DEVELOPING AND SUPPORTING A NATIONAL BIOLOGICAL CONTROL PROGRAMME

E S DELFOSSE, N C LEPPLA and M J ORAZE
National Biological Control Institute, Riverdale, Maryland, USA

DEVELOPING AND SUPPORTING A NATIONAL BIOLOGICAL CONTROL PROGRAMME

E S DELFOSSE, N C LEPPLA, M J ORAZE
National Biological Control Institute, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Office of the Administrator, 4700 River Road Unit 5, Riverdale, MD 20737-1229, USA

ABSTRACT

Several reports have identified elements that must be in place for a national biological control program to be successful, including broad agreement on its goals; identification of the customers, stakeholders and beneficiaries of the program; a thorough understanding of previously identified needs, issues and challenges in biological control that can be addressed by a national program; relationships to local, state, other national and international programs; political support and funding; and organizational placement. Unless the conditions for success of a national program are understood, established and nourished, a program can only be partially successful. The USDA National Biological Control Institute is discussed as an example of a partially successful attempt at developing a national biological control program.

INTRODUCTION

Globally, biological control has been an accepted method of pest management for over 100 years (Granados *et al.*, 1991, Wapshere *et al.*, 1989). It has been used traditionally in agriculture, forestry and rangeland areas and for medical and veterinary pests, but has great potential for management of other pests (e.g., in urban, interiorscape and environmental areas). Conservationists are "turning to biological control to help save biodiversity" (OTA, 1995). In fact, public support for biological control, particularly classical biological control (Table 1), as the preferred method of managing nonindigenous and indigenous pests is increasing in many countries (OTA, 1995, Leppla and Delfosse, 1995), but is not without challenges (Howarth, 1991). However, the risks of population-level effects to non-target species from use of specific natural enemies in biological control programs are historically very low (Bennett, 1990, Kauffman and Nechols, 1992, OTA, 1995).

Biological control is practiced at many levels and by many groups. There are four types of biological control (Table 1). Classical or inoculative biological control requires considerable infrastructure (e.g., overseas laboratories, personnel and contacts, quarantine facilities to which agents are introduced for research on host-specificity or field release, etc.) and so most often is conducted by governments. Classical biological control is essentially an ecological approach to pest management, most often using co-evolved relationships between pests and natural enemies. Relatively small numbers of a biological control agents are usually introduced ("inoculated"), and if the agent becomes established, its natural vagility can theoretically allow it to spread widely in the pest population. In practice, in the technology transfer phase of a program, classical biological control agents are often released

at several key points in the distribution of the pest to provide foci from which the agent can spread.

Table 1. The four types of biological control (modified from Wapshere *et al.*, 1989).

Type:	Characterization	Description and Examples
Classical or inoculative:	ECOLOGICAL	Nonindigenous natural enemies against (usually) nonindigenous pests; e.g., Puccinia chondrillina rust against Chondrilla juncea (skeleton weed)
Augmentative or inundative:	TECHNOLOGICAL	Indigenous or nonindigenous natural enemies against indigenous or nonindigenous pests; e.g., Trichogramma wasps against eggs of pest Lepidoptera
Conservation of natural enemies:	ECOLOGICAL	Enhancing or protecting indigenous natural enemies (usually); e.g., eliminating pesticides in rice to favor spiders, planting shelter belts to encourage predators
Broad spectrum:	TECHNOLOGICAL	Polyphagous natural enemies used specifically; e.g., confining goats on blackberry, sheep on leafy spurge, grass carp in canals or ponds, etc.

Augmentative or inundative biological control utilizes agents (which can be indigenous or nonindigenous) that ideally do not become established, and thus can be developed as commercial products. Augmentative biological control requires facilities for mass-rearing and quality control. It is essentially technological in nature, because the population level of the natural enemy is increased ("inundated") artificially at a time when the pest population is susceptible to attack.

Biological control by conservation of natural enemies is essentially ecological in approach, enhancing the population of natural enemies (and thus their effectiveness) by reducing inputs that limit their populations (e.g., chemical pesticides or fertilizers), by providing harborages (e.g., shelter belts or unmowed crop verges), or by providing a resource that is missing (e.g., a pollen-producing plant). Considerable work has been done in conservation of natural enemies for arthropod and microbial pests, but this area is still largely theoretical for biological weed control (Wapshere *et al.*, 1989).

Broad spectrum biological control (sometimes called "grazing management") is commonly practiced in developing countries, but is also used in the United States (e.g., moving sheep between fenced paddocks to graze on leafy spurge in the West). Unlike the other biological control strategies, broad spectrum biological control utilizes polyphagous natural enemies safely by confining them in an area. Thus it is essentially technological and used most often for biological control of weeds.

There is tremendous scope for solving problems for the public good through research, implementation and technology transfer of the four types of biological control. However, gaps in advocacy and philosophical support, regulation, funding, coordination and implementation of activities, and commercialization have been identified (see below). The remainder of this paper illustrates how the U.S. Department of Agriculture (USDA) National Biological Control Institute (NBCI) has tried to fill some of these gaps, pertaining mostly to classical biological control.

PREVIOUSLY IDENTIFIED NEEDS, ISSUES AND CHALLENGES TO BIOLOGICAL CONTROL IN THE UNITED STATES

Several reports have identified five main areas that should be considered in establishing a national program for biological control in the United States: advocacy and philosophical support, regulation; funding; coordination and implementation, and commercialization (Gabriel and Cook, 1990, Moran, 1992, McDonald, 1991, 1992, 1993, 1994, Metterhouse, 1985, Mullin and Fugere, 1996, OTA, 1993, 1995, Tauber *et al.*, 1985, Thomas, 1987). Although developed with American needs in mind, many of the points discussed below are universal (Leppla *et al.*, 1995, Moran, 1992).

