FIELDSCOUT®

GreenIndex+ Turf

PRODUCT MANUAL

Item # 2910TA, 2910T

Spectrum® Technologies, Inc.

CONTENTS

This manual will familiarize you with the features and operation of your new FieldScout GreenIndex+ Turf App and Target Board. Please read this manual thoroughly before using your instrument. For customer support, or to place an order, call Spectrum Technologies, Inc. at 800-248-8873 or 815-436-4440 between 7:30 am and 5:30 p.m. CST, FAX at 815-436-4460, or E-Mail at info@specmeters.com. www.specmeters.com

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General Overview

This manual explains how to use GreenIndex+ Turf as a tool for managing the health of your turf.

The FieldScout GreenIndex+ Turf App captures and processes images from an iPhone, iPod Touch, or iPad and instantly computes the DGCI (Dark Green Color Index) of your turf. DGCI has been correlated to visual ratings. Therefore, our GreenIndex+ technology is sensitive to green color levels in the turf. This can be a function of stress caused by nutrition deficiencies, lack of water, compaction, or other factors. A default visual rating is computed by the App. This number can be easily customized for different turf varieties.

Digital images taken in the field typically exhibit variation due to ambient lighting, shadows, and texture. Green and yellow reference standards provide contrast and aid the imaging processing software. This allows for images to be captured under a broad range of lighting conditions.

FieldScout GreenIndex+ Turf offers digital image analysis of the turf, providing managers with an accurate, low-cost method for managing turf quality and appearance. All data is logged and geo-referenced, and can be emailed to your PC for further analysis.

Components

- 2910TA - GreenIndex+ Turf App -   Must be purchased through the Apple App Store (see link at www.specmeters.com/greenindexturf)
- 2910T - GreenIndex+ Turf Target Board with green and yellow areas and gray calibration background
- Rear-Camera Equipped iPhone, iPod Touch, iPad running iOS 6.0 or later -   Not Included

Target Board

The Target Board (item 2910T) is shipped in a protective manila sleeve. The board consists primarily of green and yellow areas with a small gray background on the yellow half of the board. These are used to compensate for different ambient light levels. The gray area is used for adjusting the white balance setting of the device. The board has a small hole in the corner. This is meant to accommodate a length of twine or string which allows you to move the board without bending over.

Board Maintenance

The board can be cleaned with a damp cloth. If necessary, some mild detergent can be added to the wash water.

Getting Started

Locate the GreenIndex+ Turf icon on your smartphone. Tap the icon to bring up the application.
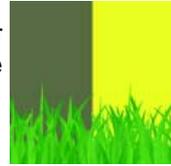
The GreenIndex+ Turf App consists of **6** screens; **Take Picture**, **Process**, **Results**, **Adjust Visual Rating**, **Settings** and **Select Variety** . When the App is brought up, the last active screen will be displayed. Details on the various screens are given in pages 6 to 11. If the device has just been powered up, the **Take Picture** screen will appear first.
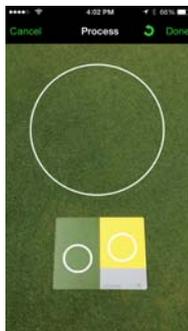
Take Picture screen   **Process** screen   **Settings** screen

Results screen   **Adjust Visual Rating** screen   **Select Variety** screen

"Take Picture" screen

The **Take Picture** screen is used to capture the photographic images GreenIndex+ Turf uses to compute the DGCI (see **About DGCI**, p. 22 and **Collecting Data**, p. 16). The numeral next to the title indicates how many readings are included in the running average.

This screen consists of 5 buttons.

CAMERA

Tap this button to take a photo of the turf. GreenIndex+ Turf will then proceed to the **Process** screen (p. 7).

SETTINGS

Tap this button to go to the **Settings** screen (See p. 9). The **Take Picture** screen is the only screen with access to the **Settings** screen.

SHARE

Tapping the SHARE button will bring up a screen which gives you the option of Emailing a copy of your logged data file (see **Log File**, p. 21). Select **Email Log** to proceed to the address entry screen. Select the CANCEL button to return to the **Take Picture** screen.

