ALACHUA COUNTY
LANDSCAPING FERTILIZER AND IRRIGATION RECOMMENDATION LITERATURE REVIEW

FINAL REPORT

Prepared for

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EXECUTIVE SUMMARY

As Florida's population increases and development continues, pollution from developed areas can contribute to algae blooms, anoxia, and biodiversity loss in aquatic environments. Meanwhile, the fresh water supply in Florida is projected by the Florida Department of Environmental Protection to be unable to meet the growing needs of Floridians in the future[1]. With these increasing pressures on water quantity, protecting the quality of the available water supply is important and reducing excess fertilization in landscaping provides an opportunity to protect water quality. Landscaping practices also provide an opportunity for protecting water quantity – a recent report from the Florida 2070 and Water 2070 projects states that reducing the amount of water used for landscape irrigation is the single most effective strategy to reduce water demand. Although landscaping like turfgrass provides important social (e.g., recreation) and environmental (e.g., reducing soil erosion) benefits, shifts in our expectations and management practices can provide opportunities to reduce negative impacts to our water resources from highly maintained turfgrass.

Wood conducted a literature review of selected relevant documents (e.g., peer-reviewed literature, outreach documents produced by the University of Florida's Institute of Food and Agricultural Sciences [IFAS], etc.) used to develop and disseminate fertilizer and irrigation recommendations for residential landscaping in Florida. The aim of the review was to identify data gaps in the development of the published recommendations and areas for improvement that could allow for lower fertilizer application rates and less of an emphasis on fertilizer and irrigation in urban landscapes.

Turfgrass fertilizer application rates for Florida developed by the University of Florida's IFAS are included in the Florida Administrative Code. The current rates are largely reflected in the DEP WM 869 Warm Season Turf Grass Nitrogen Rates and Irrigation BMP Verification study (FDEP, 2012) which was funded by the FDEP to investigate recommended fertilizer rates and nitrate leaching. A review of the projects carried out under DEP WM 869 revealed several areas where the interpretation and application of study results could allow for lower fertilizer application rate recommendations. Turf quality was one of the primary tools used by researchers to assess whether or not the turf appearance would be considered acceptable to a homeowner. Turf quality can range from 0 to 9 and researchers used a turf quality score of 6 to indicate acceptable as established by turf professionals. However, lower turf quality scores may be acceptable and could result in lower recommended fertilization rates, especially for St. Augustinegrass. Additionally, concerns with the study duration, analytes, and fate of fertilizer warrant the caveated results in the original DEP WM 860 publications. There are numerous publications publicizing the data collected under DEP WM 869, including over 20 peer reviewed publications, over 20 presentations and conference proceedings, and several trade magazine articles. The sheer volume of publications referencing this data illustrates the far-reaching implications of the findings.

Limiting residential landscape irrigation is another opportunity for lessening the environmental impact of landscaping practices. While there are recommended irrigation rates and irrigation restrictions throughout Florida, these measures do not promote minimal water use landscaping . Incorporating turf species that use less irrigation or selecting alternative groundcovers can achieve similar aesthetics while lessening irrigation needs. In a study by the University of Florida's IFAS (Haley et al., 2020), combining micro irrigation, less turf, and drought tolerant plants resulted in 39% less irrigation needs compared to more traditional lawns and irrigation practices. Large-scale adoption of such irrigation and landscaping approaches (e.g., selection of turf that does not require irrigation, incorporating alternative drought tolerant groundcovers) could result in considerable irrigation water savings.

[1] Florida Department of Environmental Protection's Annual (2020) Water Supply Report website, available at: https://floridadep.gov/water-policy/water-policy/content/water-supply

1.0 INTRODUCTION

As Florida's population grows and development continues, the potential for landscaping choices and management practices to have an impact on Florida's water resources is increasingly clear. The need to protect Florida's water resources is featured in a recent report from the Florida 2070 and Water 2070 projects – a joint effort by the Florida Department of Agriculture and Consumer Services, University of Florida Geoplan Center and 1000 Friends of Florida. The Florida 2070/Water 2070 report[2] states, "The single most effective strategy to reduce water demand in Florida is to significantly reduce the amount of water used for landscape irrigation." Additionally, contamination of groundwater from fertilizers and pesticides may pose both ecological and human health risks. Nutrient contamination from fertilizer use is of particular concern. Nutrient runoff from nonpoint sources contributes to algae blooms, anoxia, and biodiversity loss in aquatic environments (Yang and Toor, 2016). In particular, the application of fertilizer to residential landscaping has been recognized as an important source of nitrogen (N) and phosphorus pollution in urban areas (Souto et al., 2019; Yang and Toor, 2016; and Yang and Toor, 2017). Fertilizers are not necessarily the primary source of N pollution, as demonstrated in Yang and Toor (2016, 2017) who reported that chemical N fertilizers were secondary to atmospheric deposition. However, depending on environmental conditions, nitrate sources in stormwater runoff can shift from atmospheric deposition to inorganic N fertilizers under conditions of higher rainfall amounts and longer durations (Jani et al., 2020). Krimsky et al. (2021) also noted high contributions from atmospheric deposition, though reported that their study suggests that nitrogen based fertilizers contributed up to 44% of nitrate in lawn runoff. Nitrogen from fertilizer can also leach into groundwater, as demonstrated in a study of the Wekiva River Basin that found that residential fertilizer use was the only plausible source available for the observed increase in groundwater concentrations of nitrate (Tucker et al. 2014). Reducing irrigation and fertilization of residential landscapes presents an important opportunity to reduce overuse and contamination of Florida's valuable water resources. Florida has over 4 million acres of turfgrass with 75% in residential lawns (Nagata, 2003). So, although turfgrass provides important services, including recreation areas for people and pets, it also presents an opportunity to reduce the environmental impact of landscaping practices.

Wood Environment & Infrastructure Solutions, Inc. (Wood) was contracted by the Alachua County Environmental Protection Department (ACEPD or "the County") to conduct a review of current literature on Florida landscaping practices and policies as it pertains to optimal protection of water resources. This report provides an updated summary of the literature pertinent to landscaping recommendations in Florida. Survey data often reflects that the University of Florida Institute of Food and Agricultural Sciences (IFAS) is the trusted source of information regarding landscaping. In a 2019 ACEPD survey about residential fertilizer behaviors, IFAS websites were reported as the most visited websites (Uppercase Research, 2019). While IFAS has and continues to conduct valuable studies and publish numerous recommendations regarding urban landscaping, there are still gaps in the knowledge and understanding of the boundaries of current studies. For example, work conducted by IFAS on behalf of the Florida Department of Environmental Protection (DEP WM 869 [FDEP, 2012]) titled, "Warm Season Turf Grass Nitrogen Rates and Irrigation BMP Verification" was used to inform the state's recommended fertilizer rates. As part of this project, the authors examine the caveats of this and other studies from a different perspective – of landscaping impacts to water resources rather than the studies' primary focus on optimal plant health and aesthetics.

With this literature review, the County is focused on understanding how to 1) shift public expectations to landscaping that is aesthetically pleasing while minimizing maintenance, irrigation, and chemical inputs; 2)

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[2] Florida 2070 report available at: http://1000friendsofflorida.org/florida2070/wp-content/uploads/2017/08/FOF-1080-Newsletter-Spring-2017-v12-web.pdf

maintain landscaping with little to no chemical inputs and irrigation; and 3) create policies, outreach, and research to support these findings. The goal is to identify where study design and interpretation coincide with the goals of water quality and quantity protection, and to re-evaluate data from studies focused primarily on optimal plant health and aesthetics to also consider protection of water resources. The review will summarize study caveats and boundaries, and will highlight Florida landscaping alternatives that prioritize protection of water resources in addition to aesthetics.

2.0 FERTILIZER APPLICATION RATES FOR TURFGRASS

The fertilizer rates currently recommended by IFAS are included below in **Table 2-1**. IFAS recommends a range of N applications; for example, IFAS recommends from 1 to 3 lb N/1,000 ft^2/yr for bahiagrass in North Florida. According to IFAS, this range is intended to encompass homeowner preferences (lawn quality and maintenance) and potential localized environmental differences.

Table 2-1. Current (2016 to Present) Fertilizer Rates Recommended by IFAS

Species	N Application (lb N/1,000 ft^2/yr) by Region		
	North [a]	Central [a]	South [a]
Bahia	1-3	1-3	1-4
Centipede	0.4-2	0.4-3	0.4-3
St. Augustine	2-4	2-5	4-6
Zoysiagrass	2-3	2-4	2.5-4.5

[a] North Florida = north of Ocala; Central Florida = from Ocala to State Road 60; South Florida = south of State Road 60.

The IFAS recommended rates are referenced in the Florida Administrative Code (F.A.C.) (F.A.C. 5E-1.003) as part of the Urban Turf Fertilizer Rule. The rates in **Table 2-1** are based, in part, on the DEP WM 869 Warm Season Turf Grass Nitrogen Rates and Irrigation BMP Verification study (FDEP, 2012). This study is referenced in an editorial printed in the Gainesville Sun in August 2017[3] in which IFAS researchers noted that (bolding by Wood):

> *"**To provide objective, evidence-based turf management recommendations that minimize environmental impact**, the FDEP agreed to fund an eight-year, multi-location study in Gainesville, Jay (near Pensacola) and Fort Lauderdale to answer these key questions. The specific interest of the FDEP was to determine precise levels of nutrient leaching under the myriad conditions tested."*

While this statement has a focus on environmental impact, it is important to note that the IFAS recommendations do not appear to prioritize environmental impact according to the following excerpt from Dukes et al. (2020):

> *"As a land-grant university, the University of Florida has a mission to serve all stakeholders through UF/IFAS. Those stakeholders represent agriculture, horticulture, and natural resources. UF/IFAS develops fertilizer recommendations with the goal of using the least amount of fertilizer to elicit a desired response in plants, as do all land-grant universities. In agriculture, the goal is to use the smallest fertilizer application to produce the maximum yield. In horticulture, the objective is to apply the smallest amount of fertilizer to maintain optimal health and acceptable quality. **Although the development of fertilizer recommendations described here minimizes the amount used, the primary consideration is plant response rather than environmental impact.** Fertilizer recommendations are regularly reviewed to assess whether less product can be used to obtain the same response, because fertilizer is costly and the science of identifying, documenting and*

[3] Gainesville Sun opinion piece by L.E. Trenholm and B. Unruh titled "IFAS recommendations based on rigorous research" August 29, 2017.

> *measuring impacts on the natural environment is ongoing. Recent research has resulted in reduced fertilization recommendations for three turfgrass species…That said, under certain conditions, even the recommended amount could have environmental consequences."*

For various institutional reasons, IFAS has continued to focus its fertilizer recommendations primarily on plant response rather than environmental impact to water resources. While shifting those institutional drivers is primarily the role of IFAS, this project is designed to provide scientific evidence to support IFAS in making those shifts by highlighting opportunities for research that build on existing data to prioritize both plant response and environmental impact.

