Minimum Levels for Sustainable Nutrition (MLSN)

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PACE TURF

Minimum Levels for Sustainable Nutrition (MLSN)

- Why?
- Identify low soil nutrient targets focusing on reduced inputs
- Target adequate (meets expectations) turf performance, NOT optimum
- Balance turf nutrition against pest concerns
- Develop a metric to monitor advances toward sustainability (basically reduced inputs)

Outline

- How much fertilizer does turf really need
- What is sustainability for turfgrass management?
- Data and methods used to develop MLSN
- MLSN as a sustainability metric

How much fertilizer does turf need?

- What is the desired growth rate/clipping yield?
- Sunshine hours
- Water
- Temperature
- Removal of nutrients from the system

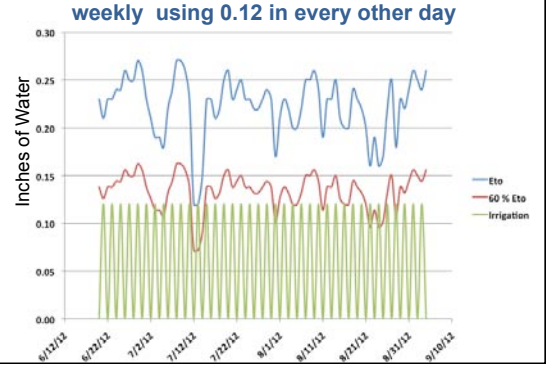
What you can't control

- Sunshine hours (you can control shade)
- Temperature

What you can control

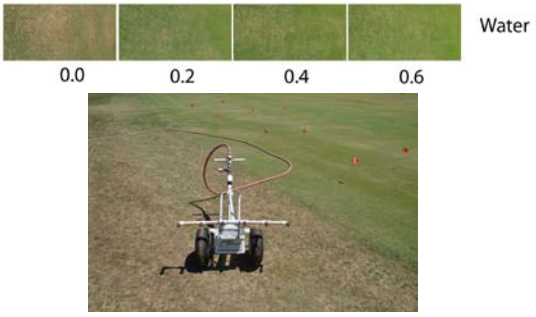
- Water
- Nitrogen

Barona Creek Golf Club, Sandy Clark, CGCS
Weekly average 1.05 in (60% Eto), 0.48 in delivered weekly using 0.12 in every other day

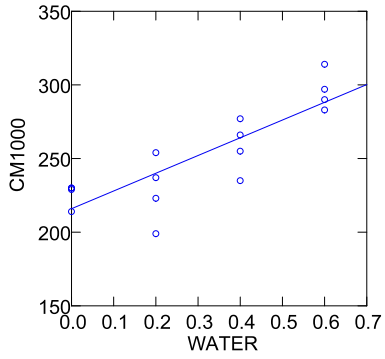


Irrigation

Inches of supplemental water per week
0.6 inches of supplemental water = 60% ETo



Irrigation



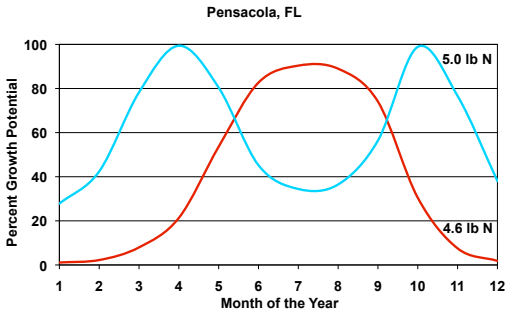
How are nutrients removed from the soil?

