

A comparison between risk assessments methods: assessing five species of cloud forest rodents in Mexico

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Abstract

Background. Red Lists have been traditionally used as the instruments to guide conservation strategies to avoid extinctions. There is little objection to the idea that categorizing species according to their risk of extinction is a good way to prioritize and implement conservation actions; however, there is little consensus in the best way to do this categorization, and different countries have developed different methods according to their specific needs. The scope of this paper is to contrast the Mexican Risk of Extinction Assessment Method (MER) and the one used by the IUCN Red List, and test how simple, objective and transparent are them.

Methods. In order to compare the we performed a search within IUCN's data base to find species ranked as critically endangered which have not been assessed by the MER. We picked 5 species from the rodent genus *Habromys* and performed a literature review to assess them through the MER guidelines; we then compared the outcomes with UICN Red List.

Results. The five assessed species of cloud forest rodents yield equivalent results through both the MER and IUCN assessments; however, the information asked for by the MER was scant for all the species, and we argue that the results of the assessments are thus not entirely objectives. Moreover, we found that the MER is not a simple method to use due to ambiguities of the criteria.

Discussion. The aim of risk assessments is to clearly define the conservation status of a given species, displayed in a simple, transparent, objective, way, which can be relevant in terms of scope and impact on conservation actions. Unfortunately the MER does not fulfil all these requirements, potentially compromising conservation actions. As a result, we propose that it is time reevaluate the current version of the Mexican Risk of Extinction Assessment Method.

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1. Introduction Red Lists have been traditionally used as the instruments to guide conservation strategies to avoid extinctions. There is little objection to the idea that categorizing species according to their risk of extinction is a good way to prioritize and implement conservation actions; however, there is little consensus in the best way to do this categorization, and different countries have developed different methods according to their specific needs (Grammont & Cuarón, 2006). In this paper, we contrast two of these methods, the Mexican Risk of Extinction Assessment Method (MER, for its Spanish acronym), and the IUCN assessment method. Throughout this exercise, we subscribe the idea that for assessments to be useful, they must be objective, simple, and transparent.

In Mexico, the Risk of Extinction Assessment Method (MER) is the only accepted method to enlist species in The National Mexican Red List (NOM-059-SEMARNAT-2010; Soberón & Medellín, 2007, Sánchez *et al.*, 2007). Sánchez *et al.* (2007) explained that while implementing the MER, IUCN's method was used as guide. However, these authors referred that at the time; the MER was considered as a better solution due to the country's own needs. This method has been evaluated and compared with IUCN's assessment method elsewhere (Grammont & Cuarón, 2006; Cuarón & Grammont, 2007; Arroyo *et al.* 2009). However, the discussion of whether the Mexican method is accurate and objective is still ongoing.

Both the MER and the IUCN assessment methods have similar risk categories. Within the Mexican Red List there are four risk categories: Probably extinct in wildlife (E), Endangered (P), Threatened (A), and Under special protection (Pr), whereas the IUCN has seven: Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW), and Extinct (EX). Sánchez *et al.* (2007) addressed the similarities between risk categories contemplated by the NOM 059-SEMARNAT-2010 and those from IUCN (Table 1). Moreover, these authors acknowledged that the IUCN risk assessment was reviewed during the development of the MER, but the idea of having a national assessment method was to customize it to the country's own needs. It is worth noting that

although assessment procedures can be different, given adequate data the expected outcomes should be roughly the same (Arroyo *et al.*, 2009).

The MER has four criteria to establish risk categories: Criteria A: distribution; Criteria B, habitat; Criteria C, intrinsic vulnerability; and Criteria D: human impact. Each of these criteria is evaluated quantitatively and the total score is calculated by adding the results from the four. The higher the value of the total score, the higher the risk of extinction of the assessed species (see Sánchez *et al.*, 2007; Arroyo *et al.*, 2009). In animals, a species with a total score between 12-14 points is considered endangered (P), between 10 -11 threatened (A), whereas a score lower than 10 can grant special protection status (Pr) providing that evidence for the urgency of protecting it exists. On the other hand, the IUCN method contemplates five criteria: Criterion A: population size reduction; Criterion B: geographic range; Criterion C: small population size and decline; Criterion D: very small or restricted population; Criterion E: quantitative analysis (IUCN, 2012). Contrary to what happens with the MER, the IUCN method does require all criteria to be completed in order to obtain an assessment, rendering the method especially useful for species with different levels of information (To learn more see IUCN, 2012).

Assessing five species of cloud forest rodents of Mexico

Frugivore rodents fulfill a role as seed dispersers, contributing to the spatial dynamics of plants populations during a key-stage of their life cycle (Nyiramana, et al. 2011; Choo, *et al.* 2012; López-Barrera, Newton & Manson, 2005; Forget *et al.*, 2011). At the same time, plants provide rodents with the energy needed to complete their own life cycles (Stephens *et al.*, 2013; Johnstone, Lill & Reina, 2014). In addition to their role as dispersal agents, rodents play several other roles within trophic webs (Martínez, 2008): they are an important source of energy for bigger mammals, function as biocontrol agents (Hanski, 1987), contribute to the nutrient cycles of soil while grazing in forest ecosystems (Virtanen, 2000; Hoset *et al.*, 2014;), and, in the case of the fossorial species, modify vegetation composition and abundance, nutrients dynamics, capture of water, and soil texture (Reichman & Seabloom, 2002; Kerley, Whitford &

Kay, 2004; Arias, 2011). Hoset *et al.* (2014) gave an example of the importance of rodents in trophic webs by keeping competitive interactions within plant communities (biocontrol), and as energy source for other mammals (prey). Thus, frugivore rodents are crucial to the maintenance of several ecosystems, including the imperiled Cloud Forest (Moran, Catterall & Kanowski, 2009; MEA, 2005; Choo, *et al.*, 2012; Koike *et al.*, 2012).

