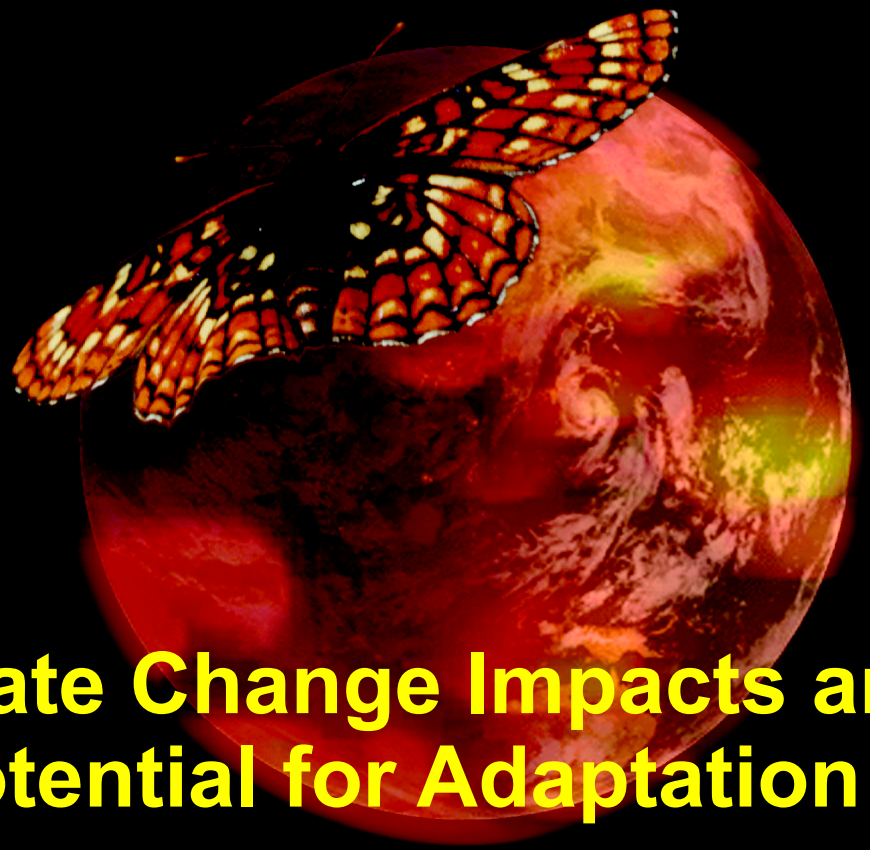
GEM3, Boise Idaho, 2019



Climate Change Impacts and Potential for Adaptation

Camille Parmesan

Theoretical and Experimental Ecology, CNRS & University Paul Sabatier, France
Geological Sciences, University of Texas at Austin, USA
National Marine Aquarium Chair in Public Understanding of Oceans and Human Health, Plymouth University, UK

ESI

NATIONAL MARINE AQUARIUM

Marine Institute PLYMOUTH UNIVERSITY

DGS The Department of Geological Sciences

UNIVERSITÉ TOULOUSE III PAUL SABATIER

Theoretical and Experimental Ecology Station

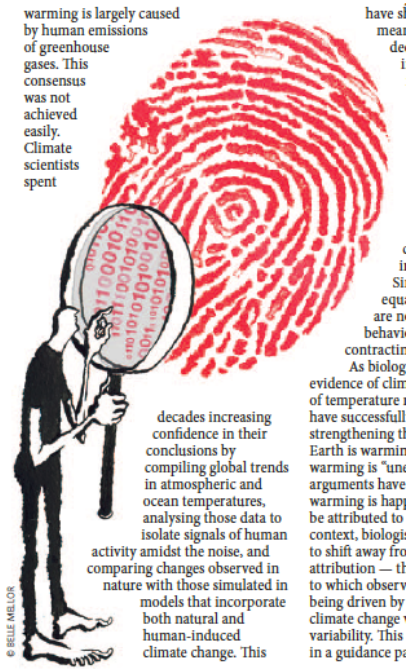
cnrs

Working Group II

ipcc

Impacts, Adaptation and Vulnerability

Working Group II assesses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequences of climate change and options for adapting to it.



ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

IPCC Expert Meeting on Detection and Attribution Related to Anthropogenic Climate Change

The World Meteorological Organization
Geneva, Switzerland
14–16 September 2009

Good Practice Guidance Paper on Detection and Attribution Related to Anthropogenic Climate Change

Core Writing Team:
Gabriele C. Hegerl (United Kingdom), Ove Hoegh-Guldberg (Australia), Gino Casassa (Chile), Martin Hoerling (USA), Sari Kovats (United Kingdom), Camille Parmesan (USA), David Pierce (USA), Peter Stott (United Kingdom)

Prior reports focused on:

- Detection of impacts
- Attribution of impacts to human climate change

opinion & comment

COMMENTARY:

Overstretching attribution

Camille Parmesan, Carlos Duarte, Elvira Poloczanska, Anthony J. Richardson and Michael C. Singer

The biological world is responding rapidly to a changing climate, but attempts to attribute individual impacts to rising greenhouse gases are ill-advised.

Parmesan *et al. Nature Climate Change* 2011

ECOLOGY LETTERS

Ecology Letters, (2013) 16: 58–71 doi: 10.1111/ele.12098

IDEA AND PERSPECTIVE

Beyond climate change attribution in conservation and ecological research

Parmesan *et al.* 2013

Summary of Changes and Surprises

- % species impacted by <1° C global warming
  - ~ half in terms of distribution changes
  - ~ 2/3 in terms of changes of timing
  - Impacts on every continent and in every ocean

- **Surprises** even at < 1°C
  - Diseases moving
  - Complex responses hide strong temperature sensitivity

- **Past analyses underestimated recent climate change impacts**

- **Above impacts at <1°C warming**
- **There WILL BE large differences in impacts between 1.5°C and 2°C**

Parmesan & Yohe *Nature* 2003, Parmesan *AREES* 2006,
Parmesan & Hanley *Ann Botany,* 2015, Duffy *et al. Science* 2019

Divergent responses to spring and winter warming drive community level flowering trends

Benjamin I. Cook[a,b,1], Elizabeth M. Wolkovich[c], and Camille Parmesan[d,e]

PNAS 2012

- DC and UK, >500 plant species
- 72% respond only to spring warming, and are flowering earlier

- **18% need winter chilling**
- **Winters are warming (more than summer)**

spring advance + winter delay
= little change

Cook, Wolkovich & Parmesan *PNAS* 2012

- **18% need winter chilling**
- **Winters are warming (more than summer)**

Simple analyses:
72% responding

New analyses:
90% responding

Cook, Wolkovich & Parmesan *PNAS* 2012

Winter chilling speeds spring development of temperate butterflies

Journal of Animal Ecology
BRITISH ECOLOGICAL SOCIETY

Sandra Stålhandske ✉, Karl Gotthard, Olof Leimar

(2017)

photo by Charles J Sharp

As winters warm in Sweden, spring starts later for this Orange Tip butterfly

yellow warbler

"Genomic signals of selection predict climate-driven population declines in a migratory bird"

Bay et al. (**Science 359, 83-86,** 2018)

- Significant correlations (Fst) across populations between genomic signatures and current climate space (mostly drought metrics)
- Population trends assessed independently: NABBS (N. American Breeding Bird Survey)
- Outlier populations (=genomic signature did not match climate space), had greatest declines

Implications:

- **ecological "climate debt"**
- **evolutionary lag**
- **constraint on future responses to CC**

“Resurrection ecology”

Ancient DNA analyses can tell us which Neanderthals had red hair, but modern technology still can’t bring past genotypes back to life …

Or can it?

Lake sediments contain ancient viable seeds and eggs that can be dated, resurrected, kept in live culture and compared with modern populations

Water-fleas (Daphnia) resurrected from pre-industrial times - up to 1,600 years ago - have been used to show evolutionary responses to past 100 yrs of human-caused climate change, eutrophication and lead pollution

Frisch et al EcoLets 2014; Yousey et al Roy Soc Open 2018; Turko et al Evolution 2016

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6th AR: Focus on Solutions

IPCC mission:

- Assess the state of science of climate change
- Be policy relevant, not policy prescriptive

- Assess options
- Risk Assessment
- Decision-Making Frameworks
- Adaptation planning

Studies of within-species variation elucidates potential adaptability (plastic and evolutionary) of wild species to future climate change and gives insight into new management options

Experiments Elucidate Mechanisms and Constraints

- Difficult to design clean experiments
  - Extreme events drive responses (ecological and evolutionary), but hard to simulate
- Model insect: *Tribolium castaneum* (red flour beetle) (K. Sales *Nature Comm* 2018)
  - Simulated Heatwaves (5-7°C above T_{opt} for 5 days) damaged sperm in both males and females. No acclimation. Multiple heatwaves nearly sterilized males
  - Transgenerational impacts: males from heat-exposed sperm had reduced reproduction and lifespan, whether the sperm were heated in the male or the female parent
- Heat/cold stress experiments on *Drosophila melanogaster* (egg-adult):
  - Heritability of thermal tolerance dropped significantly in high-temp. treatments
  - *"the results suggest that ectotherms that already experience temperatures close to their upper thermal tolerance limits have a restricted capacity to adapt to higher temperatures by evolutionary means."* (Kristensen *et al* 2015 Evolution)

