Comprehensive guide to winter turf damage and recovery in the Northern United States
March 10, 2014

Warming temperatures should start greening up turf areas in the next few weeks, so we should start seeing the full impact of the harsh winter on the turf in the northern Great Plains and throughout the country. Following is a summary of how we got to this point and what to do for recovery.

In the northern Great Plains, the two most common forms of winterkill both involve crown water content.

- Desiccation: The open, dry, and sunny conditions, coupled with record heat and cold this winter has caused widespread desiccation injury to turf around the central Great Plains region. The vast majority of exposed above ground tissue (e.g. leaves) has dried down to a level that caused the leaf cells to dye. Almost all green-up in spring will need to come in the form of new leaf emergence in the crown. While low turf crown moisture content is important for winter hardiness, water content too low can be lethal and actually reduce cold temperature tolerance (Figure 1). Factors such as winter traffic will likely exaggerated the damage during warm breaks in January and February.

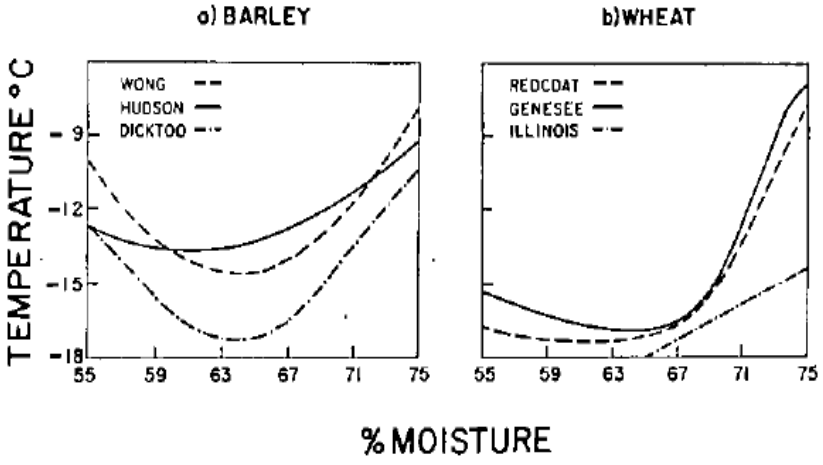

Figure 1. Survival of barley or wheat as impacted by crown moisture over the winter. Maximum cold hardiness occurs when crown moisture approaches 60 to 65% in cereals. It declines as crown moisture decreases (desiccation) or increases (hydration) (From Metcalf et al., 1970).

- Crown hydration: Death from crown hydration is the opposite of lethal desiccation. As turfgrass plants break dormancy, water content in the crowns begins to increase. More specifically, the water content between the plant cells (apoplast) increases as proteins and sugars that prevent water from freezing begin to dissipate. This process occurs before there are any visible signs of green-up, and it is accelerated by warm temperatures (Figure 2) and high soil water content. Turf species that quickly respond to warm spring temperatures, such as annual bluegrass or perennial ryegrass, rehydrate and can be easily damaged if air temperatures fall much below freezing. This scenario is most common in late winter/early spring and in low areas where water can collect. This could also happen with extended mid-winter warm periods like we experienced in the Great Plains this winter.

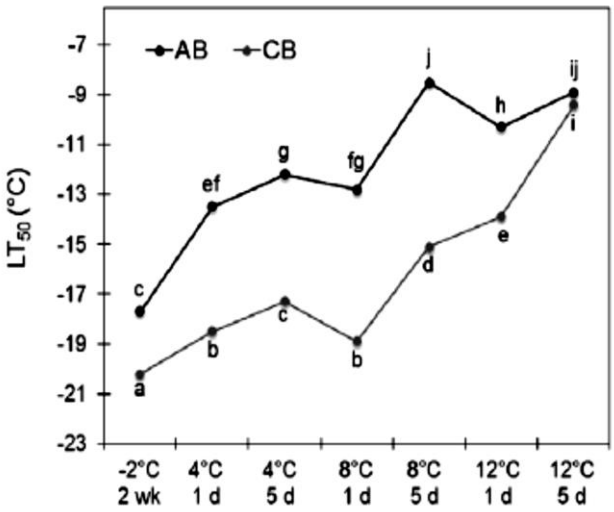

Figure 2. Annual bluegrass (AB) rapidly deacclimates compared to creeping bentgrass (CB) with warmer spring temperatures (From Hoffman et al., 2014.)

