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Developing National Research Teams: A Case Study with the Jointed Goatgrass Research Program[1]

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Abstract: Weed scientists are facing research problems, such as invasive weeds, that may require multidisciplinary approaches to solve. One example is jointed goatgrass, a winter annual grass invading winter wheat fields and not easily managed with conventional control tactics. A national research program was started in 1994 to develop jointed goatgrass management strategies. Involving more than 35 scientists with diverse scientific expertise, this national approach fostered cooperative research projects across 11 states. Research involved entomology, economics, plant breeding, plant physiology, genetics, and weed science, leading to successful management systems for jointed goatgrass. To help other scientists organize regional or national programs, we describe development and performance of the jointed goatgrass program as well as suggest ideas for possible improvement. Pivotal to the success of the program was a Steering Committee, whose role was to establish research priorities and coordinate research across the western United States.

Nomenclature: Jointed goatgrass, *Aegilops cylindrica* Host. #[3] AEGCY; winter wheat, *Triticum aestivum* L.

Additional index words: AEGCY, Congressional special grant, integrated management, strategic planning, technology transfer.

Abbreviations: BMP, best management practices; CSREES, Cooperative State Research, Education, and Extension Service; WSWS, Western Society of Weed Science.

INTRODUCTION

Weed scientists are facing research problems, such as invasive weeds on public lands and rangeland, that may require multidisciplinary or multiagency approaches to solve (Anderson et al. 2003). For example, management of knapweed species (*Centaurea* spp.) requires knowledge of population dynamics, biological control agents, livestock management, taxonomy, and rangeland restoration (Wilson 2001). Another example is leafy spurge (*Euphorbia esula* L.), which requires integrating biological control agents and herbicide efficacy with native vegetation management to restore infested rangeland (Sell et al. 1999). With both species, scientific advances required cooperation among multistate and multiagency teams.

A similar example is jointed goatgrass, where conventional control tactics are not effective in managing this winter annual grass in winter wheat. In 1994, a national research program was established to facilitate research cooperation among a multitude of scientific disciplines, such as entomology, economics, livestock management, plant breeding, plant physiology, and genetics, as well as weed science. Participants of the program included university, federal, and private-industry scientists from 11 states as well as producers and state wheat commissions. Knowledge gained from this program provided producers with numerous strategies to manage jointed goatgrass effectively in winter wheat.

The program is considering future goals with other weed species such as feral rye (*Secale cereale* L.) and ryegrasses (*Lolium* spp.) that infest winter wheat. Therefore, we assessed performance of the program to enhance effectiveness of future research with weed management in winter wheat. We also felt that explaining the establishment and functioning of the program may serve as a guide for scientists developing other national research teams. Thus, this article describes the Jointed Goatgrass Research Program, evaluates its performance, and suggests ideas that may improve a national program.

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[3] Letters following this symbol are a WSSA-approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Table 1. Activities for developing and guiding a national research program for jointed goatgrass management in the western United States. Activities in italics are planned.

Year	Activity
1989	Initial symposium to review current research programs
1991	Review article on research status of jointed goatgrass
1993	Proposal workshop at Western Society of Weed Science (WSWS) meeting
1993	State wheat commissions contact with Congressional Representatives
1993	Second workshop to develop more specific research priorities
1994	Congressional funding and beginning of research studies
1995–*2005*	Annual review of research progress and evaluation of new proposals
1995–*2006*	Development and updating of jointed goatgrass web site
1999	First research symposium at WSWS meeting
1999	Development of 5-yr strategic plan
2000	Revised priorities for research proposals
2002	First technology-transfer bulletin published
2005–2006	*Producer workshops in the four regions*
2006	*Second research symposium at WSWS meeting*
2006	*Conclusion of program*

RECOGNITION OF THE ISSUE AND NEED FOR A NATIONAL FOCUS

In the 1980s, producers and scientists recognized that jointed goatgrass was increasing in farmland of the western United States. In 1993, it was estimated that jointed goatgrass cost producers $145 million annually because of yield loss and management tactics and was spreading at the rate of 20,000 ha/yr (Ogg 1993). Also, jointed goatgrass spikelets in grain reduce wheat quality for bread, thus threatening availability of foreign markets for United States wheat (Hanavan et al. 2002). Because grain from several locations is bulked for overseas transport, jointed goatgrass control is a national issue.

