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Metal mining and natural protected areas in Mexico: Geographic overlaps and environmental implications

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ABSTRACT

Because the high biodiversity of Mexico about 12% of the country's total area is included as a Natural Protected Areas (NPAs); however, in the last years, according to the official data, an astonishing number of mining concessions covering 28% of the total area of the country has been granted already. The objective of this work is to quantify the geographical overlap of mining concessions with the federal NPAs of Mexico including the exploration/exploitation status of minerals to be extracted. We use geo-referenced polygons of the NPAs and those of mining exploration and exploitation concessions until 2010 and calculated their overlap extension with the application of ArcView GIS 3.3 (ESRI; Redland, CA, U.S.A.). Our results showed that a total of 1609 mining concessions covering an area of 1,486,433 ha geographically overlaps with the NPAs. With the exception of Natural Monuments (NM), all the different categories of NPAs in Mexico showed mining concessions; 75% of Natural Resources Protection Area (NRPA); 63% of Biosphere Reserve (BR); 47% of Protected Area for Flora and Fauna (PAFF); 22% of Sanctuary (S); and 15% of National Park (NP). The impacts of metal mining activities on NPAs are not only limited to biodiversity and affectation to human communities, but they also have a radius of influence not yet evaluated since most of the NPAs have a special role in supplying watersheds and aquifers. Obviously, currently in Mexico a NPA decree does not represent an obstacle to megamining projects; in consequence, their real environmental impacts are underestimated. It is a priority to legally support canceling the mining concessions already granted in the NPAs and stop granting new ones in the future. In the proportion to which environmental authorities continue to

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openly accept mining concessions within the NPAs, through modifying management programs that allow these activities, they may cause a significant increase in rejections of local people toward the changes in management programs and on the promotion of new NPAs in Mexico.

1. Introduction

The great diversity of Mexico, one of the highest in the world, includes not only a large number of species, ecosystems and endemic species richness, but also a great genetic variability shown in many taxa (Llorente-Bousquets and Ocegueda, 2008; Pérez et al., 2009). Mexico boasts a biological richness of 10–12% of the world's species, of which only 42% is currently known (Llorente-Bousquets and Ocegueda, 2008). Within this biodiversity, distribution patterns of variables according to the heterogeneity of the Mexican physical environment are observed, which in turn is the result of a very complex geological and climate history (Díaz-Caravantes and Scott, 2010; Espinoza et al., 2008; Sarukhán et al., 1996).

The increase in global demand for minerals and strategic metals has raised the pressure for extraction in peripheral countries (Delgado, 2010; Ceseña, 2012). This pressure has reached ecologically and hydrologically sensitive areas and even protected areas. The World Resources Institute found that globally 75% of active mines and exploration areas overlap with areas of high conservation value and high water stress basins and more than 25% of active mines and exploration overlap with or fall within the radius of 10 km from a strictly protected area, and about a third of all active mines and exploration sites are located within ecosystems either intact of with a high conservancy value (WRI, 2004).

Few studies have been made in Mexico to know the overlap of mining sites and natural protected areas (NPAs) impacting on these last ones (Hernández-Arzate, 2012; López and Eslava, 2011). This kind of studies allowed generating valuable information as a tool for decision makers. Moreover, a country as Mexico, the world's first silver producer, ranks among the top 10 producers of 16 different minerals, and by 2013 an investment of nearly 8 billion dollars had been estimated according to the Mining Chamber of Mexico (SE, 2013b).

In the mid-1990s, the leadership of the World Commission on Protected Areas (WCPA) made a recommendation approved at the World Conservation Congress in Amman, Jordan in 2000, requesting all members of the International Union for Conservation of Nature (IUCN) status outlawed all exploration and extraction of mineral resources in categories corresponding to the management related to kinds I to IV protected areas (IUCN, 2004). From this meeting, as one of the main consequences in Mexico, the application of this recommendation in the Mexican Protected Natural Area (PNA) system would be explicit and clearly categorical to forbidding mining and exploration in the core of the biosphere reserves, sanctuaries, national parks, national monuments, and areas of wildlife protection (PNUMA, 2003). Although all members of IUCN in Amman approved the recommendation, it was strongly opposed by the U.S. government (Amman, 2000).

