



Leibniz Institute of Agricultural Development
in Transition Economies



Agricultural Land-Use Change: trade-offs and constraints for potentially available croplands in Russia

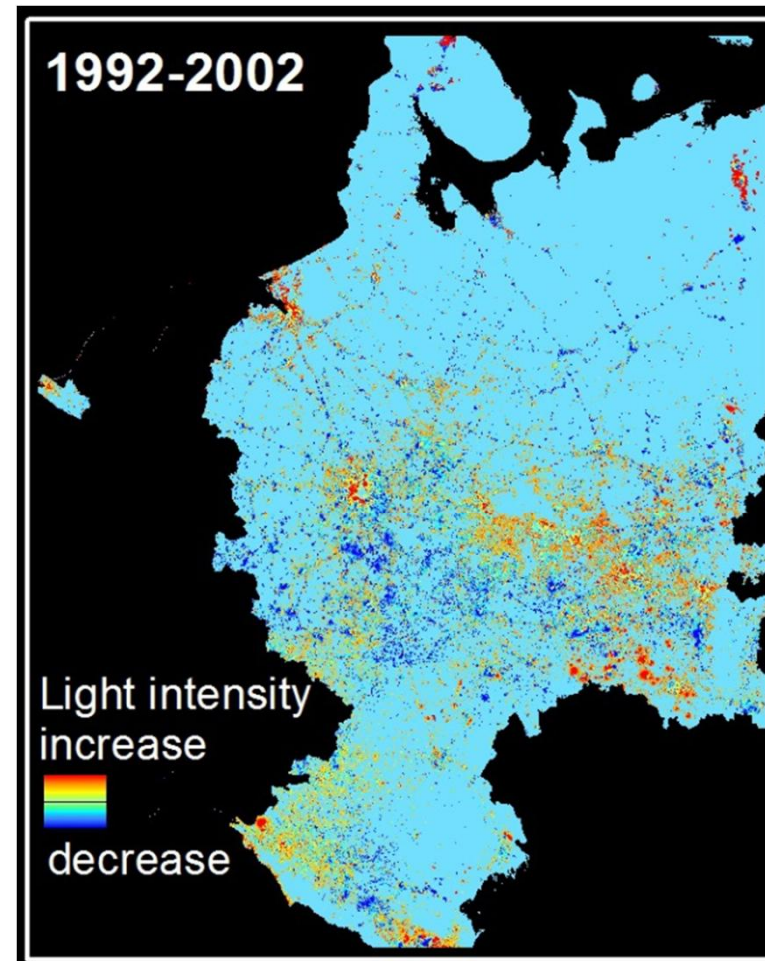
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Florian Schierhorn, Daniel Müller, Tobias
Kuemmerle

Regional NASA LCLUC Meeting, Sopron, Hungary, October 16-19, 2014

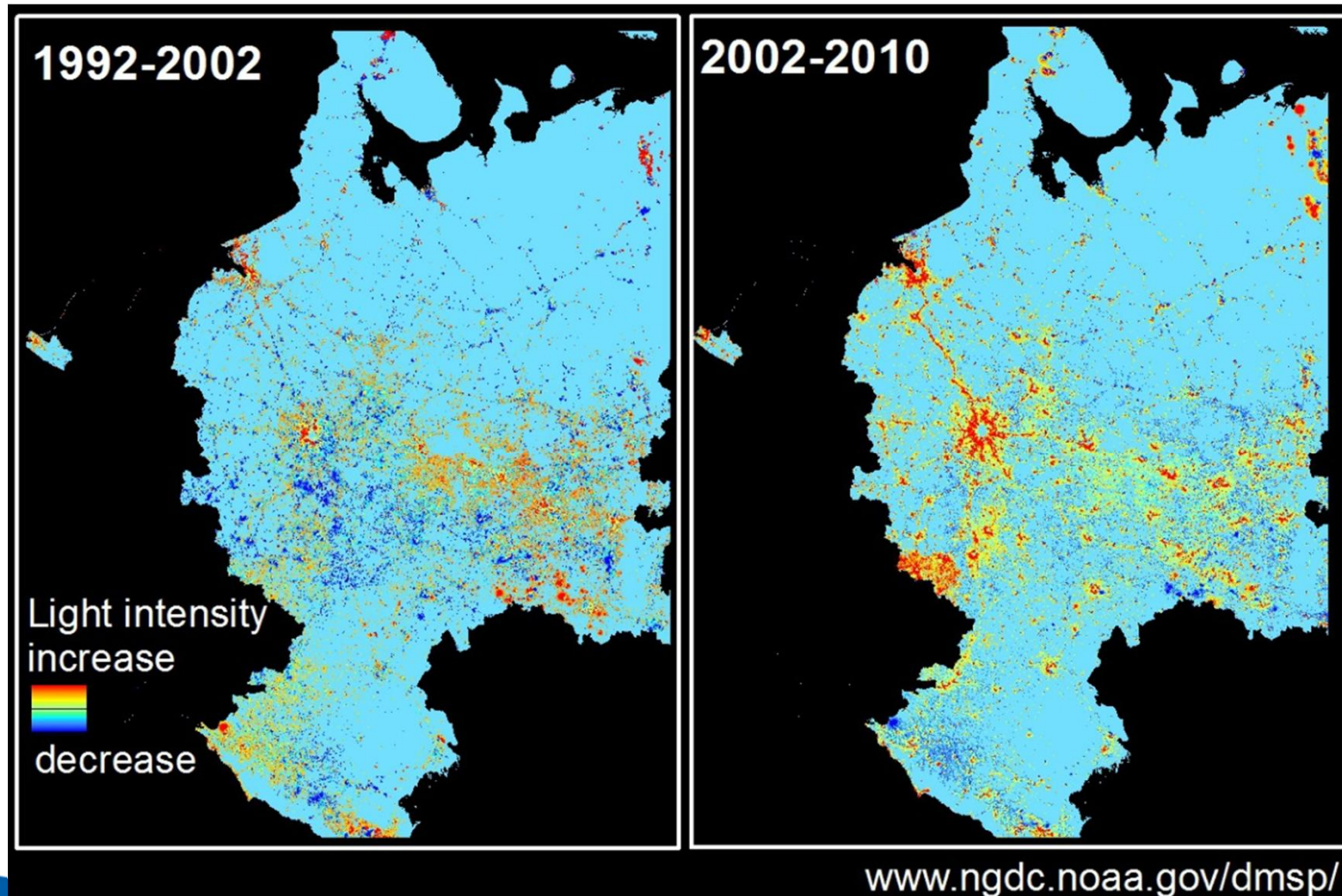
Background

- Decline in income levels, 90% reduction of agricultural subsidies (1990-2000)
- Loss of guaranteed markets
- Prices discrepancy between agricultural commodities and inputs

