# ACTION PLAN FOR THE CONSERVATION OF THE BELLO ROCKET FROG (Hyloxalus abditaurantius) IN THE MOUNTAINS OF THE COLOMBIAN ANDES

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This study aims to carry out a diagnosis of the conservation status and propose conservation strategies for the amphibian Bello Rocket Frog (Hyloxalus abditaurantius), a frog that lives in the moorlands that generate water that feed the Pacific Ocean, in western Colombia. Together with the IUCN, the Embera indigenous community and the University of Chocó, it was determined that there are a maximum of 100 mature specimens of the frog and there are no more than 250 specimens of this species. The main threats that eliminate these few organisms are: climate change, habitat destruction and the Quytrid fungus, through which populations have been decimated. A population with 8 specimens was ratreada, which were captured, isolated, vaccinated and conserved in the nursery of our organization, to protect them from death.

Through the analysis of threats, we propose strategies for the sustainable recovery of the rocket frog: delimitation and protection of natural areas in priority habitats; mapping and tracking of ecological corridors; training and sensitization of the Embera indigenous community (cohabiting with the frog) and the creation of environmental organizations, led by local personnel, for the protection of Andean biodiversity.

Communication and promotion of the biodiversity of Andean ecosystems is necessary to stimulate investment in conservation, from the Colombian government to international conservation programs.

**Keywords:** Amphibian, rocket frog, Colombian Andes, Embera indigenous community, chytrid fungus, extinction.

## 1. POPULATION INFORMATION AND TRENDS

The absence of annual estimates makes it impossible to establish with certainty the trends in its population abundance. However, the extinction of at least two local populations in a period of less than 30 years would indicate that the species is facing a process of decline. In particular, the disappearance of the Chocó species represents the loss of a significant fraction of its population since it was the one that occupied the largest body of water in its area of distribution.

The distribution of groups of individuals associated with isolated lagoons, suggests a metapopulation type arrangement of this species, each lagoon representing a local population, with different degrees of connectivity with respect to other local populations (which probably responds to environmental and environmental conditions), habitat, such as wet periods, presence of barriers or corridors such as lagoons and distance between lagoons, among others). Although there are no precise estimates of abundance at the moment, previous observations would indicate that there could be a correlation between the abundance of individuals and the size of the lagoons where they are found. In this sense.

