Remote Sensing – Detecting (illegal) waste materials within complex environments

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Aim of the pilot

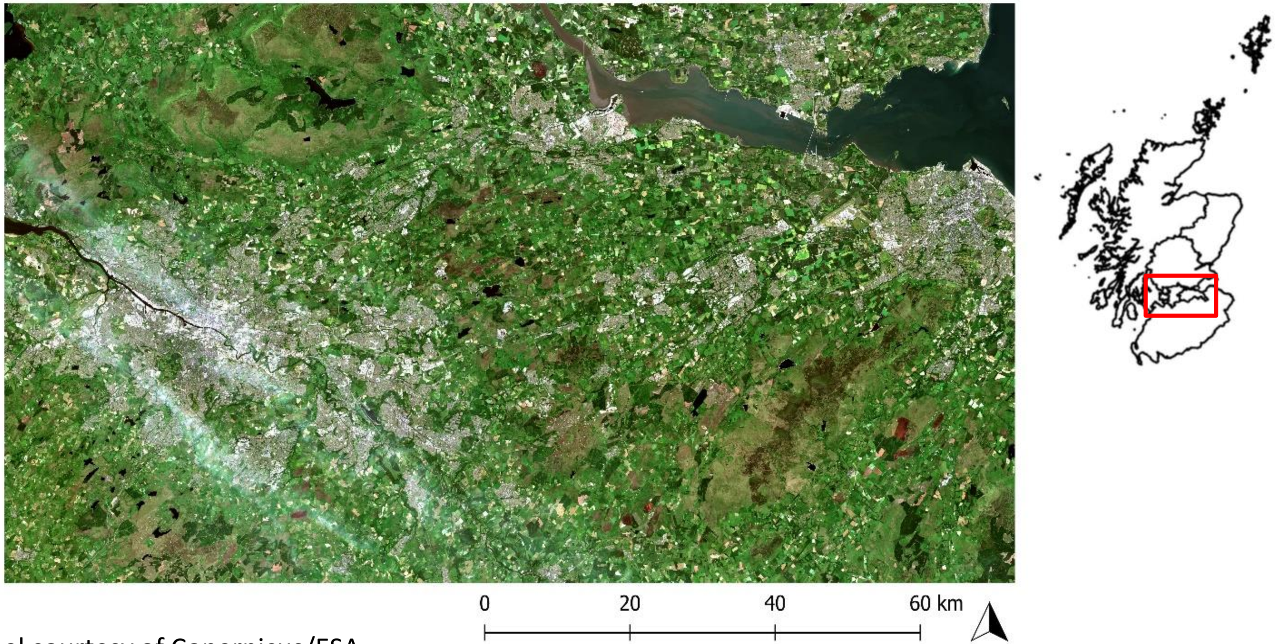
The aim was to develop a series of workflows that can be tuned to detect waste materials within complex environments. Focus on:

- Waste Tyres: A waste material that has often gained international attention over the years, with an estimated 55 million tyres sent for waste each year in Britain alone.

- Plastics: Represent an important material in consumer lifestyles, with a reported 5 million tonnes of the material used in the UK each year (WRAP, 2018).