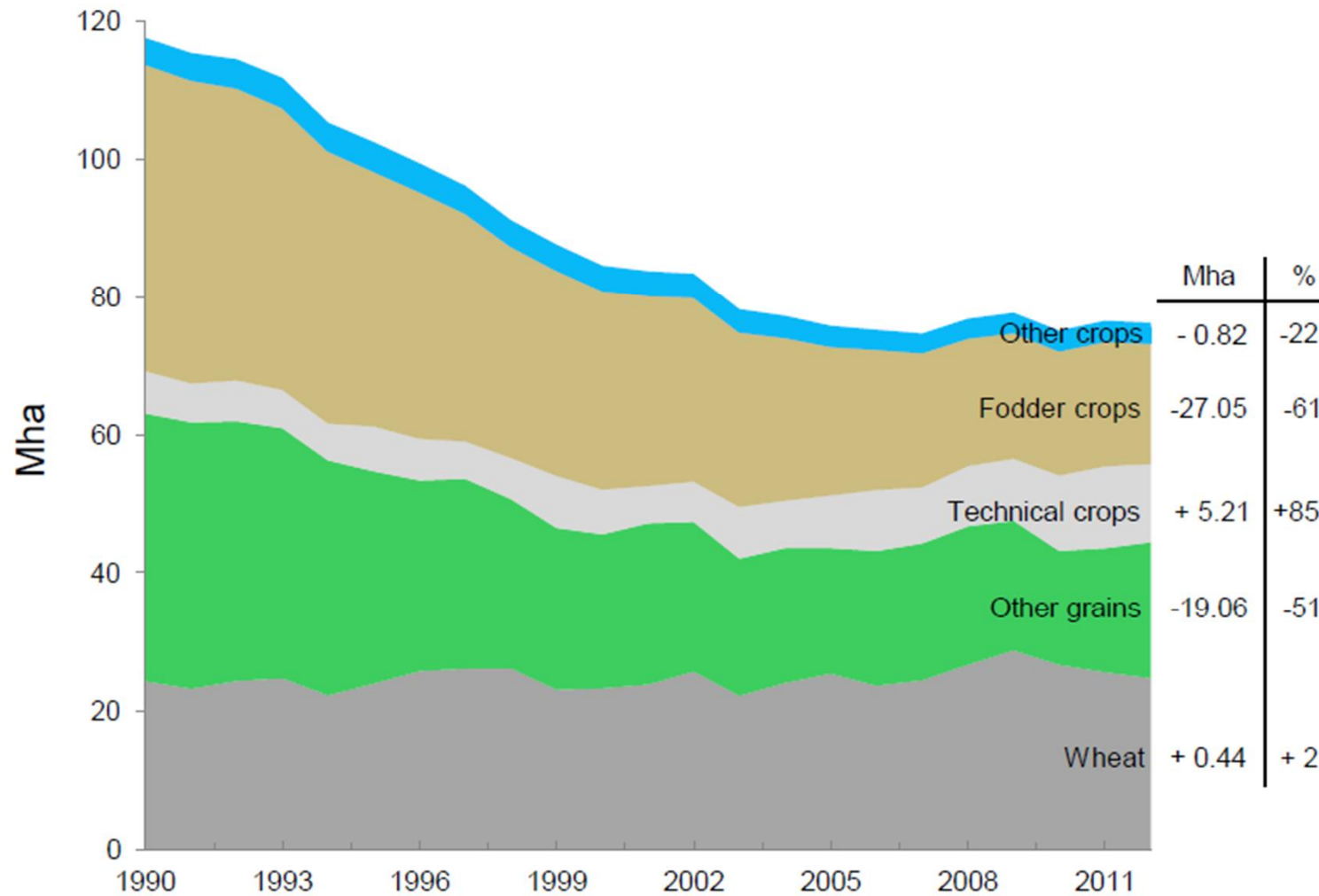
Change in night-time lights intensity (proxy for economic activity)



