Trends in Turf Nutrition:

Balancing Environmental Protection and Turf Performance

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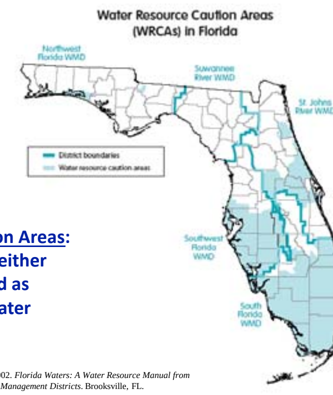
Florida's Water Situation



Water Resource Caution Areas: places where water is either scarce or contaminated as defined by Florida's Water Management Districts

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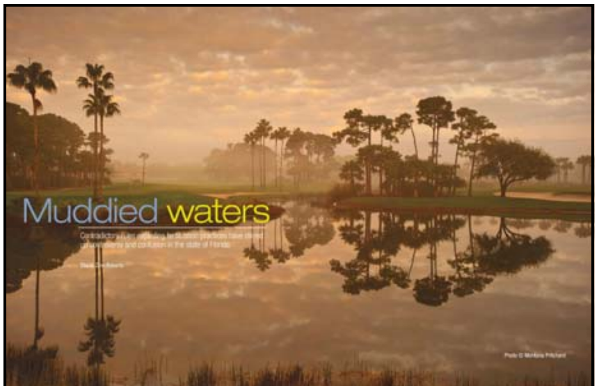
Purdum, E.D. 2002. *Florida Waters: A Water Resource Manual from Florida's Water Management Districts*. Brooksville, FL.



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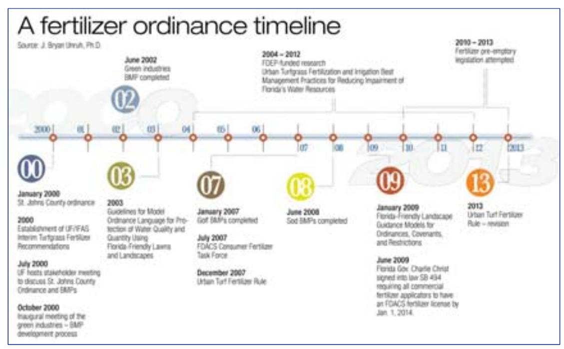

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Increased Scrutiny

- Environmental activist groups have momentum.
  - General public poorly understands the issues.
- Increasing level of scrutiny over what you do – even from those whom you consider allies (i.e., your members).
  - Some, knowingly and unknowingly, are working against the efforts of the green industry.
    - Work to educate your members about the importance of plant nutrition.

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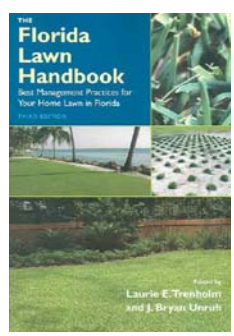

"Do not fertilize when rain is imminent."

This statement has led to numerous fertilizer "black out" ordinances – typically May through October.

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Increased Scrutiny
City of Rockledge Florida

Mark Jacobs of *Save Our Aquifer* said: "We need to stop polluting the lagoon with lawn fertilizers. It is more important to have a healthy lagoon than to have unnaturally green turf grass. Many people I know have healthy turf grass and use no fertilizers; polluting the lagoon with lawn fertilizers is a completely senseless and unnecessary waste.

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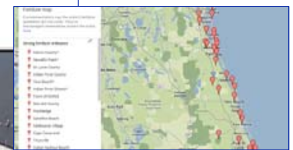
Toxic Water: Stuart tables, Port St. Lucie passes tougher fertilizer laws to protect lagoon

BY: Paul Ivice & Brittany Valdes, Scripps Treasure Coast Newspapers
POSTED: Mar 25, 2014
UPDATED: 23 days ago



Pierce also mentioned the golf courses that would be exempt from the restrictions.

Port St. Lucie Councilwoman Michelle Lee Berger said, "We can't ignore the fact that golf courses do have a huge impact, but if we have an opportunity to improve 1 to 2 percent, that's good."

"Golf courses will spray more herbicides and pesticides than other people every year," he said. "Why punish one industry and not the other?"

