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Climate Change & Turfgrass

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Climate change used to be called "global warming". The change in name reflects the fact that our climate will not just be warmer, but also different in terms of precipitation, humidity, snow cover and so on. In short, a wholesale change in our climate, hence the term "climate change". I know there are probably some of you who don't believe in climate change. I don't have room in this article to present you with all of the (very substantial) evidence that our climate is changing and will change quite rapidly over the course of this century. I will simply say this, the best climate scientists in the world all agree that our climate will warm, by about 2-4.5°C over the next 100 years, and leave it at that. At the end of this article I make a couple of reading recommendations that may be helpful to the interested reader.

That amount of warming, 2-4.5°C doesn't sound so bad, does it? What you have to keep in mind is that is the global mean temperature change. It's not the local change; some places will see much greater warming than the global mean, and of course some places will see much less warming. To give you some idea of what that means for us in Canada, Figure 1 shows the predicted mean daily air temperature in Guelph, Ontario from 1961 to 2100 as predicted by the Canadian Global Circulation Model (Environment Canada). In the figure you can see that by the end of the century winters will be about 8°C warmer and the mean daily temperature will be close to zero. In Guelph, those changes in temperatures will be accompanied by generally wetter winters and springs, dryer summers, and autumns that remain about the same as they are now. Note too, that although the trend across the century is quite clearly upward, there is still considerable year-to-year variation. This means that when we get a particularly cold winter or cool summer, it is not a sign that climate change is all bunk (and equally neither is a particularly warm winter or hot summer proof that climate change is real). You have to look at the long-term trend to see what is happening.

THAT AMOUNT OF WARMING, 2-5°C DOESN'T SOUND SO BAD, DOES IT?

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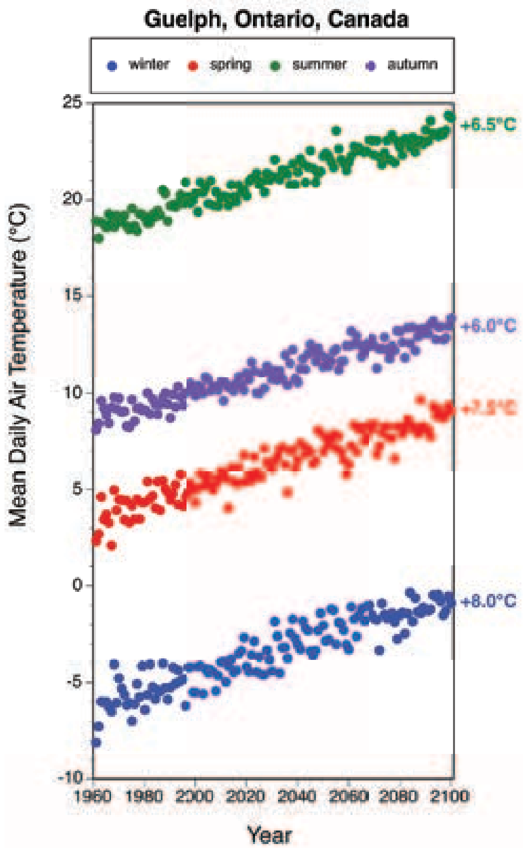

Figure 1. Average daily temperature by season for Guelph, Ontario, Canada (43.54N 80.25W) from 1961 to 2100, according to Environment Canada's Canadian Global Circulation Model (CGCM3T47) for a high greenhouse gas emissions scenario (A1B). For more information or to examine prediction for other locations, please visit http://yukon.cccsn.ca/?page=dd-gcm.

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Climate change is caused by an accumulation of greenhouse gases in our atmosphere, and while they are all important, we biologists are particularly interested in carbon dioxide because that gas has a direct effect on plant growth. At least in cool season plants (also known as C3 plants) increases in the atmospheric concentration of carbon dioxide lead directly to increased rates of photosynthesis, the process by which plants convert carbon dioxide and water into sugar and oxygen. Higher rates of photosynthesis mean that plants grow faster and larger. Indeed, your colleagues working in the greenhouse industry have known this for a long time. In that industry it is common to 'flood' greenhouses with extra carbon dioxide to stimulate plant growth. Figure 2 shows how carbon dioxide has changed over the past 450,000 years, over the recent past (since 1958), and what we expect to happen in the near future.

This graph visually depicts why climate scientists are so worried. At our current carbon dioxide concentration of 391 parts per million (ppm), we are already more than 100 ppm (40%) above any carbon dioxide concentration we have seen in the past 450,000 years up to the start of the industrial revolution, and we will certainly increase that concentration over the next 100 years; the question is by how much? That will depend on whether we get serious about reducing our carbon emissions and increasing our carbon sequestration, but the best guess is anywhere from about 550 to 1000 ppm of carbon dioxide by the end of this century.

Over the years, the turfgrass industry has developed many grass options for climates that are warmer and dryer than Canada, and so adapting turf applications to cope with changes in temperature and precipitation will probably not be such a difficult task. On the other hand, rising concentrations of carbon dioxide in our atmosphere represent an interesting challenge, and perhaps opportunity, for the turfgrass industry.