- Primarily by clipping removal
- By leaching if excessive nutrients are applied
- By leaching if the soil has high salts
- Leaching will not remove elements held on the cation exchange sites or associated with organic matter

Growth rate/clipping yield

- Grow as slow as possible for desired performance
- Slower than the maximum potential of the plant to produce biomass
- Restricted primarily by regulating nitrogen applications (assuming water is not restricted)
- Typical seasonal yield is about 82 lbs dwt/ 1000 sq ft (at 5% N in tissue = 4 lbs/1000 sq ft)

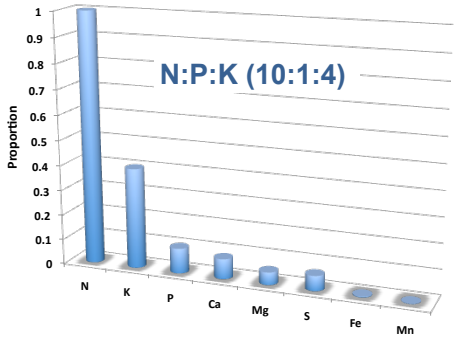
Annual N requirement (lb/1000 sq ft) for Pensacola, FL
Ryegrass = 0.7 lbs N/1000 sq ft month at 100% GP
Bermudagrass = 1.0 lb N/1000 sq ft per month at 100% GP



What is the nutrient content of turf tissue?
N:P:K (10:1:4)

Element	Tissue ppm	Ratio:N
N	50000	1
K	20000	0.4
P	5000	0.1
Ca	4000	0.08
Mg	2500	0.05
S	3000	0.06
Fe	200	0.004
Mn	75	0.0015

Proportional composition of turf tissue



Clipping removal of nutrients when
applying 4 lbs N/1000 sq ft/year non-overseeded bermuda

Element	lb/1000 sq ft	Soil Test ppm in top 4 inches
K	1.6	52
P	0.4	13
Ca	0.3	11
Mg	0.2	7
S	0.2	8
Fe	0.02	0.5
Mn	0.01	0.2

Clipping removal of nutrients when

applying 10 lbs N/1000 sq ft/year
for ryegrass overseeded bermuda

Element	lb/1000 sq ft	Soil Test ppm in top 4 inches
K	4.0	130
P	1.0	33
Ca	0.8	28
Mg	0.5	18
S	0.5	20
Fe	0.05	1.3
Mn	0.08	0.5

How much will be removed when applying 4 lbs N/1000 sq ft/year

Element	lb/1000 sq ft	Soil Test ppm top 4 inches	Conventional guidelines top 4 inches ppm
K	1.6	52	110
P	0.4	13	50
Ca	0.3	11	750
Mg	0.2	7	140
S	0.2	8	15
Fe	0.02	0.5	90
Mn	0.01	0.2	30

How much will be removed when applying 10 lbs N/1000 sq ft/year

Element	lb/1000 sq ft	Soil Test ppm top 4 inches	Conventional guidelines top 4 inches ppm
K	4.0	130	110
P	1.0	33	50
Ca	0.8	28	750
Mg	0.5	18	140
S	0.5	20	15
Fe	0.05	1.3	90
Mn	0.08	0.5	30

How much will be removed when applying 4 lbs N/1000 sq ft/year

Element	lb/1000 sq ft	Soil Test ppm top 4 inches	Florida Soil Survey PACE-Bayer
K	1.6	52	88
P	0.4	13	85
Ca	0.3	11	544
Mg	0.2	7	91
S	0.2	8	20
Fe	0.02	0.5	42
Mn	0.01	0.2	3

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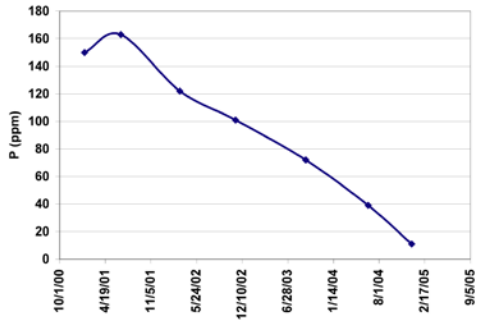
Fertilization

- Use the minimum nitrogen to meet turf performance expectations
- Apply N, P and K in a ratio of 10:1:4 (N:P:K) if soil levels are in the sufficiency range – this will maintain balance between tissue removal and inputs
- Adjust N:P:K maintenance ratios as needed if P and K soil levels drop below sufficiency guidelines
- Supplement maintenance applications if soil levels drop below sufficiency

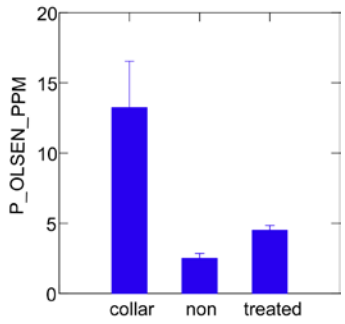
Trend in soil M3-P levels at Talega Country Club A4 Bentgrass



Talega Country Club

Talega Country Club (pH 7.5) Knockout trial ½ lb MAP/1000 sq ft

Talega Country Club (pH 7.5)



What is Sustainability?