Slight Economy recovery after 2000



Agricultural land-use change

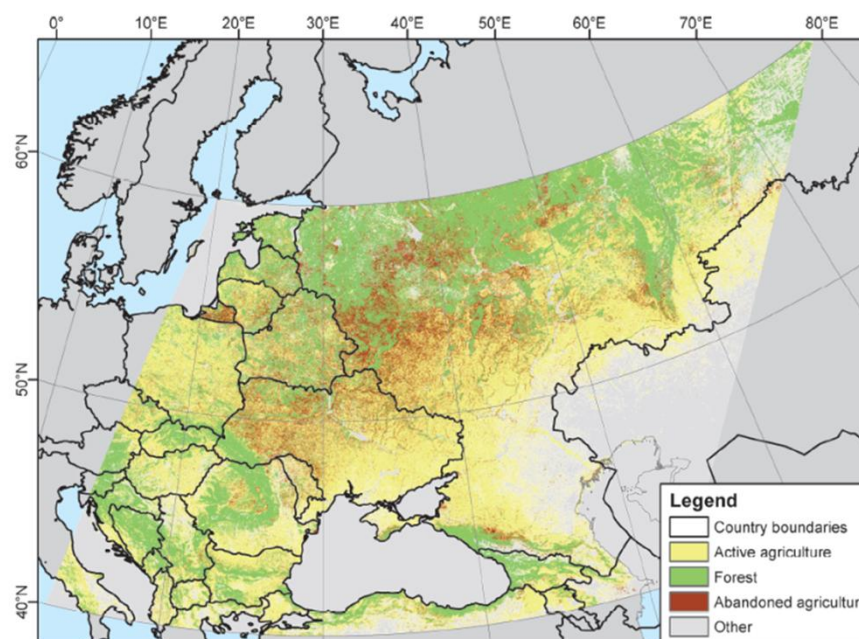


Rosstat 2013, Schierhorn et al. Accepted, Global Food Security

Patterns of agricultural land-use change- agricultural abandonment

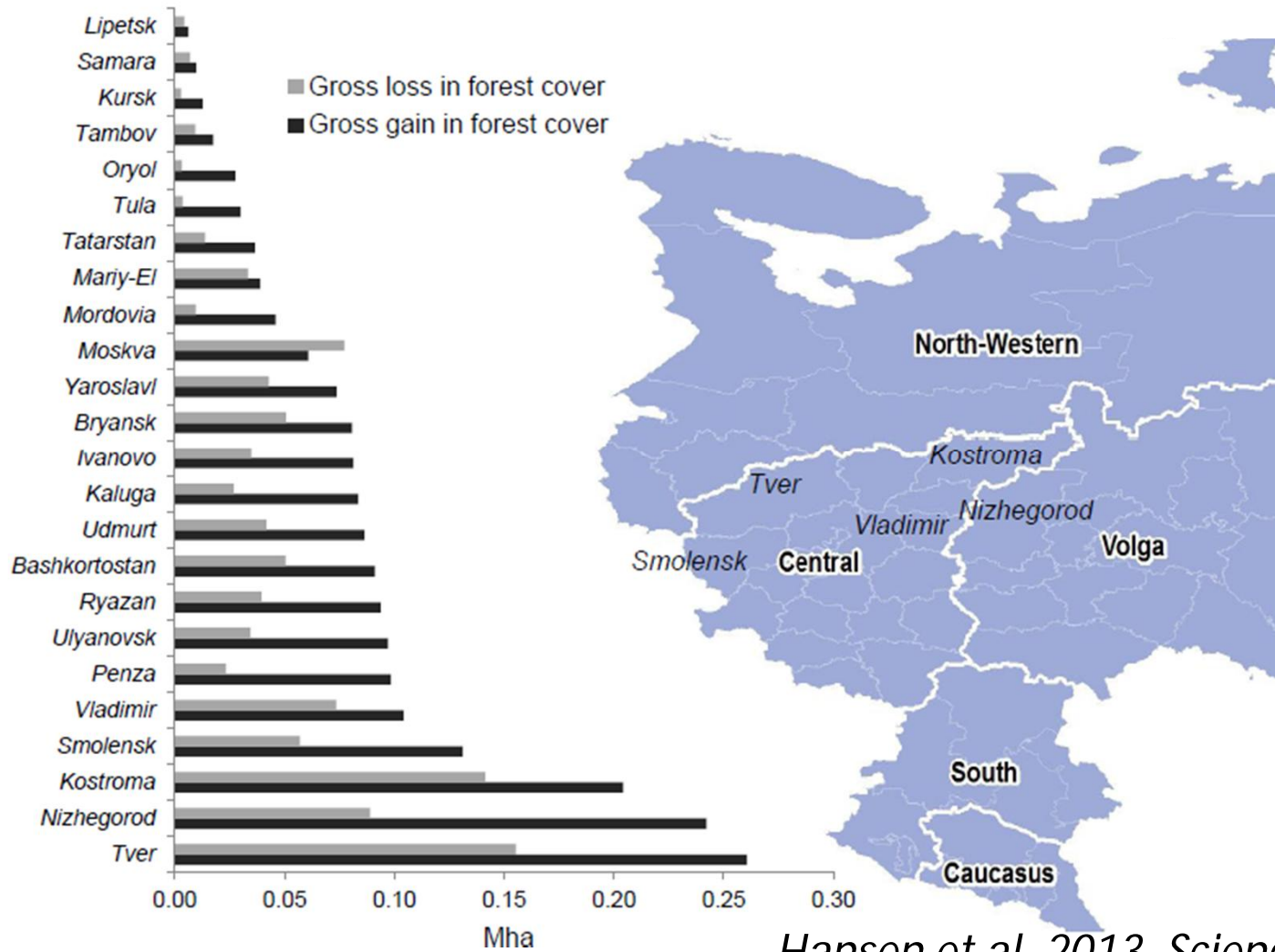
35 to 50 million
hectares of croplands
and grasslands
managed in 1990 are
abandoned by 2010

