

*UNDERSTANDING UW  
UNDERGRADUATE FOOD  
INSECURITY WITH AN  
ECONOMIC MODEL*

Honors College Senior Capstone

*Javaun Garcia*

*University of Wyoming | Honors College*

## **Abstract**

University efforts to address food insecurity have increased over the past few years. The University of Wyoming has followed this national trend after a survey identified that over one third of undergraduate students are food insecure by establishing the UW Food Security Taskforce. In collaboration with multiple stakeholders across campus, the taskforce has outlined specific strategies to help alleviate food insecurity issues. To assist in these efforts, I created an economic model to understand how the underpinnings of students' financial resources impact their potential to experience financial and food insecurity. The model provides a baseline for the taskforce to identify student populations for targeting with specific strategies and a structure for determining the costs and benefits of each strategy. The model finds that the taskforce should focus on non-need students and out-of-state students as the targeted populations for strategy implementation because they are the highest at risk. Continued work associated with the model can create specific impact reports for the proposed strategies and help to make the most effective development plans.

## INTRODUCTION

According to the 2017 “Study on Collegiate Financial Wellness, University of Wyoming: Food Security on Campus” survey, 37.4% of University of Wyoming (UW) undergraduate students experience food insecurity. Half of these students (18.7%) worry about food shortages, while the other half (18.7%) skip or reduce their meal intake due to lack of available financial or food resources.<sup>1</sup>

Food security, according to the United States Department of Agriculture (USDA), can be categorized into four different ranges: high, marginal, low, and very low. The USDA defines low food security as, “reports of reduced quality, variety, or desirability of diet (with) little or no indication of reduced food intake” and very low food security as, “reports of multiple indications of disrupted eating patterns and reduced food intake.”<sup>2</sup> Considering these definitions and the statistics mentioned previously, more than one third of UW undergraduate students experience food insecurity.<sup>3</sup>

Following the results of the survey and several years of student-led food security efforts, UW students, faculty, and staff formed the UW Food Security Taskforce to address the problem of food insecurity on campus. Students who experience food insecurity are more likely to suffer

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<sup>1</sup> The Ohio State University Office of Student Life. (2017). Study on Collegiate Financial Wellness, University of Wyoming: Food Security on Campus. *College of Education and Human Ecology*, p. 2. <https://cssl.osu.edu/posts/632320bc-704d-4eef-8bcb-87c83019f2e9/documents/2017-scfw-national-descriptive-report.pdf>.

<sup>2</sup> United States Department of Agriculture. (2020, September 9). *Definitions of Food Insecurity*. Economic Research Service. <https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/definitions-of-food-security.aspx>

<sup>3</sup> ASUW Student Food (In)Security Taskforce. (2020, May 13). *University of Wyoming Student Food (In)Security Updates and Recommendations*. [Lecture Notes, PowerPoint slides]. Google Slides. <https://docs.google.com/presentation/d/1hGYMbSRXej0PszBwcdF0LYicYBNTaAL3/edit#slide=id.p1>

from anxiety and depression,<sup>4</sup> poorer physical health,<sup>5</sup> lower GPAs,<sup>6</sup> higher drop-out rates,<sup>7</sup> and housing insecurity and homelessness, impacting every aspect of their student life.<sup>8</sup> To help alleviate these implications, the University of Wyoming, through the taskforce, prioritized finding solutions that address food insecurity. In doing so, the university is further committing to its goal of “promot[ing] opportunities for personal health and growth, physical health, athletic competition and leadership development for all members of the university community.”<sup>9</sup> The taskforce has outlined potential strategies for combatting food insecurity and is guiding efforts to implement them campus-wide.<sup>10</sup> These strategies include: meal sharing through dining, good food recovery and sharing, a campus grocery store, a central food cabinet or pantry, and growing food on campus.

Additionally, the taskforce aims to consider and address underlying factors contributing to student food and financial insecurity and systemic barriers that different groups of students may experience. The taskforce created a mission statement that addresses food security while “support[ing] strategies that ultimately aim to end staff food and financial insecurity and related

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<sup>4</sup> Arria, M., Caldeira, K., Payne-Sturges, D., Tjaden, A. & Vincent, K. (2017). Student Hunger on Campus: Food Insecurity Among College Students and Implications for Academic Institutions. *American Journal of Health Promotion*. <https://doi.org/10.1177%2F0890117117719620>

<sup>5</sup> Arria, M., Caldeira, K., Payne-Sturges, D., Tjaden, A. & Vincent, K. (2017). Student Hunger on Campus: Food Insecurity Among College Students and Implications for Academic Institutions. *American Journal of Health Promotion*. <https://doi.org/10.1177%2F0890117117719620>

<sup>6</sup> Linck, H., Maroto, M., & Snelling, A. (2014). Food Insecurity Among Community College Students: Prevalence and Association with Grade Point Average. *Community College Journal of Research and Practice*, 39(6), 515-526. <https://doi.org/10.1080/10668926.2013.850758>

<sup>7</sup> Cady, C., Dubick, J., & Mathews, B. (2016). *Hunger on Campus The Challenge of Food Insecurity for College Students*. Students Against Hunger. [https://studentsagainsthunger.org/wp-content/uploads/2016/10/Hunger\\_On\\_Campus.pdf](https://studentsagainsthunger.org/wp-content/uploads/2016/10/Hunger_On_Campus.pdf)

<sup>8</sup> Silva, M. et al. (2015). The Relationship Between Food Security, Housing Stability, and School Performance Among College Students in an Urban University. *Journal of College Student Retention Research Theory and Practice*, 19(3). <https://doi.org/10.1177%2F1521025115621918>.