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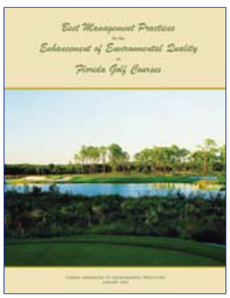
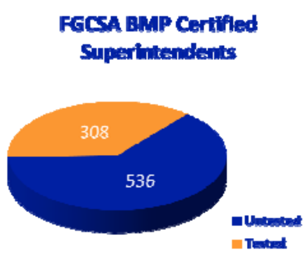
BMPs are a Starting Point





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BMPs are a Starting Point

- The goal of fertilizer BMPs is to match nutrient supply with turf requirements and to minimize nutrient losses.
  - Selection of BMPs varies by location, and those chosen for a given golf course are dependent on local soil and climatic conditions, crop, management conditions, and other site specific factors.

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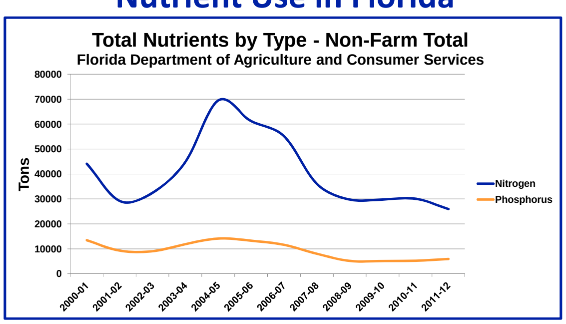
Nutrient Use in Florida



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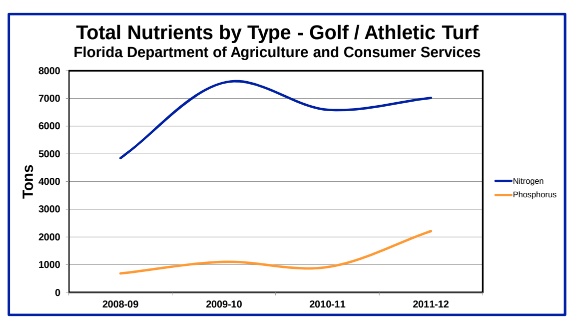
Nutrient Use in Florida



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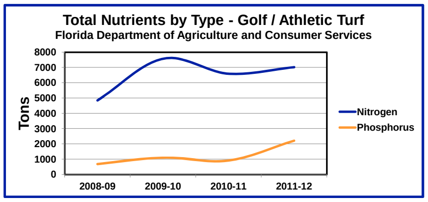
Nutrient Use in Florida

- Source data is for golf AND athletic turf.
  - No way of estimating how much was applied to athletic fields.



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Nutrient Use in Florida

- Landscape industry reduced N use by 36% and P use by 29% since 2008.
- Golf industry has increased N use by 45% and P use by 69% since 2008.
  - Likely attributed to bringing the golf course back up to par following the economic downturn.

Bottom line – these numbers are favorable for the golf industry, but . . . increased scrutiny will continue!

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Trends in Nutrient Management Education

Nutrient Use Efficiency

- Generally defined as yield per unit input of fertilizer.
  - In turf, we don't measure "yield" directly.

4R Nutrient Stewardship

- Right Source – Matches fertilizer type to plant needs.
- Right Rate – Matches amount of fertilizer to plant needs.
- Right Time – Makes nutrients available when plants need them.
- Right Place – Keeps nutrients where plants can use them.

4R Nutrient Stewardship

- Right Source
- Right Rate
- Right Time
- Right Place
  - Source, time, and place are more frequently overlooked and may hold more opportunity for improving performance.

