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Addressing the needs for improving classical biological control programs in the USA

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HIGHLIGHTS

- Biological control is a cost-effective means to control invasive species.
- Political and regulatory hurdles often impede classical biological control programs.
- These hurdles impact the discovery, pre-release, and post-release monitoring stages.
- Recommendations to improve the programs are outlines for seven areas in the process.

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ABSTRACT

For years, the development of classical biological has proven to be the most cost-effective and environmentally safe management tool for invasive species. Despite this, in the United States there are a number of political, regulatory and institutional challenges associated with the discovery stage, pre-release phase, and post-release monitoring that have restricted the full potential and the long-term success of many classical biological control programs. Among these needs, we provide recommendations for improved prioritization of specific projects, funding concerns, source countries issues, benefits sharing of biological control agents, shipping live agents, regulatory requirements and procedures, and engagement with the environmental community. We believe these recommendations and potential solutions will significantly improve the future effectiveness of classical biological control programs for the management of invasive species within the United States.

1. Introduction

It is well recognized that not all classical biological control programs are successful. Many imported natural enemies fail to establish and those that do establish may not provide suppression of the target invasive species. Mills (2014) reports an establishment rate of 35% for imported predators and parasitoids of invasive insect species, but an overall success rate of only 14.5%. The establishment rate and success rate was much higher for entomopathogens. Van Driesche et al. (2010) reported only 27% of the invasive plant programs were considered successful. While classical biological control may pose potential risks to non-target organisms and critical ecosystem processes (Carruthers and D'Antonio, 2005; Hoddle, 2004; Lockwood et al., 2001), in practice there have been very few examples where biological control programs have resulted in seri-

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ous unintended environmental consequences (van Lenteren, 2001; Suckling and Sforza, 2014). Nevertheless, a better understanding of the potential ecological impacts of biological control efforts may be used to maximize implementation while minimizing potential risks to the environment (Carruthers, 2004).

There are many examples of successful classical biological control programs with significant long-term economic and public health benefits (Greathead, 1995; Julien et al., 2012; McFadyen, 1998). While classical biological control programs do not always reduce the invasive pest species population levels below an acceptable damage threshold, they may successfully suppress the general equilibrium level of the pest population or reduce the rate of spread of the invasive species, and provide a tool that can be integrated into an effective pest management system (Table 1).

2. Economic impact of biological control programs

Among the various control options for invasive species, effective biological control may be the only option for achieving affordable and sustained management, particularly for widely dispersed pest species. Numerous studies have demonstrated a strong economic justification for utilizing biological control, particularly for agricultural invasive species. For example, McFadyen (2007) reported an annual benefit:cost ratio of 23:1 from an economic impact assessment of all weed biological control programs undertaken in Australia from 1903 to 2005. This analysis included both successful and unsuccessful programs. Thus, for every dollar spent on biological control, there was a net benefit of $23 (AD) not expended saved over time. McFadyen recommended that an economic analysis of biological control efforts should be undertaken as an integral part of any program. While the direct costs of classical biological control are often considered to be favorable when compared to other methods, indirect costs also need to be considered, including expenses for pre-release studies, post-release monitoring for efficacy and potential impacts on non-target organisms, and the delay in achieving control after release (Howarth, 1991). However, even if these indirect costs are accounted, biological control usually has a very favorable cost-benefit ratio.

In the United States, economic analyses have been conducted for some individual biological control programs. For example, two insects, the cinnabar moth (*Tyria jacobaeae* L.) and the ragwort flea beetle (*Longitarsus jacobaeae* Waterhouse), were released for the management of tansy ragwort (*Senecio jacobaea* L.), and invasive plant in Oregon and California. In Oregon alone, there was an estimated annual benefit of more than $5 (USD) million, and a minimum benefit:cost ratio of 13:1 (Coombs et al., 1996; de Lange and van Wilgen, 2010). This cost savings was calculated based on three factors. First, the plant contains pyrrolizidine alkaloids known to be poisonous to all animals. Losses to livestock after introduction of the biological control agents were reduced by 90%, resulting in a $3.7 million a year savings. Second, pasture productivity increased by $1.3 million a year. Third, herbicide use decreased by nearly $1 million a year.

The ash whitefly, *Siphoninus phillyreae* Haliday, caused dramatic defoliation of urban ornamental trees throughout California (Paine et al., 2003). The whitefly also produced a sticky substance that covered sidewalks, lawns, vehicles, patio furniture, carpeting, draperies, and windows reducing the overall quality of life in many

Table 1
Limitation and challenges to biological control, and the potential solutions and recommendations to these challenges.

Limitation to biological control	Challenge	Potential solutions and recommendations
Prioritizing biological control projects	Develop transparent criteria to prioritize those invasive species for which classical biological control is the most cost-effective control option	Better understand potential range and impacts of invasive species, expand expertise in systematics, consider potential conflicts of interest in biological control efforts, determine what non-target species are relevant and important in the evaluation process, and establish protocols for prioritizing biological control projects
Funding for identifying new biological control agents, undertaking foreign exploration, pre-release screening, and monitoring post-release	General shortage of funds for identifying candidate biological control agents in their native range, undertaking foreign exploration, screening and post-release monitoring	Other opportunities for support may become available by utilizing IPM strategies, and expanding post-release monitoring and long-term stewardship practices. Pool resources with other stakeholders through the development of consortia
Source countries	Political instability of source countries	Improve collaborations with regional and local scientists to increase opportunities for discovering potentially effective biological control agents. Consider importing biological control agents from a secondary county that has previous imported the biological control agent
Access and benefits sharing of exotic biological control agents	Countries have developed restrictions to protect indigenous genetic resources	Work with legislators and international organizations to improve the availability of biological control agents from foreign countries. Separate the issue from pharmaceuticals derived from natural products to focus on managing invasives for public good
Shipping live biological control agents	Difficulties in shipping live biological control agents from the countries of origin	Encourage US agencies to continue their efforts to streamline shipping and entry requirements for the importation of biological control agents approved for testing
Regulatory requirements and procedures	Cumbersome regulatory requirements and procedures including obtaining timely approval for importation and release of biological control agents in US	Institute a risk/benefit analysis in the regulatory decision-making process. Establish a defined process and timeline for the approval or disapproval to release new biological control agents, improve communications between decision-making federal agencies and petitioner, and review federal and state permitting requirements to improve the implementation of biological control
Environmental community concerns regarding the release of non-native biological control agents	Inadvertent consequences for native plant and animal species, potential host shifts, etc.	Minimize conflicts by improving interagency cooperation that leverages resources of traditional partner agencies and stakeholders at all stages of the biological control project, from initial exploratory efforts to field implementation and post-release monitoring