

USGA® GREEN SECTION

Record

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SPACE-Age Technology

A PUBLICATION ON TURFGRASS MANAGEMENT



BY THE UNITED STATES GOLF ASSOCIATION®

*Cover Photo:
The SPACE Program data
determined that a flat application
profile resulted in dry donuts forming
around each sprinkler with this new
million-dollar irrigation system.*



An embarrassing situation can arise if the turf is still plagued with problems after a new irrigation system is installed. See page 1.



The red-headed woodpecker is a primary cavity-nesting species. See page 16.

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All too often, problems with sprinkler coverage come to light when the turf is faced with drought conditions.

Irrigation Design, Rocket Science, and the *SPACE* Program

Selecting sprinklers and determining the spacing is not rocket science. Not when using the SPACE program to model coverage and distribution.

by MIKE HUCK

IT DOESN'T TAKE a rocket scientist to determine that the effectiveness and efficiency of an irrigation system is more greatly influenced by the distribution uniformity of complementing sprinklers than the high-tech computer controlling the system. In this era of space-age technology, countless dollars and hours are spent evaluating and installing state-of-the-art irrigation control systems that turn water off and on with split-second accuracy. At the same time, however, very little time or effort is invested in evaluating the actual performance of sprinklers, spacings, and nozzle combinations. All too often problems with sprinkler coverage are not identified until it is too late, after they are buried in the field. With the price of new irrigation systems exceeding a million dollars, a very frustrating and embarrassing situation can arise if after a new irrigation system is installed the turf

is still plagued with wet spots, dry spots, or, even worse yet, donuts.

Sprinkler performance has long been evaluated with statistical calculations such as Christiansen's Coefficient of Uniformity (CU) and Distribution Uniformity (DU). Both CU and DU are estimates of complementing sprinklers' application uniformity that were originally developed to evaluate agricultural irrigation. The ideal CU or DU is 100%; however, this is unattainable because even rainfall does not fall with 100% uniformity. A closer examination of CU and DU reveals why they alone do not guarantee success with regard to evaluating turfgrass irrigation. This is due to their methods of evaluating the under- and over-watered areas.

CU: Christiansen's Coefficient of Uniformity

The CU statistically analyzes the sprinkler pattern for uniformity based

on an average of the entire area. It treats over-watered and under-watered areas in the same way. Since it is an average, it offers no indication of how poor the coverage may be in localized areas.

$$CU = 100 (1-D/M)$$

$$D = (1/N) \sum_{i=1}^N |X_i - M|$$

$$M = (1/N) \sum_{i=1}^N X_i$$

Where: CU = Christiansen's Coefficient of Uniformity (%)

D = Average Absolute Deviation

M = Mean Application

X_i = Individual Application Amounts

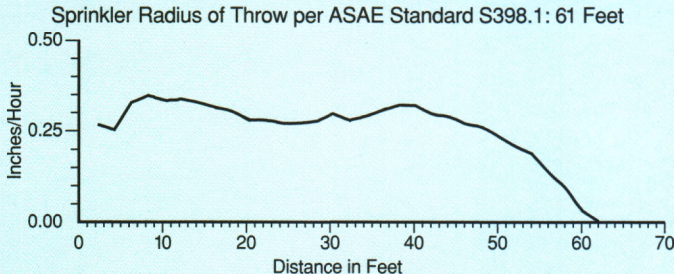
N = Number of Individual Application Amounts

∑ = Symbol for summation

* * = Symbol for absolute value of quantity between the bars

Irrigation Efficiency Analysis Poor Coverage Example

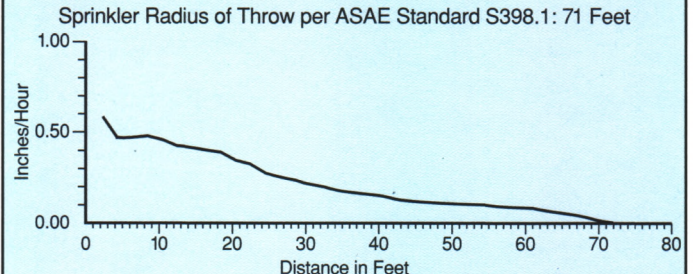
Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A3 Riser Height (inches): 0.0
 Nozzle Size: A3 Set Screw Setting: 0
 Flow Rate (gpm): 34.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
 Testing Facility: User Created Record Number: 1003
 Comment:



2.0' = 0.265	18.0' = 0.302	34.0' = 0.288	50.0' = 0.236
4.0' = 0.250	20.0' = 0.279	36.0' = 0.307	52.0' = 0.208
6.0' = 0.326	22.0' = 0.279	38.0' = 0.321	54.0' = 0.189
8.0' = 0.345	24.0' = 0.269	40.0' = 0.321	56.0' = 0.137
10.0' = 0.331	26.0' = 0.269	42.0' = 0.295	58.0' = 0.092
12.0' = 0.335	28.0' = 0.274	44.0' = 0.288	60.0' = 0.033
14.0' = 0.326	30.0' = 0.295	46.0' = 0.269	
16.0' = 0.312	32.0' = 0.279	48.0' = 0.260	

Irrigation Efficiency Analysis Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A1 Riser Height (inches): 0.0
 Nozzle Size: A1 Set Screw Setting: 0
 Flow Rate (gpm): 25.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.00
 Testing Facility: User Created Record Number: 1001
 Comment:



2.0' = 0.585	22.0' = 0.327	42.0' = 0.132	62.0' = 0.076
4.0' = 0.468	24.0' = 0.278	44.0' = 0.122	64.0' = 0.061
6.0' = 0.468	26.0' = 0.254	46.0' = 0.117	66.0' = 0.049
8.0' = 0.478	28.0' = 0.239	48.0' = 0.112	68.0' = 0.034
10.0' = 0.459	30.0' = 0.215	50.0' = 0.107	70.0' = 0.015
12.0' = 0.424	32.0' = 0.200	52.0' = 0.107	
14.0' = 0.415	34.0' = 0.180	54.0' = 0.102	
16.0' = 0.400	36.0' = 0.171	56.0' = 0.093	
18.0' = 0.390	38.0' = 0.159	58.0' = 0.088	
20.0' = 0.346	40.0' = 0.151	60.0' = 0.088	

The Profile Report shows graphically and quantitatively the precipitation amounts and their relative distance from the sprinkler to the terminal point that the water is thrown.

Irrigation Efficiency Analysis Uniformity Evaluation Poor Coverage Example

Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A3 Riser Height (inches): 0.0
 Nozzle Size: A3 Set Screw Setting: 0
 Flow Rate (gpm): 34.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
 Testing Facility: User Created Record Number: 1003
 Comment:

Distr. Uniformity: 76%	Min. (In./Hr.): 0.253	Spacing
CU (Christiansen): 88%	Mean (In./Hr.): 0.762 0.895 (Theor.)	Equilateral
Sched. Coeff. (5%): 2.2	Max. (In./Hr.): 0.952	65.0' x 56.3'

Data Grid in 0.001 Inches/Hour

265	257	283	416	468	555	632	635	708	738	754	786	807	834	843	852	831	831	852	843	834	807	786	754	738	708	635	632	555	468	416	283	257	265
257	253	311	473	541	625	647	675	702	718	725	748	800	826	834	843	819	819	843	834	826	800	748	725	718	702	675	647	625	541	473	311	257	253
286	364	413	522	576	643	687	716	745	752	755	770	776	800	806	814	783	783	814	806	800	776	755	752	745	716	687	643	576	522	413	364	286	
446	438	463	547	616	683	718	734	756	764	775	791	801	828	838	840	811	811	840	838	828	801	791	775	764	756	734	718	683	616	547	463	446	
540	528	483	583	643	690	727	748	771	781	796	811	820	851	867	859	838	838	859	867	851	820	811	796	781	771	748	727	690	643	583	483	540	
608	610	594	681	648	696	740	761	777	799	807	819	830	855	863	868	856	856	868	863	855	830	819	807	799	777	740	696	648	594	610	608		
665	664	645	665	698	759	776	802	811	828	846	874	901	887	882	882	882	882	901	874	846	828	811	802	776	759	739	698	665	645	664	665		
721	710	689	698	726	729	741	754	783	807	822	836	856	883	900	902	904	904	902	900	883	856	822	807	783	754	741	729	726	698	689	710	721	
743	745	736	706	749	749	724	764	780	803	829	847	882	900	911	930	940	940	930	911	900	882	847	829	803	764	722	749	749	706	735	745	743	
770	764	752	731	753	778	784	757	781	815	846	868	893	903	906	928	952	952	938	906	893	868	846	815	781	757	784	753	731	752	764	770		
787	776	755	792	772	792	802	790	814	845	874	867	880	894	924	945	945	924	894	880	867	874	845	814	790	822	802	792	772	755	776	787		
806	802	803	775	776	798	818	832	840	834	805	837	842	846	861	884	901	927	927	901	884	861	842	837	805	834	842	832	818	775	793	806		
816	820	809	803	807	827	844	842	852	827	796	812	834	852	877	893	904	904	893	877	852	834	812	796	827	852	842	844	827	807	803	820	816	
838	831	840	838	817	796	850	852	840	822	773	801	838	865	885	902	905	902	905	885	865	838	801	773	822	840	852	850	817	838	840	831	838	
855	863	867	882	841	815	824	833	823	833	824	815	841	862	887	893	893	893	887	862	841	815	824	833	823	833	824	815	841	862	867	855	855	
895	902	885	865	838	801	773	822	840	852	850	796	817	838	860	882	885	885	882	860	838	801	773	822	840	852	850	796	817	838	860	895	895	
904	893	877	852	834	812	796	827	852	842	844	827	807	833	809	806	816	816	809	833	807	827	844	842	852	827	796	812	834	852	877	893	904	
927	901	884	861	845	842	837	805	834	840	832	818	766	775	793	802	806	806	793	775	766	818	832	840	834	805	837	842	846	861	884	901	927	
945	924	884	860	867	845	814	790	822	807	792	777	762	765	776	787	777	776	765	776	787	792	822	820	814	845	874	867	880	894	924	945		
952	938	906	883	868	846	815	781	757	784	778	753	731	752	734	770	770	764	752	731	753	778	754	757	781	815	846	868	883	906	938	952		
940	930	911	900	882	847	829	803	780	764	722	749	741	706	735	745	741	741	706	735	745	749	722	749	741	706	735	745	829	847	882	900	940	
904	902	890	883	858	836	812	783	754	731	729	726	688	688	710	743	743	710	688	688	729	731	754	783	807	822	836	858	883	902	904	904		
882	887	891	874	846	828	811	802	776	759	750	688	665	645	654	655	655	654	645	655	665	688	759	750	776	802	811	828	846	874	891	882	882	
856	858	883	875	830	819	807	798	777	761	740	696	648	591	594	610	608	610	594	610	608	648	696	740	761	798	807	819	830	856	858	856		
838	859	867	851	820	811	796	771	748	727	690	643	583	483	528	540	540	528	483	528	540	690	727	748	771	796	811	820	851	867	859	838		
811	814	830	826	800	778	750	755	736	734	718	683	616	547	483	486	446	438	483	446	438	616	683	718	734	755	764	775	791	801	828	830	811	
783	814	806	800	778	750	755	736	745	718	687	643	576	522	413	364	286	286	364	522	576	643	687	718	755	736	745	750	778	800	806	814	783	
819	843	834	826	800	778	750	755	736	745	647	605	541	473	311	253	257	257	253	311	473	541	605	647	675	702	718	725	748	800	826	834	819	
831	852	843	834	807	786	754	738	708	635	605	555	468	416	283	257	257	257	283	416	468	555	605	635	708	754	786	807	834	843	852	831		

Critical 5% Window Size		Window Size
Mean In./Hr.: 0.762	Sched. Coefficient: 2.2	7
Min. Window In./Hr.: 0.343	Min. Window % of Mean: 45%	7
Max. Window In./Hr.: 0.905	Max. Window % of Mean: 119%	179 ²

Irrigation Efficiency Analysis Uniformity Evaluation Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A1 Riser Height (inches): 0.0
 Nozzle Size: A1 Set Screw Setting: 0
 Flow Rate (gpm): 25.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.00
 Testing Facility: User Created Record Number: 1001
 Comment:

Distr. Uniformity: 84%	Min. (In./Hr.): 0.477	Spacing
CU (Christiansen): 89%	Mean (In./Hr.): 0.613 0.658 (Theor.)	Equilateral
Sched. Coeff. (5%): 1.2	Max. (In./Hr.): 0.915	65.0' x 56.3'

