Minimum Levels for Sustainable Nutrition MLSN

Larry Stowell, Ph.D., PACE Turf

www.paceturf.org
@paceturf
Facebook.com/MLSNTurf
Facebook.com/globalsoilsurvey
YouTube.com/paceturf

PACE TURF

Outline

- What is sustainability for turfgrass management?
- Reading a soil report and using MLSN for nutrition management
- Data mining and methods used to develop the Minimum Levels for Sustainable Nutrition (MLSN)
- MLSN as a sustainability metric
- Global Soil Survey

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?
Firm?
Green?
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 US."

Examples of Sustainability

Lehman Brothers Holdings Inc.

- 1850 – 2008
- Looked sustainable
- Too big to fail
- Environments 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

http://youtu.be/h4_vBKEPTEc

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?

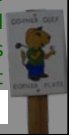
Metrics?

Sustainability Continuum

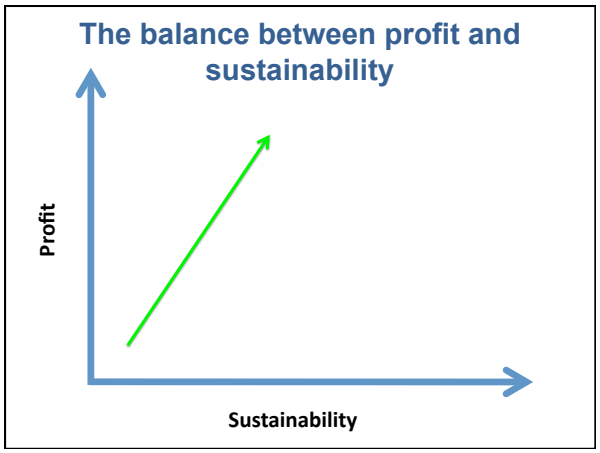
Less	More
40 acres of fairways	20 acres of fairways
40 acres of rough	20 acres of rough
Domestic irrigation water	Recycled irrigation water
Mow 6 days per week	Mow 3 days per week
Remove clippings	Return clippings
Weed free	Some weeds
Disease free	Some diseases
Insect Free	Some insects
Dark green color	Brown is beautiful
25 crew members	12 crew members
High budget	Low budget
High expectations	Balanced expectations

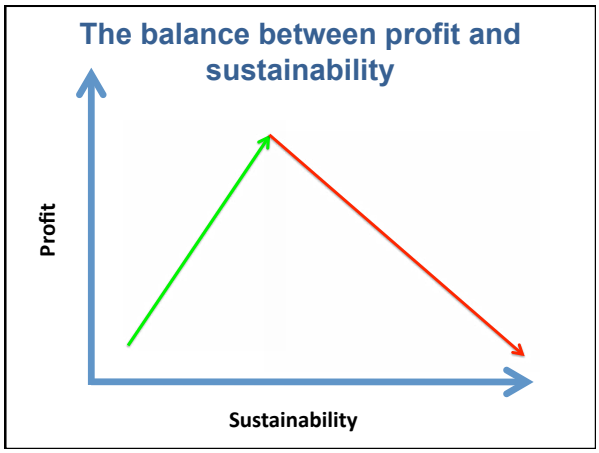
Sustainability Continuum

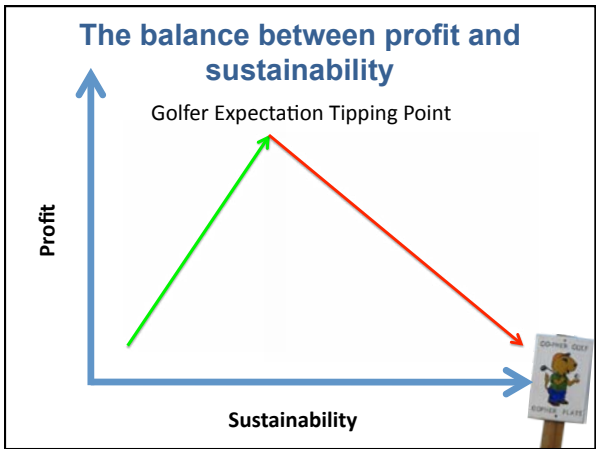
Less	More
40 acres of fairways	20 acres of fairways
40 acres of rough	20 acres of rough
Domestic irrigation water	Recycled irrigation water
Mow 6 days per week	Mow 3 days per week
Remove clippings	Return clippings
Weed free	Some weeds
Disease free	Some diseases
Insect Free	Some insects
Dark green color	Brown is beautiful
25 crew members	12 crew members
High budget	Low budget
High expectations	Balanced expectations



