Efficacy of Emerging Infectious Disease Interventions in Wildlife

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**Abstract**

**Introduction**

As humans continue to destroy habitat, utilize natural resources, alter global climate regimes, hunt unsustainable populations, and introduce invasive species and pathogens, the rate of population declines and extinctions has increased so significantly that we are entering the sixth mass extinction (for review, see Barnosky et al. 2011). While threats such as loss of habitat and climate change are established drivers of biodiversity loss (Travis 2003), infectious diseases are increasingly becoming recognized as threats to wildlife biodiversity (Smith et al. 2006). Although human diseases have been well studied since the advent of modern medicine, comparatively little is known about the ecology and epidemiology of wildlife diseases (Daszak 2000).

Diseases in plants and animals are typically defined by the impairment of normal bodily or behavioral functions, particularly when the result is a specific set of deleterious symptoms (Delahay et al. 2008). Parasites and pathogens are the primary agents of chronic and acute disease, respectively, and both affect hosts by altering normal physiological processes and/or host behavior. These adverse effects frequently lead to declines in growth rates and reproductive success, as well as increases in mortality at the population level (Hudson et al. 2002). Epizootic and especially enzootic diseases are often limited to sub-lethal effects within infected populations (Delahay et al. 2008). However, these sub-lethal affects are highly influential in complex communities over extended time periods of time, for example by modifying the structure and demography of ecological communities (Wood et al. 2007) and driving evolutionary change within the communities (Clayton & Moore 1997). Of course, some emerging infectious diseases can cause wildlife population declines that occur rapidly, particularly when spreading into naïve populations (i.e., those that have not previously come into contact with the pathogen) (McCallum 2012). In some cases, declines are so severe that they lead to extirpation of local populations or actual extinctions (Wake & Vredenburg 2008).

In recent decades, a variety of emerging infectious diseases have definitively caused the declines of multiple animal taxa. Moreover, the number of emerging infectious diseases, as well as the number of extirpations and extinctions resulting from their spread, has increased significantly (Daszak et al. 2000; Fisher et al. 2012). Some of the more well-known examples include chronic wasting disease in North American deer (Gross & Miller 2001), sylvatic plague in North American rodents (Cully et al. 2010), West Nile virus in North American birds (LaDeau et al. 2007), canine distemper virus in African dogs (Alexander & Appel 1994) and lions (Roelke-Parker et al. 1996) and North American rodents (Williams et al. 1988), white-nose syndrome in North American bats (Frick et al. 2010), and chytridiomycosis in amphibians worldwide (Berger et al. 1998). While most of these severe outbreaks have occurred in North America, this bias may due to the fact that these diseases were enzootic and causing only sublethal effects in European and Asian populations, but caused higher mortality when introduced into naïve North American fauna. One important detail to note in all of these cases is that these disease outbreaks have occurred in nearly all animal taxa. Additionally, taxa that have not yet been as severely impacted by infectious diseases, reptiles for example, are clearly vulnerable to pathogens that have the potential to cause substantial declines in the future (e.g., snake fungal disease, Allender et al. 2015).

To make this issue more compelling to a public audience, about 60% of emerging infectious disease events from 1940 to 2004 have been zoonotic in nature and 72% of these diseases originated in wildlife (Jones et al. 2008), including avian flu (Shinya et al. 2006), swine flu (WHO, 2009), Ebola virus (Leroy et al. 2004), and HIV (Gao et al. 1999). This is suggestive of the dangers that humans as a society face if we do not proactively seek solutions to infectious diseases in wildlife. The surge in frequency and severity of wildlife disease epidemics recently should be considered ample evidence for the need to implement methods of controlling these outbreaks both before and after they occur. Fortunately, successful efforts have been made to control existing outbreaks of infectious diseases (e.g., successful vaccinations for rabies: Cleaveland et al. 2006; Freuling et al. 2013), research on disease interventions is being conducted (e.g., treating infected amphibians with probiotics: Harris et al. 2009), and laws are being passed to prevent the spread of infectious pathogens into naïve populations (USFWS, 2016). This review assesses the current state of the efficacy of emerging infectious disease interventions across taxa, and seeks to predict whether current strategies successfully mitigate population declines in wildlife due to infectious diseases.

**Methods**

**Results**

**Discussion**

**Literature** **Cited**

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**Figures**