Abandoned agricultural lands



*Alcantara et al. 2013, Environmental
Research Letters*

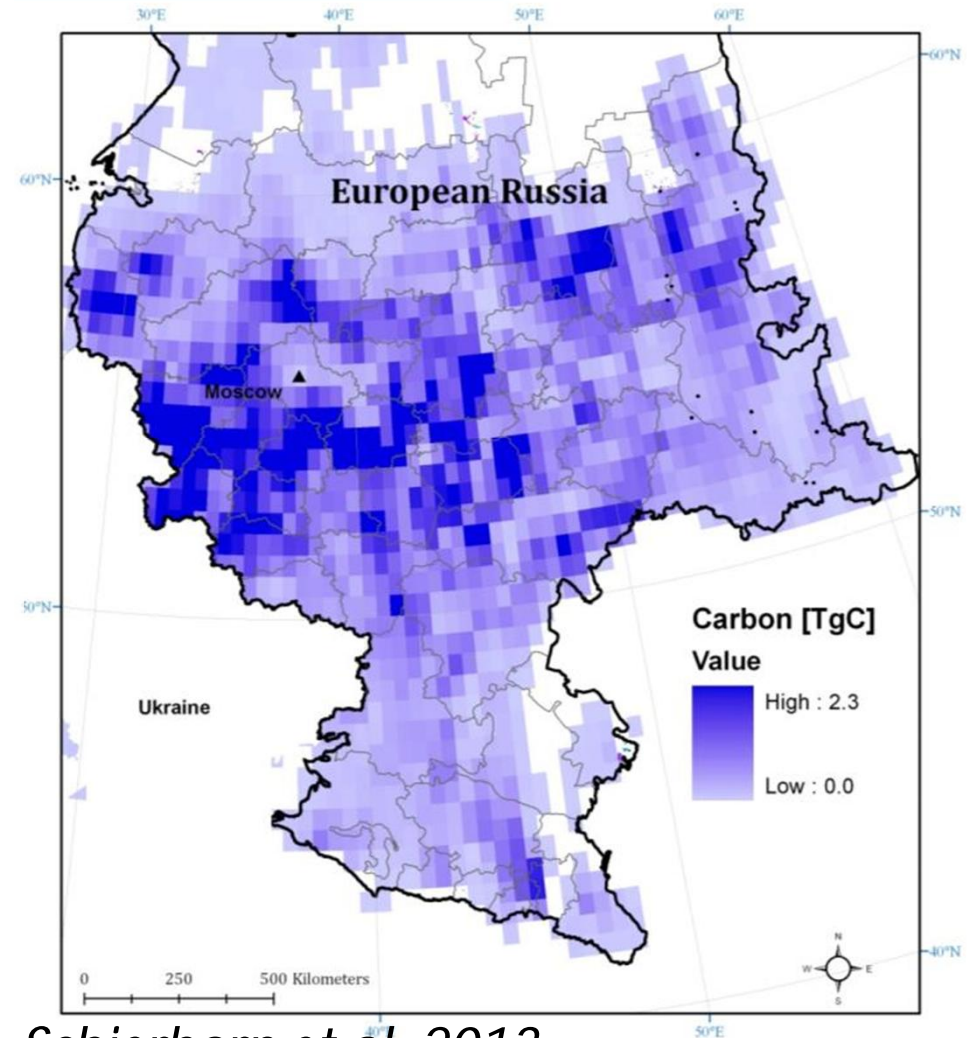
Impacts: Greening in Russia



Hansen et al. 2013, Science

Impacts: Carbon sink

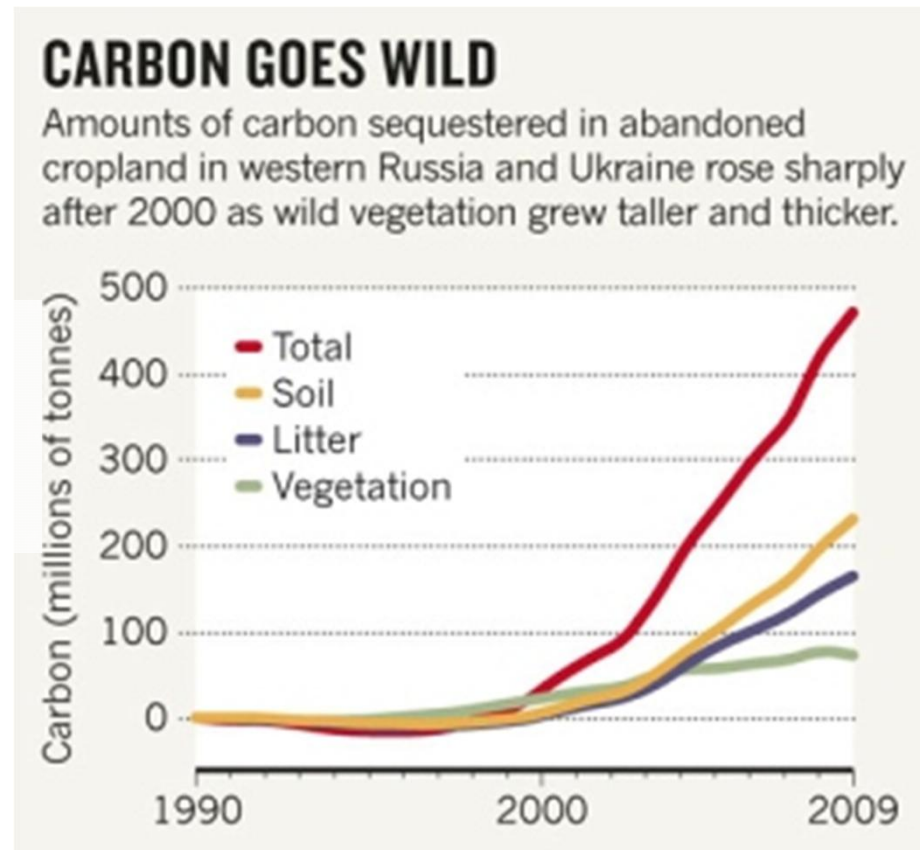
- Cropland abandonment resulted in a net carbon sink of 470 TgC for 1990 to 2009
- One third of Russia's CO₂ emission of due to industry and fossil fuels was offset due to abandonment