<sup>9</sup> University of Wyoming. (2017). *BREAKING THROUGH: 2017-2022 A Strategic Plan for the University of Wyoming*. [http://www.uwyo.edu/strategic-plan/\\_files/docs/strategic-plan-booklet.pdf](http://www.uwyo.edu/strategic-plan/_files/docs/strategic-plan-booklet.pdf)

<sup>10</sup> *Solution Options for Ending Student Food Insecurity at the University of Wyoming*. (2020, February). Solutions Food Insecurity at UW Feb 2020. Retrieved November 20, 2020. <https://docs.google.com/document/d/13wjz2TBahws8gbQpaJKoG12t0Whdj6MW/edit#heading=h.gjdgxs>

challenges within our broader community. In this way... ensur[ing] that *every* Poke is nourished.”<sup>11</sup> Moving forward, the taskforce aims to not only eliminate food insecurity but create a framework that values equity, justice, and dignity. All of these elements, in one form or another, aim to provide a platform to the populations affected, allowing them to design, implement, and oversee their own processes. The aforementioned elements are woven into the fabric of the taskforce’s value statements, giving special respect to a sharing ethos in which student and constituent voices are heard and amplified toward food justice.<sup>12</sup> Food justice is “the struggle against racism, exploitation, and oppression taking place within the food system that addresses inequality’s root causes both within and beyond the food chain”<sup>13</sup> Pursuing this concept within the taskforce framework allows for viewing food insecurity holistically and implementing strategies that address multiple contributing factors to food insecurity, rather than just one element.

The strategies proposed by the taskforce aim to positively impact student populations and reduce high rates of food insecurity. With a focus on justice and student voice, relationships with prominent student entities are essential to the success of food security-related programming. The taskforce was formed through a partnership with the Associated Students of the University of Wyoming (ASUW), the university student governing body, and the Sustainability coalition, an ASUW strategic partner. ASUW Resolution #2670 was passed in September 2019 and it formally acknowledged ASUW’s investment in the issue of food (in)security.<sup>14</sup> Since then, the

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<sup>11</sup> University of Wyoming Food Security Taskforce. (2020). *The UW Food Security Taskforce Guidelines & Functions*. [https://docs.google.com/document/d/167XKCTcmmQXc6\\_d4D1V\\_JHsrXBc3-VxYjPiTVPfb-8M/edit](https://docs.google.com/document/d/167XKCTcmmQXc6_d4D1V_JHsrXBc3-VxYjPiTVPfb-8M/edit)

<sup>12</sup> University of Wyoming Food Security Taskforce. (2020). *The UW Food Security Taskforce Guidelines & Functions*. [https://docs.google.com/document/d/167XKCTcmmQXc6\\_d4D1V\\_JHsrXBc3-VxYjPiTVPfb-8M/edit](https://docs.google.com/document/d/167XKCTcmmQXc6_d4D1V_JHsrXBc3-VxYjPiTVPfb-8M/edit)

<sup>13</sup> Hislop, R. M. (2014). *Reaping Equity: A Survey of Food Justice Organizations in the U.S.A.* (Publication No: 1590830) [Master’s Thesis, University of California, Davis]. ProQuest Dissertations.

<sup>14</sup> Director Savage. (2020, September 24). *ASUW Support for Action on Food Insecurity*. Senate Resolution #2670. [https://www.uwyo.edu/asuw/about-us/legislative-branch/senate/legislation/\\_bills-need-reorganized-later/sr-2670-final1.pdf](https://www.uwyo.edu/asuw/about-us/legislative-branch/senate/legislation/_bills-need-reorganized-later/sr-2670-final1.pdf)

108th ASUW administration has identified food security as the #1 Student Success Priority, enabling the allocation of student fee dollars and other funding to support food security agenda items. Members of ASUW and the Sustainability Coalition co-lead the taskforce, along with other student members, faculty, staff, and administrative stakeholders at UW. This student-led but collaborative structure ensures that a multitude of different perspectives, primarily student perspectives, are given authority and a degree of self-determination. Additionally, the Sustainability Coalition offered the Zero Waste & Food Recovery and Food Security and Sharing paid internship positions, which dedicated two students to help the taskforce move forward with food (in)security initiatives.

Given the taskforce's emphasis on accessibility and providing a platform for student voices, as a student at UW, I wanted to contribute an economic lens to help the taskforce understand the underlying factors that contribute to student food and financial insecurity. To assist the taskforce, I created an economic model to better understand what economic tradeoffs drive student food insecurity. The model could, if properly calibrated, provide a sense of how much daily assistance different groups of students would need (if any) to reach food security. While this model focuses on financial resource variability, it is not, however, the only indicator used to determine food security levels. There are four dimensions of food security: economic and physical access (i.e., financial resources), individual nutritional and cultural needs, "stability" of food security over time, and food supply.<sup>15</sup> Considering that the United States has a surplus of food supply, the other three dimensions are the aspects that are deemed to lead to national food security.<sup>16</sup> However, the financial strife associated with university attendance, in

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<sup>15</sup> EC – FAO Food Security Programme. (2008). *An Introduction to the Basic Concepts of Food Security*. Food Security Information for Action Practical Guides. <http://www.fao.org/3/a-al936e.pdf>

