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Cafeteria Waste Reduction Programs in Three Southern Maine Elementary Schools: A Waste Audit Analysis

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A Waste Audit Analysis

by Jeremy Ravenelle

Abstract

Solid waste is a serious environmental problem in the modern world. School cafeterias are one source of food and packaging waste that must be dealt with. Reducing the amount of cafeteria waste disposed of as trash through source reduction, recycling, and composting will not only improve environmental outcomes, but will also teach students about sustainability and save schools money. Waste audits at three elementary schools in southern Maine reveal that there are major differences in how effectively waste is sorted and the types and quantity of waste generated per student. Overall waste diversion was measured at 67 percent or greater at all three schools, with an average of 69 percent among the two schools where organics were measured. While there is still work to be done at all three schools, the programs have a major impact even in their current state.

Solid waste is a serious environmental concern in the modern world (Rootes 2009). In the United States, 164 million metric tons of municipal solid waste is deposited in landfills or disposed of via other non-reuse systems such as waste-to-energy every year (UNEP 2016). Another 87 million tons is diverted annually through recycling and composting (UNEP 2016). This implies a solid-waste-generation rate of approximately 4.4 pounds per person per day and a diversion rate of 34 percent.

Schools produce large quantities of solid waste. One major source of waste in schools is cafeterias, where students eat lunch (and often breakfast) daily. Wilkie, Graunke, and Cornejo (2015) measured mean cafeteria waste in three Florida schools in 2012 and found between 50 grams (1.8 ounces) and 137 grams (4.8 ounces) per student per day. This waste includes both packaging or serving materials and uneaten food. Food waste is compostable, and much of the remaining waste is made up of paper, cardboard, plastic, metal, and other recyclable materials (Wilkie, Graunke, and Cornejo 2015). Implementing a system to capture those materials and reduce landfilled waste not only benefits the environment in the form of reduced waste, but also helps teach students environmentally friendly habits and can reduce trash-hauling costs for schools (Evans et al. 2012; Skumatz, BeMent, and D'Souza 2014).

A waste audit sorts the waste generated in a particular facility over a specified period of time. It categorizes and quantifies the waste stream to produce data that can be used for education, program implementation, or program assessment. A 2001 study of all waste generated on the campus of the University of British Columbia assessed materials generated and their quantity across space and time on the campus. This audit led the researchers to conclude that about 70 percent of the easily divertible waste was organic material, and they recommended assessing the feasibility of a composting program (Felder, Petrell, and Duff 2001). A similar audit at University of Northern British Columbia found that 70 percent of total waste could be diverted (Smyth, Fredeen, and Booth 2010). These studies characterize waste at higher education institutions, but there are few published examples in public K–12 schools such as the audits conducted by Wilkie, Graunke, and Cornejo (2015).

This study assesses the existing waste-reduction programs at three public elementary schools in southern Maine using one-day waste audits to analyze the programs as advocated by McKenzie and Smith (1999). It attempts to answer three questions:

- How is waste sorted in each school's cafeteria?
- What waste and how much is being generated in each cafeteria?

- Are there differences between schools in either waste-sorting practices or waste-generation rates?

METHODS

I conducted waste audits at three elementary schools in southern Maine: Falmouth, Longfellow, and Reiche elementary schools (Figure 1). These schools represent urban versus suburban locations and larger versus smaller school districts. They also include a range of socioeconomic conditions and levels of funding (Table 1). These variations mean that the results can both be compared to a wider variety of schools around the country (rural schools are not included in this sample, which makes it a closer match for southern Maine conditions than for the state as a whole). However, readers should carefully consider when differing contexts contribute to how waste-reduction programs function and that some parameters may be overridden by these contextual differences. Considering these limitations, these case studies do allow for a comparison of three programs using a similar method to reduce waste within a relatively small geographic area (Figure 1) and the differences between the schools mean that the study has the potential to show more methods of running waste-reduction programs under different conditions.

