Development of extreme weather indicators and use of climate data in eastern ON Envision model

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Ottawa, ON
July 26, 2017

Extreme weather and agriculture


Photo: Tim Smith, The Canadian Press


Photo: Bob Nichols, USDA

Crop-specific weather extremes


Photo: Nati Harnik, AP


Photo: Oklahoma Farm Report

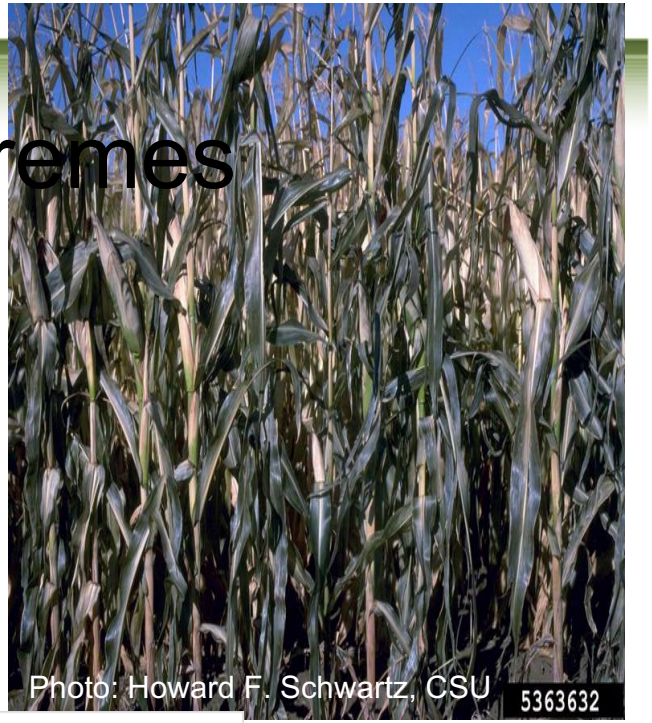
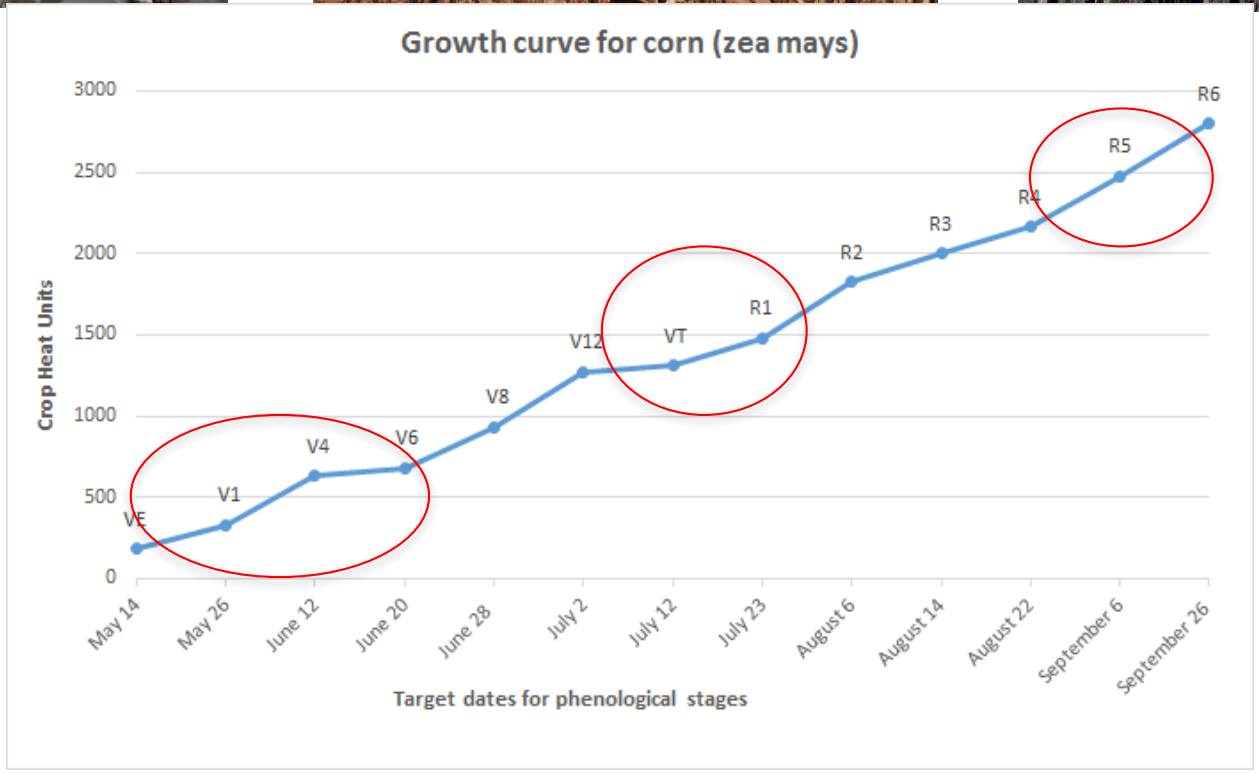


Photo: Howard F. Schwartz, CSU



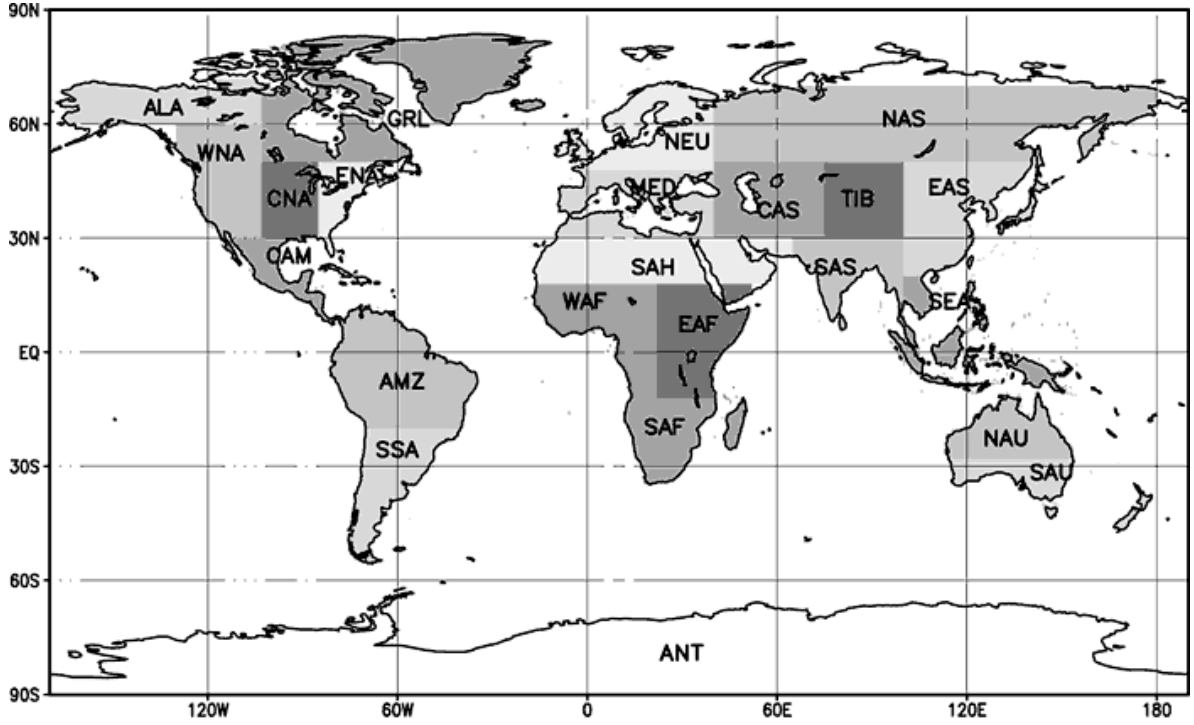
Historic climate data

- Quality controlled gap filled data for daily min and max temperature and daily precipitation from 1961 to 2010. (Sources: EC, Schroeter and Associates)

- “Surrogate” stations were used to estimate missing values at “target” stations using long-term climatic relationships between station data series.

