



# Understanding global farmland abandonment with the aid of satellite remote sensing

Alexander (Sasha)  
Prishchepov  
alpr@ign.ku.dk



## Few words about me



*Focus on measuring  
land transitions,  
human dimension of  
land system change*

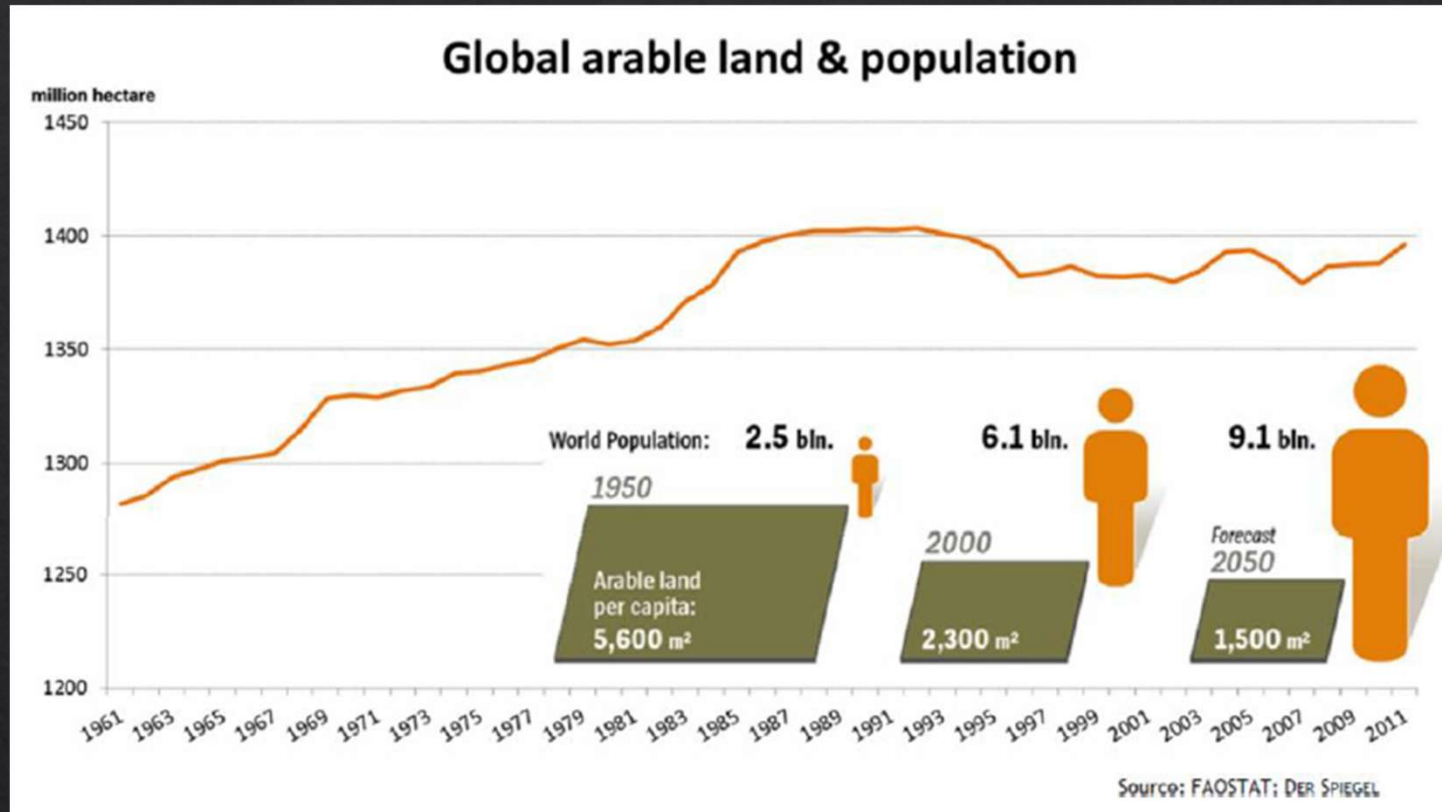
**alpr@ign.ku.dk**

- Born and raised in St. Petersburg, Russia
- Graduated from Russian State Hydrometeorological University, Russia
- 2004-2005, IREX USDS GIS certificate program, Oklahoma State University
- 2005-2010, PhD, University of Wisconsin-Madison
- 2010-2014, post-doc, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Germany
- 2014-until present, University of Copenhagen, associate professor
- Coordination of Global Land Program's "Agricultural Land Abandonment as a Global Land-Use Change Phenomenon" working group

# Structure of presentation

- Motivation
- What is farmland abandonment?
- Challenges to study farmland abandonment
- Major milestones in application of satellite remote sensing
- Existing research gaps and ways to go

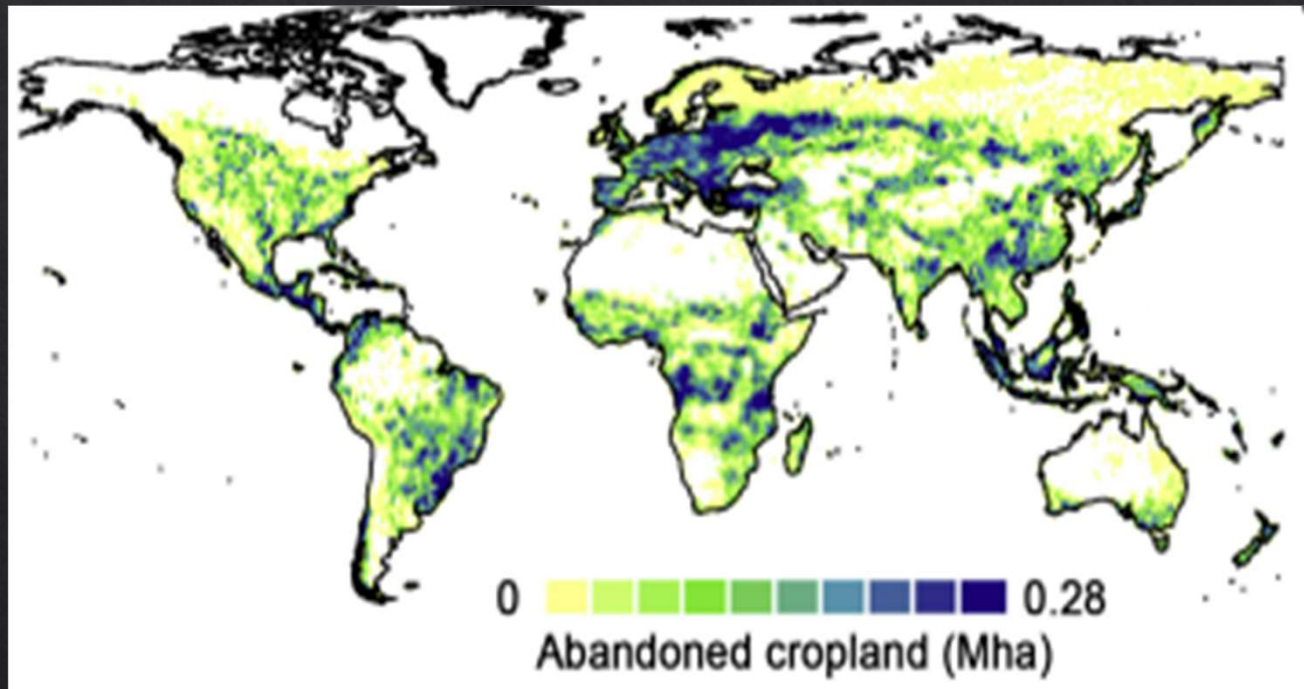
# Motivation



- Population growth goes hand-in-hand with agricultural expansion
- Vanishing remaining intact areas