The cloud forest is a group of communities distributed along the mountains, with specific floral structure and species composition (CONABIO, 2010), and best known for the presence of clouds at vegetation level (Hamilton, 1995). In Mexico, the cloud forest is the most threatened ecosystem (Challenger, 1998), currently occupying less than 1% of Mexico's territory (8,809km²), and the one with the least surface worldwide (CONABIO, 2010). At the same time, this ecosystem has the most diverse flora and fauna in relationship to its area (Challenger, 1998; CONABIO, 2014). Besides its ecological importance, the cloud forest is an important source of timber (Lamoreux, McKnight & Cabrera, 2015), medical products (May, 1978; CONABIO, 2014), and commodities such as shade-grown coffee plantations (CONABIO, 2014). Moreover this ecosystem is a priority for conservation and restoration efforts due to its crucial role in sustaining the water and nutrient cycles (Hamilton, 1995).

Anthropogenic pressure on tropical montane areas is one of the most important threats to the cloud forest (Drobovolski *et al.*, 2013 Lindenmayer, Cunningham & Pope, 1999; CONABIO, 2010; CONABIO, 2014). As a result of this process, cloud forests, as montane vegetation ecosystems in general, are becoming fragmented, sustaining only isolated vegetation patches that reduce the quality and quantity of the habitat for forest-dependent species (Lindenmayer, Cunningham & Pope 1999). Stephens *et al.* (2013) demonstrated that even the smallest fragmentation, such as a road or walk path, can change the genetic structure of small species populations as those of rodents. Additionally, edge effect, another consequence of habitat loss and fragmentation (Lindenmayer, Cunningham & Pope, 1999), is common in landscapes next to disturbed areas. Studies such as those from López-Barrera, Newton & Manson (2005) suggest that edge effect in montane forests can change the demography of small mammals populations, which in turn

change the patterns of seed consumption and dispersal preventing future regeneration of forest borders. Likewise, Banks and Dickman (2000) proposed that a lack of seeds has a direct impact in the population growth and habitat use of small rodents. Thus, both animal and plant populations are affected by changes in microclimates as a result of edge effect, and these effects become more severe the bigger the fragmentation and the smaller the remaining fragments (Forman & Godron, 1986; Laurence & Yensen, 1991; Fonseca & Jones, 2007; Craig *et al.*, 2015). Moreover, according to the metacommunity theory, colonization and extinctions are related to patch size and connectivity (Jones *et al.*, 2015). Finally, fragmentation can also have demographic and genetic stochastic consequences, especially within small populations, which can lead to local or complete species extinctions (Frankham, Ballou & Briscoe, 2002; Pardini *et al.*, 2004). The absence of seed dispersers such as small rodents may accelerate the damage to the unique, small, and fragile ecosystem of the cloud forest (Pardini *et al.*, 2005; Sullivan *et al.*, 2013) due to the lack of plant recruitment along with several other disruptions to the dynamics of the ecosystem (Cayuela *et al.*, 2006; Johnstone, Lill & Reina, 2014; Koike *et al.*, 2012).

In summary, cloud forest rodents provide crucial ecosystem services and sustain to this habitat.

Unfortunately these species are poorly studied and the information available for them is scant; their assessment and protection is compromised even more as they are not charismatic species, and have low or inexistent conservation budget. Thus, there is a need to quickly assess their risk status and enlist them in national Red Lists to pressure on their conservation.

2. Method

Selecting species for the assessment

To select the species for this study we performed a search within the mammal IUCN Red List database using the criteria listed in Table 1. We cross-referred the results of this first search with the mammals listed in the IUCN Red list but not in the National Red List (NOM-059-SEMARNAT-2010), and thus picked a set of frugivorous rodents that had been assessed by the IUCN but not at the national level.

During all searches, we checked both lists for misspelled names or synonyms, as errors and taxonomic changes might bias the exercise. Finally we gathered collection data points from the National Information System of Biodiversity (SNIB, acronym in Spanish) from CONABIO (National Commission for the Knowledge and Use of Biodiversity, Mexico) to map these species' occurrence and sought for occurrences within NPA within Mexico, to find if at least some of the non-assessed species are protected by this strategy.

Results

Our search within IUCN's data base according to our parameters returned a group of 18 mice species belonging to seven different genera (*Habromys*, *Handleyomys*, *Neotoma*, *Pappogeomys*, *Peromyscus*, *Reithrodontomys*, *Sigmodon*) enlisted in IUCN's Red List of threatened species V. 3.1 under the categories of Vulnerable (VU), Endangered (EN), and Critically endangered (CR) (Table 2), which are not included in the Mexican National Red List. All these species occur in high mountains (Table 3), and the threats for them are known and reported in their individual IUCN assessments (Table 3). The most common threat for all species was habitat loss due to anthropogenic pressures, although habitat loss can vary depending on region and species (Table 3). Furthermore, only six of these rodents occur within natural protected areas (NPA), which means that only 33% of the species are under indirect protection. Out of these 18 species, for our study we selected the five enlisted as critically endangered (CR) and which inhabit the cloud forest. The distribution for the five species can be found in Figure 1(a-e).