Data Grid in 0.001 Inches/Hour

915	854	787	708	751	717	699	995	686	679	644	634	602	603	589	578	574	578	589	592	602	634	644	679	686	695	699	717	751	788	787	854	915
851	792	780	755	748	727	706	686	675	675	646	636	606	589	584	582	578	578	583	594	599	606	636	646	675	681	686	706	727	748	755	780	851
786	770	766	756	744	720	710	695	673	660	637	621	595	591	586	575	571	571	575	586	591	595	621	637	660	673	695	710	720	744	756	780	786
754	769	752	745	728	715	712	697	682	637	619	595	574	573	566	558	553	553	556	566	573	574	595	619	637	662	697	712	715	745	752	769	754
751	748	725	725	709	707	703	691	670	630	602	569	555	559	554	548	538	544	538	549	555	569	602	630	670	691	703	707	709	725	725	748	751
732	725	702	702	681	681	665	645	622	591	544	536	512	508	502	502	508	52	51	536	544	591	622	645	665	681	692	702	702	725	725	732	
715	707	693	686	686	678	678	647	615	593	540	536	514	514	518	508	501	508	511	514	536	540	593	615	647	678	681	693	707	715	715	707	715
708	696	682	682	661	636	616	616	636	616	574	574	547	525	492					484	492	516	516	636	616	684	682	696	708	708	696	708	
693	684	677	682	671	653	645	622	568	551	538	516	484	488	481	487	488	487	488	487	488	516	538	551	568	622	653	671	682	677	684	693	
696	650	650	634	636	631	613	596	575	563	546	523	504	481	487	488	487	488	487	488	504	523	546	563	575	596	613	631	636	643	650	696	
628	616	625	633	648	637	613	603	586	563	544	530	517	485	487	487	485				517	544	563	586	603	617	638	635	627	616	628		
601	592	598	603	604	595	591	584	564	551	537	513	499	478	485	478	499	513	533	499	564	591	595	603	604	598	592	601	592	601	592	601	
540	553	556	579	595	607	600	584	561	568	545	529	510	485	480	490	500	515	533	480	568	597	595	607	600	595	579	556	540	540	540	540	
519	536	529	546	561	587	576	574	576	576	561	541	527	512	512	512	512	512	512	512	541	561	587	576	574	576	587	581	569	555	536	519	
506	529	546	564	583	574	579	575	575	579	574	563	545	529	506	509	546	575	574	579	575	575	579	574	579	583	583	564	529	546	529	506	
485	512	527	541	561	581	576	574	576	587	591	581	569	555	539	519	519	536	555	569	591	587	587	574	576	576	512	527	541	512	485		
490	505	510	528	537	551	568	581	584	587	590	597	595	584	563	540	540	553	564	591	597	587	587	564	568	551	527	537	528	510	490		
478	478	494	514	533	548	563	584	594	591	595	603	603	592	581	561	561	592	603	603	595	591	594	584	533	548	533	514	478	478			
468	487	477	510	530	543	563	584	593	603	607	618	635	627	616	596	596	616	627	635	638	617	596	583	543	530	517	487	487	468			
468	487	481	504	523	548	563	585	595	615	631	636	641	632	619	599	609	609	641	636	631	595	576	548	523	504	481	487	468				
488	487	481	516	538	551	568	602	603	635	645	653	671	682	677	684	693	683	677	682	671	602	568	551	538	516	487	487	488				
479	481	488	484	492	535	547	576	616	636	661	684	686	682	698	708	708	698	682	686	683	684	616	576	547	492	484	488	479				
501	508	514	524	536	550	574	615	647	676	681	693	702	707	715	715	707	703	693	686	681	676	647	574	524	536	514	508	501				
528	532	532	541	536	541	591	622	648	680	685	681	692	702	725	725	725	725	725	725	725	692	681	685	622	531	541	528	528				
533	558	550	559	555	565	603	630	670	691	703	709	725	725	748	748	748	745	725	709	703	691	670	630	603	559	558	533	533				
553	558	556	573	574	595	619	637	682	697	712	715	720	745	762	769	754	769	752	745	720	715	697	682	637	619	595	574	556	553			
571	575	568	568	591	621	637	660	691	710	728	744	756	768	768	768	768	768	768	768	710	710	697	660	637	621	595	571	568	571			
578	582	594	593	606	636	646	671	681	686	706	727	748	765	780	782	851	915	792	780	748	727	706	686	675	646	606	599	584	582	578		
578	578	599	602	634	644	671	686	699	717	751	788	787	854	915	915	854	915	792	788	751	748	727	706	686	671	646	602	599	578	578		

DU: Distribution Uniformity

DU represents the average of the lowest 25% of the application rates in the sprinkler pattern divided by the average application rate of the entire pattern. This method sorts all values from the lowest to highest; the average of the lowest 25% of catchments is then divided by the mean value of the entire area. This method, however, does not take into account the location of the individual values or any benefit that may be derived from values immediately adjacent to the low values. In other words, the lowest 25% of catchments could be dispersed throughout the pattern and not necessarily be in the same localized area. Therefore, a benefit may be derived from an over-watered area immediately adjacent to an under-watered location.

$$DU = 100(1-[LQ/M])$$

Where:

DU = Distribution Uniformity (%)

LQ = Average of the Lowest ¼ of the Irrigation Amounts

M = Average of the Irrigation Amounts

Golf course irrigation designers recognize that sprinklers with high CU or DU ratings could still develop significant wet or dry areas when irrigating turf. This, in turn, required many designers to rely upon past field experience when selecting sprinklers and appropriate spacings. Now, however, the advent of the personal computer has created another method. Sprinklers now can be evaluated before they are installed in the field with the SPACE program. No, this has nothing to do with rocket science; SPACE is an acronym for *Sprinkler Profile And Coverage Evaluation*. The SPACE program is personal computer software developed by the Center for Irrigation Technology (CIT), at the California State University, Fresno, California.

Capabilities of SPACE

Using the SPACE program, one can evaluate the distribution and uniformity of sprinklers either at one's own site or, for a small fee, in the CIT laboratory. This is accomplished through a combined analysis of statistical, numerical, and graphic data, all based on the actual application of water collected from one sprinkler. This can be accomplished before installing the equipment in the field.

The SPACE program is capable of evaluating two distinctly different types of data. The first type of evaluation is

known as a single-leg profile analysis, while the second is a grid analysis. The single-leg profile analysis is used when a sprinkler is being selected either for a new system design or for a retrofit or upgrade of an existing system. The single-leg profile data are then used to create overlaps and reports that simulate how one can expect the sprinkler to perform in the field. The grid analysis is used to field audit the efficiency of existing systems or examine wind effects on a single sprinkler. By following a step-by-step procedure, a great deal can be learned about an existing or proposed system.

Single-Leg Profile, Overlaps, Multiple Spacing Analysis, and Associated Reports

Creating a Single-Leg Profile: To create a single-leg profile, raw data from a single sprinkler are collected from a single row of catchments placed in a straight line on 1-foot or 2-foot intervals from the sprinkler outward. The sprinkler is operated at a specified pressure for a period of time sufficient to collect a representative amount of water in each catchment. The water in each catchment is measured to the nearest hundredth of an inch and entered into the computer. The time the sprinkler is allowed to run (in minutes), along with other data such as sprinkler make, model, nozzle size, operating pressure, flow rate (gpm), arc (degrees of rotation), test date, and minutes per revolution, are collected to become part of the test record.

Overlaps: Once a profile has been developed, overlaps can be generated with SPACE. Overlaps simulate performance and coverage using the single-leg profile data, based on spacings and configurations determined by the computer operator. Spacings of up to 100 feet can be selected, with available configurations including square, rectangular, triangular, equilateral triangles, offset rows, single row, and single head.

Reports: Once an overlap is generated, a variety of information can be viewed from the monitor or printed as individual one-page reports. Profile, Grid Listing, Densogram, Histogram, Sliding Window, and Multiple Spacing reports are available.

Profile Report: The profile report represents both graphically and numerically the water collected in the single row of catchments. The graphic portion represents the accumulation of water plotted on an X- and Y-axis. By

studying this graphic, areas of low and high precipitation can be observed as to their relative positioning from the sprinkler to the terminal point that water is thrown. Quantitative data for each catchment are also represented in inches per hour and reported numerically with a reference for the location of each catchment in the row. The most ideal profile for turfgrass irrigation is wedge shaped, as this will deliver the most uniform distribution when overlapped at a proper spacing. The wedge-shaped pattern is also the most forgiving and maintains more uniform coverage where slight spacing adjustments are required around greens, bunkers, and trees.

Grid Listing Report: Numeric data representing the overlapped pattern are termed a grid listing. A table of numbers represents each calculated value of the simulated catchments within the overlap matrix. Each number depicts the amount of water applied within that area when the sprinklers are spaced at the selected distance and configuration. All data are represented in inches per hour.

Histogram Report: The histogram report is a bar graph depicting the application rates of each data point from the overlap, categorizing them from 100% below the mean to 100% above the mean in 5% increments. This report represents graphically both the percent variation from the mean and the number of simulated catchments falling into each range. The most ideal results are represented by the least variance from the mean application in both categories.

Densogram Reports: The densogram report is a two-dimensional dot matrix graphic of the grid listing showing the relative wet and dry areas within the pattern. Darker areas represent wetter portions, and lighter areas represent drier portions of the overlap. Perfect uniformity would be represented by a uniformly shaded printout.

Sliding Windows Report: The sliding window examines a 1%, 5%, and 10% area of the overlap pattern in both its wettest and driest locations. Values for mean inches per hour, minimum window inches per hour, minimum window percent of mean, maximum window inches per hour, maximum window percent of mean, and scheduling coefficient are calculated for each size window.

Mean Inches Per Hour: This value is the average application rate of the entire pattern. Each catchment in the

entire pattern is added together and divided by the total number of catchments.

Minimum Window Inches Per Hour: This value represents the area of the pattern that receives the lowest application rate. The value listed is the lowest average of catchments found in the selected window size.

Minimum Window Percent of Mean: This value is the percentage of the mean application rate of the entire pattern that the average application rate of the catchments in the window size receive in the area receiving the lowest application rate.

Maximum Window Inches Per Hour: This value represents the area of the pattern that gets the highest application rate. The value listed is the highest average of catchments found in the selected window size.

Maximum Window Percent of Mean: This value is the percentage of the mean application rate of the entire pattern that the average application rate of the catchments in the window size receive in the area receiving the highest application rate.

Scheduling Coefficient: This value is the mean application rate of the pattern

area, divided by the average application rate found in the driest window area. The scheduling coefficient is used as a run time multiplier as it relates to the driest portion of the entire pattern. This is based on the value 1.0 being perfection. (A 1.0 is impossible to obtain, as even rain does not fall this uniformly!)

Multiple Spacings Analysis: The SPACE program has other capabilities, including that it can (1) evaluate a given sprinkler over a range of spacings, (2) examine which spacing is most efficient, and (3) determine how performance will suffer where adjustments in spacing must be made. A series of values are calculated by the computer based upon the range of spacings selected by the computer operator. The result is a graph that plots continuous values for the Scheduling Coefficient (SC), Coefficient of Uniformity (CU), and Distribution Uniformity (DU) and can be displayed or printed as a report. Numerical data listing the spacings, CU, DU, SC (based on a 5% window), minimum inches per hour, mean inches per hour, theoretical inches per hour (based on gpm of sprinkler, configuration, and spacing), and maximum inches per hour are also provided. The

program selects the best spacing based upon the lowest SC.

Grid Analysis and Associated Reports

A grid analysis is a combination of graphic and data reports based upon a conventional catch-can test. Grid analysis can be performed for two different evaluations. The first is to performance test or audit an existing irrigation system. This test determines the system's overall efficiency. The second is where a single sprinkler is tested to use this data in generating overlaps. (This can demonstrate the effects of wind on the pattern of a single sprinkler.) The overlaps that follow this test are similar to those of the single-leg profiles discussed earlier, with the exception that raw data are gathered from the entire area influenced by the sprinkler as opposed to a profile.