Schierhorn et al. 2013,
Global Biogeochemical Cycles

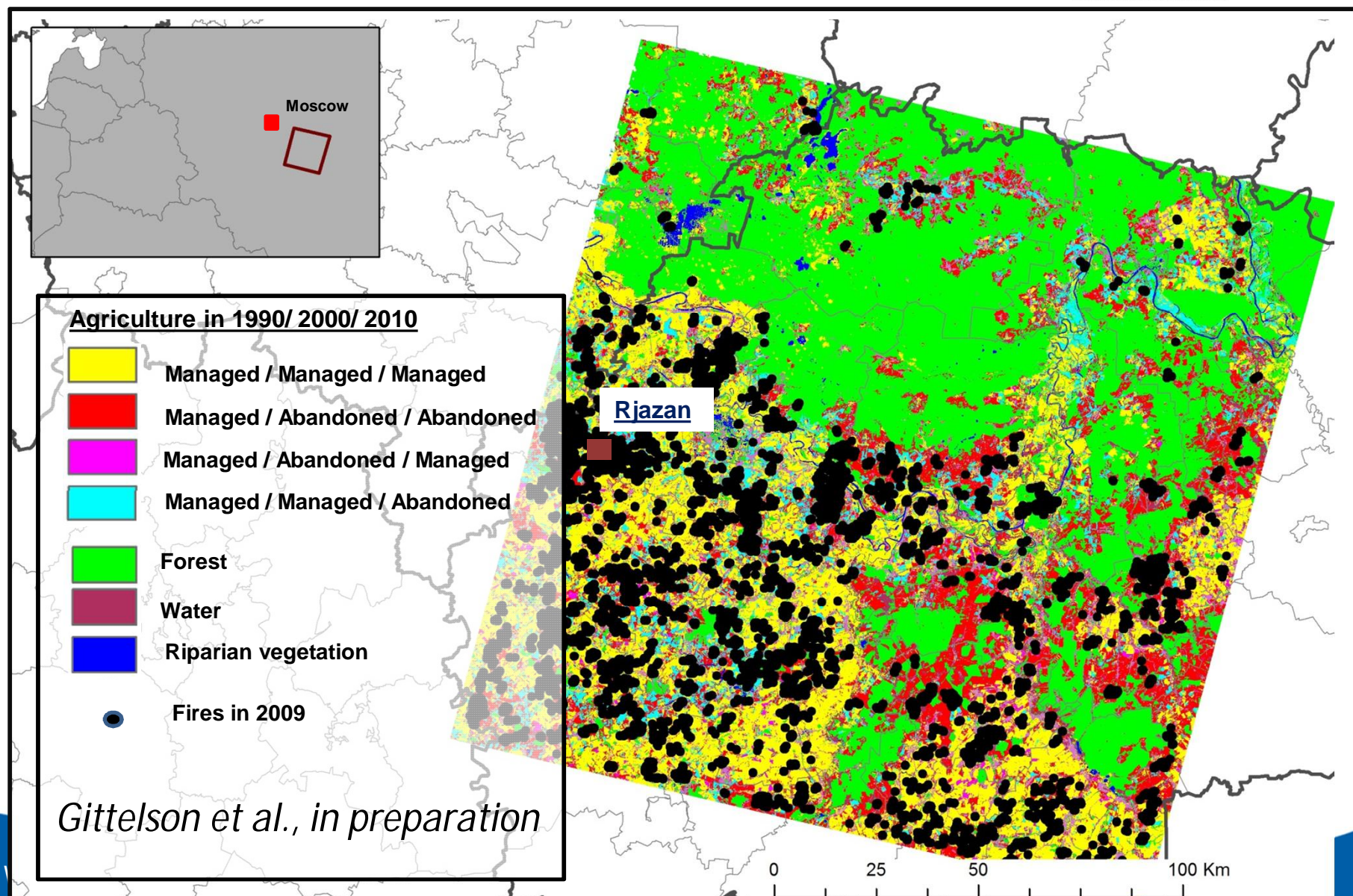
Impacts: Carbon sink

Carbon uptake substantially increases after 10 years of abandonment

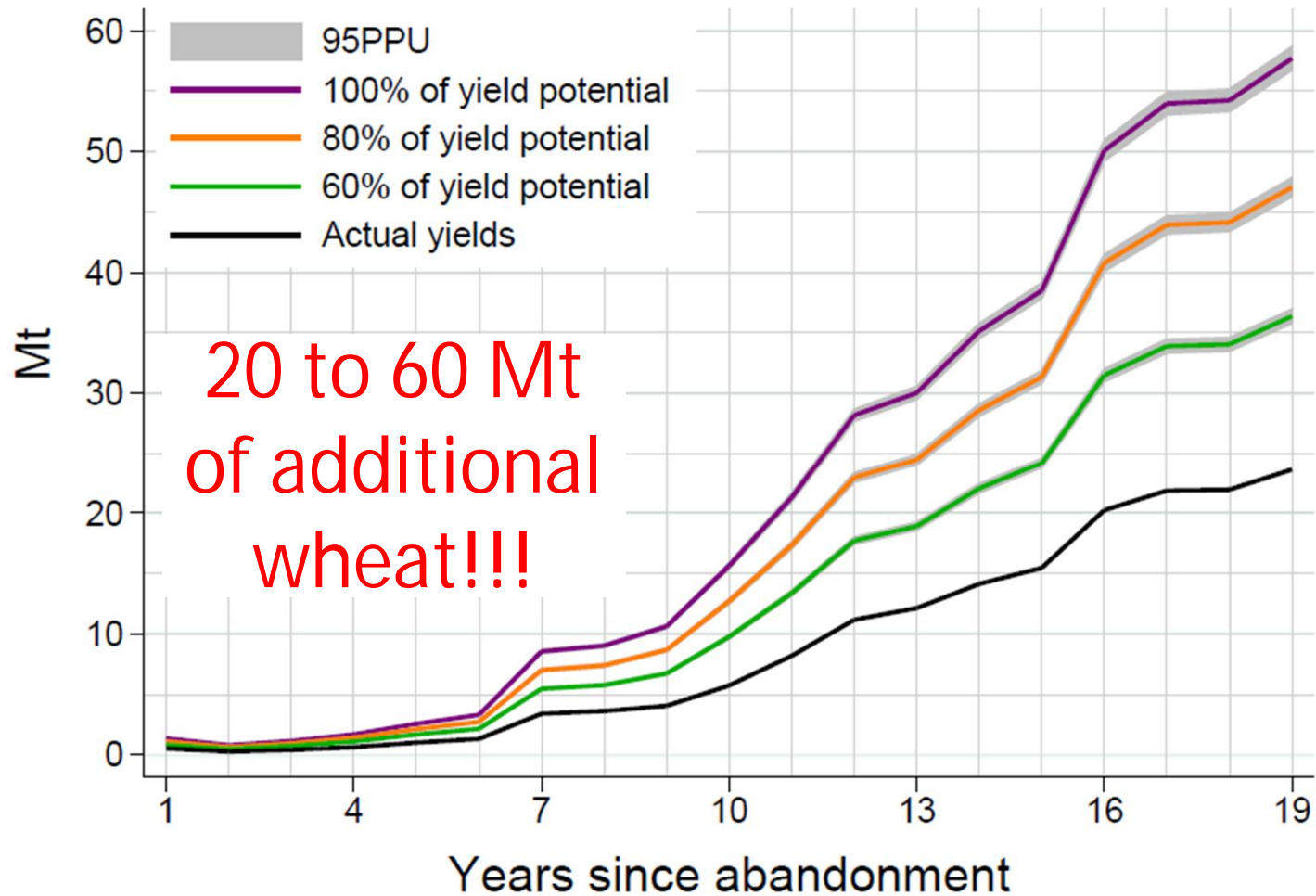


*Schierhorn et al. 2013,
Global Biogeochemical Cycles
Schiermeier 2013, Nature News*

Impacts: Contributes to anthropogenic wildfires



Impacts: Agricultural potentials



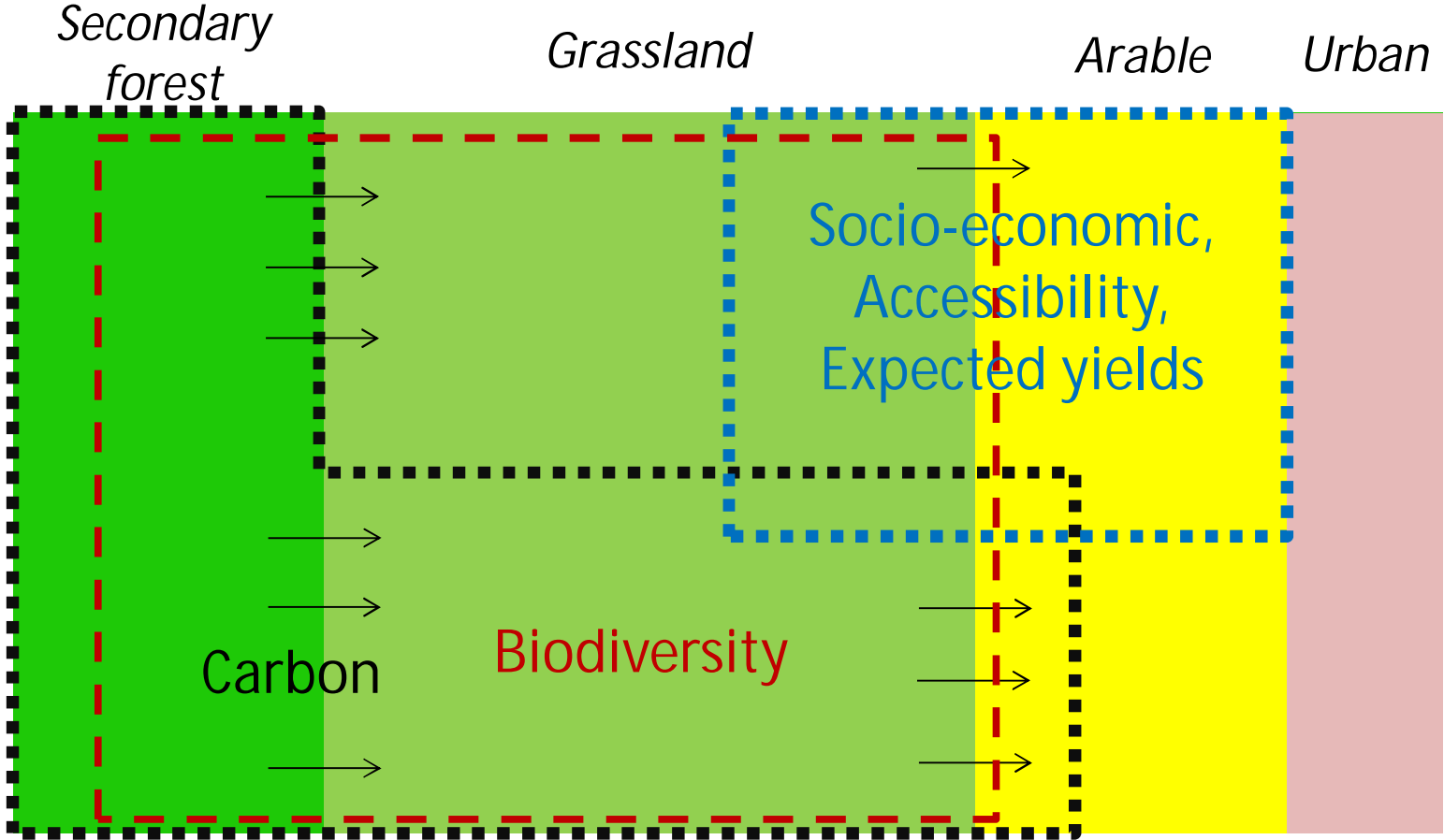
20 to 60 Mt
of additional
wheat!!!