2.1. DEP WM 869 Background

The DEP WM 869 Warm Season Turf Grass Nitrogen Rates and Irrigation BMP Verification (FDEP, 2012) study included three study locations throughout Florida (Ft. Lauderdale, Gainesville, and Jay) and began in 2005. Four turfgrass species were included (though not at all locations): St. Augustinegrass, zoysiagrass, bahiagrass, and centipededgrass. Nitrogen-containing fertilizers (typically urea-based) were applied at different rates, and concentrations of nitrate were measured in the leachate from the experimental plots. The turf response was assessed, primarily via a Turf Quality (TQ) score. TQ can range from 1 (poor, low quality) to 9 (high quality), with 6 used in the DEP WM 869 studies as the minimally acceptable TQ for homeowners. The TQ scoring methodology was based on the National Turfgrass Evaluation Procedures (NTEP). The NTEP defines turfgrass quality as a "measure of aesthetics (i.e., density, uniformity, texture, smoothness, growth habit and color), and functional use".[4] TQ is assessed visually. **Table 2-2** below is reproduced from DEP WM 869 and summarizes the different locations and project durations.

Additional information is available at https://wfrec.ifas.ufl.edu/turfgrass-science/nutrient-management-research/fdep-funded-study/. The results of the various projects (**Table 2-2**) conducted under DEP WM 869 were included in a completed studies report, referred to as the "DEP WM 869 Final Report". The Final Report includes summaries, reports, student theses, student dissertations, and peer reviewed publications using data from the DEP WM 869 projects.

It is important to note that the DEP WM 869 study produced a large amount of valuable data. **Table 2-3** provides a selection of readily accessible guidance documents, websites, and manuals that include references and/or recommendations for following the IFAS fertilizer rates, most recently revised (or maintained) based on data from DEP WM 869. A relatively brief search of turfgrass fertilization recommendations for Florida yielded 26 online resources incorporating the IFAS recommended fertilizer application rates. In addition, there are numerous publications, reports, and conference proceedings publicizing the data collected under DEP WM 869, including over 20 peer reviewed publications, over 20 presentations and conference proceedings, and several trade magazine articles. The sheer volume of publications referencing this data illustrates the far-reaching implications of the findings.

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4 A Guide to NTEP Turfgrass Ratings, available at: https://www.ntep.org/reports/ratings.htm#:~:text=Turfgrass%20quality%20is%20a%20measure,on%20the%20turfgrass%20evaluator's%20judgement.

Table 2-2. Summary of DEP WM 869 Projects (reproduced from FDEP, 2012)

Location	Project Title	Project #	Grasses	Start Date	Completion Date
Ft. Lauderdale	Nitrate Leaching From Newly Sodded Grass	1	St. Augustinegrass	Spring 2005	2006
	Nitrate Leaching From Established Grass	2	St. Augustinegrass Bahiagrass	2006	2008
	Nitrate Leaching Due to N Source and Timing	3	St. Augustinegrass	2007	2009
	Soil Test Phosphorus	4	St. Augustinegrass	2008	2009
Gainesville	Nitrate Leaching From Newly Sodded Grass	1	St. Augustinegrass Zoysiagrass	2005	2008
	Nitrate Leaching From Established Grass	2	St. Augustinegrass Zoysiagrass	2005	2007
	Nitrate Leaching In Winter Months	4	St. Augustinegrass Zoysiagrass	Fall 2006	Winter 2009
	Nitrate Leaching Due to N Source	3	St. Augustinegrass Zoysiagrass	Summer 2008	2011
	Phosphorus Requirements and Leaching	5a	St. Augustinegrass Zoysiagrass	2007	2009
	Phosphorus Leaching	5a	St. Augustinegrass Zoysiagrass	2007	2009
Jay	Nitrate Leaching From Newly Seeded/Sodded Grass	1	St. Augustinegrass Centipedegrass	2005	2007
	Nitrate Leaching From Established Grass	2	St. Augustinegrass Centipedegrass	2005	2007
	Nitrate Leaching In Winter Months	4	St. Augustinegrass Centipedegrass	2006	2009
	Nitrate Leaching Due to Slow Release N	6	Centipedegrass	2008	2011
	Nitrate Leaching Due to N Source / Timing	3			

Table 2-3. Select IFAS References Incorporating Recommended Fertilizer Rates from DEP WM 869

Document Type and Title	Link
EDIS Documents	
Bahiagrass for Florida Lawns (2/14/2022)	https://edis.ifas.ufl.edu/publication/LH006
Bermudagrass for Florida Lawns (8/21/2022)	https://edis.ifas.ufl.edu/publication/LH007
Best Management Practices for Irrigating Lawns and Urban Green Spaces with Reclaimed Water (12/5/2021)	https://edis.ifas.ufl.edu/publication/SS704
Central Florida Gardening Calendar (1/11/2021)	https://edis.ifas.ufl.edu/publication/EP450
General Recommendations for Fertilization of Turfgrasses on Florida Soils (3/21/2017)	https://edis.ifas.ufl.edu/publication/LH014
Homeowner Best Management Practices for the Home Lawn (3/15/2018)	https://edis.ifas.ufl.edu/publication/EP236
Managing Landscape Irrigation to Avoid Soil and Nutrient Losses (12/21/2016)	https://edis.ifas.ufl.edu/publication/SS586
North Florida Gardening Calendar (1/11/2021)	https://edis.ifas.ufl.edu/publication/EP451
Soils and Fertilizers for Master Gardeners: The Florida Gardener's Guide to Landscape Fertilizers (8/29/2021)	https://edis.ifas.ufl.edu/publication/MG448
South Florida Gardening Calendar (2/14/2021)	https://edis.ifas.ufl.edu/publication/EP452
St. Augustinegrass for Florida Lawns (8/15/2021)	https://edis.ifas.ufl.edu/publication/LH010
The Fate of Nitrogen Applied to Florida Turfgrass (1/10/2018)	https://edis.ifas.ufl.edu/publication/EP546
The Florida Fertilizer Label (2/20/2017)	https://edis.ifas.ufl.edu/publication/SS170
The Role of Soil Management In Minimizing Water and Nutrient Losses from the Urban Landscape (4/26/2022)	https://edis.ifas.ufl.edu/publication/SS593
Urban Fertilizer Ordinances in the Context of Environmental Horticulture and Water Quality Extension Programs: Frequently Asked Questions (2/13/2020)	https://edis.ifas.ufl.edu/publication/AE534
Urban Turf Fertilizer Rule for Home Lawn Fertilization (2/6/2018)	https://edis.ifas.ufl.edu/publication/EP353
Zoysiagrass for Florida Lawns (5/15/2022)	https://edis.ifas.ufl.edu/publication/LH011
EDIS and Related Websites	
Fertilizing Your Florida Lawn	https://gardeningsolutions.ifas.ufl.edu/care/fertilizer/fertilizing-the-lawn.html
Florida-Friendly Landscaping™ Program	https://ffl.ifas.ufl.edu/about-ffl/9-principles/principle-3-guidance/
Landscape Irrigation and Fertilization	https://edis.ifas.ufl.edu/entity/topic/landscape_irrigation_and_fertilization
Lawn Fertilizer	https://edis.ifas.ufl.edu/entity/topic/lawn_fertilization
Turfgrass Nutrition	https://edis.ifas.ufl.edu/entity/topic/turfgrass_nutrition
Your Florida Lawn	https://edis.ifas.ufl.edu/entity/topic/lawns
Your Florida Lawn*	https://hort.ifas.ufl.edu/yourfloridalawn/
Manuals and Handbooks	
Best Management Practices for Protection of Water Resources by the Green Industries	https://ffl.ifas.ufl.edu/media/fflifasufledu/docs/GIBMP_Manual_Web_English.pdf
The Florida Yards & Neighborhoods Handbook	https://ffl.ifas.ufl.edu/media/fflifasufledu/docs/FYN_Handbook_2015_web.pdf

* This website includes a link to a pdf with the previous IFAS recommended fertilizer rates.

The DEP WM 869 studies included complex study designs that incorporated different turf grass species, age of the turf, several fertilizer and irrigation application levels, and statistical analysis to explore the effect of the fertilizer on turf quality and nitrate leaching and interaction between fertilizer and irrigation. While the aim of DEP WM 869 was to investigate the fertilizer rates producing acceptable plant response, in some cases, the data was used to lower the recommended fertilizer rates and potentially reduce environmental impact. The broad reach and application of the data as the basis for statewide fertilizer recommendations necessitates careful consideration of study boundaries and data gaps.

2.2. General Limitations of DEP WM 869

Some limitations of the DEP WM 869 study are discussed below, as well as possible effects of the limitation on the interpretation of the study. It is important to note that many of the points below can be said of much scientific research; replicating real-world conditions is difficult, and budgets and project timeframes are limited. The limitations described below are primarily related to the use of the DEP WM 869 study for statewide recommended fertilizer rates and not a criticism of the standalone scientific merit of the work. Numerous peer reviewed publications have been sourced from the DEP WM 869, indicating that the methods are acceptable to the scientific community. However, there are limitations when applying the results of controlled experiments with typical experimental constraints (time, analytes, samples) to an entire state. And while a single study cannot be expected to replicate real world conditions, it is important to present study limitations (considering the broad application of the DEP WM 869) and contribute to the body of knowledge around turfgrass fertilization and environmental impact. Understanding the limitations can also help inform potential future studies to supplement the DEP WM 869 and further understand the role of fertilizer and Florida's water quality.

2.2.1. <u>Project Duration</u>

- Though commonly described as an "eight-year study," the data collection phases of DEP WM 869 projects were generally no more than three years in duration. One example of this is Project 2, "Nitrate Leaching from Established Grass," in which established St. Augustinegrass and zoysiagrass plots were fertilized at one set of application rates beginning in July 2005 and at a different set of application rates in 2006 and 2007, with the last treatment applied in October 2007 for a data collection phase of approximately 28 months.
- In a separate IFAS study (not a part of DEP WM 869), Erickson et al. (2008) monitored nitrogen leaching in two types of landscapes. Experimental plots had been established for four years prior and the experimental phase was three years. Erickson et al. (2008) described the study as "relatively long-term for experimental purposes (three years of data collection on landscapes planted over 4 yr ago)" though "still a relatively short period of time with respect to landscape persistence and performance through time." However, the Erickson et al. (2008) study duration exceeded several DEP WM 869 projects, including the Jay and Gainesville studies on leaching from established St. Augustinegrass.[5]
- In addition, as noted by Dukes et al. (2020), "fertilizer N may reside in the soil organic matter pool for years," and neither Erickson et al. (2008) nor DEP WM 869 measured soil nutrients or their availability to plants or soil porewater.
- ***Summary: Because of the shorter study duration and the ability of fertilizer nitrogen to remain in soil for years, DEP WM 869 did not account for the potential loading of nitrate in***

[5] Note that when comparing Erickson et al. (2008) and DEP WM 869 (FDEP, 2012) the fertilizer application rates were different, though ranges overlap. The annual application rate in Erickson et al. (2008) is estimated at 163 and 300 kg N/ha for the mixed species and St. Augustinegrass plots, respectively. For DEP WM 869 (FDEP, 2012) Project 2 in Gainesville annual rates ranged from 49 to 490 kg N/ha on St. Augustinegrass

leachate from residential turf fertilizer over longer, environmentally relevant periods of time. Additionally, depending on the type of fertilizer used (form of nitrogen), nitrogen may be available in the soil for longer periods of time compared to the urea-based fertilizers primarily used in the DEP WM 869.

