Automated tracking of changes in agricultural land use by means of deep learning

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Abstract

Field margins an semi-natural off-crop receive particular attention in environmental risk assessments, due to their importance for biodiversity. In this study, we tracked changes of agricultural landscapes in Germany for the last decade. For this purpose, a deep-learning based image processing method (*ALDiS*) was applied to historical and current high-resolution aerial photographs and structural differences were quantified, especially for field margins. We describe considerable land use changes within only one decade, addressing their role for future environmental risk assessment and management.

Introduction

Changes of the structure of arable landscapes have typically been studied in historical time spans over many decades or even centuries (Walz, 2008; Baessler and Klotz, 2006). Recent changes, either due to human land-use or climate change may, however, make it necessary to view land use on smaller time scales, in particular with regard to the role of field margins, which play a crucial role in sustaining the biodiversity in intensively managed agricultural lands. This study aims to examine short-term land use changes within one decade and evaluate its impact on potential exposure of semi-natural off-crop by pesticides.

Landscape selection

This study focused on the district Oberbergischer Kreis in North Rhine-Westphalia (NRW), where a notable increase (18%) of arable land from 2010 to 2020 reported (Information und Technik NRW, 2023).

Ten landscapes, each measuring 2.56km² were randomly selected, in which structural changes of agricultural land was visible. For digitisation, high-resolution (10cm/pixel for 2018 and 40cm/pixel for 2004) airborne imagery from 2018 and 2003/2004 were acquired from Geobasis NRW (2020). These images were then used for automated digitisation using a deep-learning-based image processing method called *ALDiS* (Automated Landscape Digitization System, WSC Scientific GmbH, 2023).

