How the armed conflicts affect land systems: A remote sensing perspective

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Kent State University
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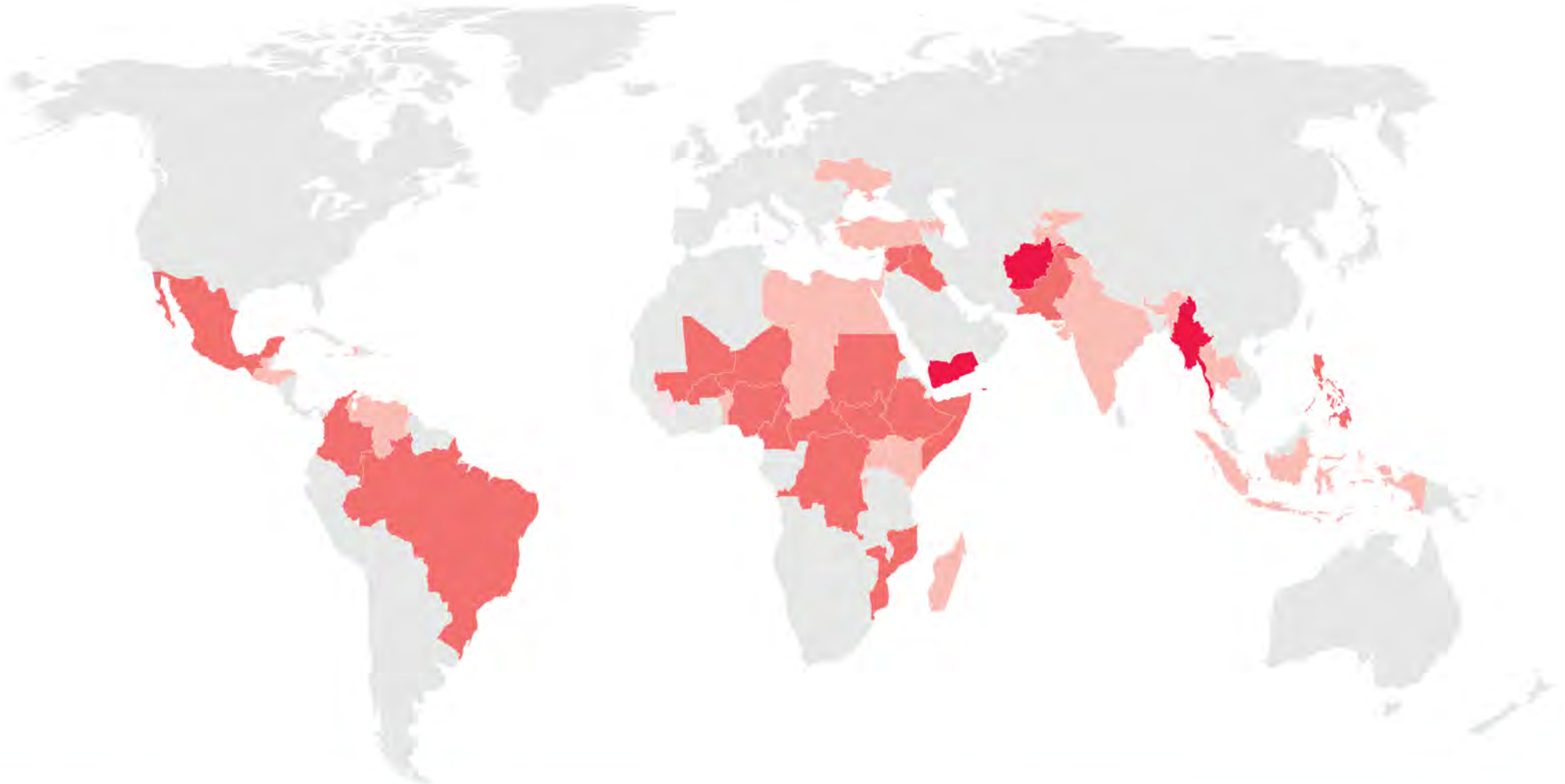
LENNON WALL
PRAGUE
30
30 YEARS OF F
CZECH REPUBLIC
1989–2019
ALL YOU NEED IS
ЛЮБОВЬ
ALL YOU NEED IS
MIŁOŚĆ
ALL YOU NEED IS
AMOR
ALL YOU NEED IS
LÁSKA
ALL YOU NEED IS
ЛЮБАВ
ALL YOU NEED IS
自由
ALL YOU NEED IS
자유
ВСЕМ НУЖНА ЛЮБОВЬ
HELPFUL
STAND WITH HONG KONG
IN COVID
27.03.22
KURDISTAN
Handy an.
Welt
RONDODASOSA
Seid Lieb

ARMED CONFLICTS IN 2021



Major armed conflicts with 10 000 or more conflict-related deaths in 2021.

High-intensity armed conflicts with 1000 to 9999 conflict-related deaths in 2021.

Low-intensity armed conflicts with 25 to 999 conflict-related deaths in 2021.

Note: The boundaries used in this map do not imply any endorsement or acceptance by SIPRI.
Source: SIPRI Yearbook 2022.

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Tech

Ukraine crisis: Satellite data firm asks for war images

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LIVE

Satellite images show damaged warplanes after Crimea explosions, despite Russian claims; McDonald's to reopen in Ukraine: Updates

Christine Fernando and Jorge L. Ortiz USA TODAY

Updated 6:20 p.m. ET Aug. 11, 2022

CNN World Africa Americas Asia Australia China Europe India Middle East United Kingdom

Drones, phones and satelli exposing the truth about R Ukraine in near real-time

Analysis by Nic Robertson, CNN

Updated 7:37 AM EDT, Thu April 7, 2022

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Satellite images show Syria conflict leaves country in dark

CARA ANNA March 12, 2015

Remote Sensing in War's Aftermath

High-tech images made from satellites and airplanes are playing a bigger and bigger part in examining ancient cultures and environments. But that's obviously only part of what remote sensing can do. The same techniques—and in some cases the same researchers—are also are playing a key role in analyzing the environmental changes that are making today's headlines.

Take the aftermath of the Gulf war. Farouk El-Baz, director of the Center for Remote Sensing at Boston University, where most of the research is in archeology, has been using an array of satellite instruments to monitor the staggering environmental problems caused by the war. Last week he returned from a month-long trip to six Gulf states where he found that even the high-tech images from Landsat, NOAA 10 and 11, and the European Metosat—precise as they are—hadn't conveyed the true horror of the situation: "I was prepared for the worst, but the damage far exceeds anything I could imagine," says the Egyptian-born geologist, who was invited to survey the region by the Third World Academy of Sciences.

Farouk El-Baz, Boston University

Aerosol spray. *Dark clouds from fires in Kuwait, shown in a Landsat satellite image, may contain large amounts of oil mist in addition to soot and gas.*

In Kuwait, El-Baz says he was appalled to find that the huge cloud spreading from hundreds of oil fires contains far more crude oil than he had expected. "The one thing that stands out like crazy is the fact that the oil is jetted out of the wellheads in an aerosol form and streams of droplets are carried on the wind," says El-Baz. "It's really an oil fog. You'll be standing there for 15 minutes and you'll find crude oil on your shirt." When he saw it dripping from date palm leaves, he predicted that the oily cloud will have a destructive impact on agricultural plants—perhaps as far away as India, where the particulates and "oil rain" have already been detected in the Himalayas.

What worries El-Baz most, however, is where that black cloud is moving. The seasonal "shemal" winds that blow from the north starting at the end of May will blast that cloud southwest toward the relatively populous areas of Bahrain, Qatar, Saudi Arabia, and the United Arab Emirates. El-Baz has entered into a research agreement with the University of the United Arab Emirates to monitor the impact of the cloud; he plans to use satellite images to compare the environmental changes in the area before and after the war.

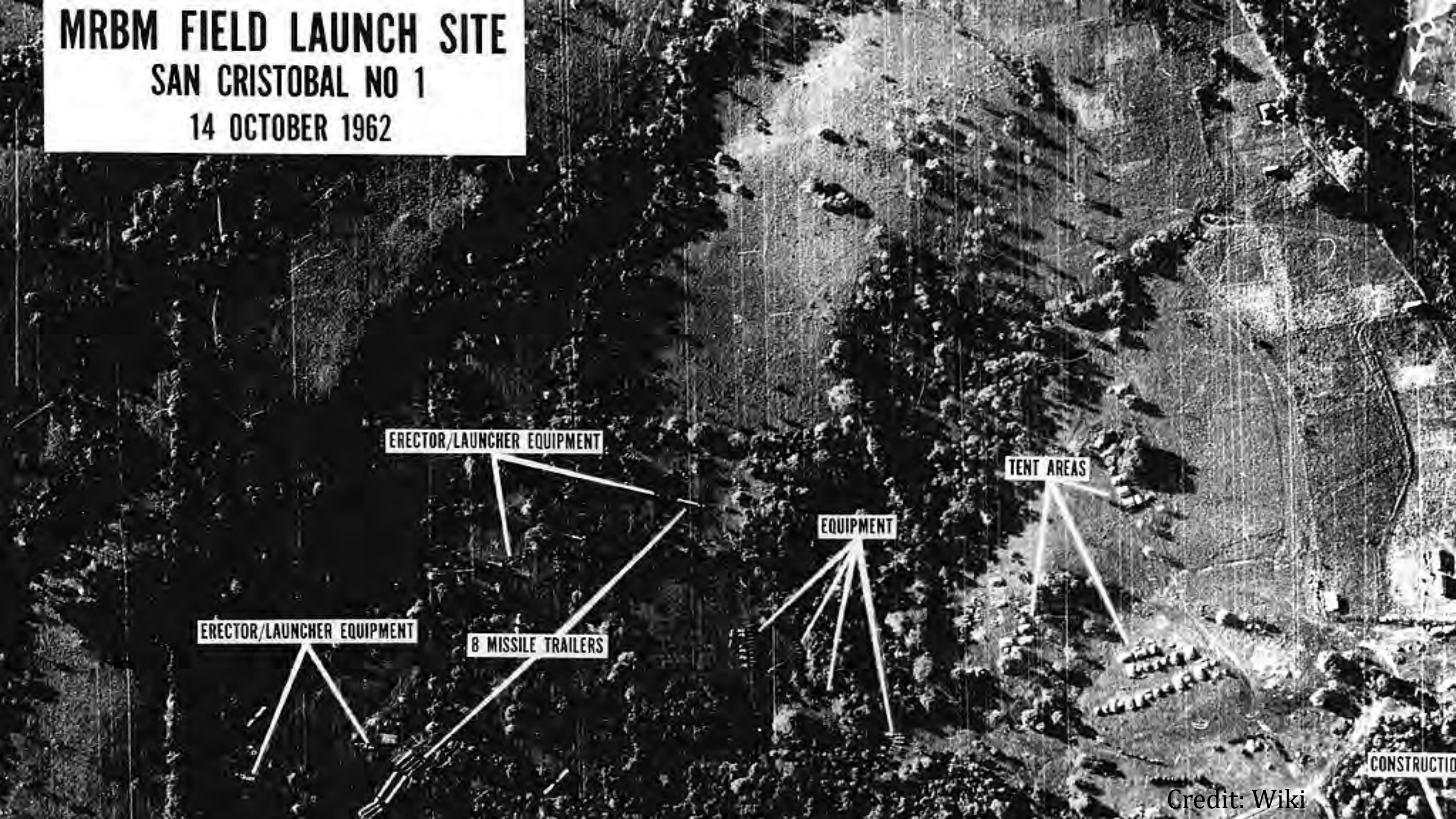
El-Baz isn't alone in his work. A team of 30 atmospheric scientists coordinated by the NSF left for the Gulf last week. That group is also studying the cloud, using remote-sensing instruments and direct sampling methods aboard two aircraft. They are concerned that the cloud will disturb weather patterns in the region, interfering with the summer monsoon and normal seasonal rainfall, says Richard Greenfield, a meteorologist who is coordinator of the mission for the National Science Foundation.

The satellite images are also offering El-Baz a way to observe and analyze the oil slicks in the Gulf that have been moving relentlessly toward the Saudi coast—and that's where concerns about the past and present come together. Although the oil slick hasn't clogged the desalinization plants at Jubail, Saudi Arabia, the Saudis may now have a new environmental problem. They stored the thick oily water in huge pools dug into the sand, where they could become a threat to groundwater supplies.

And the same oil slick—in the form of oil lapping onto beaches in the region—is threatening the last traces of the pre-Islamic Dilman civilization that flourished in the northern Gulf region. Although little is known about them, their burial mounds, with potsherds and other artifacts, have been found throughout the Gulf coast. But now they will be difficult to excavate because their stratigraphy has been damaged by oil and by trenches dug by soldiers.

The combined damage to land and sea, past and present, leads El-Baz to one depressing conclusion: "All in all, this is the mother of all environmental disasters." ■ A.G.

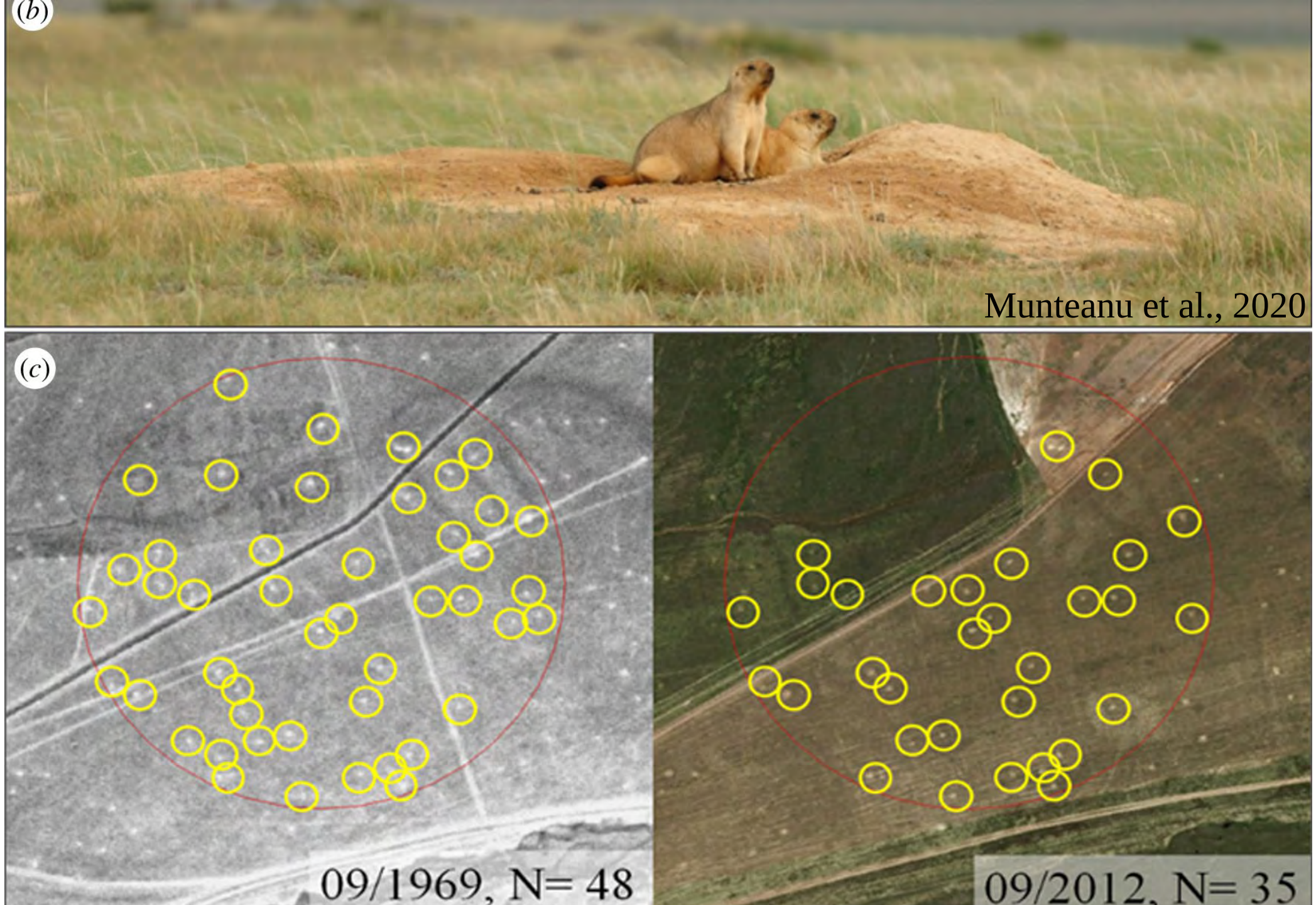
Gibbons, 1991


MRBM FIELD LAUNCH SITE
SAN CRISTOBAL NO 1
14 OCTOBER 1962
ERECTOR/LAUNCHER EQUIPMENT
ERECTOR/LAUNCHER EQUIPMENT
8 MISSILE TRAILERS
EQUIPMENT
TENT AREAS
CONSTRUCTIO

Credit: Wiki

CORONA Capsule
Credit: Air Force

Credit: Wiki


(b)
Munteanu et al., 2020
(c)
09/1969, N= 48
09/2012, N= 35

Values of RS in armed conflicts studies

- Collect information repeatedly over large areas
- Provide evidence in courts of law
- Prepare for soon-to-occur attacks
- Support humanitarian aids
- Post-conflict land use planning

Outline

- Remote sensing monitoring in conflicted areas

    → Urban, Settlement, Forest, Agriculture

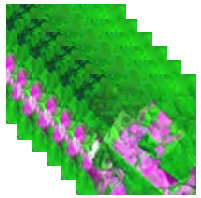
- Case studies: Armed conflicts and land use change

    → Post-Soviet wars in the Caucasus (1991-)

    → The Syrian Civil War (2011-)

- Summary & Outlook

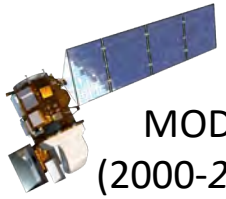
- Hands-on: Google Earth Engine practice on cropland abandonment mapping



High temporal resolution
1-day

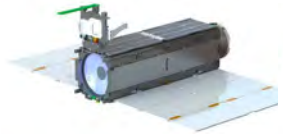
Low temporal resolution
16-day

AVHRR
(1981-)

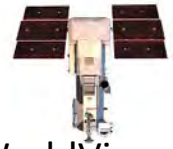


MODIS
(2000-*2026*)

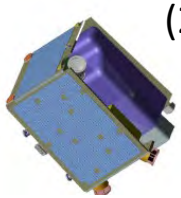
VIIRS
(2011-)



PlaneScope
(2016-)

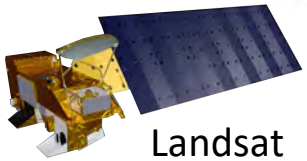


WorldView
(2007-)

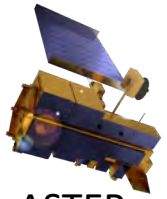


RapidEye
(2008-2020)

Sentinel-1, 2
(2015-)



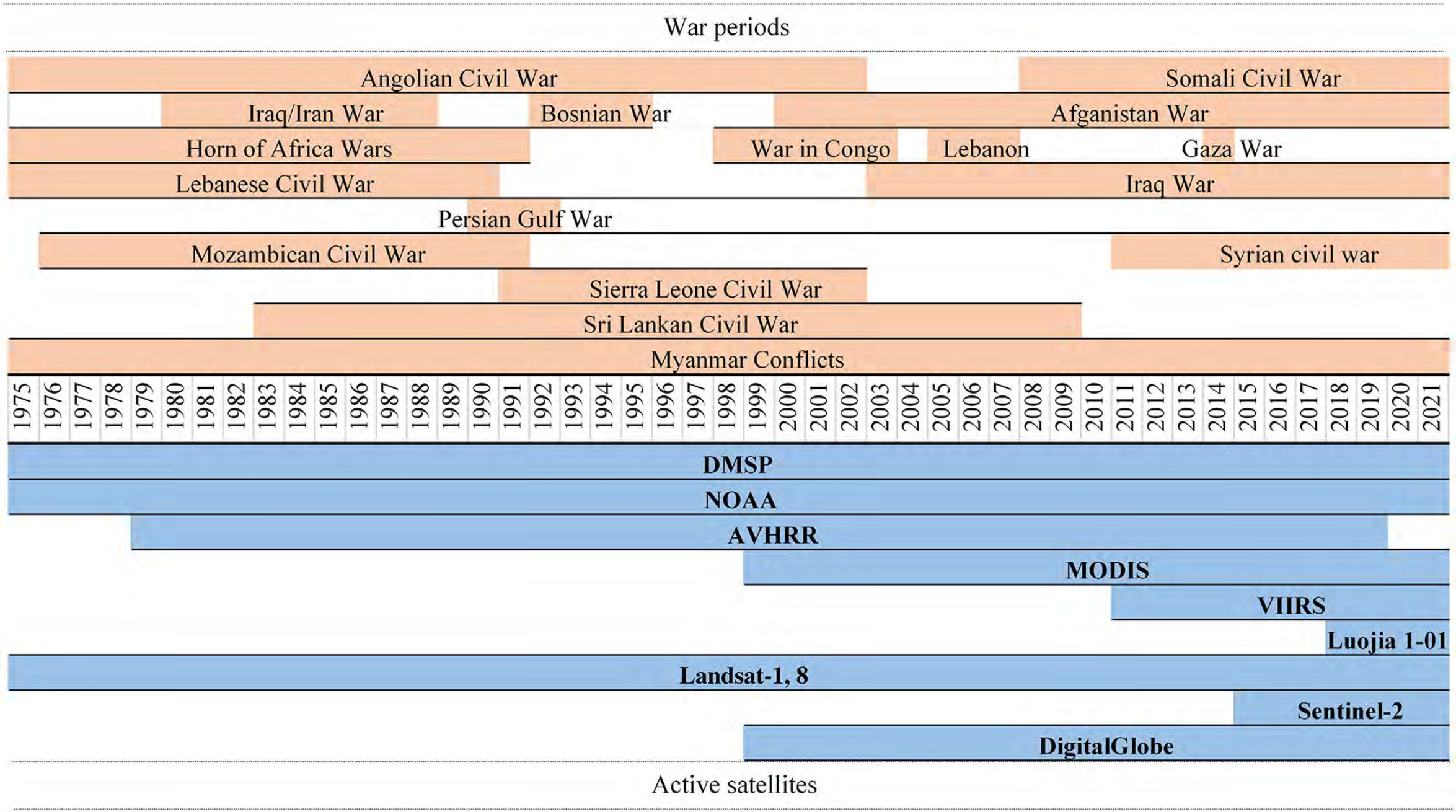
Landsat
(1972-)



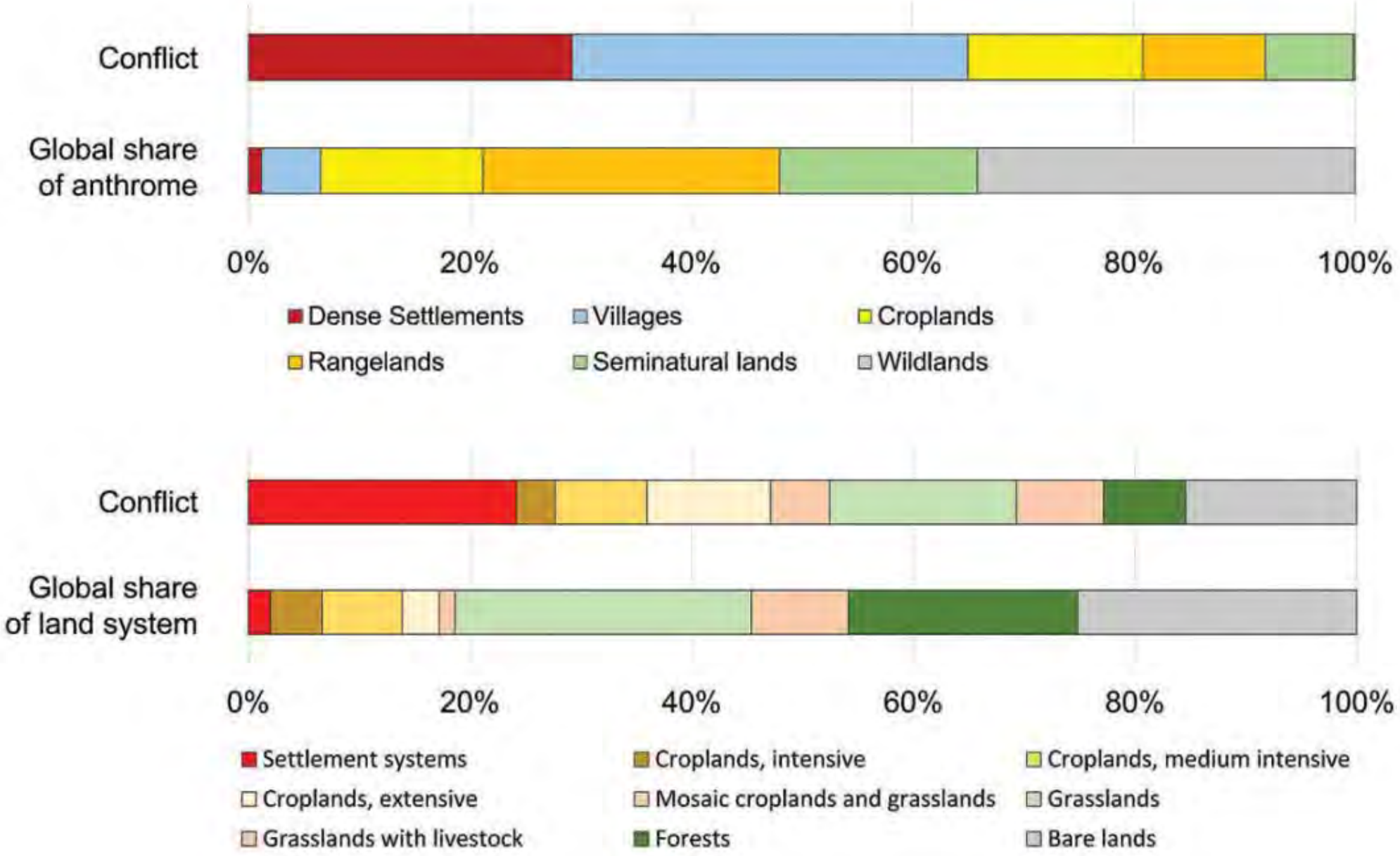
ASTER
(2000-*2026*)