- Ice and persistent snow cover will be the primary reasons for winterkill around the Great Lakes and Northeast.
  - Snow Molds: Many northern states have had well over 75 days of continuous snow cover. This increases the risk of gray and even speckled snow mold (*Typhula incarnata* and *T. ishikariensis*). Gray snow mold requires 60 days on continuous snow cover to form and produces large red sclerotia on damaged turf areas. Speckled snow mold requires 90 days of continuous cover and can be distinguished by small black sclerotia. Finally pink snow mold (*Microdochium nivale)* doesn't require snow cover and can be problematic from late fall well into the spring. It thrives under wet conditions when temperatures range 32-45°F and may have a pink ring around affected tissue (Smiley et al., 2005).
  - A series of brief thaw and freezing rain events during January have contributed to a thick layer of ice over many of the turf areas around the Great Lakes region. Much of the ice is clear and dense which limits gas exchange. Turf plants will eventually die from a combination of lack of oxygen and exposure to high concentrations of carbon dioxide (Castonguay et al., 2009). Annual bluegrass or perennial ryegrass or more susceptible to ice encasement injury than species such as creeping bentgrass. Significant injury to annual bluegrass can occur after 45 to 60 days of ice encasement while creeping bentgrass can survive for twice as long under ice.

Areas and grasses most affected:

- Primarily on the high value and lower mowed greens, tees, and fairways, but higher mowed rough height turf as well as sports and lawns may be affected.
- Well-established Kentucky bluegrass or creeping bentgrass should survive fairly well, especially if watered sometime over the winter to help limit desiccation in the Plains.
- Conversely, perennial ryegrass and annual bluegrass are the species most susceptible to desiccation, crown hydration, and/or ice cover.
- Tall fescue can be susceptible to winterkill, but its higher mowing height may protect it slightly more than lower mowed turf. Ice cover is particularly problematic for tall fescue.
- Winter irrigation should have helped reduce desiccation injury, but standing water from overwatering may have led to crown hydration in lower areas.
- Turf on soils that went into the winter dry or dried out during the winter will be most affected by desiccation.
- Turf on windblown and/or west to north facing slopes will be most susceptible to desiccation.
- Turf in lower areas, poorly drained or any areas that accumulated even minute levels of standing water may be affected by ice encasement and crown hydration.
- Turf under ice cover for more than 45-60 days could be damaged on annual bluegrass, perennial ryegrass, and tall fescue.
- Turf seeded last fall will be susceptible to desiccation and/or crown hydration, especially the later seeded turf.
- Turf that was trafficked during the winter will be more susceptible to winterkill.
- Turf that is compromised in some other way will be more susceptible to winterkill. For example, shade, poor drainage, compacted soils, low mowing heights, etc. may decrease winter survival.
- Any combination of the above will increase susceptibility to all forms of winterkill including desiccation and/or crown hydration.

Assessing damage

- Use a hole cutter or drill with a hole saw bit to remove plugs from areas you think have winterkill. Take several samples to account for the variability in the field. Place them in a sunny window, keep them irrigated, and watch for recovery. Detail instructions are available at http://goo.gl/gBt2tc.
- The different turf colors can provide hints of winter injury. However, some of our plugs from the whitest turf at our research center were also the first to green up (Figure 3). Always confirm with samples.
- Sample from suspect and potentially healthy areas to be sure the plugs weren't killed during the transplant.

- Recovery will come from new leaf growth from the crown and not leaf green-up. This is especially true from exposed sites. Please anonymously report your results here http://goo.gl/KZA7i1.
- Later this spring, look closely at the turfgrass crowns to find evidence of new leaf emergence or any signs of life.

