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

Rafael S. Ramírez[1], Esther Quintero [1]

[1] Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), Subcoordinación de especies prioritarias, Liga Periférico - Insurgentes Sur, Núm. 4903, Col. Parques del Pedregal, Delegación Tlalpan, 14010, México, D.F.

Liga Periférico - Insurgentes Sur, Núm. 4903, Col. Parques del Pedregal, Delegación Tlalpan, 14010, México, D.F.

rafael.ramirez@conabio.gob.mx,

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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.

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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

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 (De 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 way to enlist species in The National Mexican Red List (NOM-059-SEMARNAT-2010; Soberón & Medellín, 2007, Sánchez *et al*., 2007). This method has been evaluated and compared with IUCN's assessment method elsewhere (De Grammont & Cuarón, 2006; Cuarón & De 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).

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

The MER has four criteria to establish risk categories: Criterion A: distribution; Criterion B, habitat; Criterion C, intrinsic vulnerability; and Criterion 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 not 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

Frugivorous 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 Ramos, 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 Caballero, 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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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 (8,809km^2), 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, this ecosystem 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, the cloud forest 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 (Lindenmayer, Cunningham & Pope, 1999; CONABIO, 2010; Dobrovolski *et al*., 2013; 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 populations of small mammals, 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 on the population growth and habitat use of small rodents. Thus, both plant and animal populations are affected by changes in

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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; Laurance & 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*., 2005). When considering the essential role of seed dispersers such as small rodents within the endangered cloud forest, it is important to consider that their extinction may accelerate the damage to the unique, small, and fragile ecosystem (Pardini *et al*., 2005; Sullivan *et al*., 2013) due to the lack of plant recruitment along with several other disruptions to the ecosystem's dynamics (Cayuela *et al*., 2006; Koike *et al*, 2012; Johnstone, Lill & Reina, 2014).

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. In this exercise, we assess them via the MER and the IUCN assessment method as a way to compare their performance and shortfalls when dealing with low information species.

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.

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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 Natural Protected Areas (NPA) within Mexico to find out whether at least some of the non-assessed species were 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 NPAs, 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 these five species can be found in Figure 1(a-e).

The results of the assessment for each one of these five species via the MER (Annex 1) place the five species of mice 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;

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

however, in many other cases there is no congruence between assessment methods. In a recent study by Armenta-Montero *et al*. (2015) with ferns of the genus *Phlegmariurus*, these authors 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 IUCN's 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 IUCN´s method to assess risk of extinction

The aim of risk assessments is to clearly define the conservation status of a given species, displayed in a simple, transparent, and objective way, which is 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 (De Grammont & Cuarón, 2006); in this sense, many authors claim that IUCN's 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; Arroyo *et al*., 2009; Armenta-Montero *et al*., 2015).

One of the first issues we had while using the MER was with the relevance of each criterion 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 distribution into account, although it is scored differently by each of them. In our example, when assessing via 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 were classified as critically endangered CR B1ab(iii) under

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

Criterion B (geographic range) due to their extremely reduced extent of occurrence (B1) (< 100 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 in 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 to take place. In our example we found the information for *Habromys chinanteco*'s habitat and for some of its 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 have lost points in Criterion B, which at the end would lower its risk status, hampering even more the conservation actions needed when in fact the conservation of the species is a matter of urgency; the other alternative would have been to assign a subjectively high score to obtain a higher risk status, which we think is the most widely used option.

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 all criteria (A +B +C+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). Therefore, we can see that the MER is information-intensive for all its criteria; this need of high amount 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 or lack of data is a constant (Mace & Kunin, 1994), and the situation will not change. Thus, using habitat loss to assess the target species is a far better option that has been adopted by IUCN's assessments under 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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

plant taxa with very scant information for many of them, showing that the lack of information should not preclude objective assessments.

Furthermore, there is a problem with MER scores: as there is little support information for them, equal scores from different 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 evaluation is not transparent (De Grammont & Cuarón, 2006; Brito *et al*., 2010) or even publicly available. 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 the method 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 the uncertainty is clearly mentioned in the assessment.

In our view any method will have pitfalls, but the current IUCN assessment method even provides warning time for species in the future (Gärdenfors, 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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

to climate change, especially when evaluated through criteria A, B, C, & D. In addition Staton *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 a mean of 40 years warning time 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 IUCN's 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; Gärdenfors, 2001; Brito *et al*., 2010). However, the use of IUCN´s 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 a 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 current 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 resulted in similar outcomes with both the MER and IUCN´s 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 may not always be objective, and not all the information required is relevant for conservation purposes. 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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

information available has to be made 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 the MER, with the goal of making it easier to assess species, with independency among criteria due to information gaps, and with the use of 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 enlist and protect them, despite the complexity that the current MER assessments implicate.

