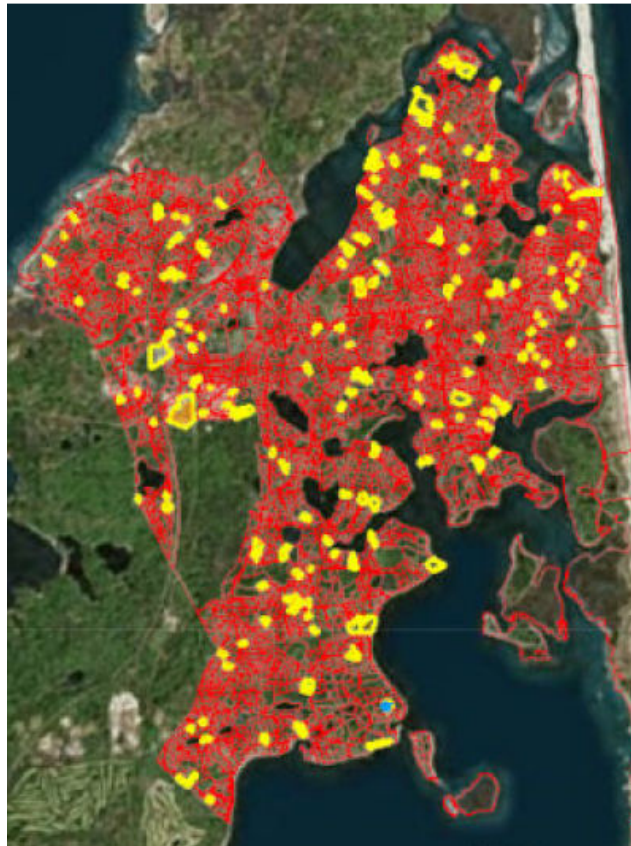


Updated Watershed Nitrogen Loading from Lawn Fertilizer Applications within the Town of Orleans

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Massachusetts Estuaries Project

Updated Watershed Nitrogen Loading from Lawn Fertilizer Applications within the Town of Orleans

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INTRODUCTION

The Town of Orleans has recognized the critical issue of nitrogen management and its relation to the quality of its coastal resources and has worked with the Massachusetts Estuaries Project (MEP) to establish the level of nitrogen loading associated restoring/maintaining high quality estuarine resources for its citizens. The MEP, through the University of Massachusetts – Dartmouth, School of Marine Science and Technology, Coastal Systems Program (CSP/SMAST) provides the scientific and technical support to the Massachusetts Department of Environmental Protection (DEP) for the development of TMDLs for compliance under the Clean Water Act. The formation of critical working linkages between local communities and CSP/SMAST facilitated by the MEP allows these communities to leverage the knowledge gained through the MEP assessments to develop and implement local watershed management plans and support nitrogen management planning, implementation, and monitoring.

To this end, in 2005 the Town of Orleans Wastewater Steering Committee partnered with SMAST to provide local measurements of lawn sizes and fertilizer applications in order to better assess the regional factors developed and utilized by the MEP.¹ The purpose was to strengthen the quantitative assessment and management modeling, as well as facilitating local discussions of management options. Specifically the effort aimed *to refine estimates of the nitrogen loading to the Town of Orleans estuaries resulting from lawn fertilizer applications within their surrounding watersheds*. The effort was part of a regional survey of lawn fertilizer usage to support the application of the MEP Linked Watershed-Embayment Management Model for developing nitrogen management targets for the estuaries of southeastern Massachusetts. The present 2015 study is a follow-up to the 2005 effort to capture lawn fertilizer inputs from “new”

¹ Howes, B.L. and L.M. White. 2005. Watershed Nitrogen Loading from Lawn Fertilizer Applications within the Town of Orleans, Massachusetts. University of Massachusetts – Dartmouth, School of Marine Science and Technology, Coastal Systems Program. New Bedford, MA.

homes built in the intervening years since the 2005 study. As such the same survey methods were employed, but with the addition of GIS analysis of the new parcels.

Residential lawn fertilizer use can be an important contributor to the mass flux of nitrogen into an estuary. Residential fertilizer use is regarded by many as an obvious, easily traced, and affordably managed source of nitrogen. However, assessment reports on nitrogen contributed to estuarine waters resulting from application of lawn fertilizers are often based on assumptions and/or limited databases and sample sets, and usually lack substantive site-specific validation. Estimates of lawn fertilizer nitrogen loading typically have to consider the integration of five factors:

1. Number of fertilizer applications per household per year
2. Lawn area (size)
3. Nitrogen added per unit lawn area
4. Leaching rate, the percent of applied nitrogen reaching groundwater
5. Attenuation, or loss of nitrogen during transport through the aquifer to the receiving waters

Many of these factors have not been rigorously reviewed. For example, assumed fertilizer use in many nitrogen loading models typically is that all homes apply fertilizer. This is not based on research data and has been found by the prior fertilizer study (2005) and the regional MEP analysis to overestimate fertilizer nitrogen loads in most communities on Cape Cod and Martha's Vineyard. This overestimation may cause errors in management plans, as it results in both an overestimate of land-based nitrogen loads and diminishes the relative importance of other sources. Because watershed nitrogen management requires a large investment of municipal resources, it is clear that each nitrogen source must be accurately determined to allow proper prioritization of management alternatives.

The focus of the present Orleans Lawn Fertilizer Survey is to provide information for the parcels developed since the MEP analyses and the 2005 lawn fertilizer survey. As in the prior survey, the current effort focuses on the factors impacting nitrogen loading from lawn fertilizers, including the amount of fertilizer applied to an average residential lawn on an annual basis. These types of updates were envisioned by the MEP Technical Team to be needed over time for some estuaries as watershed nitrogen management planning and implementation progress. These data when incorporated into the prior MEP watershed module, will allow further refinement of the relative importance of nitrogen from lawn fertilization to watershed nitrogen loading and the magnitude of change from recent development. This survey is yet another example of the partnership between the Town of Orleans and SMAST to protect/restore the coastal systems of Orleans.

METHODS

The Town of Orleans identified 213 parcels developed since the 2005 lawn fertilizer survey (G. Meservey, personal communication, 7/15) (Figure 1). CSP/SMAST staff utilized the same procedures used during the 2005 survey to develop lawn/parcel-specific information, including door-to-door resident interviews utilizing the same questions, and supplemented this effort with a review of lawn sizes based on aerial photographs.

Door-to-door interviews were conducted from July to September, as this period maximizes data capture from both year-round and seasonal residents. The 2005 interviews were conducted by 14 volunteers, trained by SMAST, on a randomly selected sample of households. In 2015, a CSP/SMAST technician attempted to conduct the same survey at all identified properties. Each interview centered on the presentation of a pre-designed and pre-tested questionnaire and the same questionnaire was used in all interviews. The structure of the questionnaire was designed to enable the researcher to acquire as much qualitative and quantitative information on application-related fertilizer use at each individual household. A secondary objective was to assess the likelihood of success of education as a means of managing nitrogen inputs through residential fertilizer usage, should it be needed.

There were essentially two parts to the survey questions (Appendix A). The first part consisted of 22 questions presented to the resident regarding household fertilizer use, attitudes, and lot location. The second part consisted of three observations (notes), completed by the surveyor, which considered: 1) lawn size, 2) lawn description/condition, and 3) proximity to water.

Survey Assumptions

A number of assumptions were accepted as part of these surveys. Some were inherent in the questions presented to residents as part of the personal interviews. The most critical and necessary inherent assumption was that residents were adequately knowledgeable concerning their use and application of lawn fertilizer. Other assumptions, such as those regarding leaching rate and attenuation, were accepted based on literature review and lack of site-specific data.

Two assumptions were made in this study regarding the number of applications per household per year. The first assumption was that the resident responding to the personal survey question about the number of lawn fertilizer applications per year was adequately knowledgeable in this regard. The possibility exists that this was not always the case, as not all respondents applied fertilizer themselves. However, discussion with the researcher and observation of the lawns helped to gauge the likelihood that the responses regarding this question were accurate. The second assumption involved the knowledge of the resident concerning the number of applications made by professional lawn care companies. It was assumed that each resident who engaged a professional lawn care company had adequate knowledge of the amount of times said company applied fertilizer each year. Fortunately lawn companies use more standardized application schedules, which are generally available.

