INDICATOR: CHANGES IN VEGETATIVE PHENOLOGY

STRATEGIC DIRECTION: Reduce Threats

TARGET: N/A

THEME: Pressures on Ontario's Biodiversity – Climate Change

Background Information:

Over the last 60 years in Ontario, increases in the average annual air temperature varied from a slight increase in the southeast to an increase of 1.3 °C in the northwestern part of the province (Environment Canada 2009). It is projected that by 2050, the average annual air temperature in Ontario will increase by 2.5 to 3.7 °C over 1961-1990 levels based on a scenario of moderate reductions in greenhouse gas emissions (Environment Canada 2009).

Changes in climatic variables such as temperature can affect biodiversity both directly and indirectly. In addition to affecting the distribution of species directly (e.g., northward shift of southern species), increasing temperatures can affect the timing of natural events (phenology) like the flowering of plants and the breeding and migration of animals. In some cases interactions between species may be altered. Predators and prey, insects and host plants, parasites and host insects, and insect pollinators and flowering plants have close interactions and depend on each other for survival. Increasing temperatures can cause the timing of important events in their life cycles to become out-of-sync (Parmesan and Yohe 2003; Crick 2004; Parmesan 2006). Further, plants that begin growing earlier in the year due to warmer temperatures may ironically be more susceptible to frost damage (Inouye 2008). A recent assessment of plant flowering data for 19 species across Canada collected through the Plant Watch Canada citizen science program showed that the average first flower bloom advanced by 9 days over the relatively brief period 2001-2012 (Gonsamo et al. 2013).

This indicator examines trends in vegetative phenology across Ontario from 1982-2010 to assess climate change impacts. Trends in the timing of the start of the growing season and the duration of the growing season are assessed using satellite imagery.

Data Analysis:

The Normalized Differential Vegetation Index (NDVI) derived from satellite imagery was used to determine the timing of the start of the growing season and the duration of the growing season for each of Ontario's terrestrial ecozones over the period 1982-2010. NDVI data are a generalized measure of the amount of greenness on the landscape and can be used to estimate important phenological events such as leaf out in the spring. Geo-referenced, bi-weekly NDVI images over a 29-year duration were downloaded for free online (Tucker et al. 2004). The software program TIMESAT was used to model annual phenological cycles and identify the start and duration of the growing season (Jönsson and Eklundh 2004). Estimates were made for every 8 km pixel in Ontario and these were averaged to produce annual estimates for each ecozone. Annual summary data were used to calculate average values for the start and duration of the growing season for the 29-year period. The differences between annual estimates and the 29-year average values (in days) were plotted against year to examine trends for each ecozone (Figures 1, 2). A detailed account of the methods used to model and analyze the NDVI data is provided in Hogg et al. (2014). The relationship between vegetation phenology and climate variables is also assessed in this report.

The NDVI has been used by scientists for over 30 years to inventory, monitor and study various characteristics of vegetation. It is a well-established method of remotely measuring and monitoring vegetation. Research has shown NDVI can successfully monitor and measure phenomena such as seasonal vegetation dynamics, forest clearance, leaf area index, biomass, percentage vegetative ground cover and photosynthetically active radiation (Lillesand and Kiefer 1994). Although, NDVI observations can be influenced by solar radiation, characteristics of the sensor and atmospheric effects, it is an effective and efficient method for examining the effects of climate change on vegetation across broad spatial and temporal scales.

- download vegetative phenology data

Results:

Trend: Deterioration **Data Confidence:** Medium **Geographic Extent:** Provincial