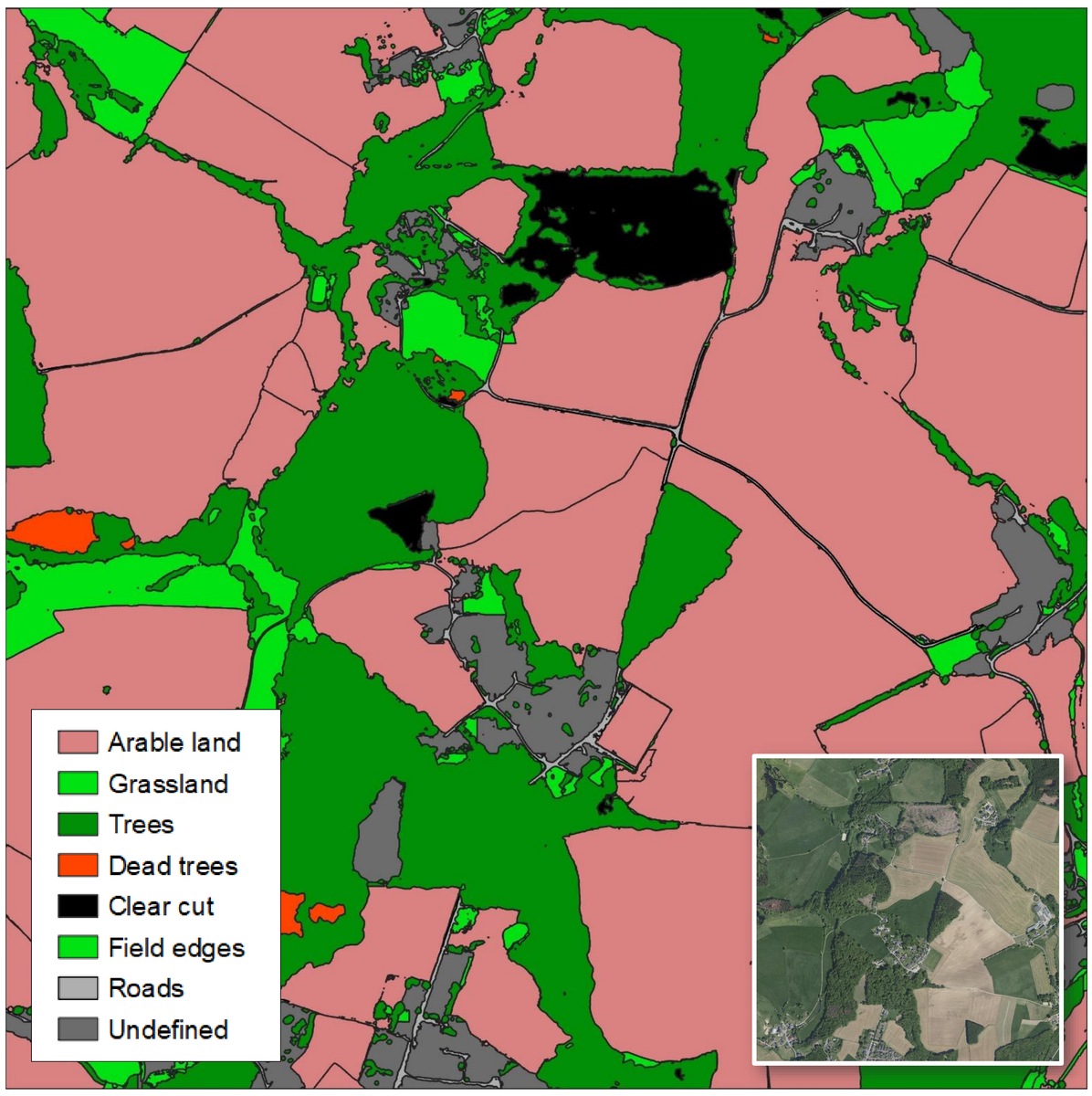

Figure 1. An example of classification results of a landscape from the district Oberbergischer Kreis, NRW, Germany (automated digitisation with *ALDiS* without any manual correction).

In total, eight classes were used for the landscape classification: Arable land, grassland, trees (hedges and woodland), field edges, roads and undefined areas (residential areas and waterbodies). As climate change related outbreaks of European bark beetle (*Ips typographus*) has been strongly affected the region, additional classes (clear-cut area, dead trees) were added to the model to distinguish infested areas. After the classification, the proportion of each habitat and the vegetation within 5m radius from the agricultural fields were calculated using GIS software QGIS 3.22 to evaluate the structure of field margins.

Results

	Overall habitat proportions in selected landscapes			Proportion of habitats within 5 m radius of agricultural fields
	Trees	Grassland / field edges	All semi-natural habitat	All semi-natural habitat
2003-2004	38%	9%	47%	7%
2018	29%	6%	35%	10%
Change	-21%	-26%	-24%	+57%

Table 1. Overall change of habitat proportions in landscape and change of the proportion of semi-natural habitats within 5 m radius of agricultural fields.

The overall area covered with arable land increased by +10% in the landscapes, which was in line with the result from German state office (18%). The area covered with trees (forest, larger hedges) decreased by 21%, due to clear cut probably related the extreme outbreak of bark beetles in the region. The overall proportion of semi-natural off-crop decreased by 24%. At the same time, the potentially exposed area of semi-natural habitat (i.e. the fraction located 5m from fields) increased by 57%.

