Greening and browning vegetation trends in northern West Siberia:

Spatial heterogeneity and correspondence to weather patterns

Prof. Andrey Soromotin (Tyumen State Univ.) measuring meteo-parameters above disturbed tundra for CLIMECO and HIARC projects, 2018

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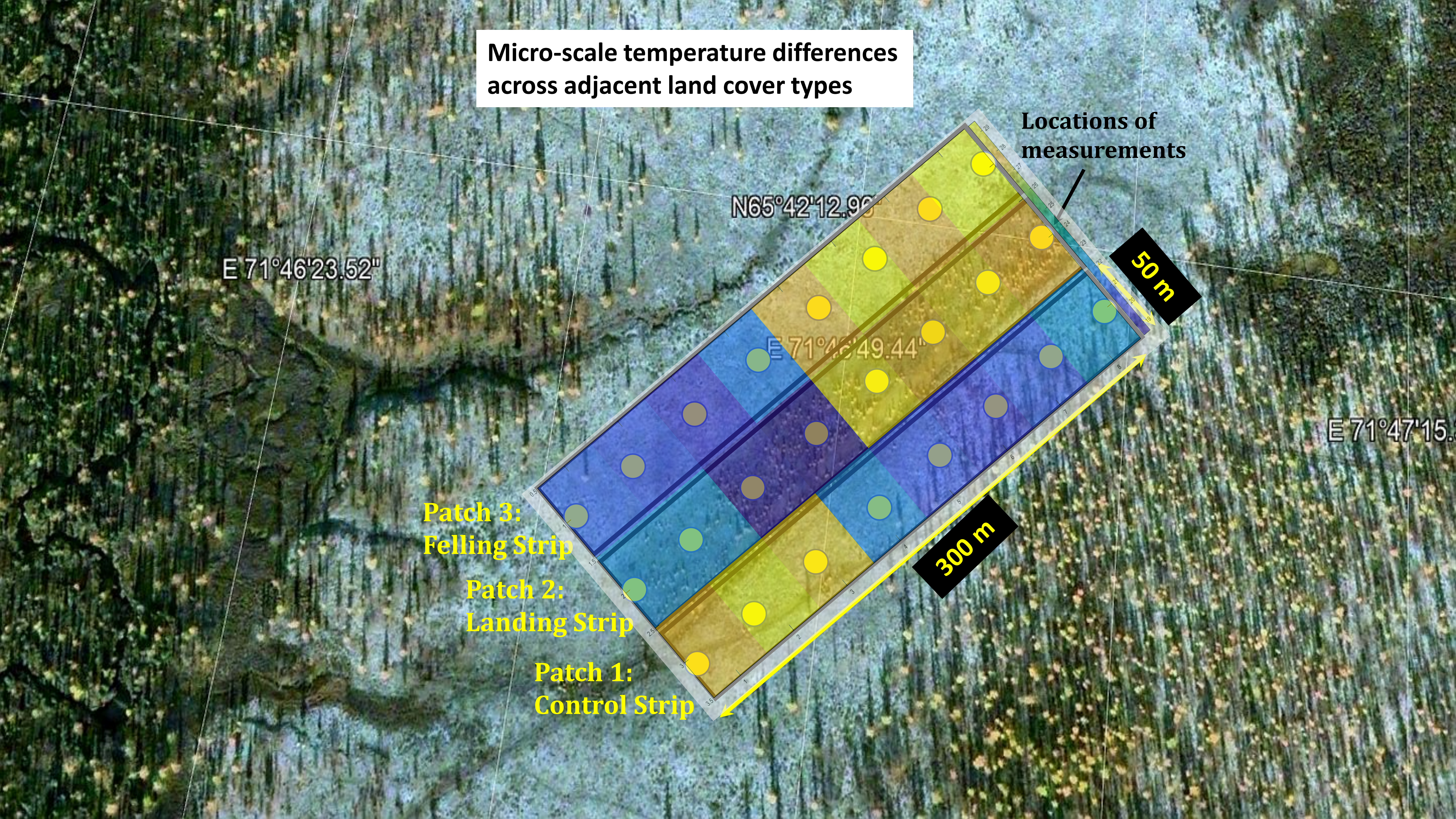
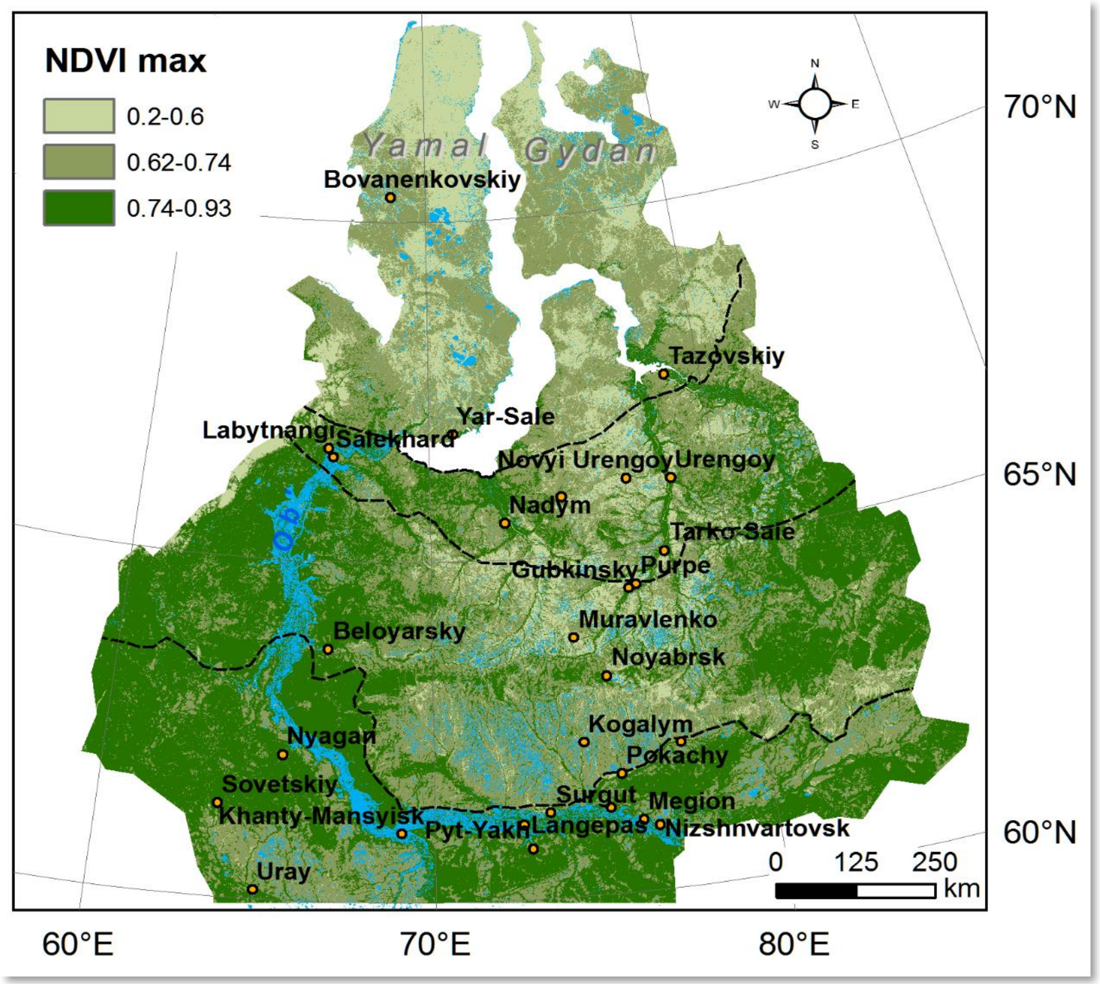
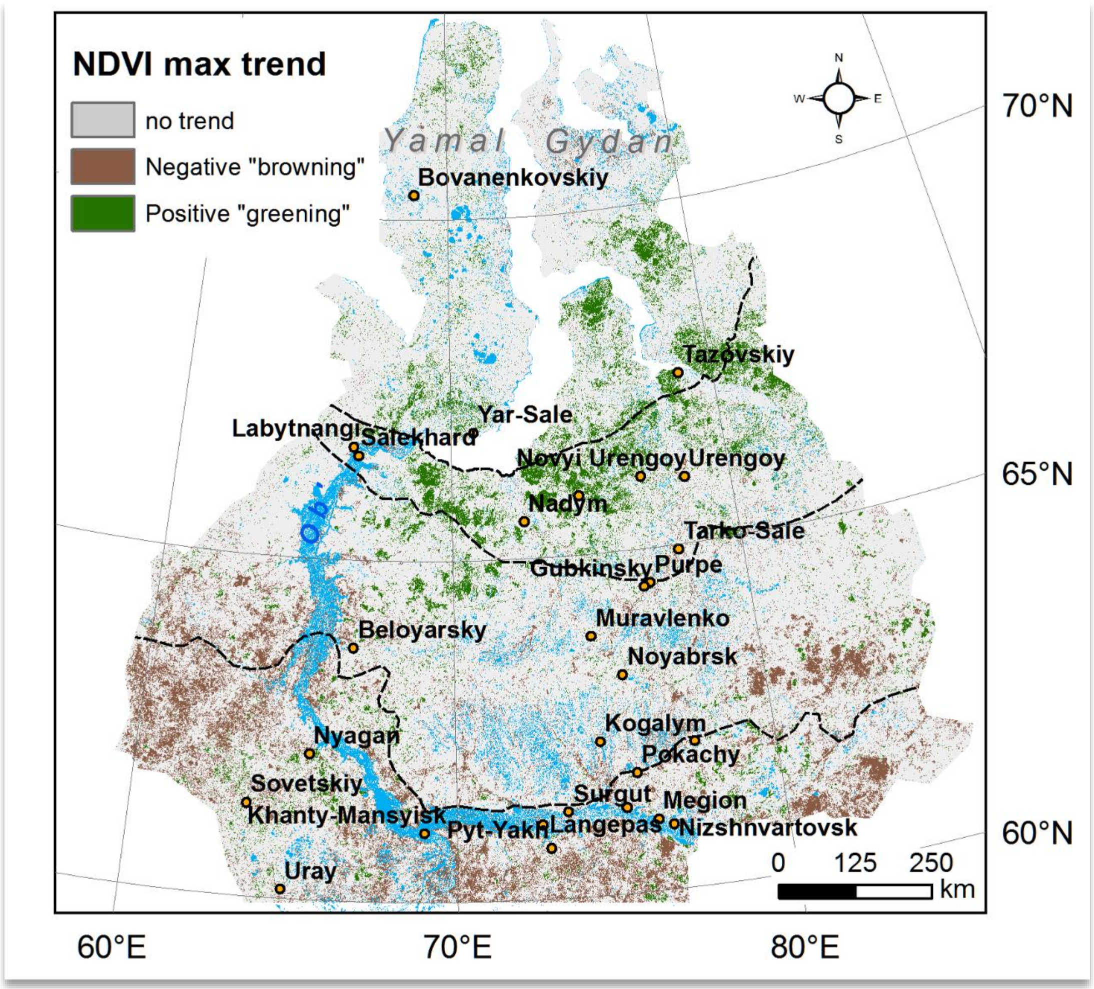
Alternative ecosystems supported by local climates


