

Survival Blueprint

Volcano rabbit, *Romerolagus diazi*



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1. STATUS REVIEW

1.1 Taxonomy:

Kingdom: Animalia

Class: Mammalia

Order: Lagomorpha

Family: Leporidae

Genus: *Romerolagus*

Species: *Romerolagus diazi*

Common name: Volcano rabbit, zacatuche, teporingo

The Volcano rabbit (*Romerolagus diazi*) is an unique species and different from the whole of the rabbits in the world. Volcano rabbit is the only species of the (monotypic) genus *Romerolagus*, and endemic to the Transmexican Volcanic Belt in Central México. It is one of the most primitive living rabbits in the world, along with the Amami rabbit (*Pentalagus furnessi*) endemic to the southern islands of the Ryukyu Japanese Archipelago and the Smith's red rock hare (*Pronolagus rupestris*) in southern Africa (Chapman and Flux 2008). The pelage of *R. diazi* is short, dense and dark brown in colour, ears are small and round, legs are short, and its tail is so small that it is not discernible (Cervantes *et al.* 1990, Fa and Bell 1990, Velázquez *et al.* 1993). Volcano rabbit weighs approximately 500 g and is the second smallest rabbit in the world (Cervantes and Martínez-Vázquez 1996b). Evolutionarily, the Volcano rabbit is considered primitive due to morphological, genetic and parasitic characteristics not shared with any other species (Porter and Van der Loo 1981, Cobert 1983, Cervantes *et al.* 2002, Matthee *et al.* 2004), and these traits have varied little since the species originated in the late Miocene (Cervantes and Martínez-Vázquez 1996b). Although it is not clear how and when the genus originated due to the scarce fossil record, *Romerolagus* is considered the most primitive genus of the leporids, as may have diversified in the late Eocene, between 35 and 38 million years ago (mya; Robinson and Matthee 2005, Smith *et al.* 2018), or much later, approximately 5.68 mya (Ge *et al.* 2013). The diversification time of the Volcano rabbit could have been similar to other pseudo-sympatric species that live at the Transmexican Volcanic Belt, around 1.5 mya; *R. diazi* could have been isolated from long before the Pleistocene in the mountains of the Transmexican Volcanic Belt, which possibly acted as a refuge during Pleistocene glaciations (Cruz-Muñoz 2006, Osuna *et al.* 2020).

1.2 Distribution and population status:

The Volcano rabbit is endemic to México, and its geographic distribution is limited to discontinuous patches on four volcanoes and their peripheral areas in two mountain ranges (Sierras in Spanish) of the Transmexican Volcanic Belt, the Sierra Nevada and the Sierra Chichinautzin. In Sierra Nevada, the Popocatepetl and Iztaccíhuatl volcanoes are two of the four remaining core areas, and in Sierra Chichinautzin, the Tlaloc and Pelado volcanoes are the other two core areas (Figure 1). The current distribution was estimated to be 386.5 km² (Velázquez 1994) in 16 polygons of habitat patches (Hoth *et al.* 1987, Cervantes *et al.* 1990), and recently Velázquez and Guerrero (2019) mentioned that this area has subsequently been reduced to 335 km².



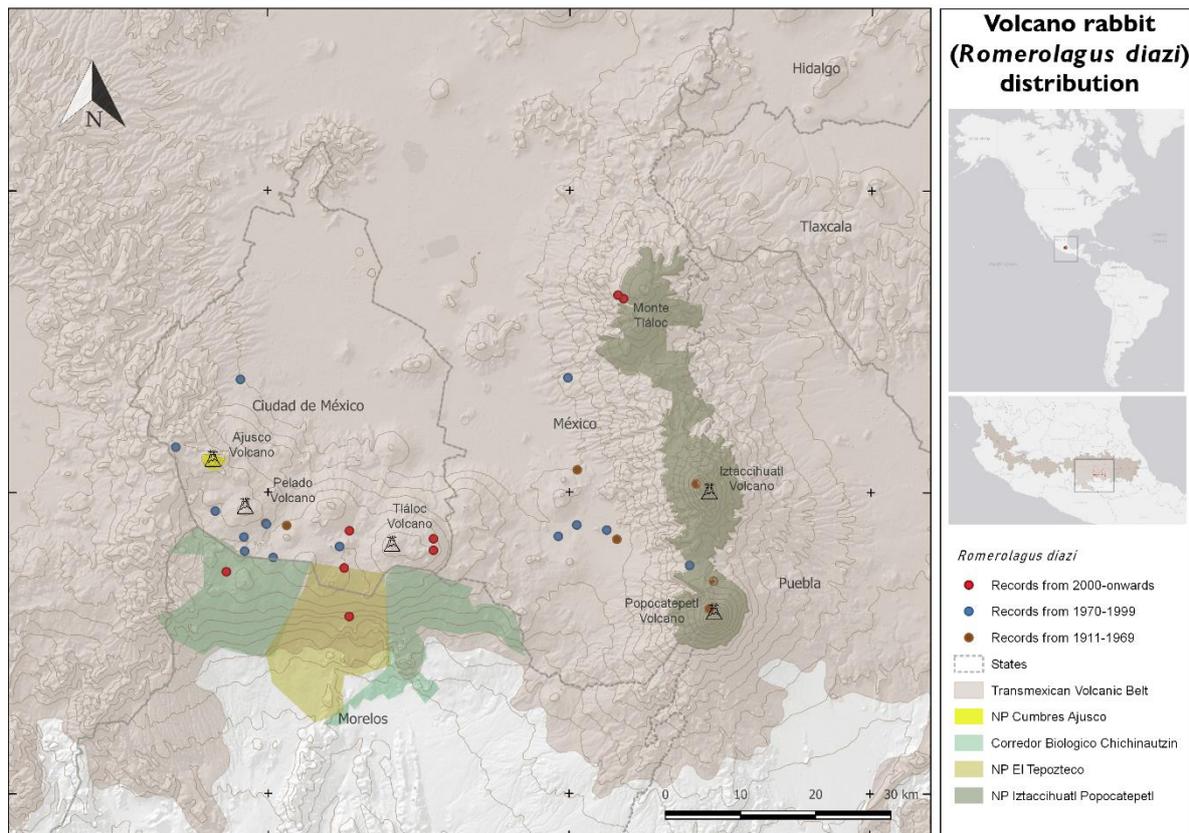


Figure 1. Geographic distribution of Volcano rabbit (*Romerolagus diazi*) based on the data available in scientific collections. NP= National Park.

