



Model 505
GreenSeeker Hand Held™ Optical Sensor Unit

Operating Manual



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The GreenSeeker Hand Held™ Optical Sensor Unit

Congratulations on your purchase of a GreenSeeker Hand Held™ Optical Sensor Unit. This manual provides the description and operation of both the Sensor Unit and the data capture program.

Introduction

The GreenSeeker Hand Held Optical Sensor Unit is a tool for crop research and consulting that provides precision measurement and data logging of the Normalized Difference Vegetative Index (NDVI) and Red to Near Infrared Ratios of plant material. These data points can be used in conjunction with other agronomic references to index basic nutrient response, crop condition, yield potential, stress, pest and disease impact in a quantitative manner. The unit can be used to monitor changing field (plant/crop) conditions during the growing season and the effects of different levels of an input compared to a local standard.

The GreenSeeker Hand Held Optical Sensor Unit utilizes NTech's second-generation optical sensor technology. The Unit generates light at two specific wavelengths and measures the light reflected off the target (typically plants in soil). The microprocessor within the Sensor analyzes the reflected light and calculates the results. The data from the Sensor is transmitted serially to an HP iPAQ Personal Digital Assistant, and can later be exported to a desktop computer for analysis.

Mechanical Specifications

- Weight of Unit: approximately 13 pounds (6 kg)
- Weight of Unit, with case and accessories: approx. 38 lbs (17 kg)
- Case dimensions: 14 x 14 x 51 inches (35.5 x 35.5 x 129.5 cm)

Accessories

- NTech Capture® program for Pocket PC™ 2002/2003 and Windows Mobile 5.0
- 100-240VAC battery charger
- Polyethylene padded case
(Airline Transportation Association rated)
with wheels and carrying handles



GreenSeeker Hand Held - Quick Start

- Insert your iPAQ into the Powered Cradle.
- Place the shoulder strap around body as desired.
- Extend the telescoping tube to desired length, and adjust Sensor angle so that it is parallel to the sensing area.
- Connect serial cable to the connector on the bottom of the Powered Cradle and the Control Box.
- Turn on the power to the Sensor (switch is located on the Control Box).
- Turn on your iPAQ and go to the Start menu. Click on Programs then the NTech Capture icon to open the program.
- Select Non Ref (Farmer Practice) or Reference (N Rich Strip) by tapping on selection. Button will change and display Monitoring..
- Select Sensor and Start GreenSeeker. (Only V2.0)
- Position the Sensor at the beginning of the target region. The Sensor should be roughly parallel to, and 32 to 48 inches above the canopy. Press the trigger switch and traverse the region. At the region boundary, release the trigger.
- When the trigger is released the number displayed in the white box is the average of all readings to that point. Each press of the trigger logs a new value.
- When you have completed the data collection, go to File and select Save to locate and name your job.



Primary Components

Battery Charger

The internal battery, located in the control box, can be recharged using the battery charger. Simply plug it into the wall, and insert the DC adapter in to the power supply socket on the control box. The charger's green LED will light when the battery is fully charged (100-240VAC in, 12VDC, 800mA out). The charger will not overcharge the battery.

CAUTION: It is not recommended to connect a vehicle 12V to the power connector, as there is a risk of over-charging which will damage the internal battery.



Control Box

The control box contains a battery and a circuit board to interface the power and switches to the Sensor and external connectors.

Power Connector

This connector goes directly to the battery for charging (12V in).

Power Switch/Indicator

The switch supplies power to the Sensor and Powered Cradle. The indicator will illuminate when power is on.

External Data Port

The serial port allows the collection of data through an RS232 connection using the serial cable provided (Com Port: 38,400 Baud, 8, 1, N; Flow: None).



Personal Digital Assistant

The Sensor Unit requires an iPAQ PDA to display and store the data from the Sensor. Refer to the iPAQ manual for operating instructions. The NTech Capture[®] program is pre-loaded on the iPAQ.

Powered PDA Cradle

This rugged mount securely fastens the PDA to the extension pole of the Sensor Unit. The Powered Cradle gets its power from the battery inside the Control Box. It will charge or extend the battery life of the iPAQ if the Power Switch is turned on.