In both studies SMAST technicians measured three parameters to the best of their ability: a) lawn size, b) lawn description, and c) proximity to water. However, there were no established methods of measurement included in this study for these parameters. Therefore, the 2005 and

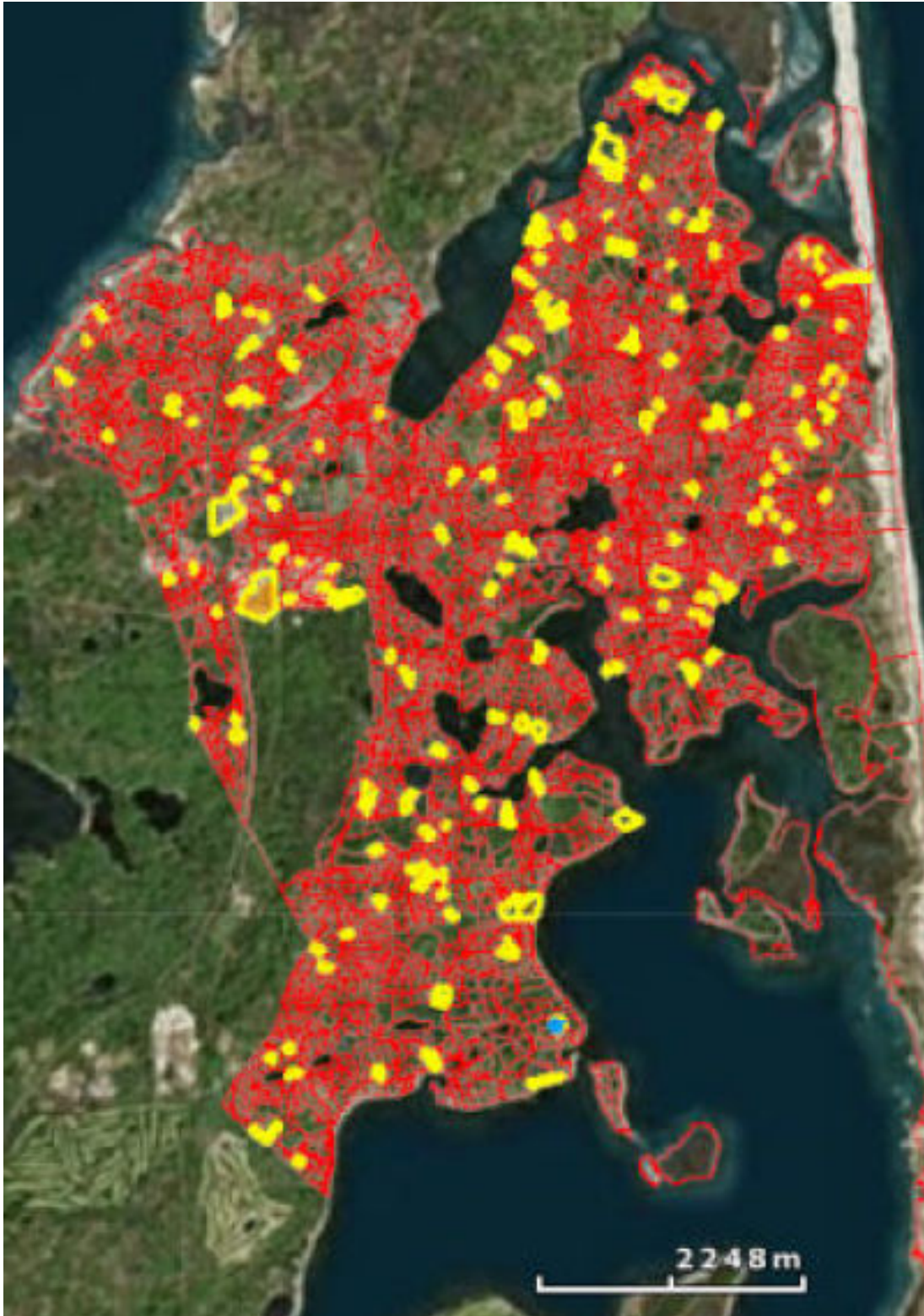


Figure 1. Parcels developed in Orleans since 2005. These parcels were reviewed during the 2015 lawn fertilizer survey. Parcels were identified by Town staff (G. Meservey, personal communication, 7/15).

2015 data sets for each parameter may lack inter-survey consistency, but were consistent within each year. Considering this, these data sets were still considered valuable for the creation of general comparisons and trends of use, as well as data base accretion for lawn fertilizer use.

There were a number of questions included in the survey which addressed attitudes towards fertilizer use and fertilizer use practice. It was assumed in this study that respondents were truthful to the best of their knowledge when answering these questions. It was also assumed that the respondents had no bias towards the volunteer/technician or the intent of the survey.

Aerial lawn area review

In addition to estimating the area of lawns during the survey visits to individual properties, CSP/SMASST staff also reviewed the area of lawns on all identified properties in aerial photographs available through Google Earth and Bing. These reviews allowed for an independent measurement and comparison to historic development available through Google Earth.

After receipt of a GIS coverage of the parcels of interest from the Town of Orleans staff, project staff reviewed the lawn area of each individual parcel. This was initially completed using the Bing aerials available through ArcGIS Explorer (generally collected between March and October 2011) and then compared to more recent aerial photographs available through Google Earth (aerials collected through May 2015). Parcel areas were measured based the clearest aerial (*e.g.*, minimal shadows from trees, best photographic angle, etc.). This review identified 26 parcels with either alternative landscaping (no turf) or no lawn and 52 parcels with turf installed after 2011. Determination of lawn area is also complicated during turf establishment periods following house construction; aerials confirm landscaping installation, but insufficient time has elapsed to determine whether it is turf based on an aerial review alone. Review also found that consistent identification of turf quality is difficult due to time of year differences (*e.g.*, green spring lawns can be brown summer lawns). Of the 188 parcels with measured turf areas, the aerial review found a mean turf area of 9,703 sq ft, a median area of 8,345 sq ft, and a geometric mean of 7,728 sq ft. If all 214 parcels are included the mean is reduced to 8,519 sq ft and the median is 7,369 sq ft. These values do not include the turf on the town landfill (12 acres). Of the 214 parcels, 182 (85%) are classified by the Town Assessor as single-family residences.

RESULTS

Lawn Fertilizer Usage

The 2005 study of lawn fertilizer use within the Town of Orleans was based on a random sample of all parcels, in an effort to gauge fertilizer use by residential parcels throughout the Town. In contrast the 2015 study, while using the same methods, aimed only at determining the fertilizer use on new parcels constructed since the earlier survey in an effort to capture this “new” nitrogen load. SMASST staff conducted the standardized analysis using the same 2005 survey. These results will allow an update to the lawn fertilizer component of the MEP Linked Watershed-Embayment Management Model.

From July through September, SMAST staff attempted to survey each of the 213 “new” properties, designated by the Town of Orleans. Responses were obtained for 96 surveys and 88 were deemed to be sufficiently complete for inclusion into the analysis for the Town of Orleans. Importantly, since 41% of the new parcels had successful data collection, extrapolation to all the new parcels can be made with a high degree of confidence. In 2005, analysis of the results by volunteer did not show any pattern or bias, especially with samples sizes >25. As a result, 2005 data from all volunteers was pooled for the synthesis presented below, including that for the SMAST technician in 2015. A compilation of the 2015 raw data and the quality assurance analysis are presented in Appendix B.

Both the 2005 and 2015 survey results clearly indicated that on average the residential lawns within the Town of Orleans use lawn fertilizers at a lower rate than recommended as part of a standard lawn care program (four applications per year and 0.75 lbs of nitrogen per 1000 ft² or 15 lbs N per 5000 ft² lawn per year). The average annual nitrogen addition to a residential lawn in the Town of Orleans was found to be about half of this rate, 6.5 lbs N per 5000 ft² (both surveys combined), with no significant difference between the 2005 and 2015 surveys. Further analysis indicates that the primary reason for the lower average fertilizer nitrogen additions was the lower average number of applications per year (2005 survey 1.76, 2015 survey 1.61) compared to the standard four applications. However, further breakdown of the data indicates that residential lawn fertilizer usage can be apportioned into three groups:

- (1) no fertilizer usage – (2005, 40% and 2015, 53%),
- (2) application by homeowners – (2005, 1.76 per year and 2015, 1.61 per year), and
- (3) application by lawn companies – (2005, 34% and 2015, 31%).