Advocacy and philosophical support for biological control

There is a strong perception of an "overall lack of advocacy to get biological control on the national agenda" (Granados *et al.*, 1991) and of a major need to ensure that biological control becomes the strategy of first consideration in pest management; "strategy-neutral" is essentially status quo or a pro-pesticide first-use strategy. Too often, biological control is only considered after a pest becomes very widespread and other management strategies have failed or produced an inadequate level of control. Thus, recommendations were made to establish national centers to supply information about biological control and demonstrate the efficacy of biological control (Granados *et al.*, 1991) and to establish a national program to promote and fund biological control as a "public good."

The "lack of leadership" of biological control and the lack of visibility of biological control are cited as problems (Chabot, 1991, Granados *et al.*, 1991). Leadership is needed to provide philosophical support for developing appropriate biological control regulations. Customers, stakeholders and beneficiaries of biological control products are often not identified, and strategic plans and coordination among agencies can be improved.

A national program for the promotion of biological control should be established, which would develop and distribute educational and informational materials, and establish demonstration projects on farms (Granados *et al.*, 1991, Chabot, 1991). A mechanism is needed to coordinate activities, and a "coalition of stakeholders" should be maintained (Chabot, 1991).

Regulating classical biological control

The need for effective, reasonable and clear-cut regulations and procedures for importation, interstate movement and release to the environment for all biological control agents has been identified by several independent groups in the United States (Granados *et al.*, 1991, National Research Council, 1996, Shantharam and Foudlin, 1991). A conflict-resolution procedure is needed, and leadership is essential in involving all partners early in discussions of programs and agents to ensure that resources are not committed to programs that are unlikely to be implemented. Regulation of biological control should be in proportion to risk to population-level effects on non-target species. Regulations and procedures should be based on science, and risk-benefit should be used (Charudattan and Browning, 1992, Coulson *et al.*, 1991, Mullin and Fugere, 1996).

There was a strong view that biological control agents should be regulated differently from chemical pesticides; in particular, regulations and procedures should be product-oriented, rather than process-oriented (Chabot, 1991, Cook and Granados, 1991, Glenister, 1991). The overlapping responsibilities of the Animal and Plant Health Inspection Service of USDA (APHIS) under the Federal Plant Pest Act and the Environmental Protection Agency (EPA; under the Federal Insecticide, Fungicide and Rodenticide Act) "pose unnecessary barriers to registration of biological-control (sic) organisms." A regulatory roadmap is needed. Public discussions about risk important (Dunn and Martin, 1993). "A sound, but scientifically sensible, regulatory system is essential for making biological control work" (Tolin, 1991).

Regulations that facilitate interstate movement is another identified need. The private sector considers federal regulation of the natural enemy producing industry "to be among their greatest challenges and wish to participate in the development of any new rules" (OTA, 1995). Agency responsibilities need to be established, and fixed times for regulatory decisions should be established. Clear, consistent and concise regulations for field testing and registration of commercial biological control agents are needed (Granados *et al.*, 1991, Marrone and Sandmeier, 1991). Finally, a process by which regulators are accessible to customers is needed. State legislation should be consistent with federal regulation (Marrone and Sandmeier, 1991).

Agencies need to define responsibilities for organism groups, define criteria/characteristics for risks and benefits, establish fixed times for regulatory decisions, facilitate access to procedures, and establish a voluntary mechanism to share results of safety testing (Granados *et al.*, 1991).

Unfortunately, the risks inherent in biological control and biotechnology are often inappropriately linked (Shantharam and Foudlin, 1991). This linkage tends to overestimate the risks due to introduction of unmodified agents, and can raise unreasonable fears of the potential for biological control agents to produce population-level effects on non-target species.

Osburn and Nicholas (1992) stated (referring to animal biotechnology) that the public should be represented, and access and participation in debate should be improved. Further, they suggested the following mechanisms for improving access: "1. Legislation regarding public participation in regulations decisions across the board; 2. Publication beyond the Federal Register; 3. Improved representation in decision-making processes; 4. Open forums; 5. Research on opening up scientific decision-making processes; and 6. Rebuilding public trust and regulatory transparency." These points apply equally to regulation of biological control.

Funding classical biological control

Five priority areas of funding have been identified: research; implementation; evaluation; meetings; and particularly, systematics. Biological control should be funded as an activity for the "public good" by a tax on pesticides (Granados *et al.*, 1991).

Public sector funding for biological control is significant, but "appears to be largely uncoordinated and to lack adequate prioritization" (OTA, 1995). Private sector investment

in augmentative biological control has decreased, due in part to "the regulatory climate" (Tolin, 1991).

Coordinating and Implementing classical biological control

Several gaps exist in coordinating and implementing biological control. The most important are economic constraints, including core funding, staff positions, and funding for mass-rearing, distribution and evaluation. Concern was expressed over the lack of understanding of basic mechanisms of biological control (Cook and Granados, 1991), and of the lack of quality control guidelines for the commercial sector. Granados *et al.* (1991) suggested establishing "national research centers to develop biological control methods with local/cooperative, clearing houses for basic and applied information on and the delivery of biological control agents." Increased technology transfer of biological control is vital (Cook and Granados, 1991).

