Evaluation of Spectral Imagery as a Tool to Differentiate Among Plant Species

Michael Pence - OrganiSyn Consulting, Lake Oswego, OR 97035,
Jennifer Budhabhatti - Metro Parks and Greenspaces, Portland, OR 97232,
Ralph Garono - Earth Design Consultants, Inc., Corvallis, OR 973331

[Note: This study was funded, in part, by a Greenspaces grant sponsored by the U.S. Fish and Wildlife Service and Metro.]

SUMMARY

Metro used imaging spectrometers to determine if spectral signatures from individual invasive plant species could be identified. The importance of being able to recognize and differentiate these signatures could result in mapping of areas with invasive infestations. The first step involved testing a commercial hand-held spectroradiometer to gather reflectance spectra of target species. Metro prepared a list of target species to be analyzed through spectral signatures. In addition, test runs were done on analyzing spectral signatures from plant components such as leaves, berries and stems.

During the summer of 2004, spectral reflectance data (350-1000 nm) 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, and 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**.**

For example, Himalayan Blackberry (HB) leaf exhibited a ~25% reflectance peak in the visible spectrum of 550 nm and 90-100% reflectance in the infrared spectrum of 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 a reflectance of 85-90% in the infrared spectrum of 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 a reflectance of ~65% in the infrared spectrum of 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

Metro Regional Parks and Greenspaces owns and manages approximately 11,000 acres of property in the Portland area. Most of Metro's properties are invaded by invasive species. Controlling invasive species is costly and time consuming. The suppression of invasive plant species and introduction or expansions of native communities are central goals to most restoration projects on these lands. Monitoring population trends in these communities, and specifically, suites of individual species, is therefore a high priority. Metro initiated an imaging spectroradiometry study to collect widespread, accurate, and precise measurements of a series of plant targets in a platform that will support long-term monitoring.

In the past, Metro has used remote sensing, aerial photo mapping and ground surveys to gather vegetation data. Metro's remote sensing analyses extracted spectral information at a coarse scale without being able to distinguish plants at a species level. Information from aerial photos is limited in its ability to distinguish species level data without a field visit. As a result, the only way to recognize species level information is by obtaining on-the-ground information. Fieldwork is expensive and time consuming and needs to be repeated over time with great precision to yield useful data and reliable trend analyses. For these and other reasons, spectral analyses offers a standardized alternative allowing more cost effective and precise species-level monitoring over a broader region.

Living plants absorb and reflect light at specific wavelengths that can be analyzed to discern the species of the plant and its health. Thus each plant and its associated structures emit a particular spectrum, depending on the structural integrity of the plant. Metro investigated the capabilities of using imaging spectrometers to measure these spectra. These "spectral signatures" were analyzed to determine if invasive plant species could be identified and distinguished from each other and their surrounding vegetation. We expect to use this information in the future to develop cost effective greenspace management assessment methods for control of invasive species.

One application of this method involves attaching an imaging spectrometer to an aerial flight that would fly to the boundaries of our properties gathering spectral signatures. These spectral signatures could then be analyzed to differentiate invasive plant species and their communities. This type of data gathering operation would be helpful in monitoring restoration projects and identifying the spread of invasive species, further reducing the time spent in the field monitoring invasive species, decreasing costs in the long term and increasing efficiency in the field.

Goals and Objectives of the Project

To determine if spectral signatures could be differentiated among invasive species by using an imaging spectrometer**.**

Objective # 1 - Obtain and use a commercial hand held spectroradiometry in a field setting.

Objective # 2 - Evaluate the software and hardware of the hand held spectroradiometry to determine if the band settings in the visible and infrared setting were able to differentiate between selected invasive plant species.

Methods

A commercial spectroradiometer system -Analytical Spectral Devices Fieldspec Pro VNIR (ASD) was selected for data collection and analysis (Image 1). Several days were spent 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 Natural Area.

Reflectance or spectral data was collected at both the visible and at the infrared spectrum ranging from 350 to 1050 nm (Figure 1). Test data were collected under optimal environmental conditions on July 15 between 10 am and 2 pm to allow for the best possible illumination conditions and to eliminate shadows. Repetitive signature data sets were collected by placing the hand-held ASD at 0.025 meter (1 inch) and 0.15 meter (6 inch) from the top of the plant. Spectral reflectance data were collected on specific plant structures by placing the ASD at a distance of 0.025 meter to spectrally dissect plant composition and then at a distance of 0.15 meter to compare species signatures.

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.

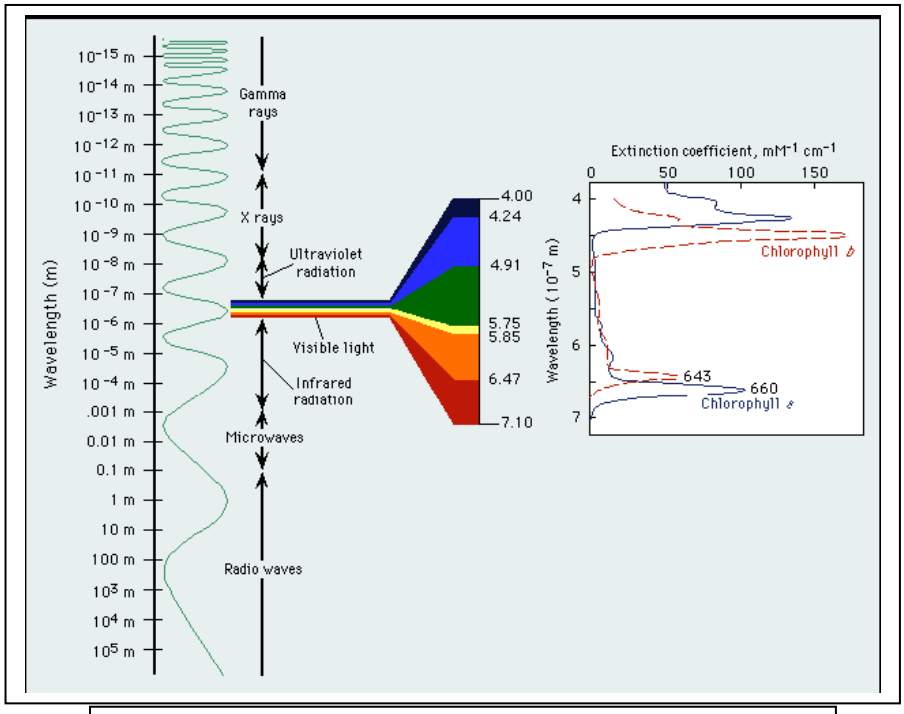
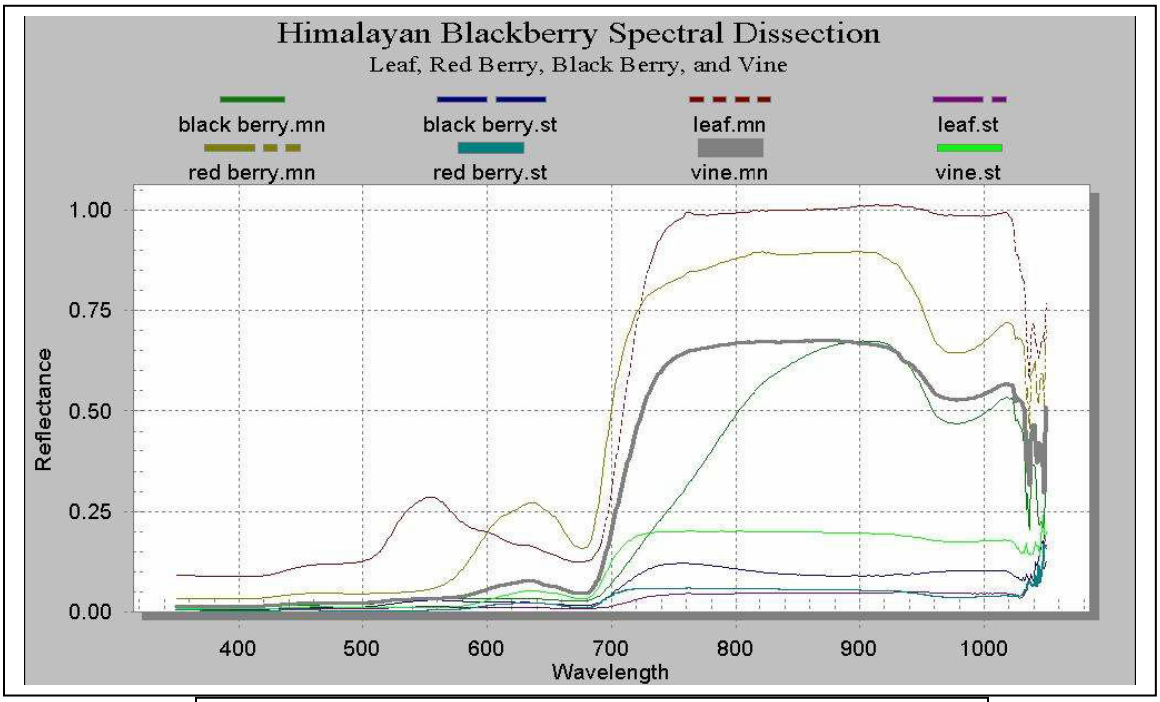
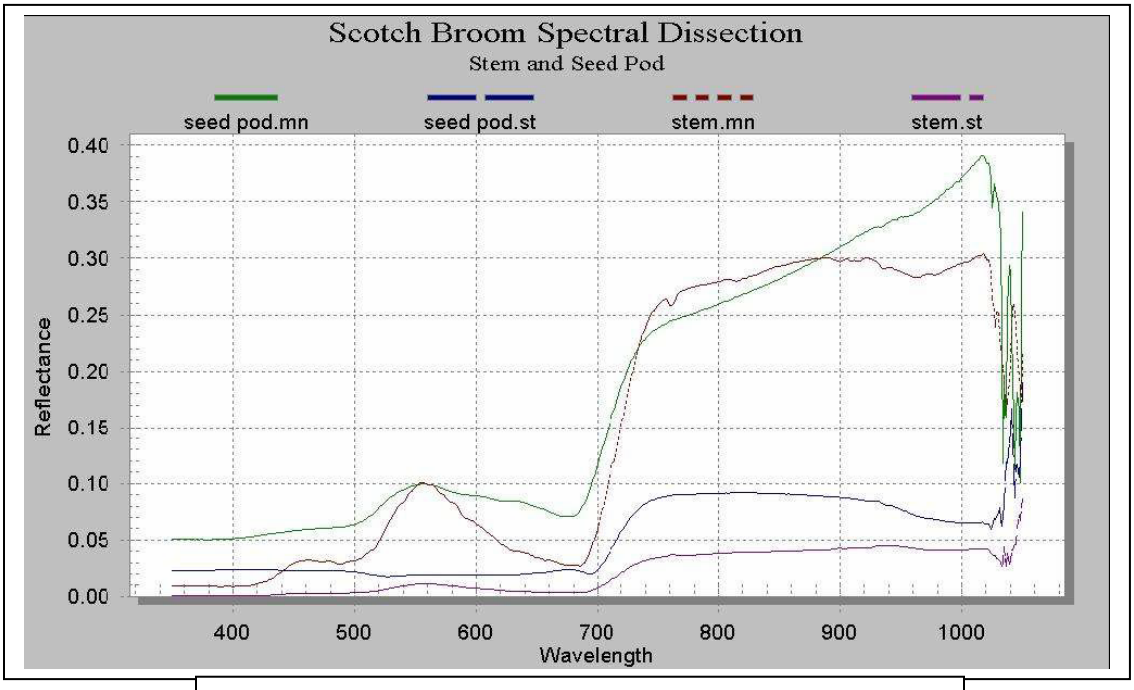


Figure 1- A diagram of the electromagnetic spectrum.



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

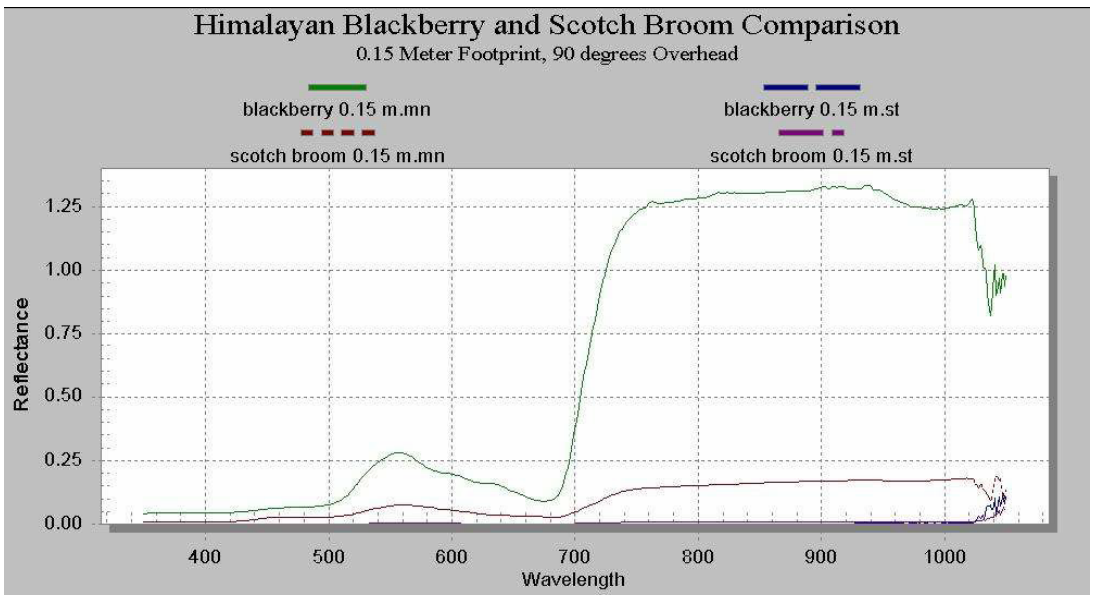
Image 2 and 3 - Berry bracts constitute a large portion (~30-50%) of the Himalayan Blackberry architecture in the summer season.



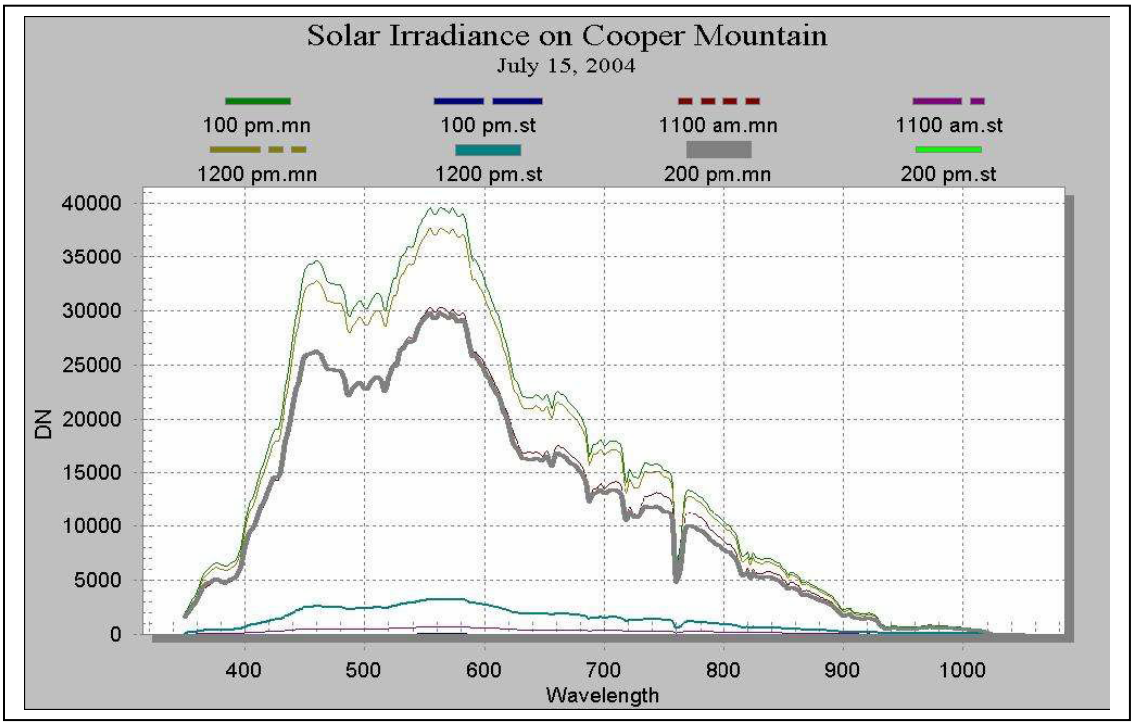
Graph 2- Scotch Broom Spectral Reflectance at 0.025 diameter footprint. Please carefully note when comparing graphs 1 and 2, that reflectance axes are not equal.

Image 4 - Close-up view of SB architecture.

Image 5- 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.



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



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

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 was successfully collected on Himalayan Blackberry (HB)(Graph 1) and Scotch Broom (SB) (Graph 2). The data demonstrated that spectral differences exist between these tested species over various parts of the visible and infrared spectrum (Graph 3).

HB leaf exhibits ~25% reflectance peak in the visible spectrum near 550 nm and 90-100% reflectance in the infrared region of 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 85-90% reflectance in the infrared region between 800 and 900 nm. Mature blackberries have almost no reflectance in the visible and minimal (5-10%) in the infrared. HB stem has very little reflectance (< 5%) in the visible with a peak near 640 nm and ~65% reflectance in the infrared region between 740 and 920 nm.

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 seedpods had a wide peak near 550 nm in the visible, and a 10% continually increasing reflectance in the infrared region of 740 and 1000nm.

Discussion

The project goal was met. The use of the ASD hardware and software was fairly easy to learn and user friendly, and adequately gathered spectral reflectance data for analysis. Species differentiation was successful with the pilot study that was completed. The difference between the signatures could be explained by different structural differences between the two plants. The Himalayan Blackberry structure is composed of leaves and berries, during the summer, which lead to high peaks in the visible and infrared spectrum. Whereas, Scotch Broom has a dark green lowly reflective stalk, no flowers, and has lost its small leaves (Images 2, 3 and 4) resulting in low reflectance. Further data collection, however, is recommended to fully characterize signatures from other invasive plants.

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

Presently, no further activities have been planned related to this project. In the future, it would be important to develop a library of signatures for different invasive and native species. This could be followed up by a test flight to identify spectral signatures and determine if the library would assist in differentiating the spectral signatures from different species

NOTES

More data collection was planned on other invasive species, but the pilot study was cut short due to a malfunction of the instrument caused by an accident. This malfunction and the resignation of the principal investigator resulted in the project ending and the remaining funds being used on another project.

SUPPLEMENTAL INFORMATION

Supplemental information about the hyperspectral imagery project follows. Raw data and field journal entries have been posted at:

http://www.organisyn.com/solutions/biomap/metro/index.html

Biomapping Portland Metro's Greenspaces

Project Plan Draft
May 20, 2004

Michael Pence
Volunteer

Metro Parks and Greenspaces

copywrite 2004 all rights reserved

Introduction

In order to effectively and efficiently manage almost 7,000 + acres of Portland's green space natural resource investment, Metro is proposing to use the latest proven technologies for environmental mapping and monitoring.

What is Metro?

Metro is the Portland Oregon metropolitan area regional government that serves 24 cities and 1.3 million citizens over a 3 county area. Metro provides a regional forum where cities, counties, and citizens can resolve issues related to regional planning and growth. Metro actively plans and manages regionally shared resources. Planning ahead for a healthy environment and stable economy supports livable communities now and protects nature of the Portland region for the future. Metro is the only organization like it in the US, if not the world, and currently 50% + of its budget comes from user fees, make it a self-sustaining governing body. More information about metro can be found at http://www.metro-region.org/

Parks and Greenspaces

A bond measure was passed in 1995 to acquire natural areas with the Portland growth boundary. Since then, almost 8,000 unique and diverse acres have been purchased. The next natural step in this process is to begin manging the lands by restoring them to their "natural state" when and where necessary and monitoring the changes to aid in future long-term management.

Why is this important?

The citizens of Portland, and Oregon in general, realize how necessary it is to preserve natural systems. These natural areas are essential for our own survival on several levels. In the near term it is essential to preserve natural spaces as the area continues to be developed, so they are not lost forever in the rush to build homes, commerce, et, and provide areas to escape from this human-made modern world. In the near and long term, these areas are essential for providing clean air and pure water, and preserving the biodiversity of our region. The citizens realize its better to preserve and manage now, rather than to destroy and try to rebuild later. Preserving these lands also helps in creating a stable, sustainable economy.

Another very important concept to realize, is that we humans don't yet understand how ecosystems function and how humans are currently impacting it. Managing natural spaces is manging a dynamic system, where as much data needs collected as possible to aid in the management process. Collecting the necessary data will help in measuring local human impact on the environment and finding and measuring ways to minimize it.

copywrite 2004 all rights reserved

Metro currently spends ~ $x/year to reclaim and manage green spaces, and we need ways to quantify the effectiveness and success of these methods, while at the same time minimizing the costs, so we are able spend the citizen capital where they can do the most good.

Managing green spaces "by-hand" is still effective in a some cases, but as the area of land increases human management is not scalable. Many areas of properties are not easily or practically accessible by humans, either seasonally or year-round, on a regular basis, so enhanced methods of gathering data are necessary.

One current issue in property management in particular that would benefit from better data gathering methods would be non-native plant invasion. Non-native plants currently reside and are overtaking some properties. Non-native plants decrease the native populations and decrease the normal biodiversity of an area. When a property is being invaded by a non-native plant, due usually to either human disturbance or some other environmental phenomenon, it is necessary to quantify the magnitude and speed of the problem in order to commit resources effectively to solve the problem. The reclamation then needs monitoring to assess the effectiveness and for possible re-invasion or invasion by another non-native species.

Current Mapping of Greenspaces

The Metro region is currently mapped annually with aerial photography at increasing spatial resolution year after year (now at 6 inch spatial resolution). This map data is stored and analyzed in the Metro Data Resource Center using standard GIS techniques and systems. The annual mapping provides a baseline for property management for the entire Metro region.

Evolution of Next Generation Data Collection Methods

In the last decade, methods for mapping "bioresources" have become common and commercial hardware and software products are available for detailed mapping. The next step for Metro is to start using these products and to continue finding ways to gather data efficiently, effectively, and flexibly to monitor land changes and improve management decision making. The Metro Biomapping project would extend the current Metro DRC infrastructure, and use the new proven technologies to take metro parks and greenspaces to the next level of managing properties. These new technologies include using a hyperspectral imaging system that is flown over the properties on various platforms to collect species specific information. This data can then be used to biomap the properties.

Other human enhancement techniques such as gps and laptop/handheld data entry devices can be brought into general day to day property management for field data collection to a central property data repository.

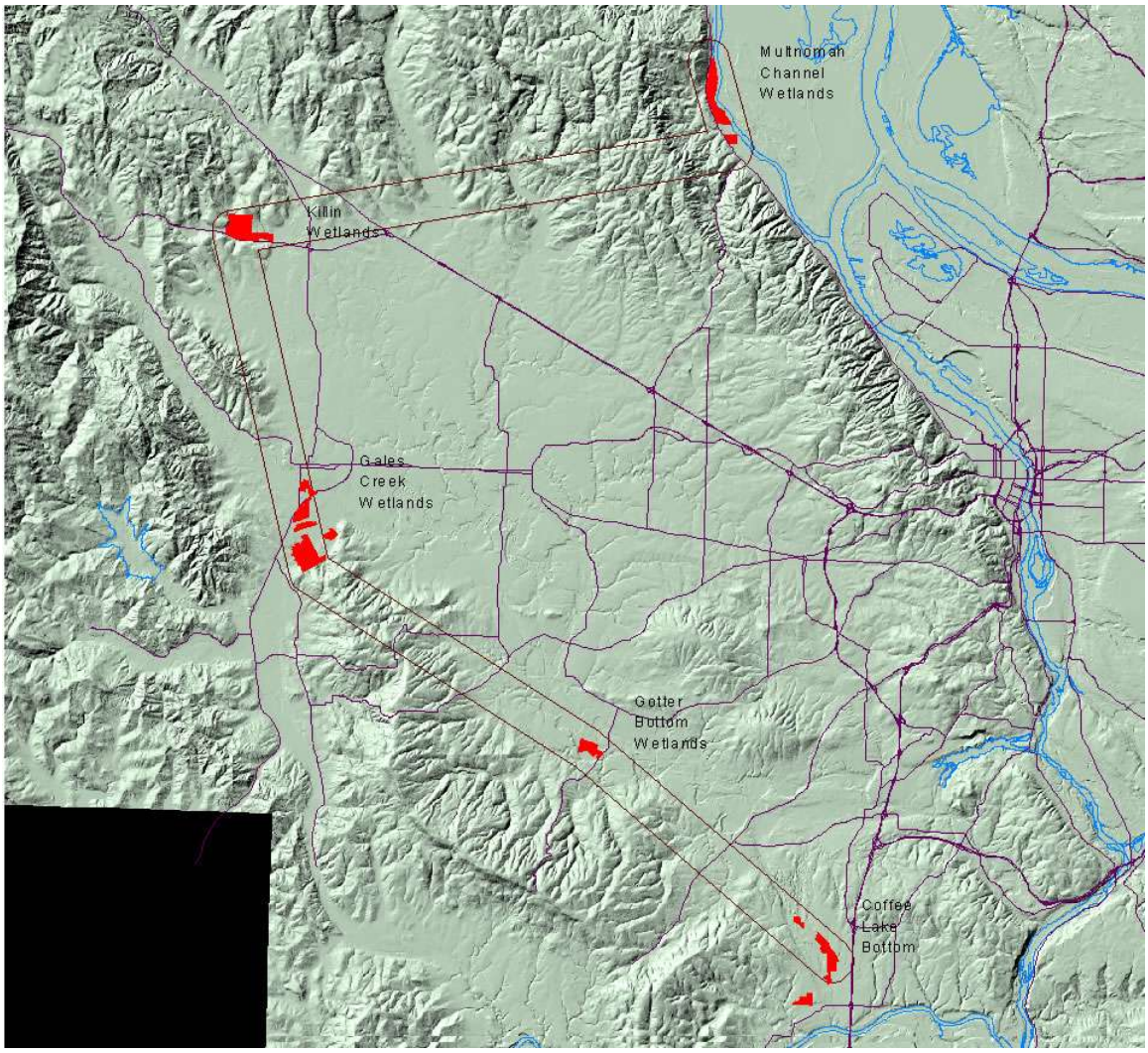
copywrite 2004 all rights reserved

Test Sites

Metro proposes to start using these techniques at several wetland properties.