1.2.1 Global distribution:

Country	Population estimate (plus references)	Distribution	Population trend (plus references)	Notes
Mexico	The only estimate of population size of the species is of 7,085 rabbits based on an estimated density of 1.22 rabbits per hectare in Pelado Volcano (Velázquez 1994) and extrapolated to the estimated distribution range of the species (Portales <i>et al.</i> 1997).	Pine forest with bunch grasses in the states of Mexico, Puebla, Morelos, and Mexico City	Decreasing (Velázquez and Guerrero 2019)	The estimate is probably inaccurate since the species have a large range of distribution and the extrapolation of the density found in one of its populations is not reliable.



1.2.2 Local distribution:

Country	Region / province	Site	Level of Protection	Population size	Reference	Notes
Mexico	Transmexican Volcanic Belt, Sierra Chichinautzin	Pelado Volcano	Communal forest protected by indigenous civil authorities	1,811 rabbits	Velázquez 1994	
	Transmexican Volcanic Belt, Sierra Chichinautzin	Tlaloc Volcano	Communal forest protected by indigenous civil authorities	3,458 rabbits	Portales <i>et al.</i> 1997, Velázquez and Guerrero 2019	Inaccurate estimate
	Transmexican Volcanic Belt, Sierra Nevada	Iztaccíhuatl Popocatepetl National Park	Natural protected area. Protected by Federal Government.	3,056 rabbits	Portales <i>et al.</i> 1997, Velázquez and Guerrero 2019	Inaccurate estimate. Possibly the biggest population of Volcano rabbit is in the Iztaccíhuatl Popocatepetl National Park
	Transmexican Volcanic Belt, Sierra Chichinautzin.	Corredor Biológico Chichinautzin. Área de Protección de Flora y Fauna.	Natural protected area. Protected by Federal Government.	Population density was estimated at 4.2 rabbits/ha for the Chichinautzin mountain range	Rizo-Aguilar <i>et al.</i> 2016	
	Transmexican Volcanic Belt, Sierra Chichinautzin.	Milpa Alta Forest.	Communal forest of 12 indigenous towns, contains an area designated voluntarily for conservation, and a small polygon that is part of El Tepozteco National Park.	Currently under study to estimate population size. Preliminary results estimated an annual mean density of 2.82 rabbits/ha.	García-Feria <i>et al.</i> (in preparation)	Population will be estimated at the end of the fellowship
	Transmexican Volcanic Belt,	Ajusco Volcano	Natural protected	Unknown		Population size and/or



	Sierra Chichinautzin.	National Park.	area. Protected by Federal Government.			density need to be addressed
	Transmexican Volcanic Belt, Sierra Nevada	Monte Tlaloc	Part of the forests in Monte Tlaloc are owned by communities, and part are within the polygon of Iztaccíhuatl Popocatepétel National Park	Unknown	García-Feria (2013)	EDGE fellow Yajaira García Feria worked during her MSc degree in Monte Tlaloc.

1.3 Protection status:

National and international laws and authorities consider Volcano rabbit in great danger of extinction (CITES 2010, SEMARNAT 2010, IUCN 2018). The Environmental and Natural Resources Secretariat of Mexico (SEMARNAT 2010) listed the species as endangered, and the Red List of the International Union for the Conservation of Nature (IUCN; Velázquez and Guerrero 2019) as critically endangered. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2010) includes it in the appendix with the highest degree of risk, and trading with Volcano rabbits is illegal.

Volcano rabbit distribution has naturally decreased since the end of the Pleistocene (in the last 12 thousand years) due to an increase in temperature that caused the end of the last ice age, in central Mexico (Cruz-Muñoz *et al.* 2009). However, in modern times, the causes of populations declining dramatically or even having disappeared are due to the loss of their habitat due to human activities such as agricultural expansion, grazing and logging, as well as illegal hunting and predation by exotic species, such as cats and dogs (Velázquez and Bocco 1994, Velázquez *et al.* 1996).

Another serious problem is that several of the remaining populations, as a consequence of urban expansion, are separated by highways, roads, cultivation areas and human settlements that isolate individuals geographically and genetically (Campos-Chávez 2005). Volcano rabbit's populations inhabiting the Sierra Ajusco-Chichinautzin could be isolated and therefore without gene flow between both zones, and with consequent loss of genetic variability, which constitutes a serious threat to population survival (Ramírez-Silva 2009). Furthermore, current climate change threatens to further reduce Volcano rabbit habitat in the lower parts of its distribution (Domínguez 2007, Anderson *et al.* 2009).

The population density was estimated at 1.2 rabbits/ha (Velázquez 1994) for the Pelado Volcano in the Sierra Nevada and 4.2 rabbits/ha for the Corredor Biológico Chichinautzin in the Sierra Chichinautzin (Rizo-Aguilar *et al.* 2016). Habitat use has been thoroughly evaluated (Fa *et al.* 1992, Velázquez 1994, Velázquez and Heil 1996,



García-Feria 2013, Hunter and Cresswell 2015, Rizo-Aguilar *et al.* 2015), but detailed information about spatial ecology, warren use, and home range size is limited.

