therefore, the interest of all those involved in the realization of this study was merely scientific and research.

Contribution by author

Fernando N. González Saldívar: original idea, support in field work, provision of tools for analysis and materials and writting of the manuscript; Cesar M. Cantú Ayala: data analysis support, provision of tools for analysis and materials and review of the manuscript; José I. Uvalle Sauceda and Bernal Herrera Fernández: data analysis support, writting and review of the manuscript.

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