The Turfgrass Genki Level

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I've been thinking about turfgrass growth and the relative degree to which the turf manager is pushing the grass to grow with fertilizer, or is trying to slow the growth from what it could be by withholding fertilizer, for a number of years. In a series of posts from February 2019, all published at www.asianturfgrass.com, I explained how the genki level concept works and its practical applications. This document puts those posts together in pamphlet form.

From temperature to standard N

This is one I've been thinking about for a long time, and have discussed with many turf managers, but I don't think I've explained it on the blog yet. So here goes.[1] This is what I call the turfgrass Genki Level.

[1] This section was published as part 1 of the series at `https://www.asianturfgrass.com/2019-02-03-the-turfgrass-genki-level-part1/`

Background, or why I think this is useful

Sometimes I get questions like this:

> "For someone that would like to begin utilizing Growth Potential with more consistency, what are you general guidelines for Nitrogen applications for Ultradwarf greens? What would those same recommendations be for Bermudagrass grown on Tees/Fairways?
>
> I've seen a reference of .8 lbs N per month when max GP. Is that a good number on greens or is that too high? I know that I can always raise or lower based on what I'm seeing or what golfers are expecting with speeds, but just curious about a starting point."

To answer that question, I want to give some idea about not only the *standard* amount for max GP, but also I want to express what turf managers are doing at any given time. The ratio of what is applied, compared to the *standard* amount, is what I call the Genki Level.

And I often want to discuss the intensity of pushing the grass to grow at a given time, or the intensity of pulling on the reins by restricting N, and to do that, I find it useful to communicate in terms of the genki level.

Here's an excerpt from an email I sent last year, explaining this:

> "About the 'predicted' [or standard] amount, that is somewhat arbitrary. That's what I think is about normal for the way bentgrass is typically managed today. The predicted amount can flip between N supply as fertilizer, and N use by the grass. Basically I tend to think of the predicted amount as what I expect for use, and if the soil will supply that amount, then the amount as fertilizer can be negligible. That's something to do, probably, with why your fairways in August didn't require N.

> Also related to the predicted amount is the relationship or ratio between the N supply and the predicted amount. This seems intuitive to me, but I have a feeling that for most golf course superintendents it would be confusing as hell—at least at first.
>
> The idea is that there is a predicted amount that is pretty normal. The amount you supply, in relation to the predicted amount, is something that I don't think there is a word for. I want to call it 'genki level'—genki being a Japanese word meaning good or healthy or how are you—or GL which could also be growth level for those who prefer a more straightforward description."

Getting started, considering 3 locations

I used the Dark Sky[2] API to get daily temperature data from each day in 2018 from three locations. That is, I took the latitude and longitude of Hazeltine National GC in Chaska, Minnesota (creeping bentgrass); Keya GC in Itoshima, Japan (manilagrass); and Van Tri GC in Hanoi, Vietnam (seashore paspalum); I then obtained the observed weather conditions from those locations.

[2] `https://darksky.net/poweredby/`

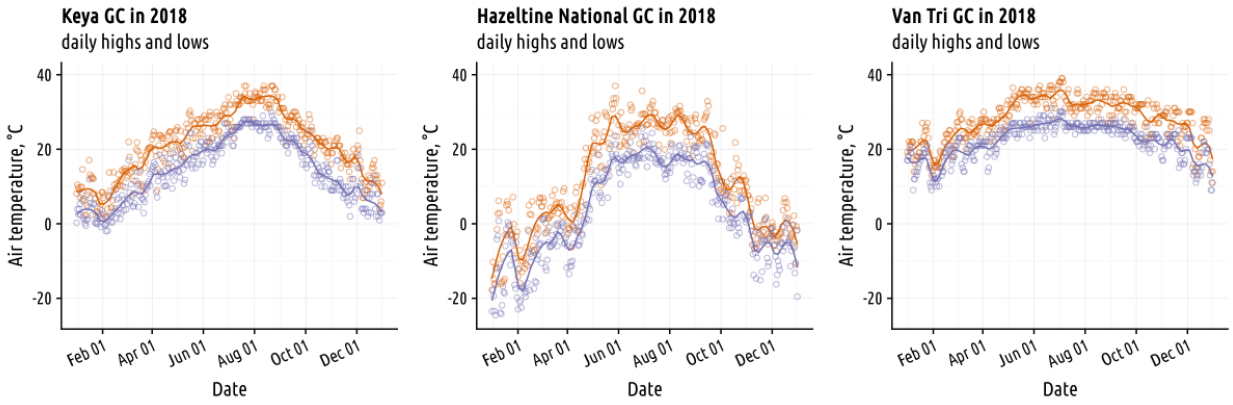

Figure 1: Temperature at three locations in 2018.

Those are the daily high and low temperature data. From those I calculated the daily average temperature, and from that one can calculate the temperature-based turfgrass growth potential (GP) of PACE Turf.[3]

Temperatures are useful. So is the GP, to quickly express on a scale of 0 to 1 the relative distance between the actual temperature and the optimum temperature for shoot growth.

The GP makes it easy to compare locations. And it is also straightforward to make an estimate of growth and N use. By multiplying a maximum amount of N by the GP, one gets an expected N use.[4] Based on the way creeping bentgrass, manilagrass, and seashore paspalum are managed as fine turfgrass today, I like to use a standard maximum of 3 g N m^{-2} $month^{-1}$.

I think it is useful to use the same *standard* N for the calculations, and then to express differences in the way turf is managed as the genki level. That makes it easy to compare the relative amount of pushing the grass, or pulling on the grass, between different

[3] W. Gelernter and L. J. Stowell. Improved overseeding programs: 1. the role of weather. *Golf Course Management*, 73(3):108–113, 2005. URL `http://tic.msu.edu/tgif/flink?recno=102720`

[4] Micah S. Woods. Using temperature to predict turfgrass growth potential (GP) and to estimate turfgrass nitrogen use. Technical report, Asian Turfgrass Center, 2013. URL `http://www.files.asianturfgrass.com/201306_growth_potential.pdf`

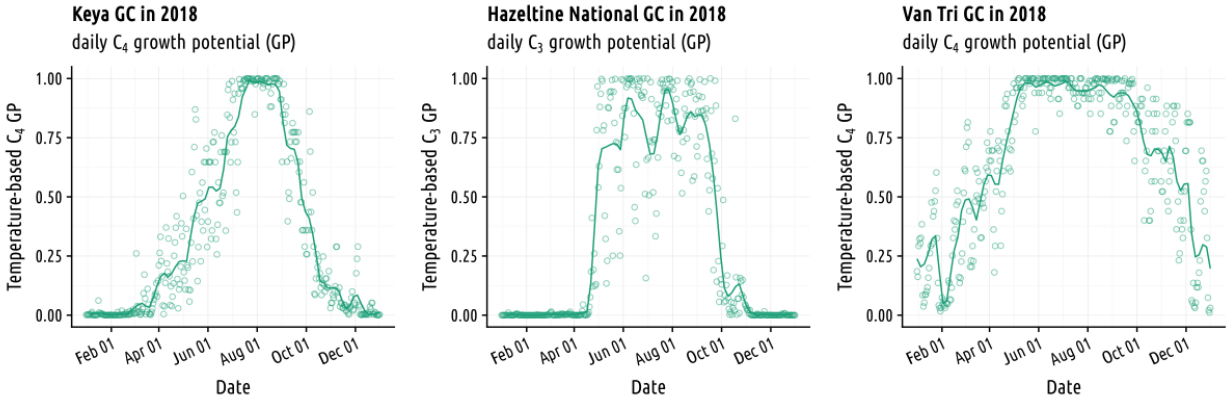

Figure 2: Temperature-based growth potential at three locations.

