DATA FUSION FOR PRECISION TURF MANAGEMENT

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- Overview of data fusion
- Demonstration of data fusion
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P R E C I S I O N  T U R F  M A N A G E M E N T

• In a perfect world:
PRECISION TURF MANAGEMENT

• In a reality:
• Precision turf treatment:

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<th>RATE</th>
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<tbody>
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<tr>
<td>1,895</td>
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<tr>
<td>152,669.5</td>
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![Image of a precision turf management diagram](image-url)
• Precision turf treatment pitfalls:

  • Snapshot from one data source frequently used
  
  • No satellite, camera, or other sensor can fully capture your turf conditions
  
  • When comparing data, different patterns and trends often emerge
  
  • NDVI and NDRE example from WorldView2 satellite below:
    • Almost 100,000 SQFT difference on 18-hole course with over 1 million SQFT
    • Which one is right? What should one do?

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Normalized Difference Vegetation Index (NDVI)

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<td>1,900.3</td>
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<td>57,041.8</td>
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Normalized Difference Red Edge Index (NDRE)
DATA FUSION & PRECISION TURF

• Recognizes 3 laws of ecology:
  • “Too much” and “too little” can stress or kill turf
  • Exact thresholds of “too much” and “too little” may vary on individual holes or between different holes and depend on “many factors interacting together”

• Data fusion:
  • All types of data have limitations
  • Can benefit from combining data and calculations
  • Create single precision management layer from data combinations that is actionable

Turf Health Index 1
Turf Health Index 2
Soils
Hydrology
Topography

ONE ACTIONABLE RX
DATA FUSION EXAMPLE

• Fairways Demonstration
  • Fuse two key turf health indices from satellite
  • 2-m WorldView-2 satellite data
  • NDVI and NDRE turf health indices from the July 10 of the 2012 growing season
  • 18 holes on a Minnesota golf course (6 holes displayed for viewing convenience)

• Management Problem
  • Targeted application of fungicide to lushest/greenest parts of fairway
  • Fungi most likely to establish in these area; want to apply before visual confirmation of establishment
DATA FUSION & PRECISION TURF

NDVI (7-5/7+5, 0.331-0.832)  NDRE (6-5/6+5, 0.423-0.796)
DATA FUSION EXAMPLE

NDVI (Normalize, make zones)

NDRE (Normalize, make zones)
DATA FUSION EXAMPLE

NDVI (152,000 SQFT LUSH TURF)             NDRE (57,000 SQFT LUSH TURF)
DATA FUSION EXAMPLE

NDVI LAYER ON TOP OF NDRE

NDRE LAYER ON TOP OF NDVI
DATA FUSION EXAMPLE

NDVI AND NDRE ANALYTICS: DEVELOPING A PLAN
ACTION RX 1:
Include all areas mapped by NDVI and NDRE (160,000 SQFT)
*AGGRESSIVE!
DATA FUSION EXAMPLE

ACTION RX 2:
Only include areas where NDVI and NDRE overlap (50,000 SQFT)
*CONSERVATIVE!
DATA FUSION EXAMPLE

CAUTION:
- Remote sensing problems on golf courses
- Trees and other obstructions

TREES
INITIAL PROTOCOLS

• (1) Identify a management problem that you want to address on your course

• (2) Don’t rely on a single piece of information to make an RX for solving the problem

• (3) Use on-the-ground knowledge of your course to “mine” multiple data sources that might help address your management problem

• (4) Let your knowledge of the course guide the data fusion process (i.e., integrate the most useful parcels of information from different data sources into ONE actionable RX file)

• (5) Manipulate data so it compliments your precision equipment
SOFTWARE USED FOR ANALYSES

• All open source (i.e., free) software was used for the remote sensing and GIS analyses of the data presented today:

  • R: [https://www.r-project.org/](https://www.r-project.org/)
  • OSGeo: [http://www.osgeo.org/](http://www.osgeo.org/)
  • GDAL: [http://www.gdal.org/](http://www.gdal.org/)
  • FWTools: [http://fwtools.maptools.org/](http://fwtools.maptools.org/)
FUTURE WORK

• Partners
  • Didn’t have enough time or resources to collect and integrate additional data
    • e.g., soil moisture, compaction, and nutrient data
  • Looking for partners to collaborate

• Contact Kirk after the talk or at 651-491-3372 or kirk@frostserv.com if you’re interested