HARLEQUIN TOAD (*ATELOPUS*) CONSERVATION ACTION PLAN 2021 — 2041

ATELOPUS SURVIVAL INITIATIVE
IUCN SSC ASG ATELOPUS TASK FORCE

Authors: Lina M. Valencia[1] and Luis F. Marin da Fonte[2, 3]
[1]Re:wild (formerly Global Wildlife Conservation), [2]Amphibian Survival Alliance, [3]IUCN SSC Amphibian Specialist Group for Brazil

Reviewers (in alphabetical order): Jose Barros[4], Gina Della Togna[5,6,7], Brian Gratwicke[8], Juan M. Guayasamin[9,10], Enrique La Marca[11,12], Margarita Lampo[13], Stefan Lötters[14], Andrés Merino-Viteri[15], Andrea Teran[16], Jamie Voyles[17]

[4]Fundación Atelopus, Colombia, [5]Universidad Interamericana de Panamá, Panamá, [6]Smithsonian Tropical Research Institute, Panamá, [7]IUCN SSC ASG Biobanking Working Group Coordinator, [8]Smithsonian Conservation Biology Institute, USA, [9]Universidad San Francisco de Quito, Ecuador, [10]University of North Carolina at Chapel Hill, USA, [11]Universidad de Los Andes, Venezuela, [12]Rescue of Endangered Venezuelan Amphibians (REVA) Conservation Center, Venezuela, [13]Instituto Venezolano de Investigaciones Científicas Academia de Ciencias Físicas, Matemáticas y Naturales, Venezuela, [14]Trier University, Germany, [15]Pontificia Universidad Católica del Ecuador, Ecuador, [16]Centro Jambatu de Investigación y Conservación de Anfibios, Ecuador, [17]University of Nevada, USA.

Atelopus Survival Initiative Coordinator: Luis F. Marin da Fonte
IUCN SSC ASG Atelopus Task Force (in alphabetical order): Jose Barros, Gina Della Togna, Edgardo Griffith, Juan M. Guayasamin, Margarita Lampo, Stefan Lötters, Luis F. Marin da Fonte, Andrés Merino-Viteri, Lindsay Renick-Mayer, Carlos Martinez-Rivera, and Lina M Valencia.

Contributors: see page 43

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We highly value diversity, inclusion and justice (EDIJ). We acknowledge the diversity of threats and solutions to *Atelopus* and have therefore convened members from different countries (the majority from South and Central America, where harlequin toads naturally occur), backgrounds, cultures, and career stages and gender identity in the development of this plan. We have strived to give voices to traditionally marginalized groups like women, Indigenous and local communities and younger generations, and our goal is to encourage the inclusion and representation of these groups in leadership and decision-making. This Action Plan was created under consideration of EDIJ best practices.

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FOREWORD

Anne Baker[1], Ariadne Angulo[2], and Candace Hansen-Hendrikx[3]
[1]Amphibian Ark, [2]IUCN SSC Amphibian Specialist Group, [3]Amphibian Survival Alliance

Since the beginning of our collective awareness of globally-scoped amphibian declines and extinctions, the Neotropical genus *Atelopus* has become emblematic of the amphibian biodiversity crisis. With almost 100 species recognized by science and about two dozen additional prospective candidate species, it is a wide-ranging group in the Americas, extending northbound from Bolivia to Costa Rica and eastbound to the Guiana Shield, occupying streams, lowland rainforests, cloud forests and Andean páramos all the way from sea level to well above the tree line. Arguably, an important *Atelopus* hotspot is comprised by the Andes.

Based on accounts by herpetologists and locals alike, until the 1990s many harlequin toad species used to be very common and even abundant. But they started to mysteriously disappear, regardless of country, habitat and whether or not they were found in protected areas. Of the 99 described species, 94 have been assessed for extinction risk on The IUCN Red List of Threatened Species, with 78 (nearly 83%) species falling in a threat category.

This plan identifies the types of threats that may face *Atelopus* across its range. While the dramatic decline in population numbers, even in protected areas, suggests that *Batrachochytrium dendrobatidis* may be a critical factor, given the difficulty of eliminating chytrid in wild populations it is important to consider that eliminating or reducing other threats, such as pollution or habitat degradation, may allow some individuals to successfully mount a defense against chytrid. Where populations are sufficiently large, employing such a strategy, and documenting and sharing the results, could result in substantial benefits for *Atelopus* conservation.

Where populations are small and their survival in the wild is unlikely, captive assurance colonies may be the only option for a species' survival. A number of *Atelopus* species have successfully bred in such colonies and existing husbandry protocols can provide guidance to those organizations considering *ex situ* breeding efforts. For rescue species combining *ex situ* breeding efforts with *in situ* threat mitigation will be the key to realizing the ultimate goal of *Atelopus* thriving in their native habitats.

The successful conservation of *Atelopus* will require building on this plan to develop specific action plans for species, or groups of species in given areas. Operationalizing this plan at multiple levels calls for leveraging each of our strengths, resources, and expertise in a coordinated and collaborative approach. Communication, sharing both successes and failures all along, will be critical to bringing the harlequin toads back from the brink of extinction and continuing to improve their conservation status for generations to come.

By coming together around this plan we can achieve a conservation impact far greater than any individual or organization could achieve on its own.

Let's get on with it!

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EXECUTIVE SUMMARY

With almost 100 species ranging across the Neotropics, from Costa Rica to Bolivia and east to French Guiana, harlequin toads (*Atelopus* spp.) are among the most threatened amphibians in the world. According to the IUCN Red List of Threatened Species, up to 90% of *Atelopus* species are threatened with extinction, with 40% of species thought to be possibly extinct in the wild and four species considered to be extinct. Over the past few decades, many *Atelopus* species have suffered severe population declines and extinctions throughout their range. The most likely primary threat driving harlequin toad declines is the lethal disease chytridiomycosis, caused by the amphibian chytrid fungus, *Batrachochytrium dendrobatidis*. Disease-induced declines may be further exacerbated by anthropogenic threats such as habitat loss and degradation, the effects of climate change, and the inherent risks of having very small distributions. As of 2021, approximately 40% of *Atelopus* species have disappeared from their known localities and have not been seen since the early 2000s despite efforts to find them. However, recent rediscoveries of *Atelopus* species in the wild, species that were previously thought to be lost, give us hope that there is still time to bring harlequin toads back from the brink of extinction.

Harlequin toads are particularly sensitive to habitat modification, environmental changes, and infectious diseases, potentially making them important sentinel species in the terrestrial and freshwater ecosystems where they occur. Their presence is an indicator of water quality and healthy ecosystems, and their demise might be an early warning to humans of critical environmental conditions. Ensuring that harlequin toads, and the areas where they live, are protected may help ensure that these ecosystems, which provide water to tens of millions of people in major cities across their distribution, remain intact and healthy in perpetuity.

Despite the dire threats harlequin toads face across their range, these animals are not well understood. Most *Atelopus* species and populations have been insufficiently studied and monitored, and their ability to recover from declines is poorly understood. Fortunately, some in-country *ex situ* conservation programs have been successful in maintaining and breeding threatened *Atelopus* species in captivity. However, to effectively advance the conservation of harlequin toads, coordinated actions in-country and across their entire distribution range are needed.

In response to the *Atelopus* crisis, people and organizations from different countries have joined forces to establish the **Atelopus Survival Initiative (ASI)** to prevent the extinction of harlequin toads and improve their conservation status. This collaborative range-wide effort unites and mobilizes a broad range of national and international stakeholders to implement substantial, long-term, range-wide conservation measures to prevent the extinction of this unique and highly threatened group of amphibians.

In November of 2019, 38 participants from 11 countries, including 7 where harlequin toads occur, representing conservation non-governmental organizations (NGOs), academic and research institutions, government institutions, civil society, and donor organizations worked together to determine the actions needed to ensure the survival and recovery of harlequin toads. This workshop resulted in the establishment of the ASI, and its founding members jointly identified and prioritized key strategic actions – reflected in the current document – necessary for saving the genus.

The Harlequin Toad (*Atelopus*) Conservation Action Plan (HarleCAP) proposes concrete strategies to address *Atelopus* conservation through the joint development of management strategies and conservation actions led, agreed, and implemented by all responsible parties whether inside or outside the natural range of harlequin toads.

The HarleCAP outlines range-wide conservation priorities and identifies needs at the local, national, regional, and international levels that should be implemented over the next 20 years (2021-2041) to achieve this vision statement:

"Harlequin toads, flagship amphibians and jewels of the Neotropics, are conserved through the collaborative participation of stakeholders that produce baseline knowledge, mitigate the threats that affect the genus, and promote the cultural and biological importance of Atelopus".

To achieve this vision by 2041, when we celebrate the 200th anniversary of the description of the genus *Atelopus*, the HarleCAP sets five goals:

1) Produce baseline knowledge,
2) Ensure viable populations in natural habitats,
3) Maintain and manage captive survival-assurance colonies,
4) Increase visibility of *Atelopus*, and
5) Create mechanisms for multi-stakeholder collaboration and participation.

This Action Plan stems from the concern expressed by stakeholders regarding the lack of coordination and poor communication to effectively develop collaborative participatory conservation efforts to bring *Atelopus* species back from the brink of extinction.

It highlights and promotes ways in which stakeholders can synchronize their efforts and exchange resources, knowledge, and capacities through regional coordination and inter- and multi- disciplinary approaches to conserve harlequin toads. Towards this target, the HarleCAP underscores the need to develop a set of range-wide actions to be implemented locally, taking into account the social, political, and cultural realities of each country.

Finally, the HarleCAP intends to be cost-effective, simple, dynamic, as well as embedded in a monitoring and evaluation framework that will keep priorities and strategies relevant, updating objectives and actions as threats and conservation successes evolve across the region.

ACKNOWLEDGMENTS

The development of the HarleCAP was generously supported by Re:wild (formerly Global Wildlife Conservation). Parque Explora hosted the regional workshop in Medellín, Colombia, which was funded by Re:wild, the Smithsonian Conservation Biology Institute and the Shared Earth Foundation, Philadelphia Zoo, the Zoological Society for the Conservation of Species and Populations (Zoologische Gesellschaft für Arten- und Populationsschutz, ZGAP), and the German Society for Herpetology and Herpetoculture (Deutsche Gesellschaft für Herpetologie und Terrarienkunde, DGHT), with the technical and advisory support of the IUCN SSC Amphibian Specialist Group (ASG), the Amphibian Ark (AArk) and the Amphibian Survival Alliance (ASA). Re:wild supported the graphic design of this document.