Micro-scale temperature differences across adjacent land cover types
Locations of measurements
N65°42'12.96"
E 71°46'23.52"
E 71°46'49.44"
E 71°47'15.
50 m
300 m
Patch 3: Felling Strip
Patch 2: Landing Strip
Patch 1: Control Strip

Vegetation Photosynthetic Productivity (Normalized Difference Vegetation Index)

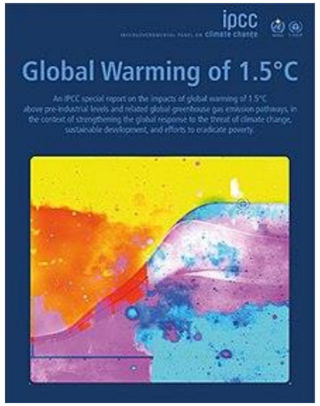


NDVImax 2000-2014



NDVImax trend($p<0.05$) 2000-2014

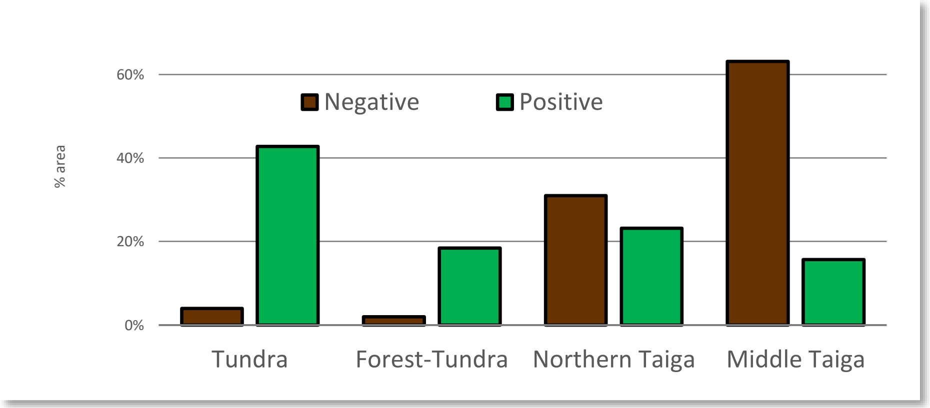
Regional, Eco-systemic and Bio-climatic Synthesis



Page 3-12. In "Unique and Threatened Systems" the transition from high to very high risk is located between 1.5ºC and 2ºC global warming as opposed to at 2.6ºC global warming in AR5, owing to new and multiple lines of evidence for changing risks for … the Arctic … (***high confidence***)