Acknowledgements

We would like to thank Edgar Saavedra from CONABIO for preparing the maps that appear in this study.

References

Arias Caballero de Miguel, P. (2011). *Distribución, Uso de Hábitat y Conservación de dos especies (Xenomys nelsoni y Hadomys alleni) de roedores endémicos de las Selvas Secas de México*.

Armenta-Montero, S., Carvajal-Hernández, C. I., Ellis, E. A., & Krömer, T. (2015). Distribution and conservation status of *Phlegmariurus* (Lycopodiaceae) in the state of Veracruz, Mexico. *Tropical Conservation Science*, *8*(1), 114–137.

Arroyo, T. P. F., Olson, M. E., García-Mendoza, A., & Solano, E. (2009). A GIS-Based Comparison of the Mexican National and IUCN Methods for Determining Extinction Risk. *Conservation Biology*, *23*(5), 1156–1166. http://doi.org/10.1111/j.1523-1739.2009.01241.x

Banks, P. B., & Dickman, C. R. (2000). Effects of winter food supplementation on reproduction, body mass, and number of small mammals in montane Australia. *Canadian Journal of Zoology*, *78*, 1775–1783.

Brito, D., Ambal, R. G., Brooks, T., Silva, N. De, Foster, M., Hao, W., Rodríguez, J. V. (2010). How similar are national red lists and the IUCN Red List? *Biological Conservation*, *143*(5), 1154–1158. http://doi.org/10.1016/j.biocon.2010.02.015

Burgman, M. A. (2002). Turner Review No. 5. Are listed threatened plant species actually at risk? *Australian Journal of Botany*, *50*(1), 1–13. Retrieved from http://www.publish.csiro.au/paper/BT01052

Cayuela, L., Golicher, D. J., Benayas, J. M. R., Gonzalez-Espinosa, M., & Ramirez-Marcial, N. (2006). Fragmentation, disturbance and tree diversity conservation in tropical montane forests. *Journal of Applied Ecology*, *43*(6), 1172–1181. http://doi.org/10.1111/j.1365-2664.2006.01217.x

Challenger, A. (1998). La zona ecológica templada húmeda (El bosque mesófilo de montaña). In *Utilización y conservación de los ecosistemas terrestres de México, pasado, presente y futuro.* (pp. 443–518). México: CONABIO.

Choo, J., Juenger, T. E., & Simpson, B. B. (2012). Consequences of frugivore-mediated seed dispersal for the spatial and genetic structures of a neotropical palm. *Molecular Ecology*, *21*(4), 1019–1031. http://doi.org/10.1111/j.1365-294X.2011.05425.x

CONABIO. (2010). *El Bosque Mesófilo de Montaña en México: Amenazas y oportunidades para su conservación y manejo sostenible* (p. 196). México: CONABIO.

CONABIO. (2014). *Bosques Mesófilos de Montaña de México diversidad, ecología y manejo*. (M. Gual-Díaz & A. Rendón-Correa, Eds.) (p. 345). México.

Craig, M. D., Stokes, V. L., Hardy, G. E. S., & Hobbs, R. J. (2015). Edge effects across boundaries between natural and restored jarrah (*Eucalyptus marginata*) forests in south-western Australia. *Austral Ecology*, *40*(2), 186–197. http://doi.org/10.1111/aec.12193

Cuarón, A. D., & De Grammont P. C. (2007). Shortcomings of Threatened Species Categorization Systems: Reply to Soberón and Medellín. *Conservation Biology*, *21*(5), 1368–1370. http://doi.org/10.1111/j.1523-1739.2007.00785.x

De Grammont, P. C., & Cuarón, A. D. (2006). An Evaluation of Threatened Species Categorization Systems Used on the American Continent. *Conservation Biology*, *20*(1), 14–27. http://doi.org/10.1111/j.1523-1739.2006.00352.x

Dobrovolski, R., Loyola, R. D., Guilhaumon, F., Gouveia, S. F., & Diniz-Filho, J. A. F. (2013). Global agricultural expansion and carnivore conservation biogeography. *Biological Conservation*, *165*, 162–170. http://doi.org/10.1016/j.biocon.2013.06.004

Fonseca, C. R., & Joner, F. (2007). Two-Sided Edge Effect Studies and the Restoration of Endangered Ecosystems. *Restoration Ecology*, *15*(4), 613–619. http://doi.org/10.1111/j.1526-100X.2007.00273.x

Forget, P.-M., Jordano, P., Lambert, J. E., Böhning-Gaese, K., Traveset, A., & Wright, S. J. (2011). Frugivores and seed dispersal (1985–2010); the "seeds" dispersed, established and matured. *Acta Oecologica*, *37*(6), 517–520. http://doi.org/10.1016/j.actao.2011.09.008

Forman, R. T., & Godron, M. (1986). *Landscape Ecology*. New York: John Wiley.