# Widespread farmland abandonment

Cropland abandonment from 1992 to 2020



Zheng...Prishchepov, Yin.. In Review

# Widespread and diverse farmland abandonment

Abandonment in the Mediterranean



Abandonment in steppe biome



Abandonment in sub-tropical regions



Abandonment in temperate regions



# Strong implications to the environmental and socioeconomic processes

Invasive *Heracleum sosnowskyi*, Russia

- Globally important carbon sink
- Various impacts on biodiversity
- De-fragmentation of landscapes
- «Rewilding»
- Invasive species
- Impacts on hydrology
- Spread of wildfires
- Impacts on livelihoods
- Population of outmigration
- Rural hollowing
- Loosing the esthetic of rural landscapes



Abandoned settlements, Spain



# Studying farmland abandonment is difficult

- There is no existing uniform definition (varies across agencies, timing of abandonment, appearance in the ground)
- Terminology is diverse “abandonment”, “set-aside”, “postagrogenic”, “deactivated”
- Abandonment can be complete, semi-abandoned, hidden abandonment
- Abandonment is a transition process-new land uses may evolve
- Dual perception of farmland abandonment-site specific
- Change of electromagnetic signal due to abandonment can be subtle (e.g., abandonment of managed grasslands in steppe biome)



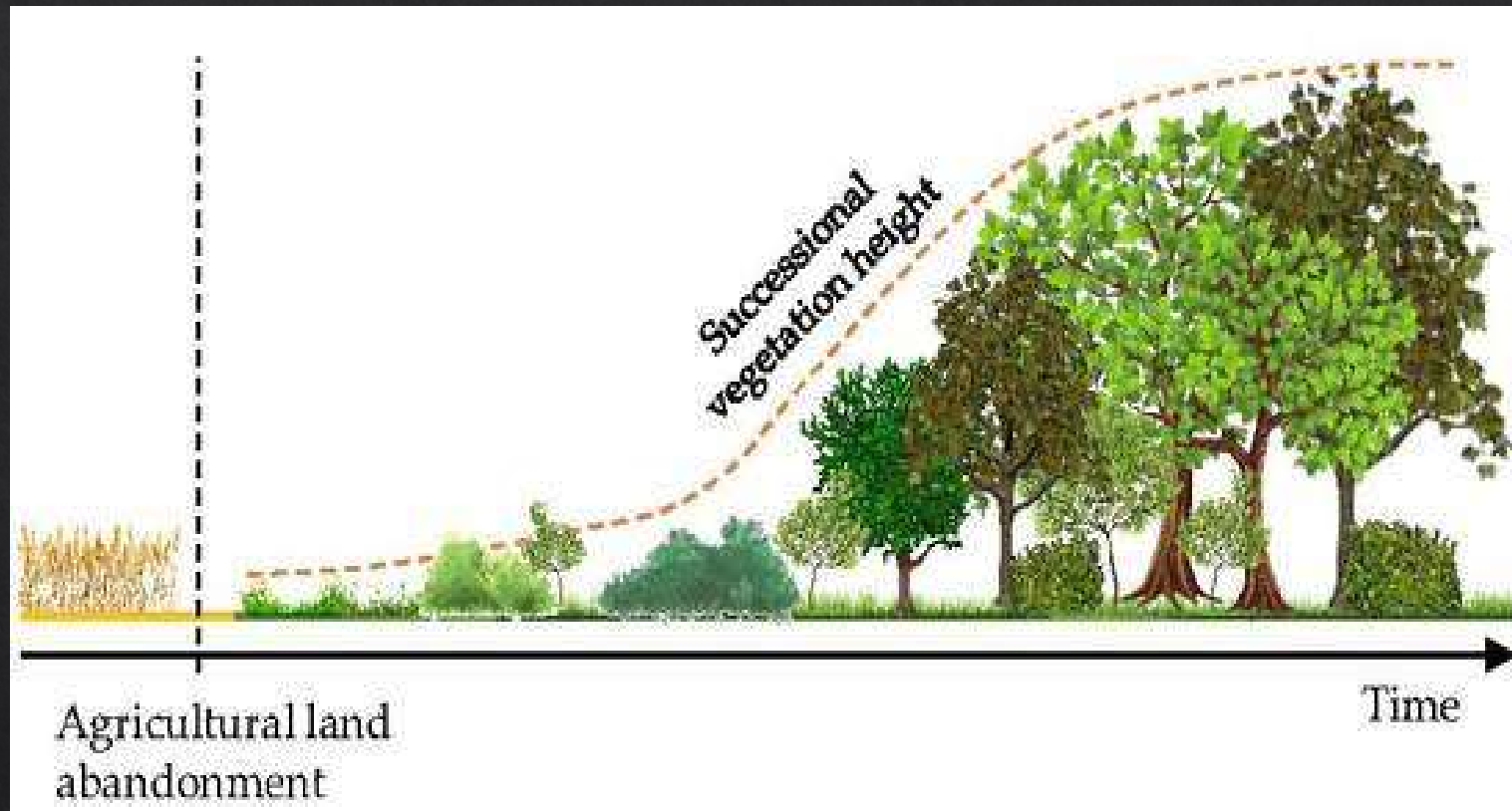
## Defining farmland abandonment

..... the cessation of farming (could be grassland, cropland) leading to the natural restoration of vegetation or degradation of farmland facilities up to four or five years (FAO 2006)

..... idle plot without signs of cultivation up to three years (European Environmental Agency)

...."cropland in time I, abandoned (e.g., shrubs) in time II"

# Abandonment in the ground



Source: Kolečka 2018

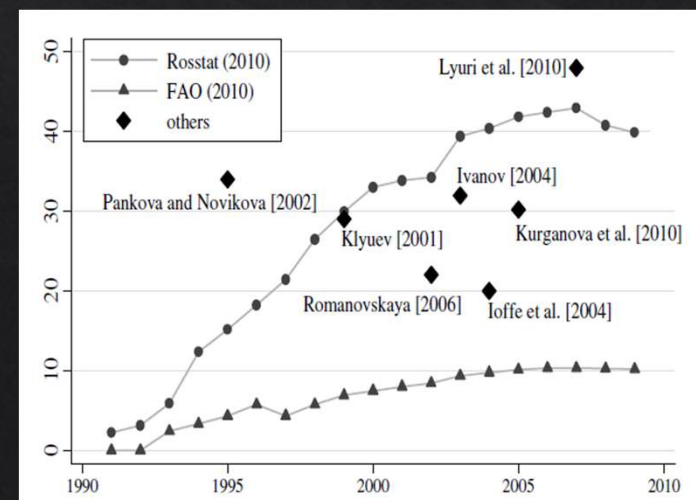
# Progress on monitoring farmland abandonment

- Point-based field surveys, e.g., Land Use and Coverage Area frame Survey in Europe-EUROSTAT (LUCAS)
  - Land cover
  - Land use