Low spatial resolution
8-km

High spatial resolution
<1m

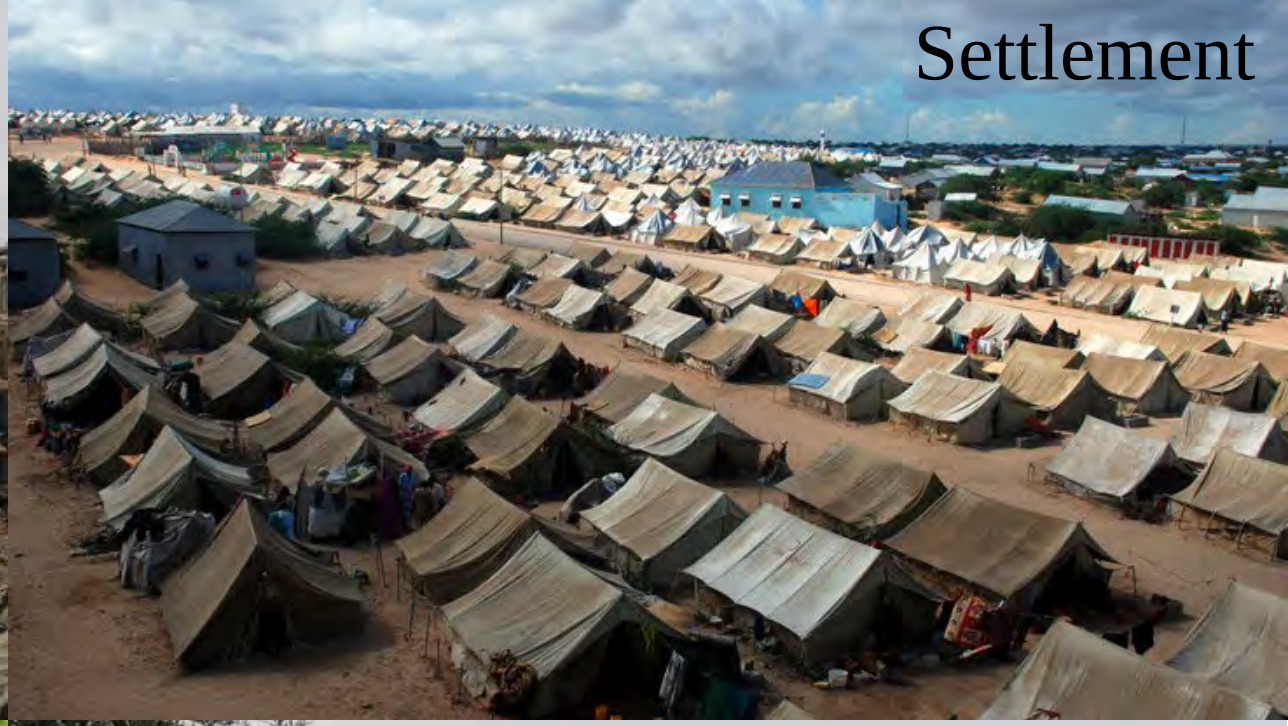


Kaplan et al., 2022



Baumann and Kuemmerle, 2016


Urban

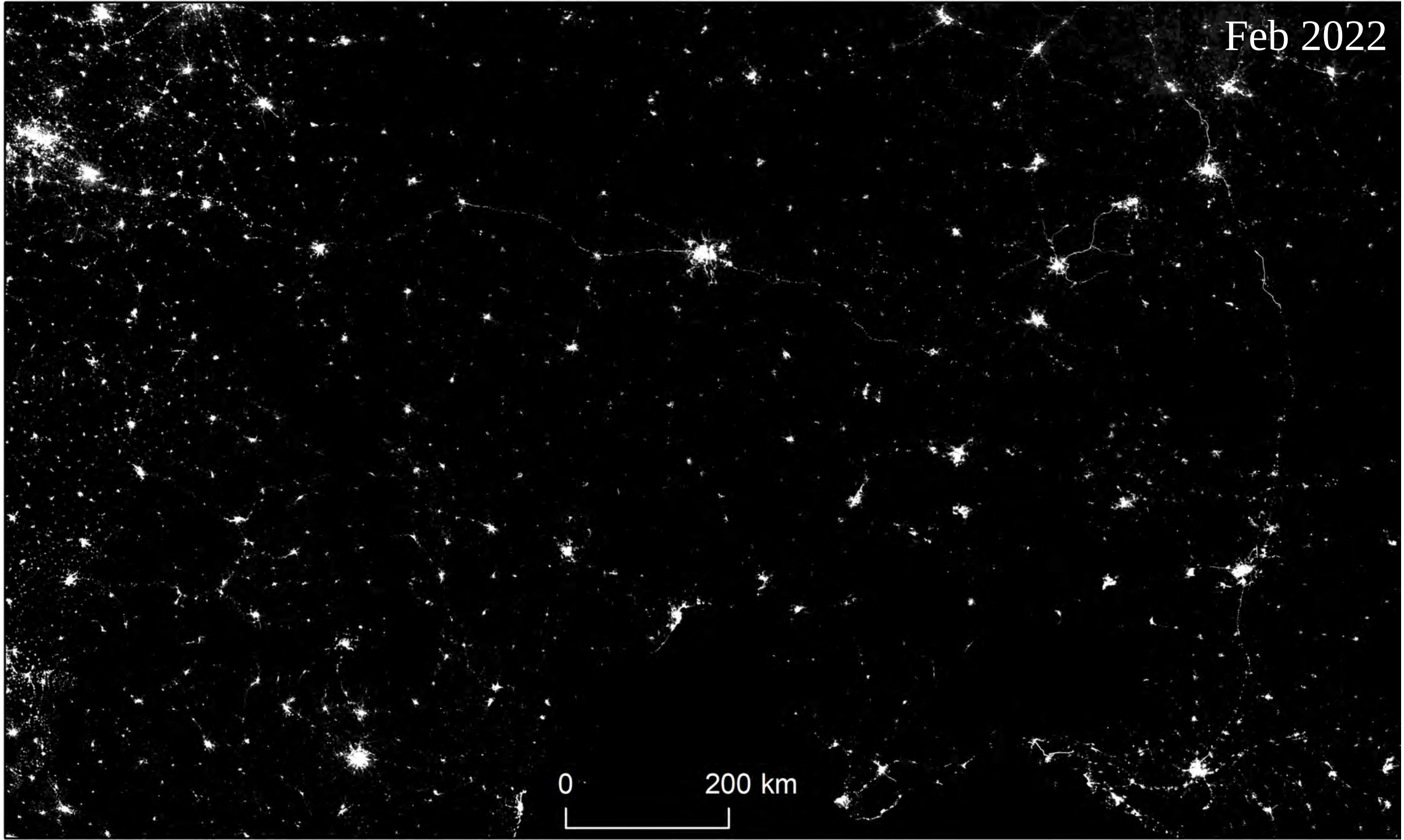

Settlement

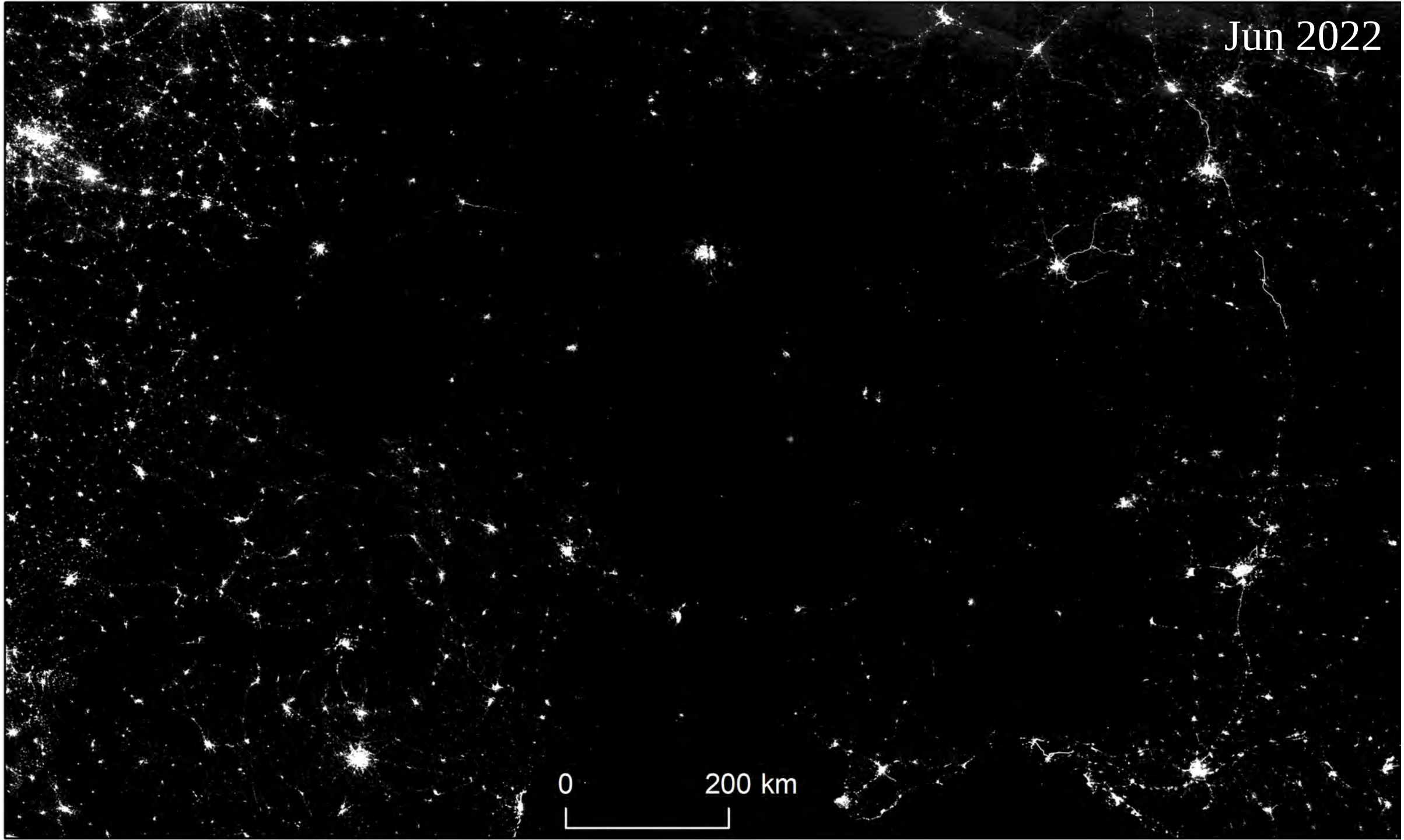

Forest

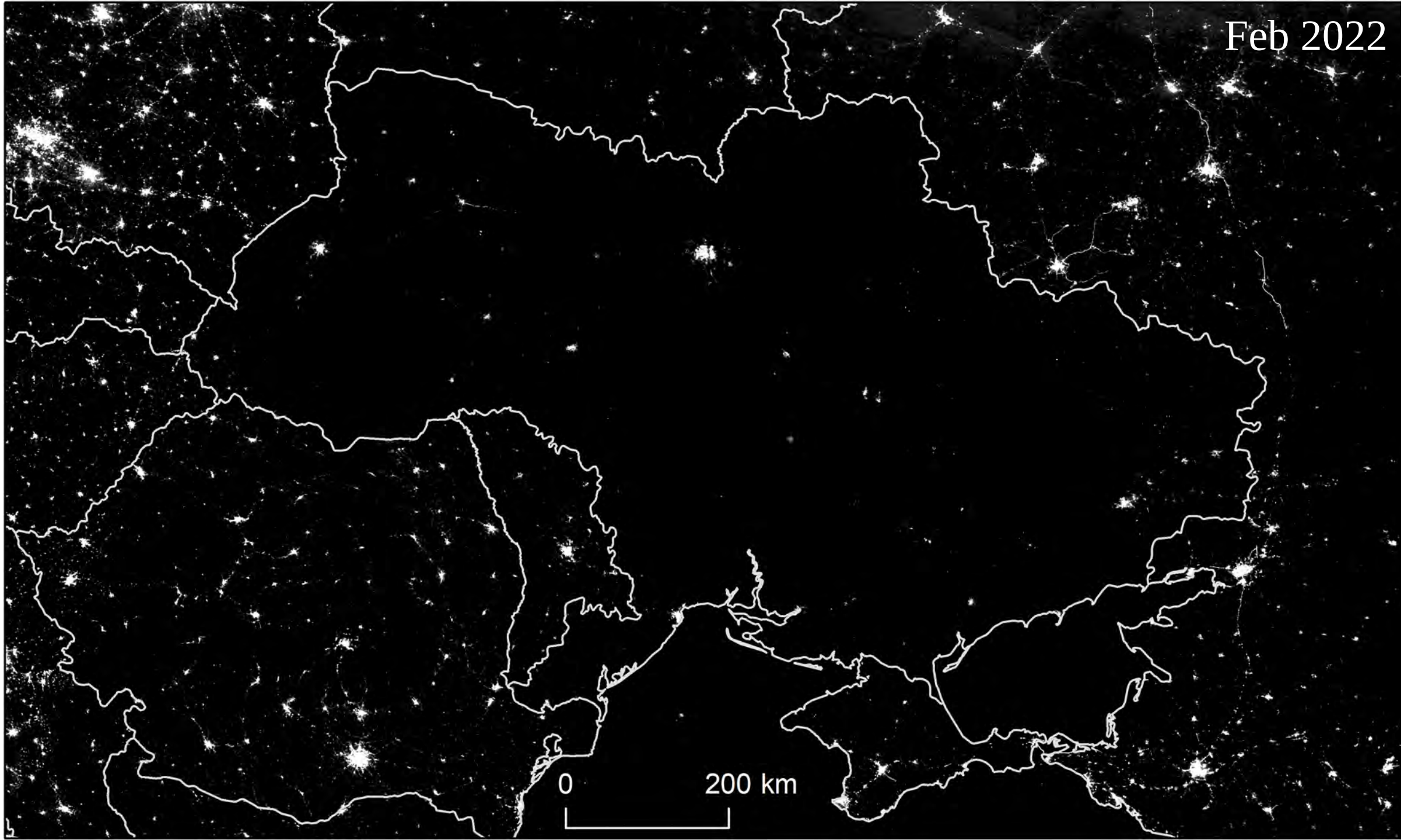

Agriculture

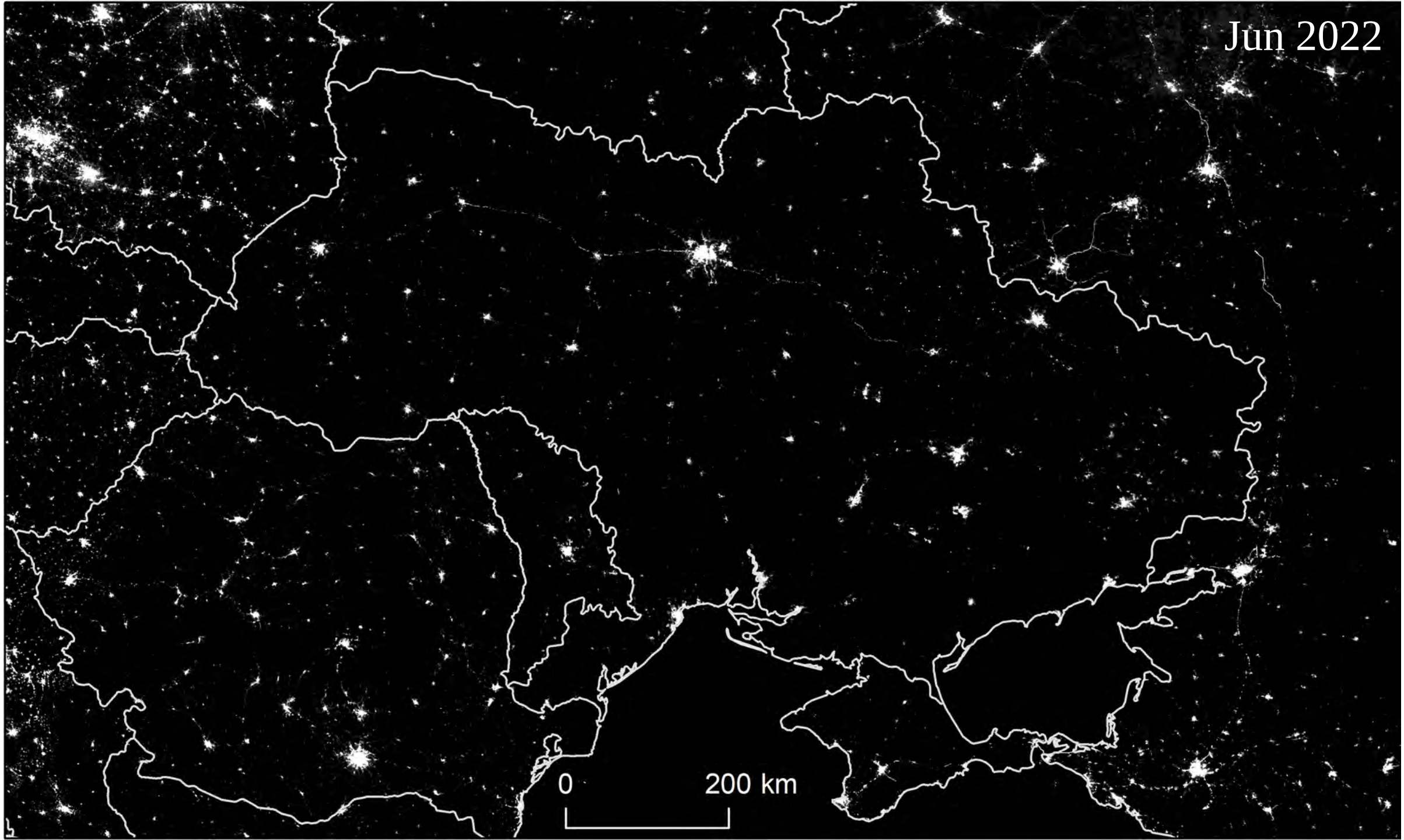

Urban damage

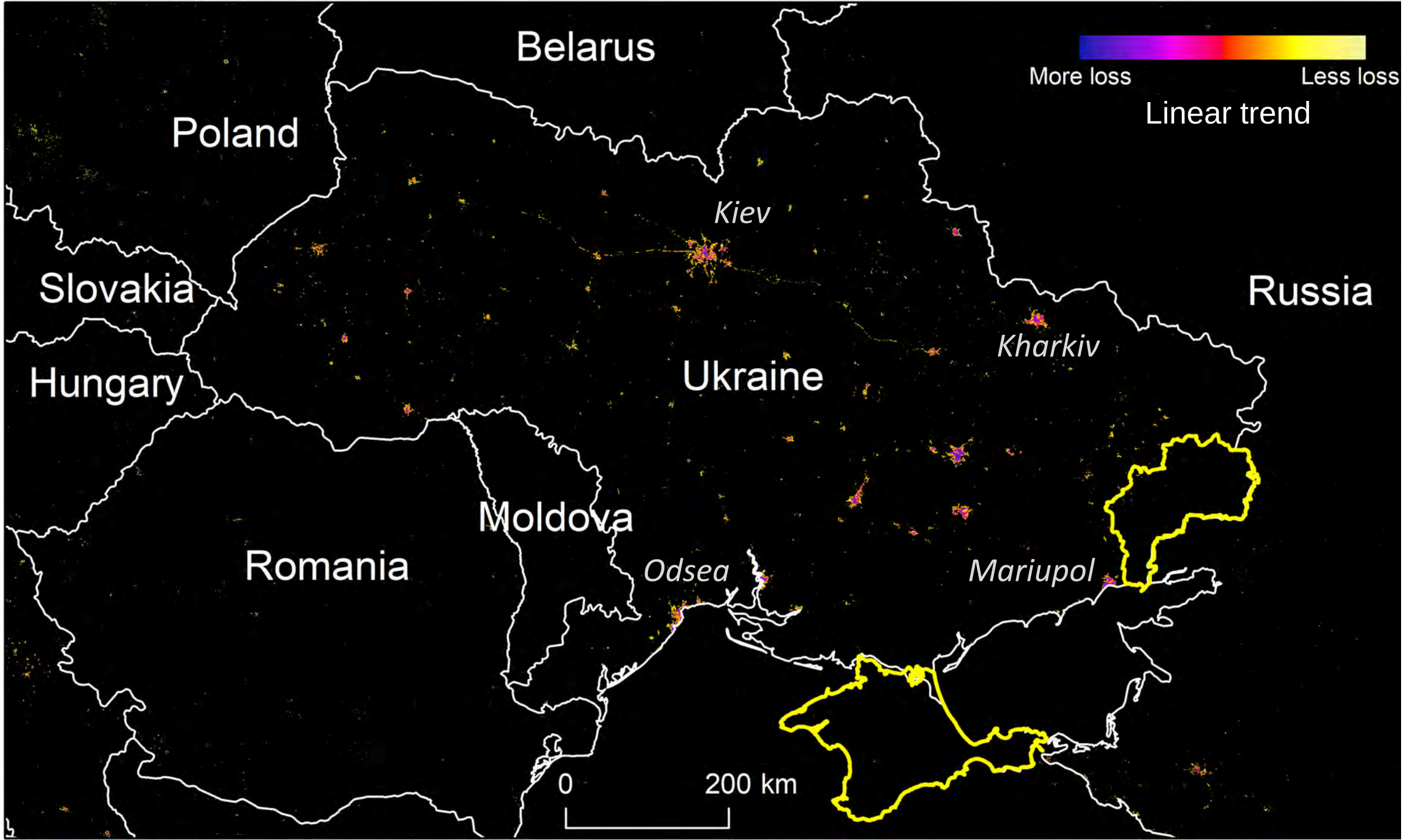
VIIRS Change in the Middle East (NASA)

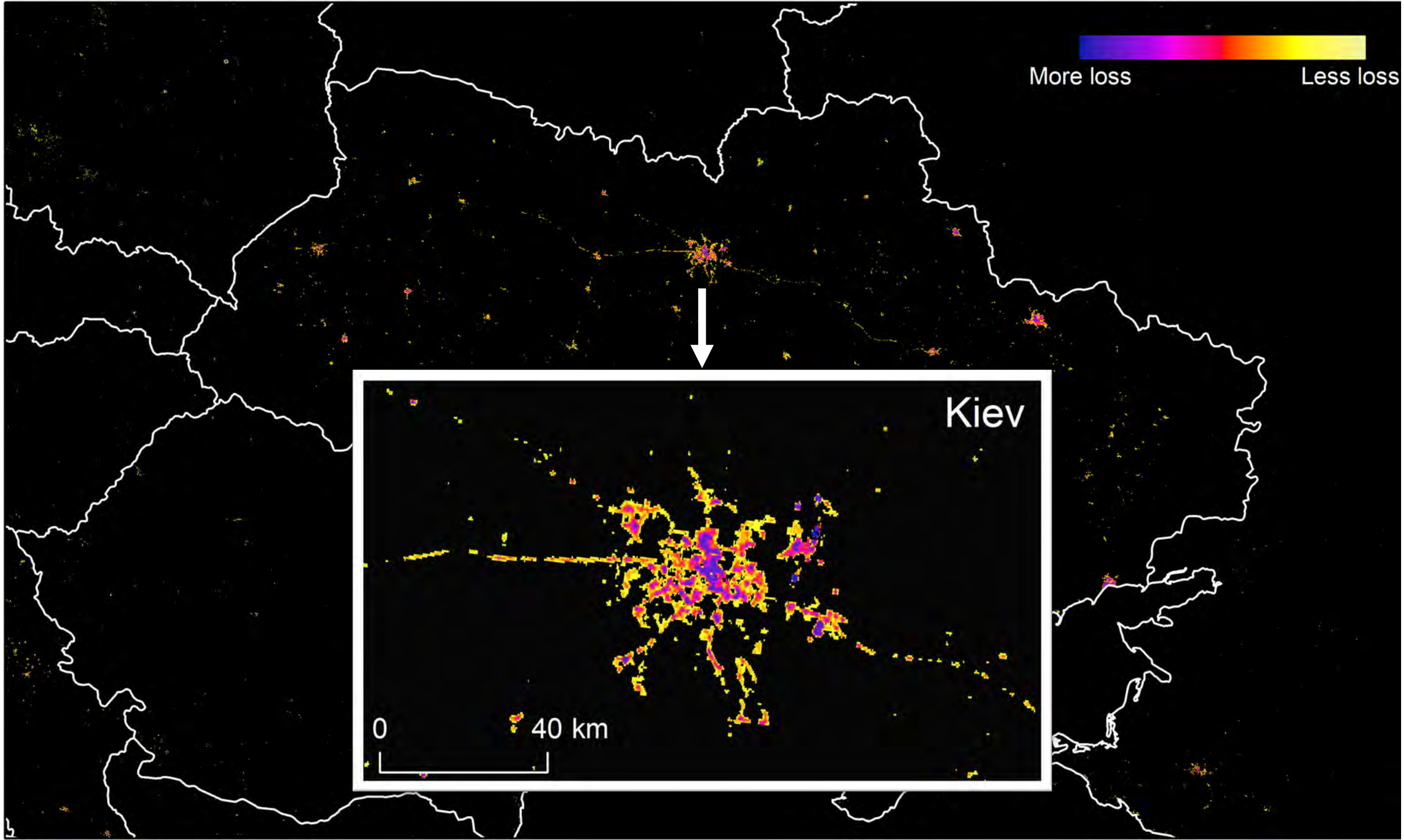

Feb 2022
0
200 km

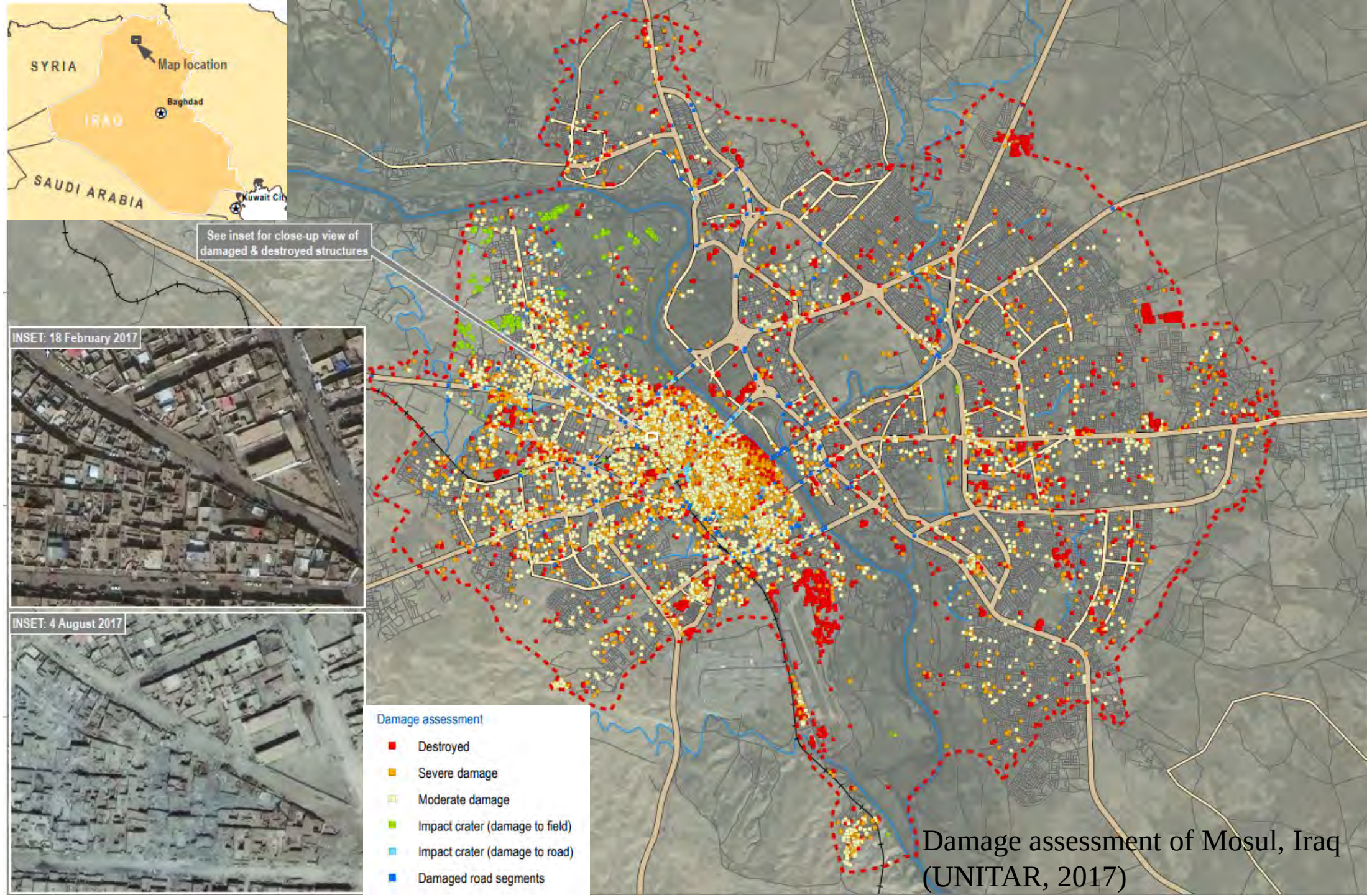

Jun 2022
0
200 km


Feb 2022
0
200 km

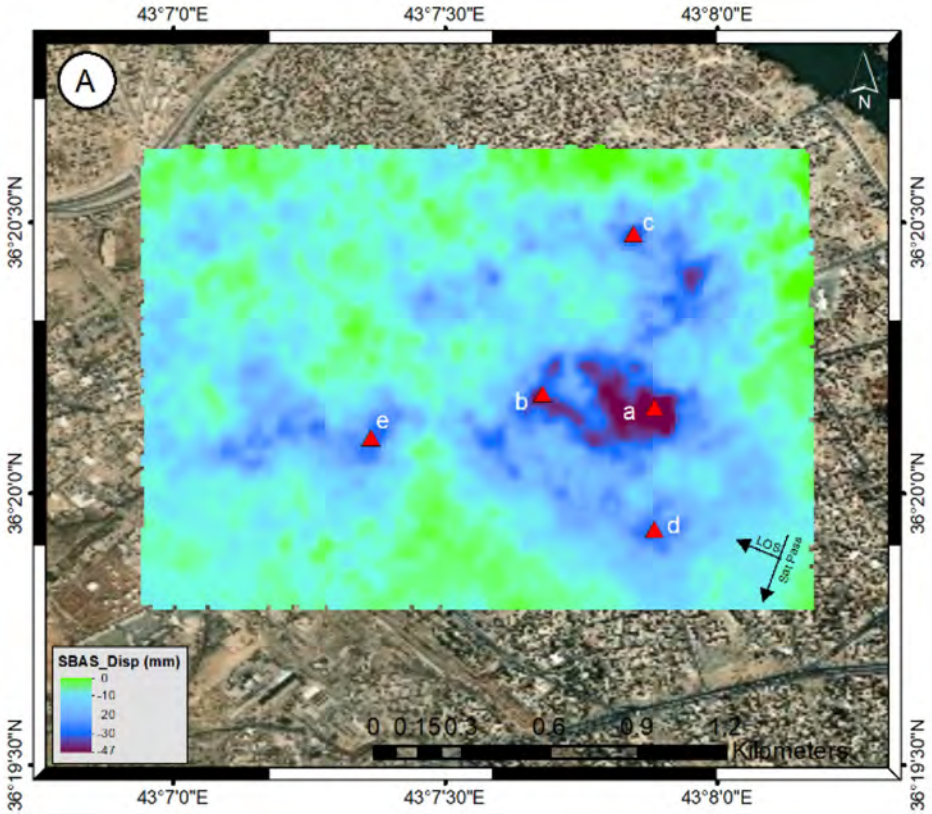

Jun 2022
0
200 km

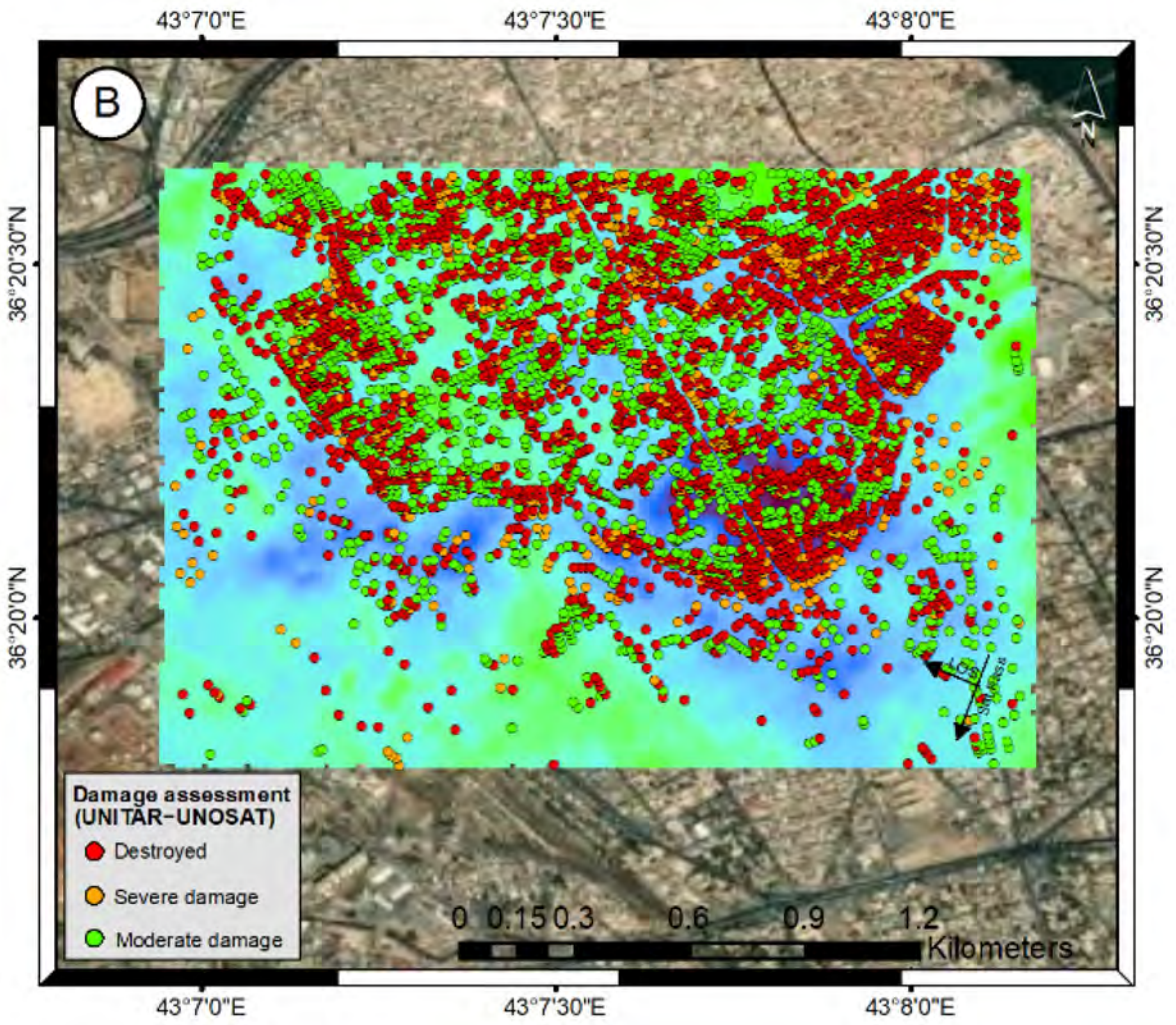

Belarus
Poland
Slovakia
Hungary
Ukraine
Russia
Moldova
Romania
Kiev
Kharkiv
Odsea
Mariupol
More loss
Less loss
Linear trend
0
200 km


More loss
Less loss
Kiev
0
40 km



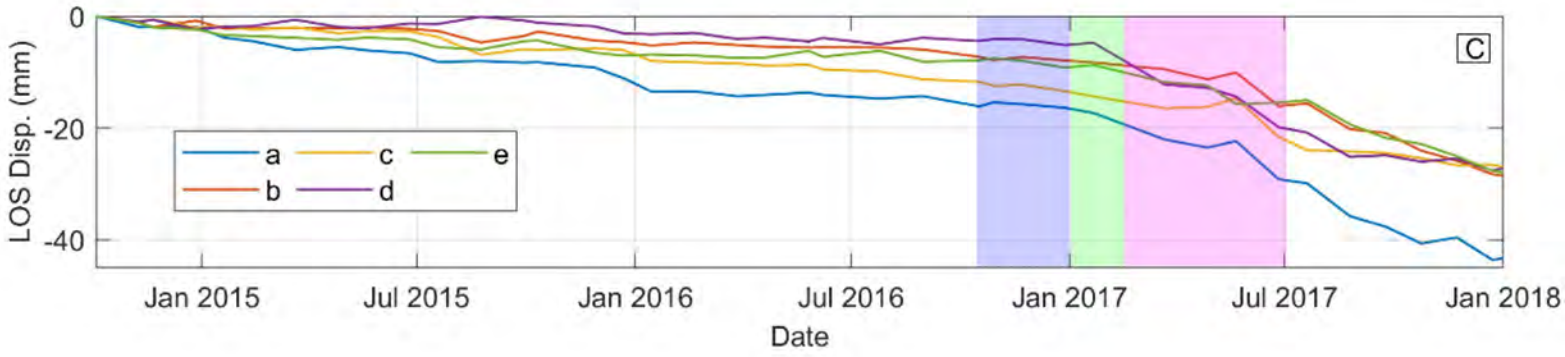
Damage assessment of Mosul, Iraq (UNITAR, 2017)

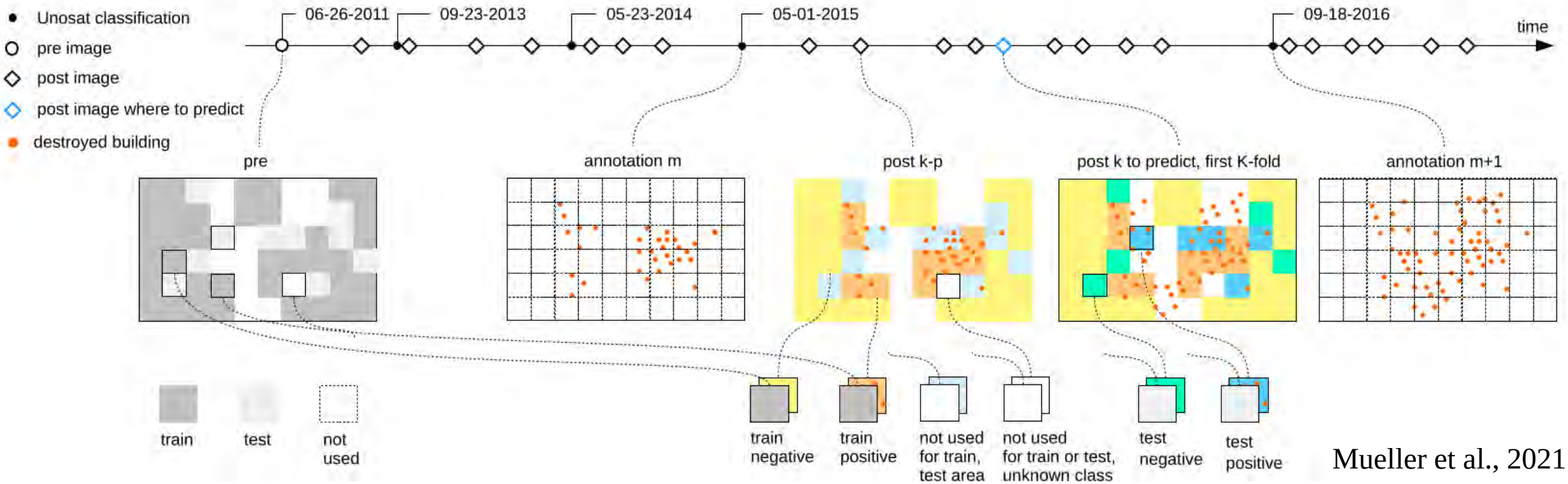




(A) Trends in Small Baseline Subset (SBAS)-displacement with five selected sites.
(B) The damaged buildings detected by the UNITAR-UNOSAT classified as the destroyed buildings (red points).
(C) SBAS-displacement time series

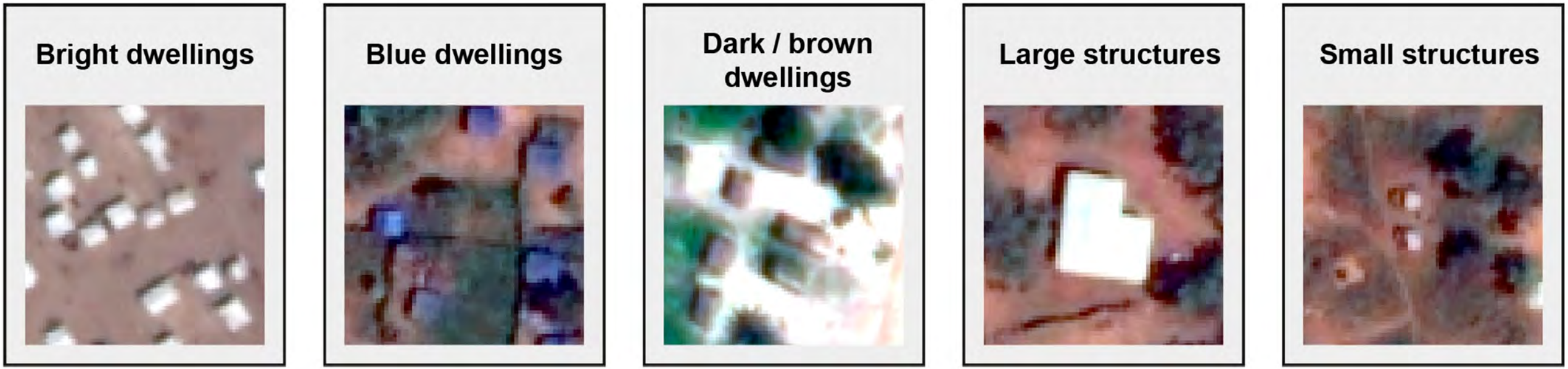
Boloorani et al., (2021)





Mueller et al., 2021

Settlement



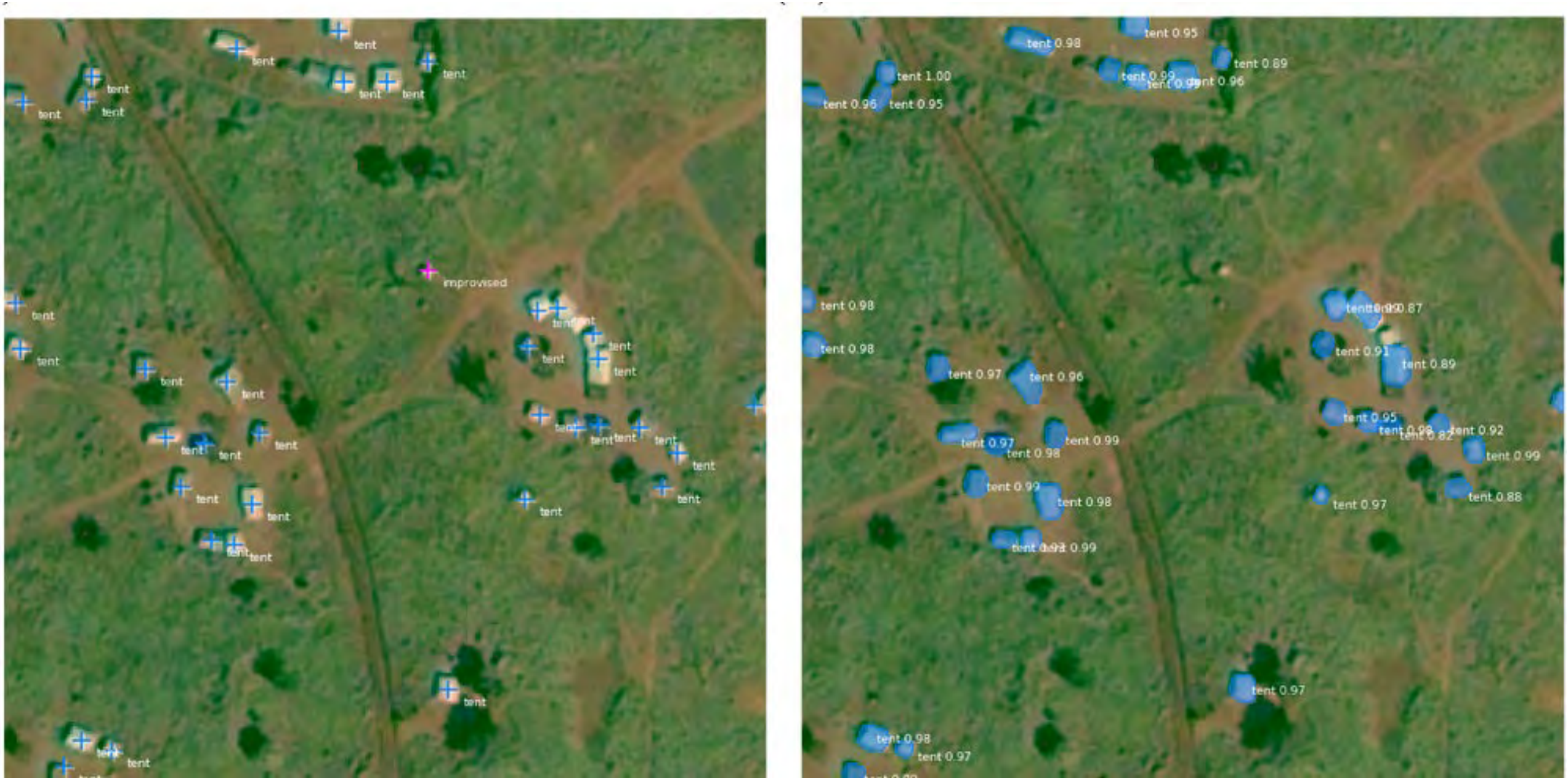
Tiede et al., 2017

Doro, South Sudan

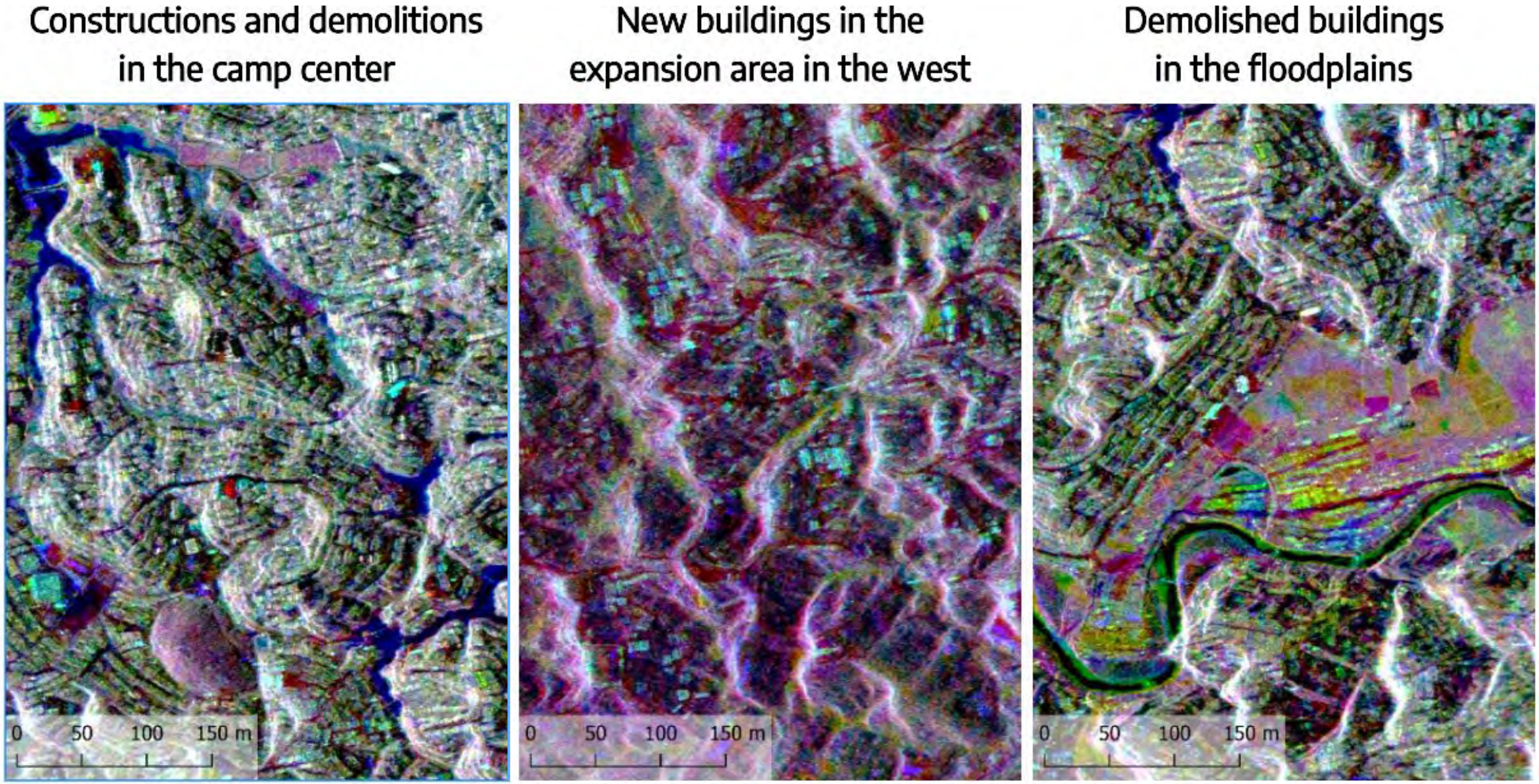
Dalakaleri, Nigeria

Juba, South Sudan

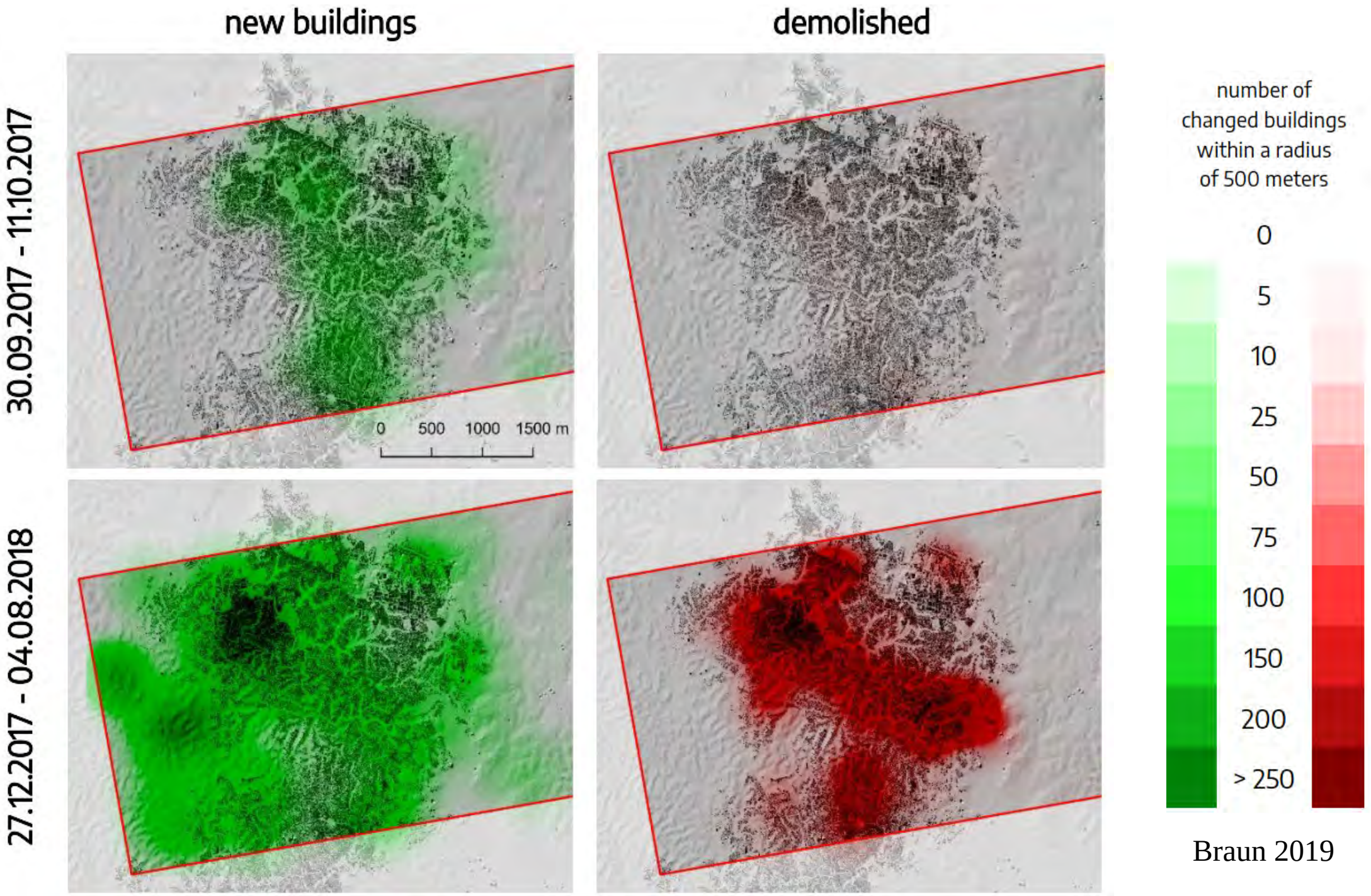
Quinn et al., 2018



Structure detections in Doro refugee settlement, South Sudan (Quinn et al., 2018)



