An action plan for amphibians of the Hoang Lien Range 2017-2021

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Cover image; Sterling's toothed frog, known only from the high elevations of Mount Fansipan.

Executive summary

Sterling's toothed frog, known only from the high elevations of Mount Fansipan

The amphibians of Indochina are both poorly known and highly threatened. Facing amongst the highest deforestation rate on the planet, and over-harvesting pressure, Southeast Asian amphibians are being driven towards an extinction crisis. One of the biggest obstacles facing amphibian conservation in the region is our lack of knowledge of amphibians. As such, it is vital that surveys and taxonomic research along with population monitoring continues so that the true patterns of diversity can be revealed and population declines detected. There is an urgent need to prioritise both species and habitats that require protection. One of the most important areas in the region for amphibian diversity and endemism is the Hoang Lien Range, home to more the 80 species of amphibian, some of which are restricted to very small areas and are the most threatened amphibian species in mainland Southeast Asia.

The higher elevations of Hoang Lien National Park are important sites for biodiversity, and are the only known location for mainland Southeast Asia's only confirmed Critically Endangered amphibians, Sterling's Toothed Toad, *Oreolalax sterlingae* and Botsford's Leaf-litter Frog, *Leptolalax botsfordi*. Both species became known to science recently, being scientifically described in only 2013. The habitat of both species is threatened by human activities, particularly tourism. Fortunately, as the impacts of tourism can be minimised, many of the associated threats facing the species are potentially reversible.

Priority actions identified to ensure the long term conservation of amphibians in the Hoang Lien Range are (1) the strict protection of key breeding sites including access restriction so that habitats can recover and pollution of the streams minimised; (2) priority amphibian species receive full and active protection by the Vietnamese government and that amphibians are considered when future developments in these upland areas are designed and implemented; (3) long-term population monitoring of the priority amphibian species; (4) Comprehensive inventories of the amphibian diversity of the Hoang Lien Range so that areas and species in need of conservation attention are identified; (5) the development of a Communication, Education and Public Awareness programme (CEPA) aimed at encouraging behavioural changes that benefit biodiversity.

This action plan will involve international collaboration and a long term commitment from all partners and could be used as a model for other taxonomic groups and areas within the region.

Horned toad metamorph measuring less than 1cm long

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Acronyms and abbreviations

The Giant fire-bellied toad reveals it's striking belly patter to scare off predators

AM	Australian Museum
AZE	Alliance for Zero Extinction
HLNP	Hoang Lien National Park
Bd	*Batrachochytrium dendrobatidis*, the causative agent of chytridiomycosis
CEPA	Communication, Education and Public Awareness programme
CR	Critically Endangered (IUCN threat classification)
CRCO	Centre for Rescue and Conservation of Organism
DD	Data Deficient (IUCN threat classification)
EDGE	Evolutionary Distinct and Globally Endangered
En	Endangered (IUCN threat classification)
IUCN	International Union for Conservation of Nature
LC	Least Concern (IUCN threat classification)
NA	Not Assessed by the IUCN
Nt	Near Threatened (IUCN threat classification)
PA	Protected area
PVA	Population viability analysis
Vu	Vulnerable (IUCN threat classification)
ZSL	Zoological Society of London

Foreword; Nguyen Quang Vinh, Director of Hoang Lien National Park

Hoàng Liên Sơn là dãy núi cao nhất Việt Nam, có vị trí vô cùng đặc biệt đối với đa dạng sinh học của Việt Nam đồng thời là mái nhà của hàng triệu dân cư sinh sống trong vùng Tây bắc. Điển hình của dãy núi này là 3 khu bảo tồn kề cận đang được đề cử thành một khu Dự trữ sinh quyển thế giới: VQG Hoàng Liên, Khu bảo tồn thiên nhiên Bát Xát và Khu bảo tồn thiên nhiên Hoàng Liên Văn Bàn, có đỉnh cao nhất Đông Dương, Fansipan 3.143m.

Động vật Lưỡng cư có cuộc sống gắn kết với thực vật và chúng được coi là vật chỉ thị của biến đổi khí hậu và đa dạng sinh học, chúng càng có ý nghĩa hơn ở các vùng núi cao, lạnh ở Việt Nam và trên thế giới. Tuy nhiên, hiểu biết của chúng ta về động vật Lưỡng cư còn giới hạn và đặc biệt hơn đối với dãy Hoàng Liên Sơn thì nhiều loài liên tục được phát hiện, điều đó cho thấy những giá trị tiềm ẩn về chúng cần được tập trung nghiên cứu toàn diện và bảo tồn bền vững. Một kế hoạch bài bản cho công tác bảo tồn động vật Lưỡng cư với sự tham dự của nhiều nhà khoa học trên thế giới, tập trung cho dãy Hoàng Liên Sơn cho giai đoạn tới là thật sự cần thiết, nó sẽ tạo ra một hành động chiến lược nhằm kiểm kê toàn diện Lưỡng cư, đánh giá tình trạng của chúng, tạo cơ hội để cộng đồng tham dự với mục tiêu xây dựng và duy trì ổn định hệ sinh thái núi cao thông qua việc bảo tồn các các loài Lưỡng cư trên dãy Hoàng Liên Sơn.

Hoang Lien Range is Vietnam's highest mountain range and includes the highest peak in Indochina, Fansipan at 3,143m. The range is extremely important as it supports a wealth of biodiversity. It is also the roof for the millions of people living in the northwest of Vietnam. Within the range, there are three adjacent protected areas; Hoang Lien National Park, Bat Xat Protected Area and Hoang Lien Van Ban Protected Area. These reserves are proposed as a single biosphere reserve.

Amphibians often have a biphasic life cycle and are associated with both the terrestrial and aquatic ecosystems. Amphibians are regarded as indicators of climate change and ecosystem health. However, our knowledge of the amphibian fauna is limited and more research is needed, particularly within the Hoang Lien Range where new and highly threatened species are still being discovered. The amphibians of the Hoang Lien Range should therefore be the focus of comprehensive research and sustainable conservation.

The plan for the conservation of amphibians in the Hoang Lien Range includes the participation of an international group of scientists; it outlines and prioritises strategic aims for amphibian research and conservation, inclusive of a comprehensive inventory and evaluation of conservation status. The action plan also provides opportunities for the community to engage with the goal of preserving the montane ecosystem under the umbrella of amphibian conservation in the Hoang Lien Range.

Forest at 2,200 m asl; Hoang Lien National Park

Foreword; Dr Helen Meredith

I am writing in support of "An Action Plan for Amphibians of the Hoang Lien Range, 2017-2021".

The Amphibian Survival Alliance works in collaboration with the IUCN Amphibian Specialist Group (ASG) to support the development of Conservation Action Plans for amphibians around the world. Conservation Action Plans lay essential foundations for cooperative and well-managed conservation programmes. They outline a carefully formulated strategy linked to appropriate indicators, permitting ongoing evaluation of agreed activities. Action Plans are a crucial step towards securing the future of the species and habitats they seek to safeguard.

This Action Plan collates pragmatic strategic directions for the protection of a rich centre of amphibian diversity and endemism in Vietnam, and is deserving of great support from the international conservation community. In the midst of extremely high rates of regional deforestation, over-exploitation and destructive tourism practices, the amphibians of the Hoang Lien Mountain Range require urgent attention to increase essential knowledge of their current situation, including ongoing monitoring to better understand their plight. Among the key species that will benefit from direct conservation activities are Vietnam's only confirmed Critically Endangered amphibians, Sterling's Toothed Toad (*Oreolalax sterlingae*) and Botsford's Leaf-litter Frog (*Leptolalax botsfordi*). The direct protection of these species and their breeding sites is crucial to secure a more positive future, and gathering general information about amphibian communities in this area will help to detect and mitigate further declines for a variety of species. Furthermore, a communication, education and public awareness strategy will help to spread information about the value of amphibians in Vietnam. Involvement of local communities will build capacity and interest in conservation among local people, helping to generate support for future actions. The development of *ex situ* conservation capacity at a local institution will also expand the potential of local agencies to protect threatened species in Vietnam.

An international team of amphibian conservation experts has been assembled to develop and implement these actions. Their long-term commitment and collaborative approach will surely deliver the Action Plan's stated objectives. This is among the first Conservation Action Plans for mainland Southeast Asian amphibians, and can provide a template for refining conservation activities for different taxonomic groups across the region.

ASA lends it sincere support to this endeavour, and will encourage regular liaison with the ASG's Species Conservation Strategies Working Group of the global Amphibian Conservation Action Plan to provide the best guidance for this initiative going forward. We wish the project collaborators every success in continuing to refine and deliver their objectives.

Yours faithfully,

HRMeredith

Dr Helen Meredith

Executive Director - Amphibian Survival Alliance

The foot of the giant fire-bellied toad is as vividly coloured as the underside

Contents

An undescribed species of horned toad from Mount Fansipan

Introduction

Ophryophryne **species; a species so poorly known it doesn't yet have a common name**

Amphibians are disproportionately threatened; no other group of vertebrates that has been comprehensively assessed is currently faced with a higher level of endangerment and over 42 % of all described amphibian species are currently threatened with extinction (IUCN, 2016). Modern day amphibian declines have been precipitous, global, and sometimes enigmatic. Many amphibian faunas remain poorly known and as a result, the threat status for amphibians in some regions may therefore be underestimated (Iskandar and Erdelen 2006; Foufopoulos and Richards 2007; Rowley et al., 2010). The diverse drivers of global amphibian population declines are often synergistic, predominantly anthropogenic and linked to uncontrolled human population growth (Gascon et al. 2007). While threats such as over-exploitation, habitat degradation, pollution and invasive species can potentially be reduced or even reversed, many others, such as climate change and infectious diseases (see review in Woodhams et al., 2011), are not currently reversible (Smith and Sutherland 2014).

The amphibians of Indochina in particular are poorly-known and highly threatened. Amphibians in the region face some of the highest deforestation rates on the planet and high harvesting pressures, and as a result there is a call for long term population monitoring alongside continued taxonomic research (Rowley et al., 2009). There is also a pressing need for the identification and strict protection of habitat assessed as having high amphibian species diversity and/or representing distinctive regional amphibian faunas (Rowley et al., 2009). One such area is the Hoang Lien Range.