Frankham, R., Ballou, J. D., & Briscoe, D. A. (2002). *Introduction to conservation genetics*. Cambridge, UK: Cambridge University Press.

Gärdenfors, U. (2001). Classifying threatened species at national versus global levels. *Trends in Ecology & Evolution*, *16*(9), 511–516. http://doi.org/10.1016/S0169-5347(01)02214-5

Hamilton, L. S. (1995). *Tropical Montaine Cloud Forest*. (L. S. Hamilton, J. O. Juvik, & F. N. Scatena, Eds.). New York: Springer-Verlag.

Hanski, I. (1987). Pine sawfly population dynamics: patterns, processes, problems. *Oikos*, *50*, 327–335.

Hoset, K. S., Kyrö, K., Oksanen, T., Oksanen, L., & Olofsson, J. (2014). Spatial variation in vegetation damage relative to primary productivity, small rodent abundance and predation. *Ecography*, *37*(9), 894–901. http://doi.org/10.1111/ecog.00791

IUCN. (2012). *IUCN Red List Categories and Criteria: Version 3.1* (Second Edi, p. 32PP). Gland, Switzerland and Cambridge, UK: IUCN.

Johnstone, C. P., Lill, A., & Reina, R. D. (2014). Habitat loss, fragmentation and degradation effects on small mammals: Analysis with conditional inference tree statistical modelling. *Biological Conservation*, *176*, 80–98. http://doi.org/10.1016/j.biocon.2014.04.025

Jones, N. T., Germain, R. M., Grainger, T. N., Hall, A. M., Baldwin, L., & Gilbert, B. (2015). Dispersal mode mediates the effect of patch size and patch connectivity on metacommunity diversity. *Journal of Ecology*, *103*(4), 935–944. http://doi.org/10.1111/1365-2745.12405

Kerley, G. I., Whitford, W. G., & Kay, F. R. (2004). Effects of pocket gophers on desert soils and vegetation. *Journal of Arid Environments*, *58*(2), 155–166. http://doi.org/10.1016/j.jaridenv.2003.08.001

Koike, S., Morimoto, H., Kozakai, C., Arimoto, I., Soga, M., Yamazaki, K., & Koganezawa, M. (2012). The role of dung beetles as a secondary seed disperser after dispersal by frugivore mammals in a temperate deciduous forest. *Acta Oecologica*, *41*, 74–81. http://doi.org/10.1016/j.actao.2012.04.009

Lamoreux, J. F., McKnight, M. W., & Cabrera Hernandez, R. (2015). *Amphibian Alliance for Zero Extinction Sites in Chiapas and Oaxaca.* (p. 320). Gland, Switzerland.

Laurance, W. F., & Yensen, E. (1991). Predicting the impacts of edge effects in fragmented habitats. *Biological Conservation*, *55*(1), 77–92. http://doi.org/10.1016/0006-3207(91)90006-U

Lindenmayer, D., Cunningham, R., & Pope, M. (1999). A large-scale "experiment" to examine the effects of landscape context and habitat fragmentation on mammals. *Biological Conservation*, *88*(3), 387–403. http://doi.org/10.1016/S0006-3207(98)00111-6

López-Barrera, F., Newton, A., & Manson, R. (2005). Edge effects in a tropical montane forest mosaic: experimental tests of post-dispersal acorn removal. *Ecological Research*, *20*(1), 31–40. http://doi.org/10.1007/s11284-004-0016-7

Mace, G. M., & Kunin, W. (1994). Classifying Threatened Species: Means and Ends [and Discussion]. *Philosophical Transactions: Biological Sciences*, *344*(1307), 91–97. http://doi.org/10.2307/56159

Maes, D., Isaac, N. J. B., Harrower, C. A., Collen, B., van Strien, A. J., & Roy, D. B. (2015). The use of opportunistic data for IUCN Red List assessments. *Biological Journal of the Linnean Society*, *115*(3), 690–706. http://doi.org/10.1111/bij.12530

Martínez Ramos, M. (2008). Grupos funcionales. In *Capital natural de México, vol I: Conocimiento actual de la biodiversidad*. Mexico: CONABIO. (pp. 365–412)

May, L. (1978). The economic uses and associated folklore of ferns and fern allies. *The Botanical Review*, *44*(4), 491–528. http://doi.org/10.1007/BF02860848

MEA. (2005). *Millenium Ecosystem Assessment. Ecosystems and Human Well Being. Biodiversity Synthesis*.