INFORMATION

Tap the INFORMATION button to go to the **Info** screen that describes the App. The Info screen also contains a tour that explains how the app works.

WHITE BALANCE

Used to lock the camera's white balance function (see **White Balance Locking**, p. 14)
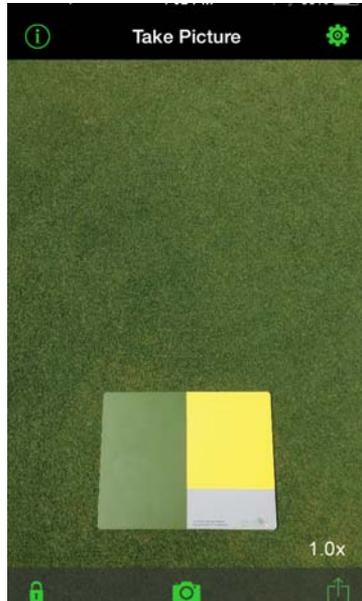
"Process" screen

The **Process** screen is where you mark the locations of the green/yellow areas and the turf on the images captured in the **Take Picture** screen so GreenIndex+ Turf can calculate DGCI (see **About DGCI**, p. 22 and **Collecting Data**, p. 16).

This screen consists of 3 buttons.

Done DONE

When you are happy with the placement of the 3 white circles on the image, tap this button to proceed to the **Results** screen where the GreenIndex+ Turf computations will be displayed. This button will be inactive until all 3 circles have been placed.
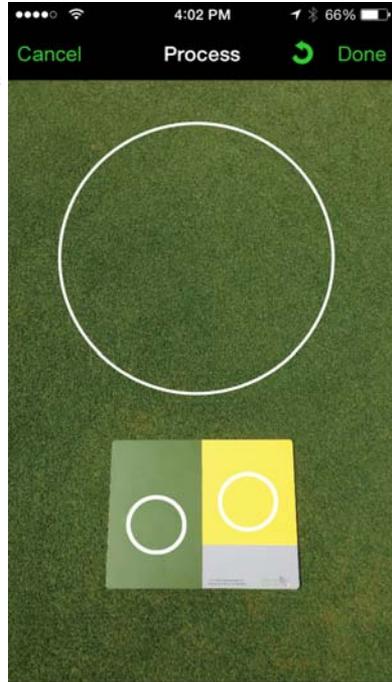
⟳ UNDO

Tap this button to remove the last circle placed. This button will be inactive until the first white circle (locating the green area) has been placed.

Cancel CANCEL

Tapping the CANCEL button will return you to the **Take Picture** screen. No computations will be made and no data will be saved.

"Results" screen

The **Results** screen is where the computed GreenIndex+ Turf data is displayed. The format of the screen is determined by what options are selected in the **Settings** screen (see also **Output** p. 18).

This screen consists of 3 buttons.

Add ADD

Tapping this button will add the current reading to the running average, increment the picture count, and return you to the **Take Picture** screen.

Cancel CANCEL

Tapping the CANCEL button will return you to the **Take Picture** screen. The data is not sent to the log file or included in the average.

END AND LOG AVERAGE

END AVERAGE

Tapping this button will end the current averaging and reset the picture count to 0. The appearance of this button depends on whether **Log Individual Readings** is set to ON or OFF (see p. 13).

"Settings" screen

The **Settings** screen is where GreenIndex+ Turf is configured. This screen is accessed by tapping the SETTINGS button on the **Take Picture** screen (p. 6). The different options are described in detail in the **Configuring GreenIndex+ Turf** section (p. 12).

This screen consists of 4 buttons.