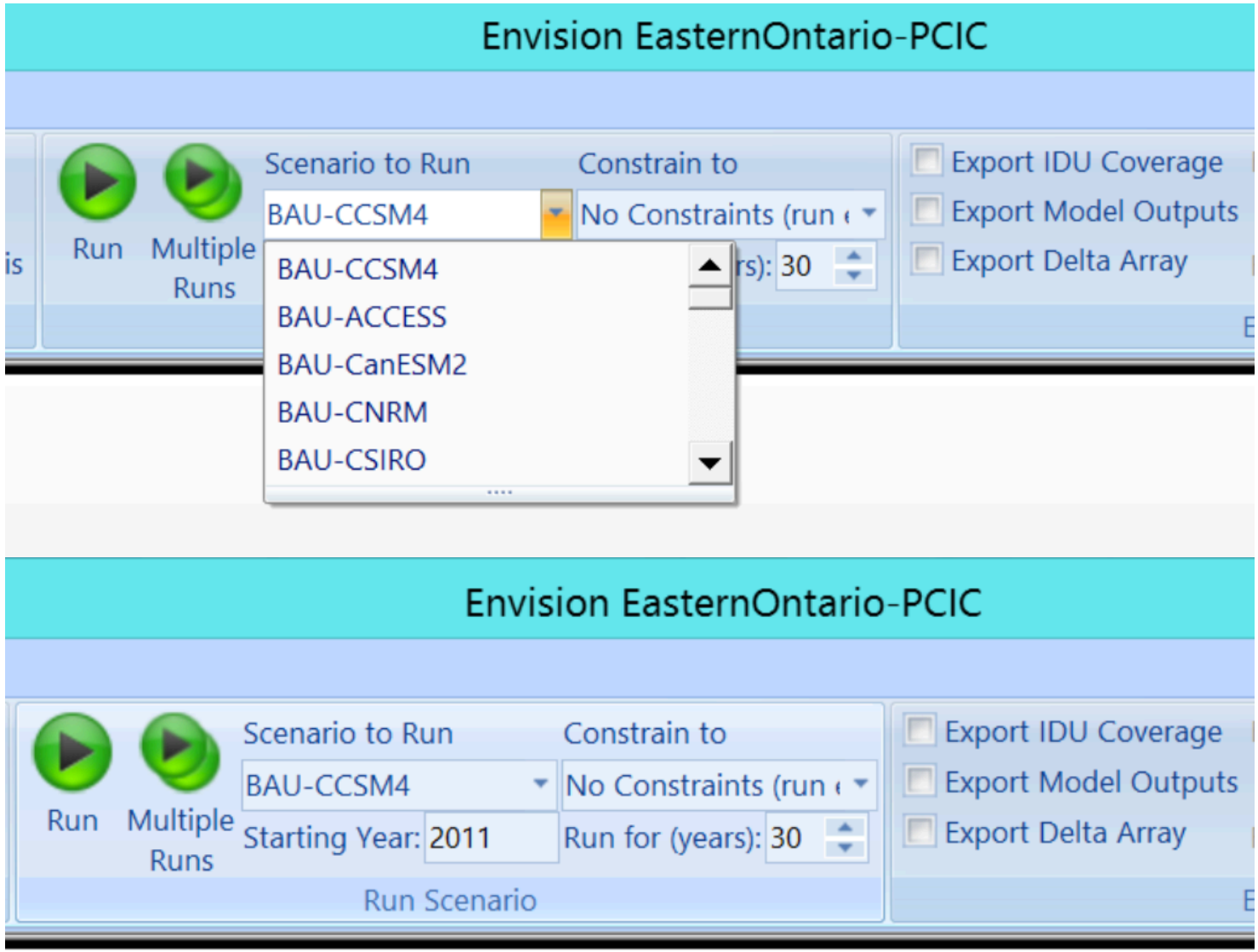
Projected climate data

- High resolution downscaled daily temperature and precipitation data for an ensemble of 12 models used in CMIP5 under RCP 8.5 from 2011 to 2035. (Source: Pacific Climate Impacts Consortium)



ALA	Alaska	NEU	Northern Europe	NAS	Northern Asia
WNA	Western North America	MED	Mediterranean	TIB	Tibet
CNA	Central North America	CAS	Central Asia	EAS	Eastern Asia
ENA	Eastern North America	SAH	Sahara	SAS	Southern Asia
GRL	Greenland	WAF	West Africa	SEA	South East Asia
CAM	Central America	EAF	East Africa	NAU	Northern Australia
AMZ	Amazonia	SAF	Southern Africa	SAU	Southern Australia
SSA	Southern South America	ANT	Antarctic		

Source: Giorgi and Fransisco, 2000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Run
Multiple Runs
Scenario to Run
Constrain to
BAU-CCSM4
No Constraints (run
rs): 30
Export IDU Coverage
Export Model Outputs
Export Delta Array
BAU-CCSM4
BAU-ACCESS
BAU-CanESM2
BAU-CNRM
BAU-CSIRO
Envision EasternOntario-PCIC
Run
Multiple Runs
Scenario to Run
Constrain to
BAU-CCSM4
No Constraints (run
Starting Year: 2011
Run for (years): 30
Export IDU Coverage
Export Model Outputs
Export Delta Array
Run Scenario

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CLIMATE DATA SUMMARY

Notes:
   directoryIn   -  the directory that includes the processed climated data.
                    This directory cannot include files other than processed climate data
   directoryOut  -  the directory that the model will write the Envision-based
                    climate summaries into.  It is required to be different from directoryIn

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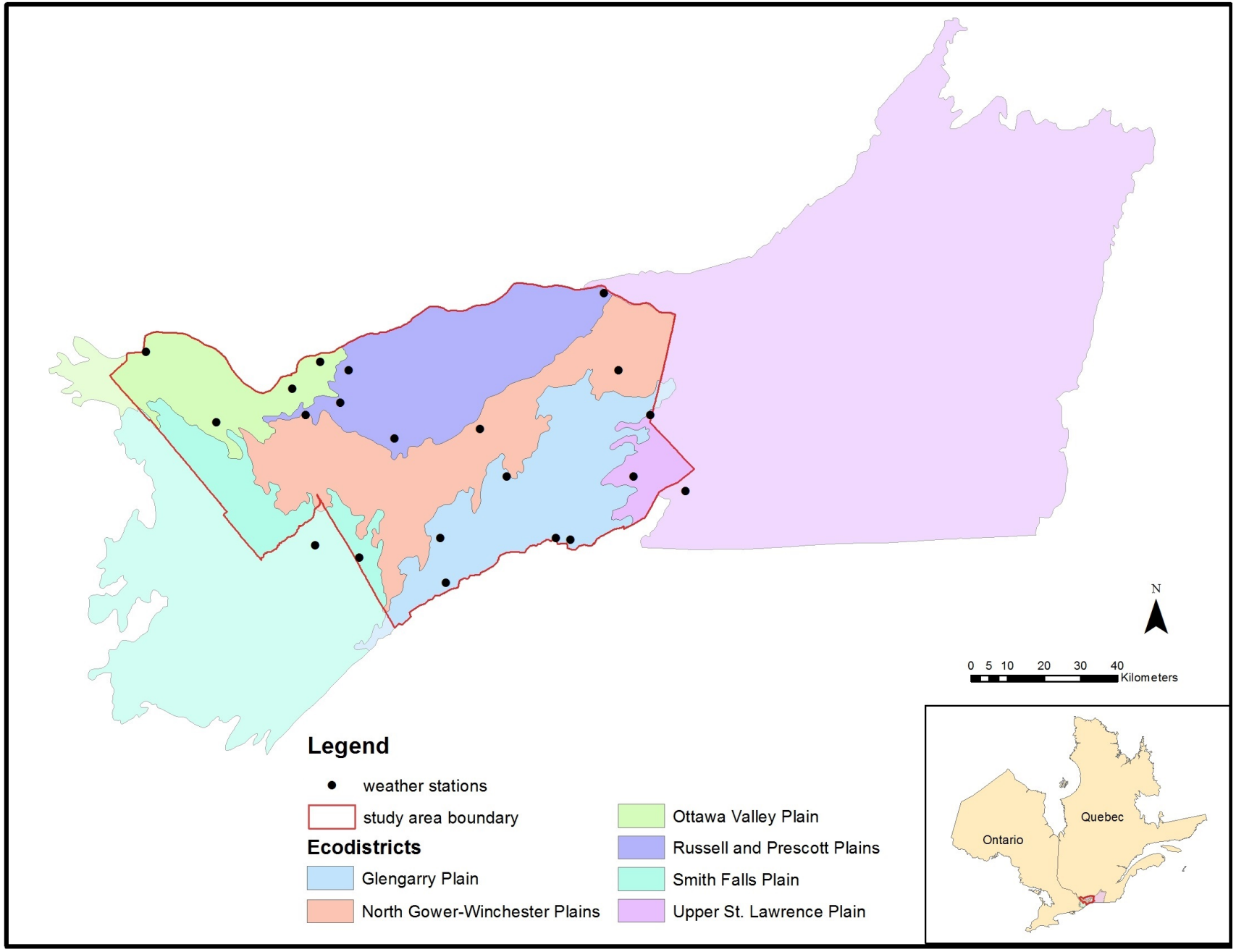
Use of representative weather stations