Compare to:
Accountability
Reliability
Measurability

GCSAA Definition

"…meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainability: a high level of "truthiness"

"Truthiness is a 'truth' that a person claims to know intuitively 'from the gut' without regard to evidence, logic, intellectual examination, or facts."

Stephen Colbert

Measuring Sustainability

difficult, because our language is subjective

Fast – what is fast?
Firm – what is firm?
Green – What is green?
Brown – what is brown?

Every metric is subjective, leaving little room for objective discussion and development of true metrics for success in moving toward sustainability

The Augusta Factor

Billy Fuller, March 2011, Bleacher Report

"Augusta is still the template for all golf course management in this country…

This can actually be a detrimental thing for many golf courses in the U.S."

Examples of Sustainability

Lehman Brothers Holdings Inc.

- 1850 – 2008
- Looked sustainable
- Too big to fail
- Economic conditions can change fast!
- Nothing is truly sustainable – not even planet Earth

We know what non-sustainable looks like

Cypress Golf Club December, 2003

Cypress Golf Club March, 2011

Barona Creek, May, 2007

Barona Creek, March, 2008

Barona Creek, November, 2012

Moving in the right direction

- Brandon Dunes, Oregon
- Sand Hills, Nebraska
- Pinehurst No. 2, North Carolina
- Barona Creek, California

- Many more but to what level, what goal? Just staying in business?

- What about Augusta?

Metrics?

Sustainability Continuum

Less	More
40 acres of fairways	20 acres of fairways
Overseed in winter	Do not overseed in winter
Domestic irrigation water	Recycled irrigation water
Mow 6 days per week	Mow 3 days per week
Remove clippings	Return clippings
Weed free	Some weeds
Disease free	Some diseases
Insect Free	Some insects
Dark green color	Brown is beautiful
25 crew members	12 crew members
High budget	Low budget
High expectations	Balanced expectations

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The balance between profit and sustainability

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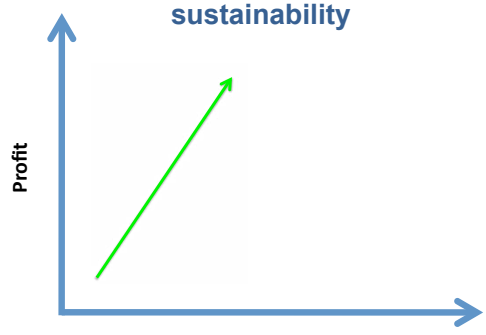
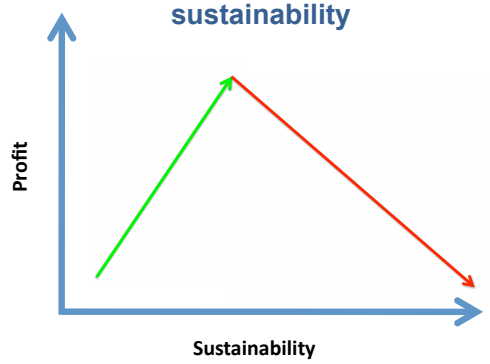
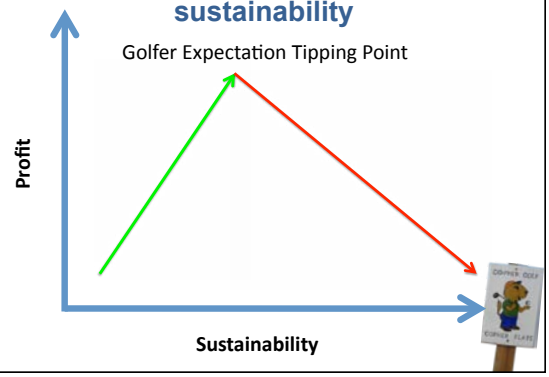


