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Development of a Remote Sensing Solution to Map Invasive Plant Species

Abstract

A workflow for Japanese Knotweed detection using hyperspectral data was developed. Object-Based Image Analysis (OBIA) and Spectral Angle Mapper (SAM) methodologies were used, returning an accuracy of 99% across four sites. Other invasive species (Buddleja, Himalayan Balsam, Bramble and reeds) were also identified, albeit with lower accuracy levels (65-80%).

Background

- Invasive Alien Species (also known as Invasive Non-native Species) are one of the greatest threats to biodiversity globally (DEFRA, 2008).
- Hyperspectral data can be used to identify the unique spectral signatures of invasive plant species (Bradley, 2014).
- Japanese Knotweed (*Reynoutria japonica var. japonica*) is a quick-growing, established invasive plant in the UK. It forms dense clusters that are difficult to eradicate (House of Commons, 2019; Jones et al. 2011).

Objectives

- Assessing Japanese Knotweed spectral separability from lookalikes
- Developing an automated approach to identifying Japanese Knotweed from hyperspectral data to support ground interventions.

Methods

Table 1. Datasets used in this study and their sensors.

Data type	Sensor/Source
Hyperspectral data	HySpex VNIR + SWIR
Canopy Height model (CHM)	Phase One iXA 180 (photogrammetry)
RGB imagery	Phase One iXA 180 Survey Camera
Field data polygons/canopy spectra	Advanced Invasives/2Excel Geo

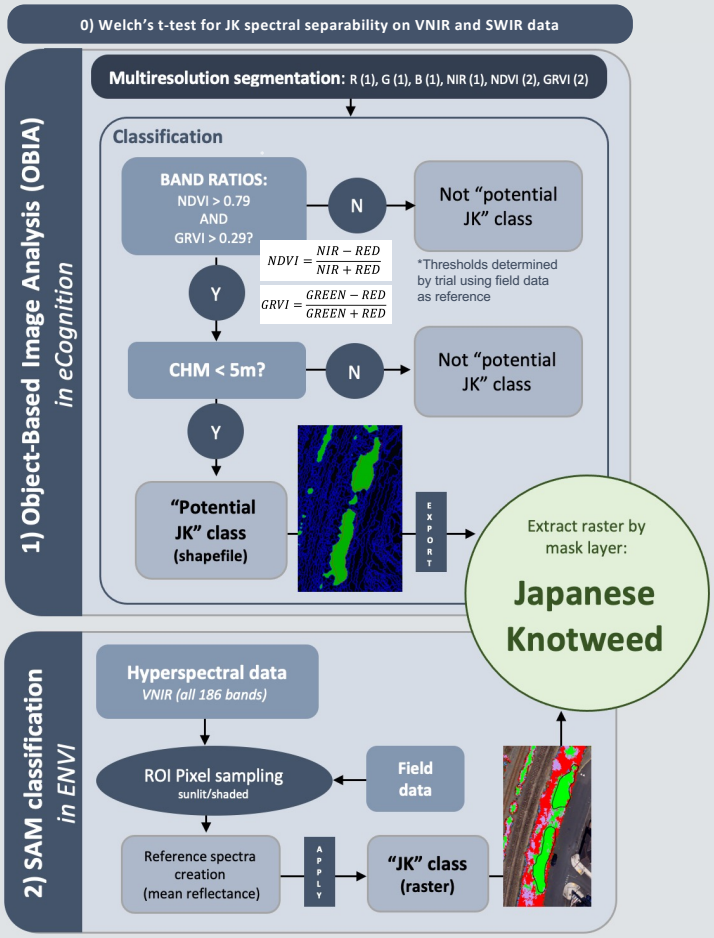


Figure 1. Japanese Knotweed detection workflow, employing both Object-Based Image Analysis (OBIA) and Spectral Angle Mapper (SAM) classification.

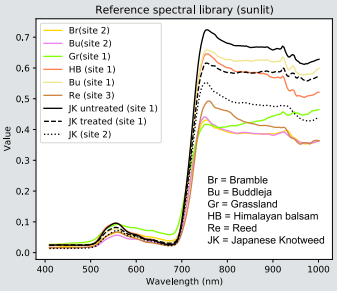
In addition:

- First-derivative analysis of field canopy spectra to identify the red edge inflection point of Japanese Knotweed vs Dandelion, Giant Hogweed, Canadian Goldenrod, Buddleja, grassland.
- Classification accuracy assessment (Confusion Matrix) using "Japanese Knotweed" class and field data ROIs / RGB image interpretation in ENVI.