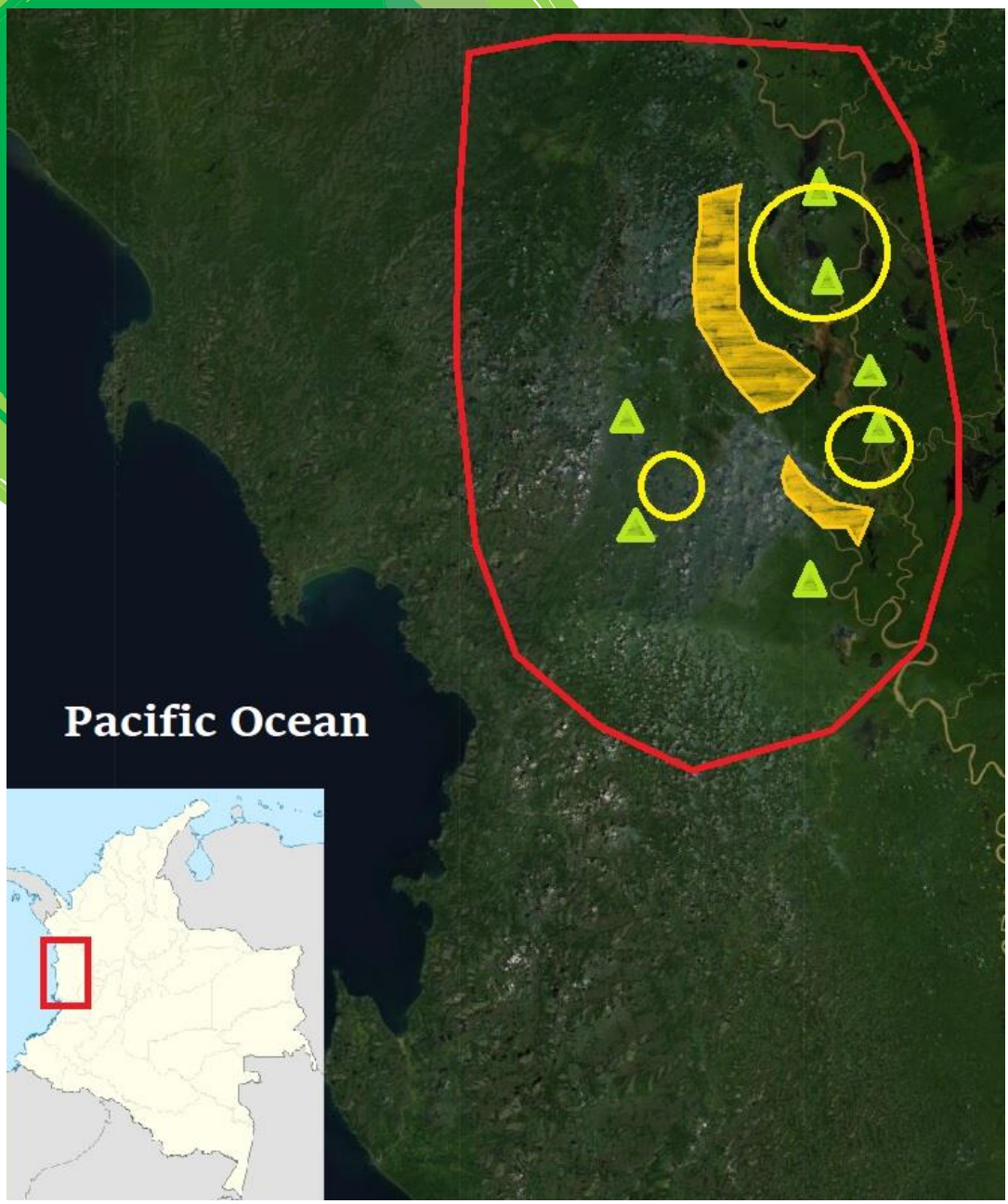
## 2. HABITAT

The lagoons that Hyloxalus abditaurantius inhabits are scattered over a steppe-volcanic landscape, which is determined by an arid climate. These lagoons present significant level fluctuations and have characteristic flora and fauna, with a predominance of macrophytes Myriophyllum quitense and Tetrachondra patagonica, which are essential as part of the microhabitat of the aquatic form of this frog. Myriophyllum quitense is a deep-rooted, submerged plant that grows in dense clumps and has long, branched stems. Its structural complexity provides a variety of refuges and sites for attachment or support of numerous aquatic organisms.

The stems of this plant that are detached by the waves, drift into logs that are then deposited in the littoral area and they generate environments conducive to microfauna. Tetrachondra patagonica is a marsh or aquatic pygmy plant with spreading stems that forms dense grasses.

Filamentous algae adhere to submerged vegetation, forming conglomerates that harbor numerous small organisms. In the peripheral sectors

## STUDY AREA

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**CONVENCTIONS**

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|---|---|
| | **Study Area** |
| | **Target Frog Populations** |
| | **Embera indigenous communities** |
| | **Deforestation hotspots** |

**SCALE**

**1cm = 50,000m**

**LOCATION**
**-Country:** Colombia
**-Department:** Chocó
-Emberá indigenous territory

**GEOGRAPHICAL COORDINATES:**
**-Latitude: 5 ° 28'57.3 "N**
**-Length: 76 ° 38'29.1 "W**

**SOURCES:**
**- COLOMBIA WILD CORPORATION**
**-University of Chocó**
**-IMAP, biodiversity map of Colombia.**
**-IUCN | Global Redlist**

**Figure 1.** Map of the study area. Source: the authors.

of the lagoons, the bottom rocks provide shelter and favor the development of algae and a variety of potential prey, such as amphipods, ostracods, hirudineans and odonate larvae (Cuello et al., 2017). A large number of migratory waterfowl visit the

lagoons annually to nest and feed. All these lagoons are naturally devoid of fish.

