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SL511

https://doi.org/10.32473/edis-SS724-2024

Effects of Urban Fertilizer Ordinances on Water Quality[1]

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Introduction

Too much nitrogen (N) and/or phosphorus (P) in water bodies can degrade water quality and may lead to eutrophication (the proliferation of plants and algae in aquatic ecosystems). Both N and P can originate from natural environmental sources and/or artificial, human sources. For example, rain naturally contains inorganic N, and dust particles can transport P across wide distances. Human sources of N and P may include wastewater (i.e., septic or sewer), fertilizers, and fossil fuel emissions. To reduce the contribution of one potential human source of N and P to nearby water bodies, urban fertilizer ordinances have been adopted in at least 35 counties in Florida and 97 additional Florida municipalities. More information is available through the Florida Friendly Landscaping (FFL)™ Fertilizer Ordinance app: https://ffl.ifas.ufl.edu/fertilizer/. The University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) has researched and developed recommendations and best management practices for the use of fertilizer in urban landscapes to protect and improve water quality (Shaddox 2017; Carey et al. 2012). The efficacy of fertilizer ordinances for improving water quality and the effectiveness of different types of ordinances are debated among the public, policy makers, and other end users; some think ordinances are ineffective while others think ordinances are not restrictive enough.

The purpose of this publication is to provide a summary of a peer-reviewed, scientific article that investigated the long-term impacts of fertilizer ordinances on four water quality metrics in Florida (Smidt et al. 2022). This publication is intended to be used by UF/IFAS Extension faculty looking to increase their knowledge of fertilizer ordinances and/or regulatory officials considering adopting or modifying an urban fertilizer ordinance. Although this publication provides a summary of the peer-reviewed article, interested readers are encouraged to review the article itself, which is publicly available, free-of-charge at https://doi.org/10.1002/lol2.10279. Information provided here is useful to guide discussion when considering different fertilizer ordinance options. We encourage county Extension faculty, local government officials, green industry professionals, and concerned community members to use this information to demonstrate the effectiveness of fertilizer ordinances while also acknowledging the relationship between nutrient demands and plant-growing periods.

Background and Justification

An article published in 2020 plainly stated that we as a society do not know for sure if fertilizer bans protect water quality (Dukes et al. 2020). According to Dukes et al. (2020) and a study funded by the Tampa Bay Estuary Program referenced therein, we would need long-term (greater than

1. This document is SL511, one of a series of the Department of Soil, Water, and Ecosystem Sciences, UF/IFAS Extension. Original publication date January 2024. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.

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Reviewed: 11/2024

seven years) studies on the relationships between fertilizer bans and water quality to confidently assess the efficacy of fertilizer bans, but no study of this duration had been conducted.

Long-term studies are difficult to coordinate, by their very nature take a long time to conduct, and can be cost prohibitive. Fortunately, there are ongoing monitoring programs where water quality data were collected for various purposes. One such program is Florida LAKEWATCH (https://lakewatch.ifas.ufl.edu). LAKEWATCH is a community volunteer monitoring program that allows for "hands-on" participation in the monitoring and managing of Florida lakes, estuaries, rivers, and springs. The LAKEWATCH program is coordinated through UF/IFAS and the School of Forest, Fisheries and Geomatics Sciences Fisheries and Aquatic Sciences Program. LAKEWATCH began in 1986 and is now one of the largest lake monitoring programs in the country with more than 1,800 trained citizens monitoring 525 lakes, 175 estuary stations, 125 river stations, 20 coastal dune lakes, and 10 spring runs in 57 counties. LAKEWATCH has been recognized in state statute since 1991 (Florida Statute 1004.49). The Smidt et al. (2022) article utilized the long-term water quality record available through LAKEWATCH to ask questions related to fertilizer ordinances and water quality. LAKEWATCH monitoring was not designed specifically to address fertilizer ordinances, but ongoing monitoring can allow investigation of questions using the data collected through the program. A benefit of long-term, publicly available data (of any sort) is the ability for researchers to use these data to address questions beyond the original scope of the monitoring.

