Applying Satellite Imagery for Forest Planning

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Abstract

Cost-effective options for providing up-to-date information on the status of forest resources to improve planning are important. Due to lower costs and improved technology, attention has recently focussed on the benefits of remote sensing to supplement and improve resource information. Since new opportunities exist to use these technologies, this paper concentrates on the application of high resolution (~5 m) satellite imagery to provide broad area coverage that can be processed to create a number of GIS-ready products to assist forest planners. The images provided are multi-spectral (five spectral bands) and in a format that can be manipulated to enhance and detect changes in vegetation or land cover. In this context the images can be used in several forestry operations, including; monitoring harvesting and the success of plantation establishment, mapping of wind and snow damage and to delineate forest species and boundaries.

Introduction

Traditionally the benchmark for mapping and planning in forestry has been aerial photography. However, recent advances in satellite technology mean that this technology offers a range of benefits to resource managers who require timely information to assist in broad-scale (1: 25 000 scale) planning.

Over the past five years the cost of satellite data has fallen and is now at a level (~$1800 NZD/100,000 ha) that provides a cost-effective option for frequent monitoring and updating of forest mapping.

RapidEye is an example of one such satellite. There are currently five identical satellites in orbit which allows daily revisit over many locations.

RapidEye Characteristics

Characteristics of the RapidEye satellite include:

- spatial resolution (~5m);
- spectral bands sensitive to vegetation composition and stress;
- wide data capture 70 x 70 km imaged in one pass and processed and delivered into 25 x 25 km tiles with <20% cloud cover;
- targeted and daily revisit potential;
- low cost (0.95 Euro/km^2 as at Oct. 15 2010) minimum order 100,000 ha;
- provided ortho-corrected and projected ready for integration into a GIS;
- able to be tasked to capture imagery over specific locations. Minimum order 500,000 ha; and
- national coverage available since October 2010. The coverage is ongoing with multiple scenes available over many locations.

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The RapidEye sensor measures reflectance across five spectral bands from 440 to 850 nm. The visible wavelengths between 400-700 nm designates the range where photosynthesis occurs and is generally referred to as photosynthetically active radiation (PAR). As leaves age or become stressed reflectance increases due to decreasing levels of chlorophyll. The near-infrared (NIR) band provides information on the leaf structure as plants become stressed as NIR reflectance decreases as a function of cell wall deterioration.

These characteristics allow for discrimination of vegetation types and detection of vegetation stress. The following figure shows the typical spectral profile for vegetation and soil over the five bands (Figure 1).

Further technical details and FAQ are available from www.rapideye.de

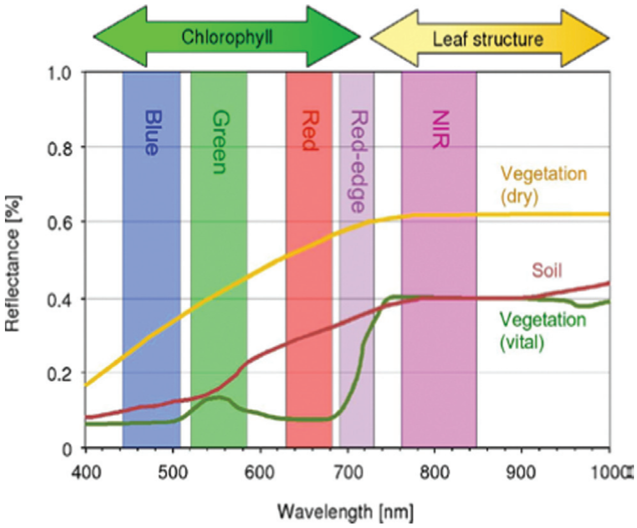

Figure 1. Typical spectral response of soil and vegetation across different spectral bands. These differences allow discrimination of vegetation types or changes in spectral response caused by land use changes (i.e. harvesting).

RapidEye has been actively acquiring satellite data since 2010. The coverage as at October 2010 is shown in Figure 2.

Figure 2. National RapidEye coverage as at October 2010.

Applications

The application of satellite imagery ranges from supplementing existing GIS datasets to providing critical base information. This is especially applicable in newly developed areas or in cases where detailed forest survey information is not available.

The immediate applications of satellite imagery to forestry are identified as:

- operational monitoring - i.e. harvesting and the success of plantation establishment;
- mapping of wind & snow damage and erosion events; and
- delineation of forest species and boundaries.

The following examples illustrate the different applications. The first example (Figure 3) shows an automated classification. The classification effectively:

- separates harvested areas and forest species (*Pinus radiata* and Douglas-fir);
- identifies areas of low stocking density due to operations such as thinning, variable establishment or wind damage.