Jointed goatgrass is difficult to control in winter wheat for several reasons. First, its life cycle is almost identical to winter wheat (Donald and Ogg 1991). Second, its seeds persist for several years in the soil, which favors jointed goatgrass expansion in a winter wheat–fallow rotation (Donald and Zimdahl 1987). Jointed goatgrass also shares a genetic ancestry with winter wheat; both species have the D genome (Zemetra et al. 1998). This genetic relationship has made it difficult to develop herbicides that control jointed goatgrass in winter wheat.

These concerns led to a series of activities that resulted in a national research program (Table 1). In 1989, the USDA-ARS Weed Science Research Unit at Pullman, WA, organized a symposium, where scientists reviewed research progress with jointed goatgrass. Two goals were identified: (1) describe distribution of jointed goatgrass in the United States, and (2) summarize knowledge of jointed goatgrass. In 1991, Donald and Ogg published a review describing plant morphology, growth and development, economic impacts, and management of jointed goatgrass. The review also suggested research needs and included a distribution map developed by participants of the 1989 symposium that showed where jointed goatgrass is common in the United States.

DEVELOPING A PROPOSAL AND INTERACTING WITH CONGRESSIONAL REPRESENTATIVES

A workshop comprising scientists and members of the Washington and Colorado wheat commissions was held at the 1993 meeting of the Western Society of Weed Science (WSWS). On the basis of the Donald and Ogg (1991) review, participants prepared a proposal for funding research and technology transfer. The wheat commissions of Washington and Colorado, in cooperation with the National Association of Wheat Growers, then contacted Congressional representatives for consideration of federal funding for the proposal. In 1993, the National Jointed Goatgrass Research Program was established through a Congressional special grant to the Cooperative State Research, Education, and Extension Service (CSREES) of approximately $350,000/yr, with Washington State University serving as the fund holder.

The state wheat commissions also asked that producers be involved in identifying research priorities. Thus, a second workshop was held in 1993 that included producers as well as scientists. Research priorities identified at this workshop included developing integrated management systems comprised of alternative rotations, tillage strategies, and cultural practices (Table 2). Also, scientists would explore herbicide options to control jointed goatgrass in winter wheat. A second priority was to understand seed bank dynamics and genetic variation among jointed goatgrass biotypes. Developing bioeconomic models to guide management planning and transferring current knowledge of jointed goatgrass to producers were also requested.

Table 2. Research priorities for the jointed goatgrass research program. The 2000 priorities were developed in conjunction with the 5-yr strategic plan.

Year	Research Priorities
1995	Integrated management a. Cultural practices and alternative rotations b. Herbicide evaluation Population dynamics a. Seed bank dynamics b. Genetic variation among jointed goatgrass biotypes Bioeconomics a. Yield loss relationships b. Decision aids Technology transfer a. Identification and awareness b. Develop web site for producers
2000	Management systems development a. Best management practices studies b. Management of herbicide resistance Technology Transfer a. Technology-transfer extension bulletins b. Regional producer workshops c. Field days at best management practices studies d. Final reports of all research published on the web site

At the suggestion of the USDA-CSREES liaison,[4] scientists at the 1993 workshop also developed a two-page Executive Summary that described the nature and scope of the problem and research priorities and listed cooperating universities and federal agencies.[5] State wheat commissions and the National Association of Wheat Growers relied on the Executive Summary as a resource when contacting Congressional offices for renewed funding each year.

[4] James Parochetti, USDA-CSREES (Weed Science), Washington, DC.

[5] The current Executive Summary is available on the Jointed Goatgrass Web page: www.jointedgrass.org. Also, copies are available from Darrell Hanavan: dhanavan@coloradowheat.org.

