Climate change:
A moving target in sanctuary management

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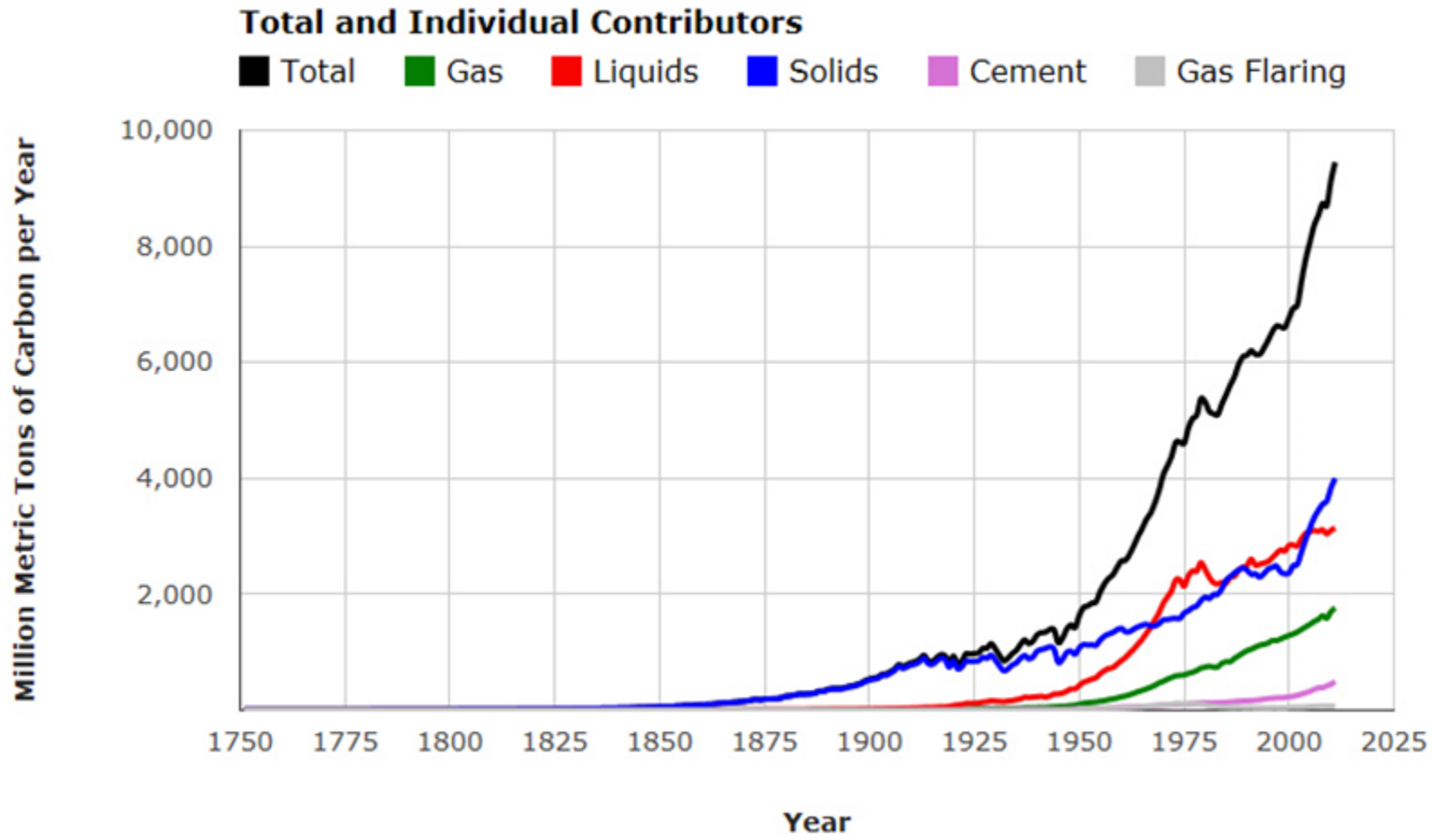
