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# Influence of the methodology (pixel-based vs object-based) to extract urban vegetation from VHR images in different urban zones

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## Abstract
In a context of sustainable development, the cities have become the main problem for spatial planning directives. Rapid urbanization has a real impact on several natural processes like the meteorological cycles. So to reduce the side-effects of urban development, consistent and accurate data are required to define urban land cover and, especially, the vegetation surface. Indeed, the vegetation presents a particular interest because of its influence on components of the urban environment like temperature or air quality. Images with a very high spatial resolution allow to obtain more details. If object-based approach (OBA) seems to give better results than pixel-based approach (PBA) to classify urban land covers, at a zone scale, this statement can be qualified according to the type of zone. On seven zones of Nantes, France, results of OBA and PBA are compared from 10 m spatial resolution image and impact of spatial resolution of images is also analyzed. Furthermore, this study explores a straightforward spatial analysis method to assess the impact of OBA and PBA. On zones where the land cover is more homogeneous, PBA and 10m image give vegetation surfaces close to surfaces obtained from OBA and 2,5m image. Zones where land covers are mixed, OBA and 2,5m image are essential to detect vegetation accurately.

Keywords: Remote sensing, spatial analysis, image processing and analysis, vegetation

## 1. Introduction
Urban area is a complex system because of multiplicity of the objects and materials consisting urban fabric. If the spatial resolution of images increases, urban objects are more easily identified, spectral mix is reduced but the level of details increases too and complicates automatic detection of urban land covers. (Myint et al., 2011). With a spectral approach, the spatial resolution allows to analyze the spectral properties of urban objects and to avoid per-pixel spectral heterogeneity. Because of the spatial heterogeneity of the urban fabric (Long et al., 2008), the object-based approach could be a solution to classify urban land covers.
In this study, we analyze seven zones of the city characterized by several built density, buildings gradually making way for the vegetation. We focus only on vegetation surface to analyze influence of methodologies. First, the difference between the vegetation surfaces detected from an object-based approach (OBA) and those from a pixel-based approach (PBA) is evaluated for each zone. Second, influence of the image spatial

resolution to detect vegetation surface is also evaluated. Our objective is to show that the kind of zone, its land cover less or more homogeneous and its urban structure must to be take into account to choose methodology and spatial resolution of image. Furthermore, this study explores a straightforward spatial analysis method to assess the impact of OBA and PBA (Gustafon, 1998; Herold et al., 2002). Performed with GIS, we propose a Map Similarity Index to compare vegetation maps.

## 2. Study area

Nantes is the sixth city of France and is located in the northwest of France, near the estuary of the Loire river. Nantes belongs to the Urban Community of Nantes, grouping 24 communities on 523 km². Within this urban community, seven zones ranging from low building density to high building density were selected (the zone number is noted between bracket) : rural zone (5), predominantly rural (7), predominantly urban (6), multifamily building (3), high density single family building (4), pericenter district (2) and city center district (1).

## 3. Methodology

The methodology is divided into two steps: land cover classification (1) and calculation of Map Similarity Index (2). Each zone covers 1 km². Surfaces of vegetation are divided into herbaceous vegetation (HV) and trees vegetation (TV). Vegetated surfaces are computed in percentage as well as a relative change from the formulae $((x - x_{reference}) / x_{reference}) * 100$.

### 3.1. Land cover classification

Land covers are defined from SPOT images (june 2004): a multispectral image (green, red and near infrared channels, Lambert 93) with a 10 meters of spatial resolution and a second one with a 2.5 m of spatial resolution (VHR image) are used. All land covers are identified from images but the result comparison is produced only on the vegetation surfaces. Two methods are tested according to the spatial resolution of images: (1) a pixel-based classification (PBA) using the supervised method Maximum Likelihood and (2) an object-based classification (OBA) with segmentation into three levels and a hierarchical classification (Baatz and Schäpe, 2000). Thresholds are fixed from 4 features: GLCM (Grey Level Co-Occurence Matrices) homogeneity, NDVI (Normalized Difference Vegetation Index), BSI (Brilliance Soil Index) and shape. Then, a confusion matrix based on images is employed to perform each classified image and to evaluate overall accuracy (Congalton, 1991).