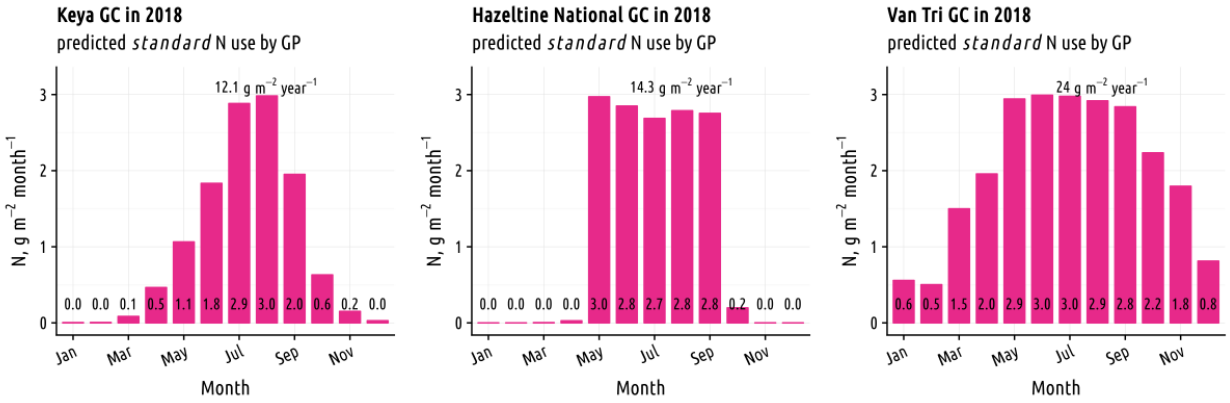

Figure 3: Temperature-based standard N at three locations.

seasons at the same location, or between different locations.

I've shown here how the temperature can be expressed as a GP and how that GP can be expressed as a *standard* amount of N. In the next sections, I'll show the genki level and how much the grass actually did grow. And I'll relate this to the turfgrass speedo[5] explained by Jason Haines.

[5] Jason wrote about the speedo at https://www.turfhacker.com/2018/12/turfgrass-speedo.html

More reading

If you just can't get enough of this stuff, or want more details and examples about these type of calculations, please have a look at:

- Using temperature to predict turfgrass growth potential and to estimate turfgrass nitrogen use, http://www.files.asianturfgrass.com/201306_growth_potential.pdf
- Nutrient requirements of tropical turfgrass, http://www.files.asianturfgrass.com/20130311_woods_handout_nutrient_requirements_tropical_turfgrass.pdf
- What fertilizer should I use?, http://www.files.asianturfgrass.com/20130313_woods_handout_fertilizer_choice.pdf
- Turfgrass speedo, https://www.turfhacker.com/2018/12/turfgrass-speedo.html
- *A Short Grammar of Greenkeeping*, https://leanpub.com/short_grammar_of_greenkeeping

Showing N applied in relation to standard N

I SHOWED HOW ONE CAN GO from temperature to a temperature-based growth potential to a *standard* N amount.

By looking at the actual N applied, and comparing that amount to the standard N for any location, one gets what I call the genki level.[6]

[6] This is a way to make site specific plans, and site to site comparisons, in a standardized way.

If less N is applied than the standard amount, the GL will be less than 1 (Figure 4). If more N is applied than the standard amount, the GL will be more than 1. The GL provides an indication of:

- how much the grass is being pushed to grow
- how much one is withholding N at a time when the grass has a high potential to use N
- how that pushing and withholding varies through the year, or from site to site

Let's look in a little more detail at the GL development at Van Tri GC in Hanoi (Figure 5). Van Tri is wall-to-wall seashore paspalum.

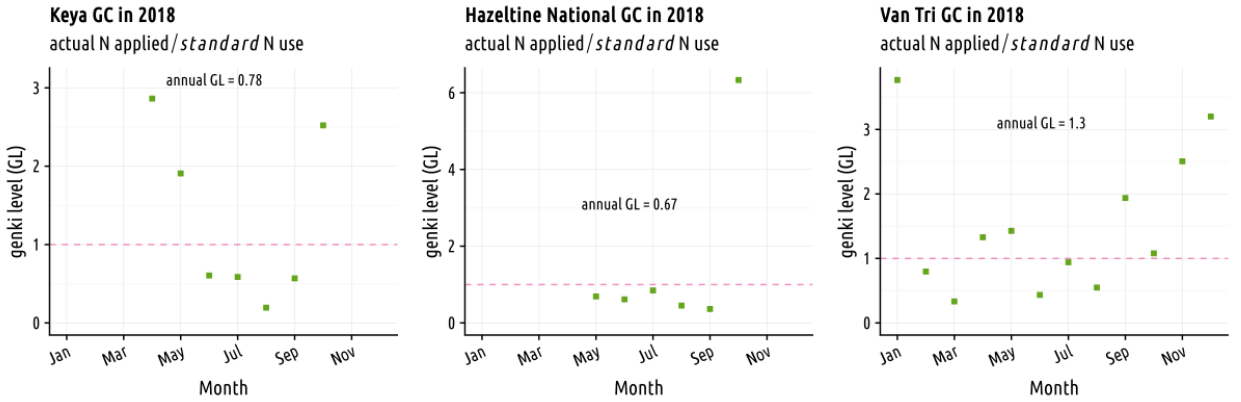

Figure 4: Genki Level in 2018 at three locations.

One can start with the temperatures, then work through to the GL as shown in Figure 6. During the winter months, more N is applied to maintain colour and to try to minimize dollar spot damage.

What about during the summer months? Why is there sometimes a high GL then too, and an annual GL of 1.3? Much of this comes down to management style and grass conditions at the time (Figure 7). And I think there is a relation to grass species too, in this case. Seashore paspalum gets overrun in this climate by *Cynodon* and sometimes even *Zoysia*. In order to minimize problems with those invading species, and to minimize problems with weeds in general, seashore paspalum is often maintained at a relatively rapid growth rate.

Figure 5: Sea Isle 2000 seashore paspalum on the 2nd green at Van Tri GC during December.