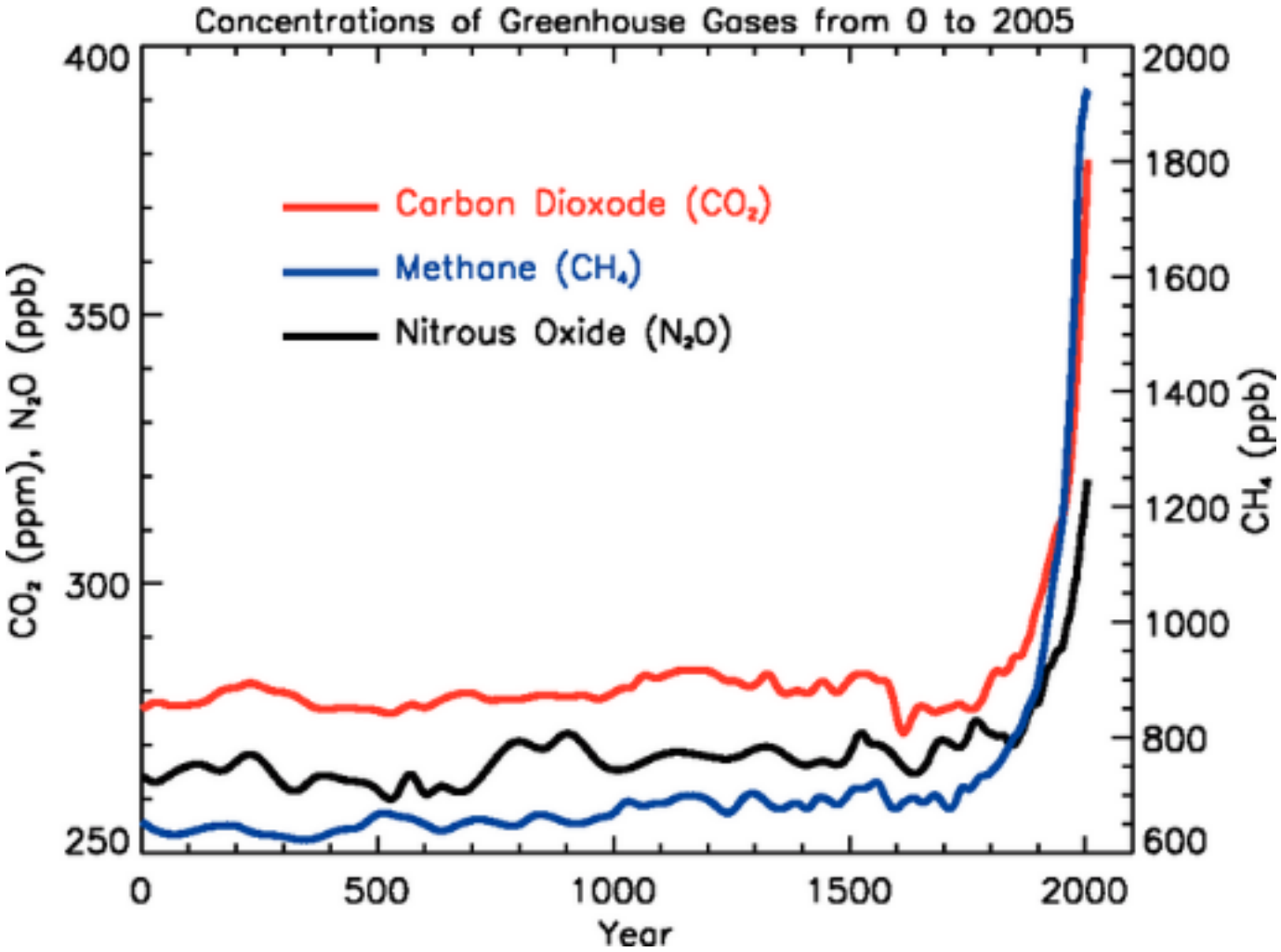
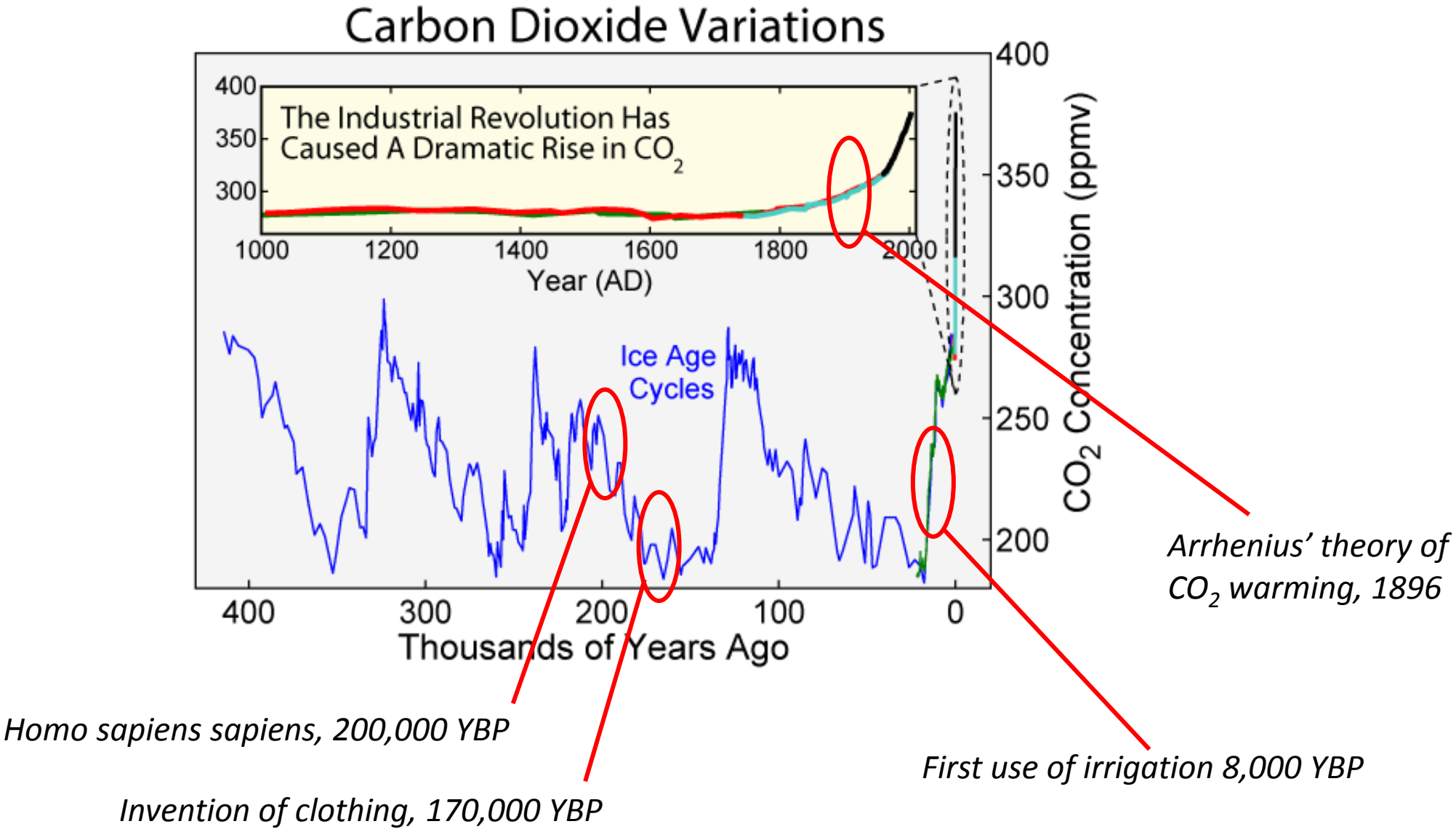
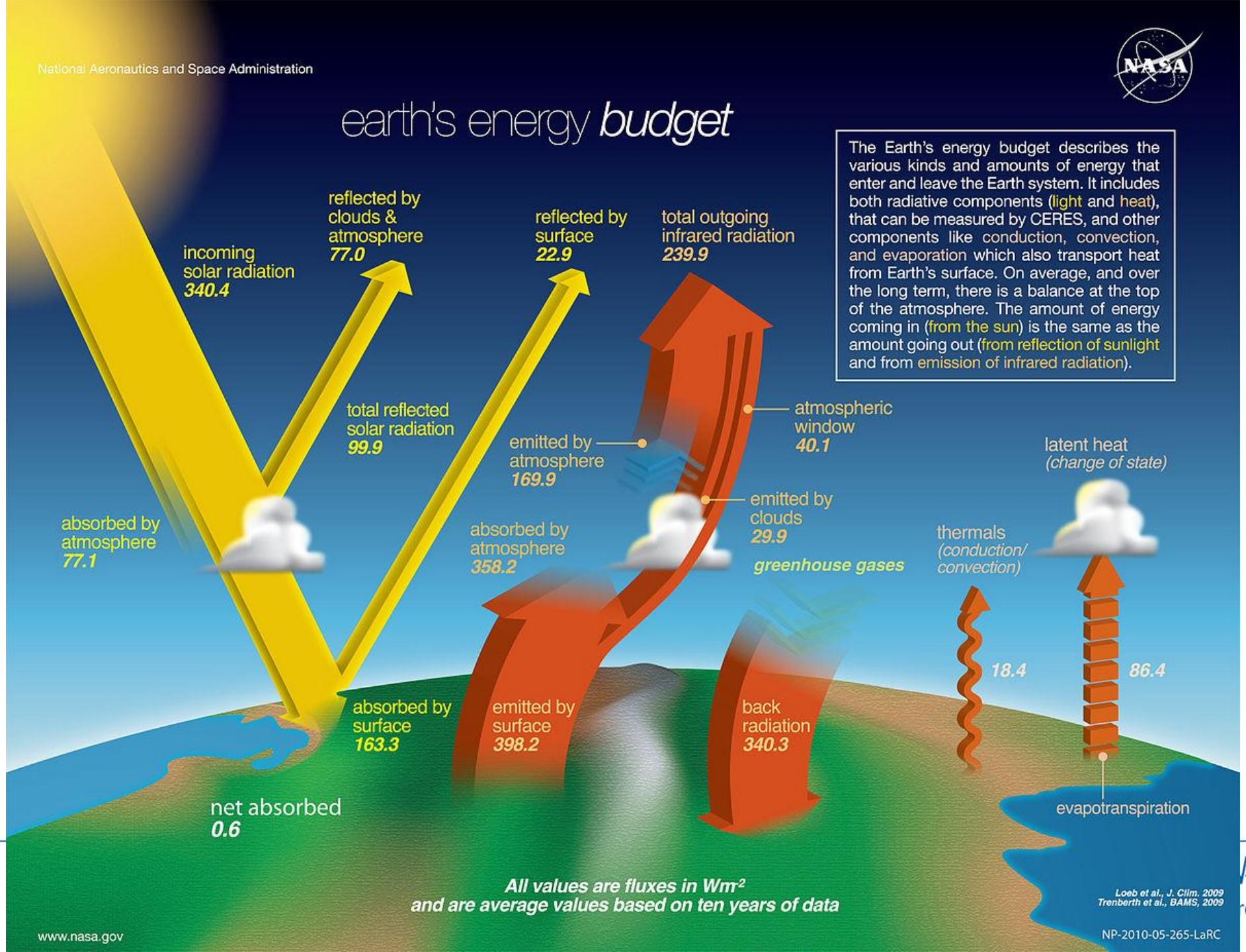
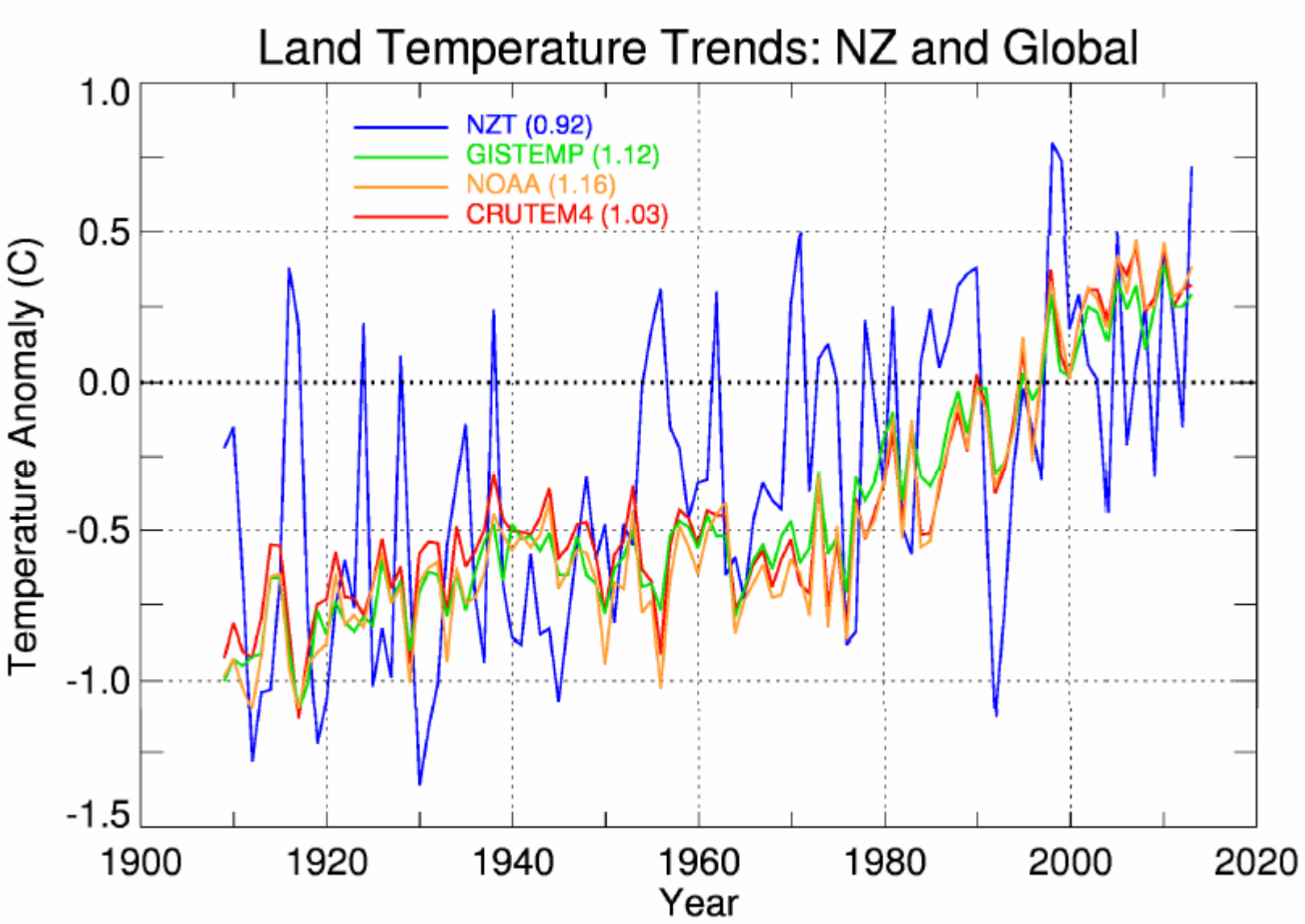

