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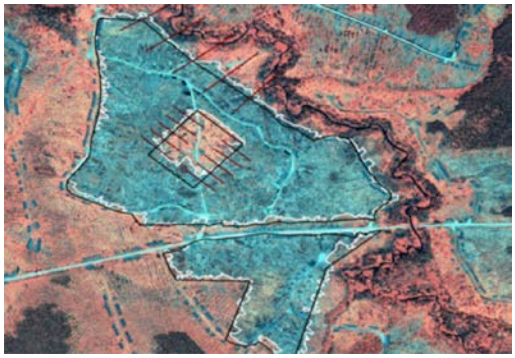
Canadian Forest Service – Great Lakes Forestry Centre

Improving aerial application technology for forest herbicides

INTRODUCTION

The Canadian Forest Service, part of Natural Resources Canada (NRCan, CFS), has a strategic priority to advance environmental leadership relating to Canada's forest resources. Effective regeneration contributes to sustainable management of these resources and herbicide applications are an important tool in this process. Herbicide application, particularly in the early stages of plantation establishment, reduces crop growth loss due to competition with other vegetation for light, moisture, nutrients and space, which is especially important on fertile sites that have the potential to produce high quality fibre. It also ensures the replacement of conifers across the boreal landscape. In 2011, herbicides were used to control competing vegetation on approximately 123,000 hectares of regenerating forests, largely in the provinces of Ontario, Alberta, and New Brunswick. In that year, and throughout the last decade, glyphosate-based herbicides have dominated the forest-herbicide use market, typically accounting for over 97% of the area treated. Aerial application is the most cost effective method for herbicide use, particularly for large, remote areas that have poor access, which is typical of the boreal forest. Continual improvement of aerial herbicide application technologies will ensure optimal targeting of herbicides, maintain cost effectiveness and minimize environmental effects.



Near infrared photo shows effectiveness of herbicide exclusion zone

GREAT LAKES FORESTRY CENTRE (GLFC) ROLE

GLFC scientist Dean Thompson has been working with colleagues in the United States and New Zealand to develop a decision support system called SprayAdvisor: one component of a continual improvement process for spray technology. The advanced technologies that are involved include geographic information systems, global positioning systems, electronic-guidance on board the aircraft, on-site meteorological monitoring and remote sensing. The SprayAdvisor decision support tool can be used to optimize on-target deposition and at the same time enhance protection of sensitive areas or those not requiring treatment.

The primary role of the GLFC has been to conduct field trials to validate spatial predictions of herbicide deposition under scenarios typical of potential use in Canada. Thirteen (13) spray blocks in northern Ontario and 7 in Alberta, involving either fixed-wing aircraft or helicopters, were intensively monitored and used as individual case studies. In each case study, detailed information was collected on site characteristics, meteorology, aerial application equipment and spray parameters together with on and off-target measurements of chemical deposition. One year subsequent to treatment, high resolution true colour and near-infrared satellite imagery was acquired to determine the area that had been successfully treated.

Differential Global Positioning System (DGPS)

DGPS (an enhanced GPS with improved location accuracy) was used at multiple stages of the operation and assessment. Initially, it was used to accurately define the spray block boundaries and exclusion zones. A hand-held ground-based DGPS unit was used to establish the corner points of the rectangular exclusion zones. During spraying, these coordinates were linked into the electronic guidance system on board the aircraft. DGPS was also used to identify the location of the chemical deposition sampling points positioned throughout the spray block and exclusion zones to assess post-spray herbicide levels.

Electronic guidance

An electronic guidance system (Ag-Nav II) provided valuable data on aircraft position and spray boom activity. This allowed for effective control over track spacing, which contributed to uniform herbicide deposition and efficacy throughout the spray block. It also allowed for greater refinement of the area to be treated and effective exclusion of areas that did not require treatment. Electronic guidance data were collected for all aspects of the spray operation, including total area treated, flying height, airspeed, swath width, flight path orientation and nozzle flow rates, and archived for subsequent use in post-treatment assessments.