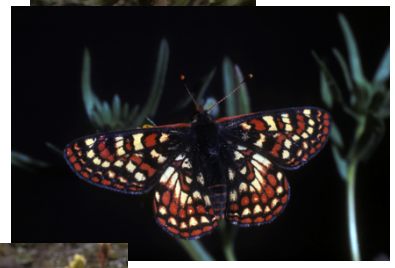
Different hosts = different micro-climates by selecting for different egg heights

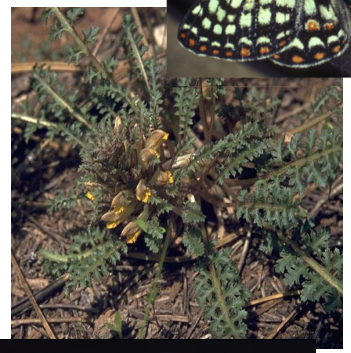
- Ephemeral plant
- eggs laid high where leaf quality best
- eggs ~6° hotter than air

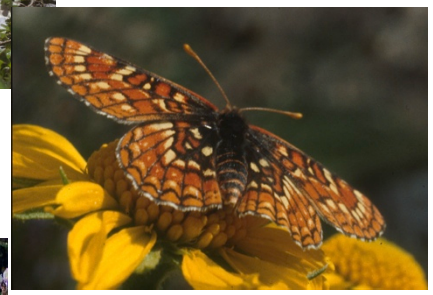
- long lasting plant
- eggs laid low to avoid grazing
- Eggs ~20°C hotter than air
- max 26°C hotter – just 1°C below lethal

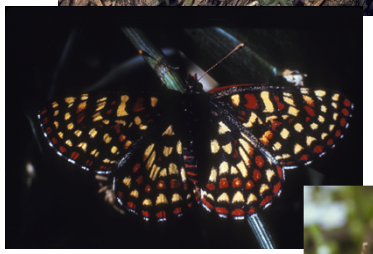
Variation among Edith's checkerspot populations in host plant choice and egg placement behavior can cause far greater changes than average warming from climate change in temperatures experienced by eggs and developing caterpillars