Moran, C., Catterall, C., & Kanowski, J. (2009). Reduced dispersal of native plant species as a consequence of the reduced abundance of frugivore species in fragmented rainforest. *Biological Conservation*, *142*(3), 541–552. http://doi.org/10.1016/j.biocon.2008.11.006

Nyiramana, A., Mendoza, I., Kaplin, B. A., & Forget, P.-M. (2011). Evidence for Seed Dispersal by Rodents in Tropical Montane Forest in Africa. *Biotropica*, *43*(6), 654–657. http://doi.org/10.1111/j.1744-7429.2011.00810.x

Pardini, R., de Souza, S. M., Braga-Neto, R., & Metzger, J. P. (2005). The role of forest structure, fragment size and corridors in maintaining small mammal abundance and diversity in an Atlantic forest landscape. *Biological Conservation*, *124*(2), 253–266. http://doi.org/10.1016/j.biocon.2005.01.033

Raimondo, D. C., von Staden, L., & Donaldson, J. S. (2013). Lessons from the Conservation Assessment of the South African Megaflora. *Annals of the Missouri Botanical Garden*, *99*(2), 221–230. http://doi.org/10.3417/2011111

Reichman, O. J., & Seabloom, E. W. (2002). The role of pocket gophers as subterranean ecosystem engineers. *Trends in Ecology & Evolution*, *17*(1), 44–49. http://doi.org/10.1016/S0169-5347(01)02329-1

Sánchez, O., Medellín, R., Aldama, A., Goettshc, B., Soberón, J., & Tambutti, M. (2007). *Método de Evaluación del Riesgo de Extinción de las Especies Silvestres en México (MER)*. México: Secretaria de Media Ambiente y Recursos Naturales, Instituto de Ecología, Instituto de Ecología de la Universidad Nacional Autónoma de México, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad.

SEMARNAT. (2010). *Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo.* (pp. 1–19 + Anexo Normativo III). México.

Soberón, J., & Medellín, R. A. (2007). Categorization Systems of Threatened Species. *Conservation Biology*, *21*(5), 1366–1367. http://doi.org/10.1111/j.1523-1739.2007.00784.x

Stanton, J. C., Shoemaker, K. T., Pearson, R. G., & Akçakaya, H. R. (2015). Warning times for species extinctions due to climate change. *Global Change Biology*, *21*(3), 1066–77. http://doi.org/10.1111/gcb.12721

Stephens, H. C., Schmuki, C., Burridge, C. P., & O'Reilly-Wapstra, J. M. (2013). Habitat fragmentation in forests affects relatedness and spatial genetic structure of a native rodent, *Rattus lutreolus*. *Austral Ecology*, *38*(5), 568–580. http://doi.org/10.1111/aec.12001

Sullivan, T. P., Sullivan, D. S., Lindgren, P. M. F., & Ransome, D. B. (2013). Stand structure and small mammals in intensively managed forests: Scale, time, and testing extremes. *Forest Ecology and Management*, *310*, 1071–1087. http://doi.org/10.1016/j.foreco.2013.02.025

Todd, C. R., & Burgman, M. A. (1998). Assessment of Threat and Conservation Priorities under Realistic Levels of Uncertainty and Reliability. *Conservation Biology*, *12*(5), 966–974. http://doi.org/10.1046/j.1523-1739.1998.96470.x

Virtanen, R. (2000). Effects of grazing on above-ground biomass on a mountain snowbed, NW Finland. *Oikos*, *90*(2), 295–300. http://doi.org/10.1034/j.1600-0706.2000.900209.x

MER	IUCN
P	CR
	EN
A	Vu
PR	NT
	LC

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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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)

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

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 &	Meseta Cacaxtla; Biosphere Reserve

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

					pesticides	Marismas Nacionales
Reithrodontomys bakeri	EN	B1ab(iii)	Guerrero	Pine-Oak forest	Habitat fragemtation, deforestation	No
Reithrodontomys hirsutus	VU	B1ab(iii)	Jalisco	Desert scrub	Vegatation loss due to monocultive	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 fragementation, Turism 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.

