• Invasive Species Advisory Committee

Control and Management Subcommittee Proposed White Paper

Addressing the Needs of Classical Biological Control Programs

Preface

Federal agencies are tasked with the responsibility of preventing the introduction of invasive species and, if required, responding to the introduction of an invasive species through eradication efforts. However, there are numerous examples where invasive species have become widely established despite the best efforts of federal agencies. For example, red imported fire ants (*Solenopsis invicta*), quagga and zebra mussels (*Dreissena* spp.), leafy spurge (*Euphorbia esula*) and downy brome (*Bromus tectorum*) are so widely distributed that it is currently not feasible to manage even a fraction of the infested area cost-effectively. Yellow starthistle (*Centaurea solstitialis*) is considered the second most invasive plant in the United States (US), infesting about 18 million acres in the western states (Duncan et al. 2004). In California, only about 1% of the total infested area is treated with a herbicide due to the high cost (apps.cdpr.ca.gov/ereglib/).

Many control options for invasive species may pose risks to desirable species. For example, insecticides may impact natural enemies (predators and parasitoids) or pollinators. Even relatively selective herbicides may injure native plants growing alongside the target invasive weed (www.epa.gov/pesticide-registration/conventional-reduced-risk-pesticide-program). Furthermore, herbicide applications may increase the competitive ability of some invasive plants or provide growth opportunities for other invasive plants, thus allowing them to become even more abundant (DiTomaso et al. 2006, Rinella et al. 2009). In wildland ecosystems, classical biological control is the primary management option that is applicable over the entire invaded range, sustainable over the longer term, economically viable, and environmentally sound. Introduced invasive species generally escape from their associated natural enemies. Classical biological control agents can achieve a population balance through parasitoid-host, predator-prey or herbivore-plant relationships that result in a stable, long lasting pest population.

Not all classical biological 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 serious 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).

Biological Control

Biological control is defined as the action of natural enemies (herbivores, parasites, predators or pathogens) in lowering another organism's abundance and then maintaining it at a lower average than would occur in their absence (DeBach 1964). Biological control is divided into three types: classical, augmentative or inundative, and conservation or enhancement. Classical biological control involves the importation and release of exotic natural enemies for the control of an established invasive pest species. The main premise of classical biological control is to reunite the pest species with its coevolved natural enemies. 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, McFayden 2000). 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. Augmentative biological control is the release of mass-reared or cultured natural enemies to augment natural enemy populations or inundate pest populations with natural enemies, particularly when the target species occurs in confined spaces (e.g., greenhouses, ponds, etc.). Since the first published study of augmentative biological control by Speyer (1930), augmentative biological control has been applied both experimentally and commercially to a large number of pest systems with varying degrees of success (Collier and Van Steenwyk 2004). Conservation biological control involves practices that enhance the survival and impact of existing natural enemies. Examples include reducing pesticide use or using selective pesticides to conserve natural enemies, and manipulating the habitat by maintain weedy borders or provide flowering cover crops to enhance the performance of natural enemies.

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. Economic analyses of biological control programs for wildland invasive species are more complex because of the need to account, in monetary terms, for factors not directly related to market values, such as increased biodiversity or other ecosystem services (Costanza et al. 1997). In addition, biological control may have inherent benefits (i.e., little or no impact on non-target species) compared to other control methods that may cause negative secondary effects.

Despite the challenges in conducting economic analyses for biological control programs, McFayden (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 gain of $23 dollars saved over time. McFayden 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 taken into account, biological control usually has a very favorable cost-benefit ratio.