"Lack of necessary coordination ... was the most prominent problem identified by every workshop and advisory panel" convened by OTA (1995). Ehler (1990) pointed out that better coordination would increase potential for biological control success, and would reduce the costs and risks. It would also reduce duplication of effort. Again, leadership in coordination of biological control efforts is needed.

Commercialization of biological control

Concern was expressed over commercial (generally, augmentative) agents not being predictably reliable, and that the incentives to develop products are insufficient (Glenister, 1991, Ridgway *et al.*, 1981, Tauber and Helgesen, 1981). The private sector often stated that the regulatory system impedes, rather than facilitates, commercial development of biological control agents. There is a lack of ecological information about the fate of commercial biological control agents. Finally, agricultural cosmetic quality standards are thought of as being too high, and unachievable for some products using biological control.

Financial incentives were needed for the commercial sector to increase the supply of biological control agents. Incentives for "private good" biological control should include "an 'Orphan Drug Act' for small market biopesticides, research and development tax credits, ... and lowering capital gains taxes to help research and development investments" (Granados *et al.*, 1991).

The U.S. Environmental Protection Agency (EPA) is primarily responsible for regulation of commercial biological control agents (Mendelsohn *et al.*, 1993). As a response to customer suggestions, the EPA has recently updated their regulatory procedures for commercial biological control agents.

Table 2. Funding for biological control in the United States (updated from OTA, 1995, Table 5-1 and Figure 5-2), in $US millions.

Group	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL	Average
FEDERAL[1]											
USDA											
ARS	82	80	82	87	101	98	104	104	104	842	93.56
CSREES	30	37	40	36	37	39	41	43	44	347	38.55
APHIS	3	4	6	7	8	10	12	10	10	70	7.78
FS	3	5	4	5	5	5	5	5	-	37	4.63
EPA	-	-	-	-	-	1	1	1	0	3	0.75
ACoE	0.9	0.8	1.3	1.2	1.4	1.5	1.4	1.4	0	9.9	1.10
DoI	-	-	-	1	1	1	1	1	1	6	1.00
Subtotal	119	126.8	133	137	153	156	165	165	159	1,314.9	146.10
STATES[2]	-	-	-	-	-	-	-	-	9.27	9.27	0.33
TOTAL	119	126.8	133	137	153	156	165	165	159	1,324.08	263.90
Adjusted[3]	110	112	112	113	124	125	130	129	122	1,076.87	-

[1]USDA = U.S. Department of Agriculture; ARS = Agricultural Research Service; APHIS = Animal and Plant Health Inspection Service; CSREES = Cooperatives States Research, Education and Extension Service; FS = Forest Service; EPA = Environmental Protection Agency; ACoE = U.S. Army Corps of Engineers; DoI = Department of Interior.

[2]28 States have biological control programs :AZ, CA, CO, CT, FL, HI, ID, IN, KS, MD, MI, MN, MO, MT, NC, ND, NE, NJ, NV, NY, OR, RI, SD, TX, UT, VA, WA, and WI.

[3]Adjusted by OTA on the producer price index (PPI). In base year 1992 the PPI was 1.00; in 1995, it was estimated to be 0.78.

VISION FOR A NATIONAL BIOLOGICAL CONTROL PROGRAM

A national biological control program for the United States has been envisioned since the early 1980s to compliment the dispersed centers of leadership across the country in universities, state departments of agriculture and the private sector. For the purpose of developing such a national program, The Experiment Station Committee on Organization and Policy (ESCOP), representing the state agricultural experiment stations of the land-grant university system, established the Working Group on Biological Control in 1985 and sponsored the national symposium, New Directions in Biological Control in 1989. This group stated (ESCOP 1985).

"A coordinated, national scientific initiative is needed to maximize our understanding and use of biological control.... Because there is currently no formal organization to coordinate the efforts of university scientists, government agencies, and industry, these sectors have often developed independent and conflicting agendas. By coordinating efforts toward a common goal, we can minimize duplication, foster cooperation, and focus effort on

important problems. Researchers should be included in the development of guidelines and regulations overseeing environmentally safe use of biological control agents."

Also in 1985, the USDA, APHIS, PPQ evaluated their biological control program and recommended that it "take a lead in establishing an interagency biological control advisory group within the USDA to provide 1) a federal focus for biological control research and development, 2) a mechanism for interagency communication and coordination of such activities within the USDA and with other agencies, and 3) a mechanism for formulating uniform Departmental policy in matters concerning biological control. This group should be composed of scientific representatives from the USDA Agricultural Research Service (ARS), APHIS, Forest Service, Extension Service, and liaison representatives from other Federal agencies (e.g., Environmental Protection Agency, Department of Defense, Department of Interior), state research and action agencies, and private industry.

Further impetus for a national biological control program was provided by the Vedalia Centennial Celebration of 100 years of biological control in the United States.
Considerable discussion took place about a proposed "National Biological Control Service Institute" in USDA APHIS. As a result, NBCI was established in January, 1990. Later that same year, the Interagency Biological Control Coordinating Committee (IBC^3) was established under the leadership of ARS and the other USDA agencies that have biological control programs, APHIS, CSRS and ES (now CSREES) and FS. The purpose of IBC^3 was to increase interagency cooperation in developing and implementing biological control, recommending policy, developing a federal and state framework to achieve mutual goals in biological control, providing leadership in biological control within USDA, proposing uniform departmental policy in such matters, reviewing and coordinating biological control programs nationwide, developing joint funding initiatives and protocols, setting priorities for target pest selection, coordinating foreign exploration and collection, and reporting these activities to the USDA Agency Administrators. In 1994, IBC^3 designed the National Biological Control Program (NBCP) that linked the existing infrastructure of the five USDA agencies and partner state institutions to mobilize limited resources to accelerate the development and implementation of biological control technologies. Additional funding of $20 million was requested for the first year. The goal was to "improve the capacity for farmers, foresters, and homeowners to solve pest problems in ways that enhance the sustainability and competitiveness of American agriculture and forestry." The ESCOP working group has had no further activity since the national conference, APHIS and NBCI received minimal funding from the NBCP, IBC^3 meets infrequently, and NBCI is being realigned with APHIS operational PPQ programs.