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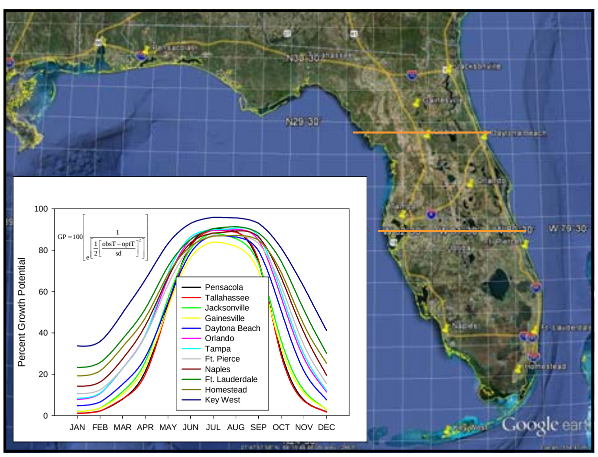
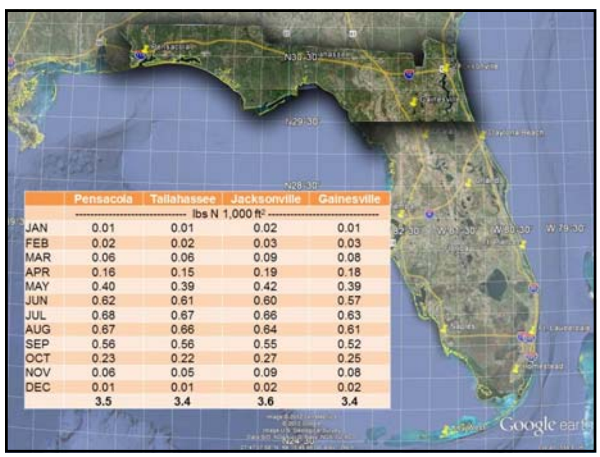
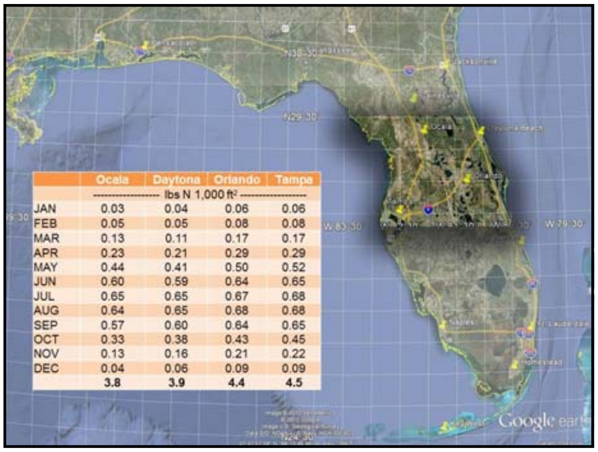
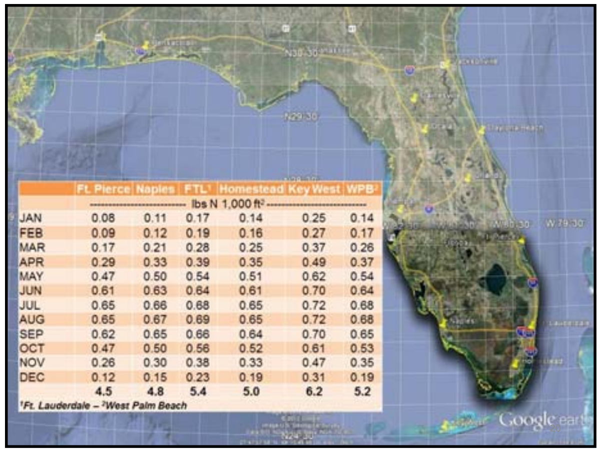




	Pensacola	Tallahassee	Jacksonville	Gainesville
	lbs N 1,000 ft²			
JAN	0.01	0.01	0.02	0.01
FEB	0.02	0.02	0.03	0.03
MAR	0.06	0.06	0.09	0.08
APR	0.16	0.15	0.19	0.18
MAY	0.40	0.39	0.42	0.39
JUN	0.62	0.61	0.60	0.57
JUL	0.68	0.67	0.66	0.63
AUG	0.67	0.66	0.64	0.61
SEP	0.56	0.56	0.55	0.52
OCT	0.23	0.22	0.27	0.25
NOV	0.06	0.05	0.09	0.08
DEC	0.01	0.01	0.02	0.02
	3.5	3.4	3.6	3.4



