

# Potential Ecological Risks and Impacts of Solar Radiation Modification and Why You Should Pay Attention

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# What is biodiversity?

The diversity of ecological systems and processes, species, clades and genetics of living things at a range of spatial scales

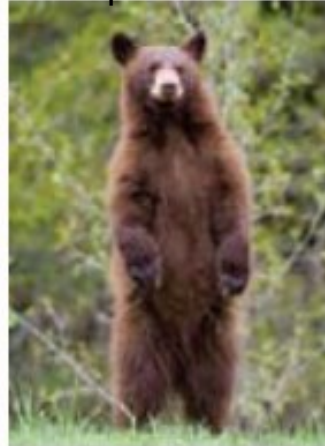
Color morphs of the American black bear in British Columbia, Canada

<http://www.biodiversitybc.org/EN/main/downloads/tnp-1.html#s11>

Rare 'spirit' bear of NW



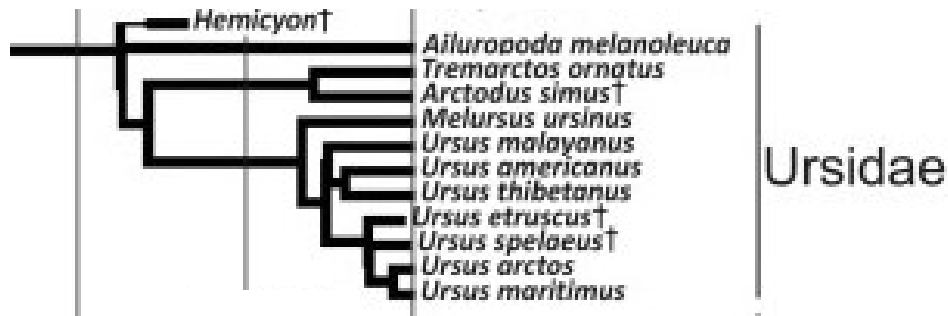
Brown morph of black bear



Common black bear

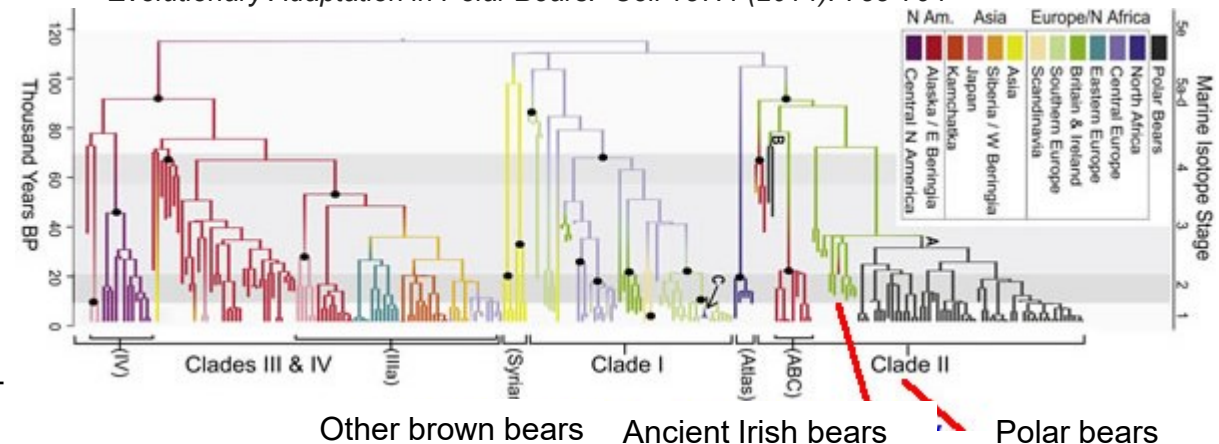


The bear family has 11 species but there is also variation within species



Bear phylogeny over past 120,000 years

Liu, Shiping, et al. "Population Genomics Reveal Recent Speciation and Rapid Evolutionary Adaptation in Polar Bears." *Cell* 157.4 (2014): 785-794