In each school, the basic setup is similar: a set of bins placed side by side for trash, recycling, food, and liquid wastes, where students sort their waste after eating. Recyclable waste consists of all paper, rigid plastic, cardboard, glass, and metal material mixed in one bin (see https://www.ecomaine.org/ for more information on recycling in southern Maine). Food waste is organic material including uneaten food and inedible parts like fruit peels and bones. All three programs began between 2012 and 2014, and students were introduced to the program through educational assemblies and demonstrations in the lunchroom.

Study Locations

Falmouth Elementary School is the only public elementary school serving the suburban town of Falmouth, Maine. The school was recently built to LEED standards and is the only school in this study with a dedicated cafeteria space and its own kitchen to prepare lunches. Longfellow and Reiche elementary schools are in the Portland Public Schools system. Longfellow Elementary School is in a more residential area, and Reiche Elementary School is closer to the downtown. Neither school has a dedicated cafeteria, so students eat in the gymnasium at Longfellow and the great room at Reiche. Food is delivered to both schools from a central kitchen in individual packages. See Table 1 for more information on each school.

Waste disposal in Greater Portland, where all three schools are located, is generally accomplished by either municipal or private haulers delivering trash and recyclables to Ecomaine, a regional nonprofit waste-management organization. Trash is burned in a waste-to-energy plant to generate electricity, with the ash landfilled nearby. Single-stream recyclables are sorted in an automated plant and sold in bulk. Ecomaine's website contains promotional materials demonstrating recyclable and nonrecyclable wastes, with the goal of zero contamination (Ecomaine 2017). The recycling plant operates

FIGURE 1: **Locations of Case Study Schools**

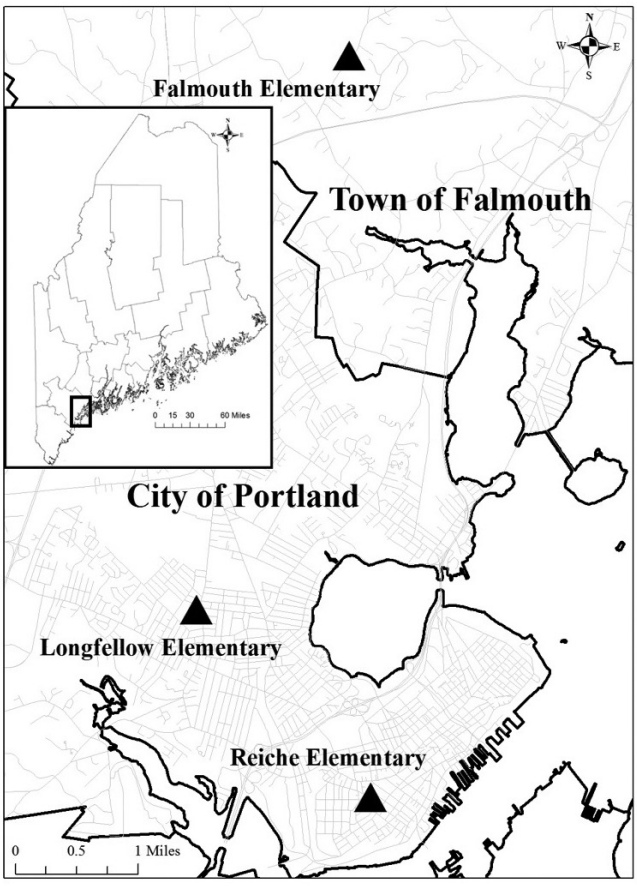


TABLE 1: **Summary of Maine Elementary Schools in Study**

	Falmouth	Longfellow	Reiche
Location	Falmouth	Portland	Portland
Grades	K–5	K–5	Pre-K–5
Number of students at school	925	340	404
Approximate percentage who eat hot lunch	49	26	70
Percentage of students receiving free/reduced price school lunch	7	25	77
District spending per student in 2017	$18,690	$16,580	$16,580
Kitchen on site	Yes	No	No

best with 7 percent or less contamination by volume in incoming recyclable materials. The plant can handle slightly more than that, however, and 15 percent to 23 percent is the industry standard (K. Venhuizen, personal communication). In this analysis, all totals are presented as weight, not volume, so the percentage of contamination is not directly comparable to the 7 percent standard. Ecomaine rejects loads of recycling that are too heavily contaminated, sending them to the waste-to-energy plant (K. Venhuizen, personal communication). Smaller private composting companies that pick up directly from the schools handle the food waste.