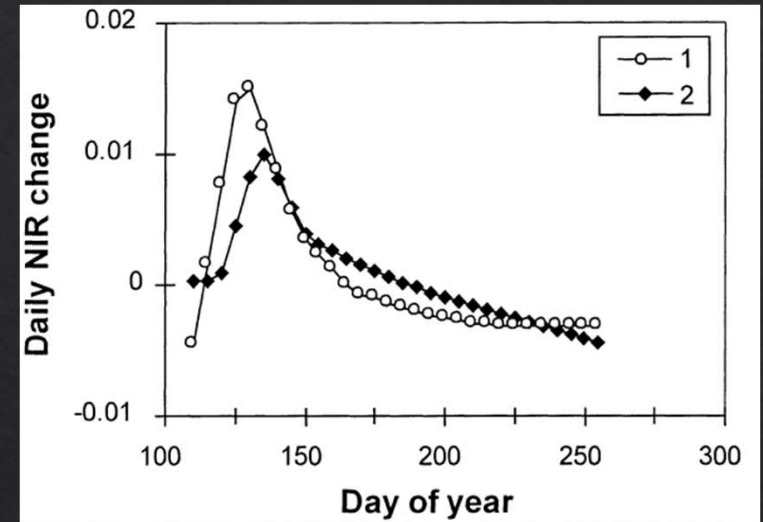
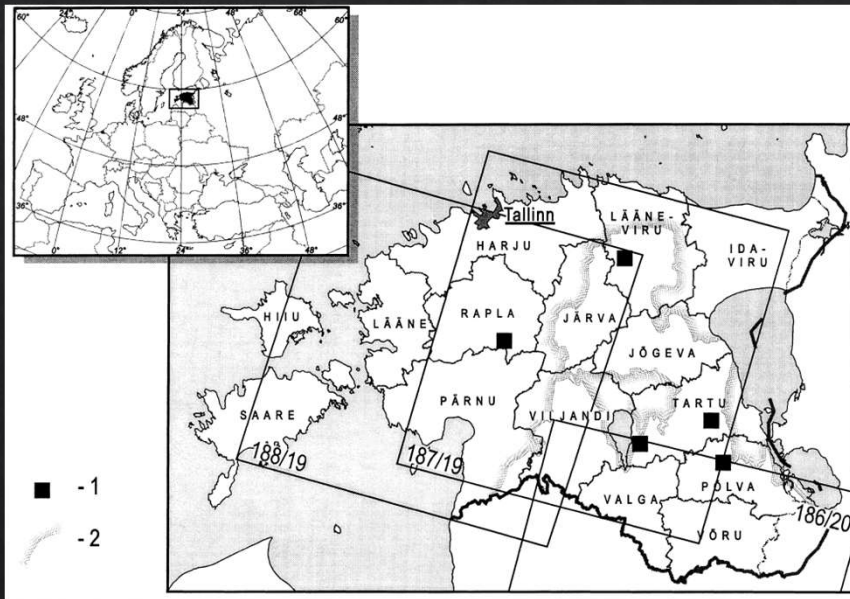
## Cropland abandonment from various sources in Russia

- National and subnational agricultural surveys, FAOSTAT
  - Dynamic of croplands and livestock
  - Aggregated data
  - No tracing abandonment, rather proxies



# Fundamental role of satellite remote sensing

Probably the very first study on farmland abandonment with the aid of single image Landsat MSS image dates (30% of claimed abandonment from 1990 to 1993, no accuracy assessment)



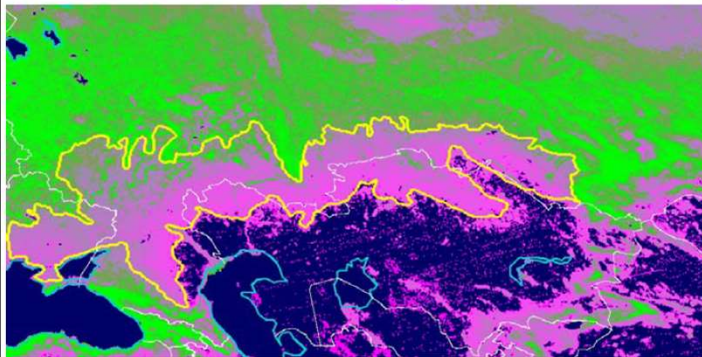
1-Actively managed grasslands,  
2-delay of greenup on  
abandoned grasslands due to  
plant litter

Peterson and Aunap, 1998

# Decisive role of NASA LCLUC program

- Witnessing implications of institutional changes on land use after collapse of the Soviet Union

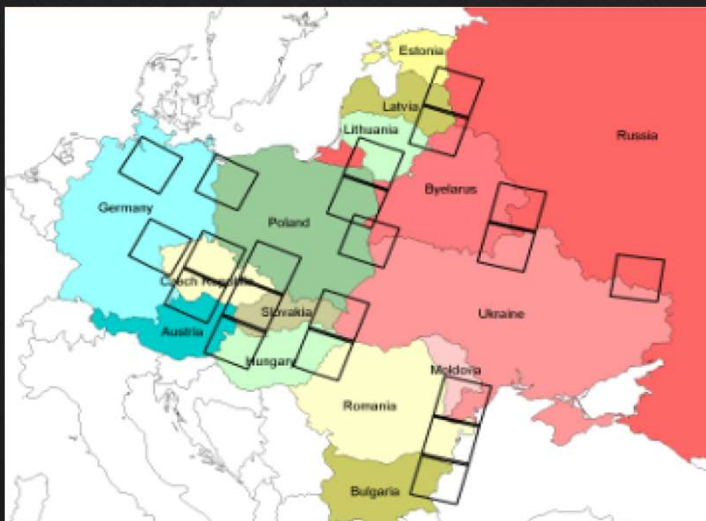
## PAL NDVI dynamics



Red: CV of counts of composites with NDVI > 0.5  
Green: sum of counts  
Blue: skewness of counts

Evaluating the effects of institutional change on regional hydrometeorology: Assessing the vulnerability of the Eurasian semi-arid grain belt (2005-2008)

PI: Dr. Geoff M. Henebry

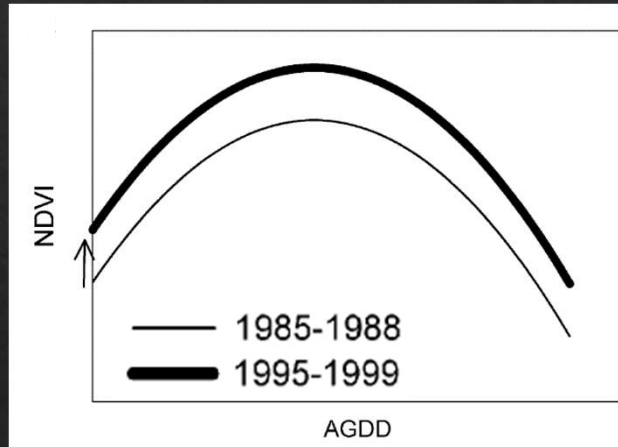


Post-USSR land cover change in Eastern Europe:

socioeconomic forcings, effects on biodiversity, and future scenarios (2005-2008)

PI: Dr. Volker C. Radeloff

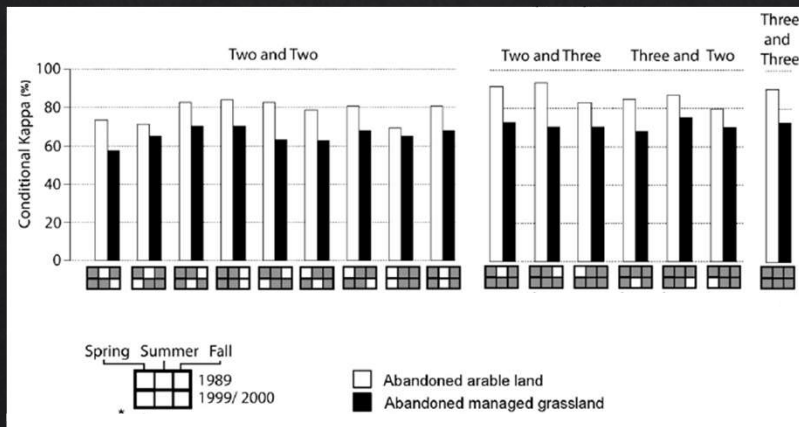
# Decisive role of NASA LCLUC program



Accumulated growing degree-days (AGDD)