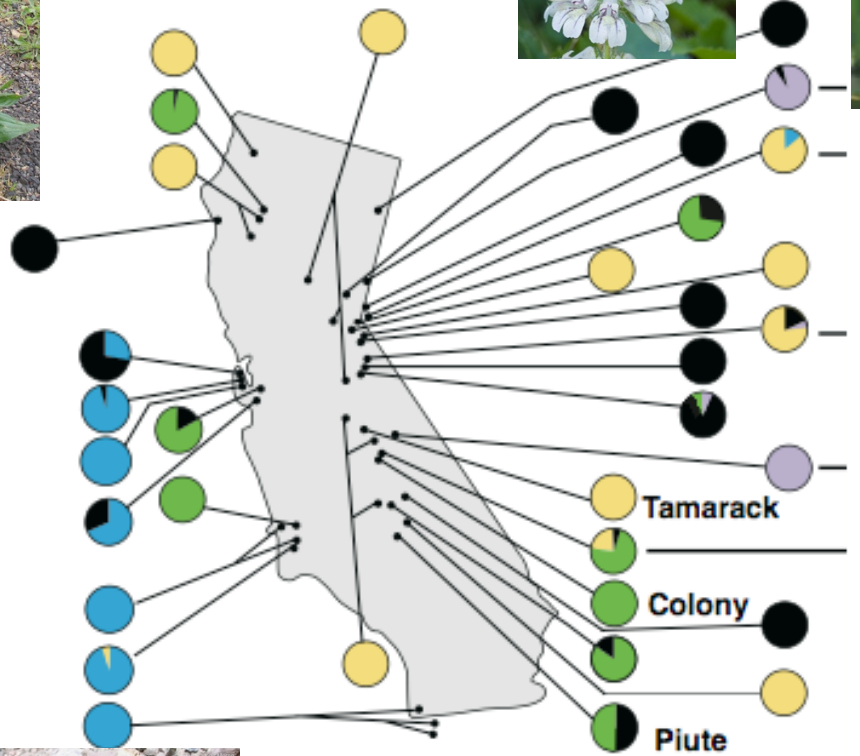
Preserve Diversity within Species











Plantago
Castilleja
Pedicularis
Collinsia
Penstemon

Map of Diet for *E. editha* from Singer & McBride 2012, *Ecology*

Climate Change: Polar bear – Grizzly (Brown) bear Hybrids

Pure

Hybrids

ECOLOGY

Chazdon & Brancallon *Science* 2019

Restoring forests as a means to many ends

An urgent need to replenish tree canopy cover calls for holistic approaches

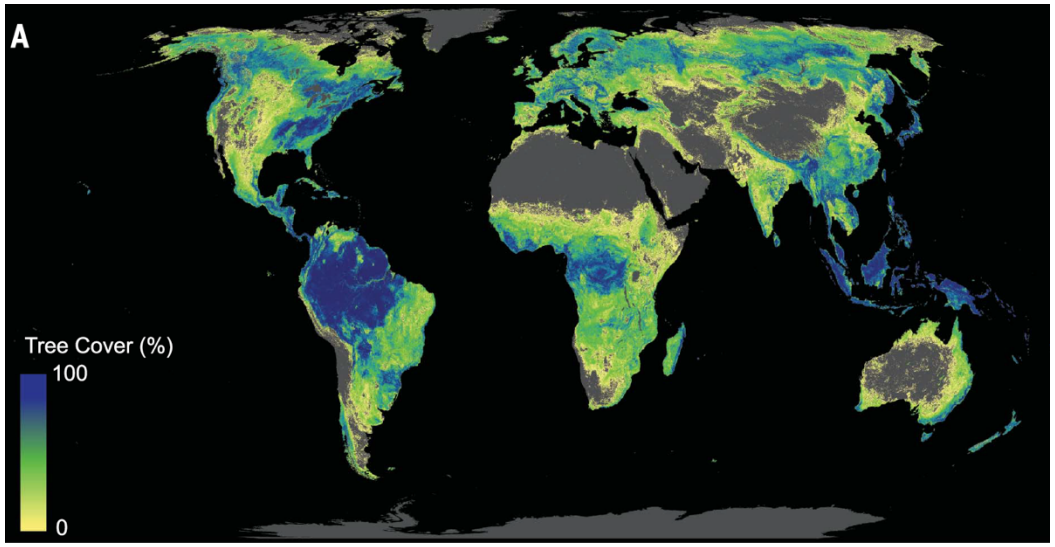
Alternative facts and carbon cycle. By Colin Prentice

OCTOBER 18, 2019

RESTORATION ECOLOGY

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

The global tree restoration potential



- **7 responses published so far, in *Science***
- **2 blogs**