Within the Hoang Lien Range, Hoang Lien National Park is recognised as an important site for biodiversity, however, it is threatened by forest fire, hunting, the exploitation of forest products, slash and burn agriculture and inappropriate livestock grazing (Reserve, 2002). The reasons behind these threats include low socioeconomic status and associated low education level in some of the communities in HLNP and surrounding area as well as inefficient farming methods (Reserve, 2002). Insufficient planning for ecotourism development is also a threat to the national park, particular at higher elevations where the countries only Critically Endangered amphibians are known to occur.

Why protect amphibians?

Horned toad tadpoles have specialised mouth-parts for feeding at the surface of the water

It is important that amphibian are conserved as they provide important ecosystem services. The loss of one or more species can reduce the quality of the services within an ecosystem as amphibians play a critical role in nutrient cycling and energy flow in both aquatic and terrestrial ecosystems (Collins & Crump, 2009). The removal of amphibians from, or reduction in numbers of amphibians in, a system can have dire consequences. For example, the over collection of frogs for the meat trade resulted in an increase in agricultural pests in India (Altherr et al., 2011). Amphibians also have an economic value; they are used for food, medicines, research and are increasingly popular as pets (Collins & Crump, 2009; Tapley et al., 2011).

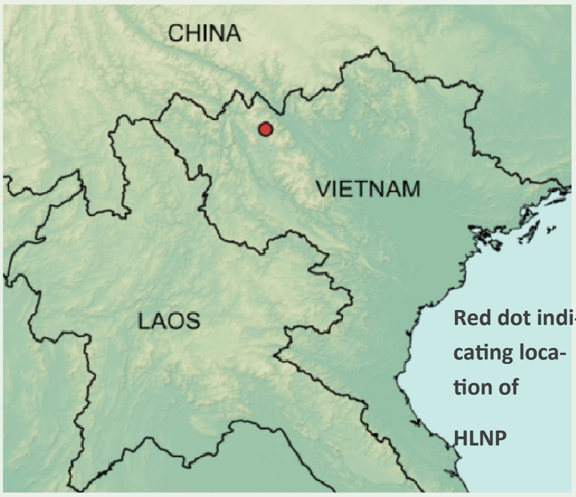
Sung's leaf-litter frog

Location


View from 2,500 m, Hoang Lien National Park

Location

The Hoang Lien Range in northern Vietnam is continuous with the Hoang Lien "Shan" in China. The Hoang Lien Range comprise probably the last remnants of native forest of the northern Vietnamese highlands (Hoang et al., 2014). Hoang Lien National Park (HLNP) covers 285.09 km^2 (IUCN and UNEP-WCMC, 2016) includes Mount Fansipan; the highest point in Indochina (Cambodia, Laos and Vietnam), at 3,143 m. HLNP was one of the first areas designated as a 'special use forest' in Vietnam (Hoang et al., 2014) and was designated as a national park in July 2002 (Hoang et al., 2014). The vegetation on Mount Fansipan between 1,800 to 2,200 m consists of tropical evergreen forest with vegetation dominated by Fagaceae, Styracaceae, Lauraceae, Theaceae, Illicium, Theaceae and Araliaceae (Vietnam, 2007). 2,200 to 2, 900 m consists of elfin-Moss forest with vegetation dominated by Ericaceae, Rhodoleiaceae, Theaceae, Aquifoliaceae, Lauraceae and Araliaceae (Vietnam, 2007). Trees reach 10 -15 m in height with low branches that support mosses and lichens particularly around the root base (Vietnam, 2007). Temperatures range -3–20 ºC (Average 15 ºC), and frosts are frequent in the coldest months (Nguyen & Harder 1996). There are no dry months, and each year 3,500 mm of rain falls on the mountain and there are typically 2-3 days of snow (Nguyen & Harder 1996; Nguyen et al., 2000). Fog is common and evaporation rates low (Nguyen 1998). The park lies at the junction of the Indomalayan and Palaearctic biogeographic realms within the Indo-Burma biodiversity hotspot (Myers et al., 2000) and supports a diverse amphibian fauna (Ohler et al, 2000) which includes two newly described Critically Endangered endemic megophryid frogs which have only been recorded from near the summit area of Mount Fansipan (Fig. 1a; Fig. 1b); *Oreolalax sterlingae* (Nguyen et al., 2013; IUCN, 2015a) and *Leptolalax botsfordi* (Rowley et al., 2013; IUCN, 2015b). Mount Fansipan has been identified as a priority site by the Alliance for Zero Extinction (AZE, 2016) due to the presence of highly threatened amphibians.



Red dot indicating location of HLNP


Sapa town is renowned for its cultural diversity

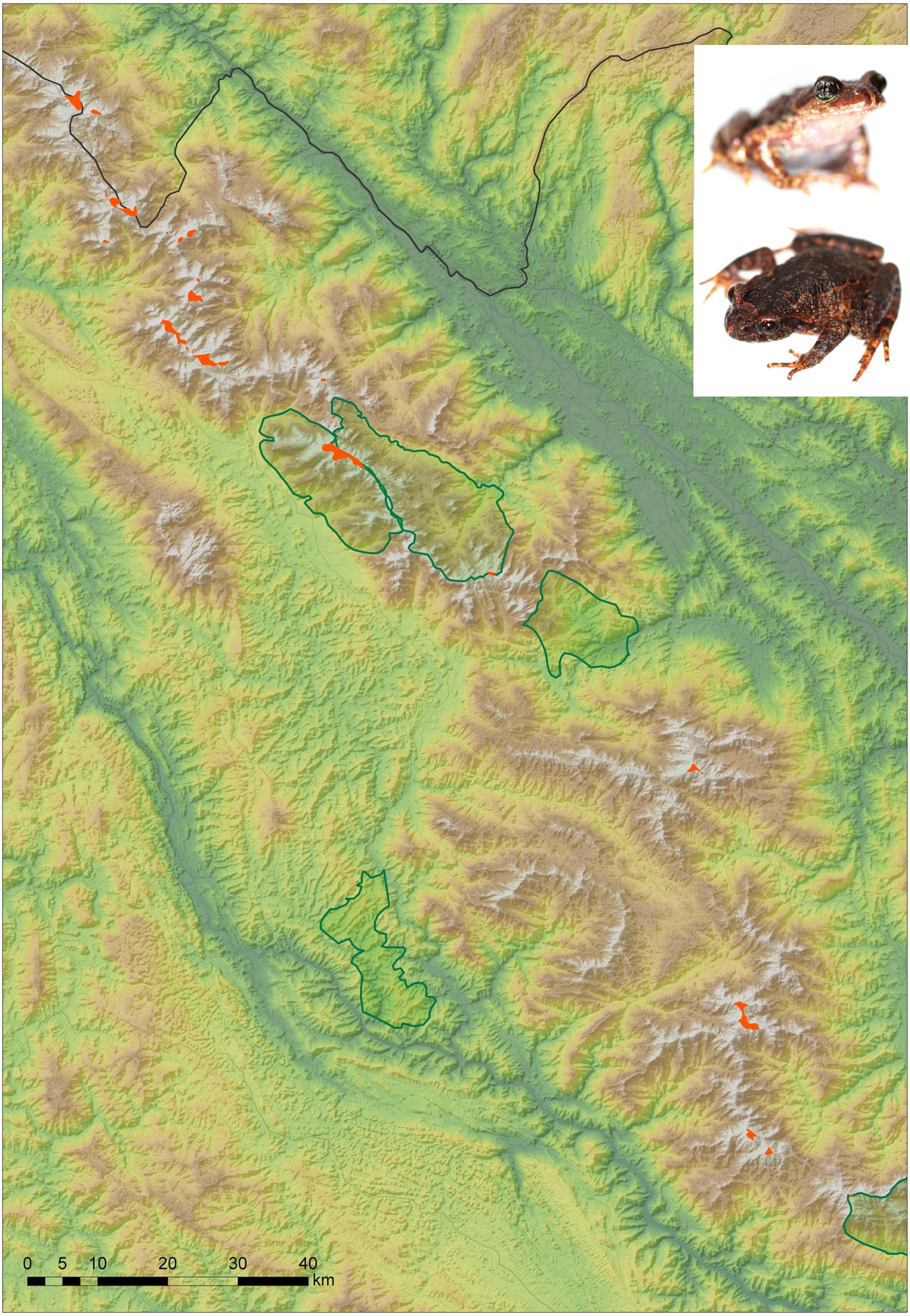
HLNP and the nearby town of Sapa are an increasingly popular tourist destination; the area has a rich cultural heritage, rugged topography and is marketed as "the roof of Indochina" (Hai et al., 2008; Hoang et al., 2014). Tourism can negatively impact ecosystems and balancing the needs of biodiversity conservation and economic development are crucial if both wildlife and people are to coexist.

