Journal of Environmental Management 144 (2014) 236–246

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

# Identification and mapping of natural vegetation on a coastal site using a Worldview-2 satellite image

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A R T I C L E I N F O

*Article history:*
Received 27 November 2013
Received in revised form
18 May 2014
Accepted 25 May 2014
Available online 25 June 2014

*Keywords:*
Remote-sensing
Vegetation formations
Very high spatial resolution
Super spectral resolution
Object-oriented classification

A B S T R A C T

Identification and mapping of natural vegetation are major issues for biodiversity management and conservation. Remotely sensed data with very high spatial resolution are currently used to study vegetation, but most satellite sensors are limited to four spectral bands, which is insufficient to identify some natural vegetation formations. The study objectives are to discriminate natural vegetation and identify natural vegetation formations using a Worldview-2 satellite image. The classification of the Worldview-2 image and ancillary thematic data was performed using a hybrid pixel-based and object-oriented approach. A hierarchical scheme using three levels was implemented, from land cover at a field scale to vegetation formation. This method was applied on a 48 km$^2$ site located on the French Atlantic coast which includes a classified NATURA 2000 dune and marsh system. The classification accuracy was very high, the Kappa index varying between 0.90 and 0.74 at land cover and vegetation formation levels respectively. These results show that Wordlview-2 images are suitable to identify natural vegetation. Vegetation maps derived from Worldview-2 images are more detailed than existing ones. They provide a useful medium for environmental management of vulnerable areas. The approach used to map natural vegetation is reproducible for a wider application by environmental managers.


## 1. Introduction

Identification and mapping of natural vegetation is a major issue for biodiversity management and conservation (Gibbons et al., 2006). Threats to natural vegetation such as urban growth (Eppink et al., 2004), agricultural intensification (Walker et al., 2004), scrub development (Burel and Baudry, 1995) or climate change (Heller and Zavaleta, 2009) are clearly identified but their spatio-temporal dynamics are largely unknown by environmental managers (MacKay et al., 2009). In the framework of the NATURA 2000 European program for biodiversity (http://ec.europa.eu/environment/nature/natura2000/), many threatened vegetation species have been sporadically inventoried by field observations, but without exhaustive coverage (Alexandridis et al., 2009).

In this context, satellite images appear to be a promising solution for natural vegetation mapping (Xie et al., 2008). Compared to aerial photography, recent satellite sensors provide images with a similar Spatial Resolution. Many studies have shown the potential of Very High Spatial Resolution (VHSR) sensors to map some vegetation communities. For example, the potential of Quickbird images has been highlighted to map *Trapa natans*, *Phragmites australis* and *Lythrum salicaria* communities (Laba et al., 2008), saltmarsh vegetation (Belluco et al., 2006) or to monitor bog vegetation (Harris and Bryant, 2009). Another study has shown the benefit of IKONOS images for characterizing *Juncus acutiflorus* and *Juncus effusus* (Andresen et al., 2007). Other research has pointed out the potential of VHSR images for mapping woody species in mangroves (Wang et al., 2004) or Mediterranean environments (Lasaponara and Lanorte, 2007). Submergent aquatic vegetation can also be identified and characterized in open lakes with Quickbird images (Dogan et al., 2009; Wolter et al., 2005).

However, most VHSR satellite sensors are limited to four spectral bands (blue, green, red, near infrared), which is insufficient to discriminate some natural vegetation communities

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http://dx.doi.org/10.1016/j.jenvman.2014.05.027
0301-4797/

(Feilhauer et al., 2013). Since 2010, the Worldview-2 sensor has been providing VHSR images in 8 spectral bands, ranging from blue to near-infrared, but including additional coastal-blue, yellow and red-edge bands. Some studies have already shown the potential of Worldview-2 imagery to estimate forest biomass and structural parameters (Eckert, 2012; Mutanga et al., 2012; Ozdemir and Karnieli, 2011) or to assess fine-scale plant species beta diversity in grassland (Dalmayne et al., 2013), but to our knowledge only one study deals with vegetation mapping tasks applied to urban tree species (Pu and Landry, 2012). Faced with natural vegetation patch heterogeneity, Worldview-2 imagery is worth evaluating to map vegetation over large areas.