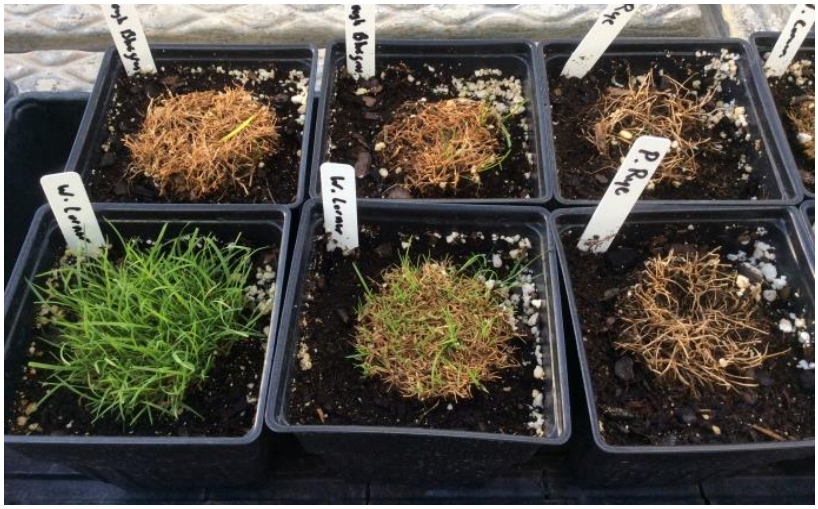

Figure 3. Confirm damage with plugs. Sometimes the worst looking turf in the field is the first to recover inside (lower left). There has been little green-up from the rough bluegrass or perennial ryegrass mowed at ¾" after 18 days.

Recovery

Seeding will be needed immediately as the cool season grasses should start to germinate when surface soil temperatures reach the mid-50F's (Table 1). However, some considerations include:

- Is the damaged area weakened by the environment? Shade, poor drainage, traffic patterns, etc. should be fixed now to limit future problems.
- What was the dominant species that was injured and is this the best for your course?
  - Annual bluegrass is most susceptible to desiccation and crown hydration, minimizing this now might limit future problems. See below for herbicide use in seedlings to minimize annual bluegrass.
  - Perennial ryegrass is also susceptible to desiccation and crown hydration. Though the immediate choice when reseeding would be to choose perennial ryegrass for its fast germination, it may be better off to minimize this grass in damaged areas in favor of Kentucky bluegrass or creeping bentgrass. If creeping bentgrass does not make sense on the area, a 90%:10% or 80%:20% mix of Kentucky bluegrass:perennial ryegrass provides quick cover on fairways but also maximizes establishment of Kentucky bluegrass. More information is available at http://turf.unl.edu/pdfctarticles/Aug_8_reseeding%20fairwayswithpoacontrol.pdf.
- Seeding dates: Seed as soon as possible as cool-season seed will germinate when soil temperatures average in the 50'sF. Seeding as soon as possible after confirmation of damage to maximize the amount of time seedlings have to get established before summer weather. Mid-May is usually the cut-off for spring seeding and later seeding dates increase the chances for having to do it over in August.
- Seeding rates: Seed creeping bentgrass at 1-2 lbs/1000 sq. ft., Kentucky bluegrass at 2-3 lbs/1000 sq. ft., a 90:10 Kentucky bluegrass perennial ryegrass mix at 4-5 lbs/1000 sq. ft. Seeding rates higher than this will speed recovery, but can also result in weak seedlings susceptible to summer stress.
- Soil preparation: Aerifying, power raking, and/or hand raking before seeding. A Graden™ or other similar wide-bladed unit should be used instead of typical greens-type verticutting units to maximize seed-soil contact. Disrupting the top 1/8 to 1/4" is ideal. After seeding, a light raking, dimpling with tires of the sand rake, or a light rolling will push the seed into better contact with soil. Seed blankets could also be used to speed germination as would light topdressing over the seed.