The test sites to be included in the pilot biomapping study include:

Coffee Lake Bottom
Gotter Bottom Wetlands
Gales Creek Wetlands
Killin Wetlands
Multnomah Channel Wetlands - 326 acres

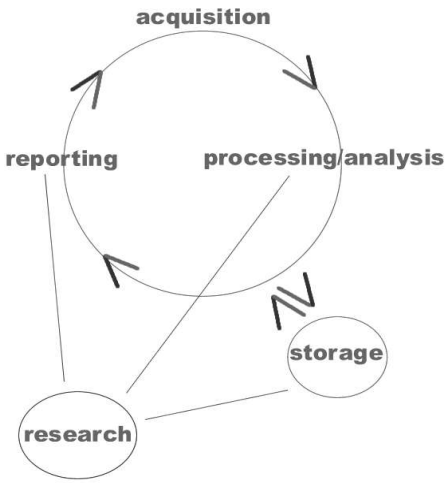


copywrite 2004 all rights reserved

Data/Mapping Flow

The data gathered would be fed into the classic cycle of processing and analysis, and reporting, which would aid in decision making for the properties. The data would bring more questions, which then continues the cycle of data gathering, etc.

Data Management Process Flow



What is proposed for Phase I is to begin preparations for mapping of the sites. This includes gathering natural history data of the sites, developing a bioclassification system of all plant types on the sites, and development of preliminary spectral signature libraries of designated plant types.

Phase I Project Goals

#1- verify use of the spectrophotometry hardware and software
#2- verify differentiation of species with spectrophotometry analysis
#3- pre-select required wavelengths for future hyperspectral image acquisition
#4- build baseline data to solicit for follow-on funding to continue next level of project
#5 optional - practice flight operations w/DRC

Final Goal

(beyond the scope of this project)

#1- build high-resolution plant species maps of metro open spaces
#2- aid decision making in management of metro greenspaces

copywrite 2004 all rights reserved

Species and Location Primary Targets

#1- Reed Canary Grass - Killin Wetlands, Multnomah Channel
#2- Himalayan Blackberry - Killin Wetlands, Multnomah Channel, Coffee Lake
#3- Scotch Broom - Cooper Mountain
#4- Japanese Knotweed – Clackamas

Secondary Targets and Goals

#1- Collect more species data
Ox-eye daisy - Multnomah Channel
Thistle - Multnomah Channel
Oregon Oak - Cooper Mountain
Madrone - Cooper Mountain
Purple Loosestrife- optional- 2nd level of difficulty (wetland/tidal)

#2- Start to build cover classes
- Co-species characterization
- Compare 80%+ monoculture and < 50% mixed culture
- Use Candleton and Green Rules of thumb

#3- Select target species sites as species type control sites

Data Collection Requirements

Spectroradiometer-
will collect spectral data at surface (5-10 mm), .25m, .5m, 1m, 1.5, 2 and 3 meter
will collect 10 datasets from each distance
will attempt to collect flower, vegetative, and architectural signatures per species

Digital Images-
will collect digital images of each spectral signature data collection point.
will specifically search for unique reflectance signatures from species.
will test differences between foroptics.

GPS Data-
will be stored and downloaded to gps/spectroradiometer software as required

General-
will collect spectroradiometer data from 10 am - 2 pm PST to minimize shadow.
will collect solar angle as feasible
will collect timestamp data
will collect all data on datasheet and (optional) transfer to database
will select baseline species sites at each site in preparation for future hyperspectral flight
will make backup data copies to prevent data loss

copywrite 2004 all rights reserved

Procedures

Field procedures will be developed and documented in the field.

Data Analysis

spectral reflectance of all species
% species in digital images
Cosine receptor hourly/daily chart
seasonal irradiance variation chart
sun angle chart
Integration time chart over test series

copywrite 2004 all rights reserved

Phase I Spectroradiometer Field Testing
Field Operation Procedures

20040801

Michael Pence
OrganiSyn Consulting

copywrite 2004 all rights reserved

Equipment Checklist

spectroradiometer
spectroradiometer batteries
spectroradiometer laptop
spectroradiometer calibration card
color calibration card (optional)
gps unit
gps backup batteries
digital camera
(future optional) digital camera w/ video monitor for remote veiwing
digital camera remote control
USB cable
data/note storage laptop
datasheets
black ladder
tripod
tripod booster (black)
height rod (black) w/ markings,torpedo level, and ground planter (stake)
compass
extension cord
plywood sheets, flat latex black, white, green paint.
handtruck
battery
inverter
bungees
tools (TBD)-pliers
tent stakes
4-wheeler

copywrite 2004 all rights reserved

Daily Operations

RULES
Only gather data in ideal conditions
Wear black/dark clothes during data collection to reduce stray reflectance
bring general field supplies - hat, water, sun screen, food

am-
complete equipment checklist
travel time depending on field location

9am
at field location, turn on and warm-up all hardware

10am
RCR data collect
begin gathering data *see detailed operations

11am
RCR data collect

12am
RCR data collect
backup data- SR and Camera
check battery voltages

1pm
RCR data collect

2pm
RCR data collect
end gathering data

2pm+
backup daily data to primary backup
Jim Morgan data download
post-day data review
planning of next days operations
post-day document

copywrite 2004 all rights reserved

***detailed operations for each data collection session**
station handdtruck, check batteries/power
setup ladder and tripod
turn on/enter/ok data logger
enter time on spreadsheet(after each significant event!)
GPS data enter/ok before/after each handtruck move
photograph site and instrument location
photograph target with height rod and compass
pre-calibrate SR(foroptic type,(default spectrum, dark current, and white reference),
check absolute reflectance for spectralon panel
select ok
For any technical issues contact tech support (phone#)

-----FOROPTIC PROCEDURES ONLY --------
FOR RELATIVE REFLECTANCE
- insert fibre cable into pistol grip
- point at spectralon panel
- Optimize
- WR(White Reference), get reflectance value of 1.00
- point pistol at target, gather data(10 readings or more), and save

--------RCR PROCEDURES ONLY ---------
FOR RADIANCE
- point at spectralon
- Optimize
- select RAD
- point at target, gather data(10 readings), and save
FOR IRRADIANCE
- point at spectralon
- Optimize
- select RAD
- point at target, gather data(10 readings), and save
select highest point on plant
measure with height rod
measure height above plant
note: for current configuration (1 meter fiber, 1.5 meter is the max height data collected)
collect image data(lots) to mimic foroptic
collect image data within target zone
position pistol on tripod/boom and collect data, save(10 reps)
collect image down pistol grip barrel for reference
collect as much data as required
GPS data enter/ok before/after each handtruck move
tear down
mark site with tape in case of data loss
move to next site

copywrite 2004 all rights reserved

Personnel Plan

2 FTE

person 1 - operator

duties

setup and maintenance of spectroradiometer(SR), gps, laptops, handtruck

SR data collection

track power consumption

person 2 - data handler

duties

maintain hardcopy records and time

enters data into laptop

keep operator aware of time and targets and daily itenerary

handles and maintains tripod

handles height rod, compass, and level

download backup data after each target data session

gather ancillary digital image data

transfer hardcopy and/or ecopy data to database

References

spectroradiometer specifications- http://www.asdi.com/asdi_t2_pr_sp_fsp_s.html

spectroradiometer techniques- http://www.asdi.com/asdi_ap_en_apnts_f_fsp.html

spectral signature references- http://speclab.cr.usgs.gov/spectral.lib04/lib04-ASD-FR.html

Analytical Spectral Devices, Inc. (ASD) Technical Guide 3rd Ed. 1999.

copywrite 2004 all rights reserved

Radiometer Footprint Measurements

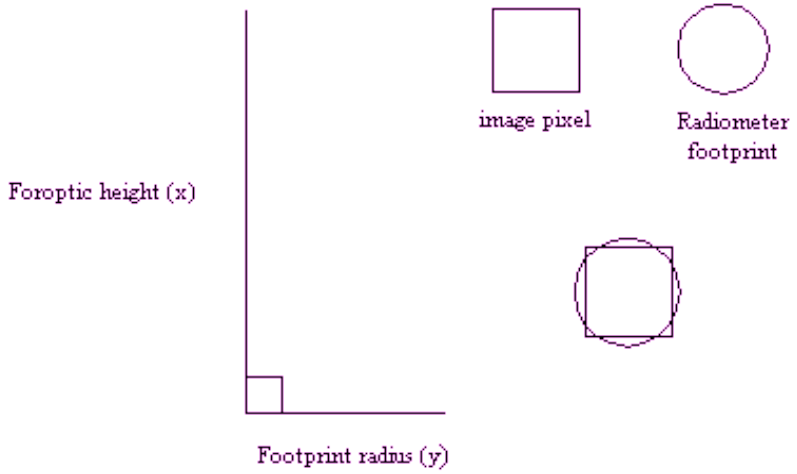
Spatial Resolution (Pixel size)	**0.15 meter (6 in)**	**.25 m (9.84 in)**	**0.5 m (19.68 in)**	**1 m (39.37 in)**	**1.5 m (59 in)**	**2 m (78.74 in)**
Spatial resolution area (square pixel area)	**.0225 m2 (36 in2)**	**.0625 m2 (96.8 in2)**	**.25m2 (387 in2)**	**1m2 (1549 in2)**	**2.25 m2 (3481 in2)**	**4 m 2 (6200 in2)**
Footprint radius (y) ****				**.57 m (22.44 in)**		
Footprint area				**1.02 m2**		
25 degree foroptic height required (x)				**2.58 m (101 in)**		

Circle area = Pi r2

a= foroptic/2
Equation x=y/tan a

x=height
Y= footprint

Double check me on this. The output numbers makes sense.
****I calculated the footprint radius based on estimating the circle area closest to the spatial resolution.



OrganiSyn Consulting copywrite 2004 all rights reserved

3 m (118 in)
9 m2 (13924 in2)

Metro Hyperspectral Project Phase I datasheet

Page of

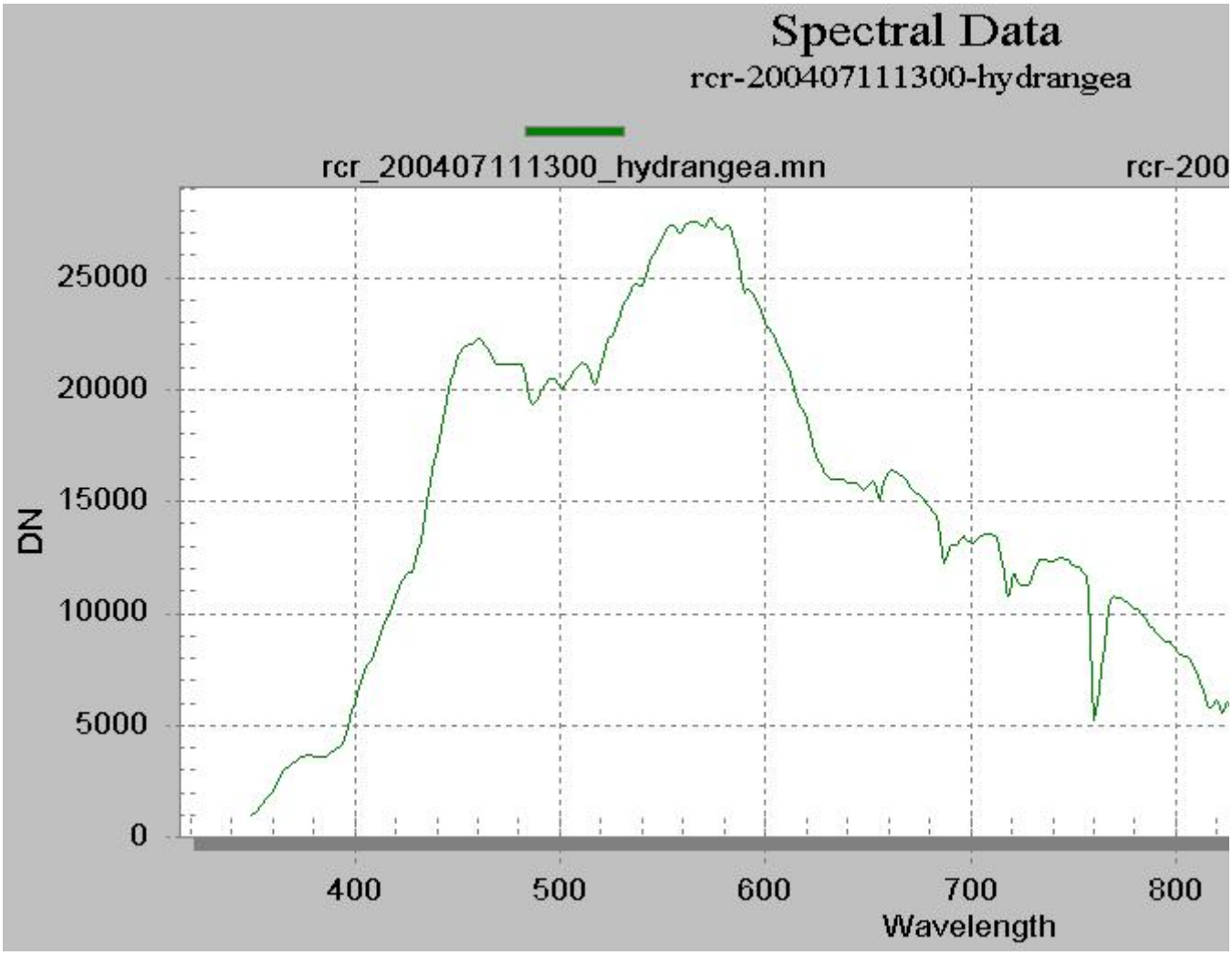
DATE	TIME	SITE	LAT	LONG	Species/Target/Sample	Data Collected	Spectrophoto	Distance	Gps	Cosine	Image #	Other	Intials
							(Y,N)	0,0.25,0.5,1,1.5,	(Y,N)				
												X

Species	Common Name	Origin			Multnomah Channel	Killin Wetlands	Cooper Mountain	Clear Creek	Coffee Lake	Other	
Phalaris arundinacea	reed canarygrass	Exotic	CG								
Alopecurus pratensis	meadow foxtail	Exotic									
Cytisus scoparius	Scotch broom	Exotic									
Rubus discolor	Himalayan blackberry	Exotic	BB								
Polygonum cuspidatum	Japanese knotweed	Exotic									
Lythrum salicaria	purple loosestrife	Exotic	PL								
Salix geyeriana	Geyer willow	Native									
Deschampsia cespitosa	perennial hairgrass	Native									
Deschampsia elongata	annual hairgrass	Native	DE	50/50							
Spiraea douglasii	Douglas spirea	Native	DS	50/50							
Quercus garyanna	Oregon oak	Native									
Carex aperta	Columbia sedge	Native									
Acer macrophyllum	bigleaf maple	Native									
Fraxinus latifolia	Oregon ash	Native									
Salix lucida lasiandra	Pacific willow	Native									
Salix scouleriana	Scouler willow	Native	PW								
Salix hookeriana	Hooker/Piper willow	Native									
Cirsium arvense	Canada thistle	Exotic	CT								
Dipsacus fullonum	teasel	Exotic	TE								
Juncus effusus	soft rush	Native/exotic									
Sagittaria latifolia	wapato	Native									
Scirpus spp.	bullrush	Native									
Nuphar spp.	water lily	Native									
Sparganium spp.	burreed	Native									
Populus balsamifera	cottonwood	Native	CW								
Bidens cernua	beggarticks	Native									
Rosa spp.	roses	Native									
Eleocharis spp.	Spikerushes	Native									
Lupinus polyphyllus	lupine										
Chrysanthemum leucanthemum	ox-eye daisy		OD								
Lupinus latifolius											
Cratageus	European hawthorne		EH								
Agrostis wxcerata			AE								

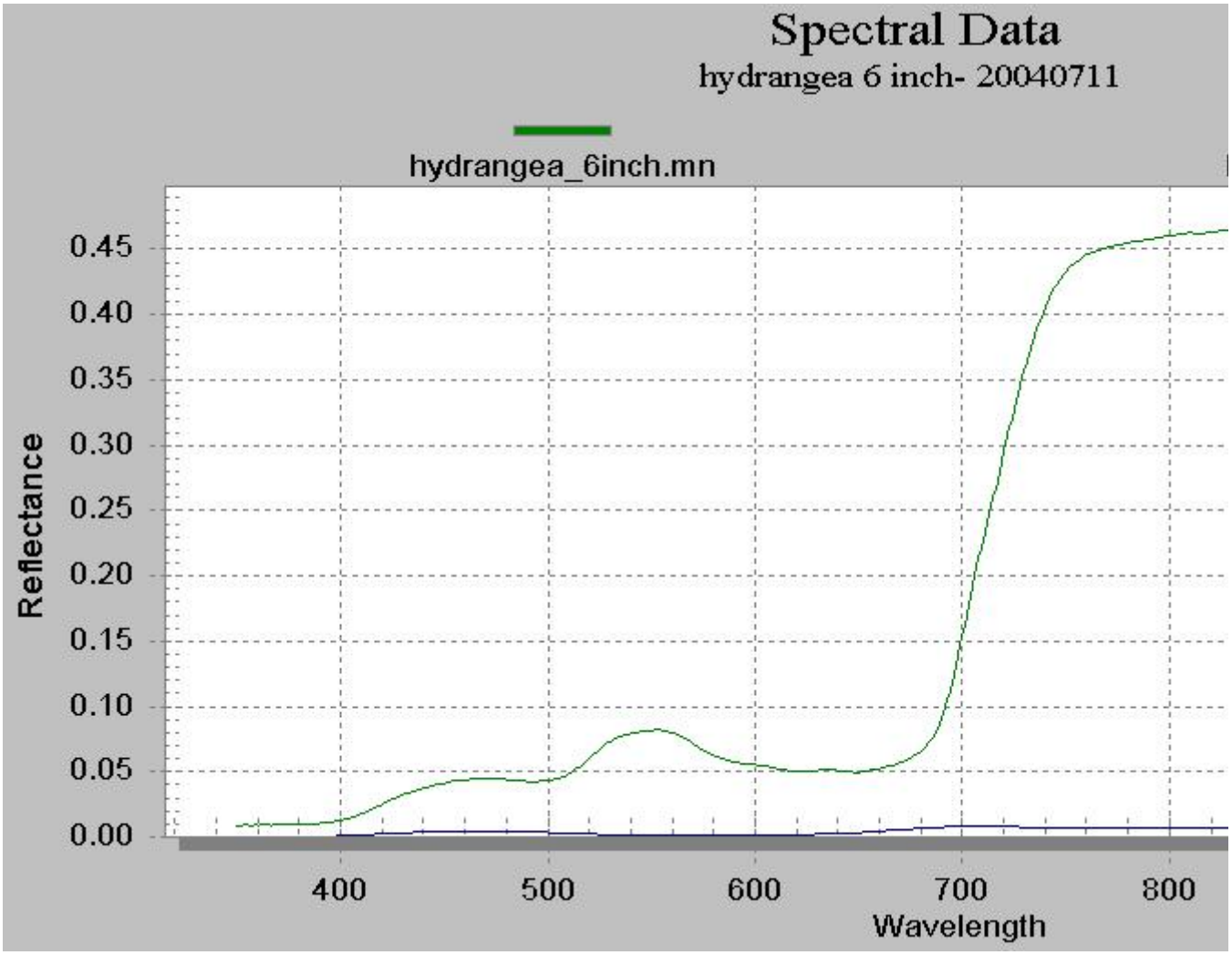
Holcus linatum	Velvet grass		VG								
Lotus coniculatus	Trefoil		TF								
Good Site =											
Potential Site =											

heres some work I did at home just to test the system on Sunday. I also have a little data from thursday and friday but mostly play files.

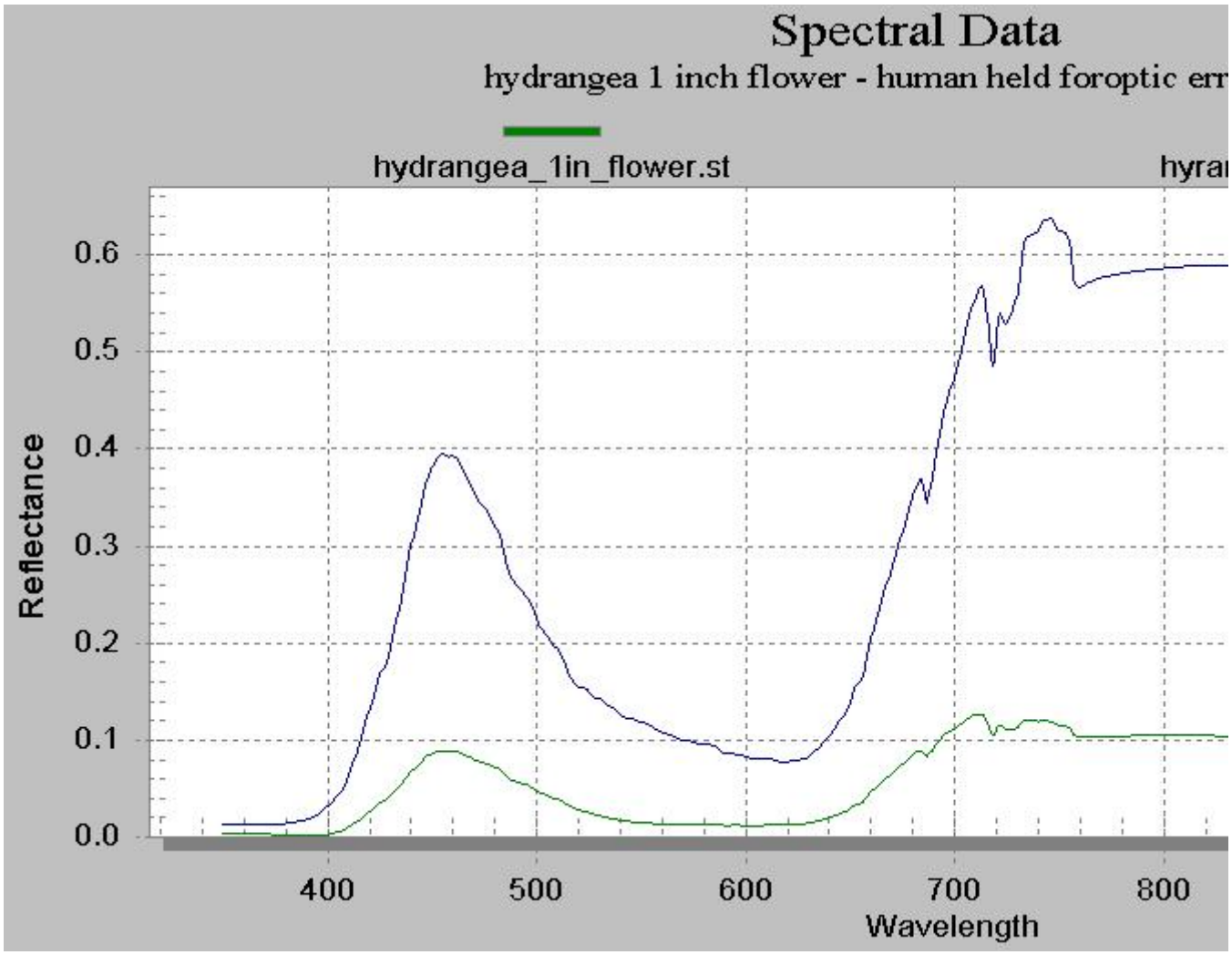
I took a remote cosine receptor reading before and after the session. I have more header data (for integration time etc.). There are at least 10 samples taken for each graph throughout.