Ariege PNR: Regional Natural Park of the Ariege Pyrenees (France)

Grasslands Crucial for Biodiversity and livelihoods

Reverts to forest without agriculture

Butterflies, birds and wildflowers have adapted to traditional farming

They would go extinct with reforestation

Farmers would lose livelihoods

France would go from agricultural exporter to importer, and lose food independence

Goals of Regional Natural Parks

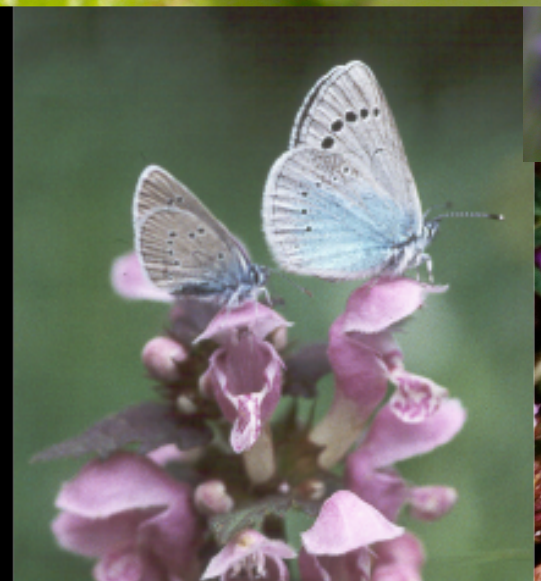
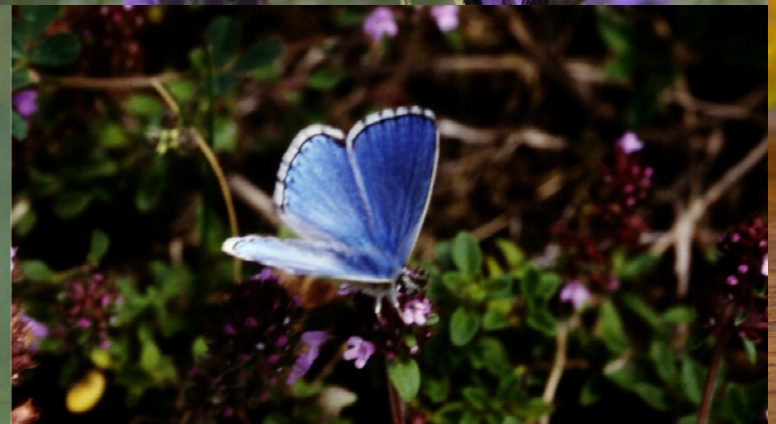
- Protecting and promoting large inhabited rural or mountain spaces.
- Protect:
  - Landscapes
  - Endemic or endangered flora and fauna
  - Historic and prehistoric sites
  - Traditional agricultural practices – e.g. transhumance
  - Traditional crafts


