Pump Up That Seed: *Priming and Pregermination*

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Have you ever worried about getting a new green established for a spring tournament? How about renovation of tees or cart path areas during the post or pre-season? Sometimes a helping hand can speed up Mother Nature although its important to know how and why some systems may be more appropriate than others.

The seed germination time of turfgrasses is based largely on the genetics of each species (Table 1). True, seeds generally germinate faster in the warmer soils of late summer than in cold soils during the spring, while there seems to be relatively little one can do to stimulate germination under a given set of conditions. But golfers don't always wait until a green is agronomically mature before playing on it, and maintaining a decent stand of turfgrass on tees and high traffic areas is a constant battle at many courses.

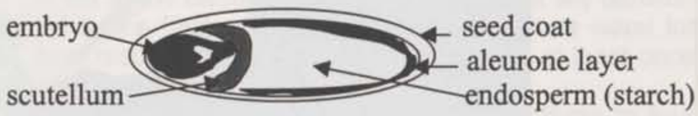
Table 1. Germination requirements of cool season turfgrasses (adapted from Christians, 1998).

Species	Species (Scientific name)	Days to Germinate
Creeping bentgrass	*Agrostis palustris*	6-10
Colonial bentgrass	*Agrostis capillaris*	7-14
Kentucky bluegrass	*Poa pratensis*	6-28
Supina bluegrass	*Poa supina*	unpublished, faster than P. pratensis
Rough bluegrass	*Poa trivialis*	6-21
Perennial ryegrass	*Lolium perenne*	3-10
Tall fescue	*Festuca arundinacea*	4-12
Creeping red fescue	*Festuca rubra*	5-12
Hard fescue	*Festuca longifolia*	5-12
Chewings fescue	*Festuca rubra commutata*	5-12

Seed germination is a risky business

Germination is a tremendous risk for a seed. Once started the process is irreversible. Inside the hard portion of the seed (the caryopsis), a miniature plant exists, complete with the first leaf and the first root (called the radicle) (Fig. 1). The majority of the space inside the grass seed is occupied by a starchy substance known as the endosperm. The endosperm provides energy to initiate growth. Seed germination begins when a seed imbibes (absorbs) water. The water causes the release of hormones from the scutellum (particularly gibberellic acid, or GA). The GA is absorbed by cells in the aleurone layer which then releases enzymes (hydrolases) capable of degrading the starchy endosperm into small sugar molecules. These sugar molecules are absorbed by the scutellum which transfers them to the embryo. The energy in the sugar molecules is used by the embryo to initiate growth — we see this as the emergence of the first root and leaf. At this stage the young plant is said to be heterotrophic, as it relies completely on stored energy rather than making its own energy.

Fig. 1. Diagram of a Grass Seed



Once the first leaf emerges above the soil and begins photosynthesis, the seedling is said to be autotrophic, that is, able to synthesize energy, in this case from sunlight. Animals, including humans, are autotrophic because we must consume other organisms for the energy they contain rather than producing our own energy. Only green plants and a few microorganisms are truly autotrophic.

The seed is truly at risk following imbibition and prior to the development of leaves and roots because once the starch in the endosperm is used up the seedling has no other energy source. This is why seeded areas are prone to failure if subjected to intermittent wet and dry periods. Each time the seed or seedling is moistened, more of the enzymes are released from the seed and more of the starch in the endosperm is degraded. When the seed dries, the seedling stops growing and the enzymes disintegrate. Planting the seed too deep can also result in poor establishment. If the enzymes and/or the endosperm are used up before the developing seedling establishes a leaf system above the soil level and begins photosynthesis, the seedling will die.

The optimal soil temperature range for germination of cool season grasses is between 60°-85°F. When germination is needed fast under suboptimal conditions several alternatives may be tried. These include soil heating, seed pregermination, and seed priming.

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Heat that soil!