	Ocala	Daytona	Orlando	Tampa
	lbs N 1,000 ft²			
JAN	0.03	0.04	0.06	0.06
FEB	0.05	0.05	0.08	0.08
MAR	0.13	0.11	0.17	0.17
APR	0.23	0.21	0.29	0.29
MAY	0.44	0.41	0.50	0.52
JUN	0.60	0.59	0.64	0.65
JUL	0.65	0.65	0.67	0.68
AUG	0.64	0.65	0.68	0.68
SEP	0.57	0.60	0.64	0.65
OCT	0.33	0.38	0.43	0.45
NOV	0.13	0.16	0.21	0.22
DEC	0.04	0.06	0.09	0.09
	3.8	**3.9**	**4.4**	**4.5**



	Ft. Pierce	Naples	FTL[1]	Homestead	Key West	WPB[2]
	lbs N 1,000 ft²					
JAN	0.08	0.11	0.17	0.14	0.25	0.14
FEB	0.09	0.12	0.19	0.16	0.27	0.17
MAR	0.17	0.21	0.28	0.25	0.37	0.26
APR	0.29	0.33	0.39	0.35	0.49	0.37
MAY	0.47	0.50	0.54	0.51	0.62	0.54
JUN	0.61	0.63	0.64	0.61	0.70	0.64
JUL	0.65	0.66	0.68	0.65	0.72	0.68
AUG	0.65	0.67	0.69	0.65	0.72	0.68
SEP	0.62	0.65	0.66	0.64	0.70	0.65
OCT	0.47	0.50	0.56	0.52	0.61	0.53
NOV	0.26	0.30	0.38	0.33	0.47	0.35
DEC	0.12	0.15	0.23	0.19	0.31	0.19
	4.5	**4.8**	**5.4**	**5.0**	**6.2**	**5.2**

[1]Ft. Lauderdale – [2]West Palm Beach

SLAN / BSCR / MLSN

- SLAN = Sufficiency Levels of Available Nutrients
- BSCR = Base Saturation Cation Ratio
- MLSN = Minimum Level for Sustainable Nutrition

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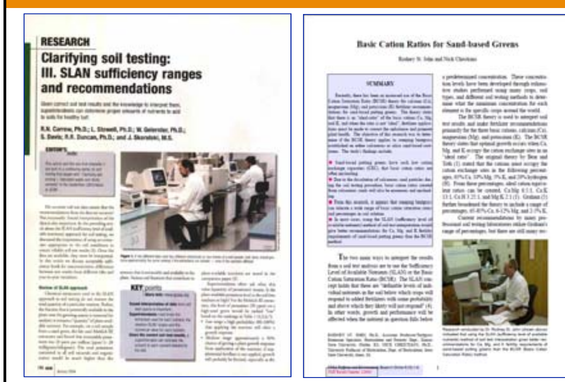

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What is MLSN?

- Minimum Level for Sustainable Nutrition (MLSN) is a new, more sustainable approach to managing soil nutrient levels.
  - Decreases fertilizer inputs and costs
  - Maintain quality and playability levels
- Developed by PACE Turf (Dr. Larry Stowell and Dr. Wendy Gelernter) and the Asian Turfgrass Center (Dr. Micah Woods).
  - All soil analyses were conducted at Brookside Laboratories.

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The Goal of MLSN?

- "To provide a scientific and data-based approach to interpreting soil tests for turfgrass sites, making sure that there is a high probability of good turfgrass performance, while minimizing unnecessary application of fertilizer."

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What is MLSN?

- From a database of > 17,000 soil samples, 1,500 were selected that were classified as having:
  - Not poor performing turfgrass
    - **LOGIC:** If turf is good – nutrients likely aren't a limiting factor.
  - pH of 5.5 – 7.5
    - **LOGIC:** Accurate for a range of elements using the Mehlich 3 soil test extractant.
  - Cation Exchange Capacity < 6 cmol/kg
    - **LOGIC:** If there is enough of an element to produce good turfgrass in a low CEC soil, then the same amount will be sufficient in a nutrient-rich soil that has a higher CEC.

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What is MLSN?

- Because all of these soils were producing good turf, one could conclude that all the soils had sufficient nutrients, so anything at or above those nutrient levels would be fine.
- Log-logistic model used to identify the concentration (in ppm) of each nutrient that 10% of the soil samples fell below – but were still performing well.
  - The 10th percentile value is the MLSN soil guideline.