When mapping vegetation using remotely sensed images, best results are usually obtained from supervised classifications using field samples whereas unsupervised methods are preferred for help in preliminary field campaigns (Zak and Cabido, 2002). Many supervised classification techniques are pixel-based using spectral dissimilarities, such as decision tree (Davranche et al., 2010; Baker et al., 2006), maximum likelihood (MacAlister and Mahaxay, 2009; Laba et al., 2008; Fuller et al., 2005), Bhattacharrya (Töyrä and Pietroniro, 2005) or Spectral Angle Mapper (Sobocinski et al., 2006) algorithms. However, these traditional per pixel approaches are not suited to discriminate vegetation species with a similar spectral response, although they provide images with salt and pepper effects related to vegetation heterogeneity. In addition to pixel-based classifications, vegetation can also be mapped from remote sensing images using an object-oriented approach (Gilmore et al., 2008; Dissanska et al., 2009). Compared to the pixel-based approach, the object-oriented approach classifies objects in images from spectral criteria but also texture, context and shape criteria (Hay and Castilla, 2008). Moreover, with an object-oriented approach, images can be also analyzed in a multi-scale framework that is suited to hierarchical typology for vegetation mapping (Bock et al., 2005; Burnett and Blaschke, 2003). Additionally, thematic layers can be integrated in the image analysis process to provide contextual information (Lucas et al., 2011). However, developments in image supervised classification techniques are still needed when applying the object-oriented approach, because only few simple classification algorithms are available compared to per-pixel classification techniques (Blaschke, 2010). Thus, it appears interesting to use a hybrid approach combining pixel-based and object-oriented approaches.

The objectives of this study are to discriminate natural vegetation in a temperate-climate coastal site and then to identify natural vegetation formations using a Worldview-2 satellite image. For this, a hybrid pixel and object-based classification approach has been applied. This challenging approach, which was conceived to be reproducible, was developed in synergy between remote sensing scientists, vegetation scientists and environmental managers in order to be easily reproducible. This study is part of a broader work whose aim was to map major vegetation types at the regional scale in Normandy, Brittany and Loire regions using remotely sensed data (Sellin et al., 2013).

## 2. Materials and method

### 2.1. Study site

The research was carried out in a 48 km$^2$ area located on the French Atlantic coastline, (46°40'N, 1°55'W) (Fig. 1). This coastal area includes urbanized areas, intensive agricultural areas (sunflowers and corn crops) but also extensive pastures, fallows, fens and a classified NATURA 2000 dune (Sauzaie dunes) and marsh system (Jaunay marshes). Indeed, threatened and protected flora, such as *Omphalodes littoralis* or *Rumex rupestris*, and habitat types of European like dune grass were inventoried in this protected site by environmental managers.

### 2.2. Field data collection

The field surveys were conducted from March to July 2009 and in July 2012 when the vegetation was fully grown.

A total of 526 training and validation points were surveyed during field campaigns or selected based on Worldview-2 image

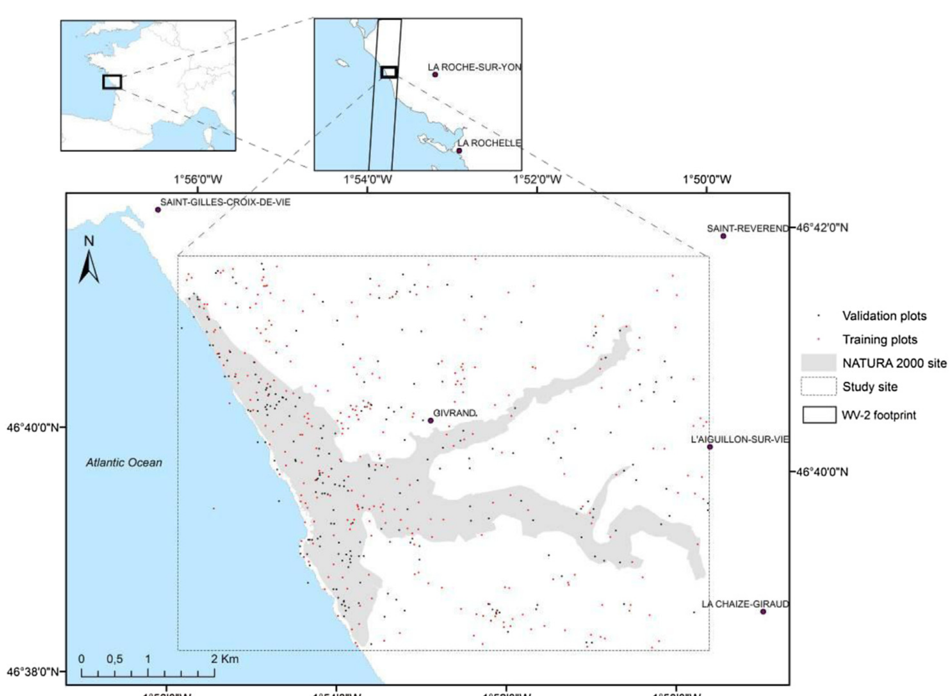


**Fig. 1.** Study site location and ground plots.