Later in 2003, the International Council on Mining and Metals (ICMM), composed of the world's largest mining companies, made the commitment not to explore or mine World Heritage Sites, which is a measure of self-regulation that may or may not be fulfilled; for example, its members also have as one of their principles, respect for human rights of the communities where they settle, and they have been accused of repeatedly violating them (e.g. Newmont Yanacocha Mine and Goldcorp with several mines listed in International Health People's Court, Tribunal de Salud, 2012).

One of the effects produced by metal mining is acid drainage. Water drags different heavy metals according to pH level, but acid drainage associated to sulfur compounds is often accompanied by arsenic, cadmium, copper, lead, and zinc (Wireman and Stover, 2011) also iron, manganese and aluminum (Johnson and Hallberg, 2005). In 1993 the US Forest Service estimated that rivers in the U.S.A. (5000–10,000 miles) were subjected to acid drainage (US EPA, 2000). It was recently mentioned that only in the Mid-Atlantic region about 4785 miles of streams with low pH have been impacted primarily by coal extraction (US Environmental Protection Agency, 2012).

Several studies have been made about mining pollution consequences in some areas in Mexico (Gómez-Álvarez et al., 2009; Herrera and González, 1995; Lizárraga-Mendiola et al., 2014; Méndez and Armienta, 2003). Considering the high biodiversity in the country, about 12% of its total area is declared as a protected area while under the astonishing rate of mining concessions granted in recent years, approximately 25% of the total area of all Mexico is now included within a mining concession (ASF 2010, 2012; López and Eslava, 2011); thus it is necessary to generate studies linking the NPAs of Mexico with mining concessions. Therefore, the aim of this work is to quantify the geographical overlap of mining concessions, including the status thereof and minerals to be extracted within federal protected areas of Mexico.

2. Materials and methods

For this paper, we analyzed geo-referenced polygons of Federal Protected Areas from the National Commission of Protected Natural Areas (CONANP, initials in Spanish) database by 2012 and geo-referenced polygons of mining exploration and exploitation concessions granted by the Ministry of Economy through the Federal Institute for Access to Information (IFAI) with information until 2010 (and is in effect on the date) were used.

The NPA surface overlapping mining concessions was calculated with ArcView GIS 3.3 (Environmental Systems Research Institute (ESRI) of Redlands, CA). Canceled concessions were removed from this files comparing with GIS Integrated System Management Mining 38 (SIAM acronym in Spanish) of the Ministry of Economy, (http://www.cartografia.economia.gob.mx/cartografia/#), and the concession surface in each NPA was merged to avoid overestimation.

3. Results

3.1. Overlap, status, and minerals of all concessions

A total of 24,748 mining concessions was found assigned until 2010. The surface for the concessions in the country ranged from 1 m^2 to 315.114 ha; 89% of total were minor concessions with less than 1000 ha (average = 1085 ha, median = 96 ha, mode = 100 ha); 1609 of the concessions match 1,486,433 ha of federal protected areas, accounting 8% of their surface. Of the 169 federal NPAs, 63 had mining concessions; 51% of concessions within a NPA were in the exploration phase and 28% in exploitation. During the development of this work, the information available on ISMM about the status of concessions (exploration or exploitation) stopped being available to the public and only 79% of the data was classified; the rest remained as ''No Information Available''(NIA; 21%) (Fig. 1).

The mining concession titles mentioned one or more substances or minerals target of the exploitation, of which 30% in NPAs state the intention of extracting precious metals (gold and silver) rising to 73% if the major industrial metals (copper, lead, zinc, iron, antimony, molybdenum, mercury, and manganese) and poly-metallic mines are taken into account. Those intended to exploit non-metallic minerals, which are mainly coal, fluorite, barite, gypsum, salt and dolomite are 9%. It is noteworthy that 11% of the titles mentioned the TSP

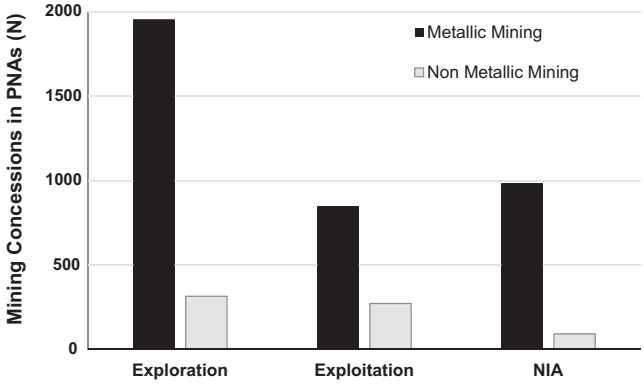

Fig. 1 – Progress status of mining concessions in NPAs in Mexico according to mineral extraction as of 2010.