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

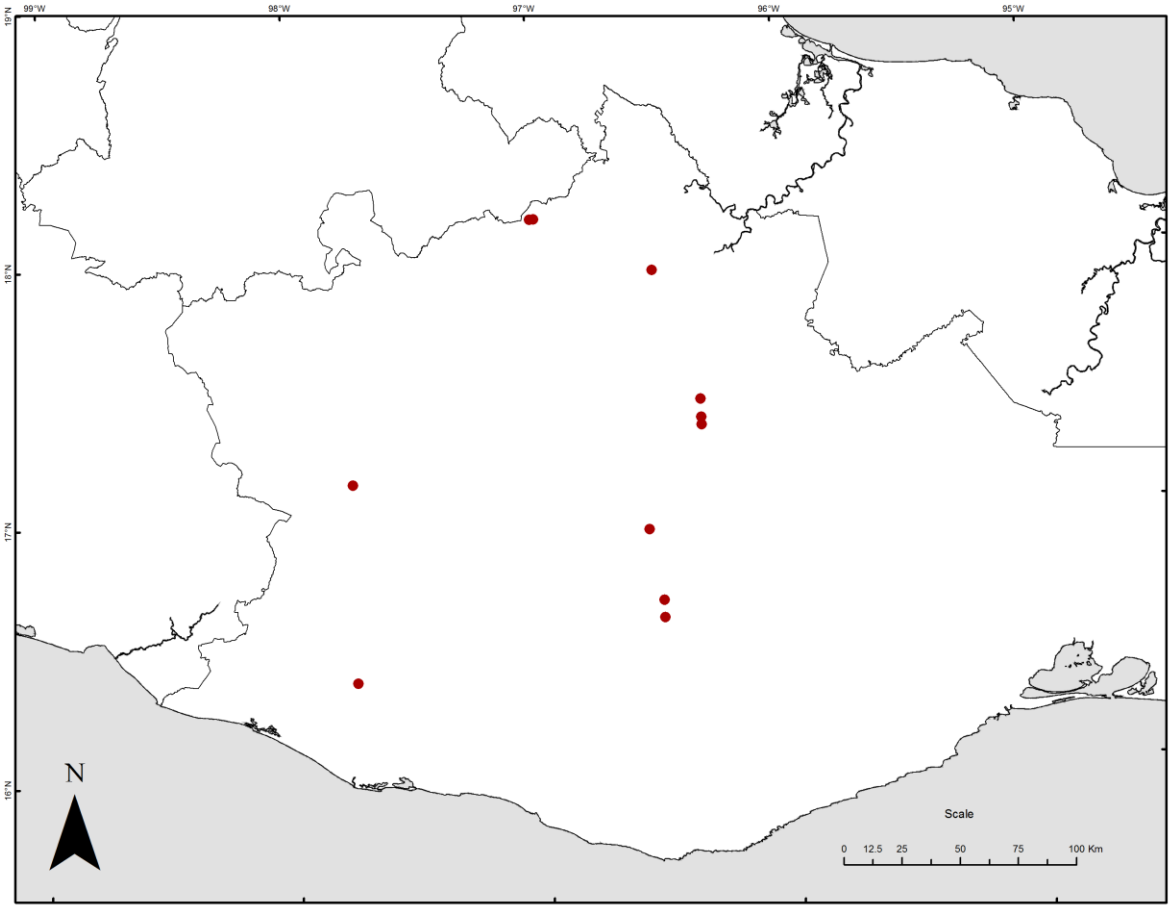
MER	IUCN

• Distribution
  ○ Description (altitude, continue or fragmented, states of the country)
  ○ Map
  ○ Map method
  ○ Distribution size assessment
• Habitat
  ○ Record (Habitat type which species occupy)
  ○ Diagnosis of the current habitat status
  ○ Evaluation of the currently habitat status focusing on the taxon's needs
  ○ Diagnosis justification
• Biological vulnerability
  ○ Record (Species' natural history)
  ○ Diagnosis of the current species status
  ○ Evaluation of factors who makes the species vulnerable
  ○ Diagnosis justification
• Anthropogenic pressures
  ○ Real and potential risk factors
  ○ Prediction analysis of species trend
  ○ Evaluation of the direct and indirect human impact
	• Population size reduction
	  ○ Population reduction measured over the longer of 10 years or 3 generations
	• Geographic range
	  ○ Extent of occurence
	  ○ 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 or area of occupancy
	• Small population size and decline
	  ○ 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
	  ○ Number of mature individuals
	• Quantitative analysis
	  ○ Indicating the probability of extinction in the wild by numeric analyses