*Changes in NOAA AVHRR land surface phenology due to farmland abandonment and livestock decline in Kazakhstan*

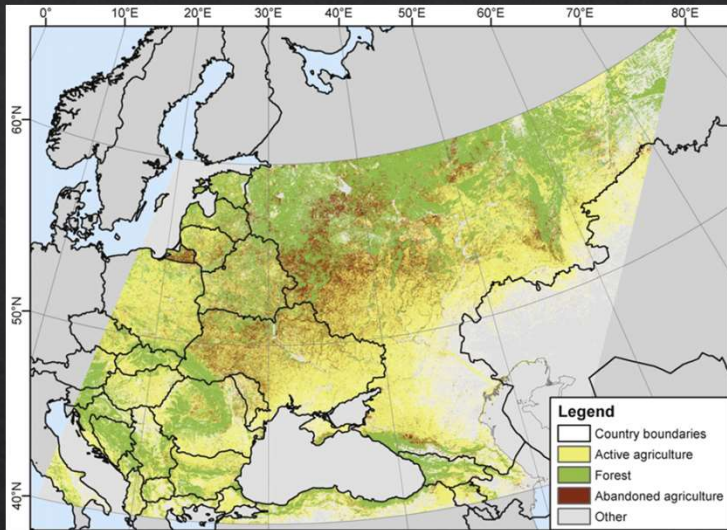
de Beurs and Henebry, 2004, RSE



*Landsat single image dates (as for forest-cover change) are insufficient to map abandonment. Specific image dates matter. Superiority of machine-learning methods.*

Prishchepov...Radeloff, 2012, RSE

# Decisive role of NASA LCLUC program

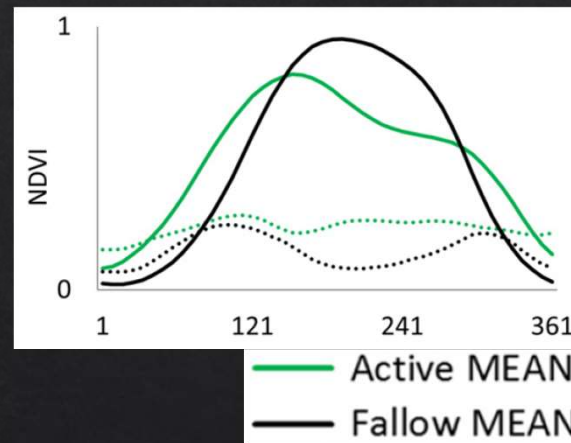


*MODIS NDVI phenology metrics and time-series boost classification accuracies and help to map abandonment at sub-continental level*

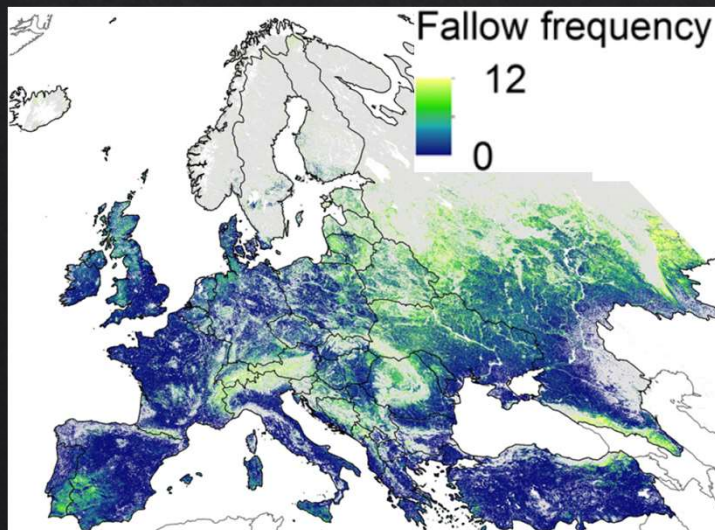
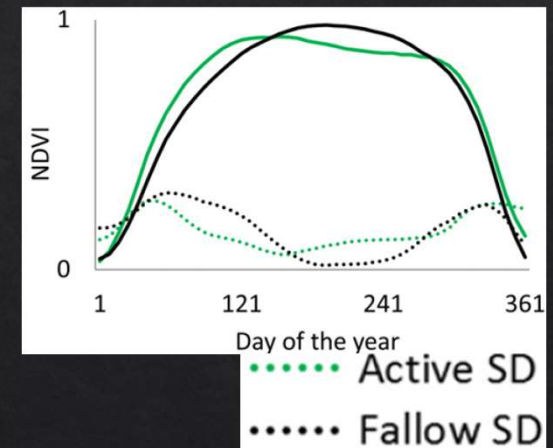
*Alcantara.. Prishchepov..Radeloff, 2012, RSE.*