Traditional grazing = daily nomadic
and yearly transhumance

Conserving Biodiversity = Preserve traditional management









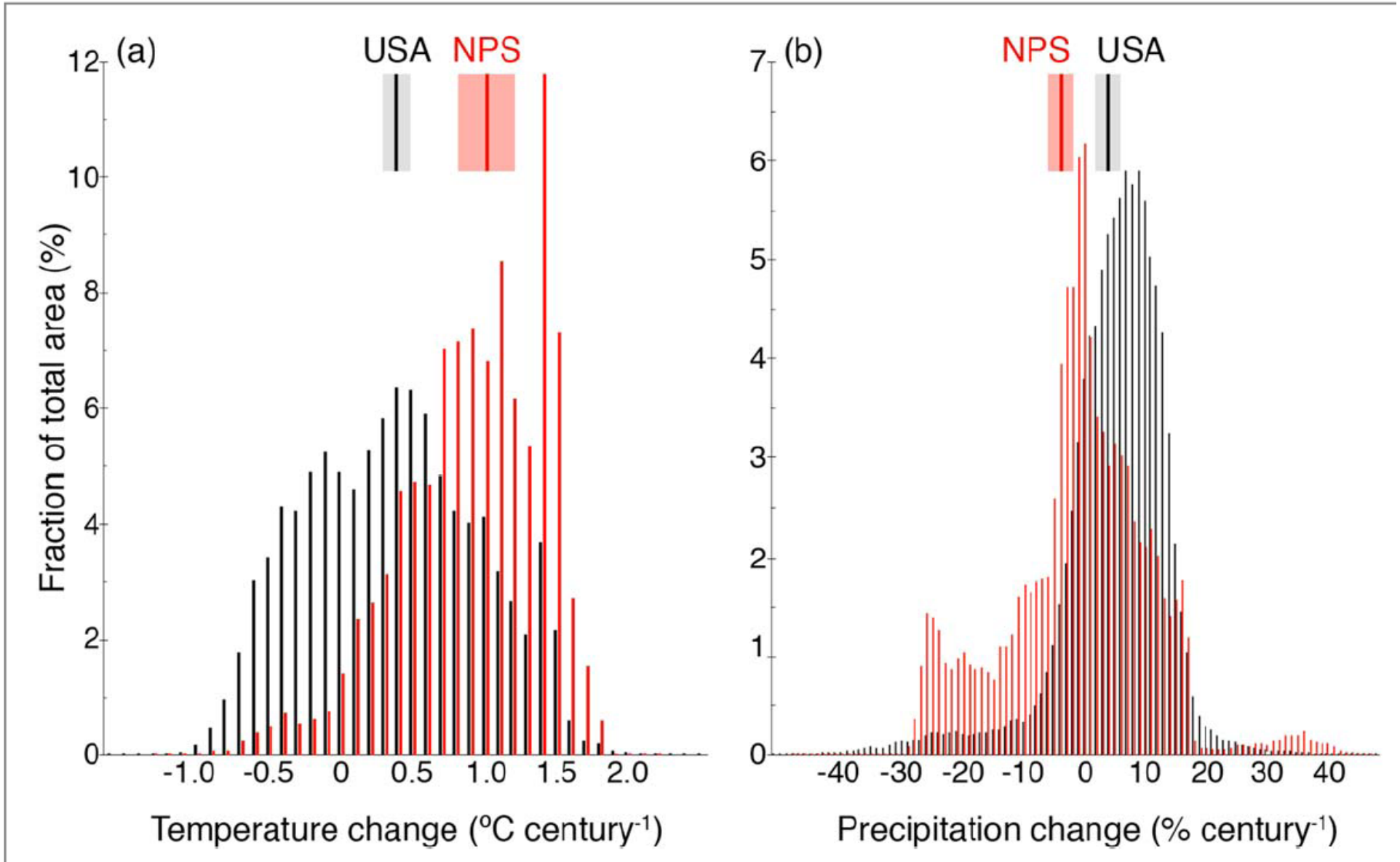


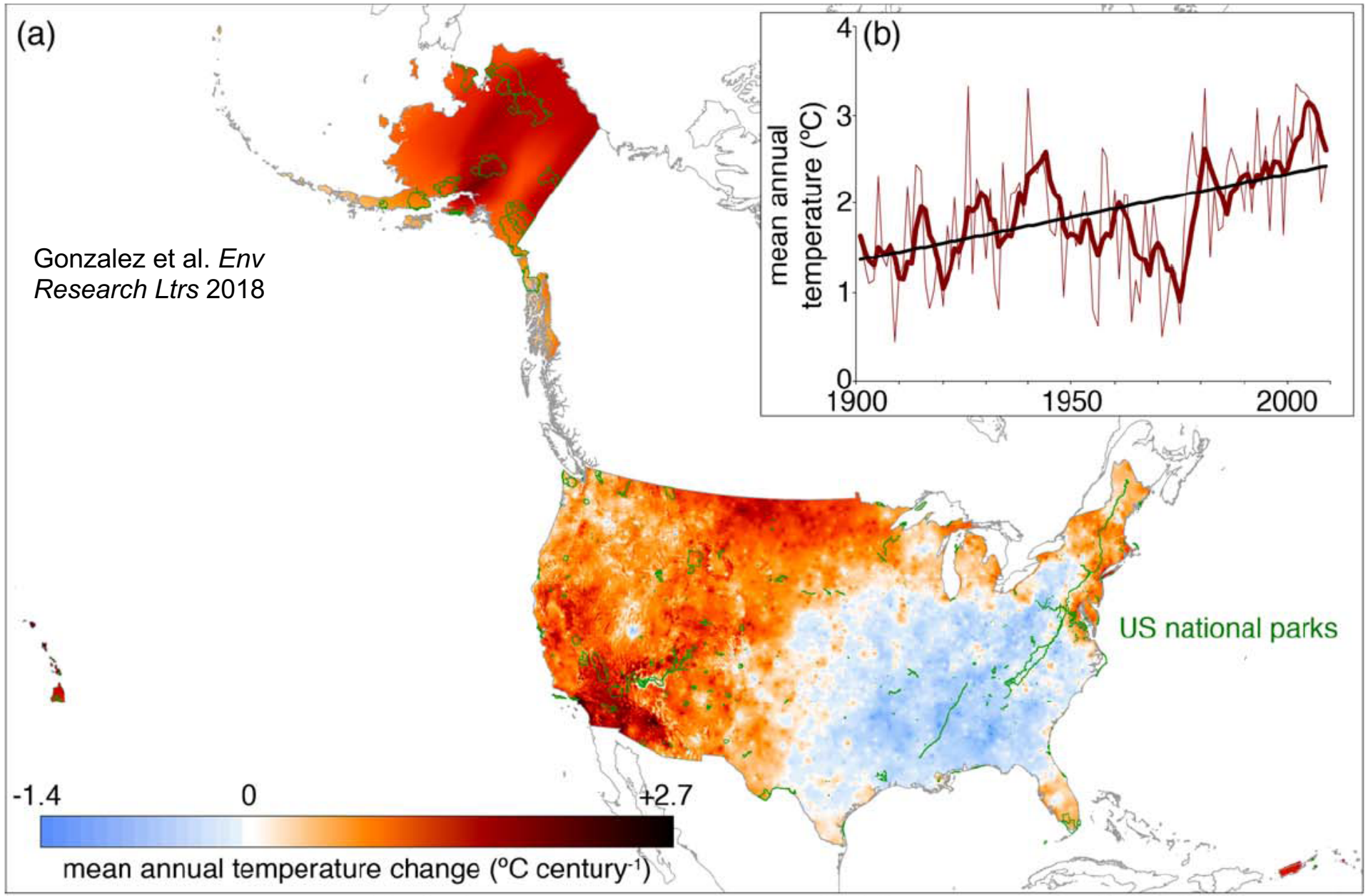
Environmental Research Letters

