MONITORING ECOLOGICAL CONDITIONS OF A RAISED BOG USING REMOTE SENSING TECHNIQUES

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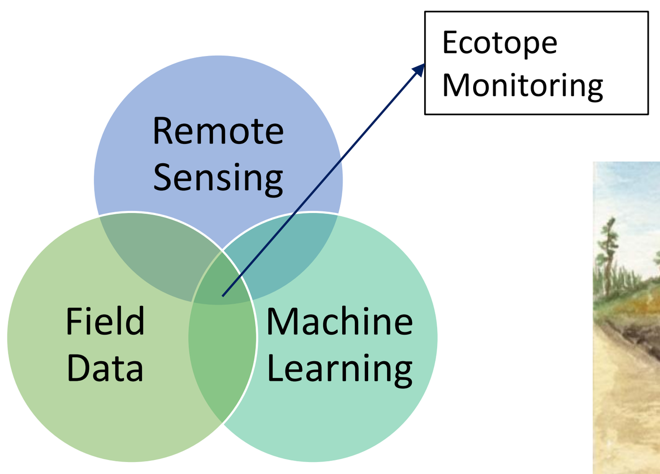
INTRODUCTION

Raised bog are the peat bog in which growth is most rapid at the centre, giving it a domed shape. This site is protected habitat under EU Habitats Directive and is under increasing pressure due to a history of mismanagement, drainage, and turf cutting. Therefore, it is important to preserve the bog.



Ecotope monitoring

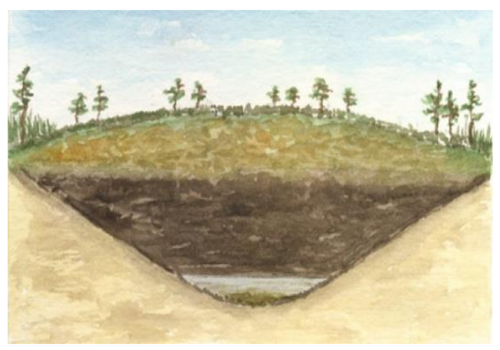


Fig 1. Raised bog

For monitoring the bog here, vegetation Indices like *NDVI, ARVI, SAVI*, and *NDWI* derived using Sentinel-2 MSI are analysed along with LiDAR derived DEM.

This study uses combination of canny edge detection, entropy filtering, and lazy snapping for delineating the boundary of the bog.

Further classification is carried out using an ensemble classifier named **Bagged Tree**. Object based image classification is achieved using information gained from BT via multi-region graph cut segmentation, aka, **maximum a *posteriori*** (MAP) estimation.

OBJECTIVE

The objective of this study is to monitor the ecological conditions of a raised bog using mid-resolution sentinel-2 data. It is achieved by:

1. Identification of bog boundary and ecotopes (vegetation communities) present in it.
2. Mapping the ecotopes using BT and Graph Cut.

In this study, we concentrate on a natural wetland **Clara Bog**, Co. Offaly, a raised bog situated in the Irish midlands [Fig 2].

The bog covers approximately 840 hectares of which 443.36 ha is uncut high bog with the remaining 393.18 ha mostly cutover bog.

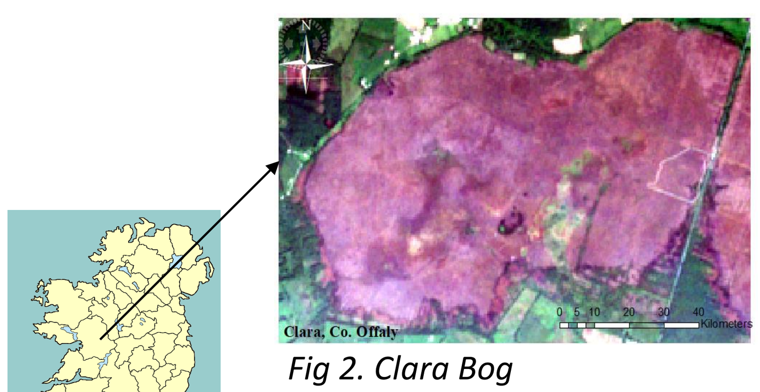


Fig 2. Clara Bog

Vegetation of Clara Bog - Ecotopes

Sentinel 2 MSI Level-2A BOA image captured on 20th June 2017 is used. Accessed from: https://scihub.copernicus.eu/

There are 5 main ecotopes classes present in Clara namely - ***marginal, sub-marginal, sub-central, central, and active flush***.