Study Details

The purpose of the Smidt et al. (2022) study was to identify the impacts of fertilizer ordinances on water quality in freshwater lakes throughout Florida. A team of UF/IFAS faculty, staff, and students accessed water quality data from lakes monitored by LAKEWATCH throughout Florida. Analyzed lakes had data available for total N, total P, chlorophyll *a*, and Secchi depth. Total N and total P represent the total concentration of all forms (dissolved and particulate, organic and inorganic) of N and P in a lake, while chlorophyll *a* indicates algal biomass. Secchi depth is an indicator of water clarity, based on how deep into the water column you can see a Secchi disk, which is a specific instrument used for taking this measurement in lake water quality studies (Figure 1). Lakes used in the study also had at least five years of data collected in 2000–2009 and at least five years of data collected in 2010–2019.

Figure 1. A Secchi disk is a black and white circular disk used to measure water clarity. The disk is slowly lowered into the water until it is no longer visible. It is then slowly raised until it becomes visible again. The depth when the disk first becomes visible is then measured and referred to as "Secchi depth." Higher Secchi depth values indicate clearer water.
Credits: "Floating Secchi Disk" by USACE HQ is marked with Public Domain Mark 1.0

The authors then categorized each lake by their county's residential fertilizer ordinance. Categories included summer ban (fertilization is prohibited during the summer wet/growing season; typically, June through October), winter ban (fertilization is prohibited during the winter dry/dormant season; typically, November through February), nonseasonal ban (e.g., restrictions after seeding or sodding), and no ban. By the end of this data organization process, the study included ~3,750 total samples representing 160 lakes (Figure 2).

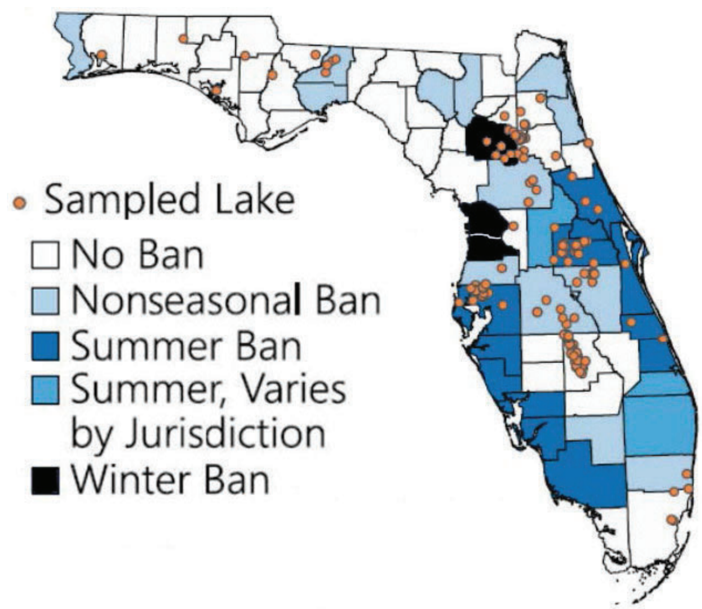

Figure 2. Florida site map of county fertilizer ordinances by type (different shades of blue). Individual lake locations used in this study are represented by (orange) circles.
Credits: Adapted from Smidt et al. (2022)

The study then used a statistical approach called linear mixed modeling to assess the long-term trends in these water quality parameters. This approach looked at how water quality conditions changed over time while accounting for individual differences among lakes. These other differences could include a range of variables, including things like lake size, surrounding land use, or other lake management actions. By comparing each lake to itself before and after an ordinance was enacted, we assumed that these other factors remained similar and were therefore not responsible for any changes in water quality. However, investigating other potential drivers of these trends could provide additional detail on how ordinances interact with physical, chemical, or biological factors at local or regional levels.

Long-term trends in water quality were assessed separately for periods before and after ordinances were enacted for any lake that was in an ordinance category. This analysis estimated the rate of change of water quality parameters over time before and after ordinances. After estimating these trends for each lake, the study tested whether water quality trends were different before and after ordinance implementation. Ordinance effects were then interpreted as improved water quality trends. In addition to fertilizer-use ordinances, there are a multitude of other potential drivers of water quality trends over this same time period. For example, in 2007, the Florida Consumer Fertilizer Task Force was created by the Florida legislature to review and provide recommendations on the state's policies and programs addressing consumer fertilizers.