Methodology: Study area

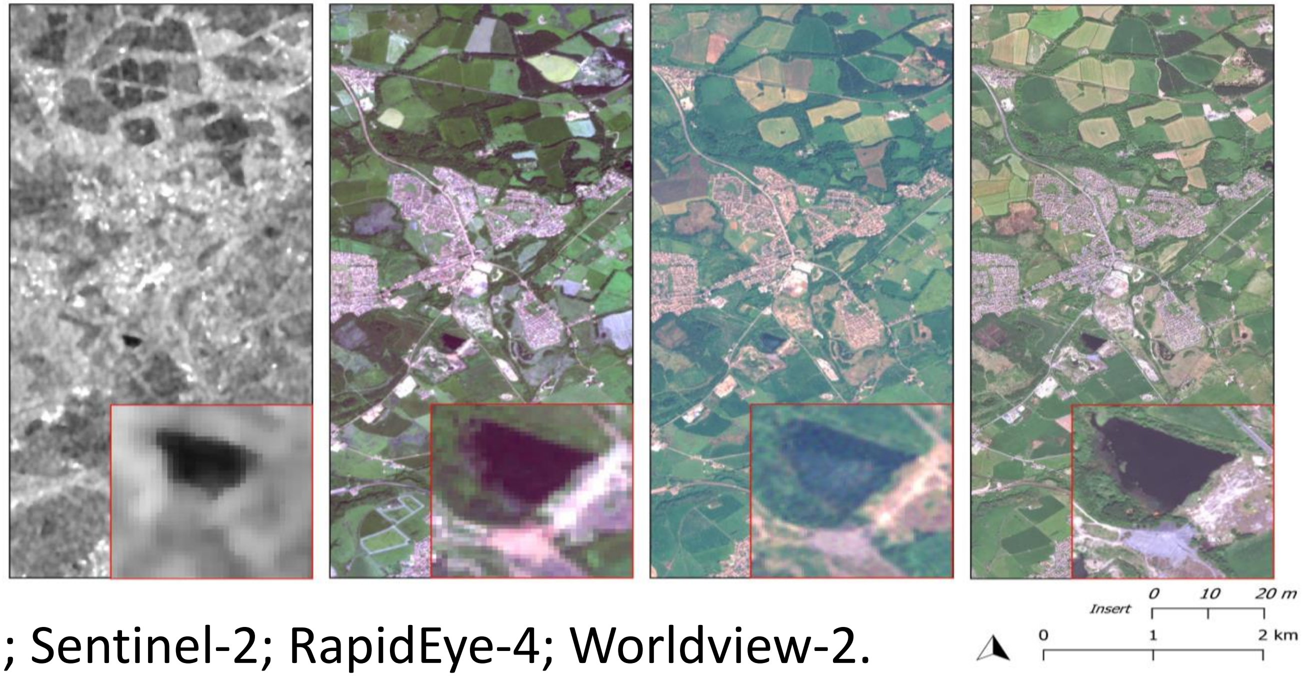
Regional subsection of Scotland focusing on Glasgow and Edinburgh containing waste sites, alongside registered waste capacity sites, and sites located using high-resolution Earth Observation (EO) imagery within Google Earth.



Sentinel courtesy of Copernicus/ESA.