The HarleCAP would not have been possible without the active participation, input and feedback of the Atelopus Survival Initiative and its members that attended the workshop in Medellin, including the Atelopus Task Force and other contributing members (list on page 43), and without the invaluable contributions of so many individuals living and working in *Atelopus* range countries (government officials, community members, park rangers, policy makers, scientists among many more), who have contributed to the conservation of harlequin toads and their habitats for decades.

We thank the IUCN SSC Amphibian Specialist Group (ASG) chair Ariadne Angulo, the ASG Program Officer Sally Wren, the IUCN ASG Atelopus Task Force, and the Amphibian Ark, especially Anne Baker and Luis Carrillo, for their guidance and support during the development of this Plan. We also thank Barney Long, Kelsey Neam and Jennifer Luedtke from Re:wild, who have generously contributed with their experience reviewing sections of this Action Plan, and for helping mobilize support for it.

INTRODUCTION

Amphibian Extinction Crisis

Amphibians have become emblematic of the current mass extinction crisis (1–3). Over the past 20-40 years, amphibian populations have faced precipitous and alarming population declines and mass mortalities (4–11). Currently, of the 7,212 amphibian species evaluated by the International Union for Conservation of Nature (IUCN) – out of 8,372 described species (12) – an alarming 2,442 are globally threatened with extinction (13). Of the 2,330 species listed as Data Deficient (DD) or not evaluated by the IUCN, approximately 50% may be threatened (14). Altogether, estimates suggest that 41% of all amphibians are at elevated risk of extinction, which is an exceptionally high proportion in comparison to birds (14%) and mammals (26%) (13). At the top of the list is *Atelopus* (harlequin toads), one of the planet's most threatened genus of amphibians.

Harlequin Toads, The Jewels of The Neotropics

Atelopus is a species-rich genus (99 described species and approximately 29 to be described) with a wide distribution in the Neotropics. These amphibians are distributed throughout 11 countries in Central and South America, from Costa Rica to Bolivia, and eastward through the Amazon basin onto the eastern Guyana Shield (Fig. 1). In many countries, harlequin toads have been imbued with tremendous cultural value. For indigenous communities in Colombia's Sierra Nevada de Santa Marta, harlequin toads are considered the guardians of the water, symbols of fertility, and indicators of environmental conditions. In the Andean highlands of Ecuador, Kichwa people used harlequin toads, or 'jambatos', in their traditional folk medicine to cure warts, scabies and headaches. In Panama, the striking Panamanian Golden Frog has been considered a symbol of fortune since the pre-Columbian era. It is currently regarded as the national animal, found on lottery tickets, on artwork in markets, and celebrated once a year (August 14th) in a government-sanctioned holiday, "Dia de la Rana Dorada" (Golden Frog Day).

FIG 1. RANGE MAP

Harlequin toads occur from 0 to 4,800 meters above sea level (masl) in a diverse array of habitats, from tropical wet forests along the Pacific coast and the Amazon basin to the montane regions and paramos of the Andes. The majority of *Atelopus* species live along mid-to-high elevations above 1,500 masl, with a small number of species restricted to elevations above 3,000 masl, an environment commonly associated with amphibian declines (1, 15–18).

Harlequin toads are typically small to medium-bodied (20–60 mm), and many of them have bright and contrasting warning colors advertising potent skin toxins (19–22). They are typically diurnal and many of them occur in the vicinity of streams all year long, while others are found inside

the forest (15). All harlequin toads aggregate to breed along small streams, with males of several species displaying site fidelity and territoriality (4, 15, 23–28). The tadpoles are morphologically adapted to live in lotic conditions and develop a large abdominal suctorial organ (15, 29, 30).

Currently, the genus *Atelopus* is composed of 99 described species (Appendix, Fig. 2) and most of them have remarkably small geographic ranges, sometimes confined to one stream (15). At least 22 species are known from only one population within a narrow altitudinal range (9, 15, 31), while at least 38 are known from at maximum two populations (ASI, *unpubl*). Over the past 20 years, scientists have described 25 new *Atelopus* species and it is estimated that 29 species remain undescribed, potentially comprising a total of 128 species globally (ASI, *unpubl*). As fieldwork efforts and the examination of museum specimens and molecular genetics continues, scientists expect to discover additional species (e.g., 32–33). Paradoxically, as numerous species in this genus remain to be named and described to science, the entire genus may be nearing extinction.

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FIG 2. A SELECTION OF *ATELOPUS*

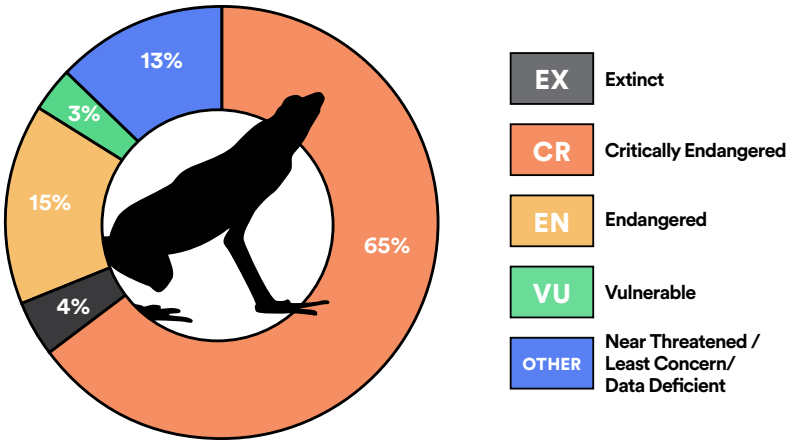

FIG 3. IUCN RED LIST CATEGORIES

A Genus in Critical Condition

Despite their biological, ecological, cultural importance, and intrinsic value, an alarming number of *Atelopus* species are at risk. Currently, 83% of the 94 species evaluated by the IUCN (13) are globally threatened with extinction, 73% are declining, and estimates suggest that up to 90% might be at elevated risk (Appendix, Fig. 3). Although only four *Atelopus* species are considered to be Extinct with some certainty, another 36 are suspected to be possibly extinct in the wild (13), and many populations are markedly reduced in number in the wild or survive only in captivity.

Most *Atelopus* species are microendemic and their very small populations within extremely restricted areas, often in montane ecosystems, coupled with their aquatic life-stages makes them particularly susceptible to a multitude of threats.

Previous research has confirmed the declines of various *Atelopus* species in Costa Rica (26), Panama (5, 34), Venezuela (35, 36), and Ecuador (27, 37, 38), including severe population declines in undisturbed and pristine

habitats. Comparatively less information has been reported on the status of populations in other countries (e.g., Colombia and Peru), where *Atelopus* species may be declining (39, 40). In other countries, such as Brazil and French Guiana, and in certain regions in Colombia, many populations seem comparatively well (13, 41, L.A. Rueda *pers comm*).

Systematic examinations of the genus have found that many *Atelopus* populations have disappeared from their known localities and have not been seen for two decades or more despite efforts to find them (9, 13). Taken together, the available evidence suggests that the genus *Atelopus* is in critical condition and that rapid and poorly explained declines may be driving the genus to extinction.

Threats

Harlequin toads are affected by a multitude of threats including infectious diseases, habitat loss and degradation, invasive species, illegal collection, pollution, and climate change (13). The HarleCAP focuses on what, collectively and regionally, we believe are the key threats that need to be mitigated in the next 20 years to ensure *Atelopus* conservation.

Chytridiomycosis

Chytridiomycosis is an infectious skin disease caused by the deadly amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) (42). Since its discovery in the 1990s, chytridiomycosis has been implicated in the mass die-offs, declines, and extinctions of hundreds of amphibian species (9, 17, 42–46, reviewed in 11). Field and laboratory studies, including the collection of harlequin toad carcasses during massive die-offs and analysis of museum specimens collected just before their disappearance, suggest that this fungal deadly pathogen is the proximate cause of several local extirpations or extinctions in the genus *Atelopus* (27, 36, 43, 44, 48–51, reviewed in 9, 11, 17). Although *Atelopus* declines due to chytridiomycosis have been confirmed for some species, most have not yet been examined for the presence of *Bd*. The lack of long-term systematic population surveys has hindered our ability to evaluate whether the evident population declines, and even extinctions of *Atelopus*, were suddenly caused by an epidemic disease such as chytridiomycosis, or whether declines were gradual and triggered by other synergistic factors. However, recent studies and survey efforts have provided evidence of limited recovery in some *Atelopus* species after populations have drastically declined due to chytridiomycosis, or evidence of *Atelopus* species coexisting with *Bd* (52–61).

To tackle the threats posed by *Bd*, one of the central actions of the HarleCAP is to develop and implement innovative methods to mitigate its devastating effects on *Atelopus* populations, and to understand the complex pathogen-host dynamics (climate and environmental) and the mechanisms of *Atelopus* resistance to the *Bd* fungus (e.g., the role of skin bacteria with anti-*Bd* activity or defensive skin secretions). Likewise, the HarleCAP outlines the need to implement long-term epidemiological and demographic surveillance programs in *Atelopus* populations, not only for *Bd* but also for other potential emerging infectious diseases such as ranavirus.

Habitat Loss and Degradation

Habitat loss, fragmentation, and degradation due to agriculture, livestock, logging, mining, and infrastructure development, as well as water pollution due to environmental contaminants resulting from illegal and legal activities, adversely affect *Atelopus* populations and their habitats (9, 13). Although there is expert consensus that a decline of habitat area and quality is detrimental to harlequin toad populations, empirical knowledge to uncover the extent of the impacts is lacking. Observed *Atelopus* declines in undisturbed and protected habitats indicate that additional causes might be involved in their demise (36, 37, 62).