The task force developed six key recommendations for State of Florida policies and programs addressing consumer fertilizers, including a recommendation that developed model language for non-agricultural fertilizer usage. Additionally, on December 31, 2007, the Florida Department of Agriculture and Consumer Services (FDACS) adopted the "Urban Turf Fertilizer" rule that limited N applications and significantly limited P applications. Although these and other (regulatory and non-regulatory) practices likely influenced fertilizer usage and downstream water quality, the Smidt et al. (2022) paper included lakes from non-ordinance counties. This approach of having "control lakes" that experience the same statewide policies and conditions other than a local fertilizer ordinance was intended to control for these potential, additional drivers. The study also used a statistical approach in the modeling called a "random effect," which is an additional factor accounting for potential external drivers beyond the focus of the study.

The study also calculated how large of an effect the different ordinances had on the different water quality parameters included in the study. More in-depth details on these effect size calculations are provided in the Smidt et al. (2022) paper, but the general approach is based on the use of an effect size metric known as Cohen's *d*, which is a standardized effect size used to compare the magnitude of a difference between two means that incorporates both the difference in means and the pooled standard deviation. Effect sizes were interpreted as no effect ($d < 0.2$), small effect ($0.2 < d < 0.5$), medium effect ($0.5 < d < 0.8$), and or large effect ($d > 0.8$). These effect size thresholds are standard when using Cohen's *d* (Sullivan and Feinn 2012).

The results of this analysis showed that water quality trends improved in regions with certain fertilizer ordinances. Although other factors may contribute to water quality trends, the consistency of the responses, particularly for winter ordinances, coupled with the likely environmental mechanism-relating ordinances with improved water quality, suggests that ordinances are at least partially responsible for these improving trends. Overall, winter dry/dormant season ordinances demonstrated large, beneficial effects on total P, total N, chlorophyll *a*, and Secchi depth. Summer ordinances showed some beneficial effects on total P and Secchi depth, but these effects were not as strong. Non-seasonal ordinances showed small effects on improving total P and total N. The overall summary of how these different ordinances affected different water quality trends is presented in Table 1.

What does this mean?

Counties with fertilizer ordinances exhibited improved water quality trends in LAKEWATCH lakes, but the magnitude and overall change in trend depended on the ordinance. Winter (dormant) season ordinances were found to result in more improved water quality trends (both in terms of more response variables and overall effect sizes) than summer (growing) season ordinances. Florida's turfgrasses are warm-season grasses and include bahiagrass, bermudagrass, centipedegrass, St. Augustinegrass, and zoysiagrass. When healthy, dense, and properly managed, these warm-season grasses have been shown to be highly effective at assimilating nutrients during the active growing season (Trenholm, Unruh, and Sartain 2012). We also note that fertilizer ordinances are not "turfgrass fertilizer ordinances." Rather, these ordinances prohibit all fertilizer applications to lawns and landscapes, except for certain gardens and/or plant establishment periods. Proper plant nutrition of all landscape plants is necessary to maintain healthy landscapes and to ensure adequate nutrient availability while minimizing nutrient loss.

If summer ordinances are implemented, it may cause fertilizer applicators to shift fertilizer application timing to periods when turfgrasses and other landscape plants are less active, such as spring or fall (Figure 3). During these less-active periods, plants are less able to use the applied nutrients, so a shift in fertilizer timing to less-active periods could lead to increased fertilizer loss to water bodies (Shaddox et al. 2016). In contrast, winter ordinances prohibit fertilizer application when landscape plants are slow to assimilate nutrients. Instead, winter ordinances promote fertilizer application during active periods of growth in the warmer seasons. This concept of applying fertilizer when grasses are actively growing is in line with the third principle of Florida-Friendly Landscaping™: Fertilize Appropriately and is supported by fertilizer BMPs (Carey et al. 2012). Ordinances that prohibit fertilizer application during periods of low plant activity in the winter exhibited the most consistent improvements across all water quality metrics while also exhibiting the largest effect sizes. Although winter ordinances may have been the most effective, all ordinance types did still lead to at least one water quality trend improvement when compared to lakes in counties without ordinances; whereas, winter ordinances were the only ordinance type to exhibit trend improvements across all water quality metrics analyzed.