The results of the assessment for each one of these five species using the MER (Annex 1) place the five species in the highest risk status of the Mexican National Red List (P, Endangered), which according to Sánchez *et al.*, (2007), is equivalent to the IUCN's critically endangered (CR) category. It is important to note that even though risk categories differ between systems (i.e., MER and IUCN), all of them should help decision makers implement the best conservation actions as needed (De Grammont & Cuarón, 2006). In this case, both assessment methods agree on the risk status of the five species of mice. but in

many cases this does not happen. In a recent study by Armenta-Montero *et al.* (2015) with ferns of the genus *Phlegmariurus*, these researchers found that only one of the nine species in the state of Veracruz, Mexico, was included in the NOM-059-SEMARNAT-2010. When they assessed the nine species following the IUCN method five of them were classified as vulnerable, three as endangered and one, the species enlisted in the NOM-059-SEMARNAT-2010 under special protection (Pr), as critically endangered.

Discussion

A Comparison between the MER and the IUCN's methods of assessing risk of extinction

The aim of risk assessments is to clearly define the conservation status of a given species, displayed in a simple, transparent, objective, way, which can be relevant in terms of scope and impact on conservation actions. Moreover, risk assessments must have support information according to the categories granted, referring to the species' present condition, and should be replicable, so different authors can reach the same result while assessing the same species (De Grammont & Cuarón, 2006); In this sense, many authors claim that the IUCN risk assessment method is currently the simplest, fastest, most accurate, and most transparent method to assess species, while other authors such as Soberón & Medellín (2007) have criticized it. Throughout this study we were particularly interested in seeing how the IUCN method compares against the Mexican Evaluation of Risk method (see for example arguments at De Grammont & Cuarón, 2006; Feria *et al.*, 2009; Armenta-Montero *et al.*, 2015).

One of the first issues we had with the MER was with how relevant each of the criteria was for assessing different organisms. For instance, knowledge of the distribution range is fundamental in planning conservation actions, and in many cases it is the only data available to assess a species; as such, every assessment method takes it into account, although it is scored differently by each of them. In our example, when assessed using the MER, the five rodents got the highest value (4 points) in distribution (criterion A) due to their very restricted area (less than 5% of Mexico's territory). On the other hand, in IUCN's

assessment, these five rodents are classified as critically endangered CR B1ab(iii). under criterion B (geographic range) due to their extremely reduced extent of occurrence (B1) ($< 100 \text{ km}^2$), the fact that all individuals occur in one location (a), as well as the continuing decline in the extent and quality of their habitats (b(iii)). However, although there is no doubt that knowledge of the status of the habitat (criterion B) is important for conservation, and in fact is taken into account on IUCN's criterion B (continuing decline in the extent and quality of their habitats), the MER asks for a great amount of detail in this criterion for the assessment. In our example we found the information for *Habromys chinanteco*'s habitat and for some of the sympatric species, but we had no information on whether the rodent was dependent on them or not. Had we lacked the information for habitat type, the species would lose points in criterion B that could at the end lower its risk status, and could hamper conservation actions when in fact the conservation of the species is a matter of urgency, or we could have assigned a subjectively high score to obtain a higher risk status.

The former point brings us to the next issue while using the MER: low values due to gaps in knowledge can prevent the listing of any species as the risk status is the result of a sum of criteria A, B, C and D. On the other hand, an IUCN assessment in which there is a fair amount of information lacking can still result in an assignment of a risk category, as each criteria is independent from each other, and each species is assessed under one or more criteria (A, B, C, D or E) depending on the information available (IUCN, 2012). The MER is information-intensive for all its criteria. This need of high amounts of information is not always convenient for conservation purposes. Moreover, for many species like the ones included in this study which inhabit in the most threatened habitat in Mexico, the cloud forest, poor data have been a problem addressed for more than 20 years (Mace & Kunin, 1994), and the situation will not change. Thus, using the risks of habitat loss to assess the target species is a far better option that, as we described, has been adopted by IUCN v 3.1 and is used to evaluate with criterion B (IUCN, 2012). To exemplify this point, Raimondo, Staden & Donaldson (2013) accomplished the task of assessing and assigning an

IUCN Red List category to all South African plant taxa with very scant information for many of them, showing that the lack of information should not preclude objective assessments.

Moreover, there is a problem with MER scores: as there is little support information for them, two equal scores could belong to two species in the same risk category), could be reflecting an actual difference or alteration in any of the four criteria (De Grammont & Cuarón, 2006; Sánchez *et al.*, 2007; Arroyo *et al.*, 2009; SEMARNAT, 2010 (Table. 4). However, these differences are not apparent in the final score as the final evaluation is not transparent (De Grammont & Cuarón, 2006; Brito *et al.*, 2010) or even available for public access. Thus, at the end, a species' final MER score and its associated risk status relies entirely on the quality and quantity of information, and on their subjective appreciation by its author.

Take for instance criterion C, biological vulnerability; it is complicated enough to have all the information on the species' intrinsic vulnerability that is asked for by the MER, but then, the assessor has to decide among 3 scores (low, medium and high) in the most objective way without really guiding the decision with any kind of objective criteria.