In addition, the effects of environmental contamination on *Atelopus* declines are largely unknown (9), although contamination from gold mining is suspected in the population decline of *A. peruensis* in Peru (R. Schulte, *pers comm*) and *A. nahumae* in Colombia (L.A. Rueda, *pers comm*). Targeted research on the effects of contaminants and of habitat destruction on *Atelopus*, and most other Neotropical amphibian species, are needed. Given that the loss and degradation of habitat is a major driver of global amphibian declines and extinctions, one of the key actions of the

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HarleCAP is aimed at promoting the protection and restoration of native forests and watersheds across the distributional range of *Atelopus* through the implementation of community-based threat reduction strategies and the establishment of protected areas.

Rainbow Trout

In Venezuela, Ecuador and Colombia, various studies have associated the presence of the non-native rainbow trout (*Oncorhynchus* sp. and *Salmo* sp.) with *Atelopus* population declines (27, 63, 64). These invasive species threaten amphibians as they prey upon tadpoles, and potentially act as disease vectors (65). Although it is possible that the introduction of rainbow trout into waterways has caused localized reductions in *Atelopus* populations, it is unlikely that this is a leading factor in the widespread declines (66), as some *Atelopus* populations in Panama, Ecuador and Venezuela have coexisted with rainbow trout for various decades before noticeable declines occurred (9, 27). To address the potential adverse effects of non-native invasive species such as the rainbow trout on *Atelopus*, the HarleCAP underscores the need to implement research and site-based projects to understand how this threat interacts with other factors and to strengthen protection mechanisms through eradication strategies.

Lack of Knowledge and Efforts

Although several *Atelopus* species are colorful and charismatic, few species have been studied in detail, and most species' ecology, behavior, and current population status remains poorly known. Numerous species have not been seen in many years, many localities have not been visited recently, and some species are known only from decades-old collections. Most *Atelopus* projects to date have been research-focused, covering only a few sites and species, that have rarely translated into conservation efforts. Sound scientific evidence to assist species management and policy-making is critical for the success of an *Atelopus* conservation strategy. For this reason, one of the central strategies of the HarleCAP is the gathering, production and dissemination of relevant scientific evidence required to inform both *in situ* and *ex situ* management of *Atelopus*. This includes determining the current population status of *Atelopus* populations, especially the 'lost' species that have not been seen in decades, as well as implementing continued surveillance programs for remnant populations to better understand the cause(s) of past declines and the mechanisms needed to ensure their recovery.

Lack of Coordination and Collaboration

Effective conservation and management of *Atelopus* is limited by the lack of collaboration, coordination, and information exchange among different stakeholders about scientific research, management actions, and policies, hindering the learning of lessons and the spread of best practices. Adequate coordination and communication are critical to developing a synchronous holistic multi-disciplinary approach that will bring harlequin toads back from the brink of extinction. To this point, the HarleCAP proposes a strategy to bolster stakeholder coordination, engagement, and participation to increase the number of targeted action-driven projects, share funding opportunities, and build range-wide capacity necessary for the long-term conservation of *Atelopus*.

Invisibility

Across the Neotropics, *Atelopus* species are little known to the public and their conservation and biological importance is frequently overlooked. Although harlequin toads have cultural importance in some places, and are regarded as beautiful and charismatic animals, there is still limited awareness about the conservation status, uniqueness, and the importance of these amphibians. Moreover, there is limited involvement of local communities in conservation efforts, resulting in low levels of political support. Raising public awareness and increasing the involvement of local people in conservation efforts are key to ensuring a successful conservation strategy. Therefore, one of the central actions of the HarleCAP is to raise the profile of *Atelopus*, elevating them to a flagship genus through communication and education campaigns that raise awareness and pride in harlequin toads. Moreover, this Plan aims to spark government endorsement from all range countries that promote the conservation of *Atelopus* at the local and national levels.

Lack of Capacity

The future of many *Atelopus* species in the wild cannot be guaranteed at present as some threats are far too great and we lack a full understanding on how to abate them. One of the key strategies to ensure the survival of some *Atelopus* species is to 'buy time' through the establishment of captive assurance populations, with the aim of reproducing them for their reintroduction back to the wild. Therefore, a priority of the HarleCAP is to expand captive breeding programs to encompass all *Atelopus* range countries and all priority threatened species to ensure the persistence of harlequin toads in a cost-effective and secure way. This includes conducting and updating Conservation Needs Assessments for all *Atelopus* species to determine which are recommended for *ex situ* conservation as well as building the technical and scientific capacity to maintain sustainable captive populations across the region where harlequin toads are distributed. A community of practice that can share best practices and lessons learned from captive breeding and reintroduction programs for priority species of *Atelopus* could help to improve success and provide stability that these programs require over the long-term.

ACTION PLAN RATIONALE & GOALS

In the early 2000s, due to an initiative led by the 'Research and Analysis Network for Neotropical Amphibians' (RANA), a group of 75 scientists and conservationists working on *Atelopus* joined efforts to review the conservation status and threats to *Atelopus* species, and to present an overview of the main strategic actions needed to ensure their conservation. The resulting paper (9) provided clear evidence of the catastrophic, widespread declines and extinctions in *Atelopus* and, for the first time, highlighted the critical condition of harlequin toads. Later, it was suggested the need for a multidisciplinary approach to ensure the survival of harlequin toads (67). Despite these early efforts, and nearly 15 years later, the conservation status of *Atelopus* as a genus remains critical and it may be worsening.

Over the past few years, it has become clear that collaborative and coordinated range-wide and genus-wide conservation efforts, with the most effective actions, as outlined in this Action Plan, are urgently needed to save harlequin toads from extinction. The implementation of the HarleCAP will not only improve the conservation of harlequin toads and their watersheds and forests in the Neotropics, but will also protect a cultural symbol for many communities and cultures in the region.

The goal of the HarleCAP is to unite and mobilize local, national, regional, and international conservation groups, governments, academic institutions, zoos, local communities, and other interested organizations and individuals to implement substantial, long-term, range-wide conservation measures for this unique group of amphibians.

The Atelopus Survival Initiative envisioned and developed the HarleCAP as a collaborative and dynamic effort that will provide a range-wide road map for *Atelopus* conservation that can be adapted and implemented locally according to needs, opportunities, and circumstances. A coordinated effort that will be adapted and updated with information acquired from the monitoring of harlequin toad populations and habitats, and with the constant evaluation of the effectiveness of the conservation measures taken.

The HarleCAP was created following the IUCN Strategic Planning for Species Conservation Handbook (68), the Guidelines for Species Conservation Planning (69), following the IUCN One Plan Approach (70), and framed under the Amphibian Conservation Action Plan (71). It sets five specific, measurable, achievable, realistic, and time-bound (SMART) goals with associated objectives and actions – expressed in a vision shared by all stakeholders – to improve the range-wide conservation of *Atelopus* over the next 20 years (2021-2041).

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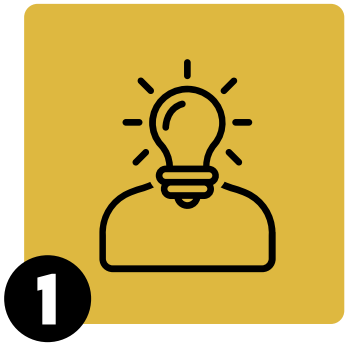
RANGE-WIDE CONSERVATION PRIORITIES

To prevent the genus-wide and local species extinctions, and improve the conservation of harlequin toads, the following range-wide goals and objectives must be implemented at both the species and site levels. Specific actions, timelines, and financial needs to achieve these goals within the time frame of the HarleCAP (2021-2041) are included in the next section and in the Appendix.



1 PRODUCE BASELINE KNOWLEDGE

Gather and produce key scientific information on the current population status, natural history, and threats to *Atelopus* populations to inform their conservation and management both *in situ* and *ex situ*.

2 ENSURE VIABLE POPULATIONS IN NATURAL HABITATS

Develop and implement innovative strategies and protocols to reduce the impacts of the main threats to *Atelopus* to ensure the viability of stable populations in their natural habitats.

3 MAINTAIN AND MANAGE CAPTIVE SURVIVAL-ASSURANCE COLONIES

Build technical and scientific capacity and share best practices across the countries of *Atelopus* distribution to implement assisted reproductive technologies and maintain sustainable captive populations of priority species, as well as implement reintroduction programs and post-release monitoring.

4 INCREASE VISIBILITY OF ATELOPUS

Raise public awareness about *Atelopus* and promote harlequin toads as the jewels of the forests, paramos and streams of the Neotropics, making it a flagship genus and an international, regional, and national symbol of prosperity, hope, and biodiversity.

5 CREATE MECHANISMS FOR MULTI-STAKEHOLDER COLLABORATION AND PARTICIPATION

Ensure the *Atelopus* conservation community has the technical, logistical, and financial support to secure the long-term conservation of harlequin toads through the collaboration and participation of key actors of the public and private sectors and the public.

GOAL 1

PRODUCE BASELINE KNOWLEDGE

Gather and produce key scientific information on the current population status, natural history, and threats to *Atelopus* populations to inform their conservation and management both *in situ* and *ex situ*.

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OBJECTIVES

1.1 Study the population status of species of *Atelopus*, especially those listed as Critically Endangered and Data Deficient on the IUCN Red List, as well as recently-described species.

1.2 Develop and implement an effective field search program for all 'lost' *Atelopus* species.

1.3 Promote the development of taxonomic studies of *Atelopus*.

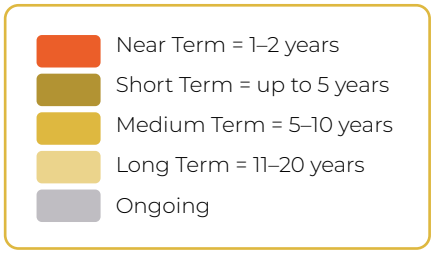
1.4 Identify the direct and indirect effects of threats on *Atelopus* population dynamics and conservation status.

1.5 Compile, generate, and disseminate all the key information on the current taxonomy, population status, natural history, threats, and conservation needs of *Atelopus* in order to inform and promote their conservation and management.

