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Mapping agricultural land abandonment from spatial and temporal segmentation of Landsat time series

He Yin[a,*], Alexander V. Prishchepov[b,c], Tobias Kuemmerle[d,e], Benjamin Bleyhl[d], Johanna Buchner[a], Volker C. Radeloff[a]

[a] SILVIS Lab, Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, 1630 Linden Drive, Madison, WI 53706, USA
[b] Department of Geosciences and Natural Resource Management (IGN), University of Copenhagen, Øster Voldgade 10, DK-1350 København K, Denmark
[c] Institute of Environmental Sciences, Kazan Federal University, Kazan, Tovarisheskaya str. 5, 420097 Kazan, Russia
[d] Geography Department, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany
[e] IRI THESys, Humboldt-Universität zu Berlin, Unter den Linden 6, 10099 Berlin, Germany

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ABSTRACT

Agricultural land abandonment is a common land-use change, making the accurate mapping of both location and timing when agricultural land abandonment occurred important to understand its environmental and social outcomes. However, it is challenging to distinguish agricultural abandonment from transitional classes such as fallow land at high spatial resolutions due to the complexity of change process. To date, no robust approach exists to detect when agricultural land abandonment occurred based on 30-m Landsat images. Our goal here was to develop a new approach to detect the extent and the exact timing of agricultural land abandonment using spatial and temporal segments derived from Landsat time series. We tested our approach for one Landsat footprint in the Caucasus, covering parts of Russia and Georgia, where agricultural land abandonment is widespread. First, we generated agricultural land image objects from multi-date Landsat imagery using a multi-resolution segmentation approach. Second, we estimated the probability for each object that agricultural land was used each year based on Landsat temporal-spectral metrics and a random forest model. Third, we applied temporal segmentation of the resulting agricultural land probability time series to identify change classes and detect when abandonment occurred. We found that our approach was able to accurately separate agricultural abandonment from active agricultural lands, fallow land, and re-cultivation. Our spatial and temporal segmentation approach captured the changes at the object level well (overall mapping accuracy = 97 ± 1%), and performed substantially better than pixel-level change detection (overall accuracy = 82 ± 3%). We found strong spatial and temporal variations in agricultural land abandonment rates in our study area, likely a consequence of regional wars after the collapse of the Soviet Union. In summary, the combination of spatial and temporal segmentation approaches of time-series is a robust method to track agricultural land abandonment and may be relevant for other land-use changes as well.

1. Introduction

Land-use and land-cover change is one of the main drivers of global change (Lambin and Geist, 2006). Growing food demand has triggered rapid agricultural expansion and the loss of forest, grassland and wetland (Meyer and Turner, 1992; Ramankutty and Foley, 1999). However, agricultural land abandonment also is a common land-use change process in many parts of the world as a result of trade, socio-economic shocks, institutional structures and land-use policies (Gellrich et al., 2007; Haddaway et al., 2014; Meyfroidt et al., 2016; Müller et al., 2009).

Agricultural land abandonment has manifold effects on both human society and ecosystems. Abandonment can have negative effects on food security and local livelihoods (Khanal and Watanabe, 2006; Knoke et al., 2013), may threaten farmland biodiversity (Beilin et al., 2014; Obrist et al., 2011), and the persistence of cultural landscapes (Van Eetvelde and Antrop, 2004). Yet, agricultural land abandonment is also an opportunity for ecological restoration (Haddaway et al., 2014; Plieninger et al., 2014), forest regeneration on abandoned fields enhances carbon sequestration (Kuemmerle et al., 2011; Schierhorn et al., 2013) and it benefits woodland birds and large mammal populations (Blondel et al., 2010; Sieber et al., 2015). Many of these effects vary

* Corresponding author.
E-mail address: hyin39@wisc.edu (H. Yin).

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