Temporal changes within Kutupalong refugee camp (Bangladesh) identified by VHR SAR color composites (Braun 2019)


new buildings
demolished
30.09.2017 - 11.10.2017
27.12.2017 - 04.08.2018
0 500 1000 1500 m
number of changed buildings within a radius of 500 meters
0
5
10
25
50
75
100
150
200
> 250

Braun 2019

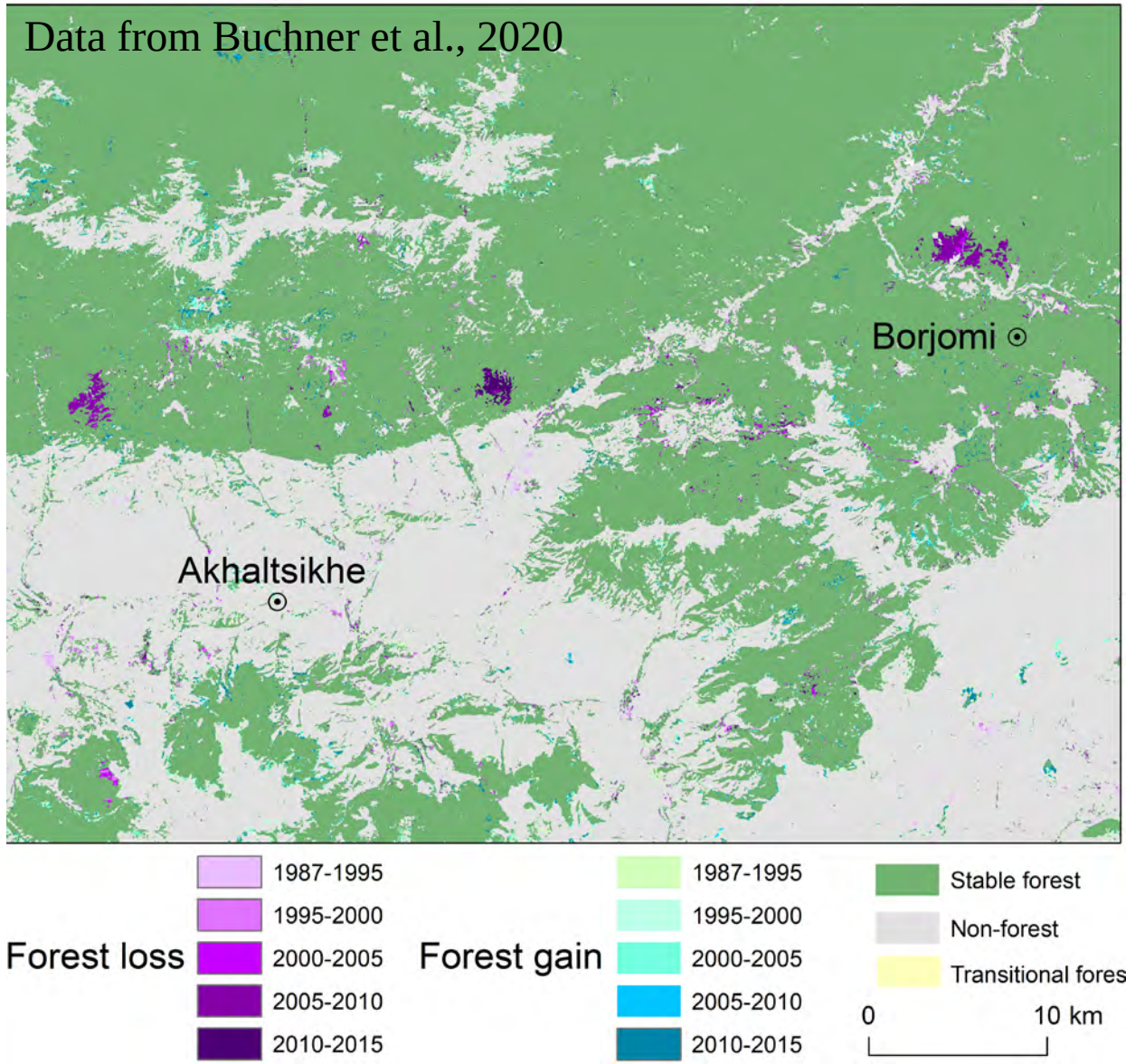
Credit: Department of Defense

Causing deforestation

Credit: Radeloff

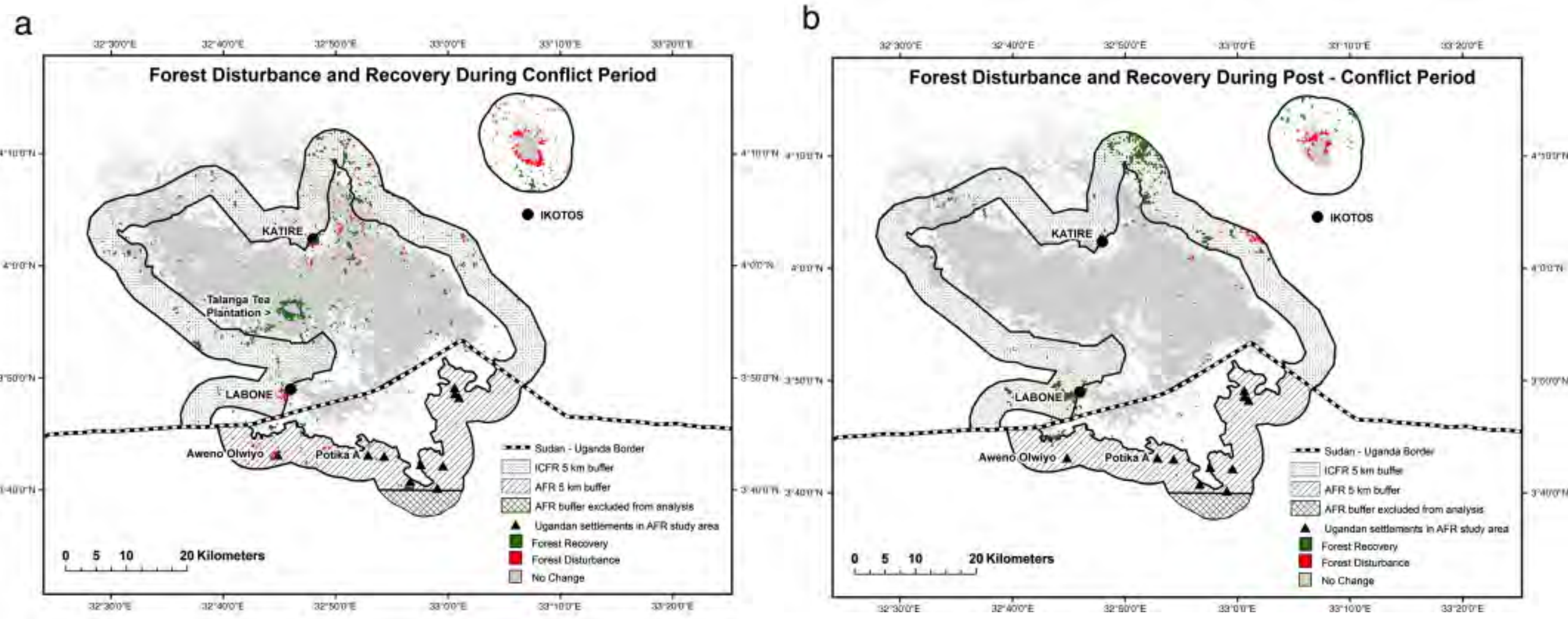
EARNINGS AUGUST 17, 2008 / 8:43 AM / UPDATED 14 YEARS AGO

REUTERS



mid-1980s to 2001

2003 to 2010

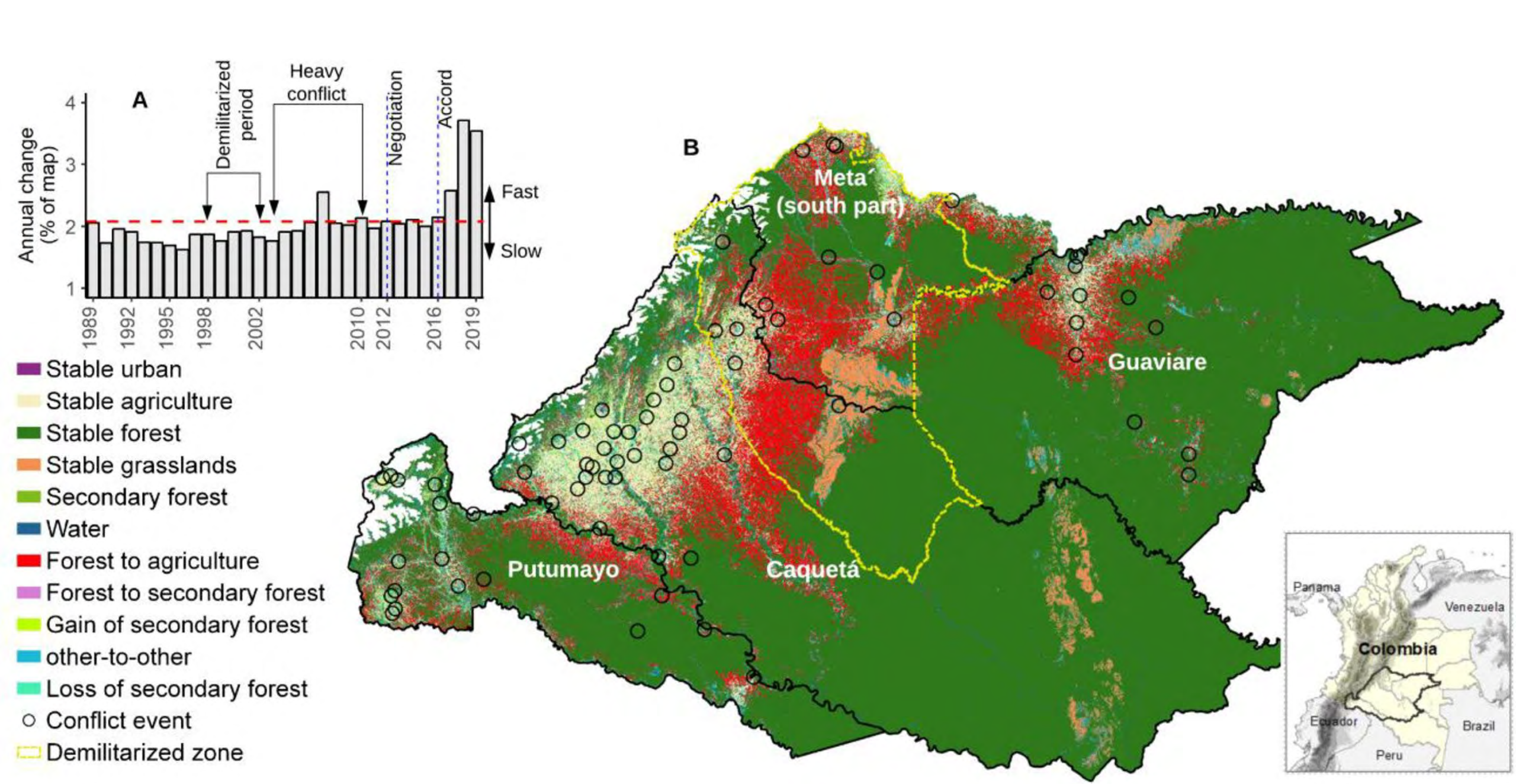


The impacts of armed conflict on the Eastern Afromontane forest region on the South Sudan — Uganda border

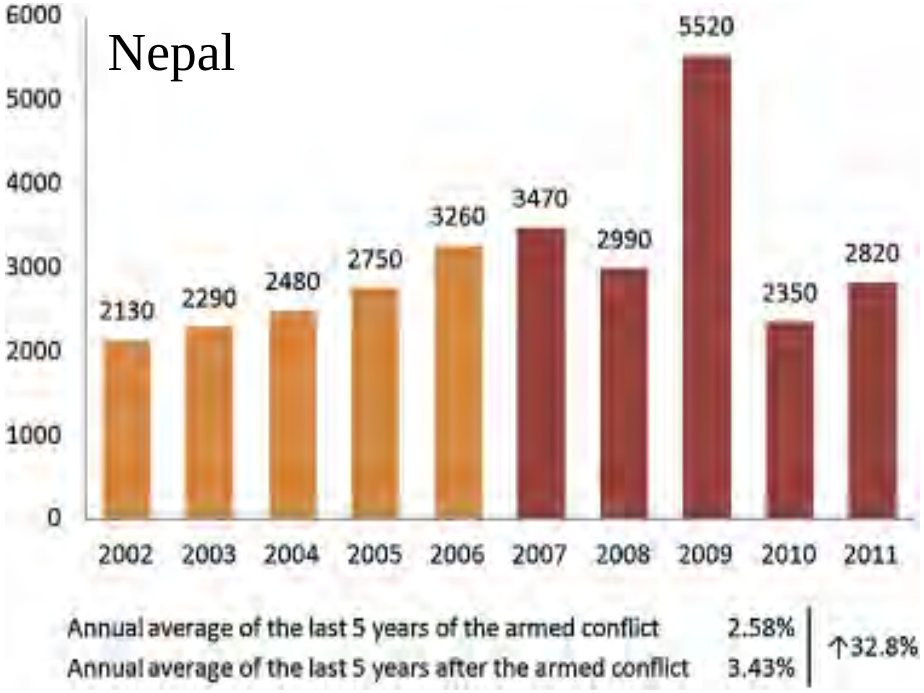
Gorsevski et all., 2012

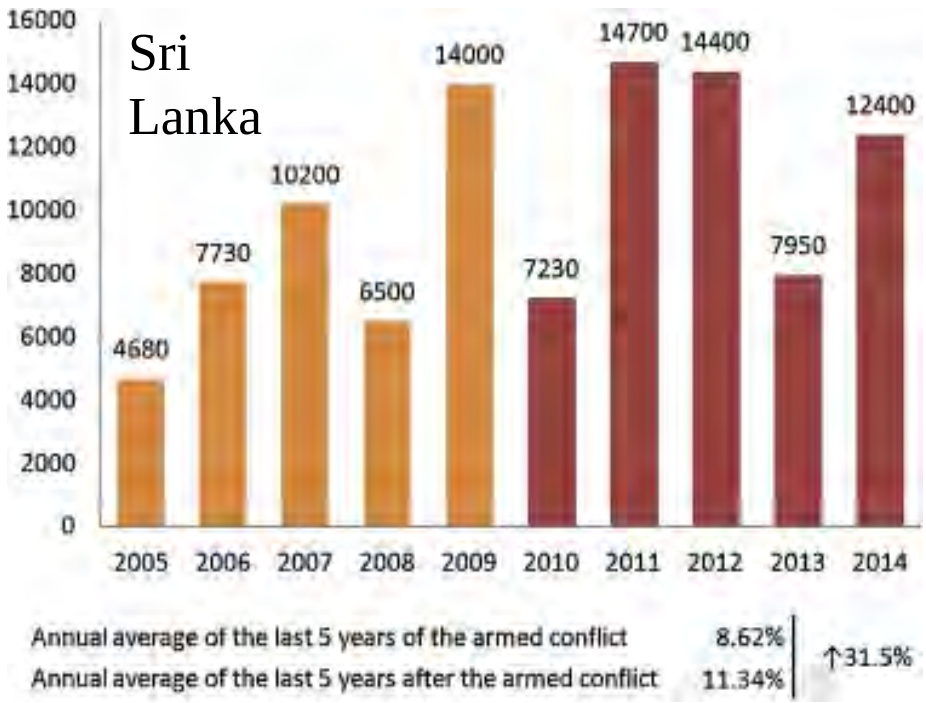
Preventing deforestation

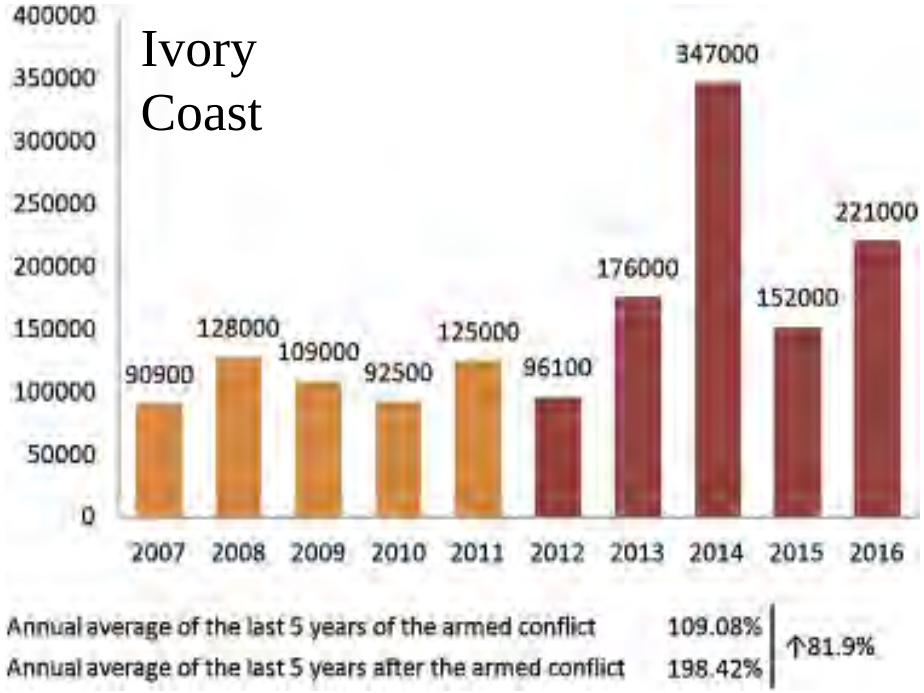
Mongabay 2017

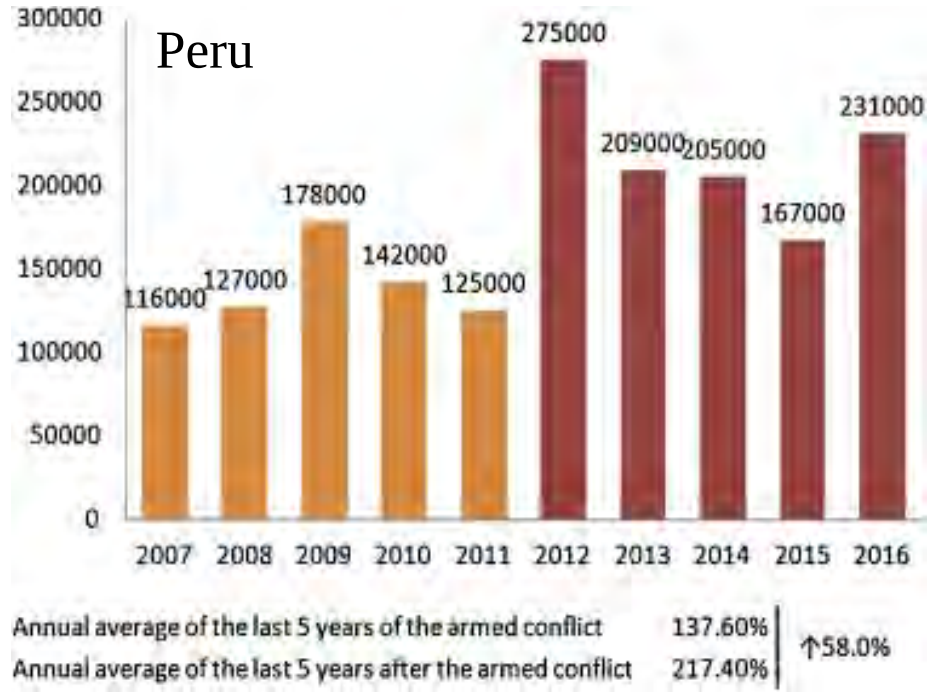


Murillo-Sandoval et al., 2021

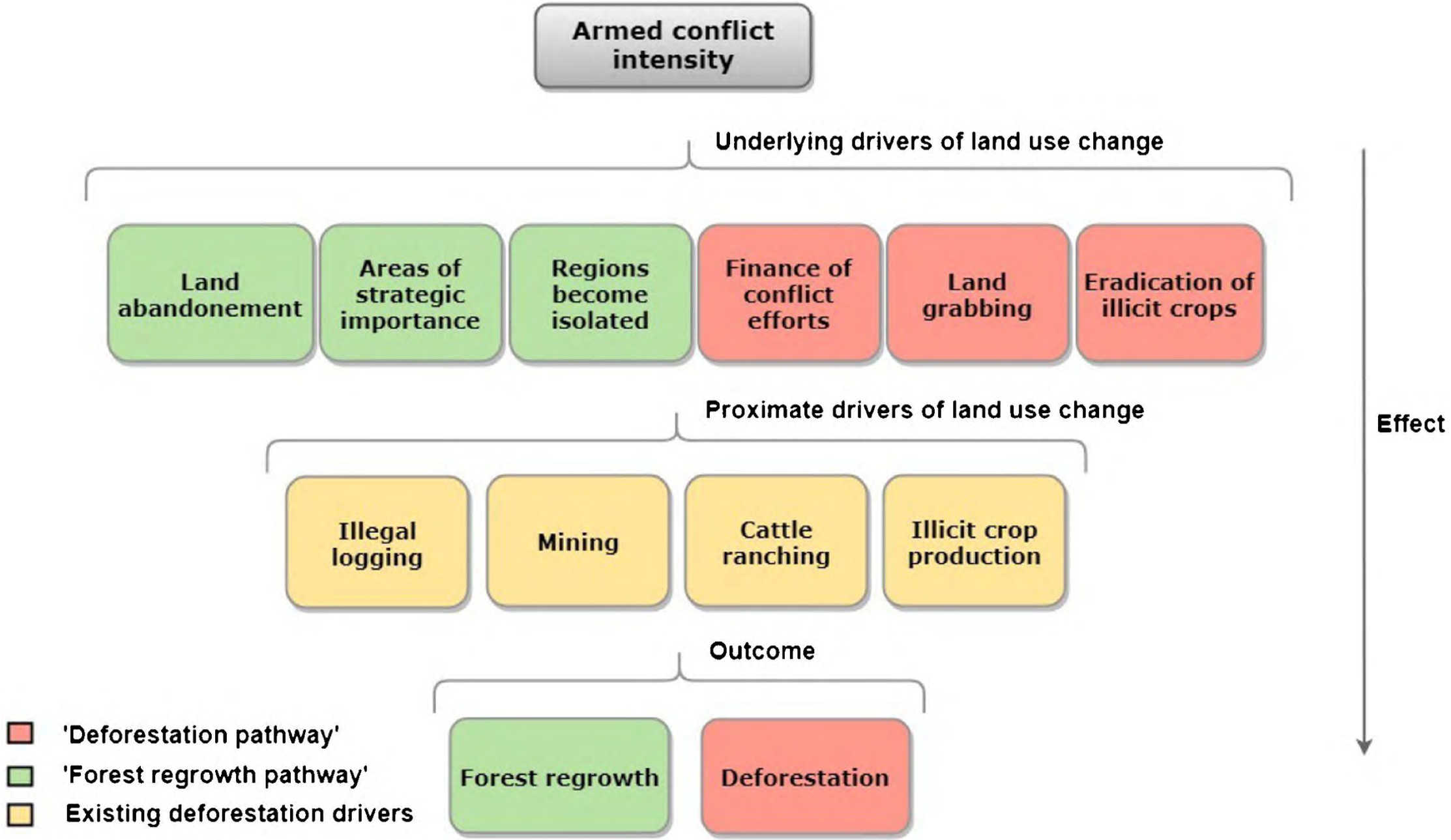




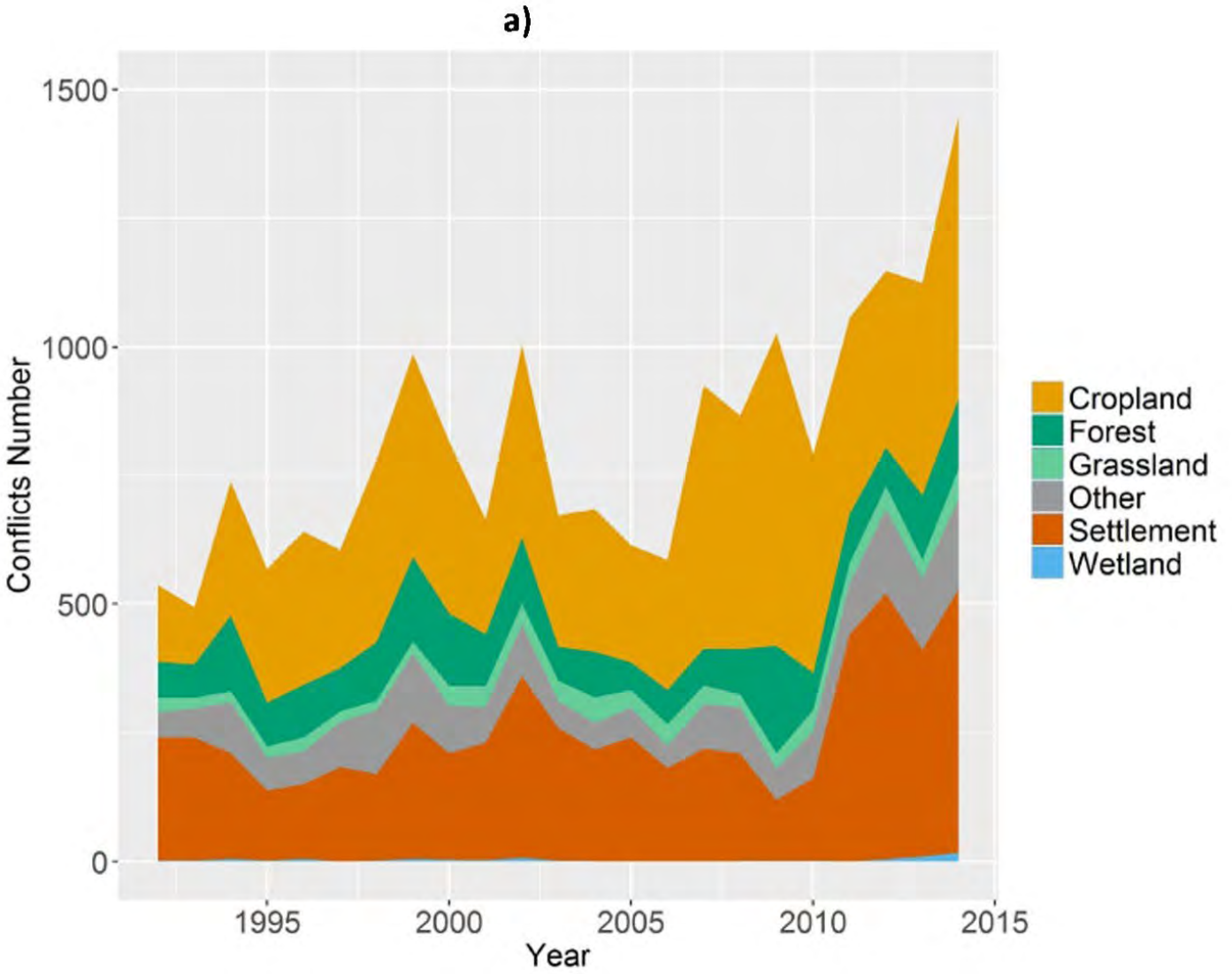


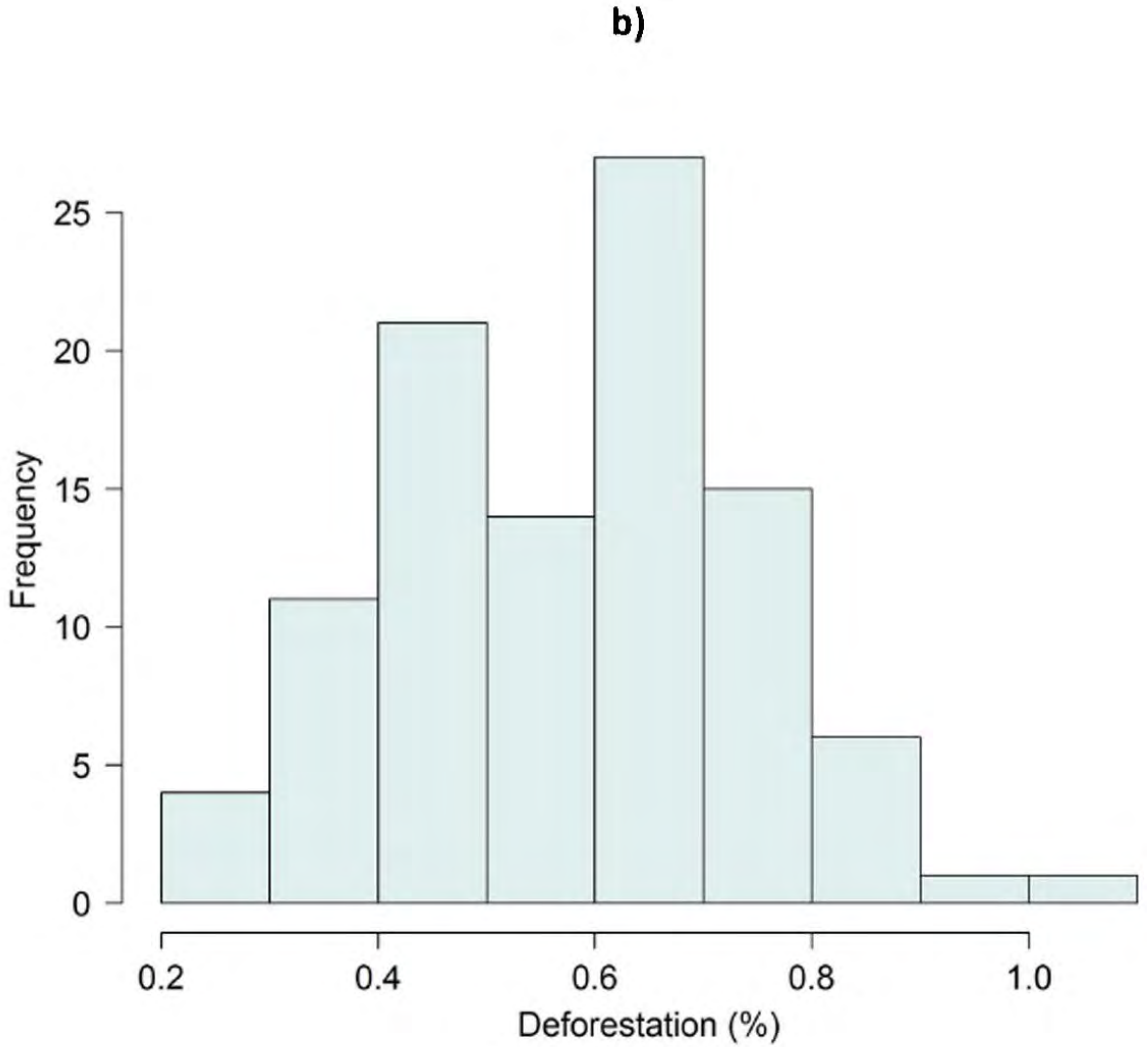


Grima and Singh, 2019



Landholm et al., 2019





Landholm et al., 2019

Agriculture

Direct influences of the war on agriculture

Crop burning

Field battles

Indirect influences of the war on agriculture

Infrastructure

Agricultural inputs

Economy

Agriculture abandonment

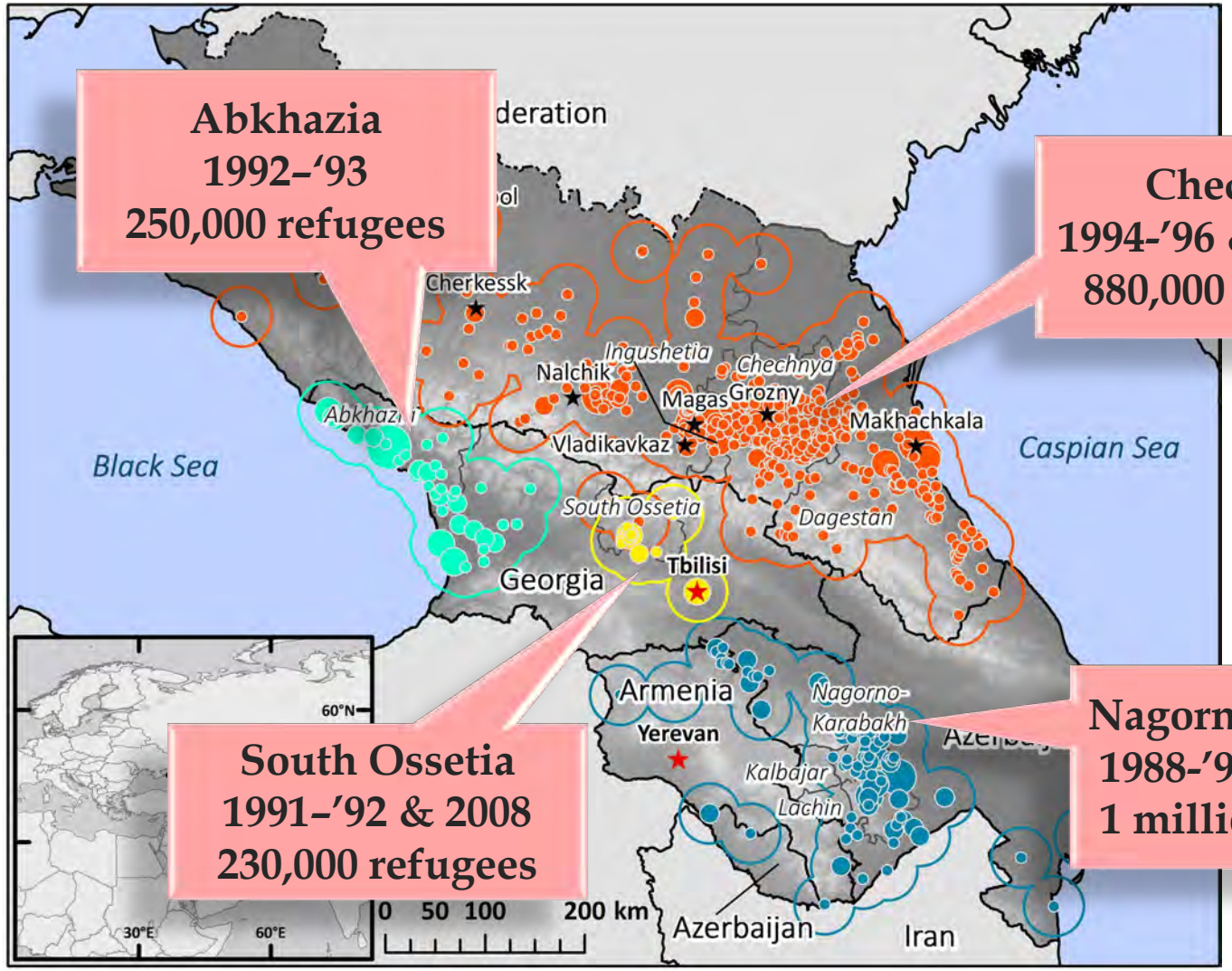
Credit: NPR

Effects of the post-Soviet wars in the Caucasus on agricultural land use

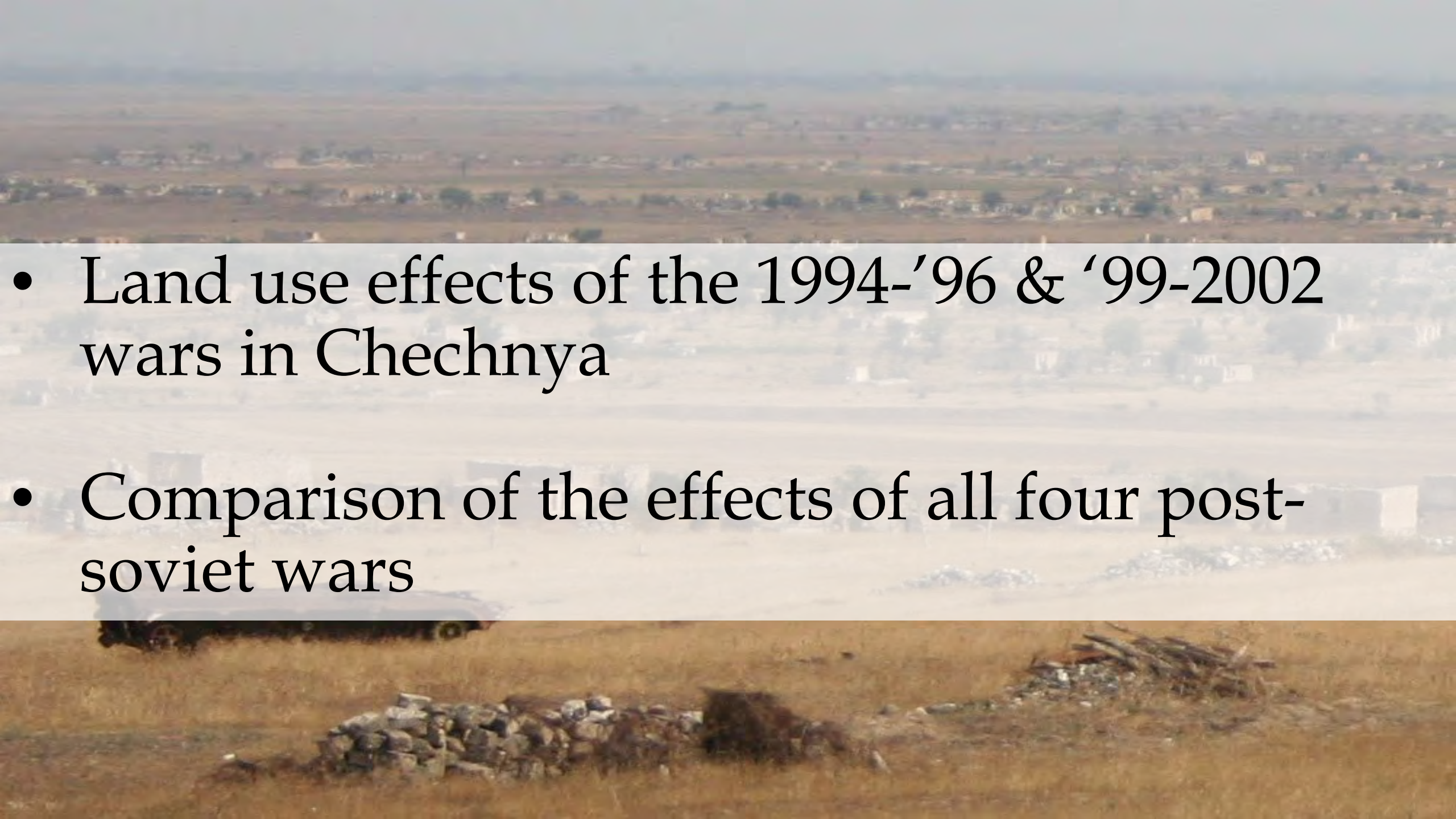
Land-Cover and
Land-Use Change Program


Russia
Chechnya
GREATER CAUCASUS MOUNTAINS
Black Sea
Caspian Sea
Georgia
Tbilisi
LESSER CAUCASUS MOUNTAINS
Armenia
Yerevan
Azerbaijan
Baku
Turkey
Iran
0 50 100 200 km