ORGANIZING THE PROGRAM

Steering Committee. A Steering Committee was formed to facilitate regional cooperation and coordination as well as allocate research funds. Members included producers (as representatives of state wheat commissions), research and extension scientists, and the USDA-CSREES liaison (Figure 1). The state wheat commis-

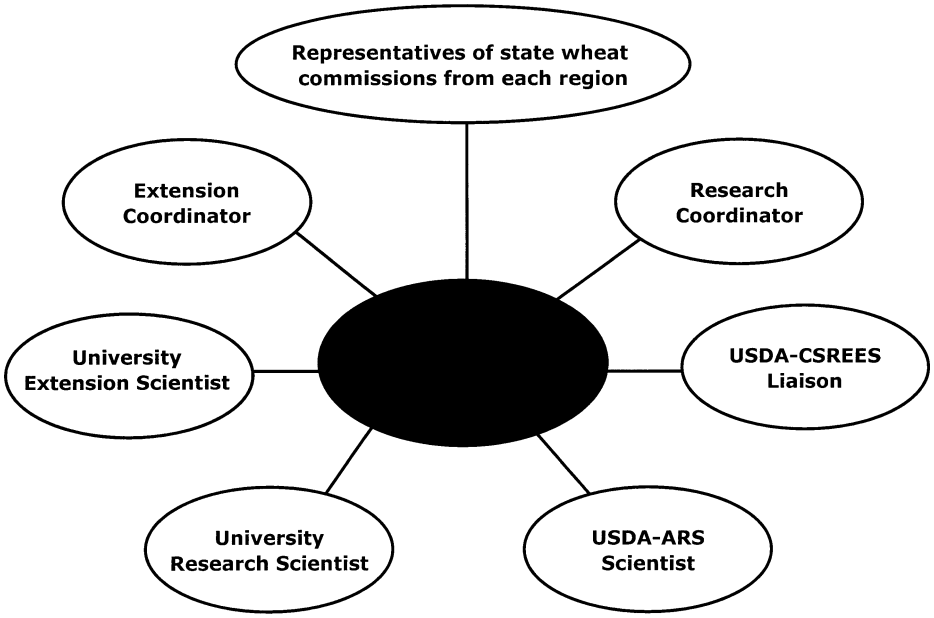

Figure 1. Member composition of Steering Committee that guided activities of the Jointed Goatgrass Research Program.

sions suggested organizing the western United States into four regions based on similarities of winter wheat production practices: Pacific Northwest (Washington, northern Idaho, and Oregon), Intermountain (Utah and southern Idaho), Central Great Plains (Kansas, Nebraska, Wyoming, Montana, and Colorado), and Southern Great Plains (Oklahoma and Texas). The Committee membership then was designed to include one producer and one scientist from each region; scientific representation included both research and extension specialists. Committee members usually served 3 to 4 yr. Replacements for producers were on the basis of recommendations from state wheat commissions, whereas the Committee selected replacements for scientific members from participating scientists in the research program. Decisions among the Steering Committee were based on consensus. The design of the Steering Committee ensured that producers were involved in all aspects of the research program.

Research Planning. Each year, the Steering Committee issued a request for proposals, on the basis of the program's research priorities (Table 2). The Committee considered research creativity, regional cooperation, and technology-transfer activities when evaluating each proposal. Funding levels were based on merit and project design, with preference given to projects that were multistate and multidisciplinary. The Steering Committee did not seek to allocate funds equally among states or regions.

To help with research evaluation and processing of proposals, the Steering Committee hired a research coordinator. An annual meeting for participants of the program, held in conjunction with the WSWS meeting, allowed scientists to discuss research progress and new ideas. This meeting provided an opportunity for producers on the Steering Committee to interact with scientists in designing research studies. After the review meeting, the Steering Committee then evaluated both current research projects and new proposals, set funding levels, and conducted business necessary for the operation of the program. The program's Executive Summary was revised each year to include research progress, and a bound report of funded projects was prepared for program participants.

Technology Transfer. To facilitate information transfer to producers, the Steering Committee hired an extension coordinator. In 1995, the coordinator developed a web site (www.jointedgoatgrass.org) that summarized research conducted before the program started as well as new knowledge generated by the program. The initial focus of technology transfer was identification of jointed goatgrass and increasing producer and agribusiness awareness of how jointed goatgrass is spread. Press releases to popular agricultural magazines and journals also informed the agricultural community of new findings by the program.