Nitrogen additions to lawns by these 3 groups were very different, again primarily due to the number of applications per year (Table 1).

Homeowners who maintain their own lawns either add no fertilizer (2005, 40% and 2015, 53%) or have very limited applications: 0.85 applications per year (2005 town-wide survey), 0.62 applications per year (2015 survey), and 0.80 applications per year (combined 2005/2015 surveys). These homeowner-maintained lawns are the norm representing about two thirds of the lawns surveyed in 2005 (69%) and 2015 (66%). The remaining third are maintained by lawn companies. All lawns maintained by lawn companies received at least some fertilizer addition and most of these had contracts for routine fertilization. As a result, the average number of fertilizer applications by lawn companies was much higher (3.85 applications per year) than for the homeowner maintained lawns. In addition, the nitrogen added per application by lawn companies was also slightly higher: 0.94 lb N/1000 sq ft versus 0.75 lb N/1000 sq ft for homeowners applying fertilizer.

The overall result is that commercial lawn care applies 5.7 (2005 survey) or 7.8 times (2015 survey) more nitrogen annually than when homeowners do the maintenance themselves: 2.03 lb N/1000 sq ft versus 0.64 (2005 survey) or 0.47 (2015 survey) lb N/1000 sq ft. Note that this difference is predominantly due to the fact that about half of homeowners do not apply fertilizer (40% in 2005, 53% in 2015) or apply it a much lower frequency than commercial lawn companies annually. It should also be noted that in all cases the homeowners are solely responsible for the fertilization of their properties and determine into which of the 3 groups their property falls.

TABLE 1. Summary of the number of fertilizer applications to an average lawn within the Town of Orleans, maintained by homeowners and lawn companies for 2015 and 2005. Note: 2005 includes data from all age homes and is represented in brackets [], while 2015 data is only for homes built over the past ~10 years.

| | Number of Applications per Year in 2015 [2005] | | | | | | | All Houses | | Overall (2015+2005) | |
|---|--|--------|---------|---------|---------|---------|--------|--------------|----------------|---------------------|----------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | Total | Wt'd Mean | Total | Wt'd Mean |
| Total Survey= Homeowner + Lawn Company | | | | | | | | count | appl/yr | count | appl/yr |
| # Houses | 47 [136] | 2 [39] | 9 [49] | 9 [30] | 14 [59] | 3 [24] | 4 [3] | 88 [340] | 1.61 [1.76] | 428 | 1.74 |
| % Houses | 53 [40] | 2 [12] | 10 [14] | 10 [9] | 16 [17] | 3 [7] | 5 [1] | | | | |
| Fertilization by Homeowner | | | | | | | | count | appl/yr | count | appl/yr |
| # Houses | 47 [136] | 2 [33] | 4 [26] | 4 [11] | 4 [18] | 0 [0] | 0 [0] | 61 [224] | 0.62 [0.85] | 285 | 0.80 |
| % Houses | 77 [60] | 3 [15] | 7 [12] | 7 [5] | 7 [8] | 0 [0] | 0 [0] | | | | |
| Fertilization by Lawn Company | | | | | | | | count | appl/yr | count | appl/yr |
| # Houses | 0 [0] | 0 [6] | 5 [26] | 5 [19] | 10 [41] | 3 [24] | 4 [3] | 27 [116] | 3.85 [3.51] | 146 | 3.57 |
| % Houses | 0 [0] | 0 [5] | 19 [20] | 19 [16] | 37 [35] | 11 [21] | 15 [3] | | | | |

Community Factors Relating to Fertilizer Usage

How these houses are used did suggest a relationship with application rate. Many of the homes in the Town of Orleans are used seasonally, primarily as vacation homes or second homes. These seasonal homes represented 24% (2005 survey) and 42% (2015 survey) of the lots surveyed, with year-round homes being the remainder. The effect of seasonality varied, with slightly lower number of applications per year in seasonal (1.40) versus year-round homes (1.87) in 2005 survey, yet in the 2015 survey of “new” homes, the opposite was observed where seasonal homes had slightly higher annual fertilizer applications (2.2 per year), versus 1.7 per year for the year-round residences. It may be that the lawns of these “new” homes are currently being fertilized at a higher rate to establish the plants or that year-round residents have become more attuned to Orleans nitrogen issues and have lowered their usage over time.

The lot-size and age of homes were also used to help predict future changes in fertilizer nitrogen inputs to the Orleans’ estuaries as result of shifts in behavior. Lot-size or housing density did not show any significant relationship to fertilizer usage in the 2005 town-wide study (Figure 2). However, there was a general pattern of lower numbers of applications per year in parcels <0.5 acres versus 0.5 to 2.0 acres, but the low number of small lots surveyed limited this analysis. Similarly, there appeared to be a pattern of slightly higher fertilizer usage in newer homes, where homes <10 years old have 1.85 applications per year while the average of all homes is only 1.67 applications per year (combined 2005 and 2015) (Figure 3). In the 2005 survey, homes <10 years old had 2.2 applications per year. It is possible that this pattern reflects the fertilizer needs to maintain or establish new lawns or a difference in attitudes of owners of new homes, many of whom are recent residents of Orleans. Regardless of the cause, to the extent that this is borne out, it appears that more recent construction may result in higher per lot nitrogen addition to the

watershed compared to earlier homes of the same size and occupancy. It appears that behavioral shifts associated with the occupancy of new homes and shifts from seasonal to year-round occupancy may accelerate increases in nitrogen loading associated with fertilizer usage, over current patterns. These potential behavioral shifts may result in predicted higher nitrogen loads at build-out than typically estimated at present and therefore would require higher levels of nitrogen mitigation than predicted from current patterns.

Homeowner Attitudes

While it has been speculated there may be a gradual shift occurring towards increasing fertilizer use within the Town of Orleans due to new construction and new occupancy rather than shifts in the activities of current residents, the data does not support this contention. For example, homeowners who currently use fertilizer (194 responses in 2005 survey and 34 responses in 2015 survey) indicated only a 9% and 6%, respectively, increased use of lawn fertilizers over the past five years. Roughly an equal amount of homeowners in the 2015 survey (6%) indicated that they had decreased their use of lawn fertilizer over the past five years. The remaining 88% stating their fertilizer use has remained the same in the last five years. Overall, homeowner applications have remained the same between 2005 and 2015.

There appears to be a sound foundation among the homeowners in the Town of Orleans for effective education relating to both: nitrogen management relating to lawn fertilizer usage, specifically, and estuarine protection/restoration in general. The 228 homeowners surveyed (combined 2005 and 2015), who are currently using fertilizer were asked about their willingness to alter their usage. On a scale of 1-5, where 1 indicated that they would not change and 5 indicated willingness for a complete change to a new regime, almost three quarters (71%) indicated a willingness to lower their current usage.

Overall, the homeowners surveyed gave responses that suggest that management of lawn fertilizer nitrogen through education would be successful if the Town decided to pursue such an effort and that they support the restoration/protection of the local estuarine systems.