The balance between profit and sustainability







Quantitative Sustainability Metrics

Getting the "truthiness" out of sustainability

- Maintained acres
- Water used
- N and P applied – use of MLSN
- 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
- Regulations are the major driving force
  - Course size restrictions
  - Water use 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

Reading a Soil Report

- Don't be intimidated or confused by the numbers on the report
- There are many ways to interpret the data
- Keep asking questions – soil test results are boring if you just file them away
- Try to use lower inputs to become more sustainable and to save money

Short Cut

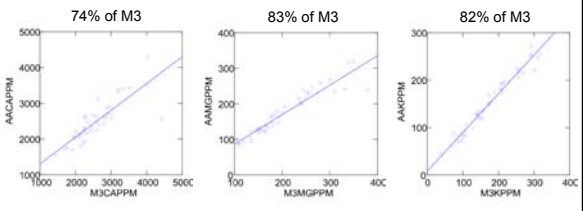
- Use a major soil lab such as Brookside, Harris, Logan or A&L
- Request Mehlich-3 extraction for major and minor nutrients
- Request plant available N (NO3 and NH4)
- Request Olsen extraction for phosphorus if soil pH exceeds 7.4
- Use SLAN and MLSN guidelines

Alphabet Soup

- SLAN Sufficiency Levels of Available Nutrients
- MLSN Minimum Levels for Sustainable Nutrition
- BSCR Base Saturation Cation Ratio – Specific ratios of cations, for example 68% Ca, 12% Mg and 4% K are not useful

Extraction Systems

- Water paste extract – for salts only
- Ammonium Acetate – calcareous soils (data from David Smith)



Keep it Simple

	SLAN	MLSN
Olsen P (pH>7.4)	12	6
Mehlich 3: P	50	18
K	110	35
Ca	750	360
Mg	140	54
S	15 - 40	13
KCL: NO3-N	3-20	1-10
NH4-N	7	0-7
Total-N	20	3-10
pH	--	5.5-8.5

Correcting Deficits

Element lb/1000 sq ft = 0.05 x (desired ppm – observed ppm)

MLSN

Calcium lb/1000 sq ft = 0.05 x (360 – 285)
Calcium lb/1000 sq ft = 3.75
Gypsum (23% Ca) lb/1000 sq ft = 3.75 / 0.23 = 16

Correcting Deficits

Element lb/1000 sq ft = 0.05 x (desired ppm – observed ppm)

MLSN

Calcium lb/1000 sq ft = 0.05 x (360 – 285)
Calcium lb/1000 sq ft = 3.75
Gypsum (23% Ca) lb/1000 sq ft = 3.75 / 0.23 = 16

SLAN

Calcium lb/1000 sq ft = 0.05 x (750 – 285)
Calcium lb/1000 sq ft = 23.25
Gypsum (23% Ca) lb/1000 sq ft = 23.25 / 0.23 = 101

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
- What about other nutrients?

How are nutrients removed from the soil?

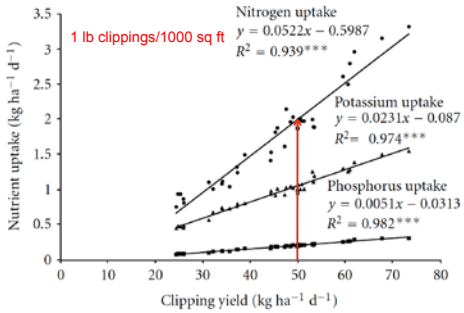
- Primarily by clipping removal
- By leaching if excessive nutrients are applied
- By leaching if the soil has high salts
- Leaching will not remove elements held on the cation exchange sites or associated with organic matter