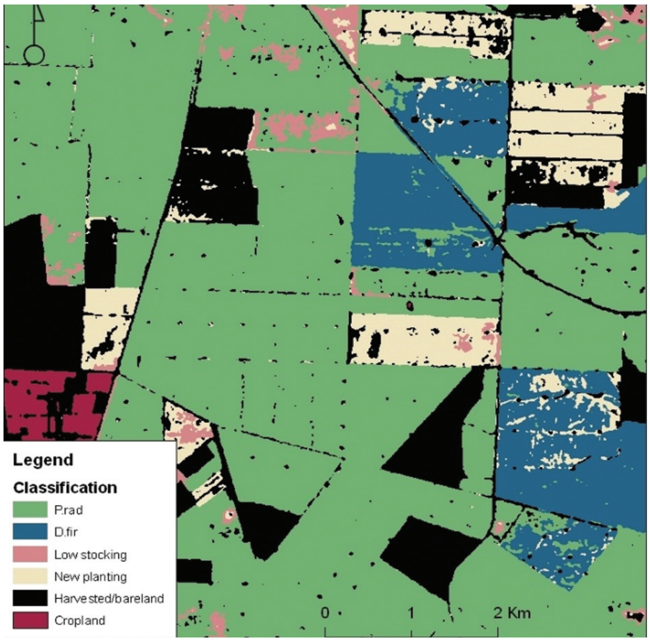

Figure 3. Processed RapidEye image that identifies harvested areas, new plantings and areas of low stocking.

For reference, the coincident image is shown in true colour using the same band combination as conventional aerial photography (Figure 4).

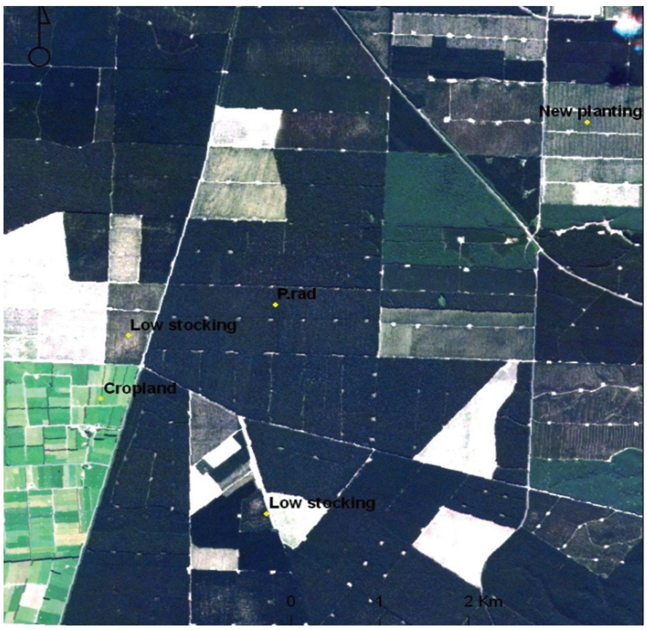

Figure 4. Reproduction of area shown in figure 3 using conventional aerial photography band combinations.

The image shown in Figure 5 covers the same area, but is displayed as a false colour composite that includes the NIR band. This band combination enhances actively growing vegetation and also harvested areas.

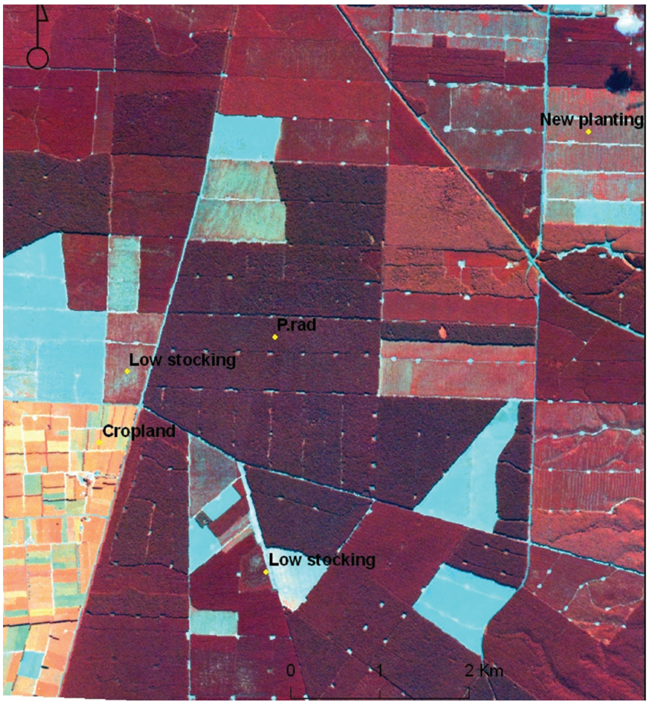

Figure 5. Processed RapidEye image showing the area described in figure 3 using a false colour composite that includes the near infrared band. The use of the near infrared band assists in highlighting the differences in crop vigour.

