The social context for conservation: amphibians in human-shaped landscapes

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Abstract

Many human-shaped landscapes support viable amphibian populations due to the habitats created and/or maintained as a consequence of human actions. The challenges and approaches required to achieve the persistence of amphibians in human-shaped landscapes are markedly different from approaches commonly applied in protected areas. Contrary to protected areas or natural landscapes where amphibian conservationists can have direct control over management, in human-shaped landscapes, management options are best approached through understanding local communities' values and socio-economic aspirations. However, consideration of the social aspects of amphibian conservation are vastly under-represented in the amphibian conservation literature. We propose that amphibian conservationists should: (i) assess the controllability of their mitigation actions for achieving long-term sustainability, (ii) understand the values and attitudes of individual landowners towards amphibians and amphibian-friendly management (local scale) and land stewardship on which amphibian conservation initiatives can be built (landscape scale), and (iii) understand the social and economic drivers of land-use change operating at regional levels, which is crucial for building adaptive potential in conservation programs. Since targeted amphibian conservation initiatives are limited in many human-shaped landscapes, consideration of the socio-economic context conducive to amphibian persistence is crucial.

Keywords: wildlife-friendly management, conservation policy, human development, biodiversity conservation, social sciences.

Introduction

Human destruction and modification of natural environments represents the greatest single threat to biodiversity (Maxwell et al. 2016). However, under certain conditions, human-shaped landscapes can support high biodiversity (Fischer et al. 2012). Examples include High Nature Value farmlands across Europe (Paracchini et al. 2008; Fischer et al. 2012) and Asia (Liu et al. 2013), and lands managed by indigenous communities across the world (Garnett et al. 2018). Common characteristics of these landscapes are widespread native vegetation cover and low-intensity human land use. In addition to the retention of native vegetation, in many instances, disturbance associated with land use (e.g. extensive farming, forestry practices, recreational activities) create and maintain valuable habitat features on which a variety of species depend (Halada et al. 2011). Given this dependence, conservation initiatives in human-shaped landscapes need to consider the socio-cultural and economic dimensions that maintain system characteristics favorable to biodiversity (Halada et al. 2011).

Amphibians are the most threatened vertebrate group, with declines primarily associated with habitat loss (Stuart et al. 2004). Yet, amphibians can thrive in human-shaped landscapes given sufficient breeding and terrestrial habitats and can be particularly abundant when breeding habitats are created as a by-product of land use. Examples of breeding habitats created and maintained by human actions include: low use unpaved roads, rice fields, stormwater ponds, irrigation ditches and canals, watering troughs for livestock, small ponds in military training areas, and small recreation ponds (Warren and Büttner, 2008; Curado et al. 2011; Chester and Robson, 2013; Hartel et al. 2014; Martinez-Abrain and Jimenez, 2016). Whether habitat features used by amphibians are intentionally created or are a by-product of human land use, the persistence of these habitats is closely aligned with the continuation of human activities from which they originate. However, land use practices are rapidly changing in many regions, with the socio-economic aspirations of inhabitants commonly oriented towards Western values and economic ideals (Milcu et al. 2014). Maintaining amphibian biodiversity in human-shaped landscapes requires understanding the socio-economic context conducive to their persistence (Forester and Machlis, 1996), and identifying development scenarios that can indirectly promote amphibian conservation by maintaining suitable land use practices.

The amphibian decline crisis has focused conservation efforts on preventing further declines and extinctions (reviewed by Scheele et al. (2014) and Garnett et al. (2018)). In general, there has been a focus on species-specific, targeted actions, with most examples from highly developed countries (e.g. Grant et al. (2019)). While the ecological and life-history basis of amphibian conservation is well-represented in the scientific literature, there are few studies on the socio-economic and institutional challenges associated with the long-term persistence of amphibian populations in human-shaped landscapes.