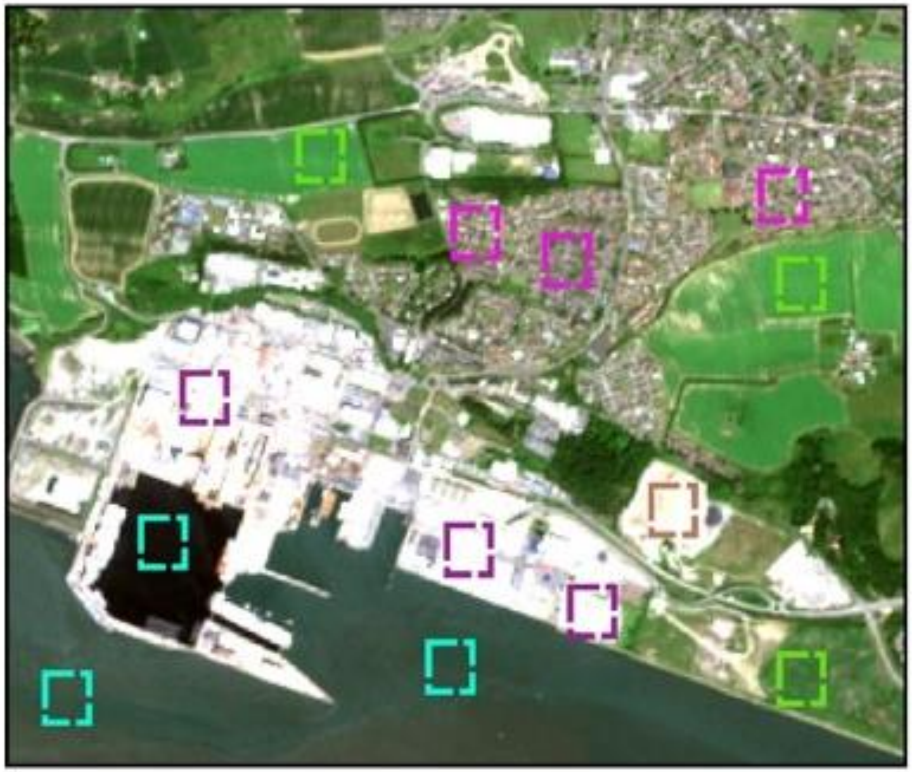
Methodology: Satellite imagery

- A time series of imagery was acquired, with dates chosen to coincide with the SEPA reference data and to minimise cloud cover. This input Copernicus Sentinel datasets totalled more than 600 GB of data.
- Additionally, high-resolution RapidEye-4 and Worldview-2 imagery has allowed a more focused study, with