Turfgrass Mastery

From Sensor to Decision.

Soil oxygen data in practice.

DGA Conference, 4 November 2026
Janne Lehto MG, CGCS · Hirsala Golf – Living Lab of Turfgrass Mastery

A familiar face returns



Janne Lehto MG, CGCS
Master Greenkeeper (BIGGA), CGCS

Hirsala Golf

Superintendent since 2016.

Living Lab: Hirsala is where we test and analyse – before we recommend anything to anyone else.

FGA

Chairman of the Finnish Greenkeepers Association.

Turfgrass Mastery

Agronomy consulting and the Turfgrass Mastery operating system for golf course management.

hirsalagolf.

FGA

Turfgrass Mastery

The question of the day

Moisture tells you how much water is in the rootzone.
Oxygen tells you whether the roots can use it.



P 1

Why oxygen.



P 2

Valid data.



P 3

Hirsala validation.



P 3

Football stadium case.



P 4

From data to decisions



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PART 1

Oxygen in the root zone.

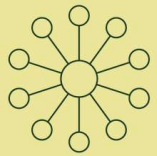
Roots breathe.

Roots respire around the clock. They tolerate dry spells and poor nutrition for a while – but oxygen is not optional.

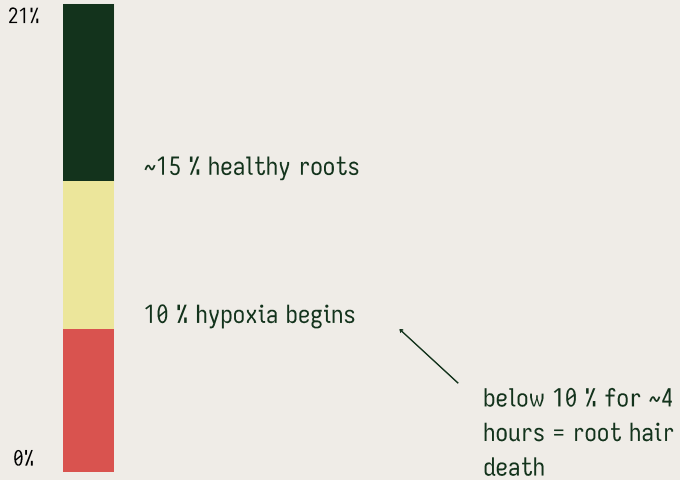
- No oxygen
- No root energy
- No water or nutrient uptake

Soil microorganisms: Many beneficial microorganisms consume oxygen while decomposing organic matter.

Key takeaway: Healthy turfgrass needs oxygen in the root zone 24 hours a day, even though its leaves typically produce more oxygen through photosynthesis than the entire plant consumes through respiration over a normal growing day.



Duration matters, not a single dip in numbers.






Turf gas exchange
Leaves photosynthesise — roots respire
O₂ released
CO₂ absorbed
AIR
ROOTZONE
O₂ consumed by roots
TURFGRASS MASTERY · TURF UNDERSTOOD

5 FAMILIAR CAUSES

What pulls oxygen levels down



Water-filled pores

After rain or irrigation.



Compaction

Traffic and machinery.



Organic matter

Build-up and layering.



Warm soil

Roots and microbes use more oxygen.



Surface sealing

Algae, black layer, topdressing layers.

Nothing new – but now we see it in the data, hour by hour.



SAME MOISTURE, DIFFERENT STORY

Moisture alone cannot tell them apart.

Two spots. The same moisture reading.

After heavy rain, one gets its oxygen back within hours.

The other takes days.



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PART 2

Measurement and data validation.

How we measure

Wireless sensors buried in the rootzone – no cables, no trenching.



Happi100

Oxygen, moisture and temperature. Hourly.

Battery up to 10 years.



Hydra100

Moisture, temperature, salinity (EC). Hourly.

Up to 20 years lifetime for battery. Sends from 2 m depth.



Dual Depth

Two depths in one hole.

The top sensor relays the deep one.

Base station

~1 000 m range, 1 000+ sensors.
Data in the Hub, alarms by email, open API.

The meter chooses the spot. The sensor shows the trend.

HANDHELD METER

A snapshot of many spots.

We use it daily to track hot spots, handwatering and to choose each sensor spot, and to cross-check the data. Surface moisture.

BURIED SOIL SENSOR

A continuous film of one spot.

Shows the trend: how fast water arrives, how fast it drains, how fast oxygen comes back. Shows the trends in maintenance practises and gives validation data.











What makes data valid

01
Right place – you know why the sensor is exactly there.

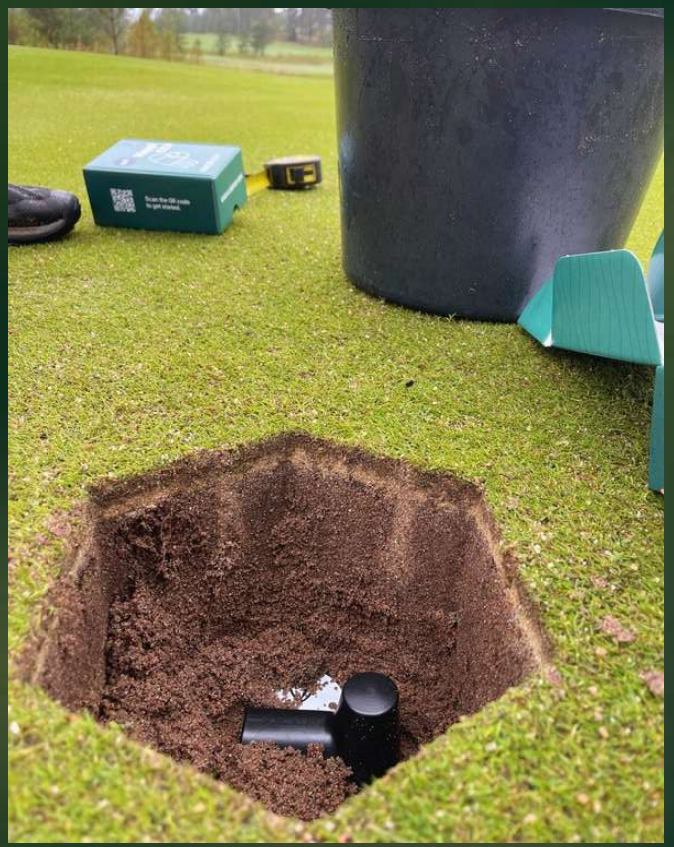
02
Right depth – recorded for every point.

