Climate-LCLUC Interactions in Eastern Europe

Focus area includes Eastern Europe, European Russia, and arctic Eurasia

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Overview of current methods and selected results

- LCLUC-Climate Interactions in Eastern Europe and European Russia
  - Selected ongoing research projects and methods
  - Selected findings
  - Selected recommendations
- LCLUC-Climate Interactions in the Eurasian Arctic
  - Climate and Landcover Changes
  - Reindeer Herding Interactions with Climate and Landcover Changes

Background - IPCC Summary

- European climate change impacts documented:
  - retreating glaciers
  - longer growing seasons
  - shift of species ranges
  - health impacts due to a heat wave of unprecedented magnitude
- Observed recent changes consistent with model predictions
- Future impacts of climate change predicted for Central/East Europe:
  - Summer precipitation to decrease, causing higher water stress.
  - Increased heat waves.
  - Forest productivity to decline
  - Peatland fires to increase.
- Future impacts of climate change predicted for Northern Europe:
  - reduced demand for heating
  - increased crop yields
  - increased forest growth.
  - more frequent winter floods,
  - endangered ecosystems

Reference: Intergovernmental Panel on Climate Change, "Climate Change 2007: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report: Summary for Policymakers; from the IPCC WGII Fourth Assessment Report, April 2007.

Climate Change, Agriculture and Wetlands in Eastern Europe: Vulnerability, Adaptation and Policy

Ellen Hartig, Ognyan Grozev, Cynthia Rosenzweig

- Assessed climate change impacts on freshwater and coastal wetlands in several East European countries
  - Based on reports for the U.S. Country Studies Program: 1995
- Significance: European bogs important on a global-level
  - 60% of global methane emissions come from peat-rich bogs in 50 – 70 degrees North latitude
  - Scandinavia: 49% of world's forested bogs,
  - Eastern Europe has 27% of forested bogs (taken at the 1° x 1° grid cell).
- History of wetland management in East Europe
  - Humans began draining wetlands for agriculture 2000 years ago.
  - Process intensified in East Europe between 1100 – 1300 A.D.
  - Peter the Great began large-scale wetland drainage in Russia ~1700
  - Pace seriously accelerated in 20th century.

Reference: Ellen Hartig, Ognyan Grozev, Cynthia Rosenzweig, "Climate Change, Agriculture and Wetlands in Eastern Europe: Vulnerability, Adaptation and Policy", *Climate Change*, Vol 36, pp. 107 – 121, 1997.

Effects of climate, disturbance, and species on forest biomass across Russia

Olga Krankina et al.

- Study site: Russia
- Main research question: How have climate and disturbance each affected biomass across Russia?
- Data:
  - detailed Russian forest inventory data (43 forests)
  - Corresponding meteorological data in/near these forests.
- Methods:
  - Calculated live biomass
    - Using conversion factors was developed by Alexeyev and Birdsey 1998
    - Krankina elaborated on a method for estimating regional stocks of coarse woody debris.
  - Developed regression models
    - Dependent variables: biomass/biomass increase
    - Independent variables: climatic variables, human disturbance characteristics,
      - Controlled for tree species and interaction effects

Reference: O.N. Krankina, R.A. Houghton, M.E. Harmon, E.H. (Ted) Hogg, D. Butman, M. Yatskov, M. Huso, R.F. Treyfeld, V.N. Razuvaev, and G. Spycher, "Effects of climate, disturbance, and species on forest biomass across Russia", Canadian Journal of Forest Research 35 no9 2281-93 S 2005

Krankina et al. Results

- Unexpectedly found a poor correlation between biomass accumulation and climate.
  - Implies difficulty in accurate biomass accumulation models under different climate scenarios
- Common practice: removal of most productive stands from the population of mature stands
  - Effect: to depress the average biomass in older stands.
- Significant correlation found between
  - biomass at age 40, and
  - amount of forest disturbance
  - This is likely due to the following:
    - More of the productive forest lands tend to be in younger age-classes because:
      - Timber harvest occurs more in the most productive forest lands, and
      - there is greater investment in artificial forest regeneration in the most productive timber-producing locations.

Krankina et al. Results

- Previous 2 points:
  - Depressed average biomass in older stands
  - Increased biomass in young stands where forest disturbance is common
- Confounds empirical data relationships between age and forest biomass accumulation for large-scale forest inventory data.
  - “Survivorship bias”, because human-induced disturbances (cutting) are nonrandom.
- Survivorship bias may affect analyses of the effects of climate change on forest productivity and biomass.
- Since forests of warmer regions tend to be more frequently harvested, the survivorship bias may be stronger in warmer regions.

