Future Arctic and Boreal Fire Regimes

Human-caused burning below the Arctic Circle in Оймяко́н, Республика Саха (Якутия) [Lat: 63.444, Lng: 142.804) on 1 May 2021. Modified Copernicus Sentinel data [2020], processed by Pierre Markuse. Image is about 19 kilometers wide.

Jessica L. McCarty

Associate Professor, Geography
Director, Geospatial Analysis Center
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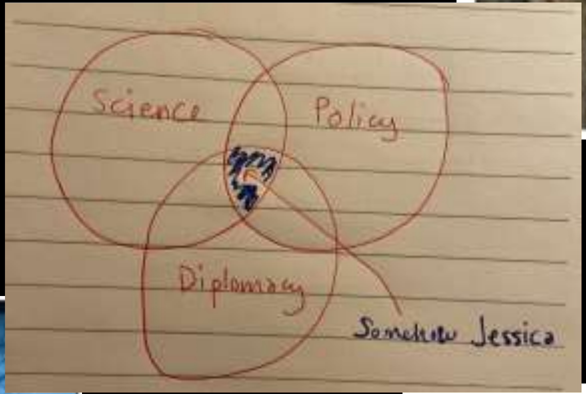
@jmccarty_geo

MIAMI UNIVERSITY
OXFORD, OH · EST. 1809

The Ames Earth Science Division is proud to announce that Dr. Jessica McCarty has agreed to serve as the new permanent supervisory branch chief, Biospheric Sciences Branch (ARC-SGE), from January 2023 onwards.
Dr. McCarty is currently a tenured Associate Professor of Geography and Director of the Geospatial Analysis Center at Miami University (Ohio). She has more than 15 years' experience in remote sensing and geospatial science to quantify wildland and human-caused fires, fire emissions, agriculture and food security, and land-cover/land-use change. She is a NASA-funded PI and author or co-author of more than 35 peer-reviewed journal articles, 3 data citations, and 1 NASA Technology Transfer. She is a member of the NASA Land-Cover/Land-Use Science Team and an Arctic Council Working Group, and has worked closely with the U.S. Forest Service, USDA, and EPA. In addition to her work as a supervisor, she will also serve as co-Associate Program Manager for the SMD-ESD Wildfire Applications Program under David Green.



https://science.house.gov/imo/media/doc/McCarty%20Testimony.pdf

NASA's Center in Silicon Valley

Ames Research Center applies the spirit of Silicon Valley to NASA's mission.

- We were founded in the San Francisco Bay Area 80 years ago, and the region has been shaped by our passion for knowledge and technology – Steve Jobs said he first fell in love with computers when he saw one for the first time as a boy visiting Ames.
- We will go forward to the Moon, through Silicon Valley – bridging public and private partnerships to capitalize on the innovation and entrepreneurship of our region. We lead experimental projects that retire risk, and outside-the-box solutions for a sustainable program of exploration.

Aerial image of NASA's Ames Research Center
Credits: NASA

EARTH SCIENCE
APPLIED SCIENCES

- NASA Land-Cover/Land-Use Change Science Team

South and Southeast Asia, Central Asia, Northern Eurasia

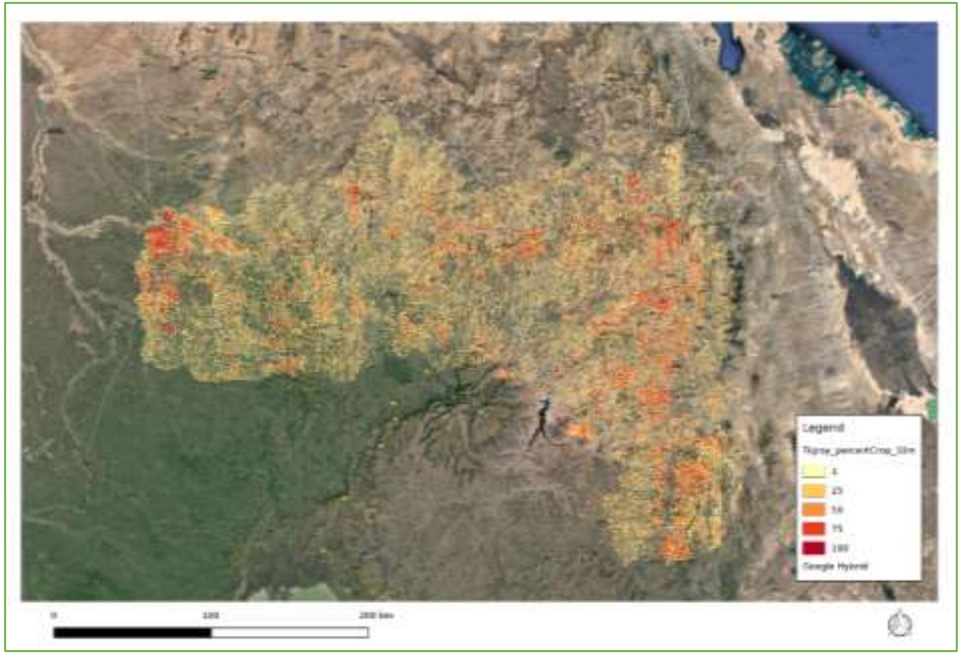
- NASA Interdisciplinary Research in Earth Science

Sub-Saharan Africa food security; index insurance and urban ag

- NOAA/NASA FIREX-AQ

- NASA Wildfires

Global, with focus on North America & Arctic



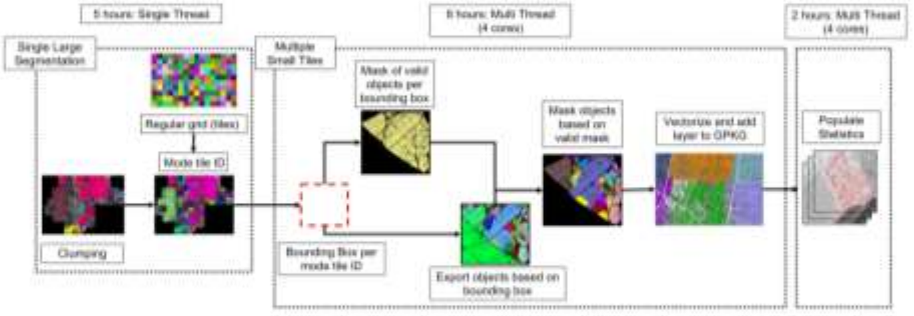


Figure 8. The run time of each step within FARMA, demonstrating the most time-intensive stages of the workflow for 1 m data for the Mekong Delta, Vietnam.

- U.S. EPA National Emissions Inventory and Greenhouse Gas Inventory

Methodology for human-caused fire activity data and emissions

- U.S. Department of Agriculture

Farmer communication + smoke transport modeling to improve local air quality

- Geospatial methods for GeoHealth

Indigenous-led research in the U.S. and Canada

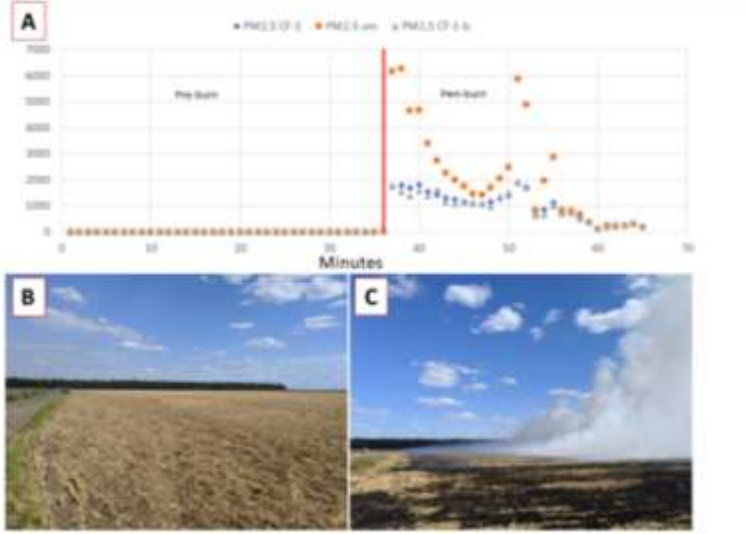


Figure 5. $PM_{2.5}$ measurements from field-based Purple Air sensors in Mississippi County, AR. [A]: The x-axis shows the minutes recorded by the sensor from 0 (start of data collection) through 70 (end of data collection) at 1-minute intervals and the y-axis shows the $PM_{2.5}$ detected. The vertical red line illustrates the approximate start of the burn. [B] Image of the pre-burn field. [C] Image of the peri-burn field.

Environmental Research

Monitoring uranium mine pollution on Native American lands: Insights from tree bark particulate matter on the Spokane Reservation, Washington, USA

Lonnie Flett, Claire L. McLeod, Jessica L. McCarty, Barry J. Shaulis, Justin J. Fain, Mark P.S. Krekeler

ARTICLE INFO

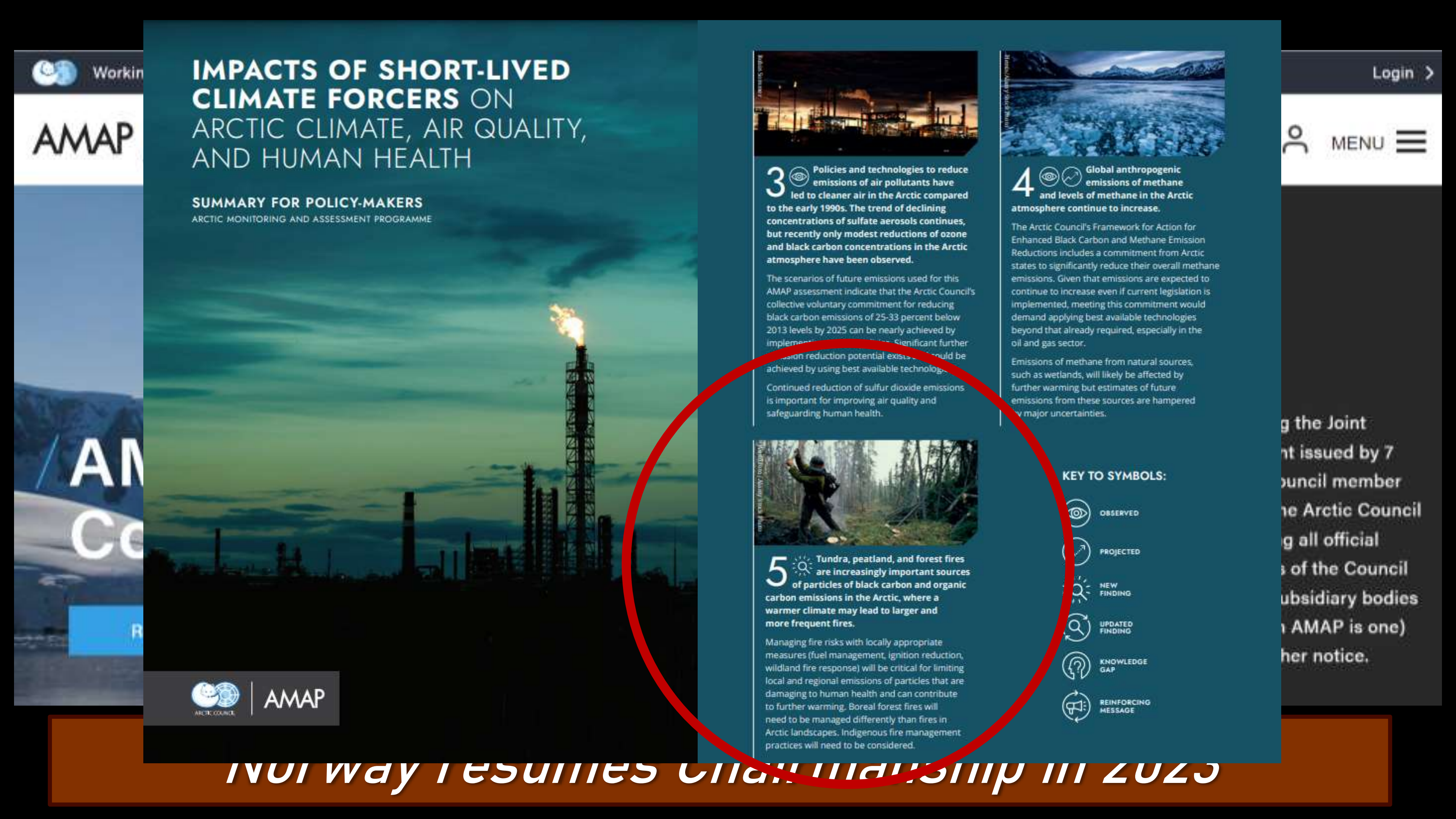
ABSTRACT

Linking Science to Policy

Who are the policymakers?