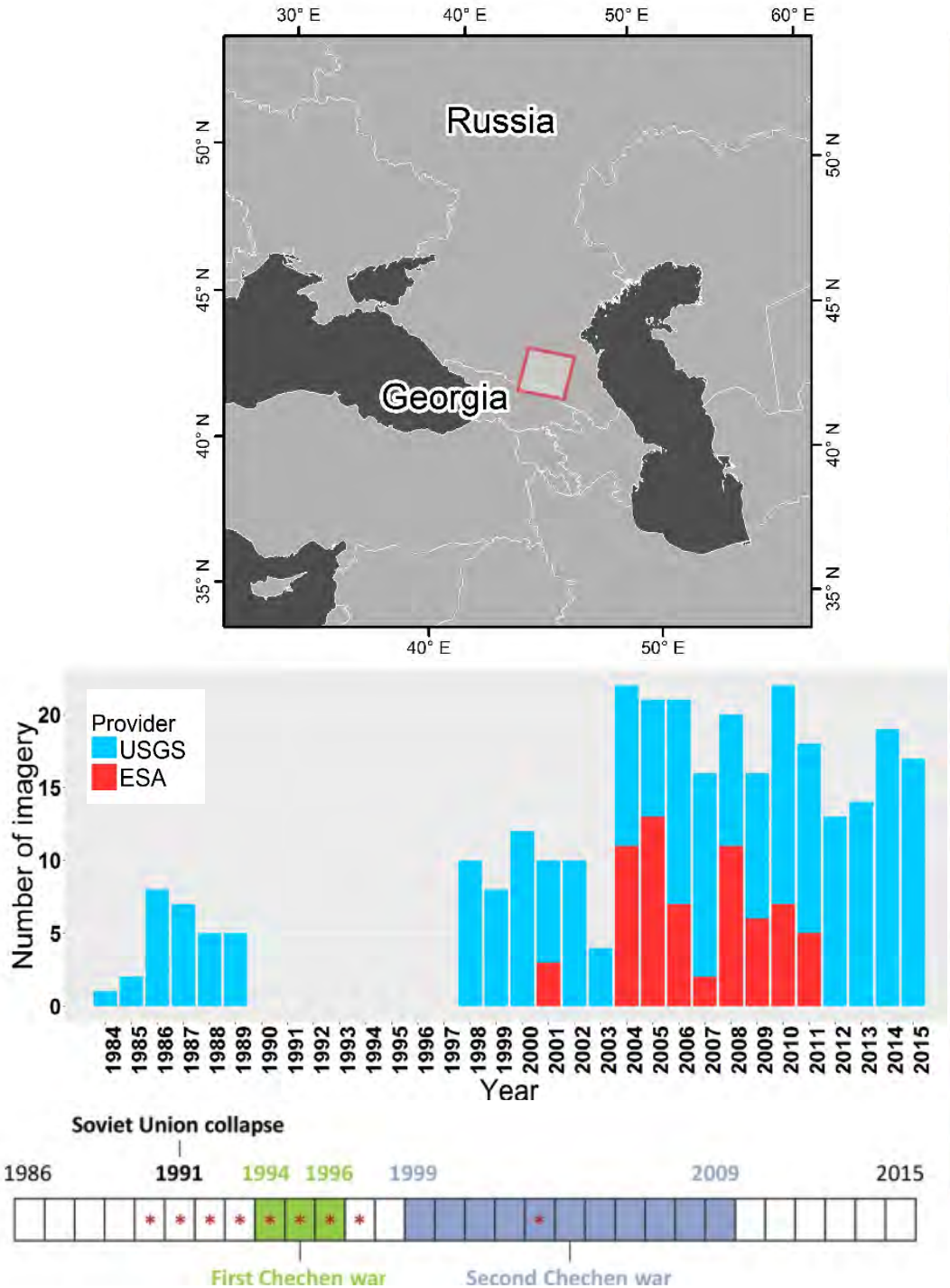

Ukraine
Rostov
Kazakhstan
Astrakhan'
Sea of Azov
Krasnodar Kray
Elista
Kalmykia
Krasnodar
Stavropol'
Stavropol' Kray
Adygea
Maykop'
Russia
Caspian Sea
Karachay-Cherkessia
Kabardino-Balkaria
Nal'chik
Ingushetia
Nazran'
Chechnya
Groznyy
Vladikavkaz
North Ossetia
Makhachkala
Abkhazia
Sukhumi
Black Sea
Dagestan
South Ossetia
Tskhinvali
K'ut'aisi
Georgia
T'bilisi
Adjara
Bat'umi
Armenia
Yerevan
Azerbaijan
Nagorno-Karabakh
Yankändı (Stepanakert)
Naxçıvan
Naxçıvan Azer. (Nakhichevan)
Baku
Turkey
Iran
Caucasian Peoples
Abkhaz
Abkhaz
Circassian
Adygey
Cherkess
Kabardin
Georgian
Georgian
Dagestani
Agul
Avar
Dargin
Lak
Lezgin
Rutul
Tabasaran
Tsakhur
Veinakh
Chechen
Ingush
Other
Indo-European Peoples
Armenian
Armenian
Greek
Greek
Iranian
Kurd
Ossetian
Talysh
Slavic
Russian
Altaic Peoples
Turkic
Azeri
Balkar
Karachay
Kumyk
Nogay
Turkmen
Mongol
Kalmyk
Sparsely populated or uninhabited areas are shown in white
Republic, oblast, or kray boundary
0 100 Kilometers
0 100 Miles



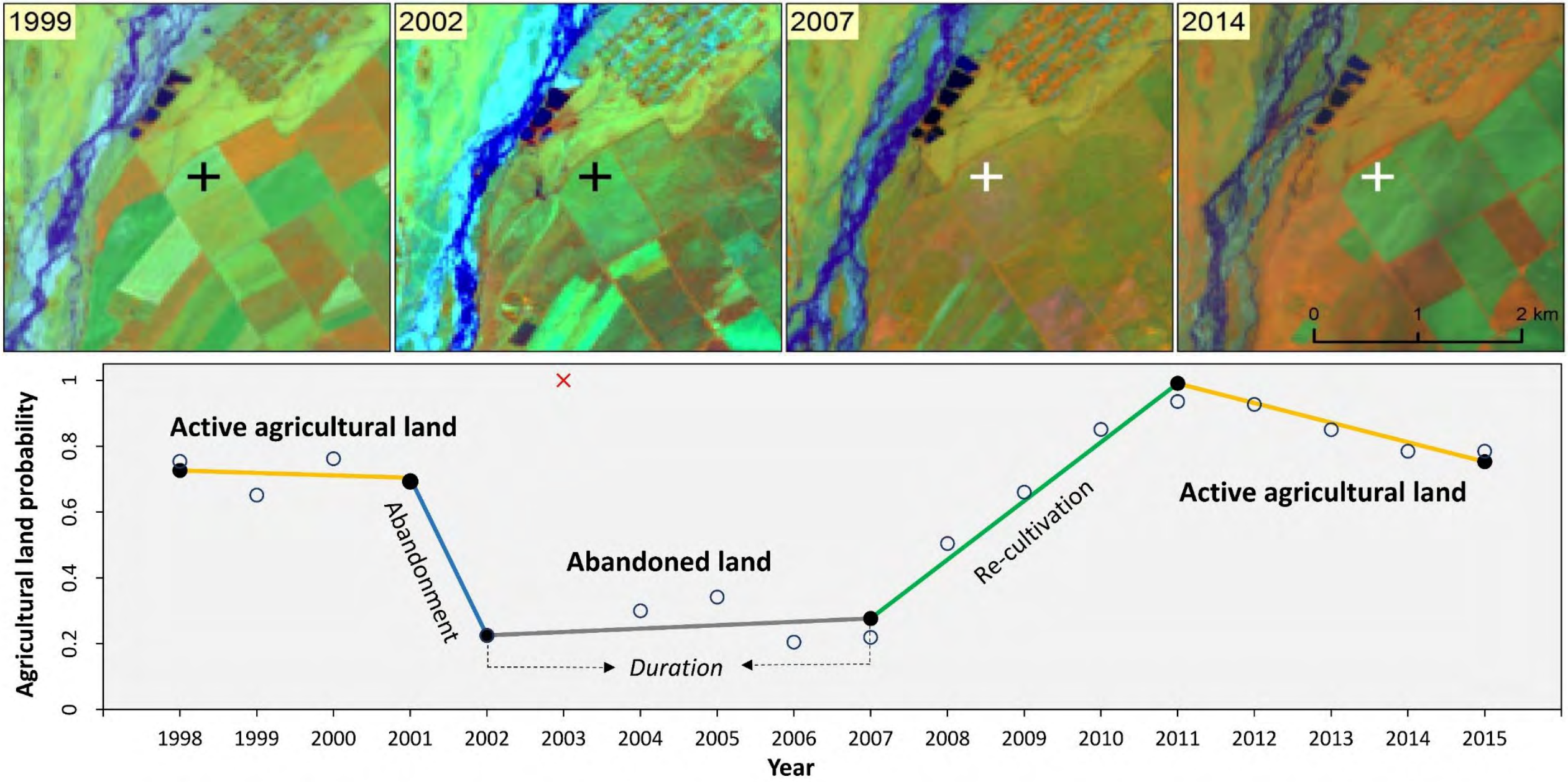
Buchner et al. 2022



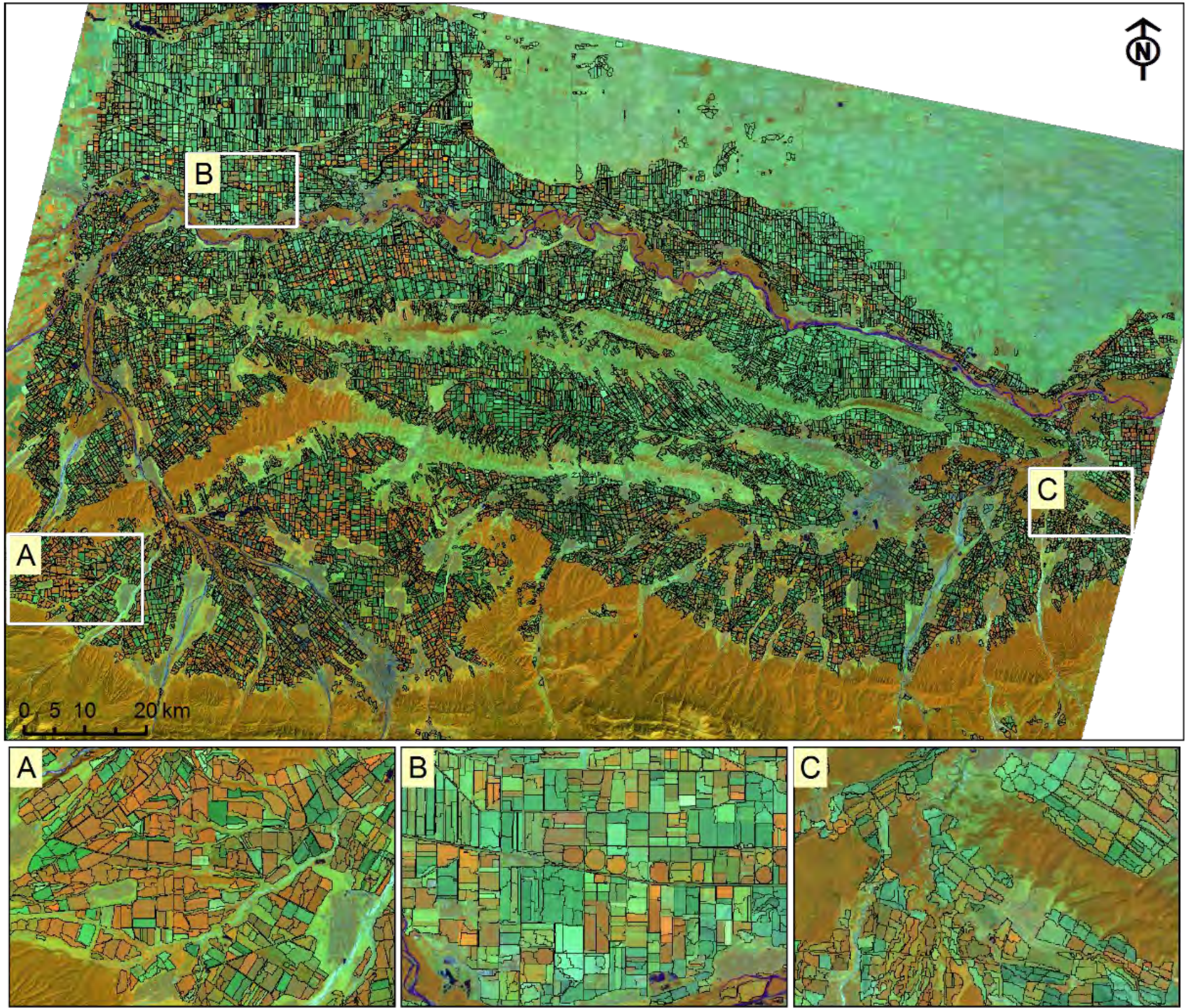
- Land use effects of the 1994-’96 & ‘99-2002 wars in Chechnya
- Comparison of the effects of all four post-soviet wars



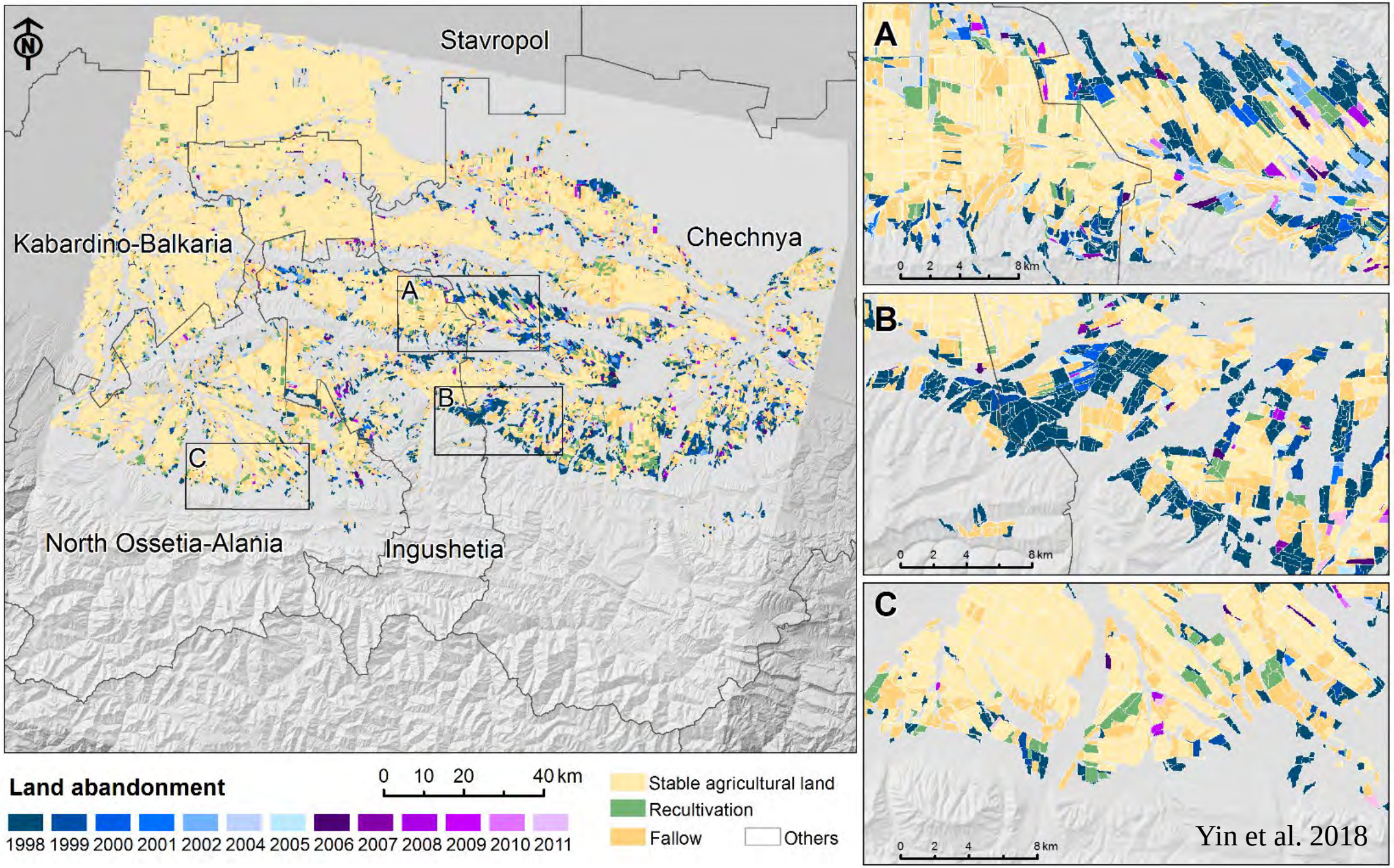
Yin et al. 2018

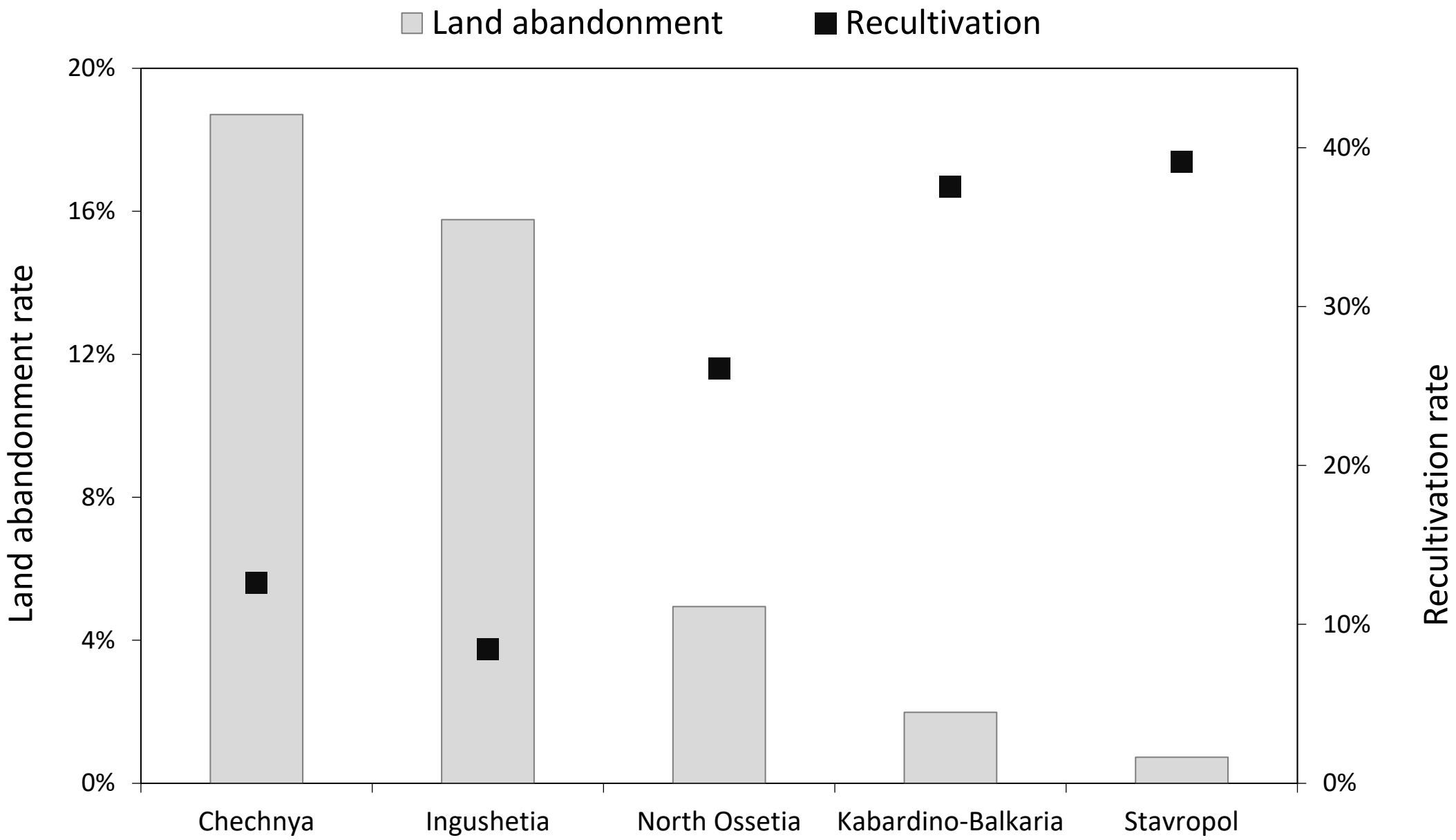


Yin et al. 2018

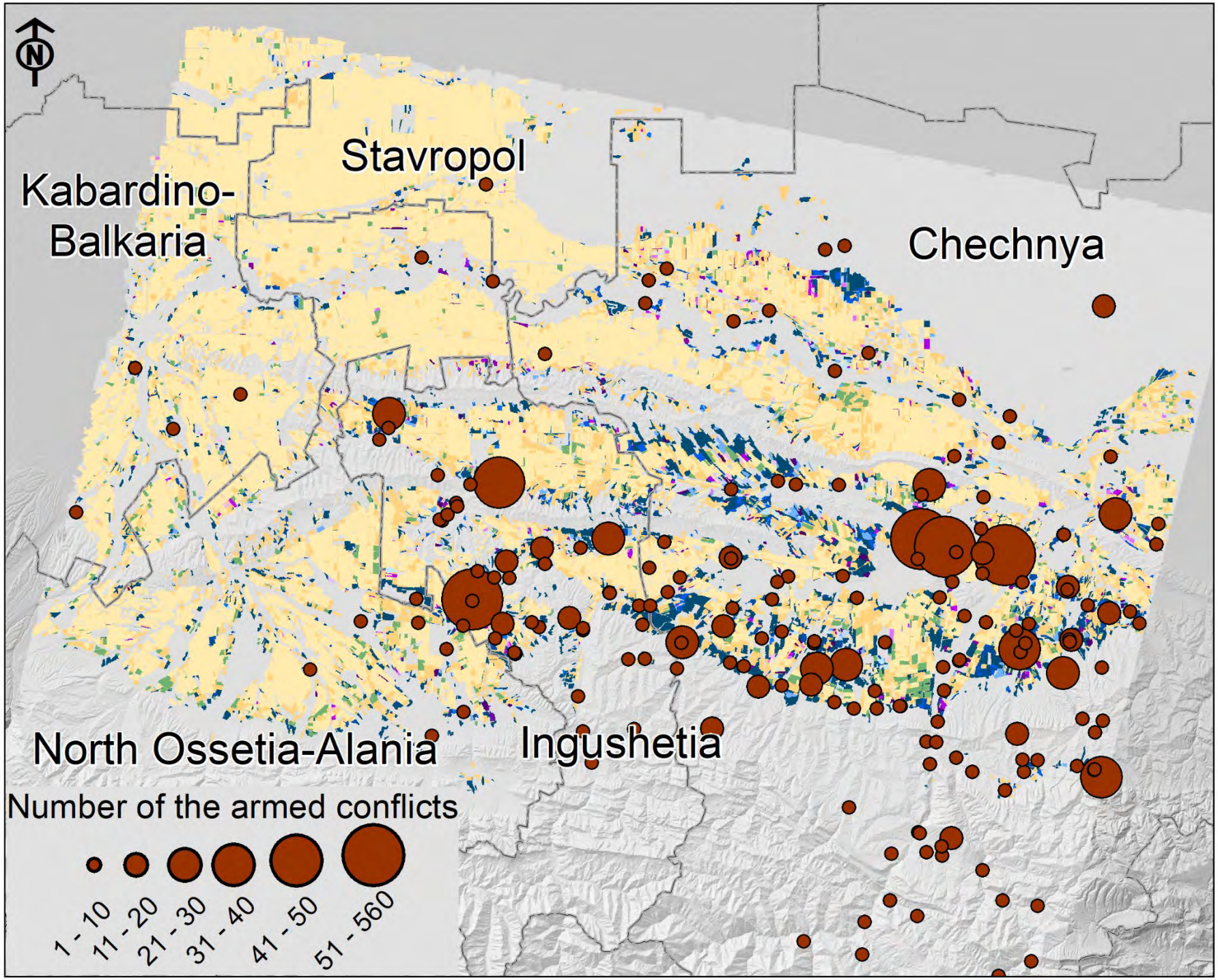


Yin et al. 2018

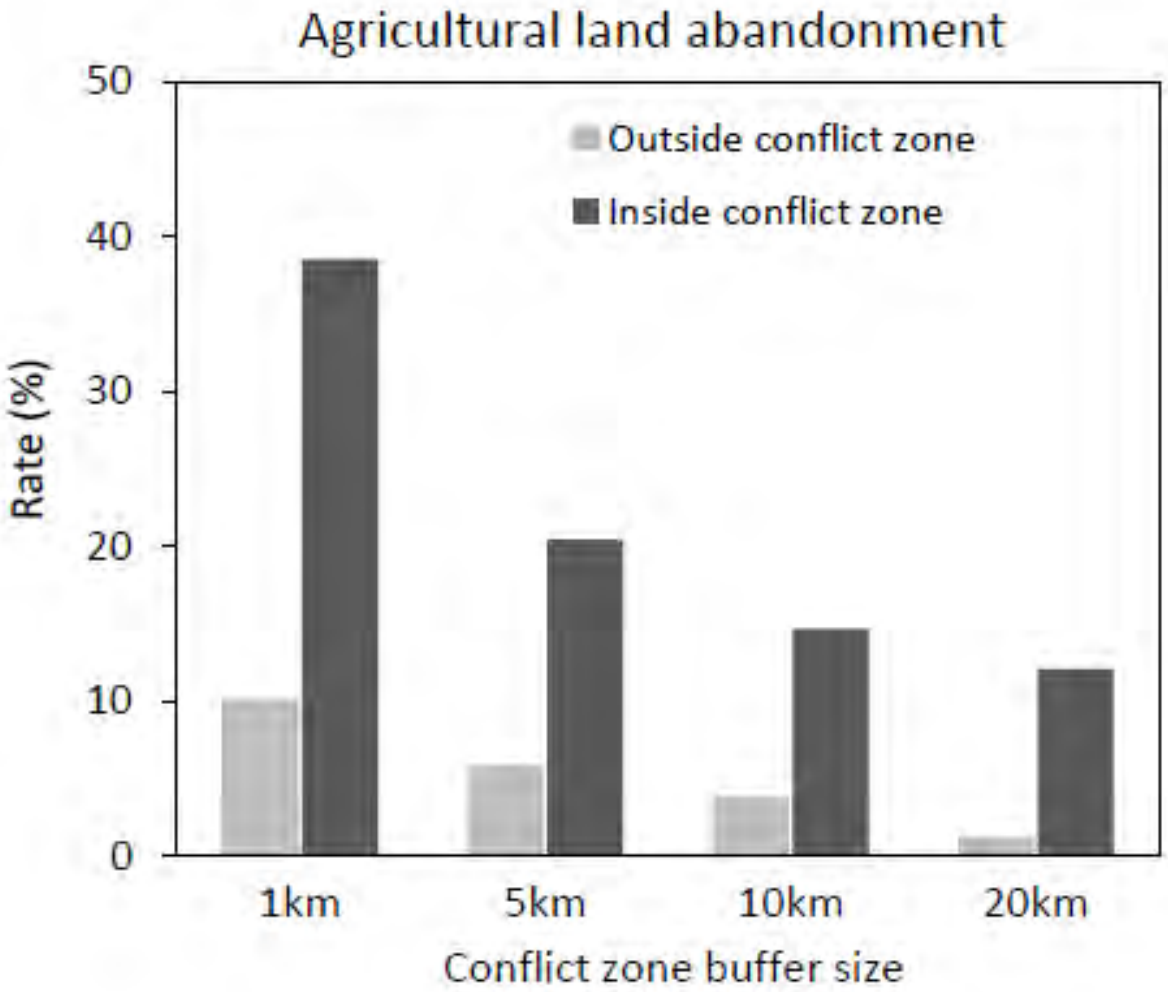

Stavropol
Kabardino-Balkaria
Chechnya
North Ossetia-Alania
Ingushetia
A
B
C
0 10 20 40 km
Land abandonment
1998 1999 2000 2001 2002 2004 2005 2006 2007 2008 2009 2010 2011
Stable agricultural land
Recultivation
Fallow
Others
0 2 4 8 km
Yin et al. 2018

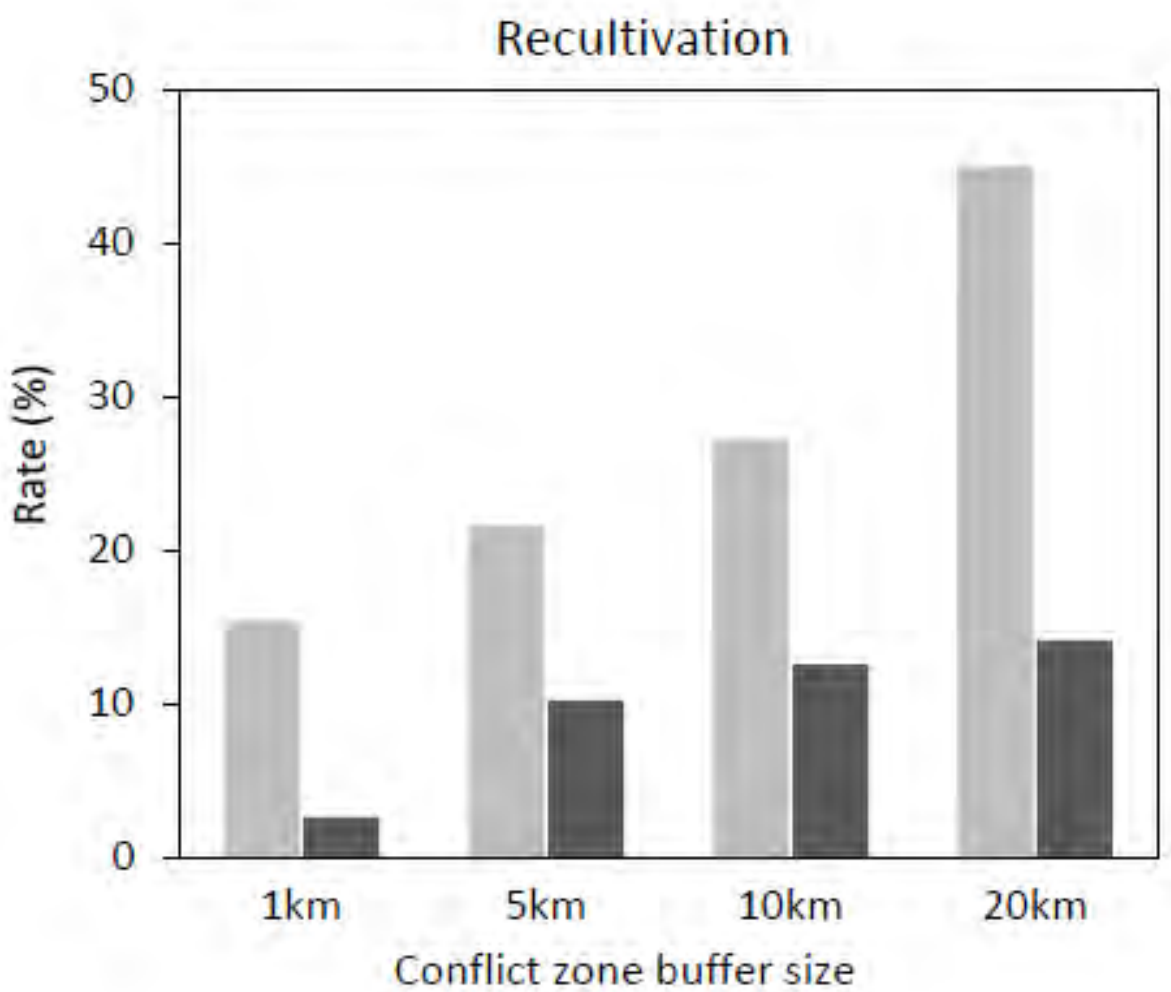


Yin et al. 2018



Yin et al. 2019



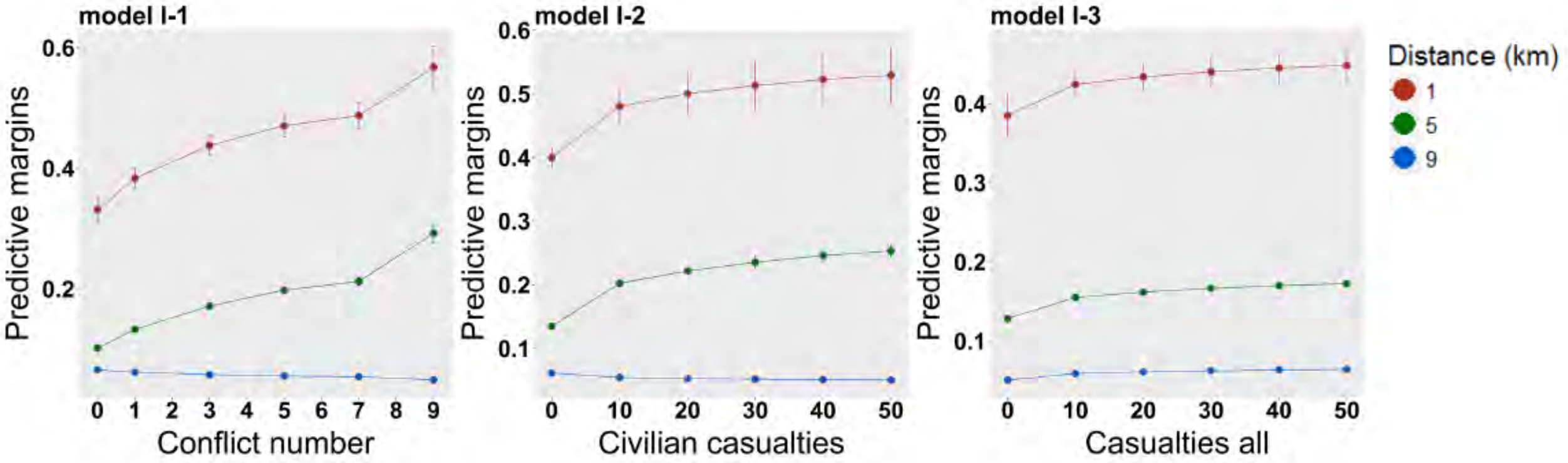


Yin et al. 2019

		Response variates		Control covariates										Covariates				
Model No.	Model type	Abandonment	Re-cultivation	Elevation	Slope	Soil organic matter	Distance to settlement	Distance to river	Distance to road	Region	Longitude	Latitude		Distance to conflict event	Conflict event Number	Civilian casualties	Total casualties	Period
I-1	logit	■		■	■	■	■	■	■	■	■	■		■	■			1989-1998
I-2	logit	■		■	■	■	■	■	■	■	■	■		■		■		1989-1998
I-3	logit	■		■	■	■	■	■	■	■	■	■		■			■	1989-1998
II-1	fixed effects	■												■	■			1999-2012
II-2	fixed effects	■												■		■		1999-2012
II-3	fixed effects	■												■			■	1999-2012
III-1	random effects	■		■	■	■	■	■	■	■	■	■		■	■			1999-2012
III-2	random effects	■		■	■	■	■	■	■	■	■	■		■		■		1999-2012
III-3	random effects	■		■	■	■	■	■	■	■	■	■		■			■	1999-2012
IV	random effects		■	■	■	■	■	■	■	■	■	■		■				1999-2012