*Alcantara.. Prishchepov..Radeloff, 2013, ERL*

Cropland



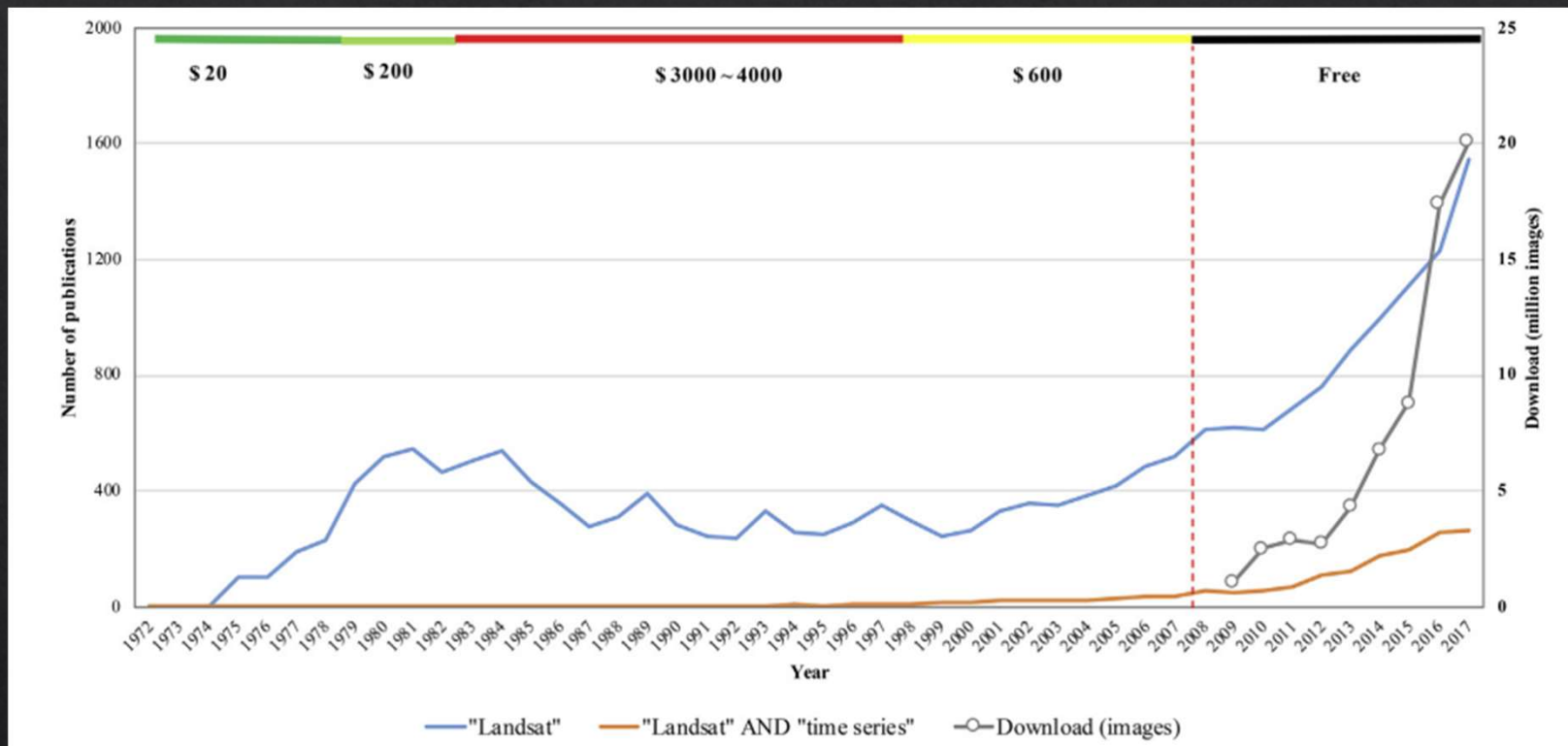
Grassland



*Mapping yearly cropland extent with MODIS NDVI, may relax definitions of abandonment (e.g., calculating land-use intensity)*

*Estel.. Prishchepov.. et al., 2015, RSE*

# Changing paradigm on data accessibility

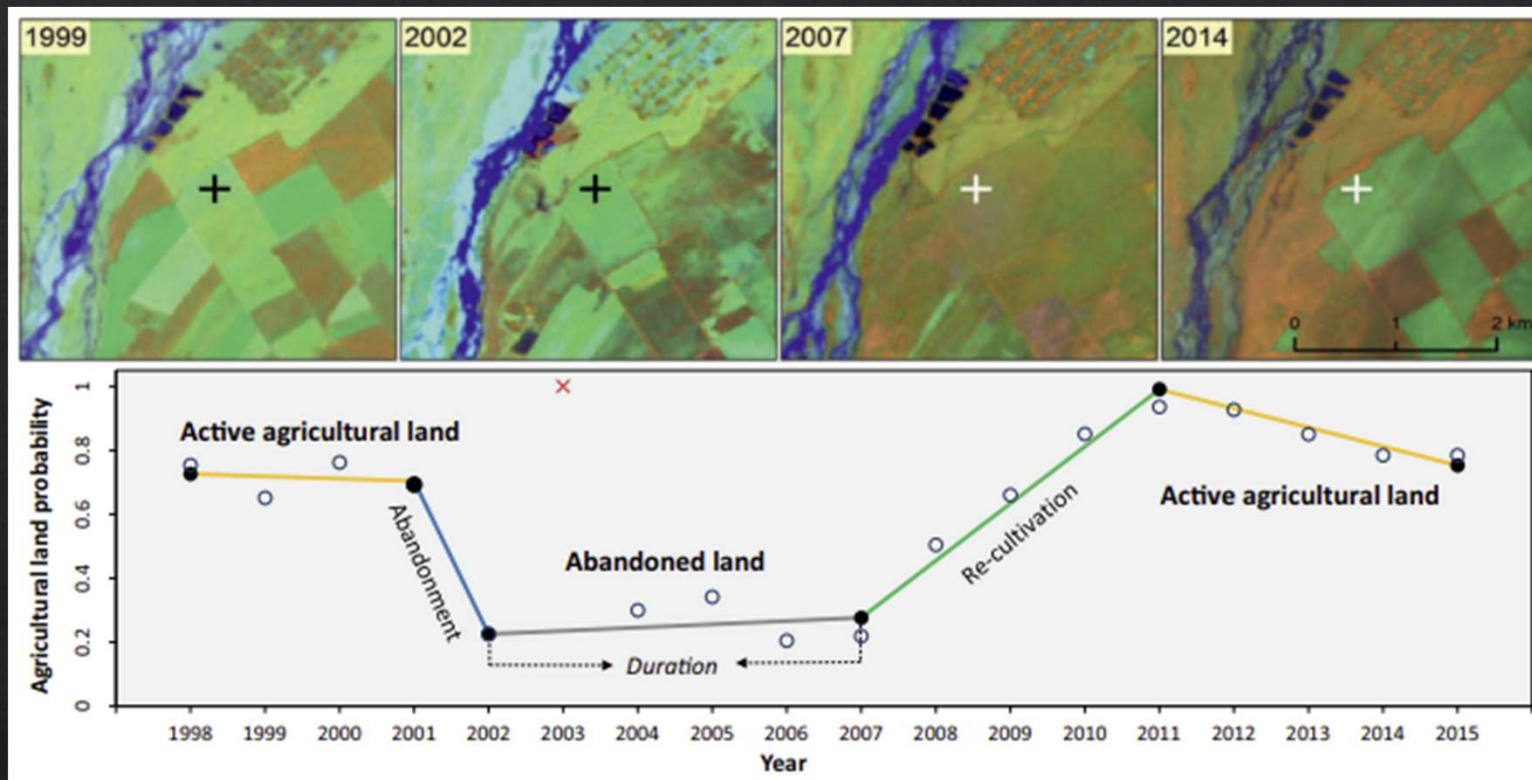


Source: Zhu et al., 2019, RSE



# Time-series analysis to capture farmland abandonment at earlier stages

Application of spectro-temporal segmentation algorithms to benefit on image times series. Example of LandTrendr

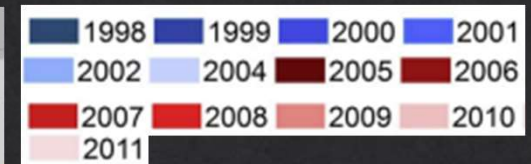
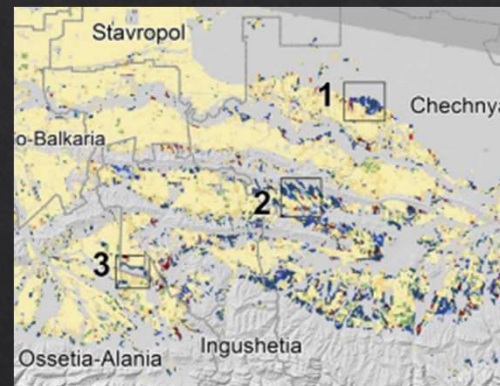


Source: Yin, Prishchepov ...Radeloff, 2018, RSE

# Time-series analysis to capture farmland abandonment at earlier stages

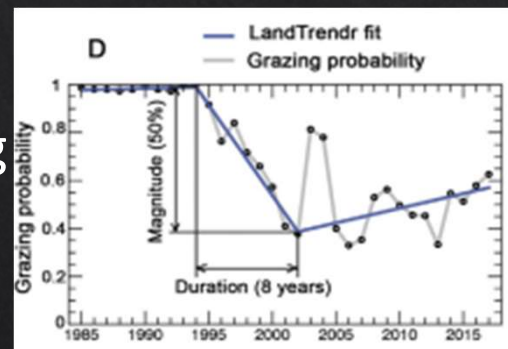
Application of spectro-temporal segmentation algorithms to benefit on image times series. Example of LandTrendr