Several authors are in good agreement that uncertainty is always associated to the data used to evaluate species, however it does not mean that information carrying a certain amount of uncertainty has to be ignored when assessments are performed (Todd & Burgman, 1998; De Grammont & Cuarón, 2006), as long as the source and the caveat of it is clearly mentioned in the assessment. In our example, we struggled with this criteria for all the five mice, specially due to lack of published information, Thus, lack of information, which is a reality for many endangered species, jeopardize the assessments when confronted with an information-intensive method like the MER.

In our view any method will have pitfalls, but the current IUCN assessment method even provides warning time for species in the future (Gärdenfrons, 2001; Brito *et al*, 2010; Raimondo, Staden & Donaldson, 2013; Maes *et al*, 2015). This latter issue has been recently addressed by Stanton *et al*. (2015), by applying niche-demographic models with habitat dynamics driven by a business-as-usual climate change scenario, to test the Red List ability to provide warning time for conservation actions. Even as the IUCN assessment method does not take into account climate change in any of its criteria, these authors found that the Red List provides decades of warning time for species which could go extinct due to climate change, especially when evaluated through criteria A, B, C, & D. In addition Stanton *et al*. (2015) found that even in the presence of uncertainty and lack of information, and even when a species is only assessed through one criterion as a result of this lack of information, the Red List assessment still provide long warning time, a mean of 40 years, for species listed as vulnerable or above, to go extinct. Therefore this is yet another benefit of using the IUCN method to assess species.

As we show in this comparison exercise we strongly support the idea that it is time to rethink the use of the MER as it is. Discussions of how to apply the IUCN method of assessment, which is global, at regional level, have been addressed widely. As a result, several different answers have been proposed (Mace & Kunin 1994; Gärdenfrons, 2001; Brito *et al*, 2010). However, the use of the IUCN method at regional levels is now more prevalent than years before (Raimondo, Staden & Donaldson, 2013; Maes *et al*, 2015), which means that some adjustments have been made to be make it useful while still remaining pertinent and objective assessment system. Our challenge in Mexico is now to transform the MER taking into account the IUCN's strengths and overcoming the weaknesses of the system to better reflect the country's needs.

Conclusions

Assessing the five species of rodents from the genus *Habromys* that we chose for this exercise resulting in similar outcomes with both the MER and the IUCN assessment method. As we have pointed out, there

will always be some discrepancies between national red lists and the IUCN red list for many species (Brito *et al*, 2010). However, the most significant difference between both methods is the flexibility and the transparency that IUCN allows, especially for species with scant information.

Our exercise demonstrates that in general MER's assessments do not require being objective, and not all the information required is relevant for conservation purposes. In our case, full description of the vegetation type and details of the associated plants were should not be required to assess a species extinction risk Most importantly, whenever some of this information is unknown for the assessed species a decision to inflate the scores of the four criteria with respect to the information available has to be make in order to achieve a score that would grant the species a risk status. This shows how many MER assessments are biased in order to get a species a risk status according to their actual situation.

We agree with many other authors (Burgman, 2002; De Grammont & Cuarón, 2006; Soberón & Medellín, 2007; Arroyo *et al*, 2009; Britos *et al*, 2010; Raimondo, Staden & Donaldson 2013), that the main objective of a Red List is to provide warning time and protection to the species, in the more accurate way. As species extinction rates are increasing faster than we can assess species, , we strongly suggest a review of MER instrument, with the goal of making it easier to assess species, with independency among criteria due to information gaps, and using only information which is significant for conservation purposes. This is evident for species like the *Habromys* mice which inhabit in the most threatened ecosystem in Mexico, the cloud forest (CONABIO, 2010; CONABIO 2014; Lamoreux, McKnight & Cabrera, 2015), a fact which by itself should be enough to list and protect them, despite the complexity that the current MER assessments, being subjective, complicated to interpret, and not transparent, implicate.

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MER	IUCN
P	CR
	EN
A	Vu
PR	NT
	LC

Table 1. Suggested equivalence between MER & IUCN Categories (Sánchez *et al.*, 2007).

Taxonomy	Mammalia
Location modifiers	Native
Selected location	Mexcio
Selected systems	Terrestrial
Threatened categories	Vulnerable (VU) Endangered (EN) Critically endangered (CR)

Table 2. Search criteria and parameters (IUCN, 2012 v.3.1)

Species	Category	Criteria	Distribution	Vegetation Type	Threat	Natural Protected Area

Habromys chinanteco	CR	B1ab(iii)	Oaxaca	Cloud forest	Deforestation	No
Habromys delicatulus	CR	B1ab(iii)	Edo. Mex	Cloud forest	Deforestation	No
Habromys ixtlani	CR	B1ab(iii)	Oaxaca	Cloud forest	Deforestation	No
Habromys lepturus	CR	B1ab(iii)	Oaxaca	Cloud forest	Deforestation	No
Habromys schmidlyi	CR	B1ab(iii)	Guerrero	Cloud forest	Deforestation	No
Handleyomys rhabdops	VU	B1ab(iii)	Chiapas	Cloud forest, Pine-Oak forest, semideciduous forest, evergreen	Degradation	Biosphere Reserve Luganas de Monte Bello
Neotoma nelsoni	CR	B1ab(iii)	Puebla	Cloud forest, Pine-Oak Forest, Tropical rainforest	Agriculture conversion	No
Neotoma palatina	VU	B1ab(iii)	Jalisco	Tropical deciduous forest	Dam, flood	Aguamilpa-El Cajón; Sierra Huicholes
Pappogeomys alcorni	CR	A2bc	Jalisco	Pine-Oak forest	Unkown	No
Peromyscus melanocarpus	EN	B1ab(iii)	Oaxaca	Montane rainforest, evergreen cloud forest	Deforestation, agriculture, human development	No
Peromyscus melanurus	EN	B1ab(iii)	Oaxaca	Tropical lowland deciduous forest, pine-oak	Habitat loss, agriculture	No
Peromyscus ochraventer	EN	B1ab(iii)	San Luis Potosí	Cloud forest	Hábitat loss, fragmentation, coffe plantation	El Cielo
Peromyscus simulus	VU	B1ab(iii,v)	Nayarit, Sinaloa	deciduous forest,	Hábitat loss due to agriculture & pesticides	Meseta Cacaxtla; Biosphere Reserve Marismas Nacionales
Reithrodontomys	EN	B1ab(iii)	Guerrero	Pine-Oak forest	Habitat	No