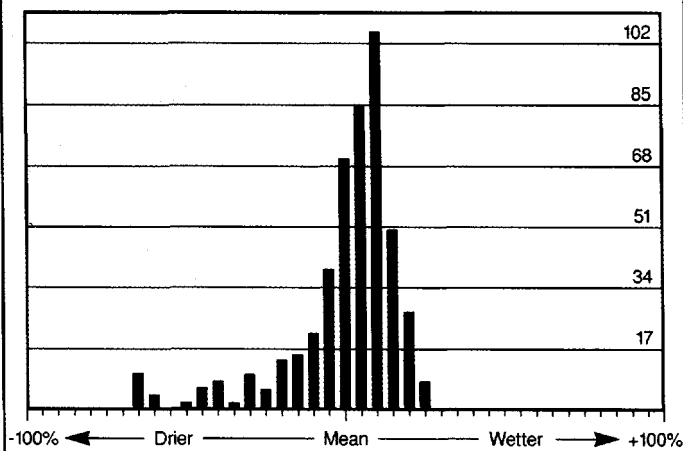
Grid Analysis of an Existing System: Data collection for grid analysis of an existing system begins with the layout of catchments between two rows of sprinklers. The catchments are laid out in square arrangements, at a predetermined distance, uniformly spaced throughout the area influenced by the

Irrigation Efficiency Analysis Uniformity Evaluation Poor Coverage Example

Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
Sprinkler Model: A3 Riser Height (inches): 0.0
Nozzle Size: A3 Set Screw Setting: 0
Flow Rate (gpm): 34.00 Degree of Arc: 360
Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
Testing Facility: User Created Record Number: 1003
Comment:

Distr. Uniformity: 76%	Min. (In./Hr.): 0.253	Spacing
CU (Christiansen): 88%	Mean (In./Hr.): 0.762 0.895 (Theor.)	Equilateral
Sched. Coeff. (5%): 2.2	Max. (In./Hr.): 0.952	65.0' x 56.3'

Frequency Distribution



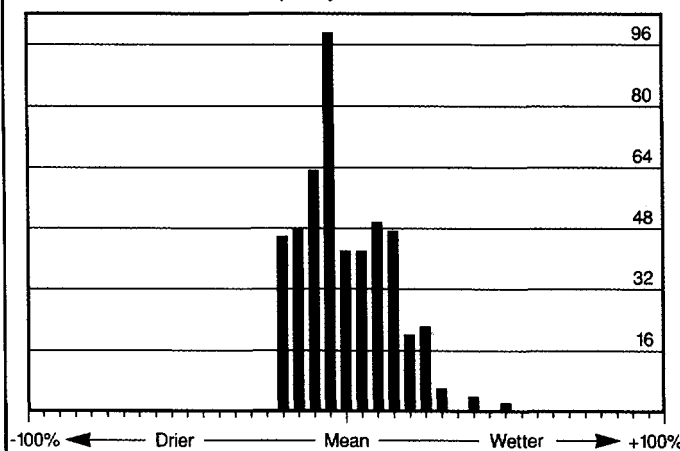
Histograms are used to represent the irrigation distribution in 5% increments. The frequency of each synthesized catchment occurs in the Grid Listing Report.

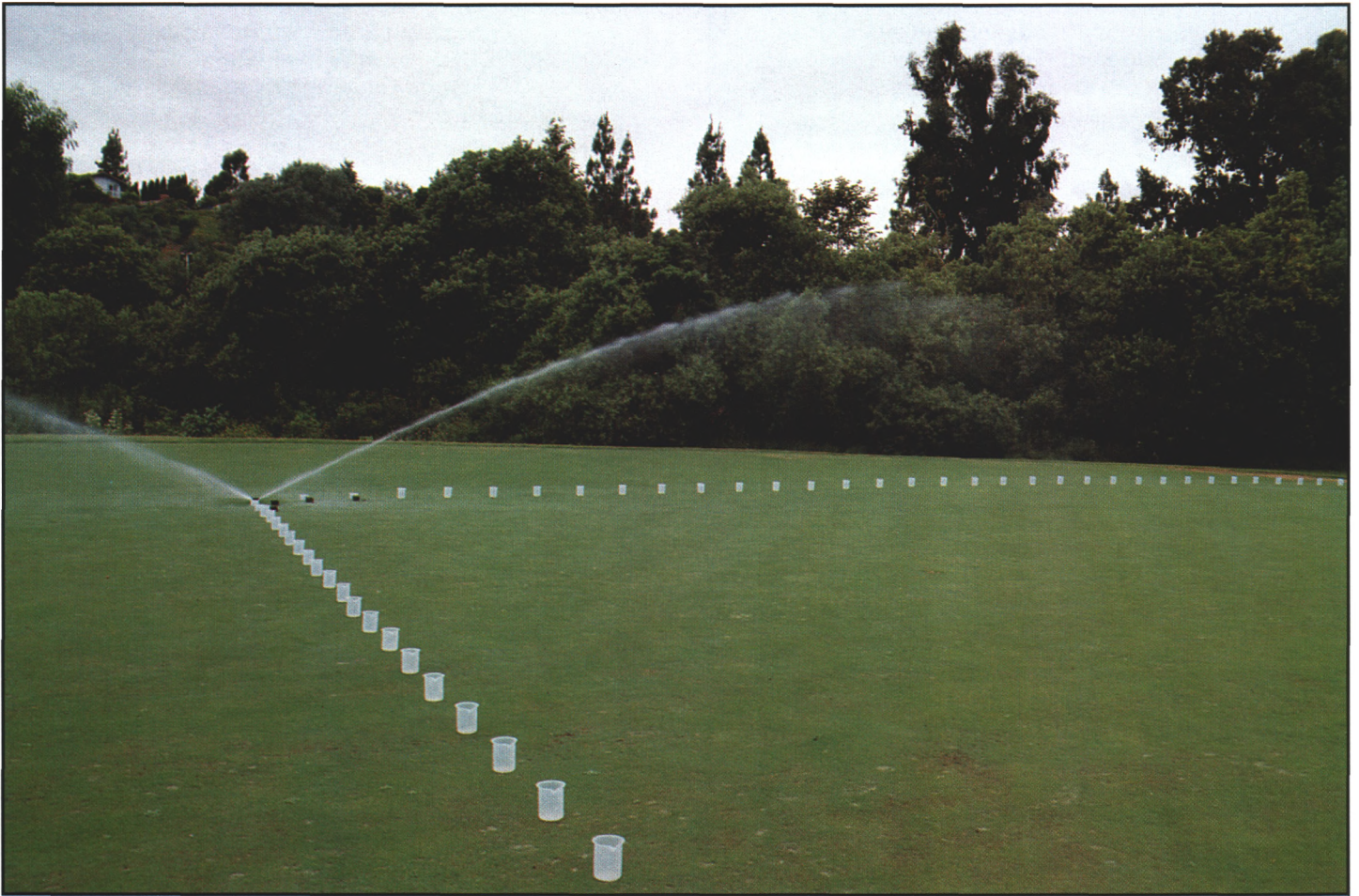
Irrigation Efficiency Analysis Uniformity Evaluation Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
Sprinkler Model: A1 Riser Height (inches): 0.0
Nozzle Size: A1 Set Screw Setting: 0
Flow Rate (gpm): 25.00 Degree of Arc: 360
Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.30
Testing Facility: User Created Record Number: 1001
Comment:

Distr. Uniformity: 84%	Min. (In./Hr.): 0.477	Spacing
CU (Christiansen): 89%	Mean (In./Hr.): 0.613 0.658 (Theor.)	Equilateral
Sched. Coeff. (5%): 1.2	Max. (In./Hr.): 0.915	65.0' x 56.3'

Frequency Distribution





On-site profile data gathered on new sprinklers or nozzle combinations with single row of catchments are later used in the SPACE Program evaluation process.

overlap of the sprinklers. Any number can be used, with a maximum of 60 rows by 60 columns for a possible total of 3600 catchments. The more catchments used, the more precise the analysis. (It is suggested by irrigation texts that the maximum spacing for catchments be 5 feet by 5 feet if sprinkler spacing is less than 60 feet, and 10 feet by 10 feet if sprinklers are spaced over 60 feet.)

The area selected for testing should be representative of the entire system and conducted in wind conditions typical of those found during normal irrigation. An ideal way to perform this test is to set up the catchments the evening before and allow the sprinkler system to operate automatically. A minimum of 15 minutes run time is suggested to obtain an adequate amount of water in the catchments. For the sake of the test, run times of all stations influencing the catchments must be set to operate for the exact same amount of time while collecting data.

The water collected in the catchments is then measured to the nearest

hundredth of an inch and entered into the computer. Data such as sprinkler run time in minutes, sprinkler make, model, nozzle size, operating pressure, flow rate (gpm), arc (degrees of rotation), test date, and minutes per revolution are recorded. These data become part of the permanent test record.

Single Sprinkler Grid: Grid data of a single sprinkler are collected much the same way as for an existing system, but the capability of operating only one sprinkler must be available. To arrange the catchments for collecting data, the radius of the sprinkler coverage must be known. After obtaining this information, the catchments are laid out in a square arrangement with the sprinkler located in the center and catchments positioned uniformly throughout as far as water is thrown.

Data are then collected and entered into the computer in the same manner as with an existing system. The difference is that these data can be overlapped, similar to a single-leg analysis, to examine different spacings and configurations. The data can then be viewed or printed as a grid listing,

densogram, histogram, or sliding windows report for either the single head or a selected overlap.

Interpretation of Data and Summary

Interpretation of the final data and reports requires some time, and all the data must be taken into consideration. The final sprinkler selection should not be based on any one numerical or graphic representation alone. A good place to start, however, is with the profile. The more wedge-shaped the profile, the more uniform the coverage can be expected. Looking beyond the profile, one needs to examine the wettest and driest areas through the minimum and maximum values presented on the sliding windows report, determine how significant these might become, look for the lowest Scheduling Coefficient in combination with the highest CU and DU, most uniform Densogram, narrowest range of variation on the Histogram, and, finally, compare how well the sprinkler performs across a range of spacings. The

Irrigation Efficiency Analysis Uniformity Evaluation Poor Coverage Example

Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A3 Riser Height (inches): 0.0
 Nozzle Size: A3 Set Screw Setting: 0
 Flow Rate (gpm): 34.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
 Testing Facility: User Created Record Number: 1003
 Comment:

Distr. Uniformity: 76%	Min. (In./Hr.): 0.253	Spacing Equilateral 65.0' x 56.3'
CU (Christiansen): 88%	Mean (In./Hr.): 0.762 0.895 (Theor.)	
Sched. Coeff. (5%): 2.2	Max. (In./Hr.): 0.952	

Critical 1% Window Size Window Size
 Mean In./Hr.: 0.762 Sched. Coefficient: 2.9 3
 Min. Window In./Hr.: 0.260 Min. Window % of Mean: 34% 33"²
 Max. Window In./Hr.: 0.941 Max. Window % of Mean: 123%

Critical 5% Window Size Window Size
 Mean In./Hr.: 0.762 Sched. Coefficient: 2.2 7
 Min. Window In./Hr.: 0.343 Min. Window % of Mean: 45% 179"²
 Max. Window In./Hr.: 0.905 Max. Window % of Mean: 119%

Critical 10% Window Size Window Size
 Mean In./Hr.: 0.762 Sched. Coefficient: 1.7 10
 Min. Window In./Hr.: 0.439 Min. Window % of Mean: 58% 365"²
 Max. Window In./Hr.: 0.885 Max. Window % of Mean: 116%

Irrigation Efficiency Analysis Uniformity Evaluation Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A1 Riser Height (inches): 0.0
 Nozzle Size: A1 Set Screw Setting: 0
 Flow Rate (gpm): 25.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.00
 Testing Facility: User Created Record Number: 1001
 Comment:

Distr. Uniformity: 84%	Min. (In./Hr.): 0.477	Spacing Equilateral 65.0' x 56.3'
CU (Christiansen): 89%	Mean (In./Hr.): 0.613 0.658 (Theor.)	
Sched. Coeff. (5%): 1.2	Max. (In./Hr.): 0.915	

Critical 1% Window Size Window Size
 Mean In./Hr.: 0.613 Sched. Coefficient: 1.3 3
 Min. Window In./Hr.: 0.485 Min. Window % of Mean: 79% 33"²
 Max. Window In./Hr.: 0.873 Max. Window % of Mean: 142%

Critical 5% Window Size Window Size
 Mean In./Hr.: 0.613 Sched. Coefficient: 1.2 7
 Min. Window In./Hr.: 0.493 Min. Window % of Mean: 80% 179"²
 Max. Window In./Hr.: 0.797 Max. Window % of Mean: 130%

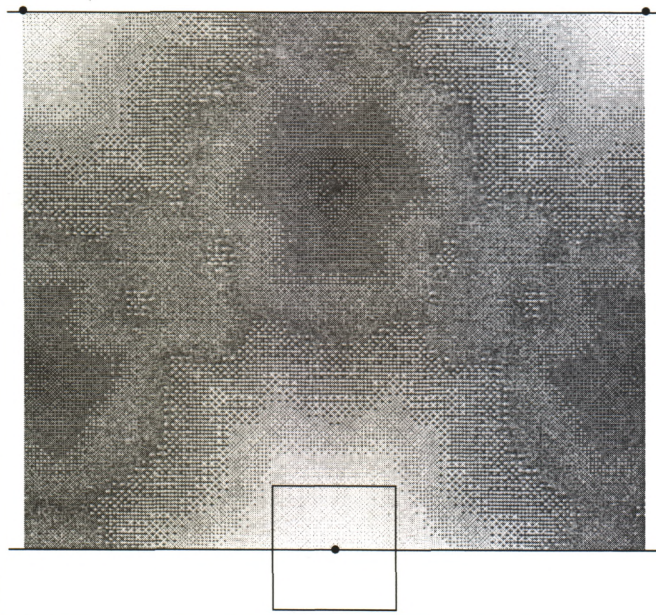
Critical 10% Window Size Window Size
 Mean In./Hr.: 0.613 Sched. Coefficient: 1.2 10
 Min. Window In./Hr.: 0.509 Min. Window % of Mean: 83% 365"²
 Max. Window In./Hr.: 0.769 Max. Window % of Mean: 125%

The Sliding Windows Report analyzes the most wet and dry 1, 5, and 10% areas of the overlap.