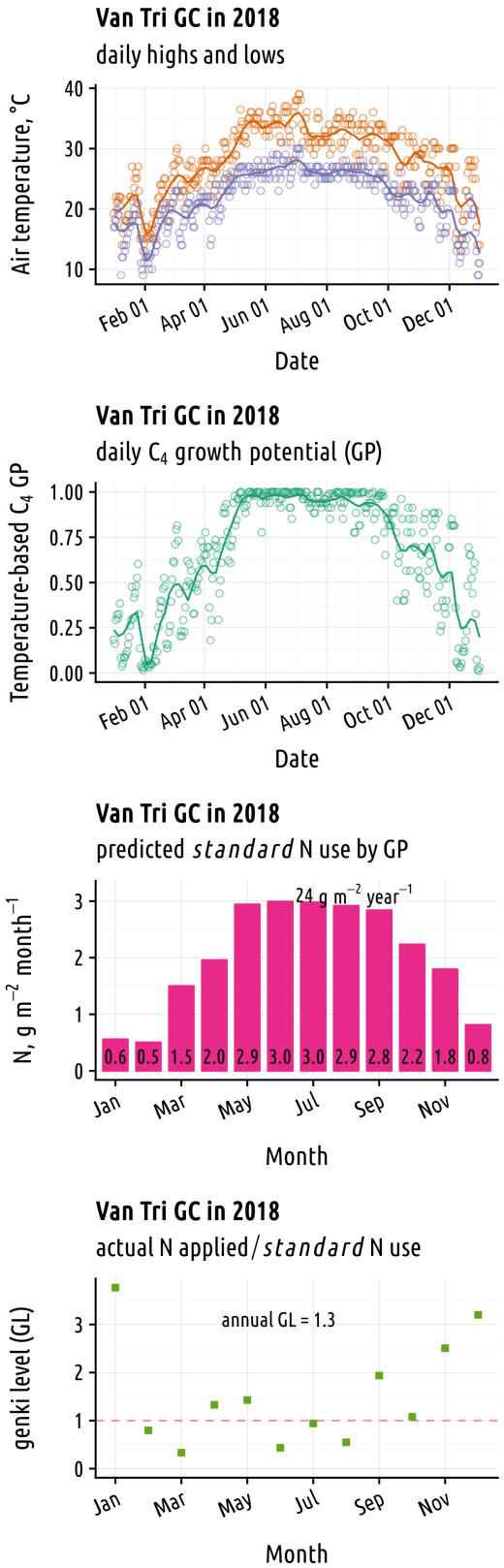

Figure 6: The progression from temperature to genki level for the Van Tri location, by calculating the temperature-based growth potential, from that a *standard* N, and then comparing the actual N to the standard.

Figure 7: Sea Isle 2000 seashore paspalum on the 12th green at Van Tri GC during May.

Turf growth response measured by clippings

I'VE EXPLAINED HOW THE RATIO of N applied to standard N gives an indication of how much one is pushing the grass to grow. I call that the genki level (GL).

How much the grass really does grow can be measured by the clipping volume[7]. With the GL as shown in Figure 4 in 2018, and the temperatures and GP as shown in Figures 1 and 2, Figure 8 shows the clipping volume at these locations in 2018.

[7] See my book, *One Bucket at a Time*, for more details of clipping volume. You'll find the book at `https://www.asianturfgrass.com/buckets/`

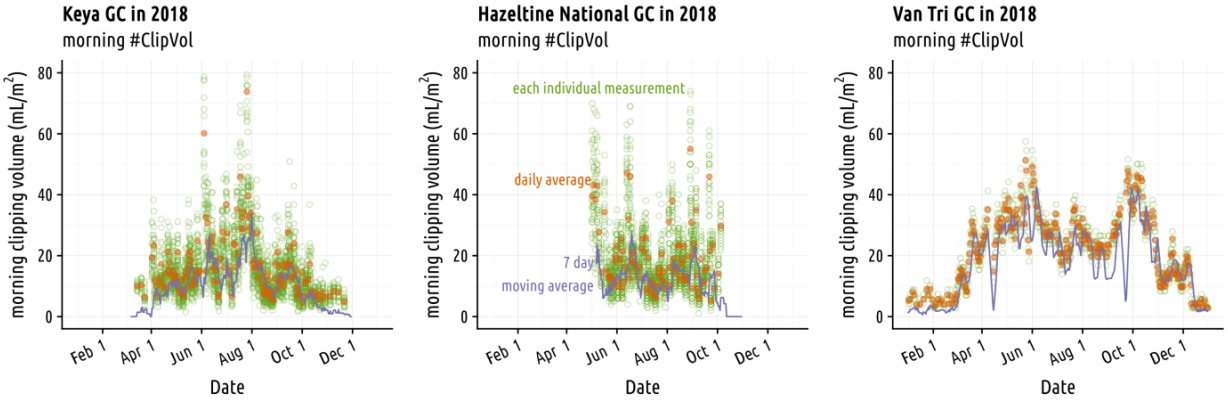

Figure 8: Clipping volume at three locations in 2018.

By looking at the GL and at the clipping volume, one can see how much one was pushing the grass to grow at any time, and then can see how the grass responded.

Jason Haines has suggested another way of looking at this. He calls this the turfgrass speedo and it is the actual clipping volume divided by the maximum clipping volume that one would ever want to see, with that maximum multiplied by the growth potential.

I took the clipping volume data from these three locations in 2018 and calculated a turfgrass speedo (Figure 9) for each month in which the greens were mown. For Keya I used a monthly maximum of 600 mL/m², for Hazeltine I used 500, and at Van Tri I used 2,000.

The speedo is of course quite sensitive to the value that one has set as the maximum for that location. I expect that the ideal maximum for any location will vary depending on traffic, grass type, turf conditions at the time, desired playability, and so on.

A normalized comparison of N fertilizer to growth rate

THE AMOUNT OF NITROGEN (N) SUPPLIED over a certain time duration, compared to a standard amount, is what I call the genki

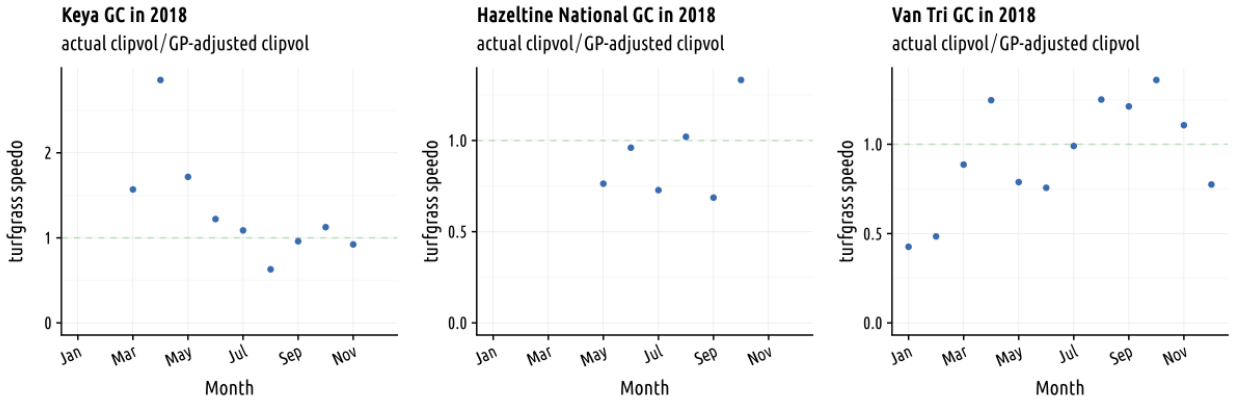

Figure 9: Turfgrass speedo at three locations in 2018.

level (GL). And the amount of clippings harvested over a certain time duration, compared to a standard amount, is what Jason Haines calls the turfgrass speedo.