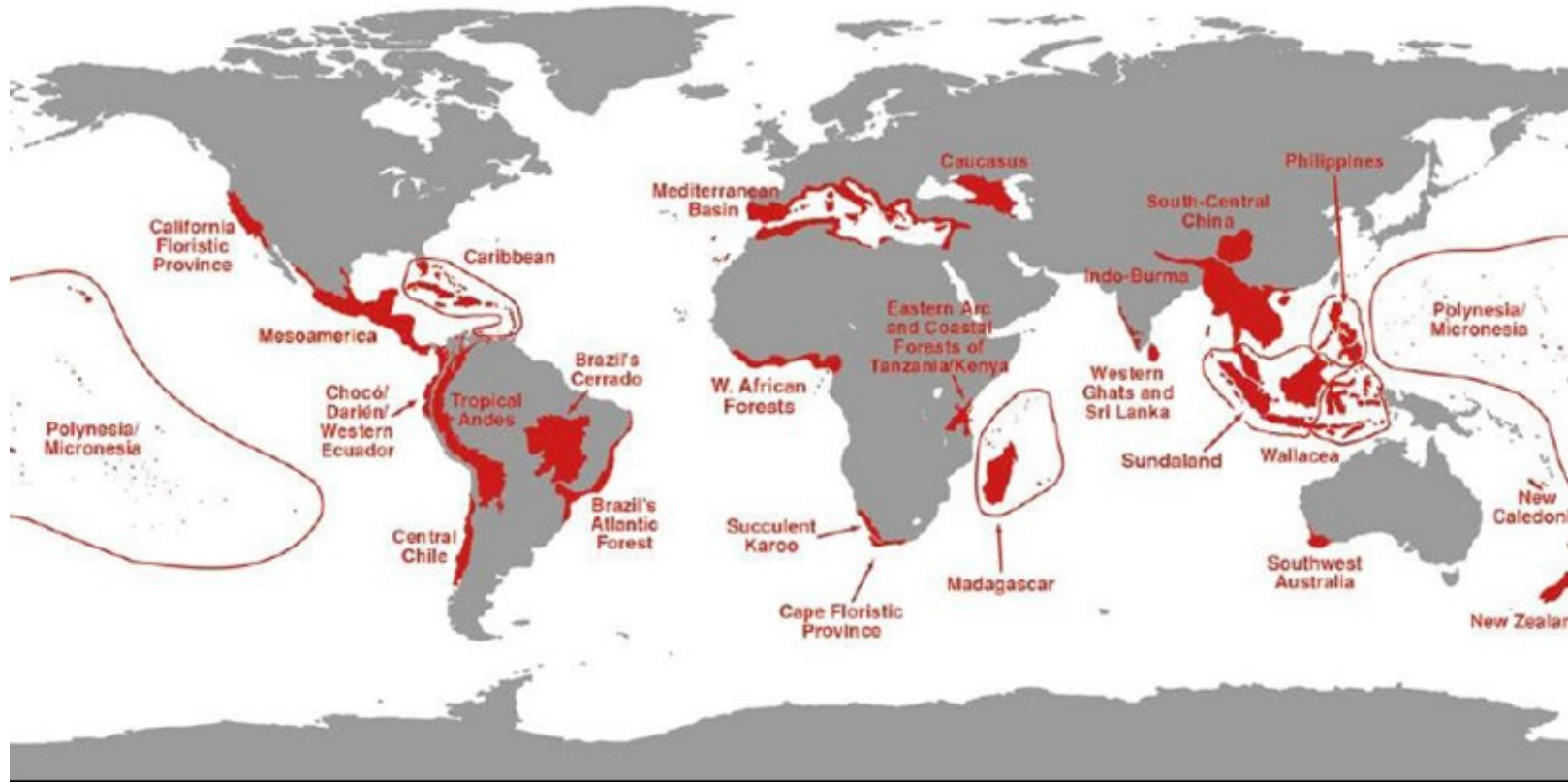
# Biodiversity loss/Extinction crisis

- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) May 2019:
  - *“The overwhelming evidence of the IPBES Global Assessment, from a wide range of different fields of knowledge, presents an ominous picture,” said IPBES Chair, Sir Robert Watson. “The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide.”*
  - **The Report finds that around 1 million animal and plant species are now threatened with extinction, many within decades, more than ever before in human history.**
  - *“Ecosystems, species, wild populations, local varieties and breeds of domesticated plants and animals are shrinking, deteriorating or vanishing. The essential, interconnected web of life on Earth is getting smaller and increasingly frayed,” said Prof. Settele. “This loss is a direct result of human activity and constitutes a direct threat to human well-being in all regions of the world.”*
  - ***The role of anthropogenic climate change in driving losses and extinctions is accelerating***
- Houston, we have a problem....**

**Biodiversity hotspots:** Regions with high/unique biodiversity that are severely threatened by human activities

What are the potential impacts of SRM/SAI on these regions? Good, bad, mixed, neither, all of the above, it all depends? Combined effects of temperature, precipitation, ITCZ movement, ENSO, VPD, extreme storm events, UV, ozone.....

WE NEED MORE RESEARCH AND A LOT MORE INFORMATION



# Major threats to biodiversity, organisms and ecological systems and processes

- Habitat destruction and fragmentation, ecosystem conversion, ecosystem degradation
- Harvesting, hunting, removal for resource use
- Invasive alien species
- Pollution and contamination
- Changes in disturbance regimes
- **Climate change**