Unless you have an in-ground heating system it may seem impossible to heat the soil to aid germination and establishment. If you have ever covered your greens, though, you know how fast the grass under the covers can start growth compared to uncovered grass. The covers help retain solar heat which increases the soil temperature. Sometimes only a few extra degrees can make all the difference. Covers can also be used to promote establishment from early spring seedings. You do need to monitor the conditions under the cover to ensure the environment does not become unfavorable for the grass (too hot, too dry) or promote diseases (e.g., Pythium). Temperature is easily monitored with an inexpensive soil thermometer. If the temperatures or humidity levels become high the covers can be temporarily pulled back to return to favorable conditions. Black plastic covers heat the soil fastest though any plastic, black or clear, can quickly result in high humidity and free moisture levels that favor fungal diseases. If plastic is used, punch holes in it to allow air movement and water penetration. Geotextile blankets may also be used, as well as Typar or Reemay. Be aware that any cover which prevents sunlight from penetrating (especially black plastic) can stop seedling growth following germination unless removed immediately prior to or at time of germination.

High intensity discharge (HID) lamps may be useful to aid soil heating when sunlight is insufficient. Metal halide or high pressure sodium lamps are the most readily available because they are used in the greenhouse industry. Depending on their wiring, either 110 or 208/220 volts may be required. Oakland Hills Country Club used lamps (borrowed from a university) to help germinate a new seeding of creeping bentgrass in preparation for the 1996 U.S. Open.

What's the difference between seed priming and pregermination?

The difference between seed priming and pregermination is basically a matter of time and stage of germination. Pregermination uses seed which has been brought to the point of germination while primed seed has imbibed some water but has not undergone all the steps necessary for germination. You can tell when pregerminated seed is ready because some of the seed has a little white fuzz on it which, on closer inspection, is not mold (hopefully!) but small roots with abundant root hairs. Pregermination can be performed using the following steps:

1. **Place up to 50 – 100 lbs seed in a 55 gallon drum.**† Smaller vessels can also be used.
2. **Fill the drum with sufficient water** to completely cover the seeds. A few seeds (up to several hundred) may float on top, don't worry about these.
3. **Stir the seeds** for a minute or two to expose all seeds equally to the water and oxygen. Leave uncovered at room temperature (60-70 F). §
4. **Replace the water daily** (each 24 hour period). This removes seed germination inhibitors which have been secreted from the seed coat. Don't worry if a little water is left in the barrel during replacement as it will be diluted by the fresh water. Use room temperature water for best results. Don't forget to stir the seeds at least once a day.
5. **Repeat steps 3-4** for at least two days, three to four days at most. Species which have slower germination rates will require more time than species like perennial ryegrass which have rapid germination rates. The water temperature and a few other variables may affect the length of soaking required.
6. **the seed** on a firm surface which will allow excess water to dissipate (e.g., a concrete slab). Let the seed dry slightly, but not completely, to facilitate spreading. If you are not ready to seed immediately, mist the seed as needed to keep it moist. You may keep the seed in this manner for a few days at most. Once you see the white roots beginning to emerge from some of the seed, plant all the seed immediately. Otherwise you are likely to end up with a mass of root-entwined seeds which cannot be spread.
7. **Plant the seed immediately.** Mulch as appropriate. You will need to keep the seed moist. Since the seed is moist during the spreading operation, this step can be challenging since moist seed tends to stick to spreaders. Sometimes the seed can be mixed with solid carriers such as sand, corn cob particles, or organic fertilizers. The best method is to use a hydraulic seeder. If a hydraulic seeder is used, set the agitation at or slightly below normal. Do not set the agitation so high that any emerging roots are sheared from the seeds as these will not regrow very well, if at all.

† To facilitate emptying water from the drum, cut the bottom off the drum before use. Invert the drum and use the top with the spigot on it to drain the water from what

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is now the bottom of the container. Fine mesh screen can be placed inside the drum to prevent the seed from flowing out of the spigot.

§ An aquarium aerator can be used to ensure good oxygen supply. Seeds are living tissues and cannot survive without oxygen for respiration.