Total and Individual Contributors
Total
Gas
Liquids
Solids
Cement
Gas Flaring
Million Metric Tons of Carbon per Year
10,000
8,000
6,000
4,000
2,000
1750
1775
1800
1825
1850
1875
1900
1925
1950
1975
2000
2025
Year

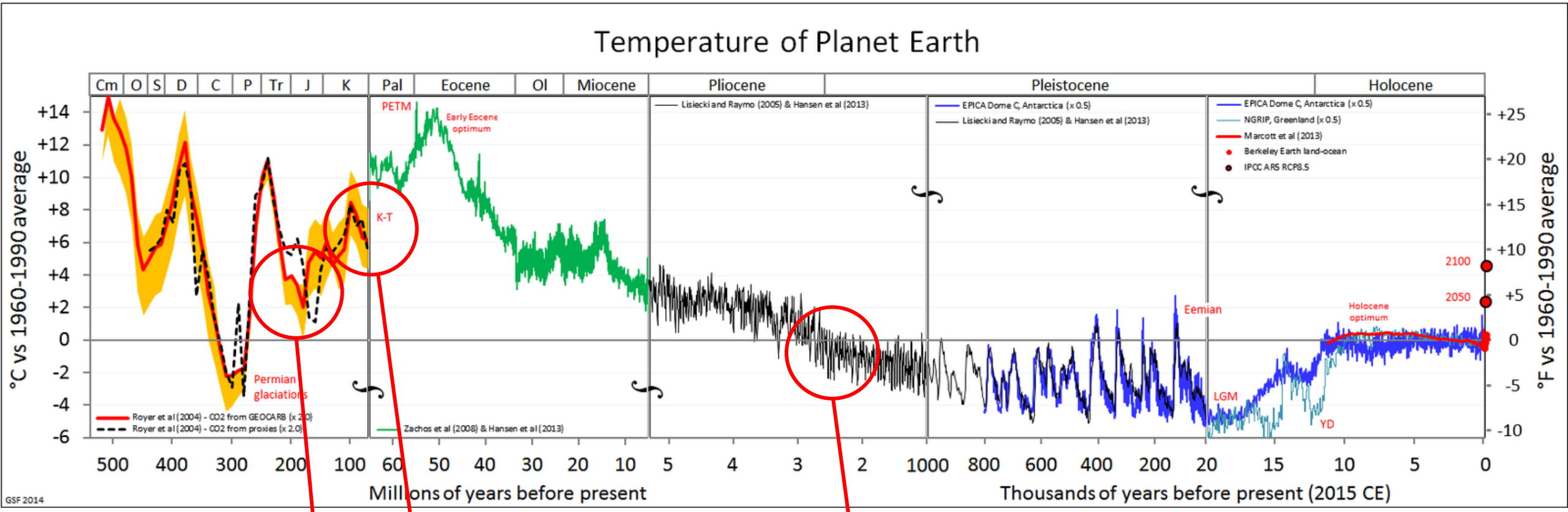

Concentrations of Greenhouse Gases from 0 to 2005
Carbon Dioxode (CO_2)
Methane (CH_4)
Nitrous Oxide (N_2O)
CO_2 (ppm), N_2O (ppb)
CH_4 (ppb)
Year
400
350
300
250
2000
1800
1600
1400
1200
1000
800
600
0
500
1000
1500
2000


Carbon Dioxide Variations
The Industrial Revolution Has Caused A Dramatic Rise in CO_2
400
350
300
1000
1200
1400
1600
1800
2000
Year (AD)
Ice Age Cycles
400
300
200
100
0
Thousands of Years Ago
400
350
300
250
200
CO_2 Concentration (ppmv)
Arrhenius' theory of CO_2 warming, 1896
Homo sapiens sapiens, 200,000 YBP
Invention of clothing, 170,000 YBP
First use of irrigation 8,000 YBP


National Aeronautics and Space Administration
earth's energy budget
The Earth's energy budget describes the various kinds and amounts of energy that enter and leave the Earth system. It includes both radiative components (light and heat), that can be measured by CERES, and other components like conduction, convection, and evaporation which also transport heat from Earth's surface. On average, and over the long term, there is a balance at the top of the atmosphere. The amount of energy coming in (from the sun) is the same as the amount going out (from reflection of sunlight and from emission of infrared radiation).
incoming solar radiation 340.4
reflected by clouds & atmosphere 77.0
reflected by surface 22.9
total outgoing infrared radiation 239.9
total reflected solar radiation 99.9
emitted by atmosphere 169.9
atmospheric window 40.1
emitted by clouds 29.9
greenhouse gases
absorbed by atmosphere 77.1
absorbed by atmosphere 358.2
latent heat (change of state)
thermals (conduction/ convection)
18.4
86.4
absorbed by surface 163.3
emitted by surface 398.2
back radiation 340.3
net absorbed 0.6
evapotranspiration
All values are fluxes in Wm-2
and are average values based on ten years of data
Loeb et al., J. Clim. 2009
Trenberth et al., BAMS, 2009
www.nasa.gov
NP-2010-05-265-LaRC



New Zealand air temperatures over the land have warmed by about 1°C over the last century.



NZ split from Gondwanaland

Tuatara

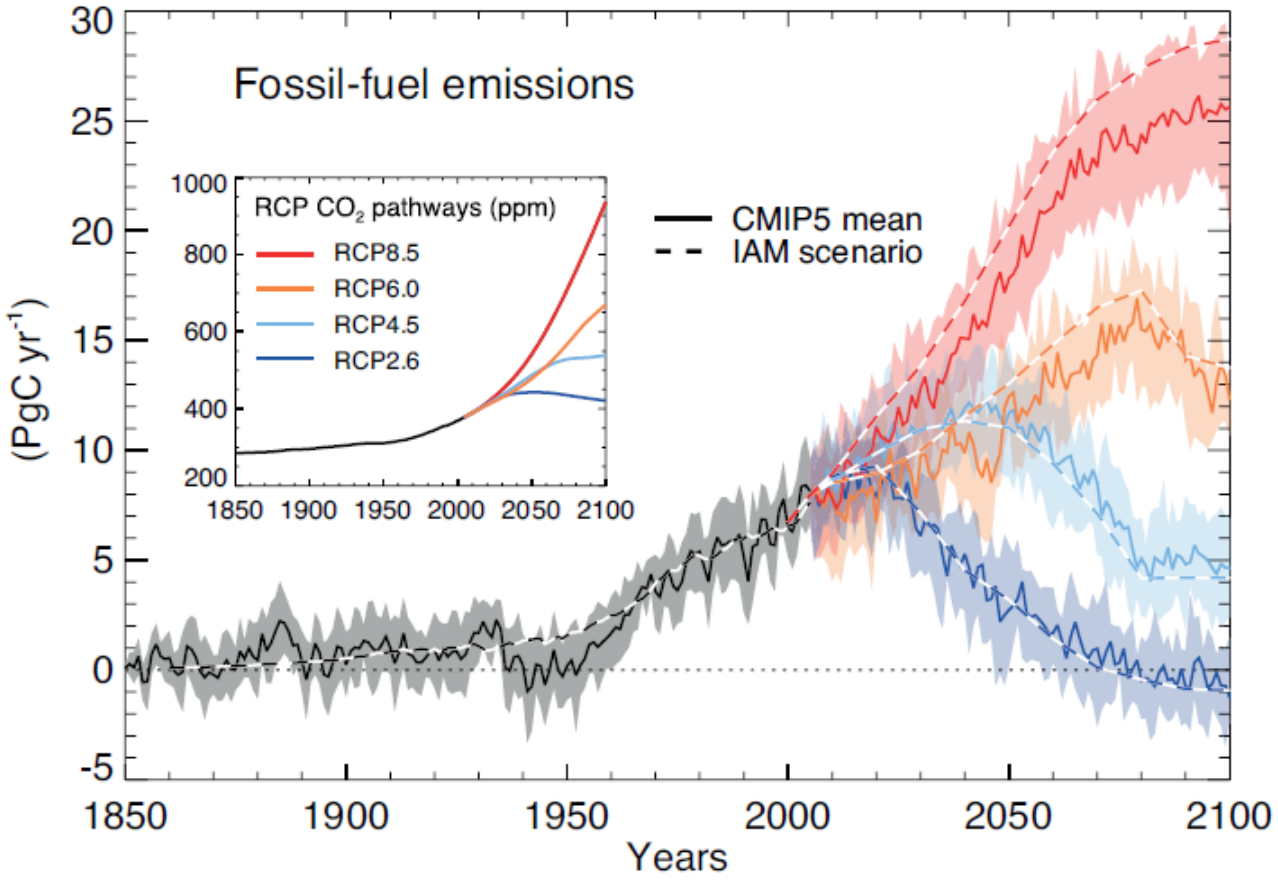
North Island brown kiwi
Great/little spotted kiwi

A problem of climate change and conservation

Many of New Zealand native wildlife evolved in climatic conditions cooler than those projected by the end of this century.