In this discussion, I've been working with monthly time durations.

What if one compares the genki level to the turfgrass speedo on a scatterplot? The result is an interesting comparison of how much the grass was supplied with N, plotted simultaneously with the actual growth, with both adjusted for the season of the year. That's what I mean by a normalized comparison.

Let's look at this for korai (*Zoysia matrella*) putting greens at Keya GC in Fukuoka, Japan. In the winter, this warm-season grass isn't growing (Figure 10), and the clipping volume during January 2018 was 0, because the greens weren't mown.

Figure 10: Korai greens at Keya GC don't grow in the winter; the clipping volume is 0.

When the clipping volume is 0, the turfgrass speedo is 0. And no N was applied in January 2018, so that gives a GL of 0 too.

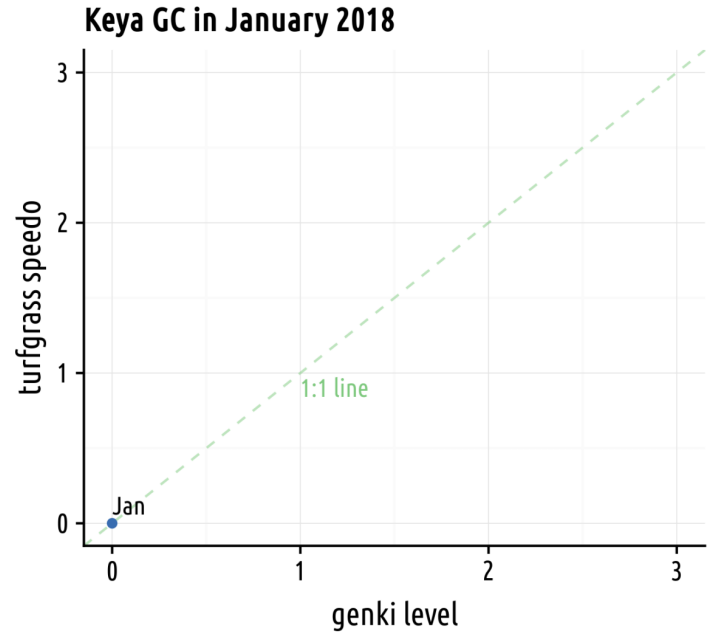

Figure 11: Genki level and turfgrass speedo for a month at Keya GC with no N fertilizer and no growth.

When the GL is the same as the speedo, the point will fall on the 1:1 line, as shown in Figure 11. What if the point would fall to the left of (or above) the 1:1 line? That means that the growth for that time duration is more than would have been expected, given the amount of N supplied. And if the point falls to the right of (or below) the 1:1 line? That means that one is pushing the grass with N fertilizer during that time duration but the growth response isn't happening yet.

Figure 12 shows this for January, August, and October 2018.

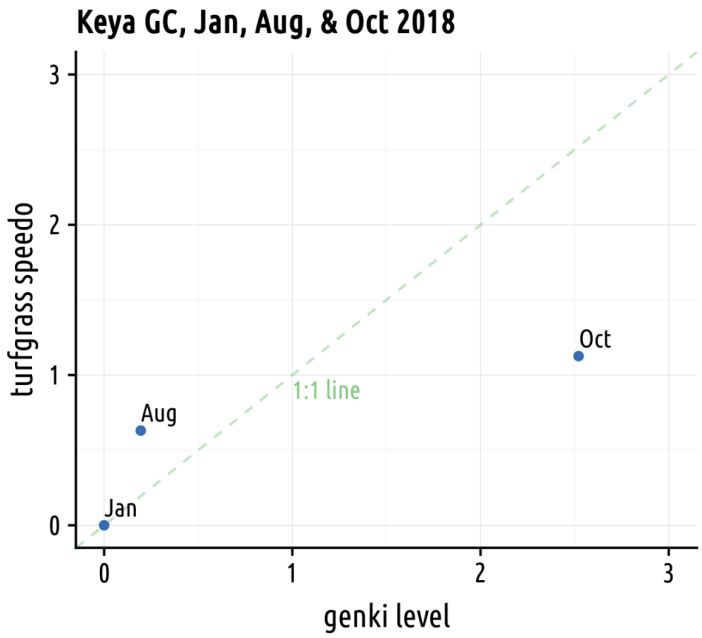

Figure 12: Genki level and turfgrass speedo for three months at Keya GC with varying N supply and varying growth.

In August, the point falls to the left of the 1:1 line, and in October, the point falls to the right of it. What's going on here?

During August (Figure 13), the temperatures at Keya GC are hot, and there is a lot of N mineralization. In addition to that, warm-season grass grows a lot when the temperatures are hot. So the speedo is more than the GL.

Figure 13: The 18th green at Keya GC in August 2018. The turfgrass speedo was 0.63 during that month even though the GL was 0.19.

But by October, the GL is now more than the speedo. That indicates that the grass is being pushed to grow but isn't responding during that same time duration. The temperatures are getting cool in October; the growth of korai slows dramatically by October in Fukuoka but by supplying N the green color of the turf[8] can be retained into the winter.

In Figure 14, I show all the months in which the greens were mown, and I show also for Hazeltine National GC and for Van Tri GC. I've also normalized this in one more way; I've set the maximum growth for the speedo at 600 mL m^{-2} $month^{-1}$ for all the locations.

I find this to be a useful way to think of, and to visualize, the turfgrass response to the N supplied. I also find this especially useful in comparing how grass is managed at different locations, and

[8] Keya GC greenkeeper Andrew McDaniel shared photos of the color in October in this tweet, `https://twitter.com/drumcturf/status/790395640932995073`, writing "These Korai greens are ready to ride out the fall season into winter.

