Climate Change and Trees: Impacts and Mitigation

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DAVEY
Proven Solutions for a Growing World

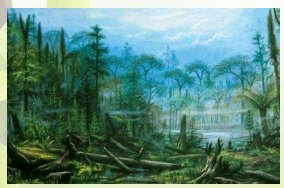
1

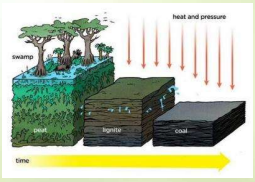
350-300 MYA: Carboniferous Period

Early Carboniferous: CO_2 = 1,000 ppm; vascular plants appear

Organic carbon accumulated as coal, oil, and gas over millions of years

Late Carboniferous: CO_2 drops to current levels; glacial era begins





2

Eunice Foote in 1856:

- Discovered CO_2 and H_20 are greenhouse gasses
- Conclusion: "An atmosphere of that gas would give to our earth a high temperature."

On the Heat in the Sun's Rays.

ART. XXXI.—*Circumstances affecting the Heat of the Sun's Rays;* by EUNICE FOOTE.

(Read before the American Association, August 23d, 1856.)

MY investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.
Several results have been obtained.

3

Svante Arrhenius in 1896:

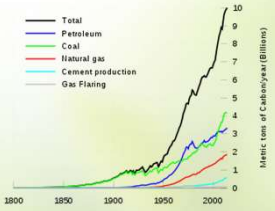
- In 1896, predicted that burning fossil fuels would cause global warming.
- Calculated that doubling atmospheric CO_2 would increase global temperature 5°C.

Nobel Prize 1903, Chemistry

4

Grand global experiment to test the prediction of Arrhenius

- 25% of Earth's fossil fuel deposits burned in 160 years



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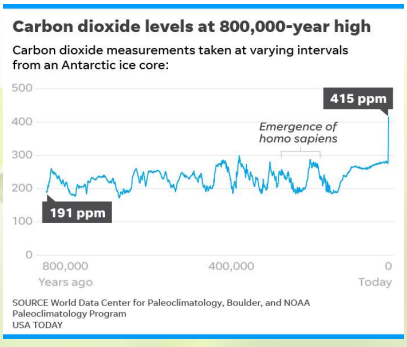
Atmospheric CO_2 is more than 100 ppm higher than anytime in the last 800,000 years



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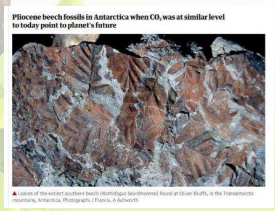
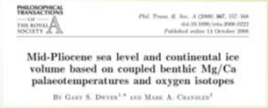
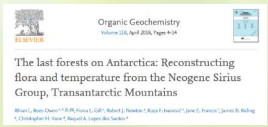
Last time CO_2 was this high: Pliocene Epoch 3 mya

- Global temp 3-4°C higher
- Sea level 60-90 ft higher
- Beech trees growing in Antarctica



www.theguardian.com/science/2019/apr/03/south-pole-tree-fossils-indicate-impact-of-climate-change


Mid-Pliocene sea level and continental ice volume based on coupled benthic Mg/Ca palaeotemperatures and oxygen isotopes


Organic Geochemistry

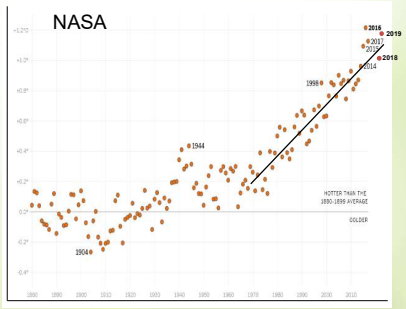
The last forests on Antarctica: Reconstructing flora and temperature from the Neogene Sirius Group, Transantarctic Mountains

7

10 warmest years since 1880

(19 of 20 have occurred since 2000)