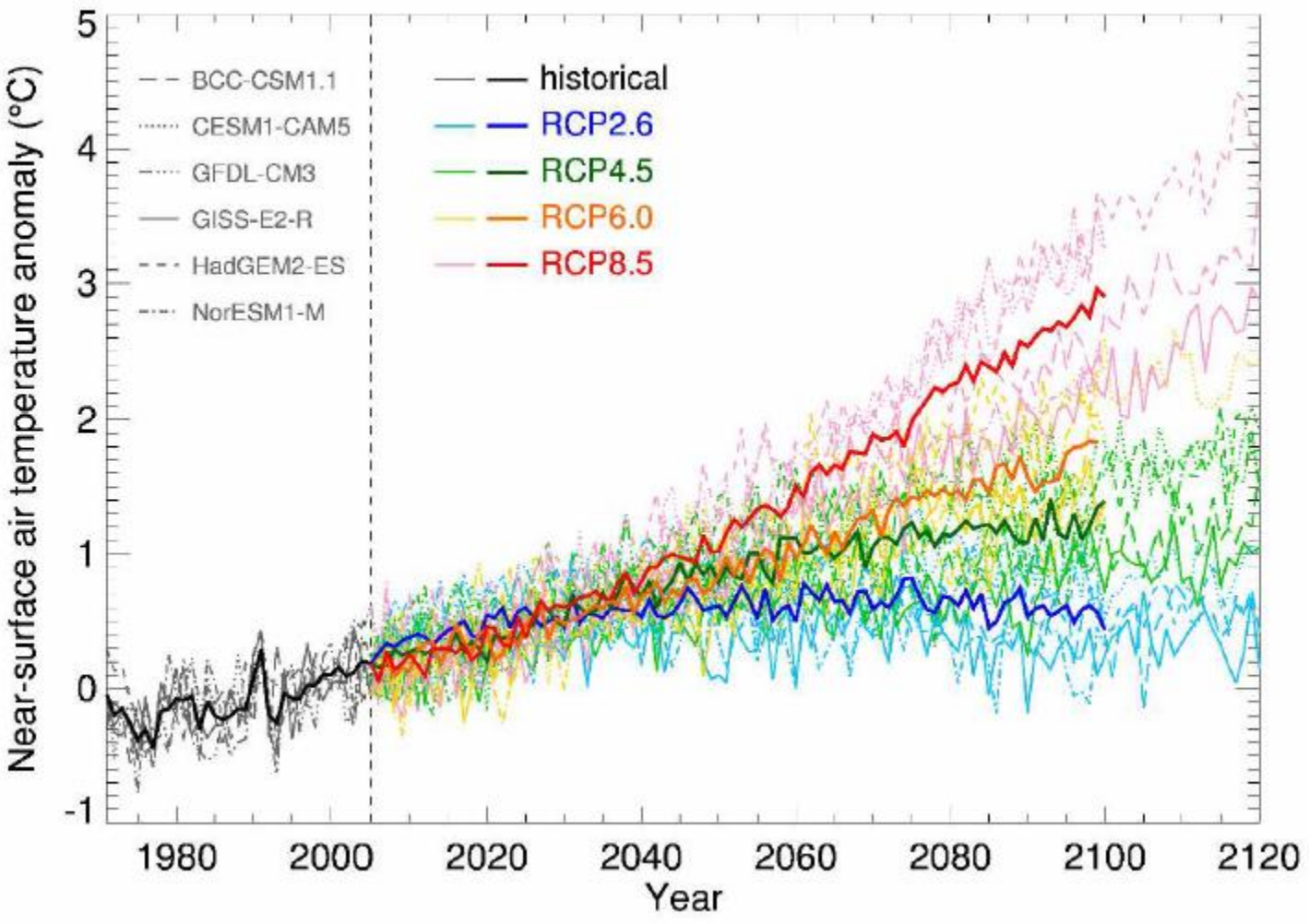
Those that evolved earlier had large habitat ranges with little or no predation. A wide range would have provided a buffer to fluctuating climatic conditions.

So how will species cope under new climate conditions where habitat options are constrained and other pressures exist?



The trajectory of society's collective greenhouse gas emissions in the future will determine how far climate will change.

Alternative trajectories are called "**scenarios**", and help us explore the implications of different levels of mitigation.



Some warming is unavoidable, even if we stopped emitting excess greenhouse gases today.

The trajectory of future warming depends mostly on global greenhouse gas emissions.

Our imperfect understanding of the climate system adds further uncertainty to the projections.

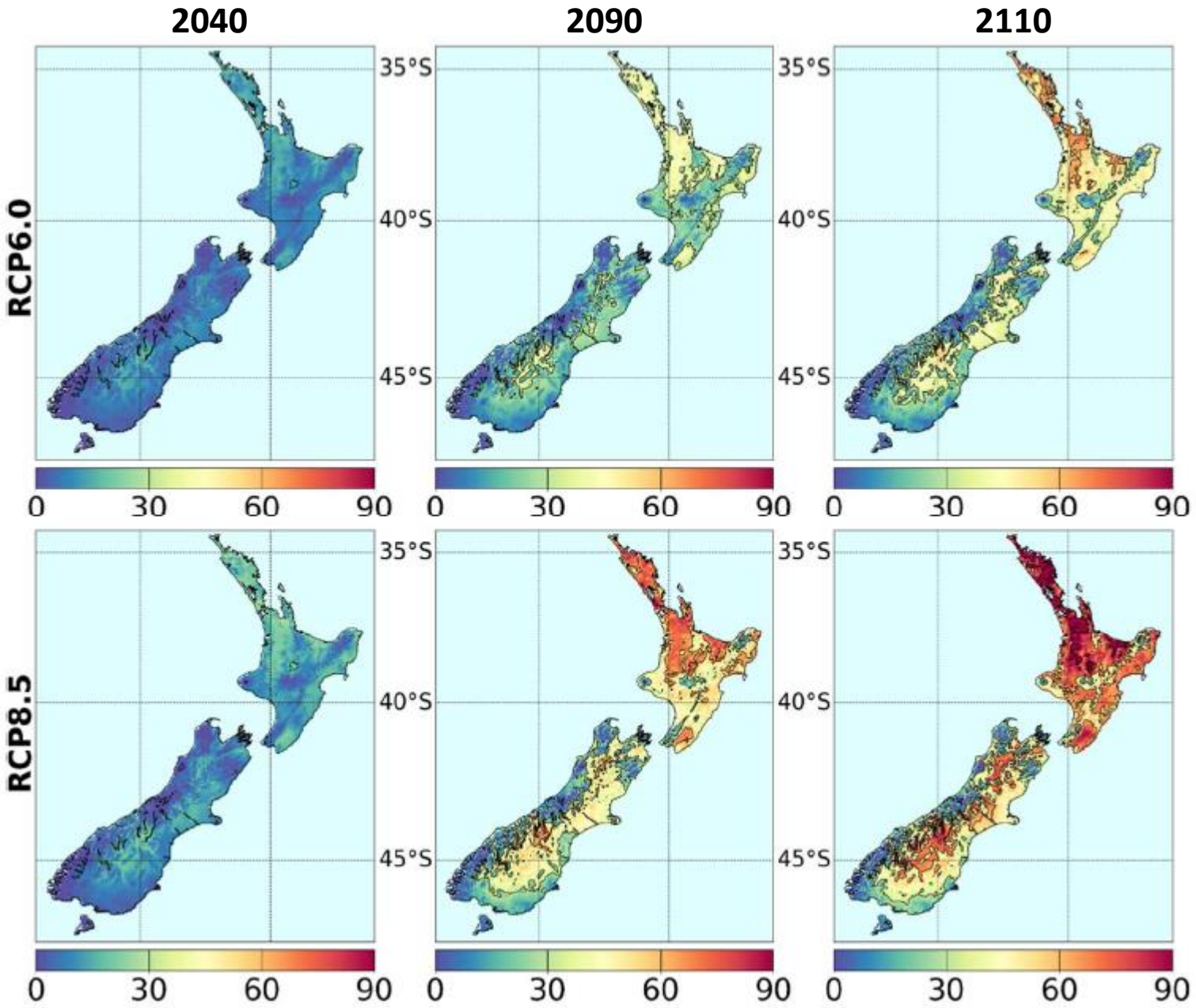
RCP6.0 would reach about 2.2°C of warming by the end of the century. The Paris Climate Agreement aims to keep global warming well below 2°C.

Impacts of climate change for New Zealand

- Higher air temperatures, particularly at higher elevations and during summer/autumn
- More time spent above temperature thresholds
- Both increases and decreases in rainfall depending in the location; winter and spring see the largest changes.
- More drought
- Less snow
- Increases in extreme winds
- Southward shift in the reach of extra-tropic cyclones, but perhaps less frequent
- Decreases in humidity
- More severe floods
- Greater societal water demand

The number of days when temperatures climb above 25°C (or any other temperature threshold) will increase.

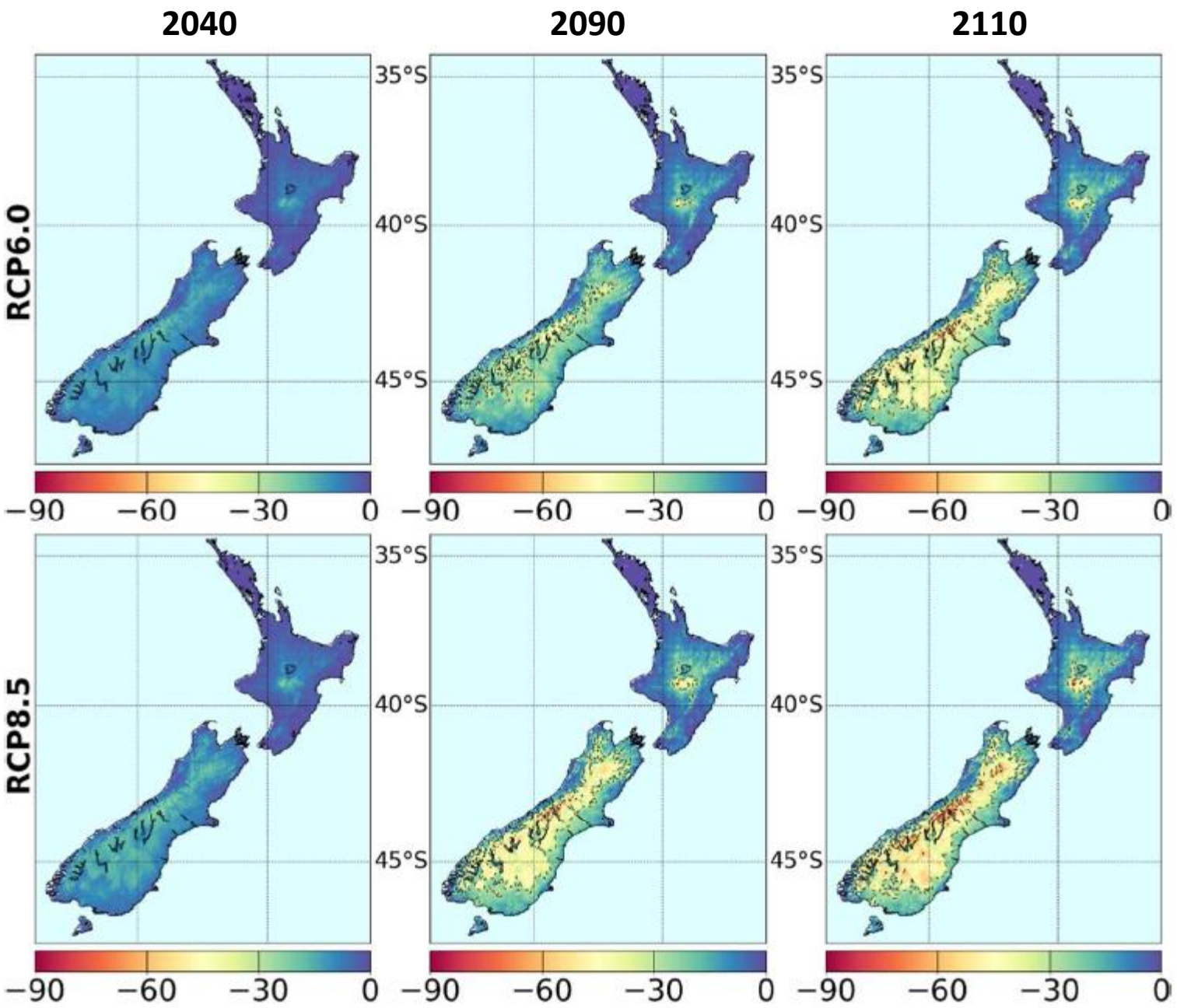
The change is more pronounced at higher towards the north and at higher elevations.



