Climate Change: Too hot for our forests to handle?

Note: we’re not dealing with future projections so title may be misleading as people tend to assume future changes.

*OR Play on*

*if a tree falls in a forest (from climate events), and no one is around to hear it – will it make a sound?*

# Climate Change

## Climate Change intro

Climate change is occurring, how is our climate changing and why we should care about it. Mention concern that ON forests may be affected by climate change. Temperatures and the amount of precipitation affects what species can grow and how healthy trees will be. I have some references.

## Climate Projections in Ontario

link to projection maps from Ontario Climate Data Portal (<http://www.climateontario.ca/CData.php>) or <https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services/display-download.html> or Climate <https://climateatlas.ca/>

focus on temperature and precipitation projections

Explain – to understand future changes we need to know what has happened before. Future projections are long-term but our climate has already been changing. So, understand how much change has happened in recent years.

# Has climate changed across Ontario over the years?

How much has temperature and precipitation changed across Ontario between 1985-2017? Understanding current climate conditions can provide a baseline to detect future shifts in forest health caused by long-term effects such as climate change (Hughes *et al*. 1986). What are considered normal temperatures and precipitation amounts for sites across Ontario? Are the differences from normal conditions increasing over the years and differ among locations?

*Need to explain why these sites and why these years.*

*I more I think about it, we could broaden our scope here to show larger patterns in spatial and temporal and variation sections and only focus on the five metrics when relating climate to decline index. People will wonder about other factors e.g., precipitation etc that they are aware of will change. Plus, we have the data assimilated for many stations across the province and it would take the same amount of work if we automate the graphics.*

*If we broaden,* use *temperature and precipitation metrics and departures from normals in climate monthly summaries. Don’t use bright sunshine as not meaningful as too crude of a measurement. Solar radiation measurements in climate normals data are better but they are not included in the climate monthly summaries and never made it into daily data archives (unfortunately for various reasons). Don’t use Heating Degree Days and Cooling Degree Days that show consumption of energy by humans and not meaningful for vegetation. Growing Degree Days (GDD) is meaningful to vegetation and we can calculate (see formula below and base temp of 5 deg Celsius for cool weather plants). However, we would need to use daily temperature data for stations and would take effort. CFS’ Bioclim models calculates normal for Growing Season Length which would be good but will also take work. “The growing season was defined as starting when the mean daily temperature was greater than or equal to 5 degrees Celsius for 5 consecutive days beginning March 1. The growing season ended when the minimum temperature was less than -2 degrees Celsius beginning August 1.”*

**

Seasonal conditions are also good as per Laura’s thesis. Just present current conditions and not time lags for sites.

## How much do climate conditions vary across the province?

These cool weather graphics links some creative visualizations which combined changes over different areas and times. We may shake up the linear approach that I outline below.

<https://public.tableau.com/profile/ludovic.tavernier#!/vizhome/weathermemories/weathermemories>

<https://public.tableau.com/profile/corey.jones#!/vizhome/WhereIsTheGrassGreener/Dashboard1>

<https://public.tableau.com/profile/joe.macari#!/vizhome/Canyouweathertheweather/7dayUKforecast>

<https://public.tableau.com/profile/andy.klatt#!/vizhome/PrecipitationinU_S_Cities/Precipitation>

<https://public.tableau.com/profile/ojoswi#!/vizhome/GreatLakeWaters/Month>

<https://public.tableau.com/profile/simon.lafosse#!/vizhome/Precipitations6/Rainiscoming>

Have graphic(s)s that show overall climate metric patterns across the province but we need to consider that different stations have different years which will confound patterns.

Another graphic to show climate anomalies are also expected to have larger changes in climate in more northern locations than southern locations. We could have a graphic where maps climate anomalies against latitude.

What is the climate like near you? Map with EECC monthly climate stations across Ontario. Have ability to click on each station and show graphic/table of climate metrics. Two pop-ups? Average conditions for all years per site and climate record over the years.

Provincial map should include regional differences and use open source National Ecological Framework’s Ecoregions that fit the decline patterns the best (see attached – open source from NEF website. I had previously downloaded shape file but now moved to different website <https://open.canada.ca/data/en/dataset/ade80d26-61f5-439e-8966-73b352811fe6>). This regional classification divides the province up into distinct areas based on their differences in climate, geological rock formations, soil types, and other factors, vegetation, and animals. “An ecoregion is a subdivision of an ecoprovince and is characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water, and fauna.” (website). I have a shape file with OFBN plots embedded and dissolved (merge separate areas into single polygon) for but we can’t use as has point locations for ofbn plots.



I had also downloaded attribute files associated with ecoregions including precipitation and temperature. I attached them all as I thought you might like all attributes for your own use. You can use Microsoft Excel to open dbf files but only after you open Excel first and then open dbf file. So we can have pop-ups when someone clicks on regions too.



## Have climate conditions changed between 1985 and 2018?

Somewhere explain – why 1985 and 2018. It is because time record for decline data except we only have data to 2017 for our dashboard. I sampled in 2018 too but not finished entering. We could add later record after 2018. Autoscript that adds year-month to each data file would make that easier.

Graphic showing changes over the years. Hmmm. We have noise as not all stations have the same years sampled so we are confounding site and annual differences. Different ways of dealing with this issue.

If we are broadening focus here, we could use all sites to show climate conditions as we have numerous stations for climate monthly summaries. I suspect we will get up and down and not clear monotonic linear trend in our time record.

Also have graphics that show Climate anomalies (differences between site and climate normal 1980-2010 for that site) over the years. We can test the prediction that anomalies are become larger because of long-term climate changes.