Growth rate/clipping yield

- Grow as slow as possible for desired performance
- Slower than the maximum potential of the plant to produce biomass
- **Growth is restricted primarily by regulating nitrogen applications**
- Typical annual yield is about 82 lbs/1000 sq ft (at 5% N in tissue = 4 lbs N/1000 sq ft)

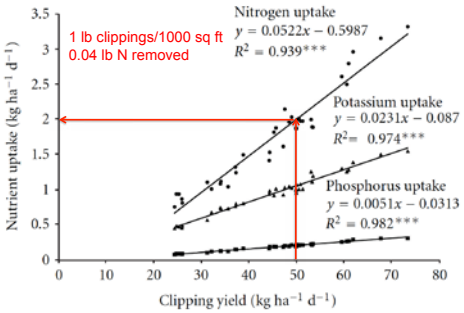
Kussow, Soldat, Kreuser and Houlihan

Agronomy doi 10.5402/2012/359284



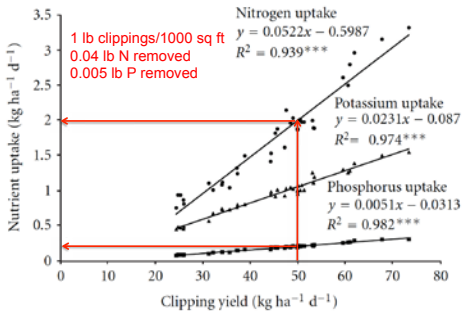
Kussow, Soldat, Kreuser and Houlihan

Agronomy doi 10.5402/2012/359284



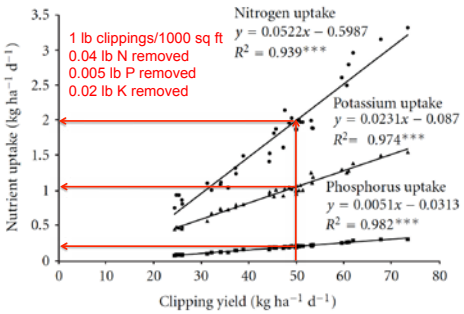
Kussow, Soldat, Kreuser and Houlihan

Agronomy doi 10.5402/2012/359284



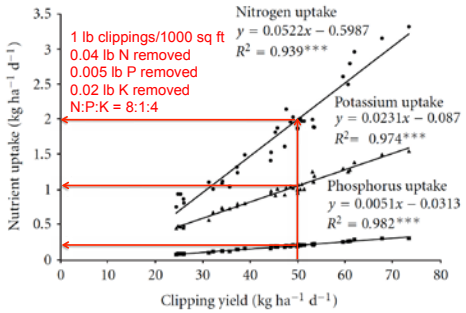
Kussow, Soldat, Kreuser and Houlihan

Agronomy doi 10.5402/2012/359284



Kussow, Soldat, Kreuser and Houlihan

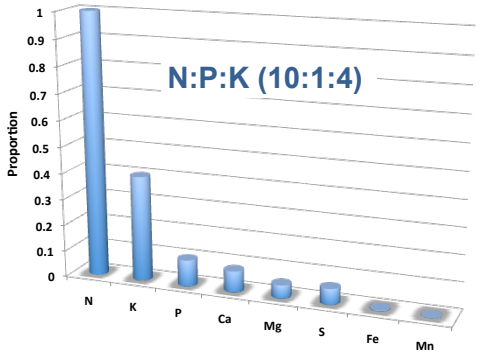
Agronomy doi 10.5402/2012/359284



What is the nutrient content of turf clippings?

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

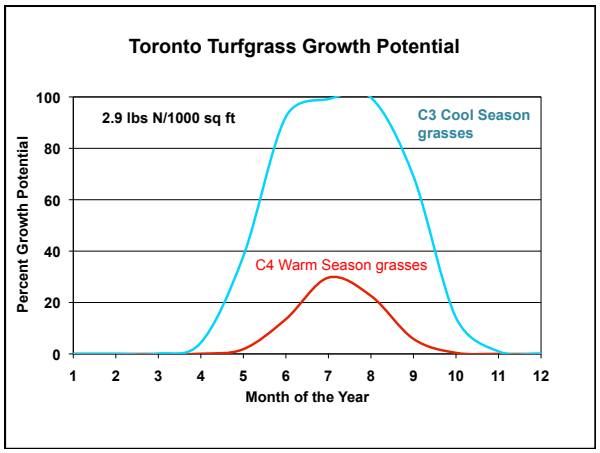


Climate Appraisal:

How much will the plant extract from the soil during the year?