Protecting the habitat of Volcano rabbit is essential to ensure the species long-term survival, although without society's involvement in decision-making, especially communal-land owners and community members who rely or take advantage of the forests, the goal of habitat conservation seems unachievable. Greater collaboration and compromise is needed between different social sectors, including forest owners and users.

1.4 Ecology, behaviour and habitat requirements:

The Volcano rabbit (*Romerolagus diazi*) is a relict and endemic species restricted to the Transmexican Volcanic Belt, and lives in altitudes ranging between 2,800 and 4,250 masl (meters above sea level). The geographic distribution range is limited to 335 to 386 km², patchily distributed on four volcanoes and 12 peripheral areas (Velázquez 1994, Velázquez and Guerrero 2019). The Volcano rabbit is a habitat specialist species restricted to pine (*Pinus*) temperate forests with subalpine bunch grasses (known as zacatonales in Spanish, Cervantes *et al.* 1990, Cervantes and Martínez-Vázquez 1992, Velázquez 1994). Bunch grasses are used for food, cover and nesting. Volcano rabbit feeds mainly on the bunch grasses *Festuca amplissima*, *F. rosei*, *Muhlenbergia macroaura* and *Jarava ichu* (previously called *Stipa ichu*, Cervantes 1980), and occasionally consumes herbaceous plants such as *Alchemilla* sp., *Donnellsmithia juncea*, *Eringium columns*, *Cirsium jorullense*, seeds of the annual vine *Sicyos parvilorus* and the bark of the alder (*Alnus* sp., Cervantes and Martínez-Vázquez 1996a). In addition to nutritional importance, bunch grasses provide burrowing sites, nesting sites, shelter, and protection against predators (Velázquez 1996).

Volcano rabbit constitutes an important prey for carnivorous vertebrates, and native main predators are bobcat (*Lynx rufus*, Romero 1987, Aranda *et al.* 2002), coyote (*Canis latrans*, Martínez-García *et al.* 2014) and long-tailed weasel (*Mustela frenata*), as well as rattlesnakes (*Crotalus* spp.) and red-tailed hawks (*Buteo jamaicensis*, Cervantes-Reza 1981). Volcano rabbit is considered a gregarious species and lives in groups of two to five individuals (Cervantes-Reza 1980). Individuals can be active both day and night, although activities are concentrated during the day. Between 10:00 am and 12:00 pm (at noon) it is possible to find a high number of individuals outside their burrows even if they are not as active (Cervantes and Martínez 1996). The use of strong and sharp vocalizations is characteristic of the species. Within this order, only the pikas of the Ochotonidae family carry out a larger number of vocalizations, which play an important role in the social interaction of rabbits (Cervantes and Martínez 1996a).

The reproductive period covers the whole year, although is more intense during the warm and humid summer months (May to September). The gestation period was registered in captive rabbits in 39 days (Cervantes 1980). Unlike other leporids, Volcano rabbit's fertility rate is very low, and the litter size is an average of 2 kits, who open their eyes between 4 and 8 days and remain in the nest until 14 days after birth (Cervantes 1980).



1.5 Threat analysis:

Threat	Description of how this threat impacts the species	Intensity of threat (low, medium, high, critical or unknown)
Human-caused fires (land use change)	The fires are a natural process of the forest, but the big problem is the intentional fires caused by intended changes in the land use. In the distributional range of Volcano rabbits, human-caused fires related to agricultural and pastoral activities represent at least 56% (SEMARNAT 2002). Bunch grasses are commonly burnt because people are interested in growing commercial plants or grazing animals (Fa and Bell 1990). Also, induced fires are commonly used to hide illegal logging.	Critical
Human-caused fires (agriculture)	Bunch grasses are burned and destroyed to grow crops such as oat and potato. Sometimes these crops are not productive, but people plant their crops every year to receive agricultural subsidies and compensations for crop loss. Territorial ordering does not allow to transform bunch grasses into agricultural areas, but legislation is poorly enforced.	Critical
Cattle grazing	In Mexico, extensive ranching is a common practice. People take their cattle to the forest and let them graze freely, which is why cows and sheep, mainly, move throughout the forest and damage the natural vegetation. In addition to this practice, shepherds burn certain parts of the forest so that fresh grass can grow on which livestock can feed. It is common that bunch grasses and grasses in general are burned. This is one of the most important reasons of habitat loss of the Volcano rabbit (Fa and Bell 1990, López-Paniagua <i>et al.</i> 1996).	Critical
Logging	Illegal deforestation is one of the main causes of forest loss where Volcano rabbit inhabits. The deforestation rates are alarming; for example, the Iztaccíhuatl-Popocatepetl National Park had 30% of its original area deforested, and in the Milpa Alta forest the deforestation reached approximately 70% of its original area and was caused mainly by illegal activities.	Critical
Hunting	Some communities hunt rabbits for local consumption. The impact on Volcano rabbit population goes further because the main problem is the way that rabbits are hunted. Generally, hunters are accompanied by hunting dogs, which destroy the burrows, and sometimes the hunters set fire to the bunch grasses to shoot and catch those rabbits trying to flee from the fire.	High