In the US, economic analyses have been conducted for some individual biological control programs. For example, two insects, the cinnabar moth (*Tyria jacobaeae*) and the ragwort flea beetle (*Longitarsus jacobaeae*), were released for the management of tansy ragwort (*Senecio jacobaea*), an invasive plant in Oregon and California. In Oregon alone, there was an estimated annual benefit of more than $5 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 and 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*, 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 urban areas. A parasitoid wasp, *Encarsia inaron* (initially identified as *E. partenopia*), specific to the whitefly was released and quickly became established throughout the state. Within one year of its release, the whitefly population in the city of Riverside declined 10,000-fold (Bellows et al. 1992). *Encarsia inaron* had a similar affect across the remainder of the state and is likely to suppress this whitefly for decades into the future (Pickett et al. 1996, Pickett and Wall 2003). For the relatively small investment in the biological control program of $1.2 million, within a decade the total estimated benefits were between $324 and $412 million and are continuing to accrue benefits (Jetter et al. 1997, Paine et al. 2003).

Limitations and Challenges for Establishing Biological Control Programs

Despite the economic and environmental benefits of classical biological control, practitioners face a complex set of challenges that must be addressed to ensure that biological control remains a viable and sustainable pest management strategy in the future. Challenges to biological control include (not in rank order): 1) a need to develop transparent criteria to prioritize which invasive species will be the target of federal, state and university biological control efforts, 2) a general shortage of funds for identifying candidate biological control agents in their native range, undertaking foreign exploration, pre-release screening and post-release monitoring, 3) the political instability of countries in the native range of invasive pests, 4) access and benefits-sharing issues with countries that are the source of the exotic biological control agents, 5) difficulties in shipping live biological control agents from the countries of origin, 6) cumbersome regulatory requirements and procedures and 7) environmental and social community concerns regarding the potential negative aspects of introducing exotic biological control agents (e.g., inadvertent consequences for native plant and animal species, potential host shifts, etc.).

<u>Transparent Criteria to Prioritizing Biological Control Projects</u>

There is a critical need to develop transparent criteria to prioritize which invasive species will be the target of biological control efforts. This will require 1) a better understanding of the potential range and negative impacts of invasive species and benefits of control, 2) expanding national expertise and training in systematics to enable better evaluation of invasive species of concern and the potential biological control agents to be considered for use, 3) assessing potential conflicts of interest (e.g., a target weed such as yellow starthistle, because of its nectar and pollen producing capabilities, may be beneficial to the beekeeping industry, but is devastating to the cattle industry and potentially lethal to horses), 4) evaluating non-target native and introduced relatives of the target species, including economically important relatives, and threatened and endangered relatives (high numbers of important relatives to a target species increases the regulatory hurdles of registration) and 5) establishing protocols and procedures for gathering and disseminating information used to prioritize biological control projects and activities. Such prioritization activities are already underway for some weed species. For example, USDA-ARS conducts community-based assessments in allocating internal base funds to support both domestic and foreign USDA laboratories for priority biological control funding (for the plant protection program, see http://www.ars.usda.gov/research/programs/programs.htm?np_code=304&docid=17895).

<u>Funding for Identifying New Biological Control Agents, Foreign Exploration, Pre-release Screening and Post-release Monitoring</u>

Despite many successes, funding for classical biological control projects continue to be difficult to obtain and few funding programs will consider providing sufficient support to conduct a program in its entirety. By increasing the scope of biological control efforts to include adoption of Integrated Pest Management (IPM) strategies, expansion of post-release monitoring, and including long-term stewardship practices (see Invasive Species Advisor Committee, Biological Control White Paper entitled “Enhancing the Effectiveness of Biological Control Programs of Invasive Species by Utilizing an Integrated Pest Management Approach” for more information), other opportunities for support may become available. These include the Agriculture and Food Research Initiative (AFRI) Foundational and Challenge Area Programs, and other National Institute of Food and Agriculture (NIFA) programs such as Crop Protection and Pest Management – Applied Research and Development Program. Furthermore, by pooling resources with other stakeholders through the development of consortia, sufficient resources can be generated to fund more comprehensive biological control programs that include, among other aspects, a more integrated management approach and extensive post-release monitoring to assess the effectiveness of the program.