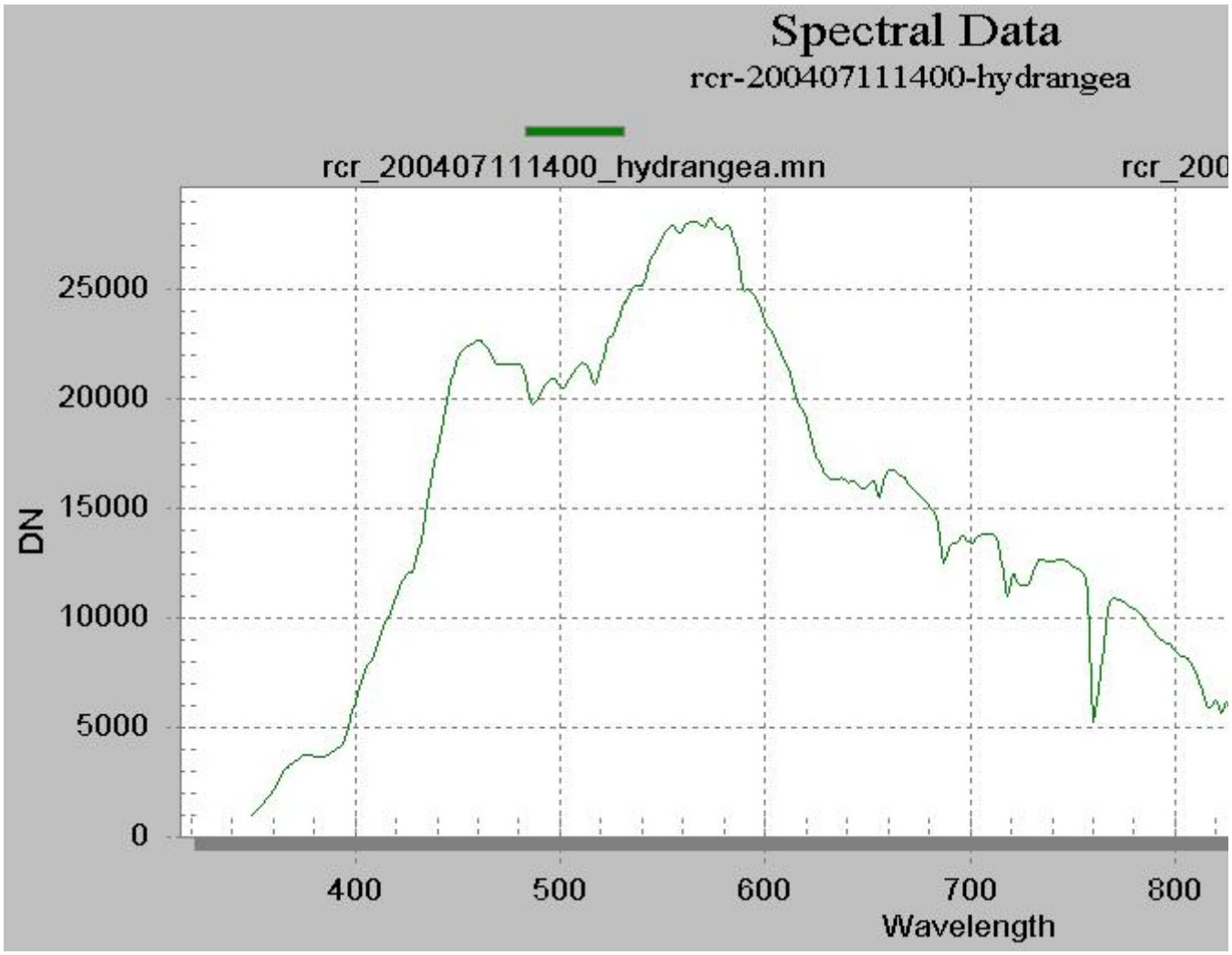


I have a lot more pictures than this, but it gives you and idea of what I'm looking at.



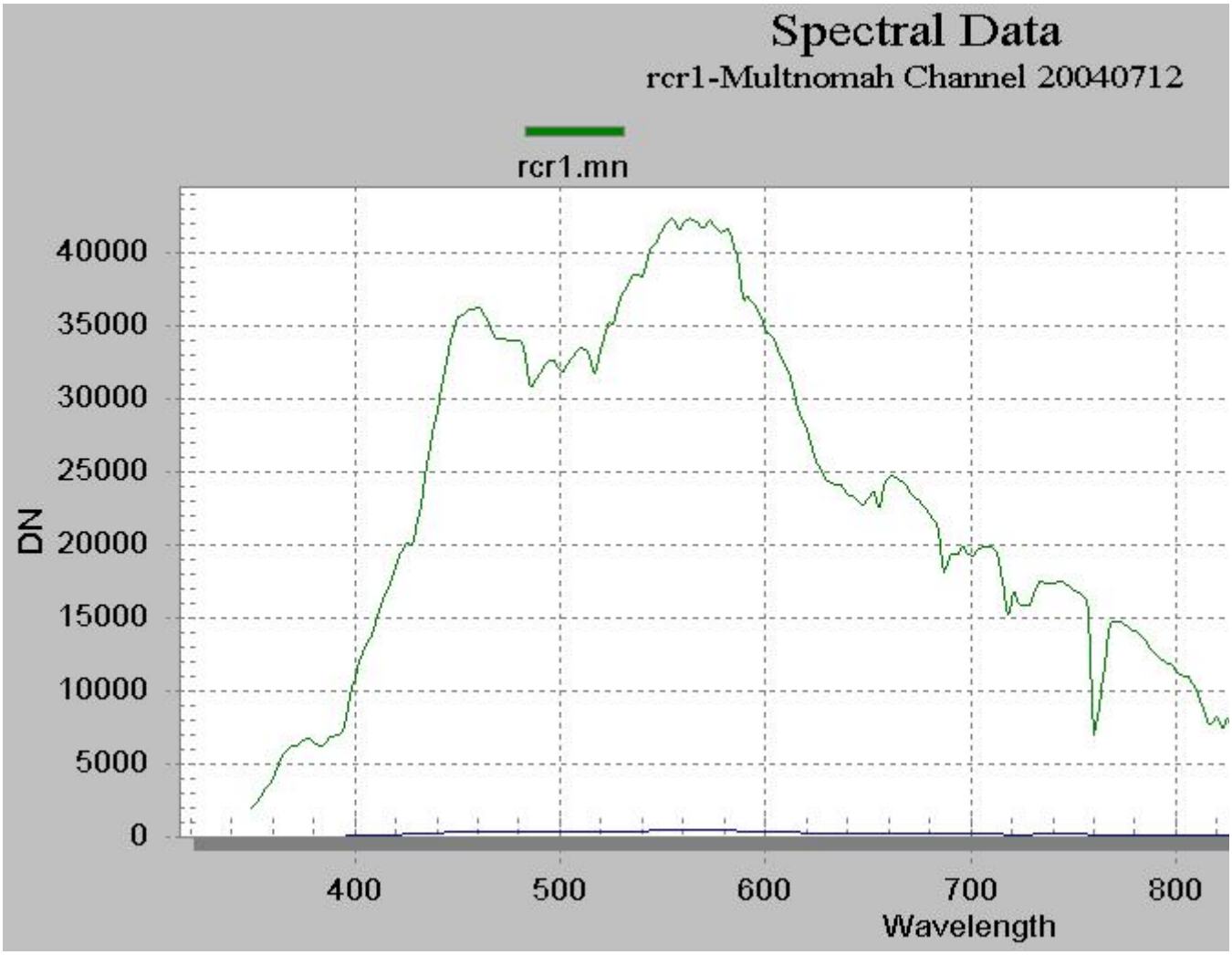
Below you can see the peak in the N-IR range. There is a high amount of std error though. I think its from hand holding of the foroptic. have been doing it all with a tripod since.


Spectral Data
hydrangea 1 inch flower - human held foroptic err
hydrangea_1in_flower.st
hyra
Reflectance
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

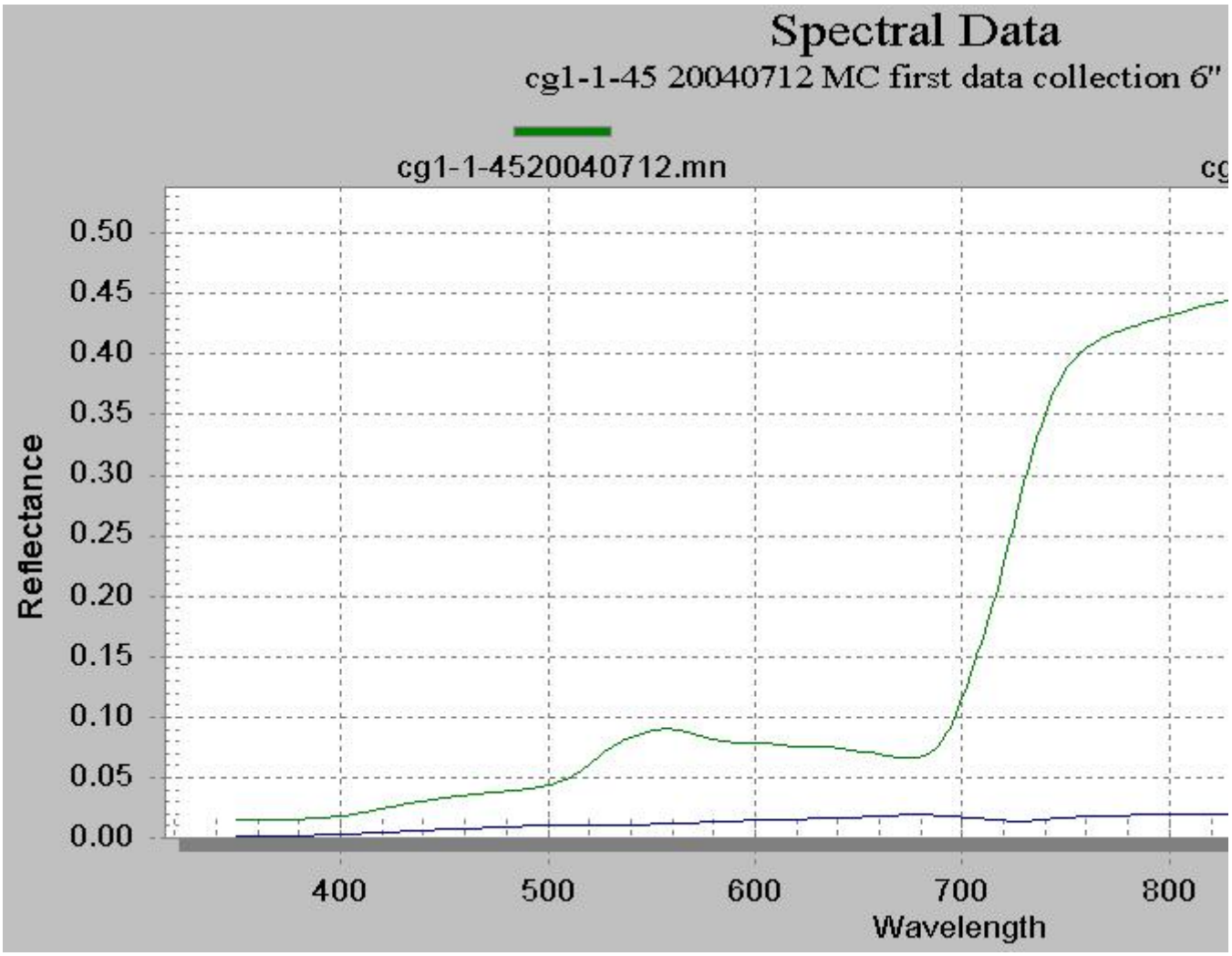

Spectral Data
rcr-200407111400-hydrangea
rcr_200407111400_hydrangea.mn
rcr_200
25000
20000
15000
10000
5000
0
DN
400
500
600
700
800
Wavelength

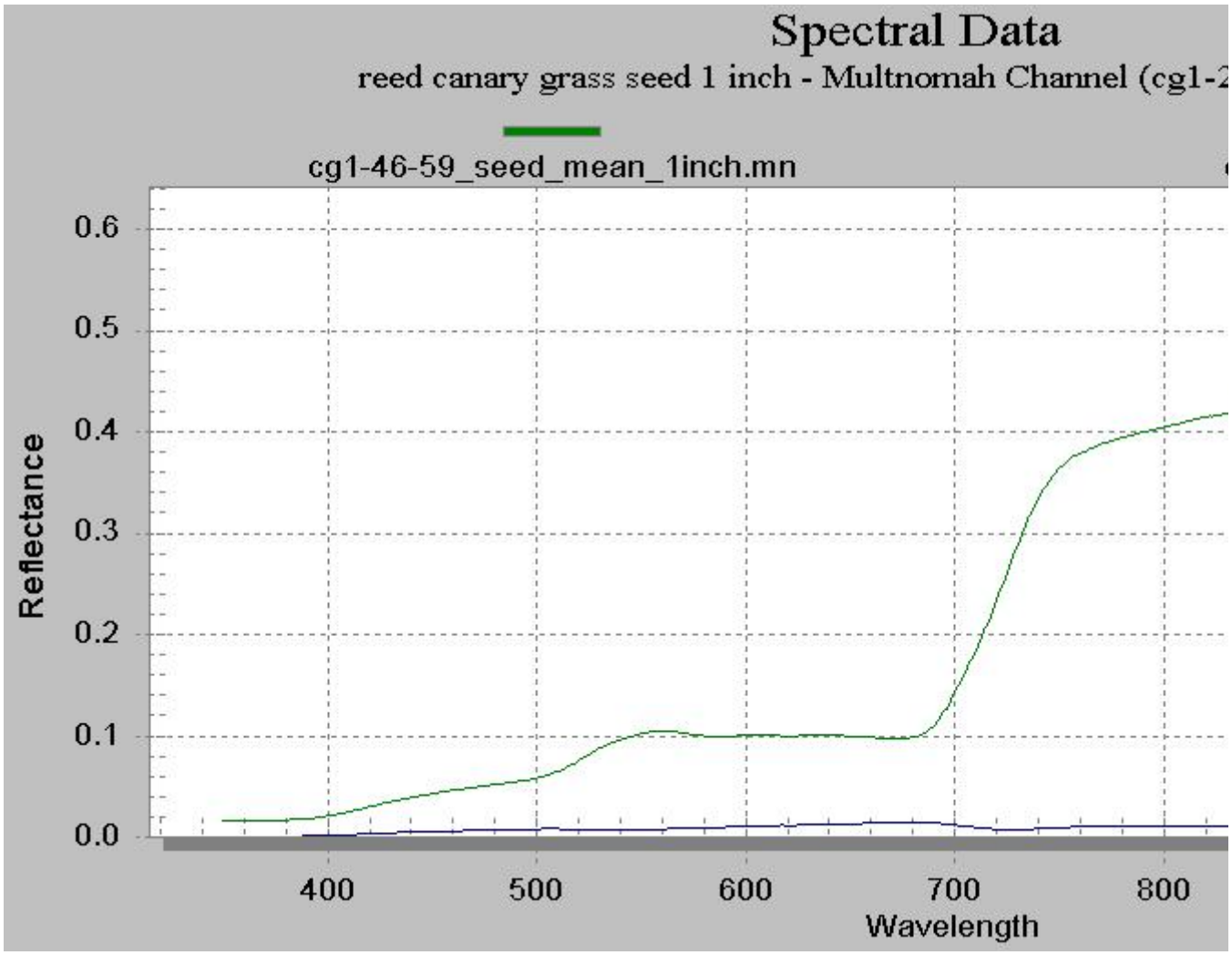
Monday in the field- Multnomah channel and visual survey of Cooper Mountain.

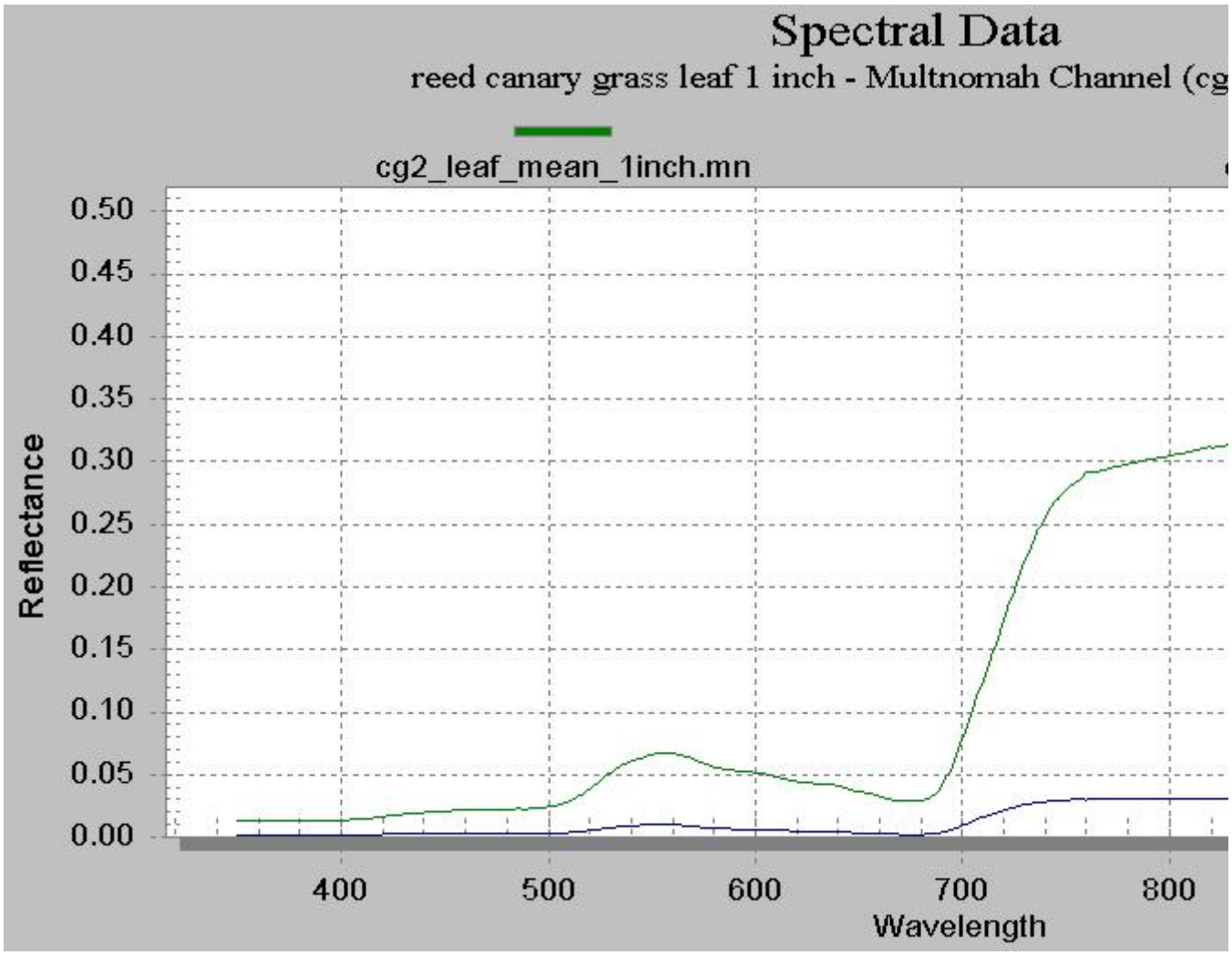
RCR= remote cosine receptor- the 180 degree foroptic. I plan to take a reading once an hour to build a irradiance profile for each day.

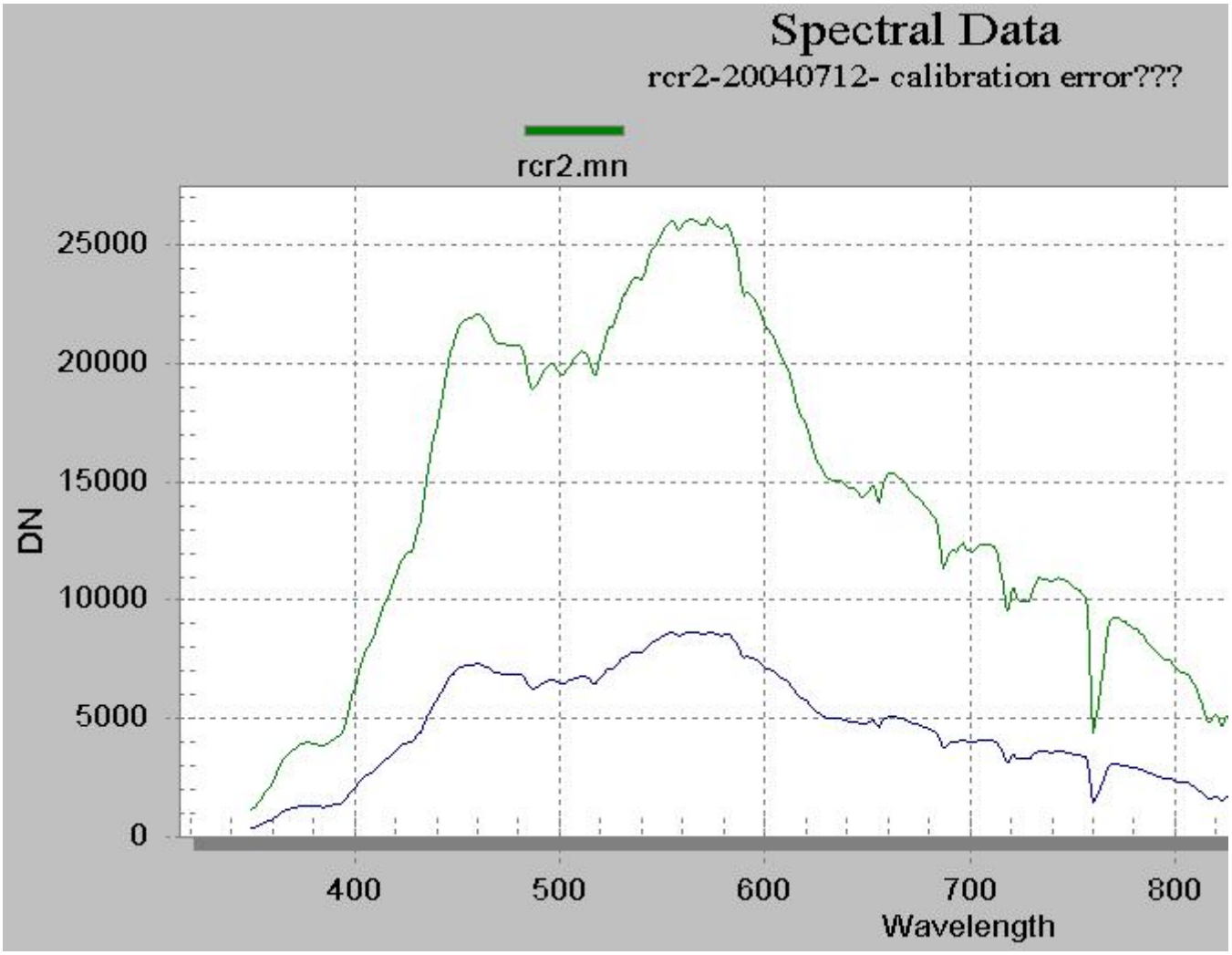


reed canary grass data

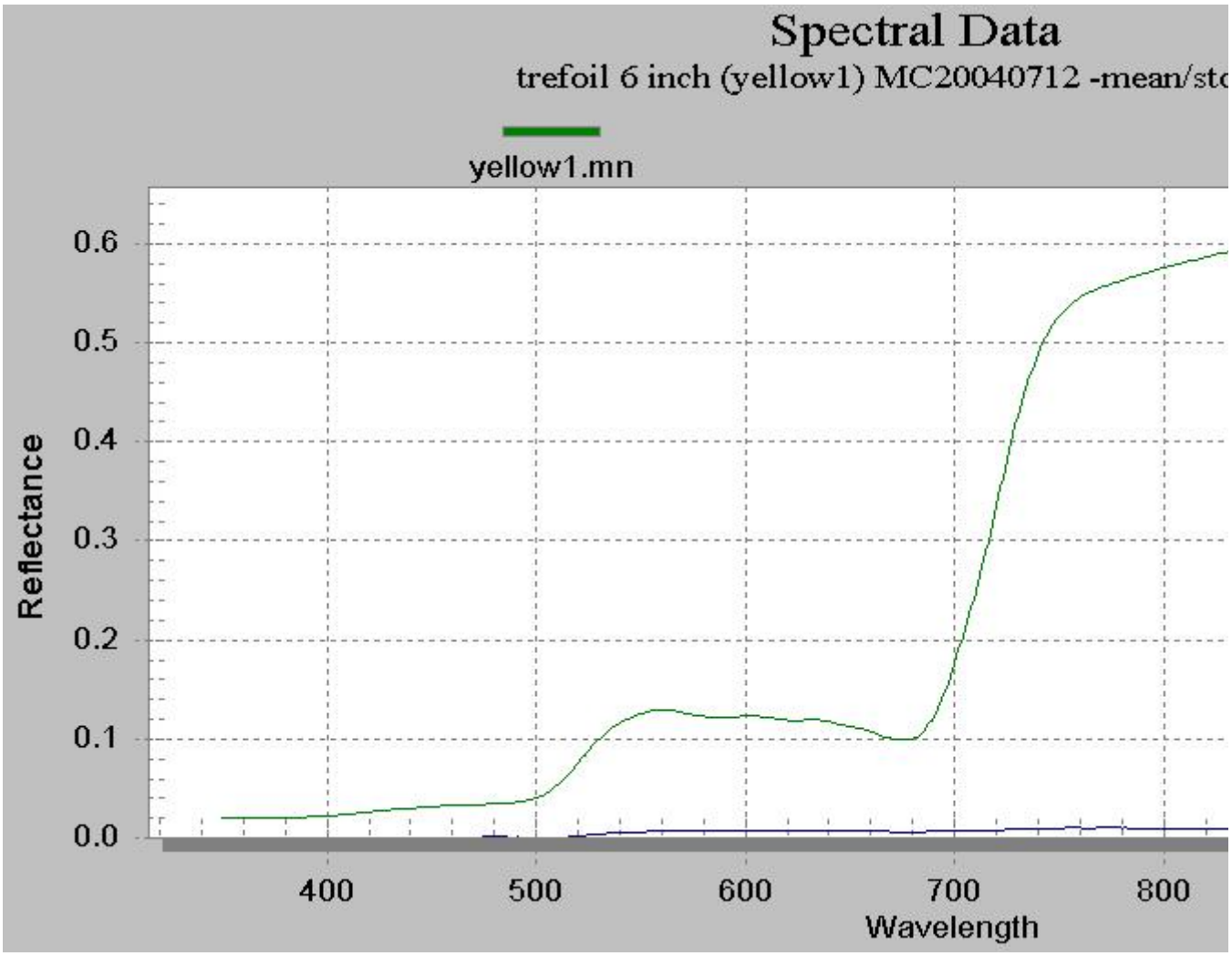

Spectral Data
cg1-1-45 20040712 MC first data collection 6"
cg1-1-4520040712.mn
cg
Reflectance
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
400
500
600
700
800
Wavelength