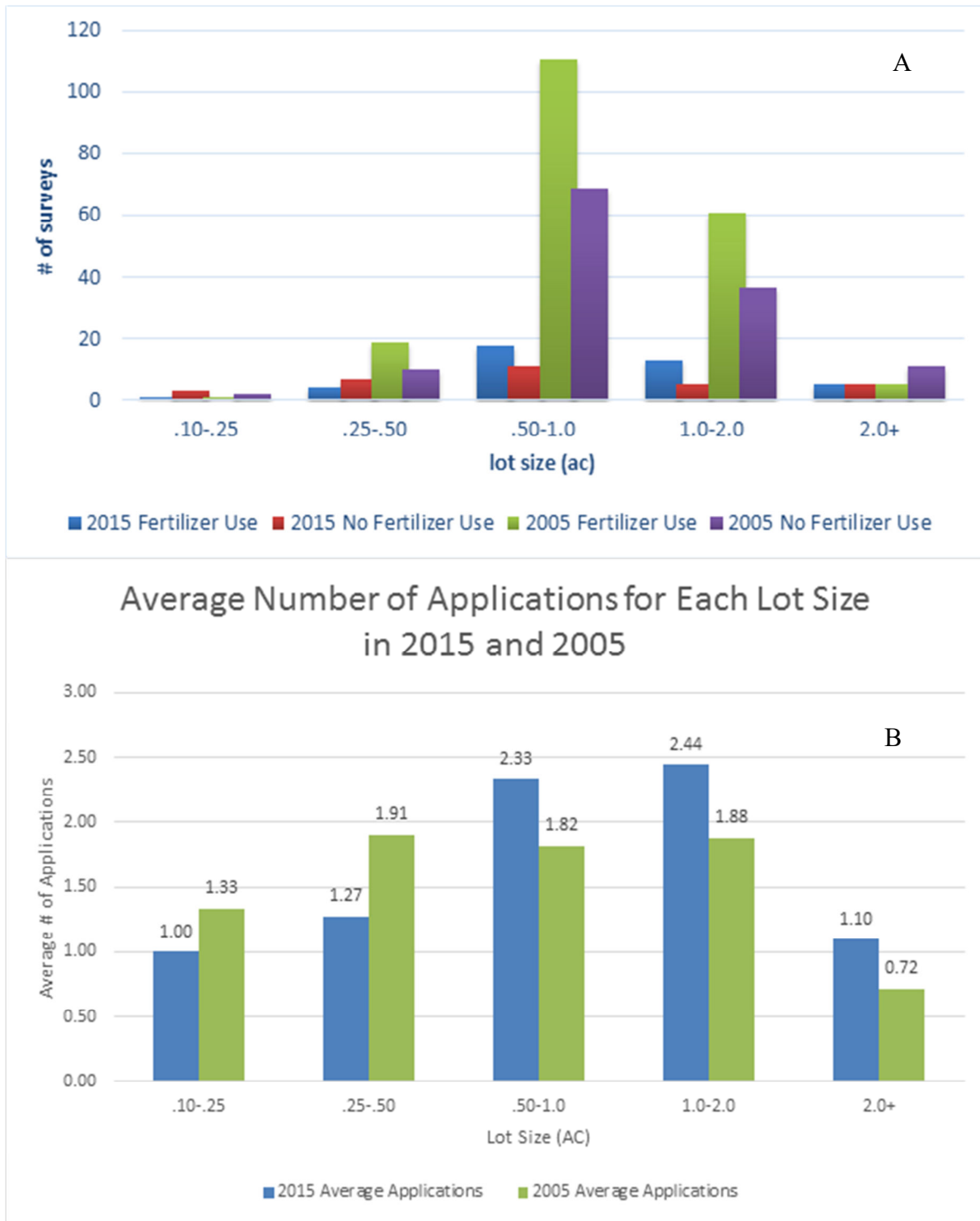


Figure 2. Relationship between lot size and number of fertilizations per year. **(A)** Lot sizes 0.25 to 2.0 acres account for 85% and 97% of the surveys using fertilizer in 2015 and 2005, respectively. **(B)** Application rates are determined by averaging the application rate of the surveys within that lot size. The number of applications per year is shown as value over each bar, and suggests that there may be more applications for lots >0.5 and <2.0 acres for 2015 vs. 2005 surveys, but low numbers of samples limits statistical analysis.

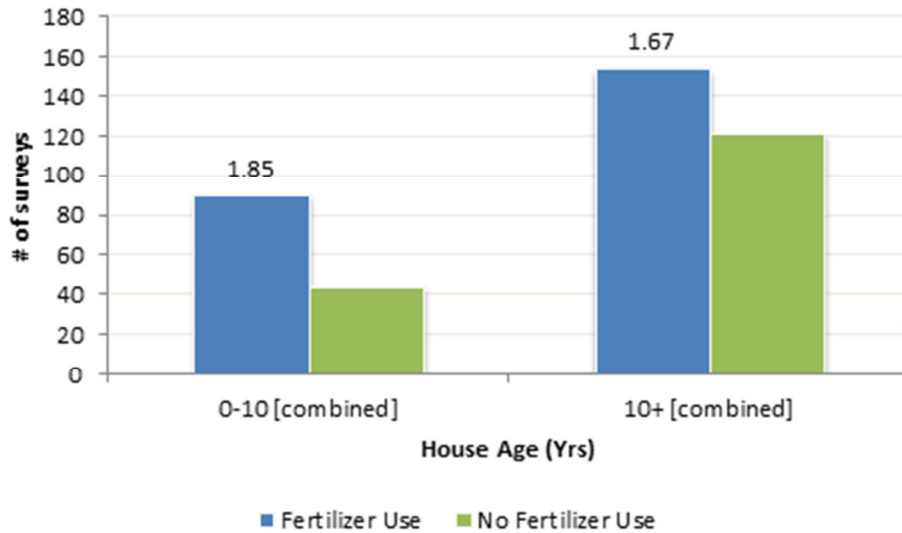


Figure 3. Fertilizer usage relative to house age, averaged over 2015 and 2005 surveys. The numbers over the bars represent the # applications per year for all homes in the age class. While there is a trend toward lower use in older homes, the difference is not statistically significant.

DISCUSSION

Residential Lawn Fertilizers and Estuarine Nitrogen Loads

The ultimate objective of the Orleans Lawn Fertilizer Surveys and the SMAST/MEP estuarine assessments is to provide a reasonable and defensible basis to develop watershed nitrogen loading assessments and water quality management strategies. The determination of the total nitrogen load from lawn fertilization to a specific estuary requires a thorough land-use analysis to determine the spatial distribution and number of lawns. In addition an estimate of the nitrogen load contributed by an average lawn within the watershed is also required to complete the loading analysis. The MEP has completed site-specific watershed assessments, where each nitrogen source (including lawns) was determined for each of the estuaries associated with the Town of Orleans. These assessments also include measurements and estimates of nitrogen loss (attenuation) during transport from the sources to the estuarine waters. The nitrogen load contributed by an average lawn within these estuarine watersheds was based upon the overall MEP watershed database, which includes each individual parcel and the 2005 Orleans survey results. The present site-specific refinement completed in 2015 can be seamlessly integrated into the existing watershed module if an update is required by the Town for management purposes.

Based upon the Survey results within the Town of Orleans, it is possible to further refine the lawn fertilizer-based nitrogen loading to groundwater within the estuarine watersheds, but this would likely be done on a parcel-specific basis rather than changing the average factors. The

average annual fertilizer loading term includes a number of factors and is estimated as: the average number of fertilizer applications per lawn *times* the average nitrogen added per 1000 ft² per application *times* the average area of lawn per house *times* the amount of the applied fertilizer which is leached to groundwater. This represents the average annual nitrogen load to groundwater from a single lawn, but due to attenuation during transport, it may not be the actual nitrogen load from lawns to the estuary. This latter determination of attenuation would be part of an update to the existing full MEP analysis.

The results for fertilizer applications did not change significantly from 2005 to 2015. Combining the survey results from 2005 and 2015 indicated that the best estimate of the average number of lawn fertilizer applications per year per residential lot is 1.74, which is essentially the same the 1.76 rate developed in the 2005 Study. Both rates are significantly lower than the 4 applications assumed in some watershed models. This number of applications is the weighted average of the 43% of residences with no fertilizer usage, the 24% with application by homeowner (2.24 times per year) and the 33% with application by lawn company (3.57 times per year). Based upon historical data, MEP data and the present survey, the use of 0.75 lb N/1000 ft² of lawn per application, as recommended by the fertilizer manufacturers, appears to be the most reasonable estimate available. Information provided by the *Scotts* Company indicated that the nitrogen load per application is slightly higher by lawn companies compared to homeowners, 0.94 lb N/1000 ft².

Review of the measured lawn areas showed that there is some variability that raises some additional questions, but the differences are not significant enough to alter the standard average area assumption of 5000 ft². Among the issues identified during this project were the lack of a standard method of measurement for lawn size, the unreliability of homeowner estimates of lawn area, the difficulty of determining lawn area without direct measurements, and whether newer houses have larger lawn areas.

The arithmetic mean of lawn area for the aerial review of parcels in the 2015 survey was 8,519 sq ft with an 87% coefficient of variance. The COV is large because of the large range of measured areas (0 to 48,178 sq ft). By comparison, the average lawn area measured during the individual site visits was 5,880 sq ft. Staff went through a statistical comparison by various grouping to see if these differences in the averages were caused by the differences in specific area groupings (*e.g.*, a few large parcels), but the differences seem to be spread more evenly (see Appendix B). This finding suggests that the difference in the averages is largely caused by differences in the measurement methods. Reconciling why there are differences between the two methods would require a more in-depth assessment separate from this project.