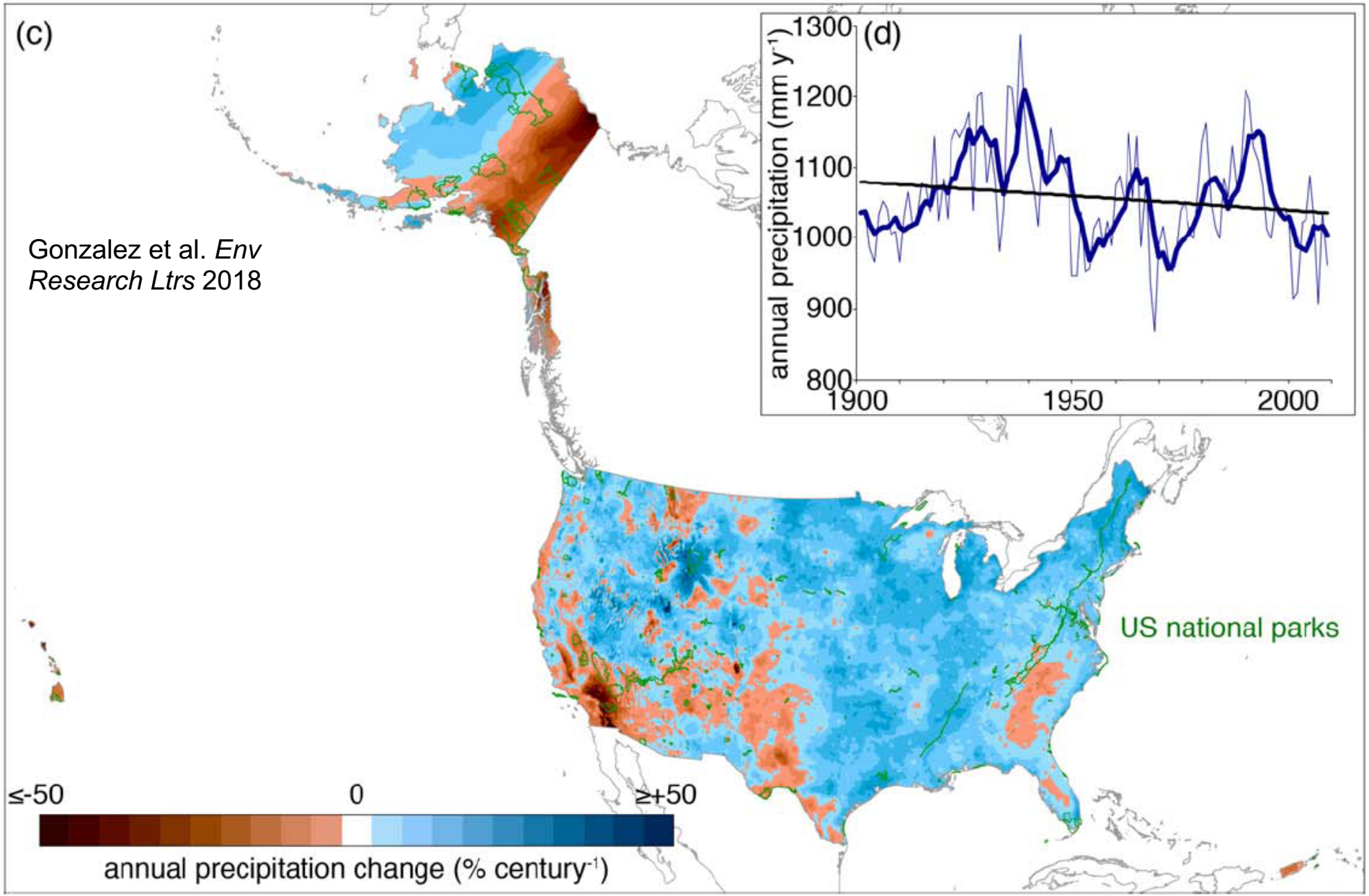
2018

Disproportionate magnitude of climate change in United States national parks

Patrick Gonzalez[1,2,3], Fuyao Wang[4], Michael Notaro[4], Daniel J Vimont[4,5] and John W Williams[4,6]