a further spatial subset taken from the regional extent.



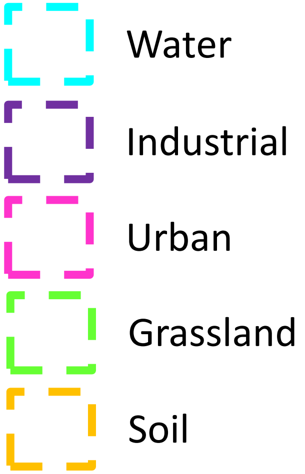
Left to Right: Sentinel-1; Sentinel-2; RapidEye-4; Worldview-2.

Methodology: Random Forests



Input Dataset

- Step 1:
  Training samples for each class are taken across the input dataset



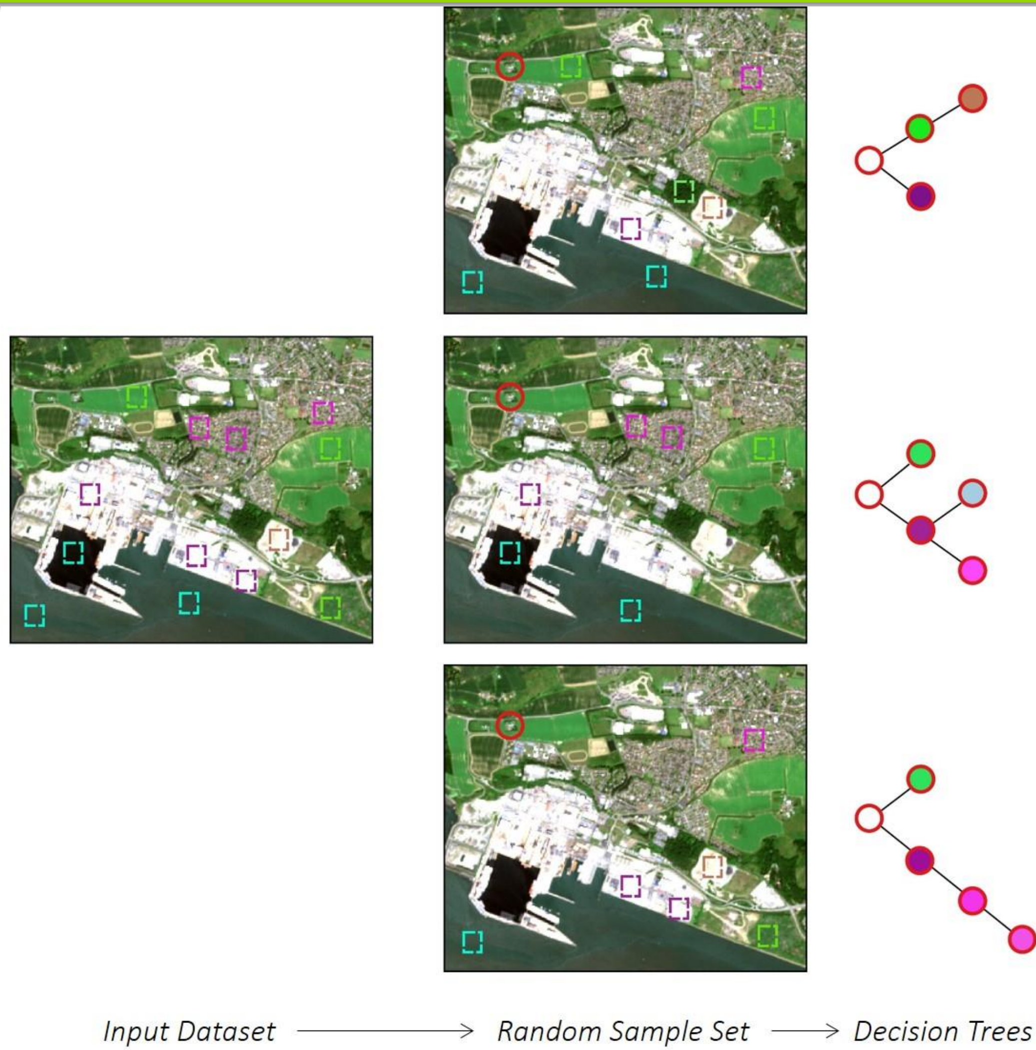
Sentinel courtesy of Copernicus/ESA.

