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Going Beyond the Zones – some next steps to knowing what can grow where in Canada

by

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Introduction and aims

There is interest in and some controversy about (e.g., Drysdale 2002), the recent update of Canada's Plant Hardiness zones. The interest stems from the added detail in the map, the use of more recent climate data and the use of more repeatable, modern methods of climate modeling/mapping. The controversy is because the zones have changed in a few places in somewhat counterintuitive ways.

In fact, the new map is a direct application of the climate-based plant hardiness formula developed by Oullet and Sherk (1967a, b and c), but uses more recent and more refined national climate models. The original Oullet and Sherk map went beyond a simple minimum temperature map like the type used by the United States Department of Agriculture. Their work was an important recognition that plants respond to more than just temperature, especially in Canada! Canada's climate is varied and complex, particularly over the winter months; each plant species has its own response to these influences. Oullet and Sherk developed their hardiness or plant suitability formula based on an analysis of how 174 trees and shrubs respond to climate conditions across Canada (not herbaceous perennial flowers although that is what the map is often used for!). The final formula and the one that was used to develop the Canadian plant hardiness zones map used 7 climate variables. For further details on the formula, on how the old and new zone maps were developed and perhaps how they should be interpreted see McKenney and Campbell (2002) and the references. This should help clarify some of the controversy.

It should be apparent to anyone who digs into the matter that both the old, and new, zone maps have limits and have not been calibrated to the wide number of plant species of interest to Canadians. Any single, national formula is bound to have limitations. For example, a decrease in snow cover may be disastrous for some plants in one part of the country, but may indicate generally warmer conditions in another region that may help some plants.

In this note we explain how we want to go beyond a single, general plant hardiness zones map. Our ultimate aim is to improve, in a scientifically based and repeatable way, our understanding of what plants can grow where in Canada. We want to produce results that will be useful to professionals in urban forestry, the horticulture industry and to the public. It should be emphasized that we are not the only people interested in this problem and many professionals have long been involved in field studies that aim to establish what can grow in particular places in Canada. We wish to tap into their legacy and work with these individuals and groups to extrapolate their results and knowledge.

What distinguishes our efforts is the linking of public awareness, professional expertise, and plant survival data to generate potential range maps. The intended result, if all goes well, will be a series of maps for individual species and a new national database of how well individual plant species survive and grow in different parts of the country. This effort should also help in developing a new generalized plant hardiness zones map that is better calibrated to current climate than the current version. It is critical to realize that no single map will ever be perfect. Ongoing effort and refinements will be needed as new species and cultivars are introduced, and as Canada's climate changes.

How we will map out potential plant ranges in Canada

The climate modeling that went into the generation of the new map can help develop **plant specific** range maps. Climate imposes a broad geographical constraint on plant distributions (Woodward 1987). For example, tropical plants do not survive where the winter temperatures dip below certain threshold levels. Conversely heat and moisture levels can limit the performance of some plants and their ability to compete in natural settings. If we accept the concept that each plant has its own set of tolerances to different climatic conditions, the challenge then becomes how can we quantify and map this? Professor Henry Nix at the Australian National University has led the development of a set of tools that can help. He first applied it to the problem of mapping out possible distributions of elapid snakes in Australia (Nix 1986; see also Busby 1991). The approach involves obtaining accurate location data for the plant or animal of interest from as broad a geographic area as possible. These data are used to generate a "bioclimatic profile" of the species using high resolution climate models. Finally the profile itself is mapped using the maps of each of the variables in the profile. Only the places that match the profile are mapped. As a 100% survey of the locations where a plant (or animal) occurs will never be practically possible, computer modeling is necessary to help make spatial predictions (maps) (see Scott et al. 2002 for a survey of this literature).

The ANUCLIM approach has been successfully used for many ecological studies in Australia and a few other countries, and has been applied to forest insects and diseases, birds, reptiles and amphibians in Canada. The approach is described in a Canadian context in McKenney et al. (1998) and some results can be seen on-line at http://www.glfc.cfs.nrcan.gc.ca/index-en/research-e/ForestLandMgmnt-e/herp-en.html. The overall steps are set out in Figure 1.

Invitation to provide data

The challenge for this project will be to obtain accurate and reliable location data for all the plants of interest. The greatest difficulties lie in plant identification and the lack of experimental trials for all the species of interest in all parts of the country. Thus we are proposing an approach that uses the power of the Internet, expert and public knowledge, to draw together the data necessary to undertake the required bioclimatic modeling.

Our Plant Hardiness web site (http://g4.glfc.cfs.nrcan.gc.ca/ph_main.pl) enables location and survival data to be entered by experts and the public. Users identify the latitude and longitude of their location. Elevation, essential to achieve accurate climate estimates at each location, will be estimated using a new Digital Elevation map of Canada that was developed by the Canadian Forest Service and the Canada Centre for Topographic Information (http://www.cits.rncan.gc.ca). Users then identify what trees, shrubs and flowering perennials survive at that location. The plant list is comprehensive but not exhaustive. Experience in the early stages of this project will influence decisions about adding other plants to the list. We are also asking users to enter some additional basic data about soil conditions and exposure. Taken together these kinds of data will provide insights about plant hardiness.