Out of which, the formation of peat is depicted by central, sub-central and active flush. Ecotopes like marginal sub-marginal are indicative of peat degradation [1].

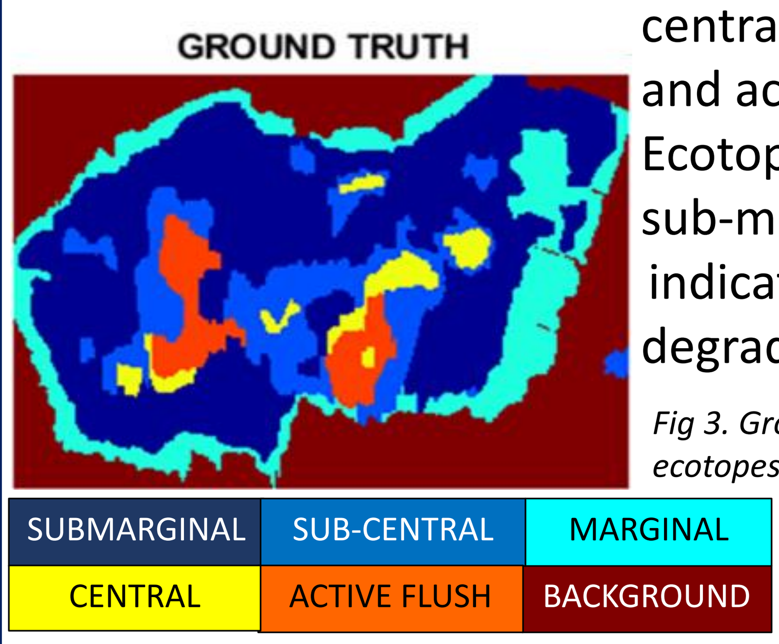


Fig 3. Ground Truth (field ecotopes)

METHODOLOGY

The methodology used is described in the following flowchart [fig. 4]