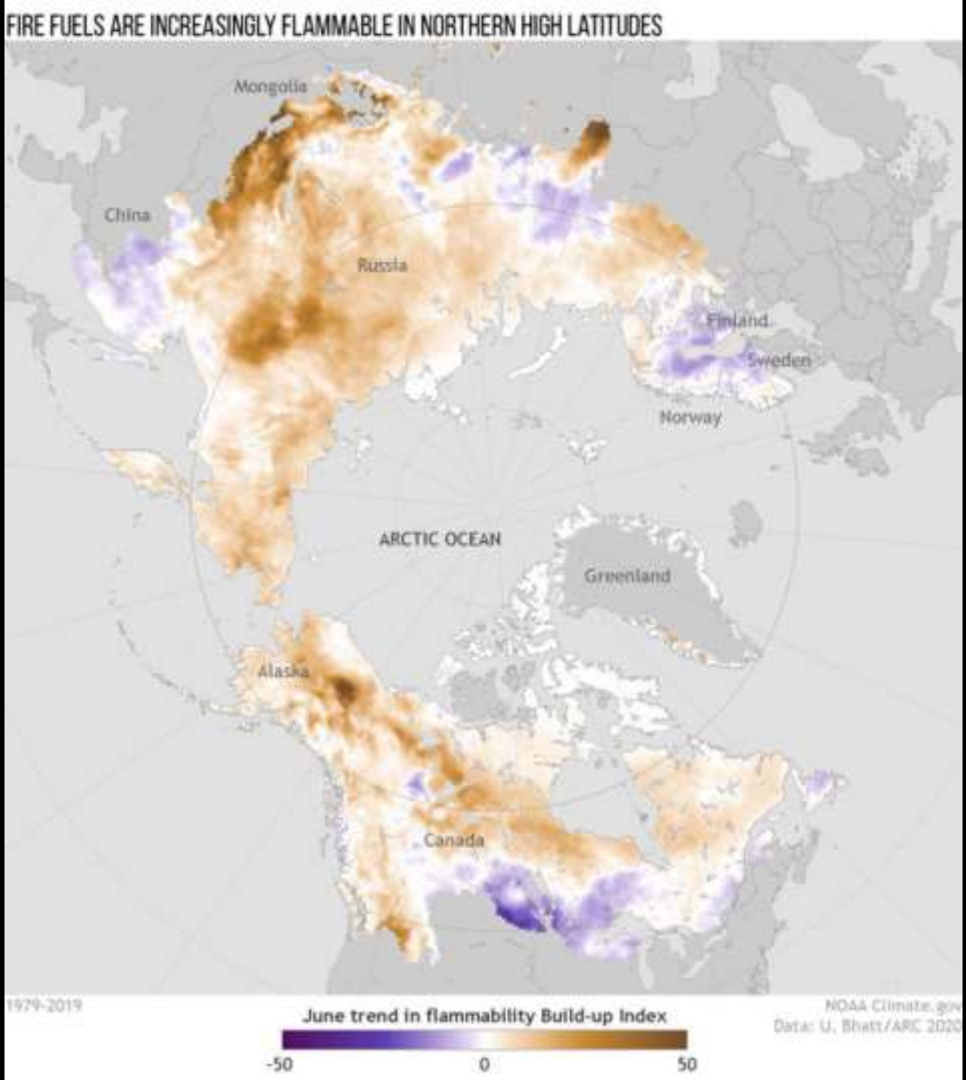
<u>Local to Supranational</u>

ARCTIC COUNCIL


Working
AMAP
Login
MENU
IMPACTS OF SHORT-LIVED CLIMATE FORCERS ON ARCTIC CLIMATE, AIR QUALITY, AND HUMAN HEALTH
SUMMARY FOR POLICY-MAKERS
ARCTIC MONITORING AND ASSESSMENT PROGRAMME
ARCTIC COUNCIL
AMAP
3 Policies and technologies to reduce emissions of air pollutants have led to cleaner air in the Arctic compared to the early 1990s. The trend of declining concentrations of sulfate aerosols continues, but recently only modest reductions of ozone and black carbon concentrations in the Arctic atmosphere have been observed.
The scenarios of future emissions used for this AMAP assessment indicate that the Arctic Council's collective voluntary commitment for reducing black carbon emissions of 25-33 percent below 2013 levels by 2025 can be nearly achieved by implemen... Significant further ...sion reduction potential exists ...ould be achieved by using best available technolog...
Continued reduction of sulfur dioxide emissions is important for improving air quality and safeguarding human health.
4 Global anthropogenic emissions of methane and levels of methane in the Arctic atmosphere continue to increase.
The Arctic Council's Framework for Action for Enhanced Black Carbon and Methane Emission Reductions includes a commitment from Arctic states to significantly reduce their overall methane emissions. Given that emissions are expected to continue to increase even if current legislation is implemented, meeting this commitment would demand applying best available technologies beyond that already required, especially in the oil and gas sector.
Emissions of methane from natural sources, such as wetlands, will likely be affected by further warming but estimates of future emissions from these sources are hampered ...y major uncertainties.
5 Tundra, peatland, and forest fires are increasingly important sources of particles of black carbon and organic carbon emissions in the Arctic, where a warmer climate may lead to larger and more frequent fires.
Managing fire risks with locally appropriate measures (fuel management, ignition reduction, wildland fire response) will be critical for limiting local and regional emissions of particles that are damaging to human health and can contribute to further warming. Boreal forest fires will need to be managed differently than fires in Arctic landscapes. Indigenous fire management practices will need to be considered.
KEY TO SYMBOLS:
OBSERVED
PROJECTED
NEW FINDING
UPDATED FINDING
KNOWLEDGE GAP
REINFORCING MESSAGE
g the Joint
nt issued by 7
uncil member
ne Arctic Council
g all official
s of the Council
ubsidiary bodies
AMAP is one)
her notice.


Smoke
Fuels
Ignitions
Fire
weather
Landscape
Climate Change

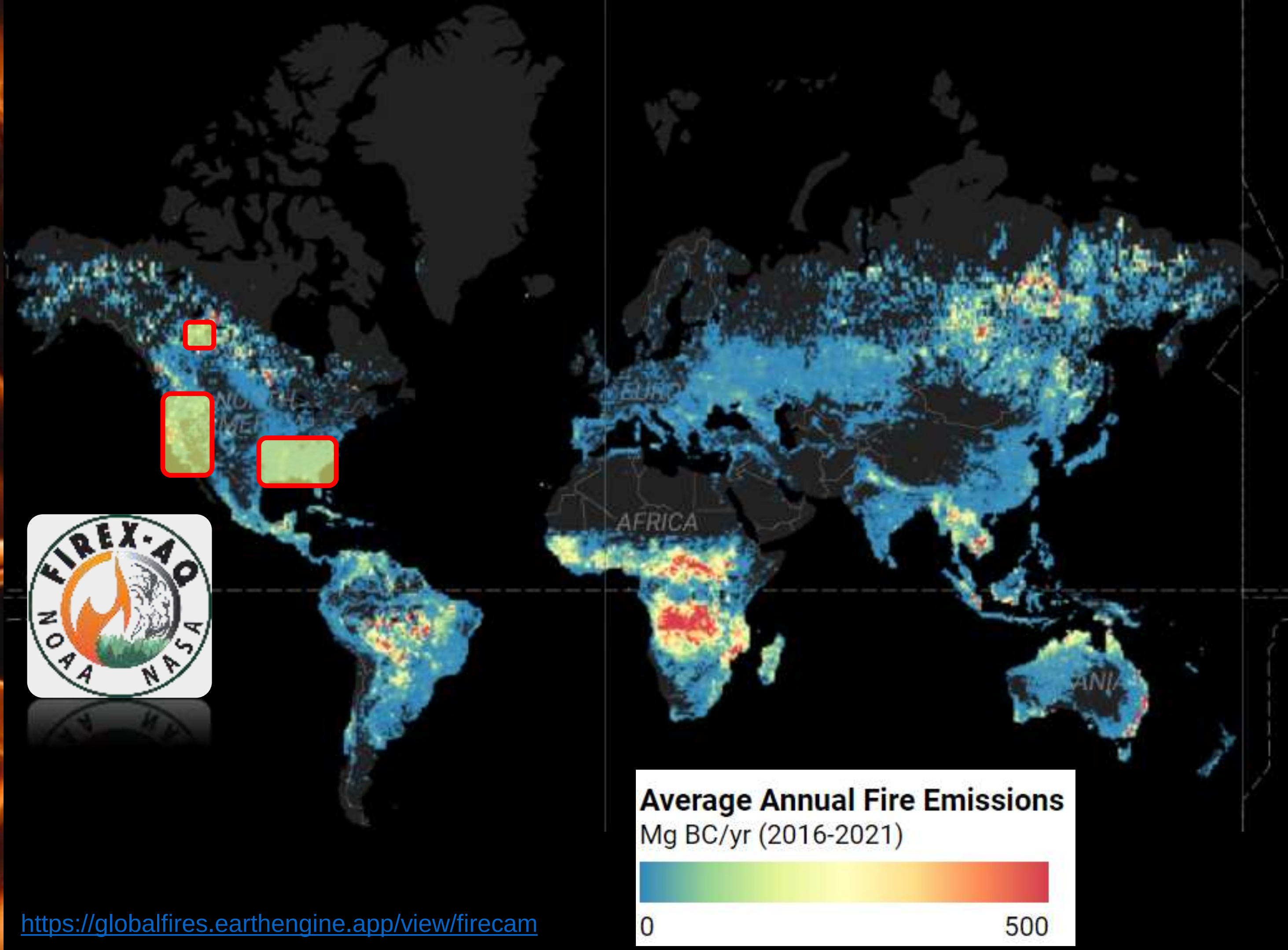
https://www.unep.org/resources/report/spreading-wildfire-rising-threat-extraordinary-landscape-fires



https://arctic.noaa.gov/Report-Card/Report-Card-2020

Global emissions from satellite-based fire emissions models:

Lack of boreal and Arctic emission factors



https://globalfires.earthengine.app/view/firecam

Atmos. Chem. Phys., 22, 12493–12523, 2022
https://doi.org/10.5194/acp-22-12493-2022