The balance between profit and sustainability



The balance between profit and sustainability

Golfer Expectation Tipping Point



Quantitative Sustainability Metrics

Getting the "truthiness" out of sustainability

- Total maintained acres
- Total water used
- Total N and P applied – use of MLSN
- Total pounds Category 1, 2, 3 pesticides applied (target only category 3 or biologicals)
- Manpower
- Fuel use
- Electrical use

Golfer Expectation Management

- Is it possible to manage golfer expectations?
- Can brown ever be the new green?
- If golfer expectations cannot be managed, expect a lot of job openings for superintendents

Golf course superintendent role

- Superintendents shoulder the greatest risk trying to increase golf course sustainability.
- The risk-burden is not fairly distributed within the golf business.

Sustainability Overview

- Technically feasible
- Quantification is important and possible
- Profitability is questionable
- Not attainable in irrigated environments
- Regulations are the major driving force
  - Course size restrictions
  - Water restrictions
  - Fertilizer restrictions
  - Pesticide restrictions
  - Small engine restrictions

Moving Toward Sustainability in Turfgrass Management

- Identify appropriate sustainability metrics and make the process transparent
- Develop generally accepted sustainability accounting principles
- Track advances toward sustainability, beyond developing best management practices

Let's reduce the truthiness of sustainability

Minimum Levels for Sustainable Nutrition (MLSN)

- Identify low soil nutrient targets focusing on reduced inputs
- Focus on adequate (meets expectations) turf performance, NOT optimum
- Balance against pest concerns
- Develop a metric to monitor advances toward sustainability

PACE Turf Soil Database

- 16,000 + soil tests ($1.2M end-user investment)
- Metadata for turf performance captured on many samples (good, average, poor)
- Wide geographic distribution, but heavily weighted in Southwestern US
- High level of data quality control

PACE Conventional Guidelines

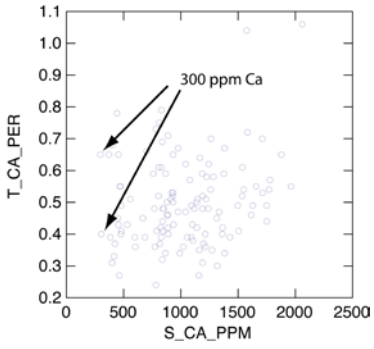
	Conventional PPM
Olsen P	>12
Mehlich 3	
P	>50
K	>110
Ca	>750
Mg	>140
S	15 - 40
NO3-N	3-20
NH4-N	<7
Total-N	<20

Distraction

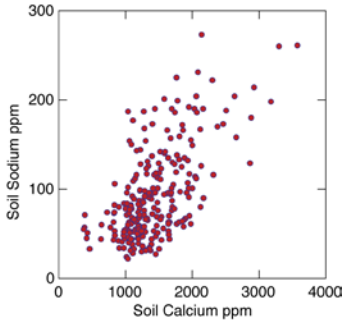
Calcium in soil and tissues

Calcium – Sodium - Salinity

Calcium in Soil vs. Tissue
Looking for a plant response



Soil Calcium vs. Sodium
Looking for a soil response



P < 0.001

Soil Calcium vs. Sodium
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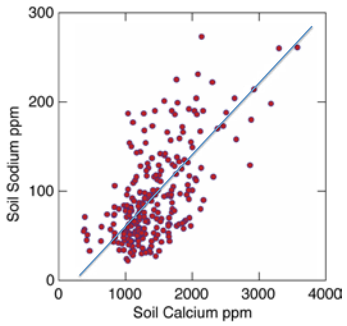

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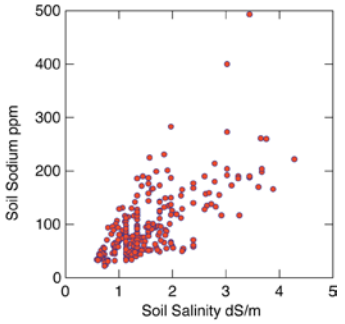