Done DONE

Tapping the DONE button saves the selected options and returns you to the **Take Picture** screen.
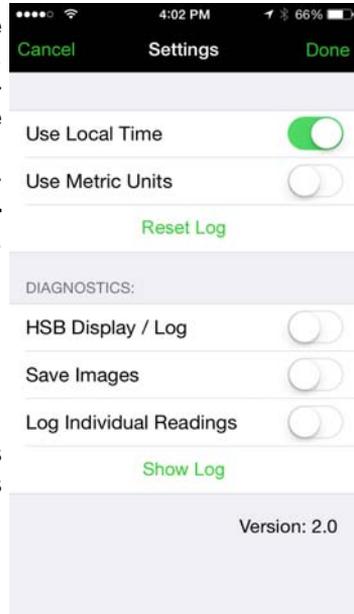
Cancel CANCEL

Tapping the CANCEL button will return you to the **Take Picture** screen without saving any newly selected options.

Show Log

Reset Log

SHOW LOG/RESET LOG
These buttons are used to manage the on-App display of the Log file (see **Log File**, p. 21).

"Adjust Visual Rating" Screen

The **Adjust Visual Rating** screen is used to create variety-specific visual ratings conversions. The procedure is described in detail in the **Adjusting the Visual Rating** section (p. 19). This screen is accessed by tapping the **Visual Rating** value on the **Results** screen (p. 8).

This screen consists of 3 buttons.

Done DONE

Tapping the DONE button saves the selected options and returns you to the **Results** screen. If the visual rating has been adjusted, the new value will now be displayed.

Cancel CANCEL

Tapping the BACK button will return you to the **Results** screen without saving any newly selected adjustments.

Reset to Default

Resets the selected variety's settings to that of the Default variety.

"Select Variety" Screen

The **Select Variety** screen is used to select or name turf varieties that will be given user-generated visual rating conversions in the **Adjust Visual Rating** screen (p. 10). This screen is accessed by tapping the **Variety** value on the **Results** screen (p. 8).

This screen consists of 1 button.

Back	**Select Variety**
Default	
Bentgrass	✓
Bermuda	
Add Variety...	>
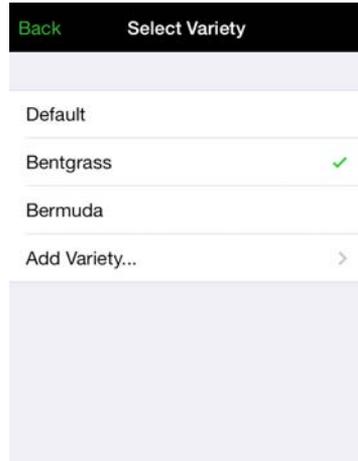
Back BACK

Tapping the BACK button will return you to the **Results** screen. The visual rating for the currently selected variety will be displayed.

Note: To delete a variety, make a leftward swipe with your finger on the right side of the screen, across from the variety to be deleted. A DELETE button will appear. Press this button to delete the variety. The Default variety cannot be deleted.

|		
Back	**Select Variety**	
Default		
s		Delete
bermuda		✓
Add Variety...		>

11
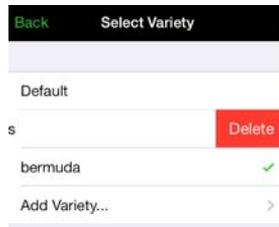
Configuring GreenIndex+ Turf

GreenIndex+ Turf is configured in the **Settings** screen (see p. 9). The different options are described below. When the configuration is complete, tap the DONE button in the upper right corner. Tapping the CANCEL button will exit the configuration process without making any changes.

The options in the upper half of the **Settings** screen are used to customize the data format. The options in the lower half are diagnostic in nature and, in general, will be disabled during general use.

Use Local Time
If ON is selected, logged data will record current time as the user would see it on their device. If set to OFF, UTC (GMT) is logged.
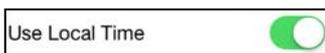
Use Metric Units
This option is currently inactive for the Turf version of GreenIndex+

Diagnostic Modes

HSB Display/Log
If the **HSB Display/Log** option is enabled, GreenIndex+ Turf will display and store the raw Hue, Saturation, and Brightness values in addition to the DGCI and SPAD equivalent values (see **Output**, p. 18).
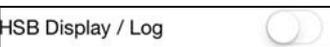
Save Images
If **Save Images** is enabled, the device will save the photographs to the camera roll. This feature is intended for diagnostic purposes. During normal operation, this option should be set to OFF.

