OSMRE National Technology Transfer Team (NTTT), **Applied Science Fact Sheet***
U.S. Department of the Interior, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

Machine Learning and UASs for Managing Autumn Olive (Elaeagnus umbellata) on Reclaimed Surface Mines

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Project Description and Objectives:

One of the most persistent challenges reclaimed mine lands face is the control of invasive species that impede the development of diverse, functional, and sustainable post-mining ecosystems. This research introduces an innovative approach for managing autumn olive (*Elaeagnus umbellata*) on reclaimed surface mines utilizing artificial intelligence, machine learning, and Uncrewed Aerial Systems (UAS). Invasive autumn olive poses a significant ecological challenge for land productivity and conservation, necessitating a more effective and efficient management strategy.

Applicability to Mining and Reclamation:

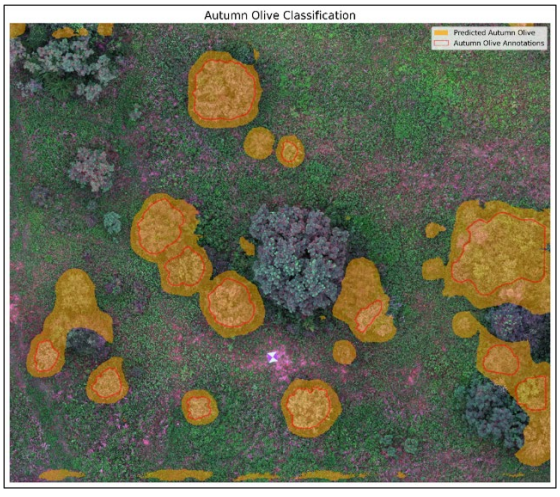
The results of this study provide a robust and improved method for managing autumn olive on reclaimed mine lands. The outcome is an adaptable means of identifying invasive plant species from UAS imagery and a safer, more efficient method of vegetation management using agricultural UAS to deliver herbicide treatments. Current practices are labor intensive and expose personnel to harmful chemicals.

Methodology:

Two reclaimed surface mines in Monongalia County, West Virginia were chosen for data collection. Both sites represented post-mining landscapes at different stages of reclamation and vegetation development. UAS-based imagery was collected on both sites monthly from January 2023 to October 2024. A GPS system was used to ground truth the locations of autumn olive canopies on both sites.

Each set of imagery was stitched together into separate high-resolution basemaps with accurate georeferencing called orthomosaics. Autumn olive in each orthomosaic was outlined with a polygon feature in GIS software. Hundreds of polygons contained the extent of each canopy, and the spectral signatures of the autumn olive from each orthomosaic. The polygon extent of each canopy and the associated spectral signatures were used to train Random Forest (RF) machine learning models and Convolutional Neural Network (CNN) deep learning models for accuracy comparisons. Once an RF or CNN model is trained on enough data, it can be used to predict the locations of autumn olive canopies in new imagery.

Autumn olive located on one of the reclaimed surface mines was treated with herbicide using an Uncrewed Agricultural Aerial System (UAAS). This system carried 10.5 gallons of herbicide and delivered targeted applications autonomously following a pre-programmed flight path.



Autumn Olive Canopy Model Training Polygons (Red) and Convolutional Neural Network Model Predictions (Orange) on top of an Orthomosaic

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Highlights:

Important conclusions of the study include the following:

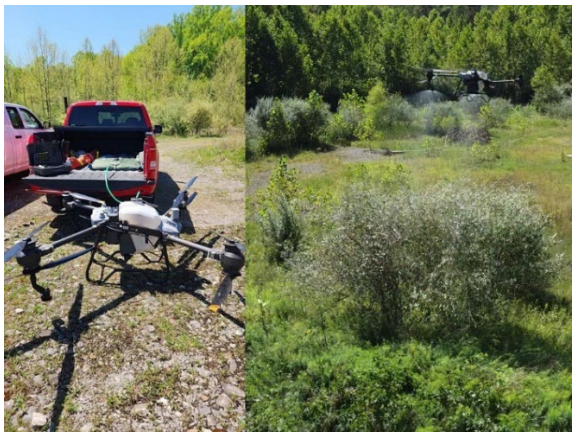
1. Both the Random Forest and Convolutional Neural Network models were trained on four different autumn olive growth stages – early growth, peak growth, late growth, and senescence – to assess model accuracies. Of the four growth stages, using the peak growth stage resulted in the highest accuracies for both model types.
2. The Convolutional Neural Network models demonstrated substantially higher accuracy across all four growing stages compared to the Random Forest Models. The highest overall CNN model accuracy was 96.7%.
3. The use of Red-Green-Blue (RGB) imagery achieved comparable accuracies to using multispectral imagery within the Convolutional Neural Network model type.

Results and Findings:

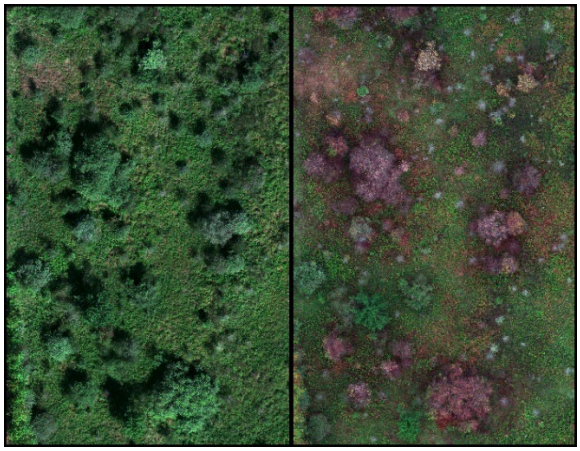
The use of RGB imagery in conjunction with Convolutional Neural Network models to detect and map autumn olive provides the most efficient, and cost-effective approach compared to the other methods conducted in this study.

The UAAS achieved desired results delivering targeted herbicide treatments to autumn olive canopies and removed many of the risks associated with ground-based spraying methods. The ability to treat autumn olive on challenging topography represents a significant benefit for managing invasive species on reclaimed mine lands.

The workflow from UAS-based detection to UAAS-based treatment represents a significant advancement toward more efficient and effective management strategies for reclaimed surface mines. The ability to accurately detect and map autumn olive across reclaimed landscapes provides critical information for assessing reclamation success and planning targeted interventions. All machine learning workflows, annotated datasets, and U-Net model architectures developed for this project are openly available via a GitHub repository at [https://github.com/DOI-OSM/Autumn-Olive], which includes a comprehensive README for replication and implementation guidance.



Uncrewed Agricultural Aerial System Tank Refill (Left) Aerial Herbicide Application (Right)



Reclaimed Surface Mine Autumn Olive Before Treatment (Left) 15 Days Post-Treatment (Right)

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