03
Right question – placement follows what you want to know.

04
Good install – firm soil contact, time to settle.

05
Consistent names and metadata.

06
Known exceptions – aeration, hole locations, topdressing.



COMMON PITFALLS

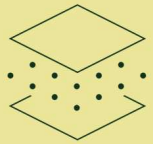
Sensor placed where it was easy to dig.

Mixed depths compared as one.

Different sensor types compared directly.

One sensor treated as “the green”.

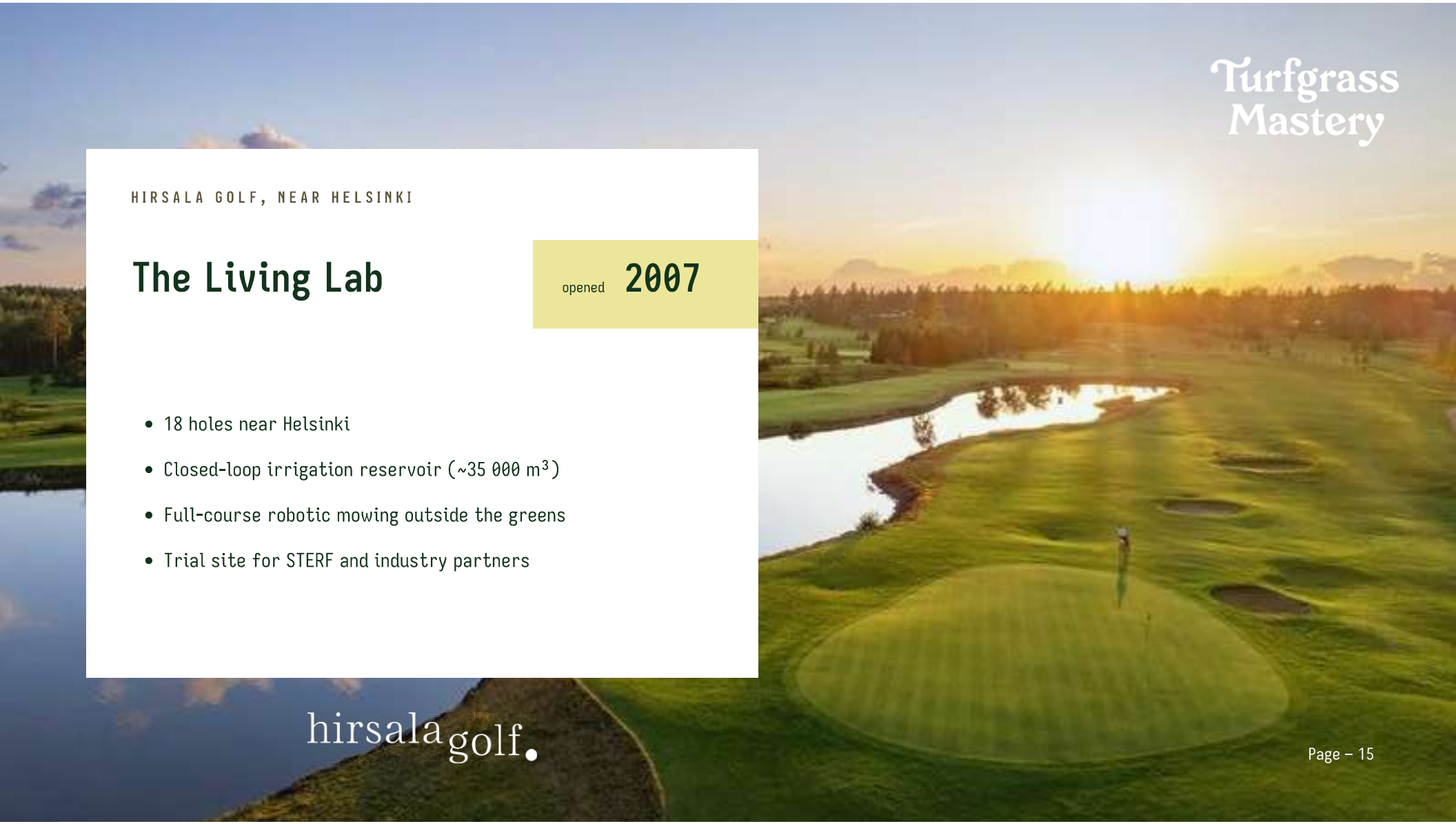
No record of where – and why.





PART 3

Hirsala validation.



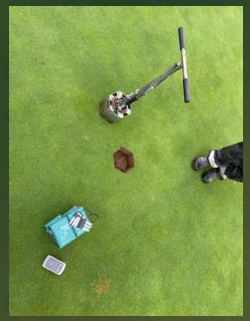
HIRSALA GOLF, NEAR HELSINKI

The Living Lab

opened **2007**

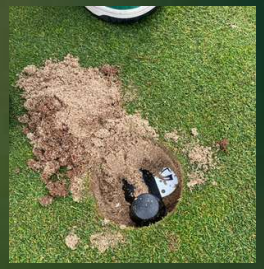
- 18 holes near Helsinki
- Closed-loop irrigation reservoir (~35 000 m^3)
- Full-course robotic mowing outside the greens
- Trial site for STERF and industry partners

hirsala golf.









Where we started - first 2 years

Hydra sensors on 11 greens.

Happi100 on greens 7, 11, 12 and the putting green.

Measured at the same hour, rootzone moisture ranged from 7.3 % (green 2) to 18.8 % (green 9).

One sensor cannot speak for the whole course.

The 2027 network, installed september 2026

+33 Happi100 and +4 Dual Depth Sensors.