Climate change	Climate change threatens to further reduce the species' habitat in the lower parts of its distribution range (Domínguez 2007, Anderson <i>et al.</i> 2009).	Critical
Exotic species	Due to a low-income situation (poverty) and lack of environmental education, people abandon dogs and cats or leave them free in the forest. These dogs associate in packs to hunt rabbits and other species and destroy their burrows. Currently, free-ranging cattle (cows) is present at Iztaccíhuatl-Popocatepetl National Park (IPNP) and although there are no induced fires, cattle-grazing has a negative effect on habitat quality for Volcano rabbits (Aguirre-López, 2020). Cows are an exotic species and while walking they flatten the soil which hinders the germination of native seeds, and cow droppings cover the native plants which hinders plant photosynthesis and growth.	Unknown

1.6 Stakeholder analysis:

Country	Stakeholder	Stakeholder's interest in the species' conservation	Current activities	Impact (positive, negative or both)	Intensity of impact (low, medium, high or critical)
Mexico	The Environmental and Natural Resources Secretariat (SEMARNAT)	SEMARNAT is the Federal Agency responsible for the conservation of endangered species and their habitat. SEMARNAT considers the Volcano rabbit (zacatuche) as a priority species for conservation. Through the National Commission of Natural Protected Areas (CONANP), SEMARNAT implements conservation actions for the species.	CONANP included the Volcano rabbit in the Program for the Conservation of Species at Risk (PROCER), which is implemented through the Program of Action for the Conservation of the Species (PACE Zacatuche 2019). To carry out these conservation actions, CONANP designates resources through federal subsidies. Some performed actions are: Monitoring of the populations; firefighting; firebreak breaches; restoration of areas	Positive Conservation efforts are important but, unfortunately, financial resources are scarce, because of this their actions are limited.	Critical



			affected by fires and local people surveillance (all realized in Natural Protected Areas).		
Mexico	National Forestry Commission (CONAFOR)	CONAFOR is in charge of forest conservation. Specifically, they have no interest in the Volcano rabbit's conservation but promote actions that have impacts on the Volcano rabbit's habitat.	CONAFOR implements the different federal programs for forest conservation mainly focused on firefighting, reforestation, phytosanity, and conservation through the Program of Payment for Ecosystem Services.	Both Positive: Communities and ejidos conserve the forest to be beneficiaries of the programs which benefits Volcano rabbit's habitat. Negative: In some occasions reforestations are done with non-native species and/or the reforestation is carried out in habitat types where trees do not belong, such as the bunch grasses areas; therefore, these actions degrade and decrease the Volcano rabbit's habitat.	High
Mexico	Secretariat of Agriculture and Rural Development (SADER), previously named Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)	SADER has no interest in the Volcano rabbit's conservation but has some programs to promote the agriculture in the range of distribution of Volcano rabbit.	Programs of SAGARPA, now SADER, promote improvement in productivity of agriculture and livestock activities through subsidies to individuals or groups of peasants, farmers and ranchers.	Negative In some places the actions of forest conservation are opposed to the productive activities promoted.	High
México	SEDEMA-DG CORENADR Secretary for Environment of	SEDEMA is in charge of protecting the Conservation Land (Suelo de	SEDEMA through the DG CORENADR applies the forest	Both Positive when legislation is enforced.	Critical



	<p>Mexico City (SEDEMA)</p> <p>General Directorate of Natural Protected Areas and Rural Development of México City (DGCORENADR)</p>	<p>Conservación) of Mexico City. Several of the forests inhabited by Volcano rabbit are within the Conservation Land of Mexico City.</p>	<p>policy in Mexico City. From 2014 to 2018 DGCORENADR supported some community brigades to carry out population monitoring of Volcano rabbit through the Program of Support Funds for the Conservation and Restoration of Ecosystems through Social Participation (PROFASE in Spanish).</p>	<p>Negative when particular interests are dominant, and the funds are not used for conservation.</p>	
Mexico	<p>SEDEMA-DGZCVS</p> <p>General Directorate for Zoos and Conservation of Wildlife (DGZCVS)</p>	<p>SEDEMA-DGZCVS have a captivity colony of Volcano rabbit in Mexican zoos: Chapultepec Zoo and Los Coyotes Zoo.</p>	<p>SEDEMA-DGZCVS conduct ex situ conservation actions with the Volcano rabbit and have interest in participating in actions for the conservation of the Volcano rabbit in situ.</p>	<p>Positive</p>	<p>Medium due to lack of funding for linking conservation ex situ with conservation in situ.</p>
Mexico	<p>State Secretaries of the Environment (States of México, Puebla, Morelos and Ciudad de México)</p>	<p>Except for Mexico City (SEDEMA), the State Secretaries have shown little interest in promoting the conservation of the Volcano rabbit in their municipalities.</p>	<p>Except for SEDEMA, no official state program, strategy or action was found.</p>	<p>Both</p> <p>Negative, because of their lack of effectiveness.</p> <p>Positive</p> <p>State and municipality support would be important to generate synergies in the conservation of the Volcano rabbit.</p>	<p>Medium due to lack of funding.</p>
Mexico	<p>Ejidos and communities are the landowners of several of the forest where</p>	<p>In Mexico, 52% of land tenure is socially owned: ejidos and communities</p>	<p>Some comuneros and ejidatarios who organized in brigades have received</p>	<p>Both</p> <p>Communities are major players in decision-making</p>	<p>Critical</p>