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

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

Figure 1a. Distribution of *Habromys chinanteco*



PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

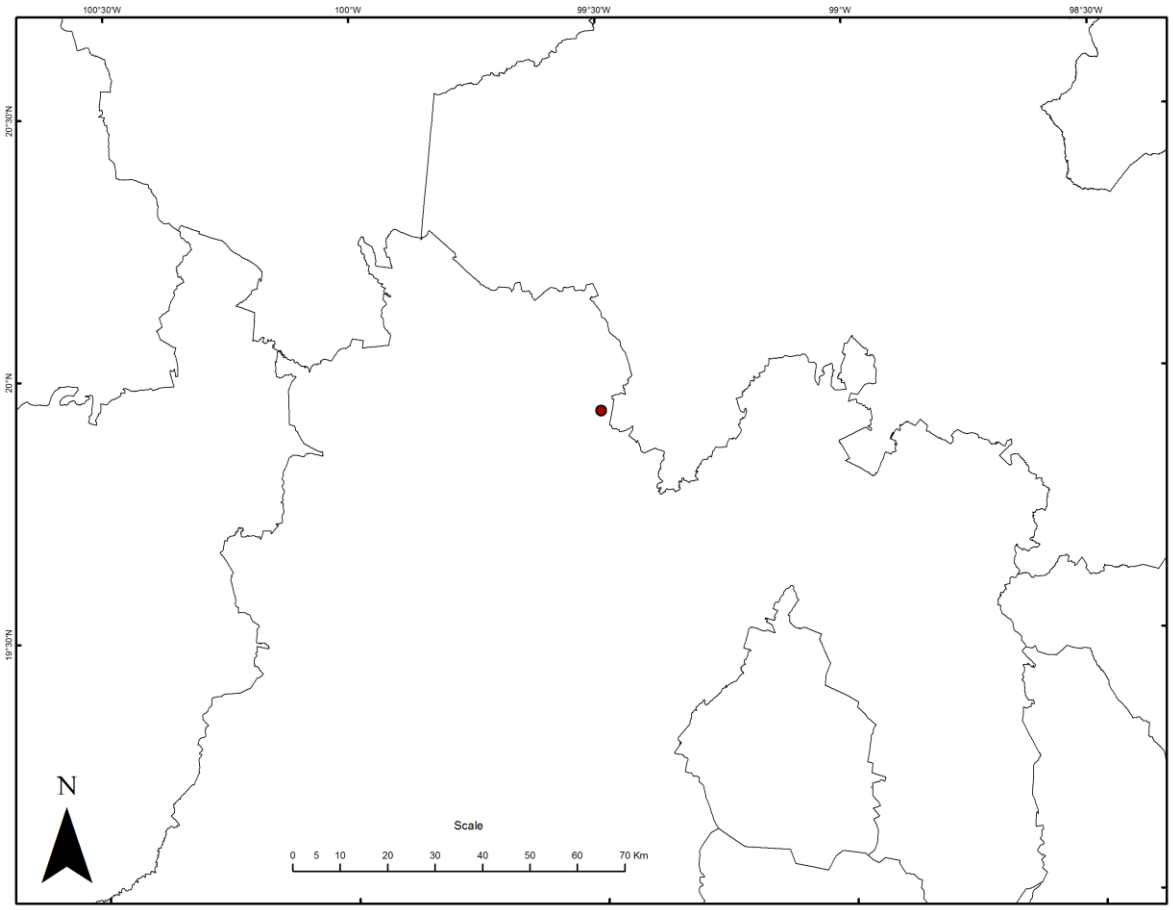


Figure 1b. Distribution map of *Habromys delicatulus*

