Defining Invasive Plant Species Spectral Signatures for Mapping of Metro Greenspaces

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Abstract

Metro began investigating hyperspectral imaging methods to quantify individual invasive plant species, plant community composition, and assist in mapping of areas to prioritize for restoration. The first step of this process involves testing a portable hand-held spectroradiometer to gather reflectance spectra of target species, which can later be used to select spectral bands for hyperspectral data collection flights over target natural spaces. Metro also completed a test design plan, species priority list based on testing sites, and a species seasonal attributes list, to help in defining key anatomical features of target species (such as flowering) which can aid in determining the best time of year to collect data from specific species. Effort also began on interspecies plant community assessment methods.

During the summer of 2004, spectral reflectance data (350-1000 nm) as well as GPS location data were collected on Himalayan Blackberry (*Rubus discolor*), Scotch Broom (*Cytisus scoparius*) and several other sample test species by using a commercial spectroradiometer (Analytical Spectral Devices Fieldspec Pro VNIR). Field operations and data collection methods were first defined in the field, then data collected on the target species. The data collected demonstrates differences between tested species over various parts of the visible and infrared spectrum, even within the short test period. Himalayan Blackberry (HB) leaf exhibits ~25% reflectance peak in the visible spectrum (near 550 nm) and 90-100% reflectance in the infrared (720-1000 nm). The berries and stem also exhibit unique signatures. Immature berries (red) have a visible reflectance peak of 25% near 640 nm and an infrared reflectance of 85-90% (800-900 nm). Mature blackberries have almost no reflectance in the visible and minimal in the infrared (5-10%). HB stem has very little reflectance (< 5%) in the visible with a peak near 640 nm and ~65% reflectance from 740-920 nm. Scotch Broom (SB) has less dramatic spectral features (in summer). Overall, reflectance was less than HB (<10% reflectance in visible, peak near 550 nm, ~20% reflectance in infrared broadband), probably due to SB's dark green stem and overall architecture. The data collected is the first step in building a local spectral signature library.

Introduction

Portland Metro is evaluating methods to develop spatial data sets describing the location and landscape setting of selected invasive plant species on 7000 + acres of public lands. As part of this process, Metro began investigating the capabilities of sensors (imaging spectrometers) which measure electromagnetic spectra between ~350-1050 nm at 1nm resolution. We collected "spectral signatures" (Figure 1) to determine if invasive plant species could be identified and distinguished from surrounding vegetation based on spectral information. We expect to use this information in the future as part of a comprehensive plan to develop cost effective greenspace management plans and assessment methods.

The pilot project began with the following plan:

Phase I
 # 1 - Obtain and use spectroradiometry hardware and software in a field setting
 # 2 - Evaluate instrument and band settings to differentiate between selected invasive plant species using spectral analysis

Phase II
#3 - Build baseline data (spectral library)
#4 - Select wavelengths for future hyperspectral image acquisition
#5 - Develop partnerships to solicit for follow-on funding
#6 - Begin cost-effective greenspace management operations

We conducted Phase I tests during the summer of 2004 at Metro Cooper Mountain and Multnomah Channel properties.

Methods

We selected a commercial spectroradiometer system (Analytical Spectral Devices Fieldspec Pro VNIR) for data collection and analysis (Image 1). We spent several days learning the hardware and software functions and preparing for mobile field operations. Data collection methods were then defined and tested in the field at Multnomah Channel, and test data collected on two invasive target species (Himalayan Blackberry (*Rubus discolor*) and Scotch Broom (*Cytisus scoparius*) at the Cooper Mountain Metro property.

Test data were collected under optimal environmental conditions; during sunny July summer days (> 30 K DN) between 10 am and 2 pm to allow for the best possible illumination conditions and to eliminate shadows. Repetitive signature datasets were collected for each plant species using 0.025 meter (1 inch) and 0.15 meter (6 inch) diameter footprint from the target species. Spectral reflectance data were collected on specific plant structures at 0.025 meter to spectrally dissect plant composition and then at 0.15 meter to compare species signatures.