Focal species

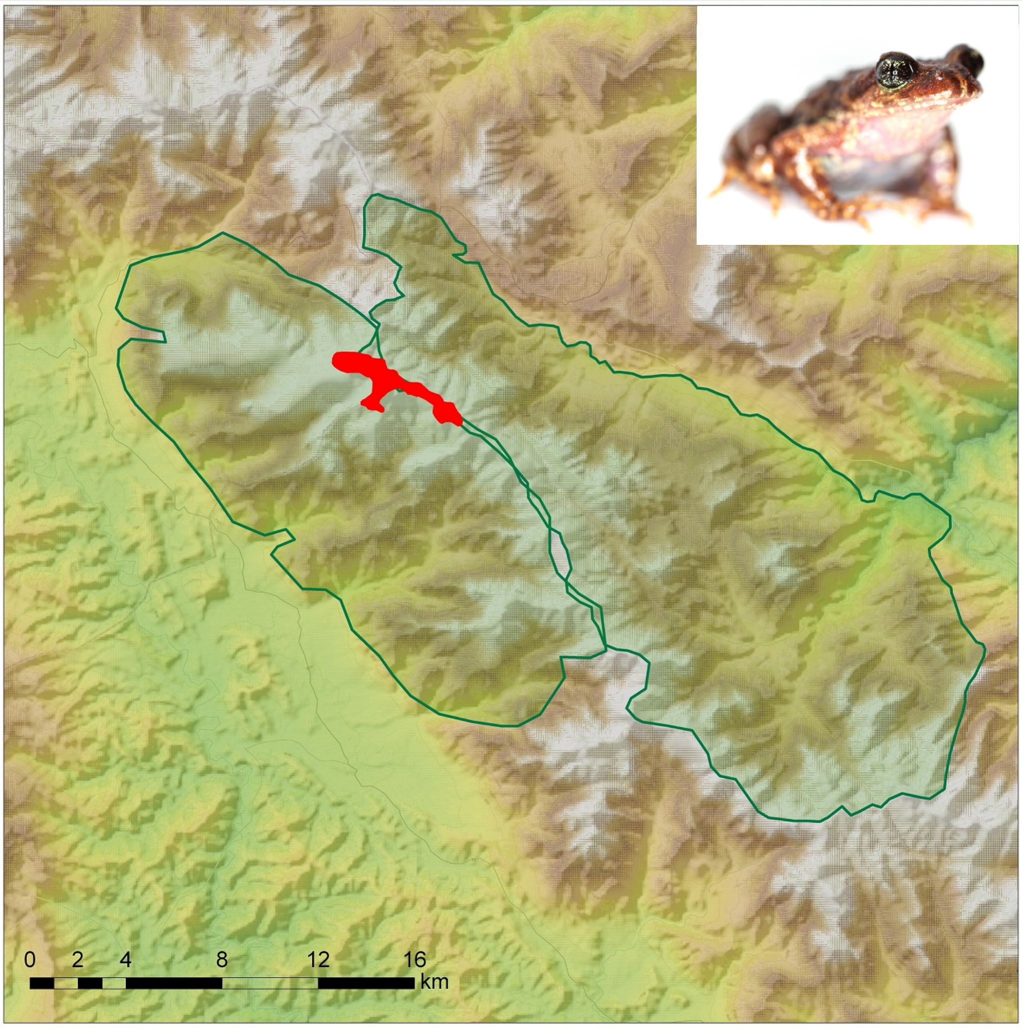
Figure 1A top left; *O. sterlingae.* Figure 1B; top right *O. sterlingae* tadpole. Figure 1C bottom left; *L. botsfordi*. Figure 1D bottom right; *L. botsfordi*.

Sterling's Toothed Frog, *Oreolalax sterlingae,* is the only representative of its genus that has been reported from Vietnam (Nguyen et al., 2013). A medium-sized frog (~4cm body size) that has only been reported from bamboo forest associated with rocky rivulets and rocky streams (Nguyen et al., 2013; IUCN, 2015a) and elfin moss forest (pers. obs). The tadpole of the species has been encountered and a formal scientific description is in preparation (Rowley et al., 2017). Its vocalisation has not been described. At present, the species is only known from a single stream at ~2,800 m asl up to near the summit at >3,000 m asl on Mount Fansipan and is thought to be extremely geographically restricted, with an extent of occurrence (EOO) of only 8 km^2 (Fig. 1D), representing a single threat-defined location (IUCN, 2015a). It is possible that the range of the species may include some of the few small, isolated areas above 2,700 m asl in other parts of the Hoang Lien Range. However, such areas are >20 km away and separated by elevations under 1,000 asl, making the species' dispersal to these parts unlikely.

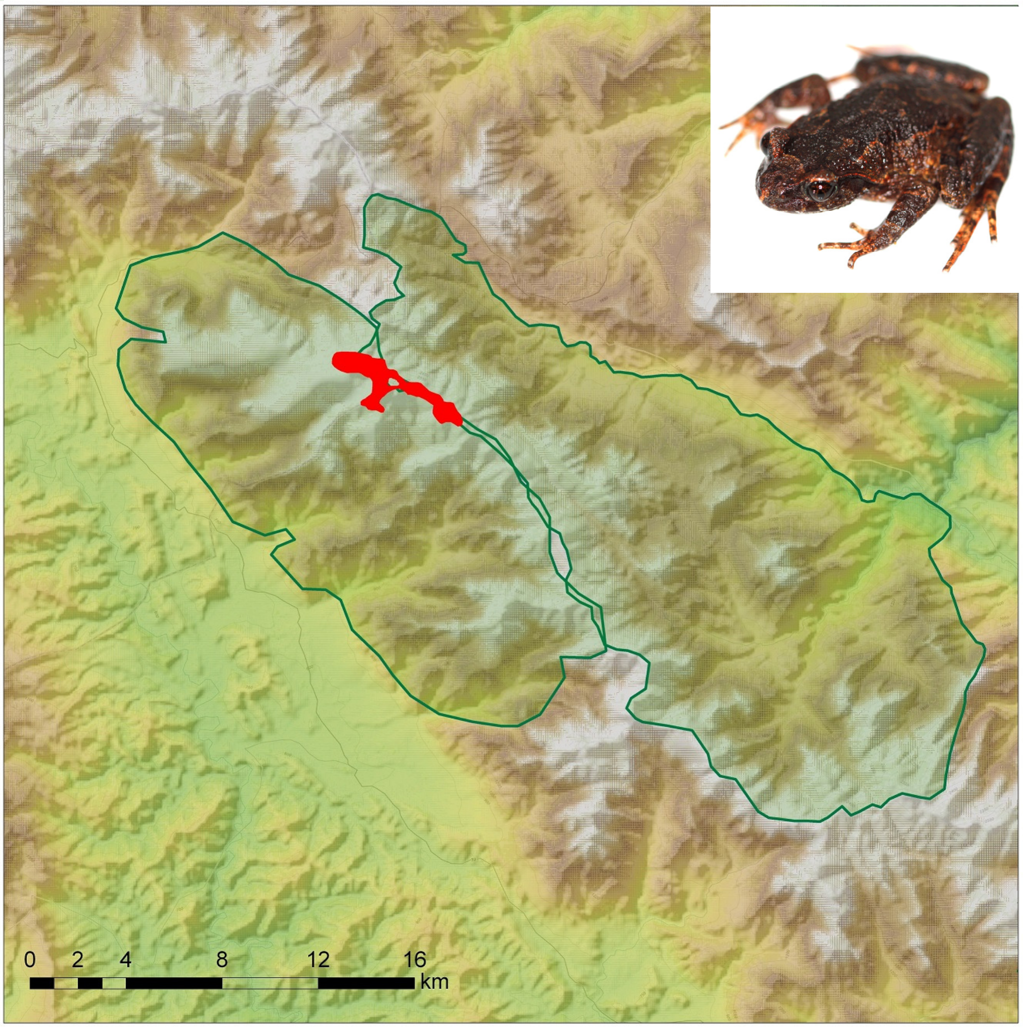
Botsford's leaf-litter frog, *Leptolalax botsfordi* is a medium sized *Leptolalax* 29.1–32.6 mm in adult males, 30.0–31.8 mm in females (Rowley et al, 2013). It has only been reported from upper montane forest between 2,795–2,815 m elevation on Mount Fansipan, higher elevations than any other species in the genus (Rowley et al., 2013). The tadpole of this species has not been described; the larva may be fossorial as the larva of some of its congeners are fossorial and often associated with gravel beds (Ohler et al., 2011). The actual distribution of *L. botsfordi* is unknown but to date it has only been reported from a single stream between 2,795-2,815 m asl on Mount Fansipan. Rowley et al., (2013) estimated that its range may include some of the few small, isolated areas above 2,700 m asl in adjacent parts of the Hoang Lien Mountain Range. However, any such area is about 20 km or more away and separated by elevations under 1,000 asl, making the species' dispersal to these parts unlikely. Therefore, the species' extent of occurrence (EOO) is 8 km^2 (Fig. 1D), representing only one threat-defined location, and is thus very restricted geographically (IUCN, 2015b). *L. botsfordi* is considered a global priority for conservation based on its evolutionary distinctiveness and global endangerment (Isaac et al., 2012).



Sites above 2, 700 m asl in the Hoang Lien Range where *Oreolalax sterlinage* and *Leptolax botsfordi* could potentially occur (orange polygons). These areas are >20 km away and separated by elevations under 1,000 m asl, making the species' dispersal to these parts unlikely.



Predicted range of *Oreolalax sterlingae* (red polygon), green polygon to the left; Hoang Lien Son Nature Reserve, Green polygon to the right; Hoang lien National Park



Predicted range of *Leptolalax botsfordi* (red polygon), green polygon to the left; Hoang Lien Son Nature Reserve, Green polygon to the right; Hoang lien National Park

Threats to Focal Species The most immediate threat to these species include habitat degradation associated with tourism. Rowley *et al.* (2013) reported considerable pollution by garbage and runoff from toilets is recorded very close to the streams used by the species. The construction of a cable car from Sapa to the summit of Mount Fansipan and associated developments on the summit is also likely to affect them. The historic burning and subsequent ecosystem conversion of the summit of Mount Fansipan and adjacent areas, which are thought to have been previously covered in forest (Nguyen & Harder 1996), is also likely to have reduced habitat quality. The restriction of these species to high altitudes near the mountain peaks is likely to present an issue as tropical montane forests are expected to be particularly prone to alteration by climate change (Rowley et al., 2013, Foster, 2001). Strategies for additional protection of habitat within its range may be warranted as habitat degradation caused by tourism continues to be a threat. Further research into the species' ecology, distribution, relative population abundance, and past and current population trends would improve conservation decisions as very little is known about these species at present (IUCN, 2015a). These species do not receive any legal protection under Vietnamese law.

Other amphibian species, undiscovered diversity & taxonomic uncertainty

Ailao moustache toad, note the scars on the face, likely sustained from fights with other male frogs

Over 80 species of amphibians have been documented from the Hoang Lien Son Mountain Range (Table 1) and it is likely that there are many more yet to be described. The incorporation of molecular and bioacoustics data has increased the rate of species delineation (Catenazzi, 2015). There is a high degree of taxonomic uncertainty in the region, and so many records of species in the literature require confirmation.

The amphibians of Indochina in particular are poorly-known and knowledge relating to the diversity, distribution and biology of amphibians in the region is deficient (Rowley et al., 2010). More than 37% of amphibian species known from southeast Asia have been described since 2010 (Frost, 2016) and many groups harbour cryptic diversity; as an example, over half the species in the genus *Leptolalax* have been described since the year 2000 (Rowley et al., 2014; Rowley et al., 2016). Due to rapid and ongoing deforestation, species in some amphibian groups are at great risk of disappearing before they are even described (Rowley et al., 2015). It is imperative that further survey work and additional systematic work is undertaken in Indochina in order to understand the true diversity of amphibians in the region so that conservation priority species and areas for conservation can be identified and effective conservation management strategies can be developed (Rowley et al., 2016).