<sup>16</sup> Chow, C.C., Dore, M., Guo, J., & Hall, K.D. (2009). The Progressive Increase of Food Waste in America and Its Environmental Impact. *PLoS ONE*, 4(11). <https://doi.org/10.1371/journal.pone.0007940>

particular, should not be understated; as the cost of higher education and associated costs of living continue to rise, there is an ever-increasing financial burden placed on students while they are attending school.<sup>17</sup> The University of Wyoming and the Laramie community try to alleviate some of these burdens by offering different transportation services, multiple grocery store options, and different food resources, but, as the current rates of food insecurity suggest, these services may not be sufficient. Therefore, for simplicity, the singular dimension of food insecurity in this model is economic access. This focus allows the model to consider UW undergraduate students in an “isolated” realm of UW, disconnecting it from the broader Laramie community by considering only university data and students that are solely reliant on university services. In other words, for simplicity and based on limited data availability, the model only considers UW students, UW data, and national averages and not the availability of broader Laramie services/options (which, in reality, individual students may additionally access). This approach offers the opportunity to understand food (in)security from a localized, UW community perspective and is shown in the following model, analysis, application of comparative statics, numerical model, variable application, graphical modeling, and conclusion.

## **THE MODEL**

The model consists of two different periods, the first period representing the time during undergraduate studies (estimated at four years) and the second period representing the time post-graduation. For the sake of the model, I assume that the student works during both periods, took

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<sup>17</sup> Maldonado, C. (2018, July 24). Price Of College Increasing Almost 8 Times Faster Than Wages. *Forbes*. <https://www.forbes.com/sites/camilomaldonado/2018/07/24/price-of-college-increasing-almost-8-times-faster-than-wages/?sh=4f9787766c1d>

out a loan to help pay for school, and consume only food and other goods. Those assumptions are clarified by the budget, consumption, and time allocation equations, for both periods, respectively.

The budget equations for each period are

$$Y_1 = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1 + c$$

and

$$Y_2 = \bar{p}f_2 + \underline{p}(2250 - f_2) + (1 + r)L + o_2 + c,$$

where  $Y_1$  and  $Y_2$  are the student's income during each period,  $\bar{p}$  and  $\underline{p}$  are the price per calorie of food (energy dense and empty calories respectively),  $f_1$  and  $f_2$  are the total amount of calories consumed in each period,  $o_1$  and  $o_2$  are the amounts spent on all other goods in each period,  $r$  is the interest rate on the loan amount,  $L$ , that has to be paid back, and  $c$  is the amount of rent and utilities that are associated with living expenses.

The income equations for each period are

$$Y_1 = wt + L + A,$$

and

$$Y_2 = WT,$$

where,  $w$  is the wage the student makes per hour during undergraduate studies,  $W$  is the wage the student makes in their post-graduate career,  $t$  is the time spent working in period 1,  $T$  represents their waking hours (after already having subtracted time spent on leisure activities), and  $A$  is the amount of aid the student receives through scholarships, grants, or other financial aid packages.



The student divides their time in period 1 using the time allocation equation,

$$T = s + t.$$

The equation that describes how time spent studying in period 1 relates to wages in period 2 is shown by the function

$$W = W(s),$$

where  $s$  is the time the student spends studying. This is important to consider since students dedicate more or less time to school, work, and life, depending on their prioritization of those matters and whether there are inhibiting factors that impact their time allocation for such activities. Based on the article “Field of Study in College and Lifetime Earnings in the United States,” the model assumes that students who spend more time studying during period 1 will have increased wages in the future.<sup>18</sup> Since these students are able to commit more time to school-related work, the model assumes they may be more likely to reap the benefits of that investment in the future. In period 2, students are assumed to be salaried employees and no longer have to consider “studying” time.

This model also analyzes the effect that food consumption will have on the overall utility,  $U$ , of the students. This assumes a student wants to maximize the benefit they get from all of their choices. To determine the overall utility-maximizing food consumption, the model must also determine the utility from food consumption during the respective periods. The functions representing this utility are

$$u(f_1),$$

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<sup>18</sup> Kim, C., Tamborini, C. R., & Sakamoto, A. (2015). Field of Study in College and Lifetime Earnings in the United States. *Sociology of education*, 88(4), 320–339. <https://doi.org/10.1177/0038040715602132>

and

$$u(f_2).$$

The student's overall utility function is

$$U = u(f_1) + o_1 + \delta[u(f_2) + o_2]. \quad (1)$$

Within the overall utility equation,  $o_1$  and  $o_2$  as the cost of other goods, represent the assumption that \$1.00 of expenditure on other goods will alter yields on the unit of utility. From the student's perspective, their  $f_1$ ,  $f_2$ ,  $o_1$ ,  $o_2$ ,  $Y_1$ ,  $Y_2$ ,  $W$ ,  $t$ , and  $s$  variables depends on their choices, implying that they are endogenous.<sup>19</sup> However,  $w$ ,  $\delta$  (the factor by which a student discounts her future utility),  $r$ ,  $L$ ,  $A$ , and  $c$ , are treated as given by the student, implying these are exogenous variables.