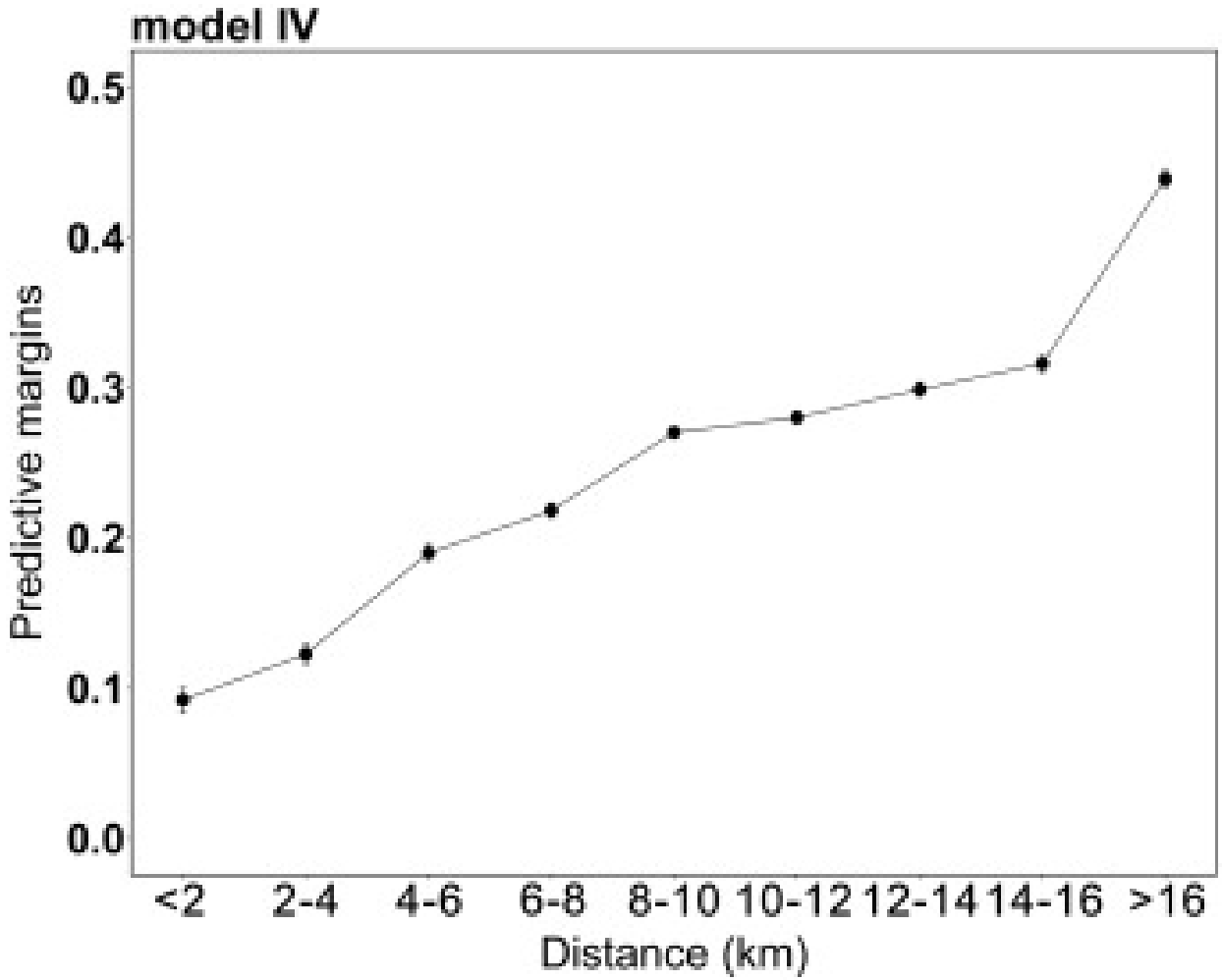
Yin et al. 2019

Abandonments are more likely in the areas close to the conflicts



Yin et al. 2019

Recultivation are less likely in the areas close to the conflicts

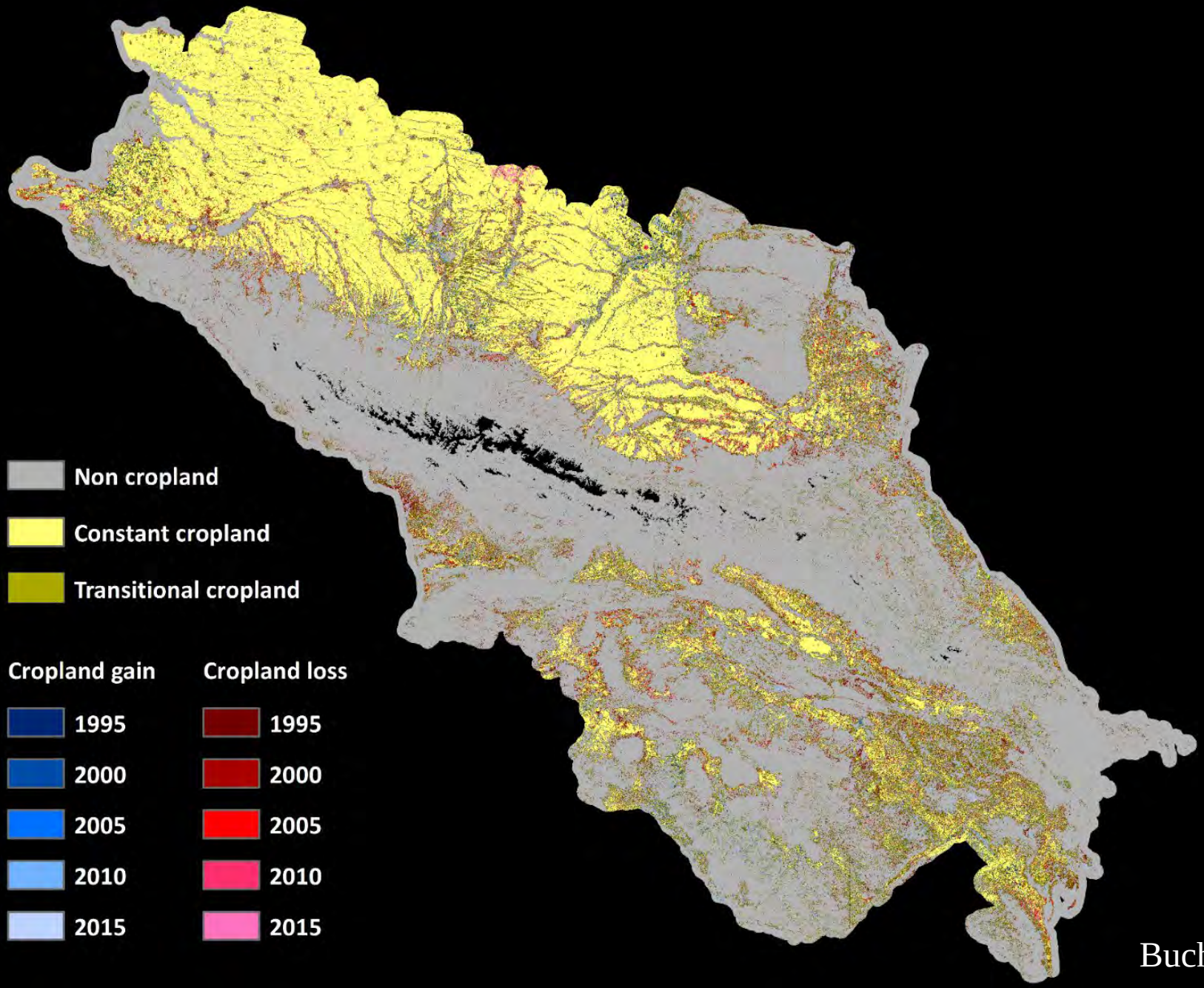


Yin et al. 2019

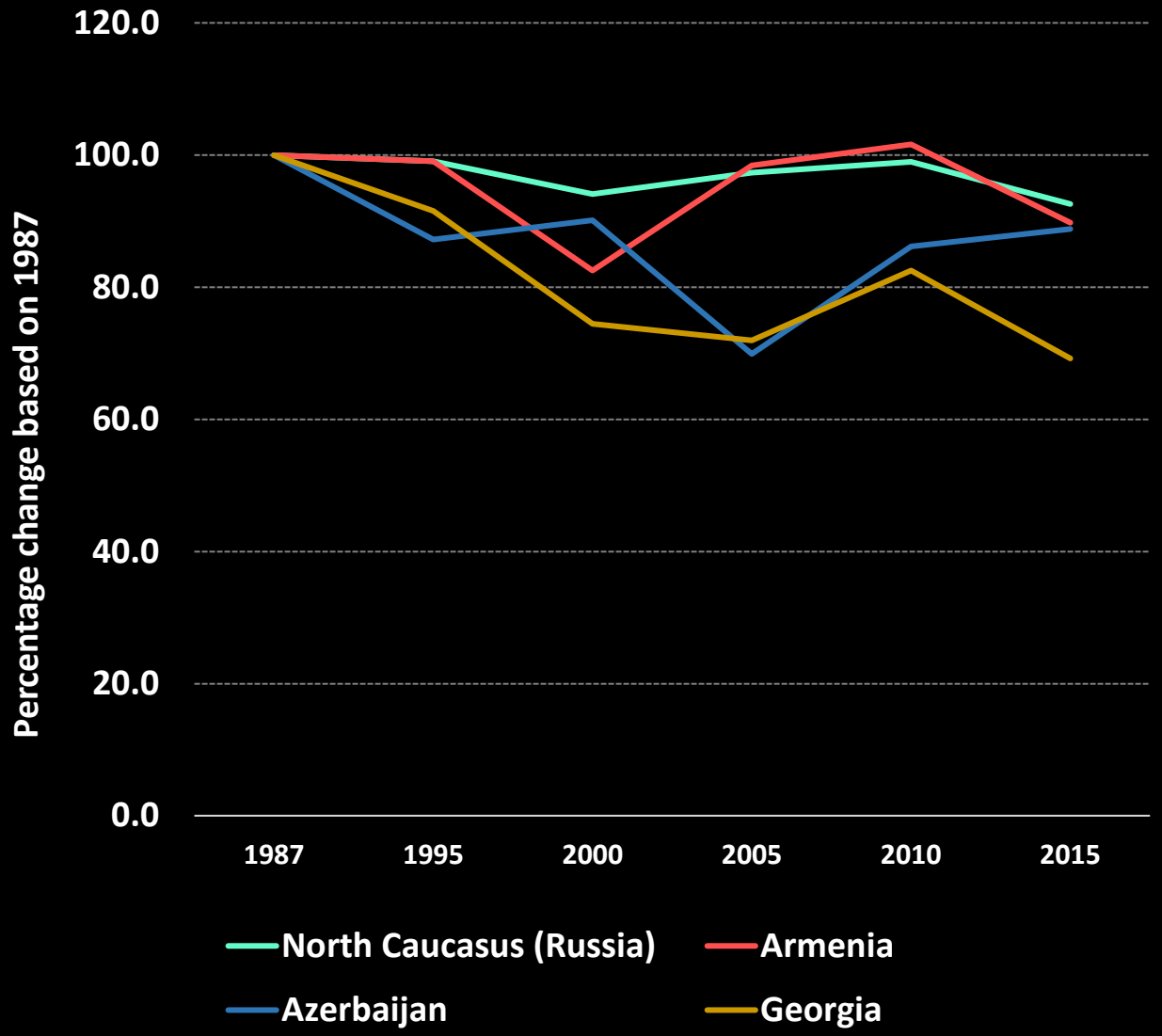
- Spatial-temporal segmentation supports better cropland mapping
- Spatial and temporal-variations in agricultural land use
- Agricultural land abandonment was related to the Chechen Wars

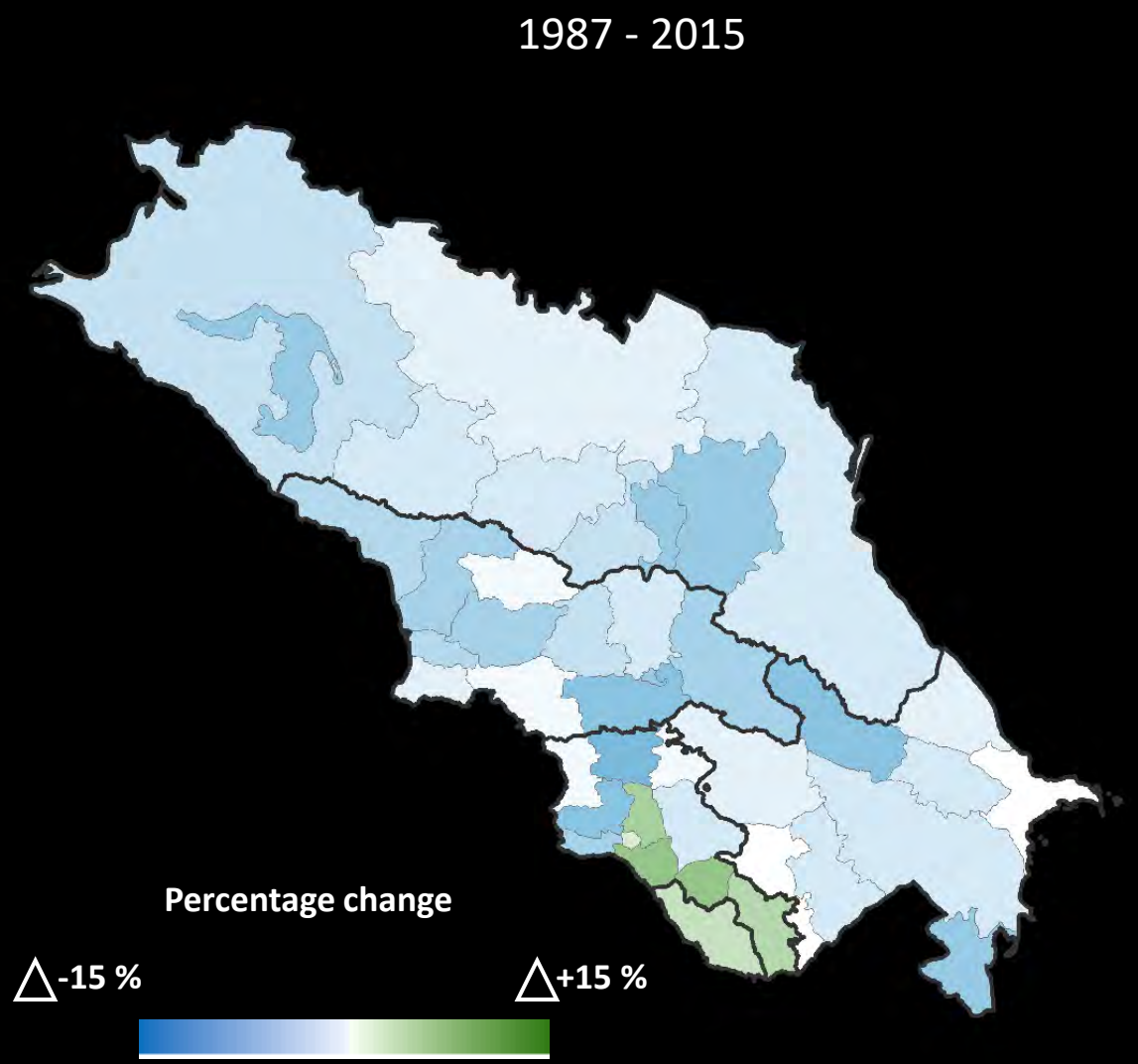
- Comparison of the land use effects of all four post-soviet wars. We predicted that:

  -- the Chechen wars affected land use most, and
  -- that multiple conflict events have additive effects

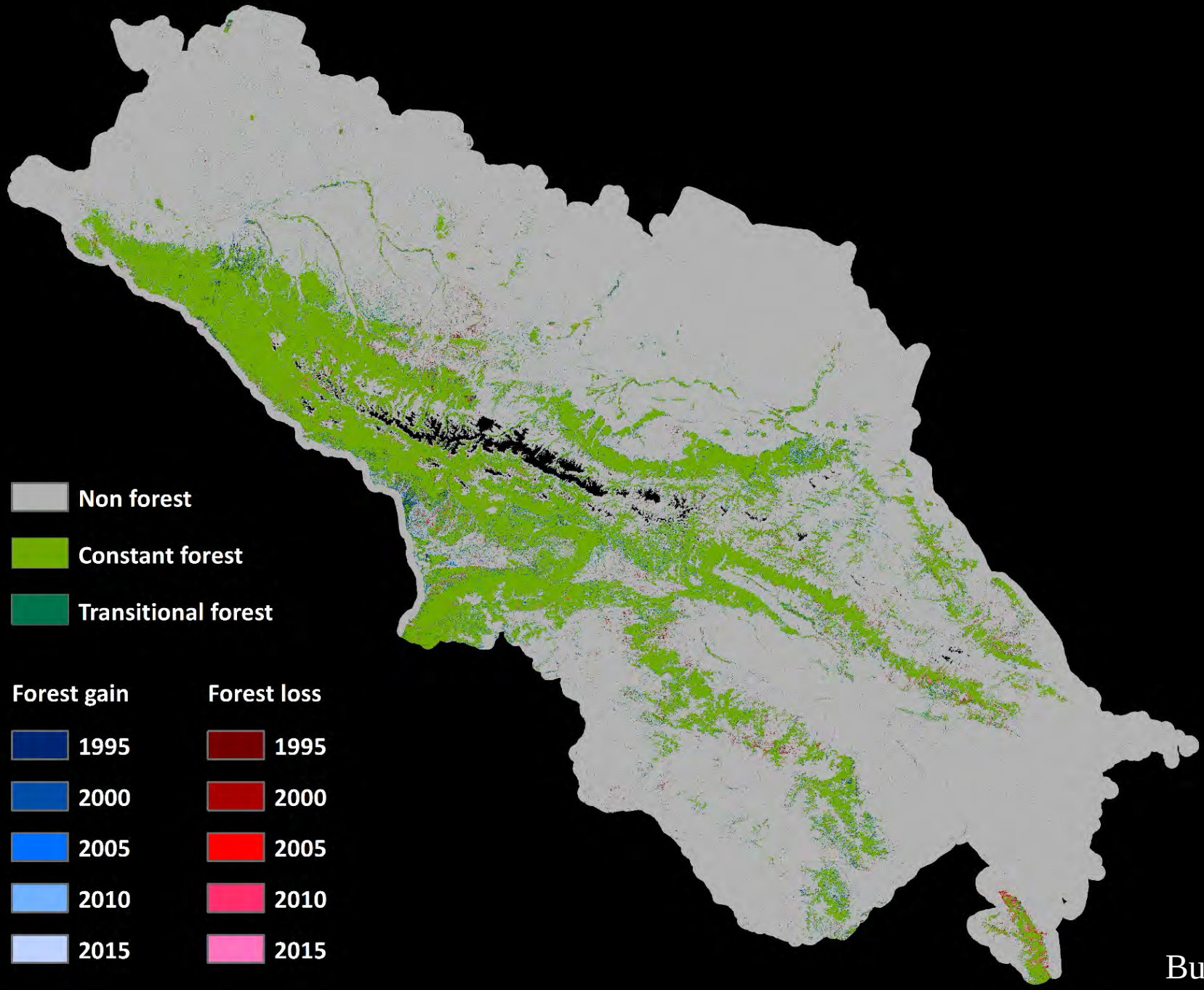


Buchner et al., 2020

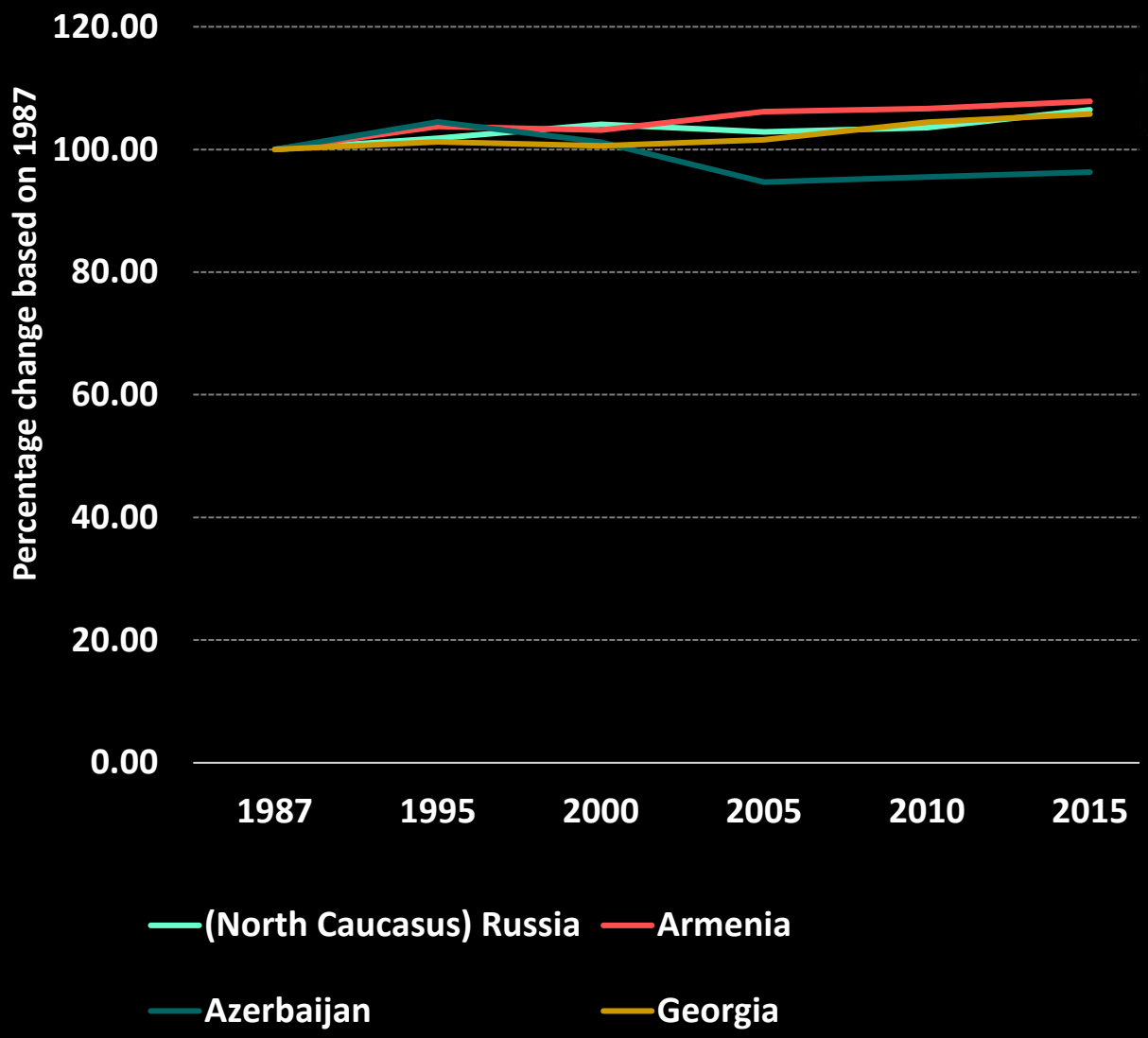


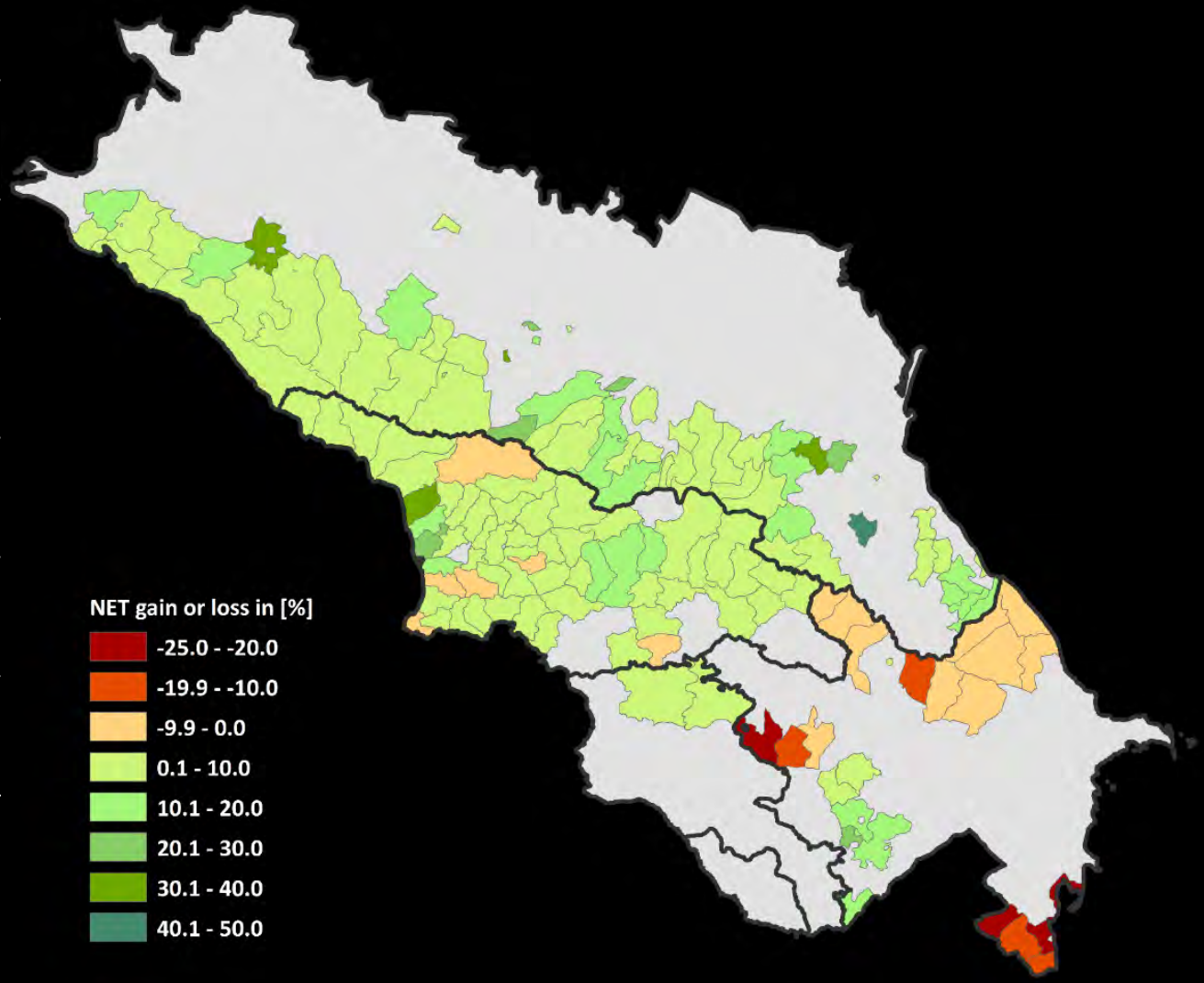


Buchner et al., 2020



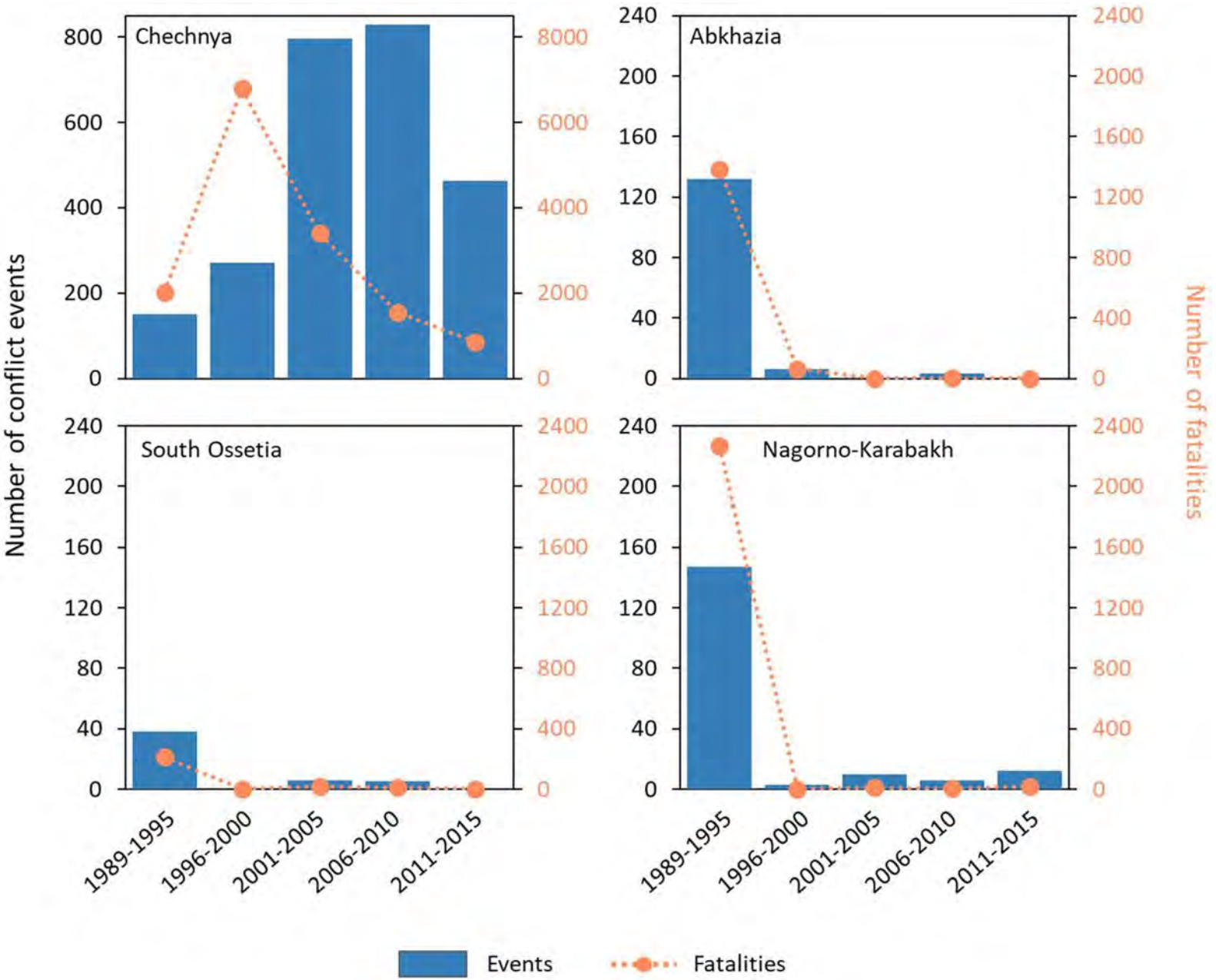
Buchner et al., 2020

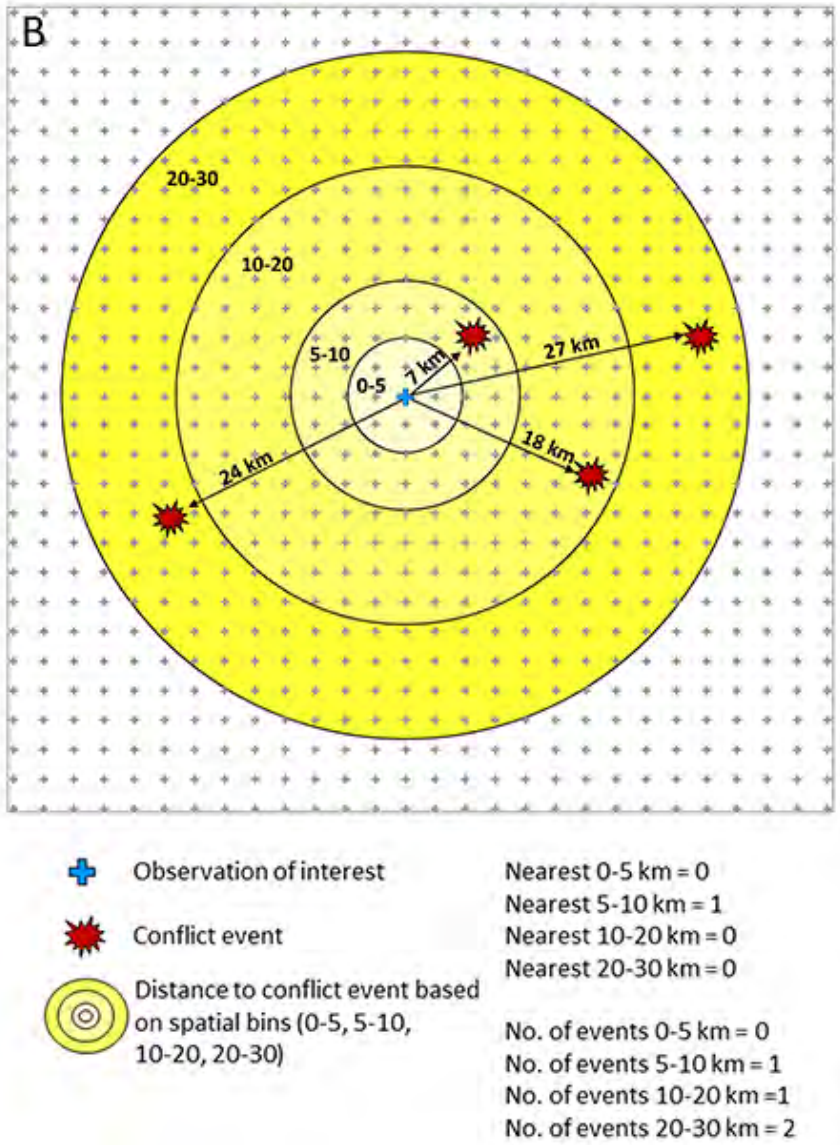




Buchner et al., 2020

Methods



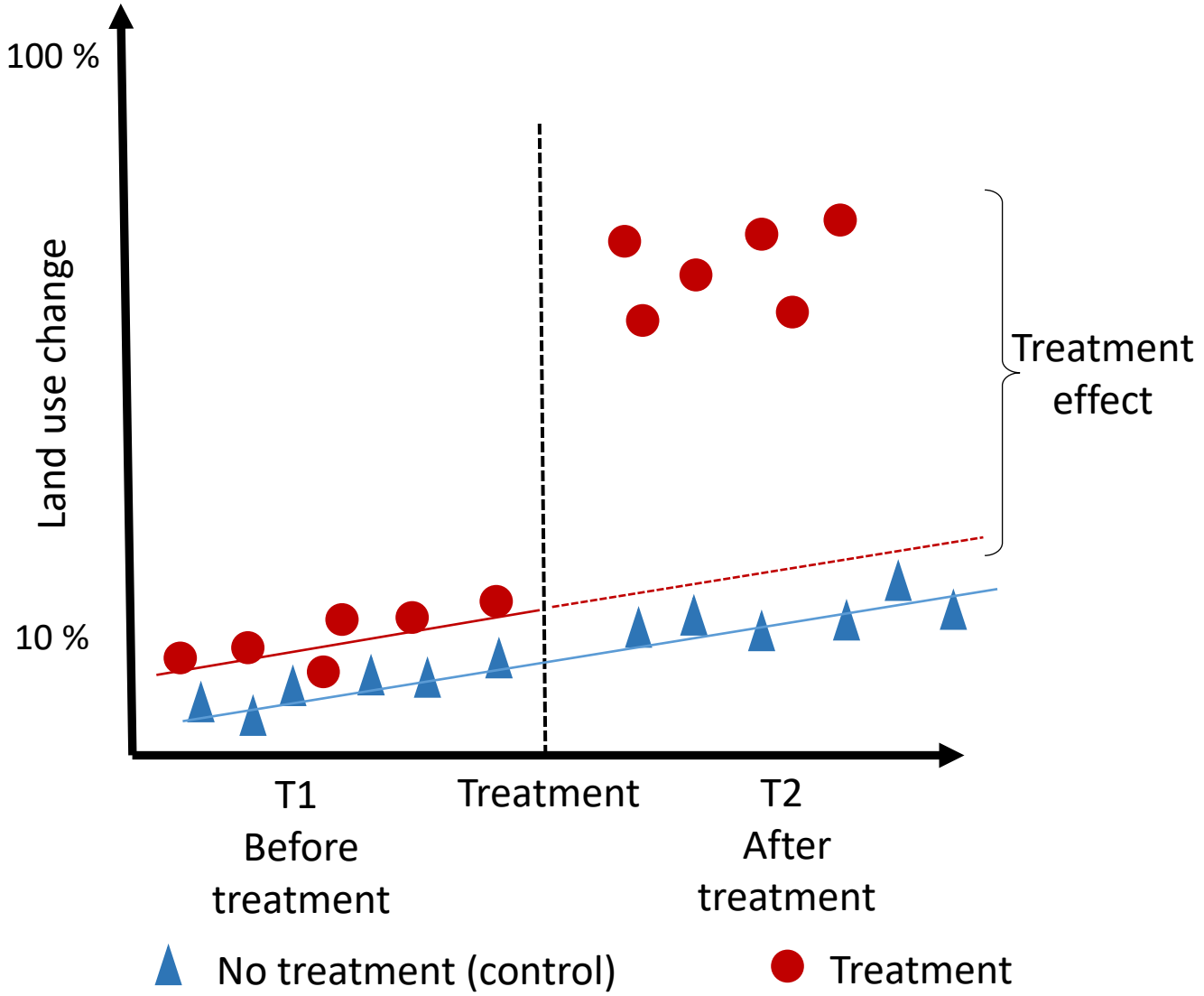


Buchner et al., 2022

Methods

Matching

Credit: StatsLab



Difference-in-differences (DiD)

Credit: Buchner

Methods

$$Y_{it}=\beta_1*nearest_{0-5km\,it}+\beta_2*I_{0-5km\,it}+\beta_3*nearest_{0-5km\,it}*I_{0-5km\,it}+$$
$$\beta_4*nearest_{5-10km\,it}+\beta_5*I_{5-10km\,it}+\beta_6*nearest_{5-10km\,it}*I_{5-10km\,it}+$$
$$\beta_7*nearest_{10-20km\,it}+\beta_8*I_{10-20km\,it}+\beta_9*nearest_{10-20km\,it}*I_{10-20km\,it}+$$
$$\beta_{10}*nearest_{20-30km\,it}+\beta_{11}*I_{20-30km\,it}+$$
$$\beta_{12}*nearest_{20-30km\,it}*I_{20-30km\,it}+\beta_{13}*C_i+\beta_{14-23}*X_{it}+$$
$$\beta_{24}*C_iX_{it}+\beta_{25}*Year_{it}+e_{it}$$

