In the late 1980s and early 1990s, the Mortenson Lake population persisted with an adult population in the low 100s, and then declined to just a few adults by 1993. Breeding output dropped from a few egg masses per year to zero. Fearing that the toad might disappear completely from Wyoming, biologists collected the few remaining individuals in 1993 and 1994 and began attempts to breed them in captivity. This effort, now involving several zoos and other facilities, generated good numbers of offspring for release into the wild. An effort in the early 1990s to establish additional populations through releases of captive-raised toads at Lake George and Rush Lake on the Hutton Lake National Wildlife Refuge was unsuccessful. At Mortenson Lake, releases of many thousands of toadlets and tadpoles beginning in the mid-1990s resulted in at least modest toad survival and even a renewal of reproduction in the wild in 1998-2000, generating hopes for population recovery. However, subsequent declines, poor reproduction, and observations of diseased and dead toads in the early 2000s, put the toad back into an extremely precarious status. The free-ranging population surely would be completely gone without annual releases of thousands of captive-reared toadlets. Accordingly, the species remains functionally extinct in the wild.

Several factors may have contributed to the toad's decline and current poor condition. As with most threatened species, the toad has experienced habitat loss and degradation. Irrigation practices in river floodplains, now used for hay production, probably made streamside areas less suitable for successful toad reproduction. For example, de-watering prior to hay-cutting may kill toad larvae before they metamorphose into toadlets capable of living on land. Also, some potential breeding sites have dried up as a result of prolonged drought, while drought-related increases in evaporation have made Mortenson Lake more saline and perhaps less suitable for toads.

However, recent evidence suggests that the primary threat to the Wyoming Toad is not habitat degradation, but rather the pathogenic chytrid fungus *(Batrachochytrium dendrobatidis)*, now associated with amphibian declines around the world. The fungus has been discovered at Mortenson Lake and in the captive population. Retrospective analyses indicate that the chytrid fungus has been present at Mortenson Lake since 1989.

Continued survival of the Wyoming toad depends on intensive management. An important immediate concern is maintenance of the toad's genetic diversity through careful management of the captive breeding stock. Excessive inbreeding and associated loss of genetic variation potentially could compromise the toad's reproductive performance and hinder the population's ability to respond to environmental variations.

Even if the Mortenson Lake population were in better condition, the toad's long-term survival and recovery would still depend on the identification of additional reintroduction sites and the establishment of several wild populations. This is a basic conservation precaution that minimizes the probability that localized events do not eliminate the entire species. Happily, private landowners have begun to step forward and allow toads to be released into suitable habitat on their property. A recent initiative that may play an important role in facilitating this effort is known as the Safe Harbor Agreement (SHA). According to the U.S. Fish and Wildlife Service, a SHA "*encourages landowners to conduct voluntary conservation activities and assures them that they will not be subjected to increased restrictions should their beneficial stewardship efforts result in increased endangered species populations. As long as enrolled landowners allow the agreed upon habitat improvements to be completed on their property and maintain their responsibilities, they may make use of the property during the permit term, even if such use results in the take of individual Wyoming toads or harm to their habitat. This approach may be critical in establishing additional sites into which captive-reared toadlets might be released with improved chances of survival and eventual reproduction.*"

Recently, a SHA was involved in the release of captive-raised toads on a private ranch near Mortenson Lake. Well-managed cattle grazing – which is compatible with and may even facilitate toad recovery – is being continued on the ranch. Only time will tell if the toads can avoid or overcome the fungal threat and establish a viable population on this and other potential reintroduction sites. Meanwhile, the Wyoming Toad remains one of the world's most threatened species.

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ESSAY 11.8. CONSERVATION ACTION FOR THE MEXICAN AXOLOTL *AMBYSTOMA MEXICANUM*

The Mexican Axolotl (*Ambystoma mexicanum*) is one of Latin America's most threatened amphibians. The vast wetland upon which Mexico City was founded – and which once provided a rich and productive habitat for the Axolotl and other endemic fauna – is now reduced to a handful of small, isolated patches surrounded by development. Of these, Lake Xochimilco is the largest, covering just over 2km² – but it is certainly no longer a lake. The development of the 'chinampas' – raised fields of mud and vegetation reclaimed from the lake – has been going on for centuries and has reduced the system to a series of canals running between islands of development. Today, the landscape is often referred to as the 'floating gardens' (a misnomer, as the chinampas are not floating at all). Habitat loss, introduced predators, pollution, and illegal collection for food and medicines have all taken their toll on the Axolotl. Consequently, the threats facing this species are complex and not easily reversible. However, its prominent position within Aztec mythology (see Essay 2.3) and the ancient lacustrine economy of the region means that the Axolotl is well known – although poorly understood – among local people. Some 2000 remeros (local boatmen) earn a living by punting visitors along the lake's canal system in gaily decorated trajineras (pleasure boats), while the chinamperos (local farmers) cultivate the adjacent land, in much the same way as their ancestors have done for centuries. Fishing is also important to the local economy, and although non-native carp and *Tilapia* may have replaced the Axolotl as the main catch, researchers have yet to improve upon the highly skilled traditional netting method used by the fishermen for finding Axolotls.

