Experimental approaches to resisting and redirecting high-latitude climate feedbacks

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Troth Yeddha' (Fairbanks)

unceded lands of the Lower Tanana Dene

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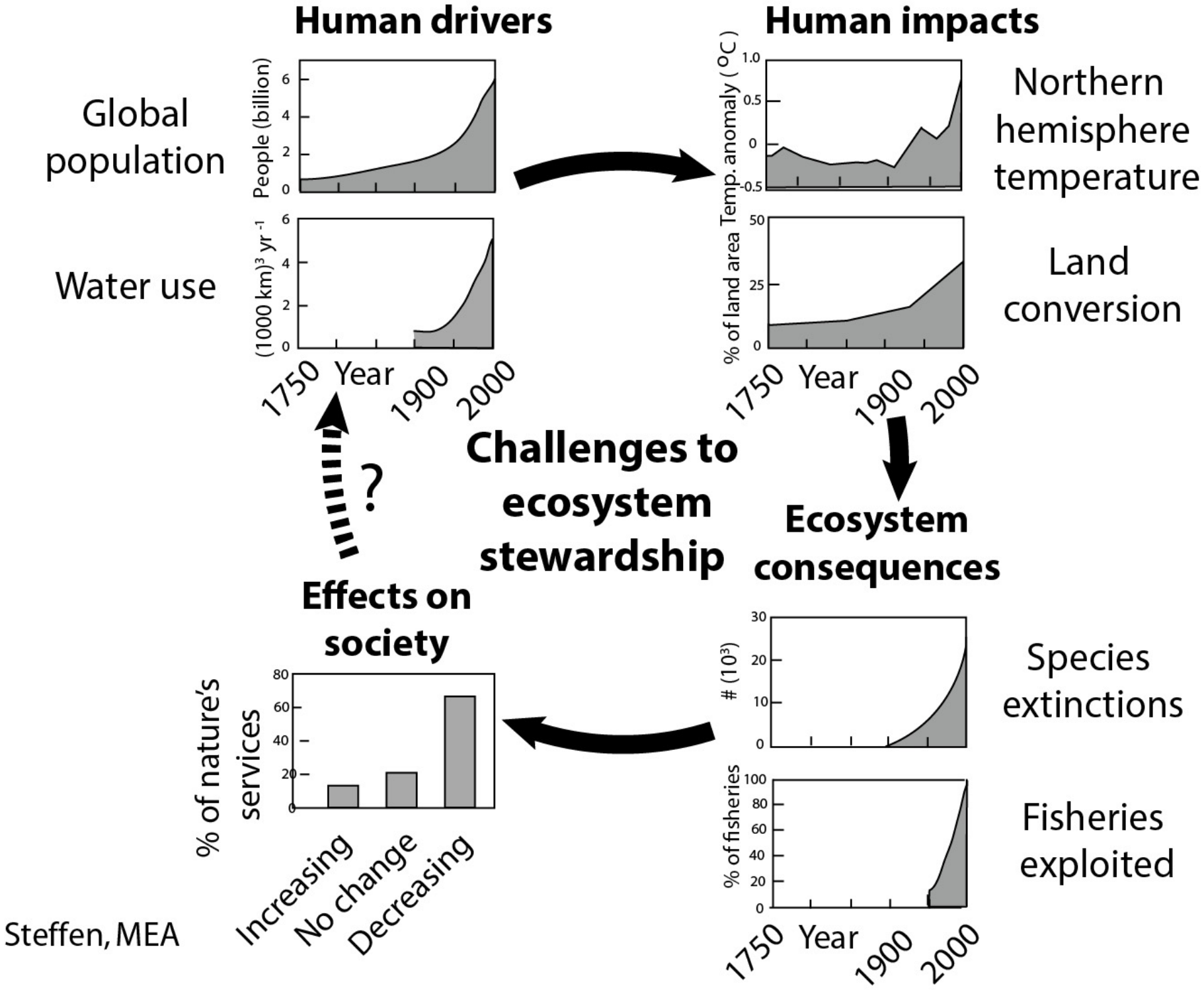
Here's where climate change is headed, and we aren't prepared!