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Soil Salinity vs. Sodium
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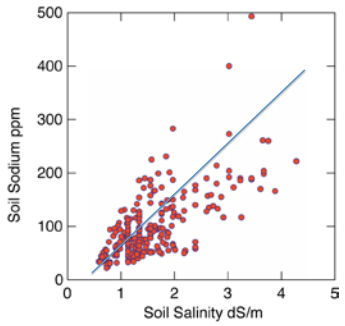
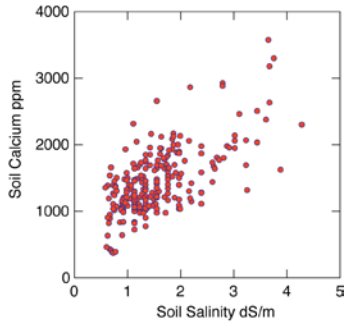


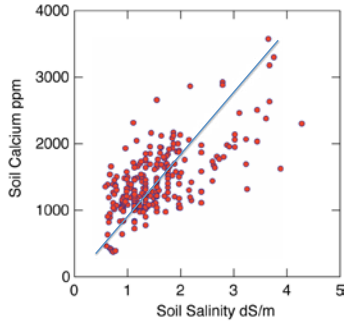
P < 0.001

Soil Salinity vs. Calcium
Looking for a soil response



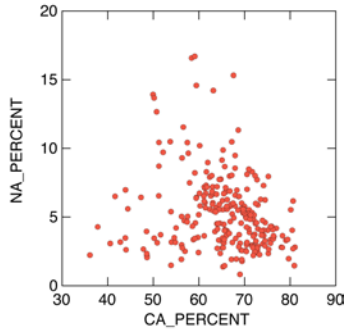
P < 0.001

Soil Salinity vs. Calcium
Looking for a soil response



P < 0.001

Soil Percent Calcium vs. Percent Sodium
Looking for a soil response



Distraction

- Calcium is an important tool for sodium management in soils – this is a separate issue
- Calcium is an important plant nutrient
- Calcium is abundant in most soils
- Not much calcium is needed for nutrition

MLSN Current Approach

Data set:

- Total exchange capacity (by summation M3 extraction of cations) less than 6 cmol/kg
- Soil pH between 5.5 and 7.5
- Soil pH above 7.5 for Olsen P
- About 1500 samples are used in most of the analyses, 270 samples meet Olsen pH restrictions

Distribution Fitting

- EasyFit by Mathwave used to identify an appropriate model for the data
- Log logistic was selected due to significant fit evaluated by Kolmogrov Smirnov statistic

Distribution Fitting

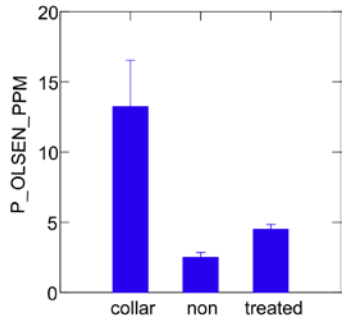
	Kolmogorov Smirnov	
	Log-Logistic p	Normal p
Olsen P	0.05	0.14
Bray 2 P	0.03	0.16
Mehlich 3		
P	0.02	0.16
K	0.04	0.08
Ca	0.05	0.04
Mg	0.03	0.05
S	0.03	0.14
KCL Extract		
NO3-N	0.04	0.24
NH4-N	0.09	0.21
Total-N	0.02	0.20

Guideline Comparison

	Conventional ppm	MLSN ppm
Olsen P	>12	6
Bray 2 P	>75	25
Mehlich 3		
P	>50	18
K	>110	35
Ca	>750	360
Mg	>140	54
S	15 - 40	13
KCL		
NO3-N	3-20	1
NH4-N	<7	1 (<7)
Total-N	<20	3 (<10)

Talega Country Club (pH 7.5)
Knockout trial ½ lb MAP/1000 sq ft

Talega Country Club (pH 7.5)