In this paper, we target the key knowledge gap surrounding the social dimensions of amphibian conservation in human-shaped landscapes. First, we discuss how conservationists can engage with local communities to enhance the effectiveness of management outcomes and assess the social realities around conservation actions. Engagement is needed at a local scale, with a focus on the values and attitudes of individual landowners towards amphibians and amphibian-friendly management actions, and the landscape scale, with a focus on land stewardship. We then turn our attention to the socio-economic drivers that shape system characteristics on which amphibians depend and social uncertainties driving landscape changes. We finish with a discussion of how to integrate the socio-economic considerations into amphibian conservation in human-shaped landscapes, highlighting possible tradeoffs and actions. Although our focus here is amphibians, the work is relevant to the broader challenge of biodiversity conservation in human-shaped landscapes.

The controllability of mitigation actions

The ecological principles for managing aquatic breeding amphibians are relatively well-known (e.g. Semlitsch (2000)) and include the control of invasive alien species (e.g. plants, predators, pathogens, competitors), hydroperiod management, and maintenance of adequate aquatic and terrestrial vegetation buffers around and between ponds. However, since human-shaped landscapes are social, as well as ecological constructs, a narrow, ecological and biological approach may be of limited practical use on its own for amphibian conservation. Amphibian conservationists should assess and understand their capacities to deliver various mitigation actions in order to evaluate whether such actions are sustainable and effective. Table 1 presents a number of mitigation measures for amphibians in human-shaped landscapes and proposes three levels of controllability for these mitigation actions for amphibian conservationists. In cases where conservation knowledge can be translated directly into actions (i.e. without engaging and/or considering the local communities), we refer to these conservation actions as being under the *full control* of conservationists (Caniglia et al. 2017). In cases when mitigation measures require some form of genuine support from the local communities, we refer to these measures as being under *participative control* (Caniglia et al. 2017). Finally, certain drivers of amphibian decline (e.g. climate change) cannot be controlled by amphibian conservationists at any scale. We refer to these as being under *no control* by conservationists (Table 1). Box 1 presents an example from Central Romania on the management of amphibian habitats, which was successful during the project lifetime but failed in the long-term due to institutional instability around the management of the protected area and low institutional involvement at the level of the local community. Communication with local communities and key institutions about the educational, intrinsic and instrumental values of amphibians can increase the overall acceptance of amphibians and this can facilitate the involvement of the local communities in conservation actions (Hocking and Babbitt, 2014).

Box 1. Decrease in amphibian pond quality due to institutional instability in Central Romania. This is an example of mitigation actions which requires long term participative control.

The Breite ancient oak wood-pasture is a protected area plateau of 133 hectares. Starting to 1970s, 15 major drainage ditches were dug to accelerate desiccation of marshy areas and increase the farmland surface. The pasture was heavily grazed with sheep (over 11 sheep/ha) up to 2004, after which grazing was reduced and then completely prohibited. Research carried out between 2006-2010 (Hartel, 2010) showed that the drainage ditches were the most stable habitats for the eight amphibian species reproducing in the area. In 2007, the custodian of the protected area installed barriers in seven of the major drainage ditches in order to increase the hydroperiod of the ponds for amphibians and decrease the water loss from the plateau. Furthermore, 50% of the dense vegetation (*Juncus* sp., *Carex* sp.) was removed from the ditches to increase the aquatic habitat diversity and reduce the biomass which would fill these wetlands. One of the authors (TH) was present in these activities as an amphibian consultant (Hartel, 2010). The project lasted four years and pond maintenance activities were carried out in partnership with schools, within educational projects run voluntarily with over 500 pupils mobilised for amphibian monitoring and pond maintenance activities. However, the continuation of amphibian and aquatic habitats monitoring, and maintenance took a dramatic turn in 2010, when a new protected area custodian took over management. Management shifted to a conventional forestry paradigm that considered the encroachment of trees and scrub, as well as the colmatation of the temporary ponds, as a natural part of ecosystem dynamics. Continuation of the amphibian conservation initiatives was also hindered by a conflictual relationship between the old custodian and the new custodian. The inability of the program to be maintained has resulted in a dramatic loss of small wetlands in just a few years. Today, more than 60% of the temporary ponds, including some drainage ditches, are no longer available for amphibians.