Meteorological monitoring

An on-site meteorological tower collected relevant weather data before spraying to ensure conditions were suitable. Throughout spray applications, the critical meteorological parameters of air temperature, relative humidity, wind speed and direction were monitored every five seconds to characterize average conditions. This allowed for predictions of both on-target deposition and potential drift into within-block exclusion areas or buffer zones.

Deposition assessment

The uniformity of herbicide deposition on-target as well as around exclusion zones was measured using artificial deposit collectors, positioned throughout the spray blocks and exclusion zones. For each of these collectors, the amount of glyphosate was measured using analytical chemistry techniques, with data subsequently compared to the predicted deposition levels. Results showed that the predictions calculated by SprayAdvisor were typically very close to actual measured levels.

Herbicide application with helicopter

Post-treatment assessment

The effectiveness of the herbicide application and efficacy of the exclusion areas was judged one year after treatment. Phytotoxicity contours (the visible boundary between live and dead vegetation) were determined using three different estimation methods. These included ground-based DGPS tracking, airborne (true colour) digital imagery and satellite-based (near-infrared) imagery. The ground-based method involved an experienced individual walking the boundary between live and dead vegetation using a hand-held DGPS. For the image analysis techniques, a contour line was drawn on images to differentiate live from dead vegetation, which appeared as green versus brown pixels for the true-colour images or pink versus aqua-marine pixels for the near-infrared satellite images. These contour lines were then used to estimate incursion distances, or actual area affected by herbicide spraying compared to planned area. There was strong agreement among each of the techniques, however remote sensing image analysis software proved to be a powerful and relatively easy method of assessing post-treatment efficacy.

Operational implications

These field trials showed that the SprayAdvisor decision support system generates spatially explicit predictions of herbicide deposition that were consistent with both measured on-target deposits and observable phytotoxicity one-year post treatment. Results also demonstrated the feasibility of silvicultural exclusions as small as 1 ha in size within operational spray blocks. Results of these studies have stimulated changes in operations, for example toward increasing use of low-drift nozzle systems and rotary aircraft. Many Canadian forestry companies already use geographic information and global positioning systems extensively, thus facilitating the potential incorporation of SprayAdvisor into their operational programs. A series of training workshops has been completed to encourage the use of SprayAdvisor as a standard operational practice for herbicide applications in Canada.

CONCLUSION

The SprayAdvisor decision support system is expected to become a component of best management practices for sustainable forest management and environmental protection in Canada. It provides a solid basis for predicting the accuracy of spray application and determining the potential for off-target phytotoxic effects. Its use will lead to synergistic benefits in relation to planning, conduct, post-treatment monitoring and data archiving phases of aerial herbicide programs.

COLLABORATORS

Ontario Ministry of Natural Resources

Tembec Inc.

US Dept. of Agriculture - Forest Service

Scion Research Institute, New Zealand

Incremental Forest Technologies Ltd.

Millar Western Forest Products

CONTACT INFORMATION

Dean Thompson
Great Lakes Forestry Centre
1219 Queen St. East
Sault Ste. Marie, Ontario, Canada
P6A 2E5
Phone: 705-949-9461
Fax: 705-541-5700
E-mail: GLFCWeb@nrcan.gc.ca
Web Site: www.nrcan.gc.ca/forests/research-centres/glfc/13459

POLICY PERSPECTIVE

Natural Resources Canada conducts research relating to the protection of the forest resources of Canada under the Forestry Act. One of the duties of Federal Minister of Natural Resources, under the Department of Natural Resource Act, is to assist in the development and promotion of Canadian scientific and technological capabilities and it is through these acts that this research is supported. The use of herbicides in Canada is regulated under the Pest Control Products Act, administered by the Pest Management Regulatory Agency of Health Canada to ensure that all products meet strict health and safety standards.

RECOMMENDED READING

Thompson, D.; Chartrand, D.; Staznik, B.; Leach, J.; Hodgins, P. 2010. Integrating advanced technologies for optimization of aerial herbicide applications. New Forests 40: 45-66.

Thompson D.; Leach, J.; Noel, M.; Odsen, S.; Mihajlovich, M. 2012. Aerial forest herbicide application: Comparative risk mitigation strategies in Canada. The Forestry Chronicle 88:176-184.

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