THE NATIONAL BIOLOGICAL CONTROL INSTITUTE: A RESPONSE TO THE NEEDS, ISSUES AND CHALLENGES

Establishment of NBCI

In 1990, USDA established NBCI to enhance the delivery of biological control and integrated pest management programs for pest species. NBCI is part of the Animal and Plant Health Inspection Service (APHIS), the USDA agency charged with protecting American agriculture.

The NBCI mission is to "promote, facilitate and provide leadership for biological control." It is an APHIS "Center of Excellence." NBCI was first located in the APHIS unit called "Science & Technology " (S&T), a group established in 1988 with scientific staff drawn from other APHIS units. When S&T was "realigned" in 1991, the scientific staff returned to their former units. However, since NBCI was formed in the interim, it had no place to return. Further, since NBCI was established to be a cross-cutting group serving both the animal and plant parts of APHIS, it would have been illogical to place it in an existing APHIS unit (Delfosse, 1991).

NBCI was asked to prepare an options paper for the APHIS Administrator, Mr. Robert Melland. Customers were polled, formally and informally, and two recommendations were made to Mr. Melland (Delfosse, 1991): 1. NBCI should report to the APHIS Administrator, preferably as a new unit, or as an unattached group, and should be moved to facilities which enable efficient operation; and 2. Pursue NBCI becoming the flagship environmental activity in the office of the Secretary of Agriculture in the future.

Mr. Melland accepted the recommendations. NBCI was moved to the Office of the APHIS Administrator in 1991, answering directly to the Administrator, where it has remained under Mr. Melland's successor, Dr. Lonnie J. King (APHIS Administrator from 26 January 1993 to 5 July 1996). This placement of NBCI is the highest organizational level that biological control has reached in any country. Discussions on the next organizational placement for NBCI are underway, under the direction of the current APHIS Administrator, Mr. Terry L. Medley.

NBCI's role in trying to meet the previously-identified needs, issues and challenges is summarized below.

Advocacy and policy support for biological control

The need to ensure that biological control becomes the strategy of first consideration in pest management was thus the first task that NBCI undertook in this area. After much internal negotiation, Mr. Melland signed an historic document on 7 August 1992. Called the APHIS Biological Control Philosophy, it states (USDA, APHIS, 1992):

> "APHIS believes that modern biological control, appropriately applied and monitored, is an environmentally safe and desirable form of long-term management of pest species. It is neither a panacea nor a solution for all pest problems. APHIS believes that biological control is preferable when applicable; however, we also recognize that biological control has limited application to emergency eradication programs. Whenever possible, biological control should replace chemical control as the base strategy for integrated pest management.
>
> In support of this philosophy, APHIS will develop regulations that facilitate the release of safe biological control agents, while maintaining adequate protection for American agriculture and the environment. The regulations will give clear and appropriate guidance to permit applicants, including specific types of data needed for review and environmental analysis and specific time limits for Agency review. They will be updated as the science progresses. APHIS believes that

public input on procedures to approve the release of biological control agents is a desirable and necessary step, and will strive to gather input from scientists, industry, and the public."

Why was obtaining public philosophical support for biological control considered a necessity by so many groups? Part of the reason appears to be the conundrum of increasing public support for biological control, yet decreasing (in real terms) funding, coordination and numbers of programs using biological control. Despite over 100 years of outstanding contributions to managing introduced pests globally with classical biological control, it is still often not considered as the first option for pest management. Other types of biological control are similarly often considered only after other options have failed.

Also, useful strategies not considered biological control by traditionally trained workers (such as sterile insect technique, use of transgenic natural enemies, cultural control, etc.) are increasingly lumped with biological control and called "biologically-based pest management" or "ecologically-based pest management," and are alleged to divert funds that formerly were applied to traditional biological control (OTA 1995). One of the most serious concerns raised was that biological control had no national advocate and was portrayed as out-of-date, but other strategies (particularly chemical control) has extremely vocal advocates and was presented as "cutting-edge.
It was recognized that the APHIS Biological Control Philosophy was just the first step in working toward a philosophically based "first option" of biological control, and this document was distributed globally. In 1994 the North American Plant Projection Organization (consisting of representatives from Canada, Mexico and the United States) formally adopted a nearly-identical version as their policy (NAPPO 1994). The International Organization for Biological Control, the only global scientific society dedicated to biological control and integrated pest management, will consider adopting a similar statement at their September 1996 meeting in Montpellier, France.

In a 1993 press release, the Clinton Administration announced a goal of "reducing the risks to people and the environment that are associated with pesticides while ensuring the availability of cost-effective pest management tools for agriculture and other pesticides users. We will intensify our effort to reduce the use of higher-risk pesticides and to promote integrated pest management, including biological and cultural control systems and other sustainable agricultural practices, under the leadership of the USDA" (USDA 1993). This statement led to the USDA IPM Initiative, leading to a goal of "... development of IPM programs and implementation strategies for 75% of acreage within 7 years ...". A comprehensive set of regulatory and programmatic initiatives accompanied this change in philosophy which are being developed.