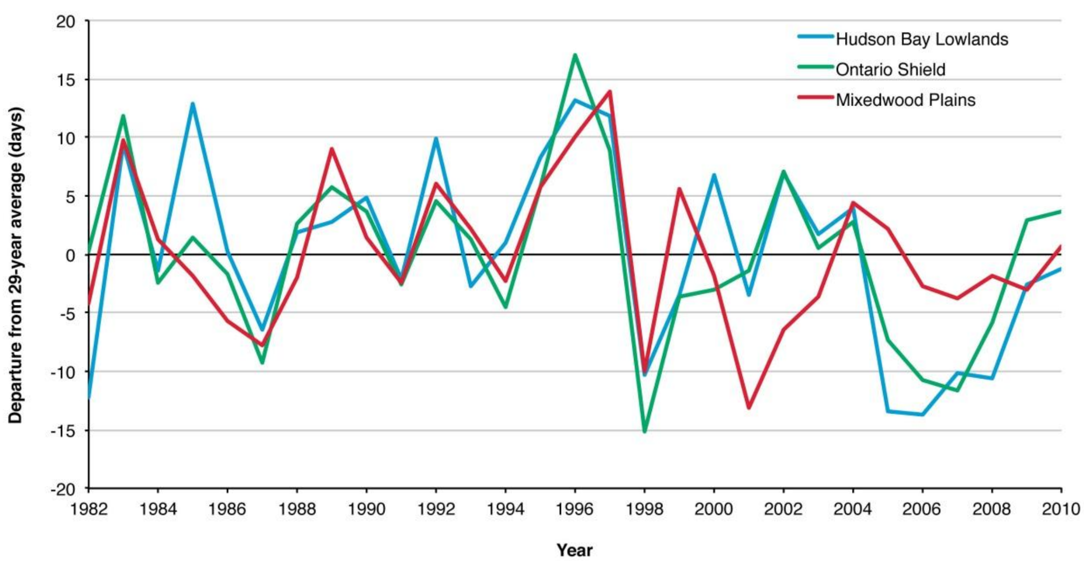

Figure 1. Change in the start of the growing season over the period 1982-2010 for each ecozone based on NDVI data.

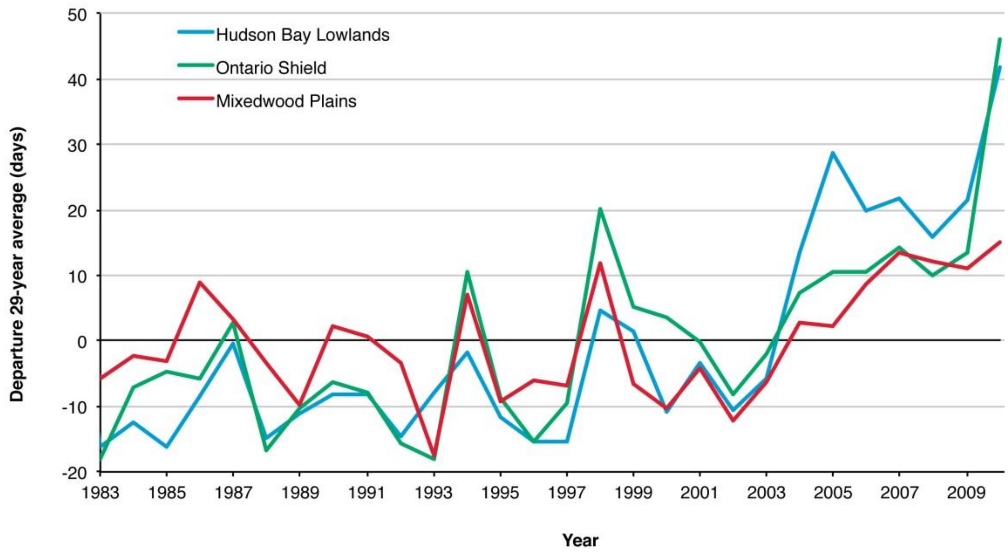

Figure 2. Change in the duration of the growing season over the period 1982-2010 for each ecozone based on NDVI data.

Status:

- There has been a trend to an earlier start to the growing season in all three ecozones over the last decade. The duration of the growing season has similarly increased over the same period.
- Observed changes are correlated with higher spring temperatures and increases in Growing Degree Days.

Links:

Related Targets: 6. By 2015, plans for climate change mitigation are developed and implemented and contribute to Ontario's target to reduce greenhouse gas emissions by 6 percent below 1990 levels.

Related Themes: N/A

Web Links:

USGS – remote sensing phenology http://phenology.cr.usgs.gov/index.php

PlantWatch Canada https://www.naturewatch.ca/plantwatch/

References:

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