Seed priming follows the same basic principle as pregermination but the process stops short of any roots or shoots actually breaking out of the seed coat. Osmoconditioning agents which control the rate of water uptake are generally considered necessary for "true" seed priming (Danneberger et al., 1992). Osmoconditioners include polyethlyene glycol (PEG) or various salts (including table salt). Because the osmotic potential of the solution, temperature, light, and air need to be closely monitored for best results, seed priming is often best left to industry. If you are a do-it-yourselfer, you can try the following steps (Brede, 1989):

1. Prepare a solution of 1 lb salt per 10 gallons water.
2. Spread a layer of seed on a hard surface (concrete or plastic sheet) and thoroughly wet the seeds.
3. Turn the seeds over several times each day.
4. Once each day, drain the seeds and replace with fresh salt solution.
5. Rinse the seeds with fresh water after seven days of treating with the salt solution and allow the seeds to air dry.
6. Plant the seeds using your regular equipment. Alternatively, the seeds can be temporarily stored in a refrigerator (up to three or four weeks).

Some people who have tried this technique suggest the above rather than letting the seeds soak in a solution for several times, probably because it limits the amount of seed which is brought to the "pregermination" or "germination" stage. Some techniques call for soaking the seed in the solution for a few days with an aerator to provide oxygen to the seed.

A number of additives have been evaluated for their effects on seed priming with mixed success. Detzel (1994) found that wetting agents, sulfuric acid seed scarification, and seaweed extracts either had no effect or decreased the percent germination and increased the germination time. Sometimes water soluble fertilizer sources seem to enhance the effects of priming although some may also be toxic (potassium nitrate).

Other techniques have been developed such as solid matrix priming and the drum priming methods. Solid matrix priming uses solids with specific water holding properties to control the amount of water available for seed uptake (e.g., Micro-Cell-E, a calcium silicate compound). Several years ago a British company (Horticultural Research International, Wellesbourne, England) patented the drum priming method in which water availability is controlled by physical means. Seeds are placed in a rotating drum and water is introduced in small amounts from holes in the drum as the drum passes over and through a shallow layer of water (Tryon, 1994).

Both pregermination and priming can allow for quicker establishment than seed from the bag, but results are generally most noticeable during cooler than optimal temperatures. Results are most impressive with slower germinating species (e.g., Kentucky bluegrass) and least noticeable with faster germinating species (e.g., perennial ryegrass).

Primed seed has three advantages over pregerminated seed: 1) Since it hasn't actually germinated, you don't have to worry about breaking off the roots or shoots which have emerged on some seeds, 2) It can be air dried and temporarily stored (usually under refrigeration) before use, and 3) Since the seed surface is dry, the seed is easier to spread uniformly compared to pregerminated seed. Pregerminated seed, however, is more likely to give a faster stand of turfgrass than primed seed since it is further along in the developmental process, although primed seed can still sometimes give faster results than untreated seed. With pregerminated seed it is critical to maintain a moist seedbed to prevent desiccation.

Because seed priming and pregermination can be more of an art than a science, and the seed from either process has only a limited shelf life, many companies have worked to perfect a commercially successful seed priming process. Unfortunately the results have not been as successful as initially anticipated. Several years ago I evaluated one company's novel priming methods which were designed to allow primed seeds to be stored for extended periods (6-12 months) at room temperature. The test used Kentucky bluegrass 'NuBlue'. I compared the company's treatments against seed I primed myself (in ordinary water for four days) and untreated seed. On August 4, 1995, twenty-five seeds from each treatment were planted in a pot containing a pasteurized spaghnum peat:perlite greenhouse mix. Each treatment was replicated four times. The pots were placed in a greenhouse and monitored at two to five day intervals for germination and subsequent growth (height and clipping yields). Air temperature highs ranged from 86-90 F for the first week and from 79-84 F for the duration of the study. Pots were misted three times daily for five minute intervals to maintain moist soil. The germination results are summarized below (Table 2). Although not all treatments are listed, the treatments shown include the entire range of results.

Table 2. Effect of long term shortage on germination of primed Kentucky bluegrass seed.