Global consequences of climate warming

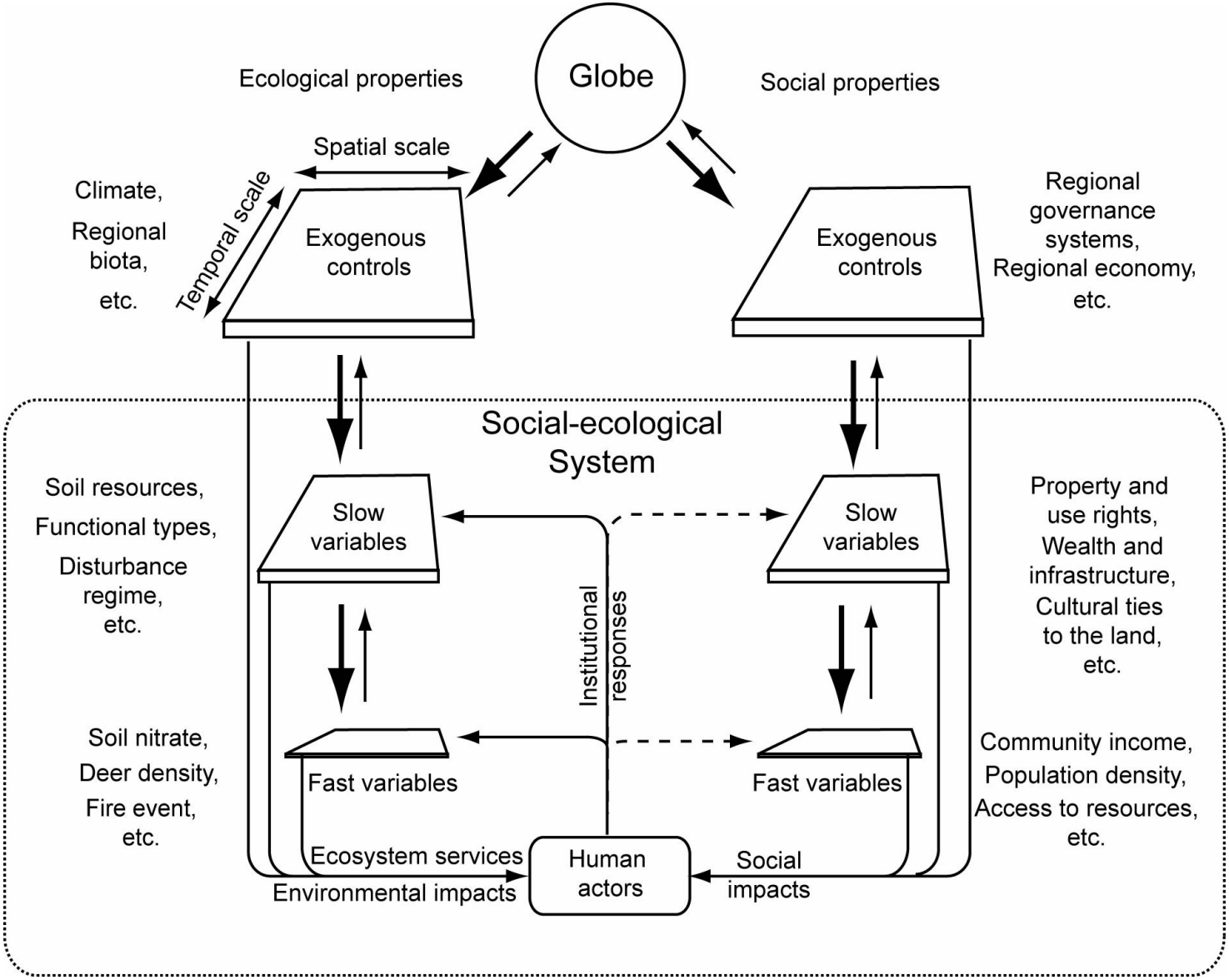
- More frequent extreme weather
  - Droughts in dry climates
  - Floods in wet climates
  - Hurricanes and storm surges on coasts
- Social disruption faced by *today's* youth
  - Food insecurity
  - Mass migration