1. 2016
2. 2019
3. 2017
4. 2015
5. 2018
6. 2014
7. 2010
8. 2005
9. 2013
10. 2007



https://climate.nasa.gov/vital-signs/global-temperature/

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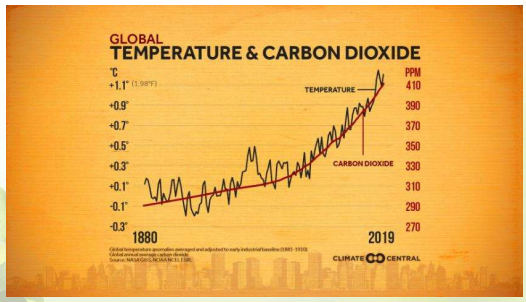

www.climatecentral.org

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Presentation Outline

1. Some current impacts of global warming.
2. How hot will it get?
3. What will it take to slow warming?
4. i-Tree and ecosystem services of trees
5. The Trillion Tree Initiative
6. Selecting trees for a changing climate.

10

More frequent and larger wildfires:

- California: 500% increase in area burned since 1972
- Western US: 200% increase in area burned since 1984

Source: Carbon Brief, fire data updated from Abatzoglou & Williams (2016); temp data from NOAA

Impact of anthropogenic climate change on wildfire across western US forests

Earth's Future — Observed Impacts of Anthropogenic Climate Change on Wildfire in California

Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

18 AUGUST 2006 VOL 313 SCIENCE

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Earlier springs cause drier, hotter summers

- 30 yrs of satellite data, 1982-2011
- Earlier spring greening in Northern Hemisphere
- Earlier transpiration
- Increased summer soil drying
- Summer heat waves more frequent and intense

Summer soil drying exacerbated by earlier spring greening of northern vegetation

Lian et al., Sci. Adv. 2020; 6 : eaax0255 3 January 2020

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Hurricanes are stronger:

- No increase in number of hurricanes.
- Frequency of strong (class 4-5) hurricanes has doubled.
- Hurricanes are moving slower and producing more rainfall.

Hurricane Patricia: strongest ever recorded in Western Hemisphere

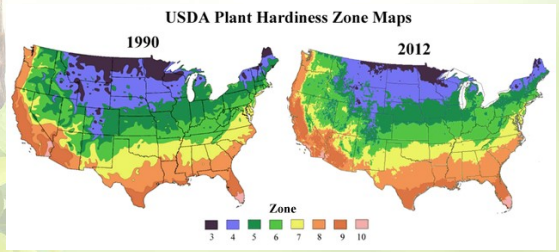
Webster, et al. (2005) Changes in tropical cyclone number, duration, and intensity in a warming environment. *Science* 309:1844-1846

Holland & Bruyère (2014) Recent intense hurricane response to global climate change. *Climate Dynamics* 42:617-627

Hall & Kossin (2019) Hurricane stalling along the North American coast and implications for rainfall. Nature Climate and Atmospheric Science. 2:17 (doi.org/10.1038/s41612-019-0074-8)

13

USDA Plant Hardiness Zone Map Update: Warmer winters in Northern US



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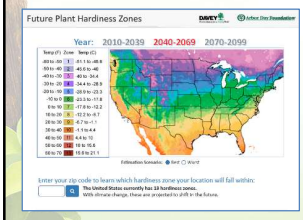
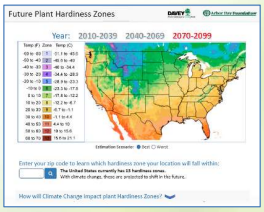
Future Plant Hardiness Zones





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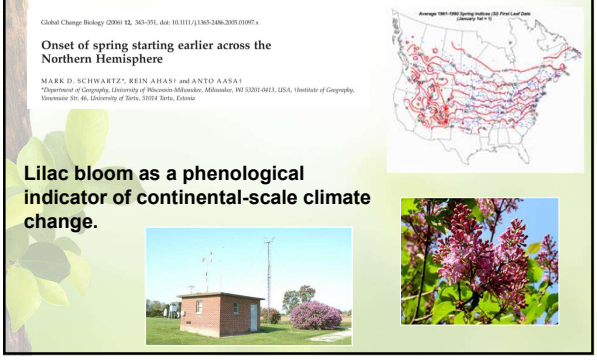
OARDC is part of the National Phenology Network that has documented earlier springs



Lilac bloom as a phenological indicator of continental-scale climate change.