Research article

Reconciling the total ca
boreal forest wildfire e
airborne observations

Katherine L. Hayden[1], Shao-Meng Li[2], John Liggio[1], M
Amy Leithead[1], Peter Brickell[1], Richard L. Mittermeier[1]
Samar G. Moussa[1], Andrea Darlington[1], Mengistu W
Jenna C. Ditto[5], Megan He[5], and Drew R. Gentner[5]
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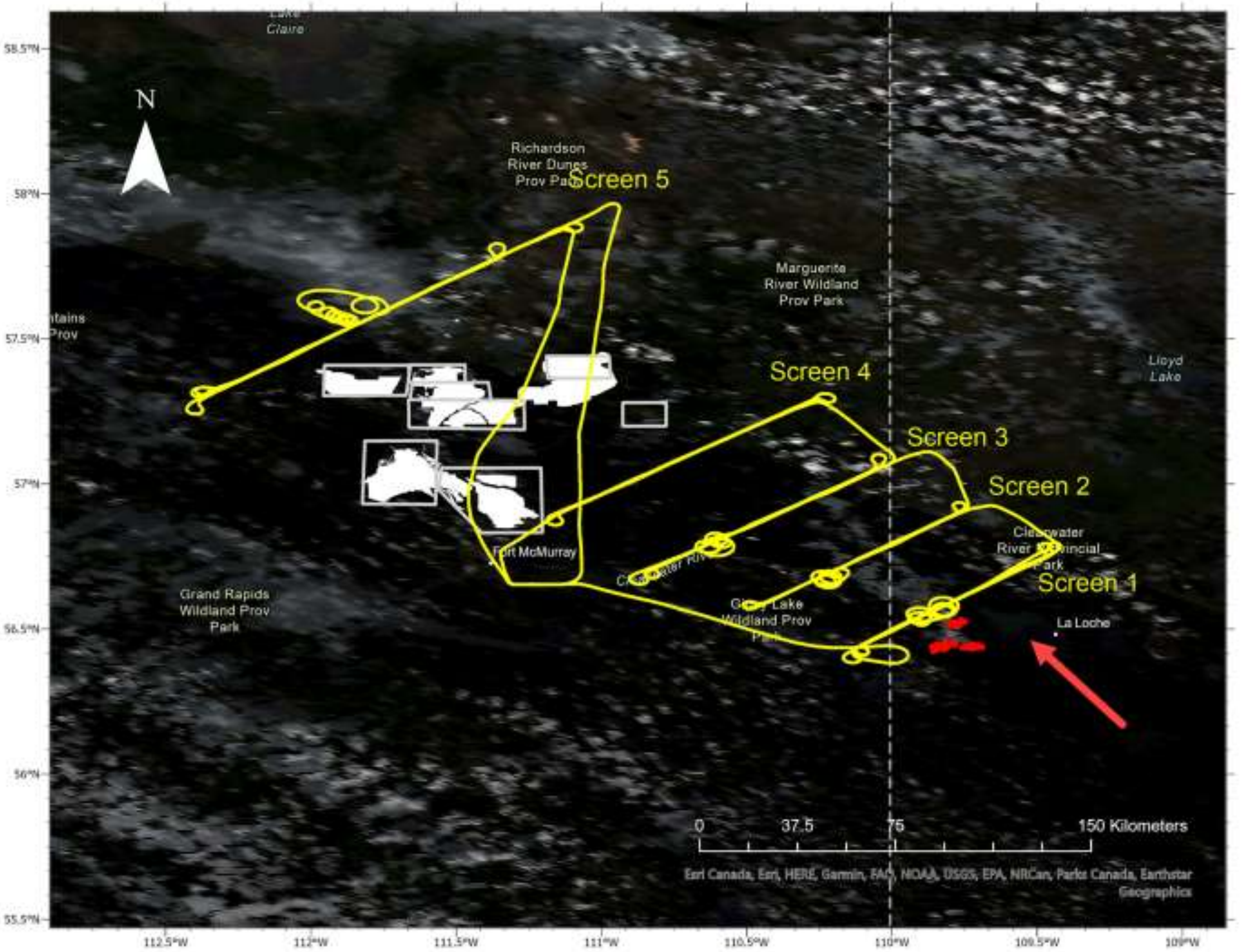
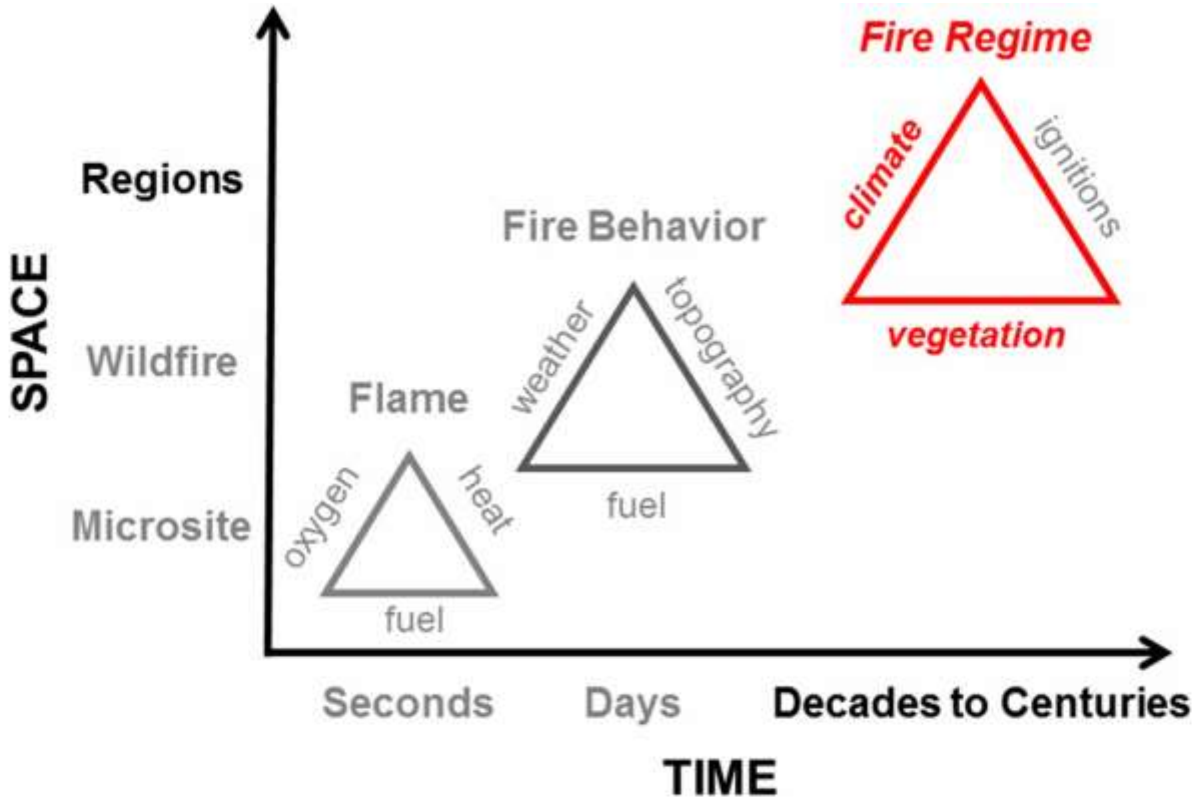
Received: 31 Mar 2022 – Discussion started: 14 Apr 2022 – R

Abstract

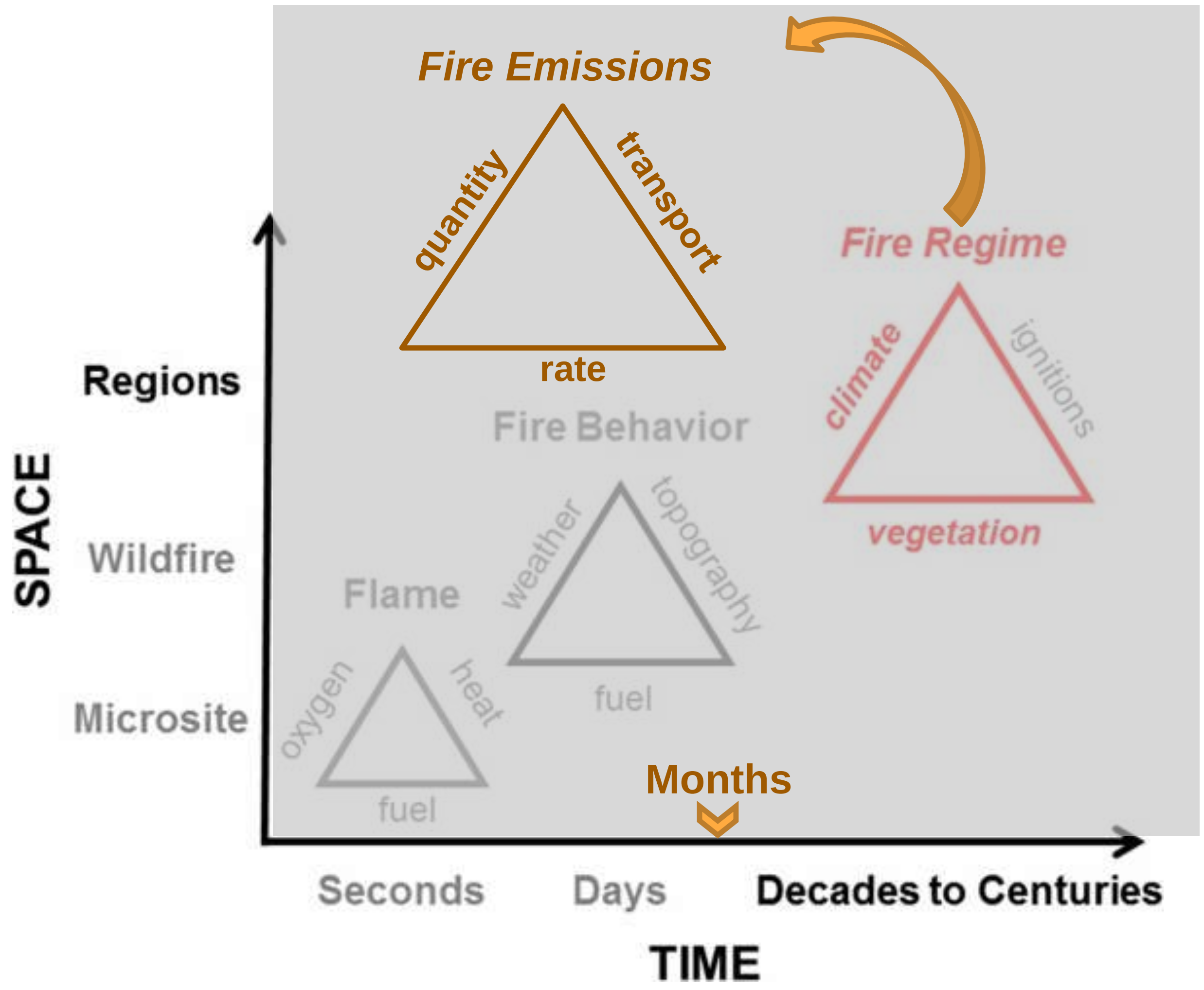
Wildfire impacts on air quality and climate are expected
in the boreal biome. Despite the large geographic cover
particularly for organic compounds, which are critical in



Adapted from:
Higuera, P.E., 2015. Taking time to consider the causes and consequences of large wildfires. *Proceedings of the National Academy of Sciences*, *112*(43), pp.13137-13138.