EVALUATION OF PROGRESS AFTER 5 YR

Research planning and funding started in 1994 (Table 1). After 5 yr of research, the Steering Committee organized a symposium at the 1999 WSWS meeting to evaluate progress. One key finding was that yield loss relationships were extremely variable, even at one location (Jasieniuk et al. 1999). For example, yield loss with 20 plants/m^2 ranged from 5 to almost 40% across years at a site in southeastern Wyoming, indicating the difficulty in predicting yield loss due to variable emergence of jointed goatgrass seedlings.

Cultural practices, such as choice of winter wheat cultivar (Ogg and Seefeldt 1999), increased seeding rate (Kappler et al. 2002), nitrogen fertilizer placement (Mesbah and Miller 1999), or tillage during fallow (Evans et al. 2001), influenced jointed goatgrass interference with winter wheat. However, cultural practices were not consistent across years, varying with environmental conditions and time of jointed goatgrass emergence. Also, impact of cultural practices on jointed goatgrass seed production often was small (Anderson 1997).

Adding crops with different life cycles to the winter wheat–fallow rotation reduced the number of seeds remaining in the soil seed bank (Daugovish et al. 1999). But, some producers do not have alternative crops that are economically viable. Another option is imidazolinone-resistant winter wheat cultivars (Newhouse et al. 1992), which enables producers to control jointed goatgrass in winter wheat with imazamox (Ball et al. 1999). However, hybrids between imazamox-resistant winter wheat and jointed goatgrass were found in Washington after 2 yr of growing these cultivars (Seefeldt et al. 1998), which suggests that imidazolinone resistance may be transferred from winter wheat to jointed goatgrass.

FIVE-YEAR STRATEGIC PLAN

On the basis of the program's initial findings, the Steering Committee recognized the need for a comprehensive systems approach that integrates cultural practices, rotational options, use of imazamox, and herbicide resistance management. To achieve this goal, the Steer-

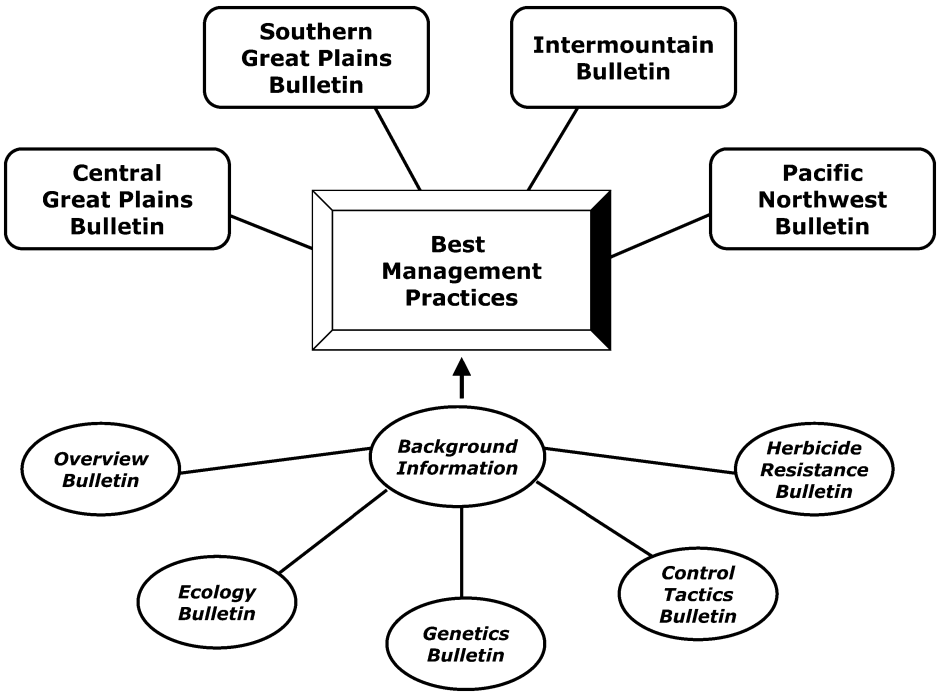

Figure 2. Proposed technology-transfer bulletins that will summarize research knowledge for easy access by producers.

ing Committee revised the program's research priorities (Table 2), and then developed a 5-yr strategic plan based on five components. First, the Steering Committee developed a general protocol for best management practices (BMP) studies, and then asked selected scientists to establish BMP studies in each of the four production regions. The purpose of the BMP studies was to integrate knowledge of jointed goatgrass ecology and control tactics into management systems that were tested with farm-scale operations. The studies consisted of one or two management systems that were compared with conventional practices used by producers in the region. The design of the management systems involved not only scientists but also producers on the Steering Committee. The studies were established by the cooperating land manager in their fields.