GOAL 1: PRODUCE BASELINE KNOWLEDGE

OBJECTIVE 1.1

Study the population status of species of *Atelopus*, especially those listed as Critically Endangered and Data Deficient on the IUCN Red List, as well as recently-described species



ACTIONS	ACTIVITIES	TIMELINE
1.1.1 Develop, implement, and strengthen long-term population monitoring programs (i.e. community or scientific) of prioritized *Atelopus* populations	1. Compile data on existing population monitoring programs in the region (e.g. who, where and what species)	Near Term
	2. Revise existing monitoring programs and identify similarities and differences between programs	Near Term
	3. Select and standardize population monitoring methods (i.e. that can be modified according to the needs and opportunities of each research team and/or protected areas' staff, and that can be adapted to each species of the genus) between the members of the *Atelopus* conservation network to ensure comparable and repeatable results	Near Term
	4. Involve government institutions (e.g. national park service) in monitoring efforts, offering training opportunities to park staff to implement monitoring programs	Short Term
	5. Develop and provide capacity building opportunities on population monitoring methods, protocol design, and data analyses for the members of the *Atelopus* conservation network and other involved parties	Short Term
	6. Implement long-term monitoring programs in prioritized *Atelopus* species	Ongoing
	7. Establish a granting mechanism to ensure long-term sustainability of monitoring programs	Ongoing

OBJECTIVE 1.2

Develop and implement an effective field search program for all 'lost' *Atelopus* species

ACTIONS	ACTIVITIES	TIMELINE
1.2.1 Compile and update information on the current conservation and population status, and search efforts for 'lost' *Atelopus* species	1. Compile geographic, ecological and last report data of 'lost' *Atelopus* species	Near Term
	2. Map historical locations and search efforts of 'lost' *Atelopus*, and when possible develop species distribution models	Near Term
1.2.2 Prioritize 'lost' *Atelopus* species to conduct search expeditions, according to previous efforts, opportunities, and needs	1. Identify potential areas to conduct search expeditions for 'lost' *Atelopus* based on previous search efforts and historical reports	Near Term
	2. Evaluate the social, economic, logistical and legal conditions (e.g. research permits) to carry out search expeditions in each of the potential localities of 'lost' *Atelopus*	Near Term
	3. Prioritize species and locations to carry out search expeditions according to social, economic, logistical, and legal conditions	Near Term
1.2.3 Develop, coordinate, and implement a search strategy for 'lost' *Atelopus* species (in both historical and new locations) to improve knowledge about their distribution, and population and conservation status	1. Create database of possible funding sources	Near Term
	2. Develop and submit project proposals with assigned leads, teams and necessary resources	Short Term
	3. Conduct search explorations	Ongoing
1.2.4 Implement and strengthen citizen science initiatives to find 'lost' *Atelopus* species and identify new localities or populations	1. Establish collaboration agreements with government entities (locally and nationally) for the implementation of citizen science and community-based participatory programs	Ongoing
	2. Develop and implement community participatory *Atelopus* education and research projects	Ongoing
	3. Implement community-based initiatives collaboratively between government entities and local communities to search for 'lost' *Atelopus* populations	Ongoing
	4. Promote the use of digital platforms (e.g. iNaturalist) by local communities and the general public to provide information on 'lost' *Atelopus* species	Ongoing

OBJECTIVE 1.3

Promote the development of taxonomic studies of *Atelopus*

ACTIONS	ACTIVITIES	TIMELINE
1.3.1 Prioritize *Atelopus* populations for delimitation of taxonomic units	1. Identify priority species and populations	Near Term
1.3.2 Collect tissue samples and swabs for genetic analyses	1. Identify bank tissues	Near Term
	2. Design and develop strategies to collect samples from museum voucher specimens	Near Term
	3. Evaluate research and export permit policies (tissue and DNA) in each country	Near Term
	4. Conduct field expeditions to collect samples	Short Term
1.3.3 Establish working groups to revise, describe, and publish new species descriptions		Short Term
1.3.4 Ensure funds and research opportunities for the development of *Atelopus* taxonomic studies		Ongoing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OBJECTIVE 1.4

Identify the direct and indirect effects of threats on *Atelopus* population dynamics and conservation status

ACTIONS	ACTIVITIES	TIMELINE
1.4.1 Identify, map, and quantify *Atelopus*' populations habitat loss, degradation, and fragmentation	1. Identify scale and scope of habitat loss, degradation, and fragmentation	Near Term
	2. Determine levels of habitat protection	Near Term
1.4.2 Model impact of future climatic events on *Atelopus* habitat	1. Identify climatic variables associated with *Atelopus* population decline or extinction	Near Term
	2. Develop models	Near Term
1.4.3 Identify scale and scope of impacts of water pollution on *Atelopus* populations		Medium Term
1.4.4 Identify the presence of invasive species in *Atelopus* habitats		Medium Term
1.4.5 Implement long-term epidemiological and demographic surveillance programs in *Atelopus* populations	1. Develop field protocols for mark-recapture studies to assess epidemiological parameters of *Bd* in wild populations	Near Term
	2. Develop analytical tools for the analysis of mark-recapture data	Near Term
	3. Develop rapid surveys protocols for monitoring changes in *Bd* prevalence	Near Term
	4. Develop mathematical models and analytical tools to identify parameter thresholds for triggering rapid responses	Near Term
	5. Develop and provide capacity building opportunities on population monitoring protocol design and data analyses	Short Term

OBJECTIVE 1.5

Compile, generate, and disseminate all the key information on the current taxonomy, population status, natural history, threats, and conservation needs of *Atelopus* in order to inform and promote their conservation and management

ACTIONS	ACTIVITIES	TIMELINE
1.5.1 Compile and update a database of the current state of knowledge of all *Atelopus* species	1. Compile data of each *Atelopus* species on current population and conservation status, threats to their survival, degree of habitat protection, and current efforts and needs for research and conservation	Near Term
1.5.2 Prioritize *Atelopus* species for conservation and research efforts according to their threats, needs, and available opportunities	1. Establish criteria for prioritization of *Atelopus* species requiring conservation and research actions	Near Term
	2. Apply prioritization criteria to all *Atelopus* species in each country of their distribution	Near Term
	3. Identify priority research and conservation actions to be implemented for each *Atelopus* species in each country	Near Term
1.5.3 Develop a virtual repository with updated information of presence/absence localities, search efforts, monitoring programs, threats, conservation status of *Atelopus* populations and habitats, and current conservation and research efforts and needs	1. Establish database format and send to key stakeholders	Near Term
	2. Create and ensure sustainability of an online platform to house database	Near Term
	3. Analyze data and generate reports	Near Term
1.5.4 Develop a decision-making tree and practical written guides of the actions (e.g. research, conservation or communication) needed in all possible *Atelopus* conservation scenarios (e.g. lost species, rediscovered species, species with population declines, stable populations, etc.)	1. Create and validate decision making tree among members of the *Atelopus* conservation network and partners	Near Term
	2. Create a communication mechanism to disseminate and train in the usage of decision making tree	Near Term
1.5.5 Identify needs and opportunities to transfer capacity and knowledge skills (e.g. technical, logistics, scientific) among members of the *Atelopus* conservation network and in countries where *Atelopus* is distributed	1. Survey to identify needs (capacity in place, access to information, experience, etc.) and establish a database of projects	Near Term
	2. Define needs and implement capacity building opportunities between members of the *Atelopus* conservation network	Ongoing

GOAL 2

ENSURE VIABLE POPULATIONS IN NATURAL HABITATS

Develop and implement innovative strategies and protocols to reduce the impacts of the main threats to *Atelopus* to ensure the viability of stable populations in their natural habitats.

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OBJECTIVES

2.1 Increase the quantity and quality of suitable habitats for the long-term conservation of viable and connected populations of *Atelopus*.

2.2 Conserve and restore priority and strategic habitat for populations of *Atelopus*.

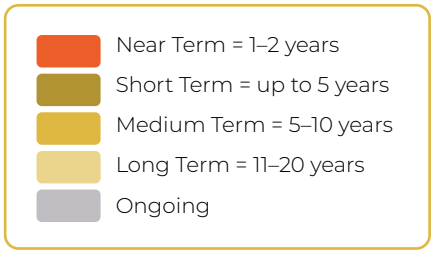
2.3 Develop and implement innovative methods to mitigate the effects of infectious diseases, particularly chytridiomycosis, on populations of *Atelopus*.

2.4 Evaluate how habitat modification and fragmentation affects *Bd*-host dynamics.

GOAL 2: ENSURE VIABLE POPULATIONS IN NATURAL HABITATS

OBJECTIVE 2.1

Increase the quantity and quality of suitable habitats for the long-term conservation of viable and connected populations of *Atelopus*



ACTIONS	ACTIVITIES	TIMELINE
2.1.1 Find and/or establish funding mechanisms to buy land and/or create protected areas for priority *Atelopus* species	1. Identify and prioritize important sites for the establishment of protected areas for *Atelopus* conservation	Near Term
	2. Collaborate with government authorities for the establishment of protected areas for *Atelopus* conservation	Ongoing
2.1.2 Identify and implement environmental incentives and/or environmental compensation mechanisms to reduce habitat loss and degradation, and promote *Atelopus* habitat conservation	1. Identify and prioritize *Atelopus* species and sites that require the implementation of habitat loss and degradation threat mitigation strategies	Near Term
	2. Develop written guidelines of the possible strategies (e.g. conservation agreements, ecotourism, live fences, certification schemes, payment for ecosystem services, water filtration systems, etc.) to mitigate threats to habitat loss and degradation	Near Term
	3. Identify and involve stakeholders (e.g. community members, local government and private institutions) in the conservation of *Atelopus* populations and their habitats	Ongoing
	4. Implement and monitor threat mitigation strategies locally and with the advice and guidance of national and regional coordinators	Ongoing
2.1.3 Implement strategies to promote habitat corridors for populations of *Atelopus* and assist the implementation of threat mitigation strategies	1. Implement strategies to improve habitat connectivity of habitats where *Atelopus* species are distributed	Ongoing
	2. Establish protected areas that will act as biological corridors for *Atelopus* species and strengthen management of existing ones	Ongoing

OBJECTIVE 2.2

Conserve and restore priority and strategic habitats for populations of *Atelopus*