The Tam Dao salamander, is harvested for the pet trade, traditional medicine and food

Giant fire bellied toads can be found at altitudes of 2,200 m in Hoang Lien National Park

Order	Family	Scientific name	Common name	Altitude m asl	Red List assessment	Reference
Anura	Bombinatoridae	*Bombina maxima*	Giant fire bellied toad	~2,050-2,200	NA	Ohler, 2000
		Duttaphrynus melanosticus	Asian toad	940-1,700	LC	Ohler, 2000
		Bufo cryptotympanicus	Earless toad		NT	Nguyen et al, 2009
		Bufo pageoti	Tonkin toad	2,020-2,030	NT	Ohler, 2000
	Bufonidae	*Ingerophrynus galeatus*	Cambodian toad		LC	Nguyen et al, 2009
		Fejervarya limnocharis	Asian grass frog	800 - 1,700	LC	Ohler, 2000
		Limnonectes kuhlii	Large headed frog	1,250	LC	Ohler, 2000
		Nanorana aenea	Doichang frog	1,270 - 1,900	DD	Ohler, 2000
		Nanorana bourreti	Bourret's Paa Frog	1,570-20,50	DD	Ohler, 2000
		Nanorana yunnanensis	Yunnan Paa frog		En	Nguyen et al, 2009
		Occidozyga martensii	Marten's frog		LC	Nguyen et al, 2009
		Quasipaa delacouri	Doichang Asian frog		DD	Nguyen et al, 2009
		Quasipaa spinosa	Giant spiny frog		Vu	Nguyen et al, 2009
	Dicroglossidae	*Quasipaa verrucospinosa*	Spiny frog	1,280-1,900	NT	Ohler, 2000
	Hylidae	*Hyla annectans*	Jerdon's tree frog	1,260-2,090	LC	Ohler, 2000
		Brachytarsophrys feae	Kakhein Hills spadefoot frog		LC	Nguyen et al, 2009
		Leptobrachium ailaonicum	Ailao moustache toad	1,600 - 2,200	NT	Ohler, 2000
		Leptobrachium chapaense	Sapa spadefoot toad		LC	Nguyen et al, 2009
		Leptobrachium promustache	moustache toad	1,300-1,400	DD	Bain et al., 2009
		Leptolalax botsfordi	Botsford's leaf-litter frog	2,795 - 2,815	CR	Rowley et al, 2013
		Leptolalax bourreti	Bourret's leaf-litter frog	1,150 - 2,200	DD	Ohler, 2000
		Leptolalax pelodytoides	Thao Asian toad		LC	Nguyen et al, 2009
		Leptolalax pluvialis	Rainy frog	1,850-2,200	DD	Ohler, 2000
		Leptolalax sungi	Sung's leaf-litter frog		DD	Bain et al, 2007
		Megophrys palpebralespinosa	Tonkin spaefoot toad		LC	Nguyen et al, 2009
		Megophrys jingdongensis	Jingdong horned toad	1,660-2,240	LC	Ohler, 2000
		Megophrys cf. *Kuatunensis*	Kuatan horned toad	1,700-1,800	LC	Nguyen et al, 2009
		Megophrys major	White-lipped horned toad	1,500-1,700	LC	Ohler, 2000
		Megophrys cf. *Minor*	Little horned toad	1,660-2,240	LC	Ohler, 2000
		Megophrys pachyproctus	Convex-vented horned toad	1800	DD	Ohler, 2000
		Megophrys cf. *parva*	Concave-crowned horned toad	1,660 - 1,900	LC	Ohler, 2000
		Ophryophryne microstoma	Asian mountain toad	1,026	LC	Nguyen et al, 2009
	Megophryidae	*Oreolalax sterlingae*	Sterling's toothed toad	2,795 - 3,000	Cr	Nguyen et al, 2013
		Glyphoglossus yunnanensis	Yunnan squat frog		LC	Nguyen et al, 2009
		Microhyla butleri	Tubercled pygmy frog	1260	LC	Ohler, 2000
		Microhyla fissipes	Ornate pygmy frog		LC	Nguyen et al, 2009
		Microhyla heymonsi	Arcuate-spotted pygmy frog	1150	LC	Ohler, 2000
	Microhylidae	*Microhyla pulchra*	Guangdong rice frog		LC	Nguyen et al, 2009
		Amolops chunganensis	Chungan sucker frog	1,700-1,900	LC	Ohler, 2000
		Amolops cucae	Sucker frog	1900	DD	Ohler, 2000
		Amolops daorum	Sucker frog	1400	NA	Bain et al, 2003
		Amolops mengyangensis	Mengyang sucker frog		LC	Nguyen et al, 2009
		Amolops minutus	Small sucker frog	2,050-2,400	DD	Nguyen et al, 2009
		Amolops ricketti	Chinese sucker frog		LC	Nguyen et al, 2009
		Amolops splendissimus	Splendid sucker frog	1,850-2,400	DD	Nguyen et al, 2009
		Amolops viridimaculatus	Sucker frog	1750	NT	Ohler, 2000
		Babina chapaensis	Chapa frog	1,900	LC	Nguyen et al, 2009
		Hylarana taipehensis	Taipei frog		LC	Nguyen et al, 2009
		Odorrana andersonii	Golden crossband frog	1,500-1,790	LC	Ohler, 2000
		Odorrana bacboensis	Tonkin odorous frog		DD	Bain et al, 2007
		Odorrana chapaensis	Vietnam sucker frog	1,700-1,900	NT	Ohler, 2000
		Odorrana chloronota	Green cascade frog		LC	Nguyen et al, 2009
		Odorrana grahami	Yunnanfu frog	1,150-2,040	NT	Ohler, 2000
		Odorrana jingdongensis	Odorous frog	1,000-1,900	Vu	Lu et al, 2016
		Odorrana junlianensis	Junlian odorous frog		Vu	Bain & Stuart, 2006
		Odorrana livida	Green cascade frog	1,100 - 1,900	DD	Ohler, 2000
		Rana johnsi	John's frog		LC	Nguyen et al, 2009
	Ranidae	*Sylvirana maosonensis*	Mauson frog		LC	Nguyen et al, 2009

Order	Family	Scientific name	Common name	Altitude m asl	Red List assessment	Reference
		Chiromantis nongkhorensis	Foam nest tree frog	1,210 - 1,660	LC	Ohler, 2000
		Gracixalus carinensis	Burmese bubble-nest frog	1,260-2,200	DD	Ohler, 2000
		Gracixalus gracilipes	Chapa bubble-nest frog	1,540-1,770	LC	Ohler, 2000
		Gracixalus jinxiuensis	Jinxiu bubble-nest frog	1,850	Vu	Ohler, 2000
		Kurixalus odontotarsus	Serrate-legged small frog	1,250-1,500	LC	Ohler, 2000
		Kurixalus verrucosus	Boulenger's bush frog		LC	Nguyen et al, 2009
		Polypedates leucomystax	Bamboo treefrog	1,260-1,680	LC	Ohler, 2000
		Polypedates megacephalum	Hong king whipping frog		LC	Orlov et al., 2001
		Polypedates mutus	Northern tree frog		LC	Orlov et al., 2001
		Raorchestes parvulus	Karin bubble-nest frog	1,700	LC	Nguyen et al, 2009
		Rhacophorus dorsoviridis	Gliding frog	1,900	DD	Ohler et al., 2000
		Rhacophorus duboisi	Gliding frog	1,210-1,890	DD	Ohler et al., 2000
		Rhacophorus dugritei	Baoxing tree frog	1,890-2,900	LC	Ohler et al., 2000
		Rhacophorus feae	Thao whipping frog	1,230-1,800	LC	Ohler et al., 2000
		Rhacophorus hoanglienensis	Hoanglien frog	1,400	DD	Orlov et al., 2001
		Rhacophorus hungfuensis	Gliding frog	1,900	DD	Orlov et al., 2001
		Rhacophorus omeimontis	Omei whipping frog	1,200-2,100	LC	Orlov et al., 2001
		Rhacophorus orlovi	Orlov's tree frog		LC	Bain et al, 2007
		Rhacophorus rhodopus	Red-webbed tree frog		LC	Nguyen et al, 2009
		Theloderma albopunctatum	Bug-eyed frog		LC	Poyarkov et al, 2015
		Theloderma bicolor	Chapa bug-eyed frog	1,210-1,890	En	Ohler, 2000
		Theloderma gordoni	Gordon's bug-eyed frog		LC	Poyarkov et al, 2015
	Rhacophoridae	*Theloderma lateriticum*	Brick red bug-eyed frog	1,300-1,400	NA	Bain et al, 2009
		Paramesotriton deloustali	Tam Dao salamander		Vu	Nguyen et al, 2009
Caudata	Salamandridae	*Tylototriton asperrimus*	Granular newt		Nt	Nguyen et al, 2009

Table 1. Amphibians reported from the Hoang Lien Mountain Range. Taxonomy follows Frost (2016). Due to the number of unverified and often dubious reports regarding species distribution in the region, species presented in the table have either been cross referenced with IUCN range maps or have been reported in reliable and recent publications that are more current the last update of the IUCN species Red List assessment.

Feae's treefrog has expanded interdigital webbing which allows them to glide when they jump

The tourism industry and its impact on amphibians

Overflow tourist bus carpark; Sapa

Background

The tourism industry is one the fastest growing global industries and contributes approximately 9% to global GDP (UNWTO, 2015). Tourism can generate income for protected area management and conservation and can also be economically beneficial to local communities (Steven et al., 2013, Barros et al., 2015). Commercial tourism concessions and visitor entrance fees, can generate revenue for protected areas at the local scale (Emerton et al., 2006; Flores et al., 2008). Tourism can offer alternatives to other potentially more damaging forms of development such as logging, mining and consumptive use of wildlife (Christ et al., 2003). However, if tourism occurs without tangible benefits to local communities and without guidelines of management standards in place that promote biodiversity and its conservation the relationship between tourism and biodiversity can be extremely negative (Christ et al., 2003). Nature-based tourism is a market undergoing significant growth (Kuenzi & McNeely, 2008) and the increase in tourism and outdoor recreational activities is now considered a major threat to global biodiversity (Christ et al., 2003).