For its part, the littoral shape is usually associated with the low humidity that is maintained under the rocky areas or even isolated rocks, especially those in a flat shape. It is under these rocks or rocky areas where Hyloxalus abditaurantius can be found sharing the microhabitat with another species widely distributed in the Patagonia and Monte regions and which is known as the Four-eyed Frog (Pleurodema bufoninum). Moisture retention and shelter from the wind and extreme weather conditions make these rocky areas shelters for a wide variety of invertebrates that are likely to provide food for these two species of frogs.

## NATURAL HISTORY AND ECOLOGY

Ecology and development of tadpoles

The Chocó frog has different larval development strategies in terms of the length of the larval period. In the more permanent lagoons, tadpoles exhibit a dual strategy in which some tadpoles have a short larval period and develop in the same growing season in which they hatched (i.e. spring-summer), while other tadpoles exhibit a short larval period. prolonged larval period with individuals that hatch in spring, spend summer and winter in the lagoon and metamorphose to a larger size in the following season. On the other hand, in temporary lagoons, the drying that occurs towards the end of summer promotes and accelerates development, favoring a short larval period. This plasticity in terms of development strategies allows this frog to colonize diverse environments such as permanent and temporary lagoons, and even face extraordinary droughts in typically permanent lagoons (Cuello et al., 2017).

**Diet**

The diet varies between morphotypes and is correlated with the micro habitats it occupies; each one of these. In this sense, differences are observed in terms of the morphology of the consumed prey, their escape response and their temporal and spatial availability, observing totally different diets according to whether it is the aquatic or coastal form.

In the case of the aquatic form, aquatic prey

live under rocks and / or are slow swimmers. Among the most common are amphipods, ostracods, hirudines, and odonata larvae. On the other hand, in the case of the terrestrial form, the prey are, generally, wanderers or fliers with weak flight, mainly insects and spiders. This diversification of prey according to the morph shows another aspect of the plasticity of the species and its ability to modify its trophic spectrum in the face of a change in environment (Cuello et al., 2017).

## STATE OF CONSERVATION

### Threats

### Emerging diseases

In some specimens of the species the existence of fungal infections of chytridium, Batrachochytrium dendrobatidis, and of viruses, Ranavirus sp. (Fox et al. 2006, Ghirardi et al. 2014). Although the specific effect of these pathogens on the species is unknown, the detection of several dead and dying individuals, belonging to different subpopulations of the species with clinical signs of disease (Fox et al. 2005), allows us to assume that these diseases represent threats real to the conservation of the species.

### Man-made riots

Like a large number of amphibian species, Hyloxalus abditaurantius is threatened by habitat degradation caused by domestic livestock. Particularly the direct negative effect is produced by trampling, when the cattle approach the lagoons to drink, but also when feeding on the peripheral and aquatic vegetation of the lagoons, which are the refuge for both larval stages and for juveniles and adults of the species (Cuello et al. 2014, 2017b).

The presence of livestock also produces an indirect negative effect, altering the quality of the water in the aquatic environments that the species inhabits, due to the increase in the supply of nutrients, via their waste, and the arrival of sediment by trampling the coasts.

### Exotic species

The main subpopulation of this species (the one that lived in the Laguna Blanca) was formally declared extinct, the main known cause being the introduction of invasive exotic fish, mainly Percichthyis sp. and Onchorhynchus mykiss, which in addition to predating directly on Hyloxalus abditaurantius individuals, compete for food and, especially Percichthyis sp, produce changes at the bento and macrophytia level of the lagoon (Cuello & Perotti, 2006).

These fish, by human means, also accessed other nearby lagoons and have already caused a decline in the subpopulations that inhabited there, exposing them to potential extinction (Laguna El Álamo, Cuello et al. 2009).