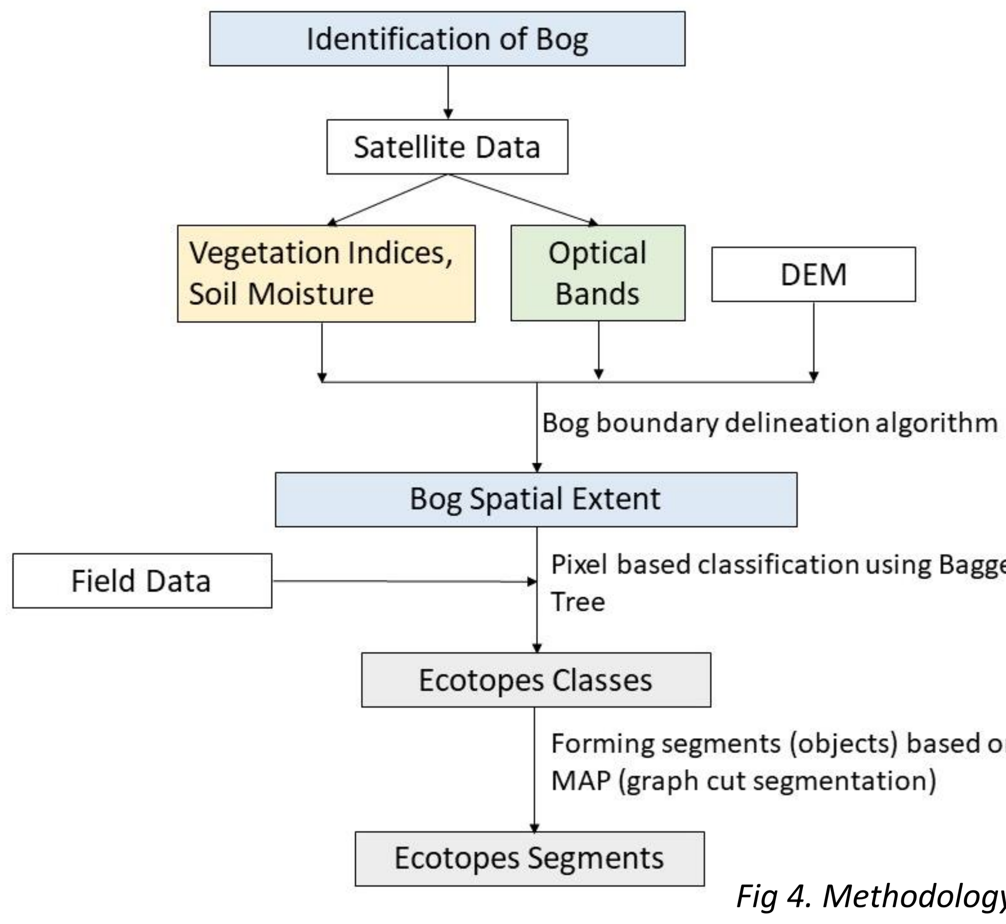


Fig 4. Methodology Flowchart

1. Bog Boundary Delineation Algorithm [fig. 5, 6]

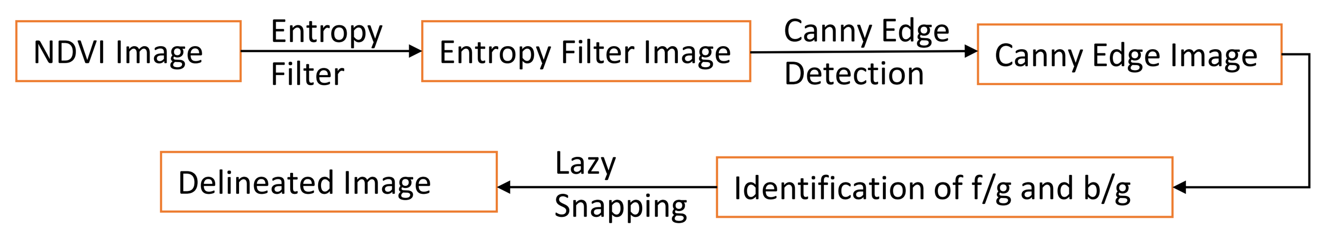


Fig 5. Boundary delineation

2. Pixel based classification

Bagged Tree Classifier: Ensemble, supervised classifier. Classification is carried out using 800 pixels per ecotope class as training data i.e., 12% of entire ground truth rest 88% as testing.

3. Object based classification

Using BT to learn posterior probabilities of every pixel for every class. *MAP estimation*: Estimation of the labels based on posteriori using the graph cut algorithm (min-cut) [2].