<u>Political Instability of Source Countries</u>

The political instability of some countries where potential sources of new biological control agents may be located is a problem for biological control practitioners and their foreign cooperators. Political unrest, such as that occurring in a number of Latin and South American, Eastern European, Middle Eastern and African countries, often makes it difficult or impossible for foreign researchers to enter or operate effectively and safely in these countries during exploration efforts for potential biological control agents. For example, Canada thistle (*Cirsium arvense*) is native to Afghanistan, Iran and Pakistan, counties with a high-risk profile for visitors.

The complex political situation complicates exploration efforts for potential biological control agents. Improved collaboration with regional and local scientists would increase opportunities for discovering potentially effective biological control agents where political instability is a problem. A viable alternative to foreign exploration in high-risk counties is to import biological control agents from a secondary country that has previous imported the biological control agent from a high-risk country. For example, alligatorweed thrips (*Amynothrips andersonii*) from Argentina was tested for control of alligatorweed in Australia. However, regulations in Argentina prohibited further export of the insect and, as a result, New Zealand scientists worked with Australian authorities to obtain the thrips for similar testing on alligatorweed control. Sharing of potential biological control agents was a common practice in the past, but regulations have since become very restrictive and it is increasingly difficult to share agents with other scientists.

Access and Benefits Sharing of Exotic Biological Control Agents

Many countries have signed the Convention on Biological Diversity (CBD), which is designed to protect indigenous genetic resources and rights to derivative benefits. The Nagoya Protocol, an international agreement governing Access and Benefit Sharing (ABS) of genetic resources under the CBD, entered into force on 12 October 2014, although the US is not yet a signatory. Although much of the discussion has focused on resources that can be commercialized (e.g., pharmaceuticals derived from natural products), the guidelines will ultimately also cover the collection of natural enemies for importation and use in classical biological control programs typically conducted by public agencies for the public good. Exploration, collection and export of natural enemies are already problematic in some countries due to restrictions on export of genetic resources, and there is the potential for new ABS processes to increase the scope of restrictions in ways that will negatively impact the global biological control community.

To address this issue, the International Organization for Biological Control of Noxious Animals and Plants Global Commission on ABS produced a position paper (Cock et al. 2010) for the Food and Agriculture Organization (FAO). In this document, the commission made recommendations for facilitating the collection and exchange of biological control agents, and urged biological control leaders in each country to enter into discussions with their national ABS negotiators to preserve the availability of biological control as a pest management option.

Shipping Live Biological Control Agents

Some commercial carriers have adopted a policy of excluding live biological control agents from international shipments, although this policy may differ between countries. Much of this reluctance to ship living biological control agents may have resulted from the old Animal and Plant Health Inspection Service-Plant Protection and Quarantine (APHIS-PPQ) shipping label, which read, "Live Plant Pest and Plant Pathogens." APHIS-PPQ has helped improve the situation by changing the shipping labels to read "Living Regulated Organisms." However, it is still unclear how much this change has helped improve the situation. APHIS-PPQ has been working with commercial carriers to standardize the types of packaging, shipping label positions on the package, and the types of information required on the shipping label. The process has been streamlined in recent years and hand-carry is now possible again. However, the process of shipping living biological control agents remains complicated, including the hand-carrying of packages on international airline flights. Not only do international airlines prohibit the carrying of living insects in cabin baggage, but also the Department of Homeland Security (DHS) requires 21 days advanced notice of incoming hand-carried shipments.

Regulatory Requirements and Procedures

One of the greatest challenges for classical biological control efforts is obtaining timely approval for importation and release of biological control agents. Since 2001, there has been a major shift in the permitting policies and permits that are currently required for 1) importation for research, 2) importation and interstate movement of "not fully established" and "fully established" biological control organisms, and 3) proposed introduction and release of biological control organisms new to North America.