(abbreviation in Spanish) whose meaning was clarified by the Ministry of Economy through the Institute of Public Information (IFAI) (Fig. 2).

3.2. Concession distribution by NPA managing categories

According to the management category of the 175 federal NPAs, we found that 75% of natural resource protection areas (NRPA) had mining concessions in Mexico, as well as 63% of biosphere reserves (BR), 47% of protected areas for flora and fauna (PAFF), 22% of sanctuaries (S), and 15% of national parks (NP) (Table 1).

3.3. Mining concessions data by NPA size

In order to organize the results and after considering that the effects of geographical overlap were proportional to the NPA surface, they were grouped according to their geographical extent. The smaller NPAs (5–5000 ha), one with 100% of its

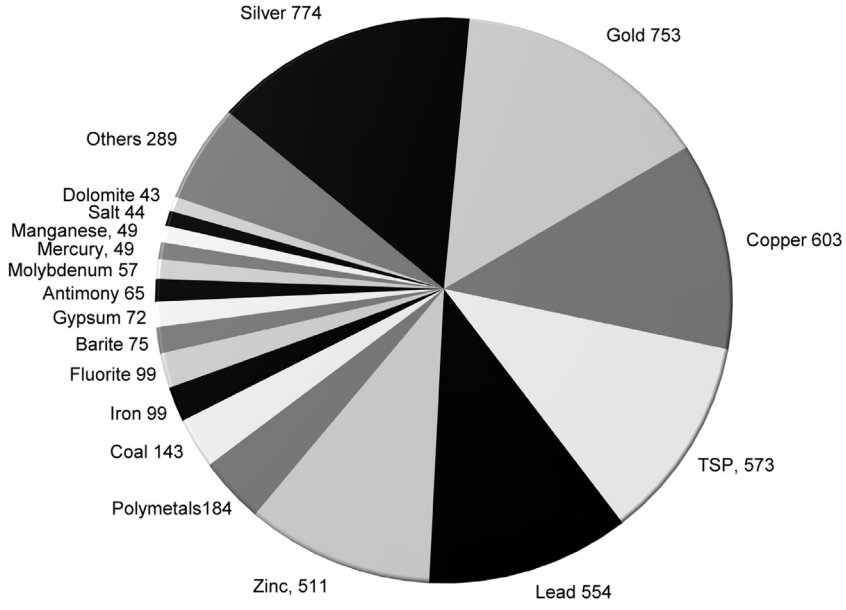

Fig. 2 – Declared minerals intended for extraction for all mining concessions overlapping with NPAs in Mexico as of 2010.

Table 1 – NPAs in Mexico with mining concessions, according to management category.

NPA management category	Number of federal NPAs	Number of NPAs overlapping with mining concessions	NPAs overlapping with mining concessions (%)	Total surface overlapping with mining concessions (%)
Protected areas for flora and fauna (PAFF)	36	17	47	6.4
Natural resources protection areas (NRPA)	8	6	75	15.6
Natural monuments (NM)	5	0	0	0
National parks (NP)	67	10	15	5.6
Biosphere reserves (BR)	41	26	63	5.1
Sanctuaries (S)	18	4	22	13.2
Total	175	63	36	7.9

surface granted to mining activities (Rayon) and the other one located in a coastal area with a 30% overlap (Playa Ceuta) could be considered in a situation of greater vulnerability; the first one because of its full concession, the second one because of its location in the lowest part of the basin, and in both cases for their extensions. El Chico reserve already had 55% under concession to mining activities (Table 2).

For NPAs whose surface is between 5000 and 50,000 ha Sierra de Quila, Los Mármoles, and Sierra La Mojonera had an overlap from 50 to 86% (Table 3).

Among NPAs from 50,000 to 500,000 ha, Cuenca Alimentadora del Distrito Nacional de Riego (CADNR, feeding basin of national irrigation district) 001 (Pabellón), Sierra Huautla and Zicuirán-Infiernillo overlap with mining concessions 22%, 23%, and 32%, respectively (Table 4); although they do not cover a large surface of these NPAs extension, they show large size concessions (Zicuirán-Infiernillo overlaps with one concession of 52,000 ha).