Treatment	5 days after planting	10 days after planting	17 days after planting
Control (untreated)	25	73	76
Recently primed	46	70	80
Test treatment # 1	18	78	82
Test treatment # 2	14	59	68
Test treatment # 3	29	69	79
LSD (0.05)	15	14	12

The results from my particular study showed seed priming (or soaking, since the water did not contain any osmoticum) followed by one day of drying at room temperature before planting performed better than any other treatments. The effect was temporary, as most of the treatments, included the untreated seed, caught up within 10 days of planting. Of course, the results may have been different if the temperatures were colder than optimum rather than above the optimum, but the results do show that a fair degree of fast establishment can be achieved with minimal effort compared to seed from the bag. If time is not limiting, though, there is probably little need to consider seed priming or pregermination.

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WE'RE GOOD TO GO!

By Monroe S. Miller

There were lots of smiles on the faces of golf players and golf course superintendents in Wisconsin as spring emerged from late winter (if winter is what you want to call December, January and February past). Mostly, conditions were simply delightful.

And why shouldn't they have been? We didn't really have any winter. Lake Mendota in our town froze the latest ever and opened early enough to set a record for fewest days of ice for as long as records have been kept. The biggest snow of the season came in the third week of March, and yet we still were able to open on March 26th. The winter was mild beyond my memory.

February was the warmest February worldwide since record keeping began in 1856. The average air temperature worldwide was 1.35 degrees higher than normal. Cause? No surprise — El Nino. Rainfall in the U.S. was at its third-highest level for February. To date, in our town at least, year-to-date precip is well above normal.

Snow mold pressure was high, probably due to the extra moisture. Some superintendents were out early making additional applications to control disease or doing some spot treating.

I've seen a lot of spring openings in Wisconsin and not one has been this good. It may be a "one year in a hundred" event, where the biggest task will be keeping conditions this good for the rest of the season.

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It's under 60 days until the U.S. Women's Open starts play at Blackwolf Run, the state's best and most famous golf course. This will be the first time ever that Wisconsin has hosted a U.S. Women's Open; can the U.S. Open be far behind? The Open has never been held in Wisconsin either. Our cover and Personality Profile recognize and honor this notable golf event in Wisconsin.

Blackwolf Run and Kohler staff worked hard for a long time to convince the USGA that Wisconsin wasn't some golfing backwater and that we'd support a major sporting event like the Women's Open. Like almost everything else they tackle, they were successful.

Good luck to Mike Lee and his staff. Do yourself a favor and take your family over to Blackwolf Run for a day during the practice rounds or the tourney itself.

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The last issue of *The Grass Roots* had been on the street and in the newsstand for only a few hours before I learned of several more father/son Wisconsin golf course superintendent families. Randy Witt wondered how I could forget the Bahrs. Joe has been in the LaCrosse/West Salem area for most of his life, many years at LaCrosse CC and The Bluffs. His son Jeff is also a western Wisconsin superintendent, and (boy, is this embarrassing)

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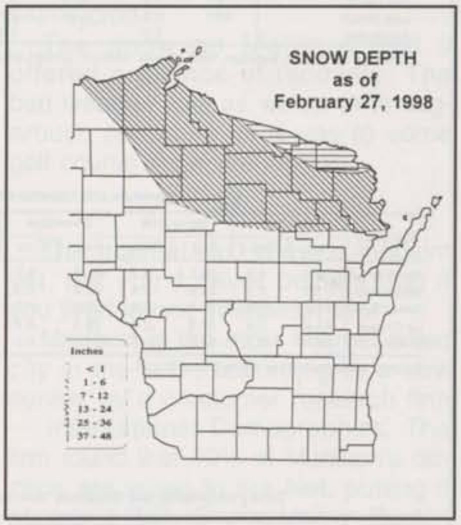