Human drivers
Human impacts
Global population
People (billion)
Water use
(1000 km)³ yr⁻¹
1750
Year
1900
2000
Northern hemisphere temperature
Temp. anomaly (°C)
Land conversion
% of land area
Challenges to ecosystem stewardship
?
Ecosystem consequences
Effects on society
Species extinctions
(10³)
Fisheries exploited
% of fisheries
% of nature's services
Increasing
No change
Decreasing
Steffen, MEA

Stewardship

- Active shaping of pathways of social-ecological change to enhance ecosystem health and human well-being
- Key features
  - Active intervention to shape change
  - System of people as part of nature
  - Two goals: ecosystem health, human well-being
    - Not people ***or*** nature, but people ***with*** the rest of nature

If exogenous controls change substantially, social-ecological systems will inevitably change



Chapin et al. 2006

Some permafrost has massive ice and carbon

Sometimes this carbon is released quickly

How might permafrost thaw influence atmospheric carbon?

- Expose more carbon to decomposition (+)
- Improve conditions for decomposition (+)
- Increase C flux to aquatic systems (+/-)
- Release N and P to enhance productivity (-)
- Increase drought and fire in some places (+)
- Foster vegetation change (-/+)
- Accelerate permafrost thaw (+?)

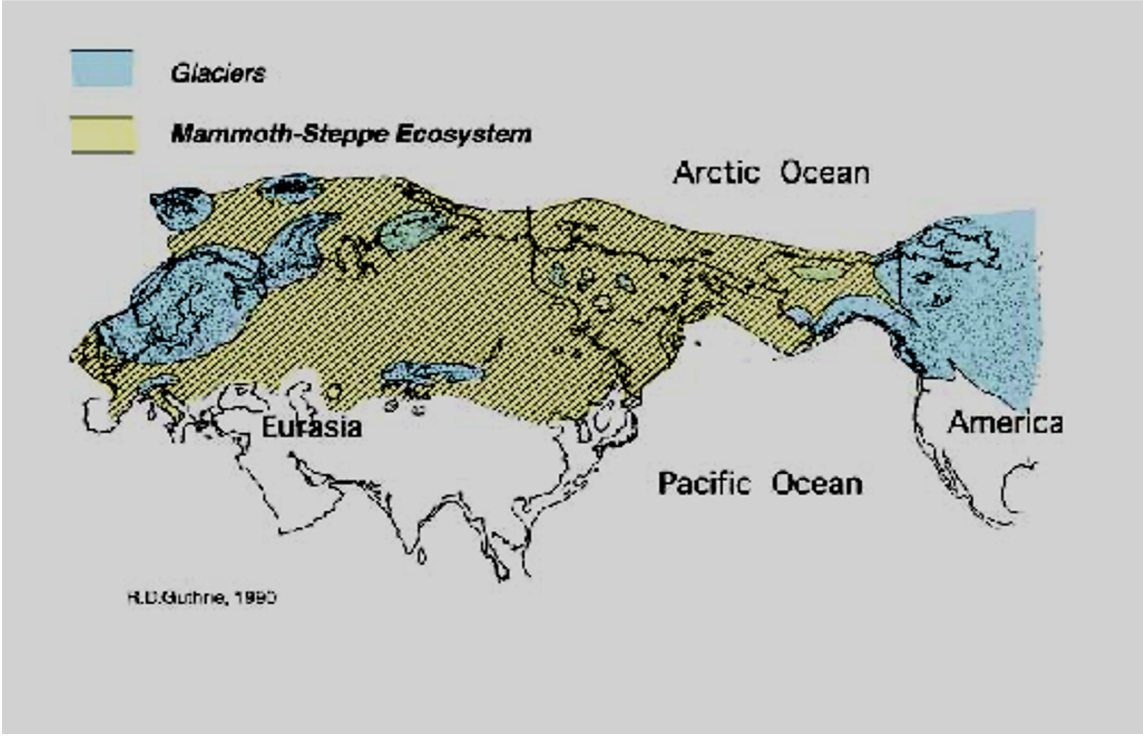
Reducing C loss from permafrost: Hypothetical solution options