bakeri					fragmentation, deforestation	
Reithrodontomys hirsutus	VU	B1ab(iii)	Jalisco	Desert scrub	Vegetation loss due to monoculture	Sierra de Vallejo- Amelca; Agua Milpa El Cajón
Reithrodontomys tenuirostris	VU	A2bc	Chiapas	Montane forest	Deforestation	Biosphere Reserve Volcán Tacaná; Biosphere Reserve El Triunfo
Sigmodon alleni	VU	A2c+3c+4c	Guerrero, Michoacán, Colima, Jalisco, Nayarit, Sinaloa	Pine-Oak forest, Deciduous forest	Deforestation	Biosphere Reserve Manantlán; Biosphere Reserve Chamela-Cuixmala
Sigmodon planifrons	EN	B1ab(iii)	Oaxaca	Deciduous tropical forest	Habitat fragmentation, Tourism development	No

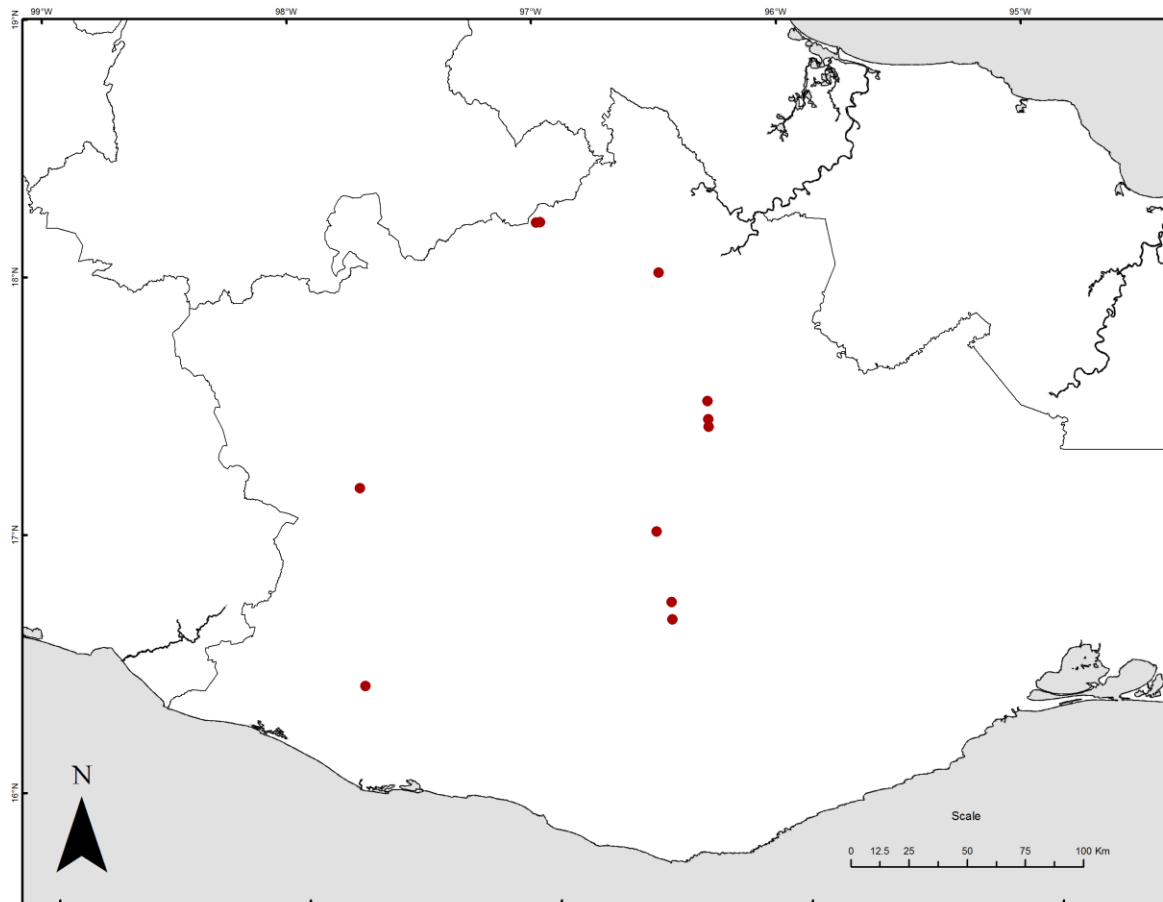
Table 3. Group of 18 endemic rodents found assessed by IUCN but no by the NOM 059-SEMARNAT-2010. Includes category, criteria threat and vegetation type from IUCN. Also distribution and whether inhabit or not within any NPA.