Spectral Data
reed canary grass seed 1 inch - Multnomah Channel (cg1-2
cg1-46-59_seed_mean_1inch.mn
Reflectance
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

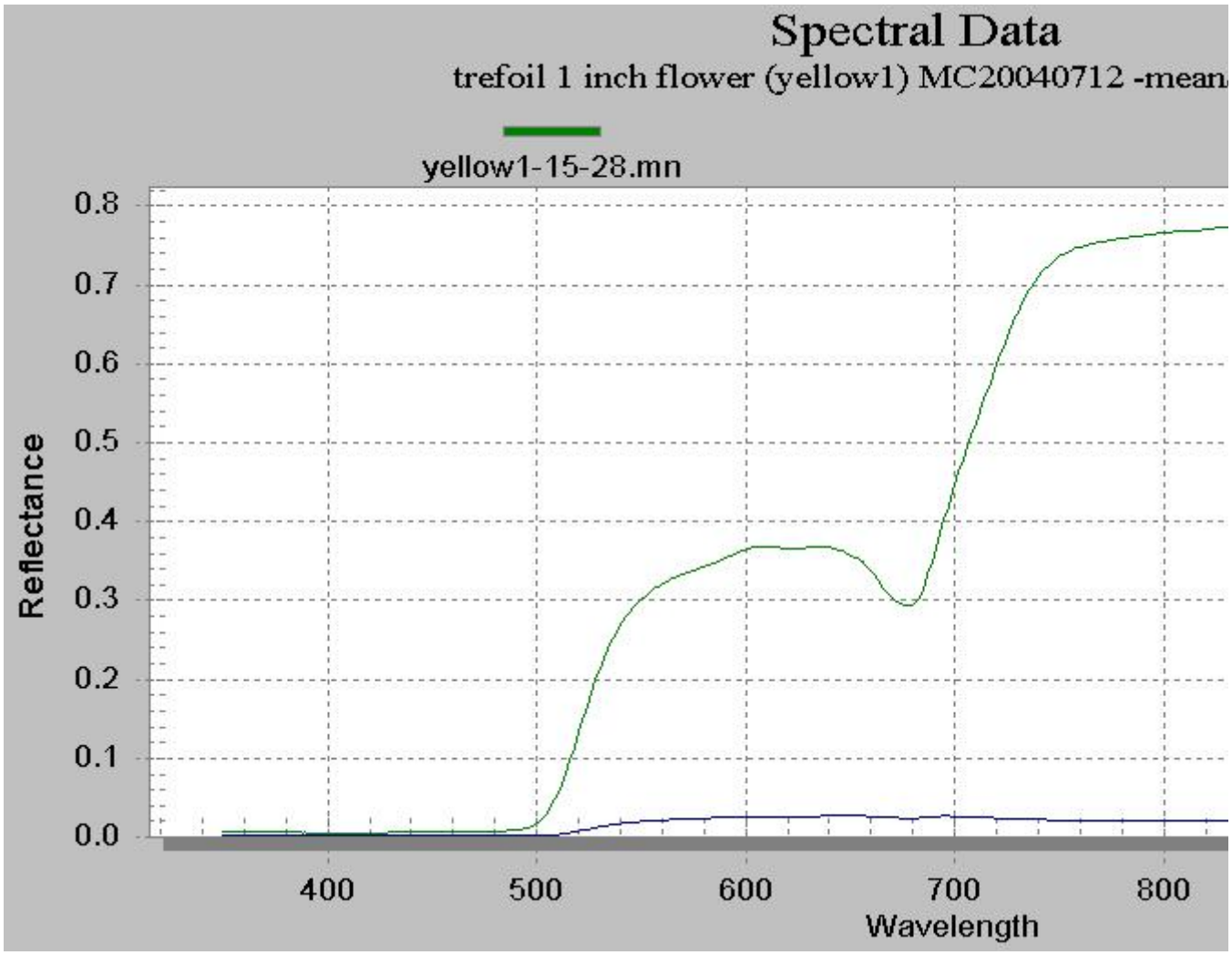

Spectral Data
reed canary grass leaf 1 inch - Multnomah Channel (cg
cg2_leaf_mean_1inch.mn
Reflectance
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
400
500
600
700
800
Wavelength

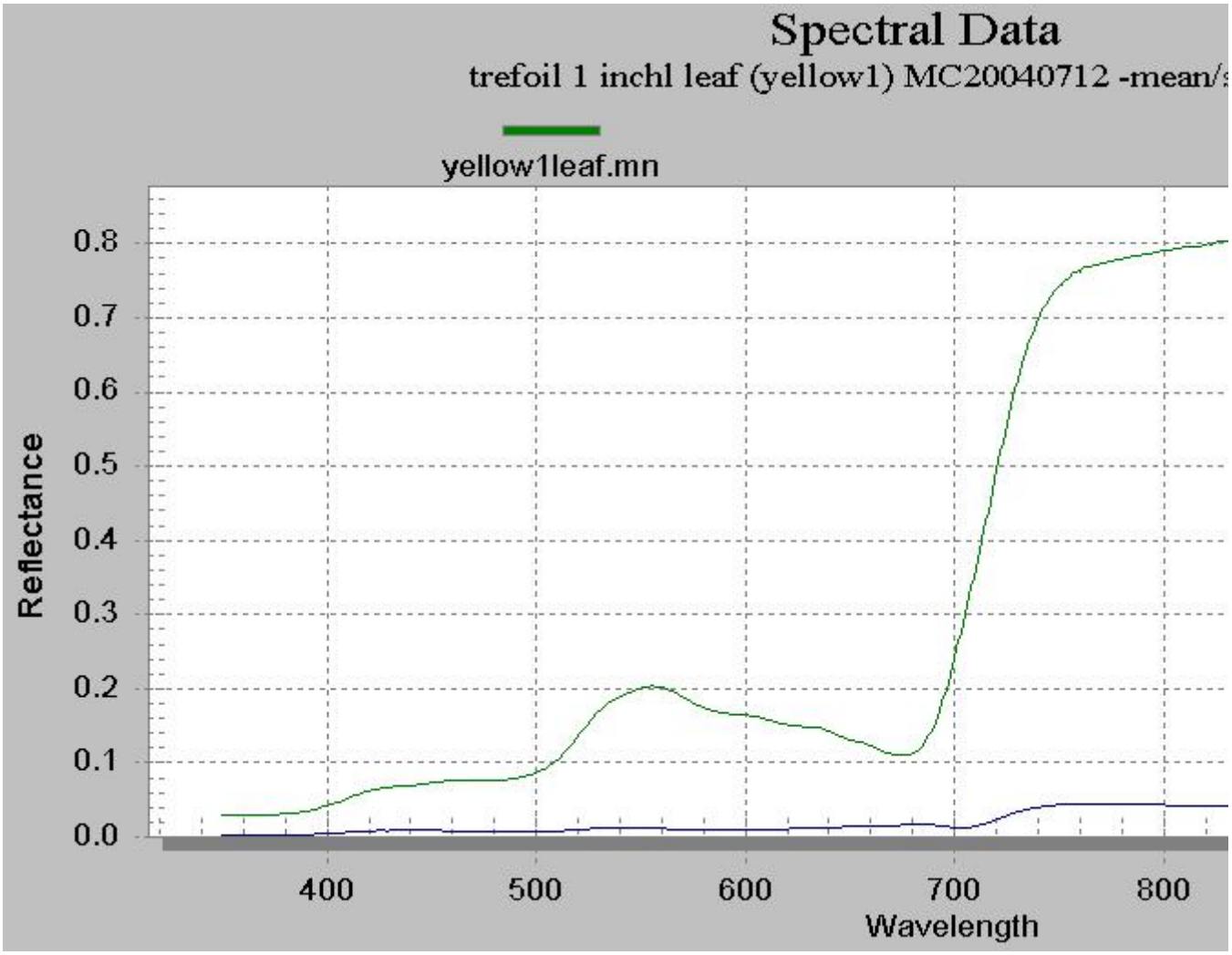


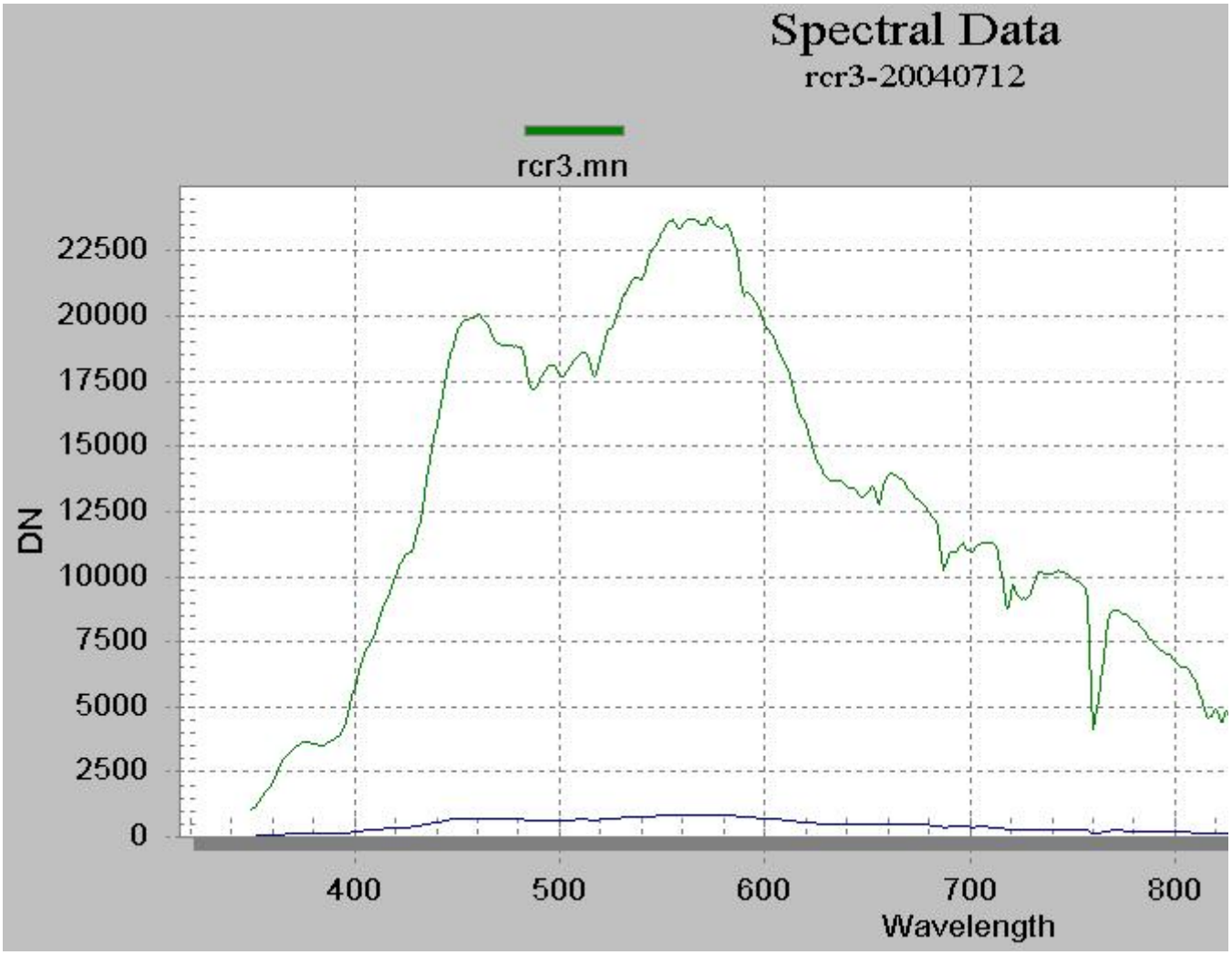
Yellow trefoil data



the trefoil flower has a nice yellow "bubble" around 600 nm


Spectral Data
trefoil 1 inch flower (yellow1) MC20040712 -mean
yellow1-15-28.mn
Reflectance
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

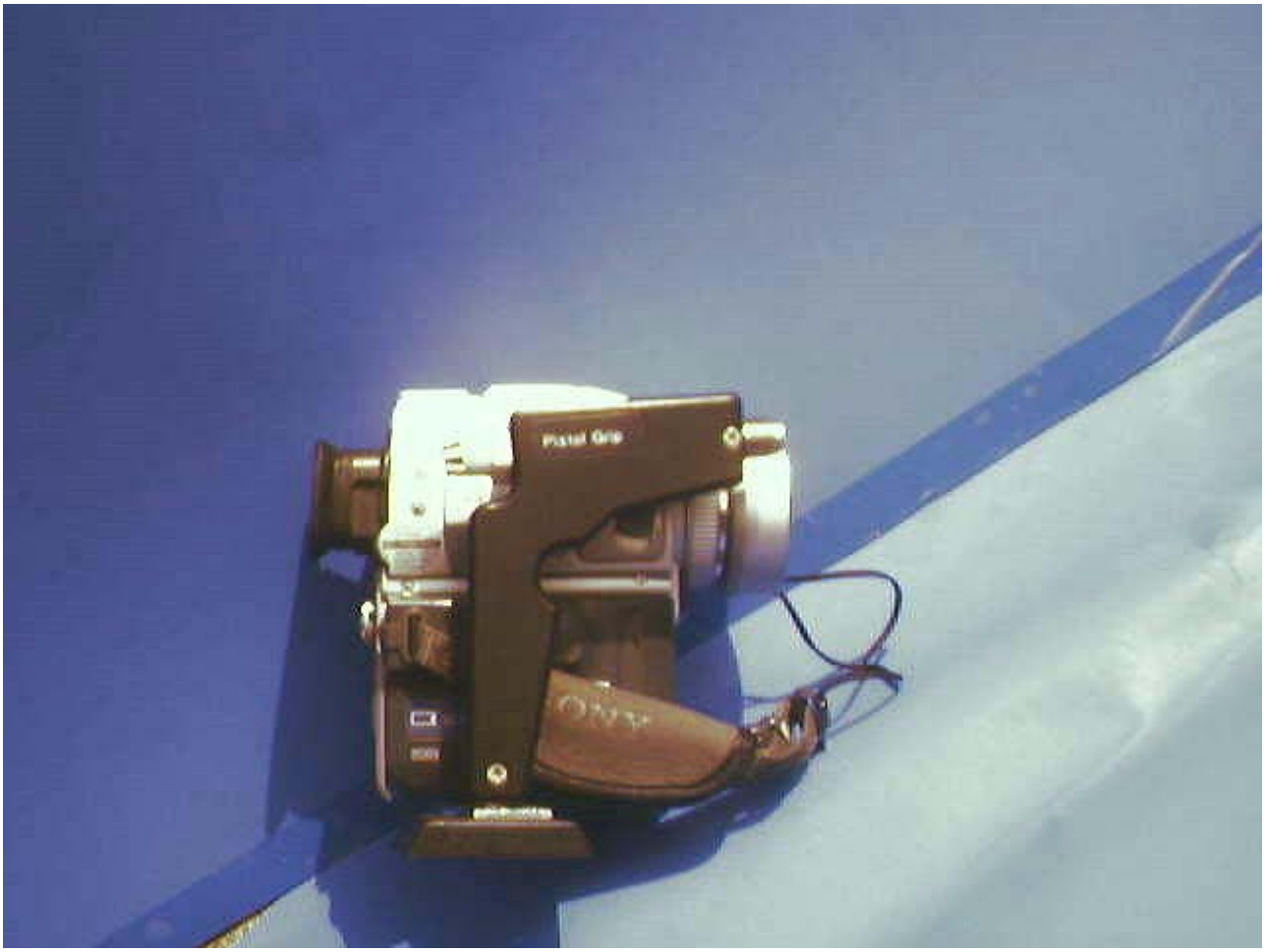

Spectral Data
trefoil 1 inchl leaf (yellow1) MC20040712 -mean/
yellow1leaf.mn
Reflectance
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
400
500
600
700
800
Wavelength



I have more pictures and I keep getting better each day on documenting with images to go with the graphs!

I'll just put up a few pictures from today to show you what I'm thinking about--

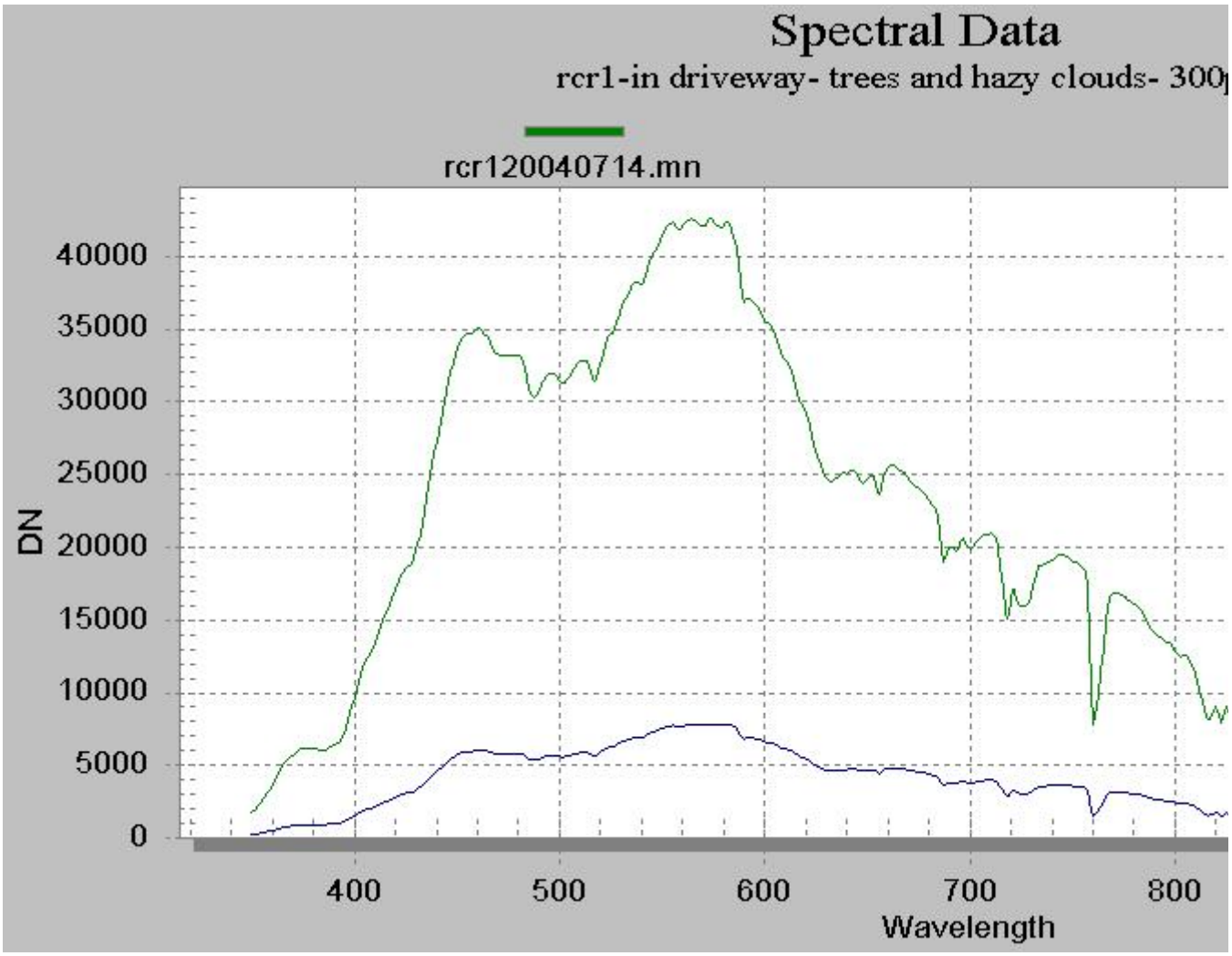
did mostly technique work. These are low quality images- I had the good camera mounted to the tripod.