ACTIONS	ACTIVITIES	TIMELINE
2.2.1 Promote the implementation of habitat restoration activities for *Atelopus* populations in priority areas with the collaboration of local communities	1. Identify and prioritize *Atelopus* species and sites in need of habitat restoration strategies	Near Term
	2. Design strategies to mitigate the effect of invasive species (e.g. rainbow trout) on *Atelopus* habitats	Near Term
	3. Identify and design potential strategies to restore habitat of priority *Atelopus* species	Short Term
	4. Implement plans to restore habitat of priority *Atelopus* species	Ongoing
	5. Implement strategies to mitigate effects of invasive species (e.g. rainbow trout) on *Atelopus* habitats	Ongoing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OBJECTIVE 2.3

Develop and implement innovative methods to mitigate the effects of infectious diseases, particularly chytridiomycosis, on populations of *Atelopus*

ACTIONS	ACTIVITIES	TIMELINE
2.3.1 Evaluate the effectiveness and feasibility of commercial fungicides in mitigating *Bd* in *Atelopus*	1. Compile a list of potential fungicides commercially available to be tested against *Bd*	Near Term
	2. Create a laboratory protocol and test for fungicides against *Bd*	Near Term
	3. Identify target fungicides currently used in agricultural practices	Short Term
	4 Design experiments to test the effect of identified fungicides on *Bd* and *Atelopus*	Medium Term
2.3.2 Identify native biological agents to control *Bd* in *Atelopus*	1. Compile list of microbes that inhibit *Bd* growing, emphasizing threatened species of *Atelopus*	Near Term
	2. Obtain microbial samples (swabs) from infected *Atelopus* and other endangered amphibians (*in situ* and *ex situ*)	Ongoing
	3. Test the inhibitory effects of microbes (bacteria and fungi) in vitro	Medium Term
	4. Test the inhibitory effects of microbes on *Bd* in vivo (*in situ* and *ex situ*)	Medium Term
2.3.3 Use genetic tools to understand the mechanisms of natural selection and develop artificial selection processes related to chytrid fungus resistance	1. Identify genes associated with survival in post *Bd* environments	Short Term
	2. Identify individuals with improved resistance or other traits (e.g. using mucusomes or exposure/ survival experiments)	Short Term
	3. Incorporate salvaging genes from “Lazarus” populations into *ex situ* populations using assisted reproduction tools	Medium Term

OBJECTIVE 2.4

Evaluate how habitat modification and fragmentation affects *Bd*-host dynamics

no set actions or timeline at publication

GOAL 3

MAINTAIN AND MANAGE CAPTIVE SURVIVAL-ASSURANCE COLONIES (CSC)

Build technical and scientific capacity and share best practices across the countries of *Atelopus* distribution to implement assisted reproductive technologies and maintain sustainable captive populations of priority species, as well as implement reintroduction programs and post-release monitoring.

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OBJECTIVES

3.1 Create and strengthen the technical and scientific capacity of *Atelopus* CSC programs in each country of the genus distribution.

3.2 Increase the infrastructure and capacity of *Atelopus* CSC programs in each range-country.

3.3 Implement genome resource banks to safeguard the germplasm and genetic material of *Atelopus* species in CSC programs in the region.

3.4 Promote the establishment of reintroduction, translocation, and post-release monitoring programs for *Atelopus*.

GOAL 3: CAPTIVE SURVIVAL-ASSURANCE COLONIES (CSC)

OBJECTIVE 3.1

Create and strengthen the technical and scientific capacity of *Atelopus* CSC programs in each country of the genus distribution

- Near Term = 1–2 years
- Short Term = up to 5 years
- Medium Term = 5–10 years
- Long Term = 11–20 years
- Ongoing

ACTIONS	ACTIVITIES	TIMELINE
3.1.1 Diagnose the current status of amphibian CSC programs housing *Atelopus* populations in the region	1. Assess CSC capacities and needs according to the priorities of each country (i.e. infrastructure, protocols, biobanks, studbooks, vivarium, reintroductions and results to date, etc.)	Near term
3.1.2 Identify and map amphibian CSC programs housing *Atelopus* populations outside the region	1. Assess capacity, results to date, and opportunities to transfer knowledge and expertise	Near term
3.1.3 Generate and disseminate a husbandry and maintenance protocol (i.e. temperature, water quality, UV radiation, number of individuals per terrarium, handling routines, humidity, biosecurity, diet/nutrition, etc.) for *Atelopus* populations in captivity that can be adjusted and adapted to each species of the genus	1. Compile existing protocols	Near term
	2. Create and adapt protocol to specific species	Near term
3.1.4 Generate and disseminate a protocol for natural and/or assisted reproduction (i.e. reproduction tanks, determination of the degree of gravity, sexual maturity, fertilization success, hormonal stimulation, artificial fertilization, artificial stimulation of reproductive behaviors) of *Atelopus* in captivity that can be adjusted and adapted to each species of the genus	1. Compile existing protocols and publications to asses the need of a unified protocol	Near term
	2. Create and adapt protocol	Near term
3.1.5 Establish a protocol for disease prevention, control, and management in captive breeding *Atelopus* populations	1. Tie with 3.1.1 and compile	Near term
	2. Compile existing protocols and publications to asses the need of a unified protocol	Near term
	3. Create and adapt protocol	Near term

OBJECTIVE 3.1 — CON'T

Create and strengthen the technical and scientific capacity of *Atelopus* CSC programs in each country of the genus distribution

ACTIONS	ACTIVITIES	TIMELINE
3.1.6 Create a shared repository of technical and scientific information about the *ex situ* management of captive breeding *Atelopus* populations	1. Compile data and create repository	Near term
3.1.7 Create and establish an inter-institutional network of veterinarians working with captive breeding populations of *Atelopus* that share expertise, experiences and lessons learnt at the regional level, and that can respond to the needs of the genus	1. Based on survey create WhatsApp group and list serv	Near term
3.1.8 Provide capacity and training opportunities for the management and captive breeding of *Atelopus* through the transfer of scientific and technological knowledge between captive and research centers	1. Based on survey results (3.1.1) identify capacity needs	Near term
	2. Fundraise for capacity building workshops	Short Term
	3. Conduct capacity building workshops	Ongoing
3.1.9 Characterize the genetic composition of *Atelopus* captive breeding populations to improve long-term population management projections		Ongoing

OBJECTIVE 3.2

Increase the infrastructure and capacity of *Atelopus* CSC programs in each country of the genus distribution

ACTIONS	ACTIVITIES	TIMELINE
3.2.1 Strengthen *Atelopus* CSC programs capacity (i.e. infrastructure, equipment and expertise) needed to improve *Atelopus ex situ* management in the region	1. Based on survey results (3.1.1) identify country and breeding center needs	Near term
	2. Devise capacity building strategy	Short Term
	3. Implement strategy	Ongoing
3.2.2 Establish new *Atelopus* CSC programs in the region according to the needs of each country and species	1. Identify CSCs that house other amphibian species and that have the capacity to house and breed *Atelopus*	Near term
	2. Link CSCs that currently don't have *Atelopus* in capacity building opportunities and other meetings and strategies led by the members of the *Atelopus* conservation network	Ongoing
3.2.3 Establish international cooperation mechanisms to facilitate the translocation between countries of *Atelopus* populations that urgently need *ex situ* conservation efforts and for which there is no in-country CSC programs or capacity	1. Research national policies and in country needs and opportunities	Near term
	2. Identify cooperation strategies at the national level and asses feasibility	Near term

OBJECTIVE 3.3

Implement genome resource banks to safeguard the germplasm and genetic material of *Atelopus* species in CSC programs in the region

ACTIONS	ACTIVITIES	TIMELINE
3.3.1. Provide capacity building training and workshops	1. Based on survey (3.1.1) identify training/workshops content	Near term
	2. Design workshop content	Near term
	3. Implement workshops	Medium Term
3.3.2 Equip *Atelopus* CSC programs with the necessary equipment for the establishment and sustainability of gene banks for *Atelopus*	1. Based on survey (3.1.1) identify needs	Near term
	2. Devise strategy	Near term
	3. Implement strategy	Medium Term
3.3.3 Generate and standardize protocols for the preservation of germplasm and genetic material of *Atelopus* species	1. Select CPAs, balance and cytotoxicity, freezing and thawing based on cell quality	Near term
	2. Create protocol	Near term

OBJECTIVE 3.4

Promote the establishment of reintroduction, translocation, and post-release monitoring programs for *Atelopus*

ACTIONS	ACTIVITIES	TIMELINE
3.4.1 Train and share experiences between CSCs in amphibian translocation and reintroduction techniques	1. Gather baseline information on programs to translocate and reintroduce amphibians	Near term
	2. Develop and implement capacity training opportunities (workshops and webinars) around amphibian reintroduction and translocation efforts	Ongoing
3.4.2 Implement reintroduction programs for priority species of *Atelopus* that have the appropriate number of animals in captivity, when their habitat is conserved and environmental parameters identified, and the risks of emerging diseases mitigated to ensure the best successes and results	1. Generate an updated inventory of individuals and bloodlines present in CSCs	Near term
	2. Offer training for the implementation of Assisted Reproductive Programs for the production of offspring aimed to be reintroduced	Near term
	3. Generate a list of possible reintroduction sites for each species	Short Term
	4. Guide the planning and implementation of reintroduction trials to evaluate preliminary results	Medium Term
	5. Implement a bigger scale reintroduction program based on the results obtained during trials	Medium Term

GOAL 4

INCREASE VISIBILITY OF *ATELOPUS*

Raise public awareness about *Atelopus* and promote harlequin toads as the jewels of the forests, paramos and streams of the Neotropics, making it a flagship genus and an international, regional, and national symbol of prosperity, hope, and biodiversity.

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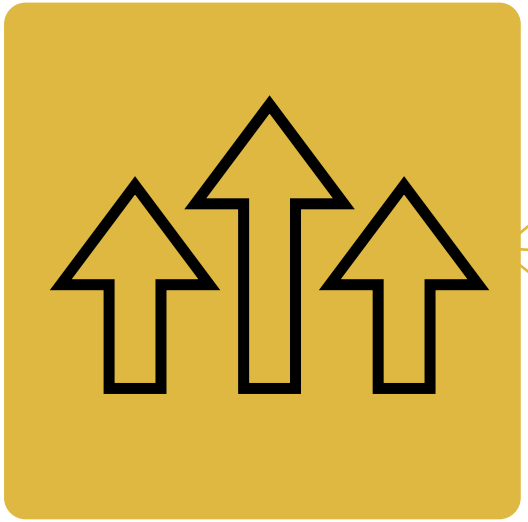


OBJECTIVES

4.1 Generate a change of perceptions and attitudes towards *Atelopus* at local, regional, national and international levels.