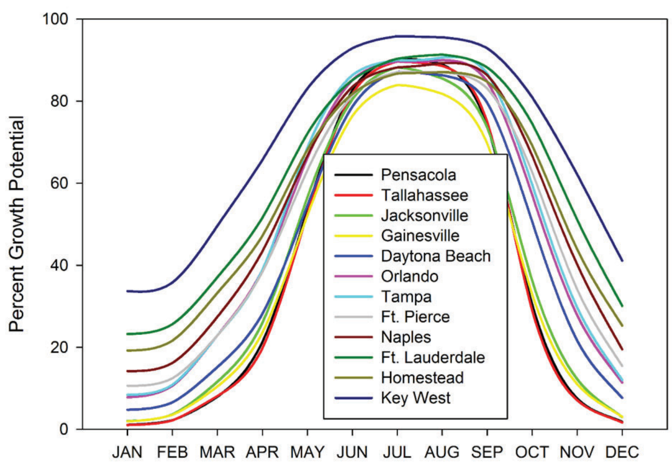

Figure 3. Growth-potential graph showing potential turfgrass growth as a function of temperature throughout an entire year at different latitudes in Florida. The main points of this figure are that 1) all locations have considerably higher growth potential during warmer summer months and 2) locations with warmer climates (e.g., Key West, Homestead, Fort Lauderdale) have higher growth potential during winter months than cooler locations. This image represents previously unpublished data. See table 2 for exact data points.
Credits: J. Bryan Unruh, UF/IFAS

It is important to note that this study only examined water quality trends and did not consider the impact of fertilizer ordinances on landscape health. Additionally, this study did not consider the pros and cons of residential landscapes from ecological or societal perspectives, and these various positive and negative aspects of residential landscape vegetation are not the focus of this publication. While this study focused explicitly on fertilizer ordinances, we should also consider the potential effects of other landscaping practices on water quality. There are several potential other strategies that could be implemented separately or in conjunction with fertilizer ordinances to improve water quality, including alternatives to synthetic fertilizers (e.g., compost, treated biosolids), alternative landscape plants and/or turfgrass species or varieties that have lower nutritional requirements, or changing societal expectations for landscapes (e.g., reducing landscape quality expectations). Note, however, that some of these alternatives contain N, P, and other nutrients. The potential contributions of these nutrients to the landscape and downstream impacts on water quality require further investigation.

Further studies are necessary to establish the effectiveness of coupled fertilizer ordinances (e.g., summer + winter restrictions). For example, Alachua County updated their ordinance in 2019 to include a summer, autumn, and winter ban. The current study did not include this change as it occurred after the time frame of analysis, but future work to analyze the effectiveness of these ordinances is warranted. Likewise, a study analyzing a county-specific transition from a summer to winter ordinance is warranted to investigate whether or not ordinances during less-active growth periods are more effective statewide. Another limitation of this study is that the pre- and post-ordinance periods were not the same across all lakes. This difference in analyzed time periods was necessary because counties enacted ordinances at different times in different locations. However, this means that lakes were exposed to different weather conditions, which could influence these trends. We minimized the potential for extreme weather conditions to influence the results by requiring at least five years pre- and post-ordinance to avoid any individual year having too large of an influence.

Results from this study show that lakes in counties with fertilizer ordinances exhibited improved water quality trends after ordinances were enacted, relative to counties without ordinances, but ordinance timing is important. More research is needed to address specific details and mechanisms that are responsible for the improvements in water quality trends associated with fertilizer ordinances to continue optimizing benefits of ordinances while minimizing any negative impacts. Identifying strategies for appropriate fertilizer use that balances plant/landscape health and water quality protection is an ongoing process. While fertilizer ordinances may be a somewhat blunt instrument for protecting water quality, the Smidt et al. (2022) study supports their effectiveness, linking urban landscaping with water quality. Moving forward, a better understanding of optimal fertilizer timing to enhance plant/landscape health could lead to more customizable ordinances and policies to protect water quality while ensuring the benefits of a functional landscape.

How can you use this information?