## ANALYSIS

The student's optimization problem is

$$\max_{f_1, f_2, o_1, o_2, Y_1, Y_2, t, s, W} U = u(f_1) + o_1 + \delta[u(f_2) + o_2], \quad (2)$$

with maximized optimization referring to the highest level of food and financial security given the level of food consumption. This problem is

subject to constraints

$$Y_1 = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1 + c \quad (3)$$

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<sup>19</sup> Kenton, W. (2020, October 30). Endogenous Variable. *Investopedia*.  
<https://www.investopedia.com/terms/e/endogenous-variable.asp>

$$Y_1 = wt + L + A, \quad (4)$$

$$T = s + t, \quad (5)$$

$$W = W(s), \quad (6)$$

$$Y_2 = \bar{p}f_2 + \underline{p}(2250 - f_2) + (1 + r)L + o_2 + c, \quad (7)$$

and

$$Y_2 = WT. \quad (8)$$

To simplify the optimization problem, all of the constraints are solved for and consolidated into the reduced optimization problem. (See Appendix A for full optimization problem reduction steps.) This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, t} U = & u(f_1) + (wt + L + A - (\bar{p} - \underline{p})f_1 - \underline{p}2250 + c) + \\ & \delta [(f_2) + W(T - t) - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L + c], \end{aligned}$$

which is now unconstrained.

Analysis of the optimization problem consolidated the utility function and the given constraint equations into one equation. This step is crucial for further development of my model, because it allows the model to isolate food consumption and time allocation as the only constraining variables. Therefore, once these variables are given associated values that can fit within the optimization problem, it becomes solvable.

**Period One:**

The optimal  $f_1$  is where the objective function “maxes out,” at which point its derivative w.r.t.  $f_1$  will be zero. Therefore, the first-order optimality condition that implicitly defines the student’s utility-maximizing food-consumption level of consumption,  $f_1^*$ , is

$$\frac{\partial U}{\partial f_1} = u'(f_1) - p = 0.$$

In words, this equation says that the optimal quantity of food consumption will be such that the marginal utility  $u'(f_1)$ —the utility the consumer gets from the last unit of food consumed—is just offset by the marginal cost—the opportunity cost of that additional food, which comes from having to give up  $p$  units of other goods, each of which costs 1 dollar and would have generated one unit of pleasure. The student’s problem of choosing  $f_2$  optimally in the second period is identical to that of the first.

Therefore,

$$f_1^* = f_2^* = \bar{f},$$

shows that the student will choose the same optimal level of calories in both periods.

**Time:**

The optimal  $t$  is where the objective function “maxes out,” at which point its derivative w.r.t.  $t$  will be zero. Therefore, the first-order optimality condition that implicitly defines the student’s utility-maximizing time spent working,  $t$ , is

$$\frac{\partial U}{\partial t} = w - \delta W'(T - t)T = 0.$$

In words, the more hours the student spends studying during undergraduate studies, the higher their future wage will be. The optimal amount of time will equate the marginal benefit of spending another hour working to the marginal cost.

## APPLICATION OF COMPARATIVE STATICS

To determine how to maximize utility of food consumption during the first period, the model uses the equation

$$u'(f_1) - p = 0.$$

We can treat this condition as implicitly defining  $f_1$  as a function of  $p$ , and can write it as

$$F(f_1, p) = u'(f_1) - p = 0.$$

The Implicit Function Theorem is then used to calculate

$$\frac{\partial f_1}{\partial p} = -\frac{\frac{\partial F}{\partial p}}{\frac{\partial F}{\partial f_1}} = \frac{-1}{u''(f_1)} < 0.$$

This derivative equation says that the student will optimally cut back on food consumption if the price of food goes up.

Similar to the first model, the second period uses the same equation to determine how to maximize utility of food consumption during the second period,  $f_2$ .

## NUMERICAL MODEL

To implement the mathematical model numerically, several different forms are created for the different functions within the optimization problem. The following forms are used:

$$u(f_1) = \alpha\sqrt{f_1},$$

$$W(s) = \underline{W} + (\overline{W} - \underline{W}) \left[ 1 - \left( 1 - \left( \frac{s}{T} \right) \right)^\gamma \right].$$

Using these specific functional forms, the numerical model is developed, and all relevant variables are accounted for. (See Appendix B for full numerical model reduction steps.)

## VARIABLE APPLICATION

To analyze the data, the given parameters in the equations above, ( $w$ ,  $T$ ,  $\gamma$ ,  $\delta$ ,  $\overline{W}$ ,  $\underline{W}$ ,  $\alpha$ ,  $\tilde{p}$ , and  $L$ ) had to be calibrated.

The price per calorie of food was calibrated from data from the USDA Food and Nutrient Database for Dietary Studies and the Center for Nutrition Policy and Promotion (see Appendix C)<sup>20</sup> and the Office of Disease Prevention and Health Promotion (see Appendix D).<sup>21</sup> Given that the optimal 2250 calories per day is 1.125% of the Office of Disease Prevention and Health Promotion's recommended intake of 2,000 calories per person, the food groups were altered

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<sup>20</sup> United States Department of Agriculture and Center for Nutrition Policy and Promotion. (2008). *Development of the CNPP prices database*. <http://www.cnpp.usda.gov/Publications/FoodPlans/MiscPubs/PricesDatabaseReport.pdf>

<sup>21</sup> U.S. Department of Health and Human Services and U.S. Department of Agriculture. (2015). *2015-2020 Dietary Guidelines for Americans*. 8<sup>th</sup> edition, p. 18, Table 1-1. <http://health.gov/dietaryguidelines/2015/guidelines/>.

accordingly. They were further adjusted by the general grams to cup conversion or the grams to ounces conversion, which are 201.6 g per cup and 28.3495 g. per oz.<sup>22</sup> Therefore, the daily values for the specific food groups were:

- Vegetables: Given the standard 2 ½ c. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 2.8125 c. of vegetables per day. With the c. to g. conversion, the person should be consuming 567 g. of vegetables a day. Using the \$0.33 price/100-g. reference, the cost of vegetables per day for an individual is \$1.87.
- Fruits: Given the standard 2 c. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 2.25 c. of fruits per day. With the c. to g. conversion, the person should be consuming 453.6 g. of fruits a day. Using the \$0.28 price/100-g. reference, the cost of fruits per day for an individual is \$1.27.
- Grains: Given the standard 6 c. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 6.75 c. of grains per day. With the c. to g. conversion, the person should be consuming 1,360.8 g. of grains a day. Using the \$0.47 price/100-g. reference, the cost of grains per day for an individual is \$6.40.
- Dairy: Given the standard 3 c. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 3.375 c. of dairy products per day. With the c. to g. conversion, the person should be consuming

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<sup>22</sup> Food and Agriculture Organization. (2012). *FAO/INFOODS Guidelines for Converting Units, Denominators and Expressions. version 1.0.* FAO. <http://www.fao.org/3/i3089e/i3089e.pdf>

680.4 g. of dairy products a day. Using the \$0.26 price/100-g. reference, the cost of dairy products per day for an individual is \$1.77.

- Protein Foods: There is a standard for 5 ½ oz. of protein products a day. This is divided into meat products and nuts, seeds, soy products.
  - Meat Products: Considering that it is recommended that you consume 34 oz. of meat products a week, that means that a person should eat approximately 4.86 oz. of meat a day. Given the standard 4.86 oz. of meat products per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 5.4675 oz. of meat products per day. Using the conversion of 1 oz. = 28.3495 g., an individual should consume 155 g. of meat products a day. Using the \$0.80 price/100-g. reference, the cost of meat products per day for an individual is \$1.24.
  - Nut Products: Considering that it is recommended that you consume 5 oz. of nut products a week, that means that a person should eat approximately 0.71 oz. of nuts a day. Given the standard 0.71 oz. of nut products per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 0.79875 oz. of nut products per day. Using the conversion of 1 oz. = 28.3495 g., an individual should consume 22.64 g. of nut products a day. Using the \$0.50 price/100-g. reference, the cost of nut products per day for an individual is \$0.11.
- Oils: Given the standard 27 g. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 30.375 g. of



oils per day. Using the \$0.37 price/100-g. reference, the cost of dairy products per day for an individual is \$0.11.

- Other Uses: Given the standard 270 kcal. per day for a person with a 2,000-calorie intake, after adjusting to a 2,250 daily calorie intake, the person should be consuming 303.75 kcal. of other uses per day. Using the \$0.22 price/100-kcal. reference, the cost of other uses per day for an individual is \$0.67.

Therefore, to meet basic nutritional needs an individual must spend \$13.44 daily or (\$13.44/2250), \$0.0060 per calorie.

After finding the price per calorie of food and the daily cost of food for a food-secure person, the  $a$  value can be found. Given the optimal daily food intake is 2250 and the  $\tilde{p}$  value is \$0.0060, the foft equation

$$\frac{a^2}{4} \cdot \tilde{p}^{-2} = f_1^*,$$

can look like:

$$\frac{a^2}{4} \cdot (0.0060^{-2}) = 2250.$$

To find  $a$ , multiply the 4 over to the  $f_1^*$  value and simultaneously find the value for  $\frac{1}{0.006^2}$ ,

giving

$$a^2 \cdot 28000 = 9000.$$

Then, dividing 9000 by 2800, it gives you

$$a^2 = 0.321.$$

After taking the square root of both sides, the value of  $a$  is given,

$$a = 0.5667.$$

To find the  $U^*$ ,

$$a * (\sqrt{fopt}) + oopt = U^*,$$

the  $o_1^*$  function,

$$(w * topt) + L - (p * fopt) = o_1^*,$$

needs to be defined first. In doing so, the  $t^*$  function,

$$\left( \frac{w}{\delta(\overline{W} - \underline{W}) \cdot \gamma} \right)^{\frac{1}{\gamma-1}} \cdot T = t^*,$$

has to be defined. Considering the variables that are undefined in the topt function are  $w$ ,  $T$ ,  $\gamma$ ,  $\delta$ ,  $\overline{W}$ ,  $\underline{W}$ , they all need to be given values before proceeding.

For the  $w$  variable, wages earned during period 1, it was assumed that the student will earn \$7.25/hr., since that is the federal minimum wage and the pay for most entry-level jobs in Laramie.<sup>23</sup> The following assumptions were made about students to represent a wide range of work/school commitments:

- Case #1: A student who works and puts a comparatively high level of time into school
  - Work - a student who uses work as a means for extra income but is not solely reliant on it for financial security. That student works part time (an average of 20 hrs. per week).
    - Weekly: \$145
    - Daily: \$20.71
- Case #2: A student who does not need to work
  - Work - a student who has other sources of income (e.g., scholarships, parents' income, etc.) and does not need to work for financial security. The student works 0 hrs. per week.

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<sup>23</sup> United States Department of Labor. (n.d.). *Minimum Wage*. U.S. Department of Labor. <https://www.dol.gov/general/topic/wages/minimumwage>

Weekly: \$0  
Daily: \$0

- Case #3: A student who must work
  - Work - a student who works as their main means of financial security. This means the student is independent and pays for all of their expenses. The student needs to work full time (an average of 40 hrs. per week).