- Starter fertilizer: apply 0.5 lb. N/1000 sq. feet plus 1.0 lb. P2O5/1000 sq. ft. in the seed bed and every 4 to 5 weeks after germination to encourage recovery. Continue frequent and light rates of nitrogen throughout the summer to encourage density but not overly aggressive top growth. Do not over fertilize hoping to speed cover.
- Water lightly and often to keep the seedbed moist. Mulch will also work to conserve water, but use sparingly. Light and frequent irrigation may have to continue well into the summer until new seedlings are mature.
- Avoid any preemergence crabgrass herbicides until the extent of damage has been determined.
- Limit traffic on newly seeded areas (golfers, golf carts, athletes), but mow the areas as soon as a few of the leaf blades reach the projected mowing height. Early and frequent mowing will increase density and spreading in seedlings.

Table 1. Optimum temperatures for seed germination.

Turfgrass Species	Optimum temperatures for seed germination*
Creeping bentgrass	59-86
Annual bluegrass	68-86
Kentucky bluegrass	59-86
Tall fescue	68-86
Perennial ryegrass	68-86
Buffalograss	68-95

*Temperatures separated by a dash indicate an alternation of temperatures. The first number is for approximately 16 hr and the second for approximately 8 hr, which would translate into cooler temperatures in the 16 hours of evening through morning followed by the 8 hours in the heat of the day. *Adapted from Beard's Turfgrass Science and Culture, 1973.*

- Thin turf or bare soils will require aggressive weed control to minimize competition with desired seedlings. Refer to label recommendations limiting use on seedling turf (Table 2). Label recommendations are conservative, always erroring on the side of seedling safety. However, experience dictates that minor damage to seedlings with aggressive herbicide use is easily compensated for by reduced weed competition.
- Crabgrass and broadleaf weed control:
  - Mesotrione (Tenacity™) or siduron (Tupersan™) can be used in the seed bed and will likely provide three to four weeks of PRE control of crabgrass. Mesotrione can be applied POST to Kentucky bluegrass at 28 days after emergence (DAE) to control crabgrass and some broadleaf weeds.
  - Quinclorac (Drive XLR8™, Quinstar™, Quinclorac™, and others) can be applied PRE or 28 DAE of Kentucky bluegrass for POST control of crabgrass and some broadleaf weeds. Omitting the methylated seed oil will enhance seedling safety, but reduce weed control.
  - Carfentrazone (QuickSilver™) can be applied at any time after seeding for POST broadleaf weed control
  - SquareOne™ (quinclorac+carfentrazone) can be applied within 7 days after emergence (DAE) of tall fescue or Kentucky bluegrass for POST control of crabgrass and broadleaf weeds.
  - Dithiopyr (Dimension™, Dithiopyr™) can be applied once the root system is well established and after at least two mowings for PRE/POST control of crabgrass.
- Goosegrass control: Most of the previously listed herbicides may only provide partial control of goosegrass. Two years of data over multiple states suggests that Speedzone™ will effectively control goosegrass when applied at 3 qts/A to even tillered goosegrass. Multiple applications at two week intervals are required for optimum control, but label statements limit applications to every 4 weeks. Some biotypes may not totally controlled. Speedzone's label recommends applications after the second mowing of seedling turf, but our preliminary data suggests adequate safety on creeping bentgrass or perennial ryegrass seedlings http://turf.unl.edu/ResearchReports/2013SpeedzoneGoosegrassSeedlingSafety.
- Annual bluegrass control: Even though the primary objective should be turf recovery, it makes sense to limit annual bluegrass during this process. Since annual bluegrass is ubiquitous in golf turf, it will start to germinate anywhere there is bare soil this spring and likely out-compete any other species we seed. Allowing the annual bluegrass to germinate will heal the area most rapidly, but also maintains or increases the susceptibility to future damage from winter and summer stresses. Therefore, the most sustainable choice is to limit the annual

bluegrass competition through aggressive herbicide use during seeding. As mentioned earlier, any seedling damage that may occur with herbicide use will likely be quickly compensated for by reduced competition from annual bluegrass.

