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PhenoCar: Assessment of phenology of thousands of trees along an environmental gradient using car mounted cameras and deep-learning based image segmentation

David Basler[1,2,3] and Andrew D. Richardson[3,4]

[1]Department Environmental Sciences - Botany, University of Basel, Basel, Switzerland
[2]Department of Organismic and Evolutionary Biology, Harvard University, Cambridge MA, USA
[3]School of Informatics, Computing & Cyber Systems, Northern Arizona University, Flagstaff AZ, USA
[4]Center for Ecosystem Science and Society

The length of the period of vegetation activity is a significant driver of the global carbon cycle. Thus, the observation of plant phenology and seasonal vegetation dynamics has become an essential tool to quantify the impact of climate change on ecosystems. However, the accurate prediction of potential shifts of plant phenology in a warmer future requires a detailed spatio-temporal quantification of phenological patterns observed today. While phenological data derived from satellite-based remote sensing platforms often lack the spatial and/or temporal resolution to resolve the responses on the species level or to even reveal intraspecific patterns across the landscape, accurate visual observations by a human observer for thousands of trees are often not feasible due to time constraints. Therefore, we here present a novel near-surface remote sensing method that allowed the accurate tracking of tree phenology along an elevation- and urbanization gradient using a car-mounted camera. Using deep-learning-based image segmentation, we were able to track distinct patterns in the timing of leaf phenology of tens of thousands of trees along a nearly 100 km transect in New England throughout two growing seasons. The efficient collection of such high-resolution, multi-species, spatiotemporal data provides an excellent opportunity to quantify variation in tree phenology down to the level of individual organisms, across landscape and regional scales and for the fine-tuning of phenological models.