The next question was whether the larger average areas in both aerial review and on-site measurements indicated a significant enough difference in lawn area to alter overall lawn loading in the watershed assessments. The difference between the average aerial area estimate and the standard area is significant, but the unresolved difference in the measurement methods does not provide a sufficient basis for altering the standard area. The differences in average areas based on the 2005 and 2015 are not significantly different based on the population variabilities and this comparison also raises an issue of whether the two populations of parcels are sufficient different to make this a reliable comparison.

During the aerial review, it was noted that a number of the 2015 parcels had houses that had been replaced during the 1995 to 2015 period of available aerial photograph, as well during the 2005 to 2015 period that was the primary focus of this project. All of the replacements had included larger houses and most had included larger turf areas. This raises the issue of whether houses built since 2005 (the parcels reviewed in this project) generally are larger and have larger lawn areas. This question of whether the age of the houses is important in estimating lawn areas is unresolved and would require a town-wide analysis of current lawn areas. It does, however, raise a potential management factor that the town may want to consider: limiting the turf area on parcels. Based on consideration of the available measurements, the average lawn size of 5000 ft² estimate currently used in the MEP models and accepted in most nitrogen loading models is still appropriate for use in watershed nitrogen loading. Individual lawn areas measured in this project could be incorporated into the MEP models if the town wanted to further refine the models.

The leaching of lawn fertilizer nitrogen to groundwater was not assessed in the present study. The MEP standard leaching rate of 20% was developed by MEP staff during the early stages of the project following extensive review of fertilizer leaching rates in sandy soils and has been confirmed in independent reviews.² This is a consistent and conservative estimate for Cape Cod soils and recognizes the use of controlled fertilizer applications.

The overall combination of the review of these factors shows that the MEP lawn fertilizer loading factors are still reasonable for determining the nitrogen load to groundwater from an average lawn in the Town of Orleans. In addition, using the survey data, it would be possible to further refine lawn loading based upon whether a lawn is maintained by homeowners or a lawn company (Tables 2, 3). These types of refinements could be considered if the Town chooses to pursue lawn fertilizer management as part of the water quality management options for restoring estuarine water quality.

² e.g., Horsley Witten Group. 2009. Evaluation of Turfgrass Nitrogen Fertilizer Leaching Rates in Soils on Cape Cod, Massachusetts. Sandwich, MA.

TABLE 2. Summary of Orleans nitrogen loading to groundwater from lawn fertilization. Town-wide average applications are weighted by observed homeowner and lawn company values. Includes both seasonal (40% [24%]) and year-round (60% [76%]) homes.

| Fertilizer Usage | % of Surveys | Predicted Lawn Size (ft ²) | Observed Application (lbsN/1000 ft ²) | Observed Application Rate (# apps/yr) | % Leaching to Ground Water | Loading to Ground Water (lbs N/lawn/yr) |
|---|--------------|--|---|---------------------------------------|----------------------------|---|
| Town-wide Average | | | | | | |
| Fertilizer Users Only | 47% [60%] | 5000 | 0.81 [.86]* | 3.46 [2.93] | 20% | 2.80 [2.52] |
| Fertilizer Non-Users | 53% [40%] | 5000 | 0 [0] | 0 [0] | NA [NA] | 0 [0] |
| Weighted Average | 100% [100%] | 5000 | 0.81 [.86]* | 1.61 [1.76] | 20% | 1.30 [1.51] |
| Homeowner – Applications | | | | | | |
| Fertilizer Users Only | 16% [26%] | 5000 | 0.75 [.75] | 2.71 [2.16] | 20% | 2.03 [1.62] |
| Fertilizer Non-Users | 53% [40%] | 5000 | 0 [0] | 0 [0] | NA [NA] | 0 [0] |
| Weighted Average | 69% [66%] | 5000 | 0.75 [.75] | 0.62 [0.85] | 20% | 0.47 [0.64] |
| Lawn Company – Applications | | | | | | |
| Fertilizer Users Only | 31% [34%] | 5000 | 0.94 [0.94]** | 3.85 [3.5] | 20% | 3.62 [3.29] |
| Fertilizer Non-Users | NA*** | NA | NA [NA] | NA [NA] | NA [NA] | NA [NA] |
| Weighted Average | 31% [34%] | 5000 | 0.94 [0.94]** | 3.85 [3.5] | 20% | 3.62 [3.29] |
| *Based upon surveys | | | | | | |
| **Based upon data provided by <i>Scotts Lawn Co.</i> , the predominant Lawn Company in 2005 | | | | | | |
| ***All lawn company maintained lawns have fertilizer applications | | | | | | |

TABLE 3. 2015 and 2005 combined summary of Orleans nitrogen loading to groundwater from lawn fertilization.

| Fertilizer Usage | % of Surveys | Predicted Lawn Size (ft ²) | Observed Application (lbsN/1000ft ²) | Observed Application Rate (# apps/yr) | % Leaching Rate to Groundwater | Loading to Ground Water (lbs N/L/yr) |
|---|--------------|--|--|---------------------------------------|--------------------------------|--------------------------------------|
| Town-wide Average | | | | | | |
| Fertilizer Users Only | 57% | 5000 | 0.85* | 3.02 | 20% | 2.57 |
| Fertilizer Non-Users | 43% | 5000 | 0 [0] | 0 [0] | NA [NA] | 0 [0] |
| Weighted Average | 100% | 5000 | 0.85* | 1.74 | 20% | 1.48 |
| Homeowner – Applications | | | | | | |
| Fertilizer Users Only | 24% | 5000 | 0.75 [0.75] | 2.24 | 20% | 1.68 |
| Fertilizer Non-Users | 43% | 5000 | 0 [0] | 0 [0] | NA [NA] | 0 [0] |
| Weighted Average | 67% | 5000 | 0.75 [0.75] | 0.8 | 20% | 0.6 |
| Lawn Company – Applications | | | | | | |
| Fertilizer Users Only | 33% | 5000 | 0.94 [0.94]** | 3.57 | 20% | 3.36 |
| Fertilizer Non-Users | NA*** | NA | NA [NA] | NA [NA] | NA [NA] | NA [NA] |
| Weighted Average | 33% | 5000 | 0.94 [0.94]** | 3.57 | 20% | 3.36 |
| *Based upon surveys | | | | | | |
| **Based upon data provided by <i>Scotts Lawn Co.</i> , the predominant Lawn Company in 2005 | | | | | | |
| ***All lawn company maintained lawns have fertilizer applications | | | | | | |

There are three basic conclusions that can be drawn from the nitrogen loading to groundwater results from the Town of Orleans (see Tables 2, 3):

- 43% of homeowners are not currently using lawn fertilizers, which greatly reduces the potential watershed nitrogen loading from this source;
- 24% of homeowners who currently use lawn fertilizers, apply them at about half the manufacturers standard rate;
- 33% of homeowners currently employ lawn care companies, which on average apply significantly more nitrogen per year than homeowner maintained lawns (>5 fold higher);
- nitrogen loading to groundwater from lawn fertilizers had been estimated pre-MEP at 3 lbs/lawn/yr with an average lawn size of 5,000 ft²; the average Orleans homeowner-maintained lawn is contributing about one-fifth of this amount (0.6 lbs/lawn/yr), while those maintained by lawn care companies contribute about 10% more than this estimate (3.36 lbs/lawn/yr).
- for the average lawn within the Town of Orleans (all lawns included) **the best estimate for the contribution of lawn fertilizers to groundwater appears to be 1.48 lbs/lawn/yr, the same as the previous 2005 estimate of 1.51 lbs/lawn/yr, but about 50% of the generic rate (3 lbs/lawn/yr).**

In conclusion, the 2015 survey revealed similar results to that of the 2005 survey, giving no indication that the Town of Orleans fertilizer applications have significantly increased or decreased with the development of new homes. There are three categories of homeowner fertilizer applications: a) homeowners that use no fertilizer, b) homeowners that fertilize themselves, and c) homeowners that fertilize using a lawn company. Comparison of 2005 and 2015 survey results showed an increase in homeowners that do not fertilize and a decrease in homeowners that fertilize using a lawn company. However, the addition of the 2015 surveys has minimal effect on the overall town-wide determination of fertilization (both surveys combined) yielding 1.74 applications per year versus the 1.76 determined in the 2005 study.