Incidentally, there is an interesting article about Andrew and his work in Japan, orginally published in *Golf Digest Japan*, posted in English at `http://www.files.asianturfgrass.com/andrew_digest_2018.html`

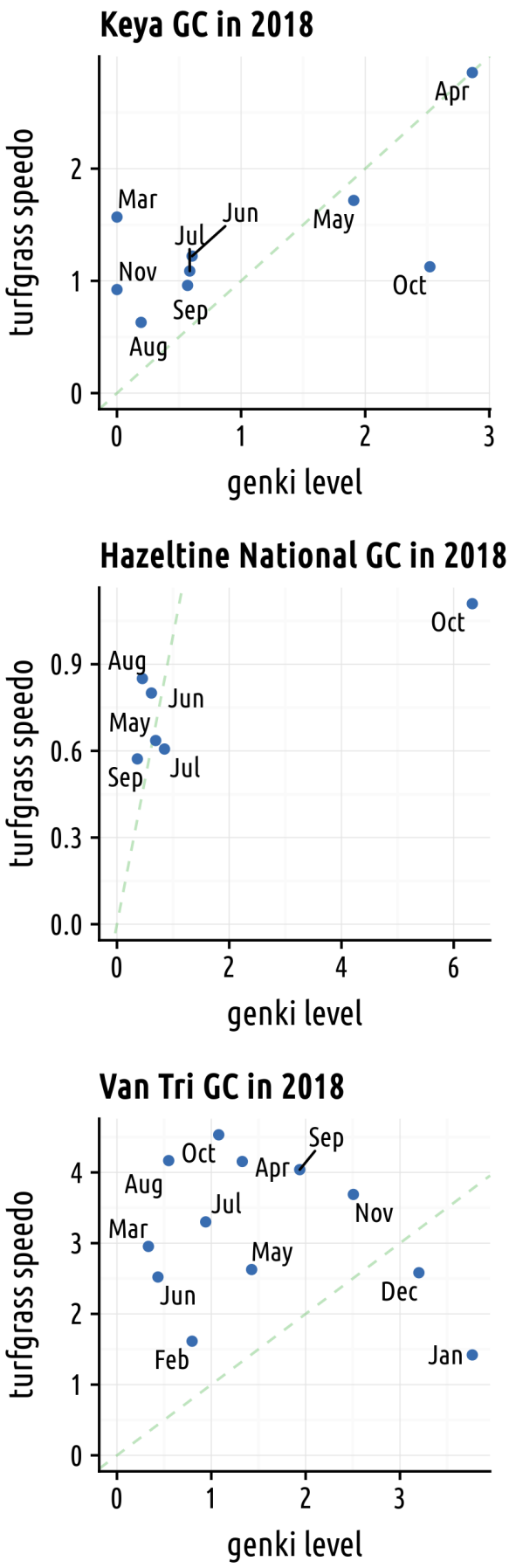

Figure 14: Relationship between turfgrass speedo and genki level for three locations in 2018.

that's another reason I've set the maximum N and the maximum growth at the same value for the speedo and GL calculations.

Is there any take-home message from this?[9] I expect these things:

1. if one is consistently to the left of the 1:1 line, either the soil is supplying plenty of N, or the grass is going to need more N sometime in the future
2. if one is consistently to the right of the 1:1 line, you can probably cut back on the N applications
3. if the speedo is almost always more than 1, I'd think about reducing N even further, restricting water supply, or increasing growth regulators
4. if the speedo is almost always less than 1, I'd think about growing the grass a little more at some times of the year by doing the opposite of the items listed in point 3

[9] I'm generalizing in this list, with the take-home messages being those that may apply to facilities with usual traffic and consequently standard growth rates. The point of all this is that these numbers can be useful as a way to fine tune the growth at one's facility, and as a way to compare the conditions one has produced, and how those conditions were produced, with other facilities. And because the GL and the speedo are normalized by temperature, I could compare Bangkok to Boston, or Sydney to San Francisco, without much trouble.

What's real, what's not, & the simplicity of this

In this pamphlet, I've showed how one can start with temperatures and go all the way to a standardized comparison of growth in response to nitrogen supply. In this one, I want to emphasize which of these are real, which aren't real but are useful, and to make an argument that this is a lot easier than it might seem.

We've looked at temperatures and standard N amounts given those temperatures. From that, we can look at the actual N, and relating that to the standard N we get the genki level. Then we looked at the grass response to the temperatures, and to the GL, by studying the clipping volume. And in the previous section the nitrogen fertilizer and the clippings were compared, both adjusted for temperature.

What is real

The only real things in all of this are:

- the temperatures
- the nitrogen applications
- the grass clippings

Not real, but useful

The things that aren't real, but are calculated values that I find useful are:

- the temperature based growth potential (GP)
- the standard N based on GP

- the actual N compared to standard N, or genki level (GL)
- the standard GP-based clipping amount
- the actual clippings compared to standard clippings—the speedo
- the ratio of GL to speedo

How are these useful?

First, for any location, these calculations provide an easy way to optimize conditions. This happens by considering and then adjusting the growth rate of the grass to produce the desired conditions. Looking backward, evaluating the present, and planning ahead, these calculated values are easy to use as a way to make improvements. Or, if the grass is already perfect, to keep it that way when temperatures are different.

Second, for any location, these calculations provide an easy way to integrate (or get started with) new maintenance strategies that have been learned from other turf managers.

I've written more about this in the *Short Grammar of Greenkeeping*.[10]

[10] You can get a copy of this book at `https://leanpub.com/short_grammar_of_greenkeeping`.

The simplicity of this

It might seem complicated, but one has this information already. All the charts and calculated values happen instantly in the background; all this can be done automatically by a computer.

Every turf manager has the temperatures and forecast temperatures. Every professional turf manager knows the N that has been applied. That's all one needs to use the GL. The calculations are all made by the computer.

To look at the growth and use the speedo, one needs some measurement of growth. And that's pretty easy to get. I've written about that in *One Bucket at a Time*.[11]

[11] This book about clipping volume is available at `https://www.asianturfgrass.com/buckets/`.

An example from start to finish

I have temperature and N application and clipping volume from Hazeltine National GC, so I'll show how this progresses. One can infer how the information might be useful.

Many turf managers will have data from an onsite weather station or will get temperatures from another local source. I've used Dark Sky[12] to get temperature data (Figure 15) for the latitude and longitude coordinates of Hazeltine National Golf Club in 2018.

[12] https://darksky.net/poweredby/

Those temperatures are something real. I then transform them to something that isn't real, but is useful. That is the temperature-based growth potential (GP) of PACE Turf[13]. The GP is useful in a lot of ways; in Figure 16 it is shown as a visual representation of the growing season for cool-season turf at that location in 2018.

[13] `https://www.paceturf.org/`

I then make a further calculation to show in Figure 17, on a monthly basis, what I call the standard N. That is based on GP and a maximum monthly N for bentgrass of 3 g N m^{-2}.