Response of forest growth to climate variability and change

Malcolm Hughes, Andrew Bunn, Alexander Oltchev

- Study site: European Russia
  - Central to the Northern limit of tree growth
- Research questions:
  - How do tree ring and satellite-image based data compare for studying forest growth and climate change?
  - Have climate, forest growth, and the relationship between these two changed in the past 30, as compared with the past 100 years?
- Data
  - satellite-image based estimates of forest growth for the past 30 years
  - 100+ years of tree-ring chronologies of European Russia
  - Meteorological data of the region (40 – 150 years of data, depending on the region).
- Ongoing project

Land Abandonment in Russia: Understanding Recent Trends and Assessing Future Vulnerability and Adaptation to Changing Climate and Population Dynamics

Kristen de Beurs, Geoffrey Heneby, Tatyana Nefedova

- Study area: European Russia
- Research goals:
  - to spatially and temporally model future land abandonment under various climate change scenarios
  - to understand how adaptive strategies could affect re-colonization and re-cultivation of abandoned lands.
- Methods: Modeling future land abandonment based on:
  - satellite-image based assessments of past land abandonment
  - Russian age-specific population data and models
  - socio-demographic data
  - distance to major population centers
  - current temperature and moisture regimes retrieved from space-borne sensors
  - Qualitative interviews with key informants and landowners
  - predicted future regimes from IPCC AR4 models.
- Ongoing project – Kristen de Beurs will discuss at this workshop.

From Spatial Continuity to Fragmentation: The Case of Russian Farming

Grigory Ioffe, Tatyana Nefedova, and Ilya Zaslavsky

- Study site: European Russia
- Research goal
  - understand the effects of population changes on agricultural production and fragmentation
- Data
  - Russian Census data
  - Russian agricultural productivity data
- Significance
  - Estimated Russian rural population loss of 7.8% between 2001 – 2015
  - Land abandonment:
    - 1970 to 1990: < 2,000,000 hectares of arable land lost in European Russia,
    - 1990 – 2000: > 10,000,000 hectares of arable land lost in European Russia
- Methods
  - Data analysis
    - Descriptive statistics
    - Statistical correlations and regressions

Source: Grigory Ioffe, Tatyana Nefedova, and Ilya Zaslavsky, "From Spatial Continuity to Fragmentation: The Case of Russian Farming", *Annals of the Association of American Geographers*, 94(4), pp. 913-943, 2004.

Findings
Ioffe, Nefedova, Zaslafsky

- Farmland abandonment occurring spatially throughout European Russia (periphery and core)
- Rural population density was the most important tested variable affecting agricultural productivity
- Main variables found to affect agricultural productivity
  - rural population density outside district center
  - Urban population potential
  - natural soil fertility

Reforestation in Central and Eastern Europe after the breakdown of socialism

Gregory N. Taff, Daniel Mueller, Tobias Kuemmerle, Esra Ozdenerol, Stephen J. Walsh

- Study site: Eastern Europe and Russia
- Research questions
  - How has forest cover changed in the region since the breakdown of socialism?
  - What are the drivers and consequences of these changes in forest cover?
- Data
  - National-level forest data from 2 time points (1990 and 2005) for all EE countries and Russia
    - Compiled by the UN – FAO
  - In-depth case studies in Latvia, Romania, Albania
    - Remote sensing
    - National statistics
    - In-situ field work
    - Interviews of key informants

Gregory N. Taff, Daniel Mueller, Tobias Kuemmerle, Esra Ozdenerol, Stephen J. Walsh, "Reforestation in Central and Eastern Europe after the breakdown of socialism", in H. Nagendra and J. Southworth (eds). Reforesting Landscapes: Linking Pattern and Process; Springer Landscape Series, pp. 121 – 148, November 2009.

