Reduction strategies for institution N footprints: A case study at the University of Virginia

Elizabeth Milo[1], Elizabeth Castner[1], Lia Cattaneo[1], James N. Galloway[1], Allison M. Leach[2]

[1]University of Virginia, 291 McCormick Rd, Charlottesville, VA, 22904 USA, esm9gq@virginia.edu

[2]University of New Hampshire, 131 Main Street, 107 Nesmith Hall, Durham, NH, 03824 USA

Abstract
Reactive nitrogen (Nr) is both essential and detrimental to life on Earth. While nitrogen is a key component of protein, it is also a pollutant that can cause climate change, eutrophication, and more. The University of Virginia (UVA) is the only university that has approved a nitrogen footprint reduction goal. This goal was approved by UVA's governing board in 2013 and aims to reduce the University's nitrogen footprint by 25% below 2010 levels by 2025. UVA has calculated its footprint for 2010 and 2014 and will continue to complete a benchmark calculation every four years. The UVA N footprint group and the Office for Sustainability have determined a number of scenarios to reduce the University's N footprint. Examples of these include implementing a Meatless Mondays program and composting all food waste at the University. Since the 2010 baseline year, UVA has increased its nitrogen footprint by 1 MT from a total of 404 MT N; the total reduction needs to be to 303 MT N. Though UVA's N footprint increased on a whole, the per capita N footprint decreased due to various measures taken to reduce UVA's N footprint. This paper examines the potential of additional scenarios that could be implemented to reach this goal. UVA hopes to serve as a model for other universities and institutions that want to reduce their environmental impact by setting and achieving N reduction goals.

Key Words
Nitrogen, food production, utilities

Introduction

Nitrogen (N) and carbon (C) are elements that are necessary for life on earth but an abundance of these elements in their reactive form can cause adverse environmental impacts.

Excess C in the atmosphere can cause intensified warming and ocean acidification. Humans contribute to the increase in C emissions in many ways, including burning of fossil fuels and clear cutting of forested systems.

Nitrogen is a key component of proteins, but excess N in the environment can cause detrimental effects such as eutrophication and global warming. Humans' activities enhance the buildup of Nr (all N species other than N_2) on Earth or in the atmosphere through destruction of N-sequestering forests and wetlands, food production and consumption, and fossil fuel burning. Institutions contribute to losses of both C and N on a large scale due to the number of people and resources needed to support them.

The University of Virginia (UVA) developed the institutional N footprint tool and is the first university to set both C and N footprint reduction goals. UVA aims to reduce the institution's N and C footprints by 25% by the year 2025 from the baseline year of 2010 and 2009, respectively. Reaching this goal will take a comprehensive, concerted effort from across the university in energy, transportation, food purchasing, wastewater treatment, and composting. This paper focuses on the strategies working towards reaching the N footprint reduction goal.

Methods

An N footprint measures the Nr released to the environment as a result of an entity's resource consumption. UVA's N footprint in 2010 was 404 MT N. The N footprint is dominated by the energy (electricity, heating, transportation) and food (production, consumption) sectors and also includes the University's research animals and fertilizer use. The University's system bounds include the University labs, residence halls,

dining halls, and research facilities. UVA's N footprint does not include the food portion of the UVA health system but will in the future as more data become available.

UVA's N footprint was calculated again in 2014. A few methodical changes were made between the 2010 and 2014 calculations. In both years, the food orders from one dining hall, one cafe and one coffee shop (i.e., representative facilities) were obtained from UVA's dining department. Then scaling factors were applied to determine the N footprint of all dining halls, cafes and coffee shops. In 2010, the scaling factors were determined based on a combination of Sysco (main provider) and small vendor data and were based on dollar value of the food products. In 2014, the scaling factors were determined on a weight basis and only from the Sysco data because of the ambiguity and incompleteness of most of the small vendor data.

Results

Though UVA's N footprint increased by 1 MT N, some sectors saw N footprint reductions despite population growth. First, in 2011, the municipal wastewater treatment plant that serves UVA updated its technology to improve N removal by conversion to N_2. This reduced the University's N footprint by 13 MT N. This was a major improvement for the University. Second, UVA slightly reduced fertilizer use (1 MT N difference).. Sectors that increased the N footprint were transportation, which contributed an additional 4 MT N above 2010 levels, utilities, which stayed relatively stable from a total of 234 to 235 MT N, and research animals, which increased by 0.5 MT N. The largest sector increase was food production which increased by 11 MT N above 2010 levels. Table 1 shows UVA's N footprint by sector in 2010 and 2014.