- Six weather stations representing each of the six ecodistricts located in the study area were selected
- Mean and extreme T and P data used in selection process
- Why not gridded data?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Kilometers
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weather stations
study area boundary
Ecodistricts
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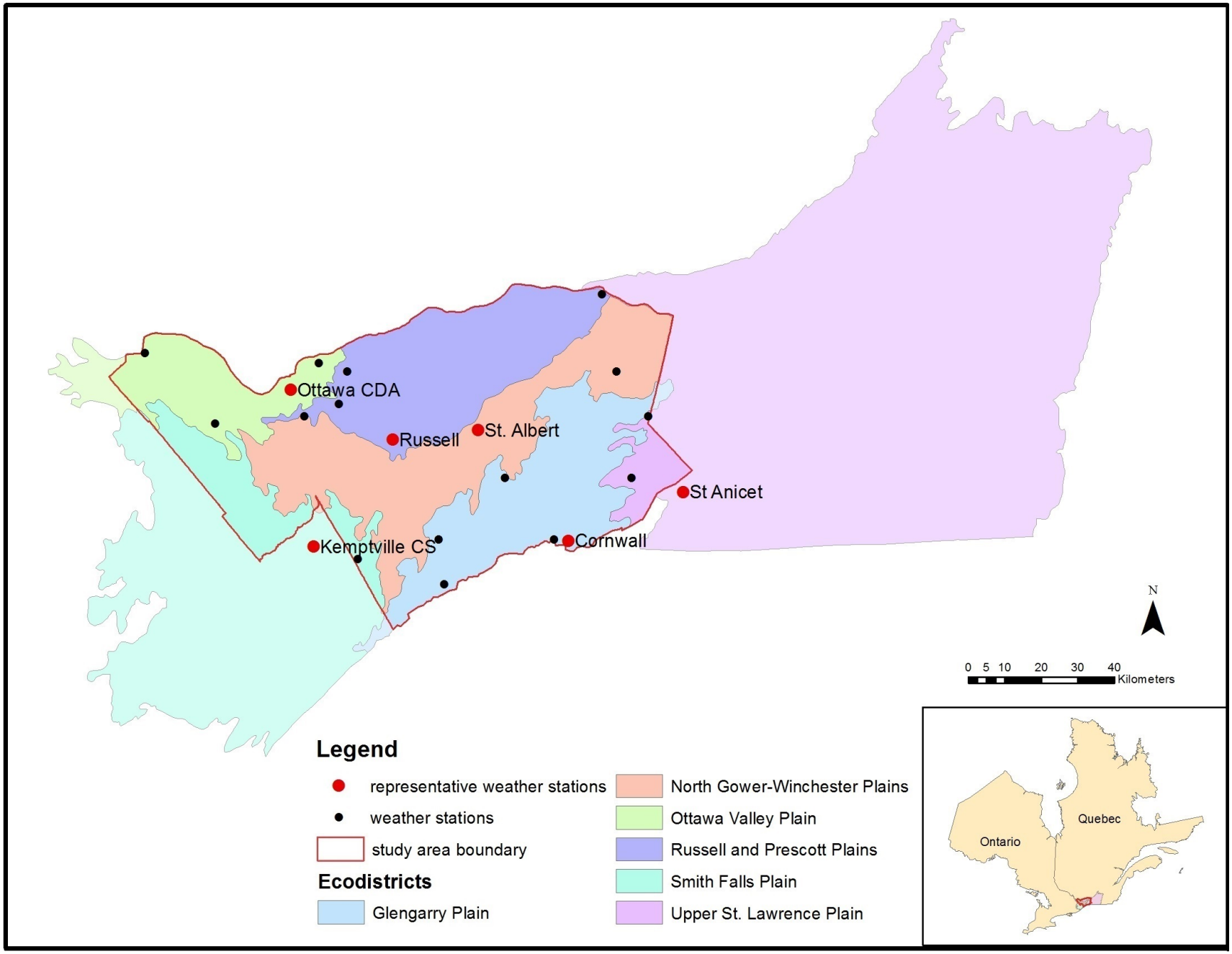
North Gower-Winchester Plains
Ottawa Valley Plain
Russell and Prescott Plains
Smith Falls Plain
Upper St. Lawrence Plain
Ontario
Quebec


Ottawa CDA
Russell
St. Albert
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Glengarry Plain
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Smith Falls Plain
Upper St. Lawrence Plain
Ontario
Quebec

Indicator development

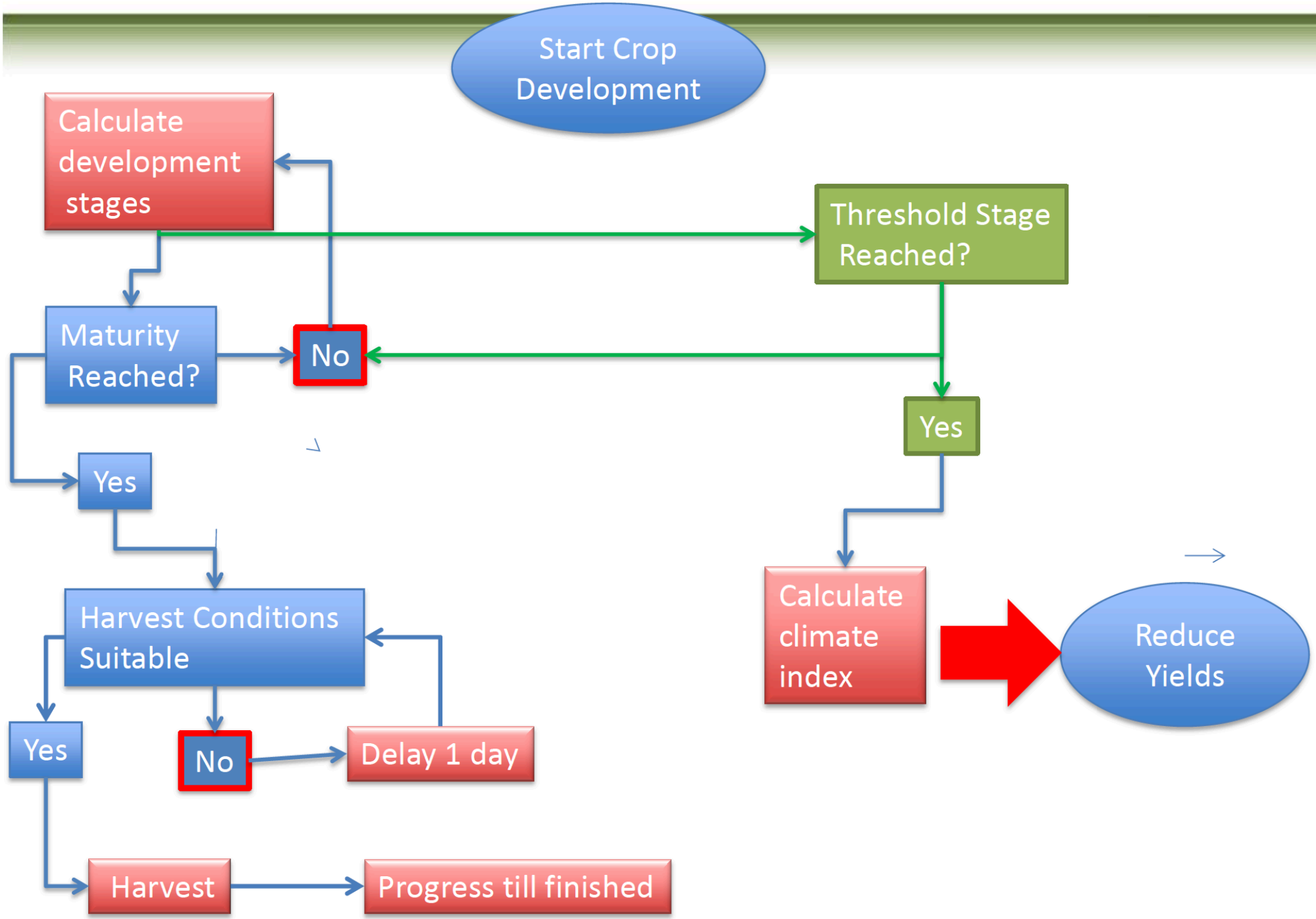
- Extensive literature review (close to 100 sources reviewed)
- Expert consultations (AAFC, OMAFRA)
- Crop tolerance thresholds to T and P conditions at various phenological stages were identified
- Yield loss percentages associated with threshold exceedance were studied