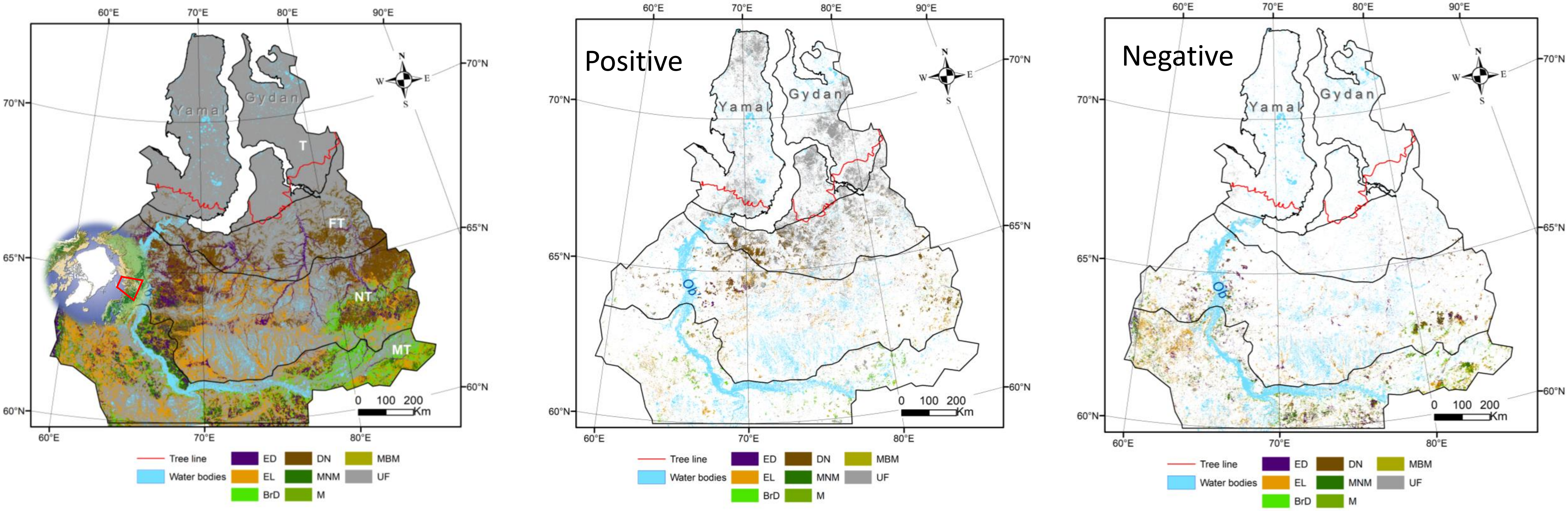
Latitudinal and elevational shifts of biomes (major ecosystem types) boreal … regions have been detected and confirmed (e.g. for shrub encroachment on tundra). Attribution studies indicate that anthropogenic climate change has made a greater contribution to these changes than any other factor (***medium confidence***).

- ***Trends proportion between bioclimatic zones***



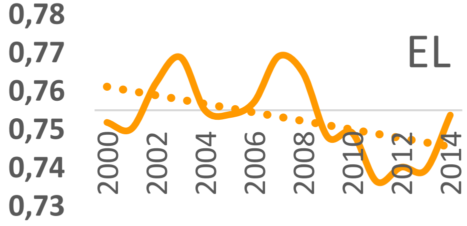
18% of the total NWS area had statistically **significant changes** in productivity, with 8.4% increasing (greening) and 9.6% decreasing (browning)

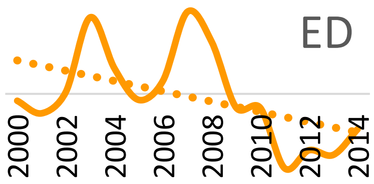
Bio-climatic trends

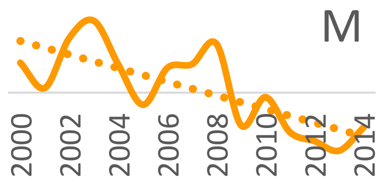


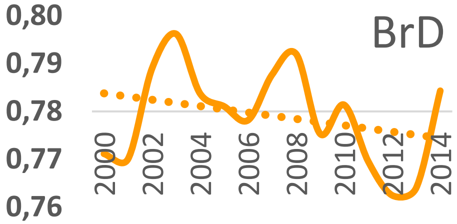
Spatial distribution of statistically significant ($p < 0.05$) trends of maximum NDVI in northern West Siberia 2000–2016: (*a*) greening (positive trend) and (*b*) browning (negative trend).