It should be noted that the addition of lawn fertilizer nitrogen to estuarine waters is small relative to wastewater inputs primarily through on-site septic treatment systems. Lawn fertilization has generally been found to be <10% of the total watershed nitrogen inputs in the Orleans MEP assessments. However, fertilizer usage is easily controllable and the residents indicated in the survey that they would be willing to lower usage if notified. If the Town decided that management of lawn fertilizers nitrogen on residential properties is needed for the protection/restoration of Orleans' estuarine systems, survey results seem to indicate that a citizen education program has a high potential for success.

Discussion of lawn fertilizer management should include clear explanation of expected level of benefits relative to water quality improvements. Clear explanation will benefit the public in the formation of realistic expectations of costs and benefits of fertilizer management versus managing other local nitrogen sources.

A greater issue relating to lawn fertilization in estuary watersheds is that the amount of nitrogen from this source could double due to changes in homeowner behavior alone, without any additional development of the watershed. At a minimum, continuation of current homeowner fertilizer practices limits the potential magnitude of this source.

Next Steps

The Orleans Lawn Fertilizer Surveys in 2005 and 2015 show that homeowners' lawn care practices generally limit lawn fertilizer applications compared to what might occur if fertilizer manufacturer recommendations were followed. Further, homeowners would be willing to further limit their applications if provided with a compelling case to do so; it is relatively easily controlled load without associated infrastructure costs if citizen support formally exists. The project also indicates that while lawn fertilizer usage is presently a relatively small part (<10%) of the current local estuarine watershed nitrogen loads, it is still a notable load and could easily double if homeowner shifted fertilizer application behavior, without any increase in the number of residences.

Recommendations for next steps include:

- continue to update land-use, nitrogen loading, and system characterization information to refine MEP assessments;
- discuss town interest in expanding existing education programs to indicate the role for lawn fertilizer nitrogen management in estuarine protection/restoration for MEP watersheds (potential education outlets: Orleans Ponds Coalition, Pleasant Bay Alliance, etc.);
- focus potential education on reducing the number of fertilizations per year in those areas documented to have nitrogen sensitive receiving waters;
- conduct a cost analysis of lawn fertilizer nitrogen management related to each of the other major sources of nitrogen contributing to the estuaries associated with the Town of Orleans, including potential effects on local businesses involved in fertilizer sales, etc.

APPENDIX A

2015 Survey Form³

Massachusetts Estuaries Project: Survey of lawn fertilizer usage within the Town of Orleans

Brian L. Howes, Eduard Eichner, & Amber Unruh

Coastal Systems Program
School for Marine Science and Technology

Survey# _____
Date _____
TOV _____

Homeowner Lawn Fertilizer Survey

Hello. I am working with the Town of Orleans and the School for Marine Science and Technology on the Massachusetts Estuaries Project. The goal of this effort is to protect and restore Orleans' coastal waters for the betterment of the citizens of Orleans. To develop accurate restoration plans, we need to have accurate information on the suite of land-uses and nitrogen applications to the land surrounding our bays and estuaries. I am here today gathering information on lawn fertilizer use as part of a town-wide survey. I was wondering if you had a few minutes to answer some questions? All answers will be kept anonymous and confidential.

My name is _____ and I am a volunteer for the Town of Orleans. I am working to provide more accurate data than is typically available to towns for comprehensive management planning.

I would like to ask you twenty-two questions, which should only take about 5 minutes of your time.

1. Do you maintain this house or does someone else? **Myself** **Someone else**
2. How long have you lived on the Cape? _____ in this house? _____
3. How old is this house? _____ **years old**
4. Are you a seasonal or year-round resident? **Seasonal** **Year-round**
5. What is your age? **(circle one)** **20-35** **36-50** **51-65** **66-older**
6. Is fertilizer applied to your lawn? **Yes** **No**
7. Do you or a commercial company apply it? **Myself** **Company**

³ Survey form is the same as developed with L. White for the 2005 Study, with some questions deleted (#21, #22)

8. If it applied commercially, which company do you use? _____
9. If you apply it, where do you generally purchase the fertilizer? **(check one)**
 _____ **lawn and garden center, such as Mahoney's or Agway**
 _____ **hardware store, such as True Value**
 _____ **large retail store, such as Sears, Wal-Mart, or BJ's**
10. What type of fertilizer do you use? **Liquid Solid**
11. How often is fertilizer applied? _____ **times per year**
12. Which time(s) of the year is it applied? **(circle all that apply)**
Early Spring Late Spring Early Summer Late Summer Fall
13. How much fertilizer is used per application? _____
14. How often do you water your lawn? _____
15. Do you water immediately after applying fertilizer? **Yes No**
16. Do you water immediately before applying fertilizer? **Yes No**
17. Have you used more, less, or the same amount of fertilizer in the last 5 years?
More Less Same (circle one)
18. If this study shows that fertilizer is a major contributor to the nutrient load of Cape Cod embayments, would this alter your current use of fertilizer? **Yes No**
19. On a scale of one to five, how much would you be willing to change your use of fertilizer, with 1 indicating no changes, and 5 indicating total change? **(circle one)**
1 2 3 4 5
20. Do you know what watershed your house is in? (And which embayment does this watershed feed into?)

Thank you very much and I appreciate the time you have taken to help me gather this information for the management of our local waters.

APPENDIX B

Summary of 2015 Survey Results

**Massachusetts Estuaries Project:
Survey of lawn fertilizer usage within the Town of Orleans**

Brian L. Howes, Eduard Eichner, & Amber Unruh

Coastal Systems Program

School for Marine Science and Technology, UMD

Summary

During the summer of 2015 the Town of Orleans Wastewater Steering Committee partnered with the Massachusetts Estuaries Project (MEP) to capture lawn fertilization data from 213 parcels with development after the 2005 Lawn Study of Orleans and if necessary to refine estimates of the nitrogen loading to the Town’s estuaries resulting these new homes. One SMAST technician undertook the field surveys using the standardized survey form developed in 2005 for this purpose by L.M. White of SMAST. The effort also feeds into the survey of lawn fertilizer usage to support the application of the MEP Linked Watershed-Embayment Management Model for developing nitrogen management targets for all of the Orleans estuaries. Of the 213 new residences, successful surveys were completed on 88, a sufficient number (41%) from which to adequately represent the full 213 new homes and as appropriate if the town wished to include these parcels into the existing MEP watershed module. A compilation of the results is presented in the “Compilation of Results” section below.

Quality Assurance

Given that the primary focus of the study was to refine the amount of fertilizer usage on the lawns of Orleans associated with new residences, we examined the average number of fertilizer applications per house. The average application rate determined from the 88 was 1.61 applications/year, compared to 1.76 applications/year town-wide in 2005. The mean application determined by the 2015 survey (#15 in Figure A-1) is similar to the average of all 14 surveyors in the 2005 study (Figure A-1).

