

Monitoring Mine Reclamation From The Air

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Site reclamation is now an integral part of the development plan and ultimate decommissioning of any mine, and an important part of a reclamation plan is the re-establishment of vegetation on disturbed areas. Plant cover serves to restore biological productivity and habitat, to control erosion, and to generally improve the aesthetic appearance of a decommissioned site. To be considered successful, vegetation reclamation must be self-sustaining, and not require interaction beyond an initial maintenance period.

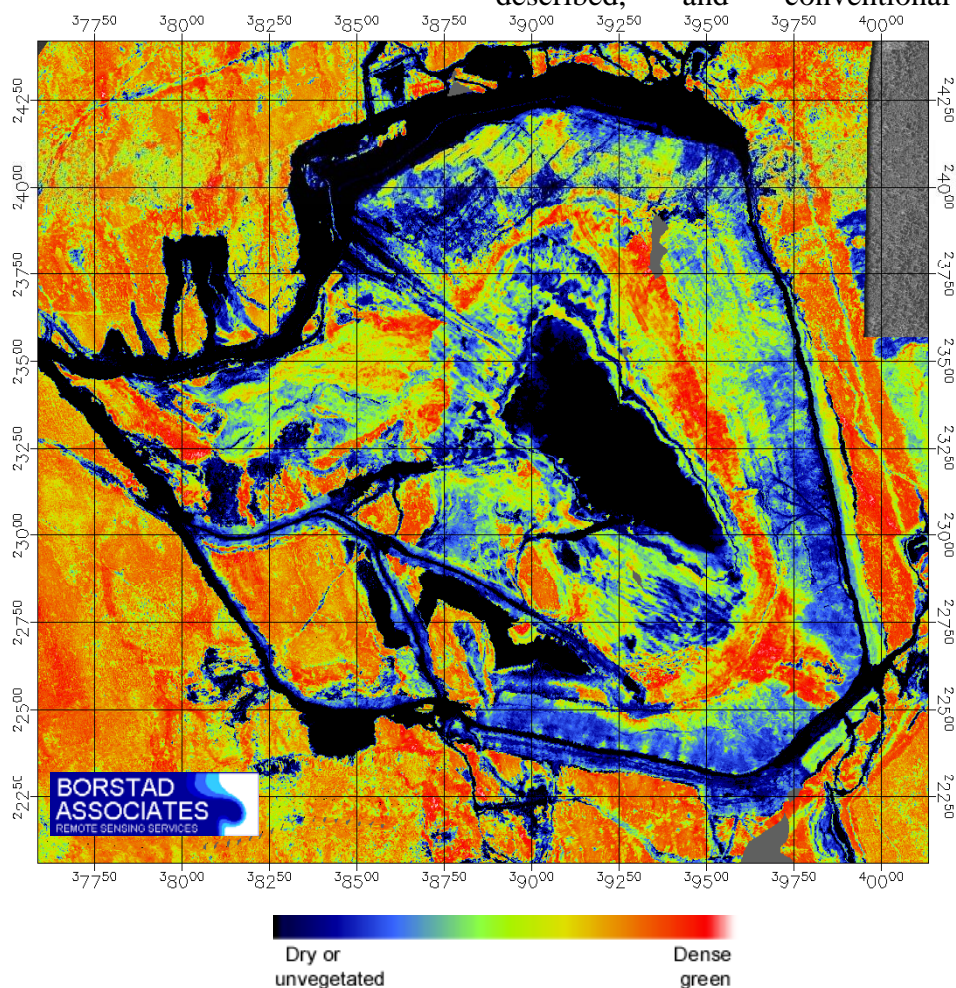
Monitoring programs form an essential component of vegetation reclamation, and are needed to determine when and how well treated sites achieve a self-sustaining state. However on large diverse sites, monitoring can be complex and very expensive. At the Highland Valley Copper Mine in British Columbia, innovative managers are exploring monitoring methods that are more cost effective than conventional approaches, and yet still achieve the end land use objectives. Since 2001 they have used remote sensing as a way of improving the efficiency and effectiveness of the monitoring program.

A portable imaging spectrometer mounted in a small aircraft is used to acquire multispectral imagery over the mine site once yearly during the summer. This instrument measures colour in nine spectral bands ranging from blue to infrared that provide information about the type, density and health

of ground vegetation. The processed data are used to create natural or colour infrared images, as well as vegetation indices and thematic classifications. These high-resolution image products provide complete coverage of the mine, showing roads, trails and other recognizable features as well as the details of vegetation patterns as small as a pick-up truck.