MER	IUCN
<ul style="list-style-type: none"> Distribution <ul style="list-style-type: none"> Description (altitude, continue or fragmented, states of the country) Map Map method Distribution size assessment Habitat <ul style="list-style-type: none"> Record (Habitat type which species occupy) Diagnosis of the current habitat status Evaluation of the currently habitat status focusing on 	<ul style="list-style-type: none"> Population size reduction <ul style="list-style-type: none"> Population reduction measured over the longer of 10 years or 3 generations Geographic range <ul style="list-style-type: none"> Extent of occurrence Area of occupancy Severely fragmented or number of locations Continuing decline of habitat, extent of occurrence or area of occupancy Extreme fluctuations of habitat, extent of occurrence

the taxon's needs	or area of occupancy
<ul style="list-style-type: none"> ○ Diagnosis justification • Biological vulnerability <ul style="list-style-type: none"> ○ Record (Species' natural history) ○ Diagnosis of the current species status ○ Evaluation of factors who makes the species vulnerable ○ Diagnosis justification • Anthropogenic pressures <ul style="list-style-type: none"> ○ Real and potential risk factors ○ Prediction analysis of species trend ○ Evaluation of the direct and indirect human impact 	<ul style="list-style-type: none"> • Small population size and decline <ul style="list-style-type: none"> ○ Number of mature individuals ○ Observed, estimate or projected continuing decline of population up to 100 years ○ Observed, estimate or projected continuing decline of population of mature individuals in subpopulations or extreme fluctuations in the number of mature individuals • Very small and restricted population <ul style="list-style-type: none"> ○ Number of mature individuals • Quantitative analysis <ul style="list-style-type: none"> ○ Indicating the probability of extinction in the wild by numeric analyses

Table 4. Aspects requested from both methods to assess species.