2.2.2. Study Analytes

- DEP WM 869 measured nitrate in leachate and did not measure other forms of nitrogen.[6]
- Study analytes are noted as a data gap in Shaddox et al. (2017), a peer-reviewed publication originating from DEP WM 869. Shaddox et al. (2017) stated that "Nevertheless, because urea was applied and only NO3–N was measured, it is possible that the total N leached was greater than the amount measured."
- Other IFAS studies where fertilizer was applied to experimental plots and nitrogen was analyzed in the leachate have included analysis for other nitrogen species . For example, Erickson et al. (2008) measured the concentrations of NH_4 over time (**Figure 2-1** and **Figure 2-2**). As seen in the right panel of **Figure 2-2** the loads of NH_4 are measurable and in some cases higher than nitrate towards the end of the study period. As noted above, the Erickson et al. (2008) duration was longer than most DEP WM 869 projects.
- Yang & Toor (2016) conducted a stable isotope modeling study and found that 34% (on average) of the NH_4 in stormwater runoff could be sourced to residential fertilizer (note that the runoff pathway was not considered in DEP WM 869, see **Section 2.2.3** for additional discussion of the additional pathways of fertilizer N).
- ***Summary: Nitrate is the primary form of nitrogen in leachate (for example, see Figure 2-1), and only nitrate was measured in the DEP WM 869 due to budget constraints. However, there are other forms of nitrogen in turfgrass leachate (for example, see Figure 2-1 and Figure 2-2). By not characterizing the additional forms of nitrogen in leachate samples, DEP WM 869 does not account for the total nitrogen load potentially reaching the environment. Other forms of nitrogen, besides nitrates, can have environmental consequences. For example, NH_4 can accelerate aquatic plant growth and contribute to fish kills.***

[6] Note that Projects 4 and 5 included analysis of orthophosphate (PO43--P) in leachate; however, the focus of this review is nitrogen.

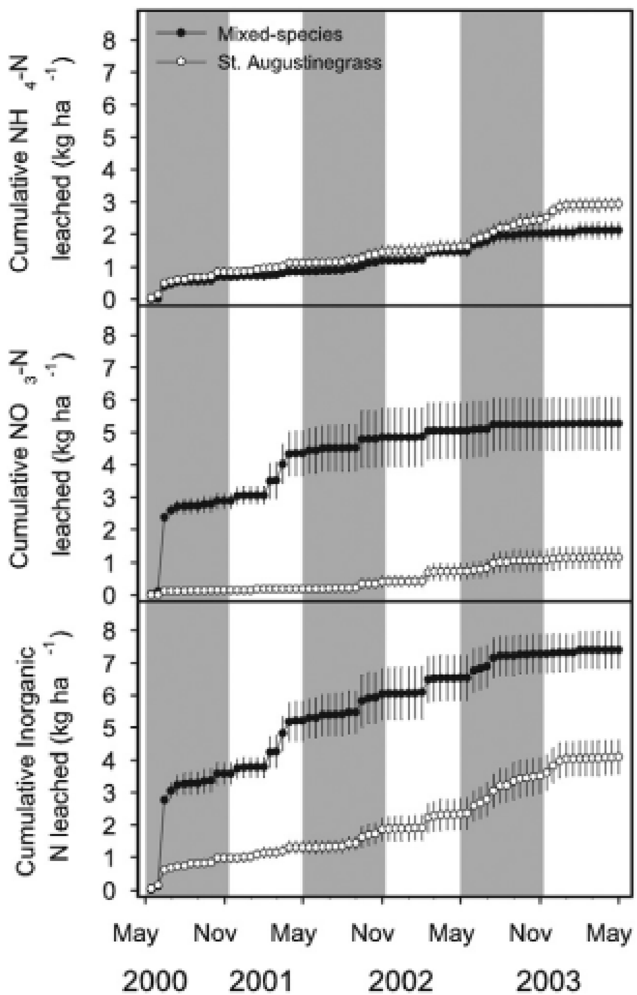

Figure 2-1. Cumulative N leaching figure reproduced from Erickson et al. (2008). Legend from Erickson et al. (2008): Cumulative mean NH_4-N, NO_3-N, and total inorganic-N leached (kg/ha^{-1}) during 36 months of data collection (May 2000 to April 2003) on mixed species (filled circles) and St. Augustinegrass lawns (unfilled circles) landscape models (n=4 plots). Data collected during the wet season are in the shaded region and the dry season data are not shaded. Error bars represent ± 1 standard error.

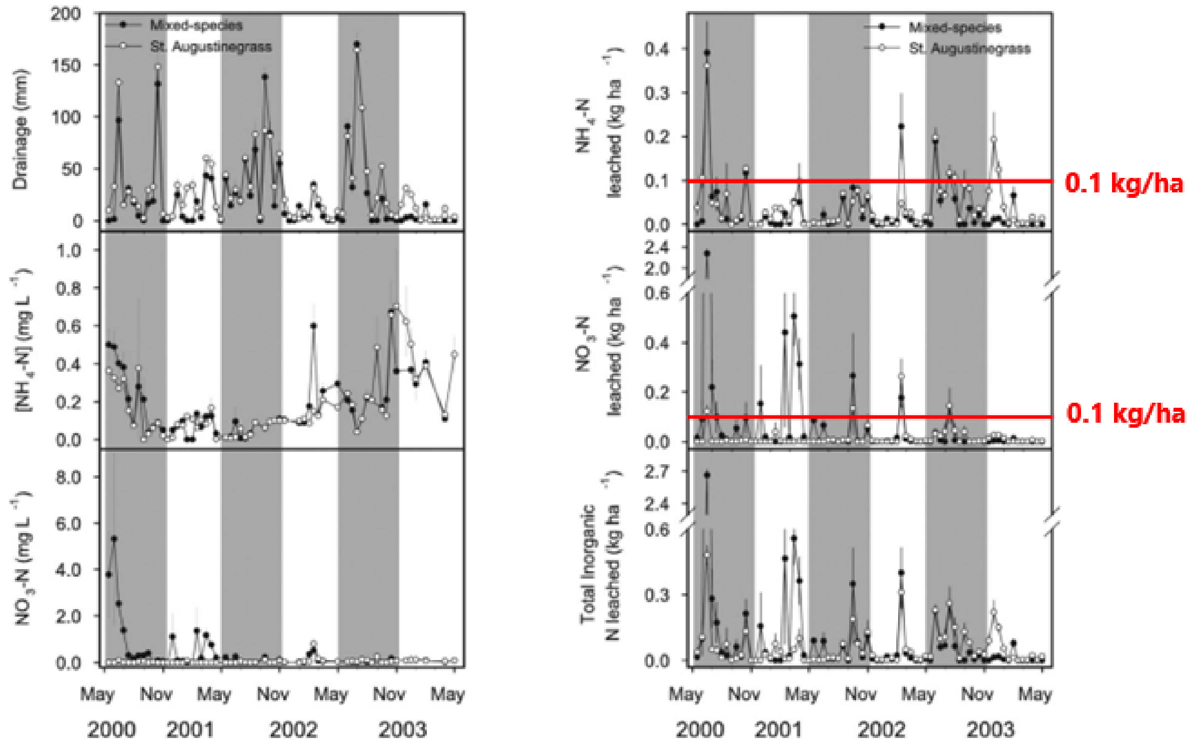

Figure 2-2. Nitrogen concentration in leachate reproduced from Erickson et al. (2008). Note that the red line showing 0.1 kg/ha was inserted by Wood for comparison purposes. **Left panel legend from Erickson et al.(2008)**: Biweekly mean drainage (mm) and NH_3-N and NO_3-N concentrations (mg L^{-1}) in sampled drainage for 36 months of data collection (May 2000 to April 2003 on mixed species (filled circles) and St. Augustinegrass lawn (unfilled circles) landscape models (n=4 plots). Note: Vegetation for both landscapes was planted in December 1998. Data collected during the wet season are in the shaded region and the dry season data are not shaded. Error bars represent ± 1 standard error. **Right panel legend from Erickson et al. (2008):** Biweekly mean NH_4-N, NO_3-N, and total inorganic-N leached (kg/ ha^{-1}) for 36 months of data collection (May 2000 to April 2003) on the mixed species (filled circles) and St. Augustinegrass lawn (unfilled circles) landscape models (n=4 plots). Data collected during the wet season are in the shaded region and the dry season data are not shaded. Error bars represent ± 1 standard error.

2.2.3. Fate of Applied Fertilizer

- DEP WM 869 projects included collection of leachate samples; however, leaching is only one of the fates of N and there are a number of pathways that represent potential environmental impacts of applied fertilizer. According to Shaddox and Unruh (2018), the potential fates of N applied to turfgrasses include: volatilization (<1–60%), denitrification (<1–5%), plant uptake (40–68%), soil storage (7–15%), leaching (<1–55%), and runoff (<1–7%). These pathways are also shown in **Figure 2-3** from Shaddox and Unruh (2018), depicting the turfgrass N cycle.
- Additionally, in a stable isotope study that was used to differentiate N sources, Yang and Toor (2016) reported that atmospheric deposition (43-71%) and chemical N fertilizers (<1-49%) were the dominant NO_3-N sources in the stormwater runoff. Yang and Toor (2017) reported similar findings, with atmospheric deposition (35-64%) followed by chemical N fertilizers (1-39%). Jani et al. (2020) found that nitrate sources in water samples can shift from atmospheric deposition to inorganic N fertilizers under conditions of higher rainfall amounts and longer durations. This suggests that both leaching, and runoff can represent a source of N under wet conditions and demonstrates the importance of the stormwater runoff pathway, as well as the potential for atmospheric deposition to influence nitrate concentrations.
- Yang & Toor (2016) also found that 34% (on average) of the NH_4 in stormwater runoff was attributable to residential fertilizer, highlighting the importance of both the runoff pathway and measuring additional analytes (see **Section 2.2.2** for additional discussion of study analytes).
- N applied as fertilizer can also be lost to volatilization. Shaddox and Unruh (2018) note that loss of N via volatilization is a "distinct disadvantage to the turfgrass". According to Shaddox and Unruh (2018), this loss of N may decrease the amount of N immediately available to move into nearby water bodies, but will increase the amount of N returned to the earth via rainfall and atmospheric deposition. The researchers note that because N is commonly applied to turfgrass as urea (like in the DEP WM 869 studies), "volatilization can be a major contributor to N lost from turfgrass systems, with losses ranging from <1% to as high as 60% of applied N (Goos, 2011)" (from Shaddox and Unruh, 2018).
- ***Summary: Although leachate is a primary pathway for N applied as fertilizer, and the leachate pathways were sampled in DEP WM 869, recent real-world research has shown that stormwater runoff can also contain nitrogen from fertilizer. Volatilization to the atmosphere is also an important pathway for urea-applied fertilizers. By not accounting for other fates/pathways of nitrogen from turfgrass fertilizer (e.g., runoff and volatilization), the DEP WM 869 studies missed important components of fertilizer fate in terms of water quality. The fertilizer rates assessed in DEP WM 869 are not able to account for the actual environmental impact of the experimental rates.***