Application in temperate regions-cropland abandonment



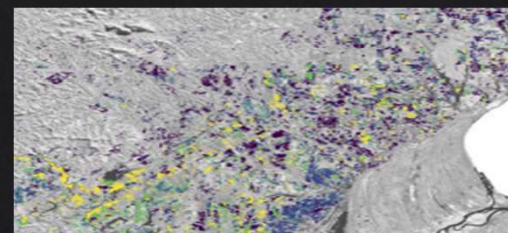
Source: Yin, Prishchepov ..Radeloff., 2018, RSE

Application in steppe biome-grazing abandonment



Source: Dara... Prishchepov et al., 2020, RSE

Application in tropics-sugarcane abandonment



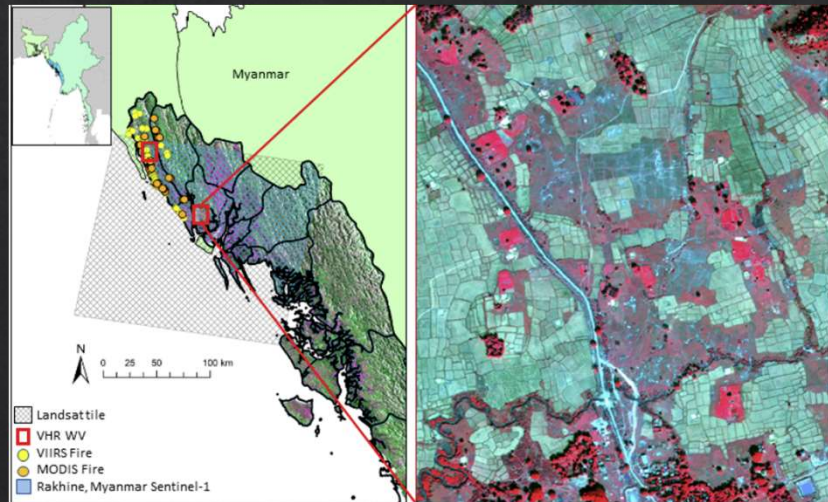
Source: de Castro et al., 2022, RSE



# Benefiting from multisource remote sensing

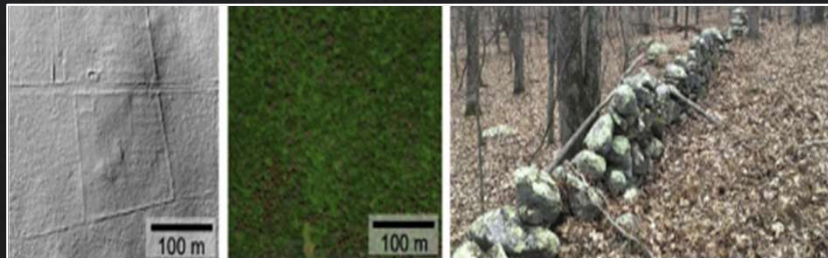
Multisource imaging helps to ascribe the unique features of abandoned fields

SAR (Sentinel-1) may perform better or in combination with optical data (Sentinel-2, Landsat 8) rather optical alone



Source: Huang, et al., 2019, Land

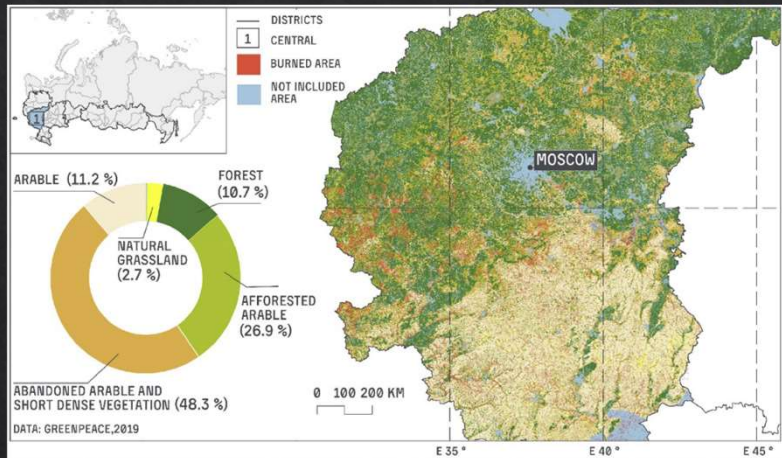
Applications of LiDAR alone or in combination with other RS products



Source: Jonson, et al., 2021, Remote Sensing, Rittenhouse, et al., 2022, Remote Sensing

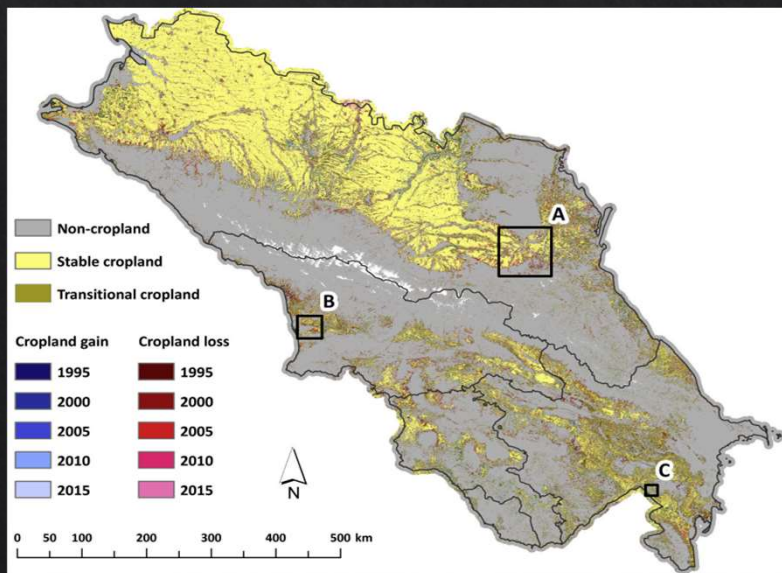
# Moving from case studies to continental level analysis

Sub-continental mapping of different stages of natural succession on abandoned fields



