Global warming effects on spring flower budding in prairie regions research paper...

Environment, Plants

ABSTRACT

Spring-time events such as flowers budding have advanced by two and a half days per decade since the 1970s in Prairie regions (Korner C, Science, 2010). The flowering of a plant is a central event in its life-cycle, especially in plants growing in temperate regions of the world. These events are known as phenological changes and phenology is the study of plant and animal life-cycles in relation to annual and seasonal climate variations. Flowering phenology combines various diverse fields of study such as plant physiology, climatology, historical studies, and botany (Tooke F, J of Exp. Biology, 2010). The break of dormancy in flowering plants during spring-time in temperate regions is believed to be triggered by temperature changes. There are several examples of plant flowering studies performed around the world in temperate regions to support the hypothesis that global warming has an effect on flower budding during spring time. Prominent among these studies are flower budding studies from Washington DC, Edinburgh, Tasmania and Oklahoma which studied spring time flowering of native species in relation to ambient temperature. All these studies indicated that first flowering of the native species has advanced in spring by a few days in relation to increase in ambient temperature. In addition, Intergovernmental Panel on Climate Change (IPCC) studied 677 species in an attempt to obtain a coherent fingerprint of climate changes overall on natural systems (Parmesan, Nature, 2003). The IPCC concluded from its analysis that global warming is already having an effect on living systems.

INTRODUCTION

The flowering of a plant is a central event in its life-cycle, especially in plants growing in temperate regions of the world. These events are known as phenological changes and phenology is the study of plant and animal life-cycles in relation to annual and seasonal climate variations. Phenophases in plants are events in a plants life-cycle such as bud-bursting, leaf formation, leaf coloring, flower budding and senescence (Preito P, Annals of Botany, 2008). As a result of climate variations, temperature and moisture become very important phenology parameters. The lengths of day, temperature, degree of winter chill and precipitation have an important effect on plants during their life cycle. The day/night length is known as the photoperiod and it is vital in protecting plants from developing flower buds too early and dying if the temperature were too low for their survival (Preito P, Annals of Botany, 2008).

Flowering during spring is directly correlated with temperature in temperate regions of the world (Abu-Asab M, Biodiversity and Conservation, 2001). Spring-time events such as flowers budding have advanced by two and a half days per decade since the 1970s in Prairie regions (Korner C, Science, 2010). In Europe, flower budding has been occurring progressively earlier during the last century (Preito P, Annals of Botany, 2008).

These phenological studies along with several early studies from the 17th century till the present day lead us to ask the hypothesis about the effects of global warming on the timing of spring-time flower budding. Global warming is the increase in global average temperature caused due to an increase

emission of greenhouse gases such as carbon dioxide, methane and ozone that are associated with industrialization and modern day living.

HYPOTHESIS

“ Is global warming responsible for having effects on the timing of flower budding in spring in temperate regions of the world?”

MAIN BODY

Early studies

Carl Linnaeus, a Swedish naturalist studied phenology in the 1700s and these are some of the earliest recorded observations of phenology (Clark RM, Int. J. of Climatology, 2001). The study of phenology was quite active during the 19th century and then was largely ignored until global warming studies became popular during recent times in the late 20th and early 21st centuries.

First flowering dates (FFDs) of the spring season of various different plant species were recorded by phenological scientists and others interested in the march of the seasons. These records help give an indication of whether spring flowering dates per species have advanced per decade or century. Direct observations have shown that on average spring-time events such as plant flowering have been advancing by 2. 4 days on average per decade during the twentieth century (Parmesan C, Nature, 2003).

Long term data of plant flowering during the past century suggests that the flowering season is extended due to the advance of first flowering in spring and a delay in dormancy in autumn by a few days at the start and the end of the season. This increase is also responsible for a longer allergy season for

those individuals with allergy to pollen.

Examples of plant flowering studies performed around the world in temperate regions to support the hypothesis that global warming has an effect on flower budding during spring time.

Washington, DC, USA studies

Climate change effects are seen on a wide variety of ecosystems and have a profound effect on the dominant plants in a particular region (Abu-Asad M, Biodiversity and Conservation, 2001). In studies performed on the flowering plants in Washington DC area with 100 flowering plant species, the first flowering dates (FFD's) were recorded during a 30-year time frame. The 100 flowering plant species studied were obtained from a database of 600 plant species and represented 44 angiosperm families (Abu-Asad M, Biodiversity and Conservation, 2001).

The trend showed an advance in flowering in these 100 species studied by 2. 4 days. However, if 11 species were eliminated from the study the advance in flowering of the remaining plant species was 4. 5 days (Abu-Asad M, Biodiversity and Conservation, 2001). Furthermore, plant flowering studies could also help with predicting the cherry-blossom tourist season in April in Washington, DC to coincide with peak-flowering times of the cherry trees.