Results

Table 2. Welch's t-test for spectral separability. Red denotes a non-statistically significant spectral separability (p>0.005).

Region	Wavelengths	JK vs. trees	JK vs grassland
Blue	400-500nm	0.030	0.003
Green	501-600nm	0.000	0.690
Red	601-680nm	0.001	0.002
Red edge	681-800nm	0.040	0.001
NIR	801-1000nm	0.000	0.000
NIR	1001-1350nm	0.000	0.000
Water abs.	1351-1550nm	0.999	0.146
SWIR	1551-1750nm	0.016	0.001
Water abs.	1751-2100nm	0.914	0.861
SWIR	2101-2300nm	0.065	0.436



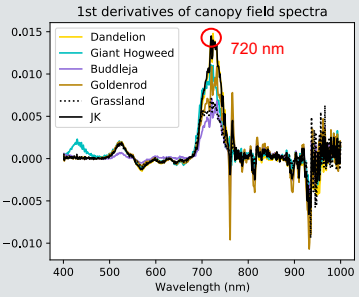
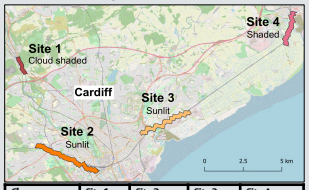


Table 3. Accuracy assessment and site location.



Class	Site 1	Site 2	Site 3	Site 4
JK*	99.99%	99.53%	-	99.43%
JK/Bu/HB**	75.62%	-	-	-
JK/Bu/Br**	-	64.51%	-	-
Bu/Br/Re**	-	-	80.17%	-

*OBIA and SAM **SAM only

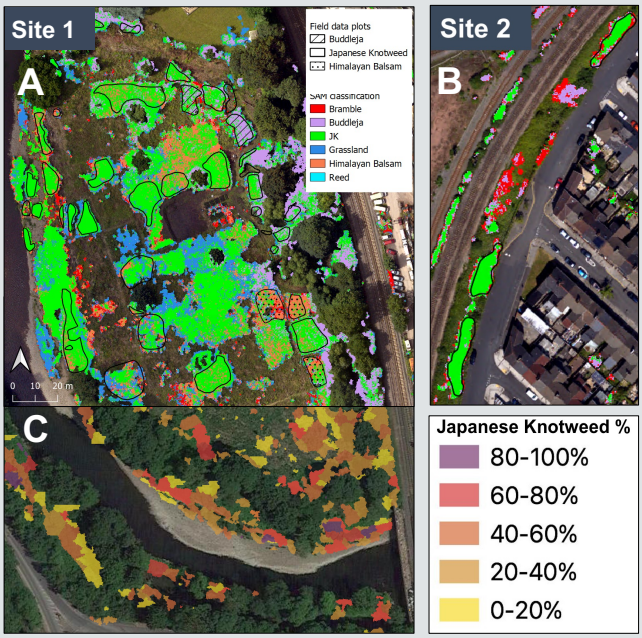


Figure 2. SAM classification of Japanese Knotweed but also Buddleja, Himalayan Balsam, Bramble and reeds at A) the Advanced Invasives research site; and B) in Cardiff. C) The final SAM output can be used to create a "Japanese Knotweed %" vector layer.

Findings

- **Japanese Knotweed has high NDVI and GRVI. Its red edge inflection point is at 720nm.**
- **The plant has high spectral separability in the VNIR region.**
- **Spectral lookalikes: Himalayan Balsam, rough grassland.**
- **The proposed solution can identify Japanese Knotweed (species of primary interest), but also other invasive plants such as Himalayan Balsam and Buddleja and also UK native invasive weeds like Bramble and reeds.**
- **The proposed solution successfully detects Japanese Knotweed at other sites with varying degrees of illumination.**

Sources:

- Bradley, B.A. (2014). Remote detection of invasive plants: a review of spectral, textural and phenological approaches. *Biological invasions*, *16*(7), pp.1411-1425.
- DEFRA (2008). The invasive non-native species framework strategy for Great Britain.
- House of Commons Science and Technology Committee (2019). Japanese Knotweed and the lived environment. Available at: https://publications.parliament.uk/pa/cm201719/cmselect/cmsctech/1707/1707.pdf
- Jones, D., Pike, S., Thomas, M. and Murphy, D. (2011). Object-based image analysis for detection of Japanese knotweed sl taxa (Polygonaceae) in Wales (UK). *Remote Sensing*, *3*(2), pp.319-342.

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