Corn-specific indices

Index name	Definition	Units
Corn:		
Poor seeding conditions	**Weekly precipitation 30% greater than weekly mean precipitation (between April 23 and May 20)**	**weeks/year**
Early flooding	**Weekly precipitation 30% greater than weekly mean precipitation with 1 to 780 accumulated CHUs**	**weeks/year**
Pollination drought	**CDD >10 with 1,301 to 1,600 accumulated CHUs**	**annual occurrence (Yes or No)**
R2 (blister) drought	**P<45mm with 1,601 to 1,825 accumulated CHUs**	**annual occurrence (Yes or No)**
R3 (milk) drought	**P<45mm with 1,826 to 2,000 accumulated CHUs**	**annual occurrence (Yes or No)**
Early killing frost	Tmin <=-2°C with 2,165 to 2,475 accumulated CHUs	days/year
R4 (dough) drought	**P<8mm with 2,001 to 2,165 accumulated CHUs**	**annual occurrence (Yes or No)**
Fall killing frost	Tmin <=-2°C with 2,476 to 2,600 accumulated CHUs	days/year

Soybean-specific indices

Index name	Definition	Units
Soybeans:		
Poor seeding conditions	**Weekly precipitation 30% greater than weekly mean precipitation (weeks between May 7 and June 10)**	**weeks/year**
Spring killing frost	Tmin <0°C 26 to 50 days after seeding	days/year
Early flooding	Precipitation 30% greater than weekly precipitation 25 to 45 days after seeding	weeks/year
Cool nights	Tmin <10°C for 5+ days 45-55 days after seeding	annual occurrence (Yes or No)
Warm nights	Tmin>=24°C 55 to 100 days after seeding	days/year
Mid-season flooding	Precipitation >90mm 60 to 80 days after seeding	annual occurrence (Yes or No)
Pod filling drought	**Precipitation <10mm 81 to 95 days after seeding**	**annual occurrence (Yes or No)**
Early killing frost	Tmin <-1°C between 90 and 100 days after seeding	days/year
Extreme heat	Mean Tmax>33°C 95-120 days after seeding	days/year
Fall killing frost	Tmin <-1°C 101 to 110 days after seeding;	days/year
Seed development drought	**P<5mm 96-115 days after seeding**	**annual occurrence (Yes or No)**



Flow chart by Dan MacDonald, AAFC

Outputs (tables)

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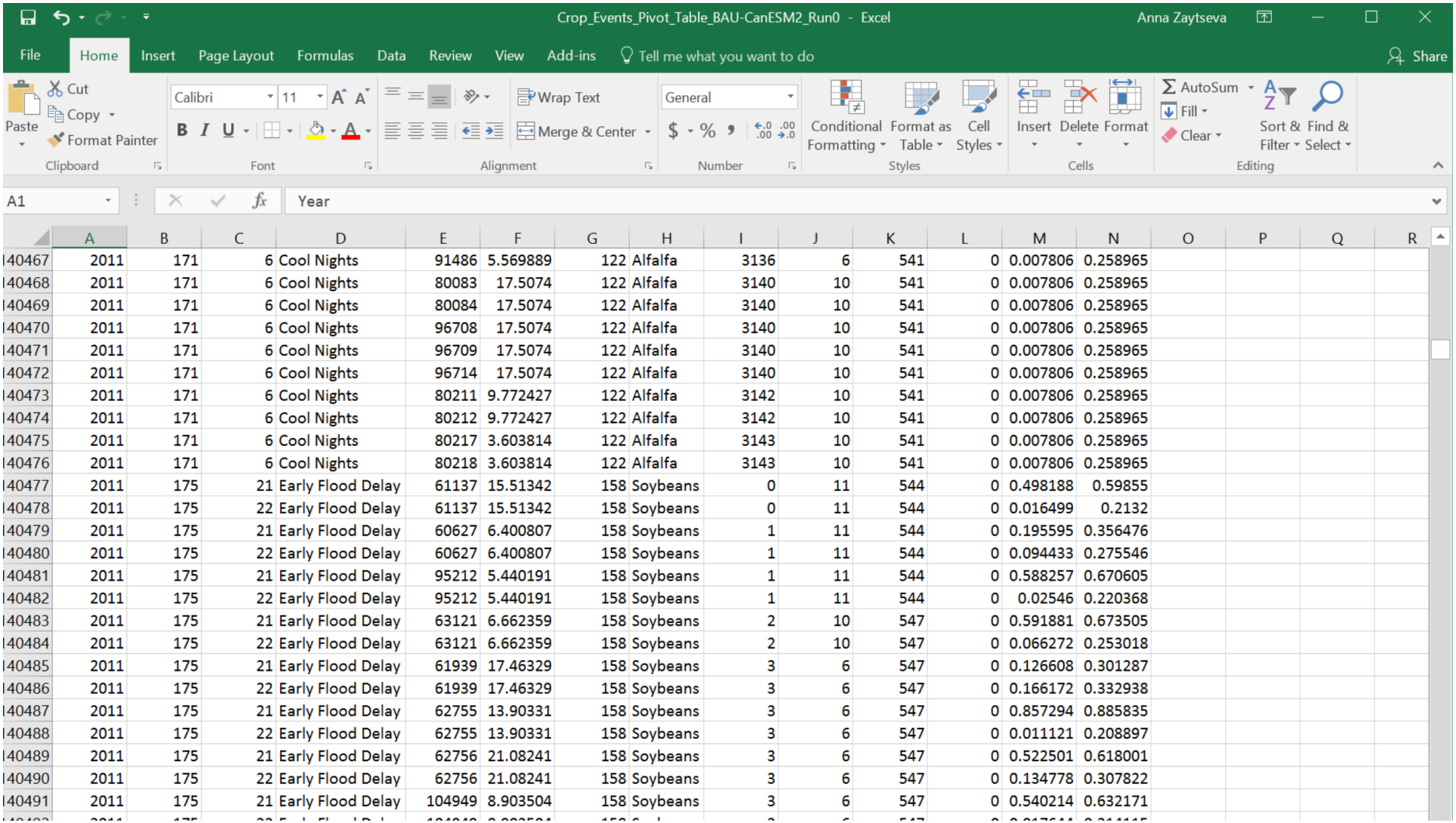
Outputs (tables)