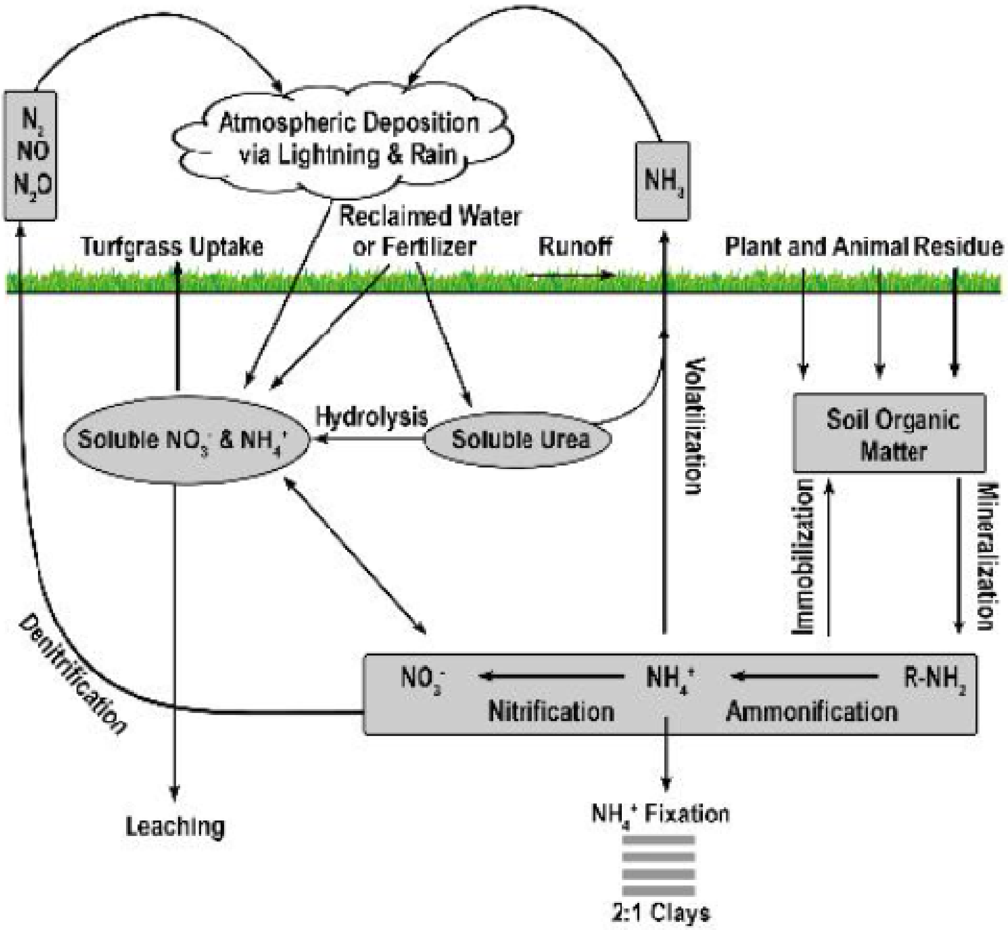

Figure 2-3. The nitrogen cycle in turfgrass, reproduced from Shaddox and Unruh (2018).

2.2.4. <u>Treatment of Nondetects</u>

- In the FDEP WM 869 Study Report (FDEP 2012), authors reported that nondetects, or leachate samples with nitrate concentrations below the method detection limit (MDL), were set to the MDL – meaning that a maximum potential concentration value was used. Nondetect sample results are a common occurrence in environmental chemistry and one solution is substitution with other values, e.g., zero, one-half the MDL, or the MDL itself as was done in FDEP WM 869.
- Researchers historically used substitution because statistical methods to deal with nondetect values were not commonly available. However, this is no longer the case (Helsel, 2012). Newer statistical methods such as imputation, where all nondetects are not assigned the same value (Helsel, 2005), are now available.
- The true concentration of an analyte in a nondetect sample is somewhere between 0 and the MDL (0.05 mg/L for nitrate in the FDEP WM 869 studies). Substituting the MDL is therefore an overestimation of any nondetect samples with true concentrations less than the MDL. While potentially overestimating a nitrate leachate concentration may appear to be a conservative and environmentally cautious approach, the use of these estimated concentration in statistical significance testing is more complicated. For example, in **Table 2-4**, reproduced from Appendix L of the Final Report, the mean nitrate percolate concentration from St. Augustinegrass in 2006 at

the 49 kg/ha treatment level is reported as 0.05 mg/L. In this same Appendix, researchers state that "concentrations that were lower than the minimum detection limit (MDL) of 0.05 mg/L were corrected to the MDL value." The mean nitrate-N concentration of 0.05 mg/L at the 49 kg/ha treatment level is potentially composed primarily of samples reported as below the MDL; other low average concentrations (e.g., 0.07 mg/L and 0.08 mg/L) in **Table 2-4** may also be primarily composed of nondetects. Significance testing with sample results that are primarily nondetects reported at the MDLs is potentially misleading, with possible overestimates of the mean concentration and underestimates of the variance. In **Table 2-4**, nitrate leachate concentrations in 2006 were reported to be similar across the different fertilizer treatment levels and researchers reported that "there was little association between [nitrogen rate] and increased NO3–N leaching in St. Augustinegrass in any year" (Trenholm et al. 2012). However, if the nitrate concentration in the lower experimental rates was overestimated, which is a potential outcome of substituting with the MDL, it is difficult to interpret whether there was truly little association between the experimental rates and the leachate concentration.

- ***Summary: Substitution of the MDL for nondetect sample results may lead to overestimation of leachate concentrations. Overestimating the concentration in a lower experimental treatment and comparing to measured (not substituted) leachate concentrations from higher experimental treatments makes it difficult to accurately assess the true relationship between fertilizer rate and leaching. The consequences are twofold: (1) the true nitrate leachate concentrations and resulting potential environmental impact from the fertilizer rates in FDEP WM 869 is unclear and (2) environmental gains (e.g., decreased nitrate leaching) from lower fertilizer rates in FDEP WM 869 is potentially underestimated.***

Table 2-4. Means of NO_3-N Concentration in Percolate for 2006 and 2007 from Established Floratam St. Augustinegrass and Empire Zoysiagrass in Citra, Fl (reproduced from Appendix L of the FDEP WM 869 (FDEP, 2012) Study Final Report and also appearing in Trenholm et al. [2012]).

Annual N rate	Nitrate–N leached			
	2006		2007	
	St. Augustinegrass	Zoysiagrass	St. Augustinegrass	Zoysiagrass
kg ha^{-1}	mg L^{-1}			
490	0.86a†	0.80a	8.72a	23.57a
343	0.21a	0.17b	2.25b	10.83b
196	0.07a	0.21b	1.79b	3.55c
49	0.05a	0.08b	1.11b	0.45d

Analysis of variance	2006	2007
N rate (NR)	***	***
Grass (G)	***	***
Irrigation (IR)	NS‡	**
NR × G	**	***
NR × IR	NS	***
G × IR	NS	**
NR × G × IR	NS	**

** Significant at $P \leq 0.01$

*** Significant at $P \leq 0.001$

† Values within a column followed by the same letter do not differ at $P = 0.05$.

‡ NS = not significant within a row at $P = 0.05$.

In addition to these general limitations (project duration, study analytes, lack of consideration of nitrogen pathways, and treatment of nondetects) there are additional, project-specific considerations regarding the interpretation of the study data and how the study data were used to adjust (or not) the recommended rates. These considerations are presented below, with special attention to the North Florida recommended rates.

2.3. Interpretation of North Florida Recommended Fertilizer Application Rates

The fertilizer application rates and data collected during specific DEP WM 869 studies were compared to the IFAS-recommended fertilizer application rates for North Florida in an attempt to gain a better understanding of how the recommended rates were supported by study data. The current recommended fertilizer application rates, DEP WM 869 experimental fertilizer application rates, and the previous fertilizer application rates are included in **Table 2-5**. The previous application rates are included because they appear to have informed the rates used in most DEP WM 869 (projects and the studied fertilizer application rates bracket (for the most part) the previous recommended rates. It should be noted that information on how the previous application rates were determined is difficult to come by. In some IFAS documents, including Shaddox (2017), the author states that "in the past, it was customary to recommend the application of 1 pound of actual nitrogen per 1,000 square feet of turfgrass." According to DEP WM 869 researchers (via email), "the previous fertilizer rate ranges were generally focused on turf quality and not necessarily balancing the environmental impact. Before the FDEP funded research, the previous rate ranges were based on the best available science. Furthermore, minimal research had been conducted on many of the turfgrasses used for Florida lawns that coupled turfgrass quality and nutrient leaching, which was one of the main focuses of the FDEP funded research."

As noted previously, replicating real-world conditions is difficult, and budgets and project timeframes are limited, and numerous peer reviewed publications have been sourced from the DEP WM 869. The considerations below highlight potential opportunities where the DEP WM 869 studies could be used to support lower fertilizer rates while maintaining acceptable turf quality.

Table 2-5. Previous and Current Fertilizer Rates Recommended by IFAS for North Florida Turfgrass and DEP WM 869 (FDEP, 2012) Study Details.