Finally, larger (in absolute numbers) mining concessions are located in the largest NPAs of the country: Valle de los Cirios, El Vizcaino, CADNR 004 (Don Martín), and 043 (Nayarit), with 1,002,043 ha of total surface of mining concessions overlapping in only these four NPAs (Table 5). Percentages do not overlap largely (19% highest) because of the large extensions of the NPAS in these cases; nevertheless, these are gigantic mining concessions (one covers 232,000 ha and another one 276,000 ha) on CADNR 043 and 004, respectively.

3.4. *Overlap in all federal NPAs*

Finally, the mining concessions overlapping in all federal NPAs can be observed, showing different colors according to their overlap percentage specified in Fig. 3.

4. Discussion

4.1. *Exploration concessions*

The majority of mining concessions were found in their exploration stage (Fig. 1), but it is worth remembering a concession lasts for 50 years and can be renewed almost automatically. This type of concession grants the permission to do enough field research to assure the amount and feasibility of the minerals to be extracted.

During this time the mining companies also wait for the best metal quote to start exploitation (specially gold) (López and Eslava, 2011; Ruiz, 2004); they sell shares of the future

Table 2 – NPAs in Mexico from 5 to 5000 ha overlapping with mining concessions, as percentages of overlapping area, number of mining concessions, and percentage of those reported as exploration, exploitation or not available information (NAI).

No.	NPA	State	Management category	Decreed area (ha)	Area overlapping with mining concessions (ha)	Area overlapping with mining concessions (%)	Concessions (*n*)	Exploration (%)	Exploitation (%)	NAI (%)
1	Rayón	Mich.	NP	25	25	100.00	3	0	0	100
2	Playa de Escobilla	Oax.	S	30	3	9.26	1	100	0	0
3	Playa El Verde Camacho	Sin.	S	62	2	3.23	2	100	0	0
4	Playa Ceuta	Sin.	S	77	23	29.39	4	50	50	0
5	Playa de Mismaloya	Jal.	S	167	17	10.08	2	100	0	0
6	Cerro de Garnica	Mich.	NP	1936	6	0.32	1	100	0	0
7	El Chico	Hgo.	NP	2739	1510	55.13	3	70	30	0
				5036	1586	31.50	16	62	19	19

Table 3 – NPAs in Mexico from 5000 to 50,000 ha overlapping with mining concessions, as percentage of overlapping area, number of mining concessions, and percentages of those reported as exploration, exploitation or not available information (NAI).

No.	NPA	State	Management category	Decreed area (ha)	Area overlapping with mining concessions (ha)	Area overlapping with mining concessions (%)	Concessions (*n*)	Exploration (%)	Exploitation (%)	NAI (%)
8	Cascada de Baseasseachic	Chih.	NP	5803	393	6.77	3	100	0	100
9	Volcán Tacaná	Chis.	BR	6378	291	4.57	1	0	0	100
10	Insurg. José María Morelos	Mich.	NP	7192	57	0.80	1	100	0	0
11	Sierra La Mojonera	S.L.P.	PAFF	9252	7978	86.23	1	100	0	0
12	Chamela-Cuixamala	Jal.	BR	13,143	1848	14.06	1	100	0	0
13	Sierra de Quila	Jal.	PAFF	15,193	7617	50.14	5	100	0	0
14	Sierra de Álvarez	S.L.P.	PAFF	16,900	699	4.14	10	90	10	0
15	Pico de Orizaba	Ver. & Pue.	NP	19,750	105	0.53	1	100	0	0
16	Sierra del Abra Tanchipa	S.L.P.	BR	21,464	82	0.38	1	100	0	0
17	Los Mármoles	Hgo.	NP	23,150	11,961	51.67	58	80	20	0
18	Pico de Tancítaro	Mich.	PAFF	23,406	76	0.32	1	100	0	0
19	Gogorrón	S.L.P.	NP	38,232	1545	4.04	7	100	0	0
20	Zona Protectora Forestal Vedada la Cuenca Hidrográfica del Río Necaxa	Puebla	NRPA	41,692	105	0.25	1	0	0	0
21	Cañón de Río Blanco	Ver.	NP	48,800	650	1.33	4	50	50	0
				290,353	33,406	11.51	95	78	17	5

Table 4 – NPAs in Mexico from 50,000 to 500,000 ha overlapping with mining concessions, as percentage of overlapping area, number of mining concessions, and percentages of those reported as exploration, exploitation or not available information (NAI).