Tourism can negatively impact ecosystems and lead to the reduction of vegetation cover, damage trees, alter plant species composition (Smith & Newsome, 2002), pollute waterways (Cole et al., 1987), cause soil loss and soil compaction (Smith & Newsome, 2002) as well as reduce wildlife abundance (Rodríguez-Prieto & Fernández-Juricic, 2005) by disturbing behavior, feeding patterns and reproduction (Steven et al., 2011). Even moderate disturbance can impact upon ecosystem composition and structure decades after the disturbance (Byers 2009). The proximity of much tourism development in areas high in biodiversity means that if tourism is not carefully managed, it could exacerbate declines in biodiversity (Christ et al., 2003). By 2020 the rate of human visitation to the world's biodiversity hotspots is expected to have doubled (Christ et al., 2003). There are growing concerns regarding the environmental impact of tourism in developing countries due to a lack of infrastructure, planning and the anthropogenic impact on biodiversity (Geneletti & Dawa, 2009).

Montane regions in developing countries often host high biological and cultural and diversity (Nepal, 2002; La Sorte & Jetz, 2010). For these reasons, they can also be popular tourist destinations. Montane regions are often characterised by their inaccessibility, marginal development and associated poverty and a high level of stress on natural resources (Nepal, 2002; Geneletti & Dawa, 2009). These areas are often promoted as ecotourism destinations in order to help resolve the issues of underdevelopment and environmental degradation (Nepal, 2002) but the ecosystems in these regions are fragile and extremely susceptible to human disturbance (Geneletti & Dawa, 2009) and it is difficult to find success stories of nature based tourism in mountain ecosystems (Nepal, 2002).

Tourist camp at 2,800 m; Mount Fansipan. A nearby stream is the type locality for two Critically Endangered frogs

In montane areas, trekking camp sanitation is an increasing problem throughout the world (Byers 2009); not only does human excrement detract from the aesthetics of a site and people's enjoyment; exposure to pathogens from human excrement is a concern to both human and animal health (Hatcher, 2003; Fong & Lipp, 2005; Green & Muths, 2005; Climburget al., 2010; Jewitt, 2011). In countries with established mountain trekking industries (e.g. Nepal and Peru), issues with tourism in alpine areas include overharvesting of fragile plants to provide fuel, uncontrolled lodge building, health hazards due to poor sanitary practices, and improper garbage disposal (Byers 2009). Littering is also a major issue with tourism, especially in mountainous areas where waste collection can be logistically difficult (Christ et al., 2003). The volume of garbage created per person during trekking can be large; in the Himalayas a trekking group of 15 people generates about 15 kg of non-biodegradable, non-flammable garbage in 10 trekking days (Lama & Sherpa 1994).

Tourism in Vietnam

Vietnam's popularity as a tourist destination is increasing. International arrivals increased from 250,000 people in 1990 to 1, 890,00 in 2000, an increase in international arrivals of 756% (Christ et al., 2003). The Government of Vietnam considers tourism an important tool of poverty alleviation and economic growth. Vietnam's Law on Tourism states, "Tourism is encouraged in remote and isolated areas and in areas with socioeconomic difficulties where there are tourism potentials so as to make use of the labour force, goods and services in the spot, contributing to raising local people's intellectual level and to hunger elimination and poverty reduction" (Truong et al., 2014).

Tourism in HLNP

Most tourists visiting HLNP arrive and depart from the popular tourist town of Sapa, located 1km from the HLNP. Although there are an increasing number of international visitors, the majority of tourists to Sapa are Vietnamese nationals; in 2012 485,000 of the 610,000 tourists visiting Sapa were Vietnamese nationals (Truong et al., 2014). In 2000 49,322 people visited Sapa, this figure increased by 39.1% to 259,079 people in 2006 (Hai et al., 2008; Hoan et al., 2014). Tourism is now considered the most important economic activity in the area, generating 58% of Sapa district's GDP in 2010 (Hoang et al., 2014).Many tourists visiting Sapa climb Mount Fansipan via a number of routes or ascend it via a cable car that was opened in March 2016. Although the proportion of visitors to Sapa that ascend mount Fansipan is currently unknown. Visitors can also visit other sites of interest within HLNP. The HLNP management board is partially financed by the money from ecotourism as a proportion of entrance fees is returned to the national park management board (Nguyen et al., 2008).

Globally, over 10% of all amphibian species are documented as being impacted upon by tourism (either development of infrastructure or tourist activities themselves; IUCN, 2015). Of 6,460 amphibian species assessed on the IUCN Red List, 7% are threatened by tourism infrastructure and 4% by recreational activities. Tourism is listed as a threat to two other *Leptolalax* species (*L. bourreti* and *L. sungi*), both of which occur in HLNP, and three other *Oreolalax* species from China

(*O. multipunctatus*, *O. omeimontis* and *O. rhodostigmatus*) (Cheng & Guanfu, 2004; Feng & Guanfu, 2004; Liang & Guanfu, 2004; Ohler & Bain, 2004; van Dijk & Ohler, 2004) but there has been no research into how tourism actually affects these species.

Impacts of tourism on the higher elevations of Mount Fansipan

Within HLNP, the area most heavily impacted by tourism is the summit area of Mount Fansipan; this is also the type locality for *L. botsfordi* and *O. sterlingae*. When these species were first encountered In June 2012, the habitat of both *O. sterlingae* and *L. botsfordi* was noticeably polluted with refuse and run off due to the presence of a tourist camp (Fig 2a) in close proximity to the type locality of both species (Rowley et al., 2013). At that time accommodation at the camp consisted of a single shelter that could sleep approximately 40 people (J. Rowley Pers. Obs.) and several temporary structures made from bamboo and tarp. In 2015 the original tourist shelter had been replaced and other structures had been built. Gravel and boulders had been quarried from the stream for construction purposes (Fig. 2d). A mound of refuse approximately 4m high (Fig. 2b) composed of plastic bottles and bags, food waste, and corrugated metal had been deposited behind the tourist camp on the edge of the stream. Raw sewage was observed flowing from the toilets in the tourist camp onto a slope 20 meters above the type locality of *O. sterlingae* and *L. botsfordi* (Fig. 2c). Faeces and sanitary napkins littered the edge of the stream. A number of rats and at least one cat (Fig.2h) was observed at the tourist camp. The stream at the tourist camp was littered with refuse (Fig. 2e and 2I). The tadpoles of *O. sterlingae* were observed in pools littered with garbage (Fig. 2I).

Riparian vegetation was dramatically reduced in 2015 compared to 2012 (J. Rowley, pers. obs.), although the degree of loss has not been quantified as suitable satellite images have not been obtained. A local worker at the tourist camp estimated that they cut 4,000 stems of bamboo every two days for construction, cooking fuel and heating (September, 2015). Very few trees remained on the banks of the stream in 2015; it is likely that these trees were felled for fuel. *O. sterlingae* reportedly occurs in bamboo forest (Nguyen et al., 2013), but they have also been observed on the trunks and low branches of the elfin trees that remained in 2012 (J. Rowley pers. obs.). It is likely that the harvesting of bamboo and wood for construction (fig. 2f) and fuel for cooking and heating has been detrimental to *O. sterlingae*, as most of the bamboo forest surrounding the type locality had been burnt or harvested.

Figure 2 A: Tourist camp at 2,800m asl. B: refuse from tourist camp at 2, 800m. C: Raw sewage from tourist camp flowing down stream bank to type locality of *O. sterlingae* and *L. botsfordi*. D: Gravel removal from type locality of *O. sterlingae* and *L. botsfordi*. E: Type locality of *O. sterlingae* and *L. botsfordi* littered with refuse. F: Temporary construction used for housing tourists, made from bamboo harvested at 2,800m. G: Dilapidated signage, this had previously informed visitors of some of the rules people needed to abide by whilst visiting the national park. H: A cat at the tourist camp at 2,800m. I: Discarded plastic, tarpaulins and toiletries in a pool where the larvae of *O. sterlingae* were found. J: Cable care construction at the summit of Mount Fansipan.

Water parameters were recorded in September 2015 and June 2016. Although there was no detectable difference in water parameters upstream and downstream of the tourist camp, this may be due to a dilution and flushing effect caused by heavy rain that fell during the field observations, which coincided with the tail end of the wettest season.