- Mesotrione (Tenacity™) can be used in the seedbed and/or 28 days after emergence to control annual bluegrass in seedings of Kentucky bluegrass and/or perennial ryegrass. Our data suggest Tenacity is extremely safe over seedlings Kentucky bluegrass and/or perennial ryegrass (Figure 4), but it should not be used on creeping bentgrass.
- Bispyribac (Velocity™) can be applied 30 days after emergence of creeping bentgrass or perennial ryegrass. Our research summarized in 2010 indicates more than adequate safety on creeping bentgrass seedlings (Figure 5).
- Ethofumesate (Prograss™) can be 1-2 weeks after emergence of perennial ryegrass, 3-4 weeks after emergence of creeping bentgrass, or 8 WAE of Kentucky bluegrass (Figure 4).
- Growth regulators that favor the desired species over annual bluegrass should be avoided until the desired turf is mature. Additionally growth regulators that limit seedheads (ethephon [Proxy™]) or (mefluidide [Embark™]) should also be avoided until the desired seedlings are mature.

We will try to provide constant updates and let us know if we can help in any way. Please keep us posted with what you are seeing and also complete our winterkill survey http://goo.gl/KZA7i1

Sources:

1. Beard, J.B. 1973. Turfgrass: Science and Culture. Englewood Cliffs, N.J. Prentice-Hall
2. Castonguay, Y., G. Thibault, P. Rochette, A. Bertrand, S. Rochefort, and J. Dionne. 2009. Physiological responses of annual bluegrass and creeping bentgrass to contrasted levels of O_2 and CO_2 at low temperatures. Crop Sci. 49:671-689.
3. Hoffman, L., M. DaCosta, and J. S. Ebdon. 2014. Examination of cold deacclimation sensitivity of annual bluegrass and creeping bentgrass. Crop Sci. 54:413-420.
4. Metcalf, E.L., C.E. Cress, C.R. Olein, and E.H. Everson. 1970. Relationship between crown moisture content and killing temperature for three wheat and three barley cultivars. Crop Sci 10:362-365
5. Smiley, Richard W. 2005. Compendium of Turfgrass Diseases. 3rd. ed. St. Paul, Minnesota: The American Phytopathological Society.

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Table 2. Application delays over newly-seeded turf of select herbicides for controlling broadleaf weeds, crabgrass/goosegrass, sedges, and/or annual bluegrass in new seedlings. Refer to the label of your specific product and formulation for specifics.

Herbicide	Application delay over seedling turf (DAE=days after emergence)			Notes
	Creeping bentgrass	Kentucky bluegrass	Perennial ryegrass	
PRE herbicides applied in seedbed				
Mesotrione (Tenacity™)	Do not use	28 DAE	28 DAE	Good control of germinating broadleaf and grassy (including annual bluegrass) and also sedges in a bare soil. Repeat applications will be needed 28 DAE
Siduron (Tupersan™)	After tillered	After tillered	After tillered	Adequate control of warm-season grasses (crabgrass, goosegrass, etc.) Repeat applications will be needed every 3-4 weeks for extended control.
POST herbicides applied over seedlings				
Mesotrione (Tenacity™) or	Do not use	28 DAE	28 DAE	Good control of small broadleaf and grassy (including annual bluegrass.
Quinclorac (DRIVE XLR8™, Quinstar™, Quinclorac™, others)	28 DAE	28 DAE	28 DAE	Good control of broadleaf and warm-season annual weeds like crabgrass, foxtail, etc.
Carfentrazone (QuickSilver™)	No delay	No delay	No delay	Provides excellent burndown of broadleaf weeds. Contact herbicide so multiple applications will be needed to extend control
Quinclorac+carfentrazone (SquareOne™)	7 DAE	7 DAE	7 DAE	Good control of broadleaf weeds and annual grasses
Dithiopyr (Dimension™, Dithiopyr™	Roots well-established and after 2 mowings	Roots well-established and after 2 mowings	Roots well-established and after 2 mowings	Good control warm-season grasses (crab or goosegrass).
Bispyribac (Velocity™)	30 DAE	NO	30 DAE	Good control of annual bluegrass
Ethofumesate (Prograss™)	7-14 DAE	56 DAE	21-28 DAE	Good control of annual bluegrass
Carfentrazone + 2,4-D + MCPP + dicamba (Speedzone™)	After 2nd mowing	After 2nd mowing	After 2nd mowing	Good control of most biotypes of goosegrass, multiple applications are needed, preferably at two to three weeks.