Guideline Comparison

	Conventional ppm	MLSN ppm	Tissue Removal 4 lbs N/1000 sq ft ppm in top 4 inches
Olsen P	>12	6	13
Bray 2 P	>75	25	13
Mehlich 3			
P	>50	18	13
K	>110	35	52
Ca	>750	360	11
Mg	>140	54	7
S	15 - 40	13	8
KCL			
NO3-N	3-20	1	
NH4-N	<7	1 (<7)	
Total-N	<20	3 (<10)	

Guideline Comparison

	Conventional ppm	MLSN ppm	Tissue Removal 10 lbs N/1000 sq ft ppm in top 4 inches
Olsen P	>12	6	33
Bray 2 P	>75	25	33
Mehlich 3			
P	>50	18	33
K	>110	35	130
Ca	>750	360	28
Mg	>140	54	18
S	15 - 40	13	20
KCL			
NO3-N	3-20	1	
NH4-N	<7	1 (<7)	
Total-N	<20	3 (<10)	

Fertilization

- Use the minimum nitrogen to meet turf performance expectations
- Apply N, P and K in a ratio of 10:1:4 (N:P:K) if soil levels are in the sufficiency range – this will maintain balance between tissue removal and inputs
- Adjust N:P:K maintenance ratios as needed if P and K soil levels drop below sufficiency guidelines
- Supplement maintenance applications if soil levels drop below sufficiency

Log-Logistic

Probability Density Function

$$f(x) = \frac{\alpha}{\beta}\left(\frac{x-\gamma}{\beta}\right)^{\alpha-1}\left(1+\left(\frac{x-\gamma}{\beta}\right)^{\alpha}\right)^{-2}$$

Cumulative Distribution Function

$$F(x) = \left(1+\left(\frac{\beta}{x-\gamma}\right)^{\alpha}\right)^{-1}$$

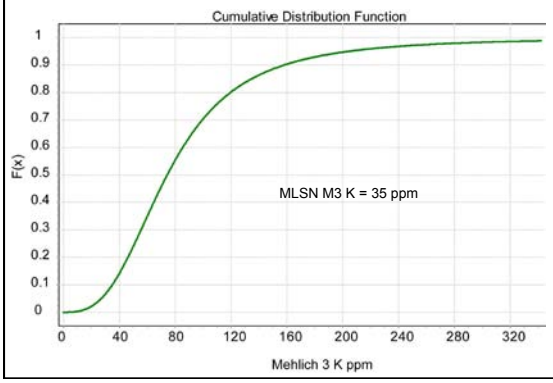
MLSN

- Defined as the soil nutrient concentration (ppm) at which 10% of the population falls below (10th percentile).
- Calculated using the best-fit log-logistic cumulative distribution function for:

F(x) = 0.10

$$F(x) = \left(1 + \left(\frac{\beta}{x-\gamma}\right)^{\alpha}\right)^{-1}$$

Mehlich 3 Potassium



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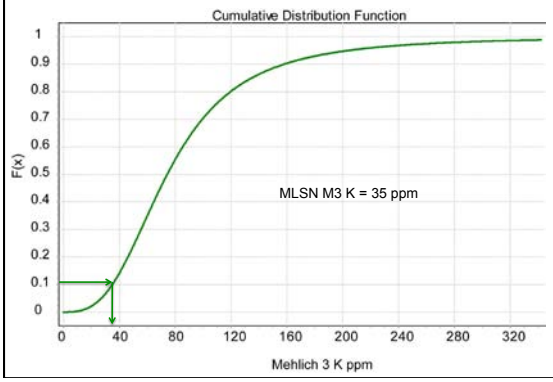
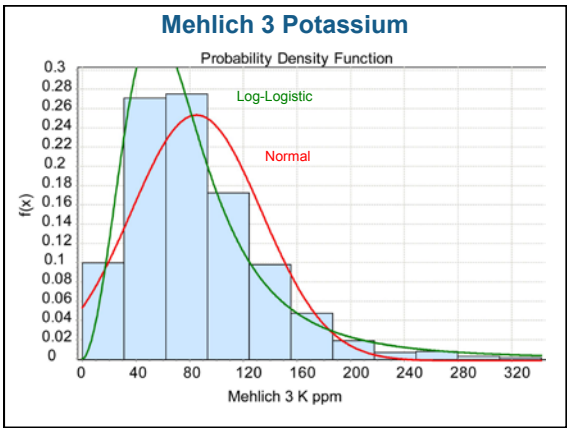
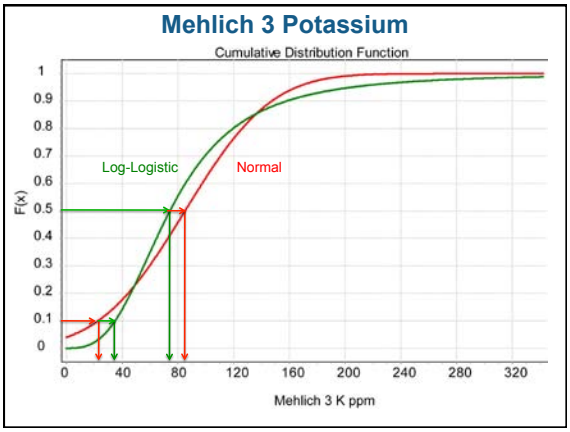