	<p>Volcano rabbit lives, and they manage the forest resources on behalf of local users.</p> <p>Ejidos and communities are agrarian systems of collective land tenure in Mexico, and land property cannot be taken away by proscription, seized or transferred.</p> <p>Ejidos are composed of ejidatarios, and communities are composed of comuneros.</p>	<p>possess a close and profound relation with the forest (CCMSS 2016).</p> <p>Large part of the forests where the Volcano rabbit lives belong to ejidos and communities. Some of these are interested in Volcano rabbit conservation, but others are not.</p> <p>Some comuneros and ejidatarios have benefited from receiving funds for carrying out forest management actions and activities related to Volcano rabbit conservation.</p>	<p>governmental subsidies to carry out firefighting, firebreak breaches, reforestation activities, and some brigades have specialized in biological monitoring.</p> <p>One example is the “Brigada de Monitoreo Biológico Milpa Alta de San Pablo Oztotepec” (Milpa Alta Brigade for Biological Monitoring of San Pablo Oztotepec). This Brigade is a key element because they are very committed with Volcano rabbit conservation.</p> <p>The Oztotepec Brigade monitors the populations of endangered species in their forest, is aware of threats imposed locally to wildlife populations, and participates in different activities related with the protection of the forest.</p>	<p>regarding the forest.</p> <p>Positive</p> <p>Capacity building and support for communities to actively participate in conservation actions is essential for the long-term conservation of Volcano rabbit. They can be strategic allies in the programs and help raise awareness and train other members of the community.</p> <p>Negative</p> <p>If community members are not included in conservation actions or given alternatives for forest management, they can continue to carry out activities that modify or eliminate the rabbit’s habitat. Therefore, it is necessary to work with them to generate environmental awareness.</p>	
Mexico	Voluntary Conservation Areas.	In Mexico, some communities and ejidos establish voluntary conservation areas legally recognized by the government but whose management is in	<p>One example is the Área Comunitaria de Conservación Ecológica (ACCE) Milpa Alta (GDF 2010).</p> <p>Currently in this voluntary</p>	Positive	High



		charge of the collective landowners.	conservation area no conservation program or strategy is applied, but it is an area of opportunity to generate synergies.		
Mexico	<p>Universities</p> <p>Universidad Nacional Autónoma de México (UNAM, National Autonomous University of México).</p> <p>Universidad Autónoma del Estado de Morelos (UAEM).</p> <p>Universidad Autónoma del Estado de México (UAEMex).</p> <p>Universidad Autónoma Metropolitana (UAM).</p>	Academics are interested in research on Volcano rabbit and its habitat.	Researchers and students develop scientific studies on Volcano rabbit biology, ecology and conservation in the Chichinautzin region, Iztaccíhuatl-Popocatepetl National Park, and Sierra Nevada Mountain range, with funding from academic grants mainly.	Positive	High
Mexico	NGO's and entrepreneurs	Some NGO's and entrepreneurs as part of their social work and environmental responsibility are interested in investing and conserving the Volcano rabbit and its habitat.	In Iztaccíhuatl Popocatepetl National Park, Volkswagen de México and Pronatura have carried out conservation actions in synergy with the National Commission of Natural Protected Areas (CONANP).	Positive	Medium because the support has been restricted to few sites.



1.7 Context and background information that will affect the success of any conservation action for this species:

	Description	Barriers to conservation	Opportunities for conservation
Socio-cultural effects and cultural attitudes	<p>The perception and attitudes of the people to the Volcano rabbit is mostly unknown. To date, there has been no comprehensive study evaluating threats jeopardizing Volcano rabbit and its habitat with a socio-ecosystemic approach. Performed studies have been mainly about the rabbit's biology and ecology.</p> <p>Traditional practices and uses of wild rabbits are subsistence hunting, sport hunting and local sale, whatsoever these activities are prohibited by Mexican environmental laws. Hunters generally prefer the larger species, the Mexican cottontail rabbit (<i>Sylvilagus cunicularius</i>), but if they find a Volcano rabbit they will hunt it because its meat is considered a delicacy. Hunting is mainly carried out by cornering rabbits with the help of dogs or by forcing them to leave their burrows using intentional fires, which when not controlled can become fires of great magnitude.</p> <p>On the other hand, people also burn the bunch grasses to promote the growth of</p>	<p>Lack of information.</p> <p>Lack of opportunities for socio-cultural development for local people.</p> <p>Environmental commitment of local civil authorities may be weak.</p>	<p>In general, people who have seen a Volcano rabbit feel empathy for the rabbit because it is so beautiful and small. Therefore, if the perceptions and attitudes negatively affecting the Volcano rabbit and its habitat are documented, an environmental education program can be designed to modify these attitudes to avoid and prevent damage to the Volcano rabbit habitat.</p> <p>On the other hand, in general the people of the communities feel good if their opinion is taken into account. People can be included in participatory planning workshops to develop a guide of good management and conservation practices for bunch grasses. Their participation would be very important, because certain local farmers, loggers, shepherds and hunters may have deep knowledge about forest dynamics. Cooperation with key forest users may significantly aid to develop a better planification and commitment to continue those activities</p>



	<p>tender grasses to feed livestock. In addition, people use the technique of "grazes grave and burns (roza tumba y quema)" prior to crop planting, and fires sometimes get out of control and accidentally burn the bunch grasses.</p> <p>Therefore, these activities and practices have a negative effect on the Volcano rabbit population and habitat. It is crucial to identify the perception and interaction that human communities are having with the Volcano rabbit and its forest, because most of their activities are placing the species at risk. For this reason, a comprehensive study is required to prepare a long-term conservation proposal.</p>		<p>that are of interest to local users under forest management and conservation.</p>
<p>Economic implications</p>	<p>Volcano rabbits do not represent an income for local people. Hunting of Volcano rabbits is prohibited, although it is done by local forest users and has not been documented yet in scientific literature. Wild rabbits (<i>Sylvilagus</i> and <i>Romerolagus</i>) are hunted for local consumption, but their meat is not necessary for people's subsistence.</p> <p>A conservation strategy that the Environmental and Natural Resources Secretariat (SEMARNAT) is promoting is the establishment of Management Units for the</p>	<p>Lack of information. Lack of inclusion of local people knowledge (forest users) in decision-making of policies or subsidies for ecosystem conservation. Economic instruments are so scarce that sometimes benefited persons are those close to political alliances, and therefore those persons committed to forest conservation are excluded.</p>	<p>The development of economic instruments that would help the conservation of the species is urgently needed. In the case of the UMA scheme, this is a good opportunity to involve the owners of the land with the conservation of the Volcano rabbit. Roots-based programs build on the knowledge of local forest users would be more promising to fulfil conservation goals linked to local economic benefits,</p>