Adapted from:
Higuera, P.E., 2015. Taking time to consider the causes and consequences of large wildfires. *Proceedings of the National Academy of Sciences*, *112*(43), pp.13137-13138.



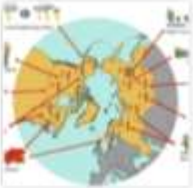
Biogeosciences, 18, 5053–5083, 2021
https://doi.org/10.5194/bg-18-5053-2021

Article | Assets | Peer review | Metrics | Related articles

Reviews and syntheses

15 Sep 2021

Reviews and syntheses: Arctic fire regimes and emissions in the 21st century



Jessica L. McCarty[1], Juha Aalto[2,3], Ville-Veikko Paunu[4], Steve R. Arnold[5], Sabine Eckhardt[6], Zbigniew Klimont[7], Justin J. Fain[1], Nikolaos Evangeliou[6], Ari Venäläinen[2], Nadezhda M. Tchebakova[8], Elena I. Parfenova[8], Kaarle Kupiainen[9], Amber J. Soja[10,11], Lin Huang[12], and Simon Wilson[13]

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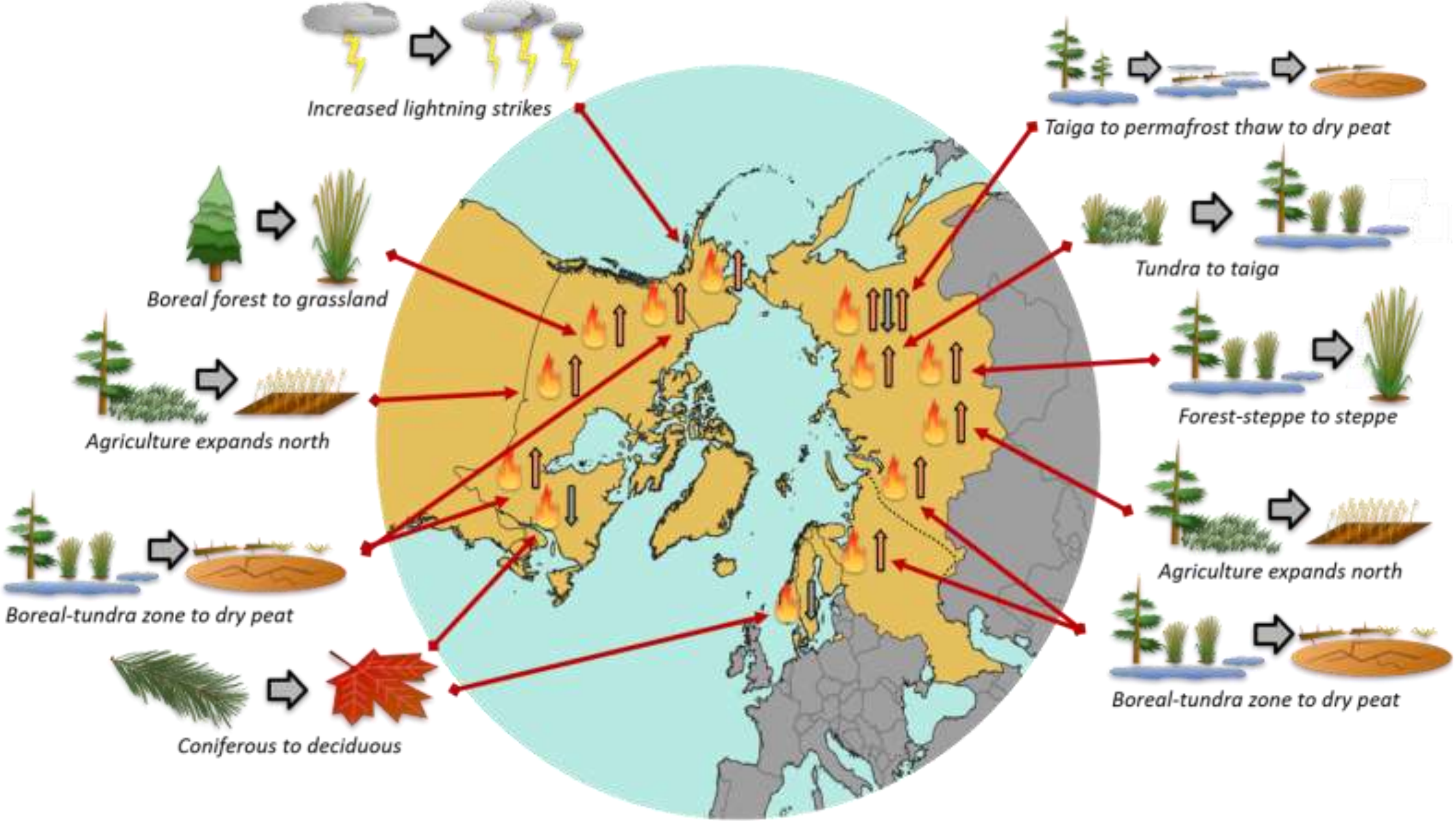
[10]National Institute of Aerospace, Hampton, VA, USA
[11]National Aeronautics and Space Administration (NASA) Langley Research Center, Hampton, VA, USA
[12]Climate Research Division, ASTD/STB, Environment and Climate Change Canada, Toronto, Canada
[13]Arctic Monitoring and Assessment Programme (AMAP) Secretariat, Tromsø, Norway

Correspondence: Jessica L. McCarty (jmccarty@miamioh.edu)

Sections

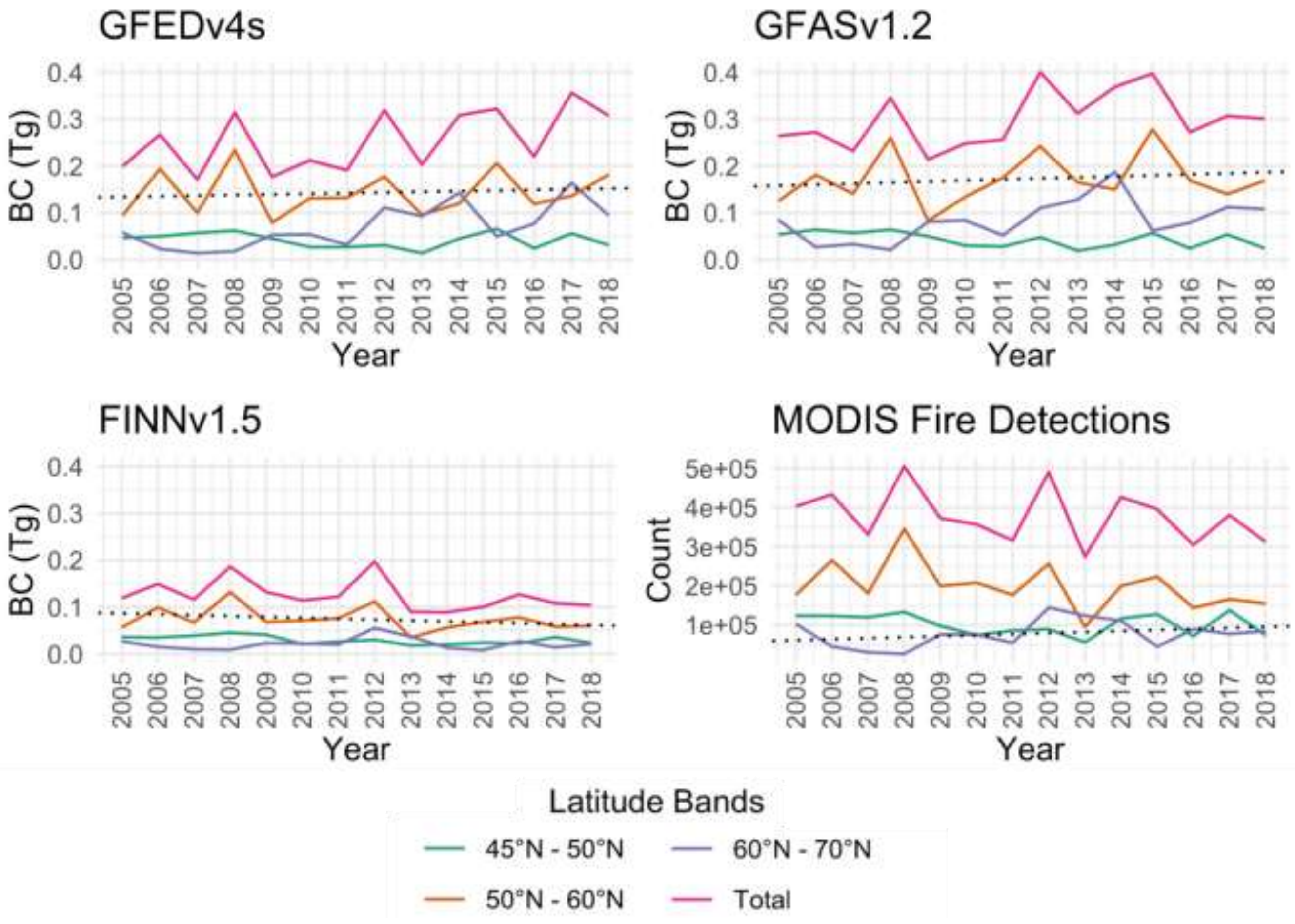
Arctic Fire Risk & Fire Regimes by mid- to late 21st Century



From McCarty et al. (2021) Reviews and syntheses: Arctic fire regimes and emissions in the 21st century, *Biogeosciences*, 18, 5053–5083, https://doi.org/10.5194/bg-18-5053-2021, 2021.