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

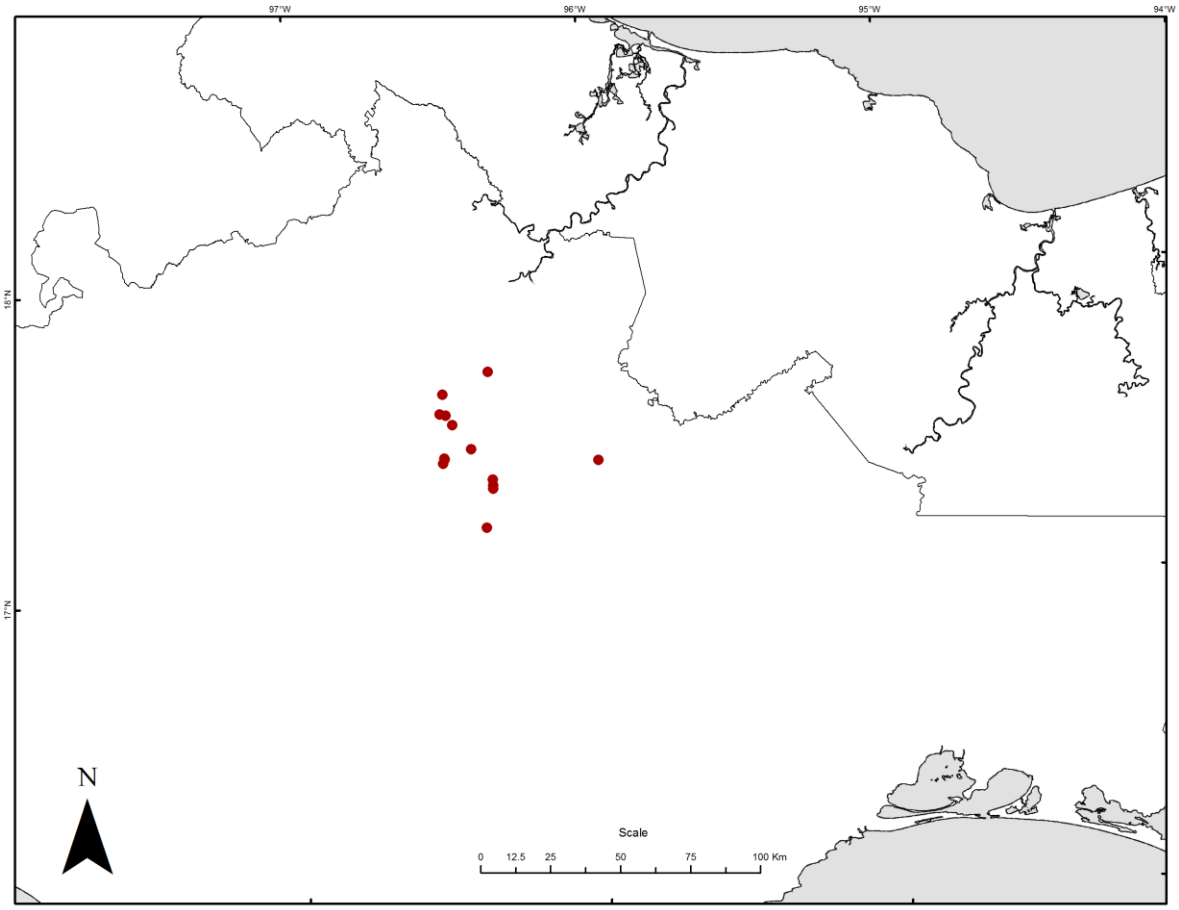


Figure 1c. Distribution map of *Habromys ixtlani*

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

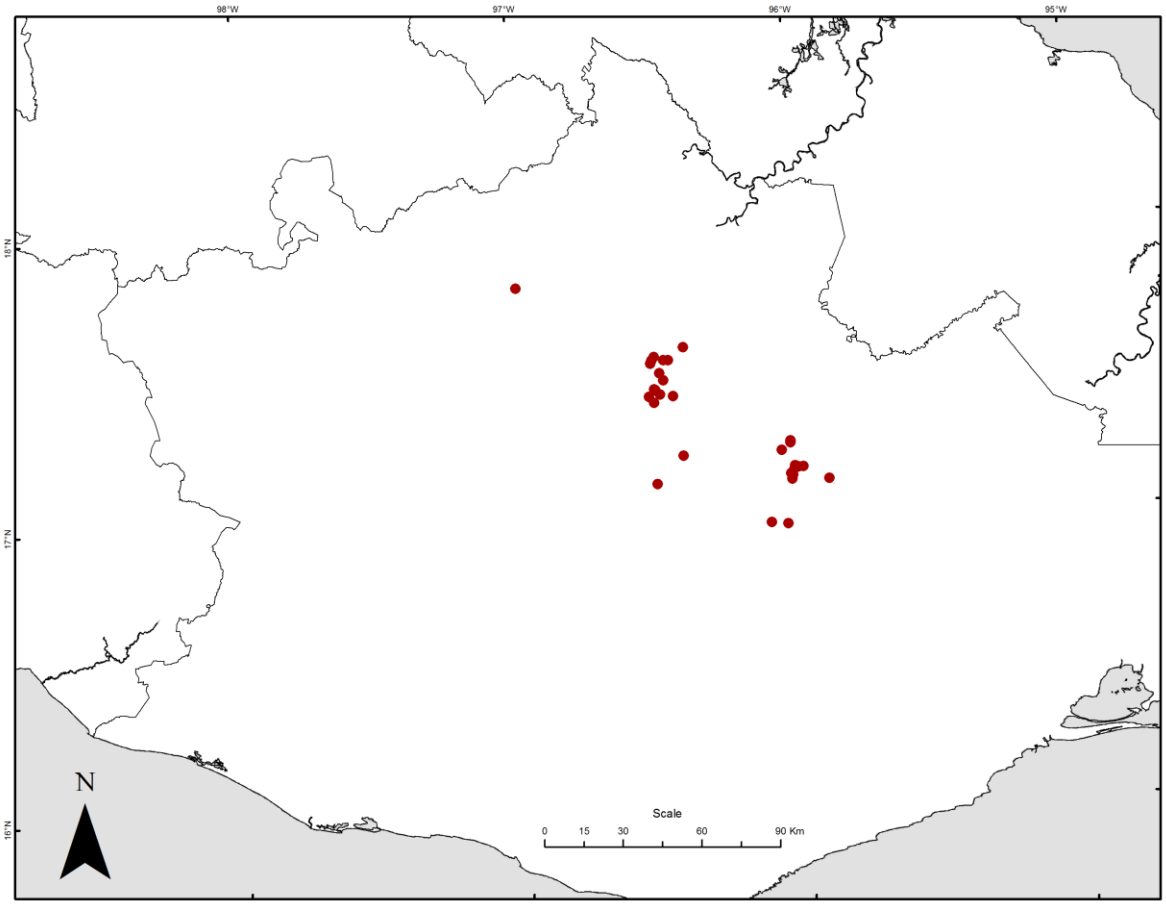


Figure 1d. Distribution of *Habromys lepturus*