**These are not independent factors but can be mutually causal and can interact together to affect living systems**

# The impacts of anthropogenic climate change have been extensively studied by ecologists

*Effects are already occurring and will increase in the future, and include:*

- Species extinctions
- Novel species combinations in communities
- Damage or loss of some ecosystems (coral reefs, others)
- Changing distributions, phenology, species interactions (pollination, insect outbreaks, expansion of pathogens and disease)
- Changes to primary productivity, nutrient cycling, and other ecosystem processes
- Affects of changes in seasonality, extreme climate events, warmer winters, increases in fire frequency and flooding
- Loss of structural elements of environment leading to ecosystem damage or loss (melting permafrost, rising sea levels)

*Could solar radiation management reduce some of the negative effects of anthropogenic climate change on species and ecological systems?*

Potential ecological impacts of climate intervention by reflecting sunlight to cool the Earth  
**WORKING GROUP; PAPER IN REVIEW AT PNAS**

**Phoebe Zarnetske**, Michigan State University, **Jessica Gurevitch**, Stony Brook University, **Janet Franklin**, University of California, Riverside, **Peter M. Groffman**, CUNY Advanced Science Research Center and Cary Institute of Ecosystem Studies, **Cheryl Harrison**, University of Texas Rio Grand Valley, Jessica Hellmann, University of Minnesota, Forrest M. Hoffman, Oak Ridge National Laboratory, **Shan Kothari**, University of Minnesota, **Alan Robock**, Rutgers University, **Simone Tilmes**, National Center for Atmospheric Research, **Jin Wu**, University of Hong Kong, **Lili Xia**, Rutgers University, **Daniele Visoni**, Cornell University, **Chang-En Yang**, University of Tennessee