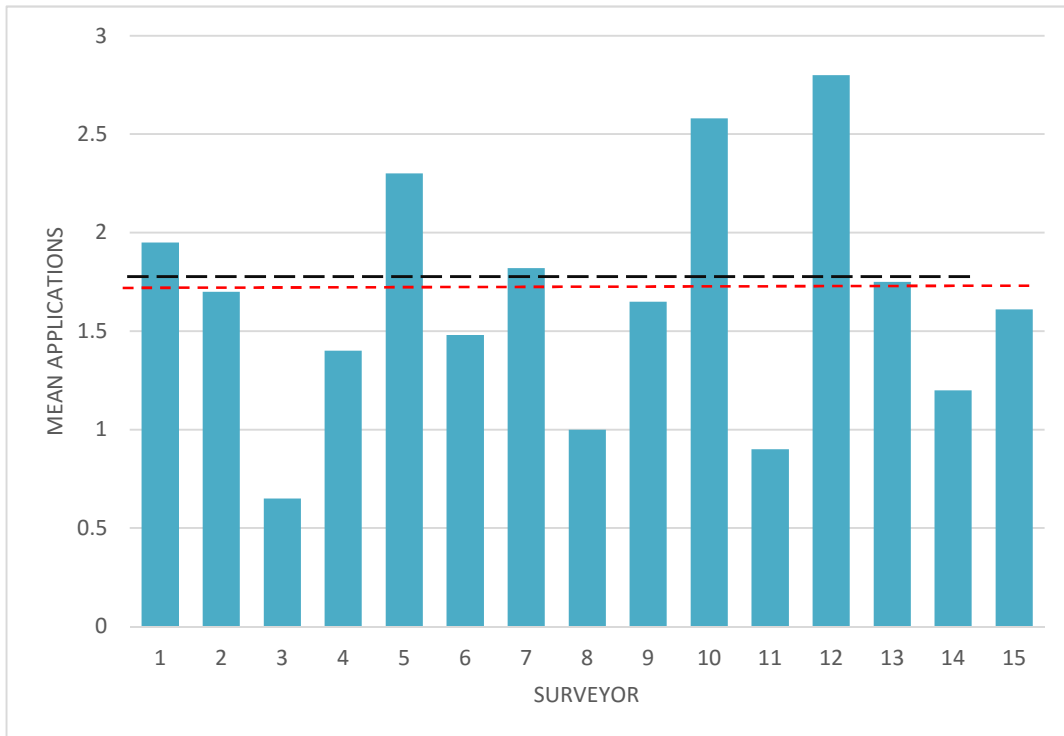


Figure A-1. Average number of fertilizer applications per year among the survey respondents by each of the 14 surveyors in 2005 and the one surveyor in 2015. The red horizontal dashed line is the mean of 1.74 applications per year for all 428 (340+88) surveys. The black horizontal dashed line is the overall mean of 1.76 applications per year for the 340 surveys from 2005. The

2015 mean of 1.61 applications per year is represented by the 15th surveyor bar. The number above the bar represents the number of residences surveyed. The high variability among surveyors appears to be related to the number of residents included in the various means.

Compiled Results of Orleans Surveys

A field survey was conducted by the Coastal Systems Program staff for the Town of Orleans in the summer of 2015. The surveyors attempted to survey each property at least once. In the event that no one was home, a questionnaire and return envelope was left for the owner to complete and return. A rapid survey was typically completed at this time. Owners had the option to complete the survey in person, return by mail, or not participate in the survey. In order, to get as many surveys returned as possible, we requested that if they did not want to participate they should return a blank survey. Overall, there were 213 properties to survey, 60 questionnaires were completed in the field, 28 questionnaires were mailed in (88 completed questionnaires), 29 properties chose to not participate, 3 properties were occupied by renters that would not accept the questionnaire, 85 questionnaires were not returned, and 8 questionnaires were lacking the appropriate information to be valid. In addition to the questionnaire, a rapid survey was also attempted at most properties to acquire a lot description and lawn area. In total, 174 out of 213 rapid surveys were completed and 83 of the 88 completed questionnaires also have a rapid survey. The completed surveys were evaluated and compared to the 2005 survey results. Presented below are the responses to the questions to the survey, found in Appendix A with the **2015 results followed by the 2005 result in []**. Overall, 213 [353] surveys were conducted, with 88 [340] being sufficiently completed in the field or returned via mail to support the data analysis. Therefore the maximum number of respondents to a question is 88 in 2015 and [340] in 2005, although occasionally answers were not filled in. The following are the results for the parameters surveyed in the 2005[2015] format:

1. House Maintenance
 - 69 [340] residents responded
 - 83% [80%] stated that they maintained their residence themselves
 - 16% [20%] stated that someone else maintained their residence
 - 1% stated they used a combination of self and hired maintenance
2. A) The average length of time a resident resided on Cape Cod was 19.3[17.9] years
B) The average length of time a resident lived in their current dwelling was 6 [14.4] years. Note: the 2015 survey was of homes <10 years old accounting for the difference.
3. The average age of their current dwelling was 6 [34.7] years
4. Residency
 - 69 [336] residents responded
 - 58% [76%] stated that they were year-round residents
 - 42% [24%] stated that they were seasonal residents
 - 42% [27%] for homes <10 year old only, stated seasonal residents
5. Resident Age
 - 69 [375] residents responded
 - 5% stated that they were 20-35 years of age
 - 7% [12%] stated that they were 36-50 years of age
 - 39% [35%] stated that they were 51-65 years of age
 - 49% [53%] stated that they were 66 years of age or older

6. Fertilizer Use (Y/N)
 - 88 [340] residents responded
 - 47% [60%] stated that they applied lawn fertilizer at least one time per year
 - 53% [40%] stated that they did not apply lawn fertilizer at all
7. Use of a Lawn Care Company for Lawn Fertilizer Application
 - 41 [204] residents responded
 - 34% [57%] stated that they used a commercial company
 - 66% [43%] stated that they applied fertilizer themselves
8. Name of Lawn Care Company
 - 27 [116] residents responded
 - 37% [67%] stated that they used *Scott's/Fairway Lawn/Chem Lawn [Scott's/The Lawn Company/ChemLawn]* as their professional lawn care company
 - 63% [33%] used a company other than *Scott's* (see index for listing)
9. Type of Fertilizer (Solid/Liquid)
 - 41 [168] residents responded
 - 61% [83%] stated that a solid fertilizer was applied to their lawn
 - 5% [17%] stated that a liquid fertilizer was applied to their lawn
 - 12% stated that both a solid and liquid fertilizer was applied to their lawn
 - 22% stated that they did not know which type of fertilizer was applied
10. Fertilizer Applications per Year
 - 41 [340] residents responded
 - The overall average number of applications per resident per year was [1.61] 1.76
 - The average number of applications per year for those residents who employed a professional lawn care company to apply fertilizer was 3.85 [3.52]
 - The average number of applications per year for those residents who applied fertilizer themselves was 2.71 [2.16] applications per year
11. Time of Year of Fertilizer Application
 - 41 [182] residents responded
 - 63% [74%] stated that they applied fertilizer in early spring
 - 49% [48%] stated that they applied fertilizer in late spring
 - 46% [51%] stated that they applied fertilizer in early summer
 - 51% [40%] stated that they applied fertilizer in late summer
 - 71% [68%] stated that they applied fertilizer in fall
 - There is a total of 114 applications
12. Amount of Fertilizer Used per Application: **Uncertain Data Results**
13. Lawn Watering Frequency of Entire Survey Population
 - 57 [283] residents responded
 - 84% [67%] of the residents stated that they watered their lawn to some extent
 - 16% [33%] of the residents stated that they never watered their lawn
14. Of those residents that water their lawn to some extent, how often to they water?
 - 47 residents responded
 - 8% stated that they water their lawn less than once per week
 - 4% stated that they water their lawn once per week
 - 8% stated that they water their lawn twice per week
 - 23% stated that they water their lawn three times per week
 - 11% stated that they water their lawn four times per week

- 8% stated that they water their lawn five times per week
 - 29% stated that they water their lawn everyday
 - 6% stated that they water their lawn but inconsistently
15. Lawn Watering Frequency of Fertilizer Application
- 41 residents responded
 - 95% of residents who fertilize also water
 - 5% of residents who fertilize did not know if they water
16. Of those residents that fertilize and water their lawn, how often do they water?
- 39 of the 41 residents who said they fertilize and water their lawn responded
 - 5% stated that they water their lawn less than once per week
 - 5% stated that they water their lawn once per week
 - 10% stated that they water their lawn twice per week
 - 23% stated that they water their lawn three times per week
 - 12% stated that they water their lawn four times per week
 - 10% stated that they water their lawn five times per week
 - 23% stated that they water their lawn everyday
 - 4% stated that they water their lawn but inconsistently
17. Lawn Watering Frequency of those who Do Not Fertilize
- 45 residents responded
 - 22.5% of residents who do not fertilize, do water their lawn
 - 22.5% of residents who do not fertilize, do not water their lawn
 - 55% of residents who do not fertilize, do not have a grass lawn
18. Of those residents that fertilize and watered their lawn, 13% [60%] stated that they watered immediately after fertilizer was applied
19. Of those residents that fertilized their lawn, 26% [4%] stated that they watered immediately before fertilizer was applied; 8% [36%] stated that they watered both before and after fertilizer was applied; 53% stated that they did not immediately water their lawn before or after fertilizing
20. 5-Year Use History
- 34 [194] Residents Responded
 - 6% [9%] stated that their use of fertilizer has increased in the past 5 years
 - 6% [15%] stated that their use of fertilizer has decreased in the past 5 years
 - 88% [76%] stated that their use of fertilizer has stayed the same in the past 5 years
21. Willingness to Alter Current Use (Y/N)
- 41 [201] residents responded
 - 71% [90%] stated that they would be willing to alter their current fertilizer use
 - 29% [7%] stated that they would not be willing to alter their current fertilizer use
22. Willingness to Alter Current Use (1-5 scale)
- 42 [200] homeowners who currently apply fertilizer responded
 - The average willingness to alter current use was 3.4 [3.6]
 - The median willingness to alter current use was 3 [4]
23. Knowledge of Watershed
- 56 [304] residents responded
 - 52% [57%] stated that they knew what watershed they resided in