A second component of the 5-yr plan was to identify gaps in the knowledge base and fund research to address these knowledge gaps. New studies are examining issues such as insect predation of jointed goatgrass seeds in the seed bank and how dormancy develops in jointed goatgrass seed.

The Steering Committee also revised goals for technology transfer. Scientists have been conducting research with jointed goatgrass for almost 25 yr, resulting in an extensive database. A plan was devised to organize this database into an accessible format for producers, on the basis of nine technology-transfer bulletins (Figure 2). Four bulletins will summarize results from the BMP studies being conducted in each production region. We anticipate that producers will first read the BMP bulletin for the region where they live; if producers desire further information, five bulletins will describe background information in more depth, such as jointed goatgrass genetics or herbicide resistance management. The bulletins will be introduced to producers at workshops held in each region. Also, bulletins will be available on the jointed goatgrass web page. To help technology transfer at producer field days and workshops, the Steering Committee developed fact sheets summarizing key findings of the program.

The final goal with the 5-yr strategic plan is to organize a symposium for the WSWS meeting in 2006. Scientists will inform the research community of the program's progress and describe management systems for jointed goatgrass. After the symposium, the Steering Committee will collate bulletins and symposium proceedings into a book that will be distributed to land grant university libraries in the western United States. The program will end in 2006.

ASSESSMENT OF PROGRAM

Favorable Aspects. We believe that several activities (Table 1) were crucial for success of the program. First, the research review symposium in 1989 and the Donald

and Ogg (1991) review paper enabled scientists to avoid duplication of previous research and to focus research on current needs.

The Steering Committee enhanced regional cooperation by its oversight of research activities. For example, a study that evaluated yield loss relationship between jointed goatgrass and winter wheat consisted of 30 site-years in eight states (Jasieniuk et al. 1999; Jasieniuk et al. 2001). A second example involved possible genetic transfer between winter wheat and jointed goatgrass. On the basis of the program's revised priorities (Table 2), several proposals were funded to examine this concern. However, the Steering Committee recognized that the studies lack a common procedure to test hybrids of winter wheat and jointed goatgrass for imidazolinone resistance and requested a scientist to develop a standard protocol for these studies. The Steering Committee's annual review meeting not only kept participants informed of research progress but also facilitated technology transfer of newly developed strategies to producers.

A third factor in the program's success was development of regional BMP studies. These studies encouraged a systematic analysis of our knowledge base to develop effective management. Producers on the Steering Committee were pivotal in starting the BMP studies, cooperating with scientists in designing treatments as well as locating study sites.

Our 5-yr strategic plan encouraged scientists to consider the final outcome of the program and to organize technology-transfer efforts. The bulletin approach was effective because producers requested more than 5,000 copies of the first bulletin published, Jointed Goatgrass Ecology, within 1 yr (Anderson et al. 2002).

Critical for funding of the program was the Executive Summary and 5-yr strategic plan. Congressional representatives viewed the summary of accomplishments and orderly conclusion of the program favorably, thus helping state wheat commissions and grower associations secure annual funding from Congress.

Suggestions for Improvement. The program effectively guided research efforts of scientists in the western United States, but as we assessed our accomplishments, we noted some possible changes that may have improved the program.

With the diversity of scientific expertise participating in the program, we felt that allocating time for brainstorming during the annual meeting, where scientists and producers explored research possibilities in a specific area, may have encouraged more creativity and regional projects. The annual meeting provided a unique opportunity for scientists of different disciplines to interact related to jointed goatgrass. A second opportunity for scientific interaction could be field tours at study sites for program participants. Tours could rotate among regions across years, thus encouraging more interaction and discussion among scientists and producers with different backgrounds.