Increase in number of hot days per year (25 degC or above)

The number of days when temperatures drop below freezing (or any temperature threshold) will decline.

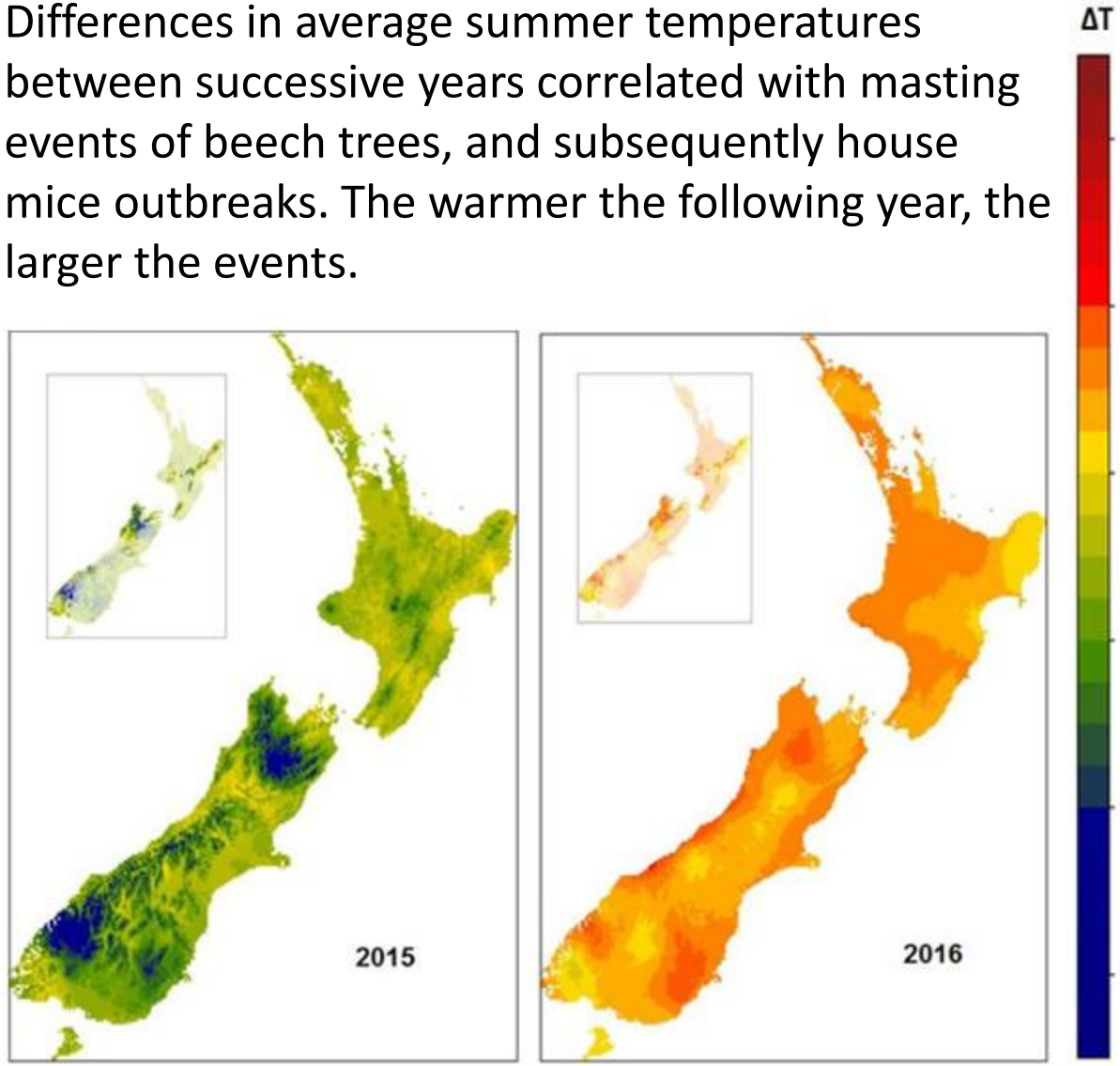
The change is more pronounced at higher elevations and towards the south.



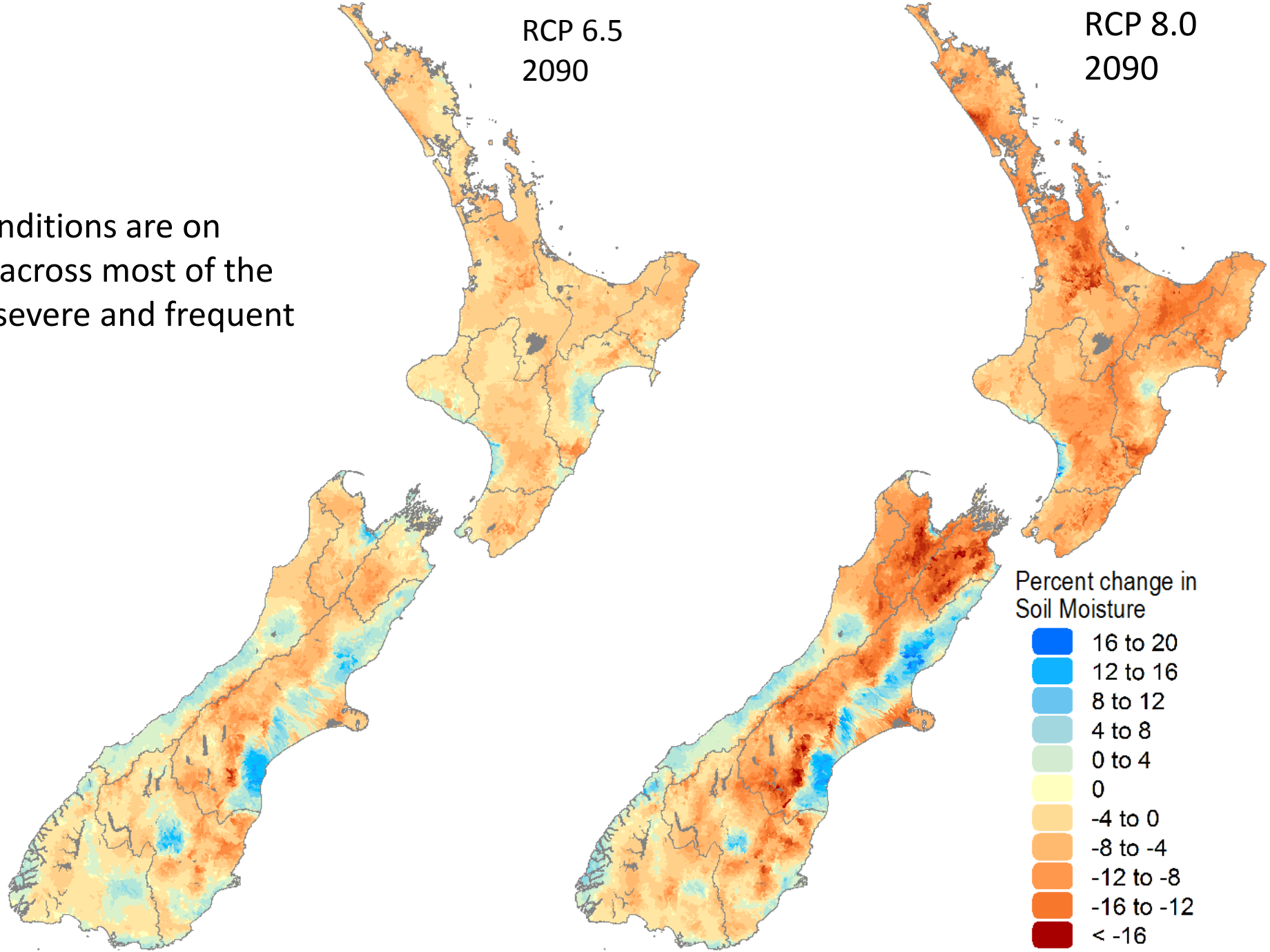
Change in number of cold days per year (0 degC or below)