Source: Glushkov...  
Prishchepov, 2021, ERL

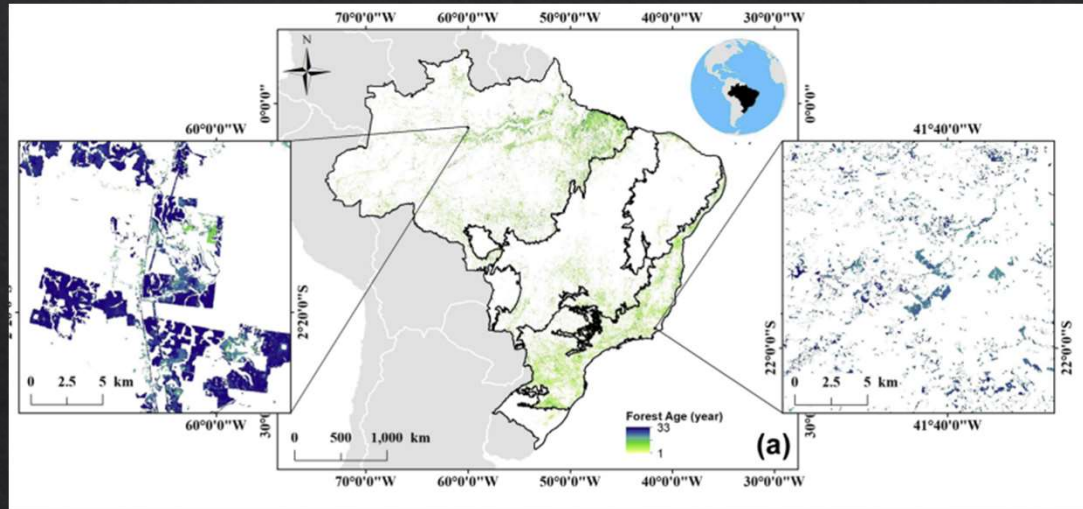
## Abandonment across Caucasus



Source: Buchner... Yin,  
Radeloff 2021, RSE

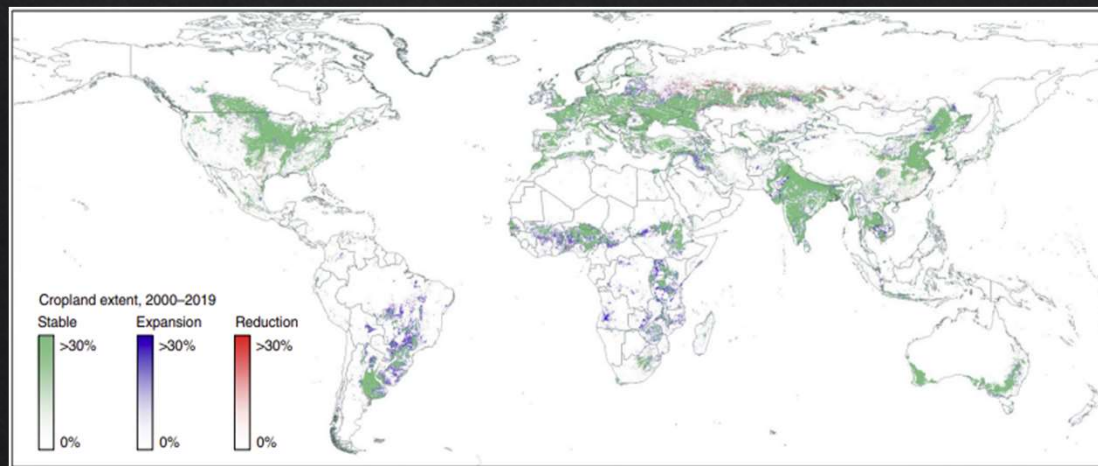
# Moving from case studies to continental level analysis

## Secondary forest regrowth in Brazil, 1986-2018



Source: Silva Junior et al., 2020, Scientific Data

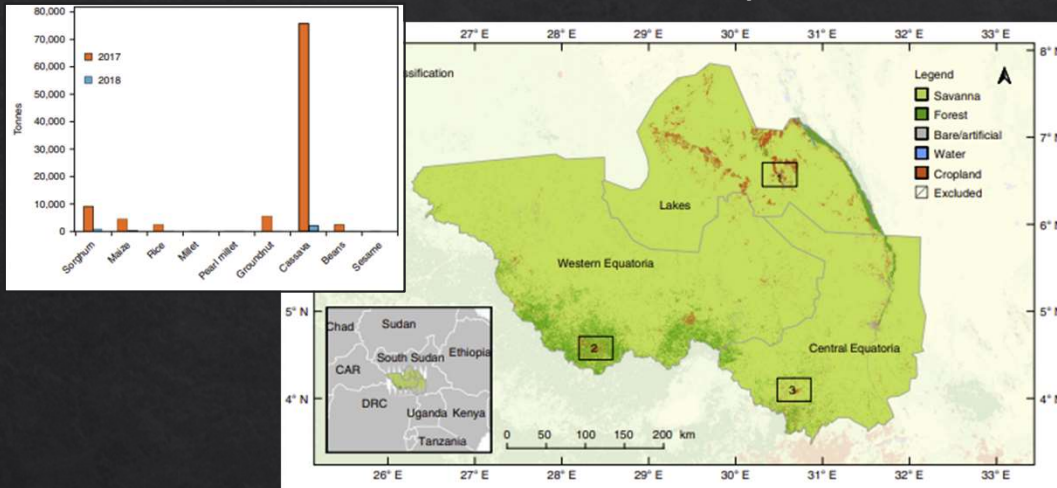
## Global cropland decline, 1990-2020



Source: Potapov et al., 2021, Nature Food

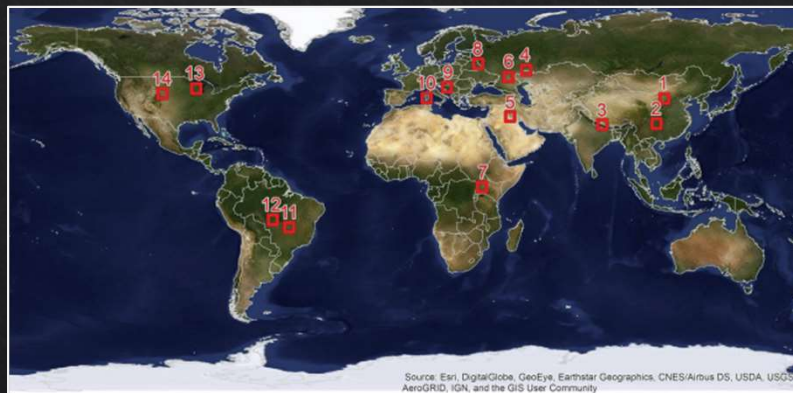
# Interesting studies linking to various processes

Farmland abandonment among smallholder farmers linked to armed conflicts and food insecurity in South Sudan



Source: Olsen ..Olofsson, ... Prishchepov, 2021, Nature Food

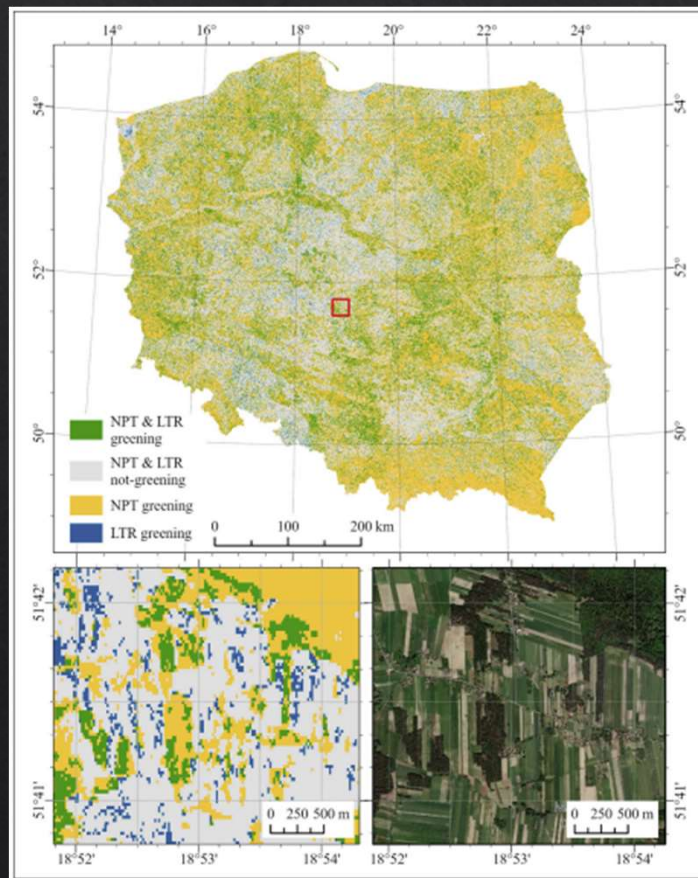
Multisite mapping of farmland abandonment