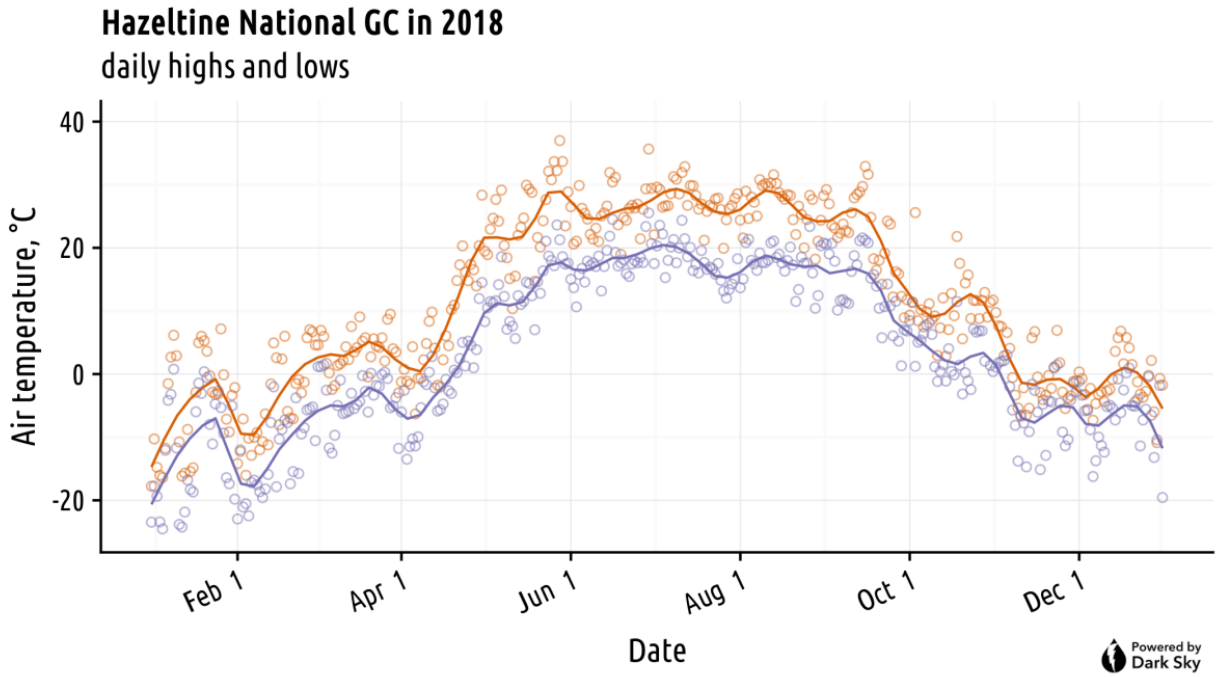

Figure 15: Temperature data for the location of Hazeltine National Golf Club in 2018.

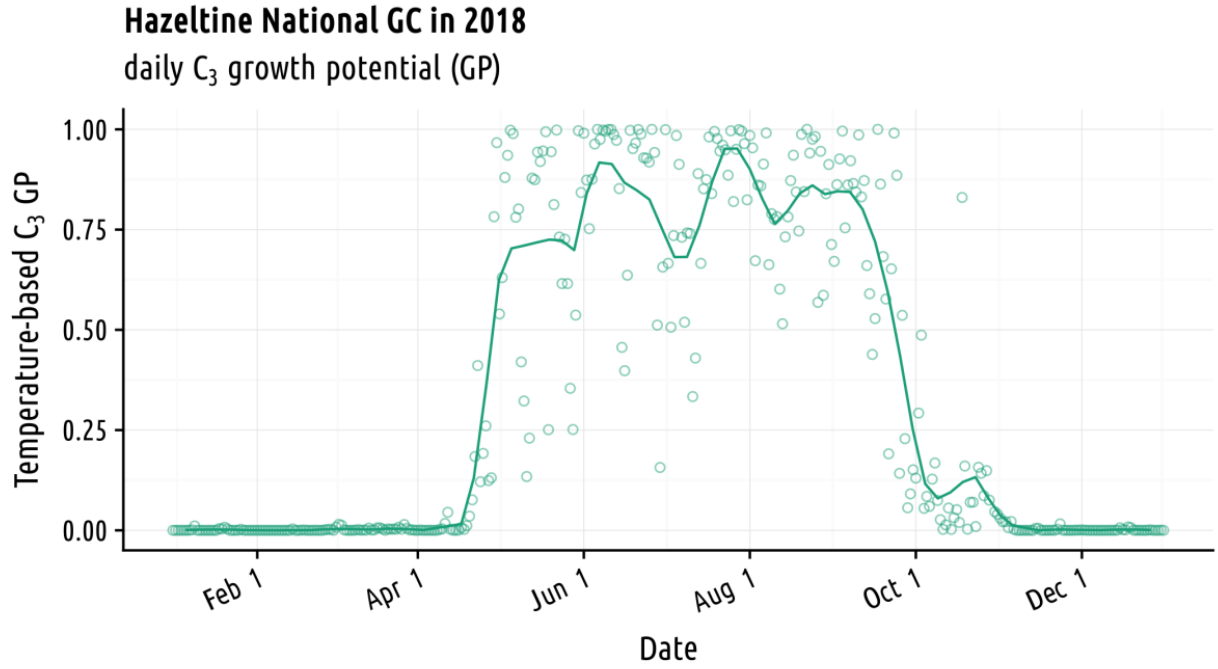

Figure 16: Temperature data for the location of Hazeltine National Golf Club in 2018, converted to temperature-based growth potential.

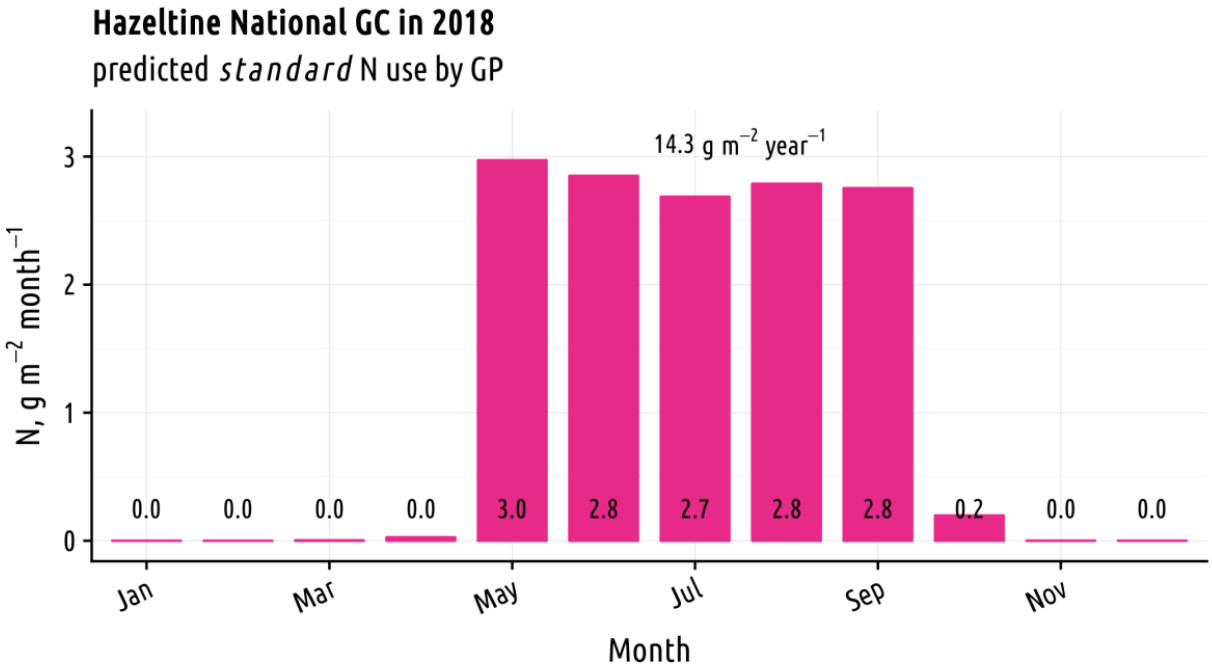

Figure 17: The *standard* N for the location of Hazeltine National Golf Club in 2018, derived from temperature and growth potential.