Obtaining permits for the movement of biological control agents across state lines can take considerable time and effort to secure and is just one of the regulatory challenges facing biological control practitioners. For some pest species, successful biological control may already be developed in one region of the US, but not yet approved or implemented in another part of the US. An example is the *Diorhabda* leaf beetles on saltcedar (*Tamarix* spp.). Initially, the beetles were approved for release in the US only in areas allopatric with the range of the endangered southwestern willow flycatcher, *Empidonax traillii extimus*, but not in saltcedar areas sympatric with the bird populations. However, as a result of lawsuits filed by two environmental groups in 2009 against the APHIS and the US Fish and Wildlife Service (FWS), a USDA-PPQ Moratorium on Biological Control of saltcedar was subsequently invoked in 2010. This action terminated APHIS-PPQ saltcedar biological control program in 13 states, discontinued new permits for field cage or greenhouse studies of the leaf beetles outside of a containment facility, and discontinued new permits and cancelled all active permits for interstate movement and field release of *Diorhabda* spp. However, because APHIS-PPQ does not have jurisdiction over the movement of *Diorhabda* beetles within a state, beetle redistribution efforts against saltcedar are continuing in states such as Colorado and Texas.

There is considerable consternation among scientists over the poor communication between agencies regarding biological control applications, as well as the confusing and continually changing regulatory requirements. Researchers have highlighted subjectivity and a lack of transparency in some regulatory decisions concerning biological control agents. In addition, there are often inconsistencies in regulatory decisions that allow the release of some agents, but not others. Biological control programs would benefit greatly if a holistic risk/benefit analysis were incorporated in the regulatory process (Paynter et al. 2015). Based on perceived risk, no matter how small, the regulatory protocol of not considering the potential benefits of the natural enemy has resulted in the loss of access to potentially useful biological control agents (Hinz et al. 2014). Biological control agents that have been found to be host-specific and pose little or no risk to non-target species by the Technical Advisory Group for Biological Control Agents of Weeds (TAG) and USDA-APHIS may still not be approved for release by FWS based on the possibility of potential adverse effects to threatened and endangered species (Hinz et al. 2014). Delays of several years, after all requested data has been collected, collated and submitted, are not uncommon. Delays have prevented funding by private stakeholder groups and federal granting agencies because of uncertainties that the research will ever be completed if a permit is not already in place before research is initiated. These delays are, in part, the result of the inherent tendency of government agencies to respond in a risk-averse manner and to decline to make decisions.

Environmental Community Concerns Regarding the Release of Non-native Biological Control Agents

The threat of lawsuits by environmental groups, particularly where biological control releases are perceived to have potential for deleterious interactions, can greatly influence the decision-making process, regardless of whether there are scientifically valid issues or arguments. Such issues may also create barriers to federal interagency cooperation and support as the result of risk-averse behavior of federal agencies. Interagency conflicts could be minimized with improved interagency cooperation that could leverage 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.

Conclusions

Classical biological control has been among the most cost-effective and environmentally safe management tools for invasive species for many years, both nationally and internationally. Addressing the political, regulatory and institutional challenges in the discovery, pre-release phase and post-release monitoring of a classical biological control program would greatly enhance the long-term potential for success. From this white paper, a number of recommendations were developed that we believe will significantly improve prioritization and effectiveness of classical biological control programs.

References

Bellows, T.S. Jr., T.D. Paine, J.R. Gould, L.G. Bezark, J.C. Ball, W. Bentley, R. Coviello, A.J. Downer, P. Elam and D. Flaherty. 1992. Biological control of ash whitefly: A success in progress. California Agriculture 46:24-28.

Boller, E.F., J. Avilla, E. Joerg, C. Malavolta, F.J. Wijnands and P. Esbjerg. 2004. Guidelines for integrated production. Principals and technical guidelines. 3rd ed. IOBC WRPS Bull./Bull. OILB SROP 27.

