HABITAT MAPPING AND QUALITY ASSESSMENT OF HEATHLANDS USING A MODIFIED KERNEL-BASED RECLASSIFICATION TECHNIQUE

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1. INTRODUCTION

Habitat loss and deterioration are two major causes of the global biodiversity crisis. The European Commission is committed to halt biodiversity loss in Europe, and created the Natura 2000 network [1], an ecological network consisting of thousands of protected sites that hold rare or threatened habitats and species. Furthermore, member states are required to monitor and regularly report on the conservation status of the Natura 2000 sites, habitats and species, in order to keep track of the trends and take conservation measures whenever appropriate.

To date, field inventories and visual interpretation of aerial images are common techniques in habitat monitoring, but these are costly, time consuming and inter-surveyor errors are an issue. Remote sensing has been recognized as a powerful, innovative tool to aid in habitat monitoring. Unfortunately, very few readily applicable procedures have been developed so far [2],[3], probably because habitats are mostly not homogeneous vegetation patches of a single or a few dominant species. Instead, they show a high variety in facies at different scale levels. At a large scale, the facies of the same habitat may differ between regions as a result of climatic or soil conditions. But also at a very fine scale, most habitats are in fact intricate mixtures of different land cover types.

To assess this gap, a framework has been developed to deal with the complete trajectory, from breaking down habitats into land cover types, to reconstructing the habitat types and their conservation status from classification results. This framework has been developed for Western European heathlands and is part of a Belgian multidisciplinary project on habitat status monitoring. Strategies for classification of the various land cover types have been described in [4], [5]. This work starts from thematic maps of the land cover types, and concentrates on the construction of habitat maps, using a modified kernel-based reclassification technique [6].

2. FRAMEWORK

Figure 1 illustrates the full trajectory of the habitat quality assessment framework. In the first step, the Natura 2000 habitats have been translated into land cover types through a hierarchical classification scheme with 4 levels of detail. The first level comprises only 6 classes: heathland, grassland, forest, sand dunes, water bodies, and arable fields. Level 2 and 3 mostly determine specific habitat types of the Natura 2000 program, containing 11 and 17 classes respectively. Level 4 comprises 24 classes, focusing on vegetation structural elements that determine the conservation status of the habitat types.

The unique way in which the data have been subdivided offers the freedom of classifying on a per-level basis, but also allows us to classify hierarchically, one level after another. In addition, in search for obtaining more readily interpretable vegetation maps, including textural/contextual features in the classification process has been an important consideration, for instance by modeling the dependencies between neighboring pixels as Markov Random Fields [4], [5].

The third step, after the classification, is the rule-based translation of the classification results back into habitats. In the fourth and final step, the quality for each of the reconstructed habitats is determined, by combining the habitat map with the level 4 classification result, leading to the desired quality measure. The main focus of this paper, is step three, the rule-based translation.