### 3.2. The Map Similarity index (MSI)

The MSI equals the percent area for each patch of a “map A” that overlaps each patch of the “map B”. The MSI is computed for each study zones and offers a way to identify joint coincidence in both geographic spaces (geometry) and data classes, thanks to OrbisGIS (Bocher and Petit, 2012). Its spatial language (Bocher et al. 2008) is used to perform geometry processing (union, overlapping) and to aggregate the results (statistics). Indeed, this similarity index is used to indicate the main changes of the classes occurring between the two maps. Are the vegetation maps

different? If so, where and in what manner?

## 4. Results

The overall accuracy varies between 89 and 91% according the images and the approaches. The methodology's influence on the images' spatial resolution is more important for the detection of herbaceous surfaces than for that of trees (Fig. 1). The relative change between the OBA and PBA is higher (> 90%) on zones with a high building city (zones 1, 2 and 4) and decreases under 40% on zones 7 and 5, predominantly rural. Trees vegetation results are more heterogeneous and do not appear linked to the building density. But the influence of the approach is less important because of a relative change always inferior to 40%. In city centre, multifamily building zone and predominantly urban zone, the surface difference is low (<10%) and in high density single family building zone and rural zone, the detected surfaces of vegetation vary between 30 and 40%. The trees vegetation surfaces are underestimated with the OBA. The same profile is obtained for herbaceous vegetation between a 2.5m image and a 10m image. The relative change is the highest on zones with a high building density (zones 1, 2 and 4) and decreases with the building density. For the trees vegetation, the spatial resolution of images seems less important to detect theses surfaces and the relative change stays inferior to 50%.

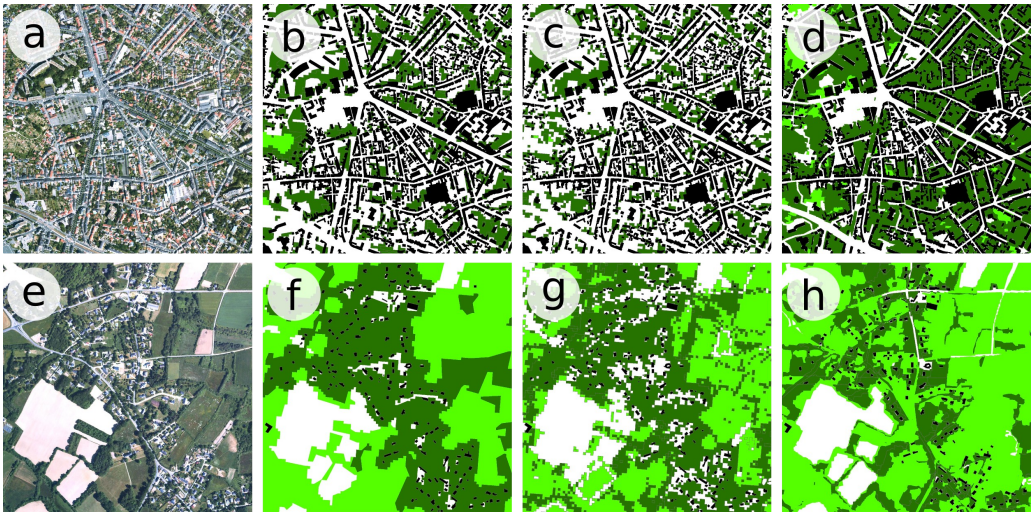



Figure 1 : pericenter zone : aerial images (a), OBA results from 10m image (b), PBA results from 10m image (c) and OBA results from 2.5m image (d); and predominantly urban zone : aerial images (e), OBA results from 10m image (f), PBA results from 10m image (g) and OBA results from 2.5m image (h) (dark green : trees vegetation, light green : herbaceous vegetation, black : buildings (from BDTOPO database IGN), white : no information)