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Range Expansion of Southern Pine Beetle New Jersey Pinelands

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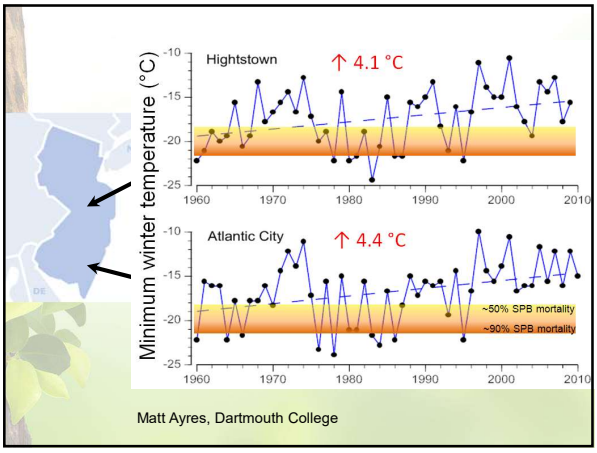

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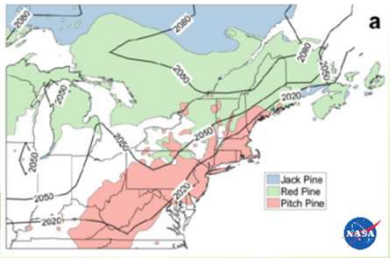
Projected range expansion of southern pine beetle



Lesk et al. (2020) Threats to North American forests from southern pine beetle with warming winters.

https://ntrs.nasa.gov/search.jsp?R=20180000174 2020-01-10T17:45:46+00:00Z

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Laurel Wilt Disease

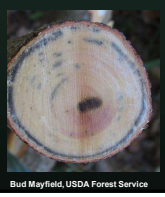
Redbay Ambrosia Beetle (*Xyleborus glabratus*) and it's fungal symbiont *Raffaelea lauricola*


Michael Thomas, Florida Dept. of Agriculture and Consumer Services


nwdistrict.ifas.ufl.edu

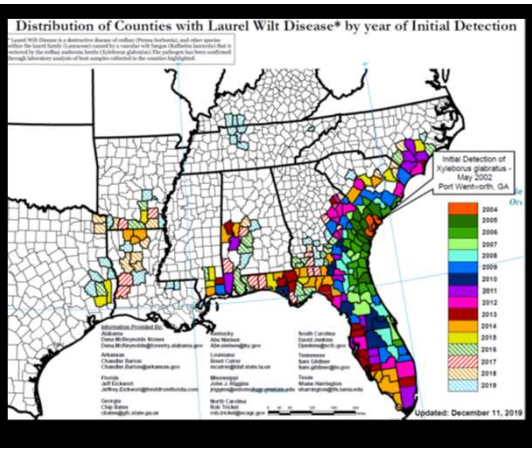

James Johnson, Georgia Forestry Commission


Bud Mayfield, USDA Forest Service


Bud Mayfield, USDA Forest Service

20

Distribution of Counties with Laurel Wilt Disease* by year of Initial Detection



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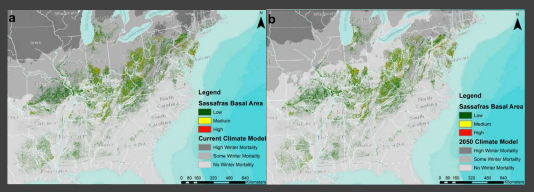
Redbay ambrosia beetle range potential



ORIGINAL PAPER

Cold tolerance and invasive potential of the redbay ambrosia beetle (*Xyleborus glabratus*) in the eastern United States

John P. Formby · John C. Rodgers III · Frank H. Koch · Nataraj Krishnan · Donald A. Duerr · John J. Riggins

Slide courtesy of Dr. John Riggins, Mississippi State Univ.