Carruthers, R.I. 2004. Biological control of invasive species, a personal perspective. Conservation Biology 18:54-57.

Carruthers, R.I. and C. D'Antonio. 2005. Science and decision making in biological control of weeds: benefits and risks of biological control. Biological Control 35:181-182.

Cock, M.J.W., J.C. van Lenteren, J. Brodeur, B.I.P. Barratt, F. Bigler, K. Bolckmans, F.L. Consoli, F. Haas, P.G. Mason and J.R.P. Parra. 2010. Do new Access and Benefit Sharing procedures under the Convention on Biological Diversity threaten the future of biological control? Biological Control 55:199-218.

Collier, T. and R. Van Steenwyk. 2004. A critical evaluation of augmentative biological control. Biological Control 31:245-256.

Coombs, E.M., H. Radtke, D.L. Isaacson and S.P. Snyder. 1996. Economic and regional benefits from the biological control of tansy ragwort, *Senecio jacobaea*, in Oregon. *In*: Moran, V.C. and J.H. Hoffmann (eds.),. Proceedings of the 9th International Symposium on Biological Control of Weeds, Stellenbosch, South Africa, 19-26 January 1996. pp. 489-494.

Costanza, R., R. d'Agre, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and J. van den Belt. 1997. The value of the world's ecosystem servies and natural capital. Nature 387:253-260.

DeBach, P. 1964. Biological control of insects and weeds. Chapman & Hall, London.

de Lange, W.J. and B.W. van Wilgren. 2010. An economic assessement of the contribution of biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. Biological Invasions 12:4113-4124.

DiTomaso, J.M., G.B. Kyser, J.R. Miller, S. Garcia, R.F. Smith, G. Nader, J.M. Connor and S.B. Orloff. 2006. Integrating prescribed burning and clopyralid for the management of yellow starthistle (*Centaurea solstitialis*). Weed Science 54:757-767.

Duncan, C.A., J.J. Jachetta, M.L. Brown, V.F. Carrithers, J.K. Clark, J.M. DiTomaso, R.G. Lym, K.C. McDaniel, M.J. Renz and P.M. Rice. 2004. Assessing economic, environmental and societal losses from invasive plants on rangeland and wildlands. Weed Technology 18:1411-1416.

Greathead, D.J. 1995. Benefits and risks of classical biological control. *In:* Hokkanen, H.M.T., and J.M. Lynch (eds.), Plant and Microbial Biotechnology Research Series; Biological control: Benefits and risks. Cambridge University Press, Cambridge, England. pp. 53-63.

Hinz, H.L., M. Schwarzlander, A. Gassmann and R.S. Bourchier. 2014. Success we may not have had: A retrospective analysis of selected weed biological control agents in the United States. Invasive Plant Science and Management 7:565-579.

Hoddle, M.S. 2004. Restoring balance: Using exotic species to control invasive exotic species. Conservation Biology 18:38-49.

Howarth, F.G. 1991. Environmental impacts of classical biological control. Ann. Rev. Entomol. 36:485-509.

Jetter, K., K. Klonsky and C.H. Pickett. 1997. A cost/benefit analysis of the ash whitefly biological control program in California. J. Arboricult. 23(2):65-72.

Julien, M., R.E. McFadyen and J.M. Cullen (eds.). 2012. Biological Control of Weeds in Australia. Melbourne, Australia: CSIRO Publ. 648 p.

Lockwood, J.A., F.G. Howarth and M.F. Purcell (eds.). 2001. Balancing Nature: Assessing the Impact of Importing Non-native Biological Control Agents (An International Perspective). Thomas Say Foundation: Proceedings. Entomological Society of America, Lanham, MD, 130 p.

McFadyen, R.E. 1998. Biological control of weeds. Ann. Rev. Entomol. 43:369-93.