**Climate change**

The intense drought that occurred in the region between 2010 and 2016 severely affected the species' habitat, due to direct drought of water bodies and consequent disappearance of the aquatic and coastal vegetation that this frog needs to take refuge, feed and reproduce. (ME Neck pers. Obs. January 2015). Although these are extreme climatic events, they are cyclical, so the species you have faced them in the past. However, at present, they would probably be enhanced by the effect of global climate change and it is expected that in the future they will be even worse (as the forecasts for the area indicate. In this context, and in synergy with other threats, it is Hopefully, this threat can be considered a high risk factor for the species.

**State of conservation**

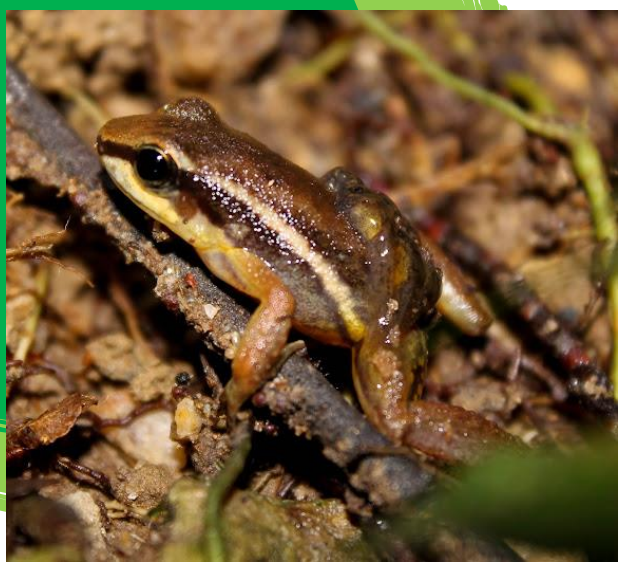
The Chocó frog is classified as Critically Endangered CR on the IUCN Global Red List (Basso et al., 2012), with a SUMIN index value of 19; and as Critically Endangered on the Red List of the International Union for Conservation of Nature (IUCN SSC-ASG, 2019), criteria A1ac (iii, iv), according to the last update made in 2019. This category It implies that the species is facing an extremely high risk of extinction in the wild, ergo, if it does not take direct actions aimed at improving its current state, it could become extinct in the short to medium term.

**Conservation actions**

The situation of the species has led the Southern Delegation of National Parks in conjunction with Universidad del Chocó researchers to carry out a series of actions aimed at promoting the protection of Hyloxalus abditaurantius with the aim of improving the conservation status of this species. Among the most outstanding we can name:

1. The transfer of results by various graphic means (brochures, posters, publications in scientific and public media); workshops; conferences; among other. The focus was on publicizing aspects of the habitat of this species, its biology and ecology and warning about the negative impact of the introduction of perch in the White Lagoon.

2. The development of a Monitoring Protocol for the survey of disturbances natural in the terrestrial and aquatic habitat



of the frog, as well as the possible alterations caused by the action of livestock and / or the introduction of fish. It is held twice a year, in spring and summer.

3. The construction by the National Park of perimeter fences to prevent livestock access to the lagoons. The first, approximately 3 km long, was built around the Laguna Verde. After two years of implementing this measure, the recovery of coastal vegetation and macrophytes could be observed. Based on this experience, it was decided to repeat this action in two other lagoons in the Park (Laguna Antiñir and Laguna Batea). In the first, water tanks were also installed fed from a nearby mallín, located outside the fence, to supply water to residents, local livestock and transhumants (source Cuello et al., 2017).

4. The annual management by the National Park of the abundance of exotic fish in the Laguna Blanca, based on the continued removal of individuals. This action allowed, after a few years, not only to reduce the abundance of perch and trout, but, consequently, to improve the state of the lagoon in terms of its physical and botanical conditions, this being a first experience of habitat management oriented to the restoration of the original conditions of the lagoon.