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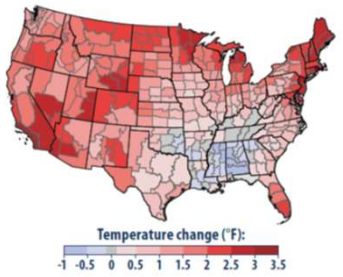

Rising temperatures in the last century. The last decade was the warmest on record throughout the West. Source: EPA, Climate Change Indicators in the United States.

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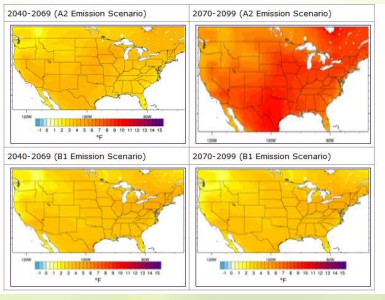
Warming Projected for US in 21st Century

- **7 – 11°F under high emission scenario**
- **4 – 6.5°F under low emission scenario**

(USGCRP 2009)



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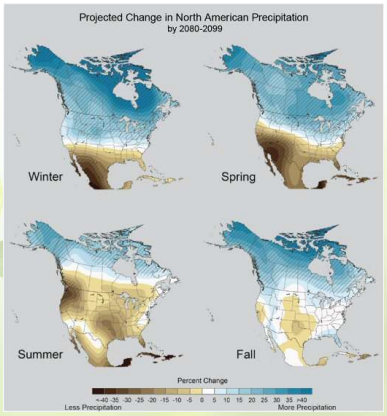

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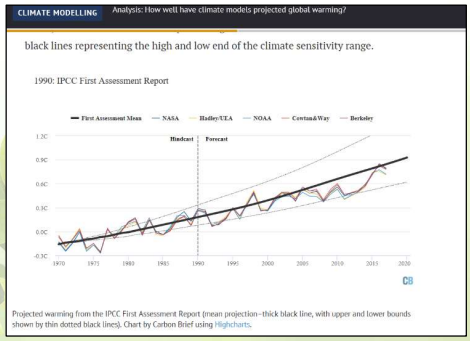
Climate models accurately predict global warming



www.carbonbrief.org/analysis-how-well-have-climate-models-projected-global-warming

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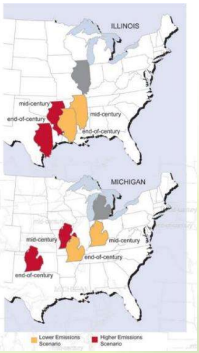
Climate Change Projections (US EPA)



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Paris Climate Accord: limit warming to 1.5°C

- Cut global C emissions by 7% per year between 2020-2030
- Emissions in 2030 would have to be 55% lower than in 2018; reach net zero by 2050
- Global C emissions continue to increase

REPORT

Emissions Gap Report 2019

26 November 2019

Authors: UN Environment Programme

www.unenvironment.org/resources/emissions-gap-report-2019

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1.5°C vs. 2.0°C Warming

- Hundreds of millions fewer people exposed to water stress and food insecurity
- Sea level rise impacts 10 million fewer people
- Fewer extreme heat days
- Fewer extreme weather and fire events
- 1.5 vs 3.0 million tons of fisheries lost
- 85% vs 99% of coral reefs lost

Source: 2019 IPCC Special Report on Global Warming of 1.5C (www.ipcc.ch/sr15/)

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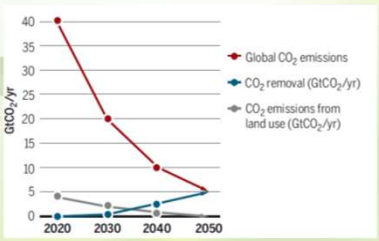
CLIMATE POLICY