Ontario (C3)

http://www.paceturf.org/ipm/f_climate_english_20131025.xls



Toronto, Canada (C3)

http://www.paceturf.org/ipm/f_climate_english_20131025.xls

Location: Toronto, Canada

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg T (F)	20.8	21.9	30.2	43.0	54.1	64.0	69.3	67.3	59.4	48.2	37.6	26.2
Rainfall (in)	1.9	1.8	2.3	2.6	2.6	2.6	2.8	3.2	2.8	2.5	2.6	2.4

Cool Season Grass Maximum N/month lb/1000 sq ft = 0.70

Cool GP	0	0	0	4	38	92	99	100	69	14	1	0	Total
N lb/1000 sq ft	0.0	0.0	0.0	0.0	0.3	0.6	0.7	0.7	0.5	0.1	0.0	0.0	2.9
K lb/1000 sq ft	0.000	0.000	0.000	0.012	0.107	0.258	0.278	0.279	0.193	0.039	0.003	0.000	1.17
P lb/1000 sq ft	0.000	0.000	0.000	0.003	0.027	0.065	0.069	0.070	0.048	0.010	0.001	0.000	0.29
Ca lb/1000 sq ft	0.000	0.000	0.000	0.002	0.021	0.052	0.056	0.056	0.039	0.008	0.001	0.000	0.23
Mg lb/1000 sq ft	0.000	0.000	0.000	0.002	0.013	0.032	0.035	0.035	0.024	0.005	0.000	0.000	0.15
S lb/1000 sq ft	0.000	0.000	0.000	0.002	0.016	0.039	0.042	0.042	0.029	0.006	0.000	0.000	0.18
Fe lb/1000 sq ft	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.003	0.002	0.000	0.000	0.000	0.012
Mn lb/1000 sq ft	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.004

How much will be removed when applying 3 lbs N/1000 sq ft/year

Element	lb/1000 sq ft	Soil Test ppm in top 4 inches
K	1.2	39
P	0.29	10
Ca	0.23	8
Mg	0.15	5
S	0.18	6
Fe	0.012	0.4
Mn	0.004	0.13

Toronto (C3)

Element	lb/ 1000 sq ft	Soil Test (4 in) ppm	SLAN ppm	MLSN ppm	MLSN +
N	3				
K	1.2	39	110	35	74
P	0.29	10	50	18	28
Ca	0.23	8	750	360	368
Mg	0.15	5	140	54	59
S	0.18	6	15	13	19
Fe	0.012	0.4	90	--	--
Mn	0.004	0.13	30	--	--

Potassium

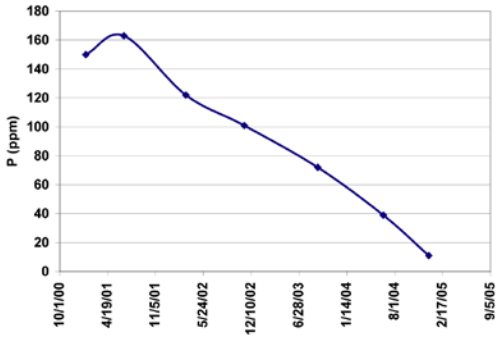
MLSN

If soil K ppm drops to 35 ppm, use a 1:2 N:K fertilizer

35 – 110 ppm K use a 2:1 N:K fertilizer

If soil K ppm exceeds 150 ppm, withhold K

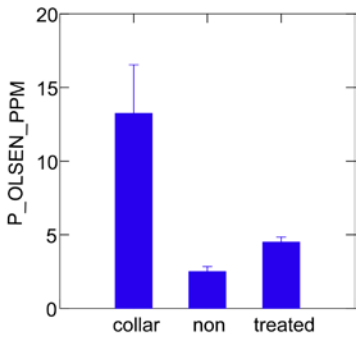
Trend in soil M3-P levels at Talega Country Club A4 Bentgrass