<u>Log Individual Readings</u>

It may be desirable to have every reading stored in the data log. In this case, set the **Log Individual Readings** option to ON. In this configuration, individual readings will be sent to the log file whenever the ADD or END AVERAGE button is tapped. In this configuration, averaged values will <u>not</u> be logged.

Log Individual Readings	◯

If you would like to record the average of several measurements, set the **Log Individual Readings** option to OFF. In this configuration, only averaged values will be stored in the log file when the END AND LOG AVERAGE button is tapped. However, for each measurement, GreenIndex+ Turf will display both the individual reading and the running average on the **Results** screen. To continue adding readings to the running average, you must tap the ADD button before taking further readings.

White Balance Locking

Before taking readings, the device camera's white balance feature should be locked. This is done with the button in the lower left of the **Take Picture** screen (see figures 1 and 2). The button has two states: "balance scale" and "lock". The "balance scale" button indicates the meter is in dynamic white balance (DWB) mode, which is the default setting. In this mode, the camera's white balance will constantly adjust to differing light levels. This is ideal for taking standard photographs but causes problems when using the camera to collect data. The "lock" button indicates the meter is in static white balance mode (SWB). When this option is selected, the camera's white balance settings are locked in. This will only apply to the camera while the app is being used. It will not affect the camera's normal operation.

Fig. 1: Dynamic White Balance (DWB)

Fig. 2: Static White Balance (SWB)

To optimize the GreenIndex+ Turf App for data collection, white balance should be calibrated to a gray standard. This only needs to be done at the beginning of a sampling session. If the device goes into power-saving mode, the white balance calibration should be retained. However, the locking procedure will have to be repeated whenever the camera returns to DWB mode. This will be the case, for example, whenever the device is powered up or if the device's camera is opened in a different App.

Locking Procedure

1. While in the **Take Picture** screen, check that the "Balance Scale" icon is visible. This indicates the camera is in dynamic white balance (DWB) mode. A warning message will also appear on the screen if the white balance is not locked. If the "lock" button is visible, tap it to shift to DWB mode ("Balance Scale" icon).

2. Hold the device such that only the gray portion of the Green-Index Board is visible in the viewing area.

3. Tap the "balance scale" button to lock the white balance and put it in static white balance (SWB) mode. The icon should change to the "lock" icon to indicate that it is in SWB mode.

Fig. 3: Device in dynamic
(DWB) mode

Fig. 4: Device in locked
(SWB) mode

Collecting Data

This section describes how to capture DGCI and visual rating (VR) values. DGCI is calculated directly from the photo taken by the device. VR can be adjusted to create user-defined turf varieties (see p. 20).

Standard Procedure

1. Open up GreenIndex+ Turf and go to the **Take Picture** screen. If the device is in dynamic white balance mode, follow the white balance locking procedure (p. 14).

2. Lay the target board on the ground adjacent to the area to be sampled such that the green and yellow areas are visible on the screen. Take great care to avoid any shadows and glare. If it is necessary that images be taken in shady conditions (such as near landscaping), both the board and the image should be in identical conditions. Future readings at that site should also be taken in similar conditions to ensure data integrity.

3. Capture the image by tapping the camera icon located at the bottom center of the screen. This will advance GreenIndex+ Turf to the **Process** screen (p. 7).

4. GreenIndex+ Turf will prompt you to tap the green portion of the board. This will create a white circle where the screen is tapped. Once placed, this circle cannot be moved. The circle should be completely within the green area. If it is not, tap the UNDO button to re-locate the circle.
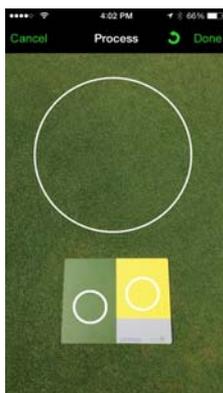
5. Repeat step 4 for the yellow color area.