A roadmap for rapid decarbonization

Rockström et al. (2017) *Science* 355:1269-1271

To achieve Paris targets: cut net emissions by half each decade



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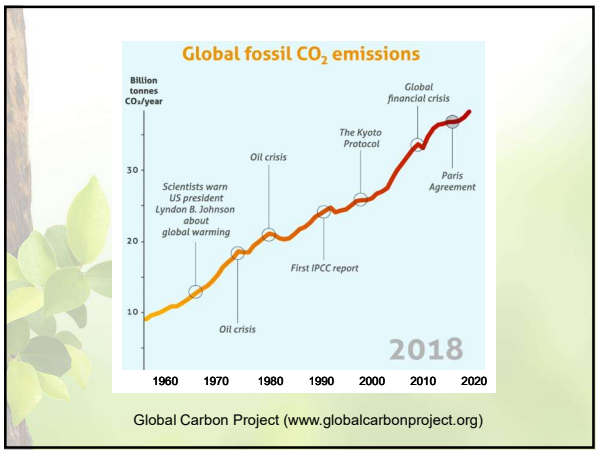

Global Carbon Project (www.globalcarbonproject.org)

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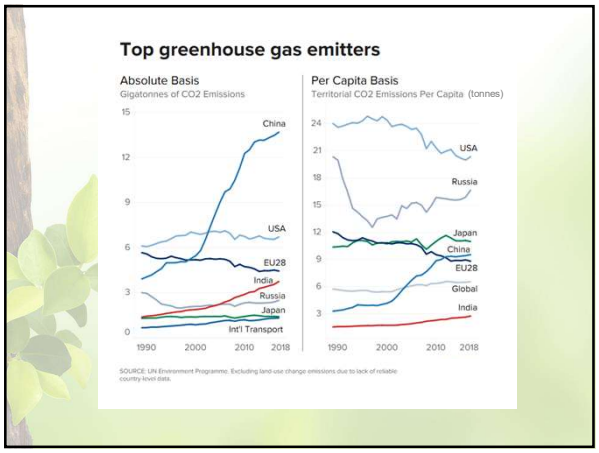

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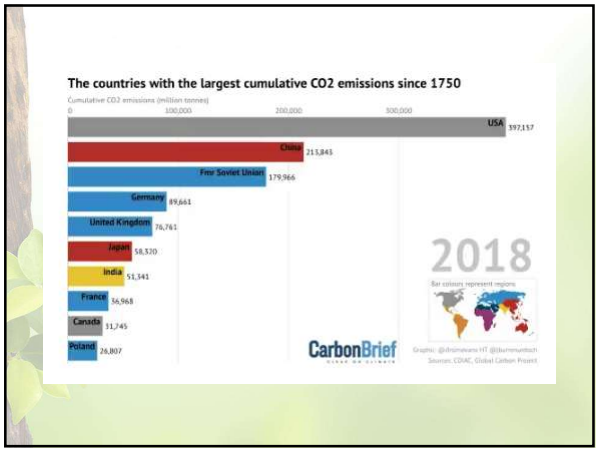

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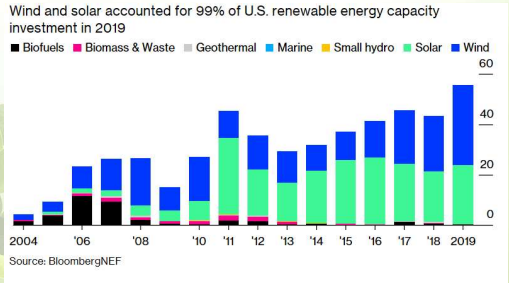
US renewable energy investment increased 28% in 2019

(US = $55B; EU = $54B; China = $85B)



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US renewable energy residential tax credit: 2016-2022

- 30% 2016-2019
- 26% 2020
- 22% 2021

Net metering in Ohio

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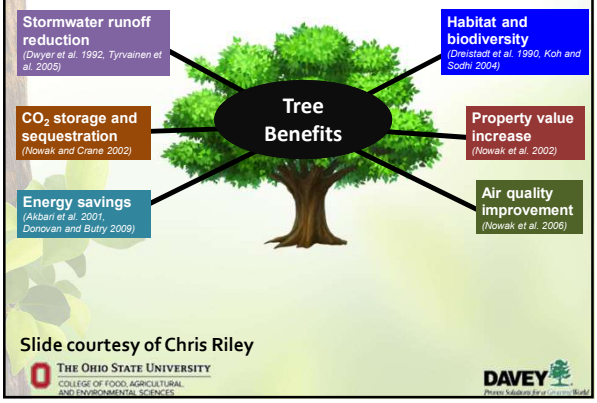
Benefits of Trees: Ecosystem Services