Talega Country Club

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

Talega Country Club (pH 7.5)



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 (whatever that means)

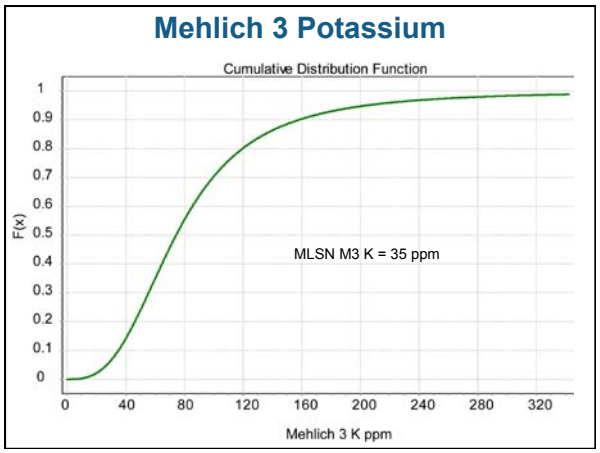
MLSN Developement

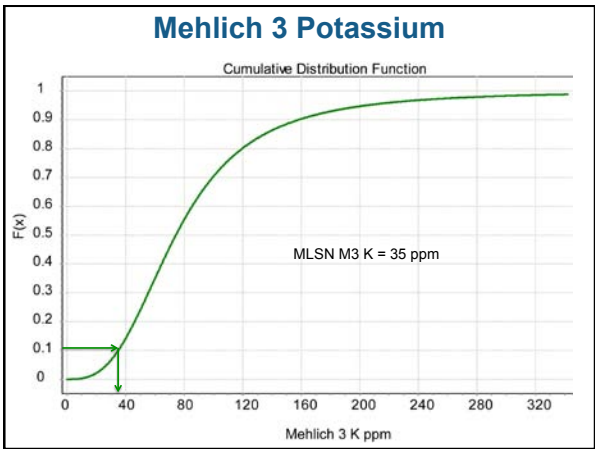
Mining the PACE Turf Soil Database

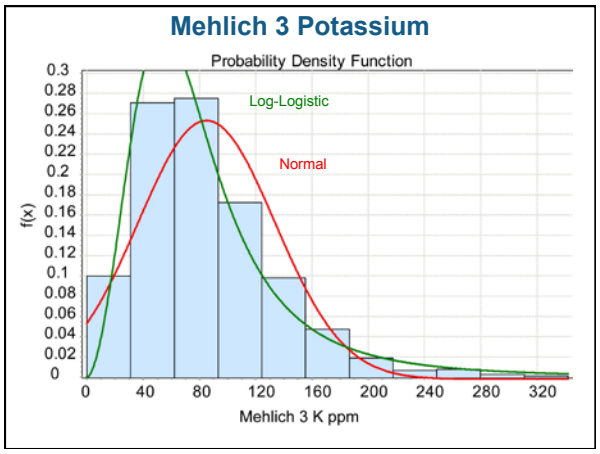
- 17,000 + soil tests ($1.2M end-user investment)
- Metadata for turf performance captured on many samples
- Wide geographic distribution, but weighted in Southwestern US
- High level of data quality control

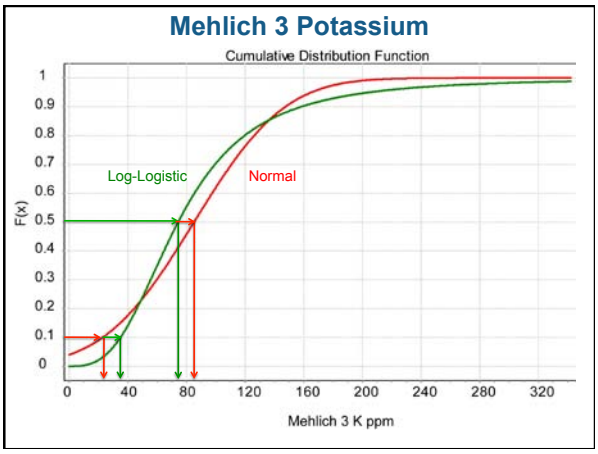
Guideline Comparison

	Conventional ppm	MLSN ppm
Olsen P	>12	6
Bray 2 P	>75	25
Mehlich 3		
P	>50	18
PSI	<0.15	0.1
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)