Interested school employees and custodians working in the lunchrooms helped organized the audits. Based on the availability of space and collection logistics, I selected grades to audit at each school. I ensured a balance of ages by making sure that for every grade K–2 audited, one grade 3–5 was also audited.

I sorted the waste from the recycling and trash bins into three categories: recyclable (all three schools use single-stream recycling through Ecomaine, and Ecomaine's published recycling list was used to determine recyclable material [Ecomaine 2017]), trash (nonrecyclable and nonfood), and food waste. Any liquid remaining in containers was poured off, and the difference in starting weight and the cumulative weight of the sorted components was assumed to be liquid. All waste was weighed in plastic trash bags to the nearest 0.5 gram and converted to pounds or ounces for reporting purposes. I also separated the two most common items in the recycling bin and the two most common recyclable items in the trash bin and weighed each.

Finally, I weighed the material in the compost bin at Longfellow and Reiche without sorting it due to logistical constraints and cleanliness concerns. Falmouth uses a different compost procedure that includes mixing their liquid waste (milk and juice) with the compost, so it was not possible to remove from the tote and would not have been comparable to the other schools' numbers.

RESULTS

All three schools diverted waste from the regular trash that would otherwise have been burned in Ecomaine's waste–to-energy plant (Table 2). A breakdown of the raw quantities of waste in each bin by school is shown in Table 3.

TABLE 2: **Actual Percentages of Waste Diverted from the Trash Stream, after Accounting for Recycling Contamination**

	Falmouth (%)	Longfellow (%)	Reiche (%)
Reduction in waste not including organics bin	53	35	33
Reduction in waste including organics bin	not measured	67	70

TABLE 3: **Summary of Total Waste Generated by Audited Lunches**

	Falmouth	Longfellow	Reiche
Grades audited	1,2,3,5	k,1,3,4	2,5
Date of audit	Jan. 8, 2018	Jan. 24, 2018	Feb. 6, 2018
Total trash bin in pounds (grams)	8.7 (3956.5)	5.4 (2429.5)	9.2 (4155.0)
Total recycle bin in pounds (grams)	12.4 (5627.0)	20.4 (9250.0)	8.1 (3657.0)
Total food bin in pounds (grams)	not measured	25.0 (11323.5)	22.2 (10086.0)