GPS data (corrected to +/- 1 meter) were collected at all sites to spatially link test data to the Metro GIS system.

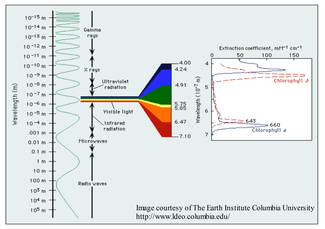


Figure 1 - A diagram of the electromagnetic spectrum. Reflectance data for the pilot study was collected at 350-1050 nm with a commercial spectroradiometer. Living plants absorb and reflect light at specific wavelengths that can be analyzed to discern the species of plant and its health.

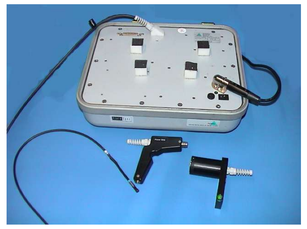
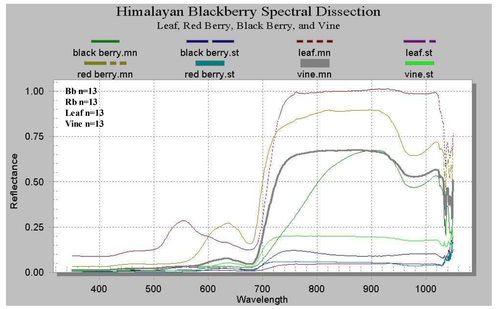


Image 1 - Portable Analytical Spectral Devices (ASD) Spectroradiometer with fiber optic cable, pistol grip, and remote cosine receptor. The spectroradiometer is equipped with a battery pack and shoulder straps for field operations.

Himalayan Blackberry

(*Rubus discolor*)

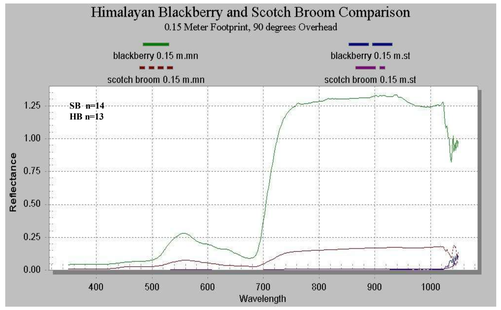


Graph 1- Himalayan Blackberry Spectral Reflectance at 0.025 diameter footprint. Reflectance is measured as watts/square meter/nanometer.

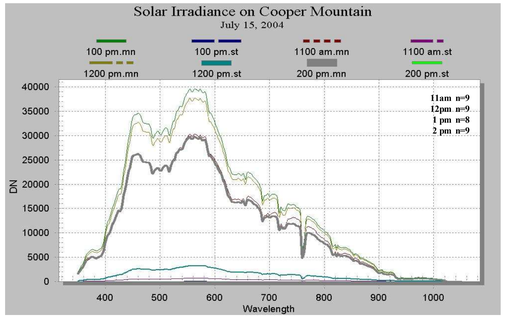
Image 2 - Himalayan Blackberry test site.

Image 3 - Himalayan Blackberry architecture is comprised of broad reflective leaves, berries at different stages of development, and a red stem, all of which have their own unique signatures.

Image 4 - Berry bracts constitute a large portion (~30-50%) of the Himalayan Blackberry architecture in the summer season.



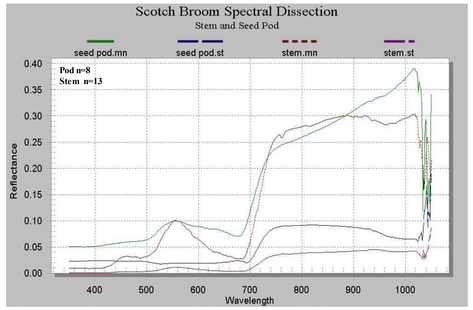
Graph 3- Comparison of Himalayan Blackberry and Scotch Broom Spectral Signatures.