Weekly: \$290  
Daily: \$41.43

Based on the previous assumptions, adding all of the daily calculations and dividing them by three (the number of cases), the student will make an average daily  $w$  of \$20.71.

For the  $T$  variable, it was assumed that students on average take 12-15 credit-hours per semester. Given that most students take 3-credit classes, according to UW scheduling patterns, they typically spend 2.5 hrs. in each class per week. According to the Liberal Education periodical, students only spend one hour on homework for every hour they have class, but this can fluctuate depending on the student's school/work/life balance.<sup>24</sup> To consider all variations of students' school/work/life balance, measured by  $s/t$  (the amount of time spent studying or working), the following cases were considered,

- Case #1: A student who works and commits the average amount of time for in and outside classroom-related activities
  - Work – This is a student who uses work as a means for extra income but is not solely reliant on it for financial security. That student works part time (an average of 20 hrs. per week).

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<sup>24</sup> McCormick, A. (2011). It's about Time: What to Make of Reported Declines in How Much College Students Study. *Liberal Education*, 97(1). <https://www.aacu.org/publications-research/periodicals/its-about-time-what-make-reported-declines-how-much-college>

- School - Given that this student does not have to be solely committed to work, the student is likely to take the average 15 credit hours per semester. Considering the student commits the average amount of time to classroom-related activities, they will spend 1 hr. studying for every credit hour.

Weekly s/t hrs.: 35

- Case #2: A student who works and commits an above average amount of time for in and outside classroom-related activities
  - Work – This is a student who uses work as a means for extra income but is not solely reliant on it for financial security. That student works part time (an average of 20 hrs. per week).
  - School - Given that this student does not have to be committed to solely work, the student probably will take 15+ credit hours per semester. Considering the outside work needs to be done and the student's ability to commit time to school, this case assumes the student will spend 2 hrs. studying for every credit hour.

Weekly s/t hrs.: 50

- Case #3: A student who works and commits a below average amount of time for in and outside classroom-related activities
  - Work – This is a student who uses work as a means for extra income but is not solely reliant on it for financial security. That student works part time (an average of 20 hrs. per week).
  - School - This student is not able to commit as much time to school and therefore will probably take the minimum number of classes (12 credit hours) to be considered

a full-time student. Considering the student's ability to commit time to school and the work that needs to be done, the student will contribute 0 hrs. per week.

Weekly s/t hrs.: 20

- Case #4: A student who does not need to work and commits the average amount of time for in and outside classroom-related activities
  - Work – This is a student who has other sources of income (e.g., scholarships, parents' income), meaning that there is no need to work. The student works 0 hrs. per week.
  - School - Given that this student does not have to be solely committed to work, the student is likely to take the average 15 credit hours per semester. Considering the student commits the average amount of time to classroom-related activities, they will spend 1 hr. studying for every credit hour.

Weekly s/t hrs.: 15

- Case #5: A student who does not need to work and commits an above average amount of time for in and outside classroom-related activities
  - Work – This is a student who has other sources of income (e.g., scholarships, parents' income), meaning that there is no need to work. The student works 0 hrs. per week.
  - School - Given that this student does not have to work, the student is likely to take 15+ credit hours per semester. Considering the outside of classroom work that needs to be done and the student's ability to commit time to school, this case assumes the student will spend 2 hrs. studying for every credit hour.

Weekly s/t hrs.: 30

- Case #6: A student who does not need to work and commits a below average amount of time for in and outside classroom-related activities

- Work - This is a student who has other sources of income (e.g., scholarships, parents' income), meaning that there is no need to work. The student works 0 hrs. per week.
- School - This student is not able to commit as much time to school and therefore will probably take the minimum number of classes (12 credit hours) to be considered a full-time student. Considering the student's ability and desire to commit time to school and the work that needs to be done, the student will contribute 0 hrs. per week.

Weekly s/t hrs.: 0

- Case #7: A student who must work and commits the average amount of time for in and outside classroom-related activities

- Work - This is a student who works as their main means of financial security. This means the student is independent and pays for all of their expenses. The student needs to work full time (an average of 40 hrs. per week).
- School - Given that this student has a heavy work schedule, the student will most likely take the minimum amount of credit hours in order to be considered a full time student (12 credit hours per semester). Considering the student commits the average amount of time to classroom-related activities, they will spend 1 hr. studying for every credit hour.

○ Weekly s/t hrs.: 52

- Case #8: A student who must work and commits an above average amount of time for in and outside classroom-related activities
  - Work -This is a student who works as their main means of financial security. This means the student is independent and pays for all of their expenses. The student needs to work full time (an average of 40 hrs. per week).
  - School - Given that this student has a heavy work schedule, the student will most likely take the minimum amount of credit hours in order to be considered a full time student (12 credit hours per semester). Considering the outside of classroom work that needs to be done and the student's ability to commit time to school, this case assumes the student will spend 2 hrs. studying for every credit hour.

Weekly s/t hrs.: 64

- Case #9: A student who must work and does not put effort into school
  - Work - This is a student who works as their main means of financial security. This means the student is independent and pays for all of their expenses. The student needs to work full time (an average of 40 hrs. per week).
  - School - This student is not able to commit as much time to school and therefore will probably take the minimum number of classes (12 credit hours) to be considered a full-time student. Considering the student's ability to commit time to school and the work that needs to be done, the student will contribute 0 hrs. per week.