FIGURE 2: **Percentage of Trash, Recyclable, Food, or Liquid Waste in Each Bin**

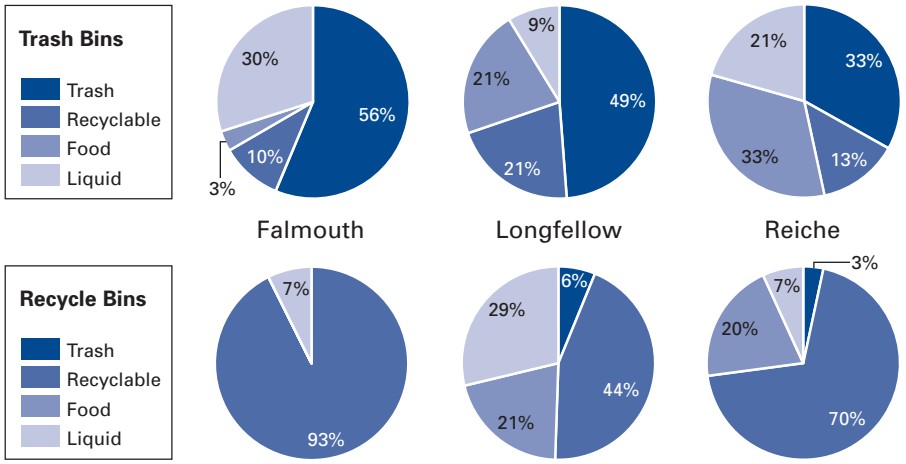
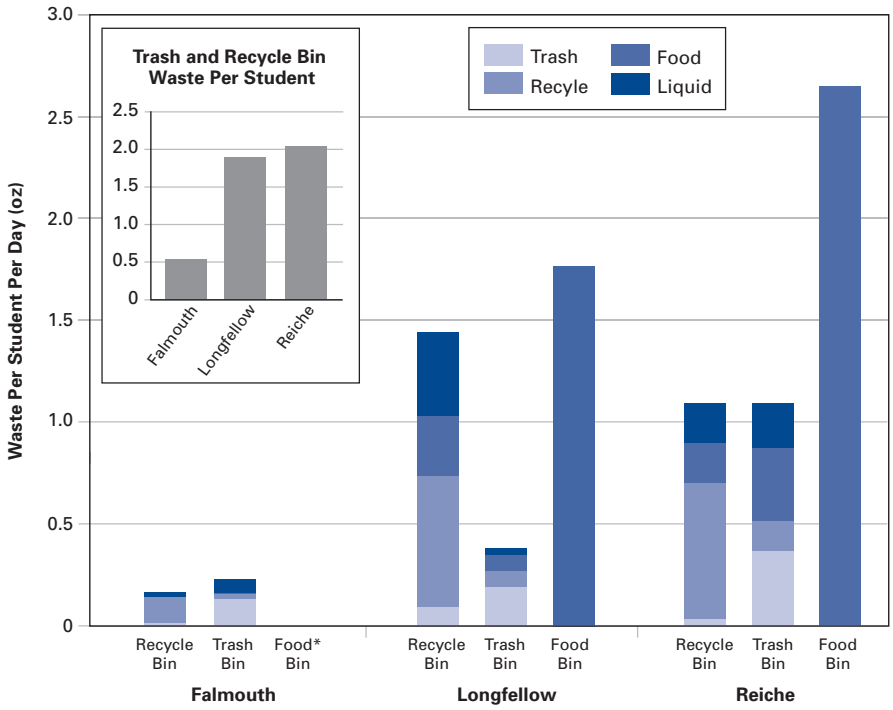


FIGURE 3: **Measured Quantity of Waste by Type in Each Bin in Ounces per Student**



Insert shows total waste per student in the trash and recycle bins only.

*Not measured.

Sorting Accuracy

The quantity of recyclable material compared with nonrecyclable material present in the recycling bins at each school varied widely. The same was true of the trash bins (Figure 2). Overall, Falmouth had the most accurate sorting, with only 10 percent contamination by weight in the recycle bin (and no food in that bin, although some milk) (Figure 2). Falmouth's trash was also the most accurately sorted, with 56 percent of the material in the trash bin actually being trash and 44 percent being recyclable or compostable. Longfellow had the least accurate overall recycling, with 56 percent contamination by weight. Almost one-third of the recycle bin weight (29 percent) was liquid contamination, and another 21 percent was made up of compostable organics. Longfellow's trash was similar to Falmouth's, with 49 percent accurate material and 51 percent recyclable or compostable material. At Reiche, the situation was the reverse of Longfellow, with more accurate recycling (only 30 percent contamination), and a trash bin with trash as only 33 percent of its contents, the rest being recyclable or compostable. Most of the recycling contamination at Reiche (20 percent of the bin weight) was compostable food waste, with relatively less liquid and trash (Figure 3). At both schools where organic waste in the compost bin was measured (Longfellow and Reiche), approximately equal proportions of the total organic waste was captured (82 percent at Longfellow and 83 percent at Reiche).

At Falmouth, the most common recyclable item to be misplaced in the trash was plastic yogurt containers, and the most common correctly placed item in the recycle bin was milk cartons. In fact, no milk cartons were found in the trash at Falmouth. At Longfellow, the recyclable item most frequently placed in the trash was cardboard serving boxes, and the most commonly recycled item was milk cartons. At Reiche the reverse of Longfellow was true, with milk cartons being the most frequently misplaced and serving boxes the most commonly recycled (Table 4).