All 18 greens covered.

Every green measured in at least two contrasting zones. Happi100 at 15 cm, Dual sensors at 5 + 15 cm.



Start from the question, not the sensor.

Soil Scout's set-up suggestions:

1	2	3	4	5
Dual-zone greens	**Hydra + Happi pairs**	**A third zone**	**Infiltration**	**Sprinkler tests**
A high and a low spot on each green. Start with the worst green?	Moisture next to oxygen - learn from each other. Cost optimising.	The full range on key greens.	Dual sensors at two depths. Learn the infiltration rates.	One sensor per head in throw radius. Future automatic control of irrigation heads.

Hirsala's version: priority greens for irrigation (single head control), two or three zones everywhere else.

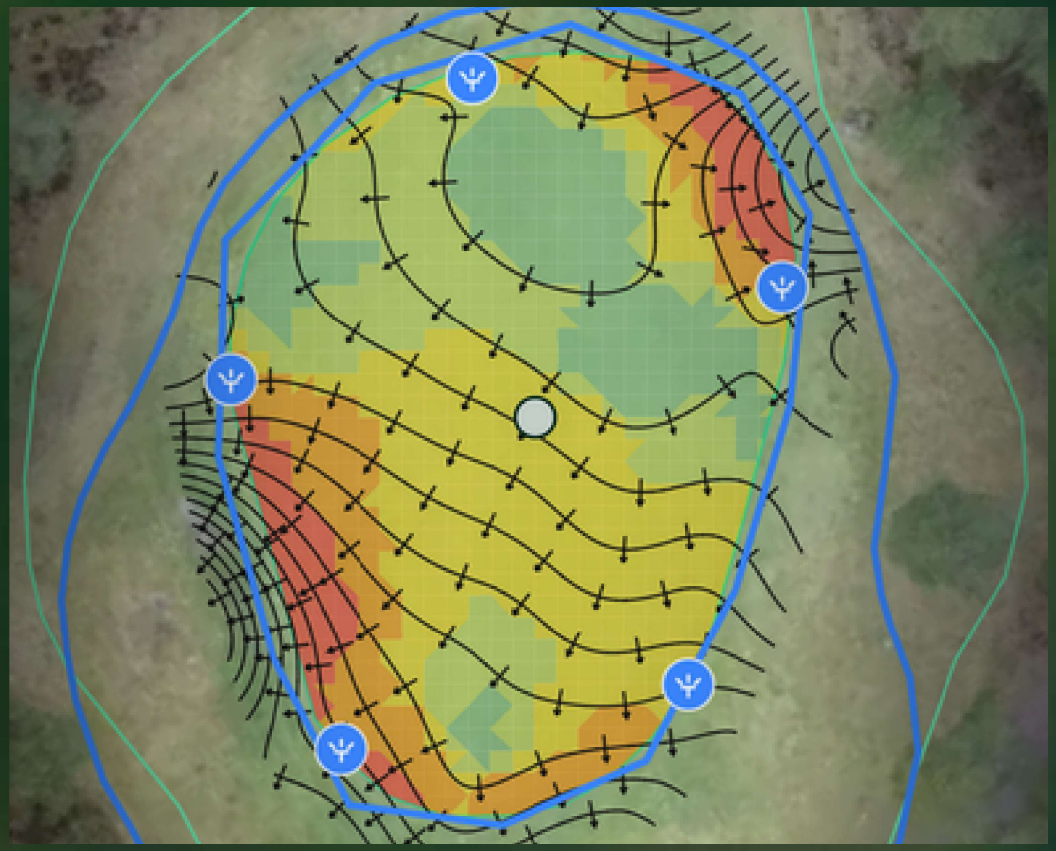
Topography supports placement

High ground dries first. Low ground collects water.

Sand splash areas?

Our 2024 slope survey by Golfkit gave slope % and flow direction for every green.

We found the high and low spots – then checked each one with a handheld meter before installations.





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SAME GOLF COURSE, DIFFERENT STORY

Priority greens: one sensor per sprinkler

- Greens 7, 15, 16, 17 – five individually controlled heads each.
- Our proof of concept design: One sensor per head, at 25 % of the throw (about 6 m), mid-sector, on the driest spot of the sector.
- One Dual sensor per green at the highest sprinkler head.
- Potential to learn and automate sprinkler action with the data.

The head test protocol - data collection

01. 24 H DRY

No irrigation for 24 h. Dry period.

02. ONE HEAD, FIXED RUN

Run one head only, fixed runtime.

03. LOG 24 H

Log the rise and drain-down for 24 h.

04. REPEAT MONTHLY

Repeat monthly – and after nozzle changes, wetting agents and aeration practises.

The curve shows nozzle wear, arc and pressure – and how fast the soil gets its oxygen back. Weather station integrated we can learn the optimal irrigation wolume per head.

