A view of your course that you've never had! New insight for Precision Management from Mobile Sensors and Geographical Information Systems

Google earth

2013 GIS San Diego

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Precision Turf Management

The precise application of resources based on site needs:

Objective: Efficiency in resource

Efficiency in resource use by applying inputs only where they're needed, in the right amounts and at the right time to produce a **high quality turf product.**

Motivations for Precision Management (Forces Shaping the Industry)

Economics

- Operational costs are increasing chemicals, fertilizers, water, electricity, fuel
- More competitive environment.
- Controlling costs through efficiency site-specific management of inputs

Regulation

• **Restrictions on resource use** – P containing fertilizers, EPA WaterSense, etc.

Quality & Playability

Improving playability through uniformity & consistency
The enduring quest for "better"

Public Perceptions/Social

- Public image as a non-essential, luxury consumer an easy target
- Turf industry must demonstrate a proactive approach to sustainability
 Requires science, technology and leadership

Environmental Sustainability & Stewardship

- Protection of natural resources water, soils, habitat, non-renewable fuels
 Pressure to reduce chemical & fertilizer use
- Reducing greenhouse gas emissions; Optimizing carbon storage
- The Water Use imperative

Precision Turf Management

The precise application of inputs based on **site needs**: Applying inputs only where they're needed, in the right amounts and at the right time to produce a high quality product.

Efficiency requires Precision requires Information requires Sensors & GIS

• Water use

- Fertilizers
- Fuel
- Chemicals
- Labor
- Equipment
- Operating budgets

 Precise application & management of all resources Critical agronomic site conditions

Soil Properties

 Moisture
 Compaction
 Fertility
 Salinity

 Turf Performance
 Topography/Relief
 Weather
 GPS



Understanding variability in site attributes is the challenge.

Variability in soil properties, turf quality, topography

Toro's Precision Sense[™] Site Assessment System

 Decision-support system through data collection & analysis

The product is Information

Three Components:

1) Data collection tools "PS 6000"

2) Data analysis using GIS (Geographical Information System)
3) Data base & data application products



"PS 6000" Data Collection Vehicle

GPS provides latitude & longitude referencing and elevation data

On-board computer processes & logs sensor data

Foamer provides navigation

Soil sensors measure moisture & salinity content plus compaction

> Spectrometers measure turf vigor

Soil moisture

- Soil salinity
- Soil compaction
- Turf quality
- Topographic relief

Data Collection Process

8'x10' sampling grid



GIS (Computing power...) Geographical Information System

Sample data ~1 pt./100 ft² 435 pts./ac. or ~1000 pts./frwy

Data Interpolation

Sampled data is Interpolated using *"kriging*" to create spatial distribution maps of site attributes.

Sampled data points for VWC 8' x 8-16" grid

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Sample data interpolated to a 2' x 2' grid — Interpolated data 1 pt./4 ft²
Or ~25,000 pts./frwy

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Primary database: Site Assessment Data

GPS Sprinkler Head Locations



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Primary database: Turf Vigor



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Primary database: Soil Moisture

ALC: NOW	Soi	Soil Moisture (VWC)									
	Dry	< 25%									
ŝ	Soil	25 - 30%									
		30 - 35%									
		35 - 40%									
		40 - 45%									
		45 - 50%									
		50 - 55%									
		55 - 60%									
	Wet	60 - 65%									
	Soil	> 65%									

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Primary database: Soil Compaction



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Primary database: Soil Salinity

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		3.5
		4.0
		>4.0

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Primary database: Topography

Elevation 1' contour interval

> Elevation Highest

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Lowest



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Primary database: Slope Steepness

Slope
Minimal (0-4.5%)
Moderate (4.5-7%)
Moderate-Steep (7-12%)
Steep (12-15%)
Steepest (>15%)

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Primary database: Slope Aspect



West (247-292 deg.)

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Data applications focused on water use:

Auditing Irrigation System Performance to Optimize Distribution Uniformity



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Course-wide Analysis: Soil Moisture variability

Soil Moisture (stretched values) Min value



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lat 44.686424° lon -93.310635° elev 0 ft

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Course-wide Analysis: Turf Vigor variability

5/2010

Turf Vigor (stretched values) Min value

– Max value

Google earth

File Edit View Tools

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Help

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Fairway scale analysis: Soil Moisture variability

Eye alt 919 ft 🔘

Google earth

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Fairway scale analysis: Sprinkler head coverage



Eye alt 919 ft 🔘

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Fairway scale analysis: Soil Moisture Uniformity around Sprinkler Heads

Sprinkler heads

States-

Soil moisture distribution depicted in 3D

New Irrigation Audit

Evaluating soil moisture distribution arour individual sprinkler heads

Th: 142 4	Moisture Uniformity: 64.6%								
5core : 1	Pattern: 1	Scale: 43.6%	Directional Variation: 21.5%						
Head Impact Area Stats	Mean	cv	Soil Moisture Correlation						
Soil Moisture	40.6	28.1%							
Compaction	213.3	4.3%	-0.86 0.79						
Turf Vigor	0.868	1.9%							
Head 162-4 Dir:W-N		Head 162-4 Dir:N-E							
Section Splikkr	CO Romalized Values	-10 0 10 2 Feet	a 30 40 s0 60 from Splitker						
Head 162-4 Dir:S-W		Head 162-4 Dir:E-S							
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Frwy #16 Head 1-162-4 MU 64.6% Directional variation 21.5% Pattern scale 43.6%

50' 40' 30' 20' 10'

Individual Irrigation Head Level - Metrics

Head ID	Min	Mean	Max	Range	Std. Dev.	CV	Moisture Uniformity	Pattern	Pattern Scale	Directional Variation	Turf Vigor Correlation	Compaction Correlation	Score
162-10	20.63	47.38	87.2	66.57	12.78	27%	67%	1	22.89	18.2	0.40	-0.63	5
162-11	23.78	56.4	89.07	65.29	12.29	21.8%	70%	9	38.78	14.7	0.68	-0.67	4
162-12	23.37	51.52	80.22	56.85	12.81	24.9%	67%	1	62.78	9.7	0.42	-0.82	5
162-13	14.8	39.25	60.53	45.73	9.48	24.2%	67%	3	26.11	17.9	0.54	-0.79	4
162-14	15.77	46.53	97.92	82.15	17.19	36.9%	59%	1	72.30	21.2	0.41	-0.54	5
162-31	23.01	38.52	57.95	34.94	7.79	20.2%	77%	5	12.84	13.6	0.79	0.13	8
162-32	16.2	43.79	104.6	88.4	21.29	48.6%	53%	1	66.96	25.2	0.06	-0.53	5
162-33	23.26	45.99	99.83	76.57	17.81	38.7%	61%	13	29.00	31.4	0.67	-0.60	4
162-34	16.76	50.03	92.82	76.06	14.24	28.5%	61%	1	46.51	19.9	0.20	-0.51	5
162-35	25.9	40.88	59.03	33.13	8.6	21%	73%	7	23.19	19.4	0.81	0.19	4
162-36	15.37	30.59	56.71	41.34	9	29.4%	69%	3	48.56	16.9	0.39	-0.29	5
162-37	24.79	37.08	48.63	23.84	4.24	11.4%	86%	3	15.06	10.1	0.02	0.00	10
162-38	18	41.33	63.16	45.16	9.36	22.6%	72%	1	50.49	11.1	0.04	-0.09	6
162-39	36.79	44.86	49.88	13.09	2.48	5.5%	93%	NA	3.85	3.1	-0.16	0.14	10
162-40	16.25	48.78	162.94	146.69	24.93	51.1%	49%	3	87.41	28.4	0.54	-0.70	4

Head 162-10

Soil Moisture



Soil Compaction







Data applications focused on water use:

Irrigation Management Zones for Precision Watering

- Site data is used to define and divide the golf course into distinct "irrigation management zones."
- All areas within each zone require similar irrigation treatments because of similar soil & site conditions.
- Each sprinkler head is assigned to a management zone. Irrigation is then programmed by zones.
- In-ground sensors monitor soil moisture continuously for regular irrigation decision-making.



Irrigation Management Zones for Precision Watering Defining the Zones



Irrigation Management Zones for Precision Watering Individual site data layers are analyzed separately and as a composite



Irrigation Management Zones for Precision Watering Sprinkler heads are assigned to zones based on surrounding site conditions



Individual heads are the most specific level of control that we have today

Irrigation Management Zones for Precision Watering Sprinkler heads are assigned to zones based on surrounding site conditions



In-ground sensors are located to represent each zone – one per zone minimum
 Two or more sensors per zone provide even more information

Irrigation Management Zones for Precision Watering Each zone is irrigated independently ONLY when water is required



In-ground sensors provide continuous soil moisture data for scheduling decisions

Irrigation Management Zones for Precision Watering Each zone is irrigated independently ONLY when water is required



In-ground sensors provide continuous soil moisture data for scheduling decisions

Thank you!

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