The Department of Defense (DoD) has made significant philosophical strides in pest management, producing "pest management measures of merit" (DoD 1994) that require "100 percent of all DoD installations [to] have pest management plans" in place by the end of fiscal year (FY) 1997; a reduction of "50% from the FY 93 baseline" of pesticide used by the end of FY 2000, and to ensure proper certification of "100 percent of all DoD installation pesticide applicators" by FY 98.

The USDA Forest Service (FS) and Department of Interior (DoI) announced major policy

changes to "ecosystem management" in 1992-93. FS established a National Center for Forest Health Management in 1993, then combined the Center with two other laboratories in an "Enterprise Team" to address forest health issues. Like NBCI, the Enterprise Team has an external board of customers that advises on policy and programmatic issues.

The USDA Cooperative State Research, Education and Extension Service (CSREES) announced a biological control section of the National Research Initiative Competitive Grants Program (NRI) in 1994, with $2.5 million (S. Rockey, personal communication, 1996). Congress eliminated the line item for biological control in 1995. NRI will continue to fund the program in 1996. Changes are anticipated for fiscal year 1997.

Bruce Babbitt (Secretary of the U.S. Department of Interior) announced science-based changes in forestry management (Babbitt, 1995), emphasizing "Science is not the problem. Science is what has made this country work. Indeed, only science-applied, interdisciplinary science-will let us realize our vision."

A National Academy of Sciences (NAS), National Research Council (NRC) five-year landmark study (NRC 1993) entitled Pesticides in the Diets of Infants and Children highlighted the danger to children from pesticides. NRC concluded that the pesticides tolerance and regulatory system were lacking and inadequate to protect young children, and residues were permitted that allowed "100-500 times" what is safe for children. Obviously, increased use of biological control can help reduce pesticide application on crops, thus lowering the risk to children of pesticide exposure.

The Office of Technology Assessment (OTA) produced two significant reports related to biological control and IPM. The first (OTA 1993a), Harmful Non-Indigenous Species [NIS] in the United States, concluded that there were >4,500 NIS in the United States, of which 15% (>675) cause severe economic or environmental harm. There have been >200 NIS introduced since 1980, and new introductions were increasing. From 1906-91, 79 NIS caused $97 billion direct damage, and OTA concluded that 1991-2000, introduction of just 15 NIS could add $134 billion direct damage. OTA made the critical distinction between accidentally introduced pest NIS, which are the type that cause the enormous damage quoted, and the beneficial NIS, including biological control agents, that should be increased because they help manage the harmful NIS.

The U.S. Congress was so concerned about the situation with pesticides that they charged the OTA (OTA, 1993b) to

> "1) evaluate to what extent biological pest control can help fill the expected pesticide gap; 2) examine the relative safety of biological pest control and how some of the problems experienced with large-scale use of chemical pesticides, such as pest resistance, can be anticipated and avoided; 3) determine whether the current system of Federal funding, research, incentives and regulations helps or hinders the development and use of biologically-based approaches; 4) address the potential for transfer of biological pest control technologies from agriculture to other pest problems; for example, to weeds on Federal lands, lawn care, household pests, and vector-borne human diseases; and 5) develop policy options for Congress"

The final report (OTA, 1995) entitled Biologically Based Technologies for Pest Control, was remarkably comprehensive. OTA concluded that "the harshest critics say that the necessary [biological control] coordination is virtually nonexistent today" and that neither NBCI nor the now-inactive Interagency Biological Control Coordinating Committee (IBC^3) fulfills this coordination role perfectly, NBCI "because it is located within an operations agency and lacks funds and authority; the committee because it has largely ceased to function." Among the options OTA proposed to Congress to help coordinate biological control are

> "Congress could select either the NBCI, IBC^3 , or a new unit (perhaps incorporating both organizations) at the institutional site for national coordination of biological control. Selection of the NBCI would require its elevation to a higher lever within USDA, because its current position makes it accountable to the priorities of one agency (APHIS). Selection of IBC^3 would require revitalizing the now inactive committee. Specific coordinating responsibilities and appropriations would need to be assigned to whatever organization is selected. and
>
> Should Congress choose to fund the USDA IPM Initiative, it could stipulate that the designated organization for coordinating biological control be a participant. Even without designating a coordinating organization, Congress could require that the NBCI be involved in the initiative to help integrate biological control and IPM programs (see also Chapter 3 for discussions of problems related to a lack of coordination between biological control and IPM)."

An NRC (1996) report on ecologically based pest management (EBPM) recommended that coordinated multidisciplinary and interdisciplinary research was needed to develop and implement EBPM, with public oversight to help evaluate risks associated with biological control organisms.

These efforts call for a strong philosophical basis for biological control. More agencies, scientific societies, Plant Protection Organizations and other groups should adopt formal policies in support of biological control. We agree with sentiments expressed by Rita Colwell, President, Sigma Xi (1991):

> "In the 1990's, the scientific and technical community possesses a body of knowledge sufficient to influence human destiny. This knowledge makes it incumbent upon us, as scientists and engineers, to take a leading role in formulating solutions to problems that will affect the quality of life on this planet in the next century and beyond."