No.	NPA	State	Management category	Decreed area (ha)	Area overlapping with mining concessions (ha)	Area overlapping with mining concessions (%)	Concessions (*n*)	Exploration (%)	Exploitation (%)	NAI (%)
22	Meseta de Cacaxtla	Sin.	PAFF	50,862	128	0.25	1	100	0	0
23	Mariposa Monarca	Mich. & Méx.	BR	56,259	9312	16.55	11	0	0	100
24	Sierra de Huautla	Mor.	BR	59,031	13,489	22.85	22	90	10	0
25	Ría Lagartos	Yuc.	BR	60,348	10,160	16.84	20	0	0	100
26	Médanos de Samalayuca	Chih.	PAFF	63,182	3467	5.49	9	20	80	0
27	Complejo Lagunar Ojo de Liebre	B.C.S.	BR	79,329	6059	7.64	3	0	03	70
28	Ría Celestún	Yuc.	BR	81,482	13	0.02	4	30	80	0
29	Cuatrociénegas	Coah.	PAFF	84,348	7525	8.92	6	50	50	0
30	Sierra de Álamos-Río Cuchujaqui	Son.	PAFF	92,890	16,124	17.36	18	80	02	0
31	Barranca de Metztitlán	Hgo.	BR	96,043	1143	1.19	1	100	0	0
32	CADNR001	Zac. & Ags.	NRPA	97,700	21,939	22.46	25	70	30	0
33	Campo Verde	Chih.	PAFF	108,067	67	0.06	1	100	0	0
34	Sierra La Laguna	B.C.S.	BR	112,437	9185	8.17	19	30	70	0
35	El Triunfo	Chis.	BR	119,177	30	0.02	3	0	0	100
36	Marismas Nacionales Nayarit	Nay.	BR	133,854	3951	2.95	2	100	0	0
37	Sierra de Manantlán	Jal. & Col.	BR	139,577	11,114	7.96	26	0	0	100
38	La Encrucijada	Chis.	BR	144,868	15	0.01	1	100	0	0
39	Los Tuxtlas	Ver.	BR	155,122	6861	4.42	5	60	40	0
40	La Sepultura	Chis.	BR	167,310	1646	0.98	1	0	0	100
41	ZPFTC Cuencas de los Rios Valle de Bravo, Malacatepec, Tilostoc y Temascaltepec	Mich. & Méx.	NRPA	172,879	26,864	15.54	14	0	0	100
42	Cumbres de Monterrey	N.L.	NP	177,396	1932	1.09	11	50	50	0
43	CADNR026	Coah. & N.L.	NRPA	197,157	1538	0.78	28	60	40	0
44	Maderas del Carmen	Coah.	PAFF	208,381	3908	1.88	19	70	30	10
45	Papigochic	Chih.	PAFF	222,764	3569	1.60	25	20	0	70
46	Sierra Gorda de Guanajuato	Gto.	BR	236,883	47,307	19.97	53	70	30	0
47	Zicuirán-Infiernillo	Mich.	BR	265,118	85,594	32.29	52	0	0	100
48	Cañón de Santa Elena	Chih.	PAFF	277,210	4074	1.47	17	50	50	0
49	Ocampo	Coah.	PAFF	344,238	26,883	7.81	34	90	10	0
50	Islas del Golfo de California	B.C., B.C.S. Son. & Sin.	PAFF	374,554	1849	0.49	10	30	60	10
51	Sierra Gorda	Qro.	BR	383,567	19,205	5.01	88	90	10	0
52	Bahía de los Ángeles, Canal de Ballenas y Salsipuedes	B.C.	BR	387,957	3372	0.87	5	20	0	80
53	Tutuaca	Chih.	PAFF	436,986	83,175	19.03	145	30	30	50
54	Tehuacán-Cuicatlán	Oax. & Pue.	BR	490,187	185	0.04	4	80	30	0
				6,077,162	431,685	7.10	683	46	22	33

Table 5 – NPAs in Mexico from 500,000 to 3,000,000 ha overlapping with mining concessions, as percentage of overlapping area, number of mining concessions, and percentage of these reported as exploration, exploitation or not available information (NAI).