Y_{it} is cropland abandonment (1), or not (0), for observation *i* in time period *t*,

$nearest_{it}$ is a dummy variable indicating if conflict location within defined distances (0-5, 5-10, 10-20, and 20-30 km) is nearest (1), or not (0),

I_{it} is the intensity measure, i.e., the number of conflict events or number of total fatalities, of observation *i* in time period *t*,

$nearest_{it} * I_{it}$ is the interaction term between $nearest_{it}$ and I_{it},

C_i is a categorical variable indicating the country,

X_{it} is the vector of control variables,

$C_i * X_{it}$ is the interaction term between Country and the control variables,

$Year_{it}$ is a categorical variable indicating the time step,

β_1-β_{25} are the coefficients to be estimated,

and e_{it} is the error term

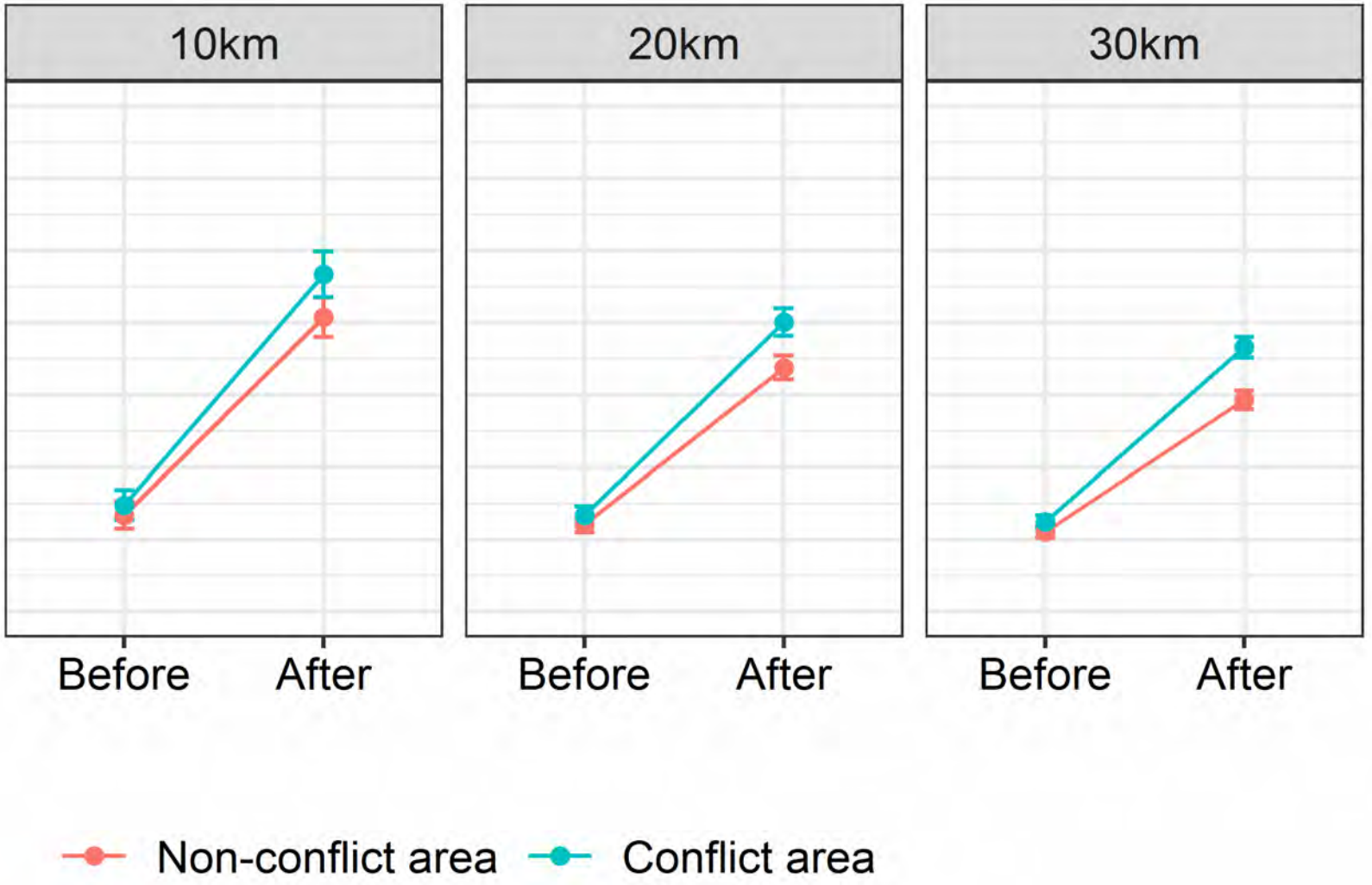
Buchner et al., 2022

Results – overall effect on abandonment

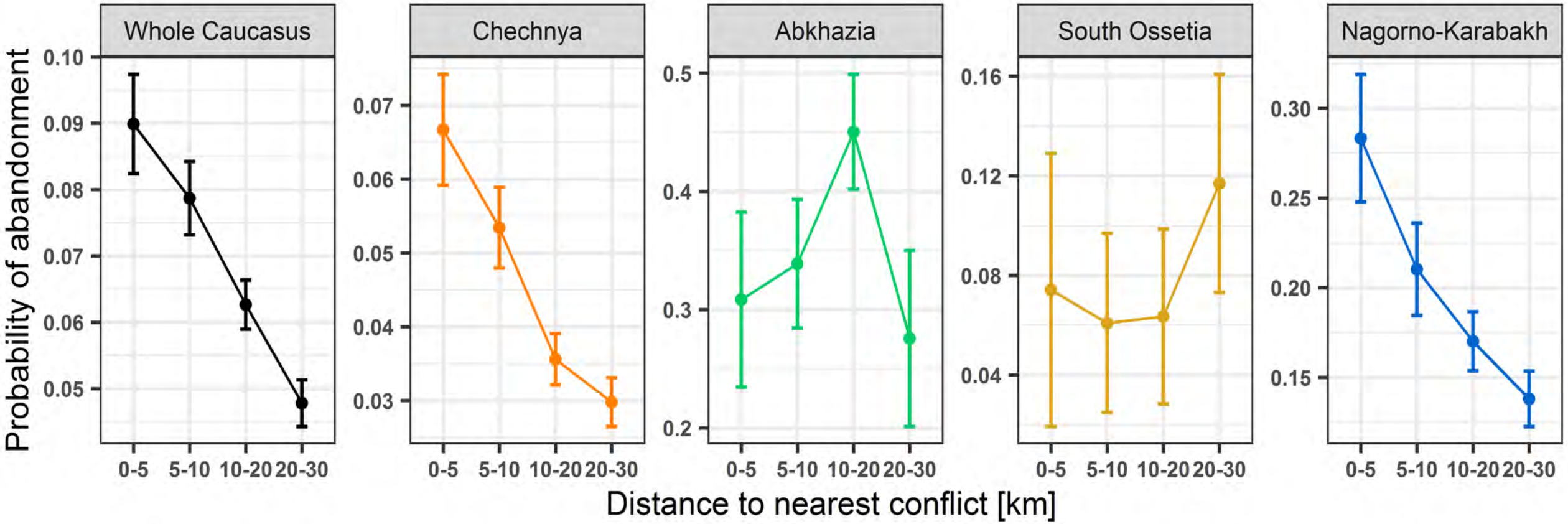
	Marginal effect (Percent change in abandonment)	
	10 km	30 km
All four wars	15.8	**27.3**
Chechnya	**46.5**	38.7
Abkhazia	19.0	**45.1**
South Ossetia	50.0	-7.1
Nagorno-Karabakh	-64.4	-39.7

Buchner et al., 2022

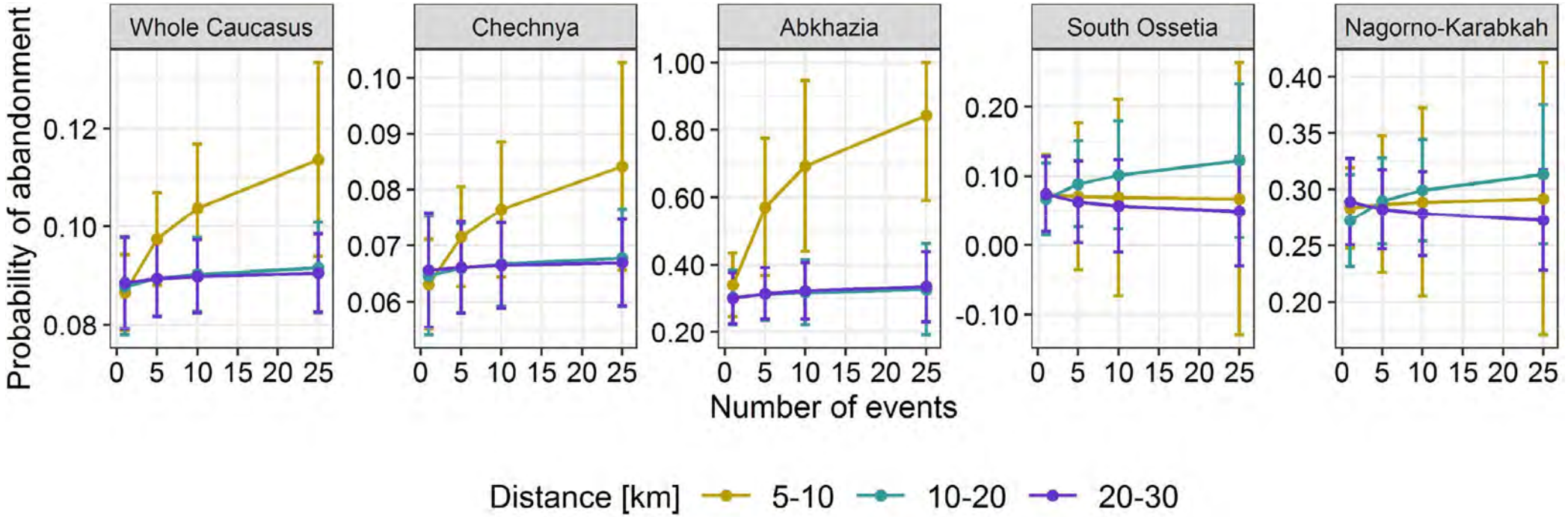
Results – overall effect on abandonment

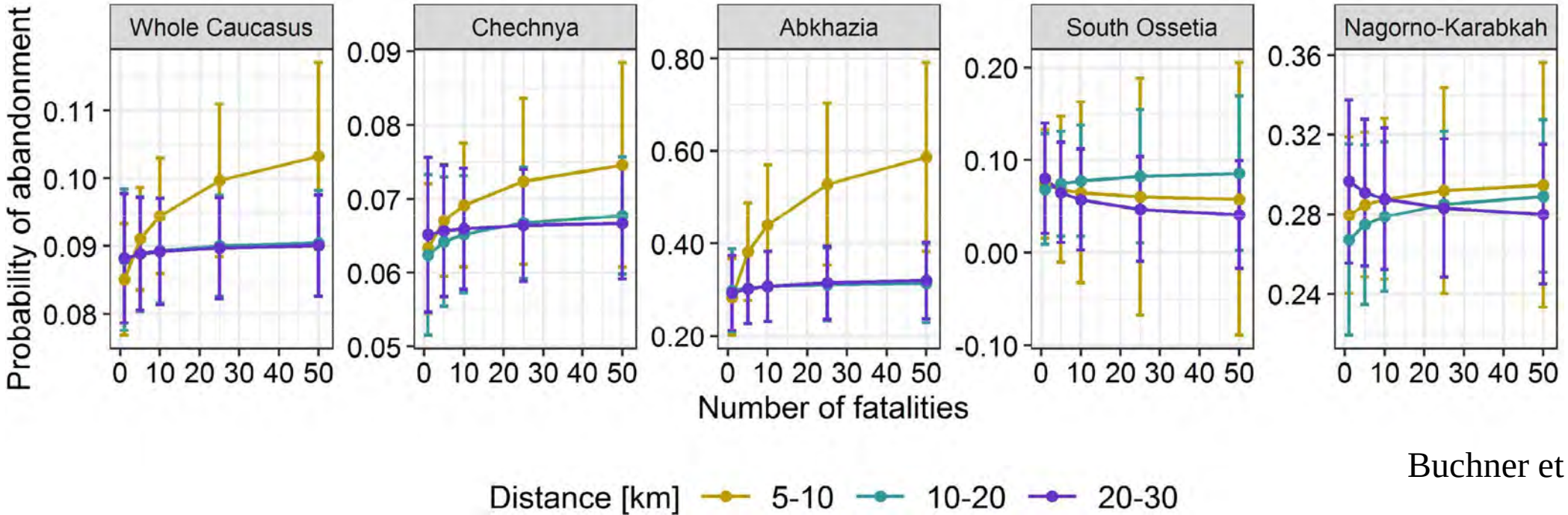


Buchner et al., 2022



Buchner et al., 2022





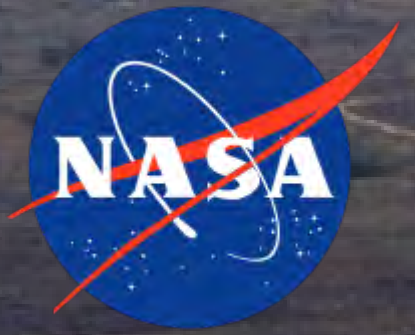
Buchner et al., 2022

- Econometric models to investigate the effects of wars
- Wars affected land use differently in the Caucasus
- Processes at different scales result in various effects

- Econometric models to investigate the effects of wars
- Wars affected land use differently in the Caucasus
- Processes at different scales result in various effects

Effects of the Syrian Civil War on cropland in the Mediterranean region

The New (Early Career) Investigator Program (NIP) in Earth Science




Turkey
Iran
Syria
Lebanon
Iraq
Jordan
Israel
Egypt
Saudi Arabia
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus


Palmyra


Turkey
Al Hasakah
Aleppo
Idlib
Raqqa
Latakia
Hama
Deir ez-Zor
Tartus
Homs
Syria
Damascus
Daraa
As-Suwayda
Jordan
0
100 km

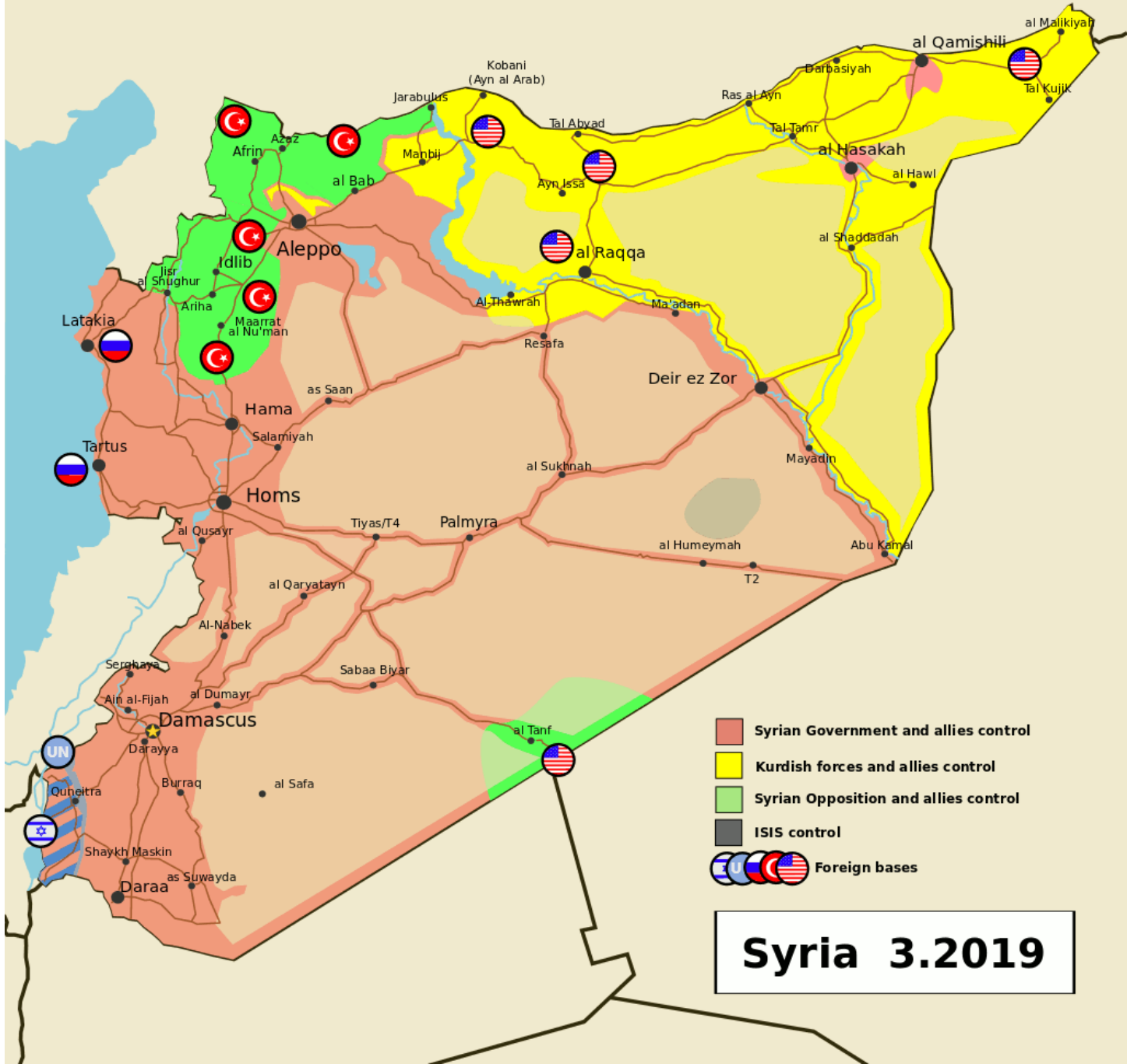
Forces

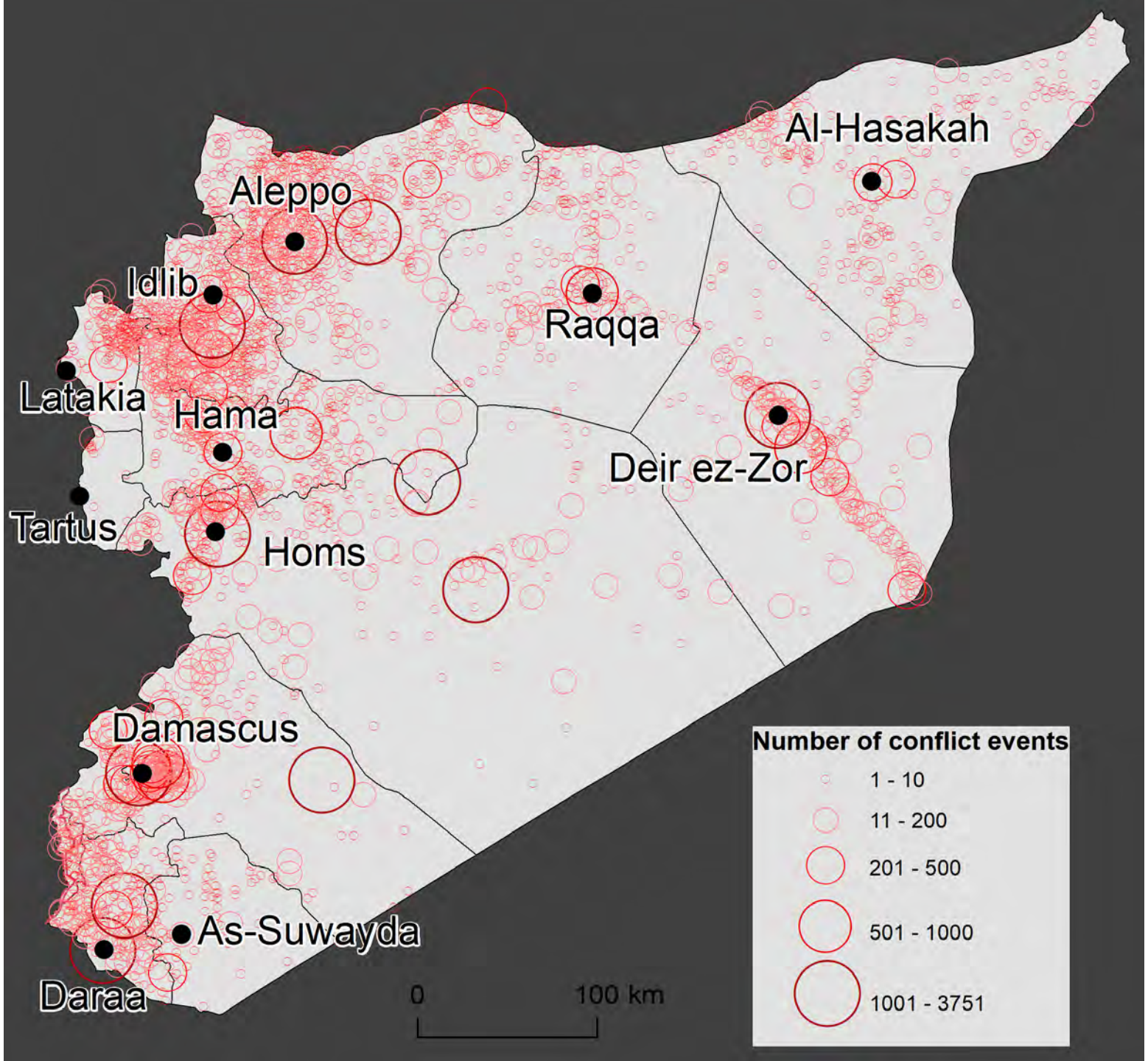
- Syrian Arab Republic
- Hezbollah
- Iran
- Russia (2015–present)
- Iraq (2017–2019)

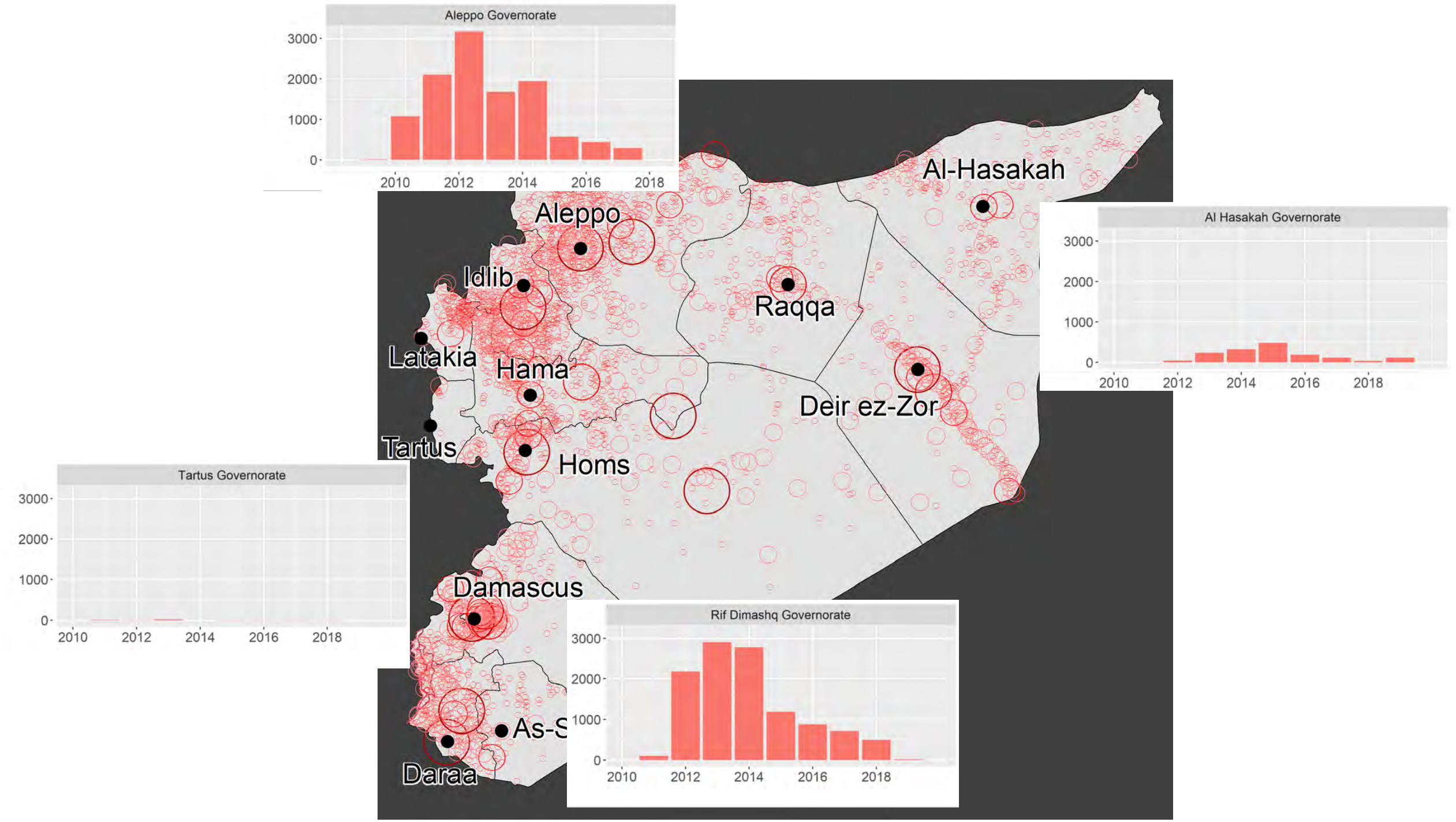
- Interim Government
- Turkey (2016–present)
- Salvation Government

- Islamic State (2013–present)

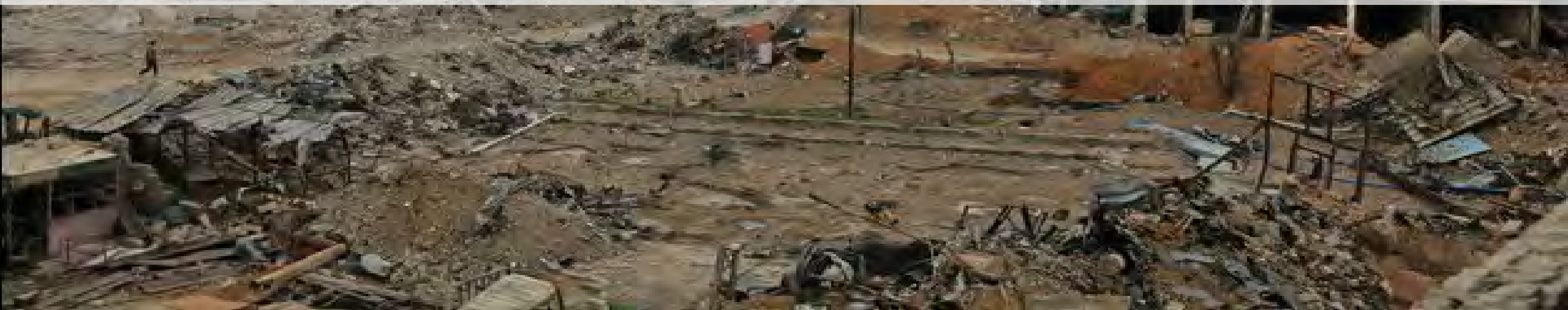
- SDF (2012–present)
- CJTF–OIR (2014–present)




Al-Hasakah
Aleppo
Idlib
Raqqa
Latakia
Hama
Deir ez-Zor
Tartus
Homs
Damascus
As-Suwayda
Daraa
0
100 km
Number of conflict events
1 - 10
11 - 200
201 - 500
501 - 1000
1001 - 3751


Aleppo Governorate
3000
2000
1000
0
2010
2012
2014
2016
2018
Al-Hasakah
Aleppo
Idlib
Raqqa
Latakia
Hama
Deir ez-Zor
Tartus
Homs
Al Hasakah Governorate
3000
2000
1000
0
2010
2012
2014
2016
2018
Tartus Governorate
3000
2000
1000
0
2010
2012
2014
2016
2018
Damascus
As-S
Daraa
Rif Dimashq Governorate
3000
2000
1000
0
2010
2012
2014
2016
2018

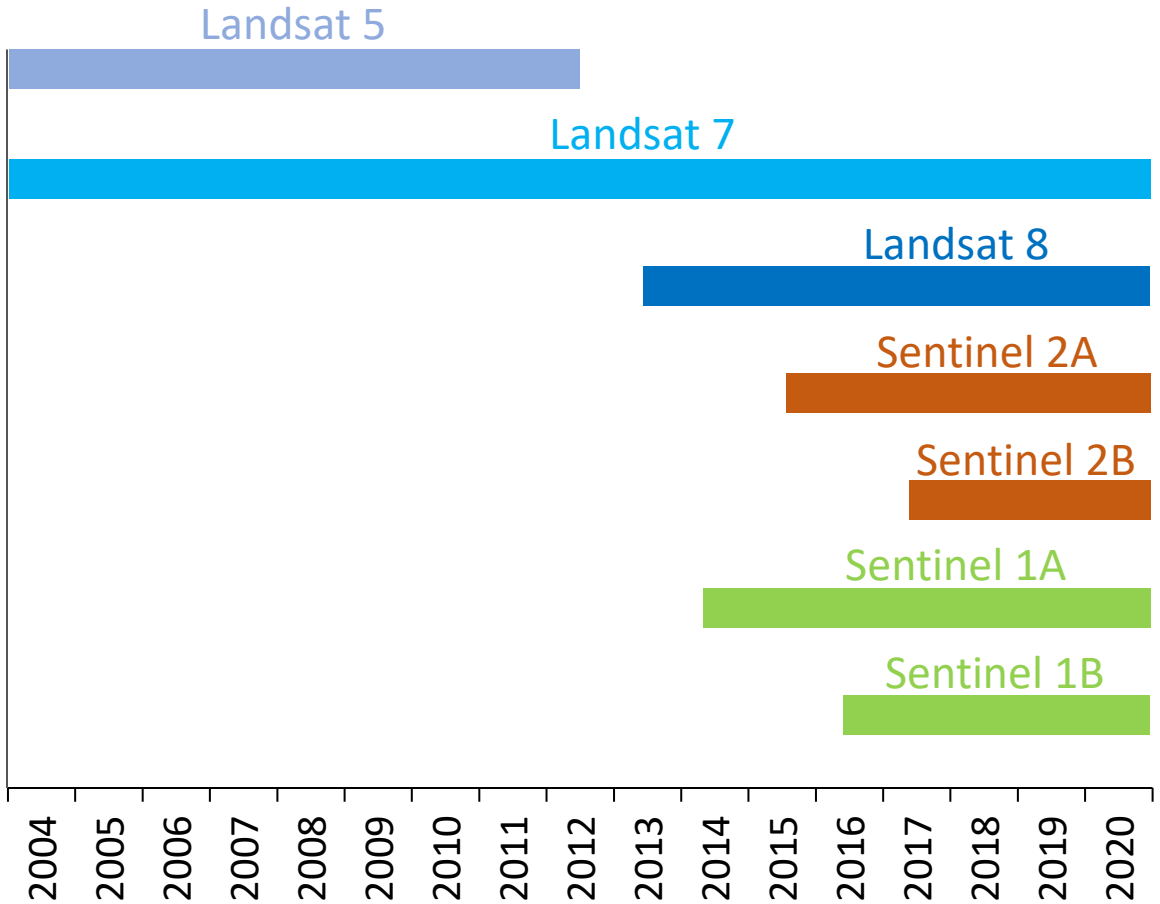
How the cropland has been changed during the Syrian Civil War?



Data analysis

1. Annual cropland mapping
   - 2004-2020
   - 30-m resolution

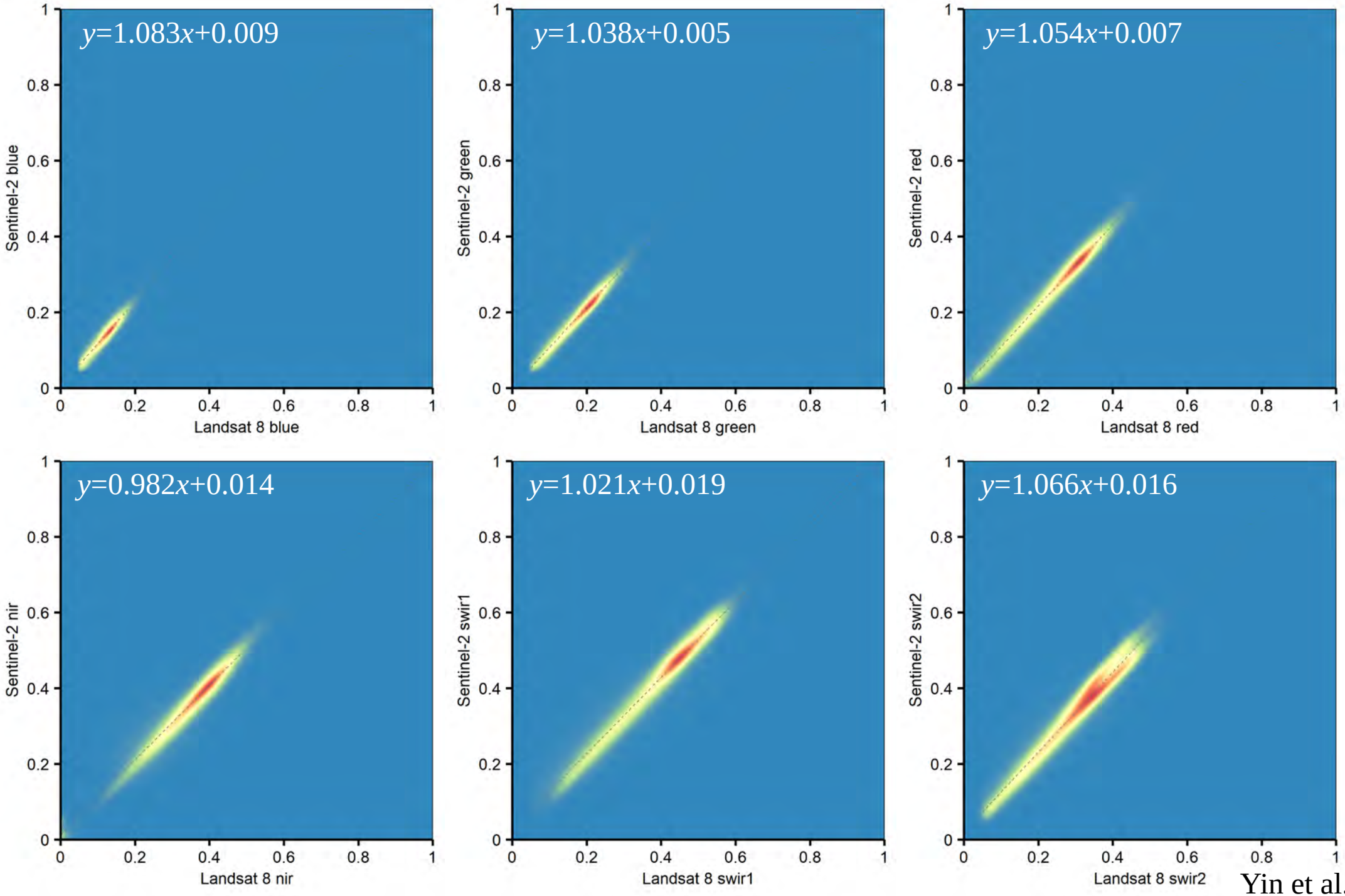
2. Mapping the timing and type of cropland change
   - Abandonment
   - Re-cultivation



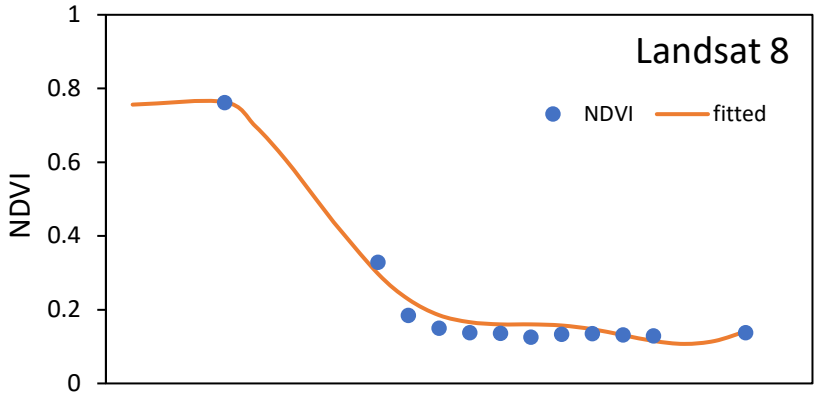
Annual cropland mapping

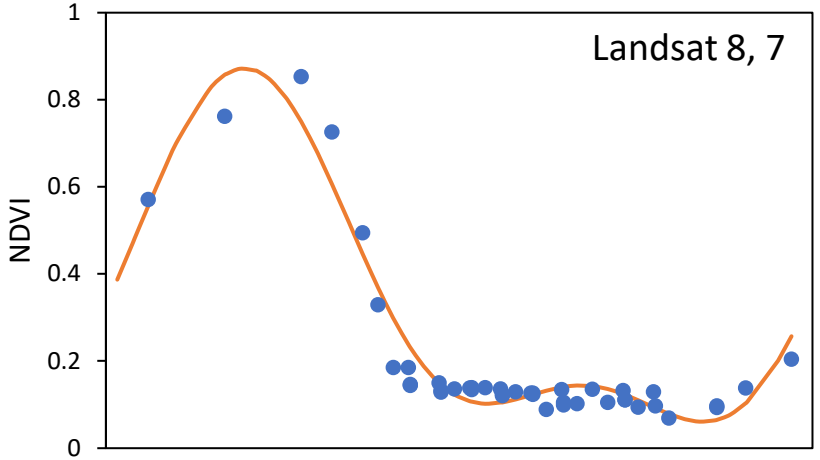
Period	Sensors	Features
2004-2013	Collection 2 Landsat 5, 7 and 8	220 input features
2014-2020	Collection 2 Landsat 5, 7, 8, Sentinel-1, 2	244 input features
2020	Landsat, Landsat+Sentinel-2, Landsat+Sentinel-1, 2	220/244 features