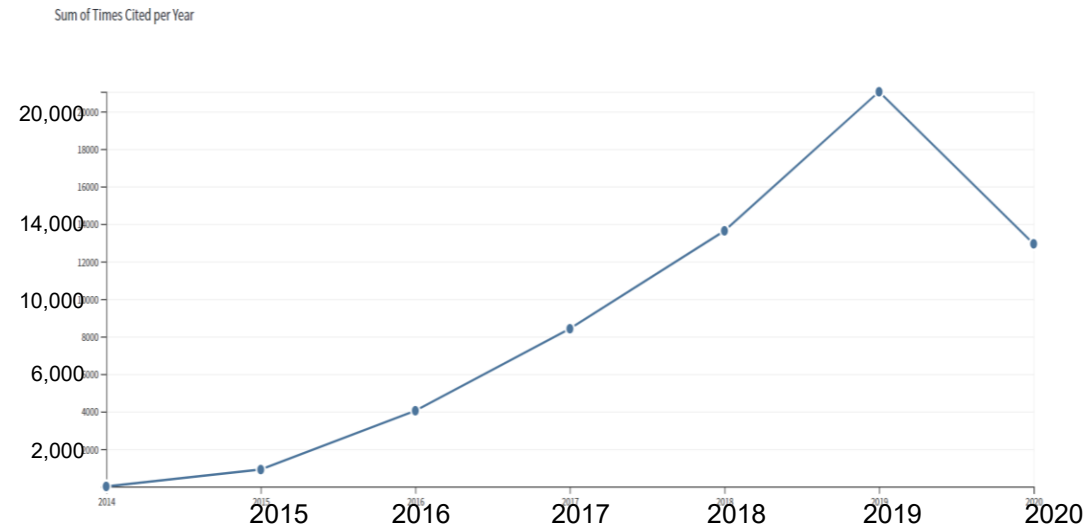


Thousands of papers have been published and cited in recent years regarding climate change and ecology