No.	NPA	State	Management category	Decreed area (ha)	Area overlapping with mining concessions (ha)	Area overlapping with mining concessions (%)	Concessions (*n*)	Exploration (%)	Exploitation (%)	NAI (%)
55	Janos	Chih.	BR	526,482	860	0.16	9	100	0	0
56	Laguna Madre & Delta del Río Bravo	Tamps.	PAFF	572,809	106	0.02	1	0	100	0
57	El Pinacate & Gran Desierto de Altar	Son.	BR	714,557	10,804	1.51	15	40	50	10
58	Calakmul	Camp.	BR	723,185	736	0.10	3	0	100	0
59	Alto Golfo de California & Delta del Río Colorado	B.C. & Son.	BR	934,756	10,097	1.08	40	40	60	0
60	CADNR004	Coah.	NRPA	1,519,390	293,679	19.33	328	60	40	0
61	CADNR043	Dgo., Jal., Nay., Ags.& Zac.	NRPA	2,329,030	336,173	14.43	328	70	30	0
62	Valle de los Cirios	B.C.	PAFF	2,521,990	180.996	7.18	91	0	20	8
63	El Vizcaíno	B.C.S.	BR	2,546,790	186,303	7.32	49	0	10	90
				12,388,989	1,019,755	8.23	864	52	33	15

mine (Ruiz, 2004) and try to obtain the permits at local levels (SE, 2013a), as well as the permit for municipal land use. Several years may pass by without reaching the exploitation stage if the conditions are not adequate or the concession might be transferred to another owner; however, this apparent inactivity in the exploration stage does not indicate the mine will not be installed.

4.2. *Breach of LGEEPA*

The General Law of Ecological Balance and Environmental Protection (LGEEPA acronym in Spanish) mentions the categories ANPR, BR, and PAFF may have "Special Exploitation Areas" where mining is permitted as long as it does not deteriorate the ecosystem, modify landscape substantially, or cause irreversible environmental impacts (Art. 47 Bis 1, LGEEPA, 2013). In our study we found that these categories of PNAs showed major incidence of mining concessions (75% of NRPA, 63% of BR, and 47% of PAFF). However, it is worth to mention that in the majority of the cases the concessions were within and out of these limited areas, and metal mining (at a great scale above all) is definitely not a low impact activity.

Special exploitation areas are not part of the zoning of the other categories (NP, S, and Natural Monuments); thus granting mining concessions in national parks as Los Mármoles, El Chico, and Rayón and in beach-sanctuaries of the Pacific coast are also a flagrant crime against this law. Perhaps, a number of permits for non-metallic mining may be allowed in some cases on a small-scale and under strict surveillance.

4.3. *The need for a buffer zone*

Usually, NPAs overlapping with mining concessions also show mining activities near the limits of their decreed area, which may increase their vulnerability. Such is the case of the Sierra de la Laguna, Sierra Manantlán, Janos, and Tutuaca. Within smaller NPAs, the situation is worse, as in the case of Sierra La Mojonera overlapping in 86% and also surrounded by concessions up to five times the length of the NPA itself within the first 10 km or El Chico overlapping in 55% by surrounding concessions doubling the size of the NPA.

Other NPAs overlapped with smaller but relatively large concessions surrounding them, as in the case of the beaches El Verde Camacho and Ceuta, sanctuaries (S) of very small extent in the coastal strip. They are surrounded by large mining concession areas in proportion to their size (from 5 to 271 times the size of the NPA). On the other hand, other NPAs are non-overlapping but have mining concessions close to their boundaries, for example El Sabinal, Yagul, and Tula.