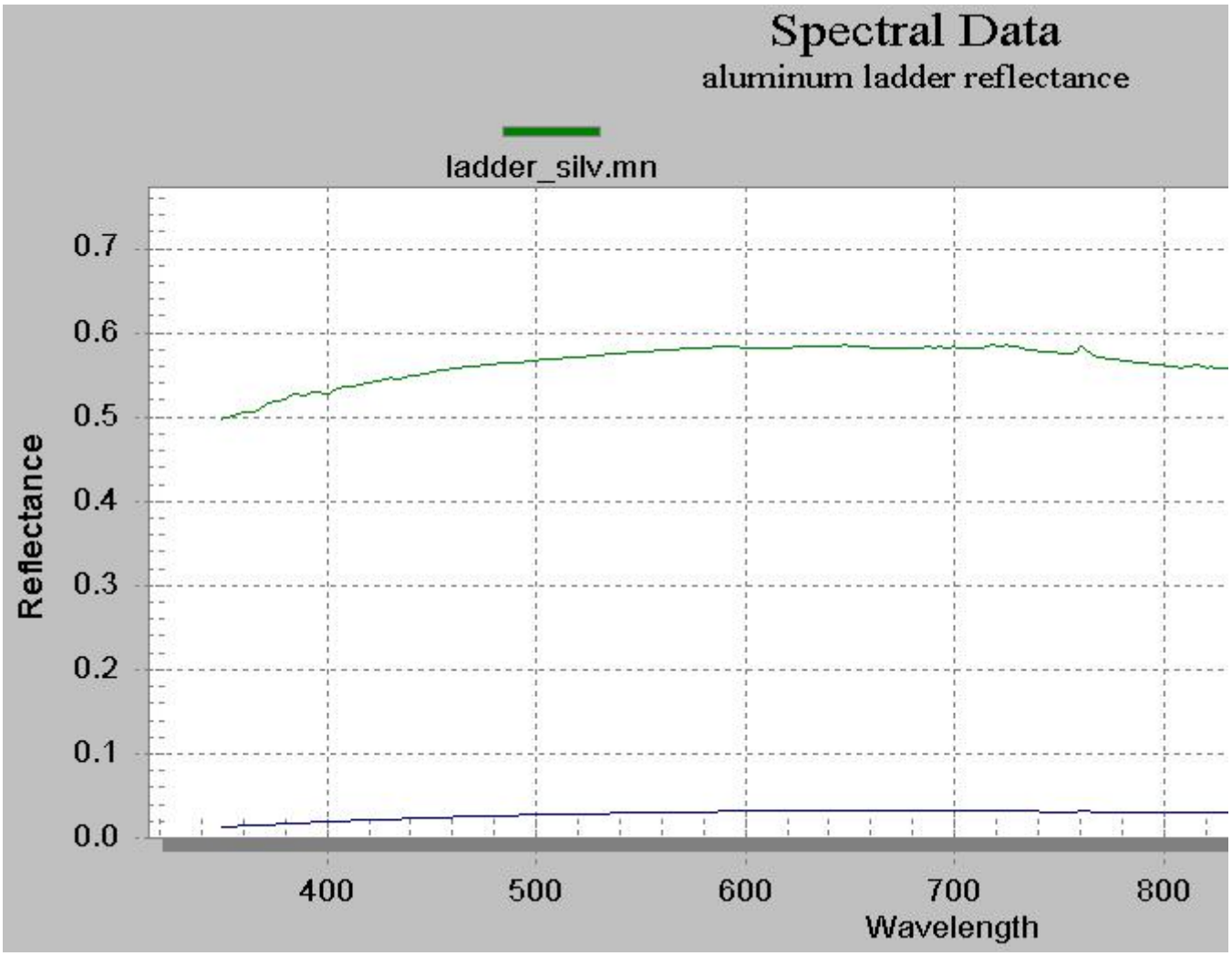
the camera is off angle from the pistol grip, so I bent the metal connector.

the blue marks on the white pole are 6" diameter (height 12.6 in) and 1 meter height (88 inches) diameter heights. sorry for the metric/english measure slaughter. I only have an english tape measure. This setup is a little on the edge of not being safe..... and barely makes the height with a plant of 0 inches....

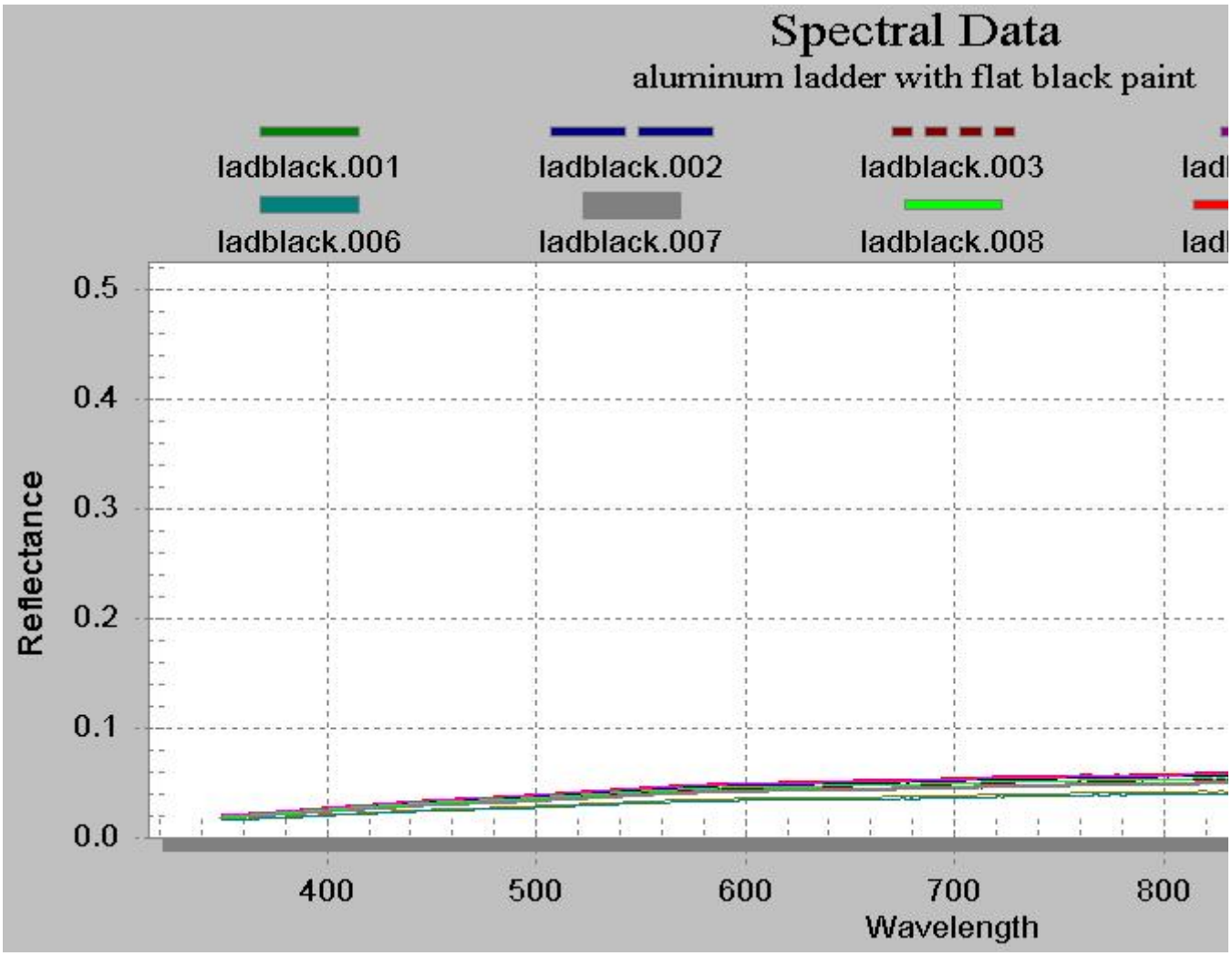
heres a little data



yes- the ladder has a high reflectance! which could skew data-



heres the solution.

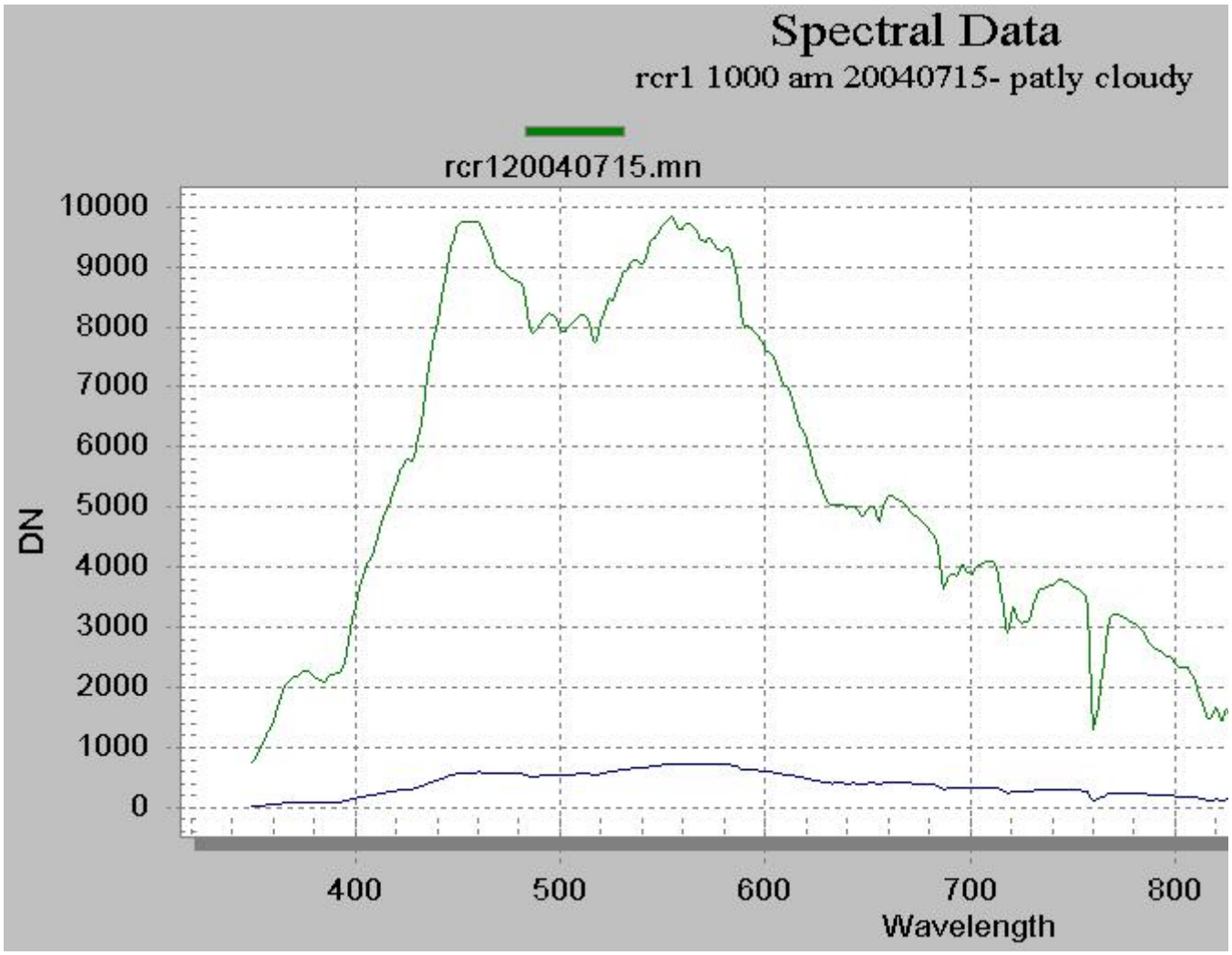


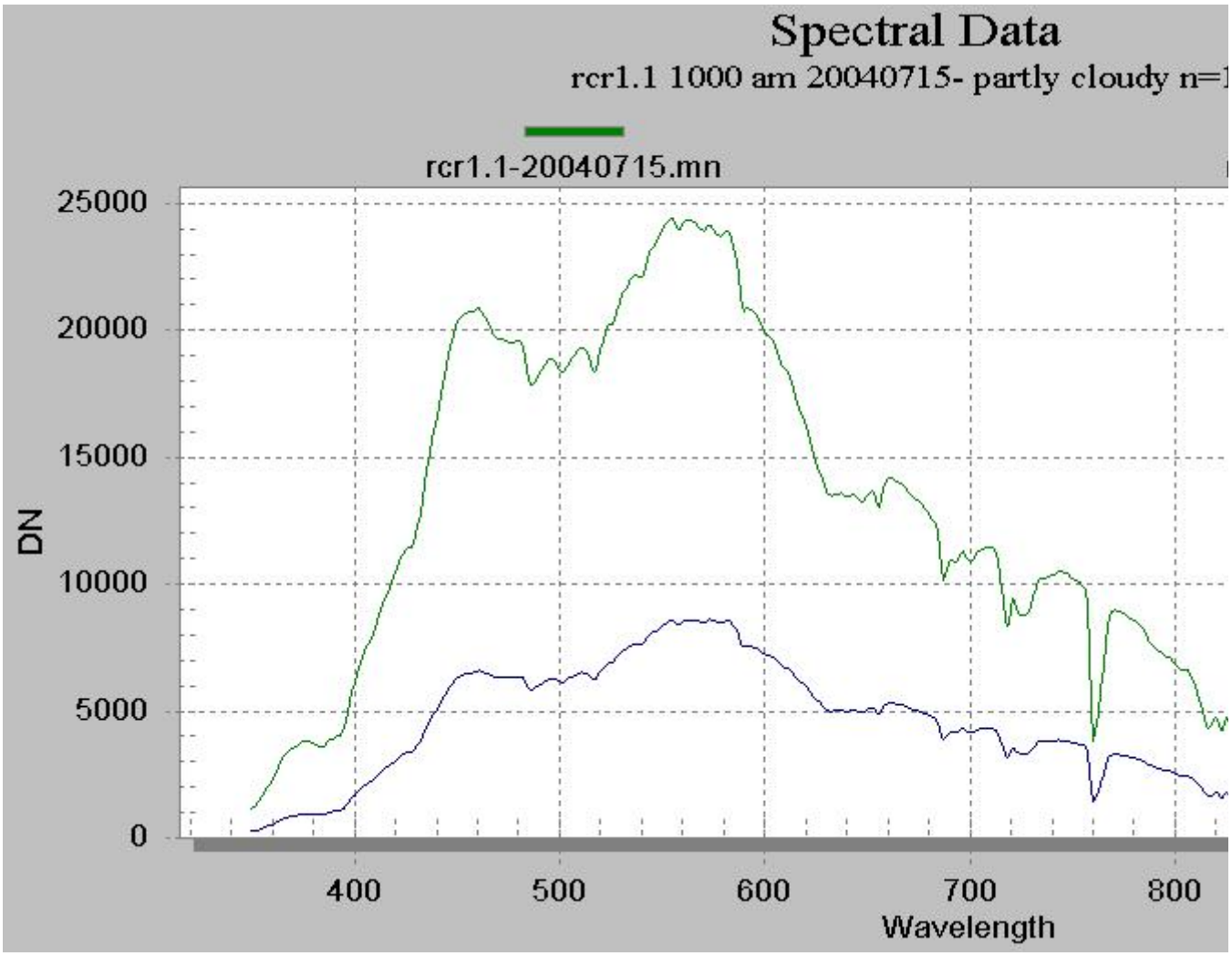
Whew--- what a busy few days!!!

Thursday July 15th, 2004

The day was supposed to start at Multnomah Channel, but the whole Columbia River was covered in heavy clouds. Luckily I have enough time in the morning schedule now that I have equipment requirements and packing figured out, to change plans and make it to another site with time to spare. Although that adds to the driving time. We need to have weather monitoring part of the daily routine, to always target a site that will have decent weather.

Cooper Mountain was a little better.

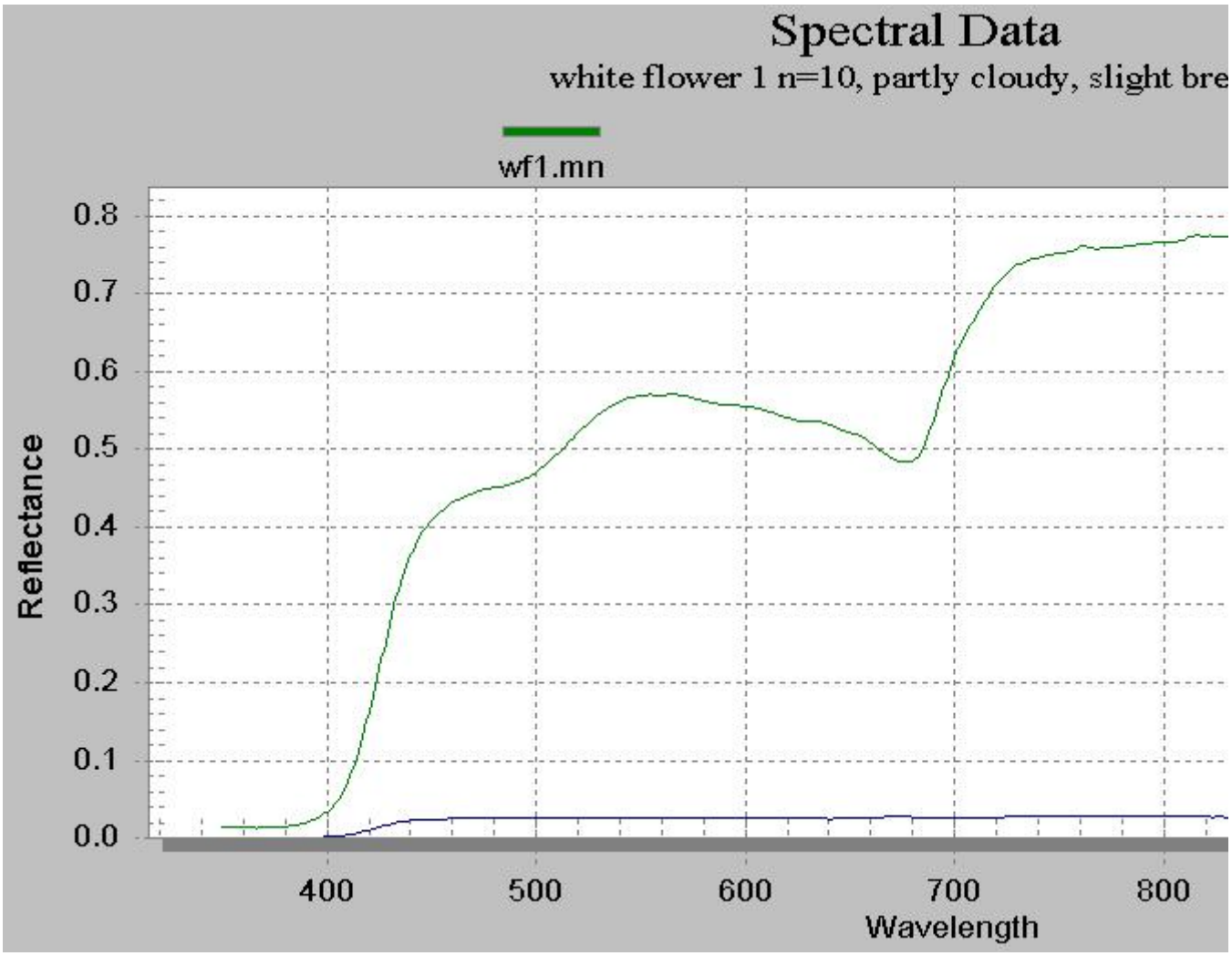

Spectral Data
rcr1 1000 am 20040715- patly cloudy
rcr120040715.mn
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
DN
400
500
600
700
800
Wavelength



White Flower

overhead architecture view.

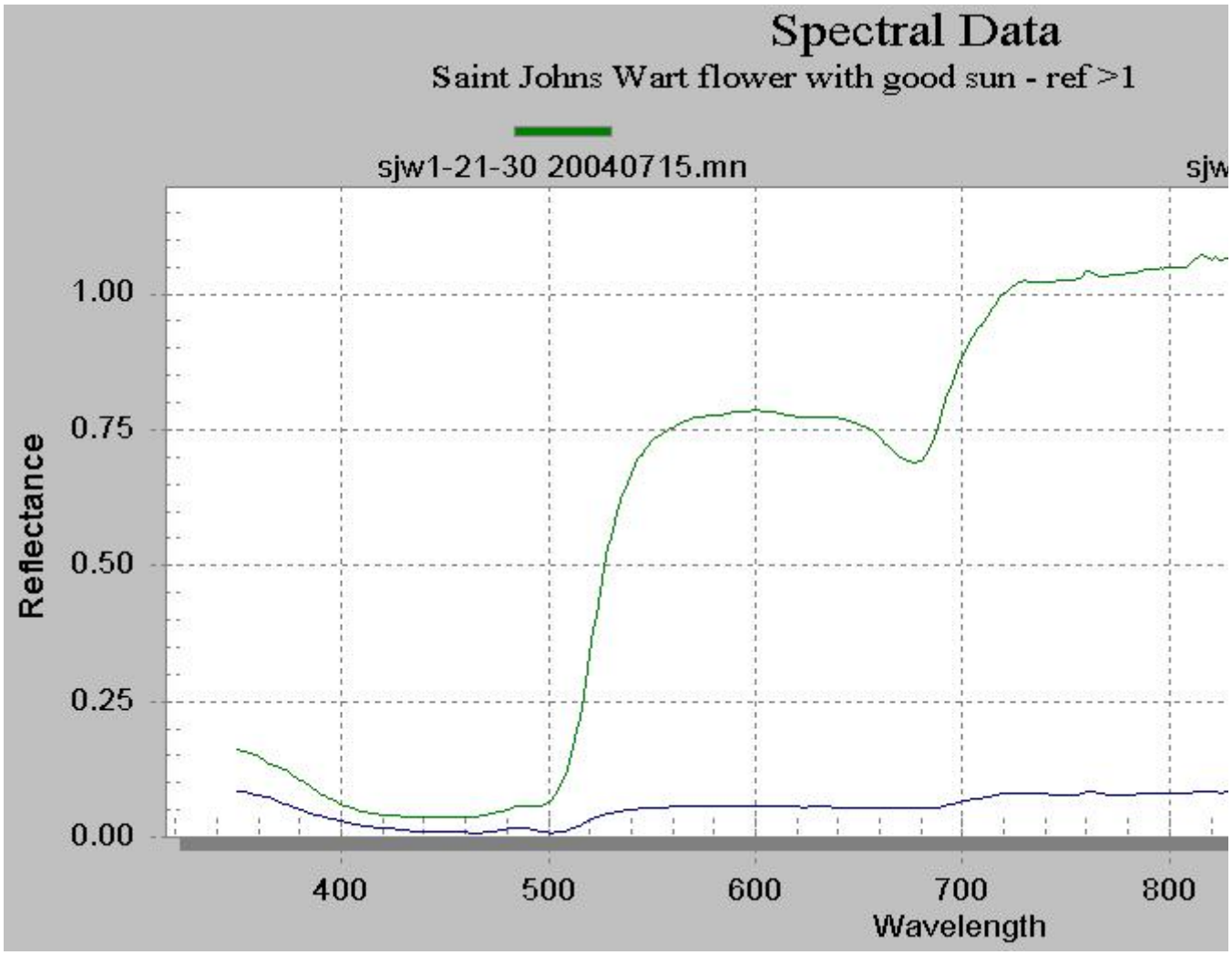
white flower from foroptic view camera mount that I created the day before.