Figure 1a. Distribution of *habromys chinanteco*



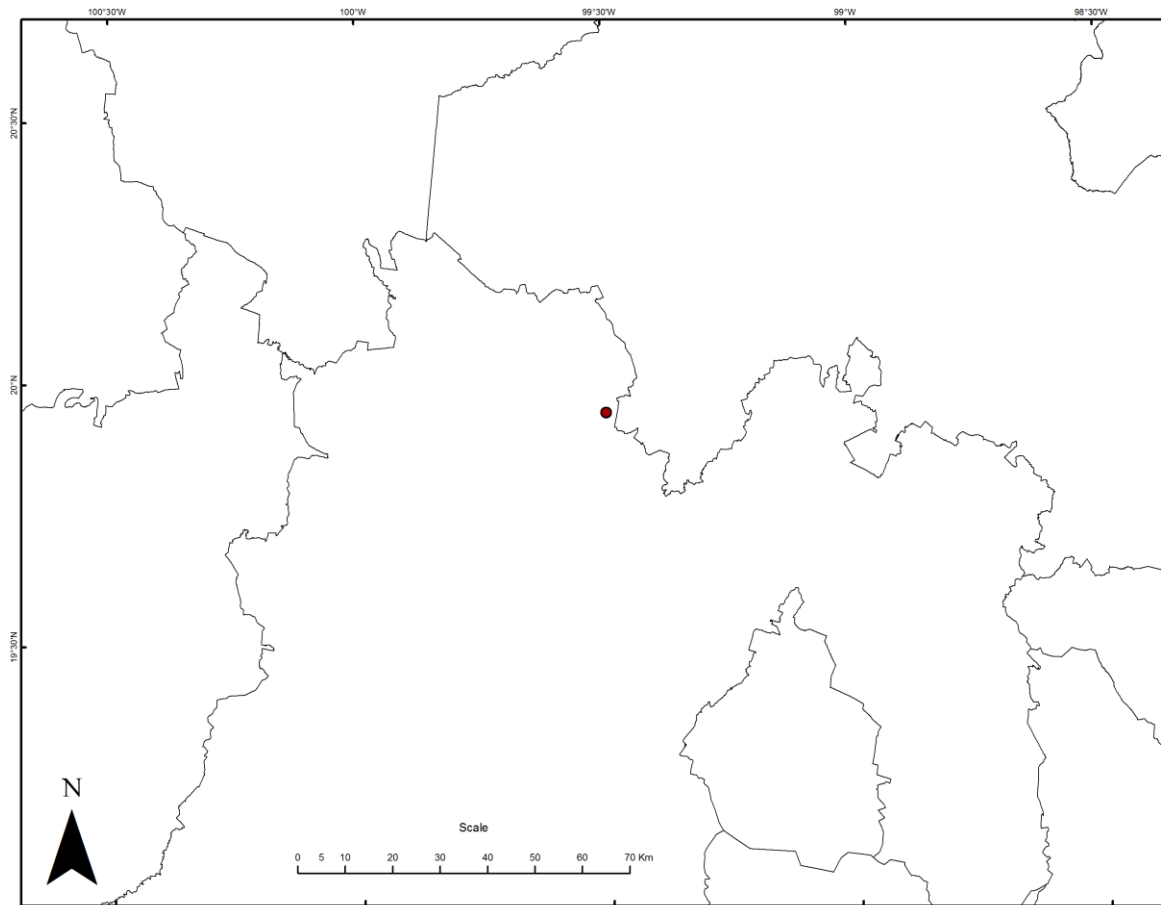


Figure 1b. Distribution map of *Habromys delicatulus*

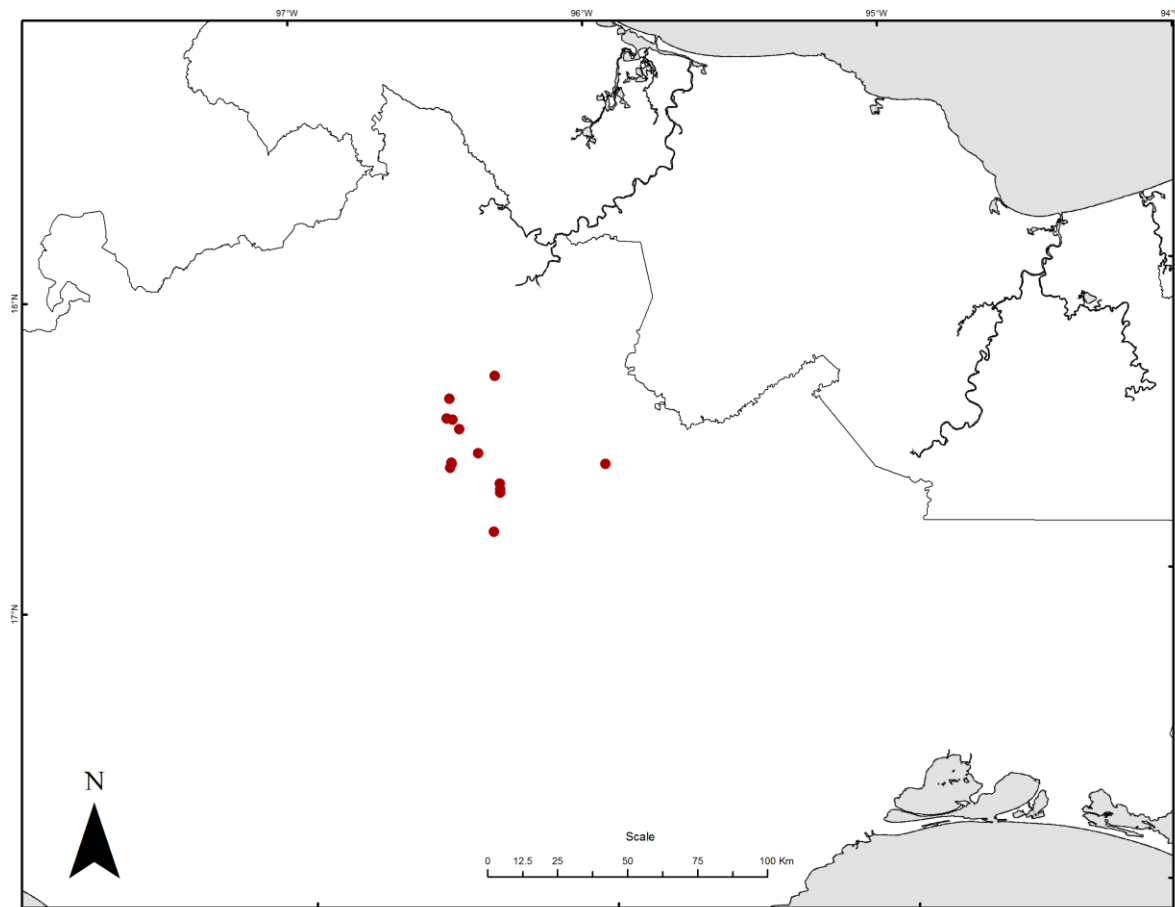