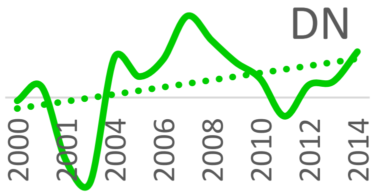
Eco-systemic trends

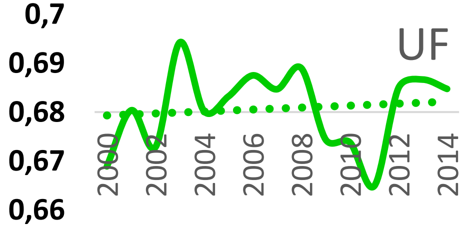












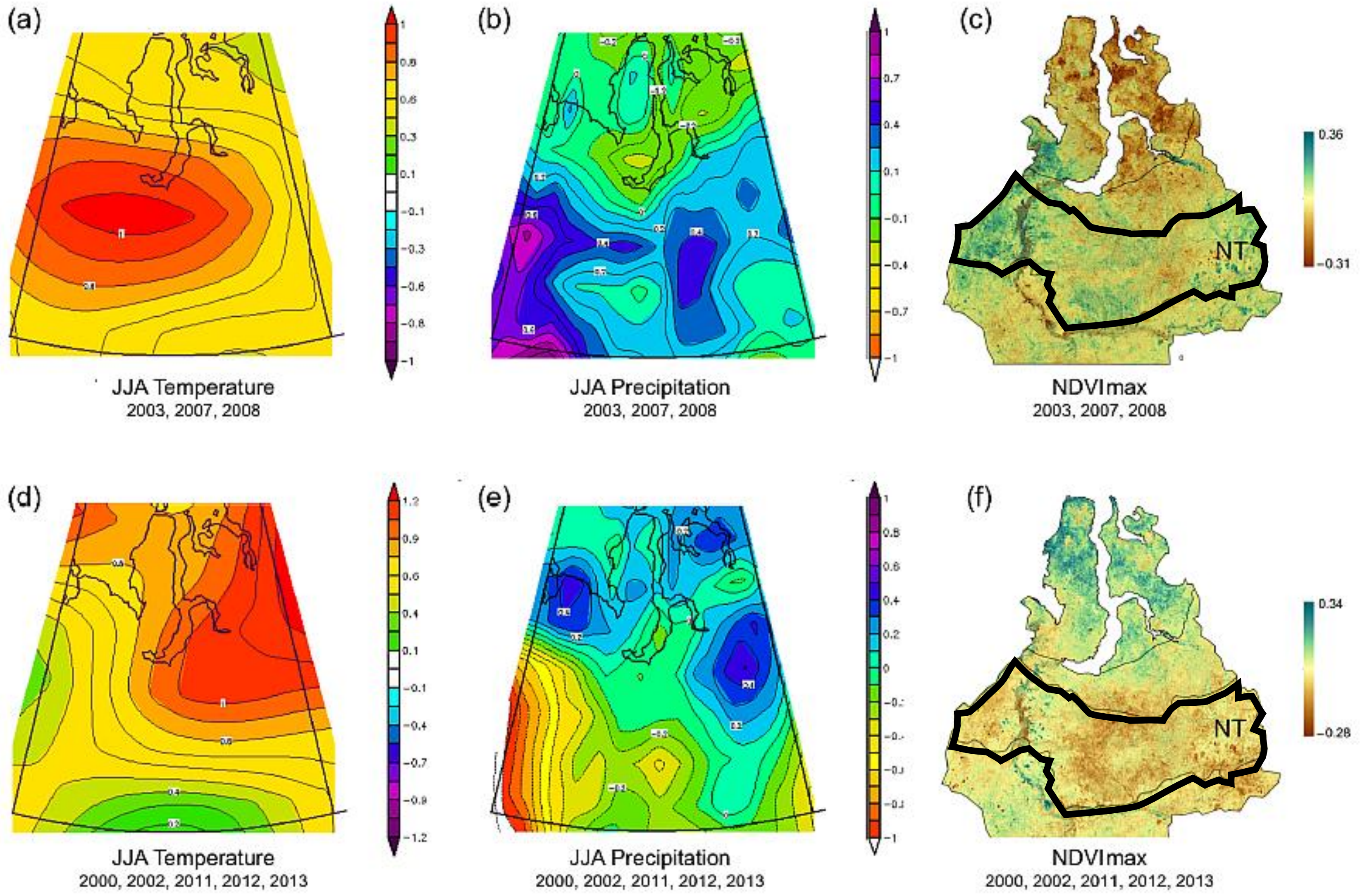
DN: Larch (*Larix sibirica*) forest, shows a significant increase in productivity, even while neighboring different species show productivity decrease

Contrasting trends for different species within the same bioclimatic zone

Negative trends in the taiga mainly related to a decline **in evergreen coniferous forest (ED,EL)**

In contrast, **needle-leaf deciduous (DN)** forest dominated by larch *(Larix sibirica)* shows significant **increase**

Regional trends: Climate – Vegetation composite analysis

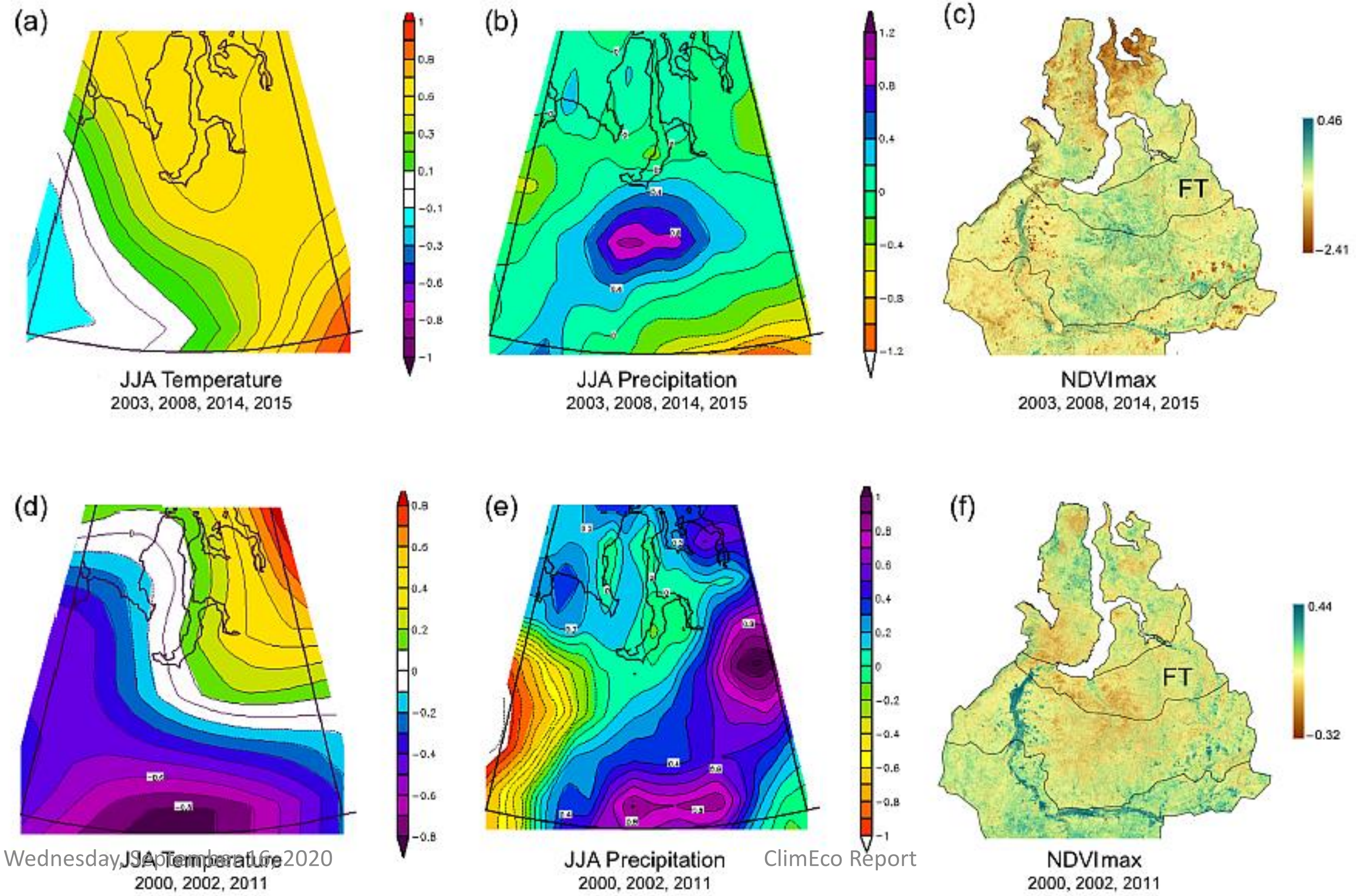


Northern Taiga

Greening: *Summer temperature and precipitation patterns corresponding the greening (positive NDVI trends) in the* ***Northern Taiga ecotone***