Trigger Switch

This allows the user to control the data flow and the count of the data collected. Grip the PDA mount and use index finger to press the switch. A small buzzer located in the control box will sound while the trigger switch is pressed. Position the Sensor over the target before pushing the trigger to avoid erroneous data. (The buzzer can be disabled. See the "Helpful Hints" section for details.)



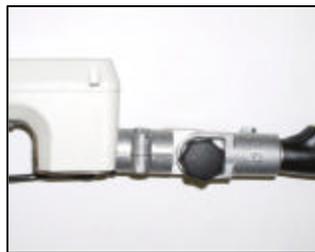
Sensor

The reflectance readings are taken in this unit. This unit uses internal illumination for use in any lighting condition, day or night. When the unit is on, a red band of light will be observed immediately below the rectangular Sensor window. The Sensor is designed to be 32 to 48 inches over the desired plant/crop canopy to be sensed. The width of the Sensor measurement is a constant 24 inches. This width does not change with height.



Sensor Mount

The Sensor is adjustable in 15 degree increments. Adjust the angle and the pole length to set the Sensor parallel to the target. *The Sensor must be angled to fit in the storage case.*



Telescoping Tube

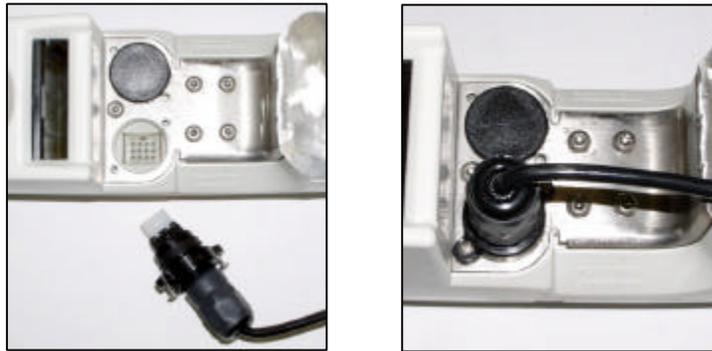
The telescoping tube is used to position the Sensor for different types of vegetation. It can be held at higher angles for tall crops, or lower angles for short vegetation, such as newly emerging wheat or turf grasses. The button located near the Sensor mount swivel is used to extend or retract the tube.

Connections

Verify the connections between the Sensor, the battery pack and the PDA per the figures below.

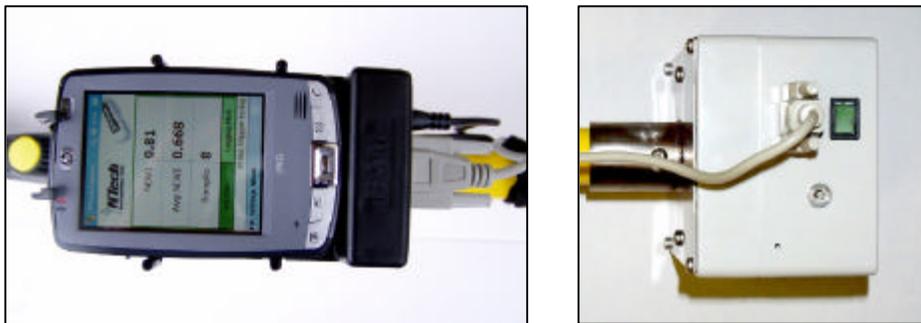
Sensor Connection

A 12-pin connector mates to the Sensor with two captive screws. Be sure it is mounted in the lower port shown below. *Do not connect to the adjacent connector port.*



Control Box to iPAQ Connections

The Control Box is connected to the Powered Cradle/iPAQ with a DB9 (RS232) serial cable. The small black power cable must be plugged in for the Powered Cradle to get its power from the battery inside the Control Box.



Wearing the GreenSeeker Hand Held™ Unit

There are three main pieces that may be adjusted for a comfortable fit. The shoulder strap adjusts in length. Use this strap to distribute the weight of the Sensor to the body. The strap works best when it is placed diagonally across the body.

The shoulder strap mount is also adjustable. Move the connection back and forth on the telescoping tube to balance it.

The PDA mount and mount handle may also be changed. The handle may be removed and turned around so the knob is suitably oriented for left-handed operation. The PDA mount may also be loosened to change its position along the telescoping tube. By optimizing the position of these items for comfort, data collection in the field becomes easier.