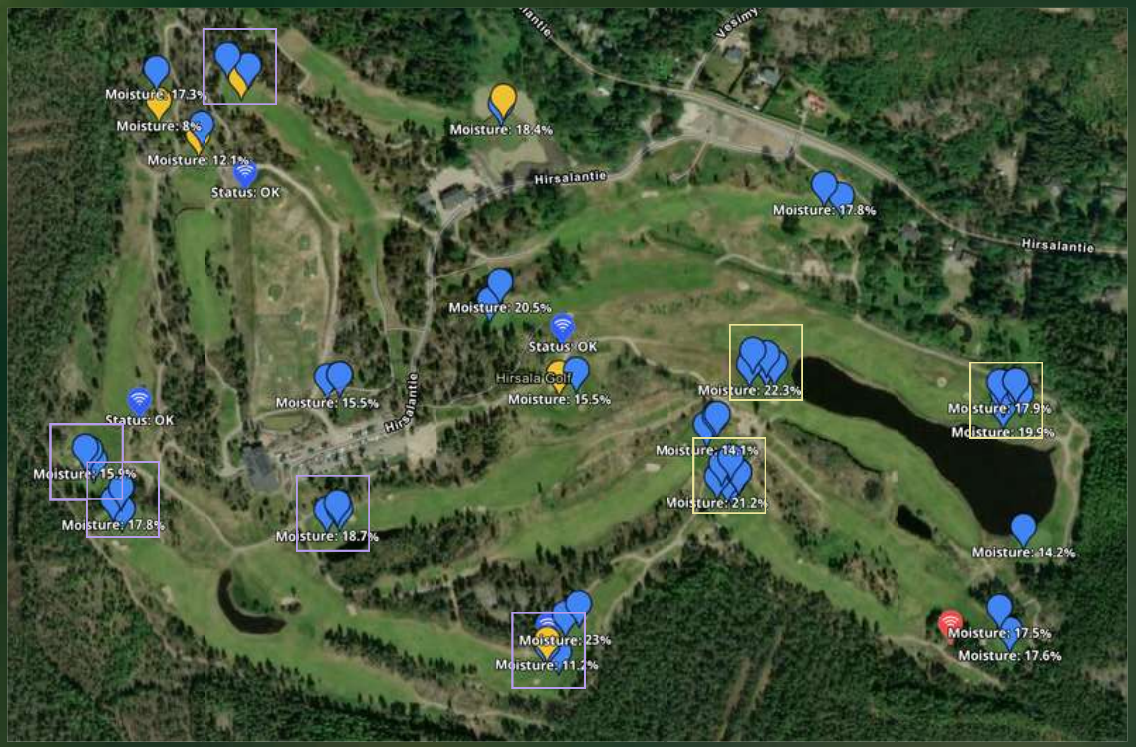


The rest of the course

Every green has at least one high and one low point.

Greens 2, 4, 9 and 18: high, average and low.

Existing sensors reused where they fit the plan.



Priority: one sensor per head

Three points: high, average, low

Two points: high and low

Installation lessons

01 - Check the spot

Handheld reading within 1 m before you install.

02 - Stay inside

At least 3 m from the green edge.

03 - Avoid hole locations

Keep sensors out of cup-cutting zones.

04 - Mark the aeration map

Dual at 5 cm: hollow-tine depth. Happi at 15 cm: deep-tine depth.

05 - Install before frost

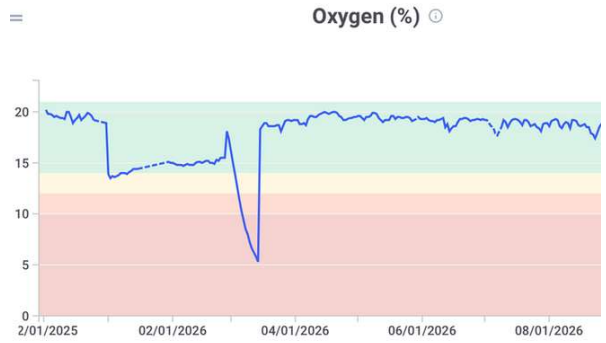
Soil should settle around the sensor before winter.

Actual data from Hirsala

Winter management

We use sensors to track:

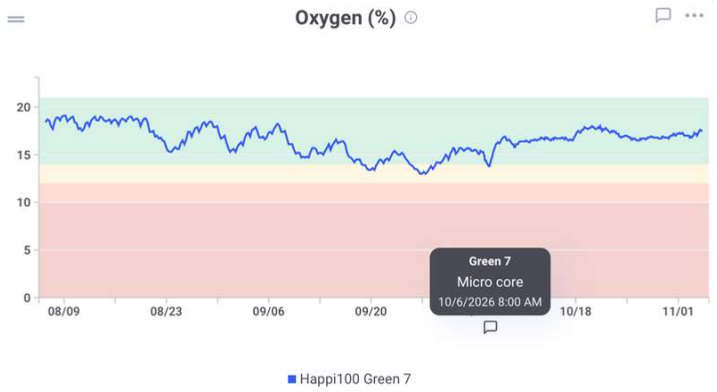
- snow composition
- ice layer formation
- surface temperature under snow cover, moisture
- When to act!



Organic matter management

We user sensors to:

- Determine when to aerate
- Assess the agronomic issue, ie. organic matter or compaction

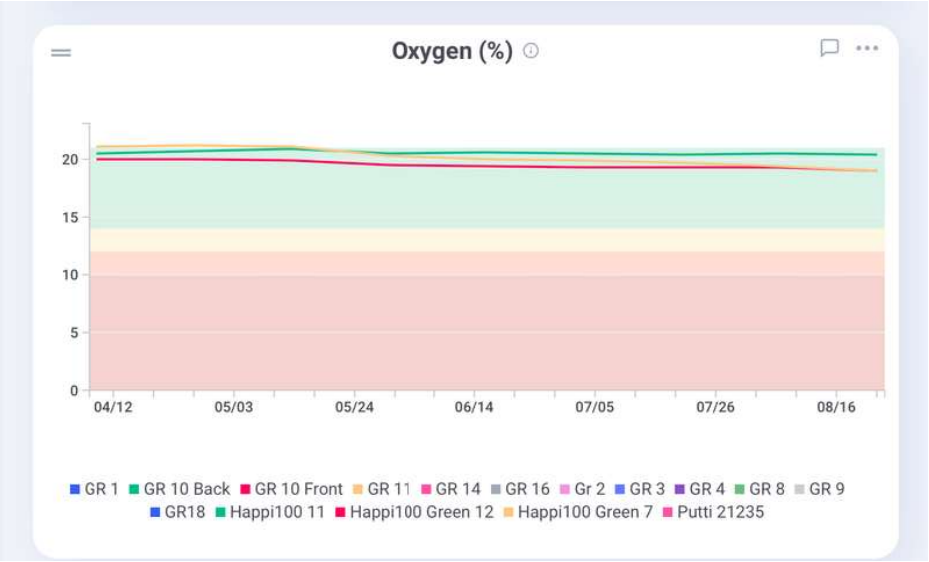


Actual data from Hirsala

Knowing when not to act

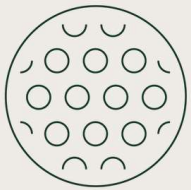
We user sensors to:

- Peace of mind
- Optimise inputs
- Optimise aeration practises



PART 4

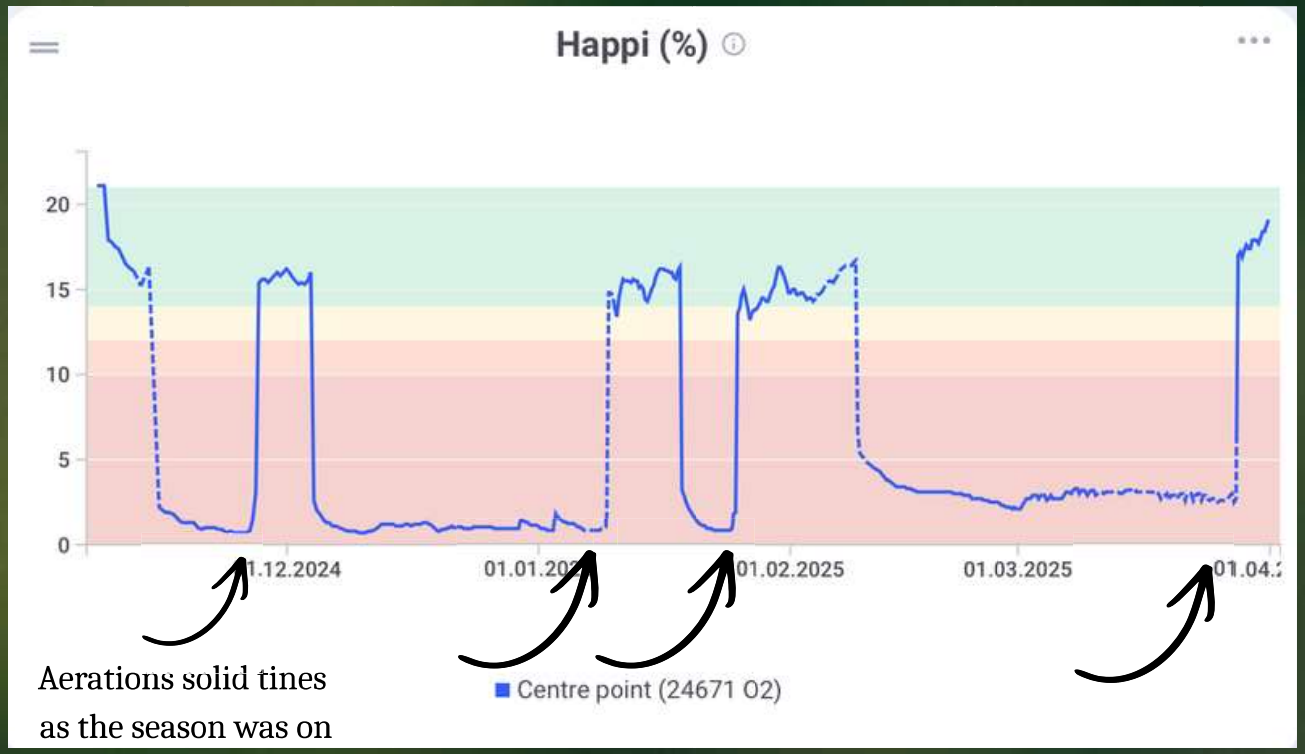
Football stadium case.



Daugava Stadium, Riga



- Natural grass.
- 2022: pitch problems moved home internationals elsewhere.
- October 2023: pitch replacement and renovation started.
- Pitch sodded with clay based turf of 4cm thick.
- Problems with airflow to rootzone.
- Clay layer acted like a plastic cover (similar to accumulated OM)
- Winter matches for Europa League.



Aerations solid tines
as the season was on

Golf green vs. stadium pitch

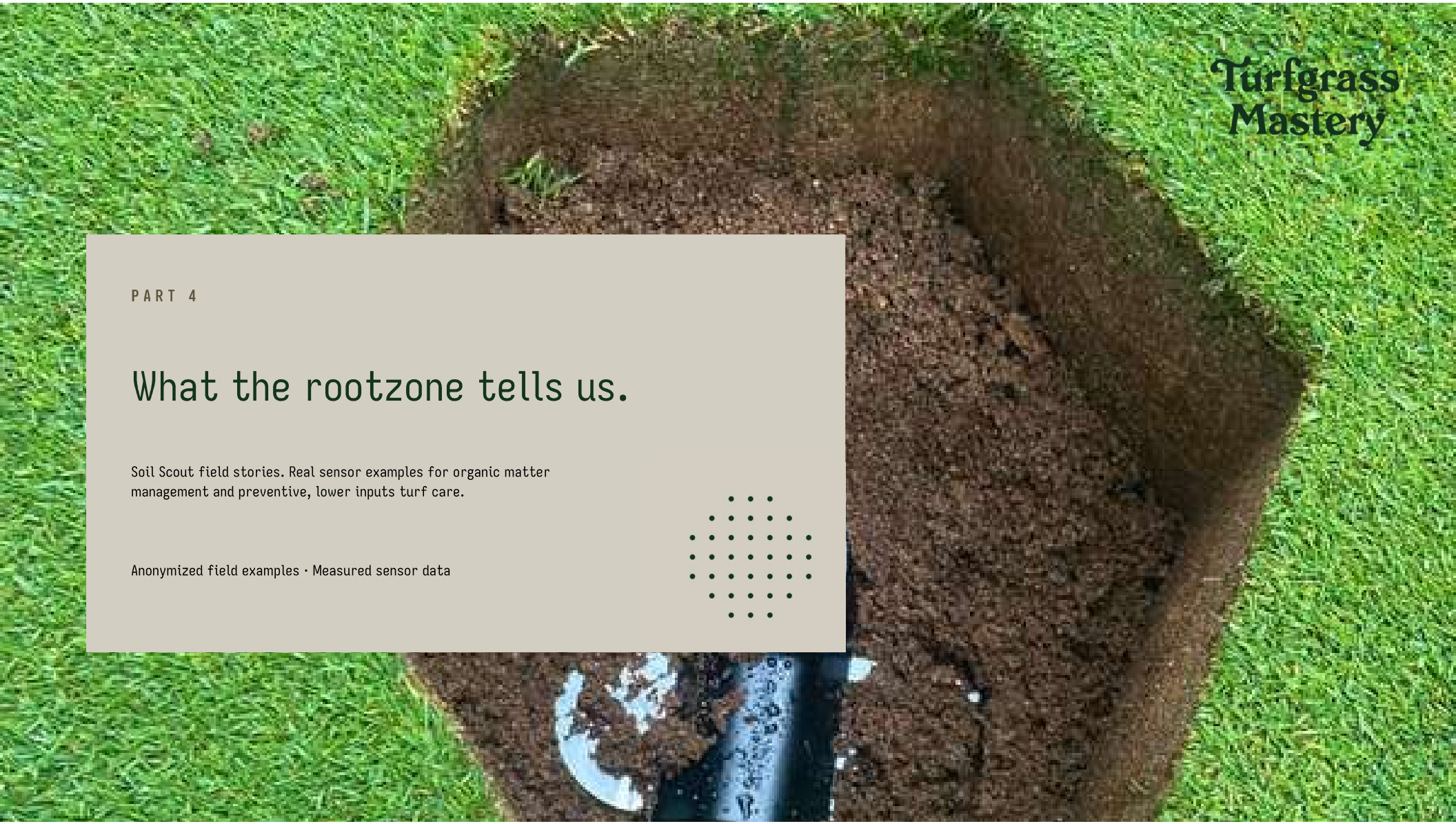
	Golf green	Stadium pitch
Use	Rounds, spread over the day	Events, concentrated wear
Rooting depth	Rootzone 30 cm; active roots 5–20 cm	Rootzone 30 cm; minimum 10 cm roots
Shade and airflow	Usually open; local tree shade	Stands block light and air; DLI and fans
Critical point for oxygen	Organic matter builds up in the top 0–40 mm	Compaction right after matches and events, organic matter management
Key action	Irrigation control + OM management (topdressing, aeration)	Wear recovery: aeration, grow lights, airflow