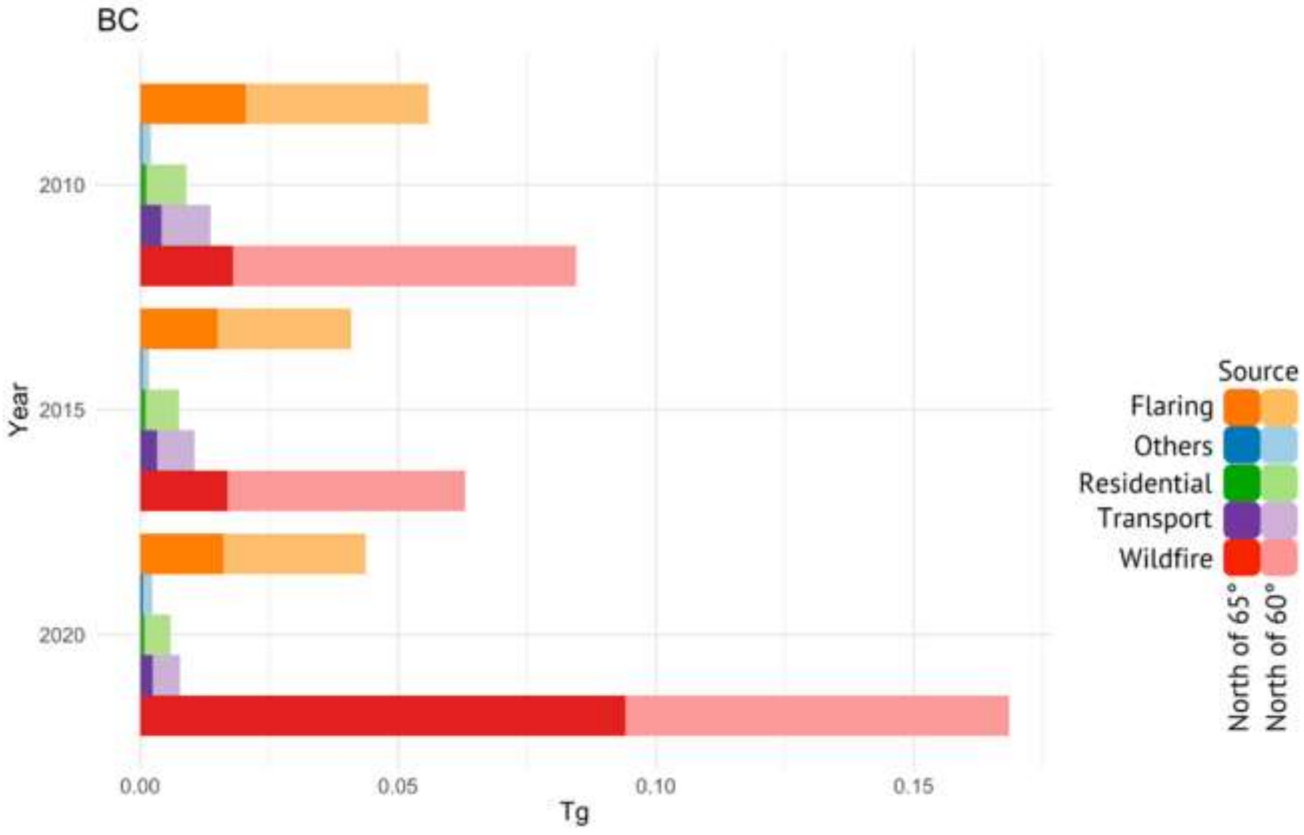
Long term emissions

Since mid-2000’s ***more fire occurring above 60° N than temperate zone*** (45° to 50° N), where large amounts of human-caused burning and wildfires occur throughout Eurasia, Europe, & North America.



Fire emissions important at high latitudes

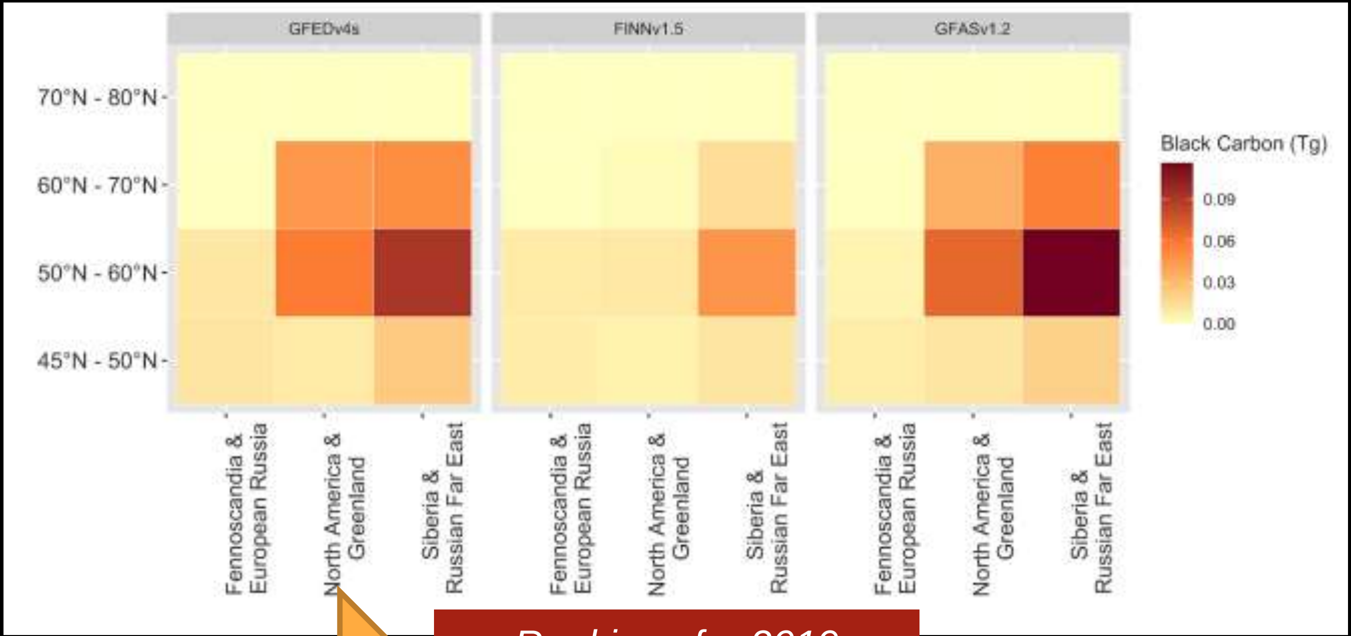
Extreme fire years, like 2020, ***outpace anthropogenic sources of BC*** originating within the Pan-Arctic.



** Source: McCarty et al. (2021);*
Wildfires emissions from GFAS;
Anthropogenic sectoral emissions from GAINS

Geographical sources of BC emissions in the boreal and Arctic

Asia is the main source region



68% of all Arctic fire activity

Rankings for 2019

1. Russia
2. USA/CONUS
3. Canada
4. USA/Alaska
5. Sweden
6. Denmark/Greenland
7. Finland
8. Norway

Even in the boreal and Arctic, people are the main ignition sources.

Photo by A.N. Adrian https://stocksnap.io/author/antonnicuadrian

ENVIRONMENTAL RESEARCH
LETTERS

LETTER • OPEN ACCESS

Spring fires in Russia: results from participatory burned area mapping with Sentinel-2 imagery

Igor Glushkov[1], Ilona Zhuravleva[1], Jessica L McCarty[3], Anna Komarova[1], Alexey Drozdovsky[1], Marina Drozdovskaya[1], Vilen Lupachik[2], Alexey Yaroshenko[2], Stephen V Stehman[4] and Alexander V Prishchepov[5,6]

Published 22 November 2021 • © 2021 The Author(s). Published by IOP Publishing Ltd
Environmental Research Letters, Volume 16, Number 12
Citation Igor Glushkov et al 2021 *Environ. Res. Lett.* 16 125005

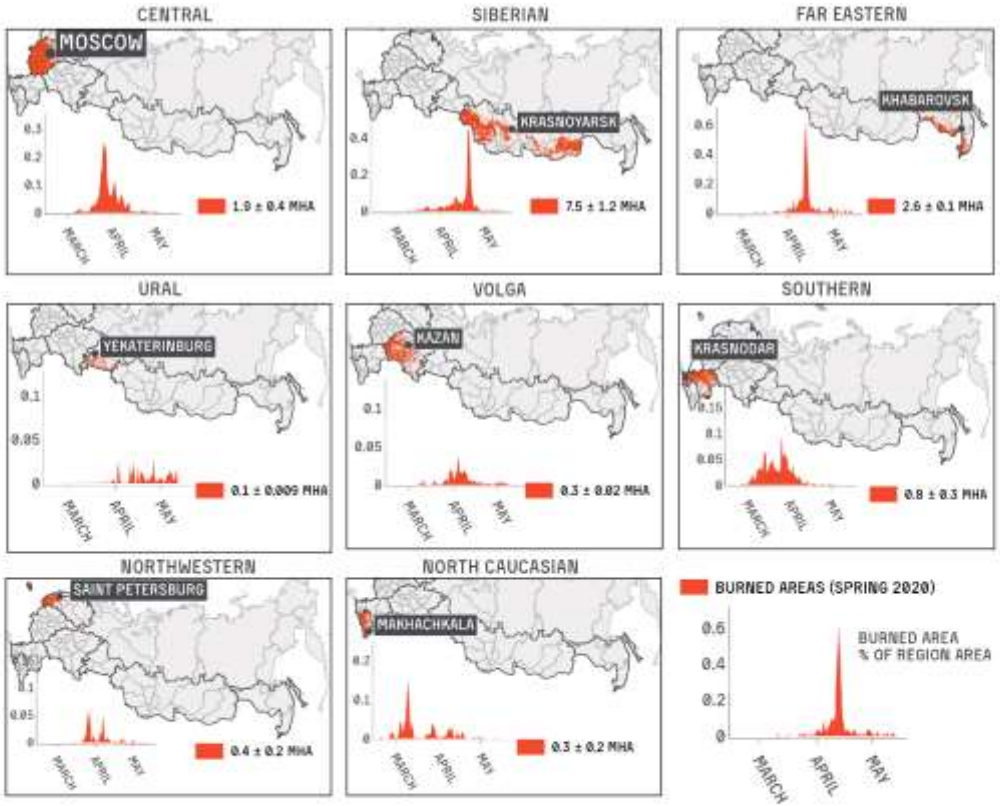
Article PDF   Article ePub

Figures ▾   References ▾

+ Article information

Abstract

Human-induced fires play a crucial role in transforming landscapes and contributing to greenhouse gas emissions. Russia is a country where human-induced fires are widespread and form distinctive spring and summer burning cycles. However, spring fires are not well documented and it is unclear which land-cover types are associated with the spread of spring fires. Using Sentinel-2 optical satellite imagery, a wall-to-wall spring burned area data set for 1 January to 15 May 2020 was created for Russia (excluding the Arctic) using a participatory crowdsourcing digitizing approach on an online platform developed specifically for this application. The 2020 spring fire product had a producer accuracy of 85% and user accuracy of 92%. Approximately 13.38 million ha, comprising 1.8% of the study area, were mapped as burned, with the majority of the 2020 spring burned areas in Siberia. Our



https://doi.org/10.17894/ucph.1cdf3d5f-c4e3-447c-8209-19ecbcd34ccf

Why map spring fires in Russia?

Supplemental Figure 1. Levels of forest fire monitoring, from regional to federal (Ministry of Natural Resource... Environment of the Russian Federation 2014)

Supplemental Figure 2. The flow of information for collecting data on "other fires", i.e., any landscape fire that is not a forest fire, including infrastructure fires, settlement areas, steppe and grass fires, reeds/wetlands/swamps, and fires on agricultural land

Source Region	Hectares
2020 Russia Spring Fires	13,380,000
2020 California (CALFIRE + USFS)*	1,696,301
2021 California (CALFIRE + USFS)*	1,010,049

* Source: https://www.fire.ca.gov/stats-events/ (8 Nov 2021)