Edinburgh, UK studies

Historical records from 1908-1930 obtained on plants from74 taxa from the Royal Botanical Garden in Edinburgh, UK attempt to address whether the air-temperature caused effects on their flowering (Clark RM, Int. J. of Climatology, 2001). They also attempted to develop models to forecast

flowering changes in the future based on 3 global warming scenarios. During this time frame (1908-1936), the variation in air temperature in Edinburgh, UK was from 5. 5 to 8. 6 °C annually (Clark RM, Int. J. of Climatology, 2001). The results showed a good association of Spring FFDs with air-temperature in 49 of the 74 species studied in the Edinburgh study (Clark RM, Int. J. of Climatology, 2001). These results indicated high temperature sensitivity of flowering in oceanic climates and in low-latitude temperate regions of the world.

Tasmania, Australia studies

Carbon dioxide and temperature effects on flowering of native-species in temperate grasslands in Tasmania, Australia were studied from 2004 to 2007 during the peak flowering times of September to December (Hovenden M, New Phytologist, 2008). The results from this study indicate that the date of first flowering is very sensitive to increased temperature in some years but the duration of the flowering season is not dependent on the temperature. In these studies, carbon dioxide levels did not seem to have on the flowering of the native-species in Tasmanian grasslands.

Oklahoma, USA studies

Early flowering and late flowering species from the tall grass bush prairie were studied in the south central Great Plains region of the US from March to November 2003 (Sherry R, PNAS, 2007). 12 species were observed for the entire annual season including 5 winter species and the species were Viola bicolor, Veronica arvensis, Cerastium glomeratum, Plantago virginica , Erigeron strigosus, Achillea millefolium, Ambrosia psilostachya,

Dichanthelium oligosanthes, Panicum virgatum, Andropogon gerardii, and Schizachyrium scoparium. These tall grass species were observed under 4 treatment conditions 1) ambient temperature and precipitation, 2) double precipitation and ambient temperature, 3) warming with ambient precipitation and 4) warming with double precipitation (Sherry R, PNAS, 2007).

The results showed that 9 early flowering species were affected by temperature and advanced their flowering before peak summer temperature while 3 late flowering species delayed their flowering after peak summer temperature (Sherry R, PNAS, 2007). The average for 9 early flowering species was 7. 6 days earlier while the delay for the 3 late flowering species was 4. 7 days later. These results were statistically significant for all of the early flowering species studied with the exception of Erigeron strigosus.

IPCC studies

Intergovernmental Panel on Climate Change (IPCC) studied 677 species in an attempt to obtain a coherent fingerprint of climate changes overall on natural systems (Parmesan, Nature, 2003). In these large-scale studies the IPCC attempted to obtain quantitative estimates of the global biological impacts of climate change. The results of these studies indicated an average advancement of 2. 3 days per decade of spring-time flower budding in temperate regions of the world (Parmesan, Nature, 2003).

CONCLUSION

Flowering phenology combines various fields of study such as climatology, historical studies, botany and plant physiology (Tooke F, J of Exp Biology,

2010). Several studies have been performed on flowering plants in temperate regions of the world to observe and record the first flowering dates (FFDs) during spring-time in relation to the ambient temperature. Global minimum temperatures have increased faster than maximum temperatures during the past few decades and this has ecological consequences on natural systems (Alward R, Science 1999).

The Intergovernmental Panel on Climate Change (IPCC) concluded from its large-scale analysis on many different species that global warming is already having an effect on living systems (Parmesan C, 2003). Overall, phenology does help drive home the urgent message about global warming and climate change since most people are likely to believe data about flowering in the spring-time in relation to increasing ambient temperature (Whitfield J, Nature 2001).

References

Abu-Asad, Mones S, Paul Peterson, Stanwyn Shetler, and Sylvia Orly (2001) Earlier plant flowering in spring as a response to global warming in the Washington, DC area Biodiversity and Conservation, 10 pp. 597-612

Alward, Richard D, James Detling and Daniel Milchunas (1999) Grassland Vegetation Changes and Nocturnal Global Warming Science, 283 pp. 229-231

Clark, Robert M, and Roy Thompson (2010) Predicting the impact of global warming on the timing of spring flowering, Int J of Climatology, 30 pp. 1599-1613

Hovenden, M, and K. Willis, and J. Vander Schoor (2008) Flowering phenology

in a species New Phytologist, 178 pp. 815-821

Korner, C, and D. Basler (2010), Phenology Under Global Warming Science, 327 pp. 1461-1462

Parmesan Camille, and Gary Yohe (2003) A globally coherent fingerprint of climate change impacts across natural systems Nature, 42 pp. 37-42

Prieto Patricia, and Josep Penuelas, and Roma Ogaya, and Marc Estiarte (2008) Precipitation dependent flower Annals of Botany, 102 pp. 275-285

Sherry, Rebecca A, and Xuhui Zhou, and Shiliang Gu (2007) Divergence of reproductive phenology under climate warming Proceedings of National Academy of Science, 104 (1), pp. 198-202.

Tooke Fiona, and Nicholas Battey (2010) Temperate flowering phenology Journal of Experimental Botany, 61 (11), pp. 2853-2862

Whitfield, John (2001) The budding amateurs Nature, 414 pp. 578-579