RAPID SURVEY NOTES

1. Proximity to Water

- 25 properties surveyed were found to have access to water
 - 14 properties surveys were found to have a view of the water
2. Approximate Lawn Size
- 182 [306] house lots were physically surveyed for lawn size
 - 213 house lots were aerially surveyed for lawn size
 - The average approximate lawn size for physically surveyed lawns was 5,880 ft² [11,879 ft²]
 - The average approximate lawn size for aerially surveyed lawns was 7,880 ft
 - Number of surveys where ground and aerial lawn areas with a relative percent difference of:
 - 0% = 18
 - 10% = 44
 - 15% = 21
 - 20% = 15
 - 30% = 21
 - 40% = 15
 - 50% = 16
 - 60% = 6
 - >60% = 26
- Total surveys with both lawn areas = 182

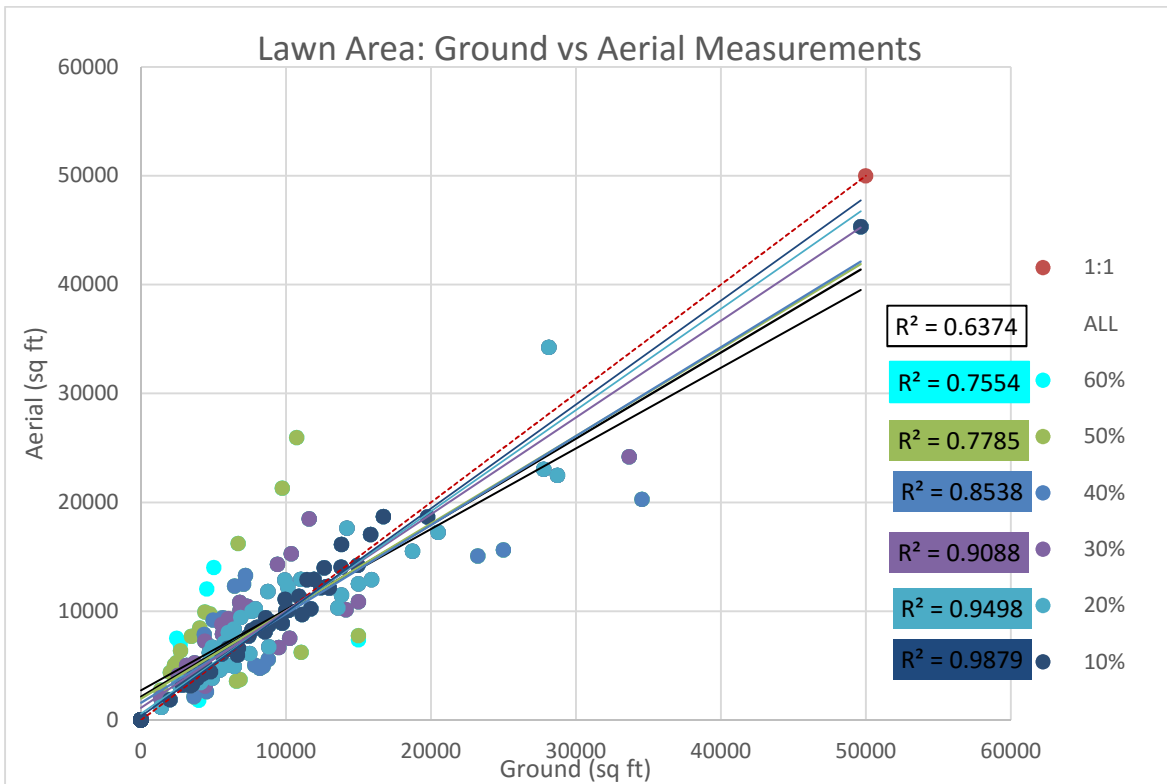


Figure B-1. Correlation of lawn areas measured using aerial imagery and on site ground measurements. Data is organized based on the relative percent difference of the two methods. R^2 values reveal the correlation of the two methods within a given relative percent difference.

Therefore, when the two methods had a relative percent difference within 60% the correlation was 0.7554.

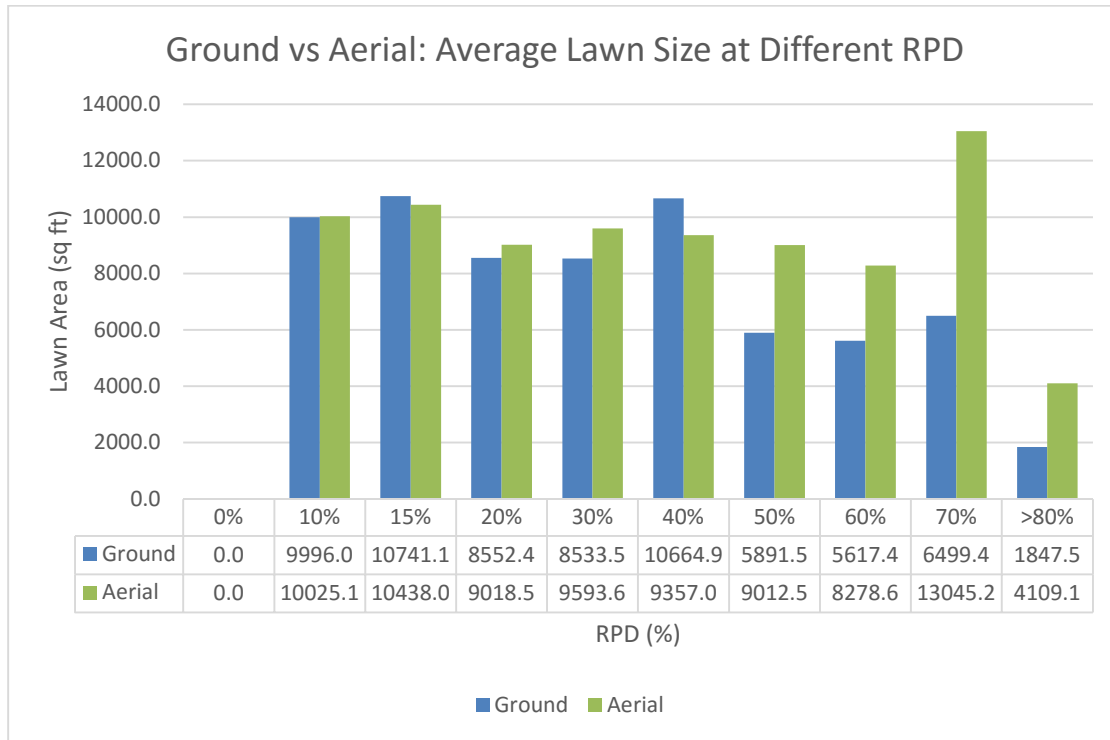


Figure B-2. Representation of the lawn size as the relative percent difference (RPD) increases for the 2015 ground and aerial lawn measurements. As the RPD increases the average lawn size gets smaller, revealing more errors in the ability to accurately determine the area of lawns less than 9,000ft²

3. Lawn Description—lawns were rated 1 through 10, depending on the lawn condition. The lawns were categorized as follows:

| SCALE | LAWN DESCRIPTION KEY | Percentage of Lawns |
|-------|---|---------------------|
| 10 | VERY GREEN MONOCULTURE | 37% |
| 9 | GREEN MONOCULTURE | 10% |
| 8 | VERY GREEN GRASSES | 3% |
| 7 | GREEN GRASSES | 8% |
| 6 | GREEN, SOME BROWN SPOTS GRASSES | 10% |
| 5 | GREEN CAPE COD LAWN | 3% |
| 4 | GREENISH, LOTS OF BROWN GRASS | 2% |
| 3 | CAPE COD LAWN | 15% |
| 2 | PLANTED VEGETATION, MEADOW WOODCHIPS, NOT MAINTAINED, NO | 2% |
| 1 | LAWN | 8% |

- 201 properties were surveyed