BICOVER - A National Research Network on Biological Control of Competing Vegetation.

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Introduction

To date, competing vegetation in Canadian forest regeneration has been controlled primarily using manual, mechanical or chemical strategies. Continued over-reliance on these techniques conflicts with the philosophy of integrated management and with public concern for the environment, particularly as it relates to the use of synthetic herbicides in forestry. Recent surveys overwhelmingly suggest that both foresters (37%), and the public (70%) view the use of chemicals in forest management as hazardous. In addition, the majority of professional foresters (57%) indicated a preference for use of biological pesticides with all relevant factors considered (1). While these views may not have a substantial basis in science, in meeting this challenge Forestry Canada has taken a lead role in addressing the two primary needs. The first of these relates to the requirement for credible research efforts in alternative vegetation management techniques. In this regard, a more holistic and ecologically oriented approach involving integration of all methods of vegetation management (no action, mechanical, manual, chemical, silvicultural, biological) applied on a site prescription basis is required (2). The logical second step is demonstration of scientifically defensible techniques as "best practices" for vegetation management through implementation in demonstration forests.

In practical terms, various constraints impair the potential for full delivery of an Integrated Vegetation Management (IVM) capability, including the facts that:

a) manual techniques are labour intensive, high risk in terms of worker-safety, and generally inappropriate for re-sprouting species (2);

b) in general mechanical methods are economically feasible only when applied in small scale situations where slope is minimal. The mechanical approach is generally inappropriate as a primary strategy for the scale of vegetation control required in Canadian forest renewal owing to costs and environmental implications of burning increasing amounts of fossil fuels;

c) the use of synthetic chemical herbicides is constrained by public opposition due to fears of potential health and environmental effects, a high degree of governmental regulation and a relatively small Canadian forest market. All of these factors combine to provide a strong disincentive to industrial interest in development of new synthetic herbicides (3);

d) taking no action to control competing vegetation is inappropriate for many Canadian cutover sites where current forest harvesting practices create conditions that favour subsequent colonization and growth of pioneer or "weedy" plant species, which typically out-compete new tree seedlings for required water, light, and nutrients;

e) the potential utility of either silvicultural (excepting prescribed burning) or biological options for control of competing vegetation is constrained almost entirely by lack of research and development.

In addressing the paucity of research and development associated with biologicals, Forestry Canada has focused efforts to discover and develop biological and/or biorational control options through initiation of a national research network. In this context the term "biological" is applied broadly to the use of any living organism *per se* to elicit control of undesirable vegetation, while "biorational" refers typically to secondary metabolites (hereinafter - natural phytotoxins) derived from microbial pathogens or allelopathic higher plants. As a whole, **BICOVER** (**Bi**ological **Co**ntrol of **Co**mpeting **Ve**getation **R**esearch) has as its goal, the successful development of economically viable and ecologically sound biological/biorational control agents against competing vegetation in Canadian forestry. This need is particularly critical to Canadian forestry since, as stated previously, small market potentials limit industrial interests in developing new synthetic products, and public concerns result in severe constraints on the limited number of products which are currently registered.

BICOVER Network Structure and Objectives

The **BICOVER** network enhances and accelerates research and development of biological/biorational control options for Canadian forestry by funding, coordinating and conducting a prioritized program of research. Proposed and initiated in 1991, the structural organization of the network has been derived in the form of a "liquid-crystal" model, which incorporates fundamental networking concepts of liquidity, flexibility, linkage, interaction and growth within a more solid overall structural framework (Fig. 1). Such a structural organization provides for significant collaboration between sub-networks focusing on the potential use of biological organisms (herbivores, allelopathic plants; bacterial, viral and fungal plant pathogens) and a sub-network studying natural phytotoxins which may play a role in plant pathogen (4,5) and allelopathic plant (6) interactions. The structural organization stimulates the multi-disciplinary interaction of biologists and chemists essential to developing a fundamental understanding of the specific plant-pathogen or plant-plant interactions. The fundamental knowledge developed in the discovery phase of the research program is critical to the ultimate development and use of either the live organisms or natural phytotoxins as biological and biorational control agents respectively in the delivery phase. The practical potential of these two strategies is demonstrated by the recent registration of BIOMAL (a fungal pathogen of *Malva spp.*) as the first biological for weed control in Canada (7) and the successful development of BIALAPHOS, a natural phytotoxin derived from *Streptomyces viridochromogenes*, as a biorational product registered in Japan for weed control in rice production.

Current Research

The ultimate objective of the BICOVER research program is delivery of biological/biorational control agents to forest managers. Priority target species include; *Rubus ideaus, Alnus rubra, Populus tremuloides, Calamagrostis canadensis, Acer rubrum, Prunus pennsylvanica,* and *Epilobium angustifolium,*

which are primary competitive species throughout many of the major forest regions in Canada. In addition, specific problem species with a more regional character, for example *Gaultheria shallon, Kalmia angustifolia, Rubus parviflorus, Rubus spectabilis* and a variety of common nursery weeds are also considered as high priorities. Current research projects being advanced under the auspices of the network include studies on indigenous fungal plant pathogens, viral plant pathogens, bacterial pathogens and natural phytotoxins directed toward control of the previously mentioned targets.