Table 1. UVA's N footprint in 2010 and 2014, MT N

	2010	**2014**
Food		
Production	101	112
Consumption	14	1
Utilities		
On-site	38	32
Purchased	197	202
Other		
Transport	30	34
Fertilizer	3	2
Research Animals	21	22
Total	404	405

While this increase of 1 MT N is disappointing, certain sectors did reduce in N footprint despite UVA's population growth. However it is evident additional actions are needed to reach the overall reduction goal of 101 MT N. Potential actions are examined in the following section.

Projections and Scenarios Energy reduction scenarios looked at improvements in the transportation and utilities sectors such as fuel-mix changes. The amount of Nr released from these processes was determined by converting metric tons of C equivalent (MTCDE) into kilograms of NO_x and N_2O (both expressed as N). The food and waste N emission factors were calculated through methods fully described in Leach et al (2013).

UVA's projected growth and development were determined before applying scenarios. Growth included an increase in students, faculty and staff working and living on campus. Projected growth numbers were sourced from UVA's institutional assessment and studies department (Data Digests 2012). The increase in students and faculty requires more building space and food to be provided on campus. Thus, more students and faculty will increase the N footprint if the university operates under a business as usual scenario. The projections included the proposed new buildings and complexes such as new dorm areas and hospital expansions obtained from facilities management and planning commissions at UVA.

From 2010 to 2014 a back-of-house (i.e., before food is served) composting system in dining halls was put in place. Food waste from dining halls and from cafes that is not composted is added to UVA's footprint. Food waste that is composted is not added. To determine the amount of food waste that is collected, the amount of food before and after it is served to students is taken. The amount of back of house compost collected was determined after the meals and this portion of the food served was not counted in the food waste section of the N emissions calculations.

Composting all of the food wasted at locations without back-of-house composting and from dining hall to-go boxes is another step the University could take to reduce its N footprint in the food waste sector.

Discussion

Scenarios to reduce UVA's N footprint include back-of-house composting, composting in locations other than dining halls, and implementing a Meatless Mondays program in dining halls and replacing 25% of the beef served with chicken.

Meat and other animal products have a higher N footprint than most plant-based foods (Leach et al. 2013). Eliminating meat at some meals served on campus would reduce the University's N footprint. Implementing a Meatless Mondays program in dining halls is the suggested way to do this. The Meatless Monday program would involve serving no meat in the three dining halls on campus on day during an average week. The first step in assessing the impact of this change would be to calculate the number of meals served, the number of meals containing meat or animal products, and the amount of meat per serving in a given meal on a given day in the dining halls.

UVA has been successful in implementing a back-of-house composting program. Implementing this is possible because of the support and oversight by dining employees eliminating contamination of the waste stream with non-compostable items. Composting in other locations around campus would not have the same reliability. Successful educational campaigns, increased contamination tolerance (i.e., products in the waste stream that are not compostable), and increased composting infrastructure need to be added in order to fully realize this scenario. Food waste outside of dining halls (e.g., food taken to a person's home) is also harder to track, which may cause problems in measuring how much of the food served at dining locations is compost.

Eliminating or reducing food waste is another way to reduce the overall N footprint. Doing so would require cooperation from dining halls and education of students and other dining hall customers. The dining halls have tried serving smaller portion sizes to reduce food waste, but this does not always achieve its goal. Also, some food, like the salad bar, is self-serve.

Implementation of a Meatless Mondays program is another proposed scenario. Its feasibility depends on student choice and demand for meat options at dining halls. Measures to encourage students to choose a more sustainable diet would need to be put in place in order to create a shift in demand. Backlash from reducing meat-based meals comes from many groups within the University, particularly the athletics department, which often raises concerns about athletes not receiving the proper amount of protein for their training. Meatless Mondays is a starting point in discovering ways to reduce the amount of meat served in dining halls. Other scenarios more appealing to students and staff may be to start on a smaller scale just serving more vegetarian meals in dining halls or serving meat-free meals for one meal each day.