Despite the severe environmental impacts caused by metal mining (Akcil and Koldas, 2006; Aleksander-Kwaterczak and Helios-Rybicka, 2009; Antoninova et al., 2012; Bird et al., 2009; Bridge, 2004; Kempter and Frenzel, 2000; Olías et al., 2011; Wireman and Stover, 2011); it is precisely this type of mining which is intended and even installed with the status of operating on several federal NPAs. Whereas 86% of exploration and 76% of exploitation concessions within NPAs are for metal mining, in the context of metal mining in Mexico almost all of it is considered mega mining scale (98–100%) (SGM, 2013). More detailed information on mining concessions is not

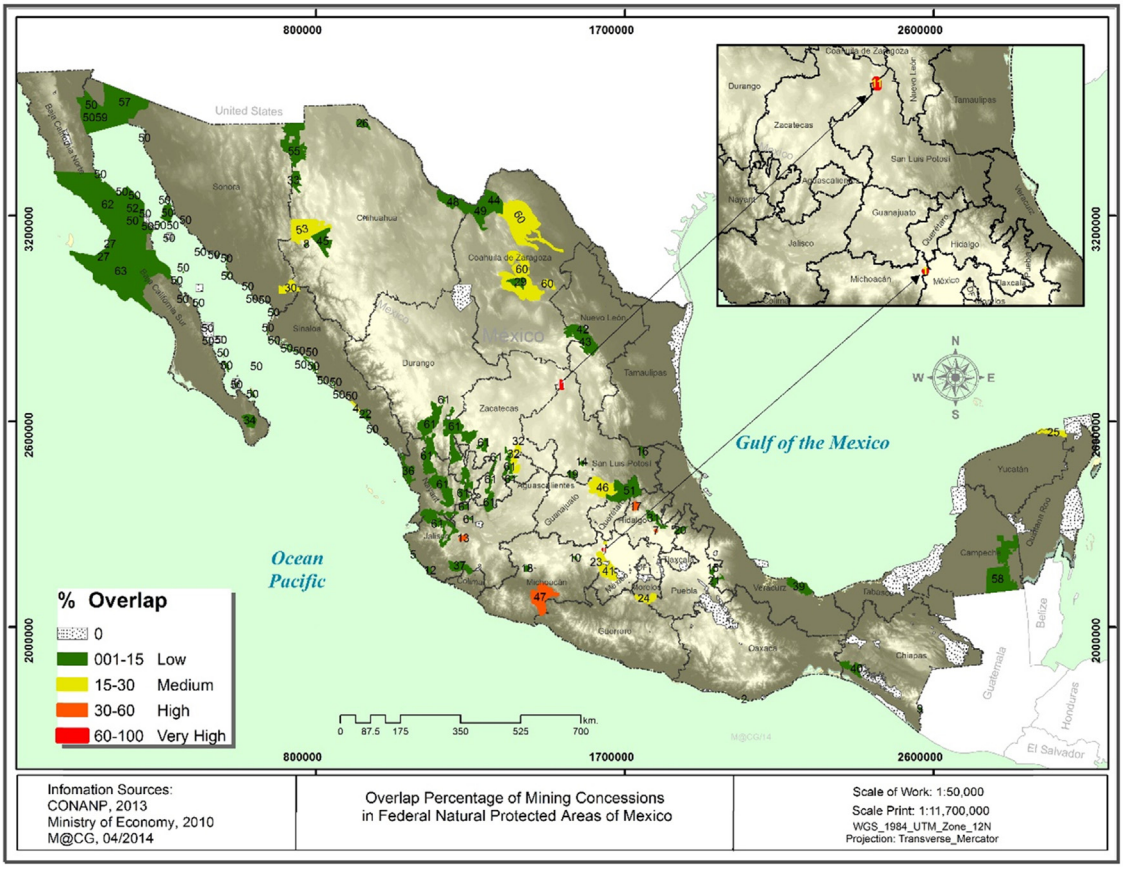

Fig. 3 – Federal NPAs in Mexico according to overlapping percentage with mining concessions. Without concessions, dotted; low: 0.001–15% (green); medium 15–30% (yellow); high 30–60% (orange); very high 60–100% (red). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

available in the web site of Integrated System Management Mining (SIAM) or accessible through the Institute of Public Information (IFAI).