Figure 4: Effect of multiple applications of Tenacity or Prograss on various ratios of Kentucky bluegrass:perennial ryegrass[a] rated eight weeks after seeding. Applications began four weeks after seeding and were made every two weeks. No treatment affected turfgrass cover on this rating date (LSD(0.05)=NS) (University of Nebraska, http://turf.unl.edu/pdfctarticles/Sep6overseedingfairways.pdf).

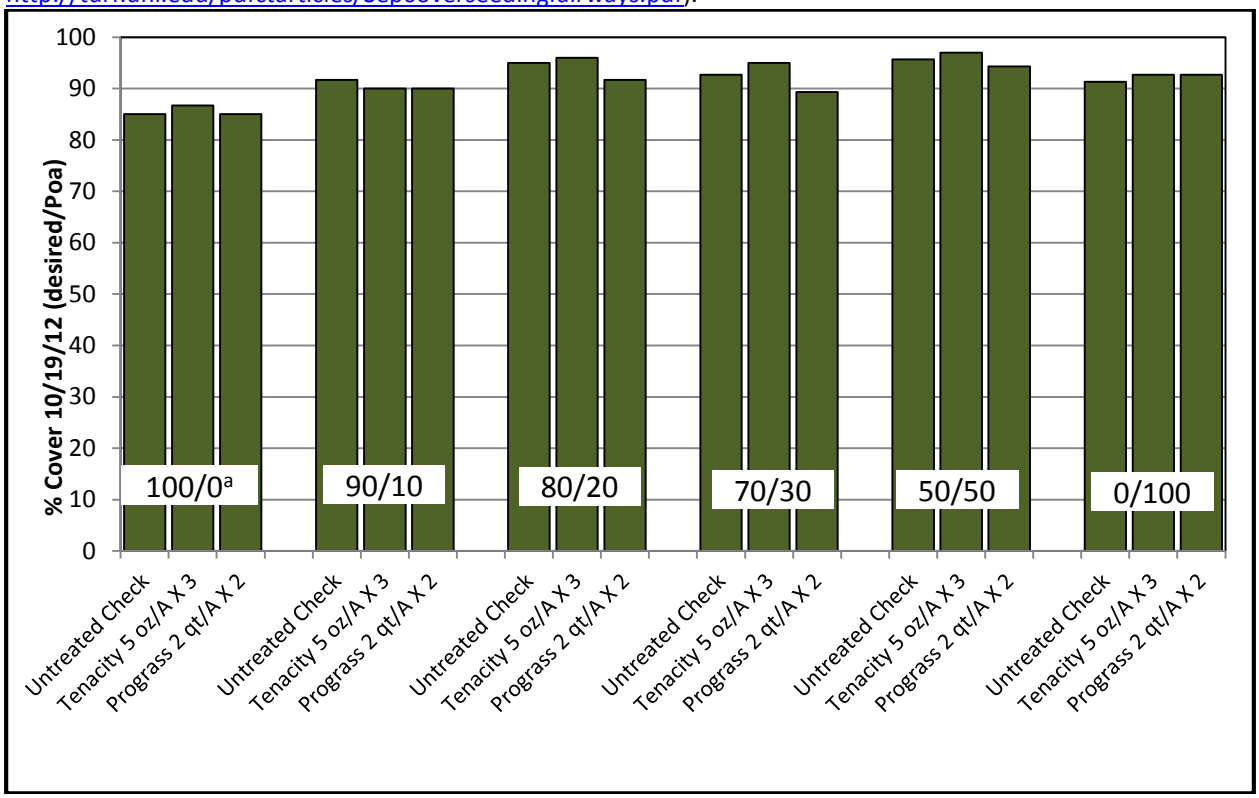

Figure 5. Safety of Velocity 17.6SG when applied over newly-seeded L93 creeping bentgrass from 1 to 4 weeks after emergence. Emergence was defined 50% of the study area was populated with one- to two-leaf creeping bentgrass. Regardless of rate or timing, Velocity had no effect on cover of creeping bentgrass rated at 8 weeks after emergence (WAE) (Adapted from Rutledge et al. 2010).