Waste Generation

Quantities and types of waste generated per student varied widely among the three schools. For this section, all reported quantities are per student unless otherwise specified. Falmouth had by far the lowest total nonfood waste generation (Figure 3 insert). The two other schools have a major source of waste not present at Falmouth in the cardboard serving boxes used to transport the meals. At Longfellow, these accounted for 12 percent of total waste and 14 percent of the recycle bin (Figure 4), while at Reiche they were 21 percent of the total waste and 39 percent of the (less contaminated than Longfellow) recycle bin (Figure 4). Food-waste generation, at the two schools measured, showed wide variation. Longfellow produced 61 grams of food waste across all bins compared to Reiche's 91 grams per student. In both cases, this food waste accounted for over half the total waste produced per student (Table 5).

DISCUSSION

All three schools are sending less waste to be burned in the Ecomaine waste-to-energy plant than they would have sent without the programs. They are moving material up the waste hierarchy and the food recovery hierarchy.[1] By that measure, the programs are successful in improving the environmental outcome. The results indicate, however, that more could be done and that there are major differences between schools.

Overall reductions in trash sent to the waste-to-energy plant (after accounting for contamination, which will presumably be sorted out at the recycling center) was in line with numbers reported in various articles. Block (2000) reported that the Wichita Kansas school district reduced their waste 70 percent, closely matching

TABLE 4: **Items Most Commonly Correctly and Incorrectly Placed in Trash and Recycle Bins (by Weight)**

	Falmouth	Longfellow	Reiche
Most commonly **incorrectly placed** in trash bin	Plastic yogurt cups	Paper serving boxes	Cardboard milk cartons
Most commonly **correctly placed** in recycle bin	Cardboard milk cartons	Cardboard milk cartons	Paper serving boxes

FIGURE 4: **Breakdown of Recyclable Material Produced and Placed in Recycling Bin**

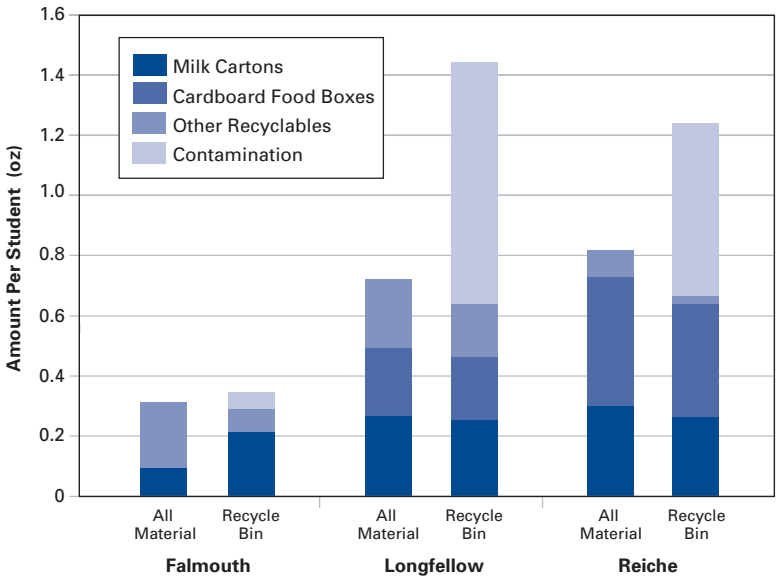


TABLE 5: **Total Waste per Student in Ounces**

	Falmouth	Longfellow	Reiche
Total waste per student not including food (grams)	0.6 (16)	1.8 (52)	2.0 (58)
Total waste per student (grams)	*not measured	4.0 (113)	5.3 (149)

the 67 percent and 70 percent (respectively) achieved by Longfellow and Reiche in this study. While Falmouth's organic waste was not measured, its overall diversion was likely even higher than the other two schools because of a higher rate of nonfood diversion and much smaller amount of food in both the trash and recycling bins. This diversion rate would be in line with reports such as BioCycle (2018), where waste was reduced approximately 80 percent, and Kadleck (2015), where waste was reduced 90 percent.