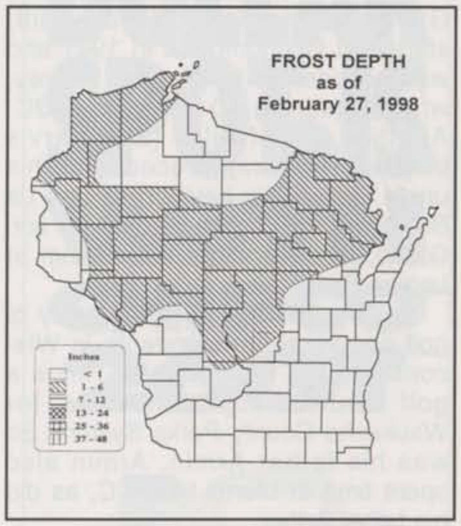

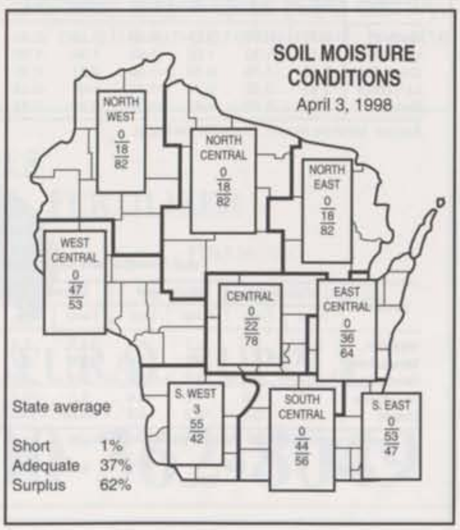

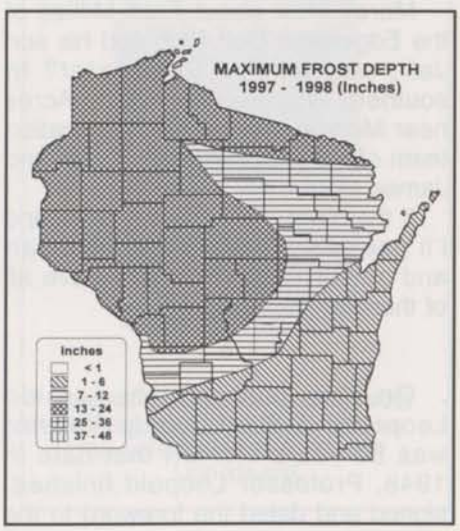

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worked at Blackhawk CC while he was working on his B.S. degree in turfgrass management at the UW-Madison. Joe has another son John who is also a golf course superintendent, at the Prairie du Chien CC.

Then Dave Noltner suggested I look close to home. Since I've lived in Middleton for 21 years, the light bulb lit quickly. Jerry Kessenich was the superintendent at Pleasant View from its very beginning, and his son Joe succeeded him. Jerry is now retired, and a couple of years ago Joe took advantage of an excellent opportunity and switched careers.

John Krutilla called and pointed out he had been the superintendent at Stevens Point CC, Lakelawn Lodge, and Grand Geneva. His son James is now the golf course superintendent at Towne CC in Edgerton. John offered more leads which I followed through on.

There have been three generations of Millers who have managed Oconomowoc GC and Lac La Belle GC for a long time. William (Bill) started at Oconomowoc in 1947 and was succeeded by his son Harvey, who is nearing 40 years at OGC. Another son of Bill's (and Harv's brother) Ken, was preceded by his uncle Gus (Bill's brother) at Lac La Belle. Ken was succeeded by his son Glenn, who remains at the helm at Lac La Belle.

Another three generation family of golf course superintendents in Wisconsin is the Honeyagers. Tim is a golf course superintendent for Waukesha County Parks System. So was his father Armin. Armin also spent time at Merrill Hills CC, as did his father Arthur.

More? How about Fred Millies of the Edgewater Golf Club and his son Jeff, now also at Edgewater? In southern Wisconsin at Windy Acres near Monroe, are the two generation team of Kriegers — James L. Sr. and James M. Jr.

If there are more, let me know and I'll pass the details on to historian and author Clay Loyd, as I have all of these families.

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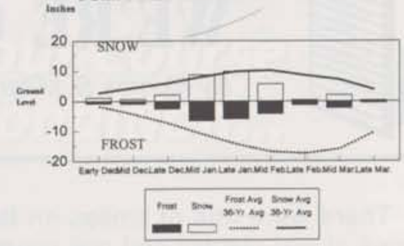
On this past March 4, Aldo Leopold's *A Sand County Almanac* was 50 years old. On that date in 1948, Professor Leopold finished, signed and dated the foreword to the

Wisconsin Average Precipitation
October 1, 1997 - March 31, 1998 1/

District	Total	Normal	Departure from normal	Percent of normal
Northwest	10.34	9.40	0.94	110
North Central	10.22	9.70	0.52	105
Northeast	10.90	10.43	0.47	105
West Central	11.19	9.19	2.00	122
Central	9.65	10.11	-0.46	95
East Central	10.00	10.69	-0.69	94
Southwest	12.28	10.03	2.25	122
South Central	11.48	10.86	0.61	106
Southeast	11.58	11.67	-0.09	99
State	10.74	10.01	0.73	107

1/Preliminary. Source: Matthew Menne, State Climatologist.

1997-98 SNOW & FROST DEPTHS COMPARED TO THE 36-YR AVERAGE



Snow and Frost Depths, Winter 1997-98

Month	Snow Depths					Frost Depths				
	1996-97		1997-98 1/		Normal 2/	1996-97		1997-98 1/		Normal 2/
	Date	Inches	Date	Inches	Inches	Date	Inches	Date	Inches	Inches
Early December	12/1	3.3	12/5	1.1	2.7	12/1	3.2	12/5	0.9	1.8
Mid-December	12/13	3.4	12/19	0.7	4.4	12/13	2.5	12/19	1.0	4.3
Late December	12/27	8.6	1/2	2.1	5.9	12/27	5.0	1/2	2.7	7.3
Mid-January	1/10	8.7	1/16	8.7	8.0	1/10	6.7	1/16	6.7	11.0
Late January	1/24	7.9	1/30	9.9	9.8	1/24	10.5	1/30	6.1	14.4
Mid-February	2/7	12.2	2/13	5.7	10.2	2/7	11.9	2/13	4.3	16.9
Late February	2/21	8.2	2/27	0.4	8.6	2/21	10.4	2/27	1.4	17.5
Mid-March	3/7	5.6	3/13	2.1	7.2	3/7	8.1	3/13	2.4	16.0
Late March	3/21	6.9	3/27	0.3	3.9	3/21	5.5	3/27	0.6	10.4
Averages		7.2		3.4	6.7		7.1		2.9	11.1

1/Survey dates vary between 1995-96 and 1996-97. 2/1961-97 and 1962-98 averages.

Mean Temperature and Departure from Normal, Fahrenheit, Winter 1997-98

Location	October		November		December		January		February		March		Six months	
	Avg.	Dep.	Avg.	Dep.	Avg.	Dep.	Avg.	Dep.	Avg.	Dep.	Avg.	Dep.	Avg.	Dep.
Madison	50.2	1.3	33.3	-2.1	27.9	6.2	23.7	7.7	33.6	12.9	34.2	1.8	33.8	4.6
Milwaukee	51.6	1.3	34.8	-2.9	30.4	6.0	26.9	8.0	34.6	11.6	35.8	2.6	35.7	3.1
Green Bay	47.7	-0.3	31.9	-2.5	27.9	7.7	22.2	7.9	31.2	13.0	33.3	1.6	32.4	4.9
La Crosse	52.9	2.8	32.8	-2.8	28.9	8.6	24.0	9.5	33.7	13.8	35.7	2.9	34.7	6.0
Duluth	43.9	0.2	24.9	-3.5	22.7	9.9	16.4	9.4	28.9	16.6	25.5	1.1	27.1	5.7

Source: Matthew Menne, State Climatologist.

Total Precipitation and Departure from Normal, Water Equivalent Inches, Winter 1997-98

Location	October		November		December		January		February		March		Six months	
	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.
Madison	1.31	-0.86	1.20	-0.89	1.25	-0.59	2.24	1.17	1.44	0.36	5.46	3.29	12.90	2.48
Milwaukee	1.11	-1.30	1.02	-1.40	1.30	-1.03	3.60	2.00	2.19	0.74	3.18	0.51	12.40	-0.48
Green Bay	0.93	-1.30	0.30	-1.86	0.61	-0.92	2.21	1.06	0.80	-0.23	3.66	1.61	8.51	-1.64
La Crosse	2.42	0.22	0.24	-1.49	0.64	-0.63	1.75	0.82	2.71	1.81	2.52	0.56	10.28	1.29
Duluth	2.29	-0.20	0.43	-1.37	0.41	-0.81	1.72	0.50	2.72	1.92	2.18	0.27	9.75	0.31

Source: Matthew Menne, State Climatologist.