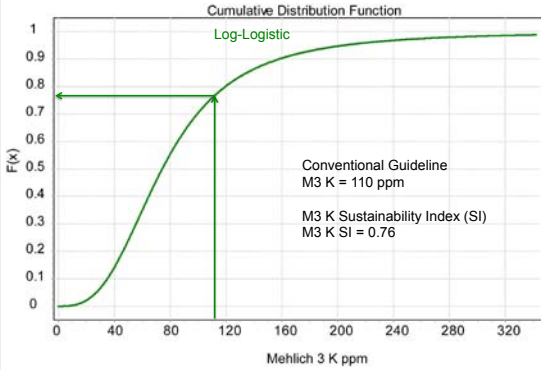
MLSN Sustainability Index (SI)

- Metric to aid turf managers in evaluation of nutrient management programs over time
- Provides a guide for development of nutrient management programs
- Rewards restriction of nutrient inputs when they are not needed to meet minimum turf performance goals

MLSN Sustainability Index (SI)

- Compares the test soil sample against the MLSN cumulative distribution function
- SI = Proportion of the MLSN cumulative distribution function that report values lower than the soil sample test value
- Lower values = greater sustainability
- Computed using the MLSN distribution function variables for each element

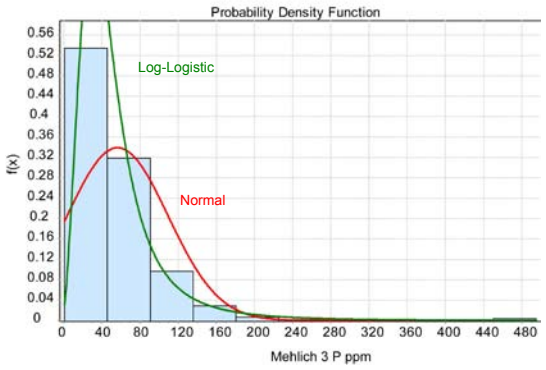
SI of Conventional Mehlich 3 K Guideline



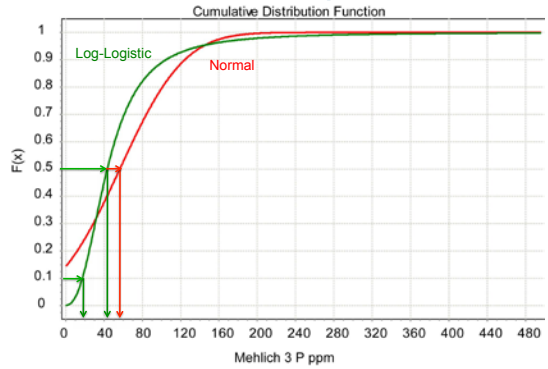
Sustainability Index Comparison

	Conventional ppm	Sustainability index
Olsen P	>12	0.61
Bray 2 P	>75	0.71
Mehlich 3		
P	>50	0.59
PSI	<0.15	0.24
K	>110	0.76
Ca	>750	0.83
Mg	>140	0.89
S	15 - 40	0.15 - 0.67
KCL Extract		
NO3-N	3-20	0.15 - 0.97
NH4-N	<7	0.91
Total-N	<20	