Software Information

NTech Capture[®] is a software program developed to capture the readings from the GreenSeeker Hand Held Sensor, display the current reading, and store them for later data analysis or to make fertilizer recommendations. Prior to shipment, the software was loaded onto your iPAQ.

NOTE: If the battery of the iPAQ discharges completely, you will have to reload the software.

The software is designed to operate like most Windows programs. Saving and opening a new file are similar to the operation of a word processing program. Make certain you note where you save the files on the iPAQ.



There are two modes available for logging data

Log Strips or Log Plots

The strip logging mode is for collecting sensor readings from large strips with different fertilizer levels. More specifically, it is for comparing nitrogen rich strips (NRS_NDVI) with lower rate, farmer practice strips (FP_NDVI) to determine recommendations.

The plot logging mode is for collecting readings from multiple “plots” and is better suited to data analysis.

Log Strips Mode

To Log Strips:

- Turn on the power switch located on the Control Box.
- Turn on your iPAQ and go to the Start menu. Click on Programs then the NTech Capture icon to open the program.
- Select Non Ref (Farmer Practice) or Reference (N Rich Strip) by tapping on selection. Button will change and display Monitoring..
- Select Sensor and Start GreenSeeker.
- Position the Sensor at the beginning of the target region. Press the trigger and traverse the region. At the end, release the trigger. Data will be recorded to the file when the trigger is pressed.
- When the trigger is released the number displayed in the white box is the average of all readings to that point.
- When you have completed the data collection, go to File and select Save.



Data: Log Strips Mode

Once saved, you can view the data collected by simply selecting the name of the file in the "Field/File Name:" box.

The *filename.txt* file contains three pieces of information:

Average FP_NDVI value

Average RS_NDVI value

Maximum NDVI from the rich strip (RS).

The data displayed can be used to generate a nitrogen recommendation when used in conjunction with the Oklahoma State University webpage:

<http://www.soiltesting.okstate.edu/SBNRC/SBNRC.php>

If you switch between modes and you have not saved the data file, you will be prompted to save the file.

NOTE: Once you switch modes or close the program you cannot open an existing file and save more measurements to it. After saving a data file, you can create a new file by selecting File and New. This will clear the data cells and allow you to collect readings for a new field.

The following is a sample of the text file for reference:

filename.txt

FP_NDVI :

AVG = 0.67112, STDEV = 0.11562

RS_NDVI :

AVG = 0.77964, STDEV = 0.01023

MAX_NDVI :

Max_NDVI = 0.77740

Log Plots Mode

To Log Plots:

- Turn on the power switch located on the Control Box.
- Turn on your iPAQ and go to the Start menu. Click on Programs then the NTech Capture icon to open the program.
- Select Sensor and Start GreenSeeker.
- Click on the Log Plots tab.
- Position the Sensor at the beginning of the target region. Press the trigger and traverse the region. At the end, release the trigger. Data will be recorded to the file when the trigger is pressed.
- When the trigger is released the software will display:
 - Sample No.
 - NDVI
 - Avg NDVI
- Each time you press the trigger switch the plot increments by one.
- When you have completed the data collection, go to File and select Save.



Data Log Plots Mode

Three files are created when data is saved. Each file is automatically saved to the following folder: My Device\My Documents\NtechCapture.

<i>filename.txt</i>	file contains all of the data collected
<i>filenameAvg.txt</i>	file contains only an average NDVI for each sample (plot)
<i>filenameDiag.txt</i>	contains all the diagnostic information for the sensor (typically empty)

If you switch between modes and you have not saved the data file, you will be prompted to save the file.

NOTE: Once you switch modes or close the software you cannot open a created file and save more measurements to it. After saving a data file, you can create a new file by tapping File and New (similar to Log Strips mode). This will clear the data cells and allow you to collect readings for a new field.

Log Plots Mode Data Management

The data collected with the GreenSeeker Hand Held may be written to the iPAQ's internal memory or a removable SD (Secure Digital) memory card. It can then be exported to your PC by syncing the iPAQ with your computer.

filename.txt and *filenameAvg.txt* are written to a comma-delimited ASCII text file suitable for direct import to Microsoft Excel.

