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Conference Abstract

Building reliable reference dataset for large-scale mapping of invasive *Solidago* spp.: insights from classification of UAV images acquired across Poland

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Abstract

Accurate large-scale mapping of invasive *Solidago* spp. (goldenrods) depends on the availability of high-quality reference data, yet generating such data remains challenging due to the ecological variability of invaded habitats and trait overlap with co-occurring vegetation. Here, we present a workflow for the acquisition and analysis of UAV (Unmanned Aerial Vehicle)-based datasets designed to provide a reference for satellite-based mapping of Solidago spp. across Poland, with emphasis on ecological drivers of classification uncertainty.

In 2024, during the flowering period of goldenrods (August–September), we conducted 79 UAV surveys (~1,100 ha mapped) located in multiple regions of Poland. Our field study was designed to cover a wide range of habitats, including abandoned agricultural

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land, ruderal sites, river valleys, and forest edges, as well as climatic conditions across the country. High-resolution RGB orthomosaics derived from UAV images were used to delineate expert-validated reference polygons representing two classes: *Solidago* and background vegetation. The orthomosaics were classified using a Random Forest model based on spectral indices and texture metrics.

Although dense, monospecific stands of *Solidago* were classified with high accuracy (F1 ≥ 0.95), performance declined substantially for patchy, fragmented, or transitional vegetation containing invasive goldenrods. Across sites, classification performance for *Solidago* was more variable than for the background class and was frequently limited by false positives. Classification errors were linked to specific vegetation structures, disturbances and weather conditions during the UAV missions. Plant species most frequently confused with goldenrods by the RF classifier included other invasive taxa, such as box elder (*Acer negundo* L.), Japanese knotweed (*Reynoutria japonica* Houtt.), and Sosnowsky's hogweed (*Heracleum sosnowskyi* Manden.), as well as native expansive and pioneer species, including grasses (Poaceae) - especially common reed (*Phragmites australis* (Cav.) Trin. ex Steud.), sedges (Cyperaceae), willows (*Salix* spp.), silver birch (*Betula pendula* Roth), common nettle (*Urtica dioica* L.), brambles (*Rubus* spp.), common meadow species, arable weeds, and even crops such as maize and oilseed rape. These species exhibited growth forms, flower colours, or leaf characteristics similar to those of invasive goldenrods. Interestingly, the majority of classification errors were not linked to yellow-flowering plants, but rather to the light-green and late-summer yellowing foliage of herbaceous plants, small trees, and shrubs. Mown or disturbed sites exhibited patchy regrowth and mixed phenological stages, increasing within-site heterogeneity and reducing separability between *Solidago* and co-occurring species. Strong direct sunlight increased reflectance variability and shadow contrast, leading to misclassification of bright inflorescences and reflective plant surfaces.

Our results show that classification errors are not random but arise from predictable environmental contexts. By linking classification performance to vegetation and habitat traits, we demonstrate that reliable remote sensing of *Solidago* spp. requires not only methodological precision but also a detailed understanding of plant community composition and structure. This integration is essential for accurate monitoring of invasion dynamics in complex landscapes.

Keywords

Solidago canadensis, *Solidago gigantea*, invasive plants, vegetation mapping, RF classification, commission errors

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