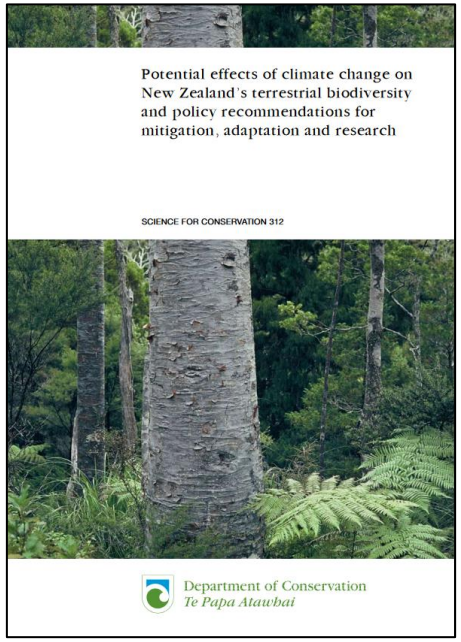
“Battle for the Birds” 2014

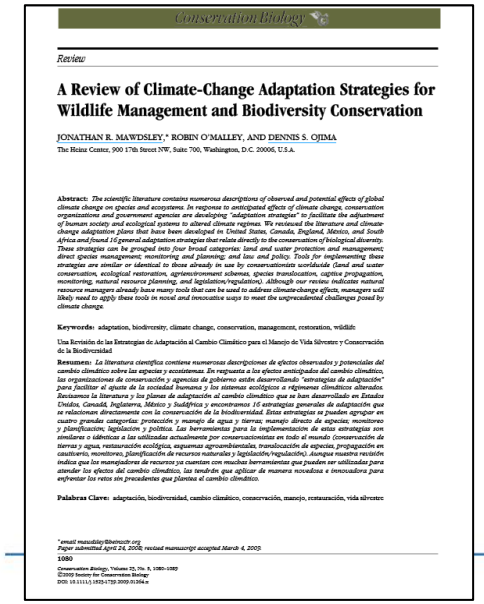
Differences in average summer temperatures between successive years correlated with masting events of beech trees, and subsequently house mice outbreaks. The warmer the following year, the larger the events.



Summer soil moisture conditions are on average projected to dry across most of the country leading to more severe and frequent terrestrial droughts.

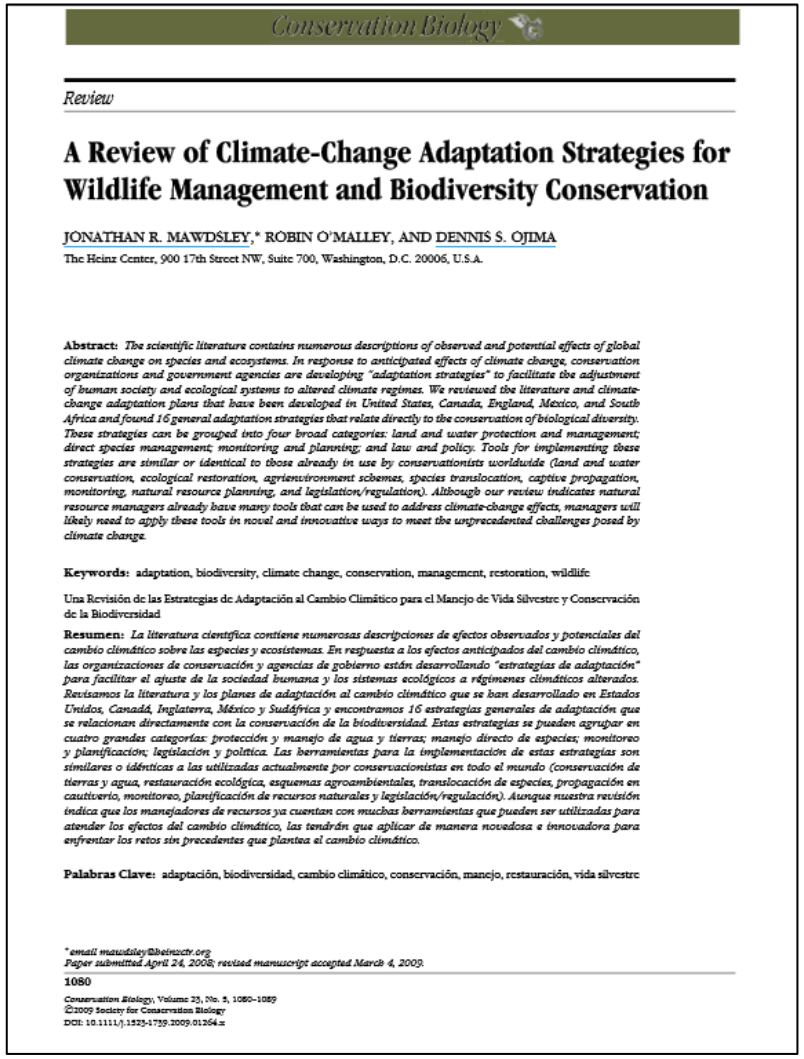






Ecological effects of climate change already observed:

- shifts in species distributions, often along elevational gradients
- changes in the timing of life-history events, or phenology, for particular species
- decoupling of coevolved interactions, such as plant–pollinator relationships
- effects on demographic rates, such as survival and fecundity
- reductions in population size (especially for montane species)
- extinction or extirpation of range-restricted or isolated species and populations
- direct loss of habitat due to sea-level rise, increased fire frequency, disease/pest outbreaks, altered weather patterns, glacial recession, and direct warming of habitats
- increased spread of wildlife diseases, parasites, and zoonoses
- increased populations of species that are direct competitors of focal species for conservation efforts
- increased spread of invasive or non-native species, including plants, animals, and pathogens



Conservation Biology

Review

A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation

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Abstract: *The scientific literature contains numerous descriptions of observed and potential effects of global climate change on species and ecosystems. In response to anticipated effects of climate change, conservation organizations and government agencies are developing "adaptation strategies" to facilitate the adjustment of human society and ecological systems to altered climate regimes. We reviewed the literature and climate-change adaptation plans that have been developed in United States, Canada, England, México, and South Africa and found 16 general adaptation strategies that relate directly to the conservation of biological diversity. These strategies can be grouped into four broad categories: land and water protection and management; direct species management; monitoring and planning; and law and policy. Tools for implementing these strategies are similar or identical to those already in use by conservationists worldwide (land and water conservation, ecological restoration, agrienvironment schemes, species translocation, captive propagation, monitoring, natural resource planning, and legislation/regulation). Although our review indicates natural resource managers already have many tools that can be used to address climate-change effects, managers will likely need to apply these tools in novel and innovative ways to meet the unprecedented challenges posed by climate change.*

Keywords: adaptation, biodiversity, climate change, conservation, management, restoration, wildlife

Una Revisión de las Estrategias de Adaptación al Cambio Climático para el Manejo de Vida Silvestre y Conservación de la Biodiversidad

Resumen: *La literatura científica contiene numerosas descripciones de efectos observados y potenciales del cambio climático sobre las especies y ecosistemas. En respuesta a los efectos anticipados del cambio climático, las organizaciones de conservación y agencias de gobierno están desarrollando "estrategias de adaptación" para facilitar el ajuste de la sociedad humana y los sistemas ecológicos a régimenes climáticos alterados. Revisamos la literatura y los planes de adaptación al cambio climático que se han desarrollado en Estados Unidos, Canadá, Inglaterra, México y Sudáfrica y encontramos 16 estrategias generales de adaptación que se relacionan directamente con la conservación de la biodiversidad. Estas estrategias se pueden agrupar en cuatro grandes categorías: protección y manejo de agua y tierras; manejo directo de especies; monitoreo y planificación; legislación y política. Las herramientas para la implementación de estas estrategias son similares o idénticas a las utilizadas actualmente por conservacionistas en todo el mundo (conservación de tierras y agua, restauración ecológica, esquemas agroambientales, translocación de especies, propagación en cautiverio, monitoreo, planificación de recursos naturales y legislación/regulación). Aunque nuestra revisión indica que los manejadores de recursos ya cuentan con muchas herramientas que pueden ser utilizadas para atender los efectos del cambio climático, las tendrán que aplicar de manera novedosa e innovadora para enfrentar los retos sin precedentes que plantea el cambio climático.*

Palabras Clave: adaptación, biodiversidad, cambio climático, conservación, manejo, restauración, vida silvestre