- Download the data file(s) to your computer by syncing the iPAQ with your computer.
- Then launch Excel and select Open from the File menu.
- Change File Types to All Files and select your .txt data file.
- Select Delimited Text, delimited by commas and spaces. This will import data into separate columns in the spreadsheet file.

CAUTION: If the iPAQ has not been charged for several days, the captured data on the iPAQ may be lost. *It is critical that you copy the data from the iPAQ and save it to your PC or a Secure Digital card.*

The following is a sample of the text files for reference:

filename.txt

```
Time(ms), Smp1, Cnt, NDVI, selected_VI,  
11000, 0, 17, 0.700, 0.171  
11100, 0, 18, 0.730, 0.156  
11200, 0, 19, 0.720, 0.157  
11300, 0, 20, 0.740, 0.148  
11400, 1, 1, 0.740, 0.149  
11500, 1, 2, 0.730, 0.156  
11600, 1, 3, 0.730, 0.153  
11750, 1, 4, 0.720, 0.156  
11800, 1, 5, 0.720, 0.161
```

filenameAvg.txt

```
GS Time(ms), Sample, Count, NDVI, selected_VI  
18570, 1, 12, 0.78517, 0.78517  
21570, 2, 13, 0.78031, 0.78031  
24570, 3, 9, 0.77944, 0.77944
```

filenameDiag.txt

```
*** Sensor Summary *****  
Model.....: 500/505  
Hardware Rev..: G*-J/B-D J  
Software Ver...: 1.6.6  
Compiled.....: Feb 14 2005  
Serial Num....: J1019  
Module Addr...: [19]  
Sensor Mode...: [HH]
```

Helpful Hints

- **CAUTION:** If the iPAQ has not been charged for several days, the captured data on the iPAQ may be lost. *It is critical that you pull the data off the iPAQ and save it to your PC or the Secure Digital card.*
- Charge both GreenSeeker Hand Held™ and iPAQ batteries completely before going to the field. The internal battery is fully charged when the charger LED is green. The iPAQ battery is fully charged when the amber LED is on solid.
- Make sure to clear enough memory on your iPAQ before going to the field.
- Make sure the Sensor is approximately parallel to the area being sensed.
- Adjust the shoulder strap and PDA mount so the Sensor can be held comfortably.
- Before going to the field, test the Sensor using the steps outlined in the Sensor Performance section.
- To disable the buzzer:
 1. Open the Control Box by removing the four screws in the corners with a Phillips head screwdriver.
 2. Carefully separate the two halves of the box making sure the cables remained plugged in.
 3. Remove the black jumper from J5 on the yellow connector PCB (ASSY 400-1-014).
 4. Close the Control Box and reinstall the four screws.
- If you do not have a current version of Microsoft ActiveSync, go to <http://www.microsoft.com/downloads/> and select ActiveSync from the “Product/Technology” pull-down menu. Follow the instructions for downloading and installing the software.

Design Revisions

Continuing a policy of research and development, NTech Industries, Inc. and its subsidiaries reserve the right of price, product or design changes without notice of obligation.

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APPENDIX A: Data Output Options

For special applications, the user can change the output of the Sensor. From the Outputs Menu, you can change the speed, format, and type of data. *Some of these options are not compatible in Capture, but are useful for proprietary data logging systems.*

Connect the serial cable to a null modem adapter (available at most electronics store or can be purchased from NTech, p/n 350-6-077) then to a PC's available serial port. Run HyperTerminal with the following Com port settings:

38,400 Baud, Data bits: 8, Parity: None, Stop bits: 1, Flow Control: None.

Turn on the Sensor and the following header will display:

```
*** Sensor Summary *****
Model.....: 500/505
Hardware Rev.: G*-J/B-D  J
Software Ver..: 1.6.6
Compiled.....: Feb 14 2005
Serial Num....: J6123
Module Addr...: [01]
Sensor Mode...: [HH]
```

Type "m" to bring up the Main Menu:

```
--- M A I N   M E N U  -----
c. AutoCalibrate [2PT]
u. Select HH or APP ....: [HH]
s. Set Sensor Address ..: [85]
p. Print Parameter Summary

o. OUTPUTS Menu
e. EXTRAS Menu
d. DIAGNOSTICS Menu
q. Quit
```

Type 'o' to select the Outputs Menu.