**Publications: 11,312**

**Citations since 2015: 60,996**

Citations 2015-2020 to papers re: climate change & ecology

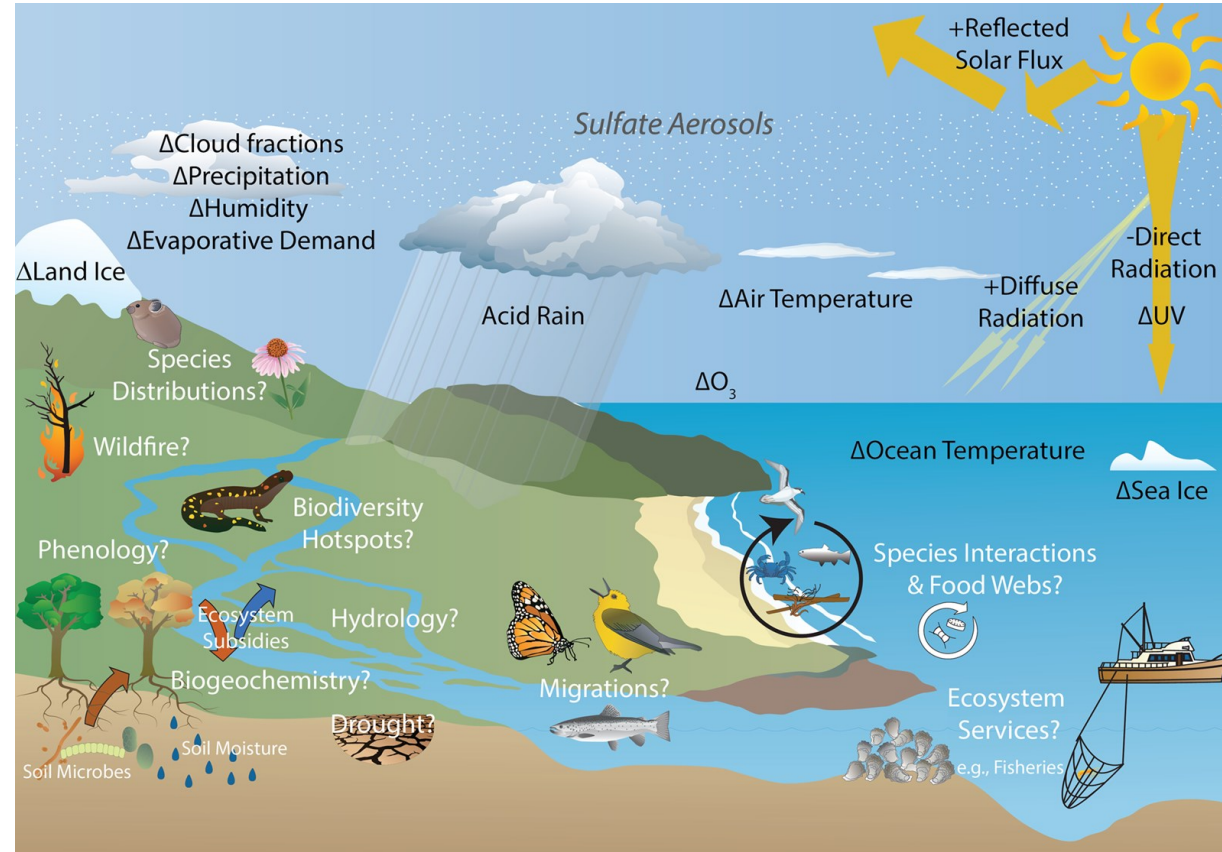


**4 papers** have been published altogether regarding climate modification and ecology (.04% of papers on climate & ecology)

**We need more attention to