Taff et al. Methods

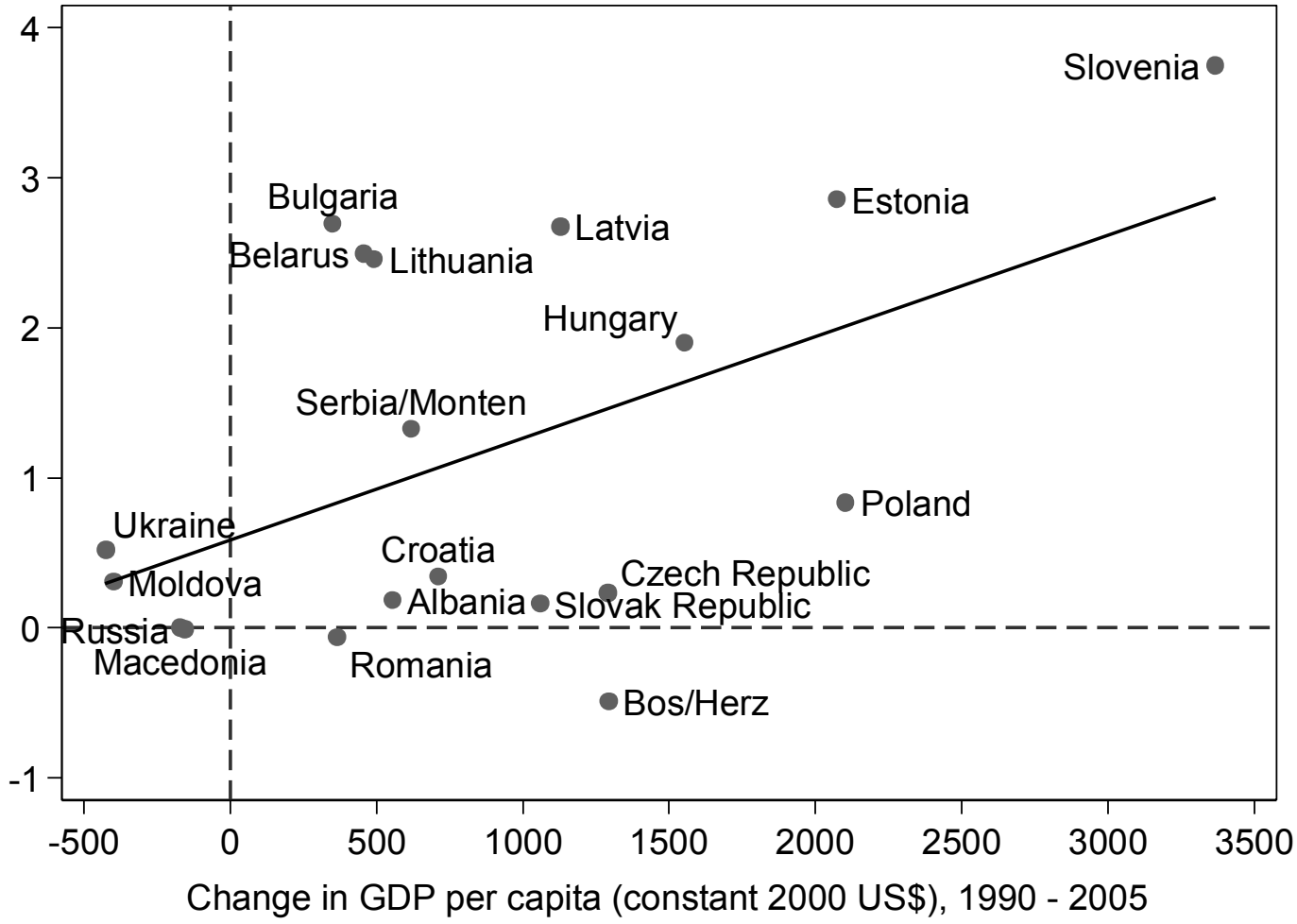
- Country-level case studies (Latvia, Romania, Albania)
  - Remote sensing landcover change analyses
    - Post-classification change analyses
      - Landsat
      - Aster
    - Analysis of country-level statistics
    - Qualitative interviews
- Multi-country analysis
  - Correlation analysis
    - National-level forest statistics (FAO)
    - National-level GDP statistics (World Bank)

Taff et al. Selected Results

- Eastern Europe is gaining forest cover (based on FAO data)
  - Only major world region gaining total forest cover
  - Case studies show in some cases forest degradation is occurring as well
    - National-level statistics may not show this
    - Medium and high spatial-resolution remote sensing data key for understanding degradation
  - Increased regional forest cover and degradation could have major effects on regional climate
- A correlation found between increased GDP and increased forest cover between ~ 1990 and 2005

Taff et al. selected results

Change in GDP vs. change in % forest cover (1990 – 2005)
Correlation: 0.5 (significant at the 0.05-level).