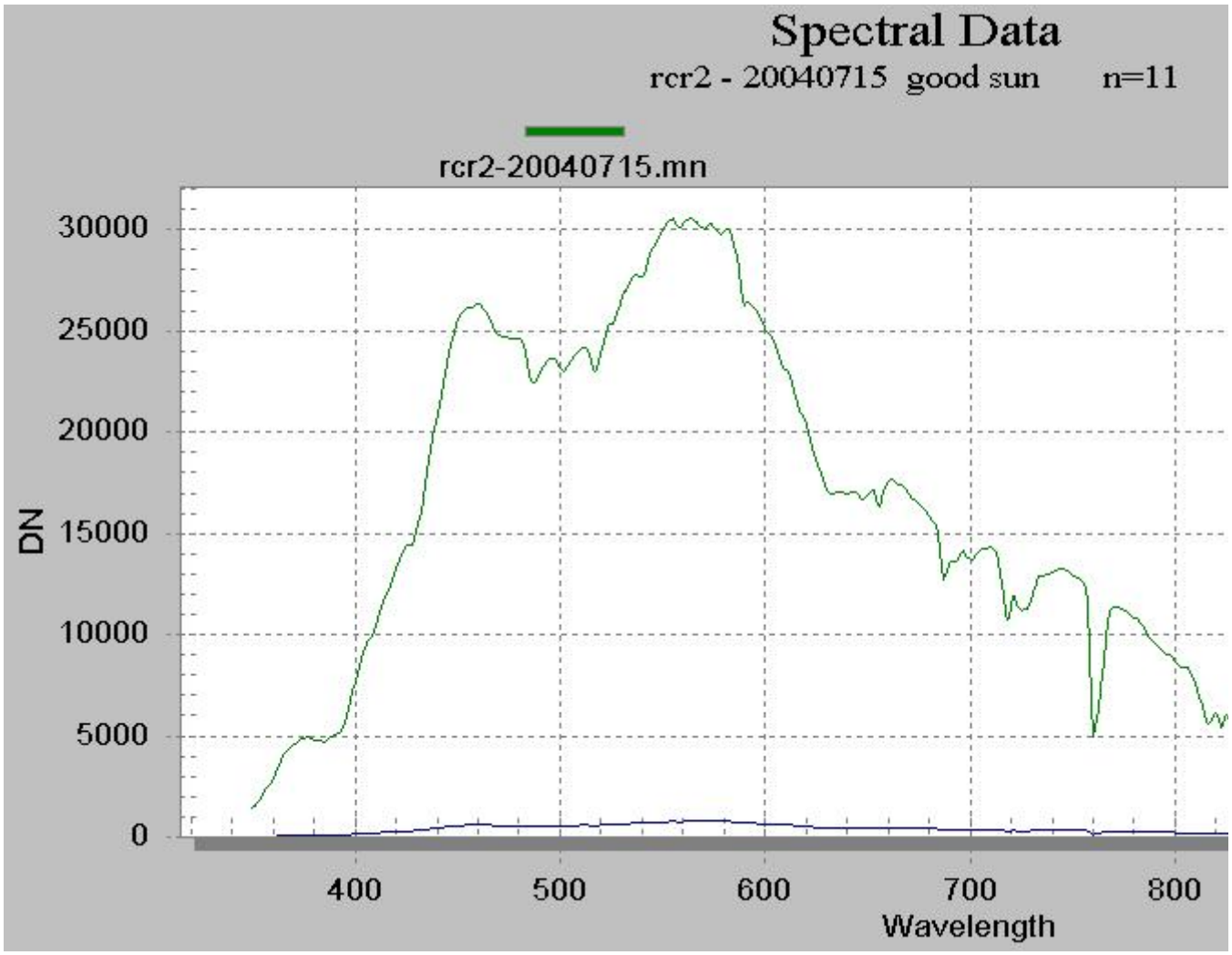


Saint Johns Wart

SJW architecture view

SJW camera mount view


Spectral Data
Saint Johns Wart flower with good sun - ref >1
sjw1-21-30 20040715.mn
sjw
1.00
0.75
0.50
0.25
0.00
Reflectance
400
500
600
700
800
Wavelength


Spectral Data
rcr2 - 20040715 good sun n=11
rcr2-20040715.mn
30000
25000
20000
15000
10000
5000
0
DN
400
500
600
700
800
Wavelength

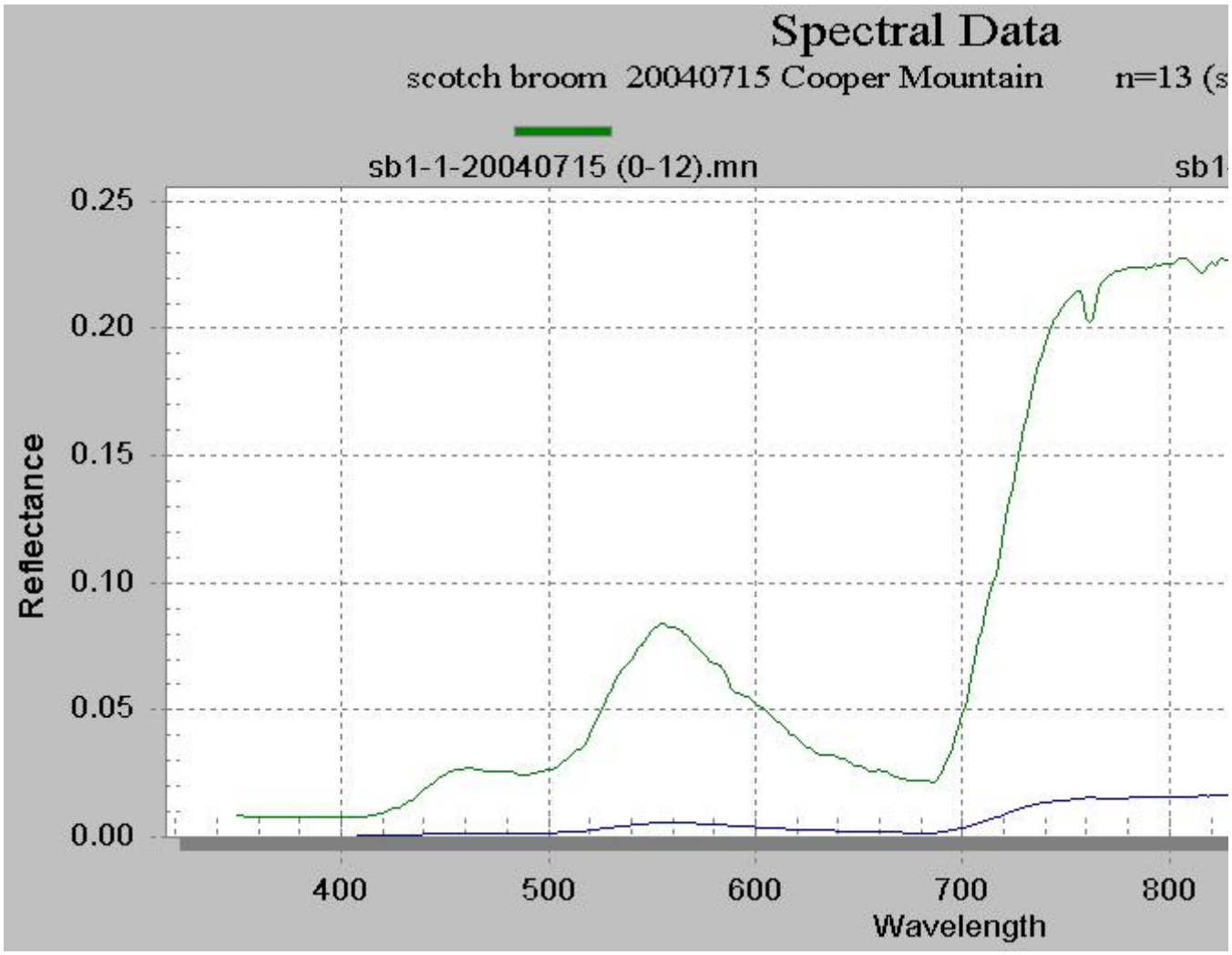
scotch broom site

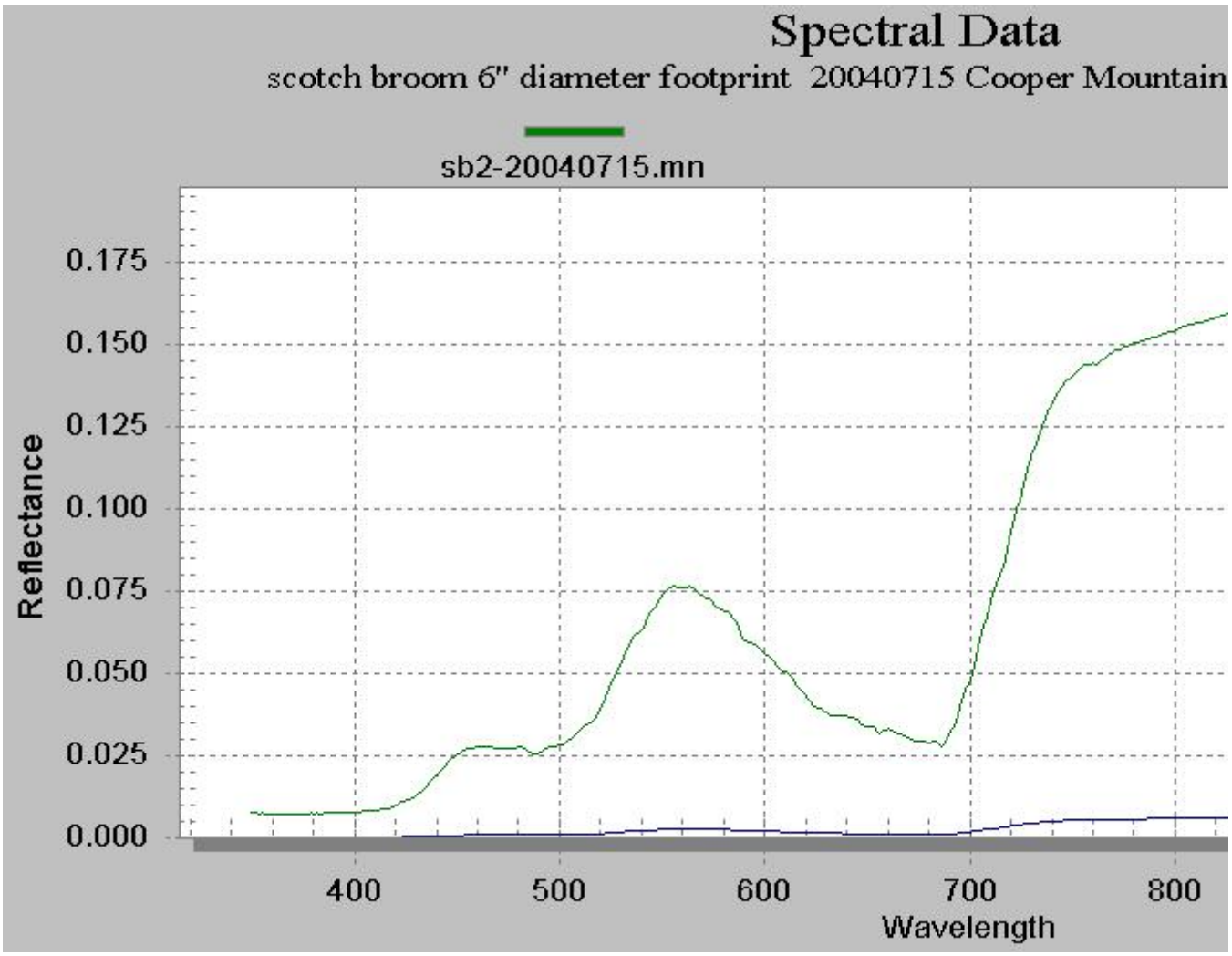
camera mount view

Pistol Grip
SONY

Pistol Grip
SONY

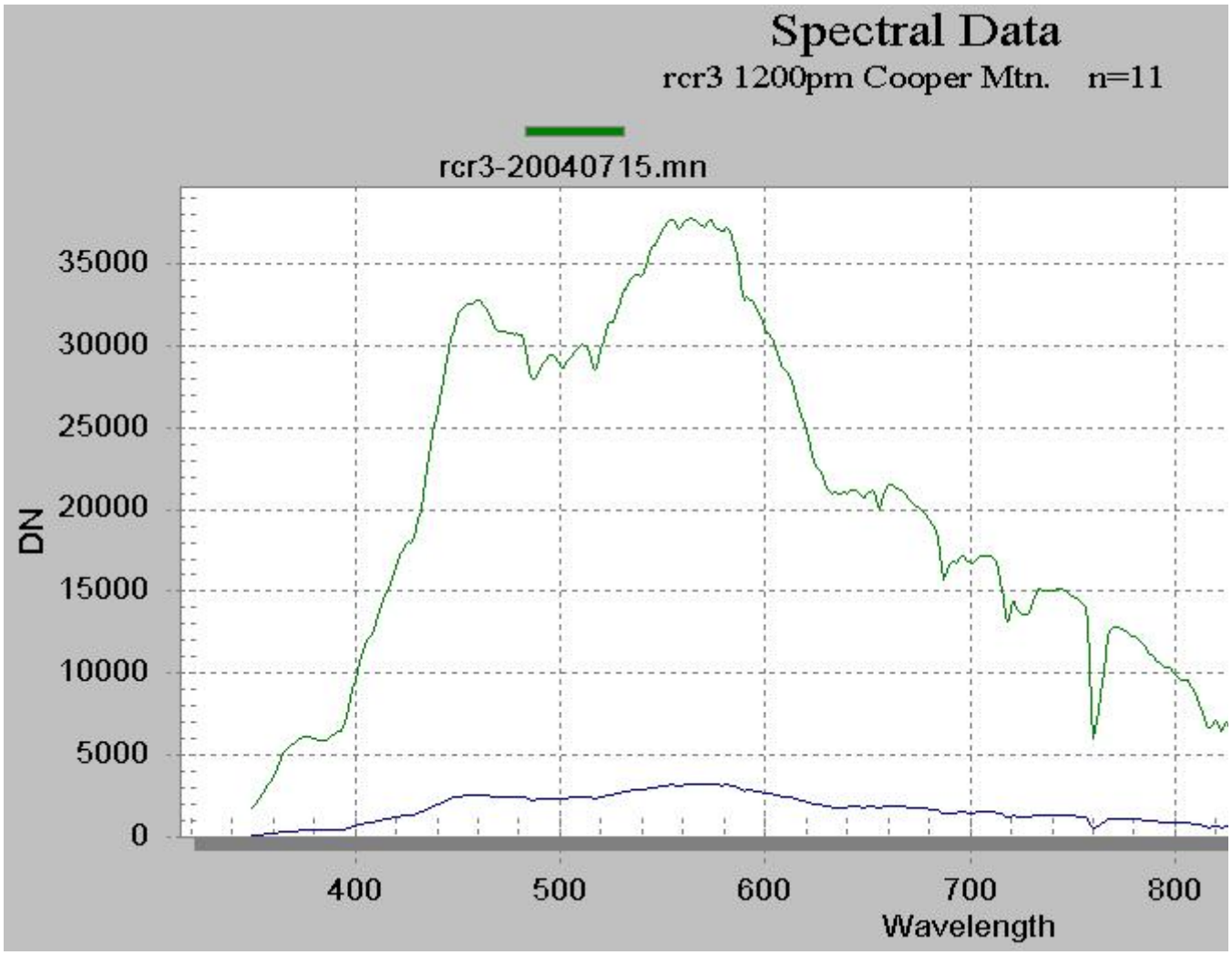
6 inch diameter and architectural view


Spectral Data
scotch broom 20040715 Cooper Mountain
n=13 (s
sb1-1-20040715 (0-12).mn
sb1
Reflectance
0.25
0.20
0.15
0.10
0.05
0.00
400
500
600
700
800
Wavelength

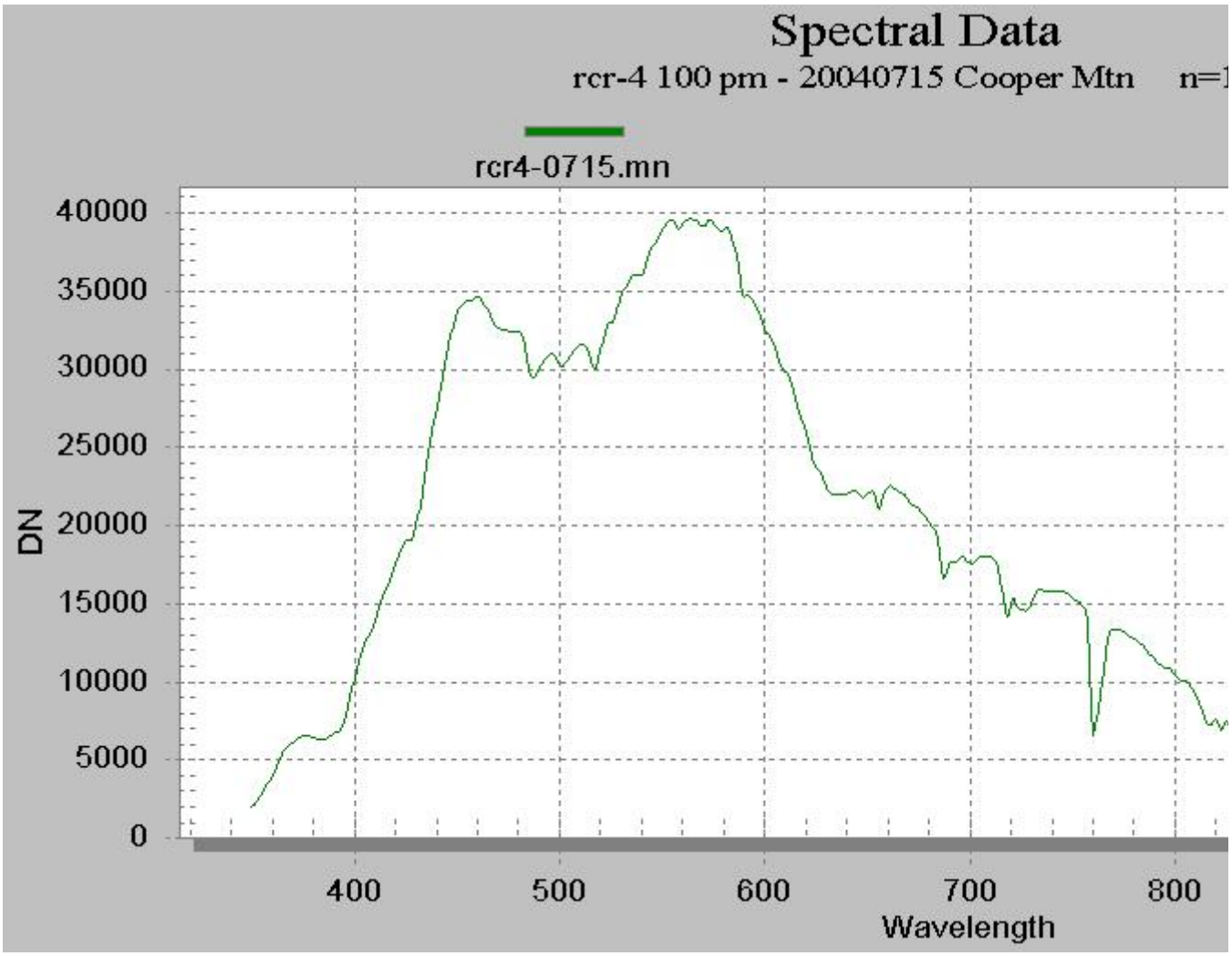


At this time, the PPU battery died and I had to switch to jeep battery and extension cord.

rcr3 taken at SB site

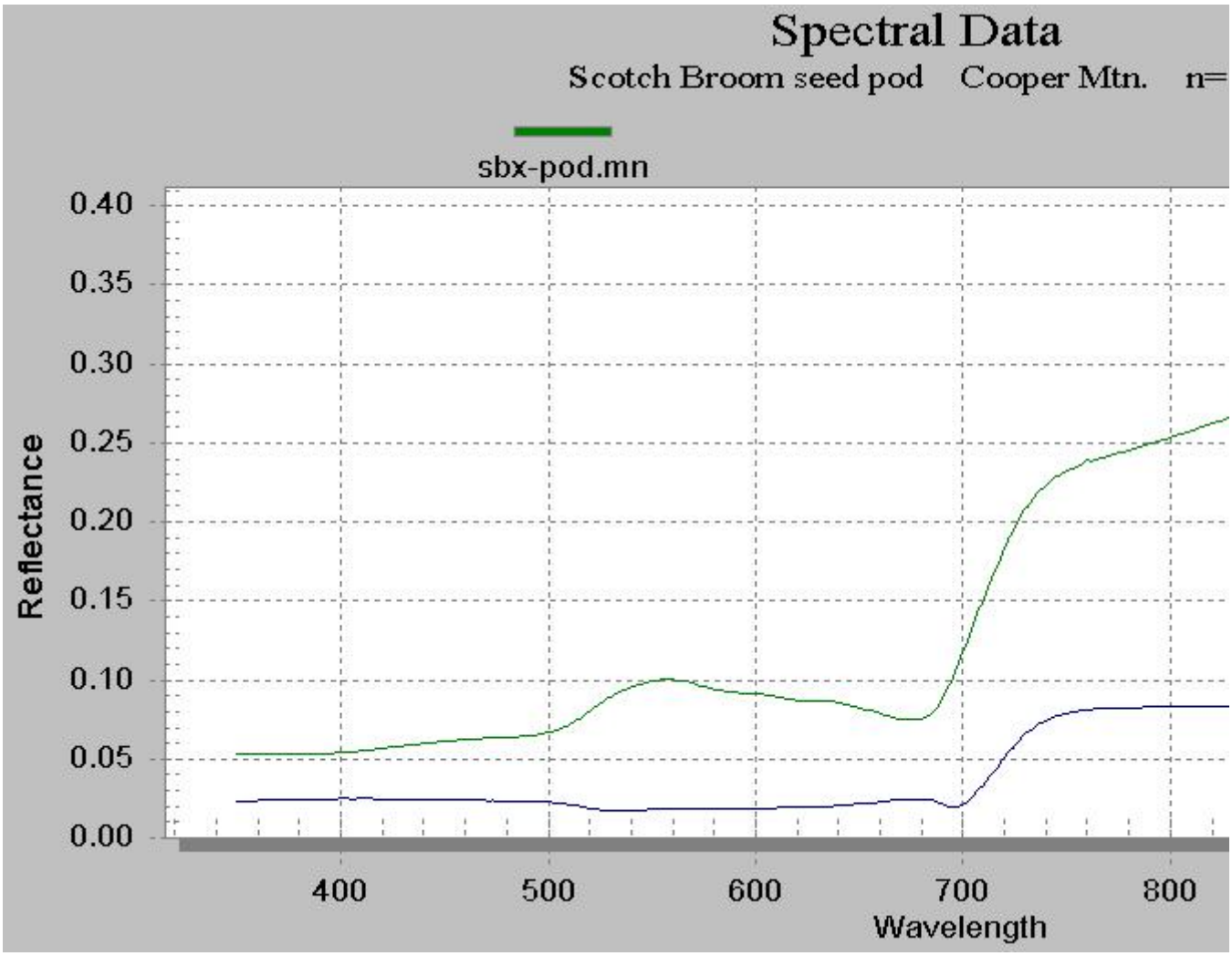

Spectral Data
rcr3 1200pm Cooper Mtn. n=11
rcr3-20040715.mn
35000
30000
25000
20000
15000
10000
5000
0
DN
400
500
600
700
800
Wavelength

HB site

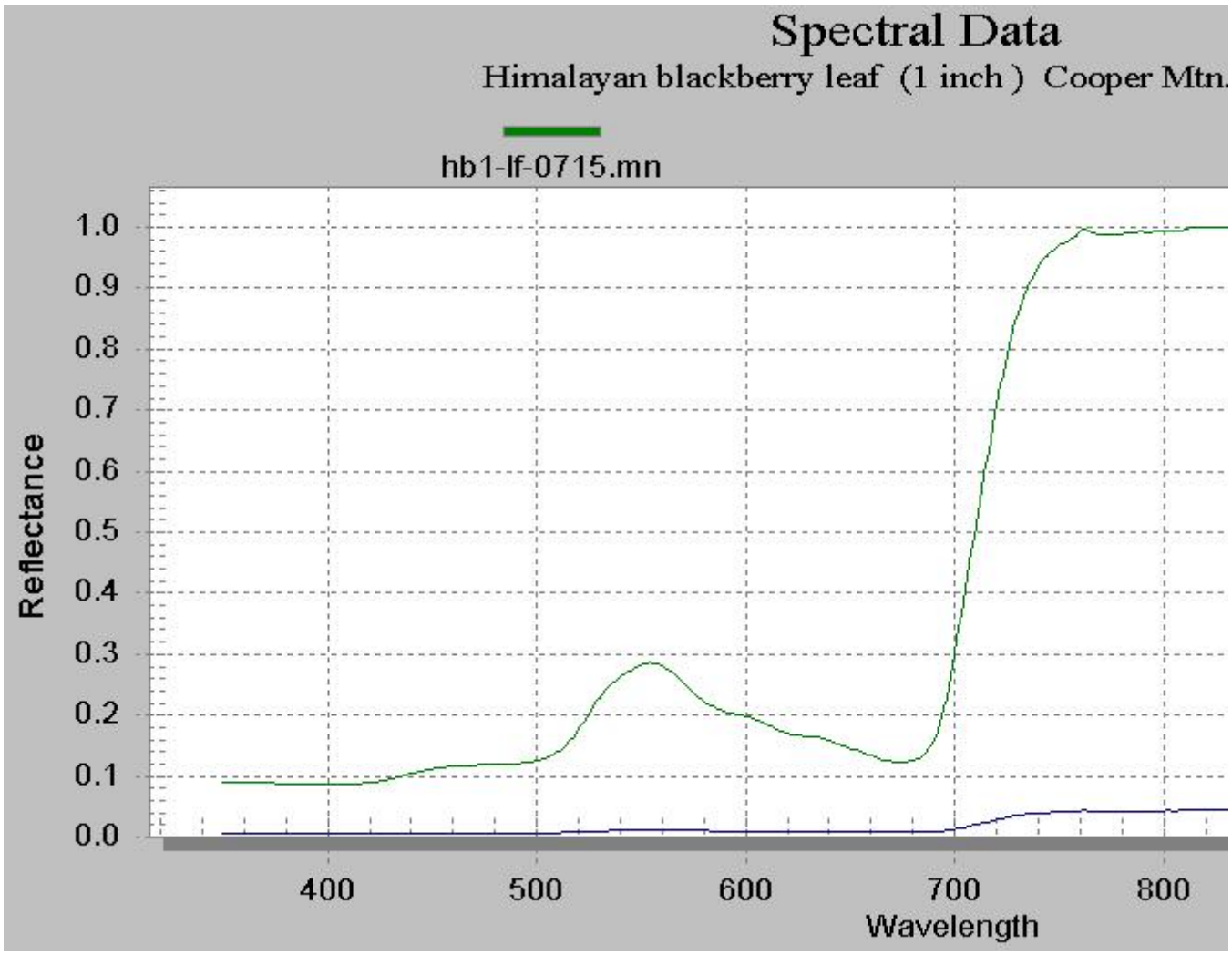


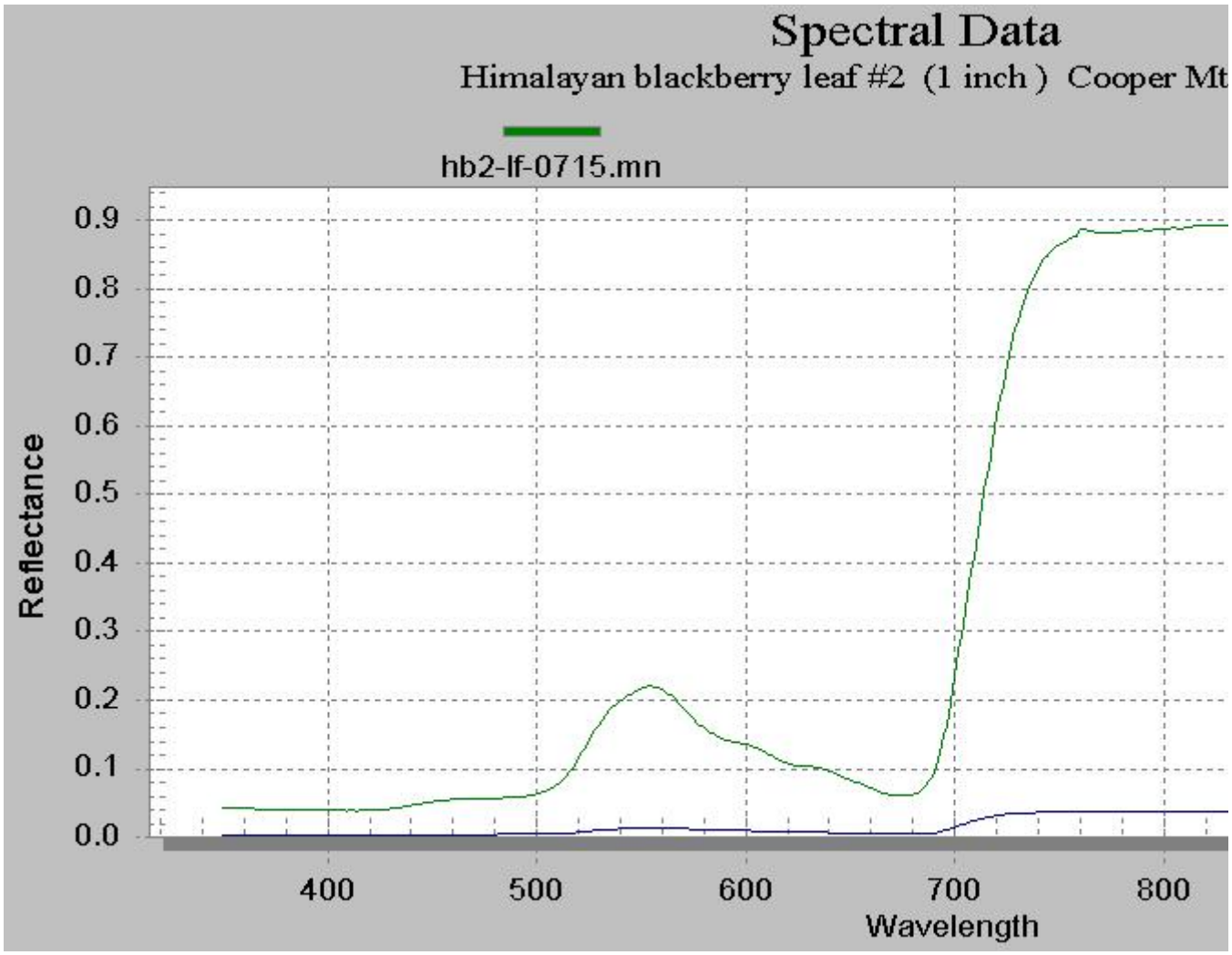
the seed pod data was actually taken at the HB site