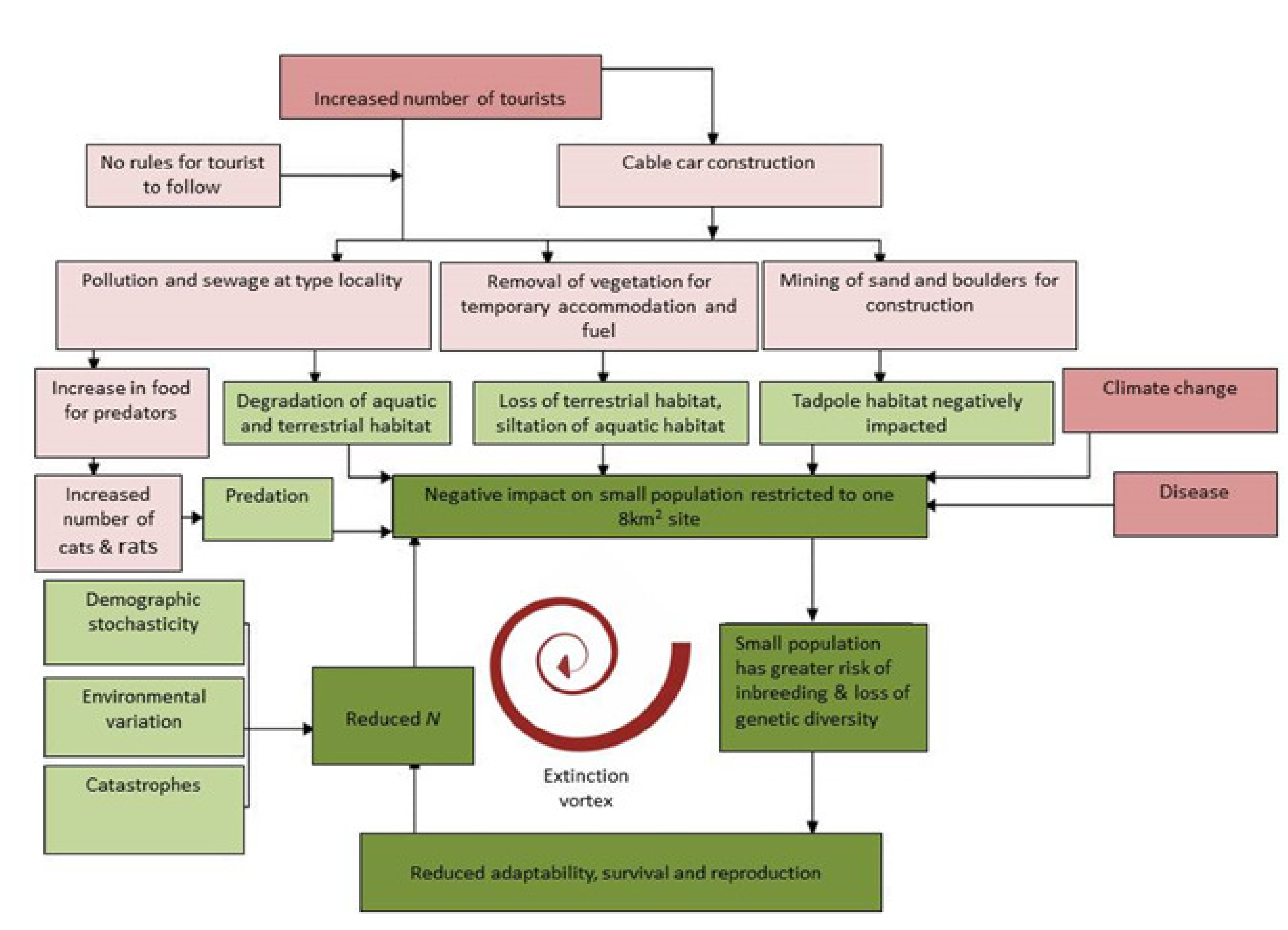


Figure 3. Hypothetical extinction vortex for *O. sterlingae* and *L. botsfordi* which demonstrates how range restricted species can be negatively impacted by a combination of anthropogenic pressures. Red boxes show causative agents, green boxes show effects, red arrow represents declining size of population.

The impact of gravel and boulder removal on potential oviposition sites and the tadpoles of *L. botsfordi* and *O. sterlingae* is unknown, although stream tadpoles have specific microhabitat requirements (Inger et al., 1986) and therefore gravel and boulder removal is likely to negatively impact tadpoles. Gravel removal may be a particular issue for *L. botsfordi,* as the tadpoles of many species in the genus are aquatic and fossorial and associated with gravel beds (Ohler et al., 2011). Alteration of the stream substrate and profile could therefore have a negative impact on reproductive success, larval development and population recruitment in this species. Additionally, removal of gravel may temporarily suspend large amounts of sediment, resulting in reduced dissolved oxygen levels and siltation downstream, potentially affecting tadpoles over a wider area.

The habitat requirements for *L. botsfordi* and *O. sterlingae,* remain unknown. Habitat loss is listed as a threat to most *Oreolalax* and *Leptolalax* species that have been assessed by the IUCN (IUCN, 2016). The habitat requirements for *L. botsfordi* and *O. sterlingae,* remain unknown. Habitat loss is listed as a threat to most *Oreolalax* and *Leptolalax* species that have been assessed by the IUCN (IUCN, 2016). No species within the park has been subject to detailed ecological studies. The habitat requirements, reproductive biology, movement and demography of these and other species is unknown and should be prioritised for the most threatened species.

During field work in June 2016 the habitat at the type locality of *L. botsfordi* and *O. sterlingae* appeared to have superficially recovered, the bamboo was taller, trees in the riparian zone had more leaves and the stream had less garbage. *O. sterlingae* and *L. botsfordi* were both still present at the site. Water parameters were recorded 20 meters downstream of the campsite and results were identical to those in 2015. Nearby habitats were assessed and no other streams in the vicinity appeared appropriate for either *O. sterlingae* or *L. botsfordi.* Very few tourists were observed ascending the mountain by foot, and the majority of tourists that were encountered were foreign nationals. The majority of Vietnamese tourists ascended the mountain via the cable car.

Sterling's toothed frog in amplexus; building site, Mount Fansipan **Lý Sử ©**

In May 2016, reports were received of *O. sterlingae* in amplexus on the summit area of Mount Fansipan. This site is being heavily developed for tourism and surveys of the summit area were carried out as a priority action in June 2016. Five adult *O. sterlingae* were observed in the construction zone of the summit, including a malformed individual. A dead adult *O. sterlingae* was also observed. The only stream in the immediate vicinity was surveyed and no frogs were encountered.

In 2015, construction of a cable car (Fig. 2J) began on Mount Fansipan (IUCN, 2015a,b) and the number of construction workers entering HLNP may have put additional pressure on the ecosystem as suitable toilet facilities and waste disposal facilities are lacking within much of the national park. Now that the cable car is open these threats, at least at the type locality of, *O. sterlingae* and *L. bostfordi* have abated. However, the cable car has capacity to transport 2,000 people per hour to the summit of Mount Fansipan; the impact of this increase in visitor numbers has not yet been quantified. The construction of the cable car has been detrimental to the summit area of the mountain as a strip of forest has been clear-cut to accommodate it. Moreover, construction workers may have put additional pressure on the infrastructure and have also directly contributed to habitat destruction and degradation through harvesting vegetation for fuel and shelter and using the stream as a sewer. In Nepal the construction of a cable allowing faster access to a pilgrimage site led to a reduction in the number of people ascending the mountain by foot (Bleie, 2003) and this appears to be the case on Mount Fansipan.

Despite limited data, it is apparent that tourism is most likely having a negative impact on *L. botsfordi* and *O. sterlingae.* The rise in the number of visitors accessing Mount Fansipan is detrimental to the fragile mountain ecosystem as it is evident that the existing infrastructure on the summit ascent route of the mountain is insufficient for the number of people visiting the site and that any mechanism for removing the large volume of human waste is inadequate.

It is highly likely that iconic protected areas such as HLNP will continue to be negatively impacted by the activities of the growing numbers of visitors due to the rapid growth of the nature based tourism industry. It is imperative that the growth of tourism in such sensitive areas is supported by the development of appropriate infrastructure and that the potential negative consequences of people's activities are mitigated against and their impacts on biodiversity are closely monitored. Ultimately the wilderness tourism industry and the associated economic benefit of wilderness tourism is dependent on the condition of the wilderness area. Poor wilderness area management resulting in degraded, polluted and aesthetically displeasing habitats may ultimately undermine the sustainability of the industry at a given site.

There is currently no information within HLNP on how tourists could minimize their impact on the biodiversity of the national park. Signs outlining responsible visitor behavior were in place on the primary ascent route in 2012, but these have fallen into total disrepair and are currently unreadable (J. Rowley & B. Tapley, pers. obs. 10 June 2015).

Tourist feedback on the park is important for directing future management. To date, HLNP has received negative feedback from foreign visitors (Table 2). Most visitors that left negative feedback complained about the amount of litter and human excrement in the park. Further research is needed in order to ascertain whether or not these issues have been raised by Vietnamese visitors and whether or not the presence of litter and human excrement would put people off returning to the park. Potential threats facing *L. botsfordi* and *O. sterlingae* as well as the potential impact of these threats is summarised in Fig. 3.

Tourists riding the cable car back down to Sapa

Comments	Source
The entire top of the mountain has been clear cut and poured with concreate like some kind of unnatural snow cone. And the thousands of tourists this place sees daily are the sprinkles. I regret coming here and I regret supporting such a corrupt company thats deatroying vietnams natural beauty here and other places like ba na.	TripAdvisor (UK) 06 October 2016
Once you reach the Camp you will be delighted to see how trashed this mountain is. The camp is very makeshift and dilapidated with trash everywhere	Kevin Roemer climbing blog, 01 April 2015
When the sun got up it was easy to follow the path all the way to camp 1 (just follow the garbage)	TripAdvisor (UK) 08 January 2016
I was very upset about it as the final part of the trek is ruined because of building the cable car facility. The final part is dirty, there are a lot of rubbish on the road.	TripAdvisor (UK) 02 December 2015
the disappointment was all the rubbish people through instead of taking with them down.	TripAdvisor (UK) 28 November 2015
The garbage, construction of the cable car, unsecured ladders, loose trail d/t change in trail from the cable car etc. is what made this hike terrible. We could not wait to get off this mountain!	TripAdvisor (UK) 24 November 2015
However the trash left all over the top of the mountain was a real disappointment and the new cable car building site just added to the feeling we'd walked a long way to see a particularly unpleasant part of Vietnam. *“Long walk*	TripAdvisor (UK) 19 November 2015
But.... Who on earth decided to build a cable car to 3000m??!!! What a shame.... Last 300m you walk through a building site and builders camp. The builders play music, cook and use the same path as your ascent to the top.	TripAdvisor (UK) 18 November 2015
Great Mtn, ruined by litter, cable car Litter - everywhere you look, in stark contrast to every other trek we've done. The piece de resistance was a bloody sanitary towel in the middle of the path!! Why???!!!	TripAdvisor (UK) 09 February 2015
The whole area is covered with garbage and human excrement I have never seen such a place and I have widely travelled in Asia. The guide explained that there recently was a bank holiday in Viet Nam and that local tourists had trashed the place. I found that difficult to believe as it would take months to get an area so full of garbage. Apparently the authorities are aware of it but do not know to solve it. I would suggest to stop sending tourists there in the meantime.	TripAdvisor (UK) 13 May 2011
Hikers have complained to her office that Fansipan trails and campsites are littered with garbage, and that tour guides slash trees for firewood.	Word Vietnam (Vietnam) 09 March 2010

Table 2. Negative reviews from tourists visiting HLNP

What can be done?

Further research is needed in order to see what impacts tourism has on amphibians, specifically on *L. botsfordi* and *O. sterlingae*. Long term population monitoring at several sites that have a high and low impact of tourism should be considered a priority action. Additional surveys should be undertaken throughout the area predicted to have the species to gain a better understanding of the true distribution of the species in terms of altitudinal ranges, habitat preferences and spatial extent.

Early morning on Fansipan summit


Porters rest on the summit trail

It is important to increase awareness of the issues caused by tourism at this site. Travel agencies and trekking companies could be approached and mitigative measures discussed, agreed upon and enforced. We recommended that ecotourism principles are strictly adhered to and that limits are set on the number of people accessing fragile sites within HLNP. Such visitor restrictions exist in other areas in Southeast Asia; only 100 visitors per day our allowed to access the summit of Mount Kinabalu in order to minimise the impact of tourists (Stewart, 2014). In the late 1970s littering was a serious problem on the summit trail on Mount Kinabalu, exacerbated due to the increased number of visitors. Sabah Parks sought cooperation of the mountain guides, who helped to collect the litter in return for the arrangement of the guides' schedules by Sabah Parks. This successful strategy aimed to reduce the litter on the summit trail as well as the demand on the parks management to remove it (Goh, 2008). Whilst restrictions to the summit of Mount Fansipan are not possible due to the construction of a cable car, restrictions could be introduced in particularly sensitive sites such as the known breeding sites of *O. sterlinage* and *L. botsfordi*.