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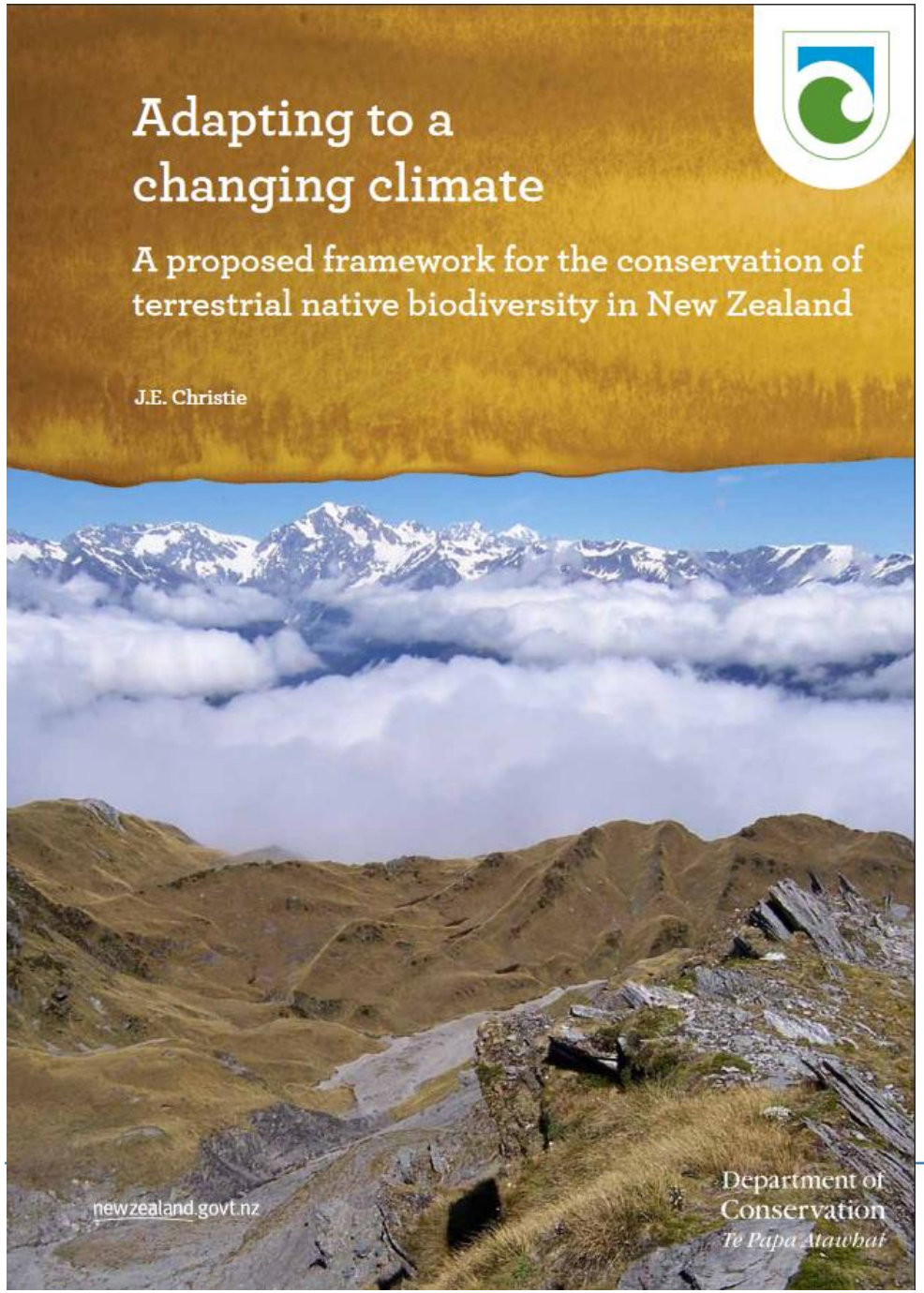
Climate change adaptation strategies

1. Increase extent of protected areas
2. Improve representation and replication within protected area networks
3. Improve resilience of existing sites
4. Design new sites to maximise resilience
5. Protect movement corridors, stepping stones, and refugia
6. Manage and restore ecosystem function rather than focusing on specific components (species or assemblage)
7. Increase landscape permeability to species movement
8. Focus resources on species that might become extinct
9. Translocate species at risk of extinction
10. Establish captive populations of species threatened with extinction
11. Reduce pressure from other sources (e.g., pests, habitat loss)
12. Evaluate and enhance monitoring programmes
13. Incorporate climate change into management plans



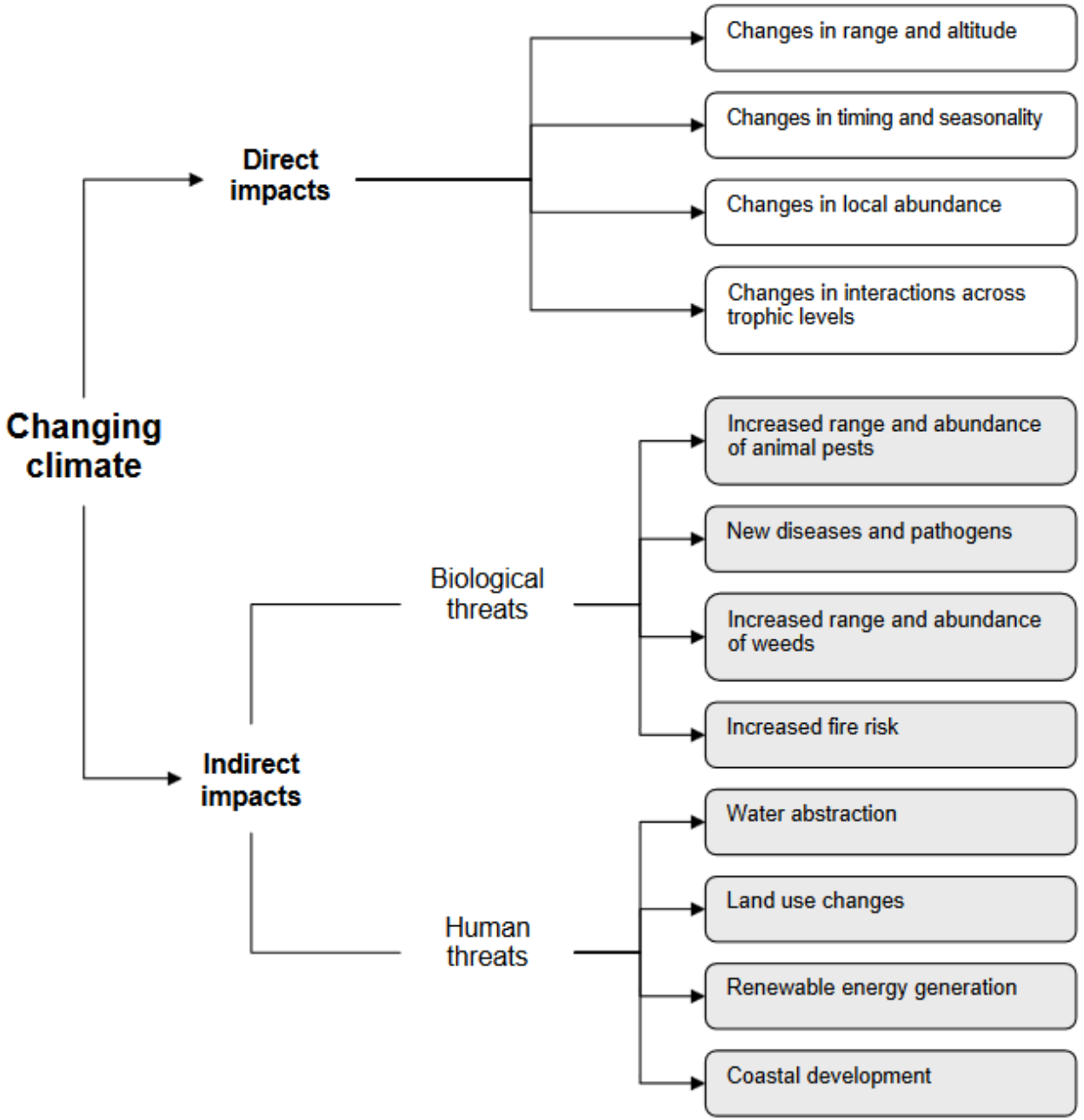


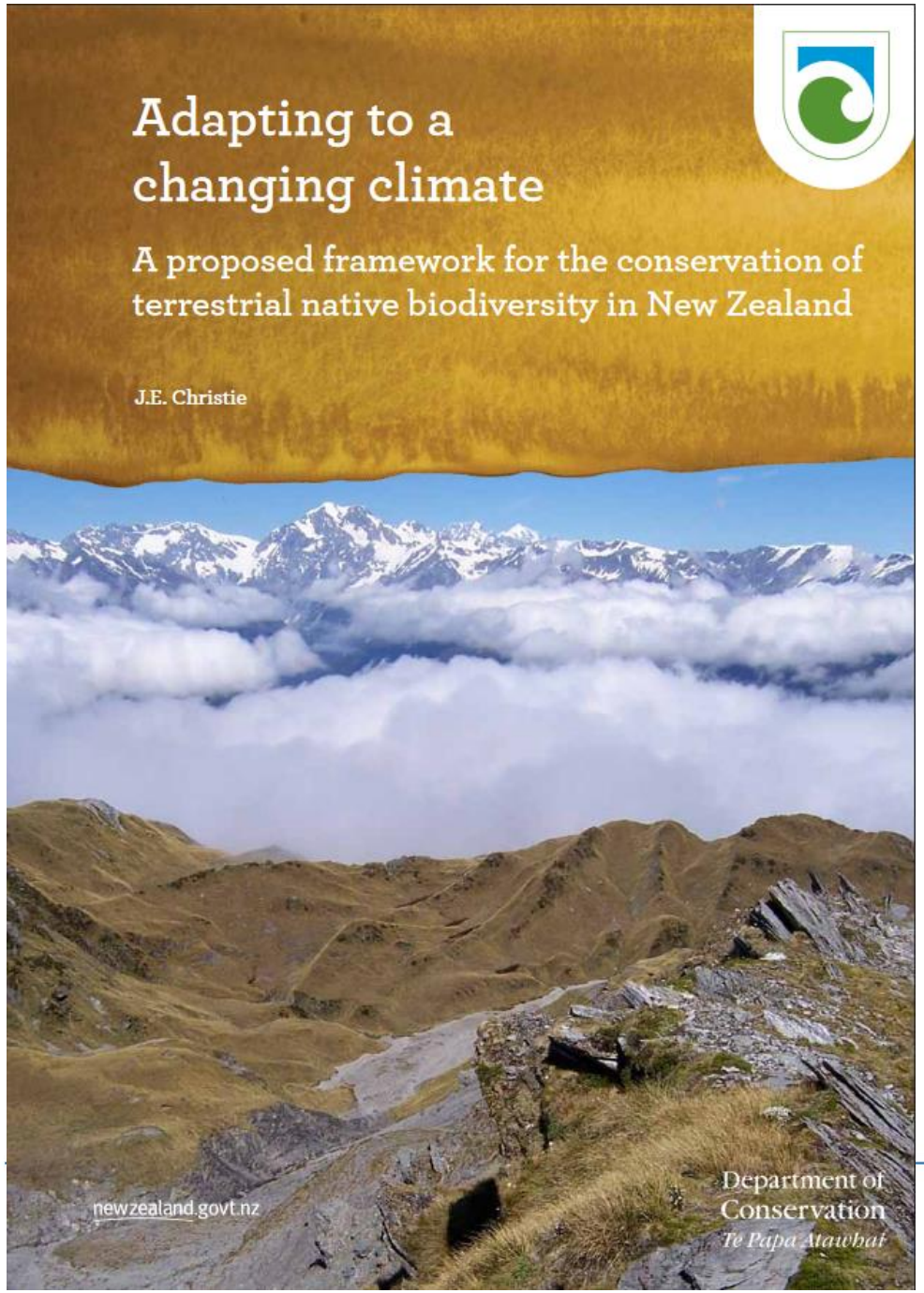
Figure 1. Examples of both new (white) and existing (light grey) threats, and their relationship to direct and indirect impacts caused by a changing climate.