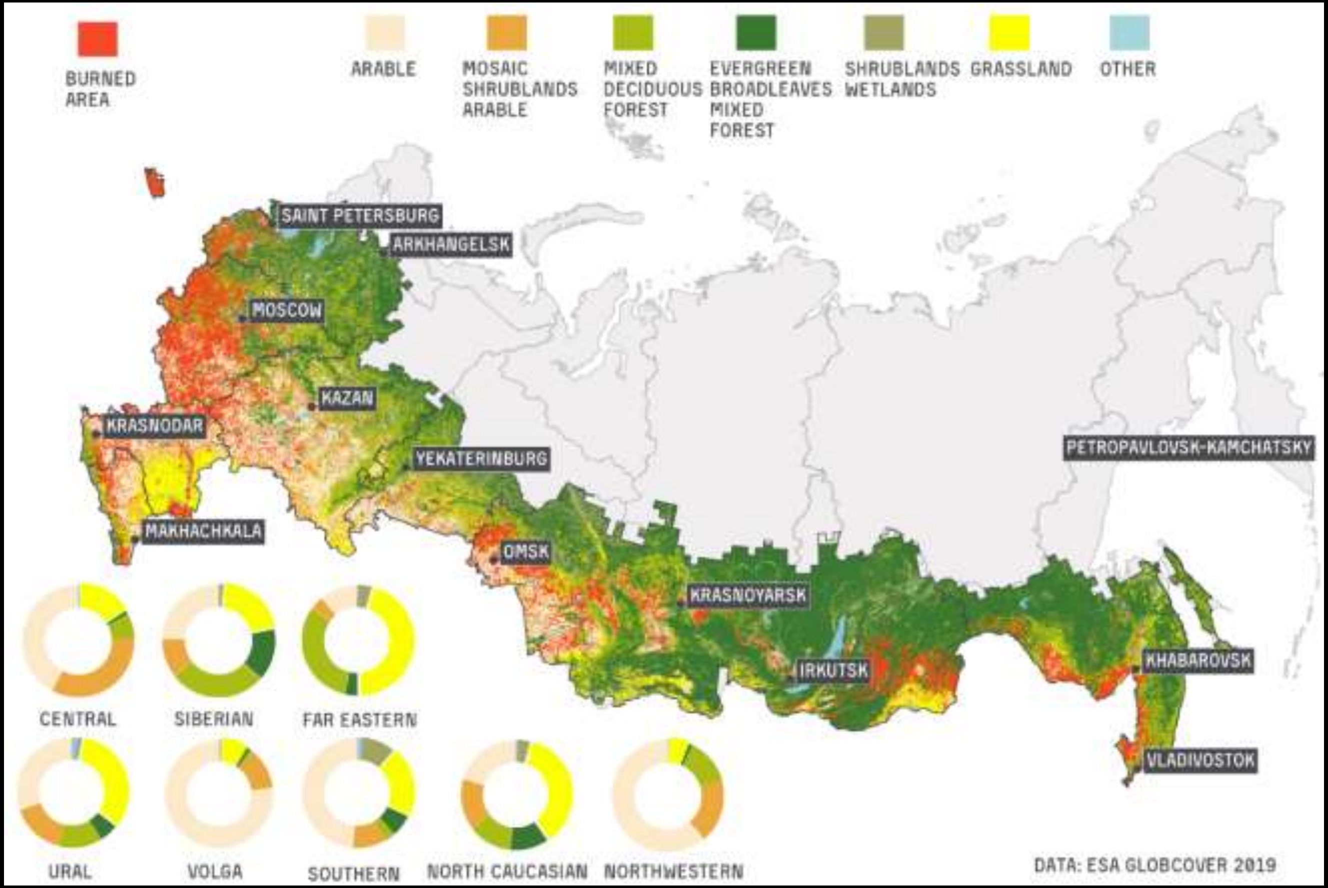
Source: International Association of Wildland Fire


CENTRAL
SIBERIAN
FAR EASTERN
MOSCOW
KRASNOYARSK
KHABAROVSK
1.9 ± 0.4 MHA
7.5 ± 1.2 MHA
2.6 ± 0.1 MHA
United Nations Framework Convention on Climate Change
ipcc
INTERGOVERNMENTAL PANEL ON climate change
UN CLIMATE CHANGE CONFERENCE UK 2021
SAINT PETERSBURG
MAKHACHKALA
0.4 ± 0.2 MHA
0.3 ± 0.2 MHA
BURNED AREAS (SPRING 2020)
BURNED AREA % OF REGION AREA
MARCH
APRIL
MAY

I. Glushkov, I. Zhuravleva, et al. (2021)

Agricultural lands are not only source of burning.

Wetlands and abandoned lands (unmanaged forests) significant sources of spring-time burning in Asian and European Russia, respectively.



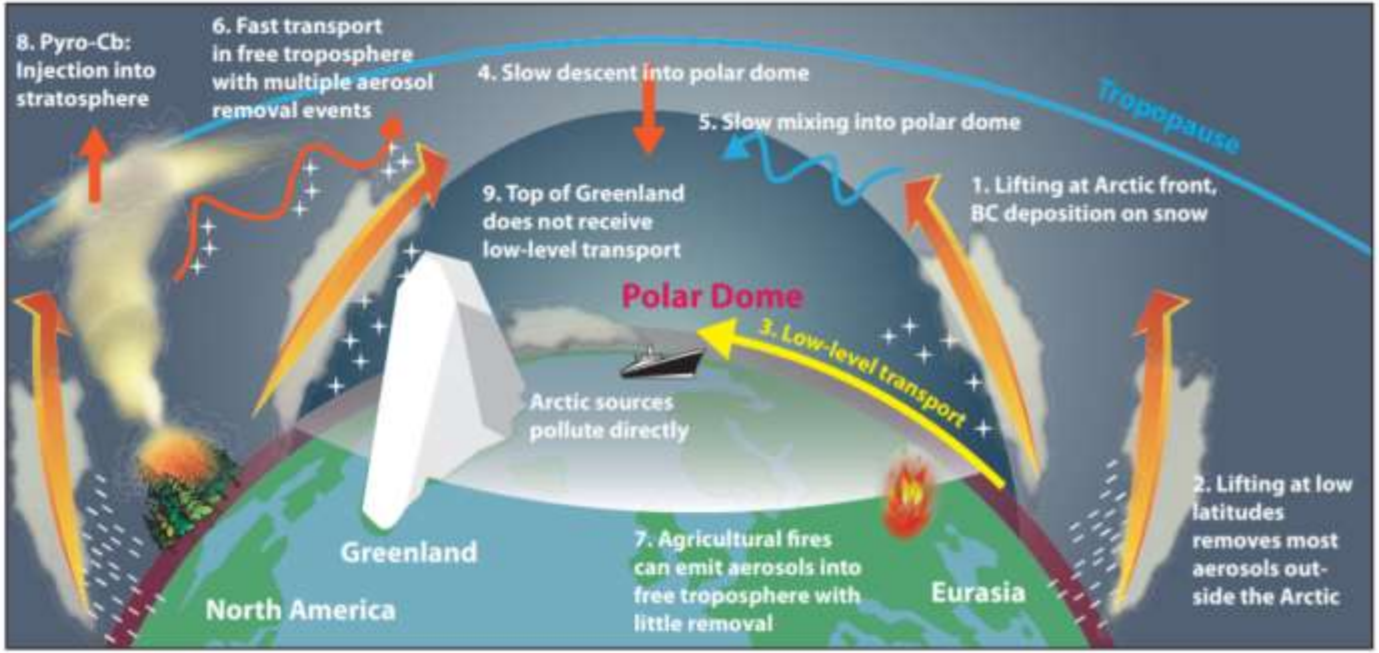


Figure 5.1. Schematic illustration of processes relevant for transport of BC into the Arctic based on the study by Stohl (2006). In reality, the polar dome is asymmetric and its extent is temporally highly variable. In addition, its southernmost extent is greatest over Eurasia. The placement of the polar dome is more typical of the winter/spring situation, whereas in summer the dome is much smaller. Also note that the dome is not homogeneous but is itself highly stratified with strong vertical gradients.

Fires in northern temperate to boreal to Arctic ecosystems matter

North American fire science has lessons to share with Nordic partners

Kalajoki, Finland

Wildfire during a record hot and dry summer, July and August 2021.

An aerial view shows a forest fire raging in Kalajoki, north-western Finland. PHOTO: AFP

PELASTUSOPISTO

Kalajoen Raution Metsäpalo 2021

Kokemuksia ja oppeja metsäpalo-osaamisen kehittämiseen

Alisa Puustinen (toim.)

Source: http://info.smedu.fi/kirjasto/Sarja_D/D3_2022.pdf

PELASTUSOPISTO

1 Johdanto

Heinäkuun lopussa, 26.7.2021 syttyi Kalajoen Raution kylällä tuulivoimapuiston rakennustyömaalla metsäpalo, joka lopulta laajeni kaksi viikkoa kestäneeksi sammutustehtäväksi. Tehtävällä työskenteli kahden viikon aikana arviolta noin 1500 henkilöä, niin pelastuslaitoksen virassa työskenteleviä kuin sopimushenkilöstöä. Metsäpalo sai runsaasti huomiota mediassa niin heinäkuussa tilanteen ollessa päällä kuin jälkikäteen syksyn 2021 aikanakin. Paloala, 227 hehtaaria, ei ole Suomen suurin maastopalo - Muhoksen palo 2019 oli hieman tätä suurempi, noin 250 hehtaaria -, mutta se lienee eniten niin sosiaalisen kuin muunkin median huomiota saanut. Raution palosta tekee poikkeavan myös se intensiteetti, jolla kaikki pelastuslaitoksen osallistuivat palon sammuttamiseen ja jälkihoitoon. Palanut maasto oli vaikeakulkuista ja vaihtelevaa: niin sanottua pirunpeltoa, kangasmetsää, turvepohjaista ojitettua sekametsää sekä tuulivoimatyömaan raivattua maastoa. Pelastuslaitosten lisäksi palo työllisti paikallisia ja alueellisia urakoitsijoita, yksityisiä sekä muita viranomaisia ja varusmiehiä.

päällä kuin jälkikäteen syksyn 2021 aikanakin. Paloala, 227 hehtaaria, ei ole Suomen suurin maastopalo - Muhoksen palo 2019 oli hieman tätä suurempi, noin 250 hehtaaria -, mutta se lienee eniten niin sosiaalisen kuin muunkin median huomiota saanut. Raution palosta tekee poikkeavan myös se

SYKE

Copernicus 10 m Sentinel-2

31 August 2021

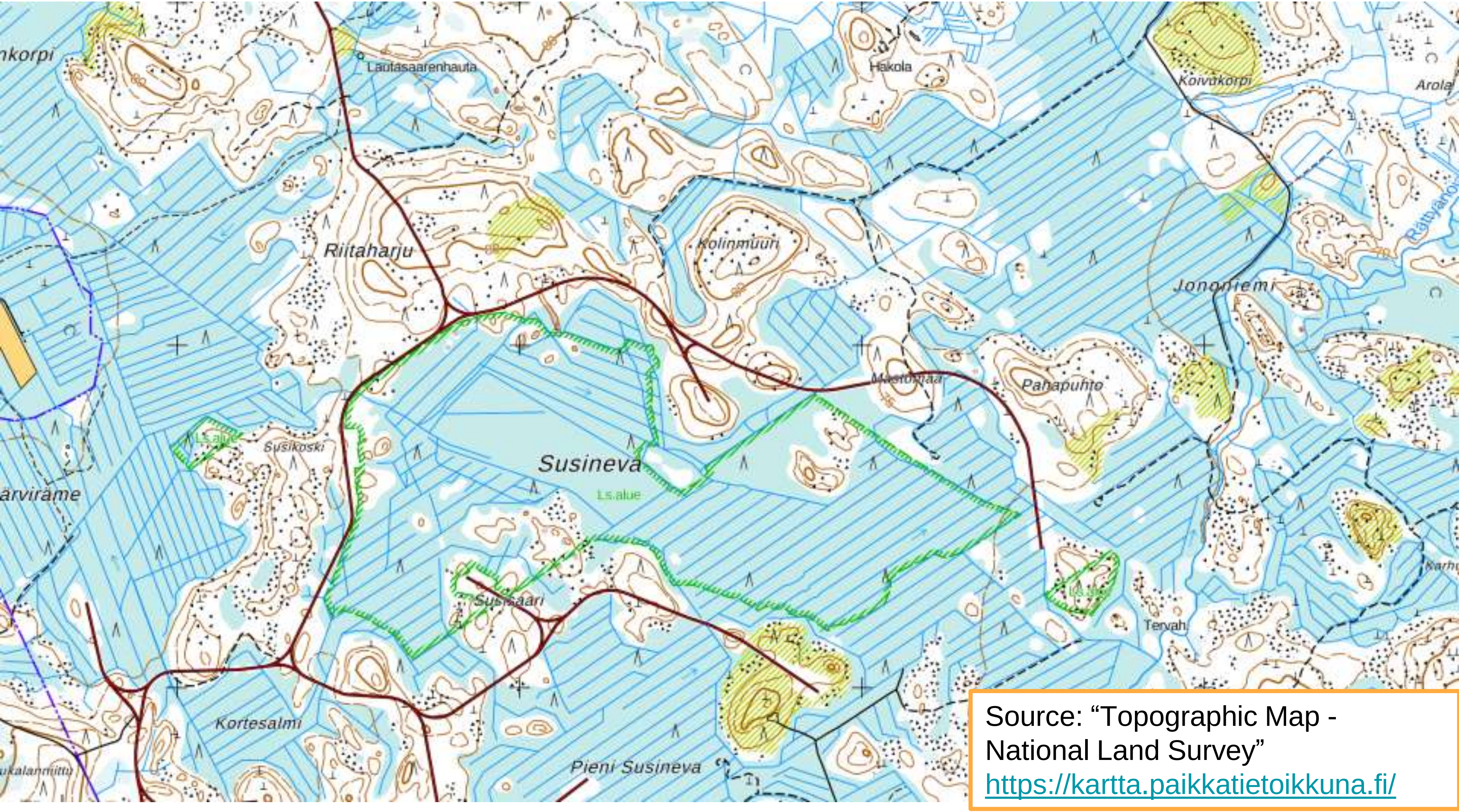
~ 230 ha of burned area (slightly > than 227 ha)