Species	Recommended N Application (lb N/1,000 ft^2/yr) for North Florida		Select DEP WM 869 (FDEP, 2012) Study Details	
	Previous Rates (prior to 2016)	Current Rates (2016-present)	Experimental Fertilizer Rates (lb N/1,000 ft^2/yr)	Project Location
Bahiagrass	2-3	1-3	1, 2, 4, 6	Fort Lauderdale (South Florida)
Centipede	1-2	0.4-2	0.4, 0.7, 1.5, 3.0	Jay (West Florida)
St. Augustine	2-4	2-4	Year 1: 0.7, 1.3, 2.6, 4.0 Year 2, 3: 1, 4, 7, 10	Gainesville (North Florida)
Zoysia	3-5	2-3	Year 1: 0.7, 1.3, 2.6, 4.0 Year 2, 3: 1, 4, 7, 10	Gainesville (North Florida)

2.3.1. Zoysiagrass

- According to Project 2 (Appendix L in the DEM WM 869 Final Report and published as Trenholm et al. [2012]), "Zoysiagrass N rates may need to be revised downward to reduce disease, improve turf cover, and reduce NO3–N leaching". Zoysiagrass N rates were then revised from 3-5 lb N/1,000 ft^2/yr to 2-3 lb N/1,000 ft^2/yr.
- Application rates of 2-3 lb N/1,000 ft^2/yr were not used in the experimental design. However, based on **Table 2-6** and **Table 2-7**, the lowest experimental application rate of 1 lb N/1,000 ft^2/yr produced acceptable TQ (above 6 during the majority of the study, **Table 2-7**, with an annual average of 6.3 in 2006 and 6.6 in 2007) with significantly less leaching in 2007 (see the annual 2007 average leaching of 5.7 kg/ha that was significantly lower than other treatment levels, **Table 2-6**).
- Turfgrass irrigation rates during the study consisted of 1.3 cm applied twice a week or 2.6 cm applied weekly; these irrigation rates were "generally equivalent to evapotranspiration (ET)" (Trenholm et al., 2012). Irrigation was suspended when rainfall met or exceeded the study irrigation rates. Trenholm et al. [2012] reported that monthly rainfall during the study period was below average, though there were several large rainfall events in the second year of the study. Authors reported that irrigation had limited effect on nitrate leaching, however, they also noted that "It is likely that greater response to irrigation might be seen […] if a wider range of scheduling and [irrigation] rates were tested, especially if irrigation rates significantly exceeded ET, thereby resulting in greater percolate volume." Current irrigation restrictions limit irrigation to 0.75 inches (1.905 cm) per zone per irrigation day, which includes two days a week for much of the year. This represents a gap in knowledge data, potentially complicating interpretation of results especially under conditions with higher irrigation or precipitation.
- ***Summary: There appears to a be a missed opportunity to reduce environmental impact while maintaining high quality turfgrass. The lowest experimental application rate of 1 lb N/1,000 ft^2/yr) produced acceptable TQ in zoysiagrass. However, the published recommended***

fertilizer rate for zoysiagrass of 2 to 3 lb N/1,000 ft^2/yr (Table 2-5) is two to three times higher than the experimental rate that produced an acceptable TQ. Furthermore, based on the earlier discussion on the MDL and possible overestimation of nitrate leachate concentrations, leaching from the lowest experimental application rate may have been less than indicated, representing a more significant benefit to the environment. Additionally, the irrigation rates did not represent typical irrigation patterns of property owners, hence may be underestimating leaching.

2.3.2. <u>St. Augustinegrass</u>

- According to Project 2 (Appendix L in the DEM WM 869 Final Report and published as Trenholm et al. [2012]), "The current recommended rates for St. Augustinegrass provide good turf cover and health, and result in minimal NO_3–N leaching." Note that at the time of publication, "current" referred to the previous (prior to 2016) rates. This interpretation of the data was used to maintain the recommended St. Augustinegrass fertilizer application rate of 2-4 lb N/1,000 ft2/yr.
- The lower recommended application rate (2 lb N/1,000 ft2/yr) was not used in the experimental design for the Gainesville site. The closest experimental application rate (1 lb N/1,000 ft2/yr) produced TQs less than 6 and DEP WM 869 researchers used a TQ of 6 as minimally acceptable by the homeowner, so maintaining the recommended rate is understandable. However, if the minimal acceptable TQ were lower, then a lower fertilizer rate may be recommended while maintaining acceptable turf. The National Turfgrass Evaluation Program (NTEP) defined the TQ of 6 as minimally acceptable to homeowners. However, in other research by DEP WM 869 researchers, a TQ of 5 is considered minimally acceptable to homeowners (Cardenas-Lailhacar and Dukes, 2012).
- If a TQ of 5 were considered minimally acceptable in the DEP WM 869 studies, a lower fertilization rate could be recommended for St. Augustinegrass, according to **Table 2-7.** Note that in **Table 2-7**, the TQ for 1 lb N/1,000 ft2/yr ranges from 4.1 to 5.4 with an average of 4.5 in 2006 and 4.2 to 6.6 with an average of 4.9 and the majority of the TQs round to 5 or above.
- ***Summary: Not considering a TQ of 5 as acceptable appears to be a missed opportunity to reduce environmental impact while maintaining acceptable turfgrass. The MDL issue noted earlier is also relevant here - the possible overestimation of leachate concentrations in treatments with a high frequency of nondetects may have made it difficult to detect significant differences among the experimental fertilizer rates. Additionally, irrigation rates utilized during the study did not represent typical irrigation patterns of property owners, hence potentially underestimating leaching.***

Table 2-6. NO_3-N Leached from Established Floratam St. Augustinegrass and Empire Zoysiagrass in Response to N Rate (reproduced from Trenholm et al. [2012]). Note that the annual rate conversions showing the recommended rates (italics) were calculated and inserted by Wood.

	Annual N rate	Nitrate–N leached									
		St. Augustinegrass					Zoysiagrass				
		SFC†	ESFC†	LSFC†	FFC†	Annual	SFC	ESFC	LSFC	FFC	Annual
lb/1,000ft²/yr	kg ha⁻¹	——— kg ha⁻¹ ———									
		2006									
10 =	490	2.3a‡	1.6a	0.3a‡	1.1a	5.3a	7.3a	6.0a	10.1	5.7a	29.1a
7 =	343	1.9a	0.3a	0.1c	0.6a	2.9a	2.9a	1.4b	5.7	3.6b	13.7b
4 =	196	0.3a	0.3a	0.2b	0.2a	0.9a	6.7a	1.4b	7.6	1.0c	16.7b
1 =	49	0.3a	0.2a	0.2b	0.1	0.9a	6.5a	2.2ab	3.7	0.3d	12.7b
		2007									
10 =	490	0.2a	0.6c	0.3a	8.0a	9.1a	29.1a	75.8a	7.0a	12.5b	124.3a
7 =	343	0.3a	1.0a	0.2b	0.6b	2.1b	22.3b	40.3b	4.0ab	17.9a	84.5b
4 =	196	0.2a	0.8b	0.3b	1.6b	2.9b	6.4c	17.2c	0.6b	6.2bc	30.5c
1 =	49	0.1a	0.3d	0.2b	0.4b	1.1b	1.9d	2.4d	0.4b	1.0c	5.7d

† SFC = spring fertilizer cycle; ESFC = early summer fertilizer cycle; LSFC = late summer fertilizer cycle, FFC = fall fertilizer cycle.

‡ Values within a column by year followed by the same letter do not differ at $P = 0.05$.

Table 2-7. Average Turf Quality in Established Floratam St. Augustinegrass and Empire Zoysiagrass in Response to N Rate (reproduced from Trenholm et al. [2012]). Note that the annual rate conversions showing the recommended rates (italics) were calculated and inserted by Wood.

	Annual N rate	Turf quality†									
		St. Augustinegrass					Zoysiagrass				
		SFC‡	ESFC‡	LSFC‡	FFC‡	Average	SFC‡	ESFC	LSFC	FFC	Average
lb/1,000ft²/yr	kg ha⁻¹	——— 1–9 ———									
		2006									
10 =	490	6.7a§	9.0a	7.8a	7.3a	7.2a	6.5a	8.7a	7.2a	5.8d	6.7b
7 =	343	6.5b	8.5b	7.4b	6.9b	6.9b	6.4b	8.6b	7.1b	6.3b	6.8a
4 =	196	5.8c	7.4c	6.6c	6.2c	6.1c	6.4c	8.5c	7.0c	6.4a	6.6c
1 =	49	4.6d	5.4d	5.0d	4.1d	4.5d	6.2d	8.0d	6.8d	5.9c	6.3d
		2007									
10 =	490	7.4a	9.8a	7.7a	7.3a	7.5a	4.9b	8.0a	7.0b	6.7a	6.2a
7 =	343	7.0b	9.5b	7.6b	7.1b	7.3b	5.5ab	8.4a	6.9c	6.4a	6.4a
4 =	196	6.2c	8.5c	6.8c	6.5c	6.6c	6.0a	8.6a	7.1a	6.5a	6.6a
1 =	49	4.2d	6.6d	5.4d	4.8d	4.9d	6.4a	8.6a	6.8d	6.4a	6.6a

† Turf quality was based on a scale of 1 to 9, where 1 = dead/brown turf and 9 = optimal healthy/green turf. A score of 6 was considered minimally acceptable for a home lawn.

‡ SFC = spring fertilizer cycle, ESFC = early summer fertilizer cycle, LSFC = late summer fertilizer cycle, FFC = fall fertilizer cycle.

§ Values within a column followed by the same letter do not differ at $P = 0.05$.

2.3.3. Bahiagrass

- Bahiagrass was studied only at the Fort Lauderdale site in the DEP WM 869 studies. In the Final Report, researchers stated that "For bahiagrass, 49 kg N ha^{-1} yr^{-1} was capable of sustaining adequate turf quality for the duration of a cycle during the experiment." 49 kg N ha^{-1} yr^{-1} is equal to 1 lb N/1,000 ft^2/yr and is the lowest treatment level in DEP WM 869 (FDEP 2012).
- This study was published in the peer-reviewed literature by McGroary et al. (2017). In McGroary et al. (2017), the 1 lb N/1,000 ft^2/yr is shown to produce a TQ averaging 6.5. McGroary et al. (2017) states that "...the low N requirements typically associated with bahiagrass may be sufficed by atmospheric N deposition, which can exceed 3.0 kg ha^{-1} yr^{-1} of inorganic N in Ft. Lauderdale

(National Atmospheric Deposition Program, 2015). Therefore, we postulate that the low N requirements of bahiagrass combined with N mineralization and atmospheric N deposition resulted in conditions that supplied sufficient N to meet the needs of the turfgrass. Thus, additional N applications were unnecessary, and a weak correlation between turf quality and N rate was observed."