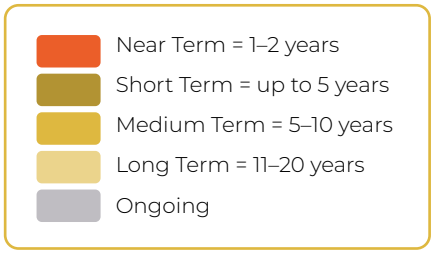
4.2 Identify and recover the biological and cultural importance of *Atelopus* in local communities.

4.3 Disseminate the messages, stories and successes of the *Atelopus* conservation network.

GOAL 4: INCREASE VISIBILITY OF ATELOPUS

OBJECTIVE 4.1

Generate a change of perceptions and attitudes at local, regional, national, and international levels towards *Atelopus*



ACTIONS	ACTIVITIES	TIMELINE
4.1.1 Identify communication and educational needs and capacities among the members of the *Atelopus* conservation network and countries where *Atelopus* are distributed	1. Create survey to identify communication and educational capacities and needs	Near Term
4.1.2 Develop a mechanism to share stories internally among the members of the *Atelopus* conservation network to help promote collaboration	1. Determine format (newsletter), timing and process for getting stories	Near Term
4.1.3 Create an open access digital archive of communication and marketing assets that can be used to share, learn, and disseminate the successes achieved by the members of the *Atelopus* conservation network		Near Term
4.1.4 Develop an *Atelopus* communication strategy at regional and international levels based on the identification of priority campaigns, key messages, and specific audiences	1. Based on 4.1 draft strategy	Near Term
4.1.5 Implement an *Atelopus* communication strategy at regional and international levels based on the identification of priority campaigns, key messages, and specific audiences		Ongoing

OBJECTIVE 4.2

Identify and recover the biological and cultural importance of *Atelopus* in local communities

ACTIONS	ACTIVITIES	TIMELINE
4.2.1. Develop and implement environmental and educational programs about *Atelopus* to different target audiences based on conservation needs and audiences at the local level	1. Understand and evaluate local community's practices, knowledge and perspectives (e.g. cosmovisions) towards *Atelopus* conservation	Near Term
	2. Develop an educational curriculum around *Atelopus* conservation targeted to local schools and implemented by trained local teachers as part of a higher education diploma	Short Term
	3. Implement educational programs in local schools to raise awareness of the conservation and importance of *Atelopus*	Ongoing
4.2.2. Develop education and communication assets, and outreach and awareness building materials around *Atelopus*, their critical state of conservation and biological and conservation importance, that can be adapted locally and regionally	1. Develop audiovisual assets around *Atelopus* conservation targeted to local communities	Short Term
	2. Design and implement a communication campaign to recover and strengthen traditional local knowledge about *Atelopus* and practices associated with *Atelopus* conservation	Ongoing
	3. Develop a magazine about local and community based strategies for *Atelopus* conservation	Short Term
	4. Develop audiovisual assets for the development of educational curriculum around environmental education of *Atelopus* conservation	Short Term
4.2.3. Develop community participatory initiatives (research and communication) around *Atelopus* conservation	1. Identify *Atelopus* species that have the potential to be recognized by local communities as biological indicators in community-based initiatives around natural resources conservation	Near Term
	2. Develop and implement initiative	Ongoing
4.2.4. Strengthen capacities of members of the *Atelopus* network and partners in the development of community participatory education and research initiatives around *Atelopus* and their habitats conservation	1. Prioritize sites, communities and conservation partners that have the potential to develop community-based education projects to recover traditional biocultural knowledge and memory of *Atelopus*	Near Term
	2. Develop educational workshops to train members of the *Atelopus* conservation community and partners in strategies to develop community based education and research initiatives	Short Term
	3. Establish a network of research institutions, local communities and national entities to plan and implement community based research and education initiatives for the protection of *Atelopus* species	Short Term

OBJECTIVE 4.3

Disseminate the messages, stories and successes of the *Atelopus* conservation network

ACTIONS	ACTIVITIES	TIMELINE
4.3.1 Develop and implement an annual editorial calendar based on the communications strategy for the Atelopus Survival Initiative.	1. Create communications strategy	Near Term
	2. Prepare and implement yearly editorial calendar	Ongoing
4.3.2. Launch the Atelopus Survival Initiative stating its vision, mission and goals, which will be officially presented to the public	1. Define audiences and platforms	Near Term
4.3.4 Develop the I Symposium of the Atelopus Survival Initiative to show progress of the Initiative and next steps		Near Term

GOAL 5

CREATE MECHANISMS FOR MULTI-STAKEHOLDER COLLABORATION AND PARTICIPATION

Ensure the *Atelopus* conservation community has the technical, logistical, and financial support to secure the long-term conservation of harlequin toads through the collaboration and participation of key actors of the public and private sectors and the public.

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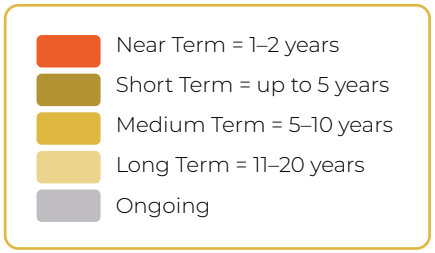
OBJECTIVES

5.1 Raise the profile of harlequin toads at international, regional and national levels including governments, funding bodies and other key stakeholders.

5.2 Ensure the financial sustainability of on-the ground *Atelopus* conservation programs to secure the long-term implementation of the actions proposed for their conservation.

5.3 Ensure the financial sustainability of *Atelopus* captive survival-assurance colonies programs in range-wide countries.

GOAL 5: MULTI-STAKEHOLDER COLLABORATION AND PARTICIPATION



OBJECTIVE 5.1

Raise the profile of harlequin toads at international, regional and national levels including governments, funding bodies and other key stakeholders

ACTIONS	ACTIVITIES	TIMELINE
5.1.1 Present the Harlequin toad (*Atelopus*) Conservation Plan (HarleCAP) to the Ministries of the Environment of each of the countries of the *Atelopus* distribution		Near Term
5.1.2 Formally declare the Atelopus Survival Initiative in national government agencies to facilitate the implementation of the strategic actions proposed by the Initiative		Near Term
5.1.3 Promote the creation of *Atelopus* Conservation Plans in the countries of the region that do not yet have one		Short Term
5.1.4 Identify key social and political actors at local, national, and regional levels (private companies, government entities) and formalize the incorporation of the activities proposed in the HarleCAP by the appropriate stakeholders in their work agendas		Medium Term
5.1.5 Present the Atelopus Survival Initiative and the HarleCAP in international forums to garner support from multilateral organizations, and to foster collaboration between governments and institutions.		Ongoing

OBJECTIVE 5.2

Ensure the financial sustainability of on-the ground *Atelopus* conservation programs to secure the long-term implementation of the actions proposed for their conservation

ACTIONS	ACTIVITIES	TIMELINE
5.2.1 Develop and implement a fundraising strategy for the implementation of the Harlequin toad (*Atelopus*) Conservation Plan (HarleCAP)	1. Create a repository of funds available locally and nationally (through governments), as well as internationally (zoos, foundations and grants) for the conservation of amphibians and biodiversity	Near Term
	2. Identify skills, opportunities, and relationships of the members of the *Atelopus* conservation network and present to donors, foundations, and grant making mechanisms	Near Term
	3. Create a portfolio of priority actions, projects and needs of the *Atelopus* conservation network to be used as a fundraising tool	Near Term
	4. Compile a list of funding opportunities to name new *Atelopus* species or name centers or laboratories for research and *ex situ* conservation	Near Term
	5. Find funding sources (e.g. Rainforest Trust) for the creation of protected areas (land acquisition) for *Atelopus* species	Near Term
	6. Develop and implement a marketing and communication strategy around *Atelopus* (e.g. Jewels of the Neotropics and *Bd*) that promotes fundraising	Near Term
	7. Apply for grant opportunities that will ensure the implementation of the different stages of the HarleCAP	Ongoing
5.2.2. Develop and implement a strategy of cooperation and collaboration between members of the *Atelopus* conservation network and national and international zoos to raise and use funds together		Ongoing
5.2.3 Use the Atelopus Survival Initiative as a platform to access and manage funds for the implementation of actions for the conservation of *Atelopus* species		Ongoing

OBJECTIVE 5.3

Ensure the financial sustainability of *Atelopus* captive survival-assurance colonies (CSC) programs in the region

ACTIONS	ACTIVITIES	TIMELINE
5.3.1 Develop inter-institutional commitments to guarantee the financial sustainability of *Atelopus* CSC programs in the region		Near Term
5.3.2 Develop a financial strategy to obtain funds to increase the capacity and basic equipment necessary to maintain sustainable *Atelopus* CSC in the region		Near Term
5.3.3 Develop self-management strategies for *Atelopus* CSC programs in the region.		Near Term
5.3.4 Incorporate and strengthen educational and sustainable strategies on issues related to species conservation in *Atelopus* CSC in the region.		Short Term
5.3.5 Develop a strategy to obtain the financing and equipment necessary for the establishment and sustainability of genomic banks for *Atelopus*		Short Term

