Habitat Mapping in Wales using multiple date remote sensing imagery

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Overview

• Habitat Mapping in Wales
  – The Phase 1 Survey
• The Berwyn Mountains: A pilot for satellite-based mapping
• Mapping habitats in Wales using eCognition
  – Pre-processing
  – Segmentation and integration of GI
  – Classification (sub-habitats)
  – Transferring to Phase 1
  – Map production
• The Concept of a Rolling Program
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‘Phase 1’ habitat mapping in Wales

- The Phase 1 Habitat map was initiated in 1979 as the Upland Survey
- Lowlands completed in 1997 by CCW and then combined
- Relied on field survey and aerial photograph interpretation
- Expensive and difficult to update
What do ecologists observe?

• Vegetation changes with season
  – Temporal variations in leafing and leaf fall, flowering and land management practices.

• Vegetation variations with terrain
  – Differences in vegetation type and environmental response with elevation, slope, aspect, morphology

• Relative degrees of variation in:
  – Moisture content
  – Surface roughness (manifested as shade)
  – Productivity
  – Proportions of live and dead material
  – Amount of woody material (i.e., biomass)

• Plants of different species are visually different to the human eye
What do RS scientists observe?

• Vegetation changes with season
  – Temporal variations in reflectance and derived products (e.g., vegetation indices)

• Vegetation variations with terrain
  – Differences in spectral reflectance with altitude, aspect and slope (i.e., related to zonations, shadowing)

• Relative degrees of variation in:
  – Moisture content (e.g., SWIR reflectance)
  – Surface roughness (e.g., shade fractions)
  – Productivity (e.g., vegetation indices, NIR reflectance)
  – Proportions of live and dead material (e.g., non photosynthetic fractions)
  – Amount of woody material (e.g., differences in shadowing, radar)

• Plants of different species sometimes spectrally different in the visible wavelength regions but more so in those beyond.
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The Pilot:

Classification of habitats & agricultural land, Berwyn Mountains NE Wales

Based on time-series of Landsat sensor data

Rule-based approach that coupled knowledge of ecology with that of remote sensing scientists
Approach to classification

Six Corrected Data layers

Additional data layers derived from the original six layers

Ecological Based Rules

Output
Vegetation Classification

Testing
Accuracy Assessment
Sequential use of rules

Stage I
- Imagery
  - No vegetation (NDVI)
  - Vegetation
    - Bare ground/bare soil (NDVI)
    - Upland cliff ledge/scree (slope)
    - Urban (slope)
    - Open water (NIR/SWIR)
    - Woodland (SWIR)
    - Other
      - Coniferous (NIR)
      - Broad-leaved (NIR)
      - Mixed (NIR)

Stage II
- Bracken (NDVI)

Stage III
- Grassland (shade/moisture fraction)
  - Unimproved acid (Shade/moisture Fraction / NDVI)
  - Semi-improved acid (Shade/moisture Fraction / NDVI)
  - Improved (Shade/moisture Fraction / NDVI)
  - Marshy (SWIR)

Stage IV
- Dwarf heath/bogs
  - Acid heath *Calluna* dominated (Shade/moisture fraction)
  - Acid heath *Vaccinium* dominated (NIR, SWIR)
  - Blanket bog (NIR/SWIR)

Notes in brackets denote the band or derived band(s) used to classify the vegetation type. Box type denotes the specific image or series of Landsat ETM+ images used for classification (see below):

- March
- April
- July
- September
- All dates
- Categories
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Division of Wales into projects

Biogeographical Regions

Image Footprints
Pre-processing and Ancillary data

• Pre-processing
  – Orthorectification
  – Atmospheric correction
  – Topographic correction
  – Cloud and cloud-shadow removal

• Ancillary data layers
  – Digital Elevation Data
  – Land parcel boundaries
  – Roads, rivers and urban areas
Multiple sensors, seasonal observations

- SPOT-5 (March)
- Landsat (March)
- SPOT-5 (April)
- IRS (May)
- Landsat (July)
- Landsat (Sept)
Geometric correction: Orthorectification
Standardisation for data comparability

- Atmospheric correction
  - FLAASH

- Topographic correction
  - ATCOR
  - Essential for spring images

- Cloud and cloud shadow removal
  - Definiens Developer
Cloud Screening
Endmember Fractions & Indices

Non-photosynthetic vegetation

Photosynthetic vegetation

Shade/moisture
Mapping wet & dry habitats: bogs, bracken & grassland

Left: Bogs (outlined in white) mapped by lower vegetation (photosynthetic) and greater moisture fraction (based on ASTER data).