- Reduce warming rate of global climate
  - Reduce human emissions
  - Increase stratospheric aerosols
- Increase albedo
  - High-latitude ecosystem change (eg, deforestation)
- Alter summer/winter heat flux
  - Alter surface insulation
- Alter ratio of respiration to photosynthesis
  - Alter plant/microbial functional groups

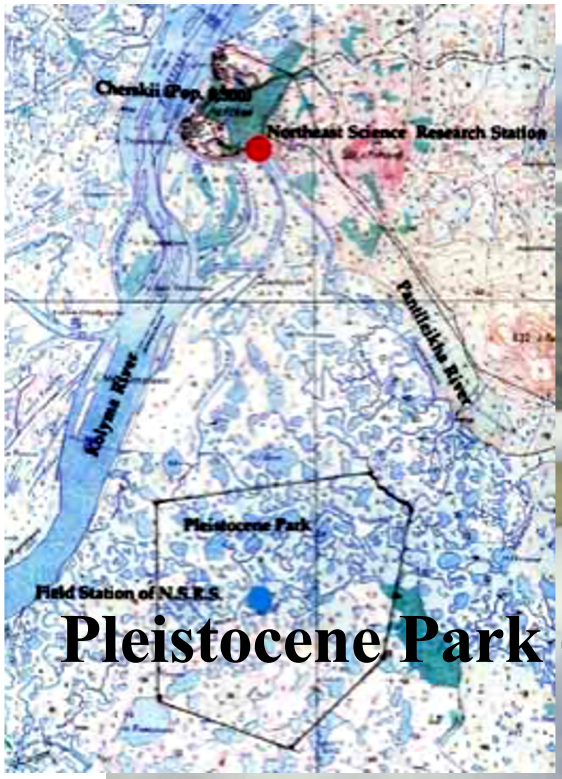

Northeast
Science
Station
Pleistocene
Park
RUSSIA
CANADA
UNITED STATES
(Alaska)
North Pole
Arctic Ocean
Laptev Sea
East Siberian Sea
Chukchi Sea
Beaufort Sea
Bering Sea
Sea of Okhotsk
North Pacific Ocean
Hudson Bay
Victoria Island
Banks Island
New Siberian Islands
Severnaya Zemlya
Wrangel Island
Arctic Circle
average minimum extent of sea ice
Noril'sk
Tura
Lensk
Tiksi
Verkhoyansk
Yakutsk
Kolyma
Evensk
Anadyr'
Provideniya
Barrow
Prudhoe Bay
Inuvik
Dawson
Whitehorse
Fairbanks
Nome
Valdez
Anchorage
Bethel
Cambridge Bay
Yellowknife
Echo Bay
Sakhalin
JAPAN
Occupied by the Soviet Union in 1945, administered by Russia, claimed by Japan.

Formulate hypothesis
Debate for understanding
Model
Debate
Develop new models

Estimate areal extent and key drivers
Estimate properties through literature review
Estimate carbon stock



Select experimental sites
(Forest-tundra border; forest-steppe border)



Pleistocene Park (160 km^2 or 40,000 acres)

Establish experiment

Fenced enclosures

Import large herbivores

Preliminary observations

Measurements

Carbon stocks

Carbon fluxes

Scientific steps

- Formulate hypothesis and model system
- Estimate areal extent, properties, and drivers
- Select experimental sites
- Establish experiment
- Preliminary observations
- Measurements
- Evaluate: estimate impact, alternative explanations, indirect effects, and interactions
- Refine and repeat this scientific process