Irrigation Efficiency Analysis Uniformity Evaluation Poor Coverage Example

Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A3 Riser Height (inches): 0.0
 Nozzle Size: A3 Set Screw Setting: 0
 Flow Rate (gpm): 34.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
 Testing Facility: User Created Record Number: 1003
 Comment:

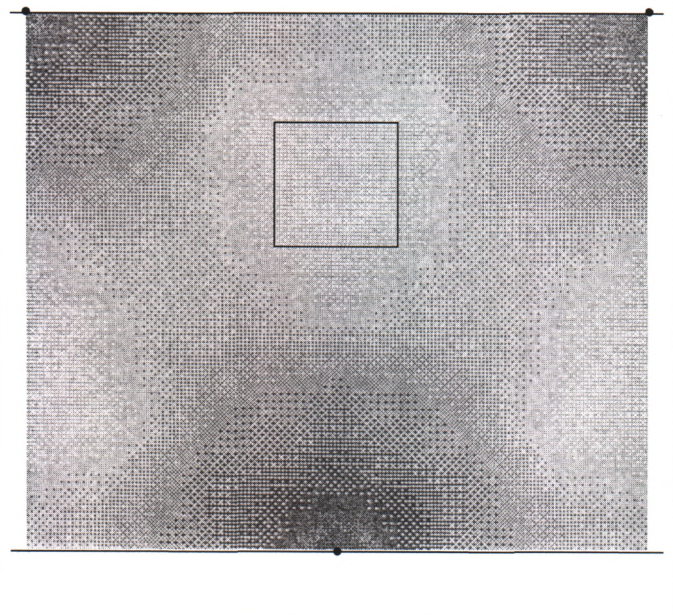
Distr. Uniformity: 76%	Min. (In./Hr.): 0.253	Spacing Equilateral 65.0' x 56.3'
CU (Christiansen): 88%	Mean (In./Hr.): 0.762 0.895 (Theor.)	
Sched. Coeff. (5%): 2.2	Max. (In./Hr.): 0.952	



Irrigation Efficiency Analysis Uniformity Evaluation Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
 Sprinkler Model: A1 Riser Height (inches): 0.0
 Nozzle Size: A1 Set Screw Setting: 0
 Flow Rate (gpm): 25.00 Degree of Arc: 360
 Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.00
 Testing Facility: User Created Record Number: 1001
 Comment:

Distr. Uniformity: 84%	Min. (In./Hr.): 0.477	Spacing Equilateral 65.0' x 56.3'
CU (Christiansen): 89%	Mean (In./Hr.): 0.613 0.658 (Theor.)	
Sched. Coeff. (5%): 1.2	Max. (In./Hr.): 0.915	



The Densogram graphically shows the synthesized coverage of overlap area. The lighter shaded areas indicate drier areas and the darker areas are more wet. The small square locates the critical dry area within the overlap pattern.

more consistent the results are at varying spacings, the more uniform the coverage will be where spacing adjustments are required.

In the case of new installations, it would be prudent to send one sprinkler for testing prior to the design phase to select the best spacing. During the system installation, sprinklers should be tested at the start of the project and then again one-third and two-thirds through completion of the project as a quality-control measure. Checking several sprinklers during the project will help insure that the manufacturer has not made any drastic change in the product or that problems with molding or machining nozzles have not occurred. This small investment could help avoid many headaches down the road.

There is a case to be made for performing on-site testing, especially at high elevations where thin air will affect the distribution pattern by how far water is thrown. You cannot expect information obtained at Fresno, California, at near sea level, to be completely valid in the Rocky Mountains at 10,000 feet elevation. Additionally, the effects of wind, temperature, relative

humidity, and other unknown variables on sprinkler distribution are not yet completely known. However, the Center for Irrigation Technology is busy working with lasers to analyze actual droplet size in relationship to wind and drift. In the future, wind effects may become more predictable.

It must also be recognized that a nozzle one size larger or smaller can result in a drastic change in the shape of a profile. Some nozzles have also shown a great sensitivity in their performance with only slight variations in operating pressure. Evaluating sprinklers alone cannot guarantee success, but it may prevent certain failure. A system still needs to be properly designed hydraulically and then installed correctly. Laboratory evaluation of sprinklers is better than any other method of selection currently available, especially compared to the old-fashioned way of just sticking them in the ground and finding donuts upon completion. So don't let sprinkler selection be rocket science. Test before you invest, and put data from the SPACE program to work for you!

(SPACE is available for either DOS or Windows. For more information on

SPACE or laboratory testing, contact the Center for Irrigation Technology, California State University — Fresno, 5370 North Chestnut Avenue, Fresno, California 93740-0018, or phone 209-278-2066.)

References

Irrigation, Fifth Edition, The Irrigation Association, 1983.

Landscape Irrigation System Evaluation and Scheduling for Southern California, U.C. Cooperative Extension, 1992.

SPACE for DOS User's Guide, Center for Irrigation Technology, 1989.

SPACE for Windows Installation and Operation Manual, Center for Irrigation Technology, 1993.

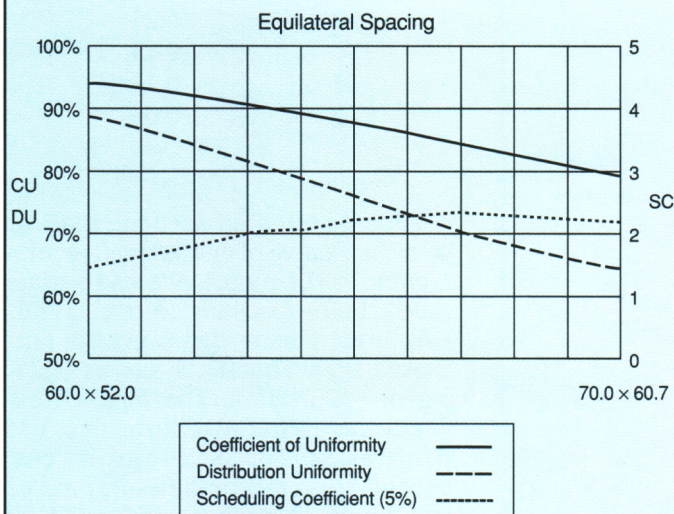
Turfgrass Water Conservation, Cooperative Extension, University of California, Division of Agriculture and Natural Resources, 1985.

"The Facts Hold Water," Alfred S. Cline, CGCS, pp. 84-86, Golf Course Management Magazine, Volume 64, No. 7, July 1996.

MIKE HUCK is an agronomist in the Green Section's Western Region. He conducts TAS visits from the California coast to the peaks of the Rocky Mountains.

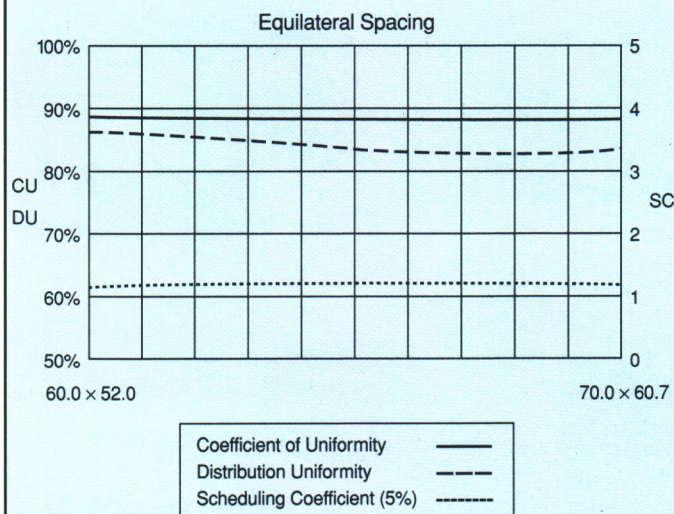
Irrigation Efficiency Analysis Uniformity Evaluation Poor Coverage Example

Sprinkler Name: Poor Coverage Base Pressure (psi): 80.0
Sprinkler Model: A3 Riser Height (inches): 0.0
Nozzle Size: A3 Set Screw Setting: 0
Flow Rate (gpm): 34.00 Degree of Arc: 360
Date/Time of Test: 02/01/91 02:41 Minutes/Revolution: 1.30
Testing Facility: User Created Record Number: 1003
Comment:



Irrigation Efficiency Analysis Uniformity Evaluation Good Coverage Example

Sprinkler Name: Good Coverage Base Pressure (psi): 80.0
Sprinkler Model: A1 Riser Height (inches): 0.0
Nozzle Size: A1 Set Screw Setting: 0
Flow Rate (gpm): 254.00 Degree of Arc: 360
Date/Time of Test: 02/01/91 12:47 Minutes/Revolution: 3.00
Testing Facility: User Created Record Number: 1001
Comment:



Multiple Spacing Graphics display the consistency or lack of consistency of the Christiansen's Coefficient of Uniformity (CU), Distribution Uniformity (DU), and scheduling coefficient over a range of spacings.

Checking Your Sand — Quality Control Begins at Home

A quick check of sand with your own testing equipment can help avoid problems later.

by JAMES F. MOORE

TO EVALUATE the suitability of sands used in the construction of greens or bunkers, samples should be submitted to a physical soil testing lab for analysis. The laboratory has the very specialized equipment necessary to determine the amounts of

silt and clay in the sand, as well as other factors such as total porosity, water retention, etc. However, every superintendent should have a nest of soil sieves and an accurate scale to monitor the consistency of sizing of the sand being delivered for topdressing and

topping off bunkers. Sands can vary widely in their makeup, even from the same source. As a rule, sand size specifications for golf course use are much tighter than in other industries. A quick screening of sand as it is delivered will prove well worth the initial cost of the equipment.

Numerous companies sell soil sieves and scales, so be sure to check around for the best price. In this office, we acquired our equipment from the company listed below.