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CONTRIBUTORS

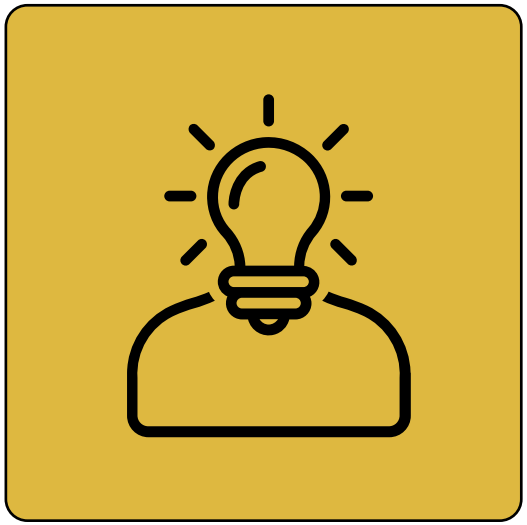
Alejandro Ramírez, Parque Explora
Alessandro Catenazzi, Florida International University, CORBIDI
Alexander Shepack, Florida International University, University of Notre Dame
Andrea Coloma-Santos, Proyecto “Conservación de Anfibios y Recursos Genéticos (PARG)
Andrea Terán Valdez, Centro Jambatu de Investigación y Conservación de Anfibios
Andrés Jimenez, Universidad de Costa Rica
Andrés Viuche Lozano, Universidad del Tolima
Carlos Andrés Galvis Rizo, Fundación Zoológica de Cali
Carlos Martínez Rivera, Philadelphia Zoo
Carolina Lambertini, Universidade Estadual de Campinas
Christopher Jordan, Re:wild
Corinne L. Richards-Zawacki, University of Pittsburgh
Diego Gómez Hoyos, ProCAT Costa Rica
Edgardo J. Griffith, El Valle Amphibian Conservation Center Foundation
Enrique La Marca, REVA Conservation Center
Ernesto Arbeláez Ortiz, Zoológico Cuenca Bioparque Amaru
Francisco Nava, Instituto Venezolano de Investigaciones Científicas
German Forero, WCS Colombia
Gilbert Alvarado Barboza, Universidad de Costa Rica
Gustavo A. González Duran, WCS Colombia
Gustavo Adolfo Pisso Flórez, Parque Nacional Natural Puracé
Jaime Culebras, Photo Wildlife Tours
José Daniel Barros, Fundación Atelopus
Juan Carlos Chaparro, Museo de Biodiversidad del Perú
Kelsey Neam, Re:wild, IUCN SSC Amphibian Specialist Group’s Amphibian Red List Authority
Lindsay Renick Mayer, Re:wild
Luis Alberto Rueda Solano, Universidad del Magdalena
Luis Carillo, Amphibian Ark
Roberto Ibáñez, Smithsonian Tropical Research Institute
Santiago Ron, Pontificia Universidad Católica del Ecuador
Vicky Poole, Forth Worth Zoo
Víctor Jassmani Vargas García, Asociación Pro Fauna Silvestre - Ayacucho, IUCN SSC Amphibian Specialist Group for Perú, Asociación Herpetológica del Perú
Victoria Flechas, IUCN SSC Amphibian Specialist Group for Colombia
Yuri Beraún Baca, Ministerio del Ambiente (MINAM) Perú

APPENDIX

SUMMARY FINANCIAL NEEDS

The table below presents the estimated indicative budget for the next 5 years of the scale of funding required to directly improve the conservation status of *Atelopus*. These budgets do not include estimates for the long-term, recurrent, or intangible recommended actions at the habitat level (e.g protected area establishment), which are difficult to estimate, and would likely exceed US$ 60 million in the next 20 years.

GOAL 1.
PRODUCE BASELINE KNOWLEDGE



Objective	Estimated budget (USD)
1.1 Identify the population status of species of *Atelopus*, especially of those species listed as Critically Endangered and Data Deficient, as well as species recently described	$100,000
1.2 Develop and implement an effective field search program for all 'lost' *Atelopus* species	$150,000
1.3 Promote the development of taxonomic studies of *Atelopus*	$ 50,000
1.4 Identify the direct and indirect effects of threats on *Atelopus* population dynamics and conservation status	$ 100,000
1.5 Compile, generate, and make available all the key information on the current taxonomy, population status, natural history, threats and conservation needs of *Atelopus* in order to inform and promote their conservation and management	$ 20,000
Total	**$ 420,000**

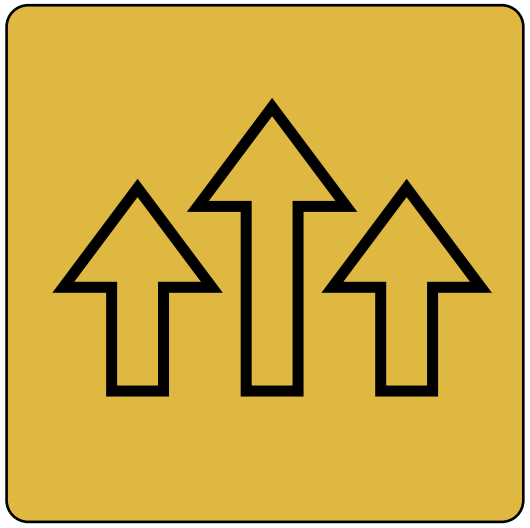
GOAL 2.
VIABLE POPULATIONS
IN NATURAL HABITATS

Objective	Estimated budget (USD)
2.2 Conserve and restore priority and strategic habitats for populations of *Atelopus* through the removal of invasive species	$ 30,000
2.3 Develop and implement innovative methods to mitigate the effects of infectious diseases, especially the chytrid fungus (*Bd*), in *Atelopus*	$ 100,000
2.4 Evaluate how habitat modification and fragmentation affects *Bd*-host dynamics	$ 100,000
Total	**$ 230,000**

GOAL 3.
CAPTIVE SURVIVAL-ASSURANCE
COLONIES (CSC)

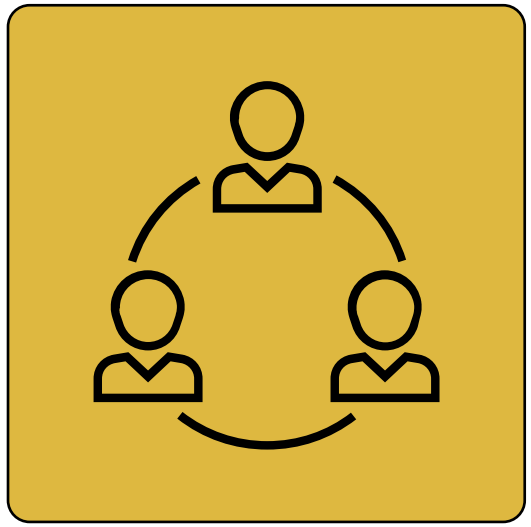
Objective	Estimated budget (USD)
3.1 Create and strengthen the technical and scientific capacity of *Atelopus* CSC programs in each country of the genus distribution	$ 50,000
3.2 Increase the infrastructure and capacity of *Atelopus* CSC programs in each country of the genus distribution	$ 200,000
3.3 Implement genome resource banks to safeguard the germplasm and genetic material of *Atelopus* species in CSC programs in the region	$ 200,000
3.4 Promote the establishment of reintroduction, translocation and post-release monitoring programs for *Atelopus*	$ 200,000
Total	**$ 650,000**

GOAL 4.
INCREASE VISIBILITY OF ATELOPUS



Objective	Estimated budget (USD)
4.1 Generate a change of perceptions and attitudes at local, regional, national and international levels towards *Atelopus*	$ 100,000
4.2 Identify and recover the biological and cultural importance of *Atelopus* in local communities	$ 50,000
4.3 Disseminate the messages, stories and successes of the *Atelopus* conservation network	$ 50,000
Total	**$ 200,000**

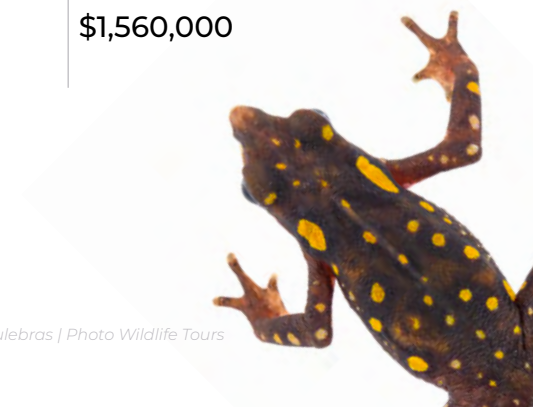
GOAL 5.
MULTI-STAKEHOLDER COLLABORATION AND PARTICIPATION



Objective	Estimated budget (USD)
5.1 Raise the profile of harlequin toads at international, regional and national levels including governments, funding bodies and other key stakeholders	$ 20,000
5.2. Ensure the financial sustainability of on-the ground *Atelopus* conservation programs to secure the long-term implementation of the actions proposed for their conservation	$ 20,000
5.3 Ensure the financial sustainability of *Atelopus* captive survival-assurance colonies (CSC) programs in the region	$ 20,000
Total	**$ 60,000**

FINAL ESTIMATED FINANCIAL NEEDS FOR THE NEXT 5 YEARS

GOAL	Estimated budget (USD)
1. Produce baseline knowledge	$ 420,000
2. Viable populations in natural habitats	$ 230,000
3. Captive survival-assurance colonies	$ 650,000
4. Increase visibility of *Atelopus*	$ 200,000
5. Multi-stakeholder collaboration and participation	$ 60,000
Total	**$1,560,000**



APPENDIX

SPECIES LIST

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus andinus Rivero, 1968	PR	EN (2018)	?
Atelopus angelito Ardila-Robayo and Ruiz-Carranza, 1998	CO	CR (PE) (2019)	↓ (2000)
Atelopus ardila Coloma, Duellman, Almendáriz, Ron, Terán-Valdez, and Guayasamin, 2010	CO	CR (PE) (2017)	↓ (1989)
Atelopus arsyecue Rueda-Almonacid, 1994	CO	CR (2017)	↓
Atelopus arthuri Peters, 1973	EC	CR (2004)	↓
Atelopus balios Peters, 1973	EC	CR (2018)	↓ (2010)
Atelopus barbotini Lescure, 1981	FG	NE	
Atelopus bomolochos Peters, 1973	EC	CR (2019)	↓ (2002)
Atelopus boulengeri Peracca, 1904	EC	CR (2004)	↓
Atelopus carauta Ruiz-Carranza and Hernández-Camacho, 1978	CO	DD (2017)	↓
Atelopus carbonerensis Rivero, 1974	VE	CR (PE) (2020)	↓ (1998)
Atelopus carrikeri Ruthven, 1916	CO	EN (2017)	↓