5. The creation of a center that has facilities for ex situ management of the species, which is located in the visitor center "Nomads" located within the APN. The objective of these facilities is to have an artificial habitat to establish Hyloxalus abditaurantius frogs and tadpoles rescued from lagoons in the process of drying up, to allow their development and eventual reproduction in ex situ conditions, to later be returned to their original habitat. Another objective of this center is to have individuals to be part of a potential future program for the reintroduction of individuals to reestablish the subpopulation that once inhabited the Laguna Blanca.

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## INTRODUCTION

The potential actions identified to be considered in the framework of the conservation of the Chocó Frog (Hyloxalus abditaurantius) are detailed below. For each action the following are detailed: 0. A general description of the scope of the action; 1. Objective; 2. stages and second-order actions to be specified to achieve the objective; 3. progress status (that is, to what extent this action has been progressed or tested); 4. temporal projection, that is, for when an action is expected to be carried out and / or in what situation, conditions, or if it is being carried out, for when it is expected to be carried out. In this sense, this action plan has the character of a guide to be taken into account as a management strategy to improve the conservation of this species, without pretending to be a declaration of actions to be carried out in the short to medium term.

## 1. IDENTIFY KEY SITES FOR THE CONSERVATION OF THE CHOCO FROG

The priority sites for conservation are areas of importance within the framework of a management that ensures the long-term persistence of the populations of Hyloxalus abditaurantius in the wild. In this sense, such sites contain suitable and key habitats for this species, since they offer the necessary resources for the healthy development of its life cycle. The characteristics of these habitats, therefore, must coincide with those recorded in the natural history studies of this species in terms of knowledge regarding its natural populations, its reproductive biology, its trophic ecology, and relevant aspects associated with the occupation. of this frog and with any new information that is relevant obtained in the framework of studies carried out in this species. Likewise, these habitats must have sufficient connectivity to each other to ensure the metapopulation dynamics that characterize this species.

**OBJECTIVE 1**. Conserve key sites to ensure long-term viability of the Chocó frog.

### STAGES AND ACTIONS TO BE DEVELOPED

1.1. Initial stages in designating key conservation sites

1. Appoint a working group to map and identify key sites for the conservation of this species.
2. Prioritize the sites according to their relative importance for the conservation of this species, taking into account their fitness, size, connectivity and the degree of threat.
3. Promote specific monitoring to verify the presence / absence of the species in places where the presence has been previously registered (detect possible local extinctions).
4. Promote expeditions to little-explored sites.

### 1.2. Studies and evaluations on key conservation sites

Once the sites have been categorized according to their relevance for the conservation of this species, surveys and evaluations must be carried out in and on the sites in question. They should include:

1. Study on the current use of the land (although a large part of the area is classified as a protected area of national domain, in some sectors there are local people making use of it).
2. Evaluation of the perspectives and objectives of all those interested in the management of the area, mainly the government agencies in charge of it, but also NGOs interested in the conservation of the environment and local species, researchers, land owners and local inhabitants, among others.
3. A description of the use of resources, at local and regional scales, and a projection of trends in the use of resources in the medium and long term.
4. An analysis of relevant policies framed in the use of land and resources.
5. Potential areas to be considered for incorporation into the Federal System of Protected Areas (SIFAP).

**1.3. Conservation proposals for key sites**

The information derived from these primary assessments can then be used to generate specific conservation proposals within the identified sites. Once there is greater knowledge about these sites and understanding of their complexity, the next stage will be to initiate actions to protect them, in order to promote the protection of this species. These actions should include:

1. Secure key sites for the conservation of this species (this may include the construction of closures).
2. If there are conservation efforts in the area, establish a network of connections aimed at maximizing efforts and use of resources.
3. Development of local work capacities through training plans in specific conservation activities.
4. Develop a series of measurable indicators aimed at monitoring these key sites.
5. Develop an educational strategy aimed at promoting knowledge of the area's problems at the local and national level.
6. Start a media campaign at the national level including different sources for the disclosure of the activities carried out and the objectives pursued.

It is important to ensure that eventually all key registered sites are protected in some way. Efforts should begin with an assessment of the status of the populations of the species under consideration. Subsequently,
They must establish measurable and defined conservation parameters for each site.