Over the last five years, a conservation programme on the Axolotl has been initiated and fostered by a partnership of British and Mexican organizations (Griffiths *et al.* 2004). This project was the brainchild of the late Dr Virginia Graue of the Universita Autonoma Metropolitana at Xochimilco (UAM-X), who contacted the Durrell Institute of Conservation and Ecology (DICE) in 1999 for assistance with the development of the project. As it was clear that addressing the many threats that the Axolotl faced would be impossible without the co-operation of local stakeholders, the project focused on embracing local people within the conservation planning process. This was done by promoting the Axolotl as a flagship species for nature tourism and conservation education within the region. Using a field station (run by UAM-X) on the shores of the lake as a base, and with funding from the IUCN/ SSC Declining Amphibian Populations Task Force (DAPTF), as well as the British Government's Darwin Initiative programme, the project partnership held training workshops on amphibian biology and conservation for local students and conservation organizations, nature guiding for local boatmen, and souvenir production for unemployed artisans.

In addition, the project has been actively engaged in ongoing studies focusing on the population status of, and threats to, the Axolotl. Despite its precarious status in the wild, the Axolotl is one of the most familiar amphibians in laboratories and aquaria throughout the world. Animals were originally collected in 1863 for the Natural History Museum in Paris, and many of today's captive animals probably stem from these founders (Smith 1989). As a result of its well-known reproductive biology, and the availability of captive populations, there is considerable interest in reintroducing Axolotls to Lake Xochimilco. However, there are several problems associated with such releases. At the very least, threats need to be neutralized and potential disease and genetic problems need to be addressed before captive animals are put back into the wild (Griffiths *et al.* 2004). Despite the wide availability of captive-bred Axolotls, wild animals are still captured and sold illegally in local markets (McKay 2003). A proposal to upgrade *Ambystoma mexicanum* from CITES Appendix II (controlled international trade) to Appendix I (species threatened with extinction and international trade permitted only in exceptional circumstances) is currently under discussion by the Mexican authorities.

As a result of a conservation workshop, held at UAM-X in December 2004, the goals for the conservation of the Axolotl and its habitat were finally distilled into eight categories: (1) biology of the species; (2) legislation; (3) social actions; (4) political actions; (5) ecological interactions; (6) local environment; (7) education; and (8) resource use and harvesting. These goals provided the framework for the Species and Habitat Action plan for the Axolotl and the Xochimilco system that was published in 2005 (DICE, UAM-X, 2005). Following the workshop, the Senate of the Congress of the Mexican government passed a motion requesting the President to instruct the Secretariat of the Commission for the Environment, Natural Resources and Fishing to initiate an urgent governmental programme to avoid the extinction of the Axolotl in Lake Xochimilco. What this decision will mean, in practice, remains to be seen, but it will certainly influence governmental actions that impact the Axolotl and Xochimilco conservation. The decision, in itself, is an indication of the leverage that such projects can achieve.

One of the most important products to emerge from the project's first phase is the partnership of diverse organizations that all have an interest in the future of the Axolotl and its habitat: the Grupo por la Investigacione del la Ajolote y Xochimilco (GIAX), which is co-ordinated by Dr Luis Zambrano of the Institute of Biology, UNAM. Despite the obvious benefits accruing as a result of raising awareness and building local capacity, initial data from this first phase of the project indicate that the status of the Axolotl has deteriorated to such an extent that the species now warrants classification as 'Critically Endangered' according to the IUCN Red List categories and criteria. This reclassification has provided a sharper focus for the implementation of the action plan. The new partnerships forged within GIAX will be instrumental in taking the plan forward during the second phase of the Darwin Initiative project. The training of remeros as nature guides has resulted in a significant increase in their income from visitors to Lake Xochimilco. Some of the remeros are currently being trained as nature guide 'trainers', with a view to the training package eventually being handed over to, and managed by, the guild of remeros. By the end of the second phase of the project, it is hoped that nature tourism will be contributing significantly to the sustainable development of the Xochimilco system, and will be independent of external funding. In parallel, research is

