Climate Change and Fire: What are the Models Telling Us?



Monica G. Turner University of Wisconsin – Madison

Summer 1988



The 1988 Fires

- Exceptionally dry, windy summer
- Size, severity surprised managers and scientists



M. G. Turner, July 1988



Fire is not new

Mentioned by early explorers:



"Tuesday, September 20, 1870 – We broke camp at half past 9 o'clock, traveling along the rocky edge of the [Firehole] river bank by the rapids, passing thence through ... a long stretch of fallen timber, blackened by fire, for about four miles."



Diary, Nathaniel Pitt Langford, Washburn Expedition

[Was likely an 1862 fire]

Yellowstone's fire regime

- Infrequent, stand-replacing fires are the norm
 - 100 to 300-yr fire return interval (FRI) over past 10,000 yrs (Romme and Despain 1989; Whitlock et al. 2003, 2008)
- Driven by climate (not limited by fuels)





Global temperature is increasing

Global average temp. has already increased by 1°C since 1800's.



(IPCC 5th Assessment, 2014)

Fire regimes also changing with climate

Fire

- More large fires
- More annual area burned

Climate

- Warmer temperatures
- Earlier spring snowmelt
- Longer fire seasons

(Westerling et al. 2006, Science)



(Map courtesy of Leroy Westerling, UC-Merced)

Number of fires (and area burned) continues to increase

Western US Forests

annual large (> 400 ha) forest fires



Note: Increase is in lightning-ignited fires

Westerling 2016, Phil. Trans. Royal Soc. B

21st Century climate change

Early work in GYE

- Warmer, drier climate would increase fire activity, reduce stand age, shift vegetation upslope
- Simulation modeling studies
 - Weather scenarios using EMBYR (Gardner et al. 1996, Hargrove et al. 2000)
 - ¹/₂ to 3 x the HRV of fire in YNPFIRE (Schoennagel et al. 2006)
 - Predicted climate x fire interaction using Century (Smithwick et al. 2009, GCB)

Conservation Biology, 1991

Implications of Global Climate Change for Biogeographic Patterns in the Greater Yellowstone Ecosystem

WILLIAM H. ROMME Biology Department Fort Lewis College Durango, CO 81301, U.S.A.

MONICA G. TURNER Environmental Sciences Division Oak Ridge National Laboratory Oak Ridge, TN 37831-6038, U.S.A.



Encouraging results!

- Climate and fire
 - Changed in the past
 - Will change in future
- Simulated changes within historic range of variation
 - Forests recovered
- 1988 fires not catastrophic

→Yellowstone well adapted to warming climate





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→Yellowstone well adapted to warming climate...or is it?





Climate projections

From Westerling 's plenary talk at 2008 IAWF and YNP Biennial Science conference, Jackson



Climate like 1988 as the norm rather than the exception.

(Courtesy of Tony Westerling, UC-Merced)

Current projections of future climate

Global average temperature projected to increase another 3 to 5°C by 2100.



Northern Rocky Mountain Climate Projections (1950-2100) (courtesy of Leroy Westerling)



AR5 climate

some AR5 temp increases are higher some AR5 temp increases are similar to what we used previously

GCM (rcp8.5): CanESM2 HadGEM2-ES MIROC5

(IPCC 5th Assessment, 2014)

What does this mean for fire season in Yellowstone?



Courtesy of Kristin Braziunas

Historical and Future Climate Envelopes Precip vs Temp (July-August-September)





Days with no Precip vs. Days > 90°F (July-August-September; all years)



All 20 years, all 20 models, all 48 grid cells

Historical record



Future climate and fire

- Warmer, drier climate likely to increase fire activity
- Many details unresolved
 - How many fires?
 - How much area burned?
 - When?
 - Where?
 - Implications?



Climate – fire modeling: Novel fire regime for Greater Yellowstone?

- <u>Much</u> greater predicted change than previously observed or suggested
 - Climate conditions conducive to large fires more frequent than in past ca. 10,000 years
 - Fire would no longer be climate limited
 - Larger fires occur more often
 - Years without fire (common historically) rare
 - Minimum area burned each year increases
 - Fuels would eventually limit fire



(Westerling et al. 2011, PNAS)

What happens in the landscape?

Fire rotation

• The time required to burn an area equal to the area of interest





A lot more fire \rightarrow decreased fire rotation



A lot more fire \rightarrow decreased fire rotation



(Westerling et al. 2011, PNAS)

Summary

Large fires expected to be much more frequent than documented for the past 10,000 years.

- Temperature and aridity projected to increase
- Initially, fire frequency, size, severity will increase
- Fire-return intervals would decline
- Fuels could eventually limit fire
- Effects on fire severity uncertain
- Projected novel fire regime not consistent with current vegetation in GYE





EXTRA SLIDES

My early (1978) experience in YNP...



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Days with no Precip vs. Days > 90°F (July-August-September; all years)



All 20 years, all 20 models, all 48 grid cells

Historical record

- 1988
- ° 2016

Climate period

- 1980-1999
- 2040-2059
- 2080-2099

Courtesy of Kristin Braziunas

Climate-fire modeling: GYE projected to be hotter and drier



Based on IPCC 4th assessment models

(Westerling et al. 2011, PNAS)