Browning

Regional trends: Climate – Vegetation composite analysis

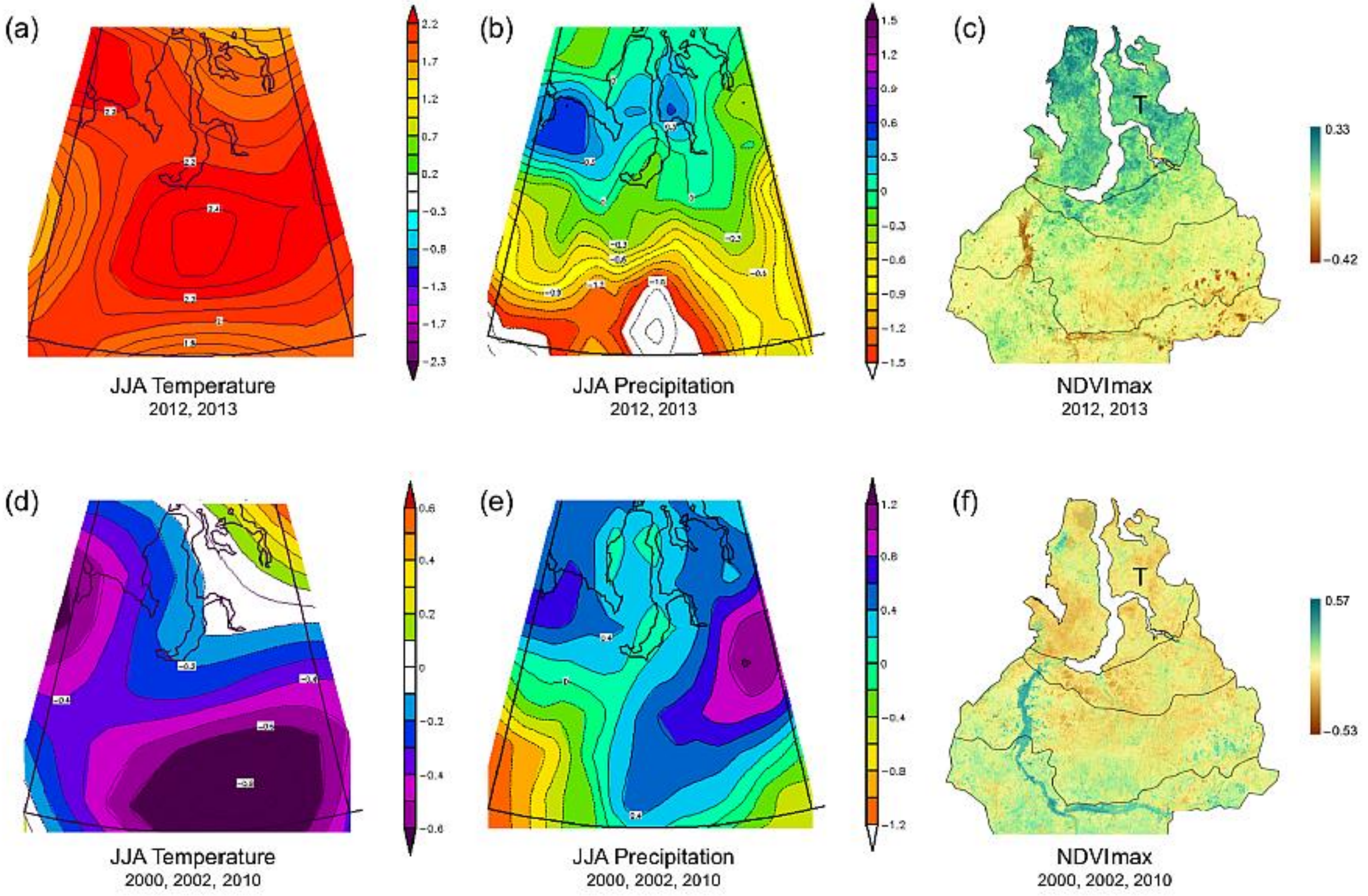


Forest-Tundra

Greening

Browning

Regional trends: Climate – Vegetation composite analysis



Tundra

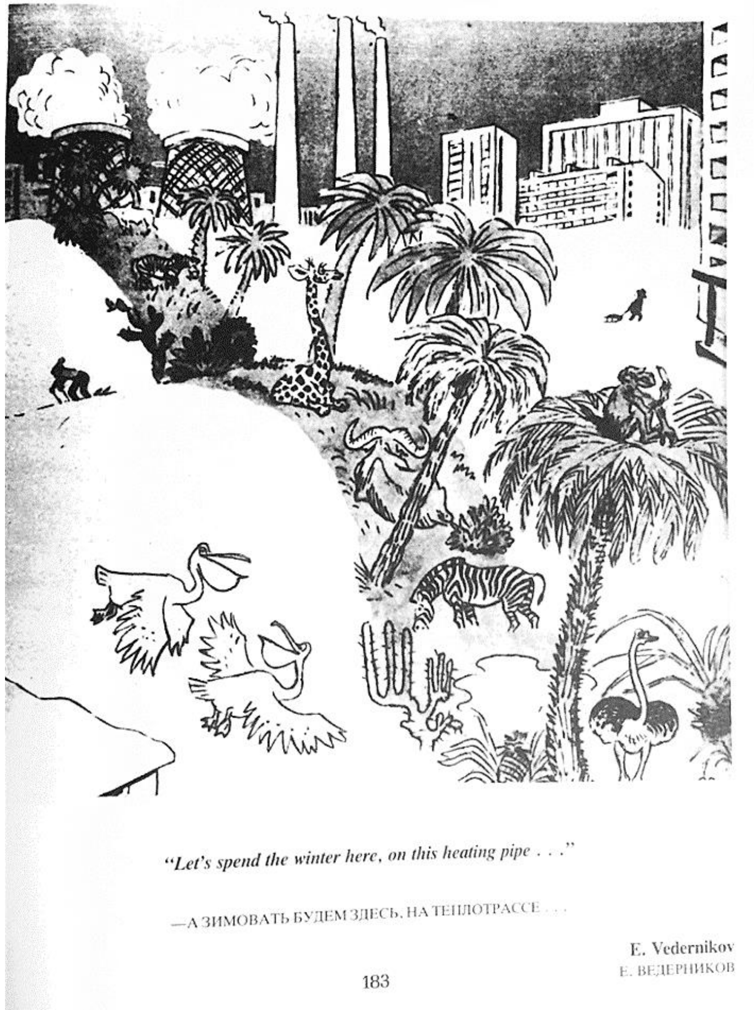
Greening

Browning

Anthropogenic Impact on Transition to Alternative Ecosystems

- Development alternative ecosystem on anthropogenically disturbed patches
- UHI affects the local climate that otherwise would only be found hundreds of kilometers to the south
- UHI effects on vegetation productivity, phenology and biodiversity