CAUTION: You should not need any of the other menu functions. ***Especially, do not select AutoCalibrate, as the sensor would lose the calibration, and no longer function correctly; it would then need to be returned to the factory.***

For special applications, the user can change the output of the Sensor. Type "o" to bring up the Outputs Menu:

```
--- O U T P U T S   M E N U  -----
1. Set Data output interval ..: 100ms
2. Set Data Smoothing Value ..: 1
3. Select Output Variables ...: [Standard]
4. Select Data Delimiter .....: [comma]
5. Select Vegetation Index ...: [NDVI]
6. Enable Graphing Mode .....: [OFF]
9. Reset all modes to default

m. MAIN menu
q. Quit
```

1. **Data Output Interval** ranges from 20ms to 1500ms (50Hz - 0.66Hz). This output interval might be decreased to gather data faster, which is useful if moving at higher speeds. It may be increased to match other data logging equipment or to limit the amount of data gathered.
2. **Data Smoothing** may occasionally be useful to smooth (filter) the data in a highly variable environment. A setting of 1 is normal output; higher values average the data over longer intervals.
3. **Output Variables.** For higher throughput on the port, the output stream may be reduced to simply NDVI only as a 3-digit integer instead of the five data fields normally output.
4. The **Data Delimiter** option can change the data output text file to either comma or tab delimited. Tab delimited is much easier to import into Microsoft Excel.
5. **Vegetation Index.** Two values are generally supplied by the Sensor. The first output is always NDVI. The second output may be selected: NDVI, SA-NDVI, WDR-NDVI, RVI, IRVI. See Appendix C for an explanation.
6. **Graphing Mode.** Useful primarily for testing, but allows a graph and min-max ranges to be seen on screen, and makes trends in the data more obvious.
7. **Reset to Defaults.** Changes all of the modes back to a standard condition, compatible with the PDA Capture program.

Press “m” to return to the Main Menu or press “q” to quit, putting the Sensor back in the mode to output data.

APPENDIX B: How To Re-install or Update NTech Capture[®]

First, you will need to determine what version of Windows Mobile™ for Pocket PC Operating System you are running. Currently there are three different versions: Pocket PC 2002 (WinCE 3.x), Pocket PC 2003 (WinCE 4.x, also known as Windows Mobile 3.0), and Windows Mobile 5.0. To determine which Pocket PC version is installed on your iPAQ:

- Find the small decal attached to the back of the iPAQ with the Operating System version and a serial number written on it, OR
- Turn on the iPAQ:
Click: Start -> Settings -> System -> About
The About screen displays:
"Microsoft Pocket PC Version x.x.x..." , or "Microsoft Windows Mobile Version x,x"

Pocket PC 2002 is indicated by Version 3.x.x

Pocket PC 2003 is indicated by Version 4.x.x

Windows Mobile is indicated by Version 5.0

Note: All CD Packets or Downloadable installation files contain "ReadMe" files for additional help if necessary.

For Pocket PC 2002:

- Connect your iPAQ PDA to your computer using Microsoft ActiveSync™.
- Once Microsoft ActiveSync™ indicates that the iPAQ is connected, insert the NTech Capture[®] CD into your computer or download the version you would like to install from the NTech Industries website. *Note: V2.1.0 is the last compatible NTech Capture version available for systems running Pocket PC 2002.*
 - If using CD, from the Windows Taskbar, select Start | Run. Once the Run window opens, type:
D:\Ntech Capture\2002\Install.exe (where D: is the CD drive)
 - If installing from the web, double click on the downloaded files and follow the on-screen instructions.
- If prompted to overwrite a file on the iPAQ, select <Yes To All>.
- Press the soft-reset button on the iPAQ (located on the bottom or rear of the iPAQ).

For Pocket PC 2003:

- Connect your iPAQ PDA to your computer using Microsoft ActiveSync™.
- Once Microsoft ActiveSync™ indicates that the iPAQ is connected, insert the NTech Capture[®] CD into your computer or download the version you would like to install from the NTech Industries website.
 - If using CD, from the Windows Taskbar, select Start | Run. Once the Run window opens, type:
D:\Ntech Capture\2003\Install1.exe (where D: is the CD drive)
 - If installing from the web, double click on the downloaded files and follow the on-screen instructions.