climate modification impacts on ecology**



# Could SRM reduce the threats from anthropogenic climate change to organisms and ecosystems?

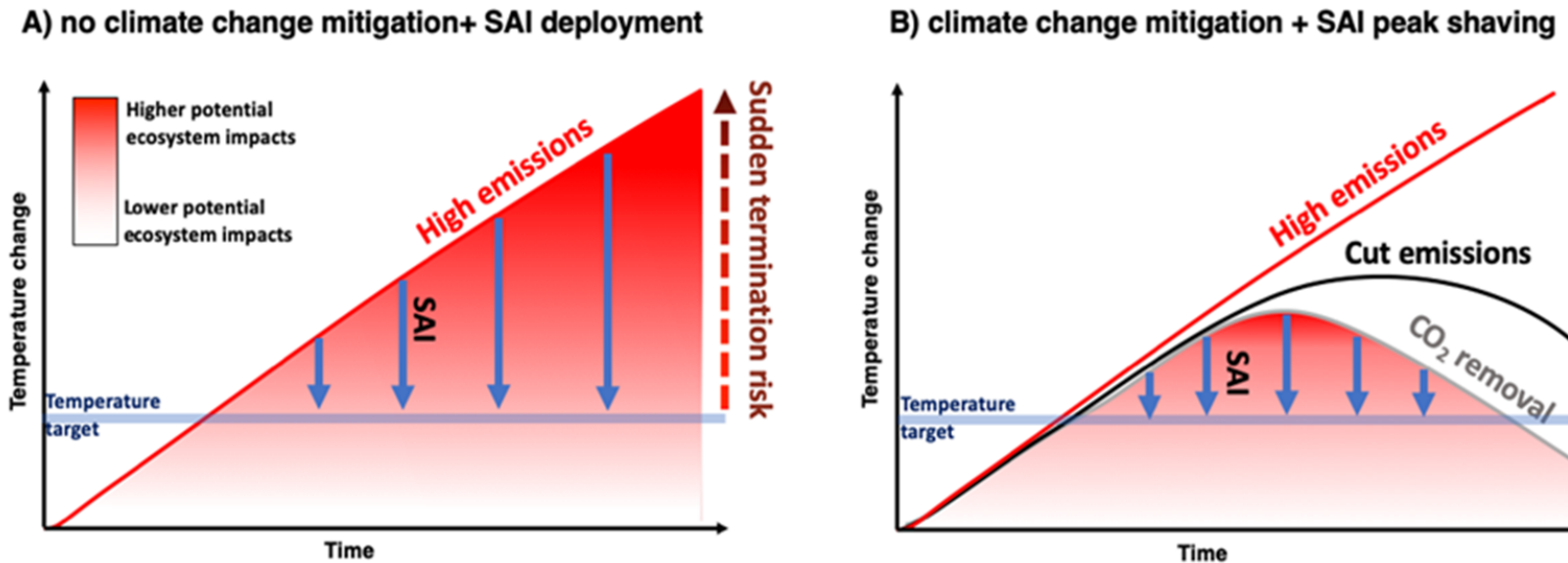


**The effects of Solar Radiation Management (SRM) with stratospheric aerosol intervention (SAI) on ecological systems are largely unknown**