Insight into the Kalajoki Fire

Role of drained peat and not being able to read maps.

Tuomas Aakala

An aerial view shows a forest fire raging in Kalajoki, north-western Finland. PHOTO: AFP



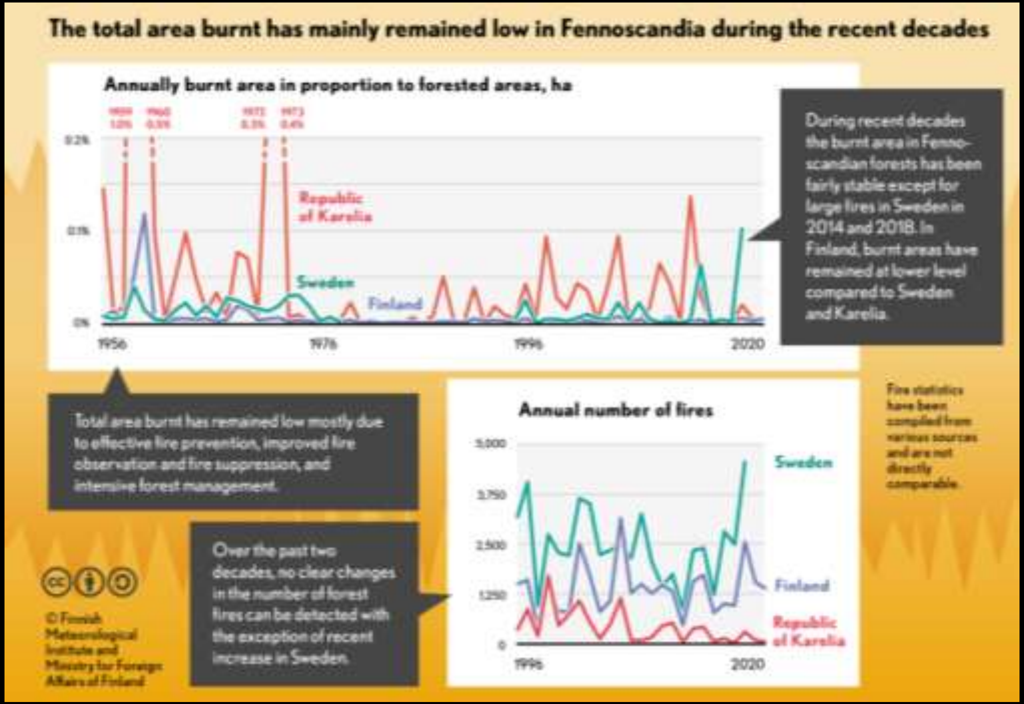
Source: “Topographic Map - National Land Survey” https://kartta.paikkatietoikkuna.fi/

Understanding that with climate change, the landscape has changed too

So, fire activity and fire emissions are changing.

3. The annually burnt forest area is relatively low in Fennoscandia

Henrik Lindberg, Anders Granström, Andrey Gromtsev, Maria Levina, Ekaterina Shorohova, Ilkka Vanha-Majamaa



1. Massive clearcutting
2. Pine-dominated (vs. spruce-dominated) resulted in low-intensity ground fires
3. Commercial thinning of forests reduced crown fires
4. Mosaic of even-aged stands
5. Rapidly developing forest road network

Source: https://en.ilmatieteenlaitos.fi/iba-forest-fires

Considerations for future fire risk

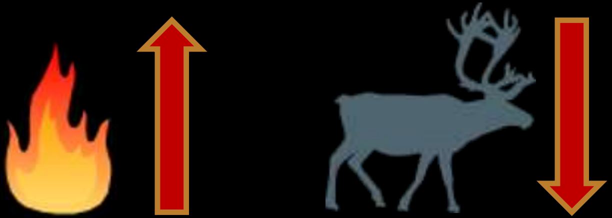
- Finland does not “read” as a low fire risk
- Road networks are not sufficient to stop high severity fires – even among a mosaic of timber stands
- Roads mean more ignition sources
- Not all forest roads are created equal

Respecting and incorporating Indigenous burn practices in science-based models and management

Photo by A.N. Adrian https://stocksnap.io/author/antonnicuadrian

Indigenous Burning in the Pan-Arctic

Short Term

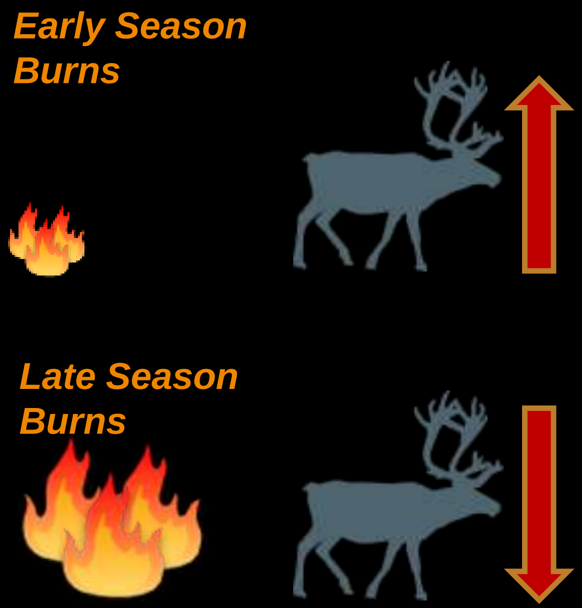


Long Term

Image credit: https://tesstimonyblog.wordpress.com/2019/08/20/modeling-prescribed-burning-integration-into-forest-management-at-landscape-scale-to-restore-lichen-pastures-in-northern-sweden/

“While ***burning can promote summer pasture and maintain the long-term availability of winter pasture, it destroys lichen pasture temporarily*** and Saami ecological knowledge shows that burning also affects the behaviour and movement patterns of the reindeer.”

Cogos, Sarah (2020). *Fire, people and reindeer in the boreal forest : the role of fire in the historical and contemporary interactions between Sami reindeer herding and forest management in northern Sweden*. Diss. Sveriges lantbruksuniv., Acta Universitatis Agriculturae Sueciae, ISBN 978-91-7760-644-4, Doctoral thesis.



How can Indigenous knowledge be brought into wildland fire management?

Edward Alexander: Part of EPPR's Circumpolar Wildland Fire project is to learn how other Indigenous Permanent Participants in the Arctic Council have managed fires and taken steps to suppress fires in a way that is useful for them as a people.

One example is that Gwich'in burn grass during early springtime in the North, when the meadows have thawed but there is still snow around the timber line. This was traditionally important because it increased the biodiversity of plant species growing in that area, fertilized the soil so that plants were more nutritious and increased the land's carrying capacity of animals. There would be an increase in rabbits, and moose would have two or three calves instead of just one. It is also a carbon-neutral practice to burn the land during that specific time due to the low amount of carbohydrates on the soil. It is important to understand that if that same fire was lit just a month later, it could be extraordinarily destructive and destroy the rich structures of those plants, interfere with migrating animals and more.

It is important to gather information like this to understand how people have worked with fire in the past to better manage what we have going forward. It is not enough to talk about management regimes without talking about Indigenous management and techniques that have been successful in the North for thousands of years.

Devlin Fernandes: In the last few decades, fire has often been thought of as a negative event and something we want to avoid at all costs. By bringing Indigenous knowledge into the conversation and into management practices, we can actually share the

https://arctic-council.org/en/news/creating-a-common-language-around-wildfire-management/

1. ***Lack of Indigenous fires/fire emissions in our current understanding of SLCFs and BC deposition***

2. ***Is transport possible from low-energy, surface fires from cultural burning?***