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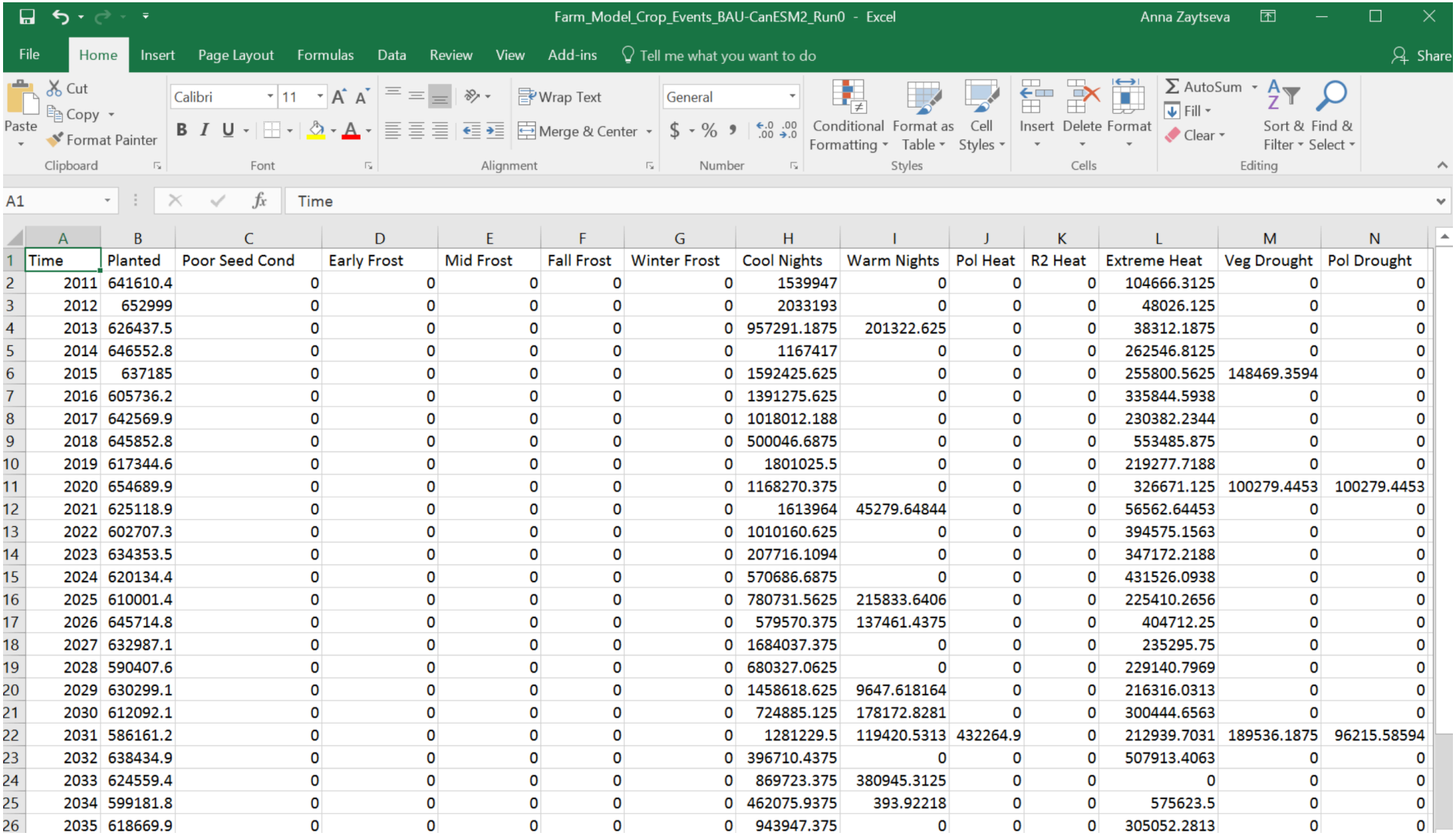
Outputs (tables)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Time	Planted	Poor Seed Cond	Early Frost	Mid Frost	Fall Frost	Winter Frost	Cool Nights	Warm Nights	Pol Heat	R2 Heat	Extreme Heat	Veg Drought	Pol Drought
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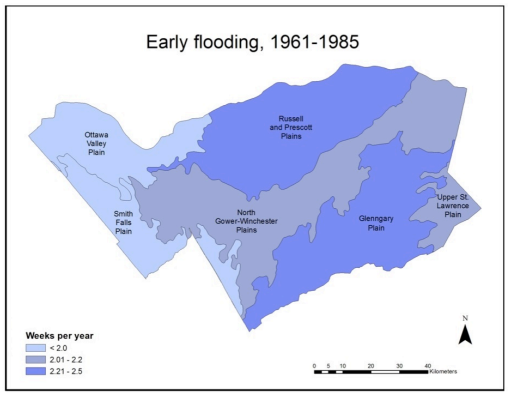
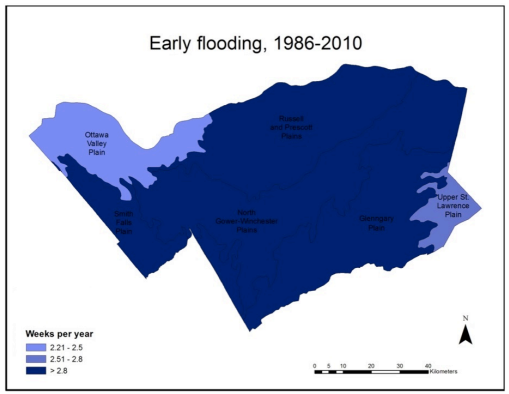
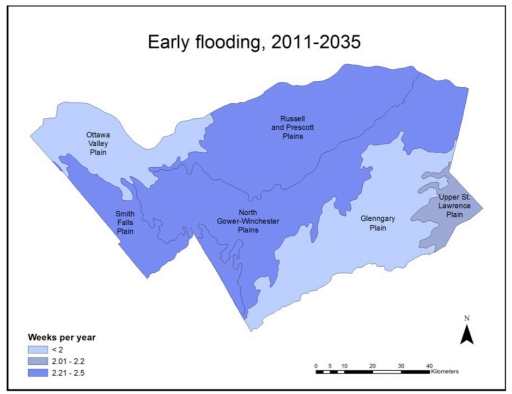
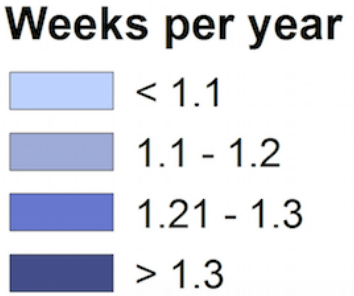
3	2012	652999	0	0	0	0	0	2033193	0	0	0	48026.125	0	0
4	2013	626437.5	0	0	0	0	0	957291.1875	201322.625	0	0	38312.1875	0	0
5	2014	646552.8	0	0	0	0	0	1167417	0	0	0	262546.8125	0	0
6	2015	637185	0	0	0	0	0	1592425.625	0	0	0	255800.5625	148469.3594	0
7	2016	605736.2	0	0	0	0	0	1391275.625	0	0	0	335844.5938	0	0
8	2017	642569.9	0	0	0	0	0	1018012.188	0	0	0	230382.2344	0	0
9	2018	645852.8	0	0	0	0	0	500046.6875	0	0	0	553485.875	0	0
10	2019	617344.6	0	0	0	0	0	1801025.5	0	0	0	219277.7188	0	0
11	2020	654689.9	0	0	0	0	0	1168270.375	0	0	0	326671.125	100279.4453	100279.4453
12	2021	625118.9	0	0	0	0	0	1613964	45279.64844	0	0	56562.64453	0	0
13	2022	602707.3	0	0	0	0	0	1010160.625	0	0	0	394575.1563	0	0
14	2023	634353.5	0	0	0	0	0	207716.1094	0	0	0	347172.2188	0	0
15	2024	620134.4	0	0	0	0	0	570686.6875	0	0	0	431526.0938	0	0
16	2025	610001.4	0	0	0	0	0	780731.5625	215833.6406	0	0	225410.2656	0	0
17	2026	645714.8	0	0	0	0	0	579570.375	137461.4375	0	0	404712.25	0	0
18	2027	632987.1	0	0	0	0	0	1684037.375	0	0	0	235295.75	0	0
19	2028	590407.6	0	0	0	0	0	680327.0625	0	0	0	229140.7969	0	0
20	2029	630299.1	0	0	0	0	0	1458618.625	9647.618164	0	0	216316.0313	0	0
21	2030	612092.1	0	0	0	0	0	724885.125	178172.8281	0	0	300444.6563	0	0
22	2031	586161.2	0	0	0	0	0	1281229.5	119420.5313	432264.9	0	212939.7031	189536.1875	96215.58594
23	2032	638434.9	0	0	0	0	0	396710.4375	0	0	0	507913.4063	0	0
24	2033	624559.4	0	0	0	0	0	869723.375	380945.3125	0	0	0	0	0
25	2034	599181.8	0	0	0	0	0	462075.9375	393.92218	0	0	575623.5	0	0
26	2035	618669.9	0	0	0	0	0	943947.375	0	0	0	305052.2813	0	0