Velbon



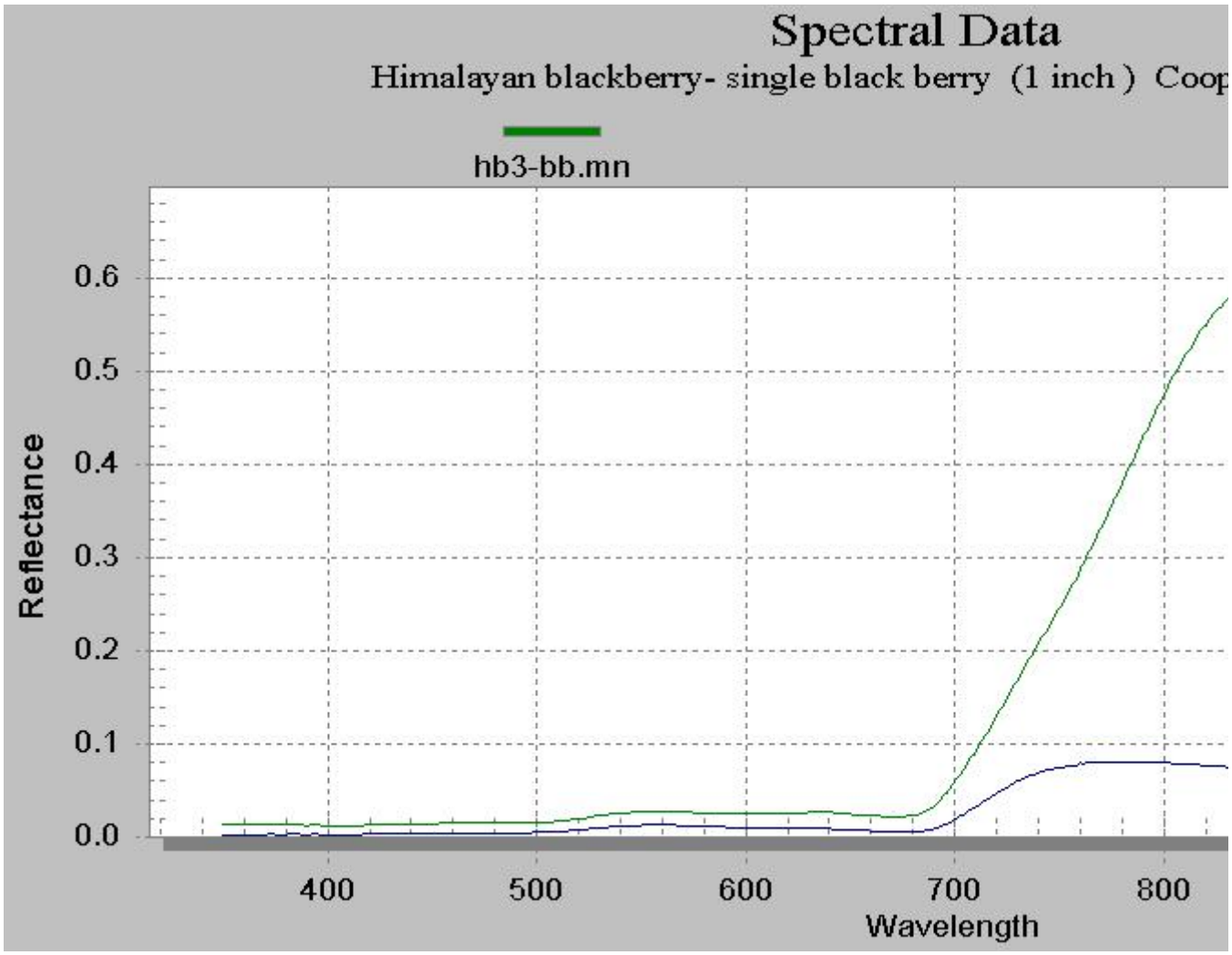
Himalayan Blackberry spectral dissection

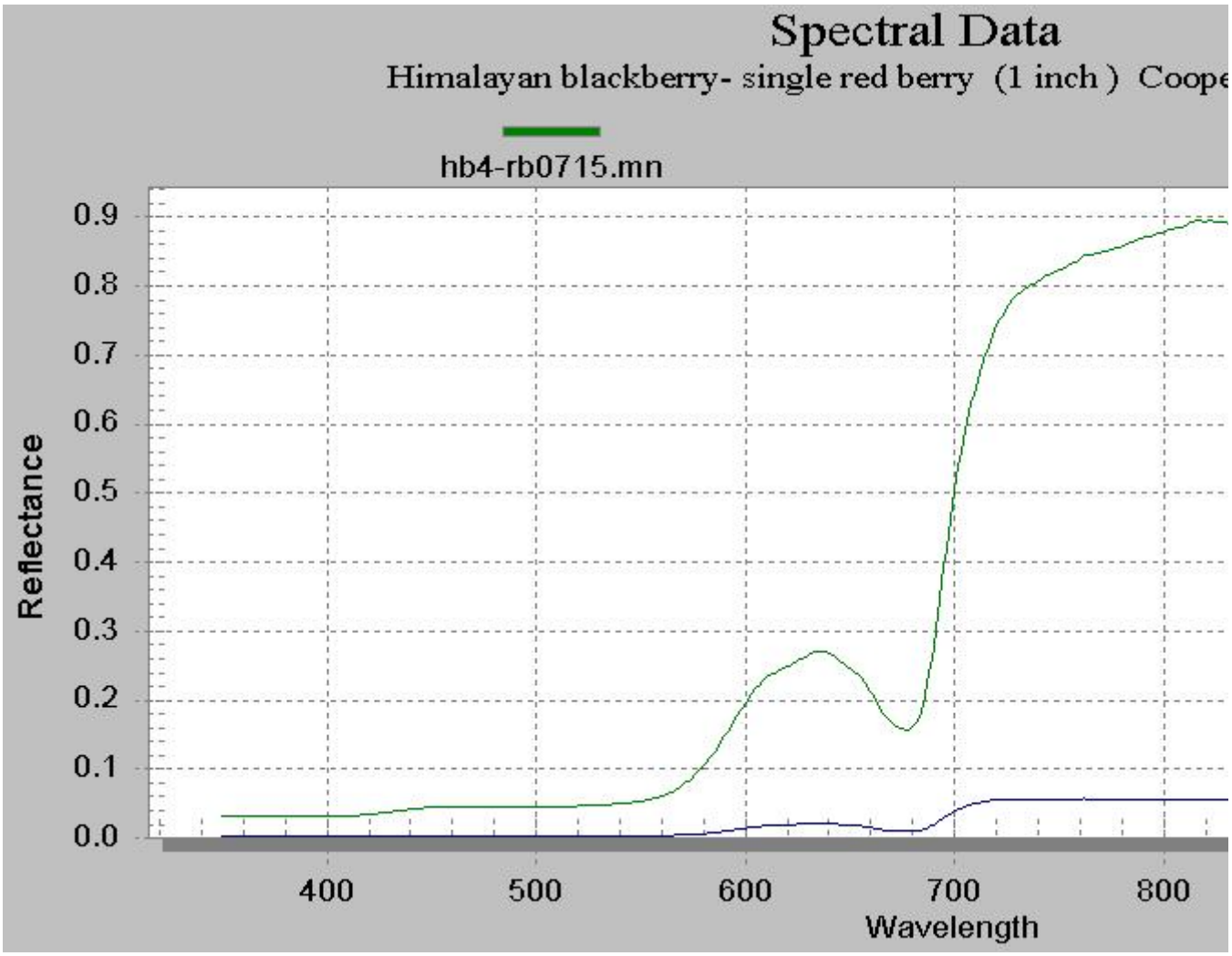

Spectral Data
Himalayan blackberry leaf (1 inch) Cooper Mtn.
hb1-lf-0715.mn
Reflectance
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

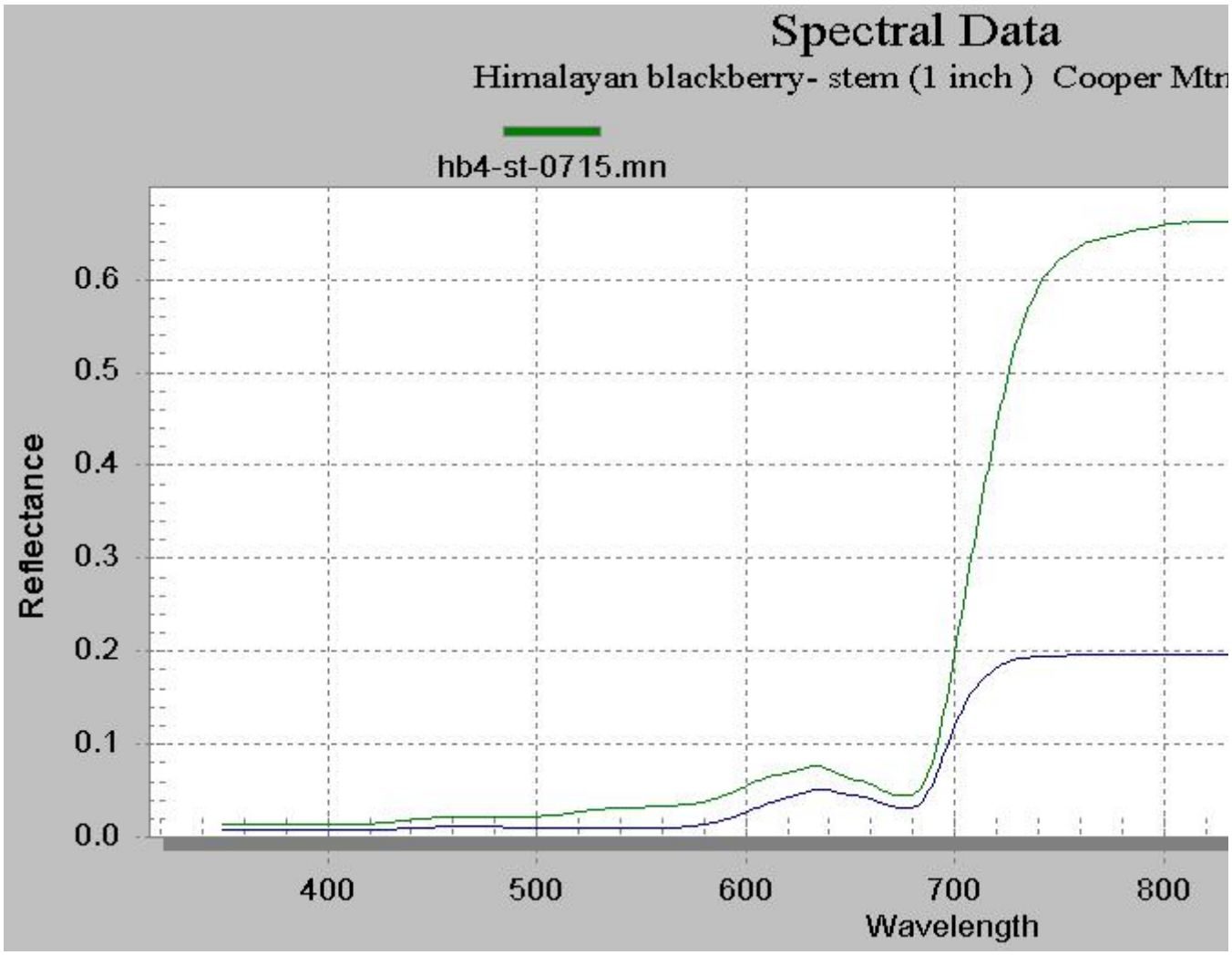

Spectral Data
Himalayan blackberry leaf #2 (1 inch) Cooper Mt
hb2-lf-0715.mn
Reflectance
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

at this time of year, the berry (bracts?) take up a large portion of the canopy (need to quantify).

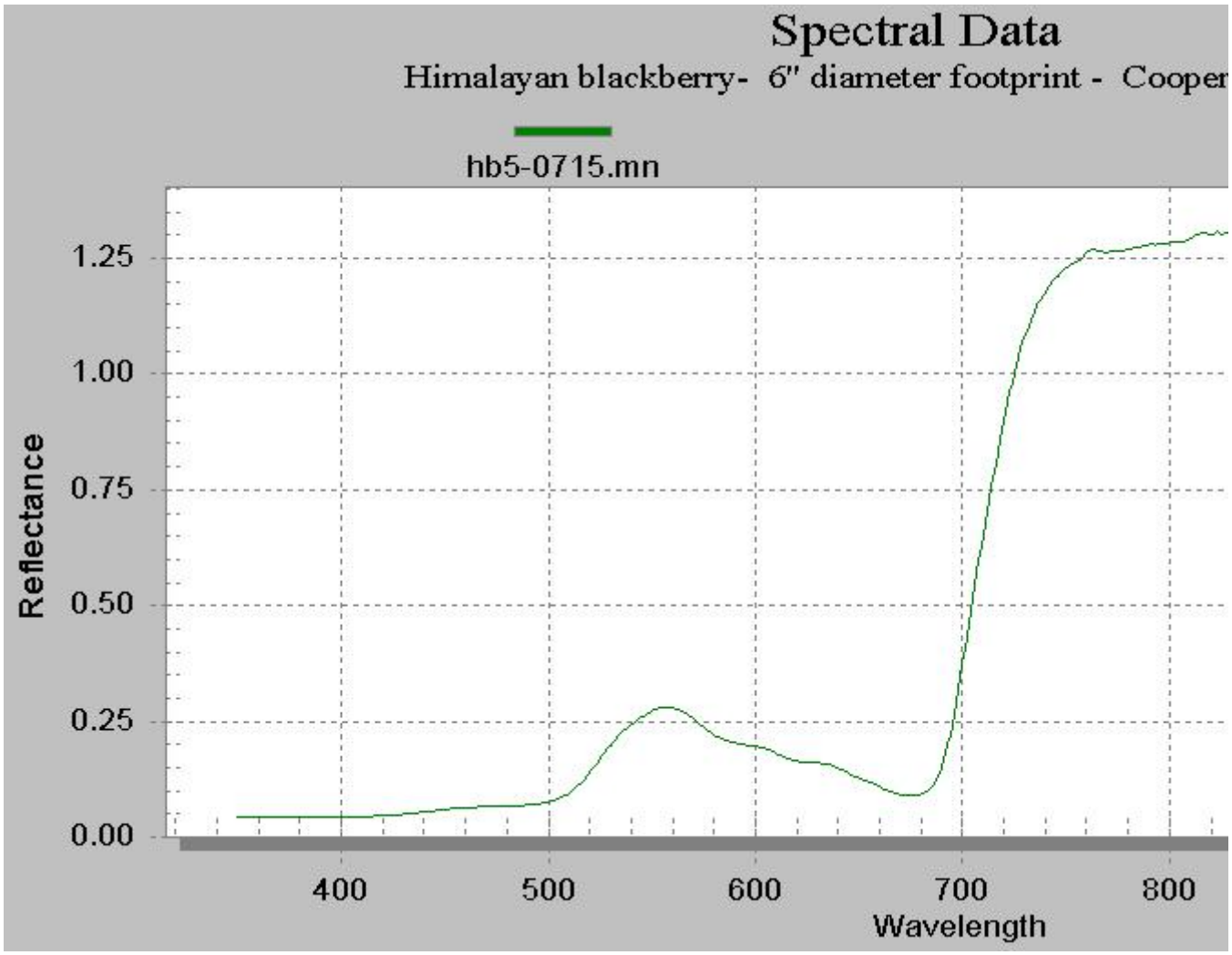
SONY

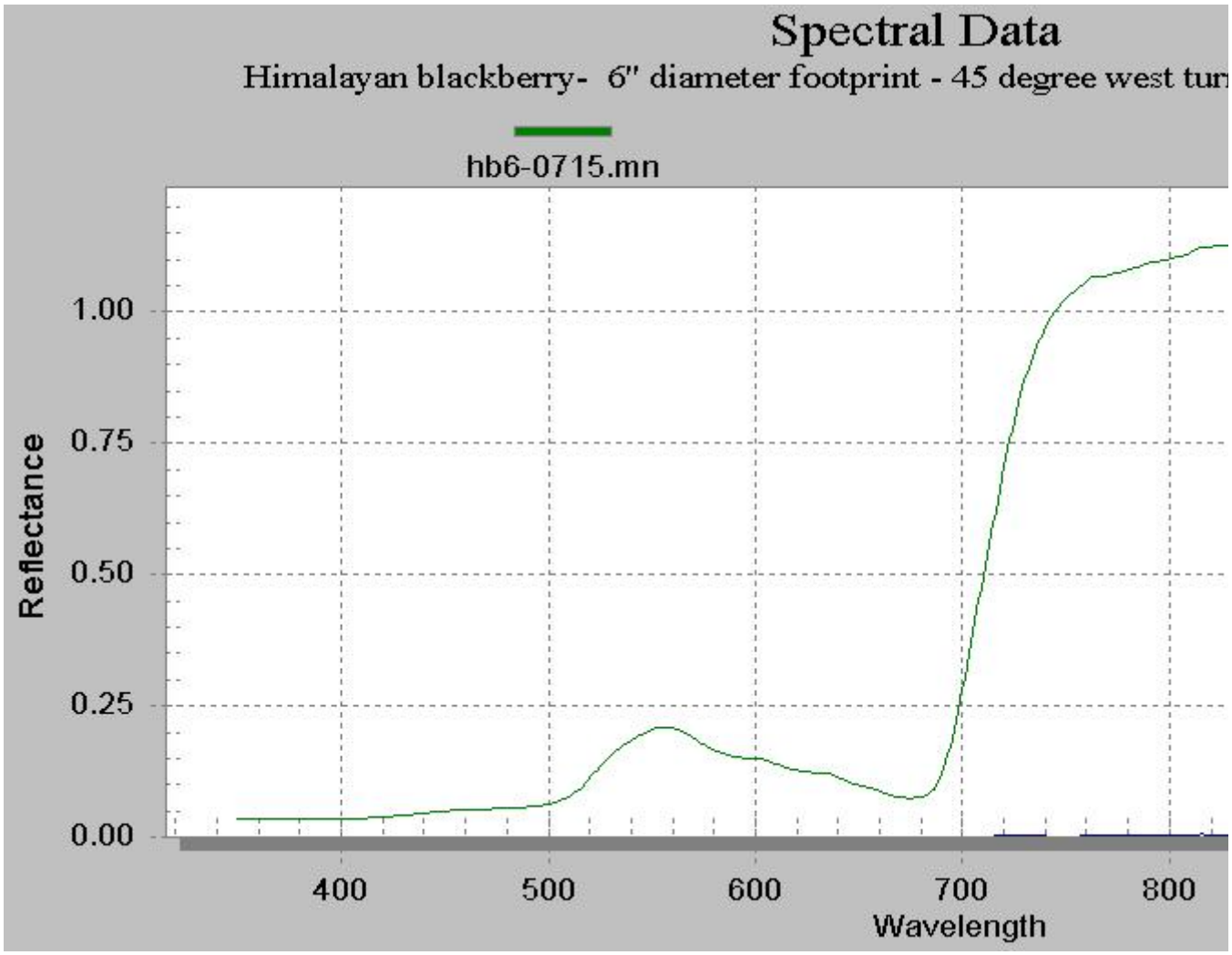

Spectral Data
Himalayan blackberry- single black berry (1 inch) Coop
hb3-bb.mn
Reflectance
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength


Spectral Data
Himalayan blackberry- single red berry (1 inch) Coope
hb4-rb0715.mn
Reflectance
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
400
500
600
700
800
Wavelength

