

# EVIDENTIAL REASONING APPLIED TO MAPPING REGENERATION OF FOREST STAND USING MULTISOURCE GEOSPATIAL DATA

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## 1. INTRODUCTION

Forest companies and government services involved in forest management need efficient mapping methods to assess regenerating forest stands. In Quebec, Canada, foresters use forest inventory maps derived from aerial photography and sometimes from satellite imagery [1]. These two products are not accurate enough to plan field operations [2]. The frequency of update and the mapping scale are two primary limitations of provincial forest inventories. In addition, the information contained in satellite image spectral bands is not sufficient to produce accurate maps of regenerating stands. Thus, map accuracy may be improved from the addition of ancillary sources of information. The data of interest for our purpose may be biophysical parameters conditioning the regenerating potential of the areas of interest.

## 2. MATERIAL AND METHOD

### 2.1. Study area and field data

The study was performed in the Watopeka forest, located in southern Quebec, where the Temperate forest landscape is dominated by sugar maple stands (*Acer saccharum*). Other important forest stands of this region include birch and balsam fir. All the tested methods are supervised; a series of ground plots were collected specifically for this study. They were selected from the regenerating stands identified in the forest inventory map. The other stands were masked. Measurements in every sample plots included species and their density, height, age and radius homogeneity.

### 2.2. Protocol

We first mapped the forest areas in regeneration with a maximum likelihood algorithm applied on the Spot image using three regeneration classes: deciduous species (maple, birch ...), coniferous species (balsam fir ...) and non commercial species (brambles, ferns ...). Then, after adding identified coniferous areas to the mask, we produced new maps with a data fusion method in which only deciduous and non commercial classes were considered. The Dempster-Shafer theory (DST) was selected at this stage for its capability to process several heterogeneous data sources simultaneously. Moreover, this method has been chosen for its ability to deal with vagueness and uncertainty intrinsic to data sets associated with vegetative ecosystems [3, 4]. The maximum credibility criterion was used. This data fusion method does not require Gaussian distribution in each source for every thematic class. The major requirement to apply the method is the mass function description for each potential class and for each source. We used the Fuzzy Statistical Expectation Maximization algorithm (FSEM) to define the mass functions for the satellite image spectral bands. This iterative method is based on Gaussian distribution classes and has the ability to produce fuzzy classes that are the union of two primary classes [5]. This is can help to assess mixed pixels. In this study, the single fuzzy class obtained can be labelled "deciduous OR non commercial species". The other sources can also be numerical or categorical types. In each case, it was not possible to obtain a Gaussian distribution for each sample class.

### 2.3. Ancillary data sources and their mass function

We were able to use different maps which represented biophysical parameters of the study area. These parameters were the drainage, the slope, the slope position, the aspect, the surface deposit and the distance to the hydrographical network. The

selection of the sources was based on various studies on forest productivity. For instance, there is a strong relation between the slope, the slope position and to a lesser extent the aspect, with the spatial distribution of Maple species or at least its growth quality in southern Quebec [6, 7]. It has also been suggested that site drainage is a parameter influencing the growth quality of the same species in this region [8, 9]. Finally we considered the distance to the hydrographical network. Because of potential beaver dams, a stand close to a stream has a higher probability of being flooded. Once the mass functions were designed, we were able to test combinations of these biophysical parameters jointly to the spectral bands of a SPOT image.

### 3. RESULTS

The maximum likelihood algorithm led to an accuracy rate of 69,14% for the three-class case and 82,75% for the two-class case (deciduous and non-commercial species). The FSEM algorithm has slightly increased the result (83,74%) when stopped after one iteration so that it is equivalent to the maximum likelihood. On the other hand, the test of various sources combinations at the fusion level gave better results. The best classification rates were 87,68% when using a single ancillary data source (surface deposit) fused with the Spot image, and 90,14% when using two sources (surface deposit and drainage) fused with the Spot image too. A decrease of the correctly classified pixel rate was observed with three sources.

### 4. DISCUSSION

We decided to stop the FSEM after one iteration because the multi-iteration mode led to worse results than the maximum likelihood (difference of 5,42%). Stopping the FSEM at one iteration is equivalent to the maximum likelihood method. This can be explained by the fact that the method is based on the same assumption (Gaussian distribution of the samples) and the same classification principle as the maximum likelihood method. Moreover at the first iteration step the prior probabilities of each class are equal. The fusion tests that were performed implicitly defined the outline of a data fusion framework usable in the context of regenerating stand mapping. The study highlighted the limits of the information contained in the data sources that we used. We showed how using a few additional sources can improve the correct classification rate but how too many sources tend to lessen the mapping quality. For some tests we had occurrence of high conflict rates between the sources. For these cases we suggest the use of the Dézert-Smarandache Theory to reduce the conflict between sources and provide increased results. The weighting of the sources according to their real impact in a forest ecosystem may provide better results too. Our study showed that regenerating stands mapping in southern Quebec can be improved from additional biophysical parameters and by the use of the DST.

### 5. REFERENCES

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