McFadyen, R.E. 2007. Return on investment: determining the economic impact of biological control programs. *In*: Julien, M.H, R. Sforza, M.C. Bon, H.C. Evans, P.E. Hatcher, H.L. Hinz, and B.G. Rector (eds.). Proceedings of the XII International Symposium on Biological Control of Weeds. pp. 67-74.

Mills, N. 2014. Plant Health Management: Biological Control of Insect Pests. *In*: N. Van Alfen (ed.), Encyclopedia of Agriculture and Food Systems, Vol. 4, San Diego: Elsevier. pp. 375-387.

Paine, T.D., K.M. Jetter, K.M. Klonsky, L.G. Bezark and T.S. Bellows. 2003. Ash whitefly and biological control in the urban environment. *In*: D.A. Sumner (ed.), Exotic Pests and Diseases. Biology and Economics for Biosecurity. Iowa State Press, Ames, Iowa. pp. 203-213.

Paynter, Q., S.V. Fowler, A.H. Gourlay, P.G. Peterson, L.A. Smith and C.J. Winks. 2015. Relative performance on test and target plants in laboratory tests predicts the risk of non-target attack in the field for arthropod weed biocontrol agents. Biological Control 80:133-142.

Pickett, C.H., J. C. Ball, K.C. Casanave, K. Klonsky, K. Jetter, L. Bezark and S.E. Schoenig. 1996. Establishment of the ash whitefly parasitoid, *Encarsia inaron* (Walker) and its economic benefit to ornamental street trees in California. Biological Control 6: 260-272.

Pickett, C.H. and R. Wall. 2003. Ash whitefly *Siphoninus phillyreae* (Haliday) (Homoptera:Aleyrodidae) and *Encarsia inaron* (Walker) (Hymenoptera: Aphelinidae) in northern California: 1990-2000. Pan Pacific Entomologist: 79:156-158.

Rinella, M.J., B.D. Maxwell, P.K. Fay, T. Weaver and R.L. Sheley. 2009. Control effort exacerbates invasive-species problem. Ecological Applications 19:155-162.

Speyer, E.R. 1930. Biological control of greenhouse white-fly. Nature 126: 1009-1010.

Suckling, D.M. and R.F.H Sforza. 2014. What magnitude are observed non-target impact from weed biocontrol? PLoS ONE 9(1): e84847. doi:10.1371/journal.pone.0084847

Van Driesche, R.G., R.I. Carruthers, T. Center, M.S. Hoddle and J. Hough-Goldstein. 2010. Classical biological control for the protection of natural ecosystems. Biological Control 54:S2-S33.

van Lenteren, J.C. 2001. Harvesting safely from biodiversity: natural enemies as sustainable and environmentally friendly solutions for pest control. *In*: Lockwood, J.A., F.G. Howarth and M.F. Purcell (ed.), Balancing Nature: Assessing the Impact of Importing Non-native Biological Control Agents (An International Perspective). Thomas Say Foundation: Proceedings. Entomological Society of America, Lanham, MD. Pp. 15-30.

Glossary of Acronyms

ABS	Access and Benefit Sharing
AFRI	Agriculture and Food Research Initiative
APHIS	USDA Animal and Plant Health Inspection Service
APHIS-PPQ	USDA Animal and Plant Health Inspection Service – Plant Protection and Quarantine
ARS	USDA Agricultural Research Service
CBD	Convention on Biological Diversity
DHS	Department of Homeland Security
FAO	Food and Agriculture Organization
FWS	US Fish and Wildlife Service
IOBC	International Organization for Biological Control
IPM	Integrated Pest Management
NIFA	National Institute of Food and Agriculture
NISC	National Invasive Species Council
PPQ	Plant Protection and Quarantine
TAG	Technical Advisory Group for Biological Control Agents of Weeds
T&E	Threatened and Endangered
TEAM	The Ecological Area-Wide Management of Leafy Spurge
USDA	United States Department of Agriculture
USGA	United States Geological Survey