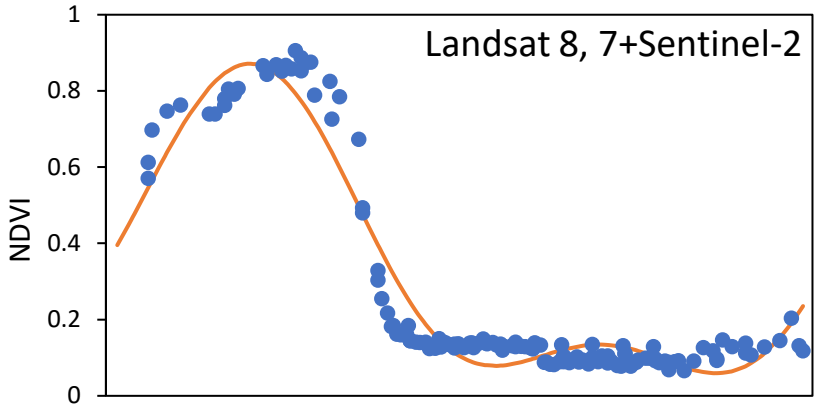
- Classifier: random forest

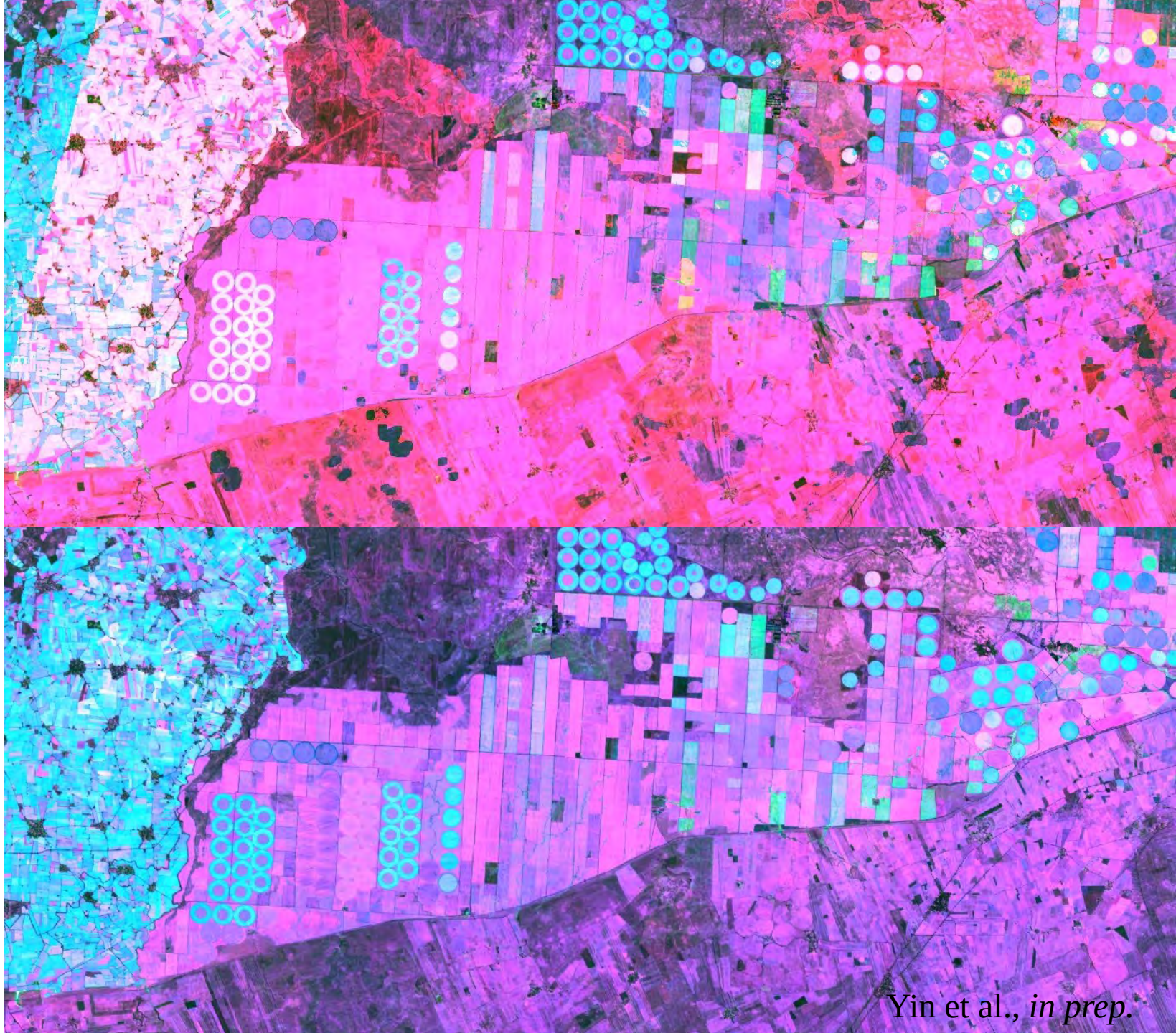


Yin et al., *in prep.*









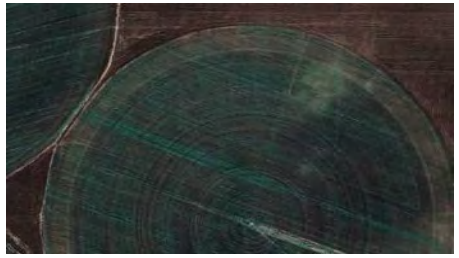
Yin et al., *in prep.*

Annual cropland mapping

Tree crops



Other crops

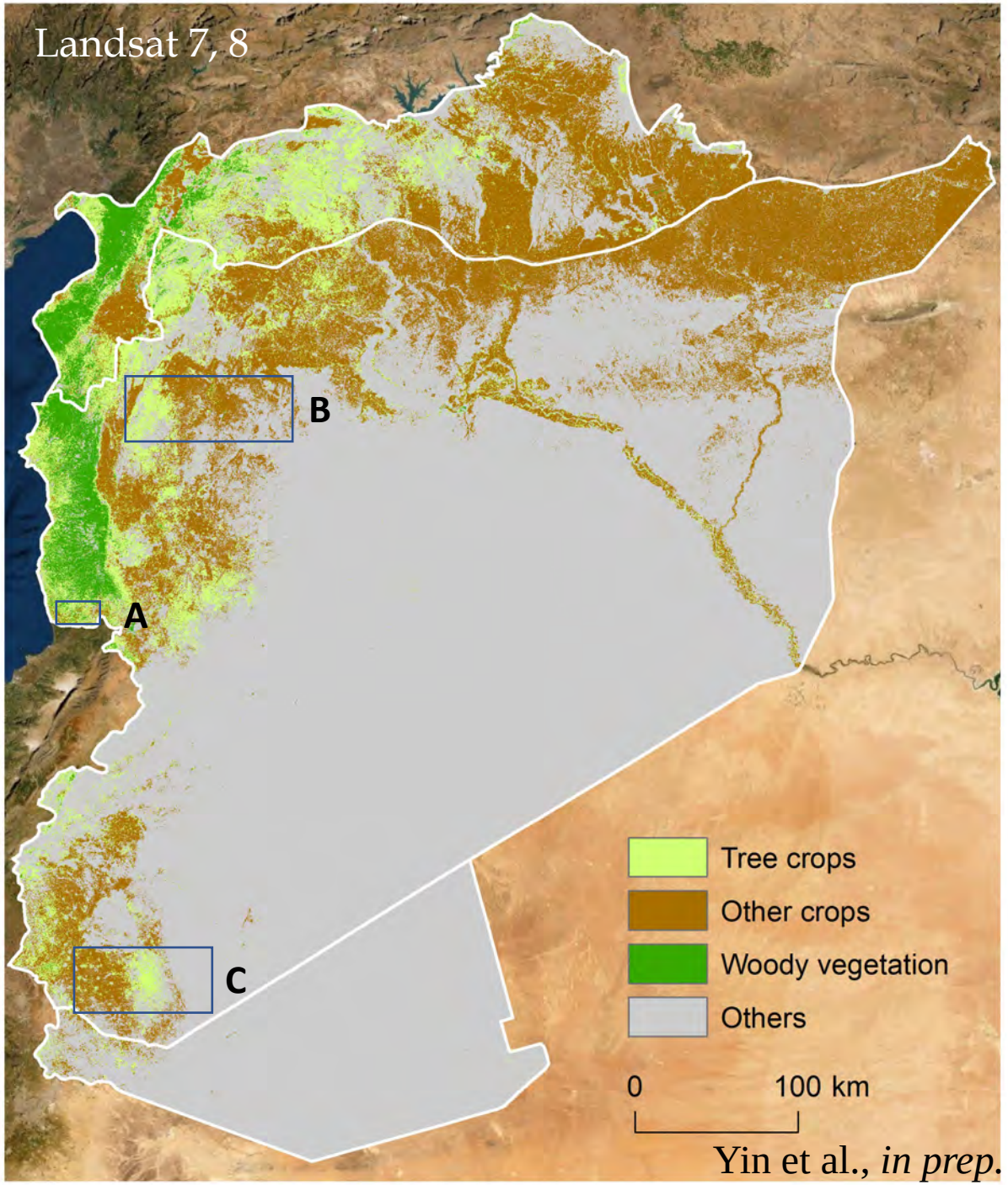


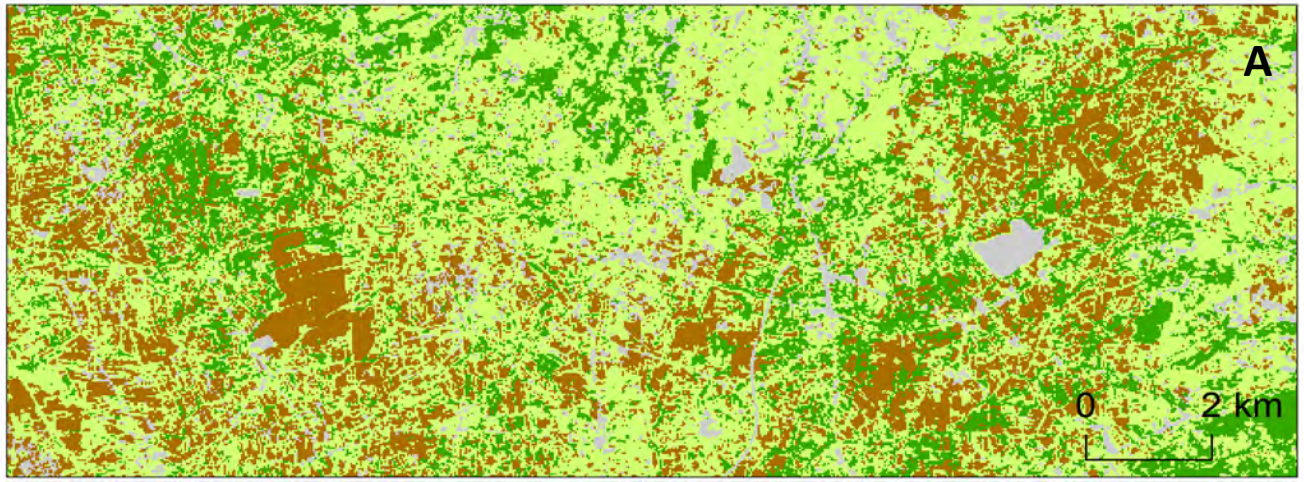
Woody vegetation

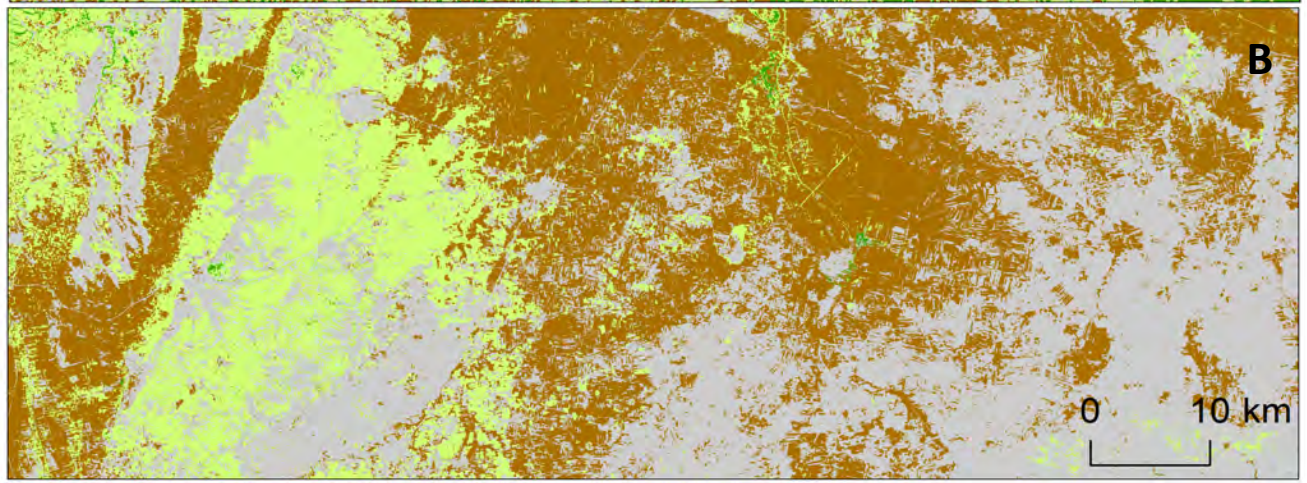


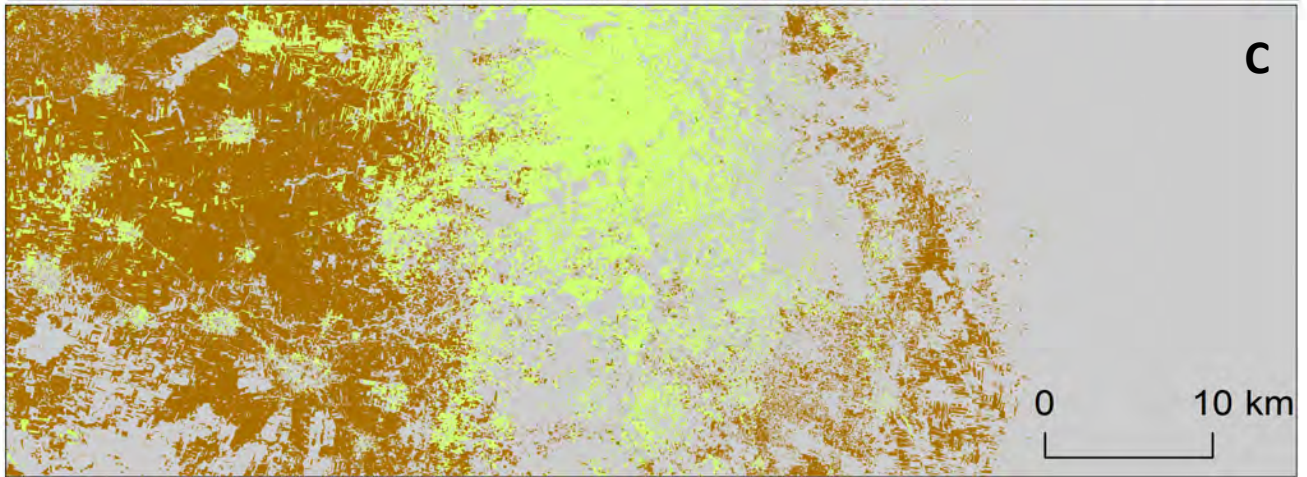
Others

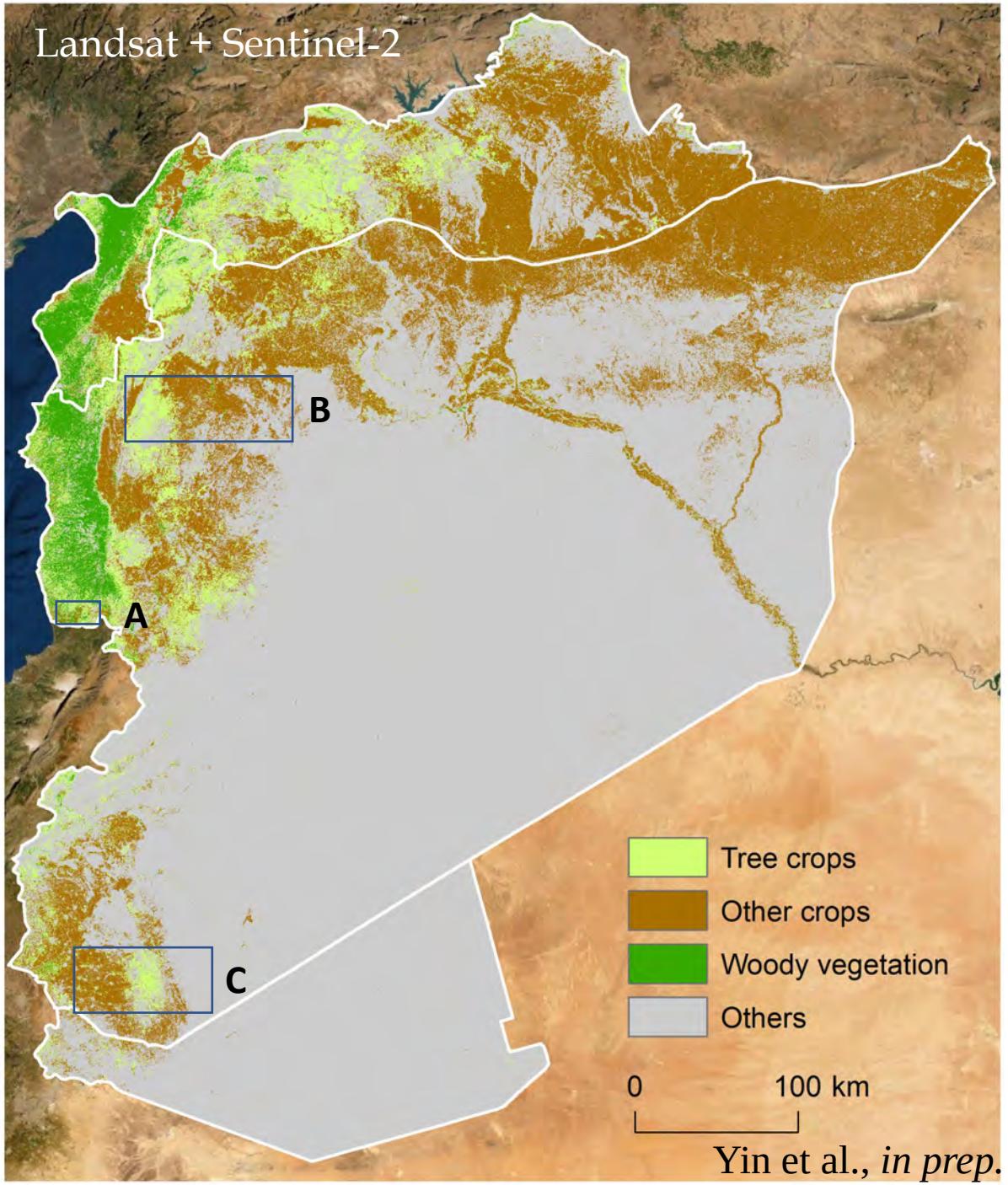


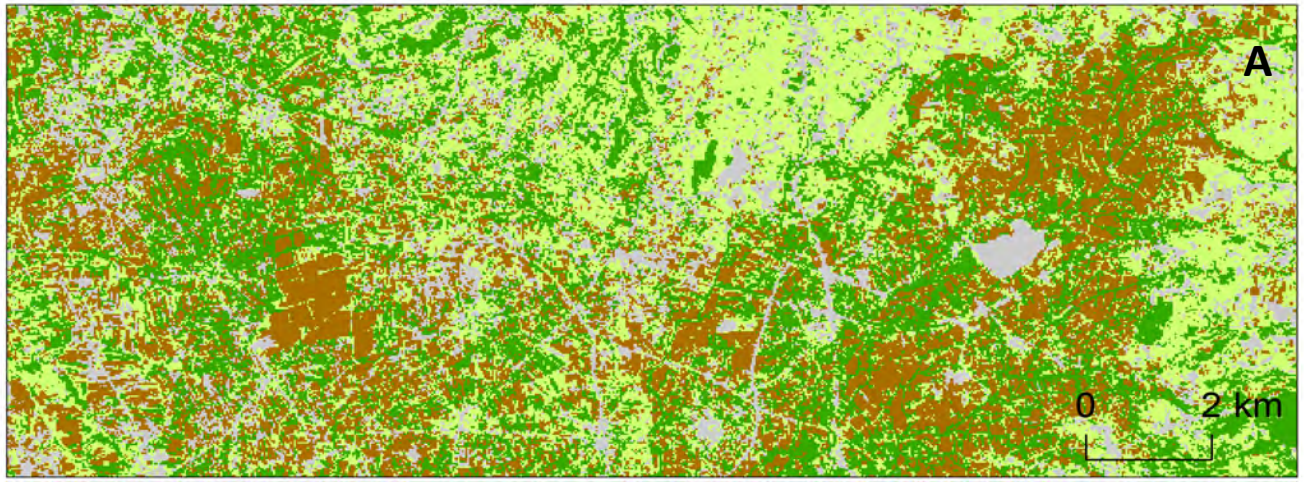

Landsat 7, 8
A
B
C
Tree crops
Other crops
Woody vegetation
Others
0
100 km
Yin et al., *in prep.*

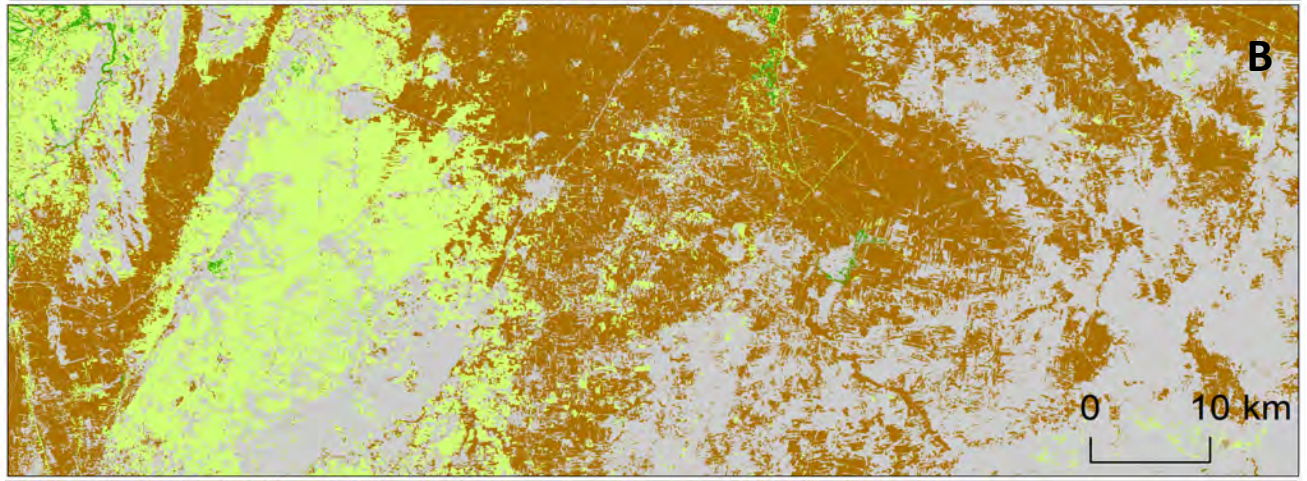

A
0
2 km

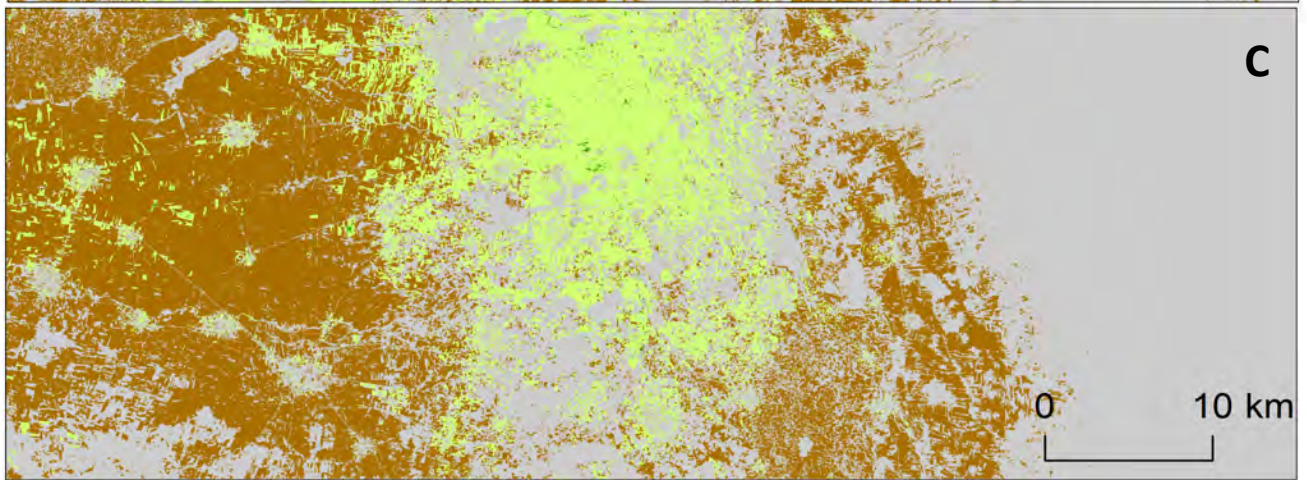

B
0
10 km

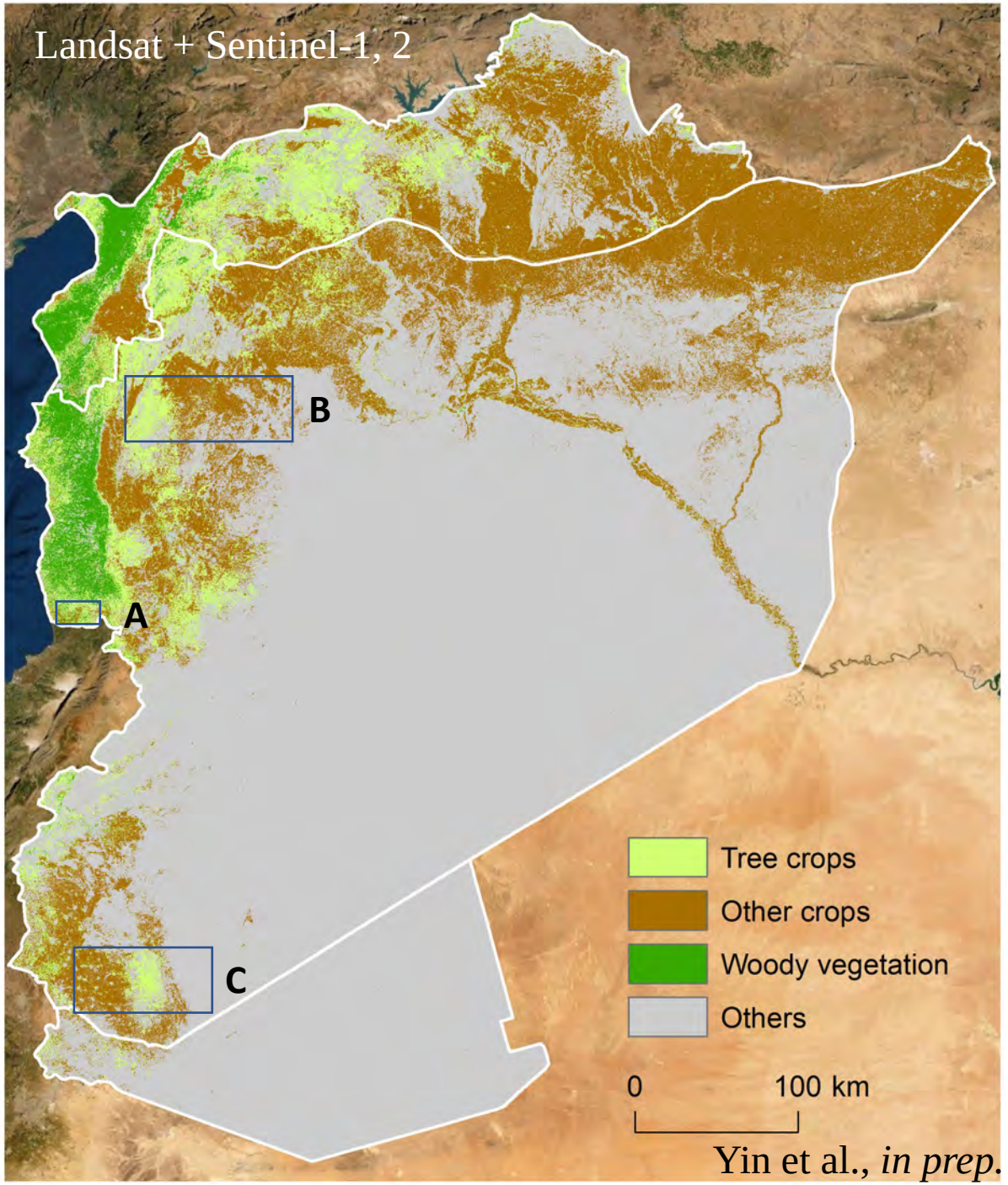

C
0
10 km

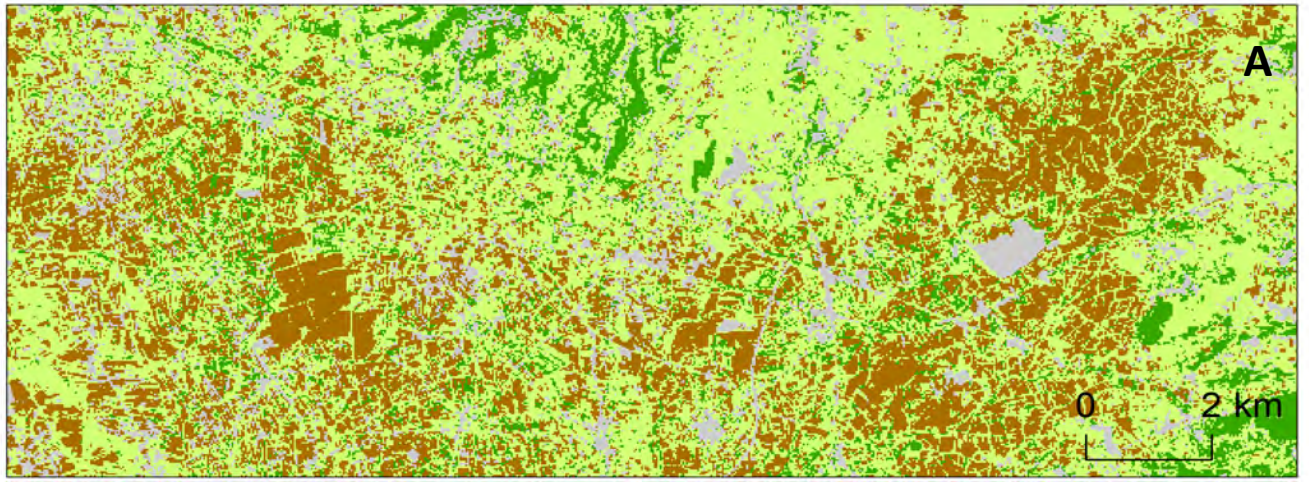

Landsat + Sentinel-2
A
B
C
Tree crops
Other crops
Woody vegetation
Others
0
100 km
Yin et al., *in prep.*

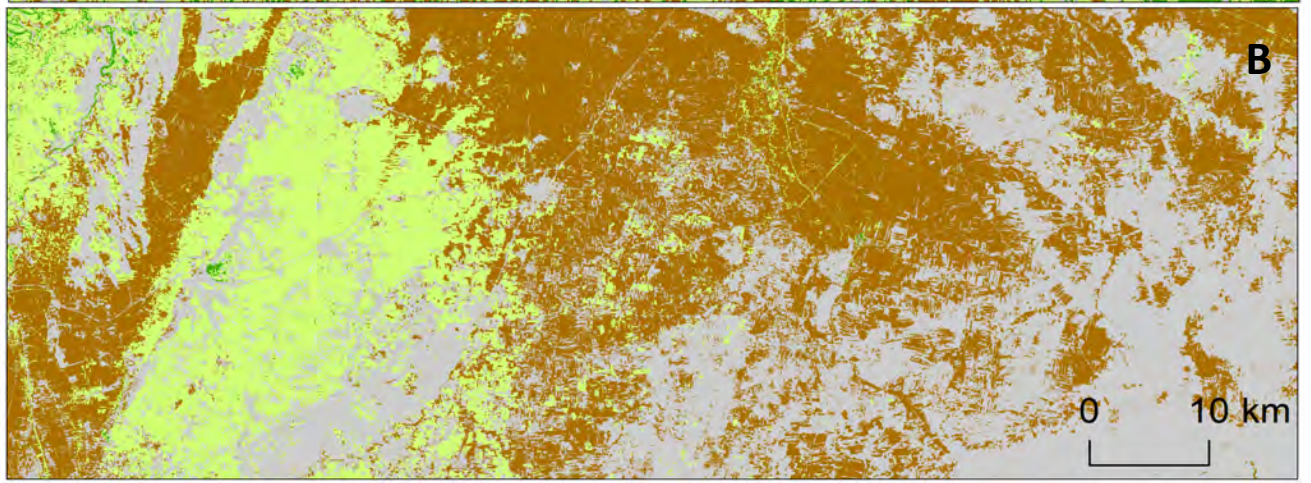

A
0
2 km

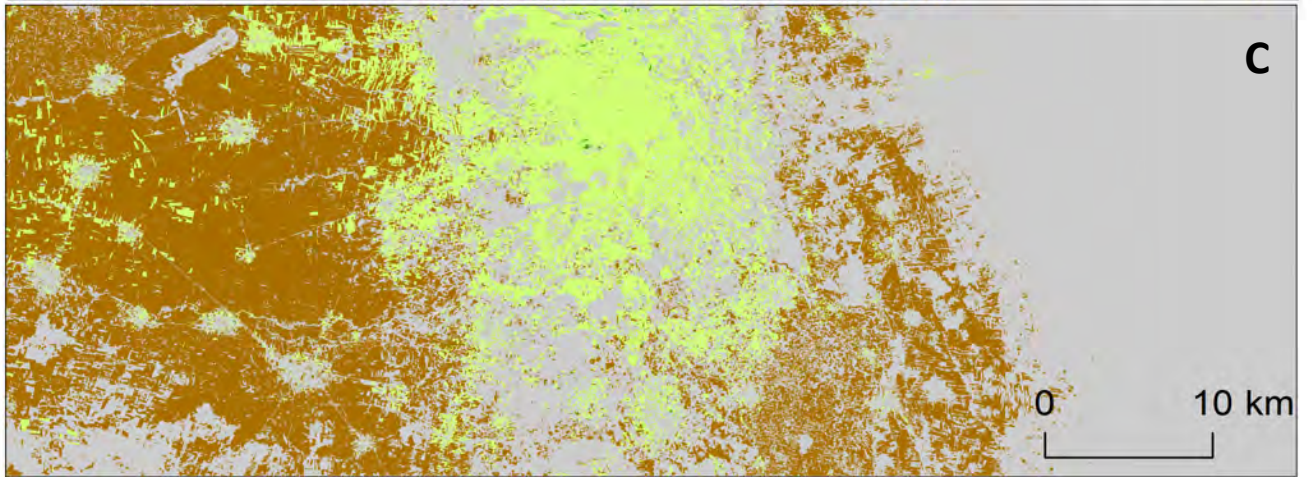

B
0
10 km


C
0
10 km

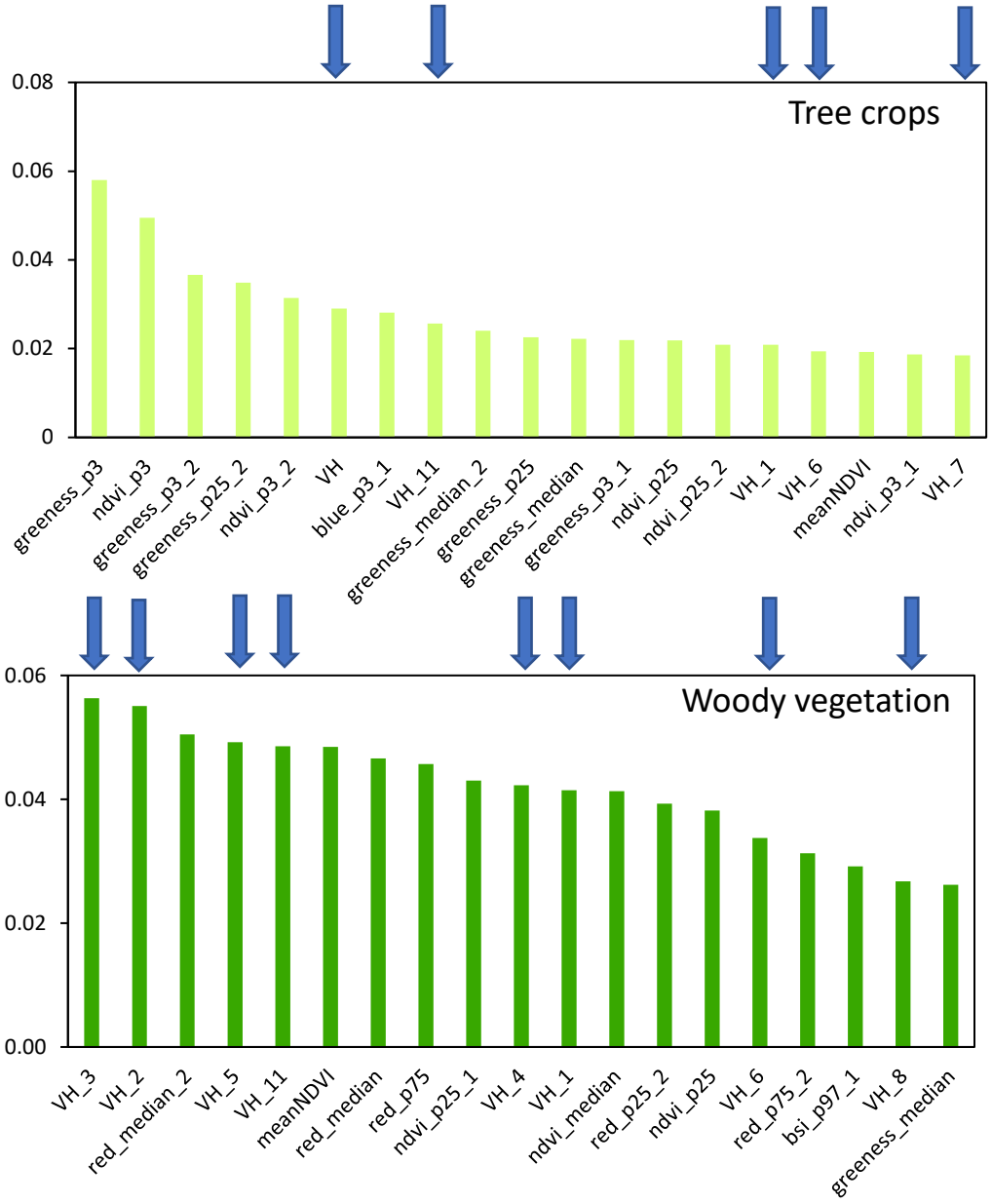

Landsat + Sentinel-1, 2
A
B
C
Tree crops
Other crops
Woody vegetation
Others
0
100 km
Yin et al., *in prep.*