- Because the study was not conducted in North Florida, where environmental conditions differ, it is difficult to assess whether or not there were additional opportunities to further reduce rates.
- ***Summary: The recommended bahiagrass fertilizer application rate in North Florida was previously 2 to 3 lb N/1,000 ft²/yr and was adjusted to 1 to 3 lb N/1,000 ft²/yr (Table 2-5). However, an above-acceptable TQ was maintained at the lowest experimental application rate of 1 N/1,000 ft²/yr and researchers postulate that atmospheric deposition may provide the needed N for bahiagrass. Retaining the high-end recommended rate (3 lb N/1,000 ft²/yr) is a potential missed opportunity to reduce environmental impact while maintaining acceptable turfgrass.***

2.3.4. Centipedegrass

- Nitrate leaching from established centipedegrass was studied only in West Florida as part of Project 2 and published by Shaddox et al. (2017). Experimental fertilizer rates were: 0.4, 0.7, 1.5, 3.0 lb N/1,000 ft²/yr. TQs were over 6 in all treatment levels.
- For centipedegrass in North Florida, the rates were revised from 1-2 to 0.4-2 lb N lb N/1,000 ft²/yr. The lower recommended rate was reduced from 1 to 0.4 lb N/1,000 ft²/yr.
- However, Shaddox et al. (2017) reported that "A 50% reduction in NO3–N leaching was observed when [nitrogen application rates] were increased from 18 to 36 and 74 kg ha−1 yr−1. This observation is contrary to many previous reports."
- Turfgrass was irrigated at 1.3 cm biweekly or 2.6 cm weekly and irrigation was not suspended during rainfall. Precipitation during the study period was lower compared to the 10-yr average for the majority of the study (see Table 4 in Shaddox et al. [2017]). Authors noted that irrigation rate did not influence nitrate leaching or the measured turf responses and postulated that "that because the total amount of applied water and precipitation was equivalent among treatments, equivalent responses were observed." However, as noted above, this knowledge gap makes it more difficult to interpret study results under more typical (higher, similar to 10-yr average) precipitation conditions.
- ***Summary: The recommended centipedegrass fertilizer application rate in North Florida was previously 1 to 2 lb N/1,000 ft²/yr and was adjusted to 0.4 to 2 lb N/1,000 ft²/yr (Table 2-5). The reduction of the lower recommended application rate demonstrates a potential environmental impact reduction. However, considering TQs were over 6 in all experimental treatment levels* (0.4, 0.7, 1.5, 3.0 lb N/1,000 ft²/yr), *retaining the high-end recommended rate (2 lb N/1,000 ft²/yr) is a potential missed opportunity to reduce environmental impact while maintaining acceptable turfgrass. Additionally, the irrigation rates did not represent typical irrigation patterns of property owners, hence may be underestimating leaching.***

2.4. Fertilizer Application Rates Summary

The DEP WM 869 studies provide data on a single form of nitrogen (nitrate) in a single turfgrass nutrient pathway (leaching) under experimental conditions. The shorter duration, collection of only leachate samples, and analysis of only nitrate are typical study constraints. However, the apparent limitations associated with how nitrate sample concentration nondetects were treated should have been better addressed. For example, newer statistical methods such as imputation could have been used, where all nondetects are not assigned the same value (Helsel, 2005). Regardless of how the nondetects were treated, there are also potentially missed opportunities to recommend lower fertilizer rates while maintaining acceptable turf quality, especially with respect to bahiagrass. Notably, the high end of the fertilizer rates was only reduced for one (zoysiagrass) of the four grasses (**Table 2-5**). While this study did not address human behavior, if homeowners follow the high end of the recommendation, the revised recommended fertilizer rates will not likely result in environmental gains (e.g., improved water quality).

The relationship between fertilizer and irrigation is also important to consider because fertilization can increase evapotranspiration rates (Barton et al., 2009) which may lead to increased irrigation rates, and overirrigating can be the main contributor to nitrogen leaching (Sun et al., 2021). Recommended irrigation rates in Florida are discussed in the next section.

3.0 IRRIGATION RATES

Turfgrass irrigation is another common landscape practice presenting an opportunity for improved environmental stewardship. Reducing irrigation use may also be beneficial to the turfgrasses – according to IFAS, "more lawns are damaged by over-watering than by any other cultural practice, so watering restrictions may not actually be as devastating as they seem[7]."

Irrigation restrictions are present throughout Florida. The Water Management Districts (WMDs) are the official entity tasked with developing and recommending irrigation standards in the State. The WMDs typically restrict irrigation to an allowed number of days and allowed time period, per week, with recommendations on the amount of water applied. IFAS has conducted research on irrigation recommended for turfgrasses; however, unlike the fertilizer recommendations, IFAS does not have a cohesive set of irrigation recommendations and the derivation of irrigation rates is unclear. The current restrictions and recommendations are described below, along with information on turfgrass irrigation research and potential areas of improvement.

3.1. Existing Irrigation Recommendations

The two overarching turfgrass irrigation recommendations from IFAS are as follows (Dukes 2020):

1) Irrigating "deep and infrequently" (0.5 inches to 0.75 inches) is recommended for wilting turf growing in a sandy soil where vertical root growth is not limited.
2) Irrigation frequency and run times are recommended based on irrigation application rate, month of the year, and different climate areas within the state.

It is important to note that the second recommendation is very broad and points to additional recommendations on how to determine frequency and run times (Dukes and Haman, 2021) which IFAS has released several publications detailing (Zazueta et al., 2020). IFAS does provide a generalized recommendation to only water a lawn when needed, which is further determined by observing a wilting lawn (UF/IFAS, 2017).

The St. Johns River Water Management District (SJRWMD) published a model irrigation ordinance for local entities to adopt (SJRWMD, 2018). The SJRWMD model irrigation ordinance falls in line with IFAS recommendations of no more than ¾" irrigation per watering event, and to only water when necessary. Residential irrigation is allowed twice per week, with the watering day determined according to the address number[8].

The SJRWMD encourages local governments to assist in enforcing the district's watering restrictions by the adoption of local ordinances incorporating the provisions of the district's rule. The District's watering restrictions apply regardless of whether a local government has adopted an ordinance. Alachua County has adopted landscape irrigation restrictions that match the WMD regulations.

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[7] IFAS website "Conserving Water – Solutions for your Florida Friendly Landscape – Selecting a Florida-friendly Turfgrass", available at: https://gardeningsolutions.ifas.ufl.edu/water/articles/turf/selection.shtml

[8] SJRWMD Watering Restrictions website, available at: https://www.sjrwmd.com/wateringrestrictions/#restrictions-summary

Irrigation restrictions can also vary by municipality within the WMD. For example, within the Southwest Florida Water Management District (SWFWMD)[9], multiple counties and cities have developed local irrigation restrictions (**Figure 3-1**), with some areas (e.g., Citrus, Hernando, Pasco, and Sarasota counties) restricting irrigation to once per week year-round, compared to the SWFWMD's twice per week restriction during the majority of the year. In the SJRWMD, local governments do not have the authority to adopt irrigation restrictions that are stricter than the district's rules. Alachua County has been seeking the necessary rule change to allow such.

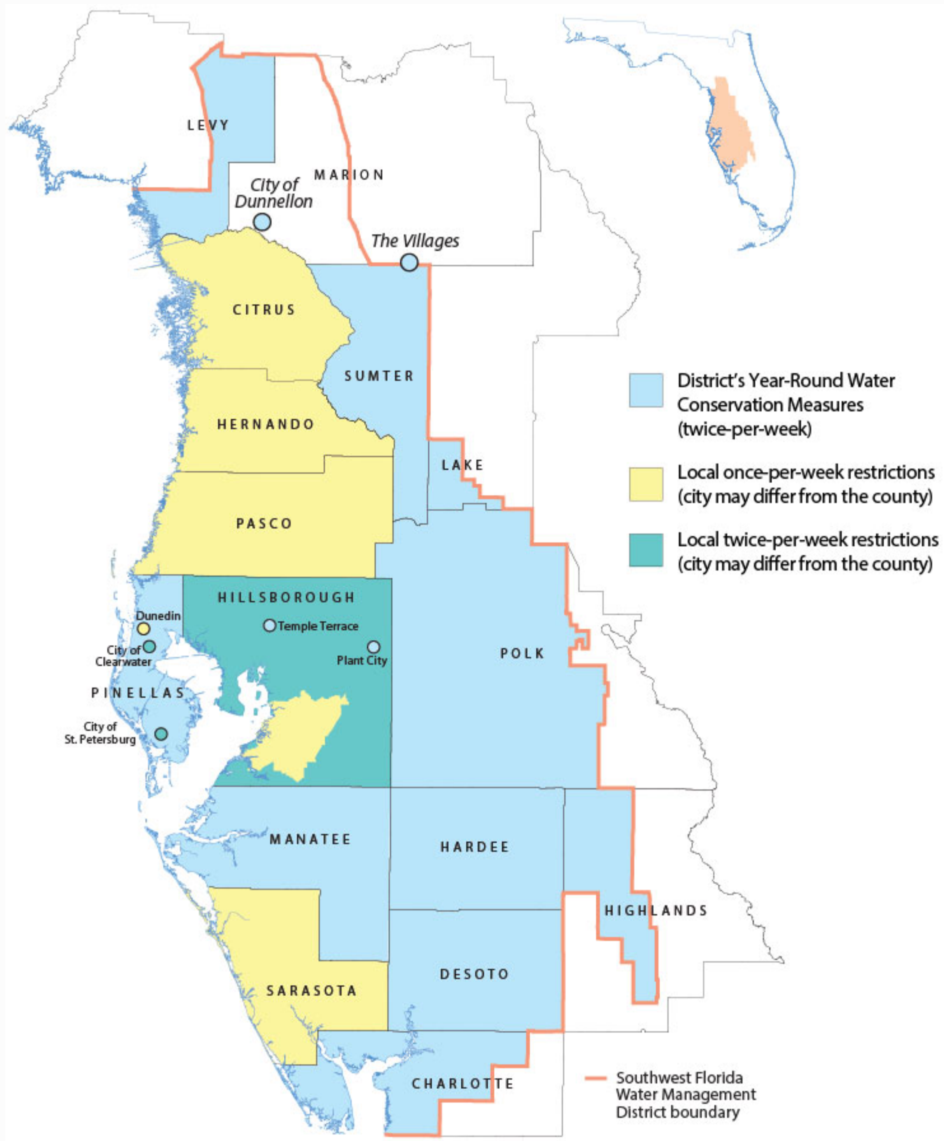

Figure 3-1. Map of irrigation restrictions within the SWFWMD, reproduced from the SWFWMD District Water Restrictions website.[7]

[9] SWFWMD District Water Restrictions website, available at: https://www.swfwmd.state.fl.us/business/epermitting/district-water-restrictions

3.2. Irrigation Research and Suggested Improvements

Irrigation recommendations for a fixed amount could lead to overirrigation of as much as 78% (Dukes, 2007). The fixed amount approach to irrigation does not account for site characteristics such as soil composition and soil moisture content. The AE220 UF/IFAS publication (Dukes and Haman, 2002) was used to develop a simple, web-based guideline for turfgrass irrigation based on weekly ET and rainfall amounts, with the recommendations adjusted seasonally to account for climatological differences. However, this online tool states that the manual irrigation recommendations are calculated using the average application rate of 0.5"/hr, which appears to still be a fixed rate.

The fixed amount recommendations are also not applicable to all locations and for all turfgrass species. Deep-rooted grasses such as bahia grass and centipede grass grow best in acidic, sandy soils that do not retain water. However, St. Augustine grass, which is the most popular lawn grass in Florida, does not perform well during extended dry periods in sandy soils[10]. Furthermore, in North Florida, soils often contain more clay, so irrigation requirements may be less than in sandy soil conditions. The generalized recommendation of 0.5" to 0.75"is not applicable to all soil conditions in Florida.

In a study by Haley et al. (2007) visual quality ratings for turf on a 100% evapotranspiration (ET) irrigation replacement schedule (Dukes and Haman, 2002) were no different than the other irrigation treatments (rain sensors, historical requirements, and soil moisture sensors) in the study. However, these homes still overirrigated with respect to theoretical requirements due to lack of soil moisture uniformity and intentionally conservative irrigation estimates derived from the McCloud ET methodology (Augustin, 1983). Temperature-based ET methods, such as McCloud's, typically overestimate ET in the summer and underestimate in the winter because they do not account for the cloud cover of humid climates (Irmak et al. 2003). This indicates the need for more data driven approaches to estimating irrigation requirements based on ET.