Mehlich 3 Potassium
Cumulative Distribution Function
F(x)
MLSN M3 K = 35 ppm
Mehlich 3 K ppm


Mehlich 3 Potassium
Cumulative Distribution Function
F(x)
MLSN M3 K = 35 ppm
Mehlich 3 K ppm


Mehlich 3 Potassium
Probability Density Function
f(x)
Log-Logistic
Normal
Mehlich 3 K ppm


Mehlich 3 Potassium
Cumulative Distribution Function
F(x)
Log-Logistic
Normal
Mehlich 3 K ppm

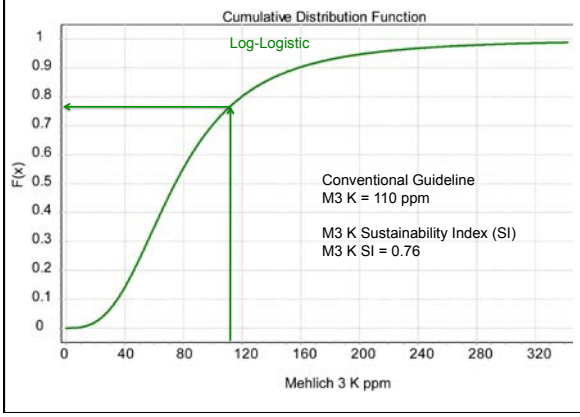
MLSN Sustainability Index (SI)

- 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

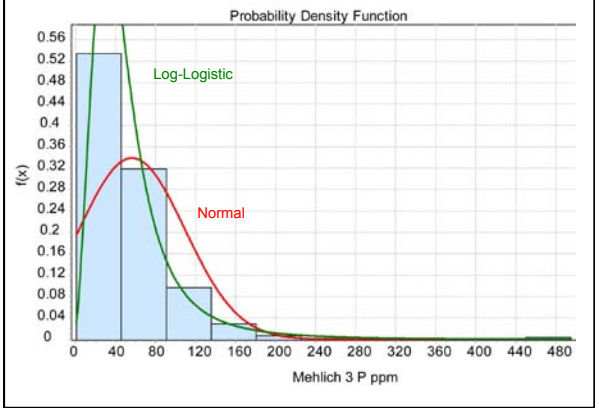
SI of Conventional Mehlich 3 K Guideline



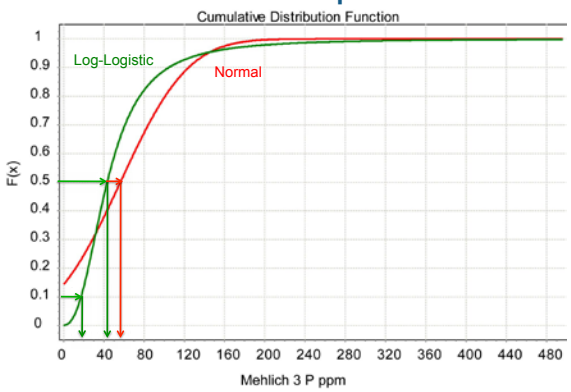
Sustainability Index Comparison

	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	

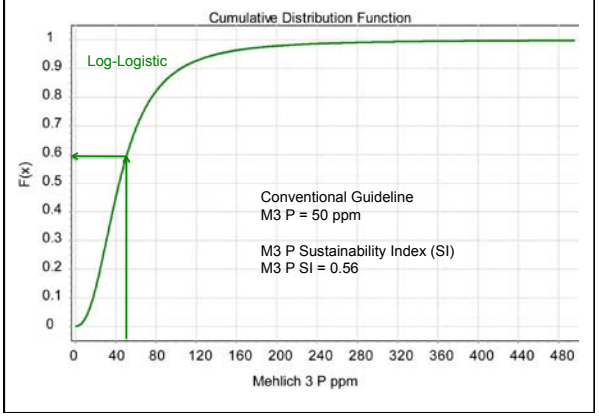
Mehlich 3 Phosphorus



Mehlich 3 Phosphorus



SI of Conventional Mehlich 3 P 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