UVA is working towards reducing the institution's C footprint by 25% within the same time frame as the N footprint reduction. The planned C footprint reduction strategies involve cutting the utilities usage of the University as well as improving the energy efficiency of old and new buildings. Since the C and N footprints have overlap in the utilities sector, reaching the 25% C footprint reduction goal would significantly enhance the potential for success in reaching the N footprint reduction goal.

The calculation below was completed using the N-print institution calculator and predict the N footprint of UVA for each of the scenarios suggested above as well as a business as usual scenario suggesting the N

footprint of UVA if no scenarios were implemented. Food scenarios include composting all food waste, switching of beef purchases with chicken, implementing a Meatless Monday's program.

Figure 1 shows the effect of implementing each of these scenarios suggested above and a business as usual scenario. These projections include growth and expansion that had been planned in 2010. The scenarios modeled project N losses to the environment in 2025.

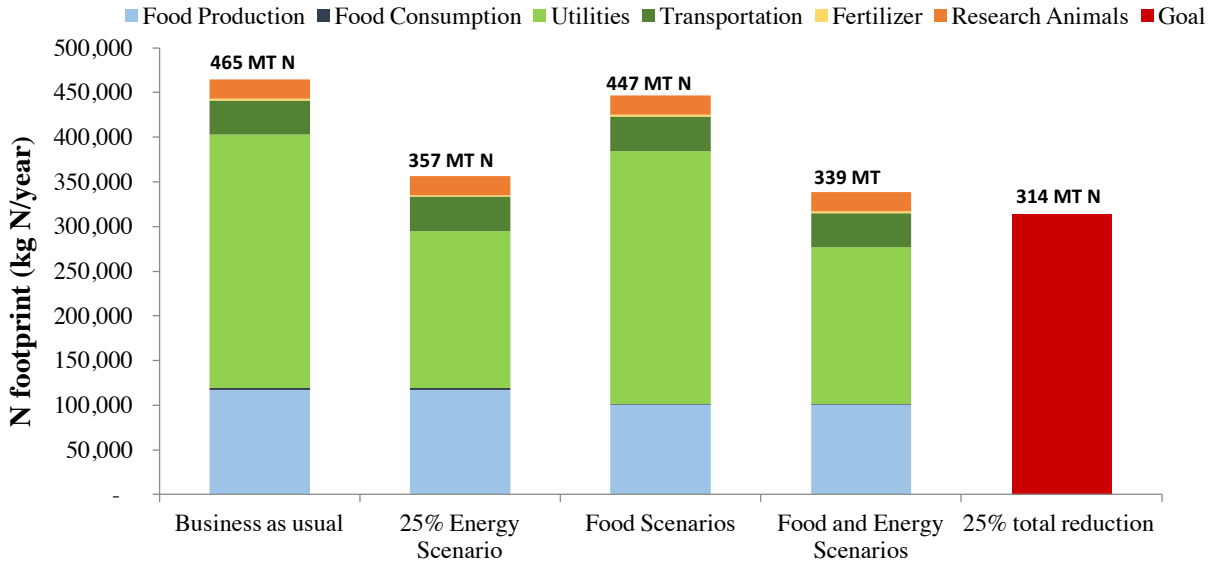

Figure 1: Reductions in the metric tons of nitrogen with scenarios implemented. Projections represent different levels of scenarios implemented along with the 25% reduction goal.

Conclusion

Between 2010 and 2014, UVA increased its N footprint by 1 MT N. Scenarios were developed to help meet the N footprint reduction goal of 25% below 2010 levels by 2025, including composting food waste independent of dining halls, implementing a Meatless Mondays program, changing the utilities fuel mix, and reducing the number of commuters. Implementing all of the proposed scenarios would effectively reduce the nitrogen footprint by 66 MT N (17%). Since the overall goal is a reduction of 101 Tg N (25%), additional options such as offsets are being explored.

UVA is used as a case study on how an institution can set goals and work to reduce its impact on the environment. Increasing institutions' awareness about their environmental impact is an essential first step in moving towards a more sustainable world. Not only has UVA become aware of its environmental impact, but it has also taken steps to reduce this impact through implementation and consideration of each of the suggested scenarios. Other institutions can use these scenarios and determine the most effective and feasible options for reducing their own N footprint.

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