Schierhorn et al. Accepted, Global Food Security

PAC-underutilized, or spare land, moderately to highly productive land that could be used in the coming years for rainfed farming, with low to moderate capital investments, and that is neither under intensive use, legally protected, nor under intact mature forest cover

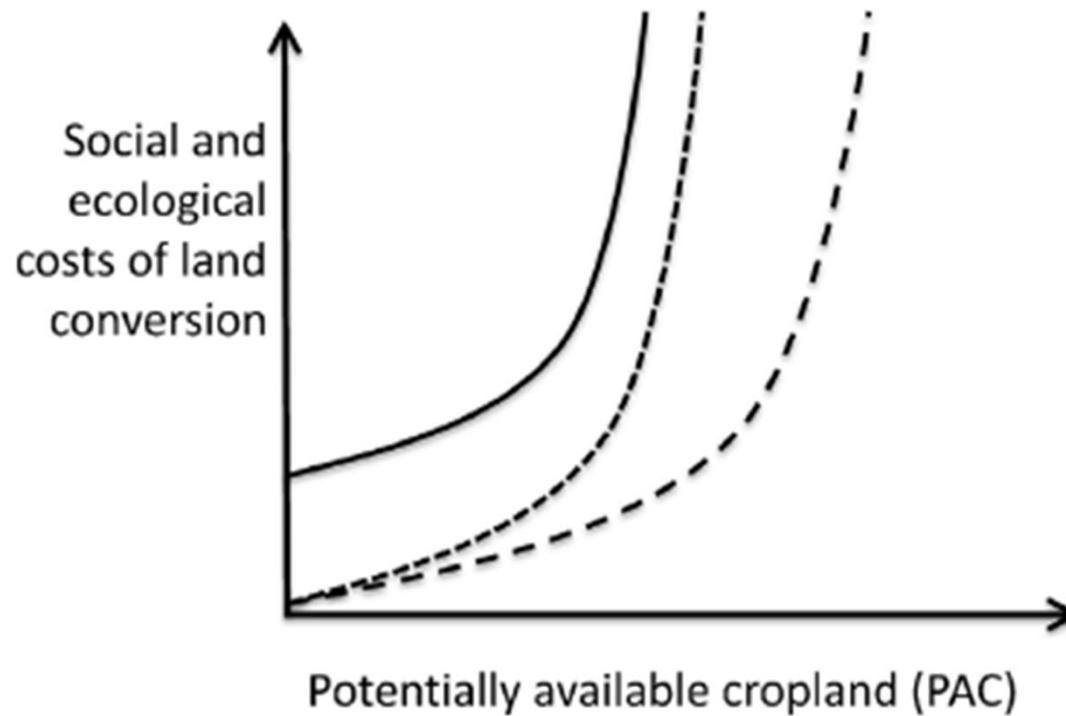
Lambin et al., 2013, Global Environmental Change

Potentially available croplands- PAC



Schierhorn et al., in preparation
Meyfroidt et al., in preparation

Potentially available croplands- PAC



Lambin et al., 2013, Global Environmental Change

- Assess broad-scale drivers of cropland abandonment and recent cropland re-cultivation at province level in Russia (1991-2008)
- Estimate fine-scale spatial determinants of agricultural land abandonment and re-cultivation, Rjazan province (1990-2000, 2000-2010)
- Establish underlying drivers of agricultural land abandonment and cropland re-cultivation using participatory interviews
- Estimate potentially available croplands in European Russia

Assess broad-scale drivers entire Russia

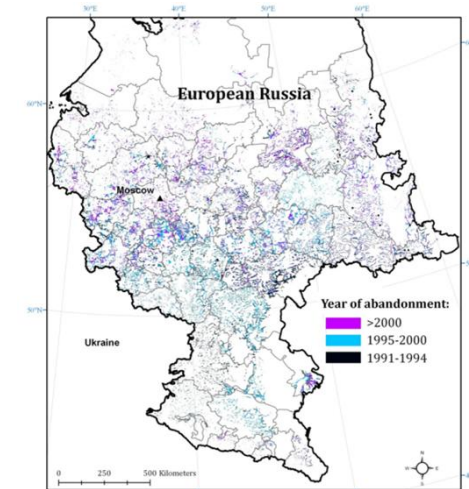
- Province-level statistics
- Spatial panel fixed effects models (1991-2008)

Fine-scale spatial determinants (Rjazan case study)

- Detailed spatially-explicit data
- Logistic regressions (1990-2000, 2000-2010)

Underlying drivers (Rjazan case study)

- Participatory interviews (2012, 2013)
- Qualitative content analysis approach



Schierhorn et al. 2013 *Global Biogeochemical Cycles*



Potentially Available Croplands – Environmental and Socio-Economic Costs

Input:

- Abandoned croplands (1990-2010)

Socio-Economic Constraints:

- Building on statistically significant factors from econometric models - strong constraints (negative fitted value, or no re-cultivation)

Environmental Constraints:

- FAO Harmonized World Soil Database (chernosem/ non-chernosem)
- World Database on Protected Areas (WDPA) (IUCN/UNEP 2013) (5 km buffer)
- Intact Forest Landscapes (IFL) (5 km buffer) (Potapov et al., 2008)
- Global 200 priority ecoregions (5 km buffer) (Olson and Dinerstein, 1998)
- Carbon estimates on abandoned lands (5 MgC/ha threshold) (Schierhorn et al., 2013)

- Rational economic behavior
- Cropland abandonment coincide with agro-environmentally and socio-economically marginal areas
- Better socio-economic conditions foster re-cultivation
- Better agro-environmental and socio-economic conditions attract investment in re-cultivation

Dependent Variables

Increment of contraction and expansion of sown areas, %
Pixel-level binary coding of abandoned/ re-cultivated lands

Independent Variables

Demography (crude birth rate, life expectancy, population density)

Income levels

Crime rate

Assets of the farms (tractors)

Yields

Economic performance of farms (bankruptcy)

Investments in agriculture (FDI)

Infrastructure (roads, settlements)

Agro-environmental endowments (quality of soils)

Objective I-Broad-scale drivers (1991-2008)