Vegetation cover changes along the gas pipeline Nadym-Punga.
Courtesy: TyumSU

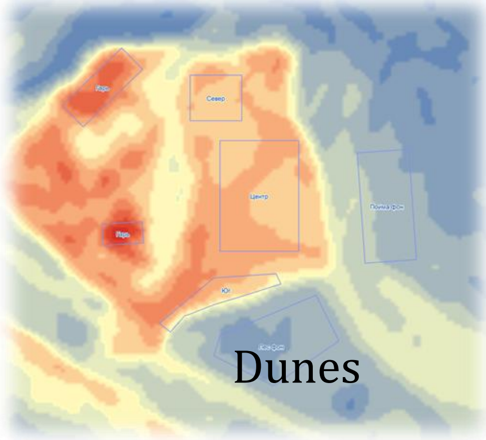


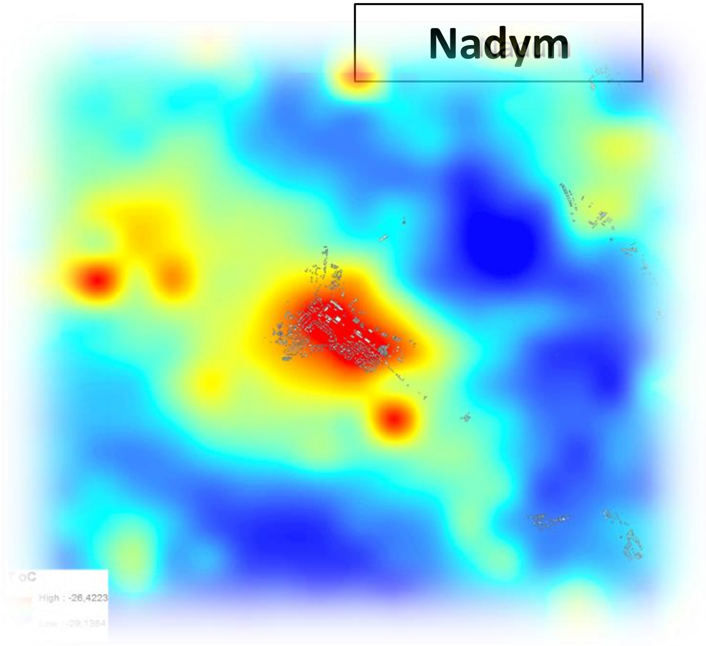
Wider Anthropogenic Impact on Environment

Long time, aggregated

0.1 – 10 m
Plant response physiology:
Controlled Arctic Tundra Warming Experiments (Elmendorf et al. 2012)

10 – 1000 m
Habitat response:
Natural plant refugia observations (Sizov et al. 2016)





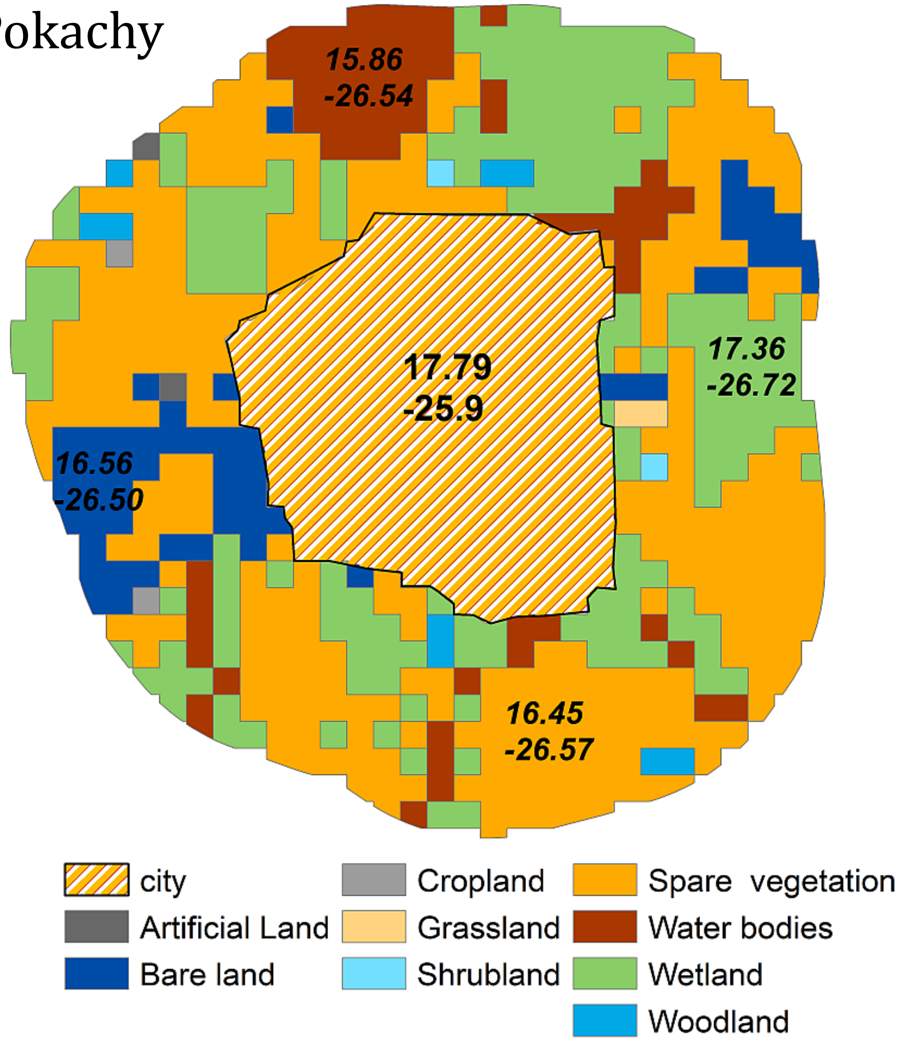
1 – 100 km
Eco-systemic response with interacting plant communities:
Local climate hot spots (Srodnykh et al. 2008)