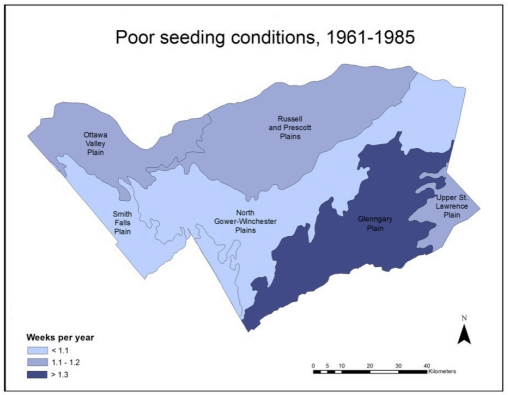
Processed post-run results (Corn)

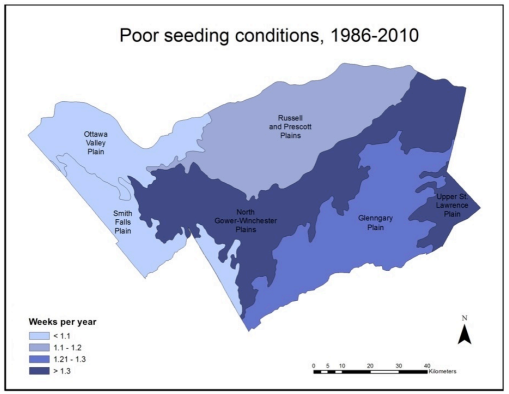


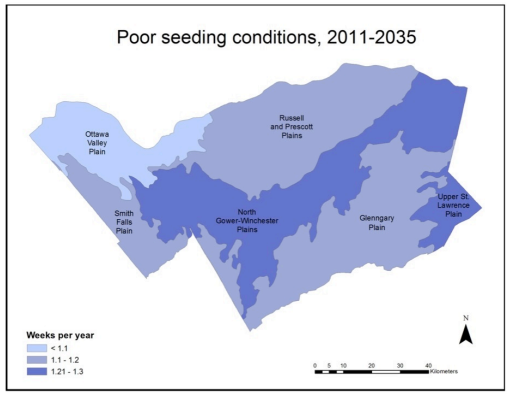


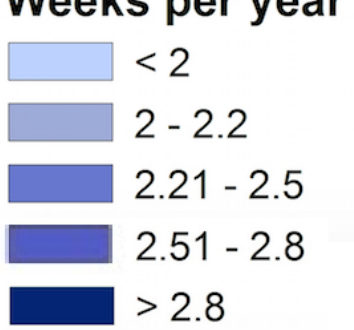




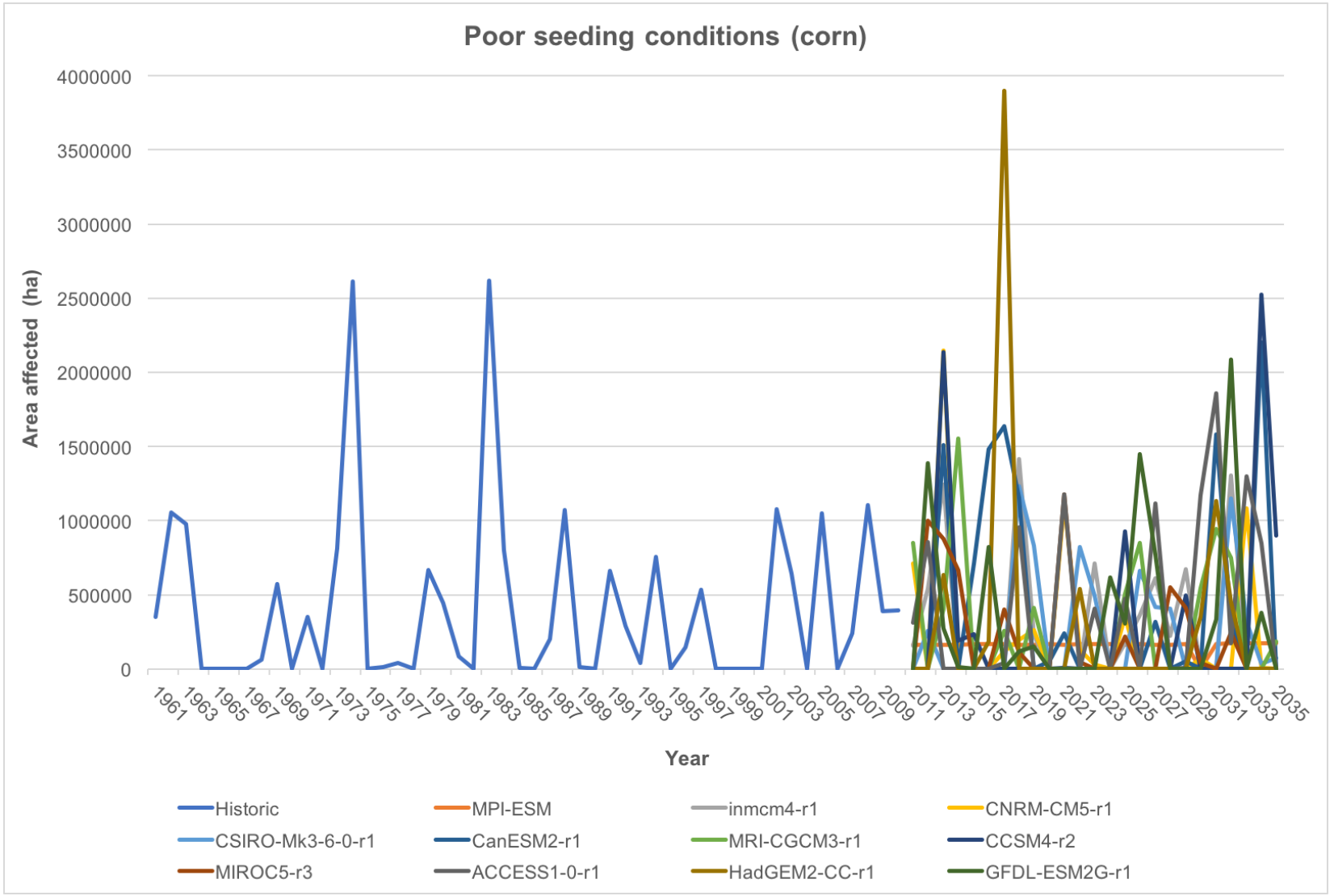