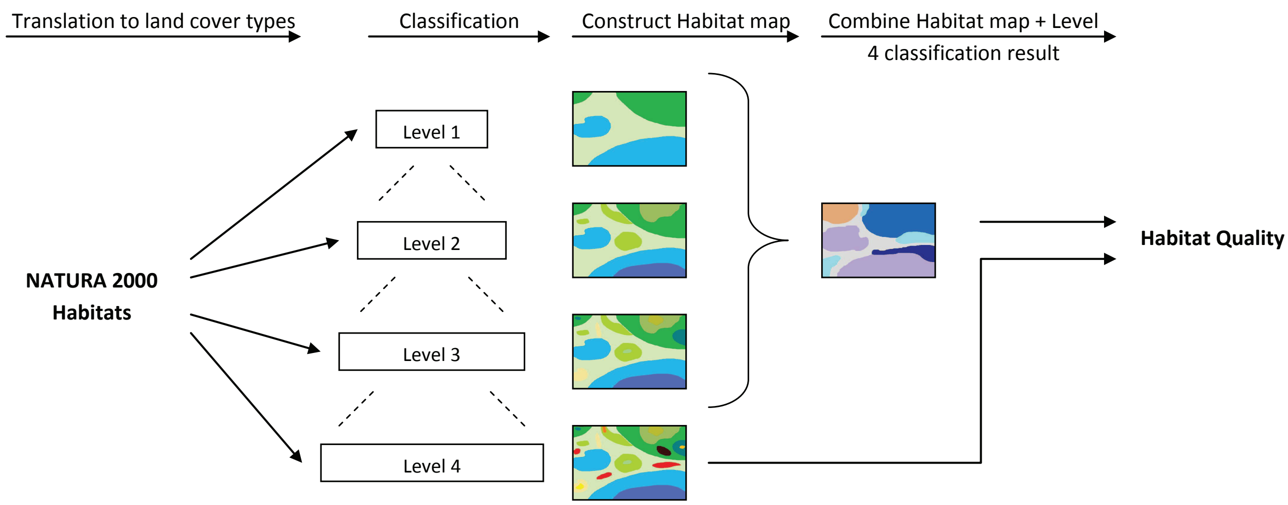


Fig. 1. Habitat quality assessment framework

3. RECLASSIFICATION

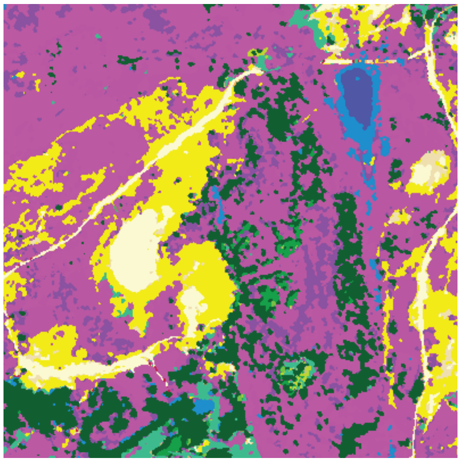
For the step in which the habitat types are reconstructed from the classification result, a method based on Kernel-based reclassification was used [6]. In Kernel-based reclassification, a simple convolution kernel is moved across the land cover image. In [6], a small square kernel generates, for every location, an adjacency matrix that accounts for the frequency of every label in the kernel window, and, additionally, for the spatial arrangement of these labels. The reclassification is then performed by comparing each of the adjacency matrices to a set of template matrices, derived from representative sample areas. This method is referred to as SPARK (SPAtial Reclassification Kernel).

In our case, for determining the habitat map from a thematic map of land cover types, a set of rules was constructed. These rules link the frequency composition of land cover classes within a certain kernel area to a corresponding habitat type for the point in the center of this kernel area. An example of such a set of rules for Northern Atlantic wet heaths is given in Table 1. As can be seen in the table, the rules do not take into account variations of the spatial arrangement of the various land cover types within a kernel window, but only the frequency with which the class labels occur. Consequently, there is no need for an adjacency matrix, as used in SPARK, since a class label frequency vector suffices.

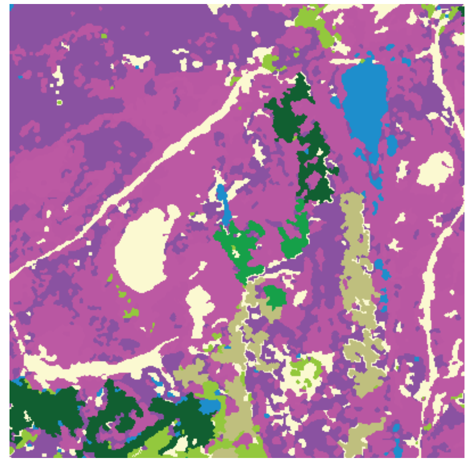
However, these rules, when applied in the field, are used with a variable kernel, both in size and in shape. Consequently, when using the same methods on a fixed-size kernel, certain points may be mapped to multiple habitat types, or may not be mapped to any habitat type at all. To circumvent this problem, the reclassification step is subdivided in two parts. The first part applies the rules for each habitat type on the thematic land cover map. As said, some locations may be mapped to multiple habitat types, while for others, none of the rules may apply. Only the points to which one, and only one, habitat type was assigned, are retained. In the second part of the reclassification step, these points are used to construct mean class label frequency vectors, one for each habitat type. Finally, a minimum distance classifier is used to assign a single habitat type to every point of the map.

Table 1. Northern Atlantic wet heaths with *Erica tetralix*

	Criteria/range
Minimum area	$50m^2$
Wet heathland	$10 - 100\%$
Grass-encroached heathland	$0 - 90\%$
Dry heathland	$0 - 20\%$
Forest	$0 - 30\%$
Shallow, vegetated oligotrophic water bodies	$0 - 30\%$
Sand dune	$0 - 30\%$
Wet heathland + Grass-encroached heathland + Dry heathland	$80 - 100\%$
Grass-encroached heathland + Dry heathland	$0 - 90\%$



(a) Land cover thematic map



(b) Habitat map

Fig. 2. Example habitat map

4. EXPERIMENTS

For the heathlands of 'Kalmthoutse Heide' in Belgium, airborne hyperspectral data were obtained in June 2007 with an AHS sensor with a ground resolution of approximately 2.5m. The range of 450nm-2550nm is covered by 63 spectral bands. During the same period, ground reference data were collected in homogeneous plots of 10 meters diameter. The vegetation data of the sampled plots, approximately 1200 in total, were analyzed and plots were grouped in the 4 level classification scheme.

For validating the land cover classification results, three strategies have been explored, together with conventional accuracy estimation, complementing traditional methods, and compensating for the absence of adequate reference data. These strategies included using multiple unsupervised cluster maps as a reference [7], using patch area and patch shape statistics [5], and a small independent field survey to confirm the results from the two former strategies.

Figure 2 shows a land cover thematic map and the corresponding habitat map for an example area of 400×400 pixels, classified on level 3 with a Support Vector Machine classifier, using a 3×3 kernel. The influence of the kernel size on the resulting habitat map was investigated. For various classification strategies on the level of the land cover maps, reclassification was done for kernels ranging from 3×3 to 13×13 pixels, corresponding to $50m^2$ and $1000m^2$ respectively. While increasing the kernel size leads to smoother results, the resulting habitat maps were shown to be stable with respect to the increase.

Of course, although these results look promising, quantitative validation is necessary. In the absence of ground reference data that provides validation information for the actual habitat types, validating the technique with conventional methods is done by statistically linking the habitat maps to the underlying land cover classification results. Since these results were validated thoroughly, the accuracies of the land cover maps are propagated in order to acquire a good indication on the accuracies of the habitat maps.

5. REFERENCES

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