# What are the potential *impacts* of SAI on ecology?

## What are the *risks*?

Risks and impacts depend on the SAI scenario: focus is on temperature



However, ecological systems **may be affected by many other outcomes** of SAI including changes to precipitation (e.g. seasonality, intensity, predictability), VPD, diffuse:direct light, ozone, IR, lots of stuff about clouds, etc.

# What are the potential impacts of SAI on ecology?

## What are the risks?

### **Potential impacts**

- Decreased transpiration with cool temperatures and high CO<sub>2</sub> leading to increased streamflow
- Complex changes to biogeography of forests due to changes in water supply and seasonality, temperature, VPD, diffuse:direct light ratio
- Cooler temperatures might reduce heat and drought stress, fire incidence affecting many biomes
- Changes to monsoonal and other rainfall patterns resulting in unknown + and - effects on biodiversity hotspots
- Small decreases in terrestrial NPP due to cooling (if CO<sub>2</sub> remains high)

# What are the potential impacts of SAI on ecology?

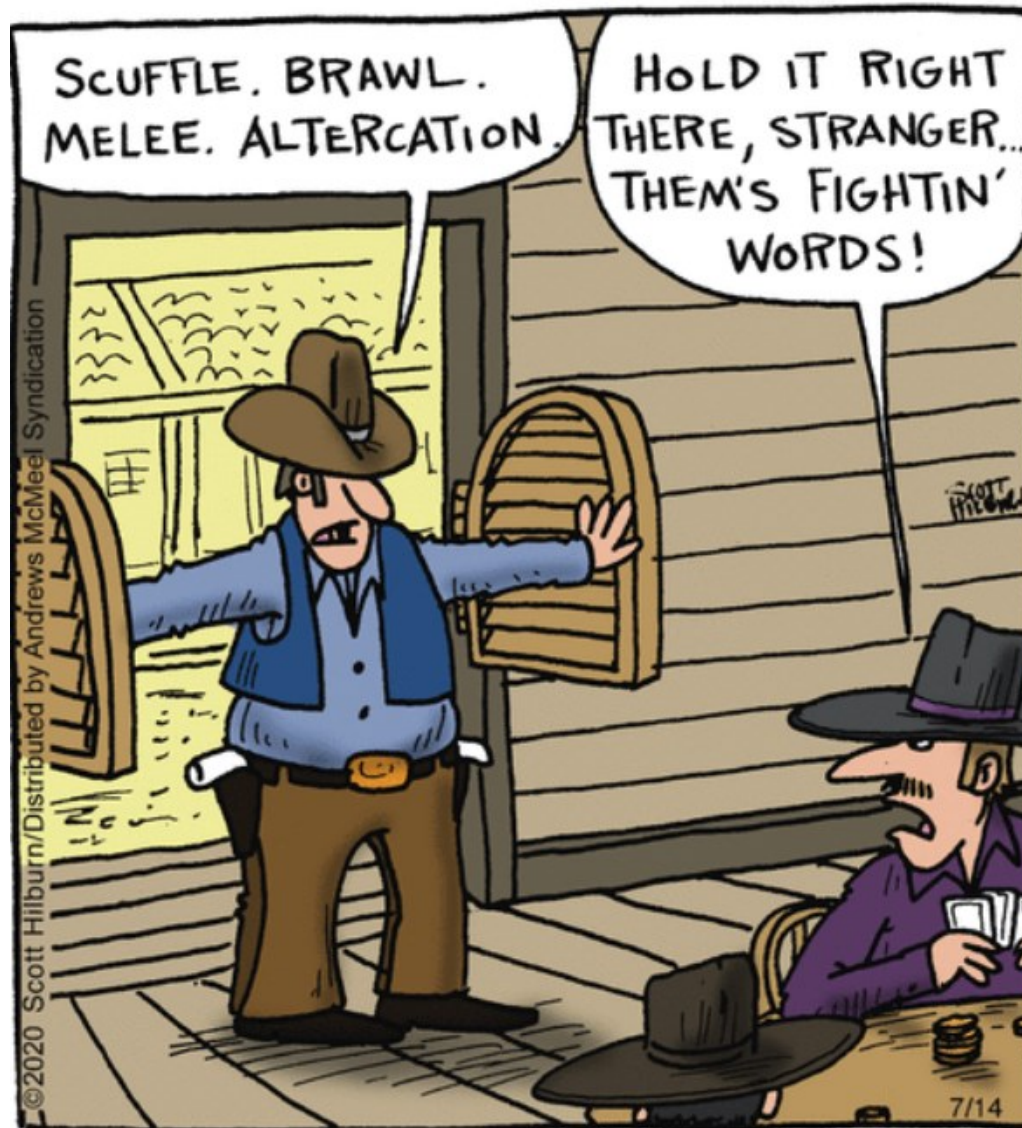
## What are the risks?

