



The Northern Margin:
Quantifying Canada's Heat
Limited Farmland Frontier
to 2100

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EXECUTIVE SUMMARY:

Growing degree days, not soil, set the outer boundary of where cereals can be grown in Canada. That boundary is moving north. Using observed present-day climate and an intermediate emissions scenario, we estimate that the area of Canada meeting the minimum heat requirement for small cereals expands by roughly 2.2 million square kilometres by 2100, an increase of about 77 per cent over the area that qualifies today.

This is a large number and it should be read carefully. It measures the removal of a temperature constraint, not the creation of farmland. Soil, water balance, infrastructure and economics all bind tighter than heat across most of the newly qualifying area. The investment relevance lies less in the headline area than in what the shift implies for land at the existing margin, where heat has been the binding constraint and where relief from it is most directly capitalised.



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METHOD:

We follow the approach of King et al. (2018), who define climatic feasibility for small cereals such as barley and oats as growing degree days above a 5-degree Celsius base of at least 1,200 in a year. Degree days are accumulated using the Baskerville and Emin sine method, which integrates the daily temperature curve between minimum and maximum rather than relying on the monthly mean. This matters at the northern margin, where days that average below the base temperature still accumulate heat in the afternoon.

The frontier moves north 310 to 460 kilometres across the prairie longitudes by 2100.

Under an intermediate emissions pathway, not a high emissions one.

The current frontier is computed from WorldClim 2.1 climate surfaces adjusted to present day conditions using the observed warming record. The 2100 frontier applies the mean warming of a 34 model CMIP6 ensemble under SSP2-4.5, an intermediate emissions pathway. We deliberately avoided the high emissions SSP5-8.5 scenario and single model projections, both of which produce materially larger and less defensible shifts.

The resulting present-day surface calibrates to within roughly three per cent of published station normals across the prairie provinces, which is the check that matters most for credibility. Peace River Country, the northernmost commercial grain region in North America, sits comfortably inside the current boundary as it should.

RESULTS:

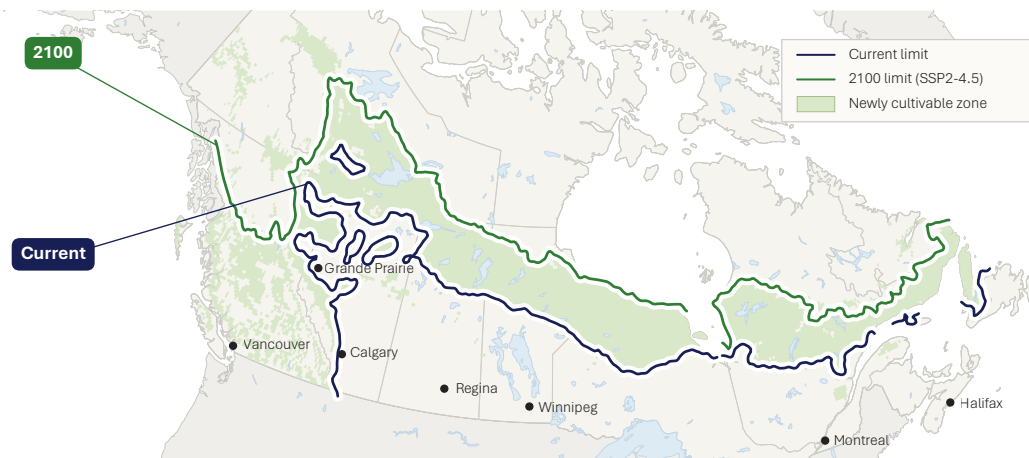
Table 1 sets out accumulated growing degree days at representative locations under current conditions and in 2100.

Table 1. Growing degree days above 5 degrees Celsius.

Location	Current	2100	Change
Lethbridge, AB	1,840	2,360	+520
Regina, SK	1,921	2,447	+527
Winnipeg, MB	1,951	2,451	+499
Grande Prairie, AB	1,428	1,925	+497
Peace River, AB	1,439	1,931	+492
Fort Vermilion, AB	1,395	1,853	+458
Thompson, MB	1,145	1,569	+423
Yellowknife, NT	958	1,319	+362

Source: Omnigence analysis of WorldClim 2.1 and CMIP6 SSP2-4.5.

Across the prairie longitudes the 1,200 degree day boundary moves north by between 310 and 460 kilometres.



Established growing regions gain roughly 500 degree days, which is the difference between a short season constrained to early maturing varieties and a season that comfortably supports a wider crop set. Locations that are currently marginal, such as Fort Vermilion, move from the edge of feasibility to a position resembling today's central Alberta.

CAVEATS AND ASSUMPTIONS:

Heat is a necessary condition, not a sufficient one. The following constraints are material and none of them are captured in the area figures above.

- Soils. Boreal soils are the binding constraint across most of the newly qualifying area. They are typically acidic, poorly drained and low in nutrients, and they store very large quantities of organic carbon that would be released on conversion. King et al. note that only about 8.5 to 9 per cent of Canada's currently feasible area is farmed at all, which is the clearest evidence that heat has never been the sole limiting factor.
- Water. Warming raises potential evapotranspiration faster than it raises growing season precipitation. King et al. project that roughly 40 per cent of newly feasible land in the North American boreal region would face growing season water deficits exceeding 300 millimetres. Heat gained is not moisture gained.
- Photoperiod. Newly qualifying land sits at latitudes with day length profiles unlike existing farmland. Cereal varieties would require adaptation, and yield outcomes cannot be assumed from southern analogues.
- Scenario and model uncertainty. Results depend on the emissions pathway and on model structure. SSP2-4.5 is an intermediate assumption. A lower pathway would compress the shift and a higher one would expand it substantially.
- Cartographic generalisation. In the Cordillera, feasibility follows valleys rather than latitude and no single frontier line exists. Lines through that region are generalised and should not be read at local resolution.
- Threshold definition. The 1,200 degree day threshold is the climatic minimum for small cereals. It is not a threshold for corn, soybeans or quality milling wheat, each of which requires materially more heat.

INVESTMENT IMPLICATIONS:

The practical signal is not the frontier itself but the interior. Land already in production gains roughly 500 degree days, which extends the viable crop set, reduces frost risk at both ends of the season and raises the option value of the existing asset. That accrues to owned farmland in established regions rather than to speculative positions in the boreal.

At the margin, regions such as Peace River experience significant improvement in growing conditions versus current. Historically, heat constrained land has traded at a discount reflecting shorter seasons and narrower crop optionality. Relief from that constraint is a plausible source of relative value, and it will be capitalised gradually rather than at a point in time.

The boreal expansion itself is best treated as a very long dated real option rather than an investable thesis. Soil, drainage, access and carbon policy all stand between climatic feasibility and cultivated acreage, and the historical record of the currently feasible but unfarmed area suggests those barriers are durable.

SOURCES:

King, M., Altdorff, D., Li, P., Galagedara, L., Holden, J. and Unc, A. (2018). Northward shift of the agricultural climate zone under 21st century global climate change. *Scientific Reports* 8, 7904. doi:10.1038/s41598-018-26321-8.

Climate surfaces from WorldClim 2.1 (Fick and Hijmans, 2017). Projections from the CMIP6 multi model ensemble under SSP2-4.5, aggregated on IPCC AR6 reference regions. Observed warming from the W5E5 dataset via the IPCC WGI Atlas. Analysis and mapping by Omnigence Asset Management.



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