Sorting

This study's sorting results are based on weight rather than volume, making them not directly comparable to Ecomaine's maximum contamination level for recyclables. However, it is possible to estimate the contamination rate by volume based on the types of material present. The contamination rate at Falmouth almost certainly falls under the threshold of 7 percent by volume since the school had only 10 percent contamination by weight and 7 percent was made up of liquids, which are the densest type of contamination. At Longfellow, since less than half the weight in the recycle bin was recyclable material, it is unlikely the load would meet the 7 percent threshold, given that trash, which likely has similar volume to recycling, makes up 6 percent of the bin before accounting for substantial amounts of food and liquid. This does not necessarily mean Ecomaine rejects Longfellow's recycling, as cafeteria waste is mixed with paper and other recyclables from classrooms and offices. Reiche's cafeteria waste likely also goes above the 7 percent threshold, but may be under the 15 percent to 23 percent operational maximum for contamination depending on the exact density of the food and recycling waste.

Longfellow and Reiche's opposite issues (Longfellow has more contamination in the recycling bin, Reiche has more recyclables in the trash) are not exactly equivalent. Due to the possibility of recyclables being rejected for too much contamination, Reiche's situation with more recyclables in the trash is probably the more desirable of the two scenarios. Considering the quantity of food and liquid waste in the recycling bin at Longfellow, it may be helpful to emphasize that containers need to be empty before they are recycled. If students are going to dispose of all their waste in one bin, it is better for that to be the trash bin, so those who sort accurately can be sure they are contributing to real reductions through recycling.

One factor to consider in the sorting accuracy between Falmouth and the two Portland schools is the variety of materials students are presented with. Falmouth students with school lunch (almost half of students) receive their food directly on a washable tray with metal utensils, meaning they only need to recycle their milk carton and dump any remaining food in the compost bin. By contrast, both Portland schools serve hot lunch in packaging. So Portland students must place the plastic utensils and box lid in the trash, any extra food in the compost, and the box itself, along with the milk carton, in the recycling bin. In my observation, the sorting process took longer in both Portland schools than it did in Falmouth. There is a possibility this packaging and subsequent sorting could decrease in the future as renovation plans at Longfellow tentatively include an on-site kitchen.

Again relating to materials, most material in the recycling bin was hot-lunch related (milk cartons and [in Portland] food boxes). While hot-lunch-related items are the most common material, the relative lack of cold-lunch recyclables being accurately sorted may reflect waste-sorting systems that rely more on individual items like milk cartons rather than students' knowledge of recyclable materials more broadly (e.g., all rigid plastic, paper, cardboard, etc.).

Waste Generation

Considering all waste generated per student, regardless of whether it was sorted correctly, the schools display some interesting similarities and differences. Total quantities of waste generated are similar to those identified by Wilkie, Graunke, and Cornejo (2015), who found mean waste-generation rates from 50 grams (1.8 ounces) to 137 grams (4.8 ounces) per student per day. Reiche's total is slightly higher, while Longfellow's is within the range on the upper end. Food-waste generation at rates similar to Longfellow or Reiche would put Falmouth in the lower to middle of the figures found by Wilkie, Graunke, and Cornejo (2015). Food waste at the two schools measured was, as in that study, the largest source of waste by weight. At Longfellow, food waste fell within the range that Wilkie, Graunke, and Cornejo (2015) found of 47 percent to 58 percent of waste. However, food accounted for an even higher proportion of total waste (61 percent) at Reiche.

There is a major (2.2 ounces [61 grams] vs. 3.2 ounces [91 grams]) difference in food waste per student between Longfellow and Reiche. Note that this was a

one-day study and that more data points are necessary to fully determine if this difference is as large as it appears. A possible contributing factor is that on the day of the audit at Reiche some students were served frozen vegetables that had not been property reheated (they were still frozen), leading many students to throw them away. Another possible explanation for the difference in food waste is that approximately 70 percent of students at Reiche eat school lunch daily compared to only 26 percent at Longfellow. Studies have found that between 20 percent and 50 percent of items served in school lunches may go to waste (Marlette, Templeton, and Panemangalore 2005; Smith and Cunningham-Sabo 2014), which is likely more food than is wasted from lunches brought from home. This would support the notion that the almost three times higher consumption of school lunch at Reiche would increase average food waste per student compared to Longfellow.