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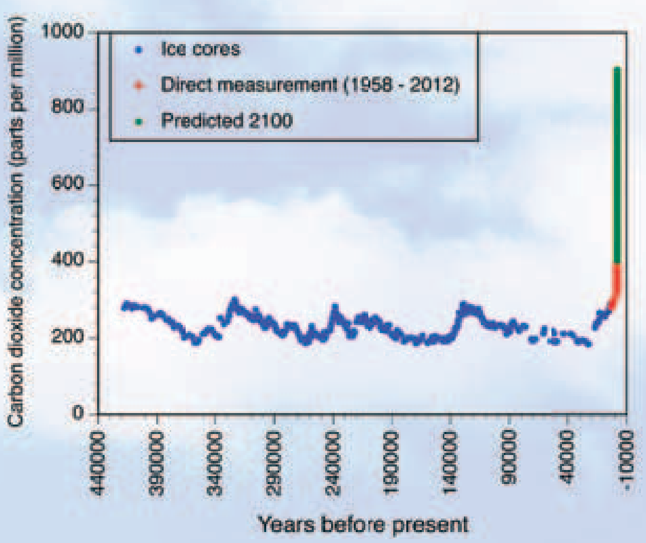

OTS HIGHLIGHT

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Figure 2. Carbon dioxide concentrations derived from studying the air bubbles trapped in ancient ice in Antarctica (blue symbols), measured directly from the atmosphere (red symbols, only available since 1958), or predicted for the future (green symbols).

It is well known from experimental research that grasses such as tall fescue and perennial ryegrass will produce a lot more biomass, about 40% more aboveground and 80% more root mass, over the course of a growing season under elevated carbon dioxide. The challenges for turf applications will be that it's not only turfgrasses that respond positively to extra carbon dioxide, weed species will too. The question is: "will grasses or weeds benefit more from the extra carbon dioxide?" We don't know the answer to that question with any degree of certainty. One exception is probably that leguminous weeds (like clover and black medic) that are able to fix atmospheric nitrogen, will probably be more competitive than they are now, compared to turfgrasses.

As plants fix more carbon from increased photosynthesis, they become even more nitrogen limited, and legumes have the ability to overcome that limitation themselves. Management implications of these kind of changes might mean, all other things being equal, that turfgrass will require more frequent mowing to maintain height, and might need heavier or more frequent applications of nitrogen fertilizer to compete with leguminous weeds.

So weeds might, or might not, be a bigger problem in the future. However there are opportunities as well. In crop agriculture, researchers are looking at selecting cultivars that can make better use of the extra carbon dioxide in the atmosphere. Turf

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Table 1: Carbon costs accrued by maintaining whole golf courses in central Ohio, USA.

Product Use	Carbon Costs Per Year (kg Carbon or Carbon Equivalents)
Diesel fuel	6,557
Gasoline	3,618
Nitrogen fertilizer	1,498
Fungicides	1,377
Irrigation	626
Insecticides	353
Herbicides	206
Potassium fertilizer	138
Phosphorous fertilizer	96
All sources	**14,469**

Source: Selhorst & Lal (2012) Carbon Sequestration in Golf Course Turfgrass Systems and Recommendation for the Enhancement of Climate Change Mitigation Potential. In: Lal & Augustin (eds.) ***Carbon Sequestration in Urban Ecosystems***. Springer. DOI: 10.1007/978-94-007-2366-5_23.

Elevated carbon dioxide experiment on tall fescue plants conducted at the University of Guelph. (Photo: J. Newman)

researchers too might like to explore this trait as a target of selection as well. In crop production selecting for increased biomass or yield in the presence of elevated carbon dioxide makes sense. For turf applications, this choice is less clear-cut. On the one hand, one might select for enhanced growth because it would increase the turf's ability to recover from the damage common in many applications. On the other hand, one might want to select for slower growth in the presence of higher concentrations of carbon dioxide, so as to keep maintenance costs low, particularly mowing costs.

We have been talking about how to adapt our management to cope with climate change; the flip side of adaptation is called "mitigation" and it deals with how we can change our management practices to reduce our impact on climate change. There are two aspects of turf management that impact mitigation: increasing carbon sequestration and decreasing carbon emissions. Carbon sequestration refers primarily to how much carbon gets stored in the soils of various ecosystems. Turf applications affect sequestration primarily through land use. Turf applications occupy a relatively small amount of land compared to other types of land use. For example, in Ontario, crop agriculture occupies more than 20 times the land area occupied by turf. Hence turf will tend to have a small impact, positively or negatively, on carbon sequestration. Nevertheless, turf applications can have a positive impact on carbon sequestration by converting depleted agricultural soils, which hold very little carbon, into turf dominated soils which can, relatively speaking, hold large quantities of carbon.

PERHAPS THE LARGER IMPACT THAT TURF SYSTEMS CAN HAVE IN MITIGATING CLIMATE CHANGE IS IN THE "CARBON COSTS OF MAINTENANCE".

Perhaps the larger impact that turf systems can have in mitigating climate change is in the "carbon costs of maintenance". Maintenance costs for golf courses in central Ohio are illustrated in Table 1. We see that the largest potential carbon savings are from reducing nitrogen fertilizer use, and cutting back on both diesel and gasoline uses. If some maintenance operations can be powered with renewable energy, the overall impact of turf systems on climate change can be significantly reduced.

That's a very quick look at some of the issues surrounding climate change and turfgrass. There is still a lot of research to be done in this area. Turf systems have received far less attention than production agriculture systems and pasture systems. Readers interested in finding out more about climate change science might be interested in reading: *The Discovery of Global Warming* by Spencer Weart (Harvard University Press). It provides a fascinating history of the discovery and development of this area of science, but it reads more like a mystery than a science or history book. Readers who want to learn more about the biological and ecological impacts of climate change might be interested in reading my new book: *Climate Change Biology* (CABI publishing).