Carbon, Climate and Managed Land in Ukraine: Integrating Data and Models of Land Use for NEESPI

Francesco Tubiello, Cynthia Rosenzweig, Gunther Fischer,
Anatoly Shvidenko, Mykola Zalogin

- Study site: Ukraine
- Goals:
  - Assess current and potential impacts of climate, socio-economic, and land use changes on agriculture, forestry, and carbon sequestration
    - Focus on context of agricultural abandonment and new export agriculture, including bio-fuel.
  - Assess local and regional drivers of land-use change
- Data
  - existing data on Ukrainian crop and forestry production including major crop management types and regimes
  - remote sensing
  - national-level statistics
  - local observations
  - forestry statistical databases.
- Methods: the following models are being used:
  - Climate and carbon-cycle modeling
  - dynamic crop models (DSSAT)
  - agro-ecological zone (AEZ-IIASA)
- Ongoing project

Regional aspects of climate-terrestrial-hydrologic interactions in non-boreal Eastern Europe

A Summary of the NEESPI Workshop in Odessa, Ukraine, 23-28 August 2008

- 39 oral and 10 poster presentations
- Approaches included:
  - Environmental Change Observations
    - in situ
    - remote sensing
  - accuracy assessment of modern observing techniques
  - assessment of available databases
  - modeling of environment and human impact in the region
  - assessing sensitivity of modeling results to errors and uncertainties in initial conditions; and
  - projections of future environmental conditions in the region.

Generalized Results

- Global and regional climate models (GCMs and RCMs) projections generally agreed about drier future climate conditions detrimental to the region.
- Observational validation data for these predictions are not yet available, and this is a key point of need for future work.

Improving Environmental Projections in Nonboreal Eastern Europe

Pavel Groisman, Sergiy Ivanov, Garik Gutman, Clemens Simmer

- Summary/synthesis on Eastern Europe
  - From Odessa, Ukraine, 23–28 LCLUC meeting, August 2008
- Regional climate warming 20th Century
  - Biome boundaries more volatile in terms of phenology and land fertility
    - Between Forests & Steppe
    - Between Steppe & semi-desert
- Dense rural population
  - Economic hardships
  - Intense landuse
    - Compounds climate problems
- Limited observational data collected in Eastern Europe
  - Has limited ability to validate climate models

Reference: Pavel Groisman, Sergiy Ivanov, Garik Gutman, Clemens Simmer, "Improving Environmental Projections in Nonboreal Eastern Europe", EOS, TRANSACTIONS AMERICAN GEOPHYSICAL UNION, VOL. 90, NO. 8, P. 63, 2009.

Recommendations from the NEESPI Odessa Workshop

- *Rigorous* fulfillment of national reforestation plans for the following reasons:
  - soil protection
  - flood protection
  - water availability and quality
  - carbon sequestration
  - aerosol and pollution sedimentation
  - recreation needs.
- International cooperation and data exchange to facilitate climate change and landuse change research *based around ecosystems* instead of country boundaries, e.g.:
  - steppe
  - forest-steppe
  - coastal zone of the Black Sea
- Better climate change scenarios and RCMs should be created for the region.
- Coherence of future regional warming predictions based on existing Global and Regional Climate Models suggest a need to *plan for optimal land use and mitigation measures based on these predictions*.

Optimization of management of forests, agriculture, and water for climate change adaptation

Sandor Szalai and Csaba Mátyás

- Study site: Central and Eastern Europe
- Goal: Develop policy recommendations for adaptation at national and regional scales
- Data:
  - Meteorological observations in forests to study temporal and spatial changes in
    - Temperature
    - Precipitation
    - Soil moisture
  - Other data
    - Tree ring data
    - herbaceous plant species composition
    - butterfly species composition
- Methods:
  - Use GIS and mathematical modeling to detect changes in forests
  - Compile an inventory of studies, policies, and adaptation measures to climate change
  - Review national policies and climate change impact projections
  - Ongoing project

Eurasian Arctic

Sensitivity and response of northern hemisphere altitudinal and polar treelines to environmental change at landscape and local scales

Friedrich-Karl Holtmeier and Gabriele Broll

- Review article
- Selected findings/conclusions
  - Vegetation lines moving
    - Northward in Scandinavia
    - Upward in the Alps
  - Suggest it is key to distinguish treeline movement due to
    - Climate change impacts vs.
    - Local human activity impacts
  - Suggest that utilizing study sites with no local human activity impacts is important to understand climate change impacts.

Friedrich-Karl Holtmeier & Gabriele Broll, "Sensitivity and response of northern hemisphere altitudinal and polar treelines to environmental change at landscape and local scales", *Global Ecology and Biogeography,*14, pp. 395–410, 2005.