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015

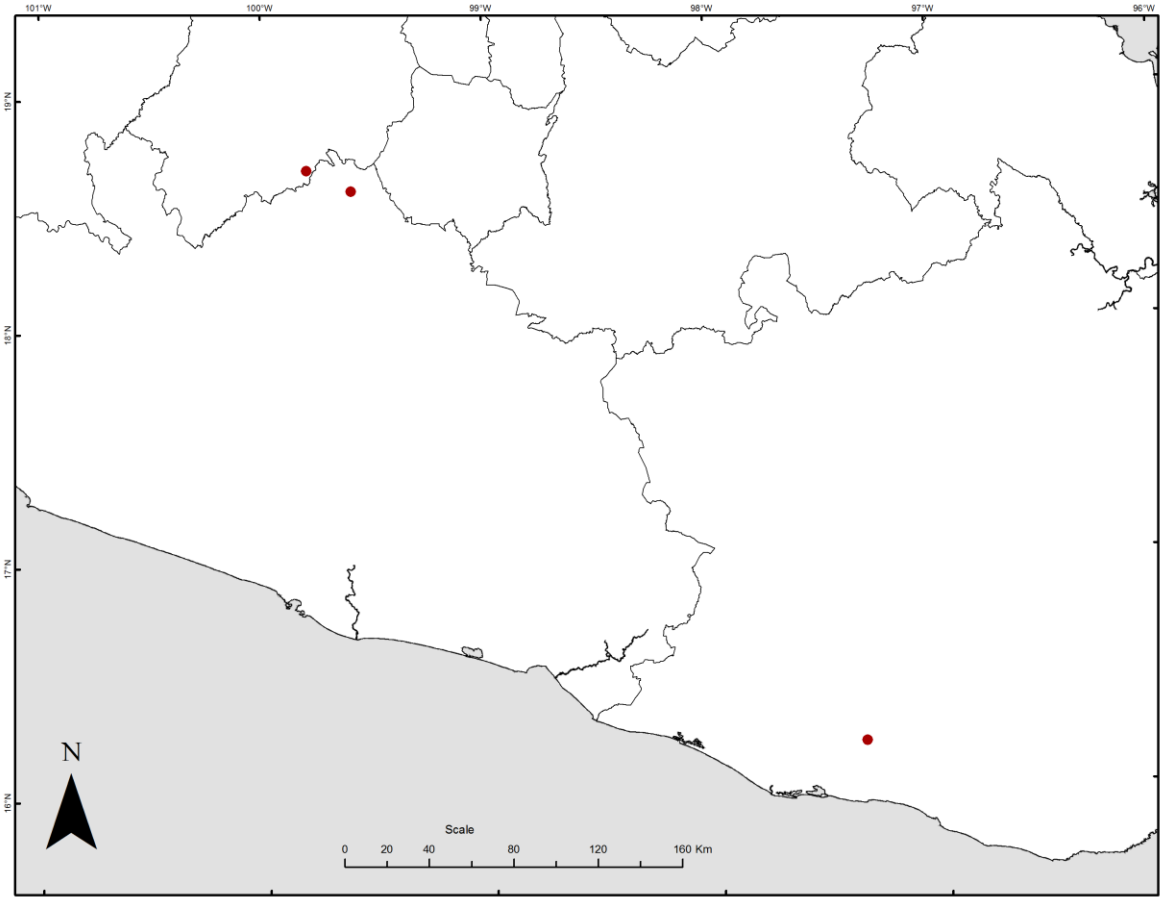


Figure 1e. Distribution of *Habromys schmydlyi*

PeerJ PrePrints | https://dx.doi.org/10.7287/peerj.preprints.1437v2 | CC-BY 4.0 Open Access | rec: 19 Nov 2015, publ: 19 Nov 2015