Figure 1c. Distribution map of *Habromys ixtlani*

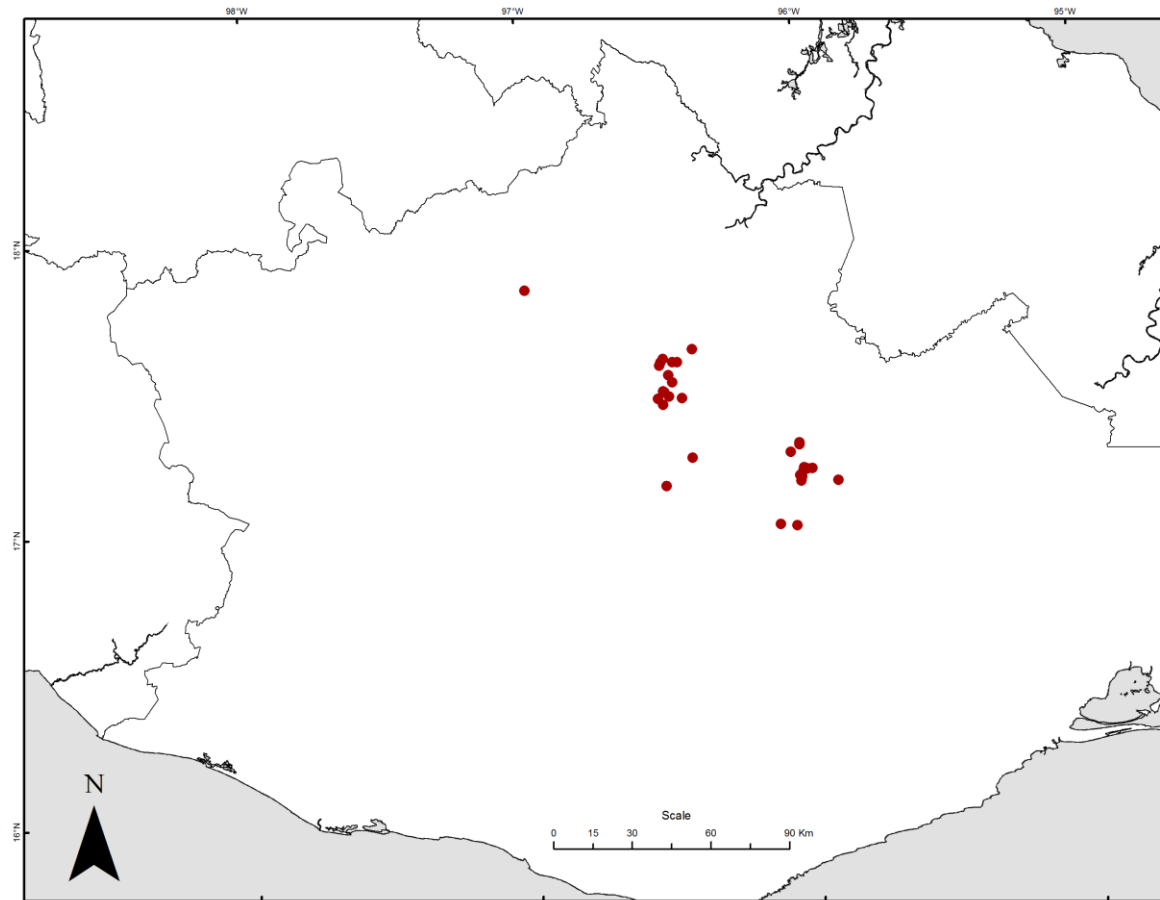


Figure 1d. Distribution of *Habromys lepturus*

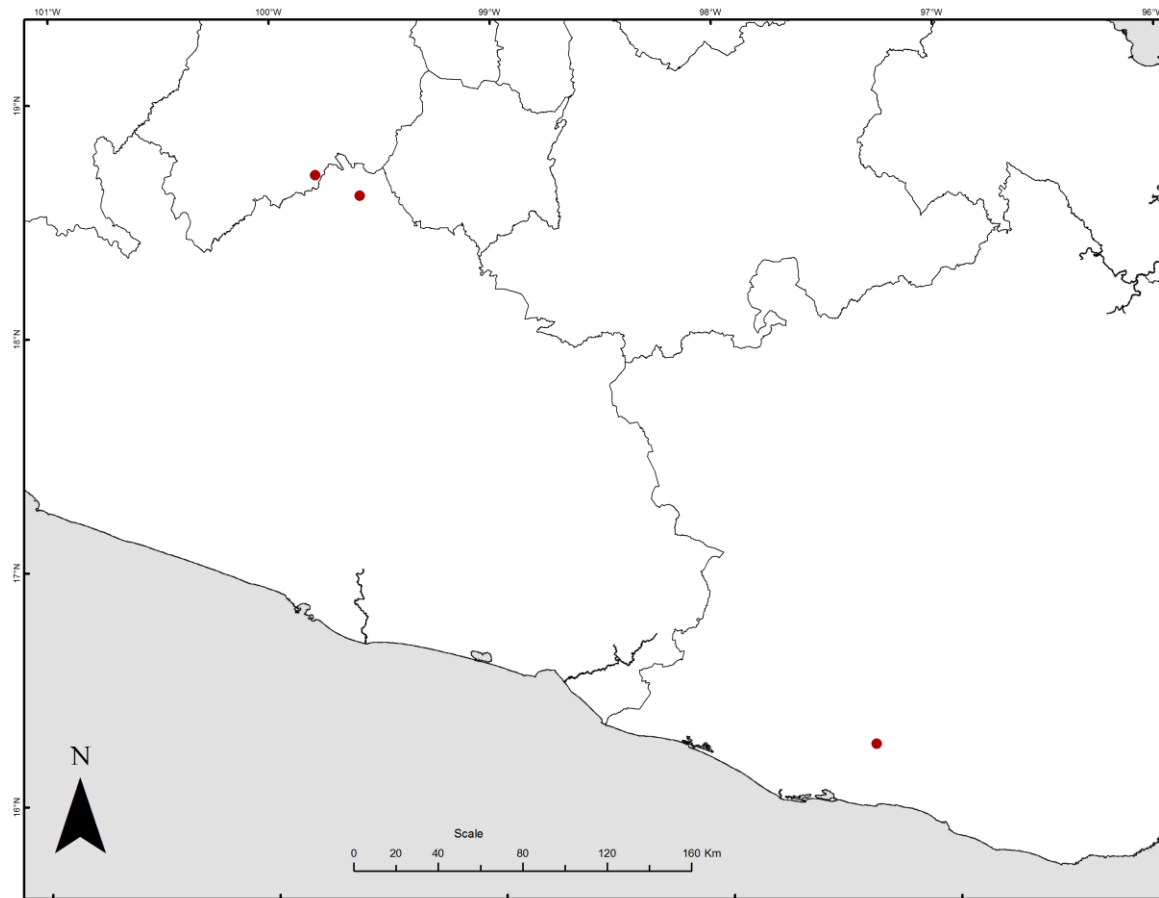


Figure 1e. Distribution of *Habromys schmydlyi*