Weekly s/t hrs.: 40

Therefore, the weekly average of studying (s) and time spent working hours (t) was calculated by adding the weekly s/t hrs. for each case and then dividing by the number of cases (9), giving an

average of 34 s/t hrs. per week. Assuming that students need an average of 8 hrs. a night for sleep, that means that they are spending 56 hrs. sleeping during the week. Since there are a total of 168 hrs. in a week, subtracting the s/t hrs. (34 hrs.) and sleeping hrs. (56 hrs.), means that the students has 78 “waking hrs.” per week, or  $T = 11.14$  per day.

The  $\delta$  variable is defined as the number of periods, four year intervals, before the student will stop working. Undergraduate studies are assumed to be a standard 4-years, (freshman, sophomore, junior, and senior year) meaning that a traditional student would typically graduate at 22 and the age at which one can receive full retirement benefits is currently 66, that means there are  $((66-22)/4)$  11 periods.<sup>25</sup> This is the value for  $\delta$ .

For the variable  $\overline{W}$ , which is the highest wages an undergraduate student can earn post-graduation, the average graduate salaries were calculated from the Advising, Career, and Exploratory Services Center data.<sup>26</sup> The average salary was calculated to be \$62,148.98 per year or  $(\$62,148.98/365)=\$170.27$  daily.

For the variable  $\underline{W}$ , which is the lowest wages an undergraduate student can earn post-graduation, it was assumed that this would be the same as a student would earn with a high school diploma. This value was provided by the U.S. Bureau of Labor Statistics.<sup>27</sup> The salary given was \$39,090 per year or  $(\$39,090/365)$  \$107.10 daily.

For the  $\gamma$  variable, an assumption was made that the  $t^*$  value would be the time spent working per day. Since the average working time per week was 20 hrs., the average daily working time would be  $(20/7) = 2.8571$ . Considering the equation for  $t^*$  was

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<sup>25</sup> Social Security Administration (2020). *Retirement Benefits*. (Publication No. 05-10035). <https://www.ssa.gov/pubs/EN-05-10035.pdf>.

<sup>26</sup> University of Wyoming Advising Career and Exploratory Studies Center. (2019). *Career Outcomes*. [https://www.uwyo.edu/aces/career-services/career\\_outcomes.html](https://www.uwyo.edu/aces/career-services/career_outcomes.html)

<sup>27</sup> United States Bureau of Labor Statistics. (2014). *Education level and jobs: Opportunities by state*. <https://www.bls.gov/careeroutlook/2014/article/education-level-and-jobs.htm>



$$\left(\frac{w}{\delta(\overline{W}-\underline{W})\cdot\gamma}\right)^{\frac{1}{\gamma-1}} \cdot T = t^*,$$

the previous variables can be inserted in the equation, giving

$$\left(\frac{20.71}{11(170.27-107.10)\cdot\gamma}\right)^{\frac{1}{\gamma-1}} \cdot 78 = 2.8571.$$

Dividing through by 73 and simplifying the term in parentheses gives

$$\left(\frac{20.71}{11(63.17)\cdot\gamma}\right)^{\frac{1}{\gamma-1}} = .0366.$$

Then, we can eliminate the exponent by raising both sides to the inverse exponent, which gives

$$\left(\frac{20.71}{11(63.17)\cdot\gamma}\right) = .0366^{\gamma-1}.$$

From there, divide through by  $\gamma$ , giving

$$\left(\frac{20.71}{11(63.17)}\right) = .0366^{\gamma-1} \cdot \gamma.$$

Then, the values inside of the parentheses can be simplified, giving you

$$0.0298 = .0366^{\gamma-1} \cdot \gamma.$$

This equation cannot be solved for  $\gamma$  explicitly and therefore will have to be done numerically within Excel, meaning the value for  $\gamma$  will be estimated by changing its value until it creates the desired output for  $t^*$ .

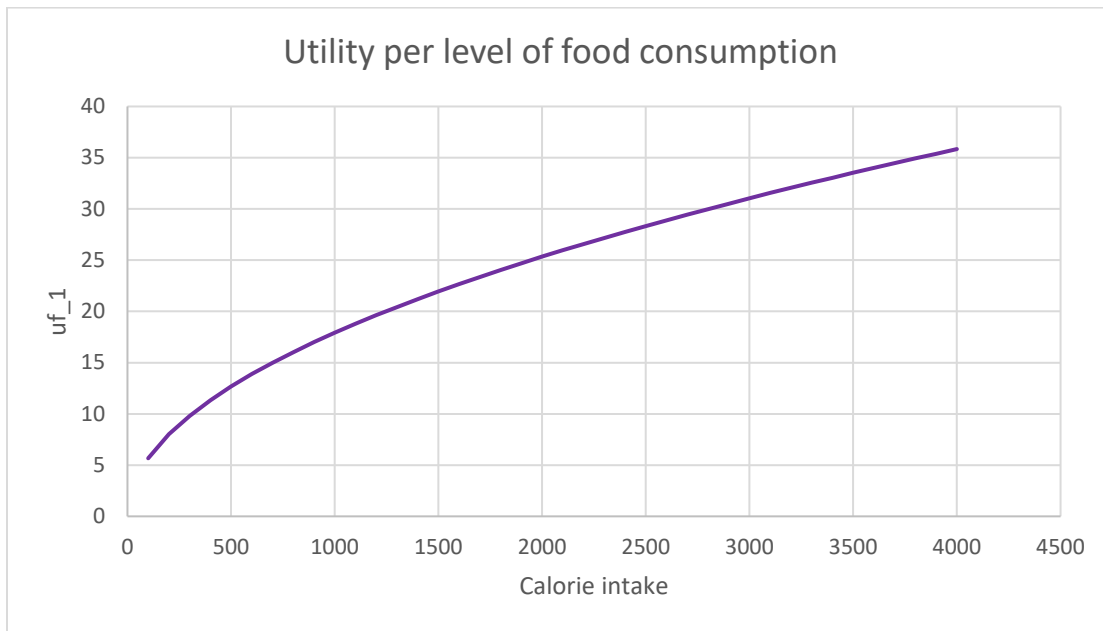
Now that values have been given to the other variables, the only other variable is  $L$ , the loan amount students take out. This value is given by the University of Wyoming Common Data Set.<sup>28</sup> There is variation in the loan amounts for different groups of students, and therefore, these values were inputted into Excel for graphical representation.