Slide courtesy of Chris Riley

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL AND ENVIRONMENTAL SCIENCES

DAVEY

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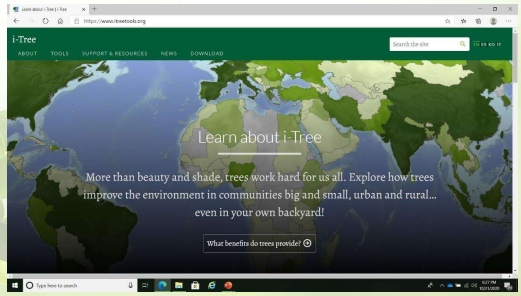
i-Tree
(www.itreetools.org)



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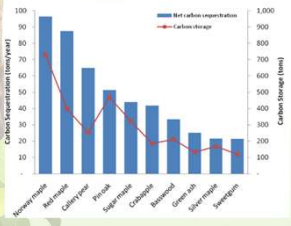
Services provided by Wooster street trees (2009)



City trees provide an estimated value of $263,857 to Wooster each year

Environmental service	Total monetary value ($/year)	Avg. $/tree
Asthetic/other benefits	$82,244	$26.44
Energy conservation	$81,915	$26.33
Stormwater remediation	$76,162	$24.48
Air pollution removal	$13,129	$4.22
Carbon sequestration	$10,406	$3.34
TOTAL	$263,857	

Avg car emits 1.6 tons of C / yr

City of Wooster street trees offset 300 cars / yr

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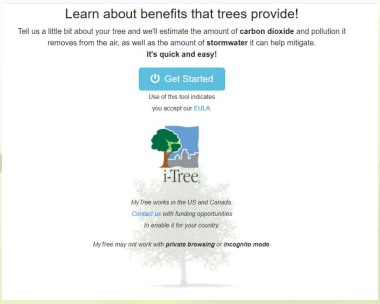
i-Tree MyTree
(mytree.itreetools.org)



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i-Tree MyTree
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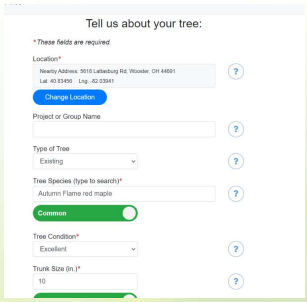

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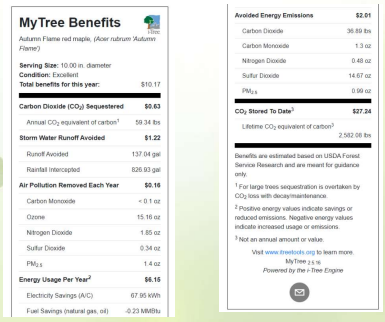
i-Tree MyTree
(mytree.itreetools.org)



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Deforestation of US Urban Forests (2009-2014)
(Nowak & Greenfield 2018)

Lost each year:

- 36 million trees
- 175,000 acres of tree cover
- $96 million of ecosystem services (pollution removal, C sequestration, reduced energy use and power plant emissions)

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Global deforestation is still increasing

Deforestation (ha / yr):

- 1990-2000: 10.6 million
- 2010-2015: 6.5 million

Reforestation (ha / yr):

- 1990-2000: 3.6 million
- 2000-2005: 5.9 million
- 2010-2015: 3.3 million

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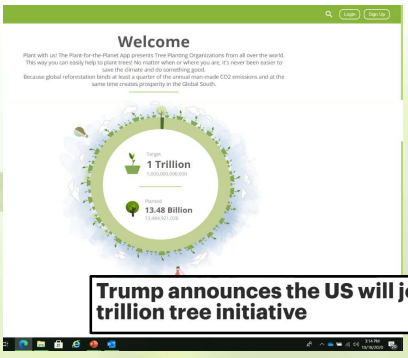
The Trillion Tree Campaign