Impacts of Global Change on Composition of Arctic Communities: Implications for Ecosystem Functioning

F. Stuart Chapin et al.

- Arctic plant communities may respond to climate warming in the following ways:
  - Increased nutrient supply from atmospheric deposition
    - Cause increased production, particularly in deciduous shrubs
  - Soil drying due to a warmer climate
    - Decreased production of many herbaceous species
    - Increased abundance of deciduous shrubs relative to graminoids and mosses
  - Decline of light intensity (due to increased cloudiness)
    - Reduce productivity and nutrient cycling rates
- Multiple effects are difficult to model accurately

Source: Chapin III, F. S. , Hobbie, S. E., and Shaver, G.R., "Impacts of Global Change on Composition of Arctic Communities: Implications for Ecosystem Functioning", in Global Change and Arctic Terrestrial Ecosystems (W.C. Oechel and J. Holten eds.), Springer Verlag, New York, 1997.

Landuse and Climate Change on the Yamal Peninsula of Northwest Siberia: some ecological and socio-economic considerations

Bruce Forbes

- Study area: Yamal Peninsula
- Types of research questions:
  - How do climate change and land use changes interact in this region?
  - How do the combination of these changes affect landcover?
- Data: in situ and qualitative fieldwork (1992 – 1997), and literature review

Bruce C. Forbes, "Landuse and Climate Change on the Yamal Peninsula of North-west Siberia: Some Ecological and Socio-economic Considerations", *Polar Research* 18(2), pp. 367-373, 1999.

Selected Findings (Forbes)

- Landuse at unsustainable levels
  - Nenets currently grazing 1.5 to 2 times the sustainable number of reindeer in the region.
  - Russian oil industry developing lands in the area since 1960's
    - Development leaves less land for Nenet reindeer to graze
- Climate change is:
  - melting ground ice and leading to thermokarst erosion
  - Reducing nearby sea ice
  - Increase growing season for many plants
- Human development of the area is leading to:
  - Increased erosion
  - Soil chemistry changes
  - Blowing sand/dust inhibiting some vegetation growth
  - Soil warming and permafrost melting (from roads and heavy construction)
- Future expected effects from combination of climate changes and human landuse:
  - Slopes to be denuded by landslides
  - Thermokarst lakes to inundate lowlands as permafrost thaws
  - Remote sensing critical tool for monitoring

Reindeer Pastoralism in a Changing Climate and Reindeer Mapper

Nancy Maynard, Boris Yurchak, Boris S. Yurchak, A. Polezhaev, Svein D. Mathiesen, Johan Mathis Turi

- Study site: Northern Russia reindeer herding lands
- Data:
  - Satellite imagery
  - Indigenous knowledge (georeferenced)
  - Property borders
  - other local data
- Methods:
  - Creating a GIS-based system to incorporate indigenous knowledge with GIS/RS data in a GIS system to help reindeer herders continue traditional herding practices and culture in the face of
    - climate change,
    - environmental change,
    - development
    - varying weather,
    - changing society,
    - land use changes, and
    - pollution

Maynard et al. - Reindeer

- Methods (continued):
  - Creation of real-time GIS data exchange for reindeer herders on topics such as:
    - safe travel/migration routes
    - various reindeer individual/herd locations of different herding groups
    - changing borders and new development
    - changes associated with climate/weather/environmental change (e.g., changes in high quality feeding grounds)
  - Development of education programs for reindeer herder youth
    - Help make it possible to combine traditional reindeer herding knowledge with contemporary education.

Results

From Maynard et al.
and Taff's preliminary results on similar topics in Scandinavia

- More common freeze-thaw events
  - Layers of ice in snow cover
- Early fall thaw-freezes can cover lichens directly in ice
- Grasses encroaching on upland, formerly lichen areas
  - Fewer winter feeding grounds
- Increased mosquitoes in lowlands
  - Forces reindeer to highlands early in summer
  - Hearty grass diet replaced with a lichen diet
- Early melting ice sometimes affects spring reindeer migration routes
- Arctic warming has made arctic accessible to oil interests, particularly in Russia
  - Development reduces reindeer herding/grazing territory

Conclusions

- Variety of data sources
  - Remote sensing
  - In situ data collection
  - Meteorological data
  - National-level population, forestry, agriculture statistics
  - Landuse/parcel boundary data
  - Tree ring data
  - Species composition data
  - Indigenous knowledge
  - Literature review
  - Qualitative interviews
- More recent research goals focus on:
  - Data quality and model accuracy assessments
  - Assessing sensitivity of modeling results to errors
  - Prediction of future conditions
  - PPGIS to help in adaptation plans
  - Applying science results to formulate policy recommendations