NBCI has begun to provide biological control coordination. For example, NBCI: initiated development of the National Biological Control Information Center (a combination of NBCI and ARS Biological Control Documentation Center information activities); established a bulletin board system and the first World Wide Web Internet Home Page for biological control; funding initiatives (see below); instituted a Customer Advisory Board with rotating 3-year terms that has involved 25 of the key biological control workers in the U.S. since 1990; provided technical advice and coordination for many biological control and IPM

programs; and other activities. Coordination from NBCI has been sought by other Federal agencies and international groups, and recently NBCI has been charged with preparing a strategic plan to coordinate APHIS' programs.

NBCI prepared a peer-reviewed Program Logic Model that specifies the intended long-term goals and outcomes of NBCI's actions. Customers have been surveyed twice-in 1994 and 1996-and changes made to NBCI's program based on their input. In five years, NBCI staff have also presented over 300 talks discussing a vision for implementing biological control as the basis of IPM.

Regulating classical biological control

APHIS was aware of the need to update its biological control regulations and procedures when it established NBCI. In January 1992, APHIS Administrator Melland formally charged NBCI with reviewing how APHIS regulates biological control. Terms of reference (Mendelsohn *et al.*, 1993) were to: (1) examine APHIS' biological control regulatory authority, policies and philosophies; (2) clarify biological control responsibilities of APHIS units; (3) document the current biological control regulatory system used by the Biological Assessment and Taxonomic Support (BATS) group in the Plant Protection and Quarantine unit; (4) consult widely with APHIS' customers about the current regulatory system (including implementing guidelines), and suggest a new system (now known as the "Strawman") based on this customer input and using the best available science; and (5) propose a mechanism to facilitate APHIS' continued involvement with customers to ensure that the regulations and implementing procedures and guidelines are changed as science and societal needs change. The outcome of this process, involving attending over 300 meetings and presenting over 200 invited talks on biological control regulations over a four-year period, was the NBCI-facilitated "Strawman," which discussed the ten area of most concern to APHIS' biological control customers (Delfosse, 1996). The "Strawman" is apparently the first scientific document placed on the Internet for peer review. Comments virtually unanimously supported the new procedures in the "Strawman" (a few reviewers liked the processes suggested, but thought they could be more strict in some areas). A coalition of eight Western States considered the "Strawman" at a biological control of weeds regulatory summit in April 1996, and concluded (Mullin and Fugere, 1996) "We support [the "Strawman"] with minor modifications, as a guiding document for biological control of weeds regulation in the United States." The Working Group on Biological Control of Weeds of the Nearctic Regional Section of the International Organization for Biological Control also supported the "Strawman" at a meeting in Billings, Montana, on 26 July 1996.

APHIS published a Proposed Rule entitled Introduction of Nonindigenous Organisms on 26 January 1995 (60FR 5288-5307, Docket No. 93-026-1). On 16 June 1995 APHIS withdrew the Proposed Rule (60 Fr 31647, Docket No. 93-026-4) following receipt of 252 public comments, all of which were opposed to the Proposed Rule as written. APHIS intends to obtain public input through an Advanced Notice of Proposed Rule-Making in 1996, which will address inadequacies in plant pest regulations with regard to providing a means of screening organisms prior to introduction to determine the potential plant pest risks the may present.

Funding classical biological control

Five areas of funding have been identified: for research; implementation; evaluation; meetings and workshops; and particularly, systematics.

NBCI is addressing the need for increased funds in biological control in several ways. First, a small grants program was established in 1990, in collaboration with other Federal and State agencies. The program was coordinated in particular with other funding bodies, to ensure that the NBCI small grants program was synergistic with their programs, and would leverage resources. A summary of the NBCI small grants program is presented in Table 3 (NBCI, 1996).

Table 3. Summary of the NBCI small grants program, 1991-6 (amounts in USD).

Type of Grant	Number	Amount	Average
Development of databases	8	$ 184,352	$ 23,044
Education and information	10	193,894	19,389
Implementation projects	47	679,829	14,464
Focus groups and workshops	4	25,700	6,425
Mentoring and staff development	7	86,770	12,396
Meetings	26	135,419	5,208
NBCI Postdoctoral Fellowships in Systematics (2-year grants)	5	373,952	74,790
Publications	22	165,229	7,510
	129	$ 1,845,145	$ 14,403

The NBCI Postdoctoral Fellowships in Systematics is particularly important for the future of biological control and understanding biological diversity. Five NBCI Fellows have been named to date, contributing vital systematic work on Aphthona, Eretmocerus, Streptomyces, and Encarsia. Three of the systematists found permanent jobs in systematics during the time they were NBCI Fellows. The potential contributions to biological control, biological diversity, ecology, training students, etc., by these scientists over their careers makes this program a very good investment.

Implementing classical biological control

Several gaps in implementing biological control were identified above. An important gap is economic constraints, including very limited core funding, staff positions, and funding for mass-rearing, distribution and evaluation. Concern was expressed over the lack of understanding of basic mechanisms of biological control, and of the lack of quality control guidelines for the commercial sector. Many of the NBCI grants (Table 3) were designed to begin to meet some the these needs, raise the visibility of biological control, and to leverage resources in other groups.

Commercialization of biological control

Concern was expressed over agents not being predictably reliable, and that the incentives to develop products are insufficient. The private sector often stated that the regulatory system

impedes, rather than facilitates, commercial development of biological control agents. There is a lack of ecological information about the fate of commercial biological control agents. Finally, the product cosmetic quality standards are thought of as being too high, and unachievable for some products using biological control.

GLOBAL IMPLICATIONS OF DEVELOPING AND SUPPORTING A NATIONAL BIOLOGICAL CONTROL PROGRAMME

Can a national biological control program play a role in successful research and technology transfer of biological control, or are scarce resources better used elsewhere? What are the global implications of providing a policy of "biological control first"?