6. GreenIndex+ Turf will then prompt you to tap the screen near the portion of the turf you want to measure. This circle can be moved and resized. The circle is moved by sliding your finger along the screen. It is resized by pinching the image with your finger and thumb. Manipulate the circle

until it surrounds the desired portion of the turf. Take care that neither the green nor yellow areas are included in the turf selection.

7. When the 3 circles are satisfactorily placed, tap the DONE button. GreenIndex+ Turf will then proceed to the **Results** screen to display the results of the measurement (see **Output**, p. 18). The displayed values will be for the most recently selected variety. At this point, you can also select a different, already-created, variety. If you wish to create a new variety, follow the instructions on p. 20.

Note: At any point, you can tap the CANCEL button to re-do the photo.

Output

After an image is captured and processed (see **Collecting Data,** p. 16), the GreenIndex+ Turf results are displayed on the **Results** screen. The appearance of this screen depends on what options are selected in the **Settings** screen (see **Configuring GreenIndex+ Turf**, p. 12).

The top of the **Results** screen will display the DGCI value (see **About DGCI**, p. 22) and equivalent visual rating (see **Visual Ratings**, p. 23) of the last turf area sampled. It will also show the currently selected turf variety (see **Creating a New Turf Variety**, p. 20).
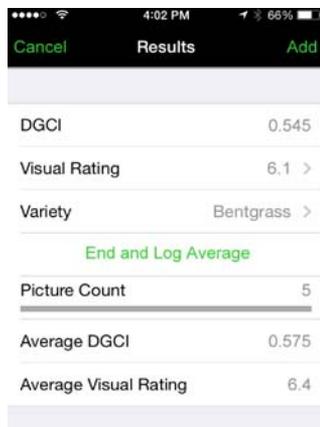
DGCI	0.545
Visual Rating	6.1 >
Variety	Bentgrass >
End and Log Average	
Picture Count	5
Average DGCI	0.575
Average Visual Rating	6.4

The number of pictures included in the average will be shown followed by the current average values for DGCI and Visual Rating as well as the number of readings included in that average. Tap END AND LOG AVERAGE (or END AVERAGE) to include this reading and end the averaged group.

If the **HSB Display/Log** option is enabled, GreenIndex+ Turf will display the raw Hue, Saturation and Brightness values for the green and yellow color areas as

Green area HSB	82 / 62% / 85%
Yellow area HSB	60 / 31% / 100%
Turf HSB	27 / 37% / 31%

well as for the selected section of turf. The color values are displayed in groups of 3. The first value is Hue, the second is Saturation, and the third is Brightness. These values will also be stored in the log file.

Adjusting the Visual Rating

After taking a reading (see **Collecting Data**, p. 16), the output will be displayed on the **Results** screen (p. 8). If the default visual rating is higher or lower than your own rating protocol, the app allows you to make an adjustment based on your observed value. Adjustments will only apply to the currently selected variety. To modify a different variety, select that variety from the list of options on the **Select Variety** screen (p. 11).

Tap the **Visual Rating** value to bring up the **Adjust Visual Rating** screen. The top section is identical to the **Results** screen. The second section shows the adjusted visual rating for the currently selected turf variety. It also shows what DGCI values will result in visual ratings of 1 and 9 for that turf variety. These can be thought of as the calibration coefficients. When a visual rating adjustment is done, one of these values gets updated. If you adjust a rating in the lower portion of the scale, the DGCI for 1 will be modified. Adjusting a rating in the upper portion of the scale will update the DGCI value for 9. The default values are 0.000 and 0.850 for visual ratings of 1 and 9 respectively. Adjust the slider bar to match the visual rating you would like to assign to the portion of turf captured by the camera. Tap the DONE button to save this adjustment. The visual rating will now reflect your change. Tap the CANCEL button to return to the **Results** screen without saving the adjustment.

Note: It is recommended that visual rating adjustments be done while creating a new turf variety (see Creating a New Turf Variety, p. 20).