**1.4. Information gaps and future targets**

For effective conservation of key sites it is necessary:

1. Spatially delimit the sites considered key as precisely as possible.

2. Develop an adaptive management strategy that allows dealing with fluctuating populations, habitat fragmentation, and changing distributions.
3. Integrate and interconnect related research (diseases, climate change, land use, etc.) in the identification of key areas.

## 2. PROTECTION AND RESTORATION OF HABITATS AND MITIGATION OF THREATS

The main habitats of Hyloxalus abditaurantius are made up of permanent and temporary endorheic lagoons nestled in depressions located on basaltic plateaus to the west and southwest of the town of Zapala. The conservation of these habitats / microhabitats implies a multidisciplinary and inter-institutional approach that allows carrying out a series of actions framed in at least some of the following fields: research, education, policy and management. The main groups of actions to be developed to achieve the proposed objective are detailed below.
In all cases, prior to the execution of a specific action, an adequate basic analysis must be carried out to establish what action will result in a positive effect for this species and for the ecosystem in general.

**OBJECTIVE 2.** Restore existing habitats and create new habitats, free of threats and in sufficient quantity to ensure the long-term viability of the Chocó Frog (Hyloxalus abditaurantius).

### 2.1. SECURE AND RESTORE HABITATS CURRENTLY OCCUPIED BY THE SPECIES

The first step is to protect pre-existing habitats, that is, those that contain existing local populations. This involves the elimination or mitigation of threats through a series of actions that are listed below:
1. Perimeter fencing of lagoons to prevent the entry of livestock and installation of water troughs for local livestock.

2. Improvement of habitats if necessary (eg translocation of rocks and native vegetation to increase the availability of refuges and breeding sites; rock paths towards the center of the lagoons).
3. Awareness-raising tasks and agreements with local people and transhumants to strengthen the protection of these sites.
4. Regulation of visitors, design and installation of informative jail
5. Systematic monitoring of frog populations and habitat status.

### 2.2. IDENTIFY CORRIDORS AND ENSURE THEIR FUNCTIONALITY

Those habitats that could act as corridors (eg Laguna Blanca-Laguna Verde) for the

exchange of individuals between subpopulations of different lagoons must be identified and their conservation must be ensured by eliminating the threats that operate on them. The restoration of said corridors may include:

1. Exclusion of livestock (local and transhumant).
2. Translocation of native vegetation in those cases where it is necessary.
3. Translocation of rocks that allow the native vegetation to settle and can act as natural refuges for frogs.
4. Maintain and / or restore the natural drainage that may exist between different bodies of water (lagoons, streams).
5. Carry out a management oriented towards the removal / control / reduction of invasive predators, such as perch and rainbow trout, of both occupied and unoccupied, potential habitats and corridors.
6. Evaluate the feasibility of creating small ponds associated with watercourses that offer optimal conditions for frogs, without altering the original habitat in any way. These sanctuaries should function as "posts" along the corridors, allowing an increase in survival and reproduction and act as micro-sources (in a metapopulation scheme) contributing individuals to natural habitats.

### 2.3. RESTORATION OF HABITATS IN CHOCÓ

Given that successive introductions of exotic fish have been carried out in Chocó, which are associated with the extinction of the most important subpopulation of the frog and with the drastic modification of the environment and its biota, it is necessary to carry out actions aimed at mitigating or eliminating the negative effects of those introductions. Such actions may include:

1. Control of fish introduced in Chocó and implementation of mechanisms to prevent their spread to other bodies of water.
2. Exclusion of livestock from the coasts and surroundings identified as potential habitats for the frog.
3. Transfer of macrophytes to potential frog occupation sites to promote rapid habitat recovery.

## 3. CLIMATE CHANGE AND DECLINATION OF AMPHIBIANS

Since a potential effect of climate change on the Laguna Blanca Frog is currently assumed, two parallel lines of action are proposed framed in research and adaptive management, which are detailed below and are framed in the following objective:

**OBJECTIVE 3.** Understand in depth the potential effects of climate change on the Chocó Ranita and begin to develop precautionary actions aimed at improving current habitats so that the species has a greater number of refuges to face an eventual scenario. negative.