Longfellow and Reiche produced around 3.5 times as much nonfood waste per student as Falmouth. As mentioned earlier, this likely has to do with the larger amount of packaging that Portland school meals require and that more liquid was retained in the waste at the Portland schools. Falmouth also uses washable cutlery, compared to the disposable cutlery at the other two schools, which may also be a factor.

An interesting, if inconclusive, comparison between hot and cold lunch at Reiche and Longfellow can be made if one assumes that similar proportions of food are wasted (regardless of which bin it is sorted into) at each school. Solving the difference between total waste generation and proportion of hot-lunch students as a system of equations yields a waste-generation rate of 6.1 ounces (173 grams) per student for hot lunch and 3.2 ounces (91 grams) per student for cold lunch. As noted earlier, this difference could have been affected by the day the data were collected. This comparison implies, however, that the schools could reduce waste at the source by reducing packaging and wasted food in hot lunches. Berry and Acheson (2017) include a variety of ways to reduce food waste in school lunches including allowing students more choice and setting up share tables to avoid wasting unwanted food.

It is also likely that differences in program design and leadership played a role in the results seen in this waste audit. The program at Falmouth was instigated primarily by a teacher at that school who convinced the school board that it was not only the right thing to do but could also save money. In the two Portland schools, although there are champions at each school (vice principal at Longfellow and lunch aid at Reiche), the initial push to begin the program came from a group of parents and administrators at the district level. Additionally, Longfellow has much more signage than the other two schools including photo examples of what goes in each bin. Falmouth has no signs, but does have a lunch aid who stands by the bins and helps students, and Reiche has neither (except lunch aids who occasionally try to monitor when they have time).

Considering that this study is a snapshot in time, its comparisons are not statistically testable. This fact leaves open the possibility of variation due to the specific days chosen, such as the kinds of food served, as well as random variation. Both sorting and waste production may have also been influenced by factors beyond the scope of this study, such as the financial resources available to each school and its students' prior exposure to concepts like recycling and composting. Analyzing schools with similar socioeconomic and surrounding contexts could show more clearly how programs differ independently of those conditions. Future studies could conduct audits on multiple days of the week over a period of time and involving all grade levels. Another limitation of this study is the inability to capture material in Falmouth's compost bin, which could be solved with better study design to avoid mixing food waste from the sample lunches with food from unsampled lunches. It would also benefit the completeness of the results to directly measure the liquid found in all locations, trash, recycling, and the liquids bucket. In this study, trash and recycling liquid was measured only indirectly and the liquid bucket not at all.

The most important takeaway from this waste audit is that all three schools have managed to divert waste that would have otherwise been sent to the waste-to-energy plant, moving their disposal practices up the waste hierarchy. Falmouth is achieving a high rate of sorting accuracy, leaving their options to further improve the program mostly in the realm of source reduction and keeping recyclables and food out of the trash. The two Portland schools both have the possibility to improve sorting in a relatively significant way, but are still diverting well over half their waste. Anything that simplifies the waste stream (such as kitchen facilities that reduce the need for packaging) would likely help improve sorting as well.

More broadly, this study confirms the value of source reduction and suggests that schools can both

drastically reduce waste and improve the efficiency of students' sorting of waste by simplifying the waste stream and eliminating packaging whenever possible. This could connect with efforts already underway in Maine to serve more local and whole foods in school cafeterias. Both that movement and waste reduction would benefit from efforts to support food preparation within individual schools where it is consumed. Repeated education, in the form of adults who reinforce where things go and assist students, also may help although this represents an added cost of having more staff.

This audit confirmed that the sometimes drastic waste-reduction numbers cited in the literature (e.g., BioCycle 2018; Block 2000) can be achieved by schools in Maine using existing programs and that food waste is a huge and divertible portion of the cafeteria waste stream. While sorting may not be perfect, it appears to be enough to result in reductions. The studied programs are already providing environmental benefits and have the potential to continue improving.

ENDNOTES

1 See these US EPA websites for more information on the food recovery hierarchy (https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy) and sustainable materials management (https://www.epa.gov/smm/sustainable-materials-management-non-hazardous-materials-and-waste-management-hierarchy).

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