Source: Yin ..Radeloff, 2019, RSE

# Interesting studies linking to various processes

Linking ongoing greening and farmland abandonment in Poland with non-parametric trend (NPT) and LandTrendr (LTR)



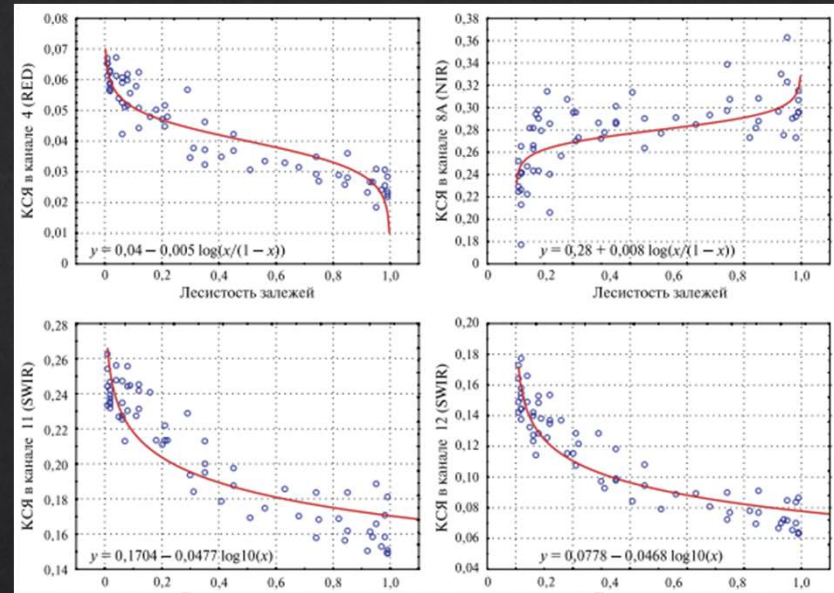
Source: Kolecka, 2021,  
RSE

# If vegetation recovery can be compared to natural conditions, relationship with spectral characteristics

Degree of afforestation



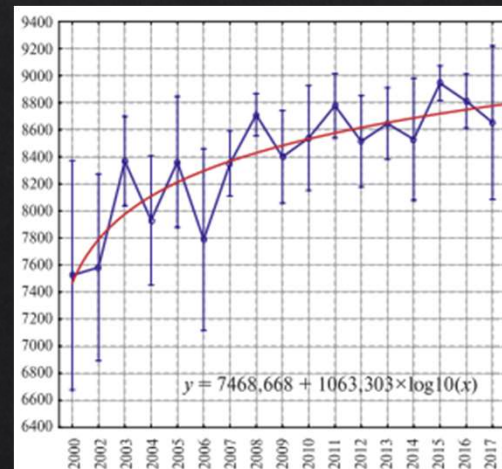
Reflectance



Forestness

Degree of afforestation is a proxy for timing and duration of farmland abandonment

NDVIx10000, June 10th



Year

Terekhin, 2022



# Interesting studies linking to various processes

## First review on land abandonment

Goga et al. “A Review of the Application of Remote Sensing Data for Abandoned Agricultural Land Identification with Focus on Central and Eastern Europe.” *REMOTE SENSING* 11, no. 23 (2019).  
<https://doi.org/10.3390/rs11232759>.

## Complexity of definitions of farmland abandonment

Grădinaru et al. “Multi-Dimensionality of Land Transformations: From Definition to Perspectives on Land Abandonment.” *Carpathian Journal of Earth and Environmental Sciences* 15, no. 1 (2020): 167–77.  
<https://doi.org/10.26471/cjees/2020/015/119>.

## What we learned so far

- Multiseasonal, multisource imagery matter, plus phenology characteristics may improve classification accuracies
- Progress in time-series analysis allowed to capture earlier timing of farmland abandonment
- Farmland abandonment is widespread
- Abandonment may or may not lead to greening and carbon intake
- Abandonment may result in novel ecosystems
- NASA LCLUC Program plays a decisive role in studying farmland abandonment

# Existing Research Gaps

- Global land cover products do not fully capture abandonment
  - *we need to move toward global abandonment maps*
- One abandonment definition “does not fit all”
  - *we need to account for regional land-use practices*
- Abandonment is not static but a transition class
  - *we need to understand new land uses, other than agriculture*
- Abandonment is not about cropland, but other land uses too
  - *testing the methods in other agricultural land-use systems*
- Abandonment represents a plethora of land transition in the ground
  - *quantifying such diversity*
- Overuse GoogleEarth-like VHR satellite imagery
  - *priority to capture land abandonment in the ground*

Other topics: resolution, drivers, syndromes, implications, context, etc.

# Stay Tuned!



ural-land-abandonment-global-land-use-change-phenomenon

19, гибель... New grants to build... SCIENCE AI Centre... Maps | Today's lates... Event | Hybrid Warf... 'No one could have... Focus on Changir

**Global LAND Programme**


An interdisciplinary community of science and practice fostering the study of land systems and the co-design of solutions for global sustainability

LOG-IN SEARCH

WHO WE ARE HOW WE WORK OUR SCIENCE NEWS & EVENTS FIND A SCIENTIST BECOME A MEMBER

## How We Work

- Open Science Meetings
- Working Groups
  - Agricultural Land Abandonment as a Global Land-Use Change Phenomenon
  - Archetype Analysis
  - BeModelS: Behavioural Models of Land Systems
  - Co-Production of Sustainable Land Systems
  - Global Dryland Social-Ecological Systems
  - Integration of Rural and Urban Land Systems
  - Remittance Dynamics and Land Change
  - Remote Sensing in Big Data Era
  - Shifting Cultivation in Transition
  - Socio-Ecological Land Systems of Latin America
  - Telecoupling Towards Sustainable Transformation
- Nodal Offices
- Workshops
- Contributing Projects
- Endorsements



Actively cultivated and abandoned terraces in Nepal. Photo: Suresh Chaudhari

## Agricultural Land Abandonment as a Global Land-Use Change Phenomenon

### Short Description

The world is facing a looming scarcity of land necessary to secure agricultural commodities production and experience competition from other land uses. At the same time, evidence shows agricultural land abandonment is a global land change process with a recent spread of abandonment in the Global South. Research on agricultural land abandonment is disproportional compared to other land change processes, such as deforestation and agricultural expansion. At the same time, agricultural land abandonment has strong implications to the environment and societal well-being, including food security. There are many challenges to understand the agricultural land abandonment process stemming from the fuzzy definition of abandonment, the ability to measure abandonment patterns, the diversity of factors driving agricultural land abandonment, and its environmental consequences.

Through seminars, thematic workshops, reports, and research papers, our working group will advance understanding agricultural land abandonment process, namely, but not exclusively:

1. role of individual decision-making and behavioral mechanisms regarding agricultural land abandonment;
2. progressing on mapping agricultural land abandonment;
3. the role of rural-urban transition in the relationship to abandonment;
4. an alternative to agriculture reuse of formerly cultivated lands;
5. policies to mitigate, but also foster retirement of cultivated lands;
6. environmental and societal impacts of agricultural land abandonment, including food security;
7. agricultural land abandonment - food security interlinks.

[https://bit.ly/1\\_aband](https://bit.ly/1_aband)



**Thank you!**  
**alpr@ign.ku.dk**