Right: Areas of *Molinea caerulea* grass (black) and *Pteridium* (orange) mapped using a combination of SPOT non photosynthetic vegetation and shade/moisture fraction images.
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Wales is a land of fields

Image segmented using unit (field) boundaries

Multi-resolution segmentation (using larger scale factors) applied within the unit boundaries

Areas outside of field boundaries (mainly uplands) using a small scale factor (1 - 2 pixels)
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Rules based on ecological knowledge

- Reflectance data
- Derived data
  - Endmember fractions
  - Vegetation Indices
  - Band ratios
  - Seasonal Differences
- Contextual information
  - Proximity to the coast
  - Relative proximity
    - Saltmarshes
  - Enclosures
  - Adjacency
- Transfers within hierarchy
  - Arable crops
- Topographic information
  - Elevation
  - Slope
  - Aspect
  - Concavity
- Ancillary data
  - Urban areas
  - Rivers and lakes
  - Field boundaries
Division of Wales into projects

Biogeographical Regions

Image Footprints
Dealing with Complex Mosaics

- Upland habitats
  - Heaths
  - Bogs

- Lowland habitats
  - Mires
  - Grasslands

- Coastal habitats
  - Dunes
  - heaths
Fuzzy Membership

• Vexcel aerial photography
  – *Calluna vulgaris* (heather)
  – *Vaccinium myrtillus* (bilberry)

• Coverage for Wales, 2006
Fuzzy Membership

- *Calluna vulgaris*
Fuzzy Membership

- **Vaccinium myrtillus**
Cambrian Mountains

An example of mapping complex habitats in the uplands
Cambrian Mountains

An example of mapping complex habitats in the uplands
An example of mapping complex habitats in the uplands
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Hedgerow Mapping
Accuracy of Mapping

- Complex given range of satellite sensor data and dates, different projects and ranges of habitats.

- Assessed through comparison with:
  - VEXCEL aerial photography
  - Phase 2 Habitat Classification
    - Protected sites with limited change
  - Phase 1 Habitat Classification

- Overall accuracy 81 %
- Consistently above 80 % for many classes
- Accuracy assessment informs on classes that are confused, allowing refinements to be undertaken
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Habitat mapping in Wales

• First implementation of an object-based classification at a national level

• Utilises data from any optical sensor

• A single adjustable ruleset that progressively classifies habitats from the coast to the highest mountains

• Three levels of information
  – Fuzzy membership
  – Sub-habitat classification
  – Phase 1 habitat classification

• Accuracies typically exceeding 80 %

• Capacity to refine and update
  – New rules or variations in those existing
A rolling programme

• Requirement to establish an existing baseline
  – Refine existing eCognition-based mapping for nominal year of 2006
    • Based on assessments of accuracy
    • Modifications of rule set
  – Develop rulebase based on imagery acquired up to 2010
  – Cross compare to further refine the 2006 and 2010 baselines and produce definitive version (accounting for areas of change)

• Development of a rule-set for change detection
  – Establish changes between 2006 and 2010 and implement rule-set for change detection
  – Use knowledge to develop a satellite-based monitoring system for Wales

• Enhancements
  – Tasking of satellite sensor data
  – Integration of finer spatial resolution datasets
Applications

- **Biodiversity and Conservation**
  - Forestry
  - Agricultural monitoring
  - Modelling amphibian metapopulations
  - Planning surveys and monitoring
  - Annex I habitats and habitats that support Annex I species

- **Ecosystem Goods and Services**
  - Carbon sequestration
  - Recreation

- **Change detection**
  - Post-classification Land Use / Land Cover change
  - Stratification for anomalous change detection
  - ‘Hindcasting’ using archival imagery

- **Land-Use Planning**
  - Sustainable land use and habitat connectivity
  - Climate change assessments
  - Context-sensitive mapping and data fusion
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Thank you for your attention

Diolch yn fawr iawn i chi