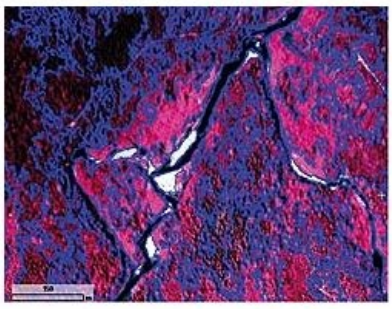
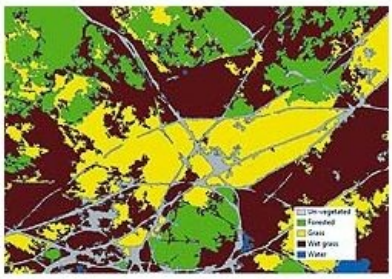
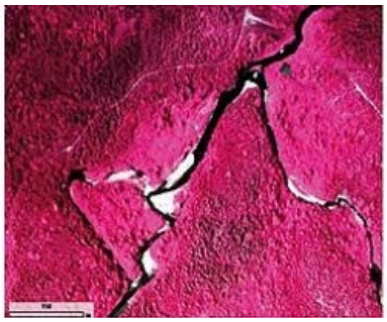
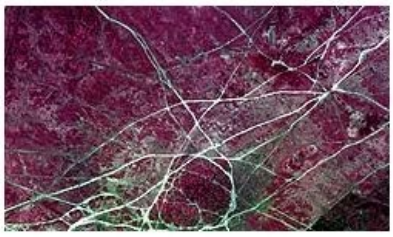
REMOTE SENSING FOR ENVIRONMENTAL PROTECTION AT CFB GAGETOWN

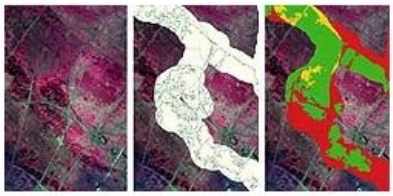
Riparian Buffer Evaluation











Years of environmental neglect and deforestation on CFB Gagetown have unfortunately caused sedimentation in the more than 2,400km of streams on the base. In an effort to control this and maintain environmental sustainability, vegetation reforestation is needed to create â€˜riparian buffersâ€™. These are vegetated areas, usually forested, near a stream, which help shade and protect it from the impact of adjacent land use. The size of the area makes it important to optimise the reforestation process by identifying those areas requiring most attention. This project was initiated to find a way of identifying these critical riparian buffers using aerial imagery and off-the-shelf software.
View Larger Map

Study Area
In June 2008, new colour infrared imagery at 40cm spatial resolution was obtained covering the Kerr Brook watershed of the training area. This 64km2 study area was selected due to the extent of deforestation caused by heavy armoured vehicles. (See Figure 2).

Segmentation
The increase in spatial resolution of aerial and satellite imagery adds additional detail that, while visually appealing, complicates automatic classification of land cover using a pixel-based approach. An object-oriented segmentation approach has proved useful in identifying land cover in high-resolution imagery, taking into account contextual information. So the image mosaic was segmented, grouping neighbouring pixels with similar characteristics using Definiens eCognition software which allows use of either a nearest-neighbour or rule-base fuzzy-logic algorithm for classification (See Figures 3 and 4). However, the latter seemed impractical because of the extent of the study area; it would have been impossible to determine rules that accurately represented the multiple photos. Such rules would apply to the study area, but not necessarily to the remainder of the Range and Training Area, so to keep the process generic the rule-based approach had to be dropped.

The feeling was that a Maximum Likelihood classification algorithm would yield more accurate results than the nearest-neighbour classifier, but this algorithm is not available in eCognition. It was therefore decided to use the PCI Geomatica software to perform a supervised classification. This way, full use was not made of eCognition and its multilevel segmentation, but priority given instead to ensuring the process could be repeated successfully in the remainder of the training area. The transfer from eCognition to PCI was easily done, exporting the result of the segmentation to a shapefile of object polygons.

The features exported for further classification were Brightness, InfraRed, Red, Ratio InfraRed, Standard Deviation InfraRed and Contrast GLCM (Gray Level Co-Occurrence Matrix). The ratio Infrared representing the value of Infrared band over the sum of all bands to accommodate for variation of exposure between images, while the standard deviation and Contrast GLCM provide a way of obtaining a numerical value for texture inside each object.

Supervised Classification

The exported polygon shapefile next required some manipulation in order to do the classification. PCI Geomatica software was used here to transfer the attributes of the shapefile into individual rasters that could then be combined to form an image. The resulting image file consisted of the six different layers obtained from the segmentation, and could therefore be subjected to a supervised classification (See Figures 5 and 6).

Having access to the study area provided the opportunity to both establish the various classes forming the land cover that would be of interest, and to gather ground-truth information. By combining photo interpretation and ground-truthing atraining layer was created that formed the basis for supervised classification. Maximum-likelihood classification was performed, resulting in a high level of classification accuracy, with a Kappa coefficient of 0.976.

This result needs to be taken in context. When exporting results of the segmentation into Geomatica the image is once again considered a raster for classification. But the polygons forming the image will each be populated solely by pixels with the same DN values; selecting multiple ground-truth pixels in the same polygon could therefore give a false sense of accuracy. It was thus important to verify the final results, not only through photo interpretation, but also onsite assessment. Such visual inspection of the results showed good representation of the land cover. The results were consequently transferred to a polygon shapefile for further analysis.

Spatial Analysis

The resulting land-cover classification is essential for restoration of riparian buffers. But for mapping and modelling sediment flow through the stream network it is also vital to classify the main water channels and tributaries. To this end, streams were digitised from 2007 aerial imagery to include, among other features, the ‘stream order' of each, implying how it is connected to the network. When trying to control sediment flow it is important to emphasise lower-order streams (orders 1 and 2) as it is these that feed sediment through the network.

Given that a healthy riparian zone is 30m wide, a buffer area this size was created around the digitised streams to focus the results of the classification on these zones. Introducing the results of classification into the riparian buffer yielded polygons with associated classes and order of each stream according to where in the network it lay. It was then a matter of determining how particular combinations of land-cover class and stream order affect the riparian zone. Table 1 (below) was used to determine the quality of each riparian buffer.

- Healthy: land-cover class = ‘Forested' with any value of Stream Order
- Unhealthy: land-cover class = ‘Grass/Wet Grass' with Stream Order 3 or greater
- Critical: land-cover class = ‘Un-vegetated' with any Stream Order or land-cover class = ‘Grass/Wet Grass' with Stream Order 1 - 3.

Table 1, Scheme of quality Determination

Symbolising buffer quality using these classes resulted in a map of the study area highlighting riparian zones considered critical (See Figure 7). This information permits efficient allocation of resources throughout the restoration process.

Concluding Remarks

The nature of their work and training mean the military has a tremendous impact on its environment. This has become evident at CFB Gagetown, where sedimentation in streams is causing concern. Projects such as reforestation of the riparian zones are imperative if the training area is to be environmentally sustainable. Using high-resolution imagery and classification software has proved an effective tool in identifying areas where the quality of riparian buffers is critical, without having to cover the training area by foot. This will prove useful, especially in areas of live fire, where ground access is limited. With reforestation due to begin this summer, CFB Gagetown will have the tools necessary to concentrate restoration effort where needed, thus optimising the control of sediment in streams.

Acknowledgement

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