Success in biological control requires a challenging combination of science, sociology and law. Programs must be based on science and carefully evaluated and monitored to begin to understand the mechanisms underpinning interactions between natural enemies, their pest hosts, and potential non-target species. Without this scientific basis, serendipitous "successes" (in the narrow sense of management of the target pest without understanding the mechanisms and interactions) will still occur, but no one will know why. Long-term evaluation on appropriate non-target species is essential to evaluate the safety and stability of biological control agents, even though many of the evaluations will likely show no deleterious effect at the population level, and to demonstrate the ethical, environmental stewardship role of most biological control practitioners. Coordination of programs requires considerable social skills and teamwork to avoid duplication and to leverage increasingly scarce resources. An open, empowering legal environment, where the public participates in changes to laws, regulations and procedures is essential to keep the legal system focused; science will always proceed much faster than the law.

A national biological control program can help provide the essential leadership to facilitate all of the above. It can provide a single reference point for biological control advocacy, and can increase the visibility of biological control in the political sphere, where it must be to ensure long-term support. Properly placed and empowered, a national biological control program can influence policy to ensure that biological control is considered as the base strategy for IPM. A national program can help facilitate mutually agreed changes in regulations by gathering input from a wide range of public and private sector customer groups and synthesizing suggested changes for consideration by the regulatory bodies. Focused funding (if not also increases in funding) and establishing priorities can be organized by a national program, and the coordination that results can greatly leverage implementation and technology transfer. A national program can also work with private sector interests to encourage an environment where investment in biological control is increased.

Thus, without broader global philosophical commitment, it is unlikely that change will be possible, and the problems of "lack of leadership" and "lack of visibility of biological control" will remain.

REFERENCES

Babbitt, Bruce. (1995). Science: Opening the next chapter of conservation history. *Science* 267:1954-5.

Bennett, F.D. (1990). Introduction. In: *Classical Biological Control in the Southern United States*. D.H. Habeck, F.D. Bennett and J.H. Frank (eds.). *Southern Cooperative Series Bulletin No.* 355:1-5

Chabot, B.F. (1991). Biological Control: Making It Work. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 199-212.

Charudattan, R. and H.W. Browning. (1992). *Regulations and Guidelines: Critical Issues in Biological Control*. Proceedings of a USDA/CSRS National Workshop, 10-12 June 1991, Vienna, VA, 203 p.

Cook, R.J. and R.R. Granados. (1991). Biological Control: Making It Work. Part 2: Technological Status. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 213-27.

Coulson, J.R., R.S. Soper and D.W. Williams (eds.). (1991). *Biological Control Quarantine: Needs and Procedures*. Proceedings of a Workshop Sponsored by USDA-ARS. U.S. Department of Agriculture, Agricultural Research Service, ARS-99, 336 p.

Delfosse, E.S. (1991). The best administrative location for the National Biological Control Institute. An assessment addressing the 1991 realignment of Science & Technology. A submission to the APHIS S&T Transition Team. U.S. Department of Agriculture, APHIS, 26 p.

Delfosse, E.S. (facilitator). (1995). Options for Changes in Biological Control Regulation in the United States: A Strawman for Comment. Ideas from APHIS' Customers Facilitated by the National Biological Control Institute. Published on the NBCI Home Page on the Internet World Wide Web (http://www.aphis.usda.gov/nbci/nbci.html), 26 p.

Dunn, P.E. and M.A. Martin. (1993). Overview. *National Agricultural Biotechnology Council Report 5. Agricultural Biotechnology: A Public Conversation About Risk.* NABC, Ithaca, NY, pp. 3-12.

Ehler, L.E. (1990). Revitalizing Biological Control. *Issues in Science and Technology,* Fall 1990, 91-6.

Experiment Station Committee on Organization and Policy. (1985). Biological Control: An Untapped Natural Resource. Introducing A National Biological Control Initiative. ESCOP Working Group on Biological Control by Agricultural Communication Services, Agricultural Experiment Station, Purdue University, West Lafayette, IN, 8 p.

Gabriel, C.J. and R.J. Cook. (1990). Biological control-the need for a new scientific framework. *BioScience* 40(3):204-6.

Glenister, C.S. (1991). Biological Control: Making It Work. Part 5: Supporting Adoption of Biological Control. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 32-7.

Granados, R.R., M.K. Hinkle. J.F. Swinnen. (1991). Workshop Report. Biological Control of Pests. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 32-7.

Howarth, F.G. (1991). Environmental impacts of classical biological control. *Annual Review of Entomology* 36:485-509.

Kauffman, W.C. and J.E. Nechols (eds.). (1992). *Selection Criteria and Ecological Consequences of Importing Natural Enemies*. Proceedings of the Thomas Say Publications in Entomology, Entomological Society of America,, Lanham, MD, 117p.

Leppla, N.C. and E.S. Delfosse. (1995). The Increasing Significance of Biological Control and An Overview of Regulations Governing Biological Control Organisms. Introduction to the Session. *Proceedings of the U.S. Department of Agriculture, Interagency Gypsy Moth Research Forum 1995*, Annapolis, MD. USDA Forest Service Northeastern Forest Experiment Station *General Technical Report* NE-213, pp. 9-19.

Leppla, N.C., E.S. Delfosse and R.S. Soper. (1995). Technical and regulatory constraints to international cooperation in biological control. Bemisia: *1995 Taxonomy, Biology, Damage, Control and Management*. Gerling, D. and R.T. Mayer (eds.). Intercept, Andover, UK, pp. 385-95

Marrone, P.G. and R. Sandmeier. (1991). Biological Control: Making It Work. Part 3: Commercialization of Biological Control Agents. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 228-37.