Methodology: Random Forests

- Step 2:
  Random subsets of the training samples are taken

Sentinel courtesy of Copernicus/ESA.

Methodology: Random Forests

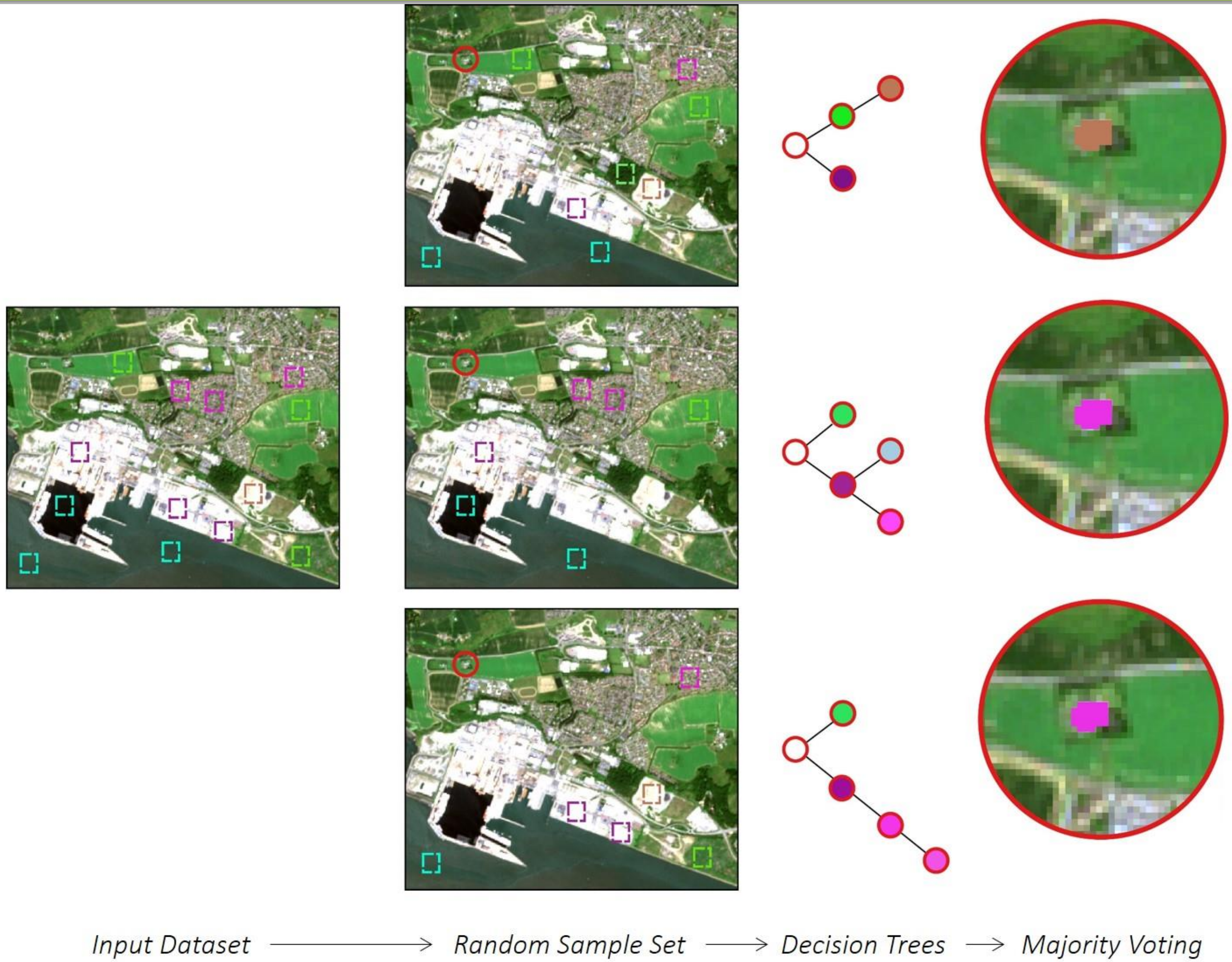


- Step 3:
  Within each random sample set, a decision tree is built for every pixel to determine the appropriate class

Unclassified Pixel
Water
Industrial
Urban
Grassland
Soil

Sentinel courtesy of Copernicus/ESA.