Impacts are not limited to biodiversity and to the human communities that inhabit NPAs and although a larger radius of influence is imminent, it is has not been evaluated yet. This is the case of many of the NPAs that are located in high mountain ranges (e.g. El Triunfo, Sierra de la Laguna, Los Tuxtlas, Tutuaca, Sierra de Manantlán, Sierra del Abra Tanchipa) or the feeder basin irrigation districts (001, 004, 026, and 043) that have a special role in water storage and distribution in surrounding areas that could cause shortages and pollution in their ranges, as well as economic activities that depend on them. Arriaga et al. (2009) noted that the priority hydrologic regions, those of greater concentration and extension, are located along the Sierra Madre Occidental and the alluvial basins of the north, specifically in the upper parts of the states of Sonora, Chihuahua, Sinaloa, Nayarit, Durango, and Jalisco. Thus a far more effective protection of the NPAs and water reserves in the region against the effects of metal mining on a large scale would be to prohibit mining concessions in the upland areas of watersheds as in the recharge zone, necessary for the conservation of biota (including human activities) in the middle and lower basin.

It is clear that in Mexico a decree of protected area is not an obstacle for this type of project, which is clearly underestimating the actual and potential impact of mining and exploration activities. Thus, the enforcement of a buffer zone outside the limits of each NPA is considered necessary as a minimum requirement for reducing direct impacts of mega metal mining since not all management categories contemplate one and sometimes core areas can be located on the periphery.

An evident and necessary step is the cancelation of mining concessions within an external buffer zone in a NPA, as it contravenes any conservation strategy and the LGEEPA itself. Currently, there is no strong protection against mining in natural protected areas because it has been considered as a ''public utility and preferred activity'' over the protection of biodiversity (Art. 6 of Mining Law, regulatory of Art. 27 of the Mexican Constitution, Ley Minera, 2006; López and Eslava, 2011).

4.4. *Poor regulation of mining concessions*

According to the surface data reported for mining concessions of the Directorate General of Mines (DGM, initials in Spanish) (López and Eslava, 2011), it is estimated that 28% of the country

was granted in concession until 2010. However, according to our GIS assessment, surely even this percentage it is not officially well calculated. According to our assessment we found that many concessions are partially or completely overlapping, among them. This overlapping among concession is a clear indicator of the poor regulation for granting the mining concessions in Mexico.

4.5. *Lobbying by the mining industry*

It is important to emphasize that the mining companies grouped in the Mexican Mining Chamber (CAMIMEX, acronym in Spanish) take advantage of legal gaps within intricacies of environmental legislation. An opportunistic pondering of mining in national politics has tried to profile metal mining as a sustainable economic activity and therefore making it possible to legally operate within the NPAs.

CAMIMEX has participated in conducting management programs such as Valle de los Cirios and Sierra de Huautla, (CAMIMEX, 2006).

At the request of several unionized mining companies, this group made a proposal to the Commission of Natural Protected Areas (CONANP) for the Tutuaca Management Program because it is intended to restrict mining in this NPA (CAMIMEX, 2013; CONANP, 2013). These requests could have been considered in preference since the new management plan for the NPA includes several mining concessions in the surrounding areas (DOF-1-11-2013). In their management programs, the concession is observed outside the Special Exploitation Areas in Valle de los Cirios (DOF-02-04-2013), and the Sierra de Huautla management program states only 2% of special exploitation use permitted (CONANP, 2005).

The ecological legislation encourages public participation for the development of management programs (Art. 73, LGEEPA rules, 2014). However, there is no mechanism to ensure equal participation of all the sectors on management programs, because it is usually not provided enough information about the potential impacts of these mining activities to the inhabitants of the NPA. Also, currently, only half of the NPAs have a management program (CONANP. gob.mx).

5. Conclusions

The Mexican government should promote the creation of management programs for all the PNAs where mining activity is regulated according to the legislation in this matter; likewise, it should assure the social participation of the sectors involved to balance the participation of the mining industry in these programs.

The impacts of metal mining activities on NPAs are not only limited to biodiversity and affectation to human communities, but they also have a radius of influence not yet evaluated since most of the NPAs have a special role in supplying watersheds and aquifers. More studies are needed to consider priority areas for conservation of biodiversity and hydrology that are out of PNA boundaries (CONABIO et al., 2007) furthermore PNAs, should prevent or minimize mining impacts with a system approach.

Obviously, currently in Mexico a NPA decree does not represent an obstacle to megamining projects; in consequence, their real environmental impacts are underestimated. It is a priority to legally support canceling the mining concessions already granted in the NPAs and stop granting new ones in the future. In the proportion environmental authorities continue to openly accept mining concessions within the NPAs through modifying management programs that allow these activities, they may cause a significant increase in rejections from local people toward the changes in management programs and even on the promotion of new NPAs in Mexico.

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