The Critically Endangered Mexican Axolotl Ambystoma mexicanum *is endemic to the canals of Lake Xochimilco in central Mexico, on the southern edge of Mexico City. © Ian G. Bride*

A typical Xochimilco canal scene beyond the busy urban area, showing a trajinera (pleasure boat) in the foreground. The boats in the distance are selling ornamental plants grown on the chinampas. © Ian G. Bride

being carried out on the productivity of the Xochimilco system, with a view to balancing the needs of the local fishermen with ameliorating the threats associated with introduced species and poor water quality. Ultimately, the future of the Axolotl will depend upon how successfully local stakeholders and their livelihoods engage with the protection of this unique wetland.

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Some of the 50-plus participants who attended the Axolotl Species/Habitat Action Plan Workshop, held at the Universita Autonoma Metropolitana at Xochimilco in December 2004. Participants are holding up the name plate of the trajinera that the Darwin Initiative project bought for CIBAC. © Ian G. Bride

ESSAY 11.9. MANAGING PROBLEMS OF OVER-EXPLOITATION AND TRADE IN AMPHIBIANS

To many cultures, amphibians are an important and commonly available source of protein. In some places, even tadpoles can be made into a local dish. The water-holding frogs in Australia store a reservoir of water in the bladder to last through the extended dry season and are used by the aborigines when no other source of water is available (Tyler 1976). Certain amphibians are also commonly used in traditional medicine. For example, in China, nine species of amphibians are listed in "The Great Pharmacopoeia" published over four hundred years ago. Up to 32 species are now recognized to be of medicinal value in traditional Chinese medicine (Ye *et al.* 1993). Some amphibians are also exploited to provide useful materials, like the poison from the various Poison Dart frogs for hunting and the skin of the Marine Toad for the leather industry in the Americas. Many exotic frogs, such as the colourful Mantellas (genus *Mantella*) from Madagascar, and a number of salamander species, are also collected to supply the pet trade. There is also quite a demand for frogs for use in the laboratory. And, in some countries such as Mexico, certain amphibians are used in witch craft and art crafts. Amphibians also play a role in shaping the local culture. For example, the Mexican Axolotl *Ambystomma mexicanum*, which has various mythological connections – the ancient Mexicans considered it the twin brother of Quetzalcoatl – has played an important role in the local communities around lakes in the Basin of Mexico (see Essay 2.3). There is even a frog festival in a branch of the Zhuang Minority in southern China.

These species survived centuries of traditional use and the 'edible frogs' remained common and widespread until commercial trade set in leading to a much larger level of exploitation that is often unsustainable. As early as the 1930s, Bourret (1942) noted the mass commercial trade of large edible frogs from Viet Nam into China. The collapse of populations of favourite 'frog legs' species in Asia shows that even in common, fast-growing and fecund species, such levels of exploitation are not without limit. Once depleted, the ecological functions carried out by these frogs are also hampered, which contributes to the outbreak of insect pests in rice paddies. The demand for amphibians is unlikely to diminish in the near future due to continual growth in human population and the increased purchasing power that accompanies growing economies. The resulting high collecting pressure often acts together with habitat destruction and degradation and poses a substantial threat to many amphibians. In China, for example, utilization adversely affects 84 species, some 30% of the amphibian fauna (Baillie *et al.* 2004).

The species hardest hit by over-exploitation are those that are rare, restricted or highly valuable. In recent years, a number of frogs and salamanders such as the Lao Salamander *Paramesotriton laoensis* (DD) and Kaiser's Spotted Newt *Neurergus kaiseri* (CR) have been subjected to commercial collection for pet trade at levels that are believed to have removed the majority of individuals from the wild (Stuart *et al.* 2006; Leahy 2006). Another example of a species hard hit by commercial exploitation, but for food, is the Chinese Giant Salamander *Andrias davidianus* (see Essay 4.7). This species, the largest amphibian in the world (adults can weigh more than 40kg) ranges widely in central and southern China and large populations once existed in many places. However, it is regarded as a delicacy and fetches a very high price. The species is particularly susceptible to over-harvesting because it is nearly fully aquatic and utilizes specific hiding places in clear mountain streams. Juveniles are also of marketable size and are collected as well as adults. Highly destructive methods, such as liming or the use of poison, are sometimes used to collect all the individuals in the stream. Individuals are also being collected as breeding stock in commercial farms. All these factors together with the long life-cycle make the Chinese Giant Salamander especially vulnerable to over-exploitation, and this Critically Endangered species has now disappeared from many areas, and a conservation action plan is urgently needed to reverse its decline.