SONZ locations

DOC National Parks

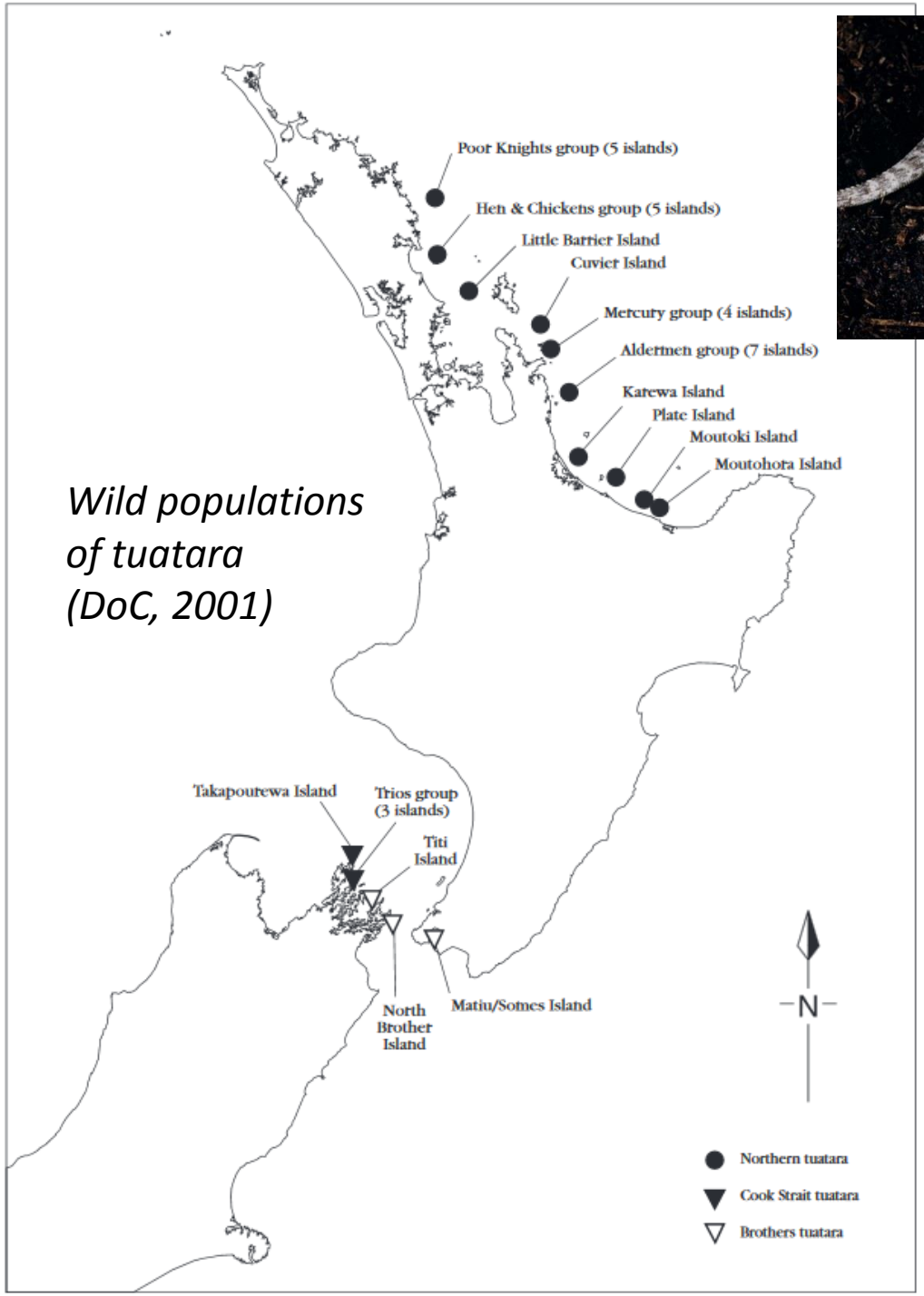
Existing SONZ locations are predominantly located in highly climate-sensitive regions and may not accommodate iso-climatic translocations.

SONZ and National Park locations combined may not provide the full range of necessary climate change refugia.



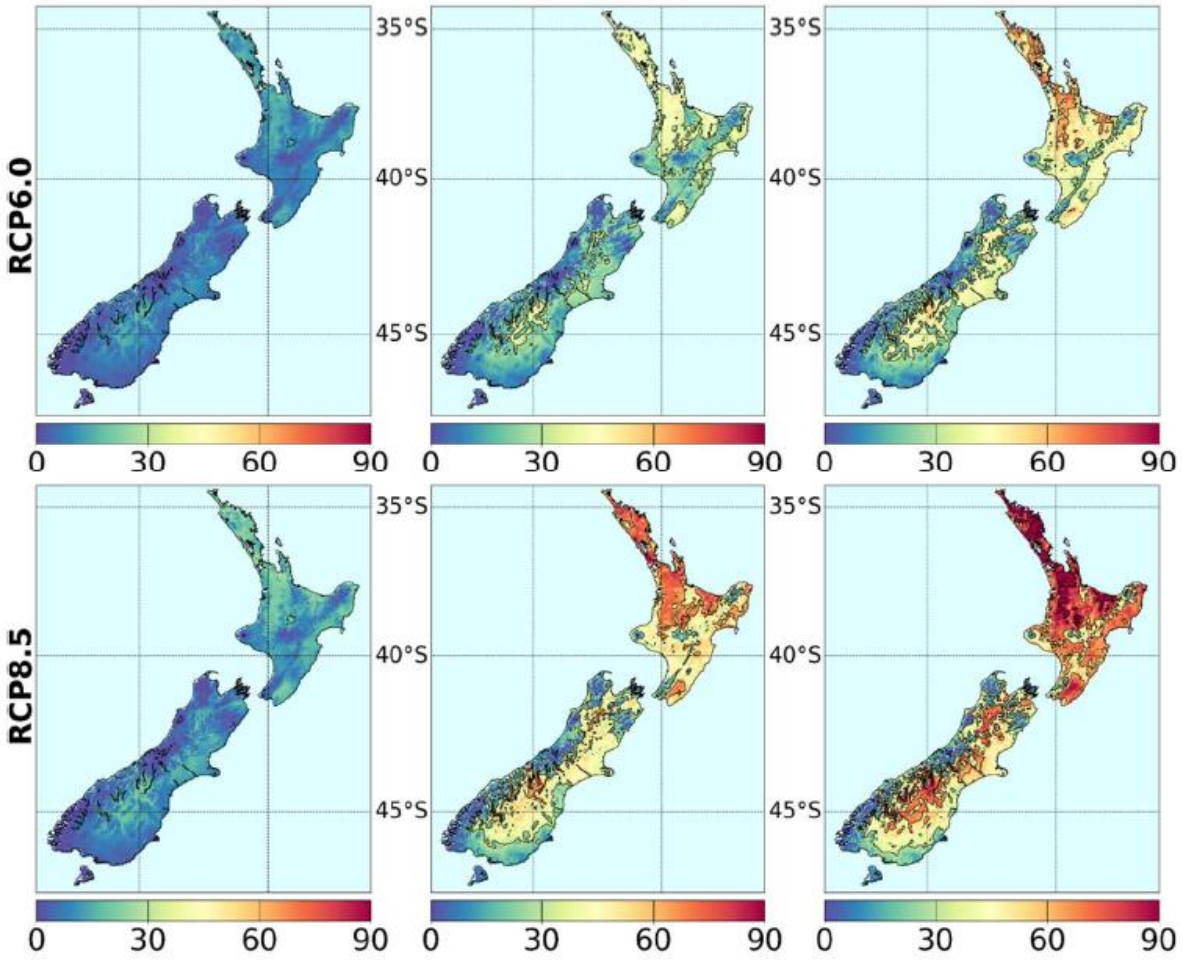
Proposed strategies

1. Improve knowledge of the impacts of climate change on species and ecosystems
2. Develop decision-support tool and adaptation methods
3. Incorporate climate change adaptation strategies into existing management and research programmes, planning and policy
4. Improve management and restoration of existing species and ecosystems to facilitate resilience to climate change
5. Raise awareness and understanding of the impacts of climate change on biodiversity



Wild populations of tuatara (DoC, 2001)

The northern island sanctuaries will experience substantial increases in the number of hot days; Marlborough and Cook's Straight sanctuaries are less sensitive to this change.



Summary

Climate change will affect habitat conditions and resource available, in turn affecting both the prevalence of pests and the distribution of habitat ranges. This is in addition to existing pest and habitat pressures.

Shifts in habitat ranges may challenge the feasibility of site-specific restoration goals, including full species dominance, and would thus prompt a greater reliance on iso-climate refugia and translocations, climate change corridors, as well as local interventions.

Mechanistic modelling can help understand potential species effects, but projections will always be uncertain. Direct observations will also lag decades behind onset of effect. Therefore adaptation must be robust and precautionary.