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MLSN potassium data

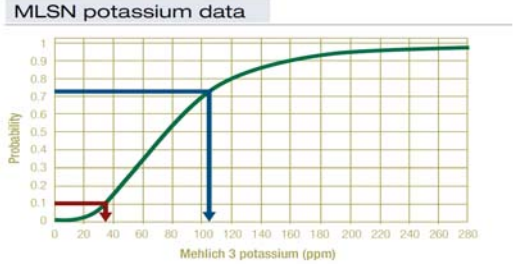

Figure 1. The cumulative distribution function for the potassium data was used to identify the MLSN guideline. At the 0.1 probability level, 10% of the samples report potassium values lower than 35 ppm (red line). This is the potassium MLSN guideline. The blue line indicates the conventional guideline of 110 ppm for potassium. Seventy-two percent (probability = 0.72 = sustainability index) of the samples report values lower than the conventional potassium guideline.

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MLSN phosphorus data

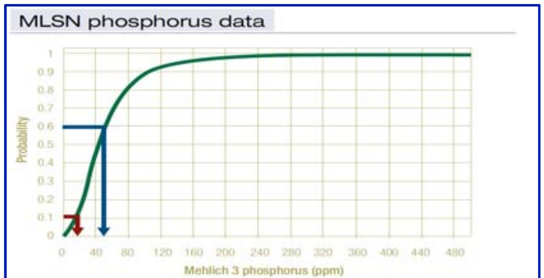

Figure 2. The cumulative distribution function for the phosphorus data was used to identify the MLSN guideline. At the 0.1 probability level, 10% of the samples report phosphorus values lower than 18 ppm (red line). This is the phosphorus MLSN guideline. The blue line indicates the conventional guideline of 50 ppm for phosphorus. Fifty-nine percent (probability = 0.59 = sustainability index) of the samples report values lower than the conventional phosphorus guideline.

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Minimum Levels for Sustainable Nutrition Guidelines

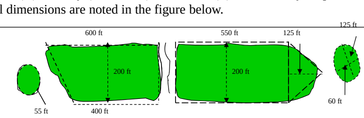
Nutrient	Analytical Test	Conventional Guideline - SLAN (ppm)	MLSN (ppm)
Potassium	Mehlich 3	>110	35
Phosphorus	Mehlich 3	>50	18
Calcium	Mehlich 3	>750	360
Magnesium	Mehlich 3	>140	54
Sulfur	Mehlich 3	15 – 40	13

Before we give her a whirl. . .

- We apply fertilizer to a two-dimensional soil surface (length X width = area).

Problem 2.1

Using the geometric method of determining area, determine the area of the green (A), fairway (B + C + D) and the tee (E) for the 435-yard par-4 hole. All dimensions are noted in the figure below.



Before we give her a whirl. . .

- But soil tests are three dimensional (length X width X depth).
  - One pound of an element (N, P, K, etc.) spread over 1,000 ft^2 on the surface (two dimensional) is equivalent to:
    - 22 ppm in the root zone (three dimensional) measuring 1,000 ft^2 to a 6" depth.
    - 33 ppm in the root zone (three dimensional) measuring 1,000 ft^2 to a 4" depth.

It's early – but let's do some math!

- Acre Furrow Slice (6" depth over an acre) has 21,780 ft^3 of soil (43,560 ft^2 X 0.5 ft).
  - AFS of soil weighs ~ 2,000,000 lbs.
    - Each cubic foot of soil weighs ~ 92 lbs.
- TEE: 1,000 ft^2 X 0.5 ft (6") = 500 ft^3 soil
  - $500\ ft^3\ soil \times \frac{92\ lbs}{ft^3} = 46{,}000\ lbs\ soil$
  - $\frac{1\ lb\ nutrient}{46{,}000\ lbs\ soil} = \frac{x\ lbs\ nutrient}{1{,}000{,}000\ lbs\ soil}$; X = ~ 22 ppm

34

Let's give her a whirl. . .