(www.trilliontreecampaign.org)



Trump announces the US will join 1 trillion tree initiative

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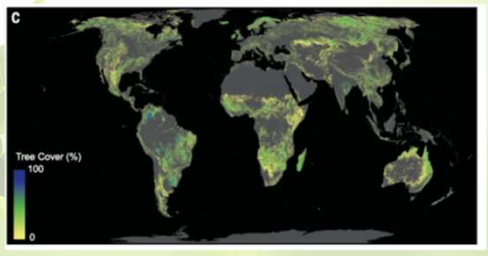
The global tree restoration potential

Bastin *et al.*, *Science* **365**, 76–79 (2019)

- Room for an extra 0.9 billion Ha of forest (1 trillion trees)
- Increase global forest cover by 25%
- Sequester 25% atmospheric C pool over 50-100 yrs



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Comments on "The global tree restoration potential"

Friedlingstein et al. (2019) *Science* 10.1126/science.aay8060
Lewis et al. (2019) *Science* 10.1126/science.aaz0388
Luedeling et al. (209) *Science* 10.1126/science.aay7988
Skidmore et al. (2019) Science 10.1126/science.aaz0111
Veldman et al. (2019) *Science* 10.1126/science.aay7976

Assumptions challenged:

- No additional deforestation
- No carbon currently stored on non-forested land
- Grasslands, savanna, and tundra can be converted to forest
- No negative feedbacks as atmospheric CO_2 declines
- Large-scale, even-aged forest plantations are sustainable

Optimistic estimate: 10% of C pool sequestered

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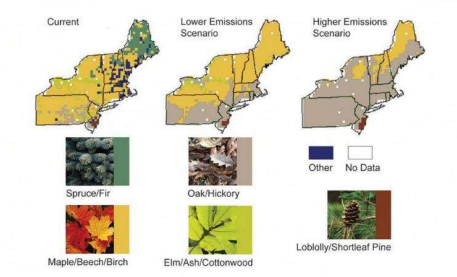
Trees stressed on south edge of distribution; benefit on north



Source: US EPA, adapted from Iverson, L., A. Prasad, and S. Matthews. "Potential Changes in Suitable Habitat for 134 Tree Species in the Northeastern United States." Mitigation and Adaptation Strategies for Global Change 13, no. 5-6 (2008): 487-516.

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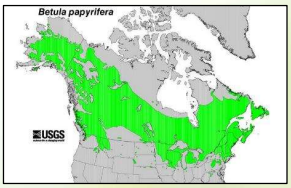
Climate change, bronze birch borer, and the distribution of paper birch



Environ. Entomol. (2012) 41:1372-1385

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Warmer, wetter weather has increased disease pressure from foliar pathogens on eastern white pine in the NE

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Response of eastern white pine and associated foliar, blister rust, canker and root rot pathogens to climate change☆

Stephen A. Wyka[a,*], Isabel A. Munck[b], Nicholas J. Brazee[c], Kirk D. Broders[a]

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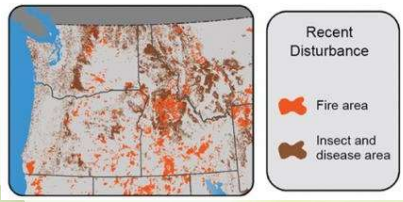
Insects and Fire in Northwest Forests



Widespread Increase of Tree Mortality Rates in the Western United States

Phillip J. van Mantgem,[1,2†‡] Nathan L. Stephenson,[1,2†] John C. Byrne,[2] Lori D. Daniels,[3] Jerry F. Franklin,[4] Peter Z. Fulé,[5] Mark E. Harmon,[6] Andrew J. Larson,[4] Jeremy M. Smith,[7] Alan H. Taylor,[8] Thomas T. Veblen[9]

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Selecting trees for a changing climate

Climate Envelope: temperature and precipitation

Current and projected: summer heat, winter cold, precipitation (average and extremes)

Tree lists based on regional projections

Macro: full set of candidate trees based on regional projections

Micro: subset of candidate trees based on site factors (soil fertility and moisture, pH, soil type, exposure, etc)

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Projecting future climate envelopes for trees

- How fast will the climate change?
- How fast will the tree migrate (generally accepted rate = 30 miles / century)
- Can a tree migrate fast enough to keep up with climate change?