### **Potential risks:**

- Changes (e.g. diffuse:direct radiation) might disfavor some species and alter species interactions
- UV radiation: + or - depending on latitude/elevation/injection strategy; potential damage to DNA, effects on species that use UV as guides
- Dissociation of temperature from atmospheric CO<sub>2</sub> concentration; unknown effects on photosynthesis, transpiration, NPP
- Precipitation: geographic distribution, intensities and seasonality changes can favor or disadvantage species, communities, ecosystems
- Acid precipitation: harm to freshwater organisms, forests
- “Moral hazard” of reduced incentives to limit GHG emissions
- Catastrophic sudden termination with very rapid temperature rise can lead to ecosystem collapse and species extinctions



For context, the original cartoon:

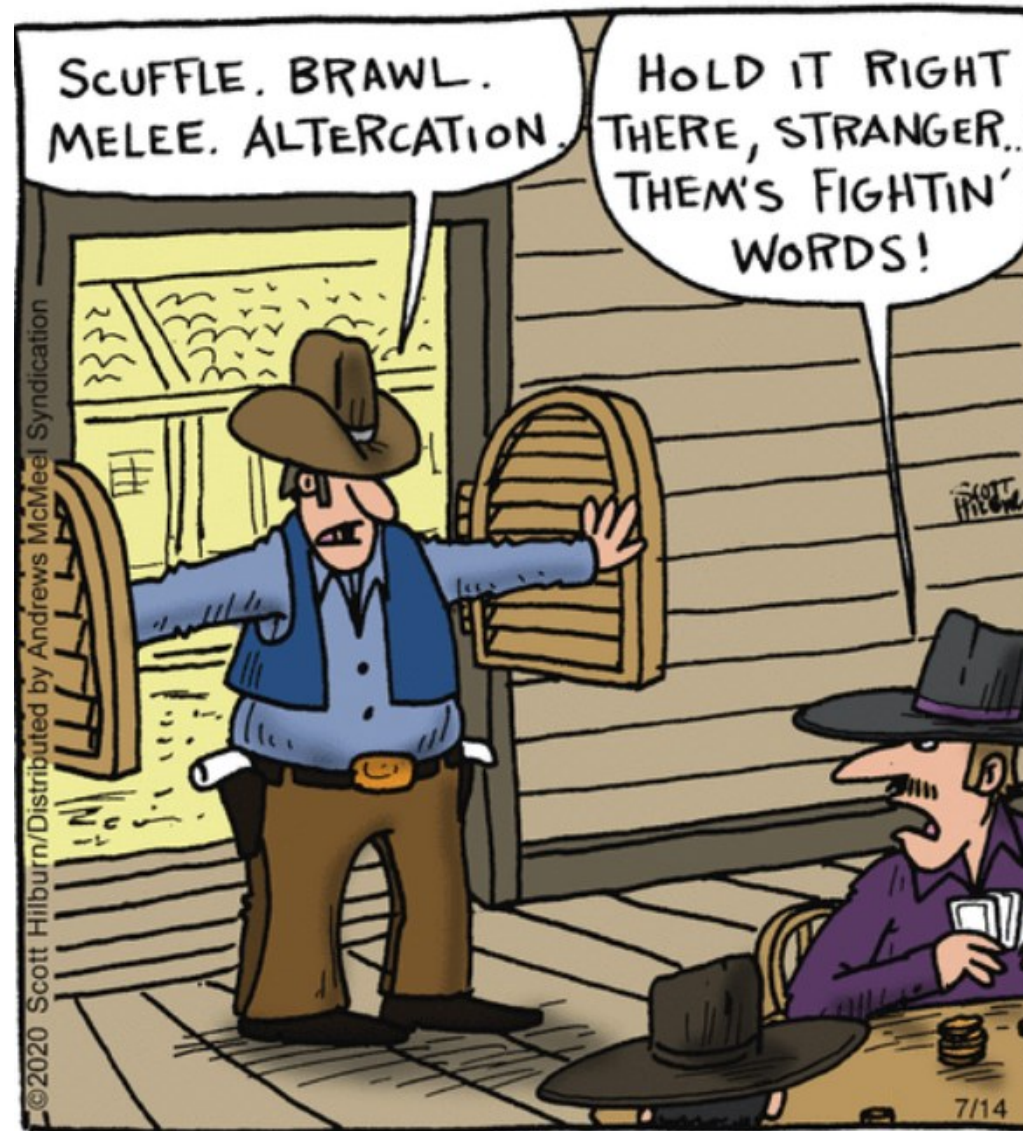


And now, my modification...

# PUBLIC PERCEPTION OF RISKS OF SRM

Uncertainty  
Risk  
Unpredictability  
Impact  
Unknown Effects  
Messing with Nature  
Confidence Limits

Climate scientist



Is the public ever going to accept SRM? Are environmentalists or ecologists going to support *any* SAI scenarios? If not, it's either a question of it's just wrong/unnatural/hubris, or else, it's about unknown risks.

# There might be potential **beneficial** effects of SAI on ecology



Potential for amelioration of effects of anthropogenic climate change

- Decreased average and extreme high temperatures globally might reduce mortality from extreme heat, reducing extinction risk for vulnerable species
- Reduced incidence of extreme precipitation events might protect riparian and other habitats, protecting certain ecosystems
- Some amelioration of warming effects in Arctic (depending on scenario), reducing losses to arctic communities and species
- Potential preservation of permafrost, sea ice and organisms and ecosystems dependent on those
- Slowing advances of tropical and subtropical pests and pathogens to temperate regions (?)
- Slowing/alteration of climate velocities and need for migration of species, relocation of communities and biomes (which is a dicey proposition anyway)





# ANSWERS: What are the risks and impacts of SAI on ecological systems

???????

We don't know.

**ONLY A TINY FRACTION OF PUBLISHED RESEARCH IN ECOLOGY, CLIMATE SCIENCE OR ENVIRONMENTAL SCIENCE HAS BEEN DEVOTED TO THESE ISSUES**

## *Why should you pay attention?*

1. Life on earth will be strongly impacted by the answers
2. Humans are part of the natural world, and our well being depends on it
3. What right do we claim to drive species extinct and destroy the natural world?



Ecologists should be more aware of SRM research, and climate scientists should be more aware of ecological issues

*Collaboration between ecologists and climate scientists can help to:*

- Identify common SAI research goals
- Elucidate potential ecological risks and opportunities of SAI
- Develop possible climate intervention strategies that meet ecological goals, and
- Improve awareness of potential SAI effects (+ and -) and risks
- Change public perception of SRM, including SAI

# Acknowledgements

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