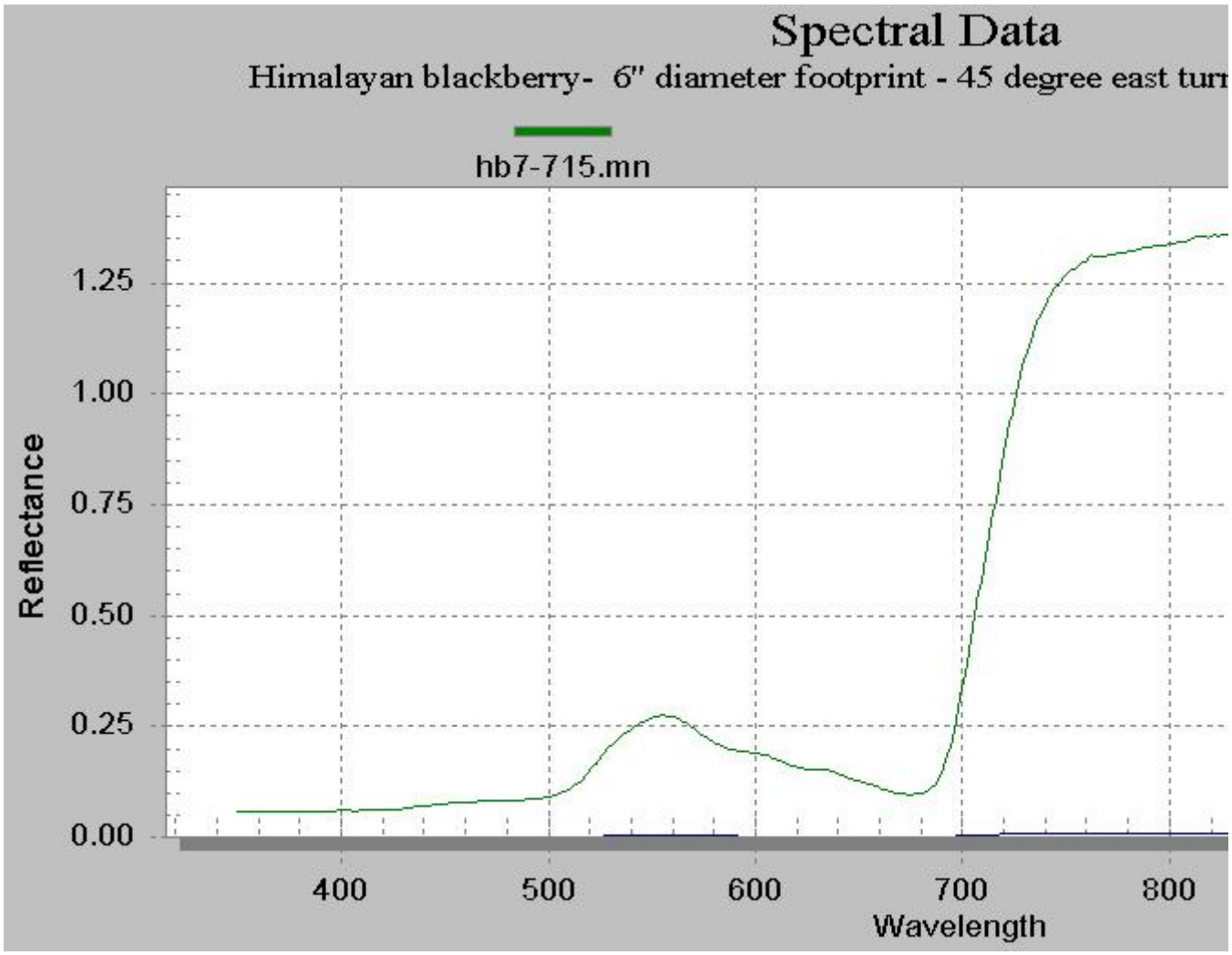


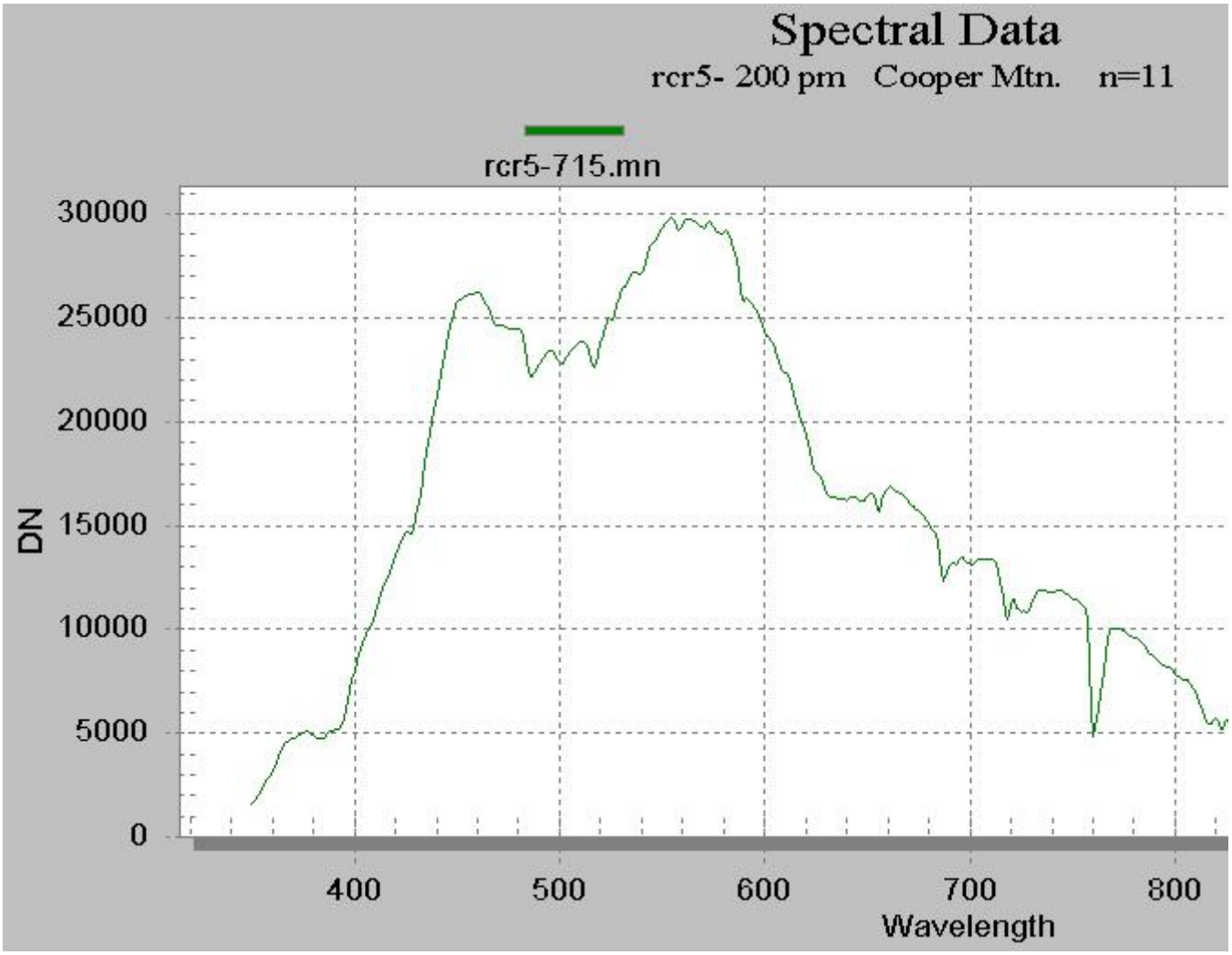
Himalayan Blackberry Whole Plant Reflectance Profile


Spectral Data
Himalayan blackberry- 6" diameter footprint - Cooper
hb5-0715.mn
Reflectance
1.25
1.00
0.75
0.50
0.25
0.00
400
500
600
700
800
Wavelength

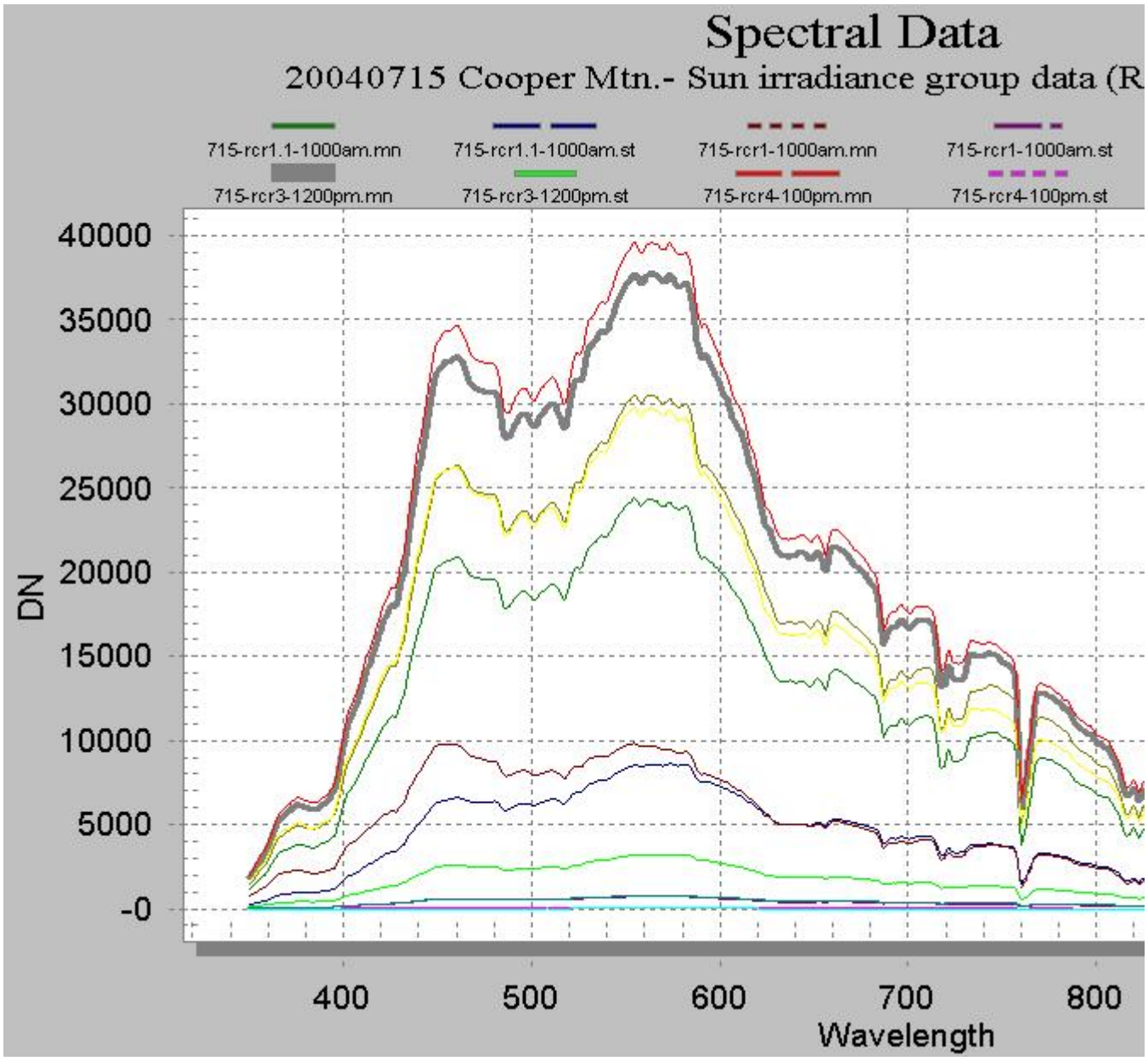

Spectral Data
Himalayan blackberry- 6" diameter footprint - 45 degree west tur
hb6-0715.mn
1.00
0.75
0.50
0.25
0.00
Reflectance
400
500
600
700
800
Wavelength

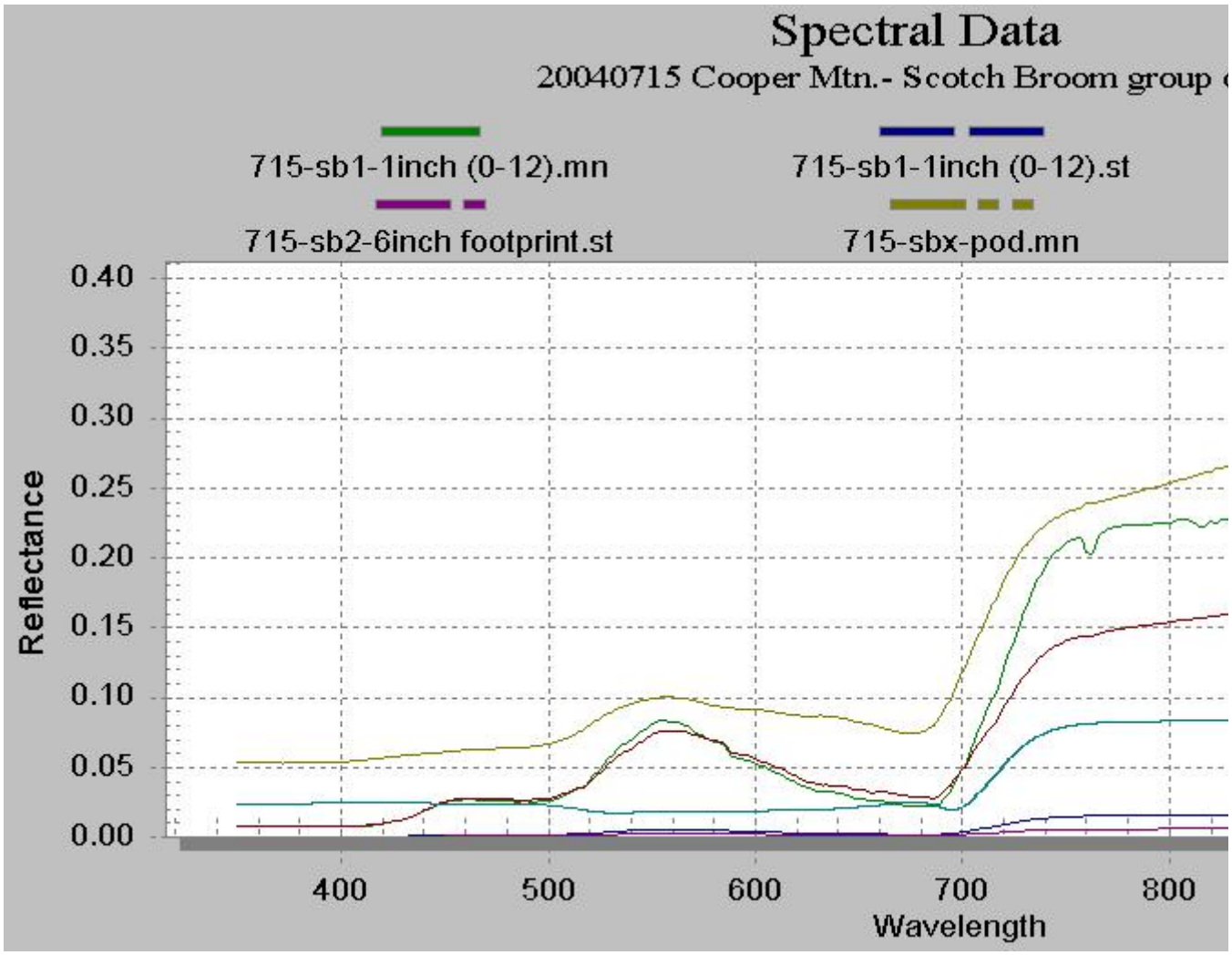
WERNER

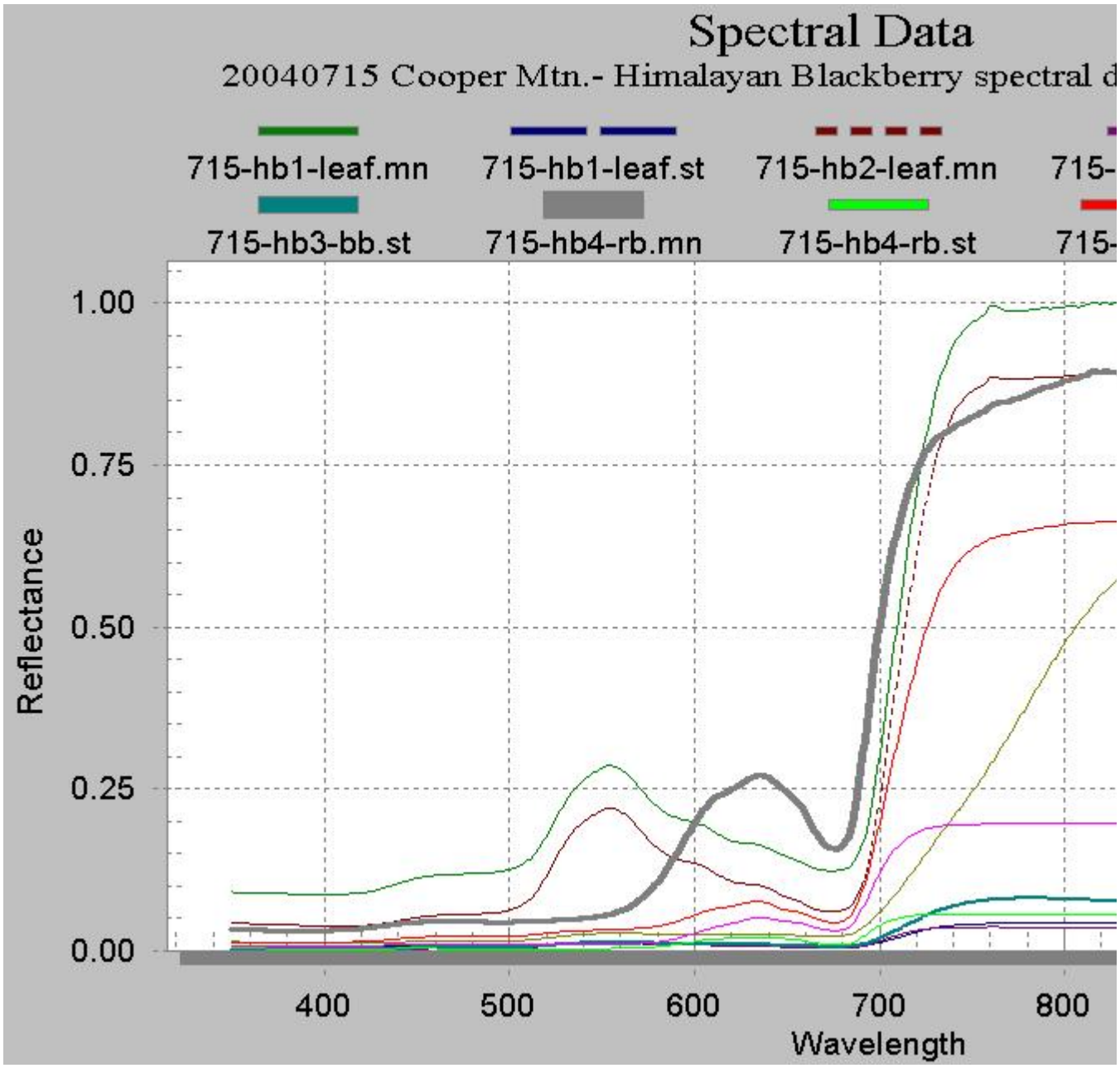

Spectral Data
Himalayan blackberry- 6" diameter footprint - 45 degree east turn
hb7-715.mn
Reflectance
1.25
1.00
0.75
0.50
0.25
0.00
400
500
600
700
800
Wavelength

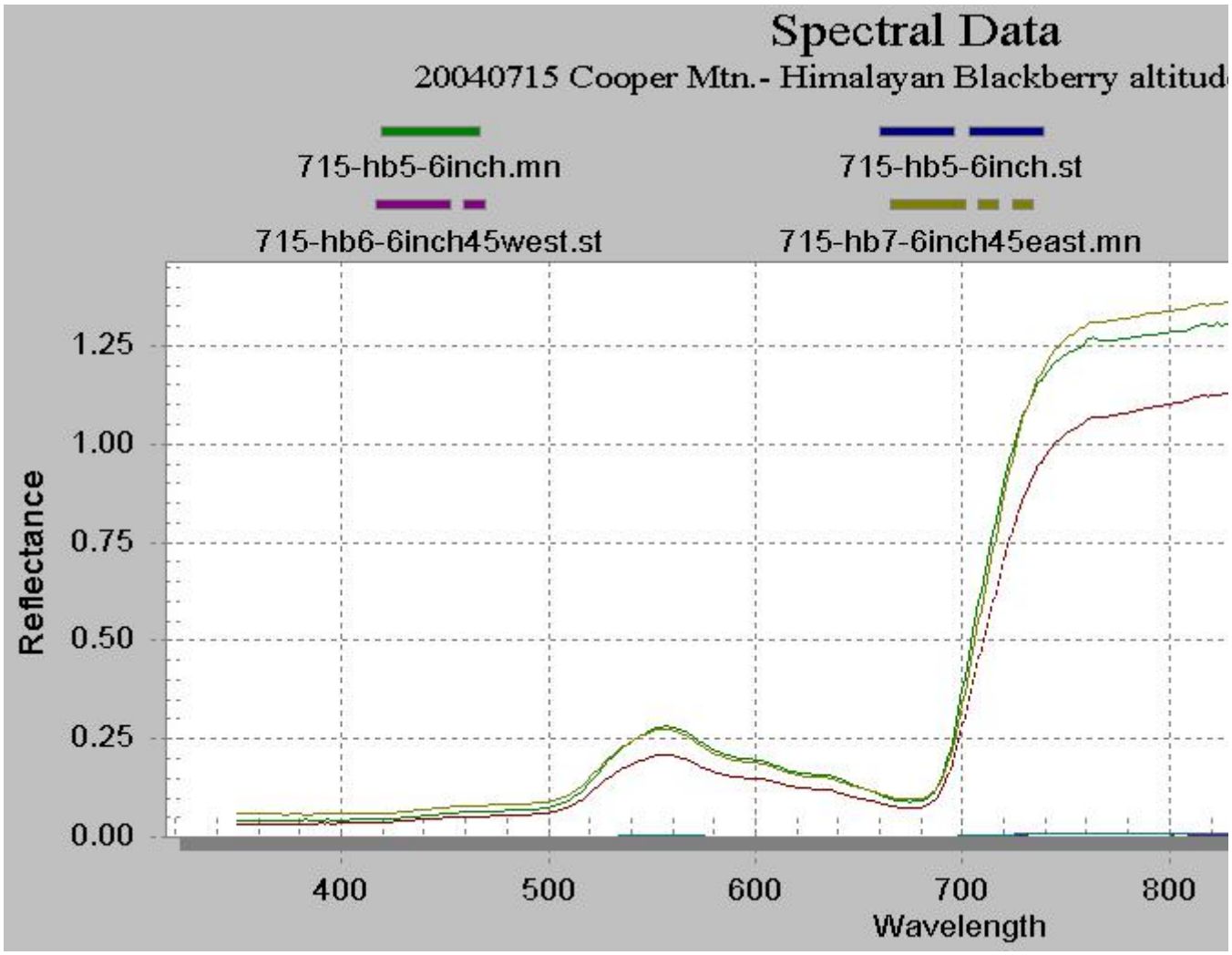


Finally getting sophisticated enough to merge individual datasets. condensed data graphs- let me know if you like this format.


Spectral Data
20040715 Cooper Mtn.- Sun irradiance group data (R
715-rcr1.1-1000am.mn
715-rcr1.1-1000am.st
715-rcr1-1000am.mn
715-rcr1-1000am.st
715-rcr3-1200pm.mn
715-rcr3-1200pm.st
715-rcr4-100pm.mn
715-rcr4-100pm.st
40000
35000
30000
25000
20000
15000
10000
5000
-0
DN
400
500
600
700
800
Wavelength


Spectral Data
20040715 Cooper Mtn.- Scotch Broom group
715-sb1-1inch (0-12).mn
715-sb1-1inch (0-12).st
715-sb2-6inch footprint.st
715-sbx-pod.mn
Reflectance
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
400
500
600
700
800
Wavelength


Spectral Data
20040715 Cooper Mtn.- Himalayan Blackberry spectral d
715-hb1-leaf.mn
715-hb1-leaf.st
715-hb2-leaf.mn
715-
715-hb3-bb.st
715-hb4-rb.mn
715-hb4-rb.st
715-
1.00
0.75
0.50
0.25
0.00
Reflectance
400
500
600
700
800
Wavelength


Spectral Data
20040715 Cooper Mtn.- Himalayan Blackberry altitud
715-hb5-6inch.mn
715-hb5-6inch.st
715-hb6-6inch45west.st
715-hb7-6inch45east.mn
Reflectance
1.25
1.00
0.75
0.50
0.25
0.00
400
500
600
700
800
Wavelength

This day was chosen to test out the feasibility of gathering data from higher heights (1-3 meters) to simulate spatial resolution data capture from different hyperspectral platforms. Fortunately, the Blue Lake group at Metro had rented a lift truck to prune trees, and Friday was the last day for them to have it, so we had the opportunity to test out different heights at no cost for one day. This truck rental requires a CL(?) license in order to be able to operate it. With equipment return and travel constraints from the Blue Lake site. A very near small site of JK was chosen to test the lift truck.

Japanese Knotweed plot- 84 East on X road.

Stationing of lift truck near the JK plot.

Unfortunately the JK stand was near a power pole which shaded the stand. It was also very near an active railroad track.

location of the lift during image collection.

1 meter

1.5 meter

2 meter

3 meter

Although this was a great site to test out the feasibility of a lift truck, this site is not adequate to gather spectroradiometer data due to the small size of the plot and shadowing..

I have lots more pictures of knotweed from several heights (1m, 1.5 meter, 2 meter, and 3 meter), but no SR data.

This accident unfortunately ended our free data collection session. But we have gathered a lot of useful knowledge for future applications of this technology and planning for an eventual hyperspectral demonstration flight.

The drive of the lift truck is a military veteran of 23 years, and is also a skilled helicopter pilot. He may be able to assist in a future demonstration hyperspectral flight on a helicopter platform. This would also be a cost savings to Metro in hyperspectral demonstration.

Smaller lift trucks-

We may be able to rent a smaller lift truck (at a cheaper price) to finish the height studies for the Phase I study. This is a smaller truck in service at the Penske Rental Center. The smaller truck does not require a license to operate the lift.