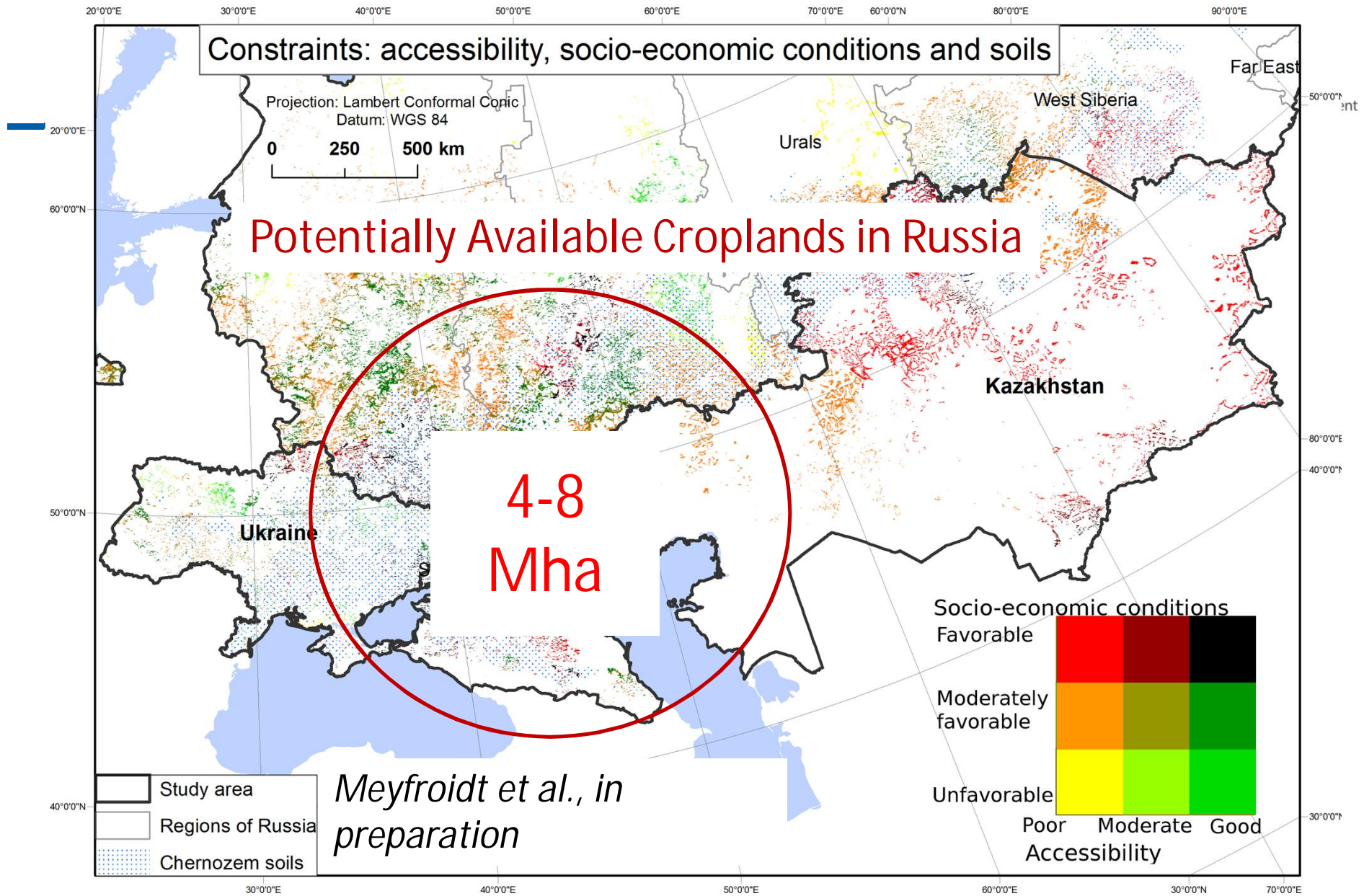
- Abandonment took place, where socio-economic conditions were marginal
- High fertility rates and population density increased likelihood for abandoned croplands re-cultivation
- FDI supported re-cultivation mainly in South-European Russia

Objective II- Fine-scale spatial determinants, Rjazan (1990-2000, 2000-2010)

- Abandonment took place on agro-environmentally and socially marginal agricultural lands in both periods
- After 2000 abandonment took place in close proximity to previously abandoned plots (bankrupt enterprises)
- Re-cultivation took place only on areas with better socio-economic and agro-environmental conditions

Objective III- Establishment of underlying drivers, Rjazan

	Abandonment	Recultivation
<i>Proximate drivers</i>		
Yields	★ ★ ★	★ ★ ★
Soils	★ ★ ★	★ ★ ★
Economic farm conditions	★ ★	★ ★
Rural infrastructure	★ ★	★
Proximities to settlements	★	★ ★
Demography	★	★
Costs of re-cultivation		★
<i>Underlying drivers</i>		
Fluctuation of governmental support	★ ★ ★	★ ★
Costs for inputs	★ ★ ★	★ ★
Market conditions	★ ★ ★	★ ★
Imperfections of land markets	★	★



- Abandonment slowed down, but cropland re-cultivation is very slow
- Expected yields often determine decision about abandonment and re-cultivation
- Investments in cropland re-cultivation were taking place mainly where socio-economic and agro-environmental conditions were favorable
- The likelihood of massive abandoned cropland re-cultivation is low
- Only 4 Mha from 30Mha of abandoned croplands in Russia correspond to our PAC definition
- Huge implications for the environment and biodiversity

Thank You!



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Abbreviation	Variables
rnabd	Rate of net abandoned area (cumulative since 1991), %
rcrcl	Rate of cumulative re-cultivated area (cumulative since turnaround) , %
bcr	Birth crude rate
rlex	Rural life expectancy
pden	Rural population density
ppeth	% of population with non-Russian ethnicity
pbpl	% of population below poverty line
dcmb	Density of combines in corporate farms
dtr	Density of tractors in corporate farms
rcralc	Rate of crime related to alcohol
shuang	Share of unprofitable agriculture enterprises
dfdig	Density of FDI in grain production
dtagl	Density of transactions of agricultural lands
rvioec	Rate of violation of rights by bureaucrats
ygto	Yields of all grain types per hectare of sown grain area

opment

Entire Russia- Abandonment	1991-1996	1995-2008	2001-2004	2006-2009
Pseudo-R2	0.28	0.2	0.17	0.38
regSER	+			
regSIB		+	-	-
regVOL				
bcr	-			
rlex	+			
pden	-	-	-	-
ppeth				
pbpl	n/a		-	
dcmb	n/a	+		+
dtr	n/a	+		
rcralc	n/a			
shuang	n/a	<i>Model for entire Russia excludes the Far East</i>		
dfdig	n/a			
dtagl	n/a			
rvioec	n/a			

ment

Regional- Abandonment, 1991- 1996	Central European Russia	South European Russia	Volga region	Siberia
Pseudo-R2	0.30	0.38	0.55	0.26
Bcr	-	-	-	-
rlex		+		+
pden				
ppeth				
pbpl	n/a	n/a	n/a	n/a
dcmb	n/a	n/a	n/a	n/a
dtr	n/a	n/a	n/a	n/a
shuang	n/a	n/a	n/a	n/a
dfdig	n/a	n/a	n/a	n/a
dtagl	n/a	n/a	n/a	n/a
rvioec	n/a	n/a	n/a	n/a
ygto				

ment

Entire Russia- Re-cultivation	2006-2009
Pseudo-R2	0.49
regSER	+
regSIB	
regVOL	
bcr	+
rlex	
pden	+
ppeth	-
pbpl	
dcmb	-
dtr	
rcralc	
shuang	
dfdig	
dtagl	-
rvioec	