At least 35 counties and 97 additional Florida municipalities have formal fertilizer ordinances. Additionally, ordinances are likely being considered by other jurisdictions. For example, Miami-Dade adopted a county-wide summer ordinance as recent as 2021, and in 2019, Alachua County extended their ordinance to include both winter and summer bans. The information provided in this publication summarizing the results of the Smidt et al. (2022) study is useful to guide discussion when considering different ordinance options. We encourage county Extension faculty, local government staff and officials, green industry professionals, or concerned citizens to use this information to demonstrate the effectiveness of fertilizer ordinances while acknowledging the relationship between nutrient demands and plant growth requirements. In the end, this study found that ordinances are effective, but mechanisms are more complex than preventing "rain from washing fertilizer away." There must be considerations given to the role of plants in the landscape as biological filters and their ability to use applied fertilizers while also recognizing other nutrient sources within and beyond urban residential landscapes (Reisinger et al. 2020; Krimsky et al. 2021).

For more information about best management practices for using fertilizer in urban landscapes, please see the UF/IFAS Green Industry Best Management Practices (GI-BMP) program (https://gibmp.ifas.ufl.edu) and the Florida Friendly Landscaping (FFL)™ program (https://ffl.ifas.ufl.edu).

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Table 1. Ordinance impacts on water quality trends for different ordinance types and water quality responses. The direction (degradation, improvement, no change) and effect size (small, medium, large) are all denoted for each ordinance-response combination. Statistical significance is denoted by asterisks. Non-significant effects are denoted where relevant.

Ban type	Ordinance impact on water quality trend			
	Total phosphorus	Total nitrogen	Chlorophylla	Secchi depth
No ban	Small degradation **	No change	No change	Small improvement *
Non-seasonal	Small improvement *	Small improvement **	No change	Small effect, but not significant
Summer	Medium improvement **	No change	Small effect, but not significant	Medium improvement **
Winter	Large improvement **	Large improvement **	Large improvement **	Large improvement **

* =statistically significant effect at $p < 0.05$
** = statistically significant effect at $p< 0.01$

Table 2. Turfgrass growth potential varies longitudinally and seasonally. Values provided by the table include the growth potential as a percentage of optimal growth for 12 different locations throughout Florida. These data are visualized in Figure 3. Growth percentages are based on the optimal turf growth potential relative to the mean monthly temperature for each individual month-location using average temperatures from a 30-year record. These data are unpublished, developed by J. Bryan Unruh, UF/IFAS.

	Pensacola	Tallahassee	Jacksonville	Gainesville	Ocala	Daytona	Orlando	Tampa	Ft. Pierce	Naples	FTL	Homestead
JAN	1.11	1.06	2.03	1.94	4.49	4.77	7.81	8.41	10.64	14.22	23.24	19.20
FEB	2.23	2.18	3.63	3.56	6.45	6.57	10.64	10.83	12.44	16.19	25.63	21.63
MAR	7.96	8.11	11.62	10.46	16.71	15.18	22.91	22.91	22.91	27.43	37.09	33.28
APR	21.31	19.79	25.99	23.57	30.47	28.18	38.86	38.86	38.41	43.42	51.62	47.22
MAY	53.61	52.61	56.62	52.12	59.14	54.61	66.20	68.69	63.18	66.70	72.13	68.19
JUN	82.68	81.83	80.52	76.42	80.52	78.73	85.17	86.36	81.39	83.53	85.17	81.83
JUL	90.37	89.68	88.25	83.94	87.13	87.13	89.68	90.03	87.13	88.25	90.37	86.74
AUG	88.98	88.62	85.57	81.83	85.17	86.36	90.03	90.71	87.13	89.33	91.36	87.13
SEP	74.06	75.01	73.58	69.68	76.42	79.63	84.76	86.74	83.11	86.36	88.25	84.76
OCT	30.47	28.93	36.23	32.87	43.42	50.63	57.12	59.64	62.67	66.70	74.54	69.19
NOV	7.52	7.10	12.23	11.03	16.97	21.63	27.80	29.69	34.11	40.20	51.13	43.89
DEC	1.85	1.68	2.99	3.05	5.96	7.66	11.42	12.02	15.43	19.49	30.08	25.28