Key lessons learned from this project are: (i) Establish a genuine partnership with a broad range of local stakeholders and motivate their engagement through the project. (ii) Highlight the benefits for the partners of being engaged in habitat restoration works. (iii) As a protected area custodian, carefully prepare for situations when the administration may be taken over by another institution. This proactive preparation includes knowledge transfer and facilitating the formation of a local institutional network for the new custodian through which the local institutions which were engaged in previous restoration works can express their desire to continue such activities.

Understand landowner preferences for certain land-use types

Understanding individual landowner's management needs and goals, the extent to which they can influence the implementation of the management they desire, and the extent to which they would be willing to cooperate for amphibian habitat management activities, can help in implementing conservation measures (see Table 1 for actions with participative control). There are simple, low-cost measures controlled by landowners that can benefit amphibians and facilitate their persistence. Here, we explore local management options with a case-study of pond owners who use their ponds for recreational and/or economic purposes. Two habitat features of

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ponds that in part determine their suitability for amphibians, and depends to the pond owner's preferences, are the fish species present, and the level of aquatic vegetation. Several amphibian species can benefit from moderate levels of vegetation cover. For example, Hartel et al. (2009) found that the abundance of *Rana dalmatina* is highest at circa 50% of reed cover in human-made permanent ponds, while Oldham et al. (2000) found that *Triturus cristatus* pond occupancy was highest in ponds with 25-50% reed cover and 50-75% of submergent vegetation cover. Furthermore, research shows that introduced predatory fish negatively affect amphibians (Hecnar and M'Closkey, 1997; Bucciarelli et al. 2014). However, pond owners may be reluctant to allow excessive vegetation cover in their ponds and they may prefer to stock their ponds with predatory fish species such as bass, catfish, and bluegill (Masser and Schonrock, 2006), that have detrimental effects on amphibians. Research on what drives the preferences of pond owner and their understanding of how their choices impact amphibians is currently scarce in the amphibian conservation literature. Knowledge on this, as well as identification of governance networks and key stakeholders (Nita et al. 2018; Rozylowicz et al. 2019) would help implementing efficient conservation at the local scale, and also contribute to policy development with relevance for amphibian conservation.

Build on existing landscape stewardship initiatives

Landscape stewardship can be broadly defined as "efforts to create, nurture, and enable responsibility in landowners and resource users to manage and protect land and its natural and cultural heritage" (Brown and Mitchell, 2000). It has been recently emphasized several landscape elements with high natural values can be created and maintained by stewardship (Brown and Mitchell, 2000; Plieninger and Bieling, 2012; Chan et al. 2016; Raymond et al. 2016). Understanding and building on land stewardship forms is another level of participatory control for conservation actions (Table 1). An example of land stewardship which is beneficial to the conservation of endangered amphibian species is the case of the endangered *Ambystoma californiense*, which is commonly found in human-shaped landscapes in California (Huntsinger and Oviedo, 2014). Cattle ranching can play a key role for this species by facilitating key metapopulation processes (dispersal, colonization) and maintaining breeding habitats at a landscape scale (Pyke and Marty, 2005) (Figure 1A). Ranchers have shown interest in being involved in pond restoration activities for rare amphibians, and these actions have been encouraged and facilitated by regulatory agencies (Huntsinger and Oviedo, 2014; Smith et al. 2018). However, livestock grazing is not always amphibian friendly and is context-dependent. In other regions, like Australia, sheep and cattle grazing can destroy vegetation in ephemeral wetlands used by amphibians, so wetlands are sometimes fenced to exclude stock (Figure 1B) (Jansen and Healey, 2003). Identifying knowledge and management approaches that achieve both conservation and agricultural goals can be used to maintain optimal habitats for amphibians (Fischer et al. 2012). For example, Molnár et al. (2016) found several overlapping visions and objectives between herders and conservationists regarding the management of biodiversity-rich pastures in Hungary, including the maintenance of pasture surface by extensive grazing, maintenance of scattered woody vegetation across the pasture and the control of scrub encroachment. Furthermore, there was an agreement between herders and conservationists regarding the controlled maintenance of wetlands across the pasture, although for different purposes (Molnár et al. 2016). Some of the management practices favored by both herders and conservationists (e.g. cattle grazing, maintenance of wetlands) are important for sustaining amphibian populations.