Short time, detailed

Micro-scale | Meso-scale | Large-scale | Regional-scale

Exogenous factors of local climate anomalies

Pokachy



Anthropic Biome Concept

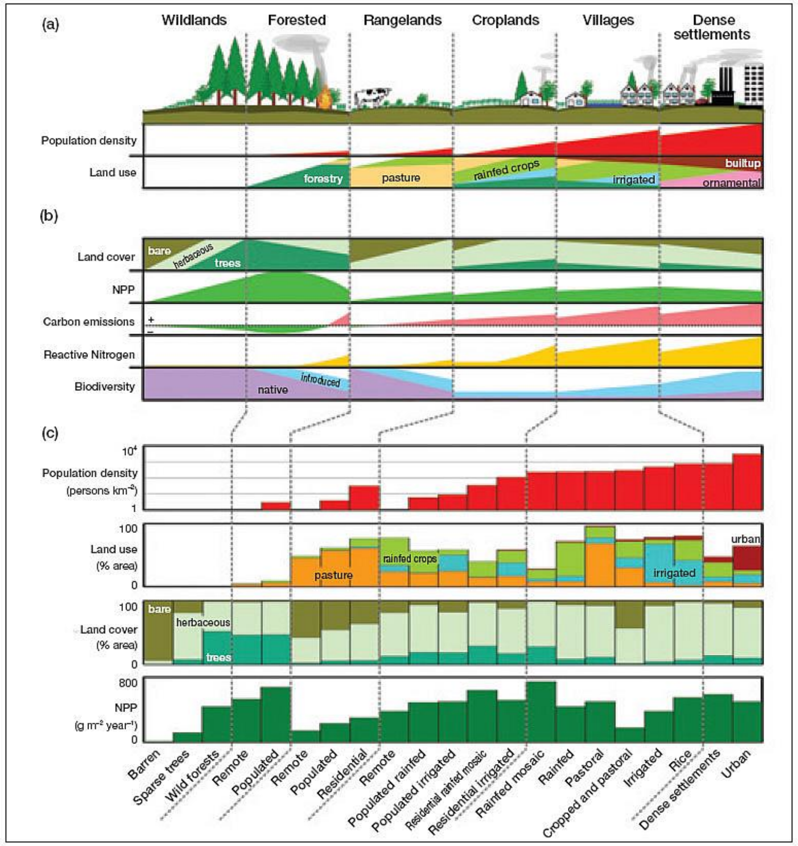
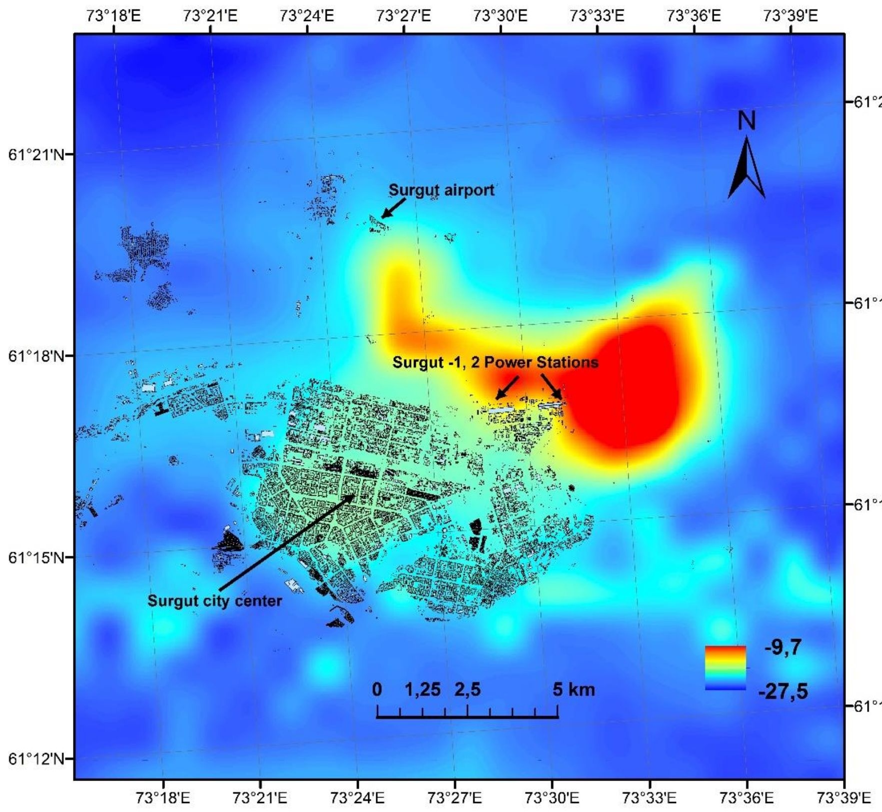


Figure 3: Conceptual model of anthropogenic biomes compared with data from Ellis, Erle C. and Navin Ramankutty, "Putting people in the map: anthropogenic biomes of the world." *Frontiers in Ecology and the Environment*, 2008; 6, doi: 10.1890/070062

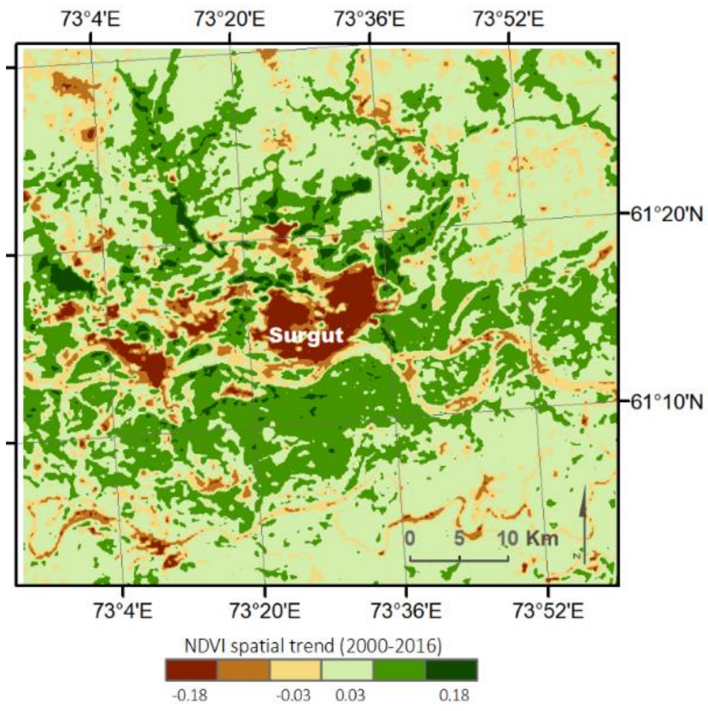
"While urban ecologists have developed a robust literature on urban soils, trees, stormwater management and other services, studies often seems to float upon ***an <u>assumption</u> that the environment in which these exist is altered.***"

Stephanie Pincetl (UCLA), 2015: ***Cities as Novel Biomes: Recognizing Urban Ecosystem Services as Anthropogenic***, Frontiers of Ecol. Evol., doi:10.3389/fevo.2015.00140

Green Rings around Cities



Large and persistent urban heat "island", e.g. Surgut (Russia) has +5C – corresponds to climate change by 2100.