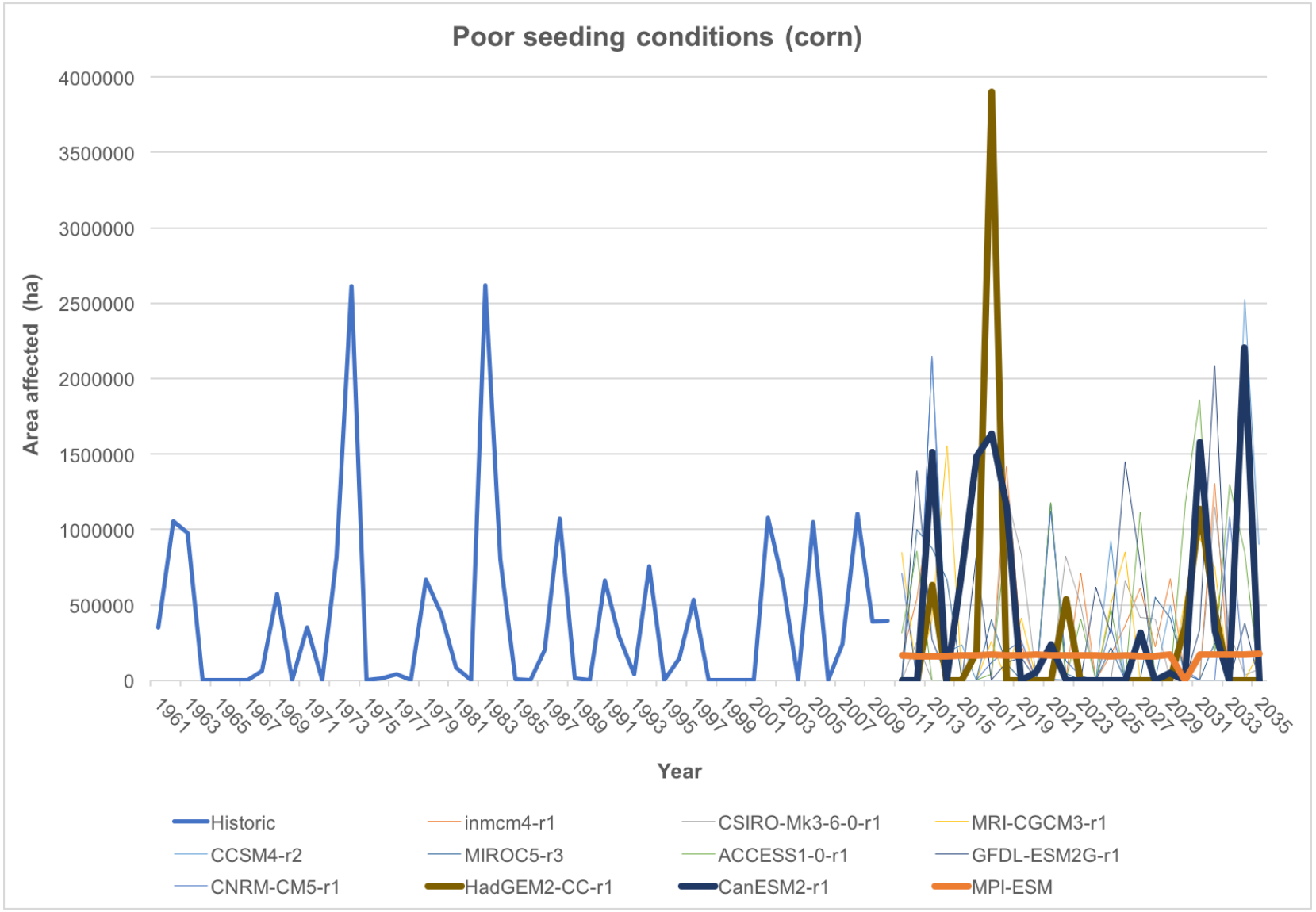




Processed post-run results (Corn)



Processed post-run results (Corn)



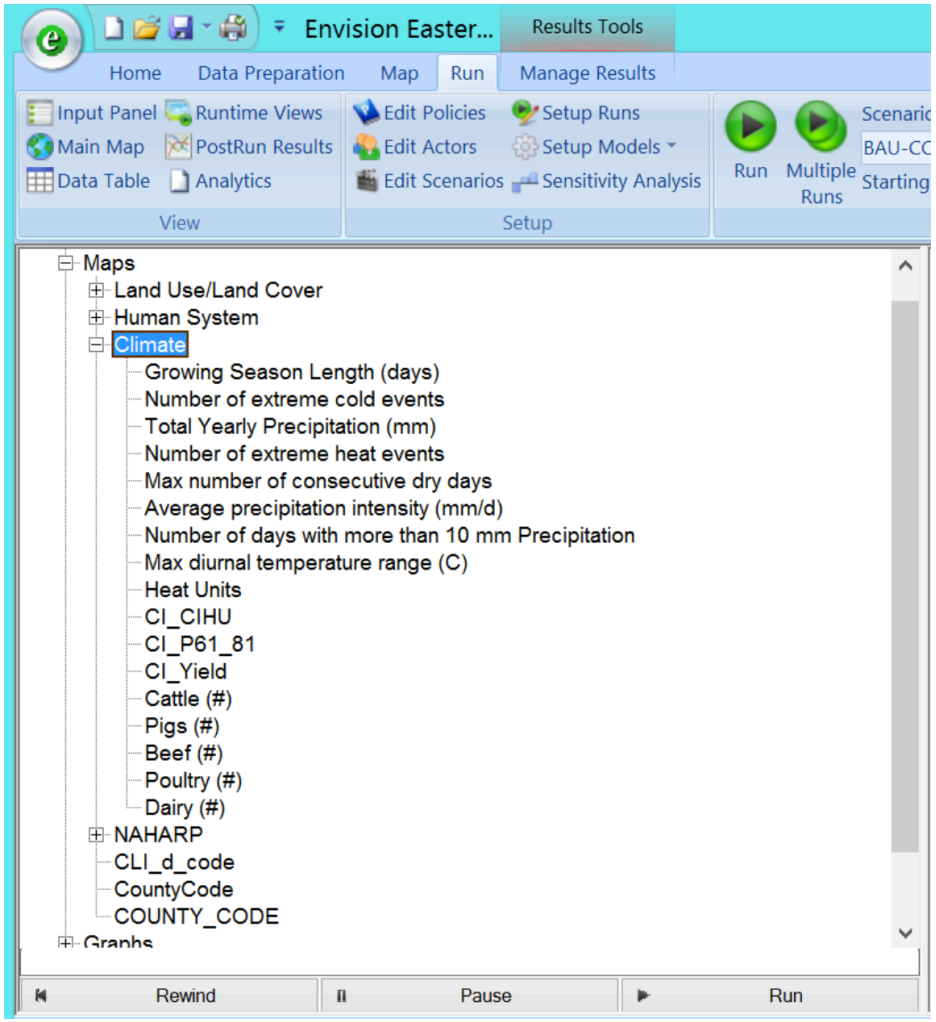
Additional calculations and outputs

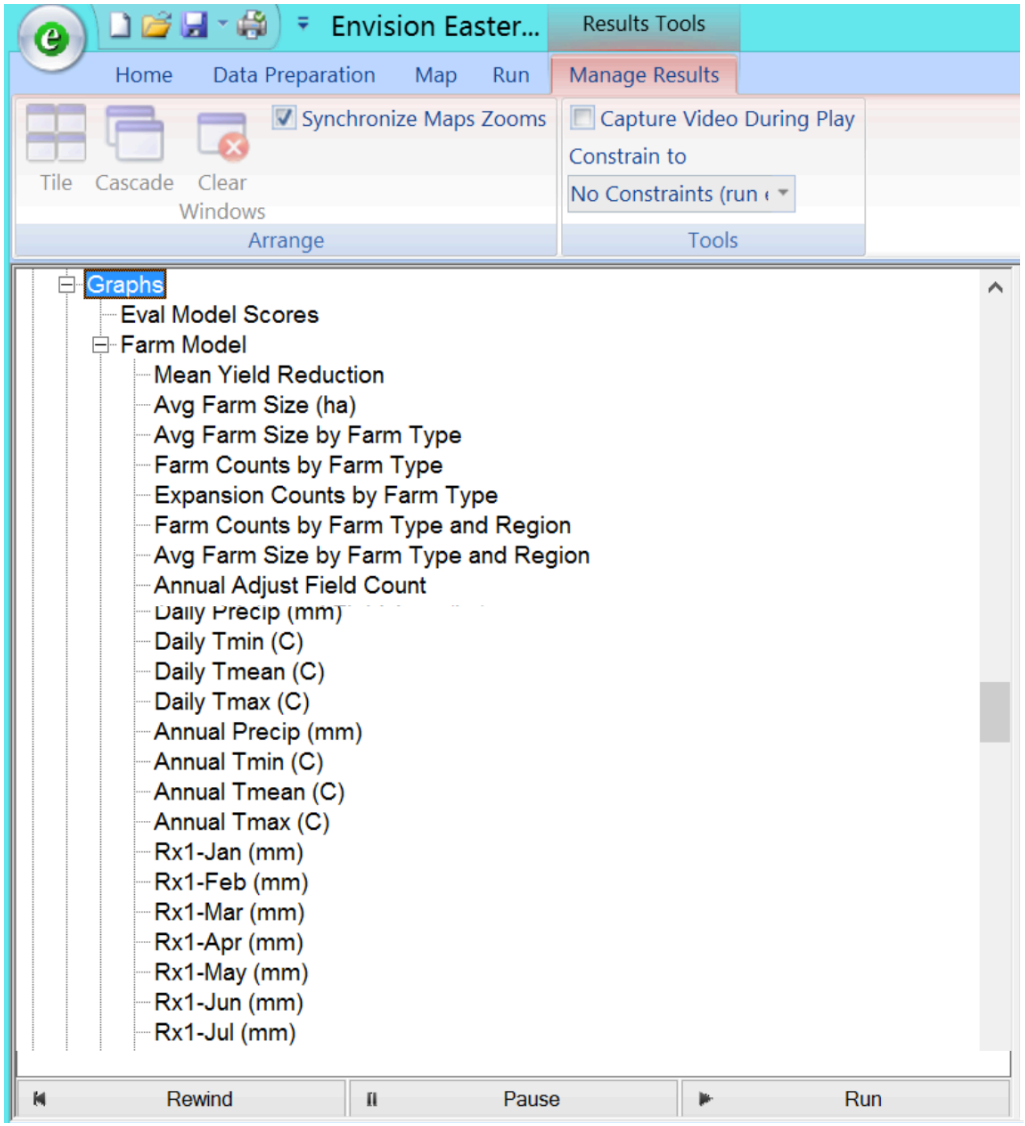
Envision / src / EasternOntario / ClimateIndicators.cpp