Another method often used to calculate theoretical irrigation requirements is based on a soil water budget (SWB). It is typically assumed that there is minimal runoff due to relatively high infiltration rates and flat slopes (Dukes, 2020), which is appropriate to characterize the sandy soils present throughout most of Florida, making this method well adapted for conditions in the state. The SWB can be calculated on a daily, weekly, or monthly basis depending on input data availability. The SWB approach presents the same limitations as the fixed amount irrigation approach in that the approach assumes sandy soil types.

Although the fixed amount irrigation recommendation is simple and easy to communicate, it could lead to overirrigation. In addition, homeowners may set irrigation amounts and not readjust properly for seasonal changes. This tendency is reinforced by water management district restrictions which mandate irrigation days. These types of irrigation restrictions have been shown to reduce municipal water use 15% to 20% in SFWMD during the spring and summer of 2007, but this amount is far below the 50% reduction expected from a 2 day/week to a 1 day/week transition (Dukes, 2020).

According to Trenholm et al. (2013) the amount of water applied during each irrigation event should not vary seasonally, though the frequency of irrigation should change by season. When rainfall is adequate to meet plant needs, supplemental irrigation systems should be turned off. Ideally, IFAS guidelines call for watering lawns on an "as-needed" basis (Trenholm et al., 2013). This can be determined by observing the grass for signs of water stress, which indicate that water lost in ET is not being replaced and the plant's needs for water are not being met. Visual signs of water stress include grass blades folded in half, blue-gray color of grass, and footprints remaining visible long after grass has been stepped on (Trenholm et al., 2013).

[10] IFAS website "Conserving Water – Solutions for your Florida Friendly Landscape – Selecting a Florida-friendly Turfgrass", available at: https://gardeningsolutions.ifas.ufl.edu/water/articles/turf/selection.shtml

Florida's climate provides a challenge to planning an efficient turfgrass irrigation program. Irrigation application efficiencies range from 60 to 95 percent, and depend upon wind speed, relative humidity, and temperature (Augustin 1983). Efficiencies can be maximized by irrigating when evaporation rates are the lowest, namely in early morning when there is no wind, relative humidity is high, and temperatures are low. It is unrealistic to expect all homeowners to install soil moisture sensors and weather stations in their yards; however, tools such as the Urban Irrigation Scheduler[11] are helping to provide more regional irrigation recommendations in "real time." It should be noted that the Urban Irrigation Scheduler does not appear to provide a complete set of specific irrigation recommendations, leaving room for improvement. Irrigation systems installed in Alachua County after October 2019 are required to have a soil moisture sensor or a smart ET controller.

Ultimately, unification of the various IFAS landscape irrigation recommendations can be expressed as placing less emphasis on fixed irrigation frequency and amount, and more emphasis on only watering when plants show visual signs of water stress (Dukes, 2020). Similarly, the Florida 2070 report[12] recommends shifting to manual irrigation (among other irrigation measures), to expand water conservation efforts. However, straying from designated days of the weeks makes enforcement nearly impossible in the absence of metered outdoor water use.

Table 3-1. Urban Irrigation Scheduler for Gainesville, FL (reproduced from IFAS Urban Irrigation Scheduler[9]).

URBAN IRRIGATION SCHEDULER : GAINESVILLE

This irrigation type has an average application rate of **0.5"/hr** and this is used to calculate all the run times below.

TURN YOUR CONTROLLER ON OR OFF BASED ON THE FOLLOWING TABLE

Station	Irrigation*	Seasonal Timer Setting	Recent Rain†
Alachua	N/A	80%	
Bronson	N/A	80%	
Citra	N/A	80%	
Putnam Hall	N/A	80%	

* Be sure your watering schedule coincides with local watering restrictions.

† If there has been recent rain (0.3" in the last 24 hrs, or 1" in the last 3 days), irrigation may not be needed *today*.

In Florida, 1/2" to 3/4" per week of water is, in general, the maximum amount needed by most home laws and landscape plants during the hottest part of the year.

Recommendations given in the above table are based on weekly ET and rainfall amounts at FAWN sites (if ET is greater than rainfall then ON is displayed, and if rainfall is greater than ET then OFF is displayed), and seasonal adjustments are based on water management district recommendations and UF research. To ensure your system run time is properly set, check with your irrigation system installer or local landscape professional. Several IFAS resources available to homeowners for lawn irrigation are listed below:

[11] Urban Irrigation Scheduler available at: FAWN - Florida Automated Weather Network: (https://fawn.ifas.ufl.edu/tools/urban_irrigation/32301/)
[12] Florida 2070 report available at: http://1000friendsofflorida.org/florida2070/wp-content/uploads/2017/08/FOF-1080-Newsletter-Spring-2017-v12-web.pdf

4.0 TURF AND LANDSCAPING PRACTICE ALTERNATIVES

A number of alternative approaches to residential landscaping are included below. These alternatives are aimed at minimizing the need for fertilizer and irrigation inputs. Shifting expectations from turfgrass monoculture to more diverse landscaping that is still aesthetically pleasing can be assisted by adopting these alternatives while minimizing maintenance, irrigation, and chemical inputs. Shifting what is collectively viewed as acceptable turf quality is another opportunity for reducing the impacts of our landscaping behaviors. Alachua County has been conducting a social marketing educational campaign asking residents to skip the fertilizer without making retrofits to their landscaping. Using survey data from the campaign, combined with spatial data, fertilizer label information, and IFAS recommendations, estimated total nitrogen loads to area surface waters and groundwater were reduced by 8,000 pounds and 12,000 pounds per year, respectively (Wood, 2019).

4.1. Alternative Turf Species (Turf Selection)

In cases where turf is required, careful selection of species can result in reduced fertilizer rates and irrigation. Based on the recommended fertilizer rates, Centipedegrass and bahiagrass require less N input for optimum growth compared to other species recommended for Florida. Additionally, the UF/IFAS turfgrass breeding program is continuing to develop new cultivar varieties of turfgrass like CitraBlue, a cultivar of St. Augustinegrass, that require less irrigation and fertilizer (Kenworthy, 2019).

4.2. Alternative Groundcovers (Turf Substitution)

Lawn-like landscapes may be desired for openness, visibility, and smooth visual texture. Some low-growing plants are listed in **Table 4-1**. Note however that these do not necessarily provide the same services as turfgrass (e.g., play areas for children and pets) and use of these alternatives will depend on personal preference.

Table 4-1. Groundcover Alternatives (Y=Yes, N=No, H=High, M=Medium).

Common Name / Scientific Name	FL Native	Mowable	Flowers	Butterfly Host Plant	Drought Tolerance	Evergreen	Walkable	Additional Notes
Perennial peanut ***Arachis glabrata***	N	Y	Y	N	H	Y*	Y	Nitrogen fixer
Sunshine Mimosa ***Mimosa strigillosa***	Y	Y	Y	Y	--	N	Y	Nitrogen fixer
Frogfruit ***Phyla nodiflora***	Y	Y	Y	Y	--	N	N	--
Asiatic Jasmine ***Trachelospermum asiaticum***	N	N	Y	N	M	Y	N	Shade tolerant
Twinflower ***Dyschoriste oblongifolia***	Y	N	Y	Y	H	Y	--	--

* May reduce growth, freeze back, or go dormant in the winter

Source: Compiled from (Silvasy, 2021), (UF/IFAS, 2018)

Perennial peanut has been used successfully in medians by the City of Jacksonville, along Highway 19, and along the Tampa Bay Skyway and for medians, lawns, hotel entryways, and roadsides in Costa Rica (Rouse et al., 2004).

4.3. Alternative Lawn Aesthetics (Turf Minimization)

New lawn models allow opportunities for greater personal creativity: planting with food, flowering plants, herbs, or wildlife habitat (Ponsford, 2020). Complete turf replacement may be daunting so the goal may have to be gradual reductions in turf areas (Damiano, 2022).

4.3.1. <u>Freedom Lawns / Wildflower Meadows</u>

A freedom lawn contains whatever plants grow without fertilizer, weed killer, water, or restrictions (UF/IFAS, 2022). Essentially, the lawn is allowed to go wild. The first places recommended to convert are around tress and wooded areas since trees generally outcompete turf for water, may develop large roots that could interfere with mowing, and can drop leaves that would smother turf if not raked (Stibolt, 2021).

4.3.2. <u>Drought Tolerant / Native Plantings</u>

UF IFAS Extension's Florida-Friendly Landscaping™ (FFL) program is promoted throughout the state to influence landscaping behaviors and is partially funded by the FDEP. It is based on nine principles: Right Plant, Right Place; Water Efficiently; Fertilize Appropriately, Mulch, Attract Wildlife, Manage Yard Pests Appropriately, Recycle Yard Waste, Reduce Stormwater Runoff, and Protect the Waterfront. Messaging is important in influencing landscaping behaviors, and simply recommending "fertilizing appropriately" legitimizes the use of fertilizer and normalizes this behavior. Alachua County has suggested that the program downplay the importance of fertilizer and irrigation on their website and create an additional tier of the program which does not include permanent irrigation and fertilizer use. As illustrated in **Figure 4-1** below from the FFL website, the description of "fertilize appropriately" leads with four benefits of fertilizer followed by two downfalls. Although the FFL program includes plant species for which irrigation and fertilizer may be recommended, there are also drought tolerant native and non-native plant species requiring minimal inputs. In a recent study by Clem et al. (2021), yards with FFL used 84% less water than traditional turf yards.

Figure 4-1. Fertilizer recommendations from UF IFAS Extension's Florida-Friendly Landscaping™ program.

FFL also includes plant species recommendations. Separate from FFL, a survey of landscape professionals identified the Florida native and resilient plants with the greatest potential for increased use and most widespread familiarity and current use. The top ten plants for each category are listed in **Table 4-2.** A 2018 poll by the American Society of Landscape Architects found that 83% of landscape architects were being increasingly asked about native plants (Ponsford, 2020). Minimizing fertilization is especially important as alternative lawn species may be less efficient at using applied nitrogen (Erickson et al., 2001) and management practices are still crucial to reducing leaching regardless of species (Erickson et al., 2008).

Table 4-2. Florida Native and Resilient Plants with the Greatest Potential for Increased Use and Most Widespread Familiarity and Current Use.