3.1. Study the potential effect of climate change on the Laguna Frog

White

In order to lessen the impacts of climate change on local populations of Hyloxalus abditaurantius, a series of basic investigations are suggested.

1. Understand how climate change will affect this ecosystem and the amphibians that inhabit it. The focus should be on changes in habitat dynamics and underlying mechanisms.
2. In light of these mechanisms, identify key elements of the climate and quantify the relevant changes.
3. Develop a predictive model on declining patterns of populations of Hyloxalus abditaurantius based on these mechanisms and observed trends.
4. Investigate why climate change is more serious today than in the past (eg. alterations in the landscape, desertification, etc.).
5. Examine the context of declines in local populations of this species to understand broader implications related to the loss of biodiversity (parallel effects on other groups).

### 3.1. ACTIONS ORIENTED TO RELIEVE THE POTENTIAL EFFECTS OF CLIMATE CHANGE ON THE LAGUNA BLANCA FROG

Beyond research, conservation actions in relation to climate change and amphibian decline need:

1. Increase public awareness of the effects of climate change: create displays in educational centers (eg, APN visitor center), websites and positions in existing institutions.
2. Promote initiatives that increase the resilience of this species and reduce sensitivity to climate change (habitat restoration, creation of new habitats, improvement of corridors, etc.).
3. Explore the possibility of locally manipulating the climate on a micro scale, that is, in relation to the micro-habitat of this species (eg creation of sanctuaries, refuges, etc .; sites with special conditions where the effect of climatic alterations is less powerful ) in light of the observed mechanisms.

## 4. EMERGING INFECTIOUS DISEASES

There are a series of steps aimed at detecting some of the main emerging diseases related to the decline of amphibians at a global level: the fungus that causes chytridiomycosis infection, Batrachochytrium dendrobatidis (Bd) and Ranavirus sp. of which we know that this species is a carrier, and for which deaths in a natural state, possibly associated, have been observed (Fox et al., 2005).

**OBJECTIVE 4.** To understand in greater depth the effect of chytrid, Batrachochytrium dendrobatidis and Ranavirus sp. on the local populations of Ranita Patagónica, its relationship with different environmental factors, both natural and anthropic, and generate palliative actions that, if deemed necessary, allow to alleviate the infectious burden on

wild populations.

### 4.1. DISEASE DETECTION AND ASSOCIATED STUDIES

Although there are a series of clinical signs associated with these diseases, they only become evident in the most advanced stages, when individuals are on the verge of death. In this sense, the pathogen must be detected by the use of microscopy (eg, histopathological methods
foot and / or groin skin standards) or biochemical methods (eg, PCR - polymerase chain reaction). To this end, it is proposed:

1. Swab (minimally invasive methods) in the field the largest number of registered individuals of this species and other species that share the habitat in order to evaluate by QPCR the presence and level of infection of them.
2. Carry out studies that allow evaluating the health status of individuals and relate this to the level of infection by Bd and Ranavirus sp.
3. Carry out studies that allow associating the level of infection by Bd and Ranavirus sp. with the state of the habitat, the presence and frequency of threats and the occupation of other species of amphibians.

### 4.2. MANAGEMENT AND PREVENTION OF THE DISEASE IN THE FIELD

The treatment of chytridiomycosis in the field is complex, as there are currently no methods that have been widely tested. Therefore, population-level strategies are the only viable option in case of infection. This could include:

1. Capture of wild individuals, treatment with drugs or heat, which kill the fungus, and subsequent maintenance of individuals in captivity prior to their release in sites considered free of the disease. This option should not be considered unless there is a mass mortality of the species that could be specifically associated with this disease.
2. Disinfection of footwear with 10% chlorine to prevent the spread of the pathogen by tourists or other people moving through the area could also be considered. However, in the particular case of this species, since the fungus is currently widely distributed, this effort would not have a significant impact.

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