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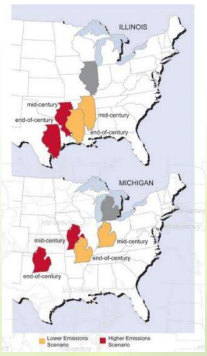
Climate Change Projections (US EPA)



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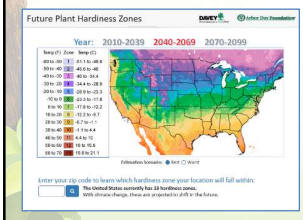
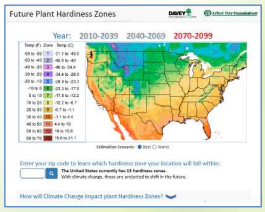
Future Plant Hardiness Zones: Arbor Day Foundation – Davey Tree Collaboration





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Tree species with large projected shifts:

American basswood	9.7 °
Sugar maple	8.9 °
Black cherry	8.5 °
White oak	8.2 °
Black walnut	8.2 °
Common hackberry	8.0 °
Bur Oak	7.9 °
River birch	7.8 °
Red maple	7.6 °

One degree = ca 69 mi

Potential Impacts of Climate Change on the Distribution of North American Trees

DANIEL W. MCKENNEY, JOHN H. PEDLAR, KEVIN LAWRENCE, KATHY CAMPBELL, AND MICHAEL F. HUTCHINSON

BioScience • December 2007 / Vol. 57 No. 11

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Ohio trees well within their climate envelope:

American Beech

Tulip Tree

Red Maple

Shagbark Hickory

Red Oak

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Northern species that will be unsuitable

Paper birch

Quaking Aspen

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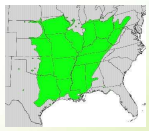
Southern trees hardy in Ohio


Black Gum


Tulip Tree


Honey Locust


Sweet Gum


River Birch


Bald Cypress

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Trees with a shaky future in Ohio


Pin Oak


Ohio Buckeye


Yellow Birch

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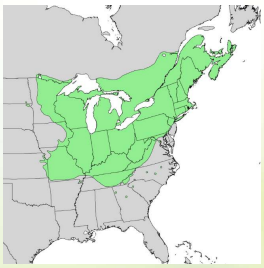
What about trees like sugar maple?


Sugar maple

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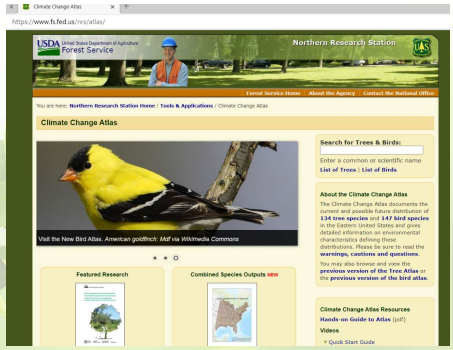
US Forest Service Tree Atlas

www.fs.fed.us/nrs/atlas



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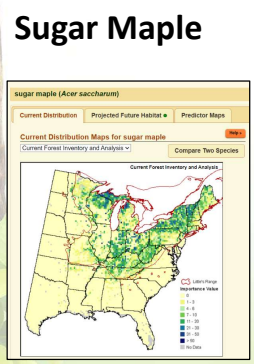
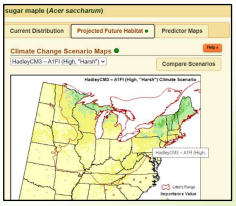
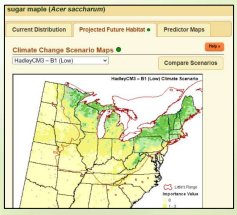
Sugar Maple







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Climate Change and Trees: Impacts and Mitigation

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