Understand socio-economic drivers that shape the future of amphibian habitats

In some contexts, population viability modeling and decision analysis provide valuable tools for projecting future populations states (Converse and Grant, 2019; Davis et al. 2019). However, in many human-shaped landscapes these approaches may have limited practical applicability, particularly where natural and cultural values are threatened by various economic interests and conflicts between stakeholders regarding nature conservation goals are common (Hartel et al. 2019). Furthermore, in certain cultures (e.g. the human-shaped landscapes of Eastern Europe), biodiversity represents a topic of little interest for influential stakeholders. Still, stakeholders may be interested and motivated to participate in discussions when natural capital is considered in connection with the social and economic drivers of land use change and subsequent consequences for key ecosystem features relevant for amphibians (e.g. wetlands, humid habitats) (Oteros-Rozas et al. 2015). Even if conservationists have no direct influence on these drivers (i.e. have no direct, nor participative control over them), understanding them can help in identifying the major barriers and opportunities for amphibian conservation. For example, stakeholders from Central Romania expressed concerns regarding the abandonment of traditional cattle and buffalo grazing, which results in scrub encroachment (Hanspach et al. 2014; Hartel et al. 2014). Changed livestock grazing regimes and scrub encroachment are also associated with a decrease in temporary pond duration and pond loss, reducing the quality of amphibian aquatic habitats (Pyke and Marty, 2005). In such circumstances, the key to managing amphibian habitats is to focus on system drivers that create and maintain amphibian habitats that are socially desired (e.g. maintaining land use forms which are preferred by the local community and are optimal for amphibians), rather than directly focusing on amphibians, for which there is low community interest. Participatory scenario planning can build on the diverse types of human needs, perspectives, values, interests, intents and goals of different stakeholders and integrate these into the decision-making process relevant for landscape planning and amphibians (Peterson et al. 2003; Oteros-Rozas et al. 2015; Abson et al. 2017). An optimistic example comes from Central Romania where participatory scenario exercises (Hanspach et al. 2014) and subsequent workshops (Nieto-Romero et al. (2016), see also https://leveragepoints.org/author/lottemlutz/) showed that participants favored a scenario that simultaneously maintained biodiversity and productivity ('Balance bring beauty') (Hanspach et al. 2014), which would indirectly maintain amphibians.

Improving amphibian conservation outcomes in human-shaped landscapes

One constant in human-shaped landscapes is that human land use practices (including abandonment) will continue to play a crucial role in influencing biodiversity values. The dependency of amphibians on many human-made habitat elements highlights the need for an integrated approach to amphibian conservation in these landscapes. Thus, in addition to employing biological and ecological sciences, amphibian conservationists should embrace the social context when implementing amphibian conservation actions.

Integration of socio-economic dimensions into amphibian conservation in human-shaped landscapes has a range of benefits. First, considering the socio-economic and cultural dimensions of land use allows evaluation of the feasibility and long-term success of amphibian conservation actions. Such dimensions range from the value systems existing at the level of the local community regarding biodiversity in general and amphibians in particular, various socio-economic (i.e. human population dynamics, technological capital, economic profitability, legislation, regional and global markets) and environmental (e.g. climatic conditions) drivers of land use and amphibian habitat quality. Second, integration of socio-economic dimensions opens opportunities for new types of collaborations with experts working in other academic disciplines (e.g. economics, anthropology, ethnography, sociology) and non-academics (e.g. landowners, various stakeholders). These are unique opportunities for developing a transdisciplinary lens and applying a systems thinking approach to social-ecological system (e.g. Hartel et al. (2019)), within which amphibian conservation efforts occur. Finally, integration of socio-economic dimensions opens opportunities for amphibian conservationists to participate in policy-relevant discussions to promote land use types which are beneficial for amphibians.