Grasses	Shade Trees	Herbaceous Perennials	Understory Trees	Shrubs	Ground Cover	Palms
Muhly Grass	Baldcypress	Scarlet Sage	Yaupon Holly	Simpsons Stopper	St. John's Wort	Coontie Palm
Fakahatchee Grass	Summer Red Maple	Blue Porterweed	Eastern Redcedar	Walter's Viburnum	Swamp Twinflower	Saw Palmetto
Purple Lovegrass	Shumard Oak	Lanceleaf Tickseed	Fringetree	Firebush	Sunshine Mimosa	Dwarf Palmetto
Sand Cordgrass	Miss Chloe Southern Magnolia	Leavenworth's Tickseed	Chickasaw Plum	Oakleaf Hydrangea	Frogfruit	Paurotis Palm
Elliot's Lovegrass	Longleaf Pine	Blue-eyed Grass	Flatwoods Plum	Wild Coffee	Oblongleaf Twinflower	Cardboard Plant
Little Bluestem	Winged Elm	Starry Rosinflower	Sweetbay Magnolia	American Beautyberry	Creeping Sage	Scrub Palmetto
Sea Oats	Sand Live Oak	Carolina Wild Petunia	Southern Waxmyrtle	Anise	Common Violet	Lady Palm
Lopsided Indiangrass	Bluff Oak	Lyreleaf Sage	Dahoon Holly	Darrow's Blueberry	Beach Verbena	Needle Palm
Splitbeard Bluestem	Tuliptree	-	Eastern Redbud	White Stopper	Narrowleaf Silkgrass	-
Wiregrass	Turkey Oak	-	Florida Privet	Sparkleberry	Partridge Berry	-

4.3.3. Rain Gardens and Green Infrastructure

Turf can also be replaced with rain gardens or other green infrastructure that are aesthetically pleasing and improve runoff water quality. Rain gardens are shallow depressions used to capture, temporarily store, treat, and infiltrate stormwater runoff. Organic mulch and soils, vegetation, and additional nutrient adsorption media facilitate nutrient removal and infiltration to the groundwater.

4.3.4. Combining Alternatives and Micro irrigation

The alternatives described above can also be combined (smaller areas of turfgrass, incorporating drought-tolerant species) for additional water conservation. In a 29-month long IFAS study titled "Home Irrigation and Landscape Combinations for Water Conservation in Florida" by Haley et al. (2020), three irrigation regimes were tested in different residential landscape aesthetics in Florida, summarized in **Table 4-3**. Using micro irrigation and drought tolerant plants in Treatment 3 resulted in 39% less irrigation water compared to the typical landscape and irrigation regime represented in Treatment 1.

Table 4-3. Summary of Treatment and Water Savings from Haley et al. (2020).

Treatment	Irrigation Regime	Water Savings
Treatment one (T1)	Existing irrigation systems and typical landscape plantings where the homeowner controlled the irrigation scheduling ("Set it and forget it" approach).	Homes in T1 consumed the most water for irrigation purposes.
Treatment two (T2):	Existing irrigation systems and typical landscape plantings with irrigation scheduling based on 60% replacement of historical ET.	Homes in T2 consumed 16% less irrigation water than T1
Treatment three (T3)	Irrigation system designed according to specifications for optimal efficiency including a landscape design that minimized turfgrass and maximized the use of native drought-tolerant plants.	Homes in T3 consumed 39% less irrigation water than T1

4.4. Case Studies

In some areas, municipalities have incorporated alternative landscaping requirements. With the aim to limit fertilizer and irrigation. Select cases are summarized – these serve as examples for creating policies to limit fertilizer and irrigation while maintaining aesthetically pleasing landscapes:

- Alachua County adopted a winter-season ban on the application of fertilizers to residential properties in 2016 and in 2019 the ban was extended to July through February
- Sarasota County, Tampa Bay Water, and Homestead have landscape ordinances that limit turf to 50-60% of open areas on new developments (Randolph, 2005)
- Nevada banned nonfunctional turf at existing non-single-family properties and required its removal and replacement with drought tolerant landscaping in a first of its kind law in the nation (Metz, 2021). Targeted areas include HOA entrances, apartments, condominiums, commercial complexes, streetscapes, and medians (Nevada Business Mag, 2022).
- California has banned watering of non-functional ornamental grass at commercial, industrial, and institutional buildings (Powells, 2022)
- Residents and businesses in counties around Los Angeles are being limited to one day of outdoor water use per week (Ramirez, 2022).
- Phoenix, Arizona charges more for water in the summer and banned lawns on new developments, reducing lawns from 80% to 14% (Ponsford, 2020).
- Montgomery County, Maryland offered to pay families and homeowner associations to design gardens that collect storm water in water features and underground rain barrels (Ponsford, 2020)

- Like Alachua County, many other municipalities are enacting Turf Swap programs:
    - Long Beach Water Department – Up to $3/sq ft for front yards $2/sq ft for side and back yards up to a total of 15,000 sq ft of turf replaced with native or drought tolerant plants.
    - San Diego County, CA - $4/sq ft up to 5,000 sq ft for residential properties and 10,000 sq ft for commercial properties. Commercial properties may receive an additional $2/sq ft up to 50,000 sq ft.
    - Colorado recently passed a bill that will require the Colorado Water Conservation Board to develop a statewide financial incentive program to inspired voluntary turf replacement for homeowners, local governments, and non-profits (Metzger, 2022).
    - Minnesota homeowners have been offered rebates to replace lawns with flowering plants for bees (Ponsford, 2020).

In the past, it has been difficult to quantify whether or not such actions by municipalities to limit fertilizer or irrigation are having a positive environmental effect, though there have been recent studies into the effect of fertilizer ordinances. In small-scale (10 households) investigation of residential landscape practices and nutrient runoff in an area in Central Florida with a fertilizer blackout period (a period during which no fertilizer may be applied), Krimsky et al. (2021) reported not observing a statistically significant difference in nutrient runoff concentrations during the blackout period compared to the rest of the year. In Souto et al. (2019), the researchers also had difficulty establishing a relationship between residential fertilizer activities and local water quality, citing the short duration of the study and lag in effects of changes in fertilizer behavior on water quality. However, in a recent study of 160 lakes throughout Florida , Smidt et al. (2022) found that fertilizer ordinances "favorably impact water quality metrics and winter fertilizer bans are the most comprehensive and effective relative to other ordinance types." Reisinger et al.[13] also found, in a preliminary study in Alachua County, support for the idea that a wet season fertilizer ordinance that prohibits N application can protect groundwater quality by reducing N leaching. Lasso de la Vega and Ryan (2016) also observed lower nutrient concentrations in stormwater ponds in Lee County after a fertilizer ordinance. Manatee and Pinellas County, two counties with fertilizer ordinances, have also reported recent decreases in nutrient concentrations in County surface waters[14].

[13] A.J. Reisinger, Ansley Levine, Eban Bean, and P. Christopher Wilson, Quantifying nitrogen leaching from residential soils in Alachua County, FL Phase 2: Effects of different landscape management practices on nutrient and organic contaminant leaching, Preliminary Final Report DRAFT

[14] Village of Key Biscayne Memorandum on Fertilizer Ordinance, accessed March 2020: https://keybiscayne.fl.gov/clientuploads/Clerk/agendas/cm_20-02-11-tab8.pdf

5.0 ADDITIONAL RECOMMENDATIONS AND RESEARCH NEEDS

In 2008, the Florida Consumer Fertilizer Task Force released a report (Blair and Jones, 2008) identifying the following research needs to address data gaps limiting fertilizer recommendations:

1. In situ or "real-world" assessment of fertilizer nutrient leaching and runoff from existing urban residential lawns.

2. Experimental and in situ assessment of nutrient leaching and runoff from ground cover, native landscapes, and other alternative landscapes. These landscapes should be assessed for nutrient loss in conditions of fertilization augmentation and where no fertilization is necessary.

3. A detailed mass balance or "box model" study to assess the ultimate sinks, fate and chemical transformations of N and P in turf, soil, and shallow groundwater systems.

4. Consumer behavior studies to assess residential urban turf irrigation rates, actual fertilizer application rates, and other factors with respect to understanding urban turf management by consumers. Analyses may be nested in a residential subdivision approach to attain trends within communities in addition to statewide trends between communities across the state.

5. Assessment of the fate of urea-nitrogen in fertilizer leachate and runoff in urban turf landscapes. Although urea-N is widely known to rapidly transform into inorganic nitrogen in the soil environment, whereby it can be rapidly assimilated by turf, what proportion of the urea-N may actually be lost in leachate and runoff needs to be researched.

Although DEP WM 869 did not address all of the research needs (and should not be expected to), the data from DEP WM 869 may be useful in design of future experiments that do address these needs. For example, some of the highest fertilizer rates tested in DEP WM 869 are double or triple the highest recommended rate (**Table 2-5).** Now that these high rates have been established as unnecessary, the DEP WM 869 treatment levels can be treated like range-finder tests and inform studies with lower ranges of fertilizer application levels (including no fertilizer on established landscapes and turfgrass).

The research needs are also underscored by a recent real-world study by Reisinger et al.[15] demonstrating that fertilizer treatments leached significantly more nitrogen than natural landscapes. Reisinger et al. conducted a small-scale study of residential landscapes in Alachua County and sought to quantify the effects of landscaping practices on nitrogen leaching. Preliminary results indicated that "regular fertilizer applications conducted by a landscape professional will increase N leaching to groundwater."

At a local level, Alachua County is also encouraged to continue their outreach campaign advising residents of the local fertilizer ordinance and educating people about local water quality issues. Krimsky et al. (2021) reported that the source and concentration of nutrients in stormwater are influenced by homeowner fertilizer behavior and recommended that nutrient management should include outreach and education. Development of additional materials is also recommended. For example, the Alachua County webpage for irrigation regulations does not emphasize the concept of only watering when necessary (i.e., when a lawn

[15] A.J. Reisinger, Ansley Levine, Eban Bean, and P. Christopher Wilson, Quantifying nitrogen leaching from residential soils in Alachua County, FL Phase 2: Effects of different landscape management practices on nutrient and organic contaminant leaching, Preliminary Final Report DRAFT

shows signs of wilt). This is mentioned in the Alachua County brochure[16], but it may be beneficial to highlight this concept on the main webpage. Additional materials could also incorporate options for residents who are interested in landscaping that requires no fertilizer use or irrigation. In a 2019 ACEPD survey about residential fertilizer behaviors, many respondents indicated that they had a yard but did not use fertilizer (Uppercase Research, 2019) – indicating that there is an audience for such materials.

Ultimately, reducing irrigation and fertilizing of landscaping provides valuable opportunities for protecting and conserving Florida's water resources. Older and lower-income neighborhoods showcase a variety of turf and landscaping alternatives that are aesthetically pleasing while needing less or no irrigation and fertilization. Shifting to this low-input aesthetic throughout Florida is possible with the data and outreach to support it. Potential opportunities highlighted in this document for reducing recommended turfgrass fertilizer application rates and placing less emphasis on fixed irrigation regimes, and more emphasis on only watering when plants show visual signs of water stress, are key practices that should be adopted to minimize the negative impacts of landscaping on our water resources

[16] Available at: https://www.alachuacounty.us/Depts/epd/WaterResources/WaterConservation/Documents/ADACompliant/IrrigationSystemBrochure_ADA.pdf

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