	<p>Conservation of Wildlife (UMA), through the Conservation Program of Species at Risk (PROCER) and with the Action Program for the Conservation of Species Zacatucho (PACE Zacatucho), in charge of the National Commission of Natural Protected Areas (SEMARNAT/CONANP 2019). These programs may allow the owners of the forests where Volcano rabbits inhabit, to develop economic activities and participate in forest management through conservation actions like habitat restoration, bird watching and touristic trekking.</p> <p>Monetary value of ecosystem services provided specifically by volcano rabbit have not been evaluated yet, but the services provided by forests surrounding Mexico City and the city of Cuernavaca in the state of Morelos are huge because these forests provide water for both cities.</p>		<p>rather that imposed programs which ignore the local traditions and customs.</p>
<p>Existing conservation measures</p>	<p>Mexican and international laws protect Volcano rabbits and their habitat.</p> <p>Mexican government consider Volcano rabbit as priority species for the conservation. At federal level, through SEMARNAT, Mexico included the Volcano rabbit in the Program for the Conservation of Species at Risk</p>	<p>The Volcano rabbit is included in the PROCER; nevertheless, it is necessary to implement more programs and activities where local people could get involved and benefited economically from the conservation of the Volcano rabbit and the forest.</p>	<p>There are some communities that have interest in participating in the conservation of the Volcano rabbit. It would be a great opportunity to train the local people in monitoring, environmental awareness, and conservation activities so that they could teach other persons in their communities.</p>



	<p>(PROCER) and developed the Program of Action for the Conservation of the Species (PACE Zacatucho) that include the actions for the conservation of the species. Monitoring and research is carried out in some natural protected areas led by academics and sometimes local people (CONANP 2010, 2011); other programs support communities to realize firefighting and forest management.</p> <p>At local level, the Secretariat of the Environment of Mexico City (SEDEMA) through the DGCORENADER supports some community members and ejidatarios to carry out firefighting, forest management actions and community-based monitoring.</p> <p>Since the late 1960s, attempts have been made to keep colonies of Volcano rabbits in captivity nationally and internationally; however, in most cases these were only viable in the short term. Abroad, attempts were made to establish colonies in captivity at the Jersey Zoo, UK (with two introductions: 1968 and 1979); Antwerp Zoo, Belgium (1977); Laboratory of the Central Institute for Animal Research, University of Hokkaido, Japan (three introductions: 1977, 1979, and 1983); and Ueno Zoo, Japan (with specimens</p>	<p>The rabbits in the captivity colonies have problems of obesity and endogamy, for this reason these animals are not eligible to be included in a reintroduction program. Funding is needed, but unfortunately is not available and has not been available in the past, to maintain captive colonies with genetic standards for reintroduction in wild populations.</p>	<p>Captive Volcano rabbits may be great ambassadors for speaking out the desperate need of conservation actions of their wild relatives. For example, school kids from Milpa Alta could be transported to the Los Coyotes Zoo to meet the Volcano rabbit captive colony and learn about the conservation efforts.</p>
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	<p>donated by the Chapultepec Zoo in 2002) (Matsuzaki <i>et al.</i> 1996, Velázquez 1996). Despite numerous efforts to establish populations of this species in captivity, the only ones that have been successful in the long term are those of the General Directorate of Zoos and Wildlife –DGZVS- of Mexico City through the Chapultepec Zoo and Los Coyotes Zoo, where guidelines for its management are well established (Campos-Morales 2007).</p> <p>The first efforts at the national level began with captures made between 1979 and 1981, by researchers from the Laboratory of Experimental Animal Biology at UNAM. Likewise, other colonies that were established were the Zacango Zoo (1982, 2001) and the San Cayetano Ecological Station, both in the State of Mexico (1989); Chapultepec Zoo (with two introductions: 1984 and 1998) and Los Coyotes Zoo (2003), in Mexico City (Velázquez 1996); and recently Aragon Zoo (Campos-Morales, pers. comm.).</p>		
<p>Administrative/political set-up</p>	<p>In Mexico at federal level the Environmental and Natural Resources Secretariat (SEMARNAT) through the General Directorate for Wildlife (DGVS) and the</p>	<p>Sometimes federal, state and local government agencies are not coordinated in their objectives.</p>	<p>The fact that the government considers the species as a priority for conservation and that it has a specific action program is an opportunity to generate alliances</p>