Several techniques exist for highlighting variations in growth. These include the calculation of vegetative indices using different spectral bands. The following two examples show newly established and young plantations (Figures 6, 7). Variation in establishment within blocks is quite apparent and can be delineated and mapped to a GIS. This information could be used to identify and target areas of poor establishment.

Potential Application

Forest condition could be monitored through repeat and calibrated coverage. This would allow for changes in forest area through harvesting to be automatically mapped.

Concluding Comments

The potential application of high resolution satellite imagery as presented depends on the quality of the existing forest description. The examples presented here illustrate how the imagery can be directly integrated into a GIS, analysed and used to update the forest description using semi-automated methods.

Less emphasis has been placed on the spectral characteristics of the imagery, but there is potential to use the imagery to monitor forest health and to automate processing to provide harvest area updates in a GIS format.

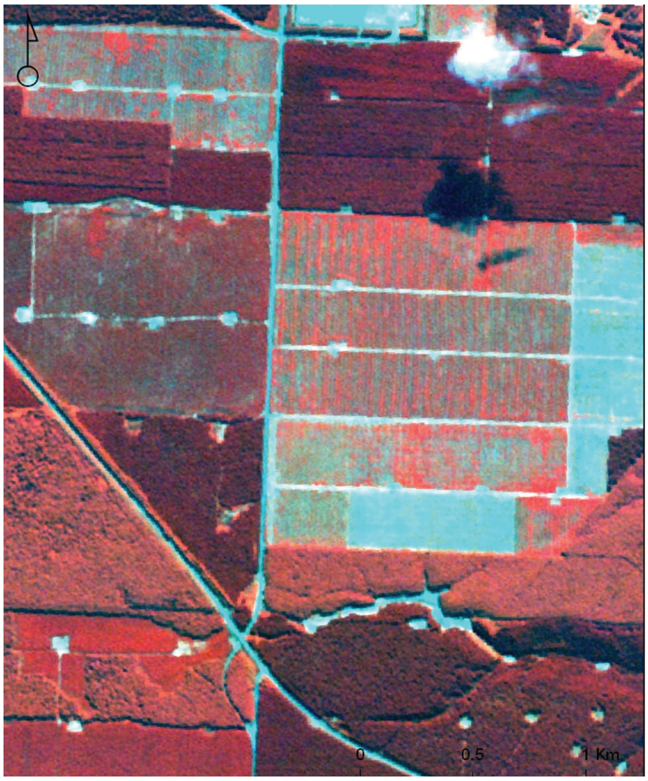

Figure 6. Processed RapidEye image highlighting variation in the spectral response within a newly established block. This variation can be used to assist in identifying areas of poor establishment.

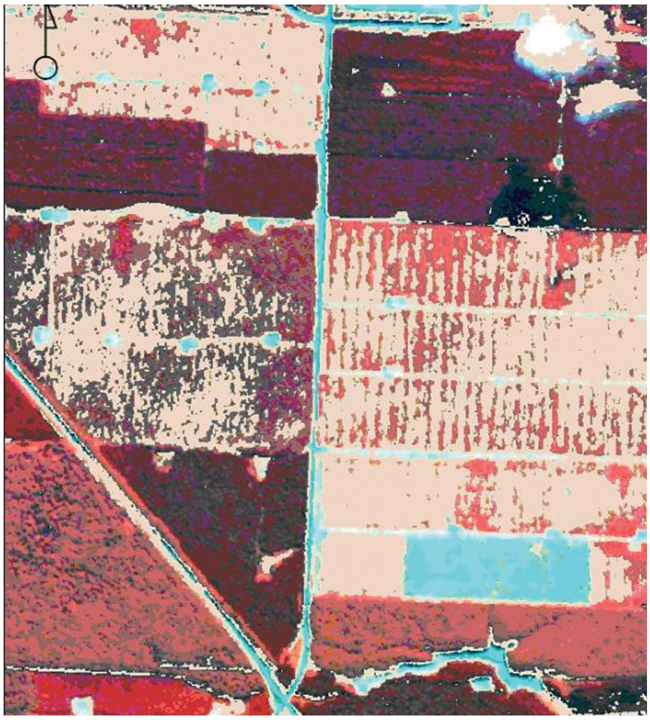

Figure 7. Processed RapidEye image showing the areas of poor establishment within newly planted blocks as mapped from the RapidEye image.