1986
ANNUAL TURFGRASS RESEARCH REPORT

SUBMITTED JOINTLY BY:

United States Golf Association
Golf House
Far Hills, New Jersey 07931

Golf Course Superintendents Association of America
1617 St. Andrews Drive
Lawrence, Kansas 66046

United States Golf Association **Green Section**

National Director
WILLIAM H. BENGEYFIELD

USGA
FRANK HANNIGAN
Senior Executive Director

Box 3375
Tustin, CA 92681
(714) 544-4411

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TO: THE READERS OF THE 1986 ANNUAL TURFGRASS RESEARCH REPORT

"From research, new knowledge flows unendingly." This began a USGA Green Section brochure in 1951. Thirty-five years later, the same truth remains. 1968 has been a year of significant progress for the USGA / Golf Course Superintendents Association joint program for the Development of Minimal Maintenance Turfgrasses for Golf. The ultimate goal is a 50 percent reduction in water use and 50 percent lower maintenance costs overall--based on 1982 figures. New knowledge does flow unendingly from research and this has been a banner year.

Attached are the Annual Executive Reports prepared by each of the researchers involved in this program. The reader will gain an understanding of direction and individual progress. To those USGA Capital Campaign Donors who may wish a copy of any of the complete, scientific reports, including accounting of all expenses, they are available on request.

In addition to the reports attached, the Research Committee offers its own capsuled appraisal of the overall program in these paragraphs. For example, there is strong conviction that each major project must receive a direct, on-site, annual personal visit by Committee Members. We believe the value of such visits is undeniable and essential to success. In 1986, every major project and all but two of the smaller grants were directly visited at least once by one or more members of the Committee. I would point out here that the Committee is comprised of appointed but unpaid volunteer members. It is easy to see therefore, the commitment and unselfish interest these individuals have in the future improvement of turfgrasses for golf! In 1986, they administered a budget of $440,000.

In regard to the Plant Breeding projects, particular note is due the Poa annua and Buffalograss programs. Several superior selections of Poa annua have shown dark green color, dense turf and limited seed head formation through last spring, summer and fall. These selections will be distributed to other USGA investigators

USGA

throughout the country for stress and evaluation. Several newly selected clones of Buffalograss have not only produced better than expected turf quality, but may possibly be adapted to a larger area of the country than originally thought.

The bentgrass, bermudagrass, zoysiagrass and native grass breeding projects are also poised with exciting, new varietal possibilities. I wish you could see some of the new cultivars now under development at these stations. There are no guarantees any of them will survive the tests ahead, but in each species, the potential for improvement is obviously present and is being exploited.

In the study of plant stress mechanisms, never before known facts on the turfgrass root hairs, stomates, etc. have been discovered and these will be of incalcuable value to future plant breeding. The Turfgrass Research Library at Michigan State University now has a data base of over 9000 entries and is available to all interested parties by calling [517] 353 7209. Ask for Peter Cookingham, or write him in care of the Turfgrass Information Center, W-212 Library, Michigan State University, East Lansing, MI 48824. This facility is ready to serve you.

So much is going on in the cultural practices area of research, I can only refer you to the interesting reports contained herein. One study, for example, is concerned with the competitive ability of Poa annua and creeping bentgrass. After three years of clipping removal from fairway test plots, Poa annua was actually decreased by 22.6%.

The Research Committee believes the program is on target and moving not only with assurance, but with gathering momentum toward its stated goals. Plans have already been made to bring all involved USGA/GCSAA major researchers together next summer for a two-day conference and exchange of techniques, data and progress. During this time, a visit will also be made to one of the most advanced commercial bio-technology laboratories in this country.

It is this kind of interaction and cooperative effort you have made possible through your generous donation and gifts directly to turfgrass research through the USGA Capital Campaign. Golf Keeps America Beautiful! Our Committee invites and welcomes your evaluation, your suggestions and your guidance. It is important to us and, we believe, to the future of The Game.

Sincerely,

Bill

William H. Bengeyfield
Chairman, Turfgrass Research Committee
and National Director, USGA Green Section

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USGA TURFGRASS RESEARCH

PROJECT	SUBPROJECT	UNIVERSITY/INVESTIGATOR	PRIOR YEARS ACTUALS 1983	1984	1985	1986	1987 BUDGET	FIVE YEAR TOTALS
STRESS MECHANISMS		Texas A&M-Coll.Sta/Beard	84,500	87,000	91,000	73,000	60,000	395,500
		SUBTOTALS:	84,500	87,000	91,000	73,000	60,000	395,500
TURFGRASS RESEARCH LIBRARY		MI State/Chapin	5,000	96,326	68,000	55,000	65,000	289,326
		SUBTOTALS:	5,000	96,326	68,000	55,000	65,000	289,326
TURFGRASS BREEDING I	Zoysiagrass	Texas A&M/Engelke	2,500	42,585	42,000	40,000	40,000	167,085
	Native Grass	Univ of NE/Riordan	0	4,100	20,000	18,000	18,000	60,100
	Native Grass	CO State/Ceany	0	0	10,000	20,000	20,000	50,000
	Poa Annua	Univ of MN/White	0	11,600	15,000	15,000	20,000	61,600
	Colonial Bentgrass	Rutgers/Funk	5,000	5,000	5,000	5,000	5,000	25,000
		SUBTOTALS:	7,500	63,285	92,000	98,000	103,000	363,785
CULTURAL PRACTICES	Soil Compaction	MI State/Rieke	3,000	3,000	3,000	5,000	0	14,000
	Management	WA State/Brauen	0	1,243	1,000	0	0	2,243
	Management	MI State/Branham	0	0	10,000	15,000	15,000	40,000
	Management	OH State/Danneberger	0	0	0	15,000	15,000	30,000
	Management	Univ of GA/Carrow	0	0	0	15,000	15,000	30,000
	Water	Texas A&M/Horst	0	3,480	15,000	15,000	15,000	48,480
	Rooting	Univ of NE/Shearman	0	4,000	23,000	20,000	20,000	67,000
	Pathology	MI State/Vargas	0	1,500	0	0	0	1,500
	Pathology	Cornell/Petrovic	0	1,500	0	0	0	1,500
	Pathology	Cornell/Smiley	0	0	7,000	0	0	7,000
	Pathology	Texas A&M/Colbaugh	0	0	0	0	10,000	10,000
	Pathology	Ohio State/Shane & Nameth	0	0	0	0	10,000	10,000
	Pathology	NC State/Lucas	0	0	10,000	10,000	10,000	30,000
		SUBTOTALS:	3,000	14,723	69,000	95,000	110,000	291,723
TURFGRASS BREEDING II	Bermudagrass	Univ of GA/Burton	5,000	5,000	5,000	5,000	5,000	25,000
	Bermudagrass	NM State/Baltensperger	0	4,500	20,000	20,000	20,000	64,500
	Bermudagrass	OK State/Brede	0	0	0	20,000	0	20,000
	Bentgrass	Penn State/Duich	4,000	4,000	4,000	4,000	4,000	20,000
	Bentgrass	Univ of RI/Skogley	1,500	1,500	1,500	1,500	5,000	11,000
	Bentgrass	MS State/Krans	2,500	2,500	0	0	0	5,000
	Bentgrass**	Texas A&M/Dallas/Engelke	0	0	47,000	40,000	40,000	127,000
	Bentgrass	New Zealand DSIR/Rumball	0	0	0	10,000	10,000	20,000
		SUBTOTALS:	13,000	17,500	77,500	100,500	84,000	292,500
ADMINISTRATION		Cte. Mtgs. & Inspections	13,500	13,766	17,500	18,500	28,000	91,266
		SUBTOTALS:	13,500	13,766	17,500	18,500	28,000	91,266
		GRAND TOTALS:	126,500	292,600	415,000	440,000	450,000	1,724,100

** Matching grant by Bentgrass, Inc.: $20,000/year

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USGA/GCSAA TURFGRASS RESEARCH PROGRAM

1986 SUMMARY OF RESEARCH

COLORADO STATE UNIVERSITY - Dr. Robert L. Cuany
Principal Investigator

Development of Dryland Western Turfgrass Cultivars

1986 Grant - $20,000 [second year of support]

Colorado State University, with principal support from the United States Golf Association, has continued research and selective breeding efforts in the development of new cultivars with improved turf performance of four western grass species. The species being evaluated and improved are alkaligrass [*Puccinellia* spp.], blue grama [*Bouteloua gracilis*], fairway wheatgrass [*Agropyron cristatum*] and inland saltgrass [*Distichlis stricta*]. Changing economic conditions and increasing demands upon limited water supplies make a strong demand upon breeders to supply special purpose grass cultivars for golf courses, parks, lawns and other turf applications. The species under study possess some unique and promising characters that will allow the breeding project to develop new cultivars for minimum maintenance turf on such problem areas as salt affected, poorly drained or droughty soils.

Alkaligrass, a species highly tolerant of salt and waterlogged soils, has been evaluated this year in a nursery of approximately 900 individual plants from six western states and five foreign countries. Two turf seeding test plots also serve to evaluate seeding rates and the performance of various sources in a turf maintenance situation. Seed production of these plants was good, and in 1987 we should select elite parent plants for production of the first generation improved plants.

Blue grama is the dominant drought tolerant grass in many of the western grasslands, and an improved turf type cultivar should do well on the alkaline western soils with a minimum of care. Collections from three western states have been evaluated, and in 1986 twenty-seven superior plants were selected from the nurseries and moved to an isolated block which will produce seed in 1987 for the first generation of the population of improved plants.

Fairway wheatgrass is another drought tolerant grass commonly found in wild stands in the West. It evolved in Eurasia but has proven to be well adapted to our continent since its importation in the 19th Century. The grass does not normally spread by rhizomes [underground horizontal shoots] as in such turf species as Kentucky bluegrass. We have evaluated 650 plants from Turkey, Iran and this country that do show a certain amount of rhizome growth. Based upon that characteristic and other selection criteria, 78 individuals were selected in 1986 to act as parents in an isolated block to produce the first improved turf type plants in 1987.

Inland saltgrass is a species that spreads vigorously by rhizomes to form dense stands that will tolerate salty, waterlogged or droughty soils. Collections from eight western states have been evaluated as space-planted individuals and in a turf planting. Selections will be made in 1987 from the nursery in order to produce the first advanced generation from the most promising and adaptable material.

<u>UNIVERSITY OF GEORGIA</u> - Dr. Glenn W. Burton
Principal Investigator

<u>Bermudagrass Breeding - Vegetative</u>

1986 Grant - $5000 [ongoing since 1956]

USGA support of Dr. Burton's work, since 1956, has been one of the most successful turfgrass research breeding projects in the history of agriculture! His improved bermudagrass varieties include Tifgreen [Tifton 328], Tifgreen II, Tifway [Tifton 419] and Tifdwarf to name but a few. His emphasis now is to try to increase winter hardiness of the Tif-turf bermudagrass hybrids that have been so well received on warm-season-grass golf courses throughout the world.

Efforts to obtain new germplasm from winter hardy bermudagrasses in South Africa continues to be frustrating. Such material is obviously present in South Africa, but Dr. Burton and co-worker Dr. Hanna have been unable to procure any of it through long distance communications although valiant efforts have been made. Eventually, someone may have to specifically travel to South Africa for this purpose.

Some plants from crosses between the winter hardy Berlin bermudagrass and the most winter hardy *C. transvaalensis* from New Jersey trials have been developed and planted for observations during the summer of 1986. These plants will now be placed under putting green conditions and a screening procedure is planned for further winter hardiness tests. The Country Club of Blairsville, Georgia is an ideal mountain location where temperatures below 0 with little snow cover can usually be expected.

A number of better quality mutants selected from Midiron bermudagrass several years ago have been maintained at Blairsville in 1985 and 1986 at two different cutting heights. They all survived the past mild winter there when temperatures were not low enough to sufficiently stress or destroy any of them.

Efforts to produce an armyworm-resistant bermudagrass continue but without earth shaking progress. Dr. Bob Lynch, USDA entomologist, found a slight resistance to armyworms in one selection out of 500 plants collected mainly from South Africa, but there has been little progress in transferring this resistance to the triploid hybrids.

Last summer a California landscape contractor contacted Dr. Burton regarding the establishment of bermuda turf in a large housing development. The specifications called for use of a bermudagrass that would shed no pollen. Of course, common bermudagrass pollen is one of the worst for people suffering from asthma and hay fever. However, Dr. Burton's Tif-turf bermudagrass hybrids are sterile, produce no pollen and therefore perfectly safe for use as the turfgrass cover on such projects. Again, the spin-off of research for better golf course turfs has benefitted all mankind.

UNIVERSITY OF GEORGIA - Dr. Robert N. Carrow
Principal Investigator

Influence of Soil Moisture Level on Turfgrass Water Use and Growth

1986 Grant - $10,000 [first year of support]

One means of conserving water on turfgrasses is to reduce irrigation frequency; thereby, allowing the turfgrass to undergo a greater degree of drought stress before irrigation. By evaluating turfgrass performance under non-limiting to moderate moisture stress conditions, minimum water use requirements for a given level of turfgrass quality can be formulated. Also, the measurement of physiological and morphological plant responses will provide insight into drought avoidance and tolerance mechanisms for the three warm season grass species in this study.

During 1986, twenty-seven research units were installed under field conditions. Each unit had individually controlled irrigation capability. Moisture sensing probes were installed at three soil depths to monitor water extraction relative to rooting patterns. The three grasses [Tifway bermudagrass, Meyer zoysiagrass, and common centipedegrass] were established with each species irrigated under a range of soil moisture from non-limiting [soil = -0.40 b] to moderate stress [soil = -9.0 b]. Detailed measurements of water use and growth parameters were initiated several times starting in mid-July. However, the TDR unit used to determine soil water content did not function properly and was returned to the manufacturer for upgrading. Intensive data collection is scheduled by 1987 and 1988 growing seasons. All scientific equipment to be provided by the University of Georgia in this joint project has been obtained and a graduate research assistant has been assigned to the project.

UNIVERSITY OF GEORGIA - Dr. Robert N. Carrow
Principal Investigator

Cultivation Methods on Turfgrass Water Relationships and Growth Under Soil Compaction

1986 Grant - $5000 [first year of support]

Soil compaction can increase water use on recreational turfgrass sites by 25 to 50%, primarily by promoting light, frequent irrigation due to low water infiltration rates. Evaporation losses are enhanced by the moist soil surface in conjunction with an open canopy that is often warmer from solar radiation absorbed by the soil. Also, water losses may occur by greater runoff or leaching beyond the shallower root systems compared to noncompacted turfgrasses.

The primary cultural tool to help alleviate soil compaction is cultivation. During 1986, we initiated a research project to study the relative effectiveness of five cultivation techniques in alleviating compaction stress with particular emphasis on factors influencing water use efficiency. Since compaction affects water relations, each treatment/replication combination required a research plot that could be irrigated separately from all others. This system was installed and grassed with Tifway bermuda. Respective plots have been subjected to compaction several times and cultivation treatments applied twice. These treatments will be continued with intensive data collection in 1987 and 1988. In this joint project between the University of Georgia and USGA, all scientific equipment and technician support to be provided by University of Georgia has been obtained.

MICHIGAN STATE UNIVERSITY - Dr. Bruce Branham
Principal Investigator

The Effect of Seven Management Factors and their Interaction on the Competitive Ability of Annual Bluegrass and Bentgrass

1986 Grant - $15,000 [second year of three year study]

A three year study was completed in the fall of 1986 measuring the effects of five cultural practices on the competition between annual bluegrass and creeping bentgrass maintained under fairway conditions. The five cultural practices were irrigation [daily at 75% replacement of open pan evaporation [OPE], 3x/week at 100% OPE, and irrigation at wilt], clippings removed or returned, nitrogen fertility level [2 lb N/M/YR or 6 lb N/M/YR], plant growth regulator treatment [mefluidide 1/8 lb/A, fluriprimidol 1.0 lb/A and a control] and overseeding with 'Penncross' creeping bentgrass or no overseeding.

The results show that clipping removal is the single most important factor, in terms of increasing creeping bentgrass populations, of the variables studied. Over a three year period removing clippings resulted in a 22.6% decrease in annual bluegrass where as returning clippings resulted in a 9.5% decrease.

The other significant main effect was bentgrass overseeding. While not significant over any single year, when averaged over three years overseeding resulted in a highly significant 18.1% decrease compared to a 14.1% decrease without overseeding.

Lowered nitrogen fertility resulted in a significant annual bluegrass decline in one of the three years, however, when averaged over all three years no effect was seen due to lowered N fertility. This points to a significant effect due to environmental interactions. Neither plant growth regulator treatment nor irrigation treatment played a significant role in annual bluegrass reduction.

Another study was concerned with the effects of compaction [compaction and no compaction] and coring [no coring, coring 1x/YR, and coring 3x/YR] on annual bluegrass and creeping bentgrass competition. Over a two year period, compaction resulted in significantly more annual bluegrass in the compacted plots than in plots receiving no compaction. Compacted plots saw a 6.1% decrease in annual bluegrass compared to a 16.3% decrease for non-compacted plots.

A separate two year study comparing flurprimidol rates and timings has shown no significant effects on the competition between annual bluegrass and creeping bentgrass. All of these studies confirm a previously held principle that creeping bentgrass is a more aggressive species than annual bluegrass. This is seen in our studies where we quantitatively measure the distribution of these species and in each year the overall species composition increased by several percentage points in favor of creeping bentgrass. However, because of annual bluegrass's unique ability to reseed itself, it can rapidly fill in any void left from disease, insect or other damages. Clipping removal is the best method for reducing annual bluegrass from fairway turf.

<u>MICHIGAN STATE UNIVERSITY</u> - Dr. Richard E. Chapin
Principal Investigator

<u>Turfgrass Information Center</u>

1986 Grant - $55,000 [fourth year of ongoing support]

In the spring of 1984, the USGA and Michigan State University signed an agreement whereby the MSU Library would design and develop a bibliographic computer database to provide access to published materials reporting the results of research that affects turfgrass and its maintenance.

The original statement of purpose of the USGA Turfgrass Information Center was to provide efficient and effective access to all published and processed materials reporting the results of research affecting turfgrass and its maintenance. Three goals were identified as necessary for the successful completion of the Project.

1. Michigan State University continues to acquire, maintain, and preserve all appropriate printed and processed materials reporting on research related to turfgrass growth, development, and maintenance.

2. Bibliographic access to the turfgrass collection is provided by on-line access to the Project's retrieval system. The Turfgrass Information File is housed in an ALPHA MICRO computer, using STAR software. Both the hardware and software work well. By June 30, 1986, 8,300 records were in the database.

3. Michigan State University Library continues to search telephone requests on demand and provide a custom bibliography to users, provide loans or appropriate photocopies for those needing access to the collection, and to finalize arrangements for direct remote access to the file, including software and documentation.

MICHIGAN STATE UNIVERSITY - Dr. Paul E. Rieke
Principal Investigator

Hollow and Solid Tine Cultivation Effects on Soil Structure and Turfgrass Root Growth

1986 Grant - $5000 [fourth and last year]

Hollow and solid tine cultivation effects as influenced by soil compaction and moisture content during cultivation were evaluated on the basis of soil structural qualities and root growth.

As expected, compaction resulted in pronounced detrimental effects on soil structure and root growth. Both cultivation methods resulted in positive and negative effects on soil structure. Cultivation increased the amount of large soil pores with hollow tine coring being the most effective in producing this response. Regardless of compaction level, solid tine cultivation increased the amount of intermediate sized pores when compared to hollow tine cultivation. Therefore, hollow tine cultivation produced the most beneficial changes in soil porosity.

Soil strength within the zone of cultivation [surface 2-3 inches] was reduced after cultivation. Initially, solid tine cultivation was more effective in loosening the surface soil than hollow tine cultivation, however this effect was reversed by the end of this study. Water conductivity rate dropped dramatically after cultivation, indicating compaction at the bottom of the cultivation zone restricted water flow.

Compaction stress decreased root growth while cultivation had a limited effect on root growth. Cultivation decreased surface rooting in noncompacted soil but had no influence on rooting in compacted soil in November, 1985. Cultivation in noncompacted soil tended to increase rooting in June of 1986 but again, had no effect on rooting in compacted soil. Throughout the study, hollow tine cultivation ranked equal to or higher than solid tine cultivation in visual quality.

UNIVERSITY OF MINNESOTA - Dr. Donald B. White
Principal Investigator

Breeding of Poa annua for Improved Cultivars

1986 Grant - $15,000 [third year of support]

We are very encouraged by the progress made during the last year. New breeding material was added from California, Ohio, Minnesota and Europe. Seed collections have been made from original crosses and have proven to possess some desirable characteristics. Superior genotypes have been advanced one to five generations.

Two hundred fifty-one selections of Poa annua and Poa supina were germinated and grown in the greenhouse for transfer to field space planting. There was also the space planting of 1200 plants representing 145 selections established in the field in 1985. Overwintering, spring green up, summer and fall performance evaluations were also made.

A field planting of stolons of 15 different materials was established and maintained at putting green height. One clone [10-C] in particular stood out during the spring, summer and fall due to a dark green color, dense turf and limited flowering. At least three other clones exhibited limited flowering habits.

One hundred twenty-one F2 plants were started in the greenhouse and transferred to field planting for observation of growth characteristics and genetic variation. Twenty-two selected clones were grown in the greenhouse and interplanted into existing collar height conditions in the field to evaluate competitive ability, growth habit under competition and disease susceptibilities.

Breeding research in incompatibility and technique development in emasculation of florets, flower suppression, stolon viability in storage, hardiness, tissue culture, selections and other practices are being explored. The project is at a point where increased support could be very productive in terms of shortening the time to introduction of an improved Poa annua. Research progress is being made which is beyond what could be normally expected under current support conditions. The 1986 results have been very satisfying.

✓ UNIVERSITY OF NEBRASKA - Dr. Terrance P. Riordan
Principal Investigator

Breeding, Evaluation and Culture of Buffalograss

1986 Grant - $18,000 [third year of support]

A. Overall Objective Accomplishments

This project has been active for slightly less than two and one-half years, but significant progress has been made toward the overall objective of the USGA/GCSAA project. At this time, buffalograss clones have been identified which have an improved turf quality suitable for golf course roughs, but still have the lower energy requirement advantages of buffalograss. Although we are still early in our breeding improvement project, progress to-date has been better than any of us expected. Selected clones have better turf quality than anticipated, they are possibly adapted to a larger area of the country than originally thought, and propagation by seed or vegetative means seem very feasible.

B. Plant Collection and Evaluation

One hundred and forty-one turf-type buffalograss clones were collected in Kansas in 1986. These were collected under both dry and wetland conditions. These will be transplanted to the field during 1987. An additional 82 buffalograss clones have been selected for additional evaluation from the 1985 plantings. These clones will be vegetatively increased into larger replicated turf plots. Ten clones have been identified as the best buffalograss plants in our program at this time.

C. Buffalograss Plant Breeding

During 1986, a seed increase planting and synthetic plantings were made. Seed will be harvested from these areas late in 1986 and again in 1987. Individual plant hybridization will be made in the greenhouse during spring 1987.

D. Mill Seeding Rate Study

This study has shown that the multiple noted caryopses can be efficiently removed from the hard to germinate buffalograss burr. In the field these hulled seeds germinate much more rapidly and at a higher rate than the burrs.

E. Buffalograss Seed Storage

Hulled buffalograss seed stored for three months had an overall 94% germination and at nine months, 92%. A germination test will also be made at 15 months.

F. Buffalograss De-hulling

A barley pearler was evaluated as a means of removing the multiple buffalograss caryopses from the burr. An average of 2.3 caryopses were obtained from each burr and germination was much more rapid for the excised caryopses.

G. Vegetative Establishment

Six studies using pre-rooted and non pre-rooted plugs demonstrated that vegetative establishment is improved using pre-rooted plugs. Spacing requirements, herbicide and fertilizer rates, and pre-rooting times were determined from these studies.

H. Buffalograss Rhizotron Study

No significant differences were obtained in root development of pre-rooted and non pre-rooted plugs in the rhizotron. Differences were possibly masked by environmental or soil factors.

I. Project Budget

During 1985-6 and again in 1986-7, we will be spending 10-15% more than the $18,000 we receive from the USGA. This deficit spending is a problem, but more significant is the problem that all of this amount is going for salary, benefits and overhead. There are currently no funds available for plant collection, student labor or operating expenses. If this funding situation continues, the progress and accomplishments of the project could be negatively affected.

<u>UNIVERSITY OF NEBRASKA</u> - Dr. Robert C. Shearman
Principal Investigator

<u>Turfgrass Cultural Practices and their Interactive Effects on Rooting</u>

1986 Grant - $20,000 [third year of support]

The USGA has set goals of 50% reduction in turfgrass water use and 50% lower maintenance costs. Results from the irrigation frequency x potassium nutrition study conducted during 1986 demonstrated that decreasing irrigation frequency and increasing potassium nutrition levels resulted in equal or better putting green conditions than turfs receiving frequent daily irrigation. Snow mold [<u>Typhula blight</u>] incidence decreased with increasing potassium. A 60% reduction in disease incidence was found between treatments of 4 and 8 lbs K/1000 ft^2/ season. These results indicate a strong potential to reduce maintenance cost by manipulating irrigation frequency and potassium nutrition, particularly on sand growing media.

The interaction of turfgrass species root growth and distribution was investigated under drought stress conditions. Species were eliminated when root growth ceased and permanent wilt symptoms were expressed. Tall fescue, creeping red fescue, perennial ryegrass and creeping bentgrass produced roots to 1220 mm to 1520 mm. Rough bluegrass ranked intermediate in root production, but wilted very early in the drought stress cycle since approximately 50% of its rooting was in the upper 0 to 150 mm of the profile. Sixteen Kentucky bluegrasses were investigated for intraspecific responses in root growth and distribution, top growth, and amount of root growth supporting top growth. Cultivars were found to vary by as much as 50% to 56% in these characteristics. Ram I, Touchdown and Eclipse had high percentages of root growth supporting top growth.

Potassium nutrition studies on creeping bentgrass and Kentucky bluegrass demonstrated that drought avoidance characteristics increased with K nutrition. Wilting tendency decreased as K nutrition was increased from 0 to 8 lbs K/1000ft^2. Turfgrass wear tolerance increased with increasing K rates.

Studies were initiated in the JSA Turfgrass Rhizotron to investigate growing media and microenvironment. An ERDAS system was purchased to be used as a means to quantitate turfgrass root growth in the rhizotron and in other rooting studies. An additional 10,000 ft^2 of creeping bentgrass green area was established for research purposes. This additional green brings the total area to approximately 56,000 ft^2. A creeping bentgrass cultivar study was initiated September, 1986. Plots were designed to incorporate cultural practice on the replicated cultivar study.

<u>NEW MEXICO STATE UNIVERSITY</u> - Dr. Arden A. Baltensperger
Principal Investigator

<u>Breeding Improved Seeded Bermudagrass for Turf</u>

1986 Grant - $20,000 [third year of support]

Partially as a result of findings from two Ph.D. studies, approximately 22,000 progenies were established in the greenhouse in the spring of 1986. These plants were subsequently selected for turf quality characteristics in both the greenhouse and field. An attempt is being made to improve several experimental strains for turf quality seed yield.

Five experimental seeded strains from the New Mexico State University breeding program were entered in a National Bermudagrass Test administered from Beltsville, Maryland. These tests were established in many states in the South and along the transition zone. Results from those tests will be valuable to the breeding program in indicating breeding progress and in determining where continued selection pressure is needed.

NORTH CAROLINA STATE UNIVERSITY - Dr. Leon T. Lucas
Principal Investigator

Spring Dead Spot Disease

1986 Grant - $10,000 [second year of three year study solely supported by contributions from Mr. Hall Thompson, Shoal Creek, Alabama]

A post doctorate position was accepted in August, 1986 by Dr. Bert McCarty to intensify investigations in this research project. Since that time, fungicide and fertility evaluation for Spring Dead Spot control has been undertaken. Three sites in the southeastern United States have been treated with several fungicides and fertilization sources for potential disease control. Disease control evaluation will be made in the spring of 1987.

Fungicide/fertility evaluation on increasing low temperature hardiness of Tifway bermudagrass is also underway. Several fungicides and fertilization sources have been applied to Tifway bermudagrass. Plugs will be extracted from these areas during the fall, winter, and spring, and subjected to artificially induced cold temperatures to determine treatment effects on bermudagrass winter hardiness.

Isolation of the Spring Dead Spot causal organism[s] is planned. Several selected media and baiting techniques are currently being used to try and isolate the SDS causal organism[s]. Isolation attempts will be during the fall and winter, 1986 as well as spring, 1987.

✓OHIO STATE UNIVERSITY - Dr. Karl Danneberger
Principal Investigator

Mechanisms for Heat Tolerance in Annual Bluegrass

1986 Grant - $15,000
[first year of support]

Twenty-five *Poa annua* biotypes collected from the continental United States were screened for high temperature tolerance. A 12°C difference was detected between the least and most tolerant biotypes. The most heat tolerant biotype in this study was sampled from Avon CC, Cleveland, Ohio and the least from Douglasville, Georgia. No correlation between location and tolerance was found. High temperature treated biotypes were more prone to drought stress than non-treated. It was interesting to note that the experiment was repeatable during the summer months but no difference in heat tolerance was detected among biotypes when screened during the fall [October].

An interesting observation was made that may explain why annual bluegrass is sensitive to drought and pest stresses. When we subjected biotypes to heat treatments, followed by a two-week recovery period, the heat treated biotypes that survived appeared visually the same as the non-treated biotypes [controls]. However, if these biotypes were subjected to a minor moisture stress [a level at which no visual affect was observed on the controls], the heat treated biotypes died. From this observation it appears that heat predisposes annual bluegrass to moisture stress. Further, work is needed to quantify this observation. It may help explain the sensitivity of annual bluegrass to summer diseases such as anthracnose that are caused by relatively weak pathogens. This is conjecture but it does bring up the possibility of future research.

The two biotypes from Avon, Cleveland and Douglasville, Georgia along with "Victa" Kentucky bluegrass and a tall fescue cultivar are being propagated in suspension culture. This plant material will be used to determine if and in what quantity heat shock proteins [HSP] are formed. These proteins will be evaluated for feasibility and practicality as a rapid screening method of determining high temperature tolerance in turfgrass genetic material.

This work will be successful and completed by the summer of. 1987. At this time, the use of HSP for determining heat tolerance in breeding programs is still feasible. Preliminary work at Cornell University has shown differences among corn hybrids with regard to HSP formation. It may turn out to be a method for "finger printing" turfgrass cultivars. The project is progressing well and will hopefully yield information important to the turfgrass community.

<u>OKLAHOMA STATE UNIVERSITY</u> - Dr. A. D. Brede
Principal Investigator

<u>Breeding and Evaluation of Cold Tolerant Bermudagrasses</u>

1986 Grant - $20,000 [first year of support]

Presently there is no cold-tolerant, seed-propogated, fine-textured turf bermudagrass variety available for use in the northern half of the bermudagrass belt. The basic objective of research jointly sponsored by the United States Golf Association and the Oklahoma Agricultural Experiment Station is the development of such varieties.

To-date, we have identified cold-tolerant bermudagrass plants with good fertility, incorporated them into breeding populations [germplasm pools], and completed two cycles of selection for increased basic fertility and growth characters. Significant response to selection has been documented. An additional cycle of selection will begin next spring.

Significant progress was made in recent months in tissue culture research with bermudagrass. Plants have been regenerated from very young inflorescence explants, and work underway with other explant tissues, including anthers, appears promising. Regeneration of plants from anthers would provide opportunity for development of haploid plants [plants containing half the normal chromosome number] which have several potentially significant benefits to breeding.

Preliminary research was initiated recently to characterize the self-incompatibility mechanism in bermudagrass. Bermudagrass plants typically are strongly self-incompatible, thus will not produce seed when self-pollinated. Although we know the mechanism exists, very little is known about how it works or about its genetic control.

Development of a reliable laboratory technique for measuring cold tolerance in bermudagrass would be of immense value in screening plants for the bermudagrass breeding program. The necessary equipment has been obtained and Dr. Jeff Anderson, stress physiologist in the Department of Horticulture and Landscape Architecture, has initiated experiments to develop the procedures. Development of a laboratory procedure would enable cold hardiness determinations without relying on the occurrence of test winters.

PENNSYLVANIA STATE UNIVERSITY - Dr. Joseph M. Duich
Principal Investigaror

Bentgrass Breeding

1986 Grant - $4000 [ongoing support since 1958]

I. Creeping Bentgrass

A. PENNLINKS creeping bentgrass [experimental designation PSU-126] was released and named by the Pennsylvania Agricultural Experiment Station Seed Committee on November 3, 1986. Application was made for Plant Variety Protection. Varietal features are upright growth habit, finer leaves than current varieties, minimal segregation after 8 years, seasonal turf quality and overall performance in a 17 state plus Canada evaluation. Limited quantities of seed are now commercially available.

B. Breeder Seed of Penneagle and Pennlinks were produced in 1986.

C. Approximately 500 creeping bent plants surviving Smiley's Cornell screening for two races each of Phialopbora graminicola and Leptosphaeria korrae were nursery established for 1987 seed increase for further screening.

D. Other experimental nursery plantings included northern and southern Penncross reselections, close-cut bent segregates under 2/32 and 3/32 cutting height for 5 years from Penncross and Penneagle, 100 French and Italian golf course selections made by Howard Kaerwer, Hawaiian and U.S. golf course selections, and early flowering selections.

E. Seed was selected from second generation salt tolerant lines for tolerance and turf testing.

F. Following Roundup renovation, Penncross, Penneagle, Pennlinks and Seaside bents were established into a Poa annua infested area. Triplex mowing was initiated with a clipping removal variable with chemical controls and growth regulators to be imposed in 1987.

II. Colonial Bentgrass

A. Selection for rhizomatous colonial bents continued on a large scale utilizing the selfing and open pollinated approach with approximately 30,000 plants in various generations including new selections.

B. Approximately 450 plants were field selfed [1 to 4 generations of inbreeding] in 1986 and are in the process of greenhouse screening along with their open pollinated counterparts. Over 2300 inbred progeny with emerged rhizomes were field planted for advanced inbreeding and selection in 1987.

C. Seeds of 277 open pollinated lines [1st to 3rd generation of sib families] was harvested for turf evaluation trials to be initiated in 1987.

D. Efforts to increase rhizomatous plant reproduction through seed propagation is proving to be a most difficult task after six years effort working with several hundred thousand plants. However, utilizing increased efficiency techniques we plan to continue our efforts to fruition.

III. Tissue Culture

A. This project was initiated with a worldwide computer reference search. LIterature review has been in progress for several months.

B. Our primary objective remains to be the development of haploid plants through microspore culture followed by colchicine chromosome doubling. To meet this objective several secondary objectives are necessary; 1] study pollen development as it correlates with macroscopic inflorescence morphology, 2] development of sterilization technique for panicle treatment prior to culture, 3] induced greenhouse flowering, 4] testing pollen culture techniques already established for small grains and grasses, and 5] chromosome doubling of haploid plants.

/UNIVERSITY OF RHODE ISLAND - Dr. Richard Skogley
Principal Investigator

Selection and Breeding of Superior Bentgrasses

1986 Grant $1500 [ongoing support since 1960]

During 1986, considerable effort was expended in trial evaluation of turfgrasses originating from collected materials. Among these grasses are:

1. Creeping and Velvet bentgrasses for putting green use. 81 selections. 49 plots seeded in 1982, and 32 in 1985.

2. Colonial bentgrasses. 95 selections. 50 plots seeded in 1984, and 45 seeded in 1986.

3. Lawn and general purpose grasses. These include Kentucky bluegrass, Canada bluegrass, fine fescues, tall fescues, Perennial ryegrass, sweet vernal and Timothy. 245 selections. 67 seeded in 1983, 100 in 1984 and 78 seeded in 1985

   All grass trials are maintained with less nutrients, water and pesticides than is normal.

The grasses collected are mostly from old, dry, low fertility stands throughout New England and the Canadian Maritime Provinces during the past four years. Several of the bentgrasses are older collections and are in second or third stage evaluation.

A collection of sweet vernal grass has also been assembled and is being evaluated for use in extremely infertile and dry conditions. This is a naturalized grass that is widely dispersed in North America. We have determined that the phenotypic diversity within the species is great. We note great differences in texture, color, growth habit, leafiness, and disease reaction. We are currently evaluating its performance under different cutting heights and fertility levels.

During the year we have constructed an automatic rain shelter which will enable us to better evaluate grasses for drought tolerances. We will be able to grow grasses in a natural, outdoor environment with only the water we supply.

We have an additional trial in progress to evaluate mixtures of grasses including creeping bent, Kentucky bluegrass, fine fescue, Colonial bent and Perennial ryegrass, for fairway usage. Performance of these mixtures is being evaluated both with and without fungicides.

Seed of several dozen of the R. I. bentgrass selections were sent to Dr. Milton Engelke and Dr. Ron Ensign for additional stress evaluations.

RUTGERS UNIVERSITY - Dr. C. Reed Funk
Principal Investigator

Breeding and Evaluation of Kentucky Bluegrass, Tall Fescue, and Perennial Ryegrass for Golf

1986 Grant - $5000 [ongoing support since 1961]

The New Jersey Agricultural Experiment Station of Rutgers University continues to devote considerable resources to the Turfgrass Breeding Project adding to the support that we are receiving from the United States Golf Association and other sources. This support enables us to make significant improvements in stress tolerance, turf performance, and pest resistance in Kentucky bluegrass, perennial ryegrass, tall fescue, and fine fescues. In addition, we are training a number of students in the fields of turfgrass science and plant breeding. We are also making contributions to basic research.

The effects of endophytic fungi on turf performance and pest resistance in perennial ryegrass, tall fescue, hard fescue, chewings fescue, strong creeping red fescue and blue fescue are continuing. Germplasm collections are being screened for new sources of potentially useful endophytes in other turfgrass species.

TEXAS A&M UNIVERSITY - Dr. James B. Beard
Principal Investigator

Plant Stress Mechanisms

1986 Grant $73,000 [fourth year of support]

1. Visual assessment via the high canopy resistance - low leaf area concept offers a rapid, economical approach for screening large numbers of mowed bermudagrass or mowed zoysiagrass plantings under field conditions for low water use rates.

2. A procedure for incorporating radioactive $^{14}CO_2$ into turfs and then assaying shoot and root sections for radioactivity has been successfully developed and tested for use in rooting studies.

3. A system for growing turf, enabling the harvest of the entire root system with undamaged root hairs has been successfully developed and tested.

4. Substantial differences in terms of root hair distribution and length are evident among 13 warm-season turfgrass species.

5. The eleven major warm-season turfgrass species and cultivars vary substantially in drought resistance.

6. Of the species studied, zoysiagrass, centipedegrass, and bermudagrass are more drought resistant than St. Augustinegrass and seashore paspalum.

7. A high leaf water potential, extensive root system, and high wax cover over the stomata contribute to a high level of drought avoidance in bermudagrass and centipedegrass. This was confirmed by the higher leaf firing in the polyethylene glycol solution.

8. Since zoysiagrass possessed a shallow root system and low leaf water potential, a high drought tolerance is probably the major mechanism contributing to drought resistance. Low leaf firing in the polyethylene glycol solution supports this conclusion.

9. Zoysiagrasses possess especially strong drought resistance due primarily to internal drought tolerance mechanisms.

10. Root extension length did not appear to be the controlling factor in drought resistance or the avoidance dimension. Tifway bermudagrass and St. Augustinegrass had long extensions, but poor drought resistance. Conversely, Texturf 10 and Tifgreen bermudagrasses had long extension and good resistance. Total root dry weight and root shoot ratio were similarly split, and no firm conclusion can be made.

11. With the exception of the St. Augustinegrass, it appears that the total number of roots in the soil profile is what influences which species are the most drought resistant.

12. Most warm-season species having good drought avoidance and/or resistance had showed closed stomata or stomata blocked by wax layers.

13. The drought susceptible warm-season turfgrass species maintained open stomata and/or less wax accumulation across the stomata.

14. Leaf extension rate, internode length, visual quality when the nitrogen fertility rate is known, and tissue nitrogen content are useful parameters in identifying bermudagrass cultivars possessing low nitrogen stress tolerance.

15. Proline content may be an indicator of proneness to drought stress injury. Those turfgrass species that are prone to drought injury usually exhibited more rapid proline accumulation than other species

that are relatively less susceptible to drought injury. This can be partially explained by the relationship between the degree of leaf firing and the ratio between the shoot proline level before and after water stress.

\ TEXAS A&M UNIVERSITY - Dr. M. C. Engelke
Principal Investigator

Breeding and Development of Zoysiagrass

1986 Grant - $40,000 [fourth year of support]

The zoysiagrass germplasm nursery continues to be maintained in both the greenhouse and in replicated field plots. The winter of 1985/86 was relatively mild, with very few of the zoysia accessions actually going dormant. Environmental parameters are being continuously monitored and visual observations recorded on relative plant performance.

Considerable emphasis was directed in 1985/86 toward identifying unique genotypes within the Oriental and Domestic zoysiagrass collections which appeared to be well adapted to turf conditions in the Southern United States. In the fall of 1985, several experimental zoysiagrass genotypes were selected from the 1980 turf trials, as well as from the Oriental zoysiagrass collection for inclusion in an accelerated field testing program. These genotypes have been and will be designated DALZ lines, to signify elite genetic resources. Of particular interest are two lines, designated DALZ8501 and DALZ8502 which are accessions from the Plant Introduction Station, Experiment GA in 1981. Data is presented in TABLE 5 to demonstrate the superior regrowth characteristics of these accessions over commercial or other experimental varieties. These two clones along with approximately 20 others are being increased in the greenhouse to provide sufficient plant material for establishment and extensive field testing beginning in 1987.

The occurrence of a rather severe nematode infestation resulted in a major delay in vegetative propagation of plant material. The nematode was identified as Meloidogyne sp. [root knot nematode], which apparently is relatively common on zoysiagrass. Regardless, the incident resulted in delayed planting of the experimental plots.

/ TEXAS A&M UNIVERSITY - Dr. M. C. Engelke
Principal Investigator

Breeding and Development of Bentgrass

1986 Grant - $40,000 [second year of support; $20,000 contributed by Bentgrass Research, Inc. of Fort Worth, TX]

In April, 1984, the Texas Agricultural Experiment Station, Bentgrass Research, Inc., and the United States Golf Association embarked upon a joint endeavor to develop bentgrasses which are genetically adapted to environmental conditions in the southern United States. The germplasm collection currently includes over 520 vegetative accessions, 168 seeded accessions, 300 'Seaside' selections, and ten commercial or experimental varieties. Facility development to accommodate testing of this material has continued, with Bentgrass Research, Inc. constructing a new 1610 sq. meters [17,000 sq ft.] sand base research green, with completion expected by November 1, 1986. Field, laboratory and greenhouse experiments are progressing toward identification of superior genotypes.

Testing is currently in progress in a greenhouse heat bench to determine sensitivity of seven cultivars and two experimental varieties to heat stress. Initial results indicate differences do exist between genotypes. Characterization of root systems to identify plants which will avoid heat-induced drought stress continues. Forty-seven Seaside and Seaside-RHT plants have been screened, with fifty additional clones under current evaluation. Completed evaluations indicate differences exist between genotypes. A manuscript summarizing the results from the first evaluation was submitted to the Texas Turfgrass Research Report - 1986. Preliminary laboratory evaluations to determine if selection for root heat tolerance has influenced shoot heat tolerance indicate significant differences in shoot hydration exists between genotypes when grown under stress.

Field testing under both native blackland soils and root zone modified 'USGA sand based greens' conditions continue. Two-hundred thirty elite vegetative accessions were planted on blackland soil during May 1986, with turf quality ratings indicating approximately 25% of these express superior adaptive characters. In addition, approximately 25% of the ELITE genotypes planted on sand base green performed in a superior manner during 1986. Two-hundred ninety-four plants of Seaside and Seaside-RHT were planted during April 1986. Periodic evaluations indicated tremendous genotypic differences in spread, texture, density, color, and overall quality, with 46 clones ranking in the top quality group. Selection for root heat tolerance has not adversely affected the quality characters evaluated.

A project contract was established in 1985/86 with Dr. Jerry Pepin, and Pickseed West, Inc., Tangent, Oregon, to assist the breeding program in seed production of elite and synthetic germplasm resources. Floral initiation and development did not occur in the field plantings at Dallas during 1986, but was successful in Oregon. The plantings of elite germplasm in Oregon determined cross-compatibility dates for the genotypes, and generated sufficient seed quantities for advanced generation testing. Three synthetics have been composed and have been transferred to Oregon for 1986/87 production.

TEXAS A&M UNIVERSITY - Dr. Garold L. Horst
Principal Investigator

Developing Salt, Drought and Heat Resistant Turfgrasses for Minimal Maintenance

1986 Grant - $15,000 [third year of support]

Research accomplished:

1. Completed planned evaluation of 40 St. Augustinegrass germplasm entries.

2. Continued refinement of the new technique for growth and development evaluation of multiple germplasm entries grown under salt stress conditions.

3. Continued reception and increase of 28 bermudagrasses, 7 bentgrasses, 74 Buffalograsses, 3 Paspalums, and 78 zoysigrasses.

Current Research:

1. Vegetative material of 29 Buffalograss germplasm entries are being evaluated for salt resistance in the new greenhouse facility.

2. Pilot studies on vegetative establishment methods for evaluating zoysiagrass vegetative material are still in progress.

Research Planned 1986/1987:

1. Complete evaluation of Buffalograss germplasm [May, 1987]. Expect to receive additional Buffalograss germplasm entries from Nebraska this fall.

2. Initiate zoysiagrass evaluation [March, 1987].

3. Initiate evaluation of Paspalum germplasm for salt resistance [March, 1987].

4. Continue accumulation of bentgrass and bermudagrass germplasm and expand cooperation with New Mexico and Oklahoma bermudagrass programs.

5. Begin to proto-type long term salt stress growing techniques for further greenhouse and field evaluations on germplasm which exhibited reasonable salt resistance [May, 1987].

DEPARTMENT OF SCIENTIFIC & INDUSTRIAL RESEARCH - NEW ZEALAND

Dr. Wm. Rumball
Principal Investigator

Colonial Bentgrass Breeding

1986 Grant - $10,000 [first year of support]

An agreement has been reached in 1986 with the Department of Scientific and Industrial Research [DSIR], Palmerston North, New Zealand in support of Colonial bentgrass breeding work at that research station. Dr. Wm. Rumball is the principal investigator and a successful plant breeder. He has already produced two superior Colonial bentgrass types for use on golf courses in New Zealand. Dr. Rumball was in the United States from January thru July, 1986 on sabatic leave at the University of California - Davis Campus. During this period of time, he made numerous Colonial bentgrass collecting trips in this country and visited with investigators of several USGA/GCSAA research projects. New Colonial bentgrass breeding work is expected to commence in New Zealand in 1987

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Long Cove Club	Hilton Head Island, SC
Longmeadow Country Club	Longmeadow, MA
Longue Vue Club	Verona, PA
*Los Altos Golf & Country Club	Los Altos, CA
Los Angeles Country Club, The	Los Angeles, CA
Losantiville Country Club	Cincinnati, OH
Maketewah Country Club	Cincinnati, OH
Manasquan River Golf Club	Brielle, NJ
Manor Country Club	Rockville, MD
Manufacturer's Golf & Country Club	Oreland, PA
Maple Bluff Country Club	Madison, WI
Mayfield Country Club	South Euclid, OH
Meadow Club	Fairfax, CA
Meadow Lake Country Club	Great Falls, MT
Meadowbrook Country Club	Richmond, VA
Meadowbrook Country Club	Ballwin, MO
Meadowbrook Country Club	Northville, MI
Medinah Country Club	Medinah, IL
Meridian Hills Country Club	Indianapolis, IN
Merion Golf Club	Ardmore, PA
Meriwether National Golf Course	Hillsboro, OR
Mid-Pacific Country Club	Kailui, HI
*Midland Country Club	Kewanee, IL
Midlothian Country Club	Midlothian, IL
Midvale Golf & Country Club	Penfield, NY
Mill Creek Country Club	Bothell, WA
*Mill Quarter Plantation CC	Powhaton, VA
Mill River Club, The	Oyster Bay, NY
*Milwaukee Country Club	Milwaukee, WI
Minikahda Country Club	Minneapolis, MN
*Minneapolis Golf Club	Minneapolis, MN
Minnehaha Country Club	Sioux Falls, SD
Missoula Country Club	Missoula, MT
Montclair Golf Club	Montclair, NJ
Montecito Country Club	Santa Barbara, CA
Monterey Peninsula Country Club	Pebble Beach, CA
Moon Brook Country Club	Jamestown, NY
Moon Valley Country Club	Phoenix, AZ
Moraga Country Club	Moraga, CA
Morningside, Club at	Rancho Mirage, CA
Moselem Springs Golf Club	Fleetwood, PA
*Moss Creek Golf Club	Hilton Head Island, SC
Moss Creek Plantation	Hilton Head Island, SC
Mount Kisco Country Club	Mount Kisco, NY
Mountain Lakes Country Club	Smallwood, NY
Mountain Ridge Country Club	West Caldwell, NJ
*Myer's Park Country Club	Charlotte, NC
Myopia Hunt Club	South Hamilton, MA
Naples, Country Club of, The	Naples, FL

Donor Clubs (Continued)

Navesink Country Club	Middletown, NJ
New Haven Country Club	Hamdem, CT
New Orleans Country Club	New Orleans, LA
Newport Country Club	Crosby, TX
North Carolina, Country Club of	Pinehurst, NC
North Hills Country Club	Menomonee Falls, WI
North Shore Country Club	Glenview, IL
Northland Country Club	Duluth, MN
Northmoor Country Club	Highland Park, IL
Northwood Club	Dallas, TX
Norwood Hills Country Club	St. Louis, MO
Noyak Golf and Country Club	Sag Harbor, NY
Oahu Country Club	Honolulu, HI
*Oak Hill Country Club	Rochester, NY
Oak Park Country Club	Oak Park, IL
Oak Tree Golf Club	Edmond, OK
Oakland Hills Country Club	Birmingham, MI
Oakmont Country Club	Oakmont, PA
Oakmont Resident's Golf Club	Santa Rosa, CA
Oakwood Club	Cleveland, OH
*Odessa Country Club	Odessa, TX
Old Oaks Country Club	Purchase, NY
*Old Town Club	Winston-Salem, NC
Old Warson Country Club	St. Louis, MO
*Old Westbury Golf & Country Club	Old Westbury, NY
Onondaga Golf and Country Club	Fayetteville, NY
Ontario Golf Club	Ontario, CA
Orchard Lake Country Club	Orchard Lake, MI
Orchard Ridge Country Club	Fort Wayne, IN
Orinda Country Club	Orinda, CA
*Orlando, Country Club of	Orlando, FL
Owl Creek Country Club	Anchorage, KY
*Oyster Harbors Club	Osterville, MA
Ozaukee Country Club	Mequon, WI
*Palo Alto Hills Golf Club	Palo Alto, CA
Panorama Country Club	Conroe, TX
*Paradise Valley Country Club	Paradise Valley, AZ
Park Country Club of Buffalo, The	Williamsville, NY
Park Ridge Country Club	Park Ridge, IL
*Pasatiempo Golf Club	Santa Cruz, CA
*Payson Golf Course, Inc.	Payson, AZ
Payson Men's Golf Association	Payson, AZ
Peach Tree Golf & Country Club	Marysville, CA
Peachtree Golf Club	Atlanta, GA
*Pebble Beach Golf Company	Pebble Beach, CA
Pelham Country Club	Pelham, NY
Penfield Country Club	Penfield, NY
Peninsula Golf & Country Club	San Mateo, CA
Pepper Pike Club	Cleveland, OH
Petersburgh, Country Club of	Petersburgh, VA
*Philadelphia Country Club	Gladyne, PA
*Phoenix Country Club	Phoenix, AZ

Donor Clubs (Continued)

Pine Brook Country Club	Winston-Salem, NC
Pine Forest Country Club	Houston, TX
Pine Lake Country Club	Orchard Lake, MI
*Pine Tree Golf Club	Boynton Beach, FL
Pine Valley Golf Club	Clementon, NJ
*Pinetop Country Club	Pinetop, AZ
Pinewood Country Club	Slidell, LA
Piping Rock Club	Locust Valley, NY
Pittsburgh Field Club	Pittsburgh, PA
Plainfield Country Club	Plainfield, NJ
Plum Hollow Country Club	Southfield, MI
*Plymouth Country Club	Plymouth, MA
Ponte Vedra Club & Inn	Ponte Vedra, FL
Portage Country Club	Akron, OH
Portland Country Club	Falmouth, ME
Prairie Dunes Country Club	Hutchinson, KS
Preakness Hills Country Club	Wayne, NJ
Presidio Army Golf Club	San Francisco, CA
Preston Trail Golf Club	Dallas, TX
*Princeville Men's Golf Club	Hanalei, HI
*Quail Creek Country Club	Naples, FL
Quaker Ridge Golf Club	Scarsdale, NY
Raveneaux Country Club	Spring, TX
Red Hill Country Club	Rancho Cucamonga, CA
Rehoboth Beach Country Club	Rehoboth Beach, DE
Ridgemont Golf Club	Rochester, NY
*Ridgemoor Country Club	Chicago, IL
*Ridgewood Country Club	Ridgewood, NJ
River Forest Golf Club	Elmhurst, IL
*River Oaks Country Club	Houston, TX
*Riverbend Country Club	Sugarland, TX
Riverside Golf Club	North Riverside, IL
Riverton Country Club, The	Riverton, NJ
Riviera C.C. of Coral Gables	Coral Gables, FL
Rochester Golf and Country Club	Rochester, MN
*Rochester, Country Club of	Rochester, NY
*Rock Spring Club	West Orange, NJ
Rockville Links Co.	Rockville Centre, NY
Rolling Green Golf Club	Springfield, PA
Rossmoor Golf Club	Walnut Creek, CA
Round Hill Club	Greenwich, CT
Round Hill Golf and Country Club	Alamo, CA
*Royal Poinciana Golf Club	Naples, FL
Ruth Lake Country Club	Hinsdale, IL
*Rutland Country Club	Rutland, VT
Saguaro Golf Club	Tucson, AZ
Sahalee Country Club	Redmond, WA
Salem Country Club	Peabody, MA
Salinas Golf and Country Club	Salinas, CA
*Salisbury Country Club	Midlothian, VA
San Francisco Golf Club	San Francisco, CA
San Gabriel Country Club	San Gabriel, CA

Donor Clubs (Continued)

San Joaquin Country Club	Fresno, CA
*San Jose Country Club	Jacksonville, FL
San Jose Country Club	San Jose, CA
San Mateo Golf Club	San Mateo, CA
*Santa Ana Country Club	Santa Ana, CA
Santa Rosa Golf & Country Club	Santa Rosa, CA
*Sapphire Valley, Country Club of	Sapphire, NC
Saucon Valley Country Club	Bethlehem, PA
Sawgrass Golf & Country Club	Ponte Vedra, FL
Scarsdale Golf Club	Hartsdale, NY
Sea Island Golf Club	St. Simons Island, GA
Seattle Golf Club	Seattle, WA
Selva Marina Country Club	Atlantic Beach, FL
Seminole Golf Club	North Palm Beach, FL
Sequoyah Country Club	Oakland, CA
Seven Rivers Golf & Country Club	Crystal River, FL
Shannopin Country Club	Pittsburgh, PA
Sharon Heights Golf & Country Club	Menlo Park, CA
Shinnecock Hills Golf Club	Southampton, NY
*Shoal Creek Country Club	Shoal Creek, AL
*Silver Spring Country Club	Ridgefield, CT
Silverado Country Club	Napa, CA
*Singletree Golf Club	Edwards, CO
Siwanoy Country Club	Bronxville, NY
Skokie Country Club	Glencoe, IL
*Sleepy Hollow Country Club	Scarborough-on-Hud.,NY
Snee Farm Country Club	Mount Pleasant, SC
*Somerset Country Club	St. Paul, MN
Somerset Hills Country Club	Bernardsville, NJ
Sonoma National Golf Club	Boyes Hot Springs, CA
South Hills Country Club	Pittsburgh, PA
Southampton Golf Club	Southampton, NY
Southern Hills Country Club	Tulsa, OK
*Southview Country Club	West St. Paul, MN
Spokane Country Club	Spokane, WA
Spring Brook Country Club	Morristown, NJ
Spring Hill Country Club	Albany, OR
Spring Lake Golf Club	Spring Lake, NJ
Spring Valley Country Club	Columbia, SC
Springdale Golf Club	Princeton, NJ
*Springs Club, The	Rancho Mirage, CA
Spyglass Hill Golf Club	Pebble Beach, CA
St. Andrew's Country Club	West Chicago, IL
St. Andrew's Golf Club	Hastings-on-Hudson, NY
*St. Charles Golf Course	St. Charles, MO
St. Clair Country Club	Belleville, IL
St. Clair Country Club (PA)	Pittsburgh, PA
*St. Cloud Country Club	St. Cloud, MN
*St. David's Golf Club	Wayne, PA
St. Louis Country Club	Clayton, MO
Steubenville Country Club	Steubenville, OH
Stockbridge Golf Club	Stockbridge, MA

Donor Clubs (Continued)

Stonehenge Golf & Country Club	Midlothian, VA
Stono River Golf Club	Charleston, SC
*Suburban Golf Club	Union, NJ
*Sugar Creek Country Club	Sugarland, TX
*Summit Hills Country Club	Fort Mitchell, KY
Sunningdale Country Club	Scarsdale, NY
Sunnybrook Golf Club	Plymouth Meeting, PA
Sunnyside Country Club	Fresno, CA
*Sunrise Country Club	Sunrise, FL
Sunset Hills Country Club	Edwardsville, IL
*Tacoma Country and Golf Club	Tacoma, WA
Tam O'Shanter Golf Club	Brookville, NY
*Tatnuck Country Club	Worcester, MA
Tedesco Country Club	Marblehead, MA
Tequesta Country Club	Tequesta, FL
Thunderbird Country Club	Rancho Mirage, CA
Town and Country Club	St. Paul, MN
Towson Golf and Country Club	Phoenix, AZ
Transit Valley Country Club	East Amherst, NY
*Trenton Country Club	West Trenton, NJ
Tucson Country Club	Tucson, AZ
Tumble Brook Country Club	Bloomfield, CT
Tuscarora Golf Club, Inc.	Syracuse, NY
Tuxedo Club, The	Tuxedo Park, NY
Twin Lakes Golf & Country Club	Federal Way, WA
Union Hills Country Club	Sun City, AZ
Uniontown Country Club	Uniontown, PA
Upper Montclair Country Club	Clifton, NJ
Useless Bay Golf & Country Club	Langley, WA
Vintage Club, The	Indian Wells, CA
Virginia Country Club	Long Beach, CA
Virginia, Country Club of	Richmond, VA
*Waccabuc Country Club	Waccabuc, NY
*Waialae Country Club	Honolulu, HI
Wakonda Club	Des Moines, IA
Walnut Hills Country Club	East Lansing, MI
Wampanoag Country Club	West Hartford, CT
Wanakah Country Club	Hamburg, NY
*Warwick Country Club	Warwick Neck, RI
Waterbury, Country Club of	Waterbury, CT
Waverley Country Club	Portland, OR
Waynesborough Country Club	Paoli, PA
*Wayzata Country Club	Wayzata, MN
Wellesley Country Club	Wellesley Hills, MA
Westborough Country Club	St. Louis, MO
Westmoreland Country Club	Export, PA
Westmoreland Country Club (IL)	Wilmette, IL
*Weston Golf Club	Weston, MA
Westwood Country Club	Williamsville, NY
Westwood Country Club	St. Louis, MO
*Westwood Country Club (OH)	Rocky River, OH
*Wheatley Hills Golf Club	East Williston, NY

Donor Clubs (Continued)

White Bear Yacht Club	White Bear Lake, MN
Wianno Club	Osterville, MA
Wigwam Country Club	Lichfield Park, AZ
Wild Dunes Golf Club	Isle of Palms, SC
*Wilderness Country Club	Naples, FL
Wildwood Country Club	Fairfield, OH
*Wildwood Golf & Country Club	Cape May Court House, NJ
Williamette Valley Country Club	Canby, OR
*Willow Oaks Country Club	Richmond, VA
Wilmington Country Club	Wilmington, DE
Wilshire Country Club, The	Los Angeles, CA
Winchester Country Club	Winchester, MA
*Winged Foot Golf Club	Mamaroneck, NY
Wolf Creek Golf Links	Olathe, KS
*Wolferts Roost Country Club	Albany, NY
Wollaston Golf Club	Milton, MA
Woodbury Country Club	Woodbury, NJ
*Woodcrest Club, The	Syosset, NY
Woodhill Country Club	Wayzata, MN
*Woodland Country Club	Carmel, IN
Woodward Golf & Country Club	Fairfield, AL
Woodway Country Club	Darien, CT
Worcester Country Club	Worcester, MA
Wyantenuck Country Club	Great Barrington, MA
Wykagyl Country Club	New Rochelle, NY
*Wyndemere Golf & Country Club	Naples, FL
Wyoming Golf Club	Cincinnati, OH
Yakima Country Club	Yakima, WA
Yolo Fliers Club	Woodland, CA
Youngstown Country Club	Youngstown, OH

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National Golf Fund, Inc.	Palm Beach Gardens, FL
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West Virginia Golf Course Supt. Assn.	Huntington, WV
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