- The Microsoft VB Runtimes Installer window will open. Click on the Next button and follow the on-screen instructions.
- The NTech Capture Installer window will open. Click on the Next button and follow the on-screen instructions.
- If prompted to overwrite a file on the iPAQ, select <Yes To All>.
- Press the soft-reset button on the iPAQ (located on the bottom or rear of the iPAQ).

For Windows Mobile 5.0:

- Connect your iPAQ PDA to your computer using Microsoft ActiveSync™.
- Once Microsoft ActiveSync™ indicates that the iPAQ is connected, insert the NTech Capture® CD into your computer or download the version you would like to install from the NTech Industries website.
 - From the Windows Taskbar, select Start | Run. Once the Run window opens, type:
D:\NTEch Capture\2003\Install1.exe (where D: is the CD drive)
 - If installing from the web, double click on the downloaded files and follow the on-screen instructions.
- The Microsoft VB Runtimes Installer window will open. Click on the Next button and follow the on-screen instructions.
- From the Windows Taskbar, select Start | Run. Once the Run window appears, type:
D:\NTEch Capture\2003\Install2.exe (where D: is the CD drive)
- The NTech Capture Installer window will open. Click on the Next button and follow the on-screen instructions.
- If prompted to overwrite a file on the iPAQ, select <Yes To All>.

Press the soft-reset button on the iPAQ (located on the bottom or rear of the iPAQ).

APPENDIX C: Vegetation Indices Available in the GreenSeeker® Sensor

There are several vegetation indices defined, evolving from more than thirty years of research in remote sensing and aerial imaging. In precision agriculture applications, two of the most commonly used indices are the Ratio and the Normalized Difference (NDVI), each comparing the relative reflectance of plant material and soils at two wavelengths. Additional modifications of the indices have been developed to compensate for various conditions of the plant canopy and background soil.

Several indices are available from the NTech GreenSeeker® Sensors. The sensor always outputs NDVI, plus an additional index (default is IRVI), which makes it possible to *compare indices on the same data at the same time*. This can be changed by connecting the sensor directly to a computer. Once selected, the output options are stored in the sensor, and remain in effect until explicitly changed.

NDVI	Normalized Difference Vegetation Index
SA-NDVI	Soil Adjusted
WDR-NDVI	Wide Dynamic Range
RVI	Ratio
IRVI	Inverse Ratio

Index Equations

The wavelength bands are in the visible (red, 660nm) and infra-red (NIR, 770nm) regions of the spectrum. Half-power bandwidths are approximately 25nm.

$$ndvi = \frac{r_{NIR} - r_{VIS}}{r_{NIR} + r_{VIS}}$$

$$rvi = \frac{r_{NIR}}{r_{VIS}}$$

$s\text{andvi} = \left(\frac{r_{NIR} - r_{VIS}}{r_{NIR} + r_{VIS} + L} \right) (1 + L)$	$irvi = \frac{r_{VIS}}{r_{NIR}}$
$wdr\text{ndvi} = \frac{a r_{NIR} - r_{VIS}}{a r_{NIR} + r_{VIS}}$	

The 'a' and 'L' values for the SA and WDR indices, respectively, are entered and stored in the Sensor. SA-NDVI reverts to NDVI if L = 0, and WDR-NDVI reverts to NDVI if a = 1. A typical value for a is 0.1; a typical value for L is 0.5.

References

University of Sheffield Remote Sensing: GEO6370 Vegetation Indices
<http://www.shef.ac.uk/~bryant/6370/veg/vegsoil.htm>

U.S. Water Conservation Laboratory: How a Vegetation Index Works
<http://www.uswcl.ars.ag.gov/epd/remsen/Vi/VIworks.htm>

Mark Servilla: The First Steps to Understanding Agriculture Remote Sensing
<http://www.eonline.com/modernagsite/archives/Servilla.html>

USGS: Wide Dynamic Range VI application
<http://www.gap.uidaho.edu/Bulletins/12/The Wide Dynamic Range Vegetation Index.htm>

BGR: A Comparison of Slope-Based Vegetation Indices for Agricultural Applications
<http://www.biogeorecon.com/vegindcs.htm>

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