GLOBAL SOIL SURVEY

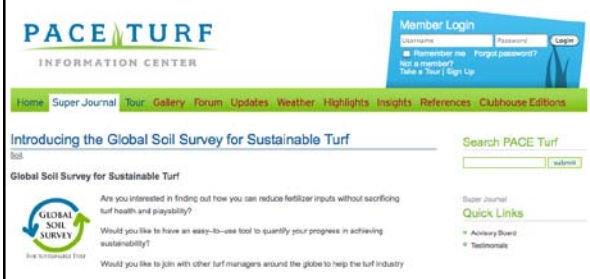
FOR SUSTAINABLE TURF

Wendy Gelernter, Ph.D, Larry Stowell, Ph.D., PACE Turf, USA
Micah Woods, Ph.D., Asian Turfgrass Center, Thailand

Global soil survey: August, 2013

- Citizen science project to validate and expand on MLSN guidelines
- Turf managers from around the world contribute soils from good performing turf
- Analytical results (Brookside Labs) pooled with existing database
- New guidelines developed
- Raw data available to academic communitv

- Participants sign up at **paceturf.org**
- $250 fee covers sampling kit, shipping, analysis of 3 samples, personalized report, recommendations, sustainability index
- New guidelines publicly available

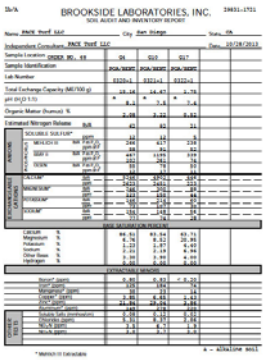


paceturf.org
facebook.com/globalsoilsurvey

Global soil survey report

- Complete soil report for each soil tested
- Sustainability Index
- Nutrient requirements for 2, 4, 8 lbs N/1000 sq ft

Global Soil Survey – Standard Report


BROOKSIDE LABORATORIES, INC.

Global Soil Survey

Key nutrients from laboratory report in ppm

Area	pH	K	P M3	P Bray 2	P Olsen	Ca	Mg	S	TOT-N	EC
G 04	8.1	73	58	102	12	2623	123	12	6.5	0.7
G 10	7.5	107	91	261	17	2451	150	12	10.4	0.8
G 17	7.4	30	52	74	11	223	44	5	4.9	0.5

Sustainability Index target is 0.1

Area	K	P M3	P Bray 2	P Olsen	Ca	Mg	S	TOT-N
G 04	0.50	0.70	0.80	0.60	1.00	0.80	0.10	0.60
G 10	0.70	0.90	1.00	0.80	1.00	0.90	0.10	0.80
G 17	0.10	0.60	0.70	0.60	0.00	0.10	0.00	0.40

Global Soil Survey

Deficits in ppm

Area	K	P M3	P Bray 2	P Olsen	Ca	Mg	S
G 04	38	40	77	6	2263	69	-1
G 10	72	73	236	11	2091	96	-1
G 17	-5	34	49	5	-137	-10	-8

Deficit in lb/1000 sq ft

Area	K	P M3	P Bray 2	P Olsen	Ca	Mg	S
G 04	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G 17	0.2	0.0	0.0	0.0	6.3	0.5	0.4

Global Soil Survey

Nutrient requirement when applying 4 lbs N/1000 sq ft
Reported in lb/1000 sq ft

Area	K	P M3	P Bray 2	P Olsen	Ca	Mg	S
G 04	0.0	0.0	0.0	0.1	0.0	0.0	0.3
G 10	0.0	0.0	0.0	0.0	0.0	0.0	0.3
G 17	1.8	0.0	0.0	0.2	6.6	0.7	0.6

Sustainability

More Than Just a Buzz Word