Model for entire Russia excludes
the Far East

Regional model Re-cultivation	Central European Russia	South European Russia	Volga region	Siberia
Pseudo-R2	0.48	0.59	0.50	0.40
Bcr		+		
rlex		+		
pden				
ppeth	-	-		
pbpl				
dcmb			-	
dtr	n/a	n/a	n/a	n/a
shuang	n/a	n/a	n/a	n/a
dfdig		+		
dtagl			-	
rvioec				
ygto	+	+		

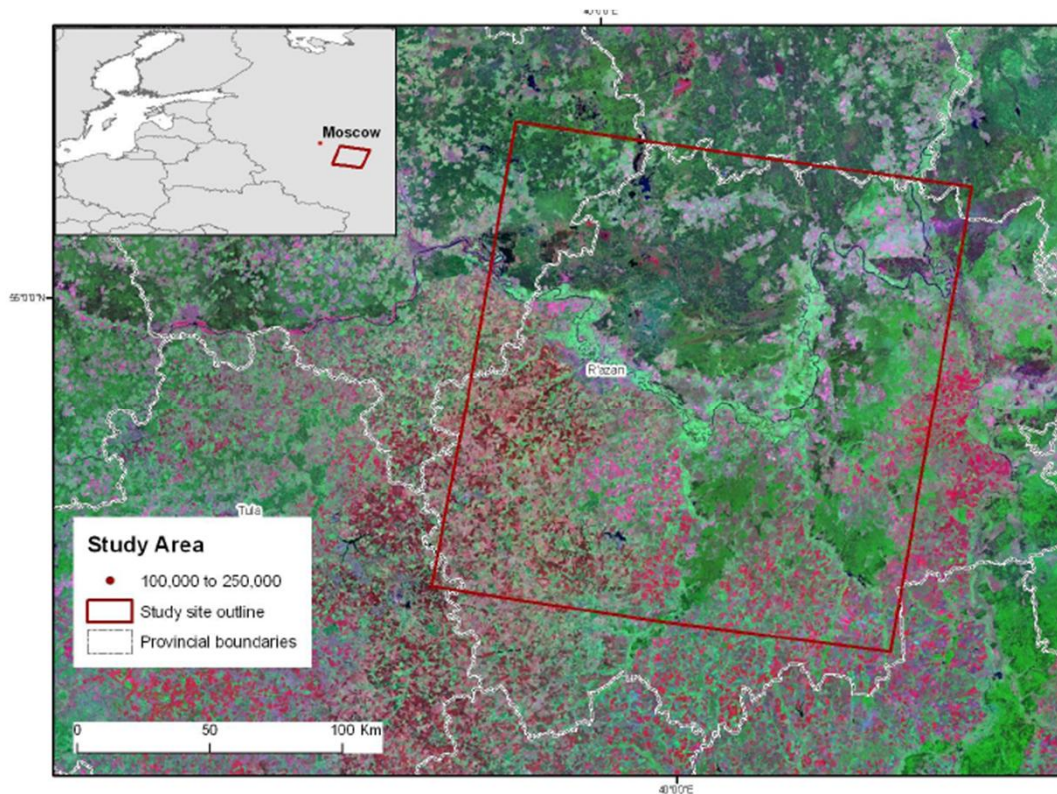
ment

Another summary of the models

Abandonment 1991-1996	Russia		Central		South		Volga		Siberia	
	Estimate		Estimate		Estimate		Estimate		Estimate	
Spatial lag (lambda)	0.80	** *	0.87	** *	0.70	***	0.78	***	0.85	***
Spatial error (rho)	-0.08		-0.49	*	0.32		-0.42		-0.83	
Crude birth rate	-0.46	** *	-0.49	*	-0.89		-0.08		-0.45	*
Rural life expectancy	-0.02		0.01		0.32		-0.45	*	-0.06	
Population Density	-0.46		-1.04		-0.78		-2.83	*	0.32	
Ethnic population	-0.53		-0.45		1.03		-1.79	***	1.73	
Yields of grains	-1.35	** *	-0.67		-1.12		-2.10	**	-8.85	***

Re-cultivation 2006-2009	Russia		Russia (all vars)	
	Estimate		Estimate	
		**		
Spatial lag (lambda)	0.60	*	-0.09	
Spatial error (rho)	-0.46	*	0.54	**
Crude birth rate	2.34	**	2.01	
Rural life expectancy	-1.74	*	-0.37	
Population Density	2.46		1.07	
Ethnic population (non-major group)	1.36	*	1.84	**
		**		**
Yields of grains	8.17	*	12.53	*
Population below poverty line			-1.06	**
Density of combines in corporate farms			1.15	
Rates of crime related to alcohol			0.92	
Density of transactions in agric. lands			-0.29	
Rates of violation of economic rights			0.31	
Notes: Significance levels: *: 0.05; **: 0.01; ***: <0.001				

Rjazan case-study



- Temperate European Russia, Ryazan province (oblast) ,forest-steppe transition zone
- ~30% forest-covered
- Rural population density 5-31 people/km²(1990)
- Grain yields 1.0-2.4 tones/ hectare (1987-1990)
- Number of livestock decline ~60% (1990-2000)
- Arable lands decline ~40% (1990-2000)

Abbreviation	Variables
Gry90/00/10	Grain Yields 90s, 00s, 10s
Soils	Soils, ranked
pcpe	Potential evapotranspiration
Fdist	Distance from forest
d2ab	Distance from abandoned fields from 1990 till 2000
d2drc	Distance from district center
d2mun	Distance from municipality center
d2s500	Distance from settlements ≥ 500 people
d2settl	Distance from settlements
d2road	Distance from roads with hard surface
d2hpp	Distance from grain silage / elevators
ldwp 88/02/10	Interpolated population counts for the settlements based on Census 1988, 2002, 2010
Dtractors 90/00/10	Tractors densities per 1000 ha
fsettl	Settlements surrounded by forest

opment

Abbreviation	Model#1 1990-2000	Model#2 1990- 2000	Model#1 2000- 2008	Model#2 2000- 2008
Ad.R2/ AUC	0.28/ 77	0.27/ 77	0.1/ 68	0.11/69
Gry90/00/10	-/ /		/ /	
Soils	-	-	-	-
pcpe				
Fdist	-	-	-	-
d2ab			+	+
d2drc			+	+
d2mun	+	+		
d2s500	+	+		
d2settl	-	-	-	-
d2road	+	+		
d2hpp				
ldwp 88/02/10	/ - /	/ - /	/ /	/ /
Dtractors 90/00/10		/ - /		/ /

ent