RESULTS

1. Bog Boundary Delineation was carried out using three algorithms in conjunction.

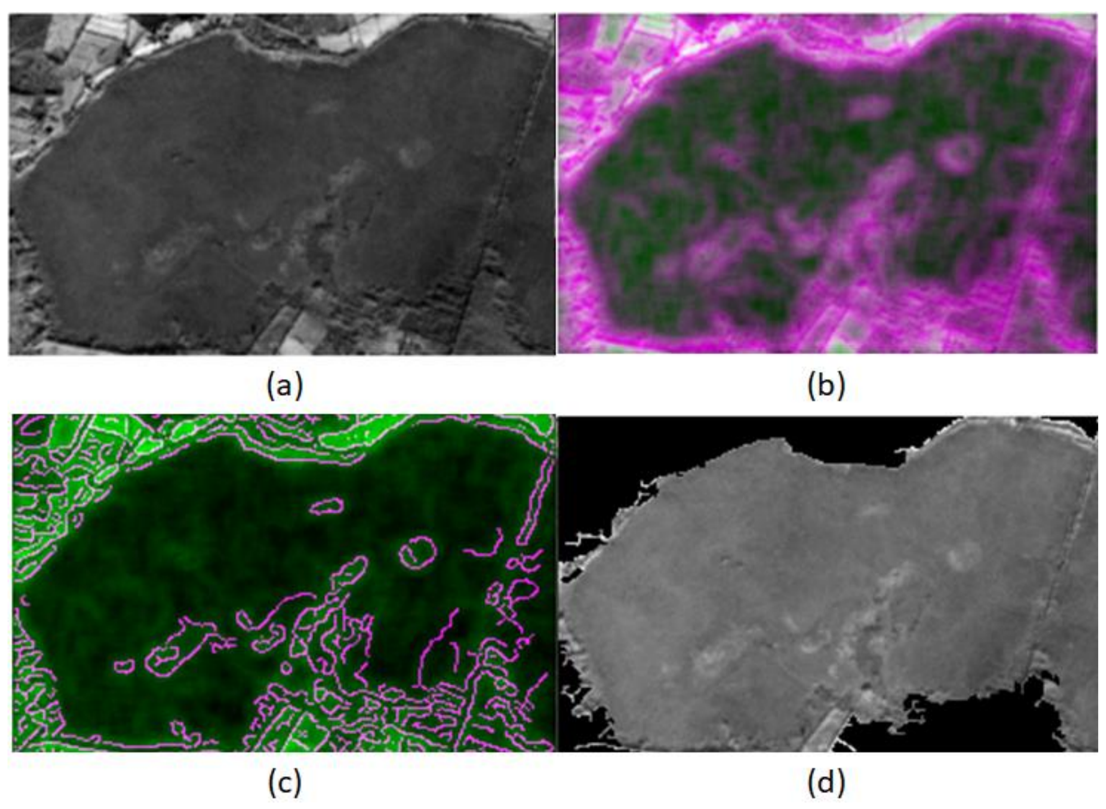


Fig 6. (a) Original Clara Image (b) Entropy Filter Image (c) Canny Edge Image (d) Boundary Delineated Image

2. Image classification

The results obtained using the classification algorithms are validated using field derived ecotopes (ground truth) [Fig 7, 8].

Overall Accuracy = TP/ TP + FP + FN + TN

kappa = Po – Pe / 1 – Pe

Precision (User's accuracy) = TP / TP + FP

Sensitivity (Producer's accuracy) = TP / TP + FN

where,
TP = True Positive
TN = True Negative
FP = False Positive
FN = False Negative
Po = observed accuracy
Pe = chance accuracy

	Bagged Tree	Graph Cut
Overall Accuracy (%)	78.89	82.89
kappa	0.7110	0.774

Table 1. Overall and kappa accuracy for classification and segmentation

	CLASSIFICATION (%)		SEGMENTATION (%)	
	PRECISION	SENSITIVITY	PRECISION	SENSITIVITY
Sub-marginal	91.80	75.43	94.68	78.61
Sub-central	67.35	74.68	74.83	79.33
Marginal	64.02	59.98	70.25	64.32
Central	66.26	89.48	69.44	90.15
Active Flush	65.56	83.29	68.47	84.97