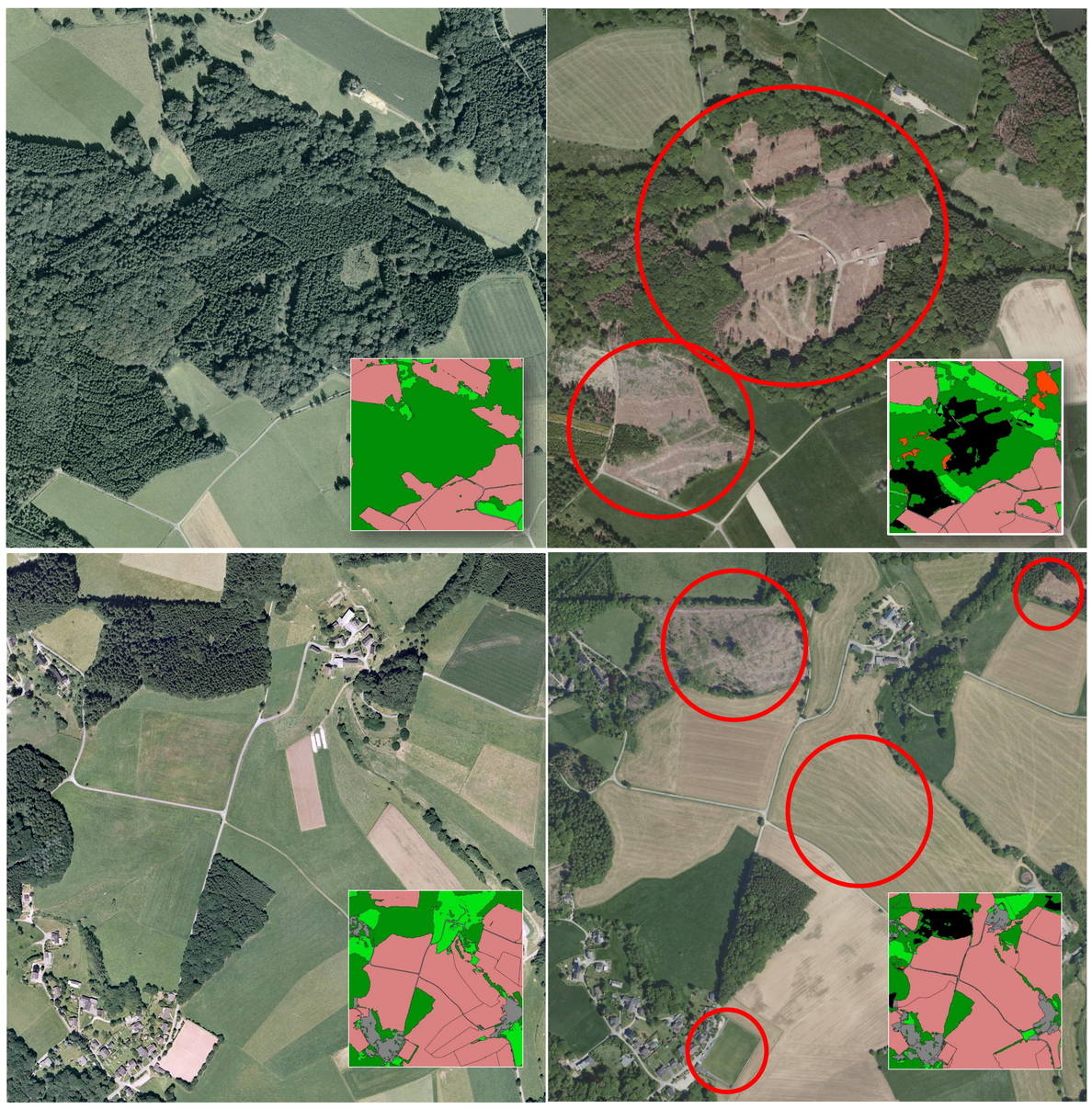

Figure 2. Examples of changes of landscape structure with airborne imagery and classified maps (left: 2003, right: 2018). Loss of woodland, changes of agricultural field structure and hedge loss are shown.

Conclusion

- These results show that some European landscapes are subject to considerable structural changes in relatively short time spans, which stresses the importance of using latest imagery for environmental assessments.
- Automated recognition system, such as *ALDiS*, can help to conduct such assessments or to track structural changes in a cost efficient manner.
- In our example, the proportion of semi-natural off-crop declined by 24% in only 15 years. On the other side, the proportion of semi-natural habitat potentially exposed to pesticides adjacent to field boundaries (in a 5m buffer) increased from 7% to 10%.
- The loss of areas covered by trees (woodland, hedges) was 21% in the study area.
- This stresses the importance of ensuring protection of the remaining semi-natural habitats.

References:

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