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PART 4

What the rootzone tells us.

Soil Scout field stories. Real sensor examples for organic matter management and preventive, lower inputs turf care.

Anonymized field examples · Measured sensor data

Same green. Different water storage by depth.

WHAT WAS OBSERVED

~23–24 %

Apparent field capacity
Upper location: 3 in

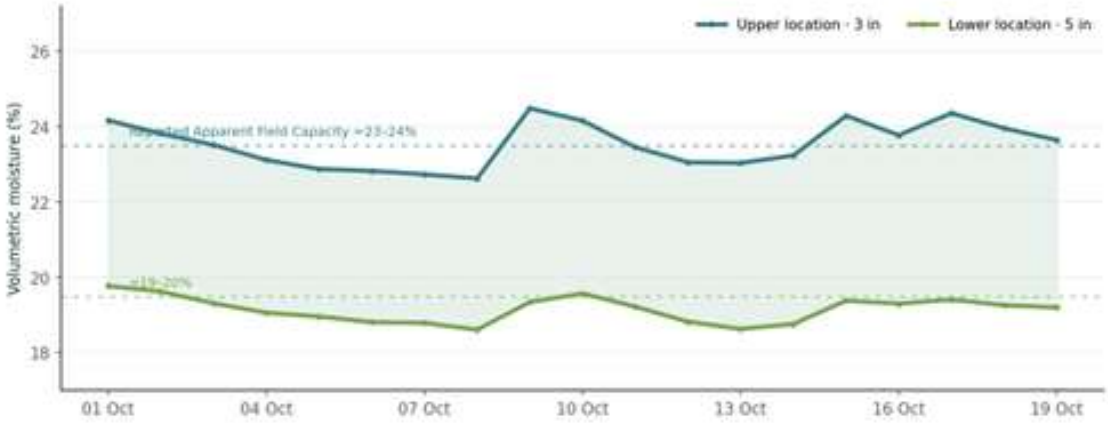
~19–20 %

Apparent field capacity
Lower location: 5 in

Consistent spatial difference.

Moisture retention varies locally with soil structure and texture.
The data shows it: field capacity, and how it evolves over time.

Repeated post-wetting patterns reveal rootzone structure.



Daily averages. 1–19 Oct 2026. Apparent field capacity references established from repeated cycles.

ANONYMIZED FIELD EXAMPLE; MEASURED SENSOR DATA

A wet reading is not the whole story.

Compare exposure duration with oxygen response – even on the same monitored green.



August: persistent moisture

Repeated wetness. Oxygen declined from ~14 % to ~5 % over weeks.

October: brief wetting + drainage

A short wetting peak drained. Oxygen stayed around 15–17 %.

Which moisture level starts restricting oxygen?

Repeated wetting and drainage cycles reveal a clear, site-specific change in rootzone oxygen availability.



6-hour mean readings. 18 Sep–14 Oct 2026. One monitored rootzone. Read alongside exposure duration and O_2 recovery – a site-specific level, not a universal soil threshold.