The type of view that makes Sapa and HLNP such an attractive tourist destination

Non–tourism associated impacts on amphibians

Snow fall on the Hoang Lien Mountain Range

Habitat loss and modification

Shifting cultivation and slash and burn agriculture has been a historic land use method by local people around HLNP (Reserve, 2002). Once burnt, the land is not used in a way that promotes long lasting fertility or reliable crop yields (Reserve, 2002). Fire is also an issue, between 1994 and 2000 there were 16 forest fires in HLNP and its buffer zone (Reserve, 2002), most of which were anthropogenic in origin. There is also a link between forest fires and global weather patterns, fires being more common in El Nino events (Reserve, 2002). This issue may be exacerbated further by future climate change. Livestock is often grazed within HLNP and this has a detrimental impact on forest recovery as well as the quality and the quantity of the forest (Reserve, 2002). Wood extraction has also been an issue and trees are cut for fuel wood by local communities for their own use and to supply Chinese markets (Reserve, 2002).

Climate change

Climate change is also a potential threat particularly to species occurring in the higher elevations of the Hoang Lien Mountain Range as some habitats such as cloud forests which support high levels of biodiversity have great sensitivity to climate (Foster, 2001). The impacts of climate change on cloud forest include biodiversity loss, altitude shifts in the ranges of species and possibly forest death (Foster, 2001). Climate change may also increase the frequency of extreme weather events and plant invasions, fire and drought are likely to increase the effects of damage caused by climate change in cloud forest systems (Foster, 2001). In some regions, climate change is also thought to intensify the amphibian declines caused by disease (Pounds et al., 2005).

Lone tree on Mount Fansipan

Harvesting

The hunting of wildlife has also been a threat to biodiversity (Reserve, 2002) and some mammals such as the Western black gibbon have not been reported from HLNP since 1998 (Rawson et al., 2011). Amphibians in Southeast Asia are widely collected for food, traditional medicine and the pet trade in southeast Asia (Rowley et al., 2010). Current understanding of the impacts of harvesting amphibians in Vietnam is lacking. There is concerning anecdotal evidence that over-harvesting may be the cause of population declines of some amphibians, particularly large bodied frogs and Southeast Asian salamandrids (Rowley et al., 2010).

Disease

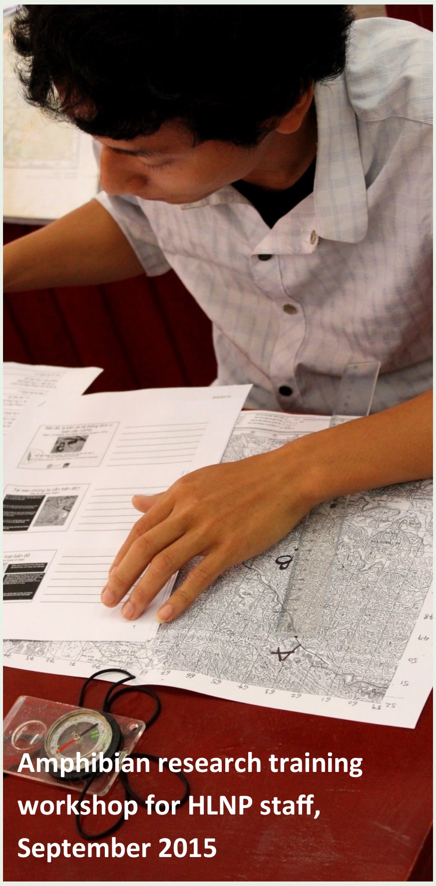
In the Americas, amphibian declines are positively associated with species living in the tropics at high elevation in riparian habitats (Stuart et al. 2004); as these high elevation sites in the tropics overlap with areas of the highest environmental suitability for *Batrachochytrium dendrobaitidis* (*Bd*), one of two causative agents of the disease chytridiomycosis, a driver of global amphibian declines (Lötters et al., 2009). Moreover, complex interactions between disease, climate and other factors such as anthropogenic stressors may further imperil amphibians in mountain ecosystems (Pounds et al., 2006). Patterns of infection and the manifestation of chytridiomycosis are host species, life stage and context specific.

Historically there has been considerable geographic bias in survey effort for *Bd*, the most neglected continent being Asia (Swei et al., 2011). To date, *Bd* mediated declines have not yet been reported in mainland southeast Asia, but research into emerging infectious disease in amphibians in Asia has been limited (Swei et al., 2011); further research is needed in order to ascertain whether or not disease, specifically chytridiomycosis, is a threat to amphibians in Indochina. It is important to compare the genetic strains of *Bd* found in Asia with those found at sites associated with mass die-offs amphibians elsewhere in order to determine if strain difference in the pathogen can explain the difference in disease prevalence in Asia. This information may be useful in the development of disease mitigation strategies. In 2015 qPCR analysis (Boyle et al. 2004) was carried out on skin swabs collected from a variety of post metamorphic amphibians in HLNP. There were detectable chytrid infections in anuran amphibians from two sites (2,200 m elevation and 2, 800 m elevation on Mount Fansipan) including a positive result from one Critically Endangered species, *Oreolalax botsfordi*. Infection burdens were low and there were no clinical signs of disease. In 2016 attempts were made to isolate chytrids from amphibian tissue samples obtained in HLNP in the hope the strain of *Bd* in the region could be identified. Attempts should be made to isolate *Bd* form anuran amphibians found in the field.

A call to action

The threats posed to amphibians, particularly in the higher elevations of HLNP are diverse and synergistic, but are, at this point in time largely reversible. Promoting low impact tourism and targeting behaviors of both tourists and people responsible for managing associated infrastructure should be a key priority. Protecting important localities for highly threatened species such as *O. sterlingae* and *L. botsfordi* will also be beneficial to the region's biodiversity and people, as the type locality of these species is an important watershed. Simple actions such as encouraging visitors to take their waste material with them back down the mountain, adopting alternative fuel sources for cooking and the use of tents away from the stream systems in specifically allocated camp areas could be promoted and included in the price of tour packages. Key areas of habitat could be designated no use zones and this would encourage plant regeneration. Currently there is little interpretation within HLNP (Fig. 2g), and no information on the problems that irresponsible tourism can cause and on how visitors can minimise their impact when trekking. This could be addressed by Investing in multilingual signage outlining and explaining responsible behaviors.

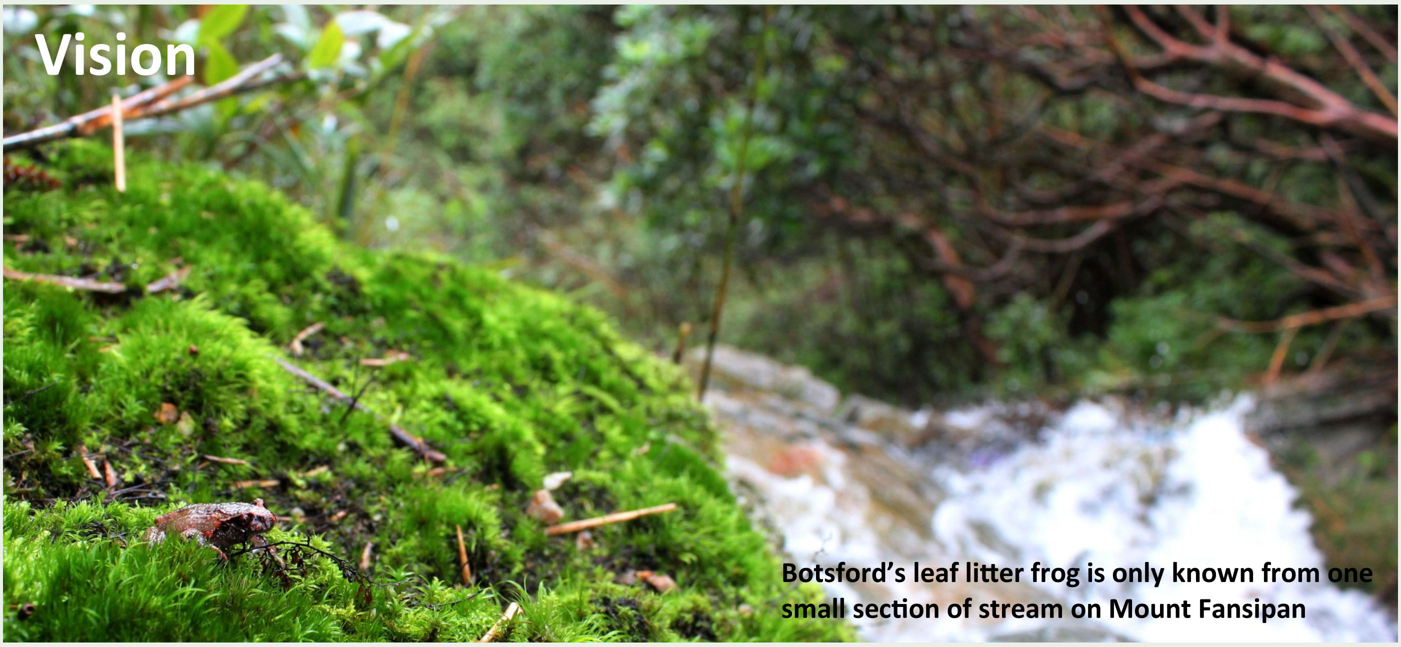
In June 2016 an international stakeholder meeting was hosted by the Centre for Rescue and Conservation of Organism (CRCO) so that an action plan for *O. sterlingae* and *L. botsfordi* and other amphibians in the Hang Lien Mountain Range could be developed. The vision for the action plan as well as actions, responsible parties and time frames was agreed. The current collaborators include HLNP facilitated by the CRCO, the Zoological Society of London and Australian Museum. These organisations shall continue to work with each other to ensure that the action plan is realised and that knowledge is shared and exchanged between all partners.



Amphibian research training workshop for HLNP staff, September 2015

The first international stakeholder meeting for amphibians of HLNP.