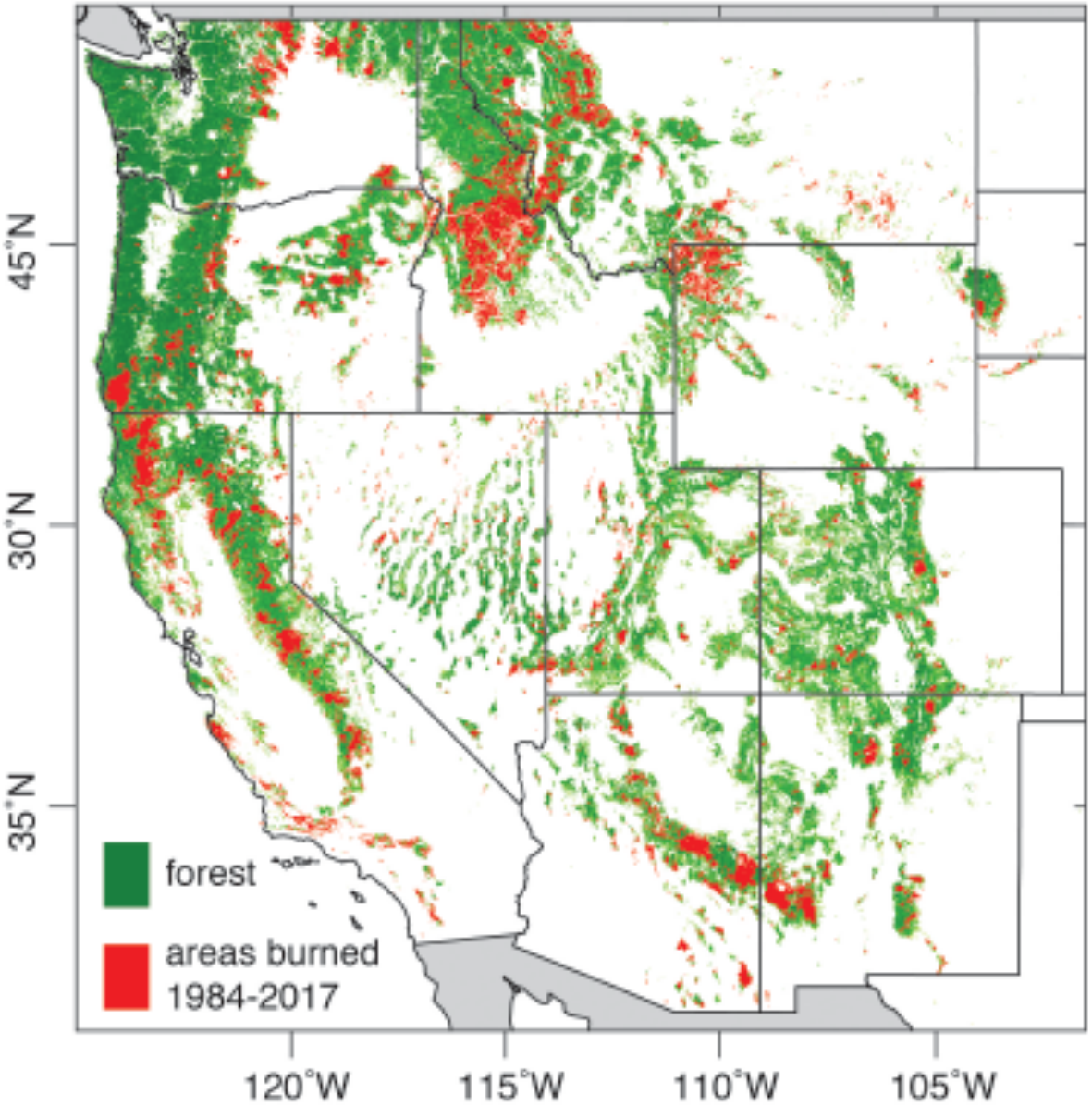


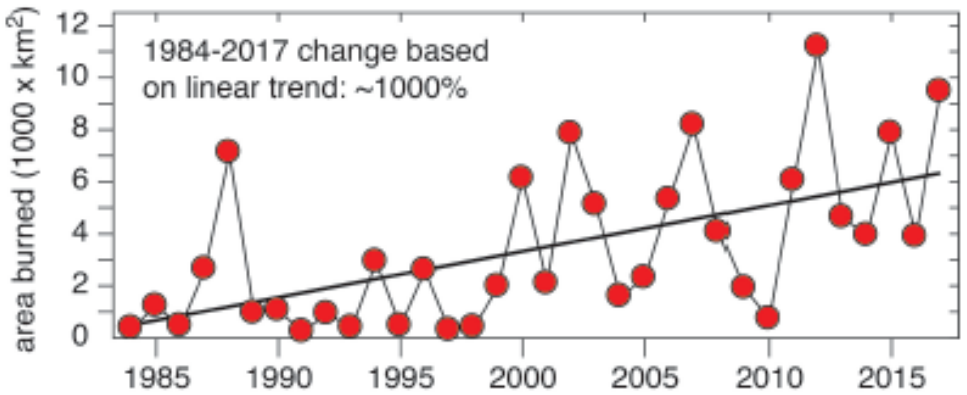

(a)
(b)
mean annual temperature (ºC)
0
1
2
3
4
1900
1950
2000
Gonzalez et al. *Env Research Ltrs* 2018
US national parks
-1.4
0
+2.7
mean annual temperature change (ºC century⁻¹)


(c)
(d)
annual precipitation (mm y-1)
1300
1200
1100
1000
900
800
1900
1950
2000
Gonzalez et al. *Env Research Ltrs* 2018
US national parks
≤-50
0
≥+50
annual precipitation change (% century-1)

Western United States Forest Fire Area

historical observations from 1984-2017





Duffy et al. *Science,* 2019