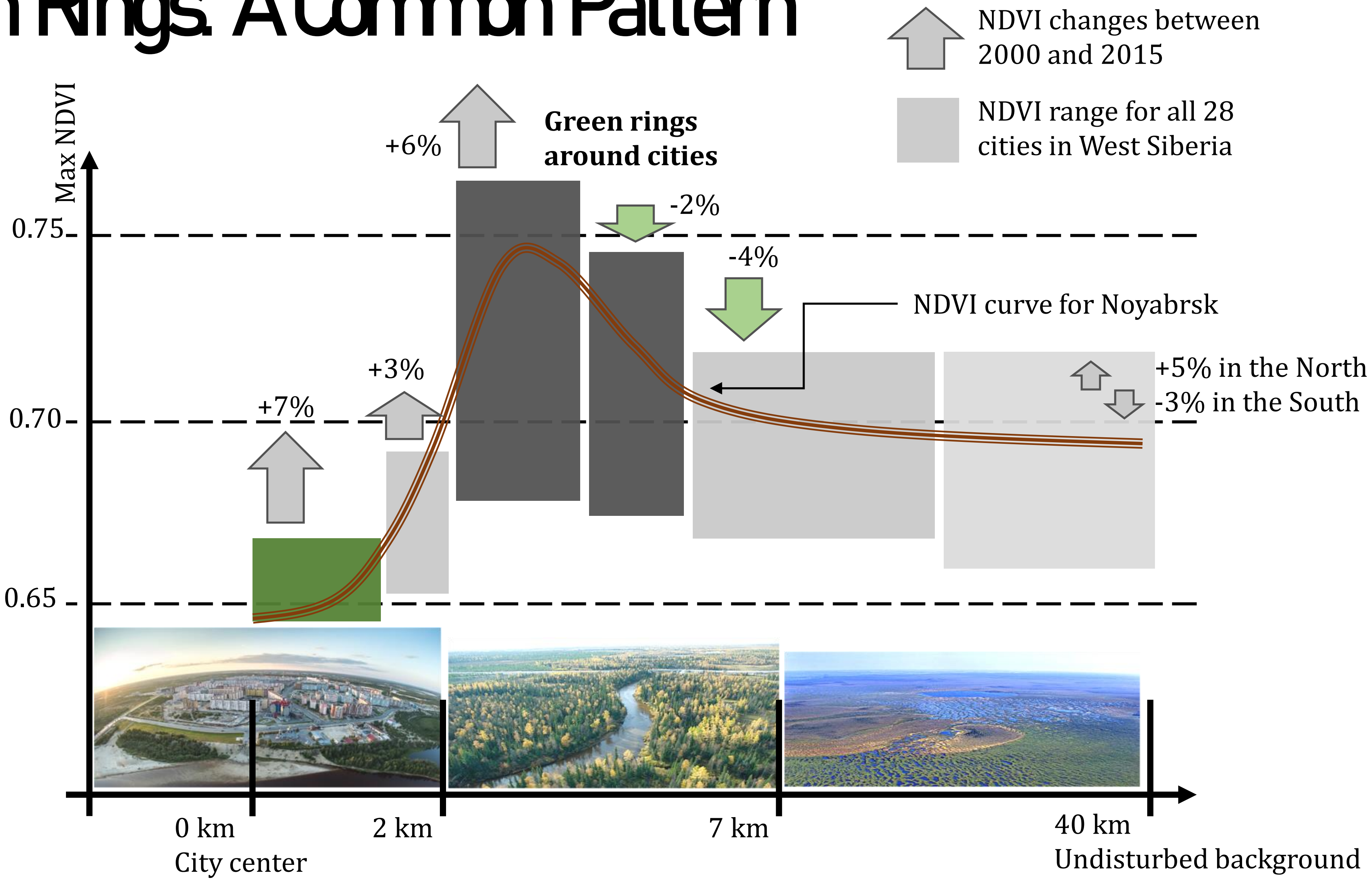


Warmer urban temperatures induce longer phenological seasons and more active biological production around the cities.

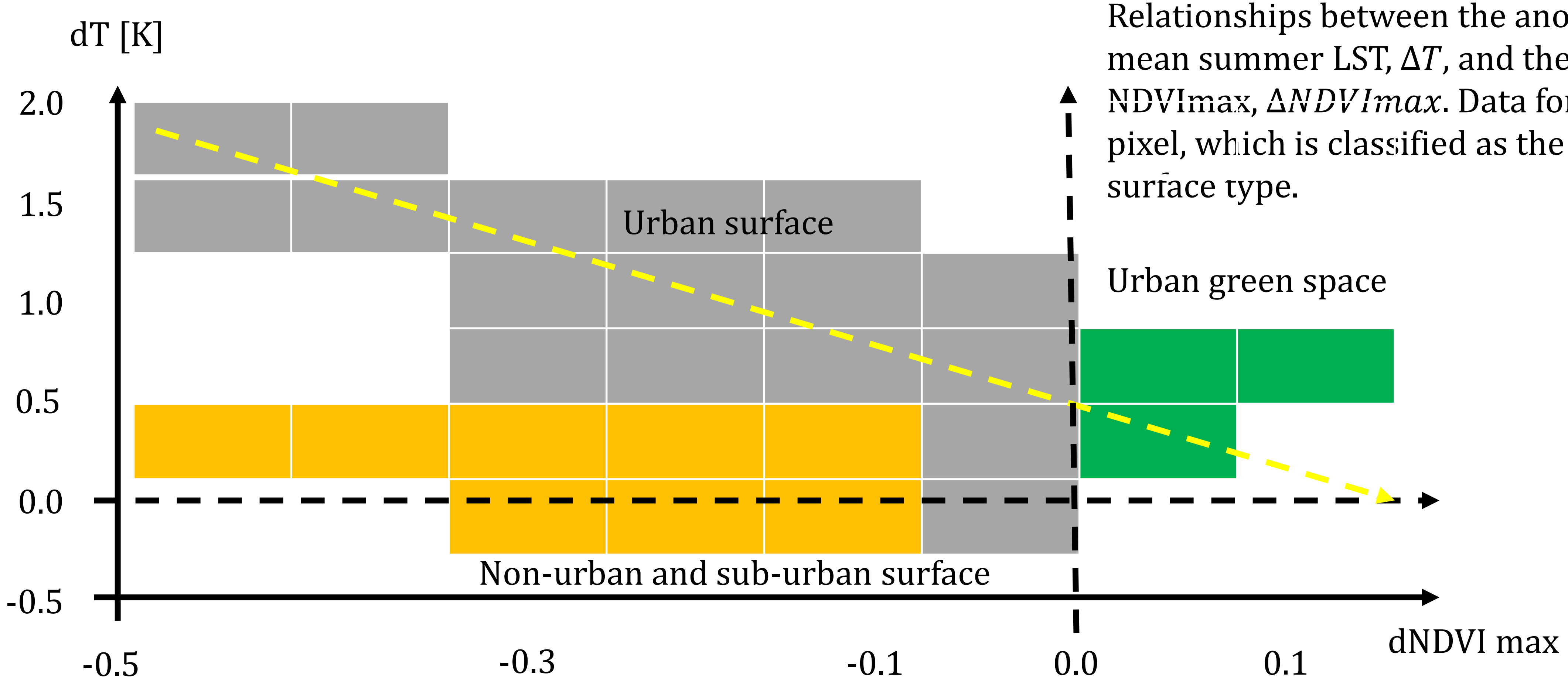
HIARC example: Vegetation around Surgut becomes more productive (positive NDVI trends) on the background of negative bio-productivity trends.

17-year (2000-2016) average NDVI max value from MODIS NDVI product (MOD13Q1).

Green Rings: A Common Pattern



Urban footprint and vegetation response



Relationships between the anomalous mean summer LST, ΔT, and the anomalous NDVImax, $\Delta NDVImax$. Data for each 1 km pixel, which is classified as the urban surface type.

Conclusions

- Northern biomes are in rapid transition to new alternative types
- Within Northern West Siberia, the most significant transition
  - In Forest-tundra ecotone; Dominated by northern shift of larch habitats and shrubification of tundra
  - In Middle taiga ecotone; Dominated by degradation of old-grown forest
- Anthropogenic impact is significant even on this sparsely populated territory
  - Anthropic biomes show the strongest changes
  - Alternative, more productive eco-systems occupy the disturbed land
  - Urban areas are surrounded by the green rings