Table 2. Precision and Sensitivity per class for classification and segmentation

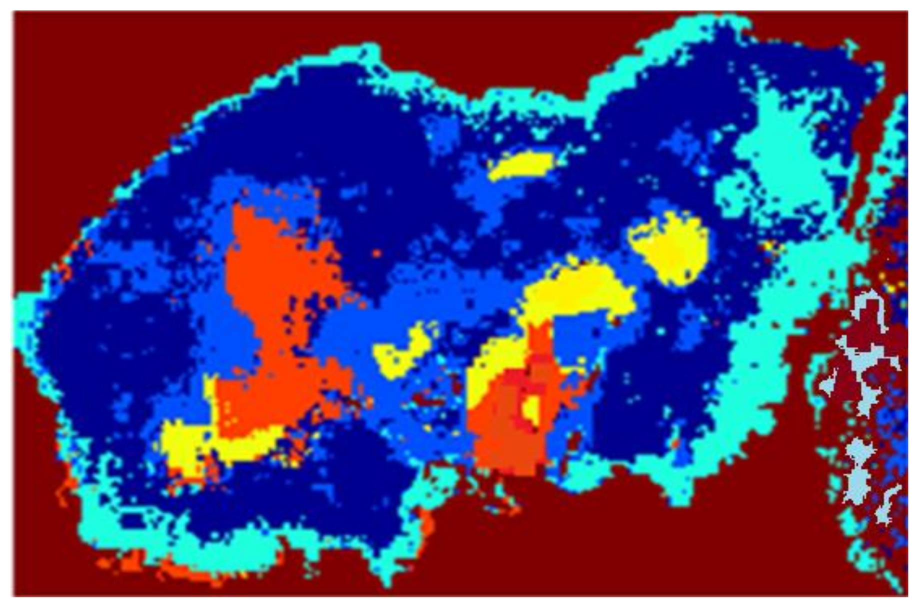


Fig 7. Classified image using Bagged Tree

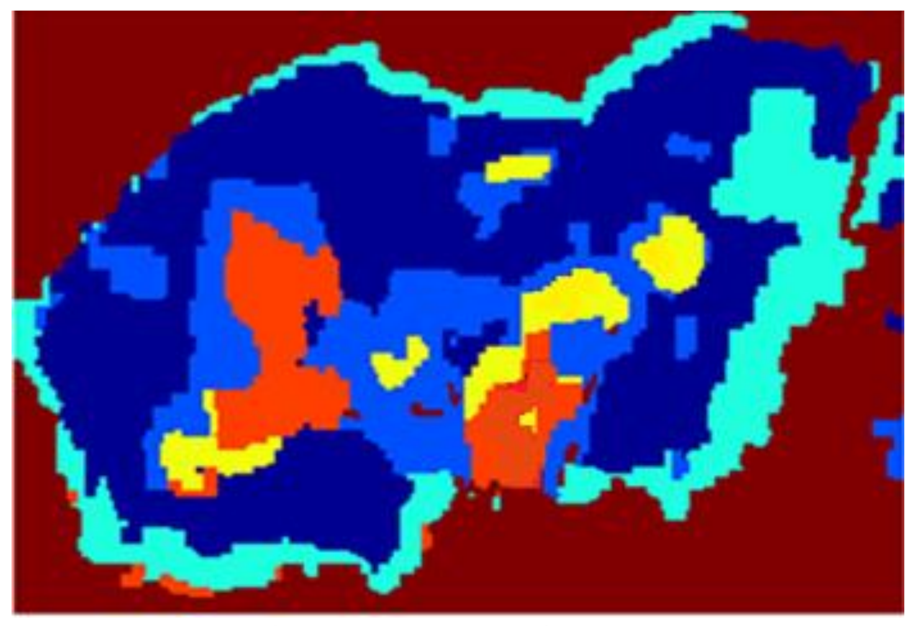


Fig 8. Segmented image using Graph cut

DISCUSSION

1.Entropy filter, canny edge detection and lazy snapping used in conjunction proved to be an effective way of delineating a complex structure from a middle resolution image.

2. Using ensemble Bagged Tree classifier, a good overall accuracy is achieved which is increased up to 4% using Graph cut segmentation [Table 1].

3. Considerable overlaps between the spectral signatures of ecotopes.

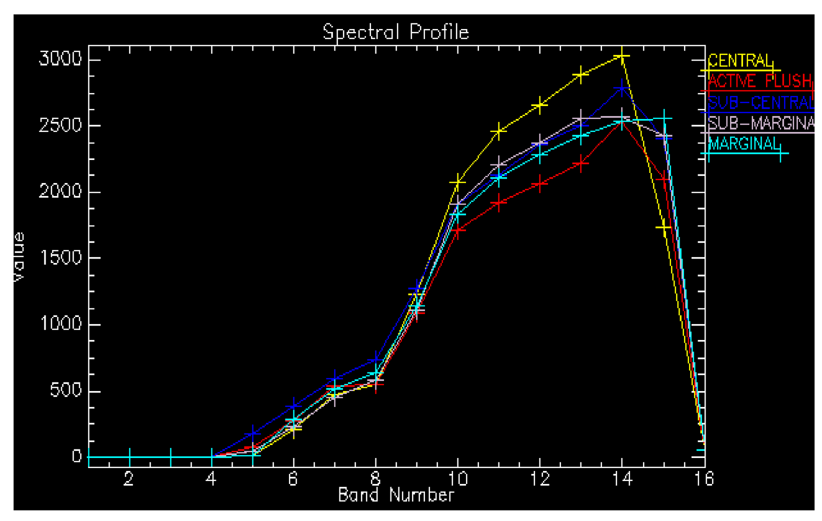


Fig 9. Spectral Profile – Clara Bog

4. Peat forming "wet" ecotopes (central, sub-central, active flush) can be best identified using SWIR bands. They appears correctly mapped in the classified image at an average of 85% [Table2].

The "dry" ecotope classes (marginal, sub-marginal), appears correctly at an average of 80%. They can be best identified using NIR and SWIR bands. [Fig 9]

CONCLUSION

This study investigates the application of medium resolution satellite data for classification of a raised bog. The study was conducted in summer (but is applicable to winter). An ensemble learner is more robust and less manpower is required for tuning the parameters. Information gained from BT is carried forward to conduct object based image classification. In comparison, segmentation provides better results than classification. The algorithm used is not shape specific and builds on maximum posteriori for all the structures.

MAJOR REFERENCES

[1] Fernando Fernandez Valverde, W. C. . S. W.: Raised Bog Monitoring Project 2011, Irish Wildlife Manuals, 62, 2012.

[2] S. Bagon, Matlab Wrapper for Graph Cut, Dec. 2006. [http://www.wisdom.weizmann.ac.il/~bagon]