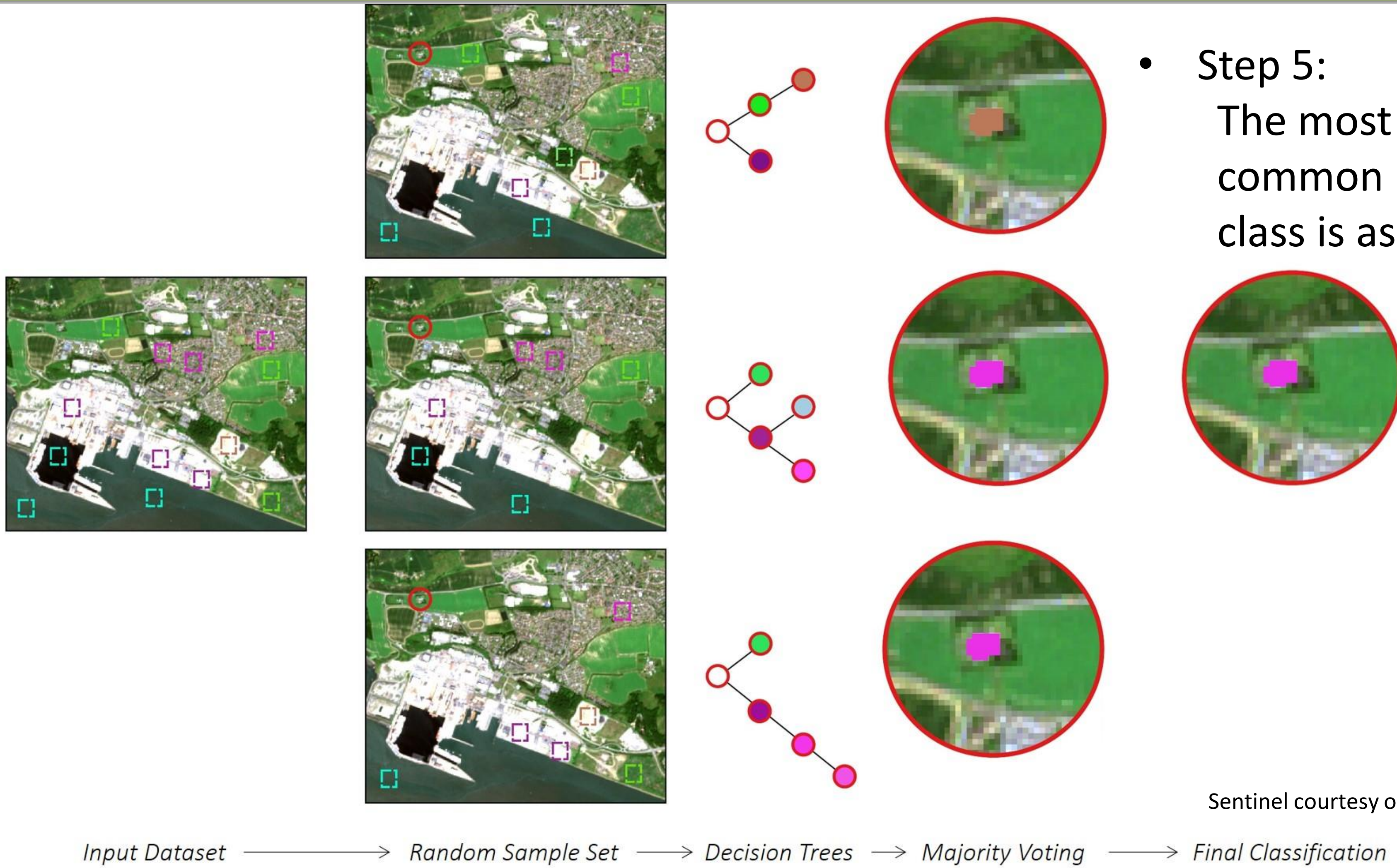
Methodology: Random Forests



- Step 4:
  All decision trees are compared to determine the class with the highest occurrence

Sentinel courtesy of Copernicus/ESA.