	<p>National Commission for Natural Protected Areas (CONANP) are the institutions in charge of the conservation of Volcano rabbit.</p> <p>In the States of Mexico, each environmental ministry of the state has the autonomy to apply conservation strategies. For example, in Mexico City the Ministry of the Environment of the City through the General Directorate of Zoos and Wildlife (Dirección General de Zoológicos y Conservación de la Vida Silvestre DGZCVS) oversees the implementation of the strategies of Volcano rabbit conservation.</p> <p>At local level, the majority of the forest where Volcano rabbit inhabits is owned by local people like ejidos or communities that have their own scheme of organization, called communal assembly.</p>	<p>It is necessary that the programs designed and implemented have a long-term vision so that conservation actions can be continued.</p>	<p>that will allow the government to fulfil its goals and programs.</p> <p>Communities (comuneros and ejidatarios) that have their forests in good condition and that verify that they have populations of Volcano rabbit can participate in government programs (federal or local) and benefit through economic incentives. Therefore, it is a good opportunity for them to take advantage of this interest and train and integrate them in long-term conservation actions.</p>
<p>Local expertise and interest</p>	<p>World-class universities located in Mexico City are working on the ecology and conservation of the species: the National Autonomous University of México (UNAM) and the Autonomous Metropolitan University (UAM); and in the state of Morelos, the Universidad Autónoma del Estado de Morelos (UAEM).</p>	<p>The researchers use different monitoring mechanisms, so the data is not comparable. On the other hand, in general they do not maintain communication, so there is no synergy.</p>	<p>A research network could be created to facilitate obtaining comparable population monitoring data. Also, through this network collaborations could be built, generating multidisciplinary research teams.</p>



	<p>Also, some local communities have been interested in participating in the conservation of this species and also they have been training in the biological monitoring, for example, the Brigade of Biological Monitoring of Milpa Alta, Mexico City.</p>		<p>The knowledge and experience of the Monitoring Brigade is an opportunity for training other communities, to transfer knowledge from community to community. This can create a network of community-based monitors of Volcano rabbit populations in their range of distribution.</p>
<p>Resources</p>	<p>Because the Volcano rabbit is included as priority species for conservation in Mexico, some federal and local governmental funds are available. These funds can be applied by Universities or local communities.</p> <p>Conservation opportunities would be greatly improved if the funds provided by the government programmes start following a more structured and long-term agenda that would permit the sustainability of the projects in place nowadays, and in the future, some of these conservation initiatives by local people could become autonomous from government funding.</p>	<p>The programs and funds are not continuous, which results in incomplete conservation actions. The programs usually change or disappear with government changes.</p>	<p>The communities, ejidos and brigades that work in the forest generally dedicate their fulltime in the activities of the forest, it can be taken advantage of the fact that they are already in those areas and that they know very well the dynamics of the forest. Government could contract local people and training to carry out long-term monitoring. This would benefit the communities and the government would not have to invest annually in the training.</p>



2. ACTION PROGRAMME

Vision (30-50 years)	
Volcano rabbit populations protected in the long-term through schemes that ensure the social and environmental well-being of the communities in the forest where it lives	
Goal(s) (5-10 years)	
Manage the main problems that put the volcano rabbit at risk through the collaboration with the different sectors of society: government, communities, universities	
Objectives	Prioritisation <i>(low, medium, high or critical)</i>
1. Asses the population size of the volcano rabbit throughout its range of distribution	Critical
2. Update the distribution and identify the critical areas for the conservation of the species	Critical
3. Identify the main threats to the species from a socio-ecological approach	Critical
4. Research the ecological requirements of volcano rabbit (home range, metapopulation dynamics)	High
5. Promote actions of environmental awareness about volcano rabbit and its habitat	High
6. Integral program of management and conservation under human care	High
7. Engage local communities in the monitoring programs and habitat management	High
8. Establish a network of collaboration between the different sectors involved in the conservation of volcano rabbit	Critical



Activities	Country / region	Priority (low, medium, high or critical)	Associated costs (currency)	Time scale	Responsible stakeholders	Indicators	Risks	Activity type
Objective 1: Asses the population size of the volcano rabbit in its range of distribution								
<p>Establish a systematic method to estimate population size in representative sites (core and peripheral areas) of its distribution.</p> <p>It is suggested to use the indirect method of population estimation through pellet count because it is cost-effective.</p>	México/ Sierra Nevada and Chichinautzin -Ajusco region	High	9,500 GBP/year	Two years	CONANP- SEMARNAT, Local environmental secretariats, Academics, Local people (communities and ejidos)	Report Peer review paper	<p>Lack of interest and institutional capacity</p> <p>Lack of monetary resources.</p> <p>Lack of interest from local communities</p>	Field research, Improving knowledge, Participatory monitoring of biodiversity
Objective 2: Updating the distribution and identify the critical areas for the conservation of the species								
Conduct extensive surveys in the historic distribution and in the areas that	México/ Sierra Nevada and Chichinautzin	Critical	5,000 GBP/year	Two years	CONANP- SEMARNAT, Local environmental secretariats,	Map of the geographic distribution range of the species	Lack of interest and institutional capacity	Field research, Improving knowledge, Participatory



models predict the species presence. 1. Document the historic distribution 2. Document models that predict the distribution of the species or generate a new model 3. Verify in the field through a systematic sampling the presence and absence of the species.	-Ajusco region				Academics, Local people (communities and ejidos)	Peer review paper	Lack of monetary resources. Failure to obtain permission from the communities and landowners to do the surveys	monitoring of biodiversity
Objective 3: Identify the main threats to the species from a socio-ecological approach to design an adaptive conservation plan								
Evaluate the impact of socioeconomic activities in the habitat of the species	Mexico/ critical areas for the conservation of the species	High	2,000 GBP/year	One year	Academics	Peer review paper	Difficulty in getting information from people	Field research, Improving knowledge
Evaluate the human perception about the volcano rabbit and its habitat	Mexico/ critical areas for the conservation of the species	High	2,000 GBP/year	One year	Academics	Peer review paper	Difficulty in getting information from people	Field research, Improving knowledge