3. ***Co-Production and Funding of Indigenous scientists and communities***

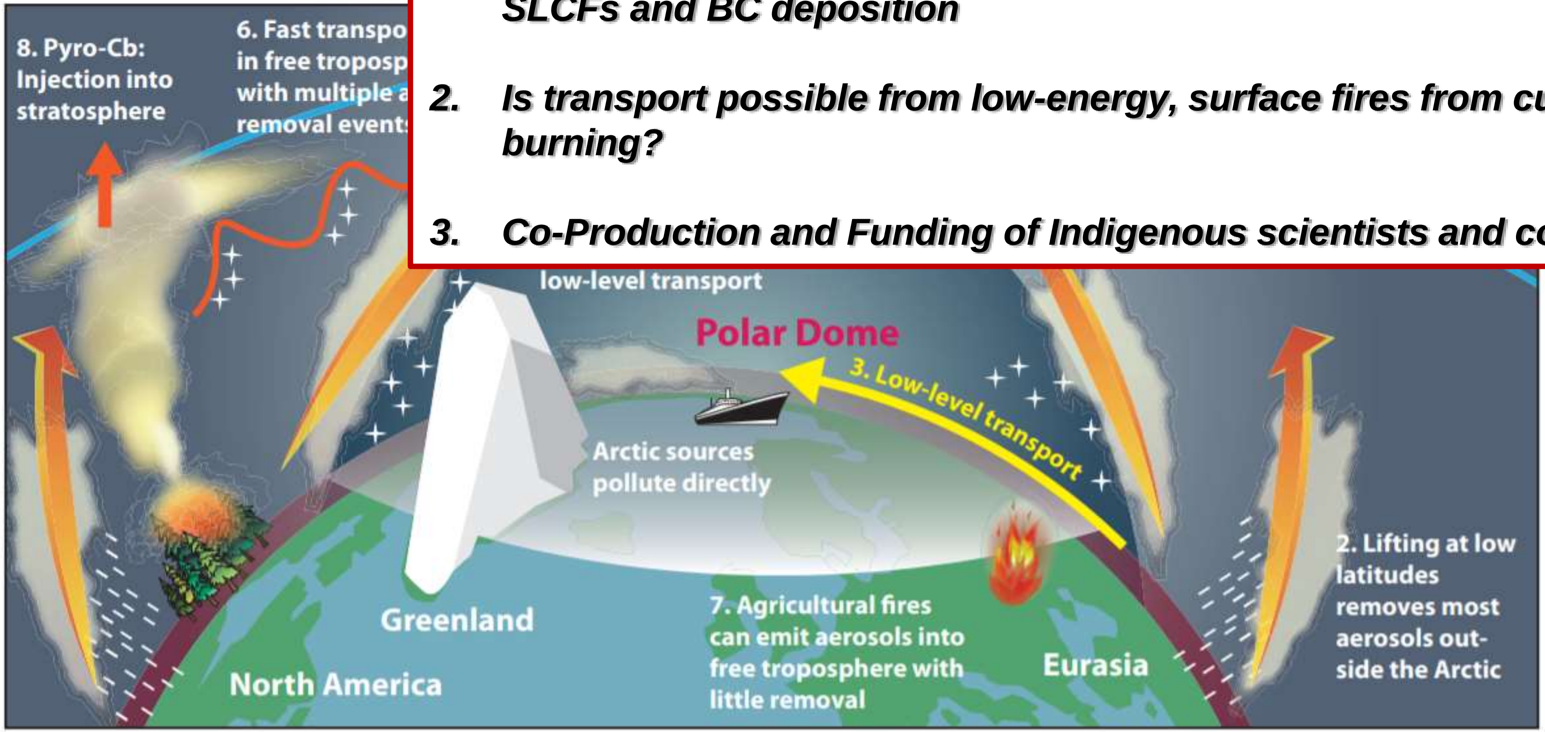


Figure 5.1. Schematic illustration of processes relevant for transport of BC into the Arctic based on the study by Stohl (2006). In reality, the polar dome is asymmetric and its extent is temporally highly variable. In addition, its southernmost extent is greatest over Eurasia. The placement of the polar dome is more typical of the winter/spring situation, whereas in summer the dome is much smaller. Also note that the dome is not homogeneous but is itself highly stratified with strong vertical gradients.

All hands on deck: Science-Policy-Management for future boreal and Arctic fires

Photo by A.N. Adrian https://stocksnap.io/author/antonnicuadrian

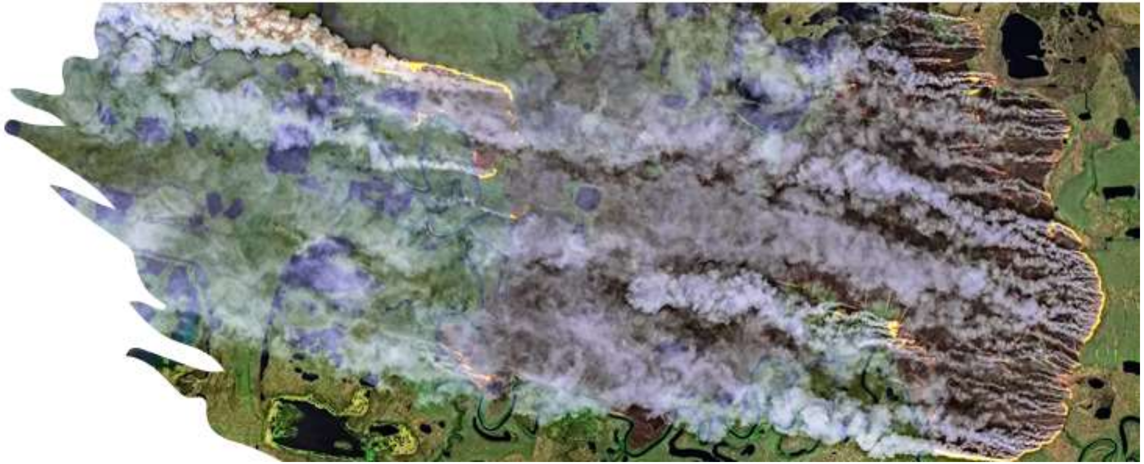
What can be managed?

Fuels, but complicated.

- Peat
- Permafrost

People, with emphasis on Indigenous & local leadership.

- Timber, energy, tourism
- Cultural & prescribed burning
- "Zombie" fires
- Arctic wildland firefighting, policy, & infrastructure



Preparing for and Predicting the future

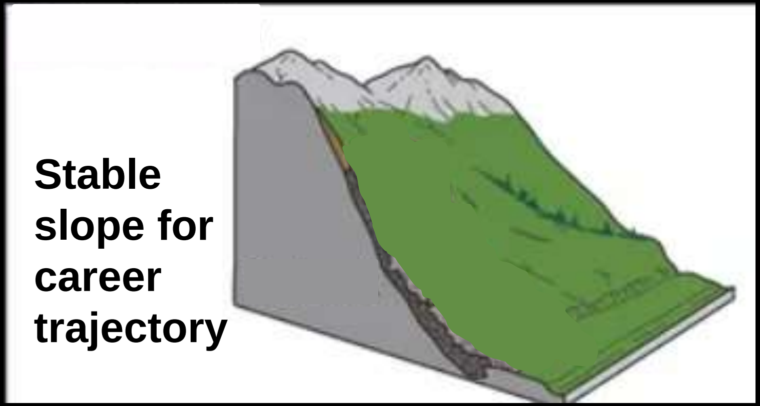
- Modelling uncertainties:
  - Inputs - emissions models & inventories
  - Fire behaviour
  - Atmospheric processes
  - Temperature important, but so are fuels, ignitions

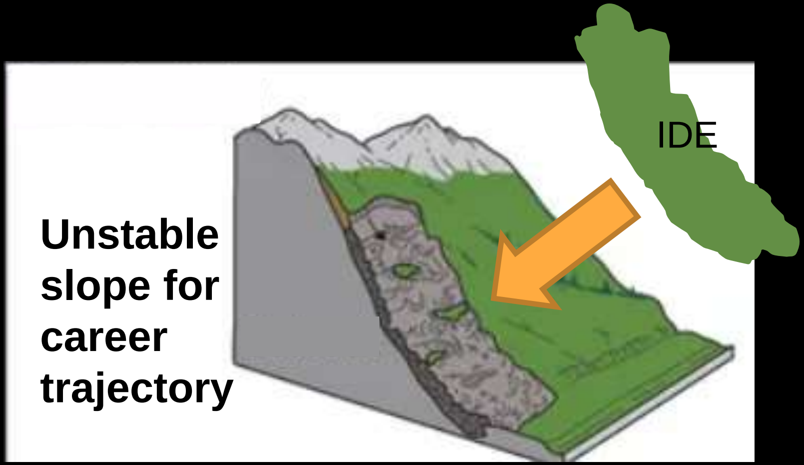
- Need for robust, dynamic future fire scenarios
  - Human-Climate-Atmosphere-Landscape Nexus

Closing Thoughts: Inclusion, Diversity, & Equity in (Fire) Science

You belong.

- From the lowest socio-economic class.
- Appalachian Kentucky.
- Financially independent since I was 17.
- Told to lose my accent to be taken seriously in Science.
- The first NASA meeting I went to as a graduate student, someone made fun of my clothes.
- At a previous job, dress code was proposed because I needed to hide my (non-thin) body.
- I was told to hide my pregnancy.
- I have been told to be more ladylike.

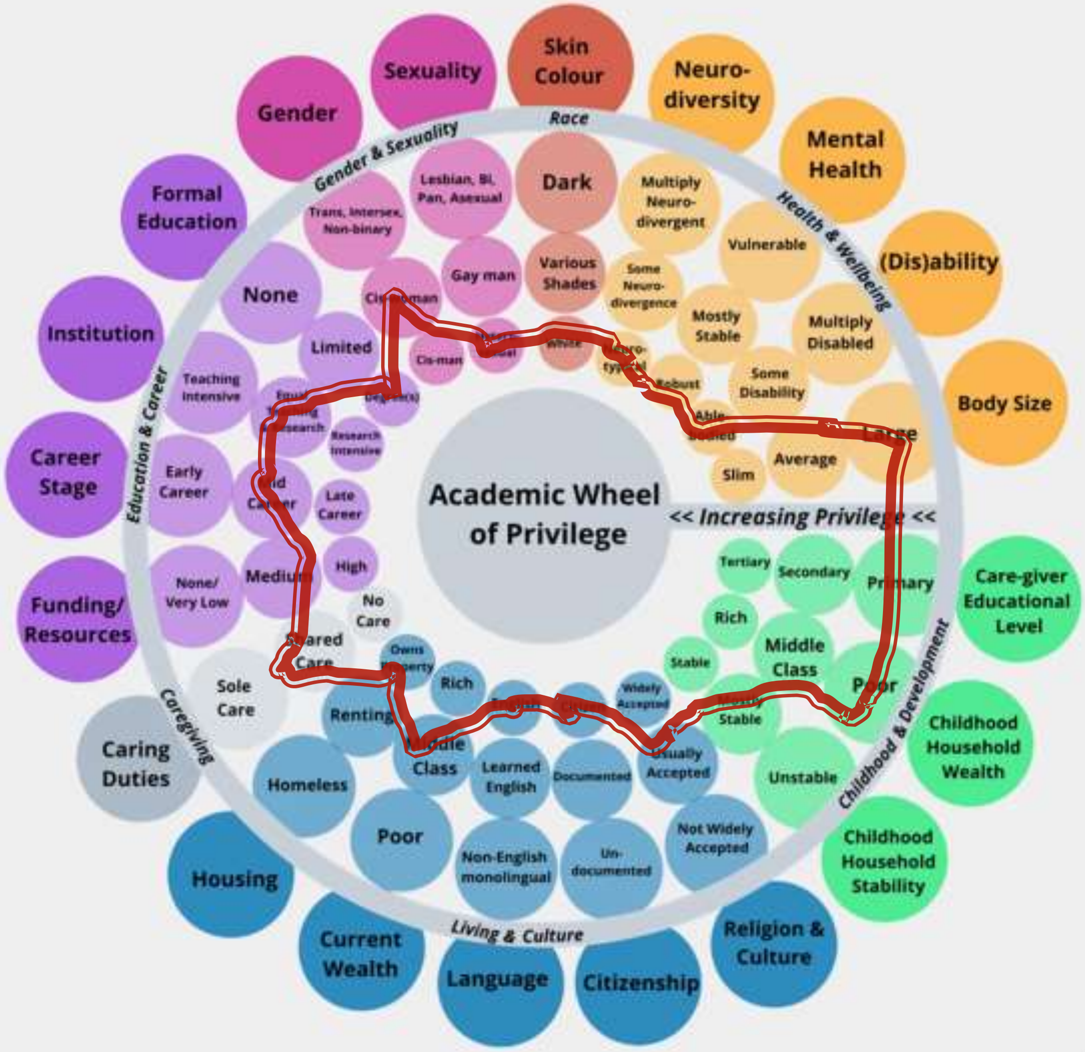




Science is hard and everyone works hard.

Inclusion, diversity, and equity stabilizes the slope for all.

The aim is equal footing.



1. Know thyself.

Photo by Markus Spiske on Unsplash

2. Form Communities.

3. Have – and give – some GRACE.

4. Do the work.

Photo by Reuben Hustler on Unsplash

Merci!

Questions
& Discussion

Register: https://abc-icap.amap.no/