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<sup>28</sup> University of Wyoming Office of Institutional Analysis. (2020). *Common Data Set*. <http://www.uwyo.edu/oia/files/cds/cds201920c.pdf>

## GRAPHICAL MODELING

For my graphical modeling, I categorized students into the following categories: average student, need-based resident, need-based non-resident, non-need resident, and non-need non-resident. Each student category has their own independent costs, financial aid packages, and loan amounts, and therefore needs individual consideration. For all categories, the following graph provides a baseline for the utility received based on food consumption.



As seen above, the student's overall utility increases as their calorie intake increases. Overall utility is shown on the y-axis and considers only the utility received from food consumption during period 1 since that is the only period considered in this part of the model. This is consistent for all students since the utility received from food consumption is not dependent on socioeconomic factors, meaning that the benefits received from food consumption are unrelated to financial or social factors (for the purposes of the model). The model and this graphical representation demonstrate that students with higher food consumption have received greater benefits.

## Need-Based Resident

The need-based resident data was compiled from the University of Wyoming Common Data Set and only included in-state residents who were determined to have financial need. The following graphs show how students within this demographic are financially affected (\$ per day) by differing levels of food consumption (calories of food). This creates a better picture how students may be affected by food insecurity and how their financial (in)security contributes to the problem.

**Figure 1:**

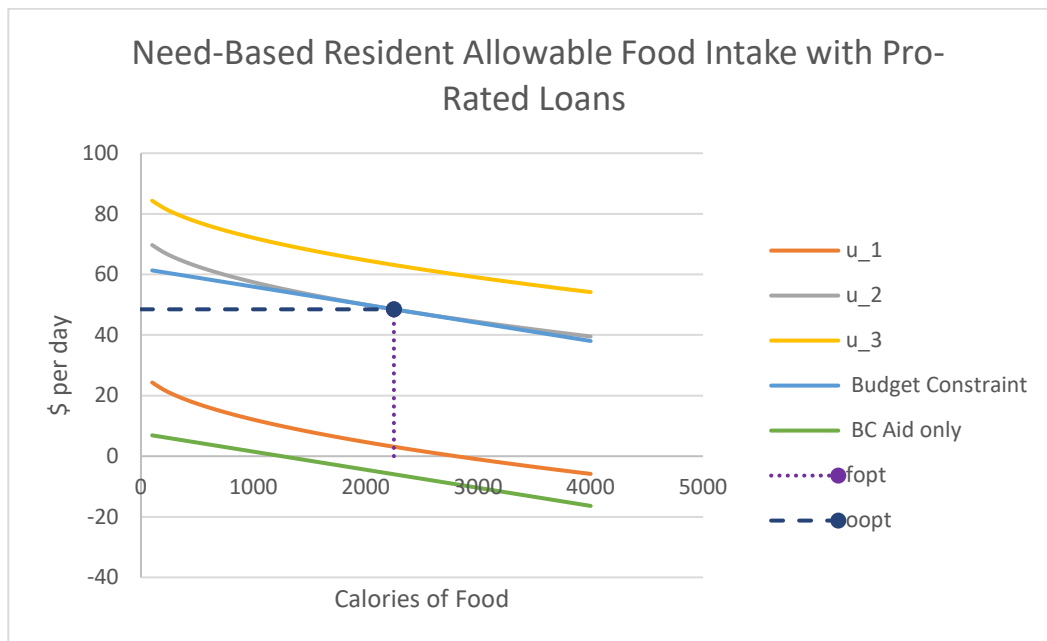


Figure 1 shows the average need-based resident's allowable food intake given their budget constraint from pro-rated loans. As can be seen by the graph, as the student consumes more food, their level of utility increases. The graph also contains the labeled indifference curves, all with different values, and  $u_2$  being equal to  $U^*$ . The budget constraint for in this graph used the equation

$$wt + L + A = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1 + c.$$

Most of the previous variables have already been identified, but the  $A$  variable, the average scholarship, financial, or grant aid the student received, and  $c$ , the average cost of attendance have not. The average amount of aid received by need-based residents is summarized in the University of Wyoming Common Data Set by Residency in section (H2j). The average financial aid package for all students who were determined to have financial need was \$9,736. For the  $c$  variable, the daily cost of attendance was calculated using the University of Wyoming cost of attendance website and information from the City of Laramie regarding mean rent and utility prices. The total cost of attendance for UW students, not including room and board and varying personal expenses, was \$14,553.66 yearly or \$39.98 daily. The pro-rated loan amount,  $L$ , also changed with this graph as, only 43% of students took out a loan, with the average loan award being \$19,816. Since the purpose of this research was to consider all UW students, in this graph I pro-rated this aid to assume an average loan rate across all UW students. According to the Common Data Set, