2018 Turfgrass Program Support

Principle Investigators: Brian Horgan, Eric Watkins, Sam Bauer

Background

The Turfgrass Science Program at the University of Minnesota continues to evolve and grow, and this is largely a result of support from the Minnesota Turf and Grounds Foundation. In 2017, we received a $5.4 million USDA grant, saw new investments of $500,000 from the United States Golf Association for the Science of the Green® initiative, continued several important projects that will benefit the Minnesota turf and grounds industry, expanded our research staff, saw employee transitions and new hires, generated new grant dollars leading to valuable research projects, provided presentations nationally and locally, and published our work in peer-reviewed journals. We also led the 2017 Great Lakes School of Turfgrass Science, a highly successful educational program that is in its 15th year; for the past 5 years this school has been entirely online, expanding our instructor and participant base. This summary document outlines our key achievements in 2017, as well as new employees and graduate students, grants, extension programs, and articles published. We are very proud of our relationship with the Minnesota Turf and Grounds Foundation, and we appreciate your continued support of our program. You will see in this Program Support document that your dollars go a long way in advancing the turf and grounds industry in Minnesota and worldwide.

Introduction

In September, we received a $5.4 million grant from the United States Department of Agriculture Specialty Crops Research Initiative (USDA-SCRI). This is the largest grant award ever given to a turfgrass science project, and we are very excited to lead this effort on the improvement of low-input turfgrasses. This project builds off of our previous USDA-SCRI award that we received in 2012. In the current grant we will be exploring how we might better educate consumers and professional turfgrass managers about low-input turfgrass species and management and investigating new options for using turfgrass cultivar performance data to drive consumer seed purchasing decisions. Our team of researchers, which includes colleagues from Purdue, Rutgers, Wisconsin, Oregon State, and the USDA-ARS in Logan, Utah, will also work diligently to improve fine fescues for important traits such as disease resistance and traffic tolerance. Finally, we will evaluate and identify strategies to help end-users more easily convert turfgrass areas to low-input fine fescue grasses.

Funding from the MTGF has been critical to our success in obtaining large grants from the

USDA and other granting agencies. These external grants are not able to fund the support needed to maintain our research facility, including the labor to run the facility, and the infrastructure (including equipment) needed to ensure our research is done efficiently and effectively.

For more information about this project, please see:
http://turf.umn.edu/news/turfgrass-researchers-receive-54-million-create-more-sustainable-lawns

Our partnership between the University of Minnesota and the United States Golf Association (USGA) is truly meeting its mission to advance our knowledge around three sustainability challenges of the golf industry: 1) economic, 2) agronomic, and 3) environmental stewardship. In 2017, we collaborated with colleagues on global golf issues pertaining to public policy (Humphrey Institute), business forecasting (Carlson School), stormwater management (College of Science and Engineering), natural capital of urban green spaces (Institute on the Environment) and instructional design (College of Education and Human Development). For these multi-year research projects, the USGA invested over $500,000 in 2017.

To learn more about this exciting partnership, visit these webpages:

scienceofthegreen.org

http://www.usga.org/articles/2015/10/research-partnership-to-launch-with-university-of-minnesota.html

http://discover.umn.edu/news/environment/usga-partnership

Our Turfgrass Science Extension program, led by Sam Bauer and Dr. Brian Horgan, continues to grow, providing valuable education and research to turfgrass managers. In 2017, we continued research and education related to home lawn irrigation practices in a collaborative project funded by the Metropolitan Council. Our Member-Driven Research Initiative with the Minnesota Golf Course Superintendent's Association continues to solve day to day management challenges that golf course superintendents face. Additionally, we continue to provide valuable Extension resources through web and social media, training workshops, and individual consultations. For more information on Extension Turfgrass Science activities, visit: www.turf.umn.edu and www.extension.umn.edu/turfgrass.

In 2017, our research was presented at 5 international, 10 national and over 30 MN turf events

reaching over 5,000 people. Additionally, our turfgrass science program received support (collaboratively with other institutions) for over $6 million in 2017. As you can see, the $60,000 MTGF gift for 2017 to support the TROE Center provided a large return on investment.

Faculty

Dr. Eric Watkins leads the turfgrass breeding program. He currently advises or co-advises five graduate students and two postdoctoral associates. His breeding program has been able to obtain significant external funding from both state and federal agencies. In addition to leading the previously described USDA-SCRI project, Dr. Watkins has continued to receive new funding for roadside turfgrass species selection and management research, including a new project focused on regional roadside turfgrass mixtures. Publications and new funding for his program are listed in the appendix.

Dr. Brian Horgan, in addition to leading the Science of the Green® initiative, continues to focus on developing practical solutions for the turfgrass industry that save time, resources and enhance the environment. He advises two graduate students and one postdoctoral associate. A list of publications and new funding for his program are in the appendix.

Sam Bauer is an Extension Educator in the program and he continues to lead Extension outreach efforts in the area of turfgrass science and management. In 2017, Sam provided approximately 70 teaching sessions, workshops, or individual trainings. Audiences reached by this program include master gardeners, homeowners, sports turf managers, grounds managers, golf course superintendents, facility management professionals, lawn care operators, pesticide applicators, sod growers, students, institutions, corporations, manufacturers and distributors, and the scientific community. Sam continues to lead the Great Lakes School of Turfgrass Science and coordinated the training for 60 participants of this online school in 2017. Sam coordinated the MTGF/MNLA Lawn Care Forum in June of 2017 and the Hennepin County Sentenced to Serve Horticulture Training Program. Finally, Sam conducts research, writes publications, and provides consultation for the audiences previously mentioned. A list of publications and new funding for his program are in the appendix.

Research staff

Andrew Hollman - Andy continues as our lead research scientist. This past year, Andy has taken on greater responsibilities with his own research goals, including projects related to no-mow fine fescues for golf course roughs and the effects of ice cover on turfgrass species

survival.

Florence Sessoms – Dr. Sessoms started in 2016 as a research scientist. Her research focus is on soil fertility, soil microbiology and the soil biome; this expertise has expanded our research into new areas and new funding opportunities. Deepening our understanding of plant-microbe interactions will help understand how turfgrass managers can more sustainably manage turf areas. Dr. Sessoms brings new strengths to our team. She makes a wonderful addition.

Jonah Reyes – At the end of the 2017 field season, Jonah moved on from the University for the City of Roseville parks department. Prior to his departure, Jonah was involved in several of our MnDOT projects and the Met Council irrigation study. In particular, he developed and studied alternative roadside irrigation systems to increase the success of our roadside plantings.

Jon Trappe – Dr. Trappe is a post-doc in our program. He came to us from Purdue University where he studied carbon flux into and out of the turfgrass system. Jon is working with Dr. Watkins on alternative turfgrass species and is involved several projects related to roadside turfgrass selection and management.

Dominic Petrella—Dr. Petrella joined the turfgrass breeding group in June of 2017. He received his Ph.D. from Ohio State University working under Dr. David Gardner. Dr. Petrella brings a wealth of plant physiology knowledge and experience to our program. He is currently involved in several projects—he is especially interested in helping us understand how we might breed plants that have the ability to outcompete weeds by producing allelopathic compounds.

Chase Straw – Dr. Straw joined the turfgrass team in January 2018. He received his Ph.D. from the University of Georgia where he studied spatial variability of athletic fields and the use of drones and GIS to define precision management units. He is currently leading the new USGA precision irrigation management research project.

Parker Anderson - Parker started in 2016 and has his Masters of Landscape Architecture and Masters of Ecology from the University of Michigan. Parker works with Dr. Horgan on the USGA Science of the Green® research initiative.

Kristine Moncada – Kristine joined our program on a part-time basis recently to assist in coordinating our large grant projects and also help with the publication of outreach and educational materials. Kristine received has extensive experience in plant science research and communication.

Graduate students

Ryan Schwab is a M.Sc. student focused on use of wetting agents to help conserve water in the managed landscape. He is also leading the USGA funded project on managed and no-mow native areas on golf courses.

Garett Heineck received his M.Sc. degree in our program and is now continuing as a Ph.D. candidate. He is investigating better ways to breed perennial ryegrass for improved seed production and studying how endophyte infection affects rust disease.

Yinjie Qiu is a Ph.D. candidate studying snow mold disease. He is conducting research that will help us better understand how fine fescues can resist this important pathogen and helping us develop genetic markers that increase the speed at which we identify useful plants for incorporation into the breeding program.

Michael Laskowski joined the turfgrass breeding program in summer 2016. He is working on prairie junegrass and his research is focused on gaining a better understanding of the reproductive biology of this native, low-input turfgrass. He is also working to identify turfgrasses with high levels of salt tolerance for inclusion in roadside turfgrass mixtures.

James Wolfin is a M.Sc. student in Entomology, co-advised by Dr. Watkins and Dr. Marla Spivak. He is building off the work of a previous graduate student, Ian Lane, trying to better understand how bee lawns can provide benefits to urban landscapes.

David Herrera graduated from New Mexico state in December 2016 and is now a M.Sc. student in the turfgrass breeding program. His research is focused on learning more about fine fescue seed production in Minnesota.

Sam Bauer is a Ph.D. student in the applied plants sciences graduate program. In addition to his full time job with Extension, Sam will be completing his research on the impact of mowing height on runoff of nutrients and pesticides from fine fescue turf.

Program needs

As in the past, our need is for general TROE Center support. We rely on the MTGF, MGCSA and MGA for support of our research facility. We have listed our recent grant funding in Appendix II. As you can see, we have been very successful in this area. It is important to note that this grant funding primarily supports graduate students and scientist positions, but does not cover costs associated with research center maintenance. Without field facility support and the TROE Center, we would not be competitive for these grants. The complete list of faculty and other researchers that utilize the TROE Center can be found in Appendix III.

Budget request: **$65,000**. We are requesting $65,000 for general TROE Center support, which will be utilized to directly fund employees charged with oversight of irrigation systems, equipment maintenance, and pesticide applications.

Our operating budget for 2018 will be $85,000. Proposals have been submitted to the MGCSA for $20,000. Our largest expense is labor but we have managed to hold this number fairly steady at $70,000 for full-time staff and undergraduates. We anticipate in-kind donations of seed, fertilizer and pesticides, and which leaves $15,000 for equipment maintenance, fuel, irrigation supplies, soft goods not donated and field space rental fees.

Appendix I: Publications

Peer Reviewed Research Publications (past 5 years)

Rice, P.J., B.P. Horgan and J. Hamlin. 2017. Evaluation of individual and combined management practices to reduce the off-site transport of pesticides from golf course turf. Science of the Total Environment. 583:72-80.

Rice, P.J. and B.P. Horgan. 2017. Off-site transport of nitrogen fertilizer with runoff from golf course fairway turf: A comparison of creeping bentgrass with a fine fescue mixture. Science of the Total Environment. 580:533-539.

Barnes, M. R., K. C. Nelson, A. Meyer, E. Watkins, S. Bonos, B. Horgan, W. Meyer, J. Murphy, and C. Yue. 2017. Public land managers and sustainable urban vegetation: The case of low-input turfgrasses. Urban Forestry and Urban Greening: https://doi.org/10.1016/j.ufug.2017.12.008.

Friell, J., E. Watkins, B.P. Horgan, and M. Cavanaugh. 2017. Sod strength characteristics of 51 cool-season turfgrass mixtures. Agronomy Journal 109:1749-1757.

Heineck, G.C., E. Watkins, N.J. Ehlke. 2017. Exploring alternative management options for multi-year perennial ryegrass seed production in northern Minnesota. Crop Science: doi:10.2135/cropsci2017.03.0136

Reiter, M. J. Friell, B. Horgan, and E. Watkins. 2017. Drought response of fine fescue mixtures maintained as a golf course fairway. International Turfgrass Society Research Journal 13:65-74.

Hollman, A.B., G. Heineck, K. Frank, S. Bauer, J. Bryan and B.P. Horgan. 2017. Effects of de-icing products on putting green turf. Int. Turf Res. Journal. 13:1-8.

Bauer, S., M. Cavanaugh and B.P. Horgan. 2017. Wetting agent influence on putting green surface firmness. Int. Turf Res. Journal. 13:1-15

Yue, C., J. Wang, E. Watkins, S.A. Bonos, K.C. Nelson, J.A. Murphy, W.A. Meyer, and B. Horgan. 2017. An investigation of trait prioritization in turfgrass breeding programs. HortScience 52:1544-1549.

Yue, C., J. Wang, E. Watkins, S.A. Bonos, K.C. Nelson, J.A. Murphy, W.A. Meyer, and B.

Horgan. 2017. Consumer preferences for information sources of turfgrass products and lawn care. Agronomy Journal 109:1726-1733.

Koch, P.L., D.J. Soldat, S.J. Bauer, A.J. Patton and B.P. Horgan. 2017. The great lakes school of turfgrass science: A nine-state online collaboration to improve the turfgrass short course. Journal of Extension. 55(3):1-6.

Hugie, K.L. and E. Watkins. 2016. Performance of low-input turfgrass species as affected by mowing and nitrogen fertilization in Minnesota. HortScience 51:1278-1286.

Yue, C., J. Wang, E. Watkins, S. Bonos, K. Nelson, J. Murphy, W. Meyer, and B. Horgan. 2016. Heterogeneous consumer preferences for turfgrass attributes in the United States and Canada.
Canadian Journal of Agricultural Economics. doi:10.1111/cjag.12128

Dabney III, C., J. Ostergaard, E. Watkins, and C. Chen. 2016. A novel method to characterize silica bodies in grasses. Plant Methods 12: doi 10.1186/s13007-016-0108-8.

Rice, P.J., B.P. Horgan and J. L. Rittenhouse. 2016. Pesticide transport with runoff from Agrostis palustris fairway turf managed with hollow tine core cultivation and verticutting. Accepted. Science of the Total Environment.

Bauer, S., B.P. Horgan, D. Soldat and D. Gardner. 2016. Effects of low temperatures on nitrogen uptake, partitioning and utilization in creeping bentgrass putting greens. Crop Sci. 57:1001-1009.

Friell, J., E. Watkins, and B.P. Horgan. 2015. Cool-season turfgrass species mixtures for roadsides in Minnesota. Ecological Engineering 84:579-587.

Koeritz, E.J., E. Watkins, and N.J. Ehlke. 2015. Seeding rate, row spacing, and nitrogen rate effects on perennial ryegrass seed production. Crop Science: In press, available online. doi: 10.2135/cropsci2014.02.0130

Watkins, E., D.S. Gardner, J.C. Stier, D.J. Soldat, R.A. St. John, N.E. Christians, A.D. Hathaway, K.L. Diesburg, S.R. Poppe, R.E. Gaussoin. 2014. Cultivar performance of low-input turfgrass species for the North Central United States. Applied Turfgrass Science: doi:10.2134/ATS-2013-0101-RS.

Stier, J.C., B.P. Horgan and S.A. Bonos (ed). 1328 pp. 2013. Turfgrass: biology, use and

management. Agronomy Society of America Book Series. Agronomy Monograph No. 56. Madison, WI.

Rice, P.J. and B.P. Horgan. 2013. Evaluation of nitrogen and phosphorus transport with runoff from fairway turf managed with hollow tine core cultivation and verticutting. Sci. of the Total Environ. doi: dx.doi.org/10.1016/j.scitotenv.2013.02.051.

Gardner, D.S., B.P. Horgan and B.J. Horvath. 2013. Spatial variability of soil amino sugar nitrogen on golf course fairways. Int. Turfgrass Journal. 12:545-551.

Johnson, P.G., F.S. Rossi and B.P. Horgan. 2013. Sustainable turfgrass management in an increasingly urbanized world. In Stier, J.C., B.P. Horgan and S.A. Bonos (eds) Turfgrass: biology, use and management. Agronomy Society of America Book Series. Agronomy Monograph No. 56. Madison, WI.

Watkins, E., L.A. Brilman, and D.M. Kopec. 2013. Development of native grasses for turf. In J.C. Stier, B.P. Horgan and S.A. Bonos (eds.) Turfgrass: Biology, use, and development. ASA-CSSA-SSSA, Madison, WI. p. 661-681.

Friell, J., E. Watkins, and B. Horgan. 2013. Salt-tolerance of 74 turfgrass cultivars in nutrient solution culture. Crop Science 53:1743-1749.

Koeritz, E., E. Watkins, and N.J. Ehlke. 2013. A split application approach to nitrogen and growth regulator management for perennial ryegrass seed production. Crop Science 53:1762-1777.

Miller, D., R. Mugaas, M. Meyer, and E. Watkins. 2013. Performance of low- maintenance turfgrass mixtures and blends. HortTechnology 23:610-612.

Abstracts (past 5 years)

Hollman, A. and E. Watkins. 2017. Survival of turfgrasses under extended ice cover in a controlled environment. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Laskowski, M., E. Watkins, and C. Chen. 2017. Salt tolerance evaluation of cool-season turfgrasses for roadsides in cold climates. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Petrella, D., E. Nangle, and E. Watkins. 2017. The impact of end of day light quality on

turfgrass morphology. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Qiu, Y., A. Orshinsky, C. Hirsch, and E. Watkins. 2017. Transcriptome analysis using RNA sequencing of hard fescue (*Festuca brevipila*) treated with triazolic fungicide. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Qiu, Y., A. Orshinsky, M. Reiter, and E. Watkins. 2017. Simple sequence repeats of single nucleotide polymorphism marker-based detection and quantification of fine fescues (*Festuca* spp.) in a mixed stand. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Sessoms, F., A. Hollman, G. Heineck, W. Sadok, and E. Watkins. 2017. Evaluation of candidate roadside turfgrasses for heat stress tolerance. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Thurston, C., E. Perkus, E. Watkins, G. Heineck, and J. Grossman. 2017. Freezing tolerance of two legume cover crops for Upper Midwest high tunnel conditions. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Trappe, J.M., E. Watkins, L. Ma, and A.J. Patton. 2017. Field and laboratory screening of fine fescues for allelopathic potential. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Trappe, J.M., S. Bauer, E. Watkins, and M. Cavanaugh. 2017. Effect of seeding date on tall fescue and fine fescue performance. ASA-CSSA-SSSA International Meeting. Tampa, FL.

Rice, P.J., J. White, B.P. Horgan, P. Coody, E. Arthur and L. McConnell. 2017. Quantification of turfgrass buffer performance in reducing transport of trichlorfon and tebuconazole in surface runoff. American Chemical Soc.

Schwab, R., F. Sessoms, B.P. Horgan and S. Bauer. 2017. Comparison of methods for quantifying soil water repellency in surfactant-applied soil. Agronomy Abstracts, Madison, WI.

Bauer, S., B.P. Horgan and R. Schwab. 2017. Reducing water use on Twin Cities lawns through assessment, research and demonstration. Agronomy Abstracts. Madison, WI.
Bauer, S., E. Watkins, B. Horgan, and J. Reyes. 2016. Establishment of roadside turfgrasses with modular irrigation systems. ASA-CSSA-SSSA International Meeting. Phoenix, AZ.

Grimshaw, A.L., S.A. Bonos, W.A. Meyer, and E. Watkins. 2016. Heritability estimates for fine fescue species (Festuca spp.) in response to wear. ASA-CSSA-SSSA International

Meeting. Phoenix, AZ.

Heineck, G., E. Watkins, and N.J. Ehlke. 2016. Exploring the possibility of multi-year perennial ryegrass seed production in Minnesota. ASA-CSSA-SSSA International Meeting. Phoenix, AZ.

Qiu, Y., A. Orshinsky, M. Reiter, and E. Watkins. 2016. Use of real-time PCR for determining species proportions in a mixed fine fescue turfgrass community. ASA-CSSA-SSSA International Meeting. Phoenix, AZ. ASA-CSSA-SSSA International Meeting. Phoenix, AZ.

Trappe, J.M., E. Watkins, A. Hollman, S. Bauer, and M. Cavanaugh. 2016. Determining optimum watering regimes for establishment of Kentucky bluegrass sod and fine fescue sod. ASA-CSSA-SSSA International Meeting. Phoenix, AZ.

Watkins, E., S. Bauer, J. Friell, and B. Horgan. 2016. Roadside turfgrass research in Minnesota. ASA-CSSA-SSSA International Meeting. Phoenix, AZ.

Rice, P.J., B.P. Horgan and J.L. Hamlin. 2016. Evaluation of turfgrass variety and management practices to mitigate off-site transport of pesticides and nutrients with runoff from golf course fairway turf. Society for Environmental Toxicology and Chemistry.

Bauer, Samuel; Cavanaugh, Matthew; Horgan, Brian. 2015. Evaluation of creeping bentgrass cultivar germination differences at various temperatures. ASA, CSSA and SSSA International Annual Meetings. P 94190.

Cavanaugh, Matthew; Bauer, Samuel; Heineck, Garett Carl; Hollman, Andrew; Watkins, Eric; Horgan, Brian. 2015. Freezing tolerance of creeping bentgrass cultivars. ASA, CSSA and SSSA International Annual Meetings. p. 94131.

Cavanaugh, Matthew; Bauer, Samuel; Horgan, Brian. 2015. Wetting agents and their effect on surface firmness and winter health of creeping bentgrass putting greens. ASA, CSSA and SSSA International Annual Meetings. p. 94097.

Dabney III, C.J., J. Ostergaard, C. Chen, and E. Watkins. 2015. The association of silica bodies with mowing quality and traffic tolerance. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Dabney III, C.J., C. Staley, E. Watkins, and M.J. Sadowsky. 2015. The impact of individual, population, and species as well as fertilizer regime on turfgrass microbial communities.

ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Friell, J., E. Watkins, B. Horgan, and M. Cavanaugh. 2015. Sod strength characteristics of 51 cool-season turfgrass mixtures. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Guzey, S., T. Michaels, and E. Watkins. 2015. Experiential learning in the plant sciences through augmented reality. National Association for Research in Science Teaching Annual International Conference. Chicago, IL.

Heineck, G.C., N.J. Ehlke, and E. Watkins. 2015. Exploring the possibility of multi-year perennial ryegrass seed production in Minnesota. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Heineck, G.C., A. Orshinsky, E. Watkins, and N.J. Ehlke. 2015. Finding benefit in endophytes to mitigate the effects of freezing stress in perennial ryegrass. ASA-CSSA- SSSA International Meeting. Minneapolis, MN.

Hollman, A., E. Watkins, and B. Horgan. 2015. Fine fescue species tolerance to controlled ice encasement. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Horgan, Brian; Leslie, Madeline; Murphy, James A.; Bauer, Samuel. 2015. Building an extension program for the fine fescue SCRI grant. ASA, CSSA and SSSA International Annual Meetings. p. 93790.

Lane, I., E. Watkins, and M. Spivak. 2015. Seeding strategies for three flowering forbs into mature lawns for use in pollinator conservation schemes. ASA-CSSA-SSSA/ESA International Meeting. Minneapolis, MN.

Lane, I., E. Watkins, and M. Spivak. 2015. Floral enrichment of turf lawns and its potential benefit for pollinator communities. Entomology Society of America annual meeting. Minneapolis, MN.

Ma, L., E. Watkins, and A. Hegeman. 2015. A method for the assessment of allelopathy and the identification of allelochemicals within fine fescue germplasm. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Reiter, M., B. Horgan, and E. Watkins. 2015. Fine fescue fairway mixtures response to acute drought. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Yue, C., J. Wang, and E. Watkins. 2015. Investigating U.S. and Canada consumer preference for turfgrass attributes. ASA-CSSA-SSSA International Meeting. Minneapolis, MN.

Yue, C., J. Wang and E. Watkins. 2015. Consumer preference for turfgrass attributes in the United States. American Society for Horticultural Science Annual Conference. New Orleans, LA.

Hoffman, L., E. Watkins, and A. Hegeman. 2014. Improving winterhardiness of temperate perennial grasses using metabolomics-assisted breeding. Plant Biology 2014: Annual Meeting of the American Society of Plant Biologists.
Portland Oregon.

Hoffman, L., E. Koeritz, D. Freund, A. Hegeman, E. Watkins, and N.J. Ehlke. 2014. Development of a metabolomics-assisted selection tool for breeding cool-season turfgrass species. ASA-CSSA-SSSA International Meeting, Long Beach, CA.

Lane, I., M. Spivak, and E. Watkins. 2014. The bee lawn: Reimagining the traditional lawn as a foraging resource for honey bees. American Beekeeping Federation Conference and Trade Show. Baton Rouge, LA.

Lane, I., E. Watkins, and M. Spivak. 2014. Investigating techniques for incorporating flowering forbs into turf lawns to improve pollinator forage opportunities. Entomology 2014: Entomological Society of America annual meeting. Portland, OR.

Leslie, M., B. Horgan, and E. Watkins. 2014. Perceptions of runoff water pathways through urban spaces: A survey of homeowners in the Minneapolis-----St. Paul, MN metropolitan area. 13th International Water Association Specialist Conference on Watershed and River Basin Management. San Francisco, CA.

Reiter, M., E. Watkins, and B.P. Horgan. 2014. Effect of trinexapac-ethyl on divot recovery and traffic damage in fine fescue fairways. ASA-CSSA-SSSA International Meeting, Long Beach, CA.

Heineck, G.C., E. Waktins, and N.J. Ehlke. 2014. Effect of Neotyphodium lolii on the freezing tolerance of Lolium perenne. ASA-CSSA-SSSA International Meeting, Long Beach, CA.

Ma, L., E. Watkins, and A. Orshinsky. 2014. Laboratory assessment of allelopathy in recently-developed fine fescue cultivars. ASA-CSSA-SSSA International Meeting, Long

Beach, CA.

Dabney, C., E. Watkins. 2014. The effect of fertilization and turfgrass species on the rhizosphere microbial community structure. ASA-CSSA-SSSA International Meeting, Long Beach, CA.

Watkins, E., T. Michaels, S. Guzey, J. Friell, and C. Dabney III. 2014. Horticulture instruction with "augmented reality". ASA-CSSA-SSSA International Meeting, Long Beach, CA.

Friell, J., E. Watkins, B. Horgan and M. Reiter. 2013. Evaluation of cool-season turfgrass species mixtures for roadsides. Agronomy abstracts. ASA-CSSA-SSSA, Madison, WI.

Friell, J., E. Watkins, B. Horgan and M. Reiter. 2013. Turfgrass seed mixture optimization. Agronomy abstracts. ASA-CSSA-SSSA, Madison, WI.

Magazine articles/proceedings (past 5 years)

Bauer. S. 2017. Managing sports turf using wetting agents: A case for full-field applications. SportsTurf. 33(12): p. 8-10.

Bauer, S. 2017. On Sight- A Directional Pivot for Member-Driven Research. Hole Notes. March. 52(2): p. 26-29.

Bauer, S. 2017. Top 5 home lawn questions & answers. MTGF Clippings. Spring/Summer. 25(1): p. 16-17.

Watkins, E, and J. Trappe. 2017. Best management practices for establishment of salt-tolerant grasses on roadsides. Minnesota Department of Transportation. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/190715.

Bauer, S. and B.P. Horgan. 2017. Spring golf course report. Hole Notes. April. 52(3): p. 24-27.

Watkins, E., B.P. Horgan, S. Bauer and A. Orshinsky. 2017. MTGF funding $60,000: Turfgrass program support. Clippings. Spring/Summer. 25(1): p. 13-14.

Bauer, S. and B.P. Horgan. 2016. Wetting agent influence on surface firmness and winter injury of putting greens. Hole Notes. April 50(3): p. 42-45, 47-50.

Watkins, E., B.P. Horgan, S.Bauer and A. Orshinsky. 2016. Turfgrass program support. MTGF Clippings. Spring/Summer. 24(1): p. 11.

Reiter, M., B.P. Horgan and E. Watkins. 2016. Response of fine fescue fairway mixtures under drought conditions. Golf Course Management.

Horgan, B.P., S. Bauer and M. Cavanaugh. 2016. Evaluation of creeping bentgrass variety germination differences at various temperatures. Hole Notes 50(1): p. 8-11.

Bauer. S. 2016. Soil Wetting Agents for Water Conservation. MTGF Clippings. Fall/Winter. 24(2): p. 6.

Bauer, S. 2016. A multitude of portable moisture meters. Hole Notes. 51(8): p. 44-55.

Bauer, S. A new face at the U of M: Jonah Reyes joins the turfgrass science program. 2016. Hole Notes. April. 50(3): p. 51.

Horgan, B., Bauer, S., Cavanaugh, M. 2015. Growing Degree Day modeling for Trimmit and Cutless applications on creeping bentgrass fairways. Hole Notes. 49(3): p. 20-30.

Horgan, B., Bauer, S., Cavanaugh, M. 2015. Growing Degree Day modeling for Primo applications on creeping bentgrass putting greens. Hole Notes. 49(3) p. 32-39.

Horgan, B., Bauer, S., Cavanaugh, M. 2015. Wetting agents and their effect on surface firmness and winter health of bentgrass putting greens. Hole Notes. April 49(3): p. 42-66.

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Watkins, E., D.S. Gardner, J.C. Stier, D.J. Soldat, R.A. St. John, N.E. Christians, A.D. Hathaway, K.L. Diesburg, S.R. Poppe, R.E. Gaussoin. 2015. Low-input turfgrass species for the north-central United States. Golf Course Management 83:133-138.

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Watkins, E. 2012. How does turfgrass breeding benefit MPSTMA? Minnesota Park and Sports Turf Managers Association Newsletter. March.

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Appendix II: Current Grant Funding

Watkins, E. N. Ehlke, A. Hegeman, G. Heineck, and D. Petrella. 2018-2021. Increasing yields in perennial ryegrass seed production systems through agronomics and breeding. Minnesota Department of Agriculture. $130,175.

Watkins, E., C. Yue, and S. Bauer. 2018-2022. Regional optimization of roadside turfgrass seed mixtures phase 2: Regional field trials and economic analysis. Minnesota Department of Transportation/Local Road Research Board. $467,139.

Watkins, E., S. Bonos, N Anderson, S. Bauer, B.S. Bushman, B. Clarke, A. Hegeman, J. Honig, B. Horgan, B. Huang, P. Koch, A. Kowalewski, W. Meyer, J. Murphy, K. Nelson, A. Patton, S. Shekhar, C. Yue, N. Zhang. 2017-2021. Increasing low-input turfgrass adoption through breeding, innovation, and public education. USDA-NIFA Specialty Crop Research Initiative. $5,485,450.

Koch, P., S. Bauer, D. Soldat and B.P. Horgan. 2018-2020. Dollar spot management through alternative fertilizer programs. Environmental Institute for Golf. $60,000.

Bauer, S.J. and B.P. Horgan. 2018-2019. Reducing water use on Twin Cities lawns through research, education, and outreach. Metropolitan Council. $199,680.

Horgan, B.P., S. Bauer and J. Friell. 2018-2020. Precision golf course irrigation. United States Golf Association. $204,876.

Horgan, B.P., E. Lonsdorf. 2017. Natural capital of golf courses. United States Golf Association. $180,885.

Horgan, B.P., S. St. Martin and V. Laird. 2017. Projected water policy and economic considerations for the golf industry: a comparative analysis between Phoenix and Minneapolis/St. Paul. $30,000.

Horgan, B.P. and P. Anderson. 2017. Sustainable golf manual. United States Golf Association. $35,787.

Horgan, B.P. and P. Anderson. 2017. Impact of green speed on pace of play. United States Golf Association. $31,458.

Watkins, E, J. Grossman, W. Sadok, N. Ehlke, K. Smith, and N. Anderson. 2017.

Programmable freezer for improving the winter survival of perennial crops. Forever Green Initiative. $28,644.

Watkins, E., M. Renz, D. Soldat, K. Frank, W. Kreuser, and J. Murphy. 2016-2019. Regional roadside testing program. Minnesota Department of Transportation $200,000.

Spivak, M., E. Watkins, and K. Nelson. 2016-2019. Bee pollinator habitat enhancement – phase 2. Minnesota Environment and Natural Resources Trust Fund. $387,015.

Watkins, E., S. Bauer and A. Hollman. 2017-2019. Establishment and Management of No-Mow Fine Fescue Roughs. United States Golf Association. $44,272.

Watkins, E. and N.J. Ehlke. 2016-2019. Fine fescue: A new grass seed crop for Minnesota. Minnesota Crop Research Grant Program. $240,217.

Watkins, E., S. Bauer, and J. Friell. 2016-2018. Regional optimization of roadside turfgrass seed mixtures. Minnesota Department of Transportation/Local Road Research Board. $142,346.

Horgan, B.P., E. Watkins, S. Bauer and A. Orshinsky. 2016-2021. United States Golf Association Master Research Agreement: Research, Science and Innovation for the Golf Industry. $2,500,000.

Bauer, S. and B.P. Horgan. 2016. Reducing water use in the Twin Cities through research, education and demonstration. Metropolitan Council. $122,592.

Rice, P. and B.P. Horgan. 2015. Fate and transport of pesticides in runoff water from turfgrass. Bayer Crop Science. $44,000.

Bauer, S., E. Watkins, and B. Horgan. 2015-2019. Expanding the success of salt-tolerant roadside turfgrasses through innovation and education. Minnesota Department of Transportation/Local Road Research Board. $168,974.

Stier, J.C., K. Kopp, E. Watkins, M. Elmore, J. Henderson, and J. Baird. 2015-2018. Documenting water use for turfgrasses in the United States. The Lawn Institute. $50,000.

Horgan, B.P. and B. Ballenger. 2014-2016. Comparative pesticide programs for reducing inputs on a golf course. Syngenta. $25,000.

Bauer, S., B. Horgan, E. Watkins. 2013- current. Member Driven Research Initiative. Minnesota Golf Course Superintendents Association. $20,000 annually.

Spivak, M., E. Watkins, and M. Meyer. 2013-2014. Bee lawns: A unique way to help pollinators. Minnesota Environmental and Natural Resources Trust Fund. $200,000.

Watkins, E., A. Hegeman, N. Ehlke, and L. Hoffman. 2013-2016. Development of new winter-hardy perennial ryegrass cultivars for seed production in northern Minnesota. Minnesota Agricultural Experiment Station Variety Development Fund. $140,642.

Watkins, E. and B. Horgan. 2013-2017. Best management practices for establishment of salt-tolerant grasses on roadsides. Minnesota Department of Transportation/Local Road Research Board. $193,677.

Watkins, E., M. Spivak, and E. Mader. 2013-2014. New course proposal: Pollinator protection in managed landscapes. College of Food, Agriculture and Natural Resource Sciences. $48,250.

Watkins, E., S. Bonos, C. Yue, K. Nelson, B. Horgan, J. Kerns, B. Huang, B. Clarke, J. Murphy, and W. Meyer. 2012-2017. Germplasm improvement of low-input fine fescues in response to consumer attitudes and behaviors. USDA-NIFA Specialty Crops Research Initiative. $2,136,489.

Watkins, E., and B. Horgan. 2012-2017. Germplasm improvement of low-input fine fescues in response to consumer attitudes and behaviors. Industry matching funds (various sources). $105,000.

Michaels, T., Watkins, E., S. Guzey, E. Hoover. 2012-2014. Experiential learning in the plant sciences through augmented reality. USDA Higher Education Challenge Grant. $109,619.

Ehlke, N., and E. Watkins. 2012-2017. National turfgrass evaluation program participation funding. University of Minnesota Office of the Vice President for Research. $20,000.

Watkins, E. 2013. Exploring new research areas in sustainable, low-input turfgrass germplasm improvement. Minnesota Agricultural Experiment Station. $15,500.

Watkins, E., and B. Horgan. 2012-2015. Adaptation and management of fine fescues for golf course fairways. United States Golf Association. $74,213.

Appendix III: Faculty, Staff, and Graduate Students

FACULTY CONDUCTING RESEARCH AT THE TROE CENTER

Sam Bauer
Associate Extension Professor AFNR Extension
University of Minnesota-Twin Cities

Nancy Ehlke, Ph.D. Professor and Head Department of Agronomy and Plant Genetics
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Brian Horgan, Ph.D. Professor Department of Horticultural Science
College of Food, Agriculture and Natural Resource Sciences
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Mary Meyer, Ph.D. Professor Department of Horticultural Science
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Angela Orshinsky, Ph.D. Assistant Professor Department of Plant Pathology
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Pam Rice, Ph.D. USDA-ARS
Department of Soil Water and Climate
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Carl Rosen, Ph.D.
Professor, Interim Associate Dean Department of Soil Water and Climate
College of Food, Agriculture and Natural Resource Sciences
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Marla Spivak, Ph.D. Professor Department of Entomology
College of Food, Agriculture and Natural Resource Sciences
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Eric Watkins, Ph.D. Professor Department of Horticultural Science
College of Food, Agriculture and Natural Resource Sciences
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College of Food, Agriculture and Natural Resource Sciences
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Matt McNeanery, Scientist
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College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Garett Heineck
Applied Plant Sciences Graduate Program
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Yinjie Qiu
Applied Plant Sciences Graduate Program
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

Michael Laskowski
Applied Plant Sciences Graduate Program
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

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Entomology Graduate Program
College of Food, Agriculture and Natural Resource Sciences
University of Minnesota-Twin Cities

David Herrera

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Sam Bauer
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