CREATING A NEW TURF VARIETY

Because different varieties have different natural green colors, each variety can have its own custom visual rating scale. If an adjustment is made to the visual rating, it is recommended that this be done in conjunction with creating a new turf variety rather than modifying the coefficients for the Default variety. The following procedure will allow the app to give you adjusted visual ratings that compare well with the expected visual ratings for that site

Before taking readings with the app, identify the best and worst quality portions of turf. Rate each of these locations on a scale of 1 to 9. See **Visual Ratings** (p. 23) for guidelines for visually rating turf.

1. Take a GreenIndex+ Turf reading at the location with the highest quality.

2. From the **Results** screen, tap the **Variety** field to bring up the **Select Variety** screen (p. 11).

3. Tap the **Add Variety** option to open the **Enter Variety Name** screen. Type in the name of the variety and tap OK. Tap the **Back** button to return to the **Results** screen.

4. Initially, the calibration coefficients will be the same as the Default variety. Follow the instructions for adjusting the visual rating (p. 19)

5. Take a reading at the location with the lowest quality. Follow the instructions for adjusting the visual rating.
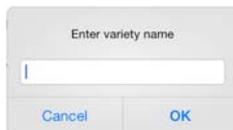
The app will return you to the **Results** screen and display the visual rating for the newly created variety. Tap the DONE button to save the result and return to the **Take Picture** screen.

LOG FILE

Transferring Data

All readings taken by GreenIndex+ Turf are stored in internal memory on your device. The data is transferred as a tab-delimited file to an external computer via an Email attachment. The Email screen is accessed by tapping the SHARE button on the **Take Picture** screen. Select the **Email Log** option to continue (Tap CANCEL to return to the **Take Picture** screen). Once in the Email screen, type the address(es) to which you would like the data sent. A default Subject line is provided but can be edited to better identify what data is being sent by this transmission. It is also possible to type a message in the text field to convey any additional information to the recipient (s). Tap the SEND button to send the Email. You must have internet access to successfully complete the transmission. If you do not want to complete the transmission, tap the CANCEL button. This will bring up a question box that will ask if you wish to delete or save this draft. Hitting the cancel button in the question box will return you to the Email screen.
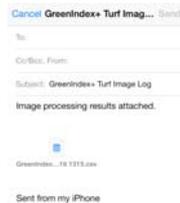
Settings Screen Options

Show Log

In addition to sending the data file to a computer, GreenIndex+ Turf also allows you to view the log on the device. The **Log** screen can be accessed by tapping the SHOW LOG button on the **Settings** screen. This screen is intended to confirm that the readings are being stored as expected. It is not designed for on-device analysis.

Reset Log

Data will be written to the log file every time a new reading is made. After data has been successfully transferred, or if it is otherwise not needed, it can be deleted from the device's memory with the RESET LOG button. You will be asked to confirm this request.

About DGCI

One way to assess the health of turf is by evaluating canopy greenness. This is an indicator of the chlorophyll levels which are impacted by stresses caused by inadequate nutrition and moisture, pest pressure, disease, or excessive compaction levels. Over the years, several objective greenness indexes have been developed and incorporated into portable devices used to evaluate plant health. The most common is the Normalized Difference Vegetative Index (NDVI). Greenness indexes are calculated from data collected by devices which measure spectral reflectance or transmittance of pre-selected wavelengths of light. These devices require specialized light emitters and/or filters to make these measurements.

In 2003, researchers at the University of Arkansas developed a method for measuring greenness in turf using images captured with a digital camera. GreenIndex+ Turf uses this same technique to quantify plant greenness using the camera contained in a smartphone.

A digital camera captures an image as a series of pixels that have different levels of Red, Green, and Blue (RGB) color. However, for the purposes of quantifying turf greenness, it is not accurate to just use the Green parameter from this color scheme. This is because the amount of Red and Blue also affect how green the turf looks. Therefore, the RGB color scheme must first be converted into Hue, Saturation, and Brightness (HSB).