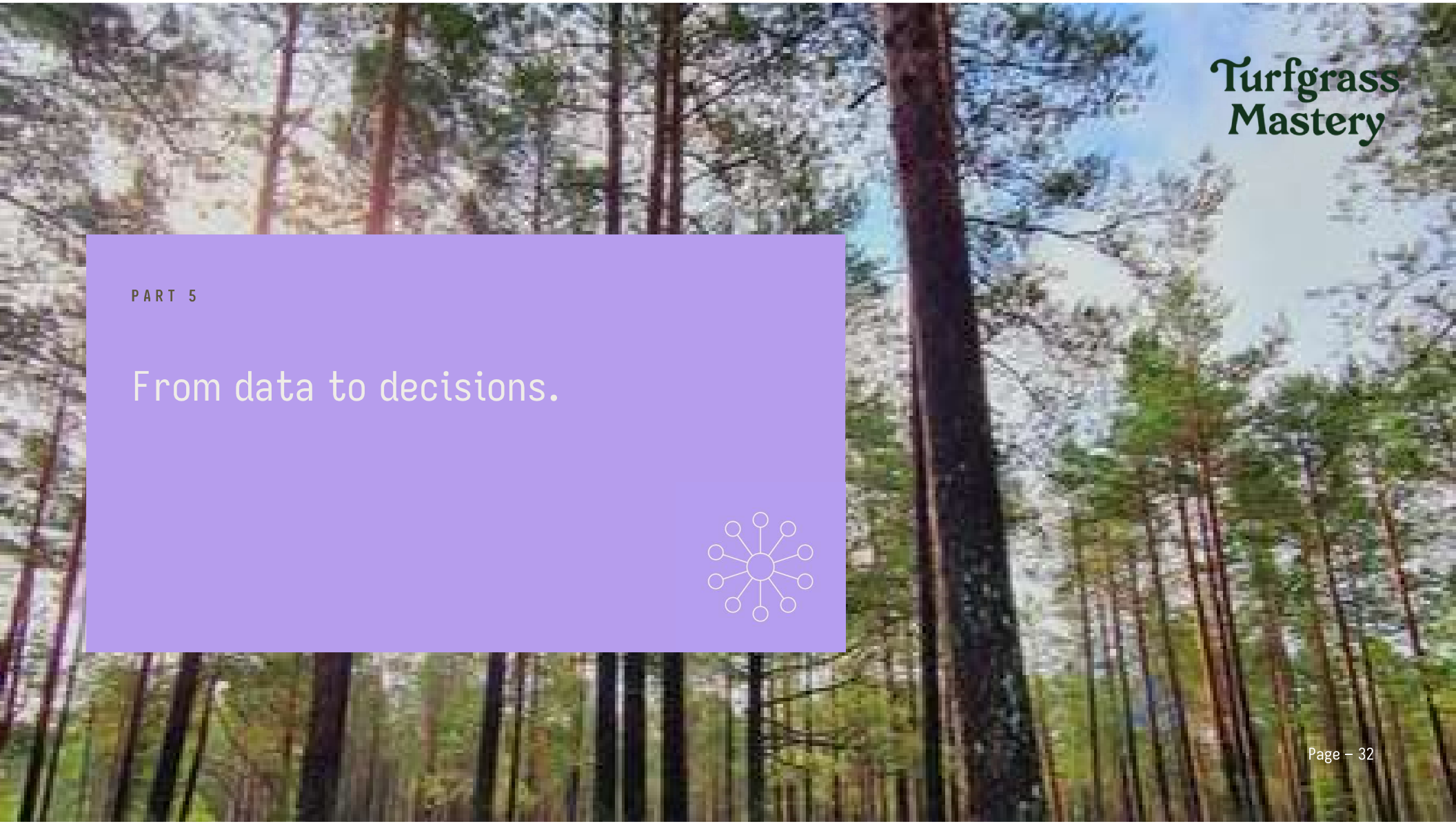
23–27 %
Generally well aerated

27–29 %
Transition: oxygen decreases

29–30 %
Restriction increasingly frequent

≥30 % VWC

Recurring severe oxygen limitation. Repeated O_2 < 12 %, often near zero.



PART 5

From data to decisions.

Reading moisture and oxygen together

OXYGEN: low → high

MOISTURE: dry → wet

Dry + high O_2

Irrigate – and check the head.

Wet + O_2 recovers fast or stays up

Drainage and air flow works. Play on.

Moderate moisture + low O_2

Compaction or organic matter limiting airflow: target aeration.

Wet + low O_2

Hold irrigation, vent with solid tines, limit traffic. Measure and repeat. Review the agronomic plan.

MAKING IT A ROUTINE

Daily alarms. Weekly compare. Season report.



Observe deeply.



Measure precisely.



Understand systemically.



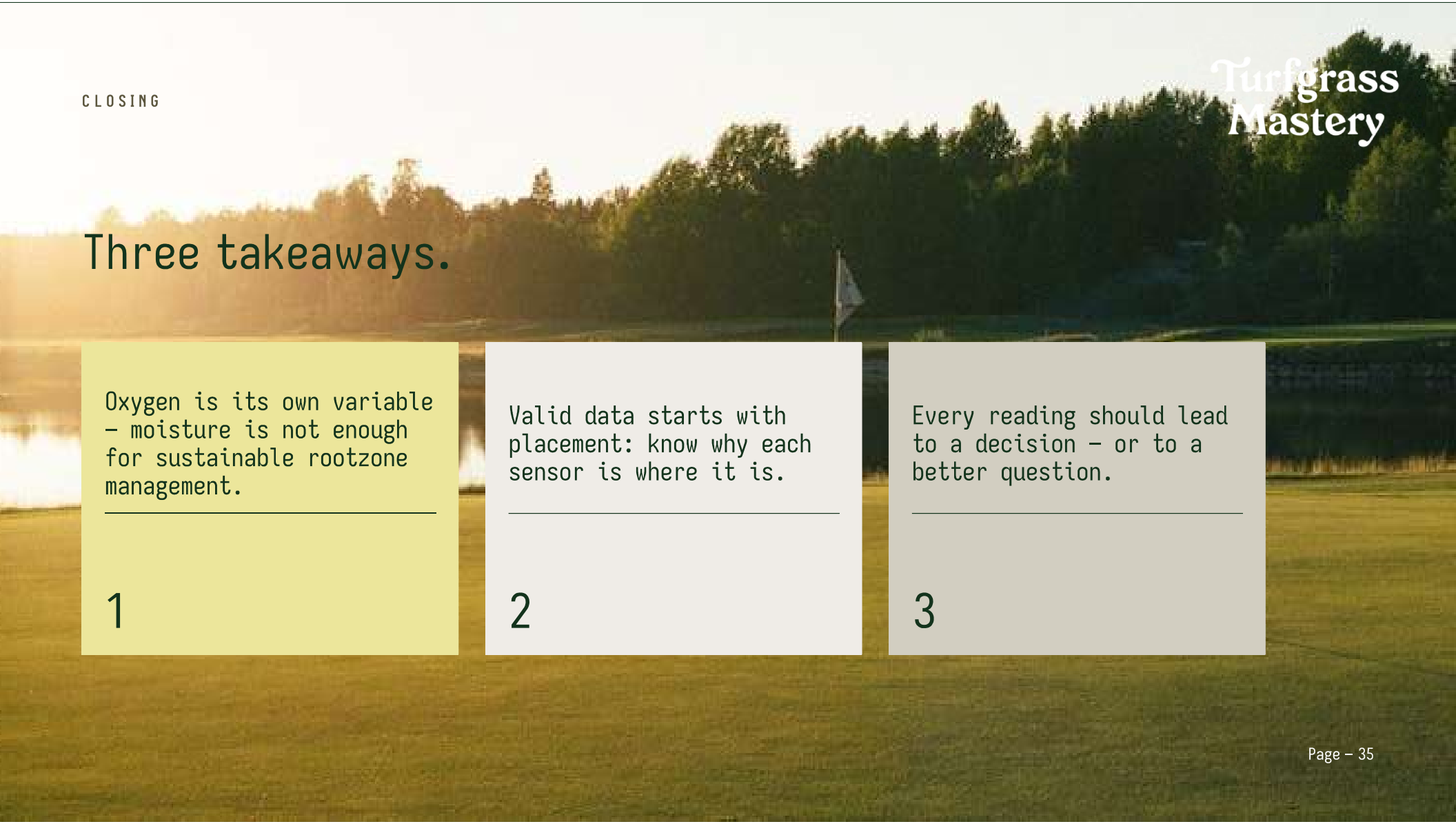
Apply intentionally.