Experts and researchers who have larger quantities of data should contact us directly if they would like to contribute to this project. Contributions can be confidential and their use restricted to specific applications. We would also be pleased to provide climate estimates/profiles to scientific contributors, if desired. Such climate estimates may be useful for additional scientific research.

An invitation to our Southern neighbours

We hope the project is of interest to our southern neighbours. Understanding plant survival in the United States will greatly aid in developing climatic profiles of individual plant species. Geographic proximity is not always a good indicator of climatic similarity, hence plant data from the United States will be extremely useful. To encourage participation from the United States the potential climatic range maps we produce will include the United States.

Maps, survival data and updates

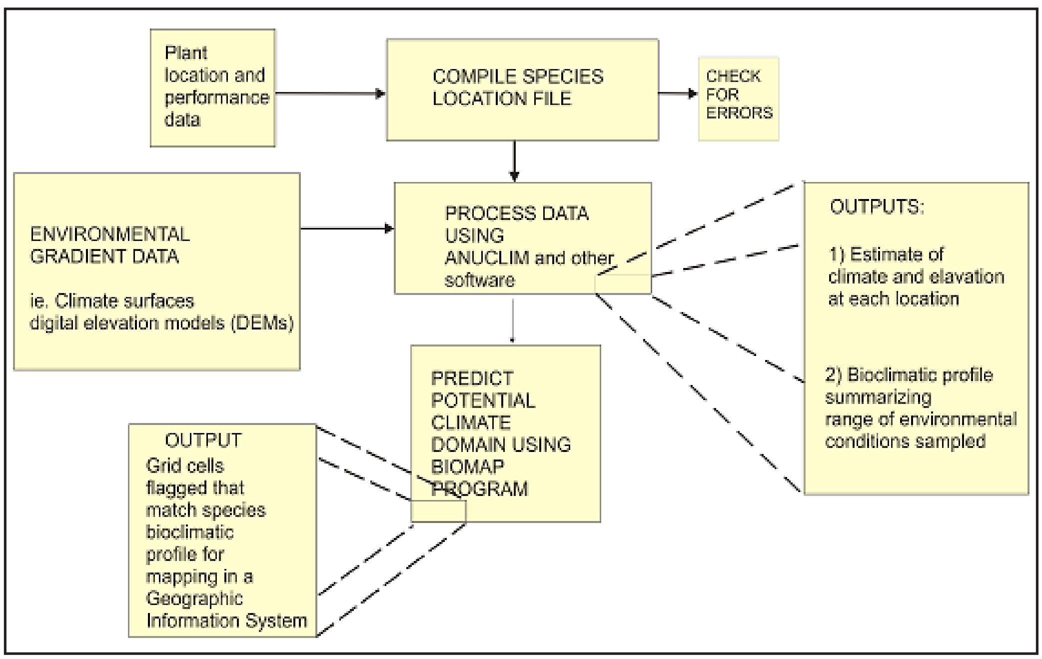
Once sufficient data are entered, a climatic profile will be generated for each species using the variables listed in Table 1. Range maps will then be developed following the procedure outlined in Figure 1 and posted on the Internet. Thirty to fifty **well-distributed** observations are sometimes all that is required to generate reasonable, stable results. An important point is that the maps can be updated relatively easily. The hope is that both experts and the public will be enticed to contribute, especially if they see their particular area is not well represented.

We will develop two sets of climatic range maps. One set will be based on data from experts and the other based on the data from both experts and the public. We feel it is important to keep these data sources separate because mistakes in plant identification are possible. We will strive to ensure data quality from all sources. If there appears to be discrepancies these data will not be used. The two sets of maps may be similar or they may not be – it is difficult to predict. Maps that are very different may indicate problems such as plant identification or they may indicate real and trustworthy responses that need to be further investigated by experts. Users will also be able to see the location data that has been entered for each species on the Internet mapper. These data will only be geo-referenced to ~ a 2-5km resolution to ensure confidentiality.

Table 1. Climate variables that may be used in the bioclimate range mapping. Some experimentation will occur to determine the best combination.

Temperature	Precipitation
Annual mean temperature	Annual precipitation
Annual mean maximum temp	Seasonality (coefficient of variance)
Annual mean minimum temp.	Precipitation of the wettest month
Maximum diurnal range	Precipitation of the driest month
Mean temp. of hottest month	Precipitation of the wettest quarter
Mean temp. of coldest month	Precipitation of the driest quarter
Seasonal temperature range	Precipitation of the hottest quarter
Maximum temp. of hottest month	Precipitation of the coldest quarter
Minimum temp. of coldest month	
Annual range	

Figure 1. Steps involved in making plant specific climatic range maps.



Concluding Comments

We hope the Internet and perhaps the interest and controversy generated by the new plant hardiness map help us achieve our goal of better quantifying what can grow where in Canada. There is a need to go beyond the old plant hardiness map, to develop new plant survival databases for Canada and to produce maps that are useful to all Canadians. The project is ambitious but we feel it is feasible with modern technology. Regardless, this project cannot be successful without the involvement and cooperation of many people. Plant survival data is needed from across the country. No single individual or agency has these data. Success requires a collective effort.

Ultimately it is important for people to realize that the vagaries of year-to-year weather variations and management activities also affects plant survival. Average climate conditions provide the basic constraints but are not the only determinant of plant survival.

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