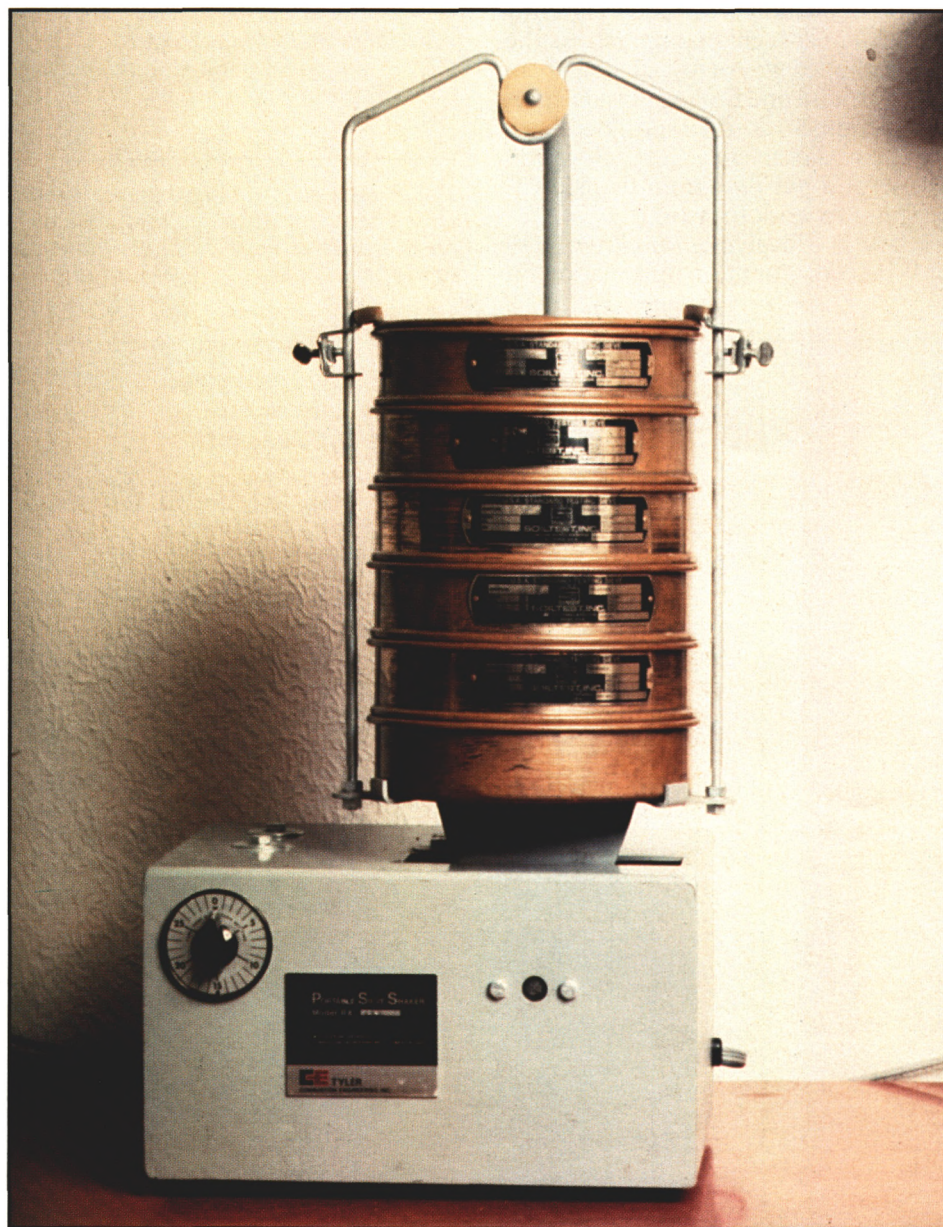
Thomas Scientific
Box 99
Swedesboro, NJ 08085-0099
(609) 467-2000

Both 8-inch and 4-inch sieves are available. We use the 8-inch sieves since they are more accurate and we test materials regularly. The 4-inch sieves should be fine for golf course use if you want to save a few dollars. You should acquire the following sieves:

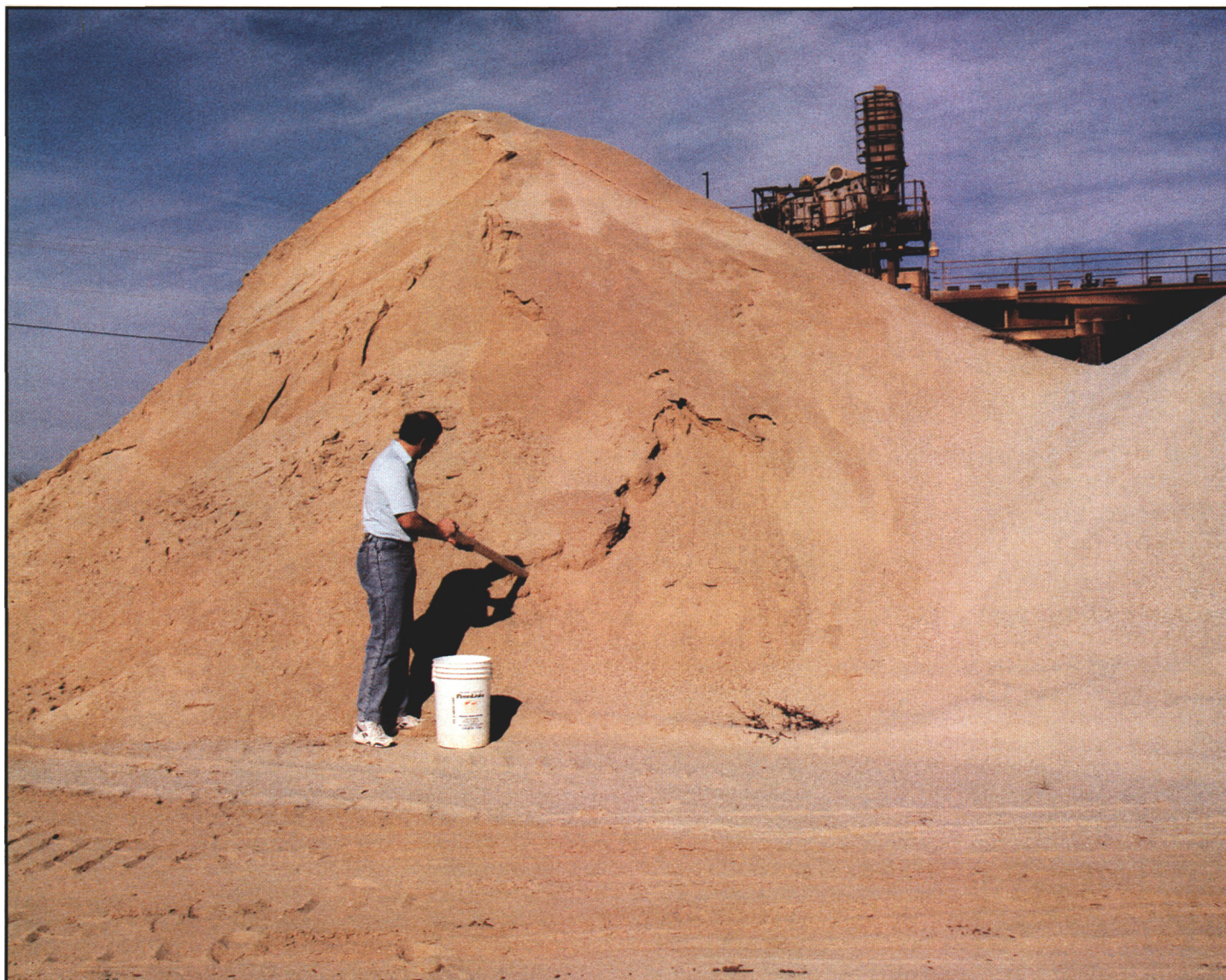
Mesh	Millimeters
10	2
18	1
35	0.5
60	0.25
100	0.15
140	0.1
270	0.05
Pan	
Cover	

You also need an accurate scale or balance capable of measuring to within 1 gram or 0.1 ounce. We use a scale called "Lume-O-Gram" (Model D1001-BA) from Ohaus that we also purchased from Thomas Scientific (catalog no. 1367-H32). The digital scale doubles as a letter scale if you like. The cost was \$89.00. Sieves vary in cost depending on the mesh. While most of our 8-inch sieves were about \$35.00 apiece, the 270 mesh was \$63.00.

There are many different methods of sieving. The procedure we use in this office is as follows. Keep in mind that



A nest of sieves is mounted on a power shaker like that used by professional labs. This is a nice accessory if you can afford it. If not, manual shaking will suffice.



When collecting sand for testing, be sure to remove samples from the inside of the pile rather than from the surface. This will ensure the sample is more representative of the entire pile.

your sand must be very dry for your numbers to be accurate.

1. Select a small container for the sand. We use the container that came with our scale. You need something that will hold about 3 cups of sand (700 to 800 grams). Place the container on the scale and adjust it to zero.

2. Put your sand in the container and record the weight. Let's assume you have 700 grams.

3. Build your nest of sieves by placing the largest screen (2.0mm) on top and getting progressively smaller as you go down, ending with the pan on the bottom.

4. Add the sand to the top sieve and cover. Shake the nest of sieves for five minutes.

5. Make sure the container is clean. Empty the sand from the top sieve into the container and record the weight.

6. Empty the container and clean. Empty the sand from the next sieve and record the weight. Repeat this procedure for each sieve and the pan.

7. Divide the weight retained on each screen by the total weight (700 grams in this case). This gives you the percentage of each fraction, as illustrated below.

Mesh	Retained on Screen (Grams)	Percentage (Retained Weight/ Total Weight)
10	0	0
18	21	3
35	175	25
60	385	55
100	49	7
140	35	5
270	21	3
Pan	14	2

Before you accept delivery of a load of sand, take the time to perform this simple test. It may not be practicable to test before the delivery is made. However, be sure you have an agreement with your supplier that you will not submit payment for any load that does not meet your specifications.

On many of today's courses, sand is used on greens in quantities second only to the amount of water applied. This simple equipment and test can help protect your course's most valuable physical asset — the greens. Although you might be discouraged with the inconsistency of your sand supply, in this case, what you do not know can definitely hurt you.

JAMES F. MOORE is director of Construction Education Programs of the USGA Green Section.

KTURF: A Pesticide and Nitrogen Leaching Model

A computer model available on the Internet and World Wide Web helps turfgrass managers predict pesticide and nitrogen leaching.

by **DR. STEVE STARRETT,**
DR. SHELLI STARRETT,
JUDY HILL, and
GREG ADAMS



Research lysimeters generate data to form the basis of the KTURF model.

THE USE OF PESTICIDES on golf courses may have some potential negative impacts, including groundwater contamination. As the golf industry continues to grow, the proper management of pesticides grows in importance. KTURF is a computer model, developed at Kansas State University and funded by the USGA, that estimates the percentage of applied nitrogen or pesticide that leaches through 50cm (20 inches) of turfgrass-covered soil in specific circumstances. KTURF was developed to allow golf course superintendents access to these models on the internet. KTURF models are available via the internet and the world wide web (www) at the following URL:

<http://www.eece.ksu.edu/~starret/KTURF/>

Because KTURF is located on the www, any superintendent with internet access can use the latest version of the model and the mathematical software required by the models. The models can be accessed at any time of day and do not require that the software be downloaded to the user's computer. The user simply enters the conditions that pertain to the situation and clicks a button. Within a minute or so, the results appear on the screen.

The KTURF Models

The KTURF models were developed using artificial neural networks (ANNs), a form of artificial intelligence. ANNs are *trained* using experimental data from lab tests. The ANN *learns* the relationships between the inputs

and the output. Once the models are developed (trained), those relationships can be applied to other sites to make predictions about the output, in this case the percentage of nitrogen or pesticide leached. The KTURF models were trained using data from USGA-funded projects.

Although completely accurate, useable models for turfgrass-covered soil have yet to be developed. KTURF does a very good job of predicting pesticide and fertilizer leaching based upon the results of USGA research. The actual results will vary from site to site, but KTURF provides an approximation of the nitrogen or pesticide leached based on four readily determined input variables. Figures 1 and 2 are KTURF's pesticide leaching predictions compared to measured values. The results from 16 test cases for the nitrogen model are shown in Figures 3 and 4. KTURF did a good job of estimating the percentage of applied pesticide and nitrogen leached for the test cases. For more information about the methodology used to obtain the training data for the ANNs, refer to Starrett et al. 1996, 1995a, 1995b, and 1995c.

Developing the KTURF Website

The web files were written in HyperText Markup Language (HTML), a programming language specific to the world wide web to be accessible by web browsers such as Netscape Navigator, Mosaic, or Internet Explorer. Combining text with tags that indicate format changes, the web browser presents the documents in the desired format.

HTML tutorials and examples are available via the world wide web, and several books are also available about this subject (National Center for Supercomputing Applications 1996a, Smith 1995).

At the KTURF website, programming scripts written in languages other than HTML were needed to perform the interactive data processing and calculation. HTML is used to execute the scripts that do the calculations. The user inputs data about a golf course's pesticide or nitrogen use on an HTML form, and the HTML script executes an intermediate script using the data input.

The intermediate programming script that KTURF uses is written in Practical Extraction and Report Language (PERL). PERL, a useful language for Common Gateway Interface (CGI) programming or interactive web programming, processes data submitted by a remote user. Some of PERL's web applications include guest books where users can leave comments about a site, access counters that count the number of times a web page is displayed, and shopping carts that allow users to buy objects for sale. The KTURF PERL script assigns the submitted data from the HTML form to variables, opens MATLAB=AE (the mathematical software used to write the ANN model), receives the data back from MATLAB=AE, and creates another form using embedded HTML to display the results.

Several informative websites about PERL are available via the internet (NCSA 1996b), and several books have

also been written that describe the basics of PERL scripting (Schwartz 1993).

Using the KTURF Website

Two interactive models are currently available at the KTURF website: one predicting the nitrogen leaching and the other predicting pesticide leaching through 20 inches of turfgrass-covered soil.

The nitrogen model predicts the percentage of applied nitrogen leaching through 20 inches of turfgrass-covered soil. It is applicable to conditions on both fairways and greens. The user must supply four input variables to compute the predicted result: the sand content of the soil, the irrigation applied to the soil, the form of nitrogen applied, and the period of time after the nitrogen application that the leached output is calculated.

To illustrate the use of the interactive nitrogen model, the following data set was entered into the input form:

Sand content of the soil: 65%.

Irrigation rate: two .5" applications per week.

Nitrogen form: liquid urea.

Time (in days): 14.

The submit button, located at the bottom of the form, is pressed and, after approximately one minute, the resulting web page should appear.

The predicted percentage of nitrogen leached during the 14 days after application for this case is approximately 2%. The exact nitrogen leached will vary from site to site depending on the conditions present.

The pesticide model currently available is applicable only to fairway conditions. It predicts the percentage of applied pesticide that leaches through 20 inches of turfgrass-covered soil. The irrigation rate and the time (in days after pesticide applications) are necessary input variables. In addition, two characteristics of the pesticide — the water solubility and the sorption coefficient — must be input. Because the water solubility and sorption coefficient may be unknown, a table of common pesticides used is provided and accessed with the click of a button. However, if a pesticide used is not listed, your pesticide sales representative can provide this information.

As an example of the interactive pesticide model, the following data were input into the pesticide form:

Pesticide name: Dicamba.

Water solubility of pesticide: 400,000 mg/L.

Sorption coefficient of the pesticide: 2.

Irrigation rate: two .5" waterings per week.

Time (in days): 14.

After submitting the data, the following result was calculated:

Output: 2%.

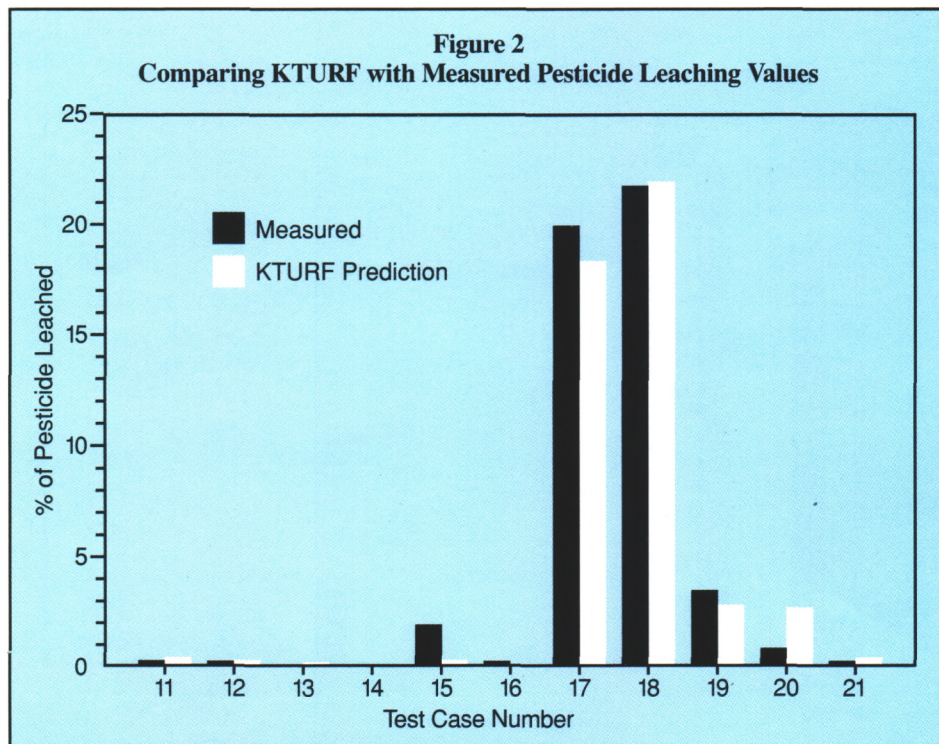
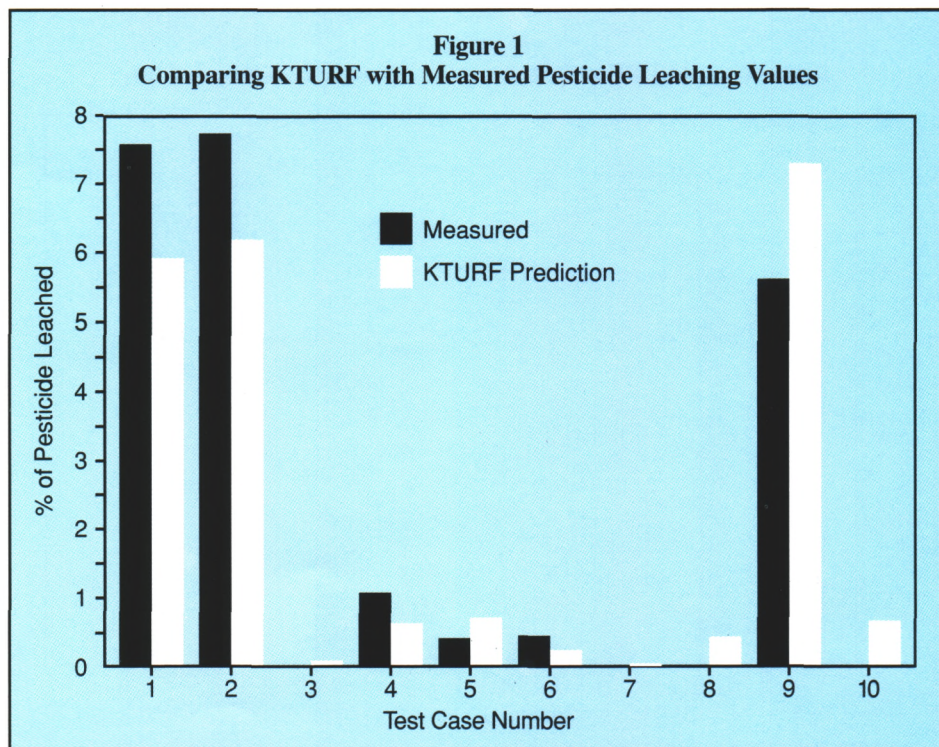
The output forms also display the variables entered to ensure the submitted data were correct. The output

value provided is an estimated percentage of how much of the applied pesticide leached.

A model applicable for pesticide leaching under green conditions is currently under development.

Range of Application

KTURF was developed from experimental data collected primarily in



Iowa. The soil used was in an undisturbed condition; therefore, many macropores (earthworm burrows, soil cracks, etc.) existed. The soil moisture content was at field capacity. If your soil moisture conditions are extremely dry, then little of the applied irrigation will leach below 50cm. If your soil moisture conditions are near saturation, then most of your applied irrigation will leach below the rootzone. KTURF was

not developed with these extreme conditions; therefore, its predictions will not be realistic for those conditions.

Conclusion

Using the interactive version of KTURF is advantageous compared to other more traditional distribution methods that are available. Accessing KTURF via the internet allows the user to use the most up-to-date versions

available. Program changes are available instantaneously, rather than waiting for a diskette to be mailed. Also, responses to user feedback will be provided more quickly by e-mail than by postal letter or telephone.

The KTURF model is an accurate, reliable method to approximate the percentage of applied pesticide and nitrogen that will leach through turfgrass-covered soil. Used as an assessment tool, KTURF can help to reduce pesticide leaching by allowing users to experiment with different pesticide/irrigation schemes. Turfgrass managers can thus optimize their practices to reduce the likelihood of pesticide leaching beyond the rootzone. The KTURF site is located at:

<http://www.eece.ksu.edu/~starret/KTURF/>

References

- National Center for Supercomputing Applications. 1996a. <http://ncsa.uiuc.edu/General/Internet/WWW/HTMLPrimer.html>.
- National Center for Supercomputing Applications. 1996b. <http://ncsa/uiuc.edu/General/Training/PerlIntro/>.
- Randal L. Schwartz. 1993. Learning Perl. O'Reilly and Associates.
- Mike Smith. 1995. <http://snowwhite.it.brighton.ac.uk/~mas/mas/courses/html/html.html>.
- S. K. Starrett, N. E. Christians, and T. Al Austin. 1996. Comparing Dispersivities and Soil Chloride Concentrations of Turfgrass-Covered Undisturbed and Disturbed Soil Columns. *J. of Hydrology*. 180:21-29.
- S. K. Starrett, N. E. Christians, and T. Al Austin. 1996. Movement of Pesticides Under Two Irrigation Regimes. *J. Environ. Qual.* 25:566-571.
- S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Fate of Nitrogen Applied to Turfgrass-Covered Soil Columns. *J. Irr. and Drain. Engg.* 121:390-395.
- S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Fate of Amended Urea in Turfgrass Biosystems. *Commun. Soil Sci. Plant Anal.* 26:1595-1606.
- S. K. Starrett, N. E. Christians, and T. Al Austin. 1995. Comparing Chloride Transport in Undisturbed and Disturbed Soil Columns Under Turfgrass Conditions. *Commun. Soil Sci. Plant Anal.* 26:1283-1290.

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Figure 3
Comparing KTURF with Anticipated Nitrogen Leaching Values

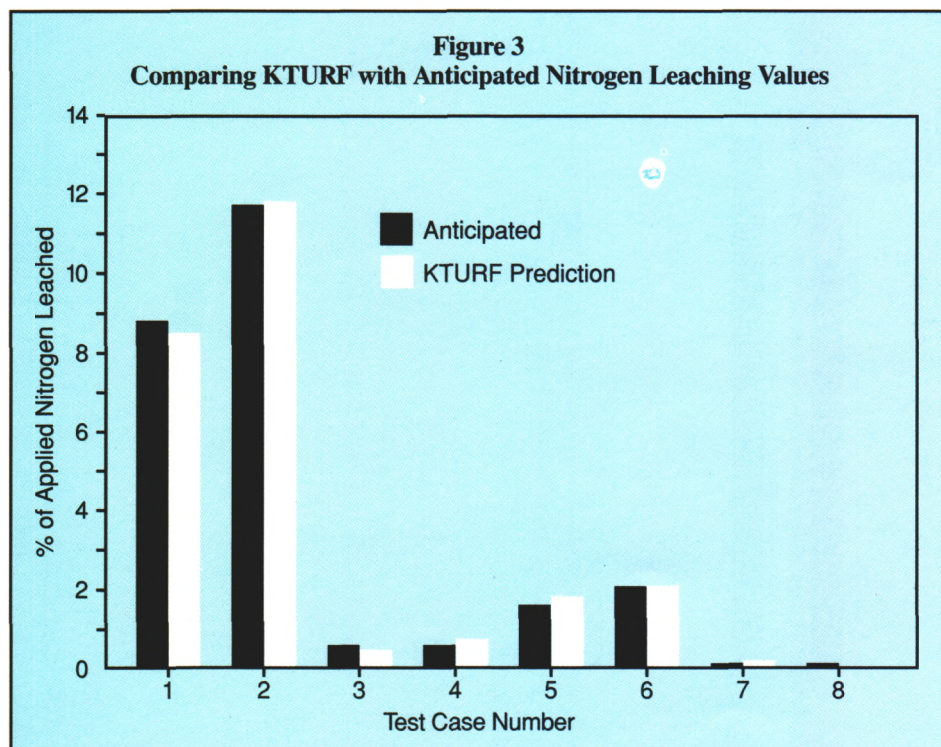
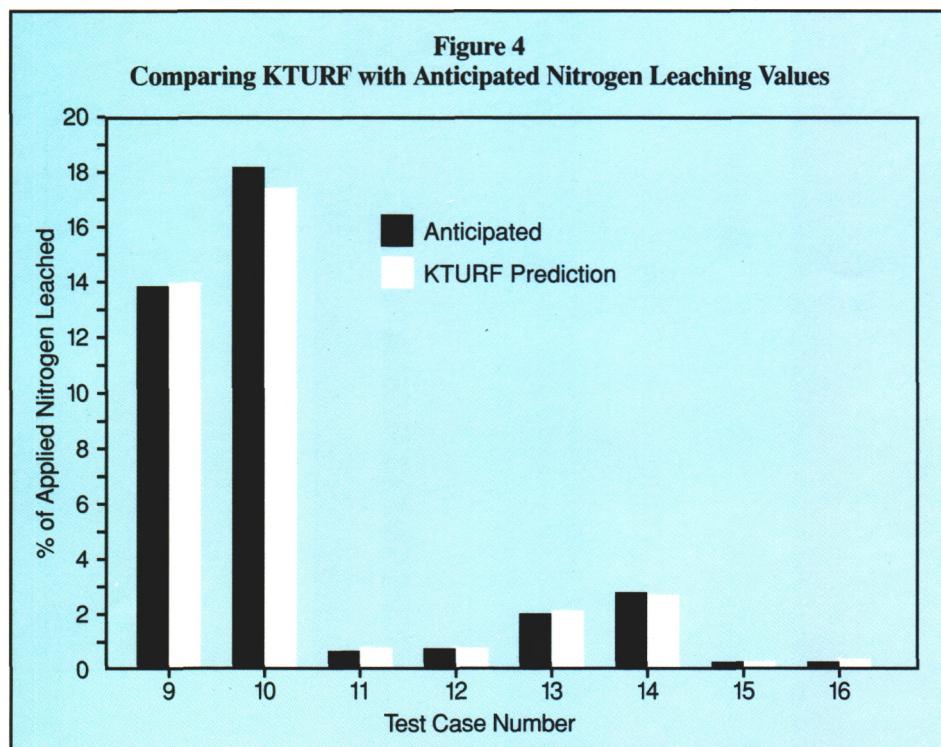


Figure 4
Comparing KTURF with Anticipated Nitrogen Leaching Values



Battling the Bermudagrass Blitz

Several key practices can help you win the war against bermudagrass encroachment.

by CHRIS HARTWIGER



Hybrid bermudagrass can encroach rapidly into a putting green.

MINIMIZING bermudagrass encroachment into bentgrass or bermudagrass putting greens is a constant challenge for golf course superintendents in warm-weather climates. The aggressive hybrid bermudagrasses commonly used on green surrounds can outcompete the bentgrass or bermudagrass used on the greens and often encroach into the putting surface. When this happens, playability can be affected and the original contours of the putting green perimeter can be lost.

A variety of chemical and cultural approaches have been used over the years in an attempt to manage encroachment problems. Unfortunately, many of these methods have had limited success. This article reviews the problems associated with bermudagrass encroachment and discusses the

relative effectiveness of different encroachment control strategies.

Understanding Bermudagrass Encroachment

It is easy to understand why bermudagrass encroachment is a problem on bentgrass and bermudagrass greens in southern climates. In the summer months, when bentgrass growth is slowed by high temperatures and/or humidity, the conditions for bermudagrass growth are optimal. Bermudagrass can and does encroach rapidly into bentgrass putting greens. Bermudagrass greens themselves do not offer much more resistance to encroachment. A more coarse and aggressive hybrid bermudagrass such as Tifway can move into a Tifgreen or Tifdwarf putting surface. After several years of encroachment, the size of a green can

decrease and the original design will be lost.

Collars

Superintendents often select the grass for putting green collars based on its resistance to encroachment. Zoysiagrass and bentgrass are popular choices on bentgrass greens. These grasses do not eliminate encroachment, but act as a buffer between the bentgrass putting surface and the bermudagrass surrounds to slow the movement of bermudagrass into the greens.

Before selecting a grass for the collar, it is important to understand the characteristics of each grass type. A bentgrass collar provides an excellent playing surface most of the year, but is more difficult to maintain in the summer than a zoysia or bermudagrass collar. Specifically, a higher mowing



The Greens Encroachment Barrier System is installed in 100-foot sections using a vibratory plow.

height on a bentgrass collar will result in a higher evapotranspiration rate. If the root system is limited and cannot meet the plant's demand for water, wilting can become an ongoing problem. This problem may be magnified by the composition of the soil under the collar. If the rootzone mix is tapered from the green to the collars, the varying mix depth will cause a change in available water to the plant. If some or all of the collar is grown on native soil, a similar water availability problem can occur. Putting green and collar water management under these circumstances is time consuming and labor intensive.

The use of zoysiagrass on collars has become popular in recent years. A properly maintained zoysiagrass collar is aesthetically pleasing and does not detract from playability. Since zoysiagrass is a warm-season grass, the water management difficulties associated with bentgrass are not as great a concern. If a zoysiagrass collar is established, there are a few challenges a superintendent must meet. First, the addition of a zoysiagrass collar creates an environment whereby there are three grasses with three different management requirements within a span of four to five feet. Balancing the water and nutrient needs of each grass within this small area is difficult. Excessive fertilization and watering are common problems on zoysiagrass collars. The slow recuperative rate of zoysiagrass is another concern that must be addressed. Effective management of mower and foot traffic during the fall, winter, and spring is essential to maintaining a high-quality zoysiagrass collar. Weak zoysiagrass will be slow to recover during the warmer months

and will be less competitive with the encroaching bermudagrass.

The use of bermudagrass on collars arguably will provide the best playing conditions with the lowest level of management intensity. A hybrid bermudagrass such as Tifway performs well at collar height, thrives on variable soil conditions, and recovers rapidly from injury. Historically, bermudagrass has not been a popular option due to the aggressive encroachment of the bermudagrass into putting greens. In the upper portion of the transition zone, winter injury on bermudagrass collars is a periodic problem as well. However, bermudagrass may become a more popular choice for putting green collars with the development of a new barrier system that is discussed later in this article.

On courses with bermudagrass greens, bermudagrass is the overwhelming and logical choice for the

collars. To discourage encroachment, most new courses and renovated courses have extended the bermudagrass variety used on the greens and collar at least five feet beyond the collar on all sides of the green. On some new bermudagrass courses designed with closely mowed green slopes in hot climates, the entire green complexes have been established with Tifdwarf. Encroachment in this scenario is highly unlikely.

Encroachment Control Measures

The type of grass used on collars will dictate the encroachment control methods that are available. Outlined below are several encroachment control methods currently being used throughout the South today.

Chemical Control: Chemicals such as Tupersan, Cutless, or Prograss have been used for many years to suppress bermudagrass encroachment in a bentgrass green. Dr. Bob Carrow and Dr. B. J. Johnson wrote an excellent article on this topic in the November/December 1991 issue of the *Green Section Record*. Remember that these chemicals offer a means to suppress bermudagrass in a bentgrass green or collar, but they will not eliminate the bermudagrass. Further, these chemical applications normally result in varying degrees of bentgrass thinning or discoloration.

Fusilade is the primary chemical used to suppress bermudagrass in a zoysiagrass collar. Initial use of this product on zoysiagrass collars has given excellent suppression of encroaching bermudagrass.

Cultural Methods: A wide variety of cultural methods have been used to



The 8-inch depth of the barrier blocks rhizome movement into the green and can act as a wicking barrier between green rootzone material and the soil in the surrounds.

prevent bermudagrass encroachment into bentgrass and bermudagrass greens. If a bermudagrass collar is in place, these methods traditionally have been the only means to manage encroaching bermudagrass since chemical control is not an option.

Mechanical Edging: Mechanical edging is a labor-intensive task that must be performed regularly throughout the bermudagrass growing season to maximize its effectiveness. This process can be performed in several ways. Some superintendents physically remove by hand any stolons encroaching into a green. Other superintendents prefer to use a mechanical edger to cut into the soil around the perimeter of the green to sever encroaching stolons or rhizomes. One of the inherent problems associated with mechanical edging is the creation of a new bermudagrass plant when a stolon or rhizome is severed. The majority of the severed stolons can be physically removed from a green or collar, but any severed rhizomes cannot be removed efficiently from beneath the soil. If this occurs, the severed rhizomes can initiate new roots and begin growing in the putting green or collar. When mechanical edging is used, it is extremely difficult to maintain the original perimeter of the green.

Resodding: Other golf courses have resigned themselves to periodic stripping of contaminated collars, followed by fumigation to eradicate the bermudagrass. Following fumigation, the contaminated areas are resodded. Surprisingly, some areas of bermudagrass may remain following fumigation. Considering the expense and disruption to play, this approach is not a practical and cost-effective solution for most courses.

Physical Barriers: Theoretically, the installation of a physical barrier would offer an effective means to control encroachment. Materials such as concrete, aluminum, plastic, and wood have all been used in attempts to stop bermudagrass encroachment. Until recently, the major problem associated with these barriers has been movement following installation and a subsequent disruption to play.

The Greens Encroachment Barrier System developed by Tom Waite appears to be an alternative to the older barrier methods. Mr. Waite has developed a heavy plastic barrier that will block encroachment. When installed, this molded plastic barrier extends eight inches into the soil. The molded



A line edger is one method used to prevent bermudagrass stolons from encroaching above the barrier.



barrier is characterized by a small "V" or channel.

This patented system corrects the previous problems associated with physical barriers. Mr. Waite overcame displacement problems by installing the barrier with a vibratory plow in 100-foot sections. Typically, three sections are needed for a green, and these sections are securely fastened together. Once the barrier is installed, it is extremely difficult to move. The eight-inch depth blocks the movement of rhizomes into the green. A reciprocating edger is used once or twice per week to prevent stolons from encroaching above the barrier.

Currently, many courses throughout the Southeast have installed the Greens Encroachment Barrier System. The barrier offers several other benefits in addition to providing an excellent means of encroachment control. Because the barrier is made of a heavy plastic, it can serve as a wicking barrier and help reduce the loss of water from sandy soils when they have direct contact with a clay or other fine-textured soil.

Further, the permanent nature of the barrier ensures that the perimeter of the green will not be lost. Mowing patterns will be more accurate and the green will retain its intended shape much longer than a green with no barrier. Finally, the barrier offers a realistic means to have a bermudagrass collar with little fear of encroachment. At a cost of approximately \$2,000 per green, the barrier is an excellent long-term investment and can eliminate the need for other expensive, time-consuming, and labor-intensive encroachment control measures.

Conclusion

Battling bermudagrass encroachment is difficult for all superintendents in warm climates. Battling encroachment begins with selecting an appropriate grass for the collars, understanding the methods available for control, and implementing a sound strategy.

CHRIS HARTWIGER splits his time as a USGA Green Section agronomist between the Southeastern and Florida Regions.

THE LIVING DEAD

Dead trees offer habitat and sustenance to all living things.

by RON DODSON



Gull Lake View Golf Course (Michigan) left cavity nesting trees standing during construction.

DEAD TREES? Why, you may wonder, shouldn't those dead trees on your golf course be cut down? What possible function can a dead tree serve? For wildlife, dead or partially dead standing trees (also called snags) serve as sites for nesting, shelter, and food for the living. Leaving dead and dying trees standing when they don't pose a safety concern will provide valuable resources to a wide range of wildlife species. Dead trees can also be used to mount bird houses, and by creating more nesting sites, you can increase the breeding success of cavity-nesting birds. Two main groups of wildlife can benefit from a tree snag program — primary cavity nesters and secondary cavity nesters.

Primary cavity nesters are those species that must make their own cavity nest by drilling or pecking it out of the wood of a tree. Secondary cavity nesters make their homes either in cavities made by primary cavity nesters or in holes that have been created by the process of natural decay or damage caused by wind or lightning.

It's good to leave as many snags on the golf course as possible. As a good rule of thumb, some forest managers recommend up to five dead or dying trees per acre. Some golf course managers, with guidance from the Audubon Cooperative Sanctuary System and by educating themselves, have started their own snag manufacturing projects. One method involves cutting away a strip of bark and some of the pithy underlying tissue of a tree to kill it. Others have pruned trees back to such an extent that they will die because of the lack of foliage.

These snags become areas of insect activity, fungal growth, and overall decay. This will attract insect-eating wildlife species, some of which will be primary cavity nesters. This could include all of the woodpecker species or nuthatches. Secondary cavity nesters, like chickadees, tufted titmice, brown creepers, as well as several species of larger birds such as the screech owl

and American kestrel, will also use these trees. Some of the larger trees, such as the shagbark hickory, also provide roosting and resting places for several species of bats. Bats are the single most important form of insect-eating wildlife that flies at night.

All of this insect-eating activity is just one benefit of a tree snag program — nature's own way of controlling pests. Once a snag falls to the ground, it continues to be beneficial to wildlife as a source of food and shelter, and it returns important nutrients to the soil. You may be able to use a fallen snag and other downed limbs, twigs, and debris as part of a brush pile, providing additional wildlife shelter and protection.

Do wildlife a favor and start a snag conservation program if you don't already have one. Develop a management strategy to retain snags in various stages and in a variety of habitats. Monitor snags for safety and development of undesirable pest problems. Provide additional nesting sites for birds by leaving snags as a source of shelter and food. Reduce the number of trees and limbs you have to dispose of by leaving them standing to help all of the cavity-nesting forms of wildlife that are looking for homes.

And, most important, educate your golfers about the economic and environmental benefits of leaving dead trees to enhance habitat and provide nature's resources for the living. Write a short article for your newsletter, post a sign on a snag explaining its natural resources, take slides and post photos to demonstrate the integration of nature's way as part of the golf course — a contribution to the environment as well as to the aesthetic uniqueness of the course.

RON DODSON is president of Audubon International, based in Selkirk, New York. He coordinates the "On Course With Nature" feature for the USGA Green Section Record.

BUYER . . . BEWARE

*Products without
active ingredients
may not be active!*

by STANLEY J. ZONTEK

CONSIDER THIS STORY. You're sitting in your office and you don't feel well. You go to your local drugstore to find something that you hope will make you feel better. You stand at the shelf and pick up a product called "Makes You Feel Good." Next to it is another product called "Makes You Feel Very Good." What is your first impulse? You read each label to check their active ingredients. You base your purchase decision on what is contained in the product. This is being a smart consumer, and it makes good common sense.

Consider this story. You're sitting in your office and your turfgrass is under stress. It does not feel well. In walks a salesman with a product or series of products that, according to the salesman, will solve your problem and make your grass perform better.

You ask the salesman, "What's in your product?" The answer could include any number of materials that sound interesting or even logical. You look at the label. Sometimes there is a list of items or benefits like "complex carbohydrates, bio-stimulants, all-natural ingredients, stimulates beneficial microbes," etc. Sounds good, but does it work? While there may be a list of ingredients, are *active ingredients* and nutrient percentages clearly stated or defined on the label? There is a difference.

Think about this for a second. *If no active ingredients are claimed on the label of a product, there may not be anything active in the product!*

You ask, "Who else has used this material?" The salesman responds with a long list of turf managers (usually at the best courses in the area) who have purchased the product and who are, according to the salesman, raving about how well it performs.

Your next question may be, "Has your product been tested by a university?" This is where it can get interesting. Normally, some sort of diplomatic answer is given like, "Well, no, but," or "We are trying to interest a few universities in doing some research." (Believe me, almost any university, for a fee, will test any material.)

You are concerned about the health of your grass, so why not give it a try? You reason that it won't hurt anything; after all, it is natural and just maybe it will help your grass.

All too often, a decision to use a product is based upon testimonials, claims by the salesman, and/or a list of interesting ingredients without clearly knowing how the product actually functions. This may not be wise. It can also be expensive.

I am seeing a trend in our industry to use more and more "feel good" products, many of which claim no active ingredients. Yet, these products have a long list of claims on the product label — claims, by the way, that do not have to be proven because there are no active ingredients. Let me repeat this point. There seems to be a proliferation of materials available to the turf manager that claim any number of benefits on the label, but actually con-

tain no active ingredients! Think about it.

One respected plant pathologist calls these products *muck and magic* materials. In the past, these materials were simply referred to as *snake oils*.

The purpose of my opinion article is simple. I want to remind you, the turf manager, that:

A. One of the most common sales techniques is to use testimonials, not science. It is easy to claim that a product improves turf quality or solves a problem. However, independent university testing under varied conditions is needed to verify these claims.

B. Active ingredients are just that; they are chemicals that do a job. Don't confuse a simple list of ingredients with a list of *active ingredients*. I am constantly amazed, when reading labels, how many claims are made without a list of active ingredients! I once heard a fellow say, "But will it do any harm?" The answer is, "Probably not." The real question is, however, "Does it do any good?"

C. When looking at a list of ingredients, it is important to know how much material is actually contained in that product. This is especially important for nutrients. When the need exists, is it more cost effective to spray calcium, for example, onto grass at a rate of only several pounds per acre, or apply lime or gypsum at several hundred to several thousand pounds per acre? It may be a lot cheaper and more effective, in the long term, to use tried-and-true bulk materials versus products that contain only a few pounds of material on a per-acre basis. Are we losing sight of the basics?

D. The final purpose of this opinion article is to remind the turf manager to always remember the basics. Never try to do with a *feel good* chemical what aeration, topdressing, balanced fertility, good water management, and reasonable mowing heights can accomplish.

The late Professor Lawrence S. Dickinson, from the University of Massachusetts, said it best: "Let grass grow, don't make it grow." Those are good words to live by. You cannot find this wisdom in a bottle, especially one without any active ingredients!

STANLEY J. ZONTEK is the director of the Green Section's Mid-Atlantic Region.

United States Golf Association Green Section Education Conference



Tuesday, February 11, 1997, 1:00 - 3:45 p.m.
Las Vegas Convention Center, Room N250
Las Vegas, Nevada

Teaching Young Dogs Old Tricks

Moderator: James T. Snow, National Director, USGA Green Section

1:00 p.m. Welcome

Joe England, USGA Executive Committee

1:15 p.m. Dedman Curves

Robert Dedman, CEO, Club Corporation

As head of one of the largest golf course management companies, Mr. Dedman successfully applies many principles for achieving success in the golf course industry. He will discuss his techniques for working with and motivating people.

1:45 p.m. The Best Turf Tips from the Green Section Staff

Patrick O'Brien, Director, Southeastern Region

Matt Nelson, Agronomist, Northeastern Region

John Foy, Director, Florida Region

2:00 p.m. Sage Advice from a Young Pup

Bill Bengeyfield, National Director, USGA Green Section, 1982-1990

In his 34 years with the Green Section, and many other activities in the golf industry, Mr. Bengeyfield has espoused sound golf course management practices worldwide. He will share recurring ideas from his many experiences that are still important today.

2:30 p.m. More of the Best Turf Tips

Paul Vermeulen, Director, Mid-Continent Region

Bob Vavrek, Agronomist, North-Central Region

Mike Huck, Agronomist, Western Region

Stanley Zontek, Director, Mid-Atlantic Region

2:50 p.m. That's Why They Call Them SUPERintendents

Judy Bell, President, United States Golf Association

The president of the USGA talks about how golf course conditions have changed from her early playing days, and about how she sees golf evolving in the years ahead.

3:20 p.m. The Best Turf Tips Just Keep on Coming

David Oatis, Director, Northeastern Region

Bob Brame, Director, North-Central Region

Larry Gilhuly, Director, Western Region

3:35 p.m. Closing Remarks

1997 GREEN SECTION NATIONAL & REGIONAL CONFERENCES

NATIONAL CONFERENCE

February 11	Las Vegas Convention Center	Las Vegas, Nevada
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FLORIDA REGION

April 14	Orlando Airport Marriott	Orlando, Florida
April 17	Palm Beach Gardens Marriott	Orlando, Florida

MID-ATLANTIC REGION

March 20	Woodholme Country Club	Baltimore, Maryland
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MID-CONTINENT REGION

March 6	Dallas Athletic Club	Dallas, Texas
March 11	Old Warson Country Club	Ladue, Missouri
March 12	GCSAA Headquarters	Lawrence, Kansas
April 1	Des Moines Golf & Country Club	Des Moines, Iowa

NORTH-CENTRAL REGION

March 25	The American Club	Kohler, Wisconsin
March 27	Meridian Hills Country Club	Indianapolis, Indiana

NORTHEASTERN REGION

March 11	Country Club of Rochester	Rochester, New York
March 18	Marriott Windwatch Hotel	Hauppauge, New York

SOUTHEASTERN REGION

March 25	Carmel Country Club	Charlotte, North Carolina
April 22	Springhouse Golf Club at the Opryland Hotel	Nashville, Tennessee

WESTERN REGION

March 5	Sheridan Holiday Inn	Sheridan, Wyoming
March 20	Indian Summer Golf & Country Club	Lacey, Washington
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March 31	Industry Hills Golf Course	City of Industry, California
April 1	TPC Summerlin	Las Vegas, Nevada
April 2	Castlewood Country Club	Pleasanton, California
April 3	Moon Valley Country Club	Phoenix, Arizona
April 7	Waialae Country Club	Honolulu, Hawaii



The Proof of a Golfer

by EDGAR GUEST

The proof of the pudding is the eating they say,
But the proof of a golfer is not
The number of strokes he takes in a day
Or the skill he puts into a shot.
There is more to the game than the score which you make
Here's a truth which all golfers endorse:
You don't prove your worth by the shots which you make;
But the care which you take of the course.

A golfer is more than a ball-driving brute
He is more than a mug-hunting czar.
To be known as a golfer, you don't have to shoot,
The course of your home club in par.
But you do have to love every blade of the grass,
Every inch of the fairway and greens.
If you don't take care of the course as you pass,
You're not what "a good golfer" means.

Just watch a good golfer some day when you're out,
And note what he does as he plays,
He never goes on leaving divots about,
Till the grass is put back, there he stays.
Observe him in traps as he stands for his shot,
Then note when the ball has been played,
He never unthinkingly turns from the spot,
Till he's covered the footprints he made.

You may brag of your scores and may boast of your skill,
You may think as a golfer you're good;
But if footprints you make, in traps you don't fill,
You don't love the game as you should.
For your attitude unto the sport you enjoy,
Isn't proven by brilliance or force;
The proof of a golfer — now get this my boy,
Is the care that you take of the course.



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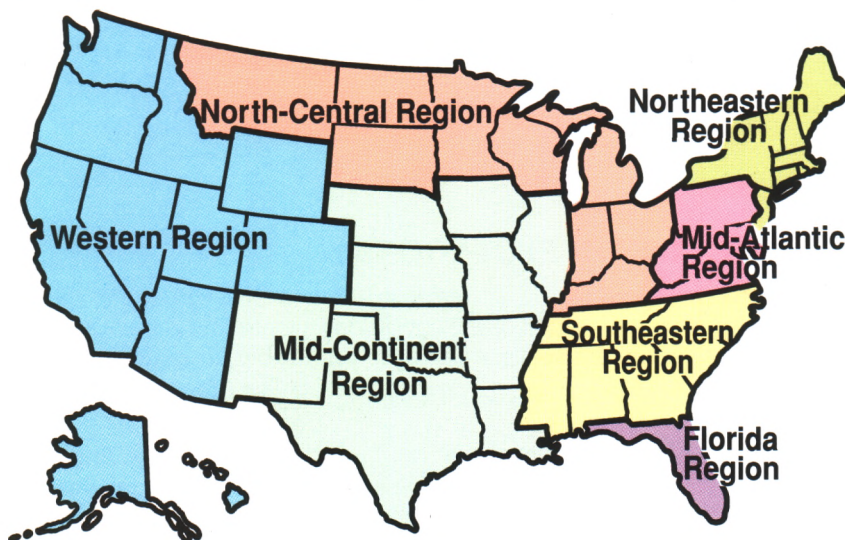
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TURF TWISTERS

MEET HIGH EXPECTATIONS

Question: The golfers at my course have very high expectations, but they don't give me the budget I need to achieve the conditions they desire. Is there an objective way to determine what is a realistic level of maintenance based on our budget? (California)

Answer: Developing a set of golf course maintenance standards can help reconcile the needs of the golfers with your available resources. The superintendent and course officials should work together to develop the guidelines, which should include such items as recommended mowing frequencies, a range of suitable mowing heights, bunker maintenance, course marking, tree pruning, course cleanup, and all other maintenance activities. It is then possible for the superintendent to determine the number of labor hours and resources needed to meet the desired goals and match this with the current budget. In this way, the course officials can see what it actually takes to maintain the golf course, after which they can set priorities accordingly.

BY PROVIDING VIABLE ALTERNATIVES

Question: Is overseeding fairways with *Poa trivialis* a viable alternative to avoid spring transition problems? (Arizona)

Answer: Some courses have had fairly good results overseeding fairways with *Poa trivialis* at the rate of 90 lbs. to 100 lbs. per acre. Although the seed is more expensive per pound, it generally is planted at $\frac{1}{3}$ to $\frac{1}{4}$ the rate of perennial ryegrass. *Poa trivialis* will not produce the same brilliant green color as perennial ryegrass; however, the newer cultivars have acceptable winter color without causing significant spring transition problems. It is important to note that *Poa trivialis* generally takes longer to germinate and may totally transition in the spring before bermudagrass resumes active growth. If your goal is to avoid transition problems, you may wish to try *Poa trivialis*. If winter color is the primary concern, you may be better off overseeding with perennial ryegrass at a reduced rate.

TO TRAFFIC TROUBLES

Question: The daily-fee golf course I manage receives about 50,000 rounds of golf a year. Needless to say, wear injury from cart traffic is a problem. I have tried requiring carts on paths at certain times, but the golfers loudly object and it seems like this policy is more trouble than it is worth. Any suggestions for this problem? (Florida)

Answer: A good solution would be to require carts on the path on one hole on the front nine and one hole on the back nine each week. After nine weeks, each hole has received a reduction in traffic of approximately 11 percent. This policy should be started early in the season before cart traffic has caused significant problems. Of course, during extremely wet periods, requiring carts to remain on the path is needed to protect the course from severe damage.