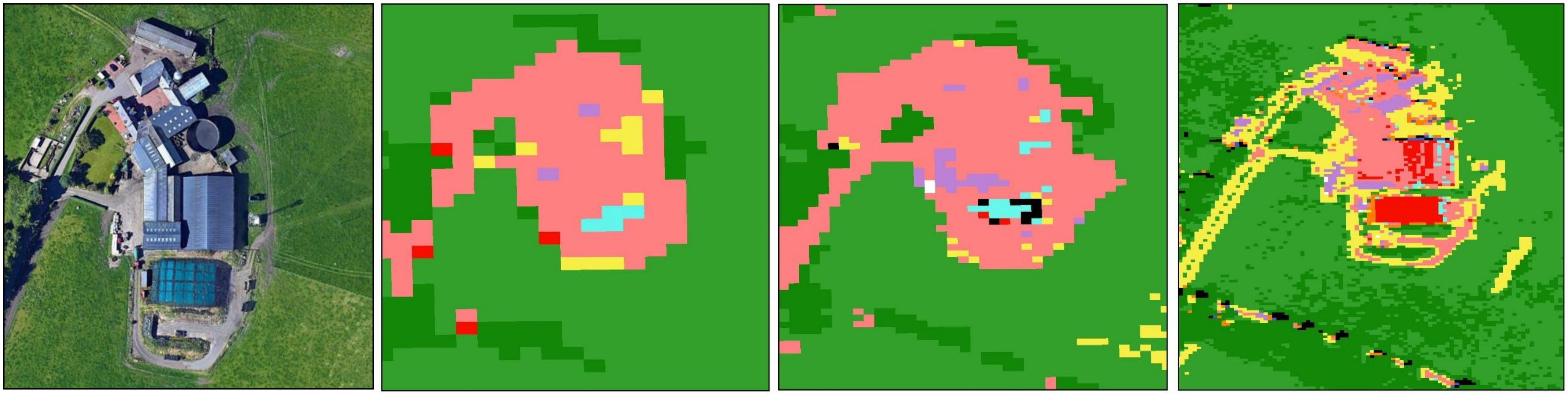
Methodology: Random Forests



- Step 5:
  The most common pixel class is assigned

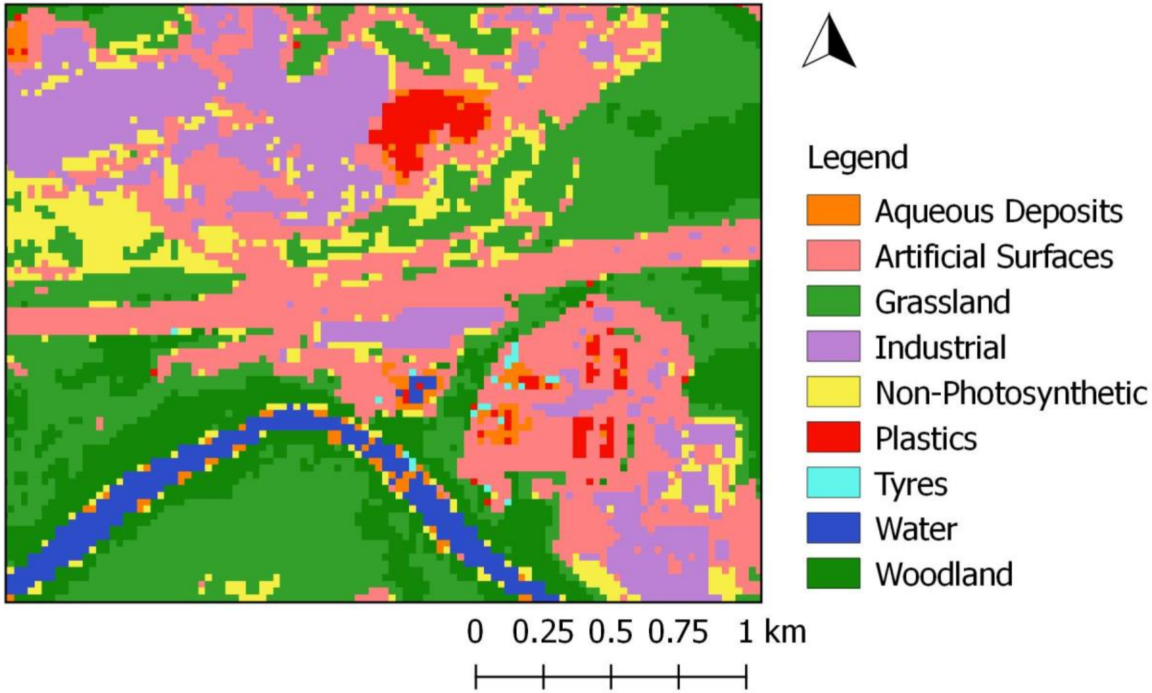
Sentinel courtesy of Copernicus/ESA.

Results: Tyres example



Left to Right: Google Earth (aerial); Sentinel-2; RapidEye-4; Worldview-2.

Results: Plastics in various environments



The classification of plastics has led to the identification of:

- Plastic capping of the landfill site
- Classification of some of the sewage ponds

Conclusion and Potential applicability

- The most robust results were when detecting waste present in rural scenes and less complex environments, due to a combination of Scotland's abundance of rural land and the Sentinel data's pixel size (10 m).

- The accuracy was assessed using 10 000 training samples and varied from 99% for plastics and tyres, within the Sentinel dataset, to 97% for RapidEye-4 and Worldview-2.

- With a revisit time of 2 to 3 days, the Sentinel dataset would allow weekly investigations into detecting waste across Scotland; dependant on cloud cover.

Remote Sensing

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