We also noted a tendency for participation in our program to evolve toward mainly weed scientists. To encourage participation from other disciplines or agencies, we suggest that the Steering Committee plan brainstorming workshops every 3 or 4 yr, where scientists with diverse expertise are invited to attend; program funds could be allocated to pay for their travel costs. Not only will multiagency or multidisciplinary cooperation be fostered, but also unique ideas or perspectives may lead to new program priorities and research projects.

A key component of the program's success was long-range planning; we suggest that a national team develop a strategic plan at the start of the program and then evaluate progress at 5-yr intervals. A strategic plan encourages participants to think with both a national and a long-term perspective.

Including producers on the Steering Committee broadened the perspective of the program, but it also led to large differences in scientific background. To help producers evaluate proposals, the Steering Committee initially asked that proposals focus on objectives, justification, experimental procedures, and activities related to technology transfer. After several years, producers requested that scientists include the hypothesis guiding the research proposal and identify management recommendations as their research progressed. To further help producers understand experimental procedures, we suggest that proposals include detailed diagrams of the study's layout in the field. We also believed that assigning a producer from the Steering Committee to each BMP study would enhance involvement of producers in study design as well as increase communication between investigators and the Steering Committee.

With the differences in scientific expertise involved in the program, we suggest that yearly synopsis of key research findings would help technology transfer. As new knowledge is developed, scientists in that field of expertise could develop fact sheets or templates for field day handouts to ensure that new concepts or principles are accurately explained to producers.

BLUEPRINT FOR DEVELOPING NATIONAL TEAMS

To help others organize national teams, we provide a blueprint based on our experiences (Figure 3). We en-

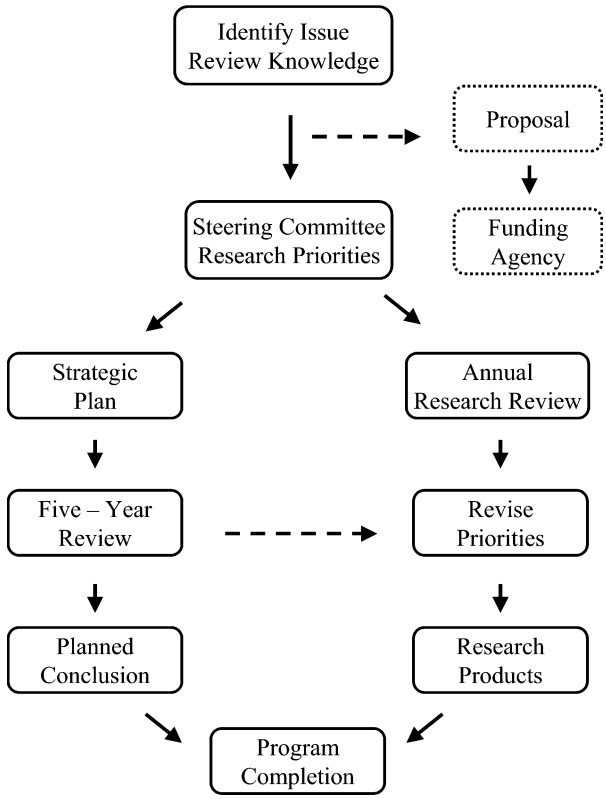

Figure 3. Blueprint for developing a regional or national team, based on experiences with the Jointed Goatgrass Research Program.

courage teams to consider a review paper on the status of knowledge related to the research issue; participants of our program continuously referred to the Donald and Ogg (1991) review as the program evolved. A review paper also facilitates writing a grant proposal, if outside funding is pursued.

A Steering Committee will help the program maintain a broad outlook in research ideas and goals. We suggest that the committee be composed of a diversity of program participants, including producers and users of the research accomplishments. Diversity of membership broadens the perspective of scientific thinking in suggesting research goals and approaches.

An annual review meeting facilitates scientific interaction among the diversity of disciplines, thus enhancing multidisciplinary research projects. We also stress the value of strategic planning, periodic assessment of program progress, and establishing a plan for concluding the program.

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