Hue has a value between 0 and 359, Saturation and Brightness have values between 0.0 and 1.0. DGCI is then calculated from the HSB values as follows:

$$DGCI = \frac{1}{3}[(\frac{Hue-60}{60}) + (1 - Saturation) + (1 - Brightness)]$$

Visual Ratings

The primary output of GreenIndex+ Turf is an index (DGCI) which quantifies the greenness of the turf. Research has shown that this index can be related to the visual rating (VR) of turf (Karcher and Richardson, 2003).

Visual ratings are a subjective method of assessing turf quality. They are based on a scale of 1 to 9 with 1 being poor and 9 being high quality (Morris, 2002). A rating of 6 or higher is typically considered to be acceptable quality. A rating of 9 is assigned to ideal turf. Although it is recommended that ratings are only given as whole numbers, there are some raters that opt to also assign ratings in half unit increments because it gives them more flexibility. GreenIndex+ Turf gives VR's in decimal form because it is converting from an optical measurement that has more precision. These adjusted visual ratings can be rounded to the nearest whole (or half-unit) increment, as desired.

Quality ratings are based on several factors. These include color, density, uniformity, and texture as well as the functional use of the turf.

Tips
- Before rating, walk the site to identify the range of visual differences at the site. You may wish to mark these sites to use as a reference.
- Cloudy conditions are ideal for rating because shadows and reflections are minimal. Data is best taken between mid-morning and early afternoon.
- Mowing direction can influence how light reflects from the canopy. If turf is mowed prior to rating, it should be in a consistent direction each time.

Morris, K.N. 2002. A guide to NTEP turfgrass ratings. National Turfgrass Evaluation Program (NTEP), Beltsville, MD. http://www.ntep.org/reports.htm (accessed 27 Aug. 2013)

Karcher, D.E., and M.D. Richardson. 2003. Quantifying turfgrass color using digital image analysis. Crop Sci. 43:943-951.

Frequently Asked Questions

1. Does the number of pixels affect the GreenIndex+ Turf reading?
No. The number of pixels required to do the DGCI computations is much smaller than are found in a standard smartphone camera image.

2. What is the effect of light?
The colored areas on the board are designed to compensate the GreenIndex+ Turf readings for differences in light levels. However, it is important to ensure that the board is uniformly illuminated with no glare and uniform or no shadow.

3. How does the position of the board impact the readings?
To maintain consistency, the board should be placed in a similar manner for all readings. Typically, this will be at the bottom of the image.

4. How does DGCI compare to Visual Ratings?
DGCI has shown good correlation to visual ratings. The app also gives the user the ability to adjust the default visual rating to match their observations.

5. What is the impact of different turf varieties?
Because different turf varieties will have different color characteristics, the optimum DGCI value will vary from one to another.

6. Does a change from dynamic white balance to static white balance change other camera functions on the phone (i.e. camera roll)?
The white balance lock is only active for the GreenIndex+ Turf app. If another camera app is run, the white balance lock will be lost and have to be re-established when GreenIndex+ Turf is re-opened.

7. Will the GreenIndex+ Turf app work with an older iPhone or iPod?
Older iPhones and the cameras they possess are more than adequate for GreenIndex+ Turf purposes. However, version 2.0 of GreenIndex+ Turf requires iOS version 6.0 or later. Note that the IDevice must have a rear-facing camera.

14. GreenIndex+ Turf is not recording the GPS coordinates?
When GreenIndex+ Turf is first installed, you should be prompted to allow the app to use your current application. You must allow this to bring GPS information into the data file. If you are not getting GPS coordinates, you must go to the iDevice settings and enable them for use in GreenIndex+ Turf.

Warranty

The GreenIndex+ Board Turf Board is warranted to be free from defects in material or workmanship for one year from the date of purchase. During the warranty period Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty does not cover damage due to improper installation or use, lightning, negligence, accident, or unauthorized modifications, or to incidental or consequential damages beyond the Spectrum product. Before returning a failed unit, you must obtain a Returned Materials Authorization (RMA) from Spectrum. Spectrum is not responsible for any package that is returned without a valid RMA number or for the loss of the package by any shipping company.

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