The nitrogen applied each month is something real; I'm representing it in Figure 18 as the genki level—that is the actual N supplied divided by the standard N.

The genki level corrects for the expected or potential growth that can occur at any location because of temperature. When the grass grows more, it uses more nutrients. When the grass grows less, it uses less nutrients. By using the genki level to look at N applied, one gets an idea of how much the grass was being pushed or starved of fertilizer N at any particular time.

A note here: I made the calculations here monthly. One can set it up to look at these daily, weekly, or on any time interval of convenience.

The grass growth response can be monitored by the clipping volume. Now we are looking at something real again. Temperature is real. The actual N applied is real. And the clipping volume in Figure 19 is real.

I'm going to make another correction to the clipping volume data, however, by converting it to a turfgrass speedo. For Figure 20, I'm using a maximum volume of 600 ml m^{-2} $month^{-1}$, and then calculating the speedo as the actual clipping volume divided by the product of the GP and 600 mL.

What good does that do? Just like the genki level adjusts the N fertilizer to the potential for the grass to grow, so the speedo adjusts the actual growth to the temperature-adjusted expected growth.

Finally, I compare the genki level to the speedo in Figure 21. These are two real things—the N applied and the clippings collected—adjusted by another real thing, the temperature at that location.

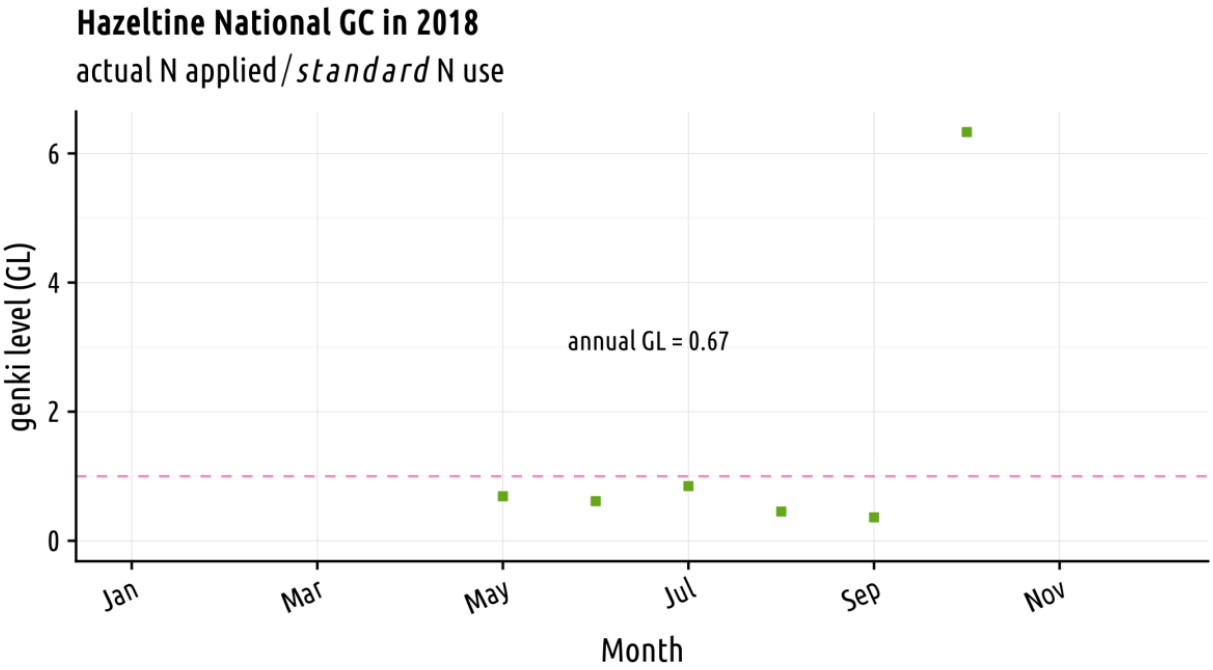

Figure 18: Genki level for Hazeltine National Golf Club in 2018.

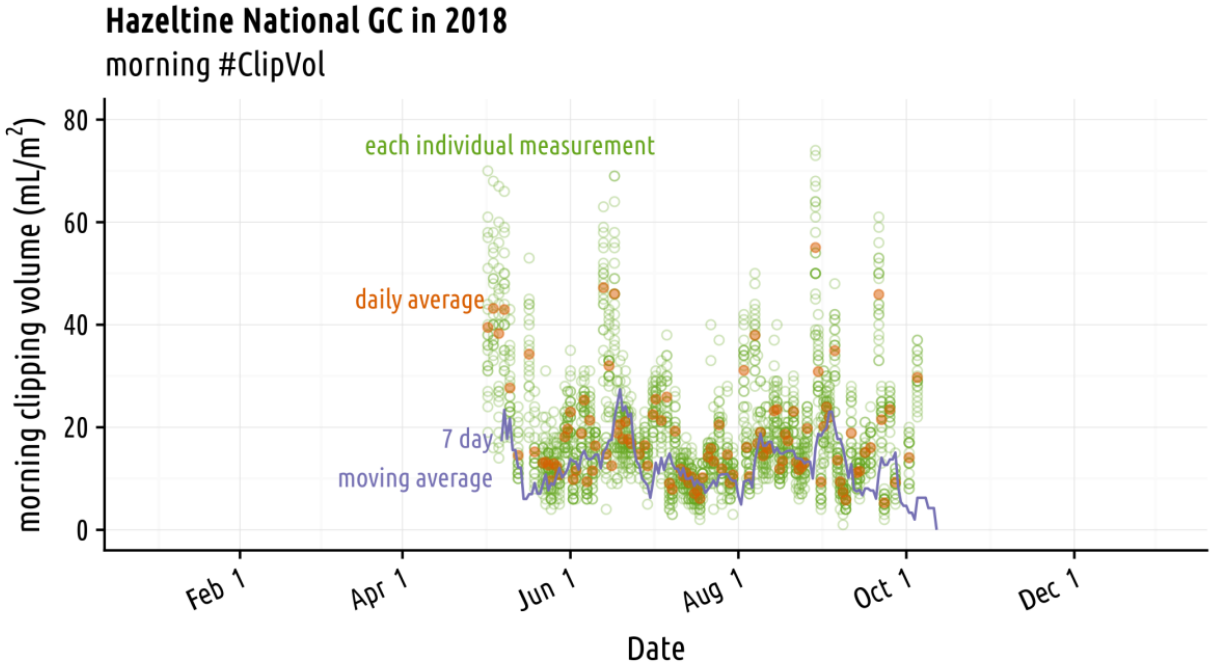

Figure 19: Clipping volume from putting greens at Hazeltine National Golf Club in 2018.