# When does a forest become stressed?

*This background introduces forest stresses. Do we need this background? I think it adds meat and different than the normal climate approach. What do you think of the conceptual principles outlined? We could use images to illustrate the stress events on the continuums presented below.*

So now that we see how the climate varies across the province and years, how does this stress affect forests? When and how do forests get stressed?

## Stresses vs. Disturbances

*This background paragraph is too long and can make more plain language but what do you think of the concepts introduced? Paragraph repeats concepts outlined in 5 factor graphics below but gives specific examples. Break up this paragraph by putting some explanations with below graphics? However predisposing and contributing combines multiple aspects e.g., timing/periodicity/severity etc so not clear separation. Or have 5 factors first and then forest blurb?*

Numerous stresses can influence forests but when do these stresses become harmful to forests. When they do cross the edge. When does a stress become a disturbance with more impacts? Five factors influence whether and how much a forest is likely to be stressed.

Many factors can stress forests. Cumulative effects are influenced by how multiple stresses act sequentially, concurrently, synergistically, antagonistically, or cumulatively on a forest stand. Forest stresses have been categorized into inciting, predisposing or contributing factors. Inciting factors are intense stresses, usually of short duration, which can cause severe injury. Examples of inciting factors include defoliating insects, such as forest tent caterpillar, severe drought, flooding, frost, weather extremes, and acute fumigations of phytotoxic air pollutants. Inciting factors may kill trees outright. Predisposing factors tend to be long-term or endemic (i.e., occur naturally in local area). Examples include subtle climate stress (e.g., drought or spring heat waves), nutrient deficient soil, aluminum toxicity to fine tree roots, tree genetics, advanced tree age, and chronic pollution levels. These factors impose a permanent stress on the forest ecosystem, resulting in reduced tree vigour that in turn renders the tree more susceptible to damage from other agents. Predisposing factors rarely directly result in tree mortality but are significant links in the decline cycle. Contributing factors can also be long-term in nature or endemic to the forest ecosystem. These include bark beetles, canker fungi, root and wood rot fungi and viruses. Contributing factors find it easier to infect and may even act more aggressively in trees that have been weakened by predisposing or inciting factors. The contributing agents may eventually kill trees that are in a weakened condition. Usually, healthy trees that have not been adversely stressed by the various predisposing and inciting factors can resist infection or even recovering from contributing stresses. Atmospheric pollutants, such as acidic precipitation and ozone, are hypothesized to act as either predisposing or contributing factors leading to tree decline. The effects of chronic stress may be hard to detect given annual acute stresses that vary across the years and swamp the signal of chronic effects.

### How severe or intense is a stress event? (Severity)

Stress Disturbance

|  |
| --- |
| Low (Chronic, sub-lethal) High (Acute, Lethal) |

Image: drooping leaves dead tree

### How big of an area is affected by a stress event? (Magnitude)

Stress Disturbance

|  |
| --- |
| Small individual tree(s) Widespread and large regions |

Image: Single tree large forest areas of dead

### How long does the stress event last? (Duration)

Stress Disturbance

|  |
| --- |
| Long-term Short-term |

Image: trees on a cliff bowed over by wind? acute fumigation

### When does the stress event occur? (Timing)

Stress Disturbance

|  |
| --- |
| On-going chronic SeasonalSpecific Events |

Image: nutrient deprived tree? snow/ice wind storm fallen trees

### Do stress events occur at regular or irregular intervals? (Periodicity)

Stress Disturbance

|  |
| --- |
| Regularly repeating RegularIrregular/Unpredictable |

Images: Winter freeze insect damage extreme storm damage

# Have these climate differences affected Ontario forests?

Introduce the OFBN program and Decline Index (DI) develop to indicate symptoms of cumulative stresses. Have a map that shows all OFBN sites overlaid with Ecoregions. We could use Ecoregions mean temp and precipitation attribute data to have pop-ups that show regional differences for all sites.

Climate can vary locally and show that particular climate metrics have influenced hardwood forest crown condition. Introduce the 5 key climate metrics from Oswald et al. 2018.

*Note: Oswald et al excluded the effects of sites and disturbances to focus on the residual effects of climate. They standardized their forest stress index by Z transforming measurements for each plot and for each metric used in their Forest Stress Index. Z is when the scale of the measured values is centralized (mean/average = 0) and standardized (range from -1 standard deviation value to +1 standard deviation value). I did Z transformations too but I didn’t do by plot as I wanted to show the plot and regional variation. I would like to do this but alas no one can do this just using the plot-year DI means which is what open data are available to us.*

*5 key climate metrics*

1. April minimum temperatures
2. Preceding August minimum temperature
3. Preceding October minimum temperature
4. No. of January days w/Tmax > 2 SD
5. No. of preceding August days w/Tmax > 2 SD

We could add metrics used in laura’s thesis if we have time to do and space on dashboard. We would need to do weighted average of monthlies to calculate seasonal metrics. Maximum temperature in the spring (Mar, Apr, May), summer (June, Jul, Aug) , fall (Sep, Oct, Nov) or winter (Dec Jan Feb) (current year or 1-year lag i.e. from previous year)

1. Minimum temperature in summer
2. Maximum temperature Winter (1 year lag)
3. Total rain in spring or winter (Previous 1-year lag).
4. Winter total precipitation (current and previous year’s snowfall 1-year lag)

The timing of extremes influences the severity of impacts.

1. # of spring heat wave events (temperature > 32o C for 5 consecutive days)

Have a graphic that relates each of the climate metrics that we use to overall decline index across sites and years.

Have a map up with pop-ups of the 14 stations that relates our climate metrics to DI record.