Fungal Pathogens

Research efforts by Wall and coworkers (8,9) have clearly demonstrated the potential of *Chondrostereum purpureum* for control of resprouting of *Populus tremuloides* as well as other competing brush species (*Alnus spp., Rubus spp.*). Current efforts are focused on further examination of the efficacy under field conditions, optimization of fermentation culture as well as initial bioassay of culture filtrates to determine the possible role of high molecular weight phytotoxins in pathogenicity of this species.

Colletotrichum dematium is second fungal pathogen under investigation. Patented by Dr. A.K. Watson and R.S. Winder (MacDonald College, McGill University), *C. dematium* is an indigenous pathogen of *Epilobium angustifolium*, a common pioneer and problem species in many forest cutovers across Canada. Further research and development on *C. dematium* currently involves optimization of culture conditions for conidia production in conjunction with host range and virulence studies. In addition, basic formulation research is being conducted to establish conditions required for maintaining conidia viability preparatory to small plot field screening during the next growing season.

Natural Phytotoxins

The potential of phosphinothricin, a natural phytotoxin derived from *Streptomyces viridochromogenes*, the active ingredient of bialaphos, has been shown to provide effective control of both *Rubus idaeus* and *Kalmia angustifolia* in near-operational research trials (10,11). Notwithstanding problems associated with industrial patenting, the fact that this product is registered for use on a major food crop (rice) in Japan, confers an increased probability of a future registration for Canadian forestry. In advancing this product, research within the network is currently focused on experiments investigating the tolerance of primary crop species *Picea glauca, Picea mariana, Pinus resinosa* and *Picea abies*.

Additional research in the natural phytotoxins subnetwork includes isolation and structural elucidation of secondary metabolites of *Bipolaris sorokiniana*, a fungus with documented pathogenicity on grass species including *Calamagrostis canadensis* and recently initiated studies on the possible role of phytotoxins of indigenous rhizobacteria known to inhibit germination and/or root growth. As noted previously, similar studies are continuing on the role of phytotoxins in pathogenicity of *C. purpurem*, while studies on *C. dematium* are imminent.

Bacterial Pathogens

Following screening of over 800 isolates of indigenous rhizobacteria from forest sites in Ontario, 8 isolates (presently unidentified) that clearly inhibit seed germination and growth have been selected for further culturing, identification and study. Similarly, rhizobacteria associated with decadent *C. canadensis* in the interior of British Columbia have been collected and isolates therefrom are currently being purified, characterized and stored in working culture (as well as semi-permanent culture to minimize attenuation of virulence). The most promising candidates will subsequently be screened using a variety of bioassay techniques to identify the most promising candidate organisms for future work.

Viral Pathogens

The possibility of using viral plant pathogens as biological control agents in control of competing vegetation has been recognized by the network as a novel idea with sufficient merit for preliminary investigation. A review of the literature on plant virology associated with priority target plant species has been conducted and will be the basis for a network decision as to whether and how to proceed with further research in this area. In addition, basic work has been initiated on collection and development of pure cultures of viral pathogens of *Rubus, Calamagrostis* and *Epilobium* host plants together with development of appropriate antisera.

Herbivores and Allelopathic Plants

Funding limitations and research prioritization have prohibited research efforts in these sub-networks in year one of network operation, however flexibility in network structure provides for future research in the use of herbivores and/or allelopathic plants. The strong potential of the latter approach for control of undesirable vegetation in forestry has been previously demonstrated (12,13,14).

Summary and Prospectus

Fundamental research on a number of fungal and bacterial pathogens of priority competing species in Canadian forestry provide a basis to suggest that these areas have promise as potential biological control agents. Further research required to develop and ultimately deliver these products as components of an integrated vegetation management strategy will be a high priority in future research initiatives. Since guidelines for registration of microbial pesticides in Canada are still evolving, and identification of natural phytotoxins involved in plant pathogenicity has become a requirement for registration of microbial products (R-Memo R9003, August 1, 1990), research on natural phytotoxins will also continue as a high priority area of research within the network. In this regard, research specifically directed at development of knowledge-based regulatory protocols for these products is essential. Finally, while research on viral plant pathogens, allelopathic plants and herbivores has not yet been undertaken to any extent, there is no *a priori* reason to reject these areas as additional avenues that may ultimately provide products with a role in biological/biorational control. Thus, the

comprehensive approach to research within the BICOVER network will continue with an appropriate emphasis on short and long term projects which may ultimately lead to delivery of biological/biorational control agents as cost-effective, efficient and environmentally acceptable alternatives in an overall integrated vegetation management strategy.

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