Frog farming has gained momentum in many places and commercial feed is now available to feed the frogs and their tadpoles. These farms can make a positive contribution towards conservation if the supply from breeding farms substitutes for that from the wild, or if part of the income generated is directed back into biodiversity conservation. However, there remain challenges, including disease control within farms and the economic cost/benefit of farming efforts as a business activity (Kusrini and Alford 2006). One negative consequence of amphibian farming is that the American Bullfrog is one of the favourite species in many parts of the world. These animals often escape and become invasive, affecting the local ecosystem and biodiversity. In Mexico, for example, this species has been introduced into 16 of the country's 32 states. Most places actually have their own 'edible' frogs that are more suited to the local environment and are much better candidates for farming than exotic species. However, regardless of species, frog farming still runs the risk of transmitting diseases from captive frogs to those in the wild anywhere from the farm surroundings and transport routes to destination markets.

An alternative to farming and its associated problems is to explore options for sustainable use of local wild populations. The short life-cycle, high fecundity and high population size of many large frogs actually renders them quite resilient to certain levels of harvesting. If the requirements of the species concerned are known, and proper management is in place, these frogs can be harvested without affecting their population. There are examples in northern China where harvest of the Chinese Brown Frog *Rana chensinensis* (LC), a species used in traditional Chinese medicine, can be increased by providing breeding ponds and raising the tadpoles (Ye *et al.* 1993). Another example of sustainable use of amphibians is the harvesting of the grass frog *Rana forreri* (LC), which is a popular laboratory animal. These animals are harvested according to an annual quota and then exported to the United States. In Thailand and Indonesia, frogs (mainly *Hoplobatrachus rugulosus*, *Fejervarya cancrivora* and *Fejervarya limnocharis*) living and breeding in rice paddies, not only feed on crop pests but also are harvested for local consumption and export (Kusrini and Alford 2006). When combined with sustainable land-use practices, such as organic farming, this increases the economic gains, reduces or eliminates the need for and use of chemicals, and can bring additional conservation benefits to many other amphibians and wildlife. It might also provide an additional incentive to conserve their natural habitats in the case of non-commensal species.

To prevent unrestricted exploitation and possible extirpation of populations and species, several countries have implemented legislation that specifically regulates or prohibits the exploitation of particular amphibian species. Legislation usually also exists to protect particular natural areas as parks or sanctuaries, and amphibian populations inside such areas may be partly or completely protected by the regulations in force for the area. For species threatened by international trade, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is quite effective in regulating levels of trade and even in banning the commercial trade in highly threatened species (see Chapter 11). Adequate local legislations and enforcement is also needed as many amphibians are consumed locally. Wildlife trade is dynamic, and monitoring and reporting are important to provide an early warning system.

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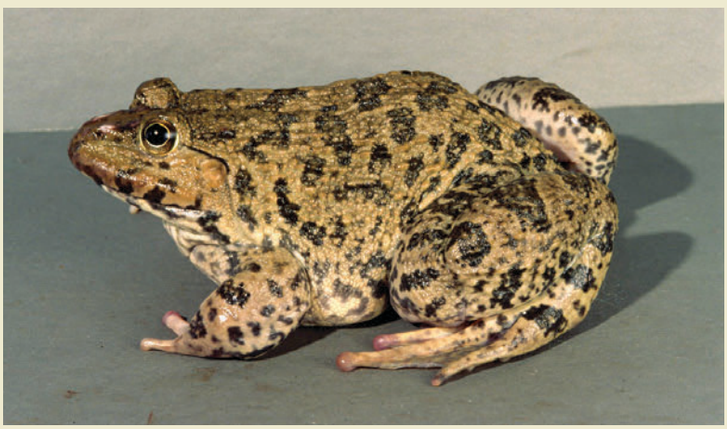

A farmed, market-bought Hoplobatrachus rugulosus *(Least Concern), the most common species used in the frog-leg trade in Asia, showing obvious signs of farm rearing, including bulbous toe-tips and transport damage behind the nostrils. © Peter Paul van Dijk, 1994-2000*

An assortment of local language frog-farming manuals for the rearing of Hoplobatrachus rugulosus *(in Chinese and Thai),* Rana catesbeiana *(Thai),* Paa *spp. (Chinese) and local ranids (Chinese). © CI/Peter Paul van Dijk, 2007*