Integrate the socioeconomic aspects with the ecological knowledge of the species to evaluate from a systemic perspective the interactions	Mexico/ critical areas for the conservation of the species	High	No costs associated after the data is collected	One year	Academics	Peer review paper	Not enough data to perform the analysis	Improving knowledge
Develop and implement an adaptative conservation plan for the species	Mexico/ critical areas for the conservation of the species	High	2,500 GBP/year	One-two years	CONANP- SEMARNAT, Local environmental secretariats, Academics, Local people (communities and ejidos)	Report	Lack of intersectoral coordination	Management of habitat
Objective 4: Research the ecological requirements of volcano rabbit								
Evaluate habitat availability and connectivity	Mexico/ Sierra Nevada and Chichinautzin -Ajusco region	High	5,000 GBP/year	One year	Academics	Peer review paper	Lack of monetary resources	Field research, Improving knowledge
Estimate home range size and dispersion	Mexico/ Sierra Nevada and Chichinautzin	High	7,500 GBP/year	Two years	Academics	Peer review paper	Lack of monetary resources	Field research, Improving knowledge



	-Ajusco region						<p>Failure to obtain governmental permissions and/or from the landowners to do the capture and monitoring.</p> <p>Failure to capture enough volcano rabbits or collect enough locations for home range estimation</p> <p>Failure in the radio-transmitters and lack of enough data.</p>	
Research on the metapopulation dynamics	Mexico/ Sierra Nevada and Chichinautzin -Ajusco región	High	5,000 GBP/year	Two years	Academics	Peer review paper	Lack of monetary resources	Field research, Improving knowledge



Objective 5: Promote actions of environmental awareness about volcano rabbit and its habitat								
Generate a guide of good practices and management of the bunch grasses aimed at comuneros and ejidatarios who have activities in the forest.	México/ Sierra Nevada and Chichinautzin -Ajusco region	Critical	3,500 GBP/year	One year	Academics, Local people (communities and ejidos)	A guide	Lack of monetary resources.	Environmental awareness, Habitat management Local capacity building
Implement an environmental awareness program that includes the problematic of the Volcano rabbit and its habitat	México/ Sierra Nevada and Chichinautzin -Ajusco region	High	7,500 GBP/year	Three years	CONANP-SEMARNAT, Local environmental secretariats, Academics, Local people (communities and ejidos), NGO's, entrepreneurs.	Number of people and communities involved in awareness activities	Lack of monetary resources. Lack of interest	Environmental awareness
Objective 6: Integral program of management and conservation under human care								
Transition of the management of the Volcano rabbit colony to an integral conservation model where the rabbits are in conditions that are like their habitat.	Ex-situ	Critical	15,000 GBP/year	Three years	SEMARNAT, SEDEMA-DGZCVS	Exhibitors with similar conditions to the Volcano rabbit habitat	Lack of monetary resources. Lack of institutional capacity	Species management



Implement a breeding program that allows increasing genetic diversity	Ex-situ	Critical	7,000 GBP/year	Five years	SEMARNAT, SEDEMA-DGZCVS	Decrease in the level of inbreeding of the colony	Lack of monetary resources.	Species management
Develop a reintroduction program, so that in the future releases of rabbits to wildlife can be made.	Ex-situ	Critical	5,000 GBP/year	Ten-thirty years	SEMARNAT-CONANP, SEDEMA-DGZCV	<p>Reports on the progress of the program.</p> <p>In the long term, Volcano rabbit individuals with favourable conditions to be reintroduced</p> <p>In the long term, number of Volcano rabbits released to the wild and their survival rates</p>	<p>Lack of monetary resources.</p> <p>Lack of institutional capacity</p> <p>Lack of governmental interest</p>	Species management



Objective 7: Engage local communities in the monitoring programs and habitat management								
Train ejidatarios and comuneros to carry out population monitoring of the rabbit and its habitat	México/ Sierra Nevada and Chichinautzin -Ajusco region	High	7,000 GBP/year	One year	CONANP-SEMARNAT, Local environmental secretariats, Academics, Local people (communities and ejidos)	Number of people trained	Lack of monetary resources. Lack of community interest	Local capacity building
Establish in the long term a monitoring program of the size and density of the Volcano rabbit populations. In addition, monitoring the habitat and the effect of the human activities.	Mexico/ Sierra Nevada and Chichinautzin -Ajusco region	High	7,500 GBP/year	Continuou s	CONANP-SEMARNAT, Local environmental secretariats, Academics, Local people (communities and ejidos)	Report Peer review paper	Lack of interest and institutional capacity Lack of monetary resources. Failure to obtain permission from the communities and landowners to do the surveys	Field research, Improving knowledge, Habitat management
Objective 8: Establish a network of collaboration between the different sectors involved in the conservation of volcano rabbit								
Workshops to promote the synergies of the government, communities, and academics in the	México/ Sierra Nevada and Chichinautzin -Ajusco region	High	3,000 GBP/year	One-two years	CONANP-SEMARNAT, Local environmental secretariats, Academics,	Number of workshops carried out	Lack of intersectoral coordination Lack interest	Law and policy



actions of management of the habitat and conservation of the Volcano rabbit					Local people (communities and ejidos)	Reports with the commitments made Implement a network		
Workshops to promote the intersectoral coordination between the governmental programs that concurred in the habitat of the volcano rabbit	México/ Sierra Nevada and Chichinautzin -Ajusco region	Critical	3,000 GBP/year	Two years	Federal agencies: SEMARNAT, and local environmental secretariats, por example SEDEMA.	Reports with the commitments made Collaborative actions established in the conservation programs of the species.	Lack of intersectoral coordination Lack of political interest	Institutional capacity building
Workshops to promote collaboration between academics to work with methodologies that produce comparable results.	México/ Sierra Nevada and Chichinautzin -Ajusco region	Critical	3,000 GBP/year	Two years	Academics	Implement an academic research network	Lack of interest Personal interests not compatible with the research network	Improving knowledge



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