Conclusions

The conservation of amphibians in human-shaped landscapes requires a genuine understanding and involvement of human societies. When the human dimensions of social-ecological systems are combined with thorough ecological knowledge of amphibian biology, there are genuine opportunities to manage for the persistence of amphibian populations in human-dominated landscapes, even as drivers of change reshape various elements of the systems. This necessary shift in our approach requires interdisciplinary collaboration between the natural and social sciences and transdisciplinary approaches to involve non-academic sectors in conservation strategies. Future, successful amphibian conservation in humans shaped landscapes will mean that conservationists and land managers are able to harmonize the various social, economic and environmental drivers that shape the persistence of biodiversity in human-shaped landscapes.

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Table 1 Main threats to amphibians, the proposed mitigation measures at local and landscape levels and the level of control of the implementation of mitigation measures by amphibian conservationists in human-shaped landscapes (No control, Participative control, Full control, see text for description). The table also presents social consideration relevant to various mitigation measures.

Threat	Mitigation measures	Controllability of interventions by conservationists	The social aspects of mitigation in human-shaped landscapes
Climate change	Global: Reduce greenhouse emissions	No control	
	Local: Decrease the drainage of wetlands, restore wetlands	Participative control	• Understand the extent at which local communities perceive drought as a socio-economic issue • Establish restoration projects in partnership with the local community
Acidification	Global: Reduce industrial pollution	No control	
	Local: in severe situations add lime to neutralize	Full control	• Experts and non-academic stakeholders apply lime in wetlands to neutralize its acidity
Habitat degradation, loss and fragmentation	Restore degraded habitats, maintain optimal habitats, reduce fragmentation by providing dispersal corridors	Participative control	• Understand the social drivers of land cover persistence and change at local and regional scales • Understand landscape stewardship forms and explore the ways which amphibian conservation can be mainstreamed in these • Create alternative scenarios and use backcasting methods to design medium-long term amphibian participative conservation strategies

Threat	Mitigation measures	Controllability of interventions by conservationists	The social aspects of mitigation in human-shaped landscapes
Introduction of predatory fish	Removing fish, education	Participative control	• Understand pond owner's preferences for certain fish species • Understand the attitude of pond owners towards amphibians • Explore ways to promote a ponds management which works for owner as well as for amphibians
Water contamination	Promote organic agriculture and discourage the use of pesticides	Participative control	• Understand the motivations and the socio-economic constrains determining the implementation of conventional farming practices • Join or initiate initiatives to establish environmentally friendly farming
Road kills	Restrictions of traffic, tunnels, etc.	Full control	• Advocate the inclusion of efficient mitigation measures in the road construction plans/build new infrastructure in order to facilitate migration and dispersal
Alien species (predators, competitors, habitat modifiers)	Eradicate or contain the spread of alien species	Participative control	• Understand the pathways of alien species establishment (deliberate or accidental introduction) • Explore ways with landowners to eradicate or control alien species
Reduction in the number of available temporary ponds for breeding	Promote traditional watering practices that will benefit also amphibians Promote amphibian friendly grazing	Participative control	• Explore the socio-cultural and economic challenges and opportunities of traditional farming • Understand how environmentally friendly farming practices can be mainstreamed into existing landscape stewardship initiatives

Threat	Mitigation measures	Controllability of interventions by conservationists	The social aspects of mitigation in human-shaped landscapes
Human consumption (frogs as food)	Regulate collecting frogs from the wild	Participative control	• Understand the socio-cultural and economic importance of amphibians as food and financial resources (including pet trade) for the local communities. • Understand how local communities perceive the vulnerability of amphibians to harvesting. • Develop regulatory processes for amphibian harvesting together with the local communities if needed. • Inform pet owners of the risks associated with releasing captive animals in the wild.
Pet trade (collecting from the wild and risk of pathogen and parasite transmission).	Regulations and enforcement, education	Participative control	

Figure 1. A stock pond near San Francisco, California. Ranching maintains perennial and ephemeral ponds in this region. Removing people and their livestock from these rangelands degrades the quality of these habitats and negatively affects endangered amphibian species (photo A: credit Sheila Barry). In contrast, in Australia, sheep and cattle grazing can destroy vegetation in ephemeral wetlands used by amphibians, and wetlands are sometimes fenced to exclude stock (photo B).