McDonald, J.F. (Ed.). (1991). *Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns. National Agricultural Biotechnology Council Report 3*, Ithaca, NY.

McDonald, J.F. (Ed.). (1992). *Animal Biotechnology: Opportunities & Challenges. National Agricultural Biotechnology Council Report 4,* Ithaca, NY.

McDonald, J.F. (Ed.). (1993). *Agricultural Biotechnology. A Public Conversation About Risk. National Agricultural Biotechnology Council Report 5*, Ithaca, NY.

McDonald, J.F. (Ed.). (1994). *Agricultural Biotechnology & the Public Good. National Agricultural Biotechnology Council Report 6*, Ithaca, NY.

Mendelsohn, M., E. Delfosse, C. Grable, J. Kough, D. Bays and P. Hutton. 1993. Commercialization, facilitation and implementation of biological control agents: a government perspective. Chapter 11 In: *Biological Control of Postharvest Diseases. Theory and Practice*. Wilson, C.L. and M.E. Wisniewski (eds.). CRC Press, Boca Raton.

Metterhouse, , W. (Chairperson). (1985). Biological Control Program Evaluation: A Review Team Report. U.S. Department of Agriculture, APHIS, Report, 38 p.

Moran, V.C. (1992). A report to the Director of the National Biological Control Institute. U.S. Department of Agriculture, APHIS Contract Report on the Possible International Role for the NBCI, 32 p.

National Research Council (U.S.). (1993). *Pesticides in the Diets of Infants and Children*. Committee on Pesticides in the Diets of Infants and Children, Board on Agriculture and Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. National Academy Press, Washington, D.C., 386 p.

National Research Council (U.S.). (1996). *Ecologically Based Pest Management*. Board on Agriculture, National Research Council. National Academy Press, Washington, D.C., 144 p.

North American Plant Protection Organization. (1994). NAPPO Biological Control Philosophy. Signed by William S. Lanterman (Canada), B. Glen Lee (United States) and Marco A.C. Zuñiga (Mexico) on 17 October 1994, 1 p.

Osburn, B. and R.B. Nicholas. 1992. Workshop Report on Animal Biotechnology: Opportunities & Challenges. *National Agricultural Biotechnology Council Report 4. Agricultural Biotechnology: Opportunities & Challenges*. NABC, Ithaca, NY, pp. 171-4.

Ridgway, R.L., J.R. Ables, C. Goodpasture and A.W. Harstack. (1981) *Trichogramma* and its utilization for crop protection in the U.S.A. *Proceedings of the Joint American-Soviet Conference on Use of Beneficial Organisms in the Control of Crop Pests*, 13-14 August 1979, Washington, D.C. Coulson, J.R. (ed.). Entomological Society of America, College Park, MD.

Shantharam, S. and A.S. Foudlin. (1991). Federal Regulation of Biotechnology: Jurisdiction of the U.S. Department of Agriculture. Chapter 16 In: *Biotechnology for Biological Control of Pests and Vectors*. Maramorosch, K. (ed.). CRC Press, Boca Raton, FL, pp. 239-50.

Tauber, M.J. and R.G. Helgesen. (1981). Development of biological control systems for greenhouse crop production in the U.S.A. *Proceedings of the Joint American-Soviet Conference on Use of Beneficial Organisms in the Control of Crop Pests*, 13-14 August 1979, Washington, D.C. Coulson, J.R. (ed.). Entomological Society of America, College Park, MD.

Tauber, M.J., M.A. Hoy and D.C. Herzog. (1985). *Biological control in agricultural IPM Systems:* A brief overview of the current status and future prospects. Biological Control in Agricultural IPM Systems, Academic Press, pp. 3-9.

Thomas, E.A. (Chairperson). (1987). Biological Control Program Review Group Recommendation and Justification. U.S. Department of Agriculture, APHIS, Biological Control Review Report, 12 p.

Tolin, S.A. (1991). Biological Control: Making It Work. Part 4: Regulation of Biological Control Agents. *National Agricultural Biotechnology Council Report 3. Agricultural Biotechnology at the Crossroads. Biological, Social & Institutional Concerns*. NABC, Ithaca, NY, pp. 32-7.

USDA, APHIS. (1992). Biological Control Philosophy. Signed by Robert Melland, Administrator, 7 August 1992, 1 p.

USDA. (1993). Press release R-141, 0518.93, from Mike Espy, Agriculture Secretary, Carol M. Browner, Environmental Protection Agency Administrator, and David A. Kessler, Food and Drug Administration Commissioner, June 25 1993, 2 p.

U.S. Congress, Office of Technology Assessment. (1993). *Harmful Non-Indigenous Species in the United States*. OTA-F-565. U.S. Government Printing Office, Washington, D.C., 391 p.

U.S. Congress, Office of Technology Assessment. (1993). *Harmful Non-Indigenous Species in the United States*. OTA-F-565. U.S. Government Printing Office, Washington, D.C., 391 p.

U.S. Congress, Office of Technology Assessment. (1995). *Biologically Based Technologies for Pest Control*. OTA-ENV-636. U.S. Government Printing Office, Washington, D.C., 204 p.

Wapshere, A.J., E.S. Delfosse and J.M. Cullen. (1989). Recent Developments in Biological Control of Weeds. Invited Review In: *Crop Protection* 8:227-50.