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus certus Barbour, 1923	PA	CR (2019)	↓
Atelopus chiriquiensis Shreve, 1936	CS (EX), PA	EX (2020)	(1996)
Atelopus chirripoensis Savage and Bolaños, 2009	CS	DD (2020)	?
Atelopus chocoensis Lötters, 1992	CO	CR (PE) (2017)	↓ (1998)
Atelopus chrysocorallus La Marca, 1996	VE	CR (2020)	↓
Atelopus coynei Miyata, 1980	EC	CR (2004)	↓
Atelopus cruciger (Lichtenstein and Martens, 1856)	VE	CR (2020)	↔
Atelopus dimorphus Lötters, 2003	PR	DD (2019)	↓ (1980)
Atelopus ebenoides Rivero, 1963	CO	CR (PE) (2017)	↓ (2005)
Atelopus elegans (Boulenger, 1882)	CO, EC	EN (2019)	↓
Atelopus epikeisthos Lötters, Schulte, and Duellman, 2005	PR	EN (2018)	↓
Atelopus erythropus Boulenger, 1903	PR	CR (PE) (2018)	↓ (2004)
Atelopus eusebianus Rivero and Granados-Díaz, 1993	CO	CR (PE) (2021)	↓ (2005)

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus eusebiodiazi Venegas, Catenazzi, Siu-Ting, and Carrillo, 2008	PR	CR (PE) (2018)	↓ (1997)
Atelopus exiguus (Boettger, 1892)	EC	EN (2018)	↓
Atelopus famelicus Rivero and Morales, 1995	CO	CR (2017)	↓
Atelopus farci Lynch, 1993	CO	CR (PE) (2017)	↓ (2003)
Atelopus flavescens Duméril and Bibron, 1841	FG	VU (2004)	↔
Atelopus franciscus Lescure, 1974	FG	LC (2019)	↔
Atelopus fronterizo Veselý and Batista, 2021	PA	NE	
Atelopus galactogaster Rivero and Serna, 1993	CO	DD (2017)	?
Atelopus gigas Coloma, Duellman, Almendáriz, Ron, Terán-Valdez, and Guayasamin, 2010	CO	CR (PE) (2017)	? (1970)
Atelopus glyphus Dunn, 1931	CO, PA	CR (2019)	↓
Atelopus guanujo Coloma, 2002	EC	CR (PE) (2018)	↓ (1988)
Atelopus guitarraensis Osorno-Muñoz, Ardila-Robayo, and Ruiz-Carranza, 2001	CO	DD (2017)	?

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus halihelos Peters, 1973	EC	CR (PE) (2018)	↓ (1989)
Atelopus hoogmoedi Lescure, 1974	GU, FG, SU, BR	NE	
Atelopus ignescens (Cornalia, 1849)	EC	CR (2018)	↓ (1988)
Atelopus laetissimus Ruiz-Carranza, Ardila-Robayo, and Hernández-Camacho, 1994	CO	EN (2014)	↔
Atelopus limosus Ibáñez, Jaramillo, and Solís, 1995	PA	CR (2019)	↓
Atelopus loettersi De la Riva, Castroviejo-Fisher, Chaparro, Boistel, and Padial, 2011	PR	NT (2020)	↓
Atelopus longibrachius Rivero, 1963	CO	EN (2017)	↓
Atelopus longirostris Cope, 1868	EC	EX (2004)	(1989)
Atelopus lozanoi Osorno-Muñoz, Ardila-Robayo, and Ruiz-Carranza, 2001	CO	EN (2017)	↓
Atelopus lynchi Cannatella, 1981	EC	CR (PE) (2018)	↓ (1984)
Atelopus manauensis Jorge, Ferrão, and Lima, 2020	BR	NE	

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus mandingues Osorno-Muñoz, Ardila-Robayo, and Ruiz-Carranza, 2001	CO	DD (2017)	?
Atelopus marinkellei Cochran and Goin, 1970	CO	EN (2017)	↓
Atelopus mindoensis Peters, 1973	EC	CR (PE) (2018)	↓ (1989)
Atelopus minutulus Ruiz-Carranza, Hernández-Camacho, and Ardila-Robayo, 1988	CO	CR (PE) (2017)	↓ (1985)
Atelopus mittermeieri Acosta-Galvis, Rueda-Almonacid, Velásquez-Álvarez, Sánchez-Pacheco, and Peña-Prieto, 2006	CO	EN (2017)	↓
Atelopus monohernandezii Ardila-Robayo, Osorno-Muñoz, and Ruiz-Carranza, 2002	CO	CR (PE) (2021)	↓ (1982)
Atelopus moropukaqumir Herrera-Alva, Díaz, Castillo, Rodolfo, and Catenazzi, 2020	PR	NE	
Atelopus mucubajiensis Rivero, 1974	VE	CR (2020)	↓
Atelopus muisca Rueda-Almonacid and Hoyos, 1992	CO	CR (2020)	↓

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus nahumae Ruiz-Carranza, Ardila-Robayo, and Hernández-Camacho, 1994	CO	EN (2014)	?
Atelopus nanay Coloma, 2002	EC	CR (2018)	↓ (1990)
Atelopus nepiozomus Peters, 1973	EC	EN (2018)	?
Atelopus nicefori Rivero, 1963	CO	CR (PE) (2017)	↓
Atelopus nocturnus Bravo-Valencia and Rivera-Correa, 2011	CO	CR (2017)	?
Atelopus onorei Coloma, Lötters, Duellman, and Miranda-Leiva, 2007	EC	CR (PE) (2018)	↓ (1990)
Atelopus orcesi Coloma, Duellman, Almendáriz, Ron, Terán-Valdez, and Guayasamin, 2010	EC	CR (PE) (2018)	↓ (1988)
Atelopus oxapampae Lehr, Lötters, and Lundberg, 2008	PR	EN (2018)	↓
Atelopus oxyrhynchus Boulenger, 1903	VE	CR (PE) (2020)	↓ (1994)
Atelopus pachydermus (Schmidt, 1857)	EC, PR	CR (PE) (2019)	↓ (1995)
Atelopus palmatus Andersson, 1945	EC	CR (2018)	↓

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus pastuso Coloma, Duellman, Almendáriz, Ron, Terán-Valdez, and Guayasamin, 2010	CO, EC	CR (PE) (2018)	? (1993)
Atelopus patazensis Venegas, Catenazzi, Siu-Ting, and Carrillo, 2008	PR	CR (2013)	↓
Atelopus pedimarmoratus Rivero, 1963	CO	CR (PE) (2021)	↓ (1963)
Atelopus peruensis Gray and Cannatella, 1985	PR	CR (PE) (2018)	↓ (1998)
Atelopus petersi Coloma, Lötters, Duellman, and Miranda-Leiva, 2007	EC	CR (PE) (2008)	↓ (1996)
Atelopus petriruizi Ardila-Robayo, 1999	CO	CR (PE) (2017)	↓ (1998)
Atelopus pictiventris Kattan, 1986	CO	CR (PE) (2021)	↓ (1996)
Atelopus pinangoi Rivero, 1982	VE	CR (PE) (2020)	↓ (2008)
Atelopus planispina Jiménez de la Espada, 1875	EC	CR (PE) (2018)	↓ (1985)
Atelopus podocarpus Coloma, Duellman, Almendáriz, Ron, Terán-Valdez, and Guayasamin, 2010	EC, PR	CR (PE) (2018)	↓ (1994)
Atelopus pulcher (Boulenger, 1882)	PR	VU (2018)	↓

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus pyrodactylus Venegas and Barrio, 2006	PR	CR (2019)	↓
Atelopus quimbaya Ruiz-Carranza and Osorno-Muñoz, 1994	CO	CR (PE) (2017)	? (1997)
Atelopus reticulatus Lötters, Haas, Schick, and Böhme, 2002	PR	DD (2019)	↓
Atelopus sanjosei Rivero and Serna, 1989	CO	CR (2019)	↓
Atelopus seminiferus Cope, 1874	PR	EN (2018)	?
Atelopus senex Taylor, 1952	CS	EX (2020)	(1986)
Atelopus sernai Ruiz-Carranza and Osorno-Muñoz, 1994	CO	CR (PE) (2017)	↓ (2001)
Atelopus simulatus Ruiz-Carranza and Osorno-Muñoz, 1994	CO	CR (PE) (2015)	? (2003)
Atelopus siranus Lötters and Henzl, 2000	PR	DD (2017)	?
Atelopus sonsonensis Vélez-Rodriguez and Ruiz-Carranza, 1997	CO	CR (PE) (2017)	? (1996)
Atelopus sorianoi La Marca, 1983	VE	CR (PE) (2020)	↓ (1990)
Atelopus spumarius Cope, 1871	BR, CO, EC, FG, GU, PR, SU	VU (2010)	↓

Species [1]	Countries [2, 3]	IUCN Red List Category (Year Assessed) [3]	Population Status (Year Last Seen) [3]
Atelopus spurrelli Boulenger, 1914	CO	NT (2017)	↔
Atelopus subornatus Werner, 1899	CO	CR (PE) (2017)	↓ (1993)
Atelopus tamaense La Marca, García-Pérez, and Renjifo, 1990	CO, VE	CR (2020)	↓
Atelopus tricolor Boulenger, 1902	PR, BO	CR (2020)	↓
Atelopus varius (Lichtenstein and Martens, 1856)	CS, PA	CR (2020)	?
Atelopus vogli Müller, 1934	VE	EX (2020)	(1957)
Atelopus walkeri Rivero, 1963	CO	DD (2017)	↓
Atelopus zeteki Dunn, 1933	PA	CR (PEW) (2019)	↓ (2009)

[1] Frost, Darrel R. 2021. Amphibian Species of the World: an Online Reference. Version 6.1 (2 August 2021). Electronic Database accessible at https://amphibiansoftheworld.amnh.org/index.php. American Museum of Natural History, New York, USA. doi.org/10.5531/db.vz.0001;

[2] BO=Bolivia, BR=Brazil, CO=Colombia, CS=Costa Rica, EC=Ecuador, FG=French Guiana, GU=Guyana, PA=Panama, PR=Peru, SU=Suriname, VE=Venezuela;

[3] IUCN 2021. The IUCN Red List of Threatened Species. Version 2021-1. https://www.iucnredlist.org. Downloaded on 2 August 2021. CR=Critically Endangered, EN=Endangered, VU=Vulnerable, EX=Extinct, NT=Near Threatened, LC=Least Concern, DD=Data Deficient, NE=Not Evaluated, PE=Possibly Extinct, PEW=Possibly Extinct in the Wild, ↓=Decreasing, ↔=Stable, ?=Unknown