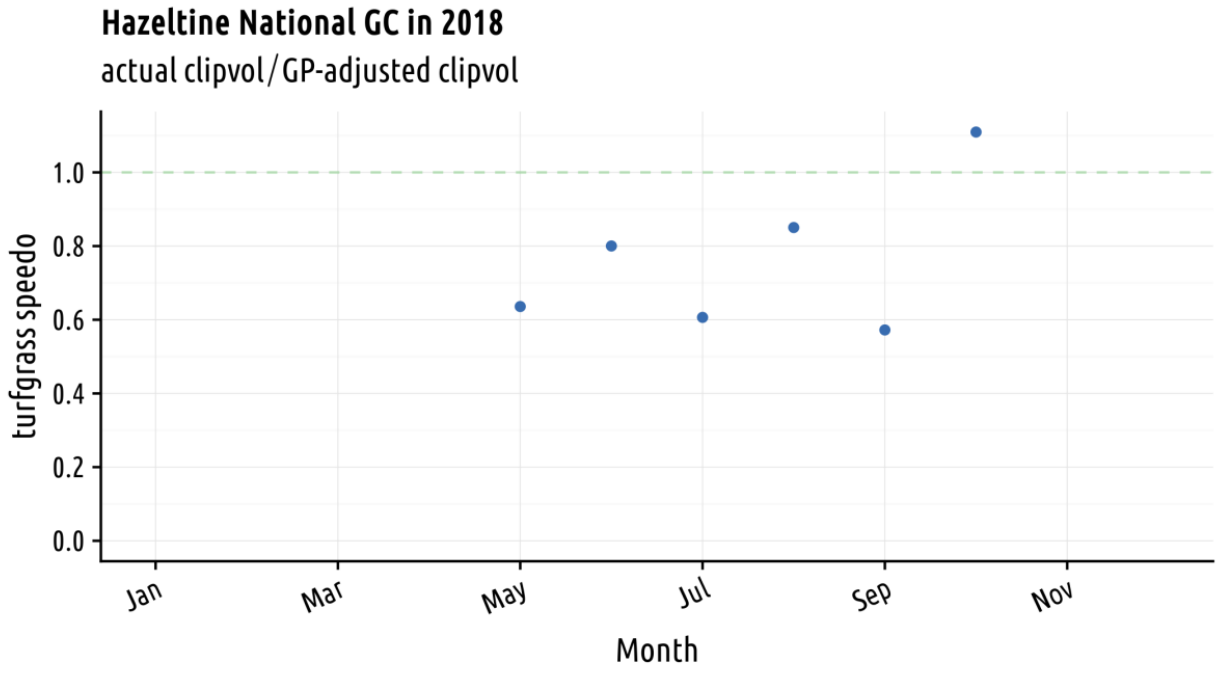

Figure 20: Turfgrass speedo at Hazeltine National Golf Club in 2018.

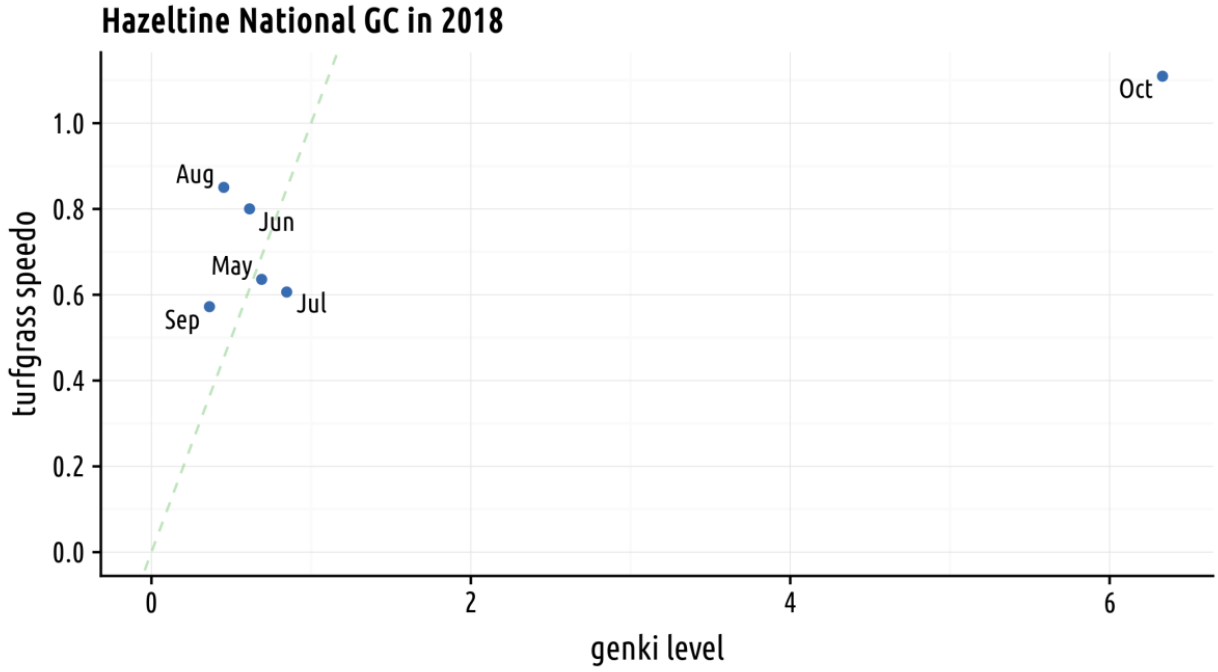

Figure 21: The turfgrass speedo compared to the genki level at Hazeltine National Golf Club in 2018.

Turfgrass perfect and want to do exactly the same as last year? Then do the same, adjusting for this year's forecast temperatures. See some areas that can be improved? Consider how adjusting the growth and the timing of the growth might move the turf closer to the desired conditions. Talked with a friend from a neighboring state or from another part of the world, and learned how their management is producing great results at a certain growth rate or timing or fertilizer rate? Easily apply the same processes at your facility, adjusted for the growing conditions at your site.

And if you have read all the way to the end of this, don't like numbers, and are happy managing by feel, then thank you for reading. That's a fine way to manage turf too.