Mehlich 3 Phosphorus



Mehlich 3 Phosphorus



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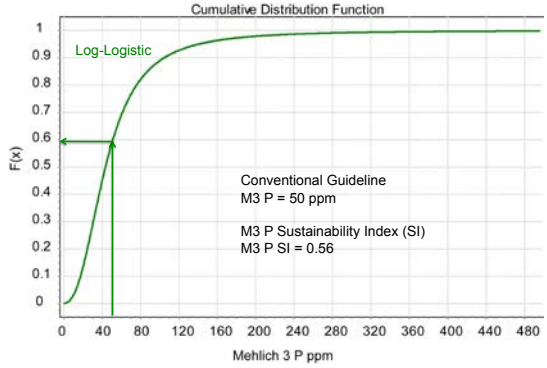
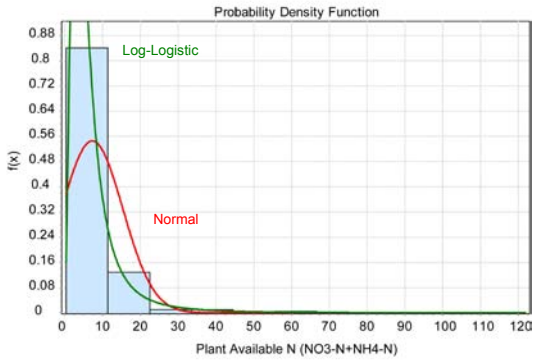
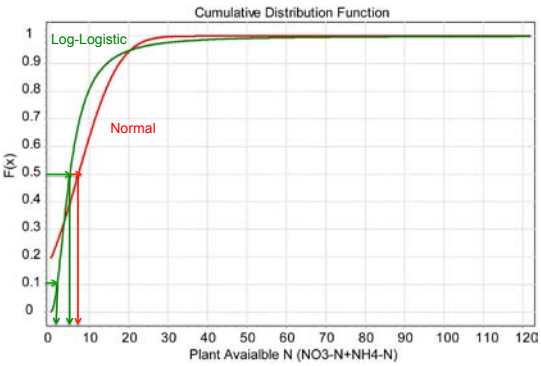


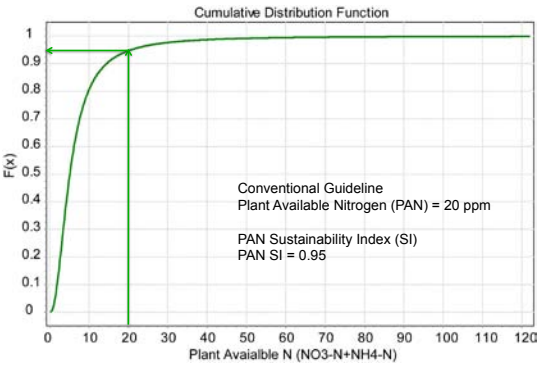
Plant Available Nitrogen



Plant Available Nitrogen



SI of Nitrogen Conventional Guideline



What's next

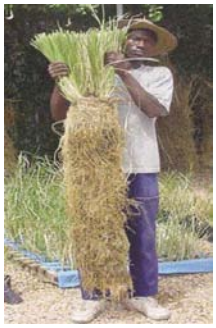
- Target reduced/minimum/zero inputs
- Continued refinement of data mining techniques
- Quantify temporal changes in soil nutrients
- Use MLSN to stimulate discussion of nutrient management in turf
- Quantify sustainability
- Monitor turf performance vs. expectations

Reduce the "truthiness" of sustainability

Posted on Facebook by Semillas Picasso Company

Seeded 4/8/2011
Photo 7/9/2011
5% peat moss
100 g Terracottem

Dr. Simeon Materchera, South Africa, Vetiver grass



- Soil erosion control/remediation
- Tolerates 7 – 135 F temps
- Soil pH 3.0 – 10.5
- Living soil nail

•Crysopongon zizanioides