The MSI method confirmed these results (Fig. 2). The MSI is built: (1) between PBA_10m and OBA_10m, (2) between OBA_10m and OBA_2.5m. The figure 2 collects the results about the vegetation classes and presents them using a dataviz approach. The first bubble row shows that the vegetation surface area is most covered using the PBA_10m than the OBA_10m except for the zone 5. However, the differences are quite small

because of the maximum is only about 10 points. Focused on the second row, the OBA_2.5m highlights a growth of the vegetation area. The maximum difference between PBA_10m and OBA_2.5m is up to 32 points. The last two rows illustrate the overlapping areas calculated by the MSI method. Firstly, we note that there are not major changes from PBA to OBA. Except for the zones 1, 2 and 3 where the orange circle (that represents the part of the superposed area) does not fill all the vegetation areas (colored in green and purple). We notice a certain level of consistency between vegetation classes (light and dark orange). The herbaceous vegetation is always underestimated, apart from the zone 5 where the ratio is reversed.

## 5. Conclusion

Because of the multiplicity of urban objects and materials consisting urban fabric, the choice of methodology to analyze images and of the pixel size are fundamental to obtain an accurate land cover classification. The accuracy of the classification depends on the land cover variability, urban morphology and so, spectral heterogeneity. An OBA and VHR images must be used to analyze images in districts where the building density and the building height is high. On the contrary, the vegetation detection should be more accurate in rural zone with the same method but the detection of the trees vegetation is less accurate from OBA than from PBA. The MSI method confirms these results and highlights the differences between the maps of vegetation.

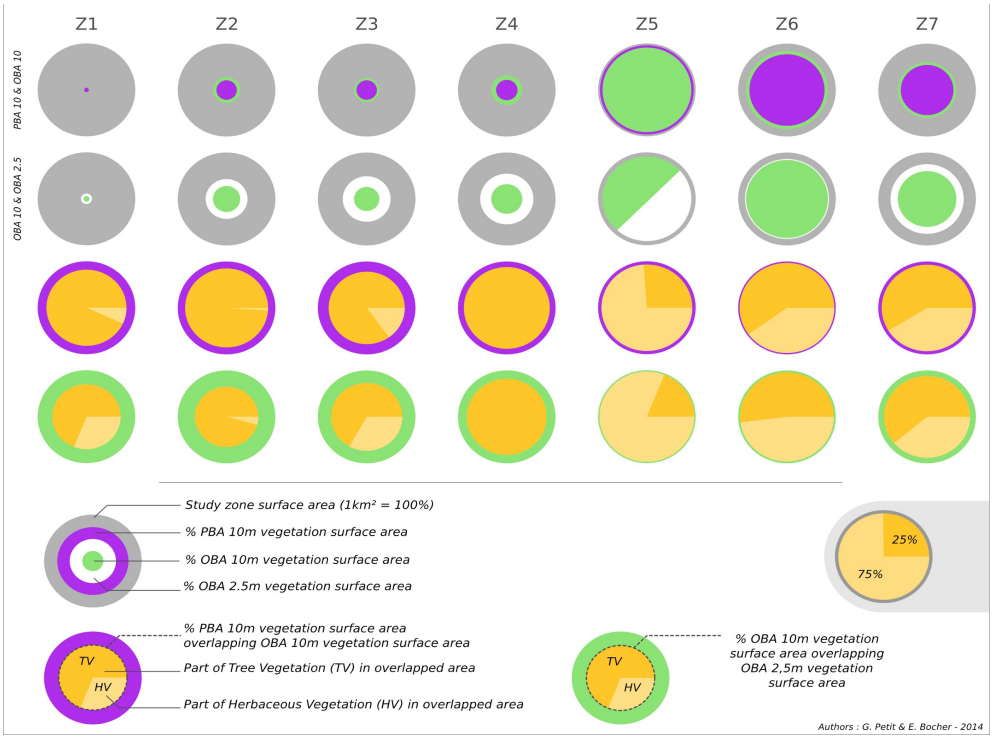



Figure 2. Map Similarity Index dataviz for vegetation


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