Total Snowfall and Departure from Normal, Inches, Winter 1997-98

Location	October		November		December		January		February		March		Six months	
	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.	Total	Dep.
Madison	3.9	3.7	3	-0.4	14.3	1.8	18.9	7.2	1.8	-6.2	12	2.8	53.9	8.9
Milwaukee	T	-0.4	1.1	1.6	10.6	-0.8	23.7	10.8	0.5	-10.7	3.7	-5.1	39.6	-4.6
Green Bay	0.2	0.0	0.7	-3.9	6.2	-6.3	24.2	12.5	1.2	-6.8	11.5	2.3	44.0	-2.2
La Crosse	T	0.0	1.8	-9.6	6.0	-10.1	16.2	-1.0	3.8	-6.5	10.4	-3.7	38.2	-30.9
Duluth	1.2	-0.1	16.9	5.5	6.0	-10.6	29.9	12.7	9.6	-0.7	14.2	0.1	77.8	6.9

T=Trace. Source: Matthew Menne, State Climatologist.

Almanac. The book brought him world fame, respect and acclaim; sadly, he died not long after that while helping fight a forest fire on the farm of a neighbor near his shack north of Baraboo.

Leopold wrote the Almanac in Madison, most of it in his office on the UW-Madison campus. He was chairman of the Game Management Department in the College of Agriculture. The building that housed that department has long since been demolished.

On this past March 4, the anniversary was celebrated in the Wisconsin State Capitol building. His daughter, Nina Leopold Bradley, was among those who participated in a public reading of Leopold's words.

The final words written by Professor Leopold are these:

"That land is a community is the basic concept of ecology, but that land is to be loved and respected is an extension of ethics. That land yields a cultural harvest is a fact long known, but latterly often forgotten...

"Such a view of land and people is, of course, subject to the blurs and distortions of personal experience and personal bias. But wherever truth may lie, this much is crystal clear: our bigger-and-better society is now like a hypochondriac, so obsessed with its own economic health as to have lost the capacity to remain healthy. The whole world is so greedy for more bathtubs that it has lost the stability necessary to build them, or even to turn off the tap. Nothing could be more salutary at this stage than a little healthy contempt for a plethora of material blessings.

"Perhaps such a shift of values can be achieved by reappraising things unnatural, tame, and confined in terms of things natural, wild, and free."

His words are ones we all need to contemplate from time to time.

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The early on again/off again spring had great effects on anyone growing plants and crops outdoors, from golf courses to gardens. That includes those who harvest sap from Wisconsin's maple woods.

There was little sap flowing when the season started, due simply to the balmy temperatures, compliments of El Nino. The fear was the delay would be such that the sap would flow when the trees were budding, a process that changes the flavor of the syrup; such a product is called "buddy" syrup.

This comes in a season following a small harvest in 1996. Producers expected good prices this year since ice storms ravaged the heavy production areas of New England, New York and Quebec. Wisconsin ranks fifth in syrup volume based on last year's crop.

The snow on March 8 and 9 offered a chance of recovery. The bad weather was as welcome to sugarbush operators as it was to some golf course superintendents!

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The Internet isn't a mass medium yet, but you'd never believe that if you lived in one Wisconsin town.

Madison is the most Internet wired city in the U.S., according to a new survey by a consumer research firm — International Demographics. The firm found that 49% of Madison's citizens are wired to the Net, putting it ahead of D.C., Silicon Valley, Boston and other hi tech cities of the country.

I'm still underwhelmed by the medium myself, although it is, on occasion, useful. The Noernet sees some activity and it would be interesting to know what percent of the WGCSA membership routinely uses this new communication technology.

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Another of Wisconsin's naturalists was honored on February 3, 1998, at his home and final resting place in Martinez, California. The United States Postal Service issued a 32-cent stamp that day in honor of John Muir. The official release of the stamp

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