Graph 4 – Remote Cosign Receptor (RCR) data of solar illumination during data collection.

Scotch Broom

(*Cytisus scoparius*)



Graph 2- Scotch Broom Spectral Reflectance at 0.025 diameter footprint. Please carefully note when comparing graphs 1 and 2, that reflectance axes are not equal.

Image 5 - Scotch Broom test site.

Image 6 - Closeup view of SB architecture. During summer SB is spectrally boring. SB has a dark green lowly reflective stalk, no flowers, and begins to lose its small leaves.

Image 7- Overhead view of SB. SB architecture is very sparse and ~50% "open"allowing light to pass through unreflected, which results in a lower spectral reflectance.

Results

The hardware and software tested worked adequately to collect quality plant reflectance data at 350-1050 nm with 1 nm resolution to analyze spectral reflectance characteristics.

Spectral reflectance data were successfully collected on many species, and high quality data were collected on Himalayan Blackberry (HB) and Scotch Broom (SB). The data collected demonstrate spectral differences between these tested species over various parts of the visible and infrared spectrum.

HB leaf exhibits ~25% reflectance peak in the visible spectrum (near 550 nm) and 90-100% reflectance in the infrared region (720-1000 nm). The berries and stem also exhibit unique signatures. Immature berries (red) have a visible reflectance peak of 25% near 640 nm and an infrared reflectance of 85-90% (800-900 nm). Mature blackberries have almost no reflectance in the visible and minimal in the infrared (5-10%). HB stem has very little reflectance (< 5%) in the visible with a peak near 640 nm and ~65% reflectance from 740-920 nm. During the later summer months, berry bracts constitute a large portion (~30-50%) of the Himalayan Blackberry architecture.

SB has less dramatic spectral features in summer. Overall, reflectance was less than HB, <10% reflectance in visible, peak near 550 nm, ~20% reflectance in infrared broadband, probably due to SB's dark green stem and overall architecture. SB seed pods had a wide peak near 550 nm in the visible, and a continually increasing reflectance in the infrared. Seed pods also had relatively high variation (~10%) in the infrared region.

Discussion

The goals of the first phase of the project were mostly successful. The use of the ASD hardware and software were fairly easy to learn and user friendly, and adequately gathered spectral reflectance data for analysis.

Species differentiation was successful with the small pilot study that was completed. Further data collection however is necessary to fully characterize the unique signatures of these and other invasive species. The data products presented are the result of one day of field effort, after three days of equipment and field operations testing. More data collection was planned on other invasive species, but unfortunately the pilot study was cut short due to an accident with the spectroradiometer hardware.

Other parameters also need to be tested including seasonal variation that may allow us to find unique signatures for each species that need to be mapped. Preparation for a hyperspectral imager flight will also involve collecting data with a larger footprint (~1 m) to simulate data collection during a spectral imager flight, grouping reflectance data to mimic the spectral resolution of different airborne sensors, and finding species common spectral ranges to make a future hyperspectral imager flight more effective.

Conclusion

- The equipment and software tested worked adequately to gather spectral reflectance signature
- The study was able to demonstrate that specific spectral features from plants can be discriminated, specifically in Himalayan Blackberry and Scotch Broom.

Future Efforts

Data will be gathered in 2005 on more target invasive species to complete Phase I of the pilot project.

Phase II research will begin classification of plant communities and their unique spectral characteristics. Related to this work, required spatial resolution (~ 1 meter) will also be addressed.

Phase I-
- Continue collection of invasive species spectral signatures

Phase II-
- Continue building a spectral library of species at ~ 1 meter spatial resolutions
- Begin classification of plant communities
- Continue to attract future partners for larger collaborative efforts

Final Goals
- Construct high spatial and spectral resolution plant species maps of Metro properties
- Aid decision making in management of metro greenspaces.

Special Thanks

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There is a lot of data from this pilot study that was not presented in the poster. All data and a daily study journal is freely available online at (http://www.organisyn.com/).