Validate continuously.

Day: alarms + dashboard · Week: compare zones and heads · After each intervention: did the curve change? · Season: report and adjust.

The Turfgrass Mastery philosophy: five principles that turn sensor data into a routine.



CLOSING

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Three takeaways.

Oxygen is its own variable – moisture is not enough for sustainable rootzone management.

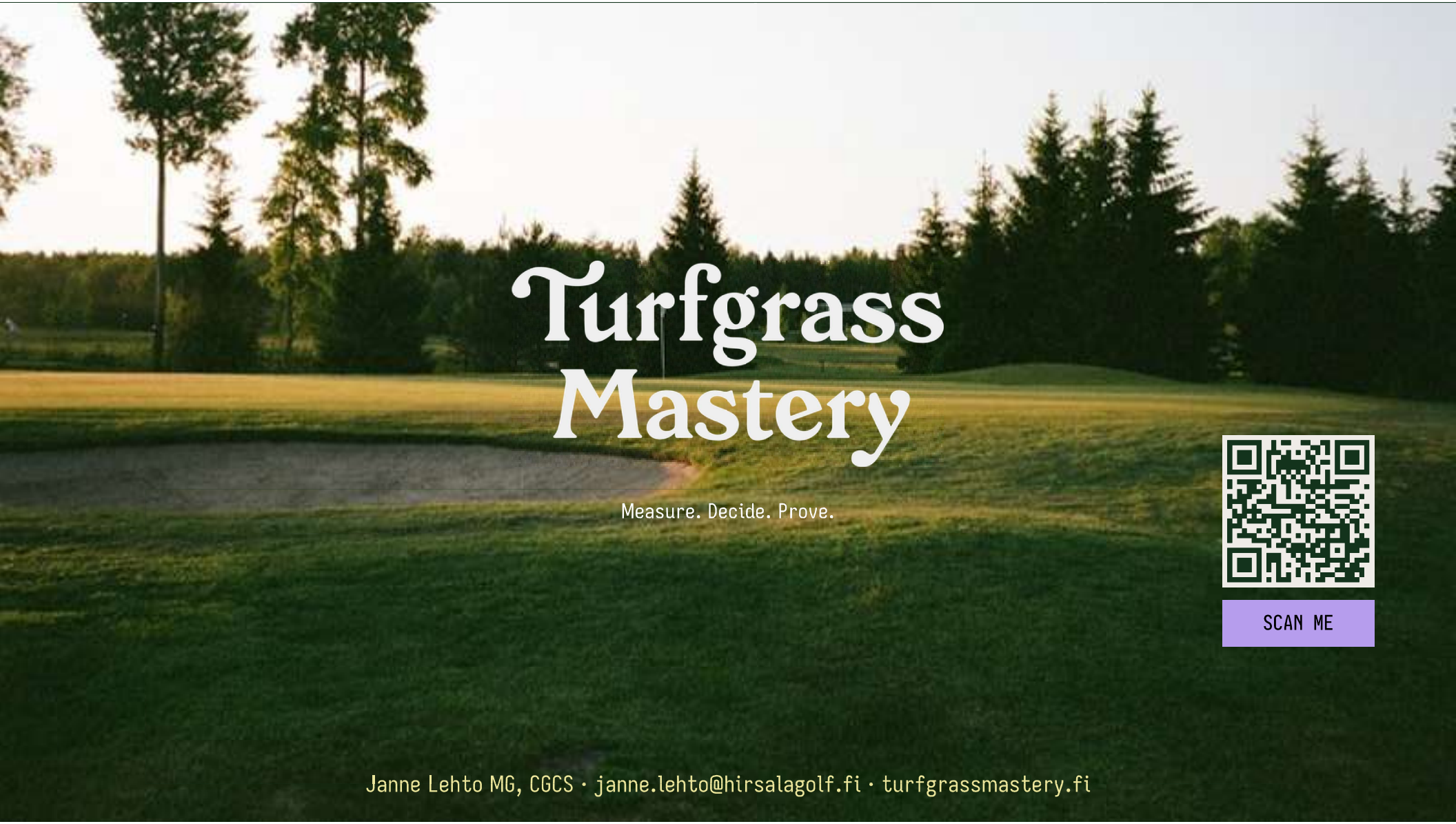
1

Valid data starts with placement: know why each sensor is where it is.

2

Every reading should lead to a decision – or to a better question.

3



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Questions? Mange tak!