The repeated annual surveys produce an image time series that

sustaining are readily identified, and areas requiring additional maintenance are easily located. If additional maintenance is required, precise areas requiring treatment can be targeted, rather than unnecessarily blanketing large blocks with extremely costly reclamation. Because remote sensing provides a measurement for every point in the image with about a 2.5m spacing, the patterns of vegetation are very well described, and conventional



shows a very detailed picture of the trends in vegetative growth across the entire mine site. Areas that have become successfully self-

sampling issues such as sample placement, spacing and associated error are not a concern. On the other hand, interpretation of

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remotely sensed data can sometimes be problematic. Remote sensing indices are therefore in 2001, monitoring the status of a wetland being established in Highmont tailings pond at uniquely characterized by their colour. Although it can provide an index of plant cover, vegetative biomass or health, it cannot presently provide foliar compositional analysis. On the other hand, remote sensing provides an excellent

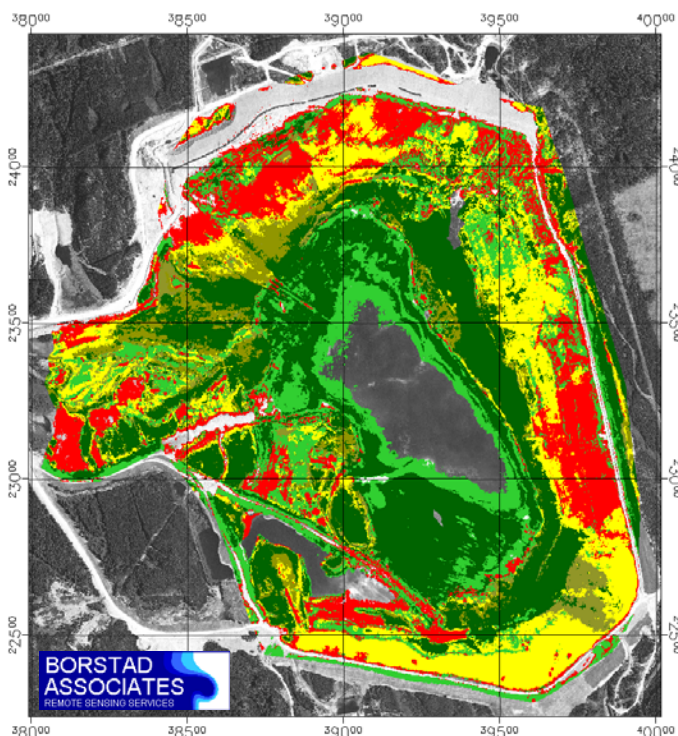
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calibrated with conventional measurements, and quantitative estimates of vegetation biomass are obtained that can be compared with standard criteria for reclamation success.

Remote sensing methods are also being used at Highland Valley Copper to assess aquatic vegetation being re-established in

Highland Valley was essentially impossible because the area was too shallow for boats, and the fine tailings substrate was too soft to walk on. The aquatic vegetation was mapped using multispectral imagery in both 2001 and 2002, and at the time the presence of abundant vegetation in the centre of the pond came as a surprise to field biologists. It was only

synoptic view that permits the more costly, time consuming conventional sampling to be undertaken on a reduced, more selective basis, with the knowledge that any measurements so acquired can be placed within the context of the larger picture provided remotely. The strength of Highland Valley Copper's remote monitoring program is that it



Reclamation Status in 2007

- Successfully reclaimed areas with a vegetation biomass greater than 1500 Kg/Ha in 2007.
- Areas with variable biomass affected by desiccation and above 1500 Kg/Ha in 2007.
- Areas showing a rapid growth that were still below 1500Kg/Ha in 2007
- Areas of very variable biomass, strongly affected by desiccation, and below 1500 Kg/Ha in 2007.
- Areas with biomass much below 750 Kg/Ha since 2001.

decommissioned pits and tailings ponds. This is an important benefit, because these areas can be extremely difficult to sample by conventional means. For example, before remote sensing was adopted

sampled from the ground after the pond was drained in 2003.

Remote sensing does not provide all the answers to a reclamation manager's questions. It does not identify species unless these can be

provides quantitative time series maps of vegetation across the large mine site in a consistent manner. The image maps are intuitive and easily understood by the public.