Vision



Botsford's leaf litter frog is only known from one small section of stream on Mount Fansipan

Vision: *To ensure the diversity of amphibians in Hoang Lien be better understood, and maintained in perpetuity for the benefit of future generations.*

Action plan for Amphibians of the Hoang Lien Range

Objective number	Priority	Aim	Activity	Indicators of success	Risks & opportunities	Suggested collaborators	Time frame
1	1	Protect critical habitat of *O. sterlingae* & *L. bostfordi* and undertake annual threat assessment for this key habitat.	Restrict access to critical habitat to reduce threats to species	Habitat secured Anthropogenic impacts on the protected habitat are reduced when compared to less strictly protected habitat *O. sterlingae* & *L. bostfordi* populations persist in protected habitat *O. sterlingae* & *L. bostfordi* listed as AZE species	Permission to protect habitat not granted No entry zones not respected. Protection not enforced Anthropogenic pressures persist but may not be obvious Population extirpation due to factors outside of our control e.g. diseases, climate change	HLNP *	2017
2	1	Ensure project is sustainable - eventual handover of projects in its entirety to Vietnamese counterparts	Provide training & support for CRCO & HLNP	Staff at CRCO & HLNP able to conduct surveys without the presence of AM & ZSL HLNP & CRCO team train other researchers in relevant methodologies	Communication (lack of Vietnamese / English language skills Staff turnover Failure to follow established methodologies New partners / team members unwilling to participate	AM, ZSL	Ongoing
3	1	To deliver educational messages that lead to quantifiable changes in behaviour	Development & implementation of CEPA program	Survey carried out on attitudes & perceptions of visitors to HLNP New interpretation erected in HLNP Key audiences identified Community groups formed Activities that promote or enhance biodiversity conservation undertaken Resources (e.g. self-guided trails, books & website are used)	Lack of interest. Other agencies unsupportive e.g. cable car operators.	ZSL, CRCO, HLNP, AM	Ongoing
4	1	Ensure financial stability, project can run continuously without interruption due to funding constraints	Secure funding for five years of programme	Enough funds secured to allow all activities in action plan to be actioned Surplus funds available that can be accessed in the case of emergencies e.g. surveys needed after disease outbreak etc.	Time constraints Funding applications not successful Project fatigue – funders lose interest	ZSL, CRCO, HLNP, AM	Ongoing

Objective number	Pri-orit y	Aim	Activity	Indicators of success	Risks & opportunities	Suggest-ed col-laborato rs	Time frame
5	2	Research into the biology of *O. sterlingae* & *L. bostfordi*	Determine true distribu-tion & macrohabitat requirements of *L. bostfordi* & *O. sterlingae*. Survey additional sites throughout the predicted range of *L. bostfordi* & *O. sterlingae* at HLNP Revise ecological niche models of species based upon surveys Categorise breeding & non-breeding habitat of species	Distribution & macrohabitat requirements known Scientific manuscript submitted to journal for publication Presence or absence at other sites assessed Altitudinal range established Ecological niche model fully ground-truthed Breeding & non-breeding habitat known	Population extirpation Low detection probability Time constraints Funding constraints Site access difficult Model not robust due to lack of data	ZSL, CRCO, HLNP, AM	2019
			Determine breeding biology of *L. bostfordi* & *O. sterlingae*. Use histology to deter-mine reproductive state of *L. bostfordi* & *O. S terlingae* using existing museum specimens Observe & document calling & breeding of species including oviposi-tion sites. Locate & scientifically describe eggs & tadpoles of *L. bostfordi* & *O. sterlingae*. Determine season & weather variables that predict breeding activity	Call description of *O. sterlingae* published Breeding triggers, reproductive behavior & life history data known Tadpole descriptions for *L. bostfordi* & *O. sterlingae* published Research disseminated	Small sample size Population extirpation Poor detection probability Failure to detect breeding sites Poor accessibility of sites Collection permits or specimen export not granted Time constraints Funding constraints	ZSL, CRCO, HLNP, AM	2019
			Estimate population size & trends of *L. bostfordi* & *O. sterlingae* at two sites Conduct mark recapture surveys Skeletochronology to determine age	Population size esti-mated Population trend estimated Age structure of wild populations estimated Longevity determined through skeletal chronology Long term data set estab-lished. Data set incorporates multiple surveys at different times of year Updated Red List assessment published for both species	Small sample size Population extirpation Poor detection probability Failure to detect breeding sites. Poor accessibility of sites Small size precludes marking Small sample size for skeletochronology. Time constraints Funding constraints	ZSL, CRCO, HLNP, AM	ongoing

Objective number	Priority	Aim	Activity	Indicators of success	Risks & opportunities	Suggested collaborators	Time frame
5	2	Research into the biology of *O. sterlingae* & *L. bostfordi*	Determine the prevalence, intensity & effect of disease	Infection prevalence and intensity two populations of both species established Changes in infection prevalence and intensity detected	False positives False negatives Difficulty in identifying pathogens Small sample size Population extirpation Poor detection probability Time constraints Funding constraints	ZSL, CRCO, HLNP, AM	ongoing
			Assess habitat change & impact of climate change to *L. bostfordi* & *O. sterlingae*	Habitat change quantifiable Weather stations in to *L. bostfordi* & *O. sterlingae* habitat operational PVA analysis run under different climate change scenarios If appropriate, climate change mitigation strategy developed	Lack of historic data Funding constraints Time constraints Equipment malfunction Equipment theft Not enough data to run PVA	ZSL, CRCO, HLNP, AM	ongoing
			Determine movement & microhabitat use of *L. bostfordi* & *O. sterlingae*	Radiotelemetry study undertaken Movement and microhabitat use quantified. Research disseminated Results of research used to inform PA management	Small size precludes radiotelemetry studies Funding constraints Time constraints Equipment malfunction Population extirpation	ZSL, CRCO, HLNP, AM	2020
6	2	Obtain legal protection for *O. sterlingae* & *L. botsfordi.* To list *O. sterlingae* & *L. bostfordi* on the 160 decree	To list *O. sterlingae* & *L. bostfordi* on the 160 decree	Species listed & protection enforced Legal protection improves conservation status of *O. sterlingae* & *L. bostfordi*	Application rejected. Paper protection only	HLNP, CRCO*	2017
7	2	Visitors to summit area have an understanding of the parks biodiversity after they visit & are more engaged with biodiversity conservation	Development of self-guided interpretation trail at love waterfall, & Fansipan summit	Educational trail launched. Trail widely used Trail used as an educational tool by HLNP	Conflict with commercial entities existing within the park Lack of interest / not used Interpretation may detract from aesthetic appeal of trail	HLNP, CRCO*	2019

Objective number	Priority	Aim	Activity	Indicators of success	Risks & opportunities	Suggested collaborators	Time frame
8	2.	Amphibian inventory surveys carried out at key sites within HLNP	Comprehensively document & assess conservation status of amphibian diversity in HLNP & identify sites of conservation priority.	Species presence / absence confirmed New species described Altitudinal ranges & key aspects of biology known for each species	Unable to gather enough information on each species Time constraints Funding constraints Poor accessibility of sites Collection permits or specimen export not granted	ZSL, CRCO, HLNP, AM	2021
			All known amphibian species within HLNP have conservation status assessed	Red List assessments of all newly described species undertaken All amphibians species in HLNP have been subject to Red List assessments in the past 10 years	Rapidly changing taxonomy / taxonomic uncertainty means that content may be rapidly out of date Time constraints Funding constraints	ZSL, CRCO, HLNP, AM	Ongoing
			Sites within HLNP that are priorities for amphibian conservation have been identified	Process informs protected area management & resource allocation	Data deficiency Taxonomic uncertainty Survey bias (seasonal / habitat) Not all sites can be surveyed	ZSL, CRCO, HLNP, AM	2021
9	2.	Develop resources that will facilitate research on amphibians in the Hoang Lien Range.	Develop multi language book series on Amphibians of Hoang Lien range to facilitate further research.	Book printed & disseminated PDF book on ASA website	Printing cost prohibitive Poor printing quality	ZSL, CRCO, HLNP, AM	2019
			Establish website www.fansipanfrogs.com to promote amphibian research & conservation & raise awareness	Multi language website published online Website visited by Vietnamese and international visitors Website receives more than 100 visits per week	Institutions not supportive Website not publicised Website not visited Website not updated	ZS, AM#	2017
10	2	Continue to develop husbandry capacity at CRCO	CRCO has a management strategy for every species it maintains.	Regular training workshops All species kept to a high standard. Other rescue centers approach CRCO for husbandry training	Lack of funds & resources Staff turnover Poor communication Facility becomes overstocked due to increasing numbers of confiscations No exit strategy for captive animals.	ZSL, CRCO, HLNP	2017 onward

Objective number	Priority	Aim	Activity	Indicators of success	Risks & opportunities	Suggested collaborators	Time frame
11	3	Long term trends in weather patterns can be identified	Long term environmental monitoring in HLNP	3 weather stations established at different altitudes within HLNP (2,200m, 2, 800m, 3,000m) Data collected regularly Data informative & used & used to inform conservation intervention.	Cost of procurement Equipment malfunction Data not collected	ZSL, CRCO, HLNP, AM	2018
12	3	Increased engagement & support of conservation action plan, tasks disseminated, outputs increased, biodiversity protection enhanced	Development of community groups	At least one community group established Activities such as litter collection carried out biannually	Lack of interest Lack of leadership Logistical difficulties e.g. collecting litter & moving it out of the protected area	HLNP, CRCO*	2017
13	3	Areas outside of iconic PA receive conservation focus	Expand program to incorporate additional sites in Hoang Lien Range	Amphibian surveys undertaken at key sites along Hoang Lien Son Range focusing on HLNP, Van Ban & Bat Xat initially New species described in scientific literature Results published Key habitats & species in need of conservation action identified	Access to areas difficult Time & funding constraints Areas already heavily impacted	ZSL, CRCO, HLNP, AM	2017-onward

***ZSL and AM will provide support where needed. [#]Assistance required from CRCO and HLNP in the form of translation.**

1 – Urgent action; 2 – Short term goal; 3 – Long term goal

Boulenger's bush frog

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Bourret's leaf-litter frog was described from Mount Fansipan in 1983

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Metamorph sucker frog, sucker frogs are associated with fast flowing streams, torrents and waterfalls

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The Chapa bubble-nest frog has a call reminiscent to that of a birds

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