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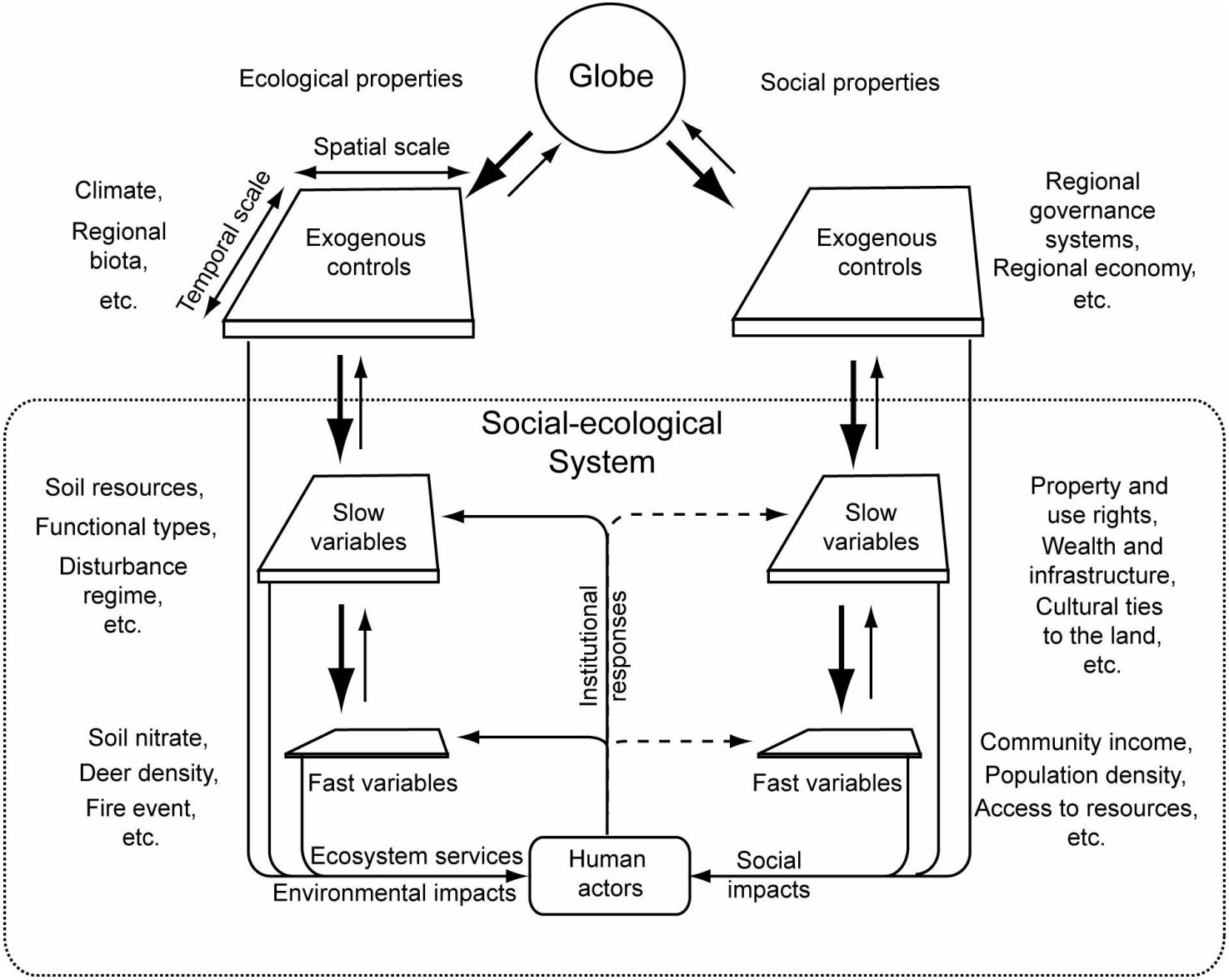

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