- Assumptions:
  - The grass cannot use more of an element than it harvests.
  - The growth and nutrient uptake are driven by the amount of nitrogen applied.
  - The concentration of macronutrient and secondary nutrients in the leaves are estimated to be proportional to the applied nitrogen.

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Research Article

Evidence, Regulation, and Consequences of Nitrogen-Driven Nutrient Demand by Turfgrass

- "Nutrient utilization by turfgrass has the characteristics of 'demand driven uptake'
- Paired soil and clipping samples from 419 putting greens located throughout Wisconsin.

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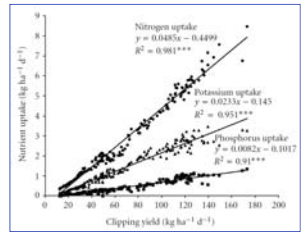
Evidence, Regulation, and Consequences of Nitrogen-Driven Nutrient Demand by Turfgrass

Wayne R. Kussow, Douglas J. Soldat, William C. Kreuser, and Steven M. Houlihan

- Nutrient uptake is strongly dependent on growth rate.
  - As grass growth increases, nutrient uptake increase.
  - Typically accounts for > 90% of the variation in nutrient uptake.



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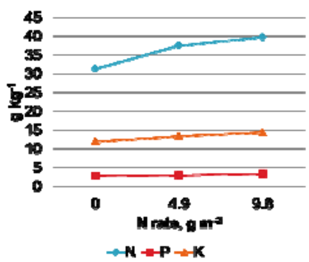
'Tifgreen' Bermudagrass Response to Late-Season Application of Nitrogen and Potassium

J. M. Goatley, Jr.,* V. Maddox, D. J. Lang, and K. K. Crouse

- Three rates of late season N applied to bermudagrass linearly increased clipping production and leaf N, P, and K content.



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Evidence, Regulation, and Consequences of Nitrogen-Driven Nutrient Demand by Turfgrass

Wayne R. Kussow, Douglas J. Soldat, William C. Kreuser, and Steven M. Houlihan

- Once the external nutrient supply attains the level where demand is satisfied, tissue nutrient concentrations plateau – little or no change with further increases in nutrient supply.
  - Application of additional P and K did not alter clipping P and K content.

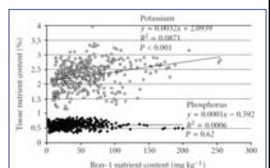

Figure 3: Relationship between Bray1-extractable soil P or K levels and tissue P or K content of cool season turfgrass species collected from 419 golf greens in Wisconsin (Experiment 1).

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Bermudagrass Putting Green Growth, Color, and Nutrient Partitioning Influenced by Nitrogen and Trinexapac-Ethyl

Patrick E. McCullough, Haibo Liu,* Lambert B. McCarty, Ted Whitwell, and Joe E. Toler

- Applied four rates of N with and without Primo to a bermudagrass putting green.
  - Primo reduced clippings by 67% over the 4 N rates.
    - Did not alter the N required to maintain acceptable turf.
  - Nutrient removal by the clippings when Primo was applied was decreased by 70%.
    - Clipping production accounted for 83 – 99% of the variation in clipping removals of N, P, K, Ca, Mg, S, Cu, Fe, Mn, and Zn.

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Bottom line

- Pretty convincing evidence that N supply is a primary factor governing turfgrass nutrient demand.
  - The application of a PGR changes demand in accord with the degree of suppression of turfgrass growth at any given level of N application.

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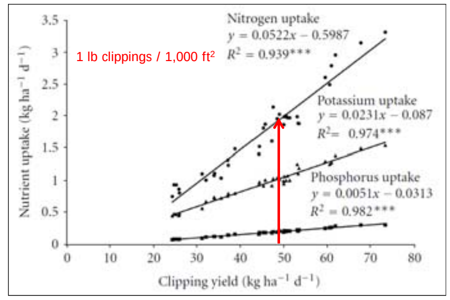
Let's give her a whirl. . .

- Assumptions:
  - The grass cannot use more of an element than it harvests.
  - The growth and nutrient uptake are driven by the amount of nitrogen applied.
  - The concentration of macronutrient and secondary nutrients in the leaves are estimated to be proportional to the applied nitrogen.

Kussow, Soldat, Kreuser, and Houlihan

Agronomy doi 10.5402/2012/359284



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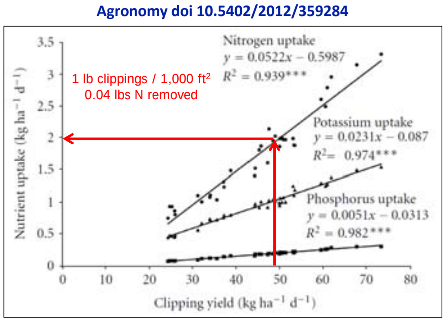

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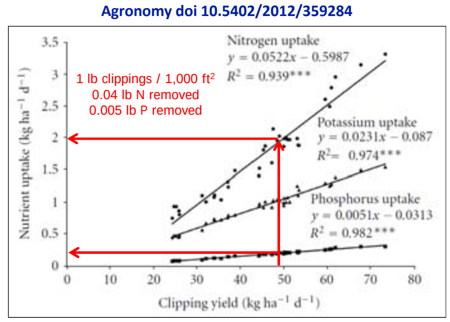

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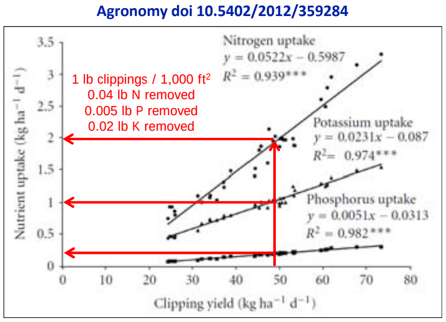

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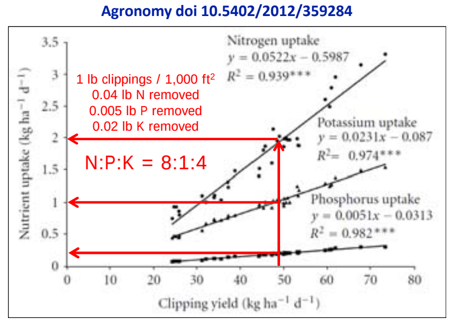

Expected Leaf Nutrient Content

- In the dry matter of turfgrass leaves, after the leaf water has evaporated, we can expect these approximate concentrations:

Nutrient	Expected % in leaf dry matter*	Amount in proportion to nitrogen
Nitrogen	4	1
Potassium	2	0.5
Phosphorus	0.5	0.125
Calcium	0.5	0.125
Magnesium	0.2	0.05
Sulfur	0.2	0.05

*These values are a good starting point for most turfgrass species. If site specific data are available, those values can be substituted to better site specific management.

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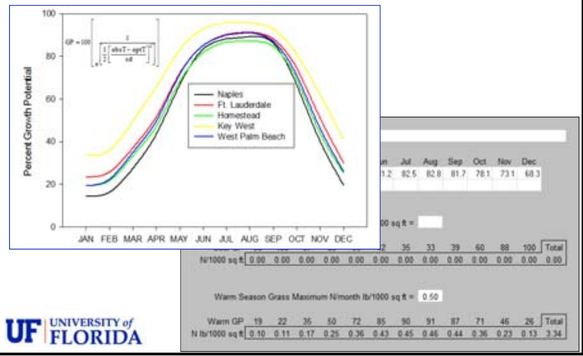
Growth Potential Model



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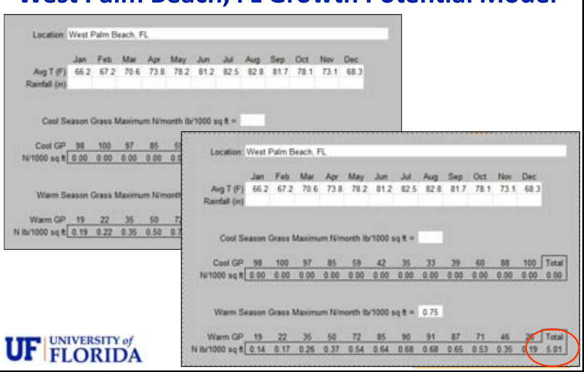
West Palm Beach, FL Growth Potential Model



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Expected nutrient removal when applying 5.01 lbs N / 1,000 ft² / year

Nutrient	Amount in proportion to nitrogen	lb / 1,000 ft²	Soil Test ppm in top 4"
Nitrogen	1	5.01	
Potassium	0.5	2.51	83
Phosphorus	0.125	0.63	21
Calcium	0.125	0.63	21
Magnesium	0.05	0.25	8
Sulfur	0.05	0.25	8

- Remember: One pound of an element (N, P, K, etc.) spread over 1,000 ft² on the surface (two dimensional) is equivalent to 33 ppm in the root zone.
- Potassium = 2.51 lbs X 33 ppm = 83 ppm

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Expected nutrient removal when applying 5.01 lbs N / 1,000 ft² / year

Nutrient	Amount in proportion to nitrogen	Removed		MLSN	
		lb / 1,000 ft²	PPM in top 4"	lb / 1,000 ft²	PPM in top 4"
Nitrogen	1	5.01			
Potassium	0.5	2.51	83	1.06	35
Phosphorus	0.125	0.63	21	0.55	18
Calcium	0.125	0.63	21	10.9	360
Magnesium	0.05	0.25	8	1.6	54
Sulfur	0.05	0.25	8	0.39	13

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MLSN Example

- We know that at the MLSN level, there is enough of that element in the soil to produce good turf – so we want to stay at or above the MLSN level.
  - We can estimate the amount harvested from the soil each year.
- The amount "A" gives us the total amount of an element in the soil.

$$A = MLSN + Harvest$$

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Nutrient	Amount in proportion to nitrogen	Removed		MLSN	
		lb / 1,000 ft^2	PPM in top 4"	lb / 1,000 ft^2	PPM in top 4"
Potassium	0.5	2.51	83	1.06	35

- The amount "A" gives us the total amount of an element needed in the soil to keep the soil above the MLSN guideline.

$$A = MLSN + Harvest$$

$$A = 1.06 + 2.51 = 3.57 \text{ lbs} / 1{,}000 \text{ ft}^2$$

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MLSN Example

- To find how much of an element needs to be added as fertilizer (F), subtract the actual amount on a soil test.

$$F = A - Soil_{test}$$

– We have tested a putting green and found it to contain 55 ppm (1.67 lbs / 1,000 ft^2) potassium.

$$F = 3.57 - 1.67 = 1.9 \text{ lbs} / 1{,}000 \text{ ft}^2$$

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SLAN Example

Nutrient	Amount in proportion to nitrogen	Removed		SLAN	
		lb / 1,000 ft^2	PPM in top 4"	lb / 1,000 ft^2	PPM in top 4"
Potassium	0.5	2.51	83	3.33	> 110

- The amount "A" gives us the total amount of an element needed in the soil to keep the soil above the SLAN guideline.

$$A = SLAN + Harvest$$

$$A = 3.33 + 2.51 = 5.84 \text{ lbs} / 1{,}000 \text{ ft}^2$$

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SLAN Example

- To find how much of an element needs to be added as fertilizer (F), subtract the actual amount on a soil test.

$$F = A - Soil_{test}$$

– We have tested a putting green and found it to contain 55 ppm (1.67 lbs / 1,000 ft^2) potassium.

$$F = 5.84 - 1.67 = 4.17 \text{ lbs} / 1{,}000 \text{ ft}^2$$

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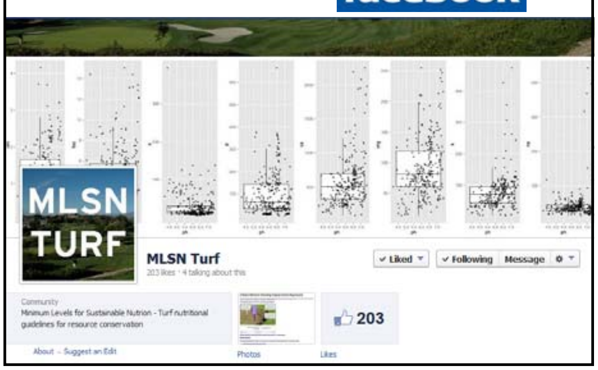

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