Revision: HEAD

```
102     theModel->m_outVarCountClimate = 20;
103     theModel->m_outVarIndexClimate = theModel->AddOutputVar( "Average Corn Yield (bu/ha)", m_cornYieldAv, "" );
104     theModel->AddOutputVar( "Total Corn Yield (bu)", m_cornYieldTotal, "" );
105     theModel->AddOutputVar( "Total Corn Area (ha)", m_cornArea, "" );
106     theModel->AddOutputVar( "Average Soy Yield (bu/ha)", m_soyYieldAv, "" );
107     theModel->AddOutputVar( "Total Soy Yield (bu)", m_soyYieldTotal, "" );
108     theModel->AddOutputVar( "Total Soy Area (ha)", m_soyArea, "" );
109     theModel->AddOutputVar( "Average Hay Yield (tonnes/ha)", m_hayYieldAv, "" );
110     theModel->AddOutputVar( "Total Hay Yield (tonnes)", m_hayYieldTotal, "" );
111     theModel->AddOutputVar( "Total Hay Area (ha)", m_hayArea, "" );
112
113     theModel->AddOutputVar( "Growing Season Heat Units", m_growingSeasonHeatUnits, "" );
114     theModel->AddOutputVar( "Growing Season P", m_growingSeasonP, "" );
115
116     theModel->AddOutputVar( "Diurnal Temp Range", m_dtr, "" );
117     theModel->AddOutputVar( "Growing Season Length", m_gsl, "" );
118     theModel->AddOutputVar( "Hot Weather Extremes", m_hwe, "" );
119     theModel->AddOutputVar( "Cold weather extrememes", m_cwe, "" );
120     theModel->AddOutputVar( "Av Precip Intensity", m_api, "" );
121     theModel->AddOutputVar( "#Days > 10mm Precip", m_d10mm, "" );
122     theModel->AddOutputVar( "Max # Consecutive Dry Days", m_cdd, "" );
123     theModel->AddOutputVar( "Precip Total", m_pt, "" );
124     theModel->AddOutputVar( "Heat Units", m_hu, "" );
125     }
126
```

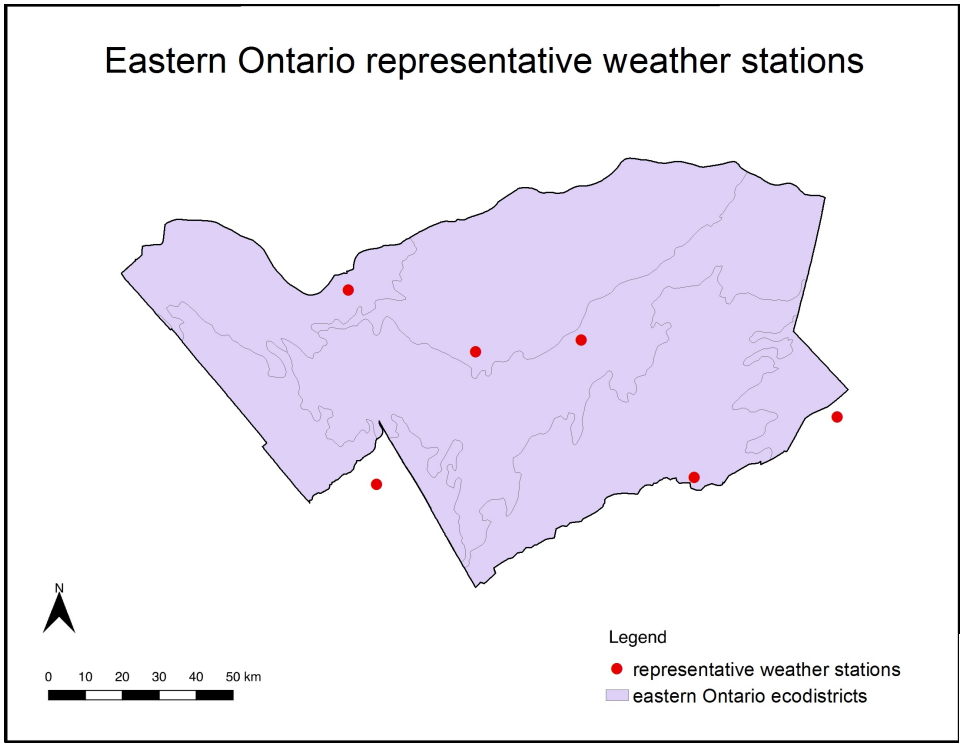
Output maps and graphs (generic weather variables and extremes)

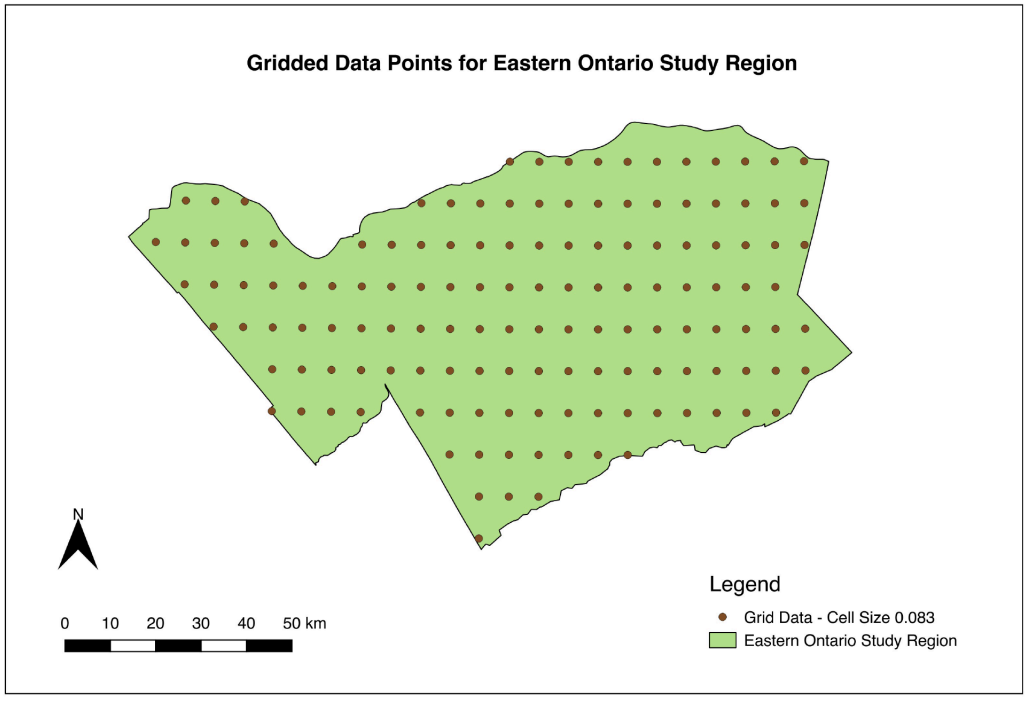




Future directions

- Use gridded climate data to enable indicator calculation at a finer spatial scale
- Refine indicators by incorporating soil moisture and evapotranspiration calculations in formulas
- Develop indicators for a wider variety of commonly grown crops
- Analyze indicator performance using historic production data


Eastern Ontario representative weather stations
N
0 10 20 30 40 50 km
Legend
representative weather stations
eastern Ontario ecodistricts


Gridded Data Points for Eastern Ontario Study Region
N
0 10 20 30 40 50 km
Legend
Grid Data - Cell Size 0.083
Eastern Ontario Study Region

Thank you!