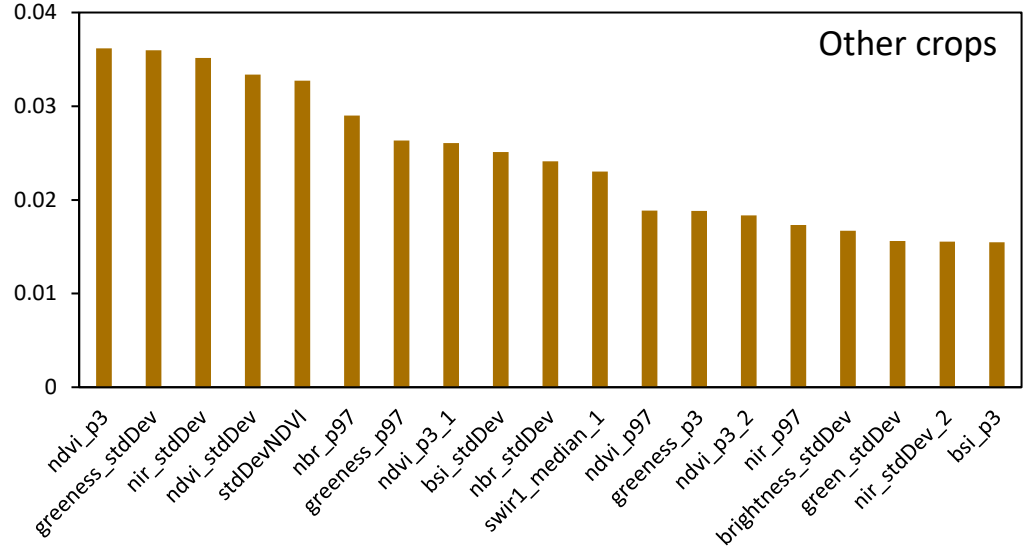

A
0
2 km

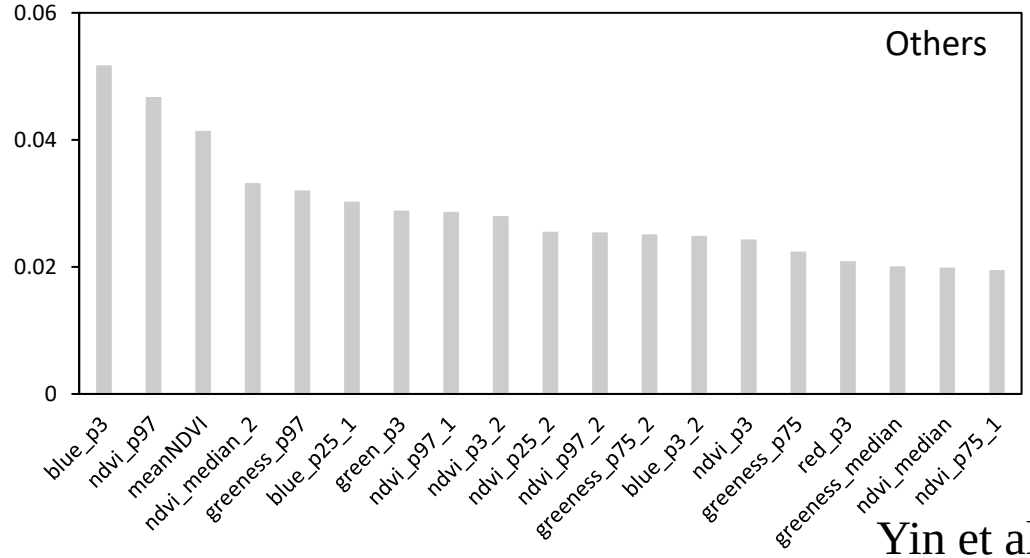

B
0
10 km


C
0
10 km

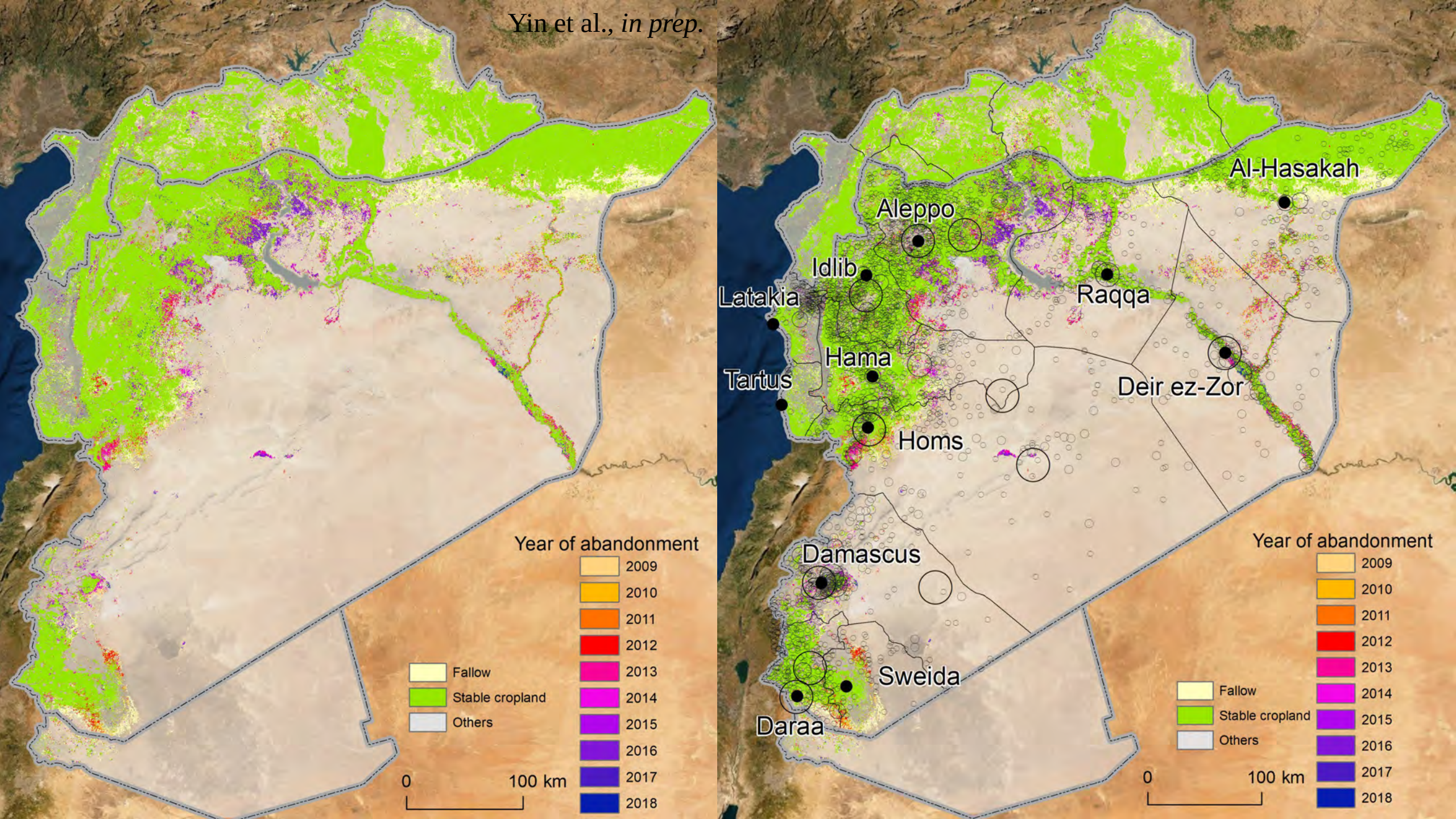
Feature importance

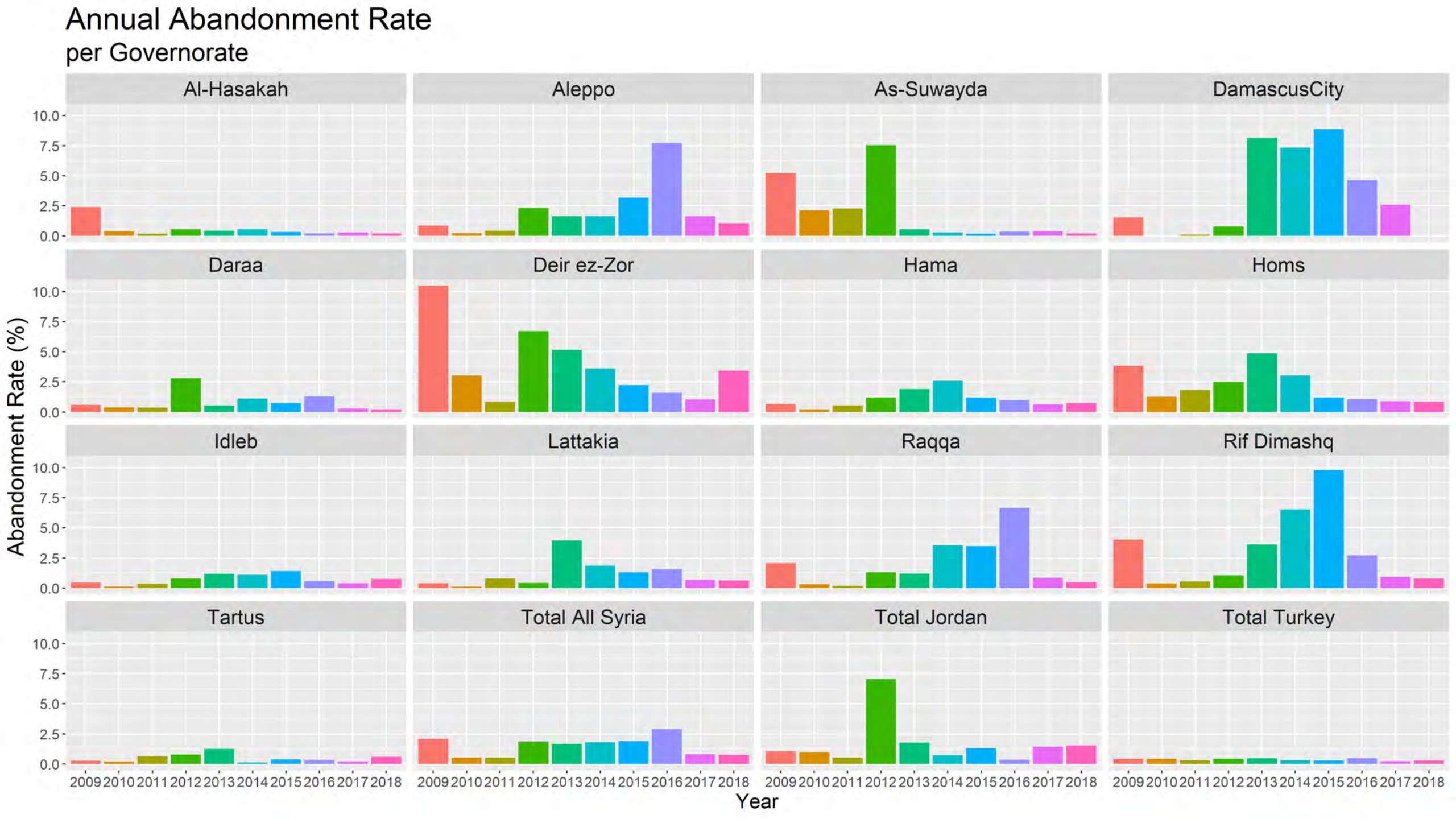


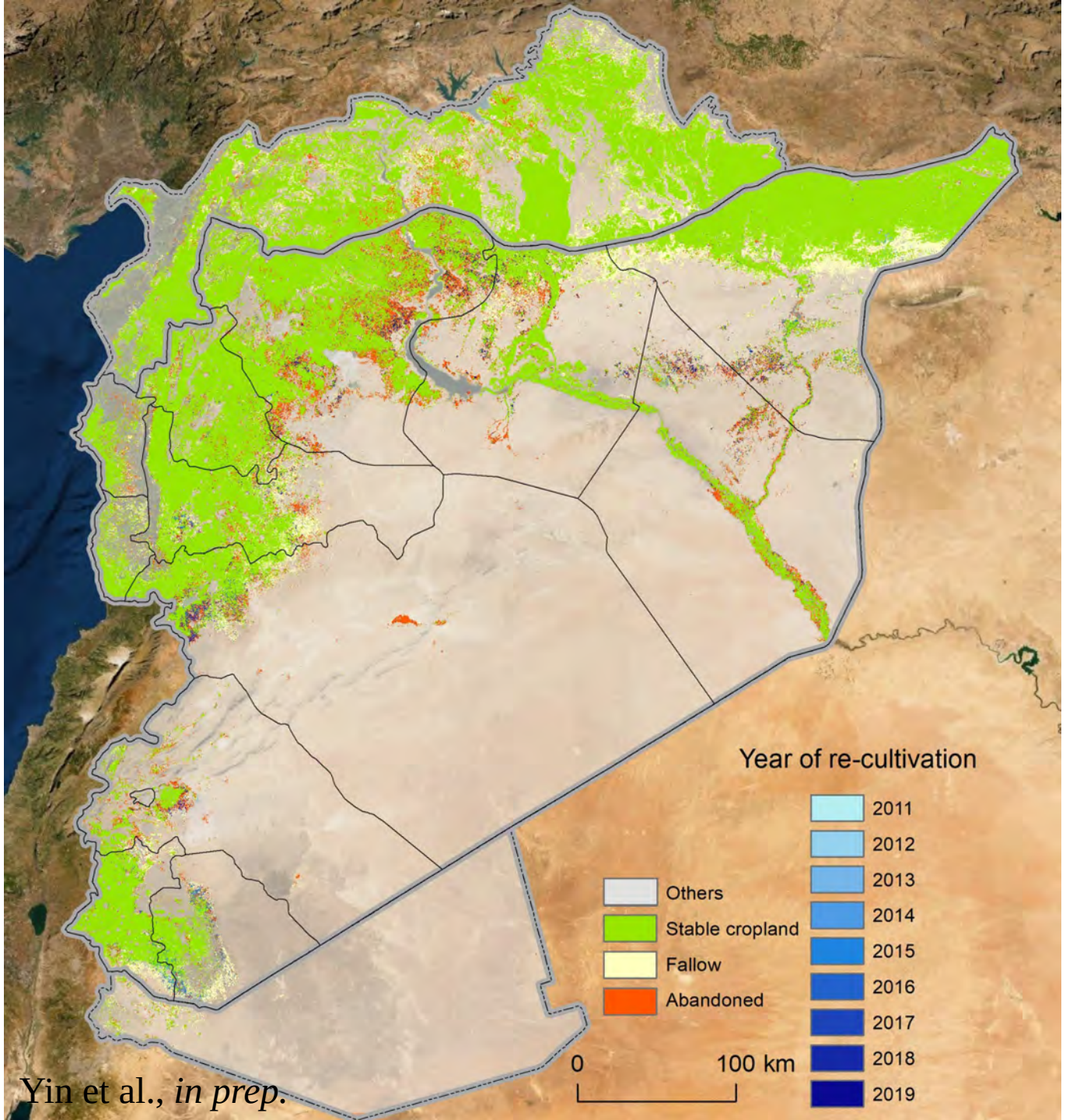




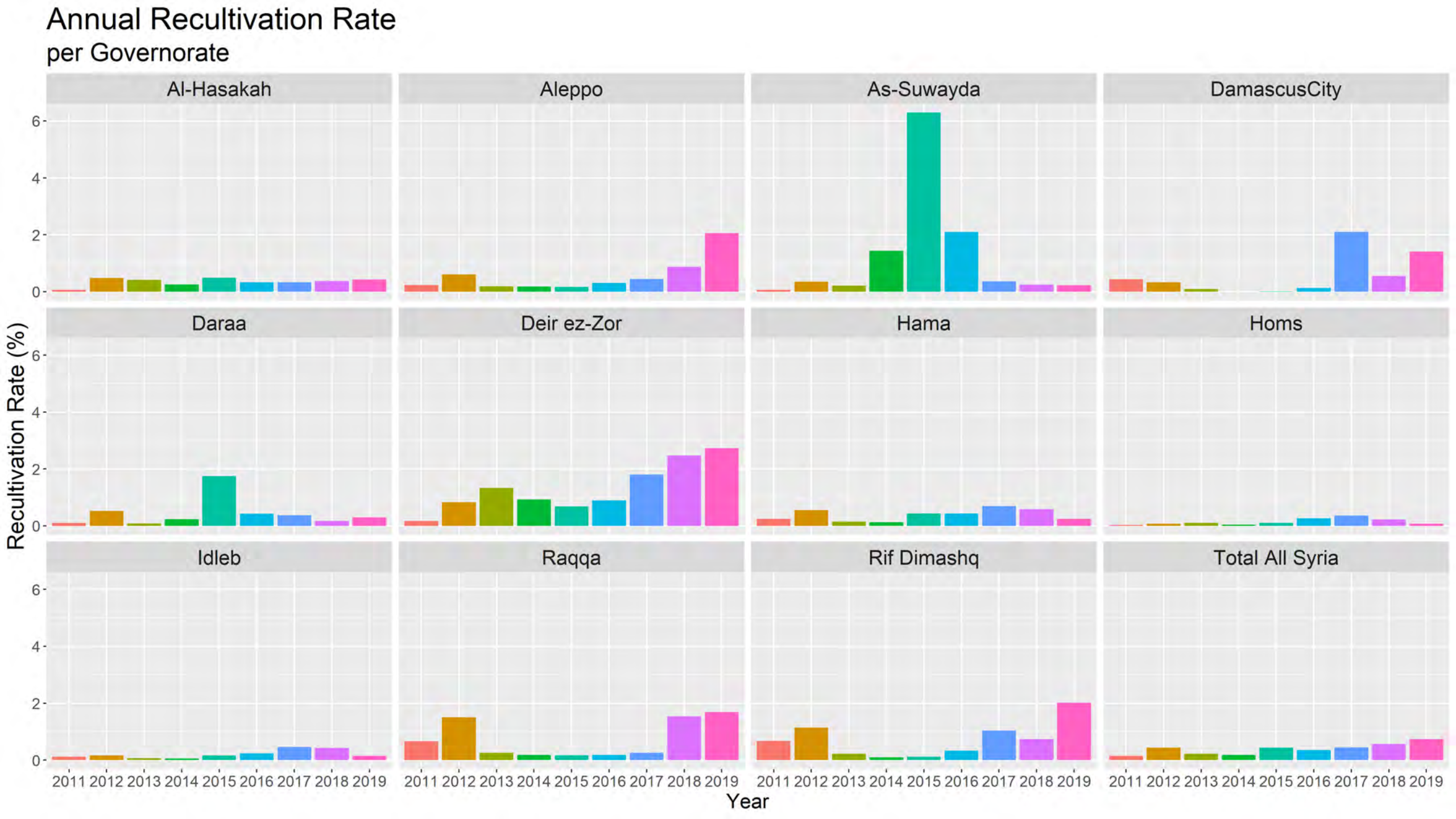
Yin et al., *in prep.*

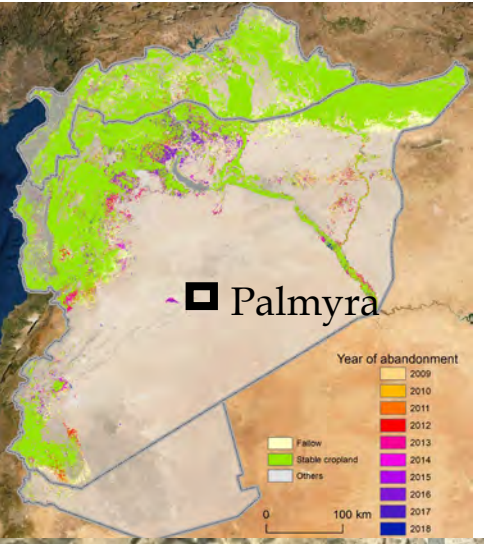

Yin et al., *in prep*.
Al-Hasakah
Aleppo
Idlib
Latakia
Raqqa
Hama
Tartus
Deir ez-Zor
Homs
Damascus
Sweida
Daraa
Year of abandonment
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Fallow
Stable cropland
Others
0
100 km


Annual Abandonment Rate
per Governorate
Al-Hasakah
Aleppo
As-Suwayda
DamascusCity
Daraa
Deir ez-Zor
Hama
Homs
Idleb
Lattakia
Raqqa
Rif Dimashq
Tartus
Total All Syria
Total Jordan
Total Turkey
Abandonment Rate (%)
10.0
7.5
5.0
2.5
0.0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
Year

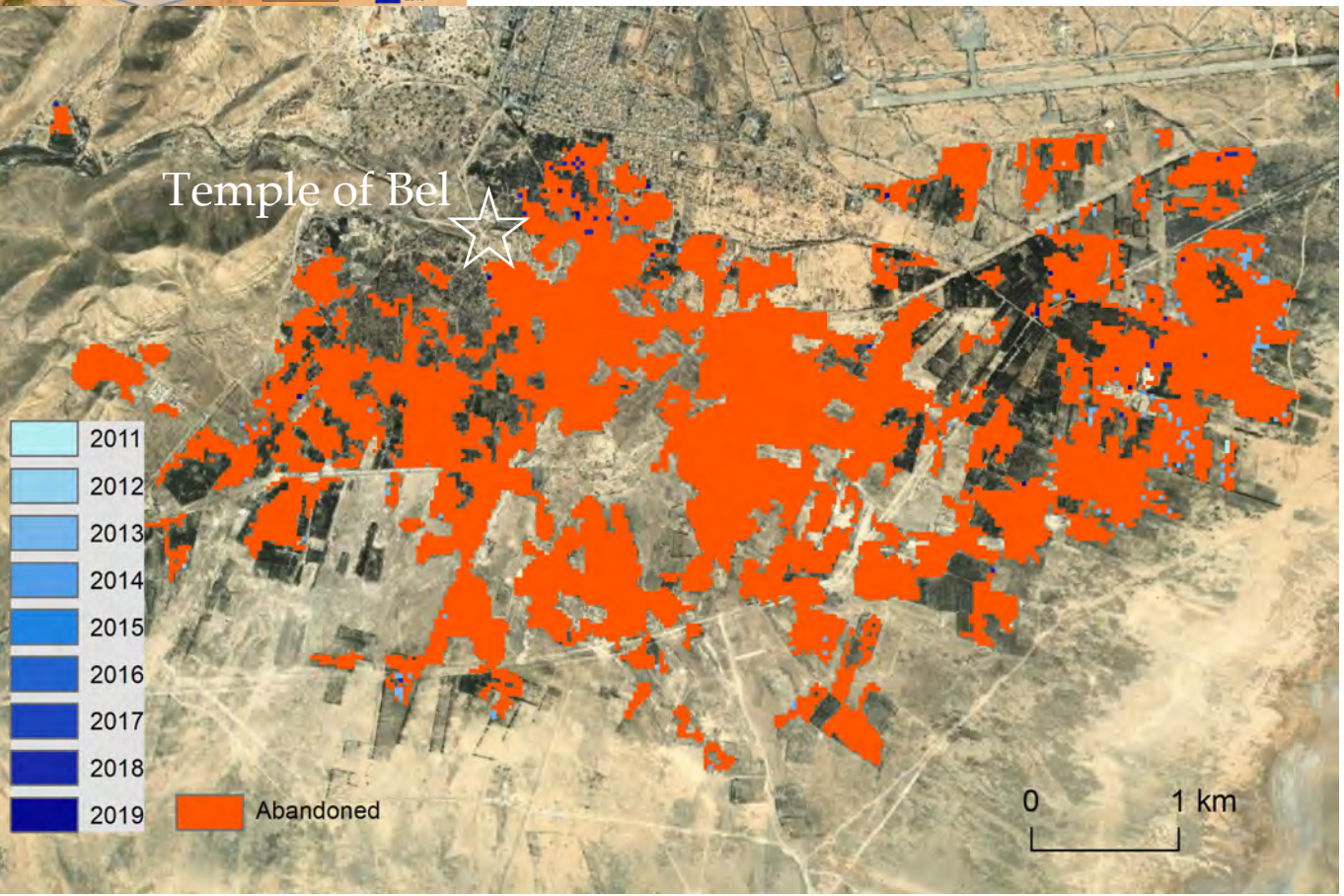


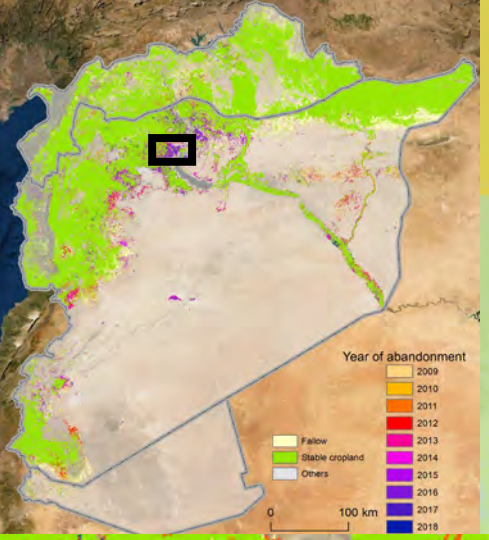
Yin et al., *in prep*.

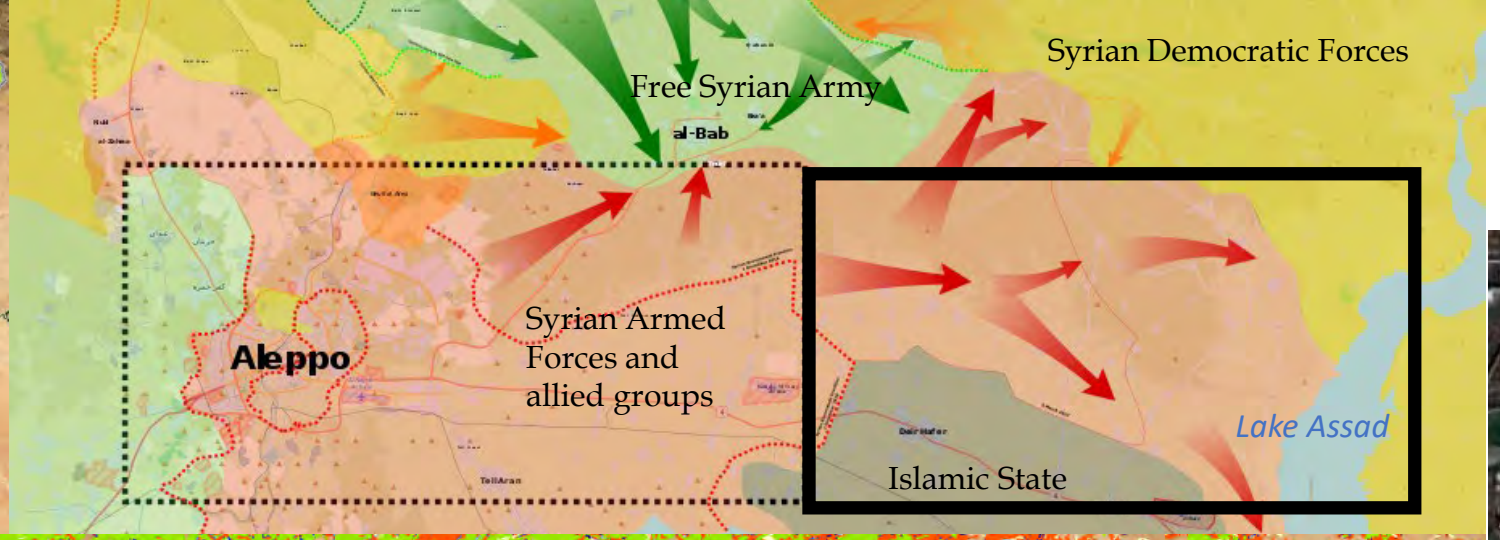

Annual Recultivation Rate
per Governorate
Al-Hasakah
Aleppo
As-Suwayda
DamascusCity
Daraa
Deir ez-Zor
Hama
Homs
Idleb
Raqqa
Rif Dimashq
Total All Syria
Recultivation Rate (%)
0
2
4
6
2011 2012 2013 2014 2015 2016 2017 2018 2019
Year

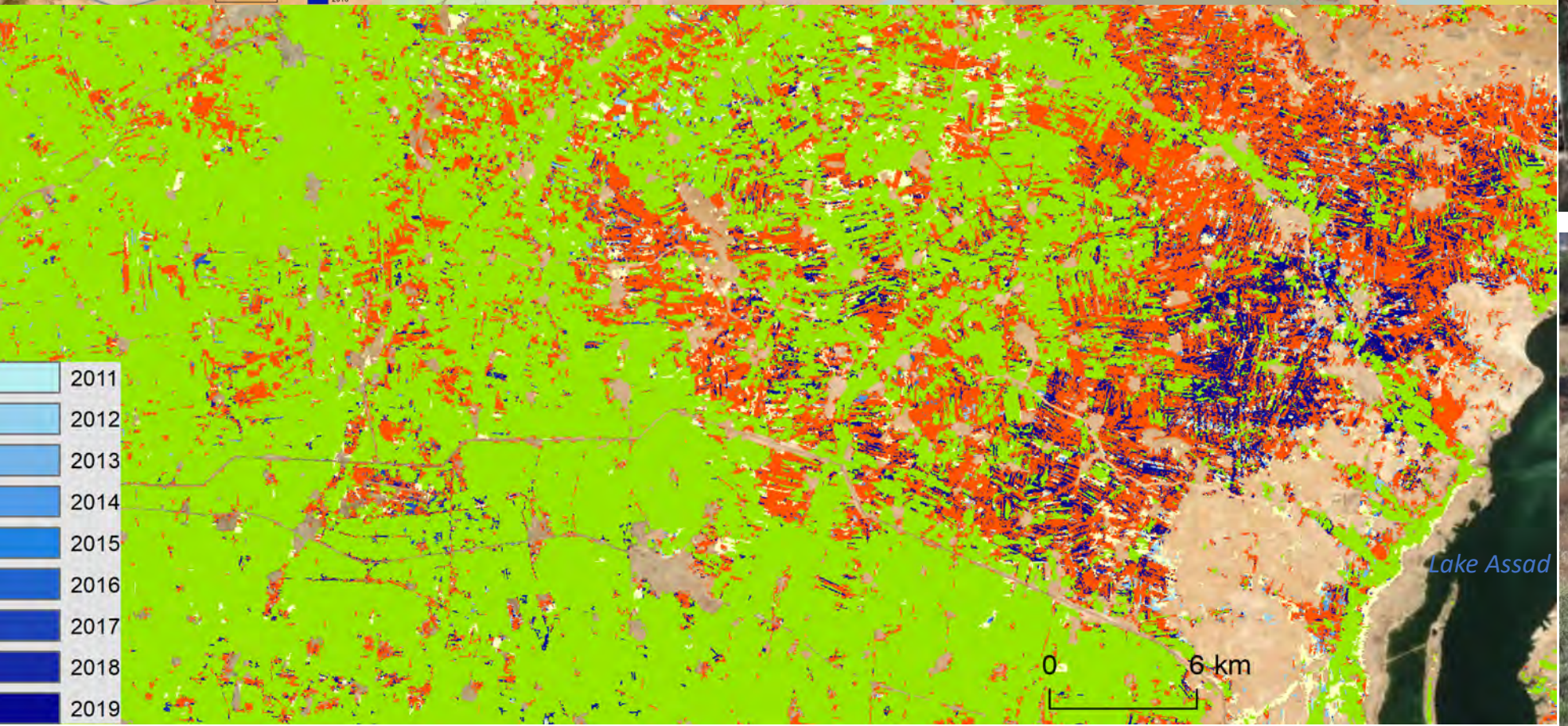


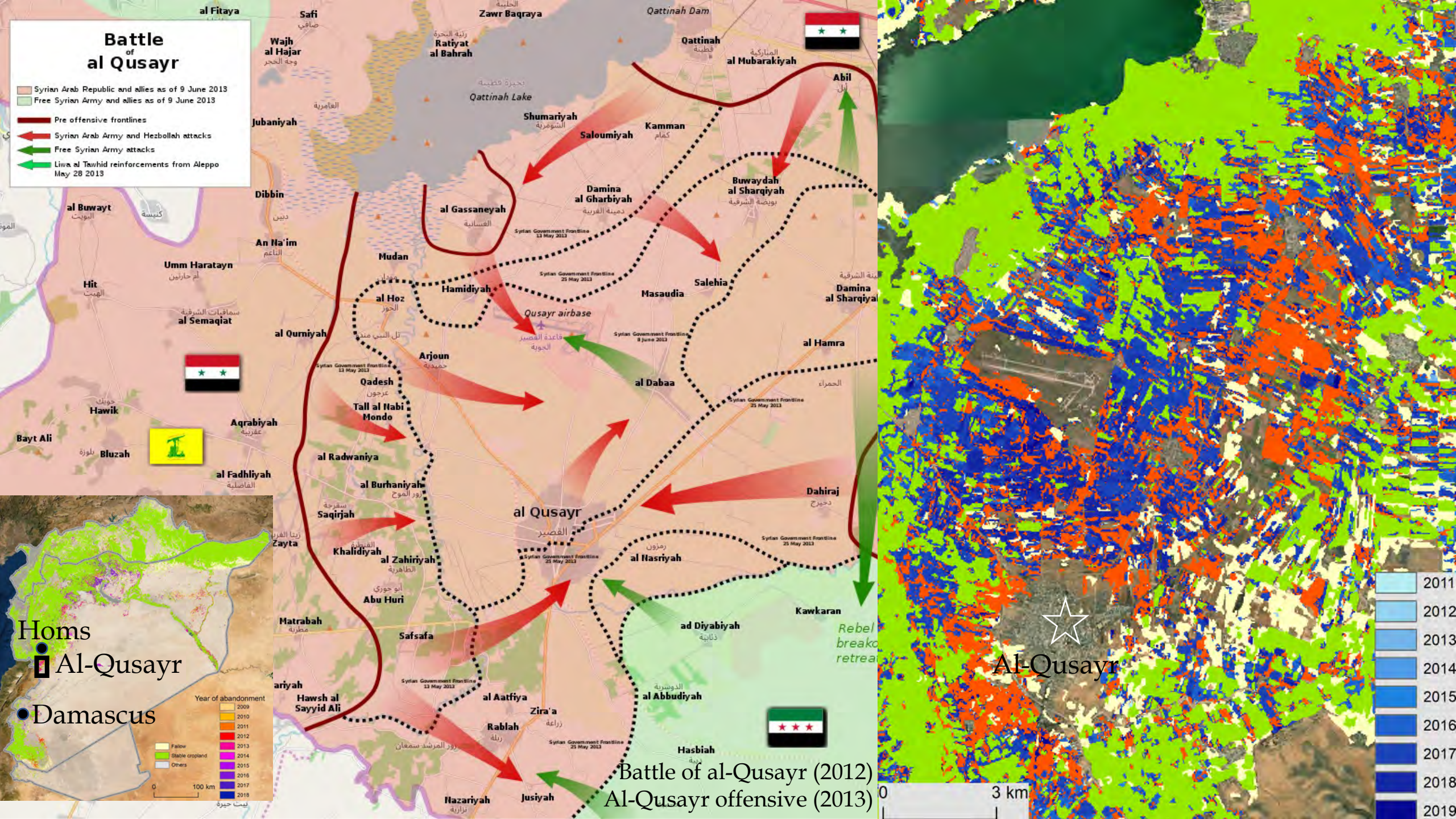
- UNESCO World Heritage
- Destroyed May 2015
- Return of the IS in 2017




Year of abandonment
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Fallow
Stable cropland
Others
0
100 km


Syrian Democratic Forces
Free Syrian Army
al-Bab
Aleppo
Syrian Armed Forces and allied groups
Lake Assad
Islamic State


2011
2012
2013
2014
2015
2016
2017
2018
2019
Lake Assad
0
6 km



Battle of al-Qusayr (2012)
Al-Qusayr offensive (2013)

- Multi-sensor imagery supports better cropland mapping
- Annual land cover mapping enables better change detection
- Farmers are resilient in Syria!

Summary & Outlook

Effects of armed conflicts on land system

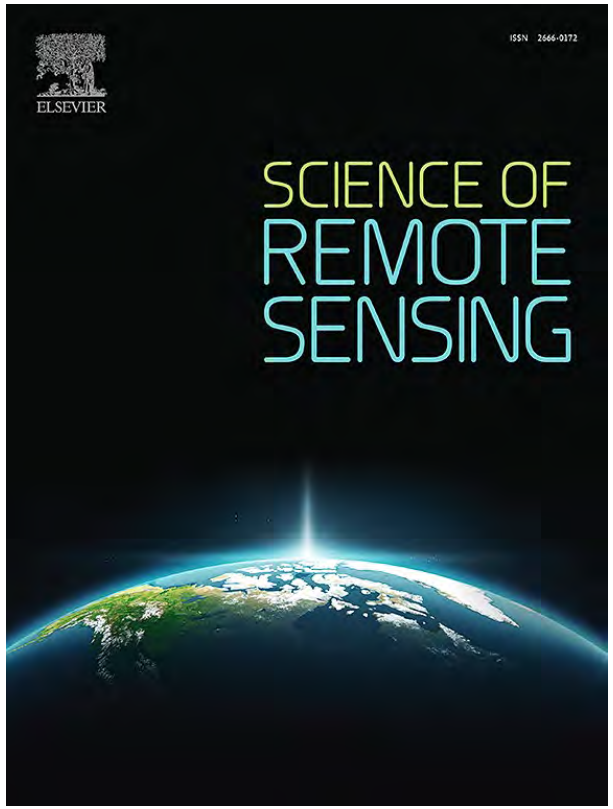
- The effects of armed conflicts are diverse
- The direct effects of armed conflicts are mostly local
- Yet, the indirect effects are far-reaching and long-lasting
- Population movement and policies matter

Outlook

- Future directions of using RS in studying armed conflicts
  - → Changes in land use management
  - → Dense time series enables real-time monitoring
  - → Potential of fusing multi-sensor imagery
- Building a causal inference using RS
  - → Econometric models and field surveys
  - → Baseline need to be carefully examined

- NASA Impacts of Regional Conflicts on LCLUC - Webinar Series 2021

- Science of Remote Sensing special issue: Armed conflicts and land use change (*tba*)



Thank you!

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SENS LAND Remote Sensing and Land Science Lab

www.senslandlab.com