ENVIRONMENTAL SCIENCE JOURNAL FOR TEENS

MARCH 2017

A burning question: How much will climate change cost?

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Abstract

Earth's *climate* is changing and summers in many places are getting warmer and longer. If you live in a relatively cold region, such as Canada, warmer summers might not sound too bad. Yet a closer look into the long-term effects would surely give you the chills.

In this study, we focused on one of these effects: increases in the area burned by wildfires and the cost of fighting them. We examined historical data and used *models* to predict future costs. Our calculations revealed some eye-opening news. If *greenhouse gas* concentrations in the atmosphere continue to rise, then many Canadian provinces could experience extreme fire years more often than ever. Consequently, Canadians may be spending a whopping $1.4 billion annually (a 119% increase) by the end of the century to fight those fires. This does not even include human health evacuation costs or insurance payouts.

Introduction

Imagine a wall of flames: reaching up to the sky, moving quickly and burning everything in its path. Wildfires are uncontrolled fires in wildlands. Although they are a natural and important process for some ecosystems, wildfires can be devastating for humans.

Suppressing wildfires–trying to put them out–is not only dangerous but also a very expensive task. Between 1970 and 2009, Canadian provinces spent an average of $537 million annually to fight wildfires. In some years, this cost was higher than in others. Hot, dry *weather* conditions cause more fires to burn over larger areas, which results in higher suppression costs.

Our world is warming and greenhouse gases from human activities are the most significant causes of this climate change. This raises a question: In a warming climate, how much more will wildfire suppression operations cost Canadians?

Figure 1:
Wildfire can have a large impact on the landscape by burning trees, creating smoke and impacting local weather patterns. Under the right conditions, Canadian forests can burn like candlesticks, creating smoke and lots of heat.
Can you spot the airplane? It is a special type of aircraft designed to carry water to help put out fires from the air. (Photos: Doug McRae)

Methods

To answer our question, we studied the relationships between historical costs, the areas burned, and climate on a province-by-province basis:

1. Area Burned and Suppression Costs: We used historical data for wildfires that occurred during the summer (May-August period) between 1980 and 2009.

2. Scientific models provided us a glimpse into the future climate.

a) *General Circulation Models* (GCMs) are climate prediction models. We used two possible greenhouse gas concentration scenarios:

- Peak concentrations are reached between 2010-2020 and then decline for the rest of the century (more optimistic scenario)
- Concentrations rise throughout the 21st century (more pessimistic scenario)

b) *Climate Moisture Index* (CMI) is a measure of surface water balance using both temperature and precipitation. Low CMI indicates dry surface conditions which are conducive to wildfires. We used the GCMs to generate CMI values for each province for the rest of 21st century.

First, we calculated the statistical relationship between the CMI and the area burned. Then we estimated the relationship between the area burned and the provincial wildfire suppression costs for the years 1980 to 2009.

By combining the scientific models' predictions of climate and information about past spending, we projected our findings into the rest of the 21st century and calculated wildfire suppression costs.

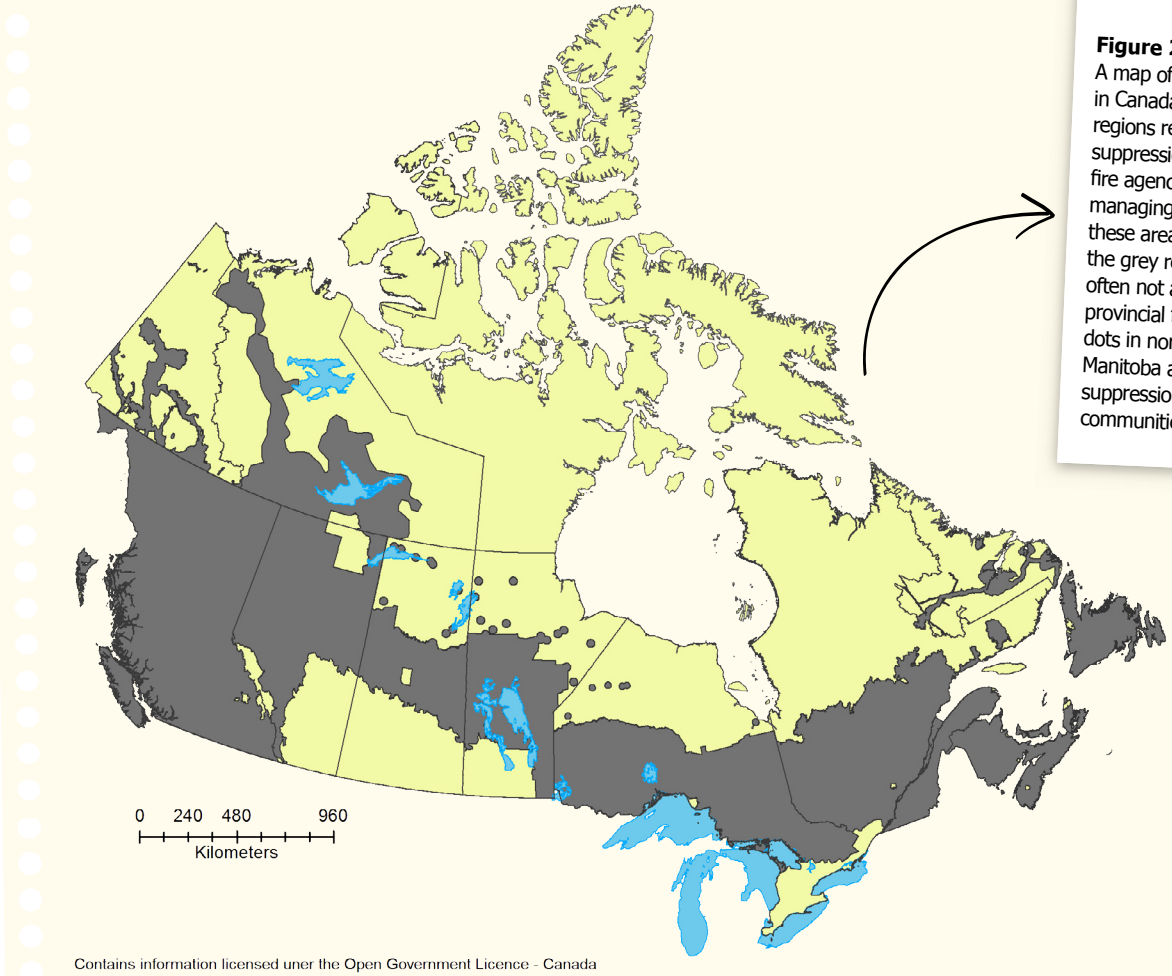

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Figure 2:
A map of the areas examined in Canada. The grey-shaded regions represent the provincial fire suppression zones. The provincial fire agencies are responsible for managing any fires that occur in these areas. Fires that occur outside the grey regions are monitored but often not actively put out by the provincial fire agencies. The grey dots in northern Saskatchewan, Manitoba and Ontario are small fire suppression zones around northern communities.

Results

Our findings for the two possible greenhouse gas concentration scenarios:

1. Optimistic scenario:

a) Provinces that experience frequent low CMI events (Manitoba, Ontario, and Northwest Territories) will likely experience more frequent extreme fire events.

b) Total annual average provincial costs will increase by 60%, reaching about $983 million Canadian dollars by the end of the century.

2. Pessimistic scenario:

a) The frequency of extreme fire years will increase in all provinces.

b) In the second half of the century, things will get even worse: the annual area burned could regularly exceed 10 million hectares (an area larger than the surface area of Lake Superior or the entire country Iceland).

c) Low fire years will happen less than 1% of the time.

d) Total annual average costs will increase 119%, exceeding $1.4 billion Canadian dollars by the end of the century.

Discussion

Our results show some of the financial consequences of climate change in most Canadian provinces. Low CMI, warm temperatures, and long summers dry out the soil and vegetation. Consequently, there are more opportunities for large and severe fires.

Human activities contribute to global climate change. It is not too late to take action. If we can lower greenhouse gas emissions, we can also keep wildfire suppression costs in a more affordable range.

Sadly, current trends in human activity cause greenhouse gas concentrations to increase rapidly. Events that we consider extreme today (i.e. mega-fires, large burned areas, high wildfire suppression costs) may well become commonplace in some provinces by the end of the century.

Forest management officials could seek ways to reduce wildfire suppression costs. Some solutions may possibly include responding to fewer fires, keeping human development far from the wildlands, and using new technologies to fight fires such as drones.

Conclusion

Now that we answered the burning question, what can we do about it?

1. Learn and Prevent: In 2015, human-caused wildfires burned almost 150,000 hectares in Canada (compared to about 800,000 hectares in total). Understand the basics of wildfire, fire's important natural role and campfire safety. You *can* prevent fire! #smokeybearhugs

2. Think outside the box: There is no limit to human ingenuity. Scientists, engineers, architects and many others come up with new solutions every day. Unleash your creativity! Be an inventor of low-carbon energy technologies!

3. Reduce greenhouse gases: No effortis too small. Save energy by using energy-efficient bulbs and appliances, burn less fossil fuels and recycle: make conscious decisions every day.

4. Speak Up: Talk to your family and friends, voice your concerns, and demand action from the officials. After all, there is only one Earth.

Glossary of Key Terms

Climate Moisture Index (CMI) – The CMI is a number or "metric" that illustrates dryness. The CMI indicator ranges from -1 to +1, with wet climates showing positive CMI, and dry climates-negative CMI.

Climate and Weather – The difference between climate and weather is a measure of time. Weather is the short-term changes in the atmosphere. *(The weather is supposed to be nice this weekend.)* Climate is the weather conditions prevailing in an area in general or over a long period of time. *(We almost have the same climate here as they do in Toronto.)*

General Circulation Models (GCM) – Computer models representing physical processes in the atmosphere, ocean, cryosphere (frozen water system) and land surface. They are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations.

Greenhouse Gas – Gases that trap heat in the atmosphere. These gases are the main cause of the enhanced greenhouse effect which is creating global warming and consequently climate change. Carbon dioxide, methane, nitrous oxide and fluorinated gases are the greenhouse gases emitted in the atmosphere.

Models – A representation of a thing or system. A mathematical model represents real-world situations using a variety of mathematical structures (eg. graphs, equations, diagrams).

Check your understanding

1. My city experienced an extremely cold winter in 2015. Does that mean climate change is a myth?
2. Carbon dioxide is the most important greenhouse gas emitted by humans but several other gases contribute to climate change too. Can you name any other greenhouse gases and their sources?
3. Scientists use models and simulations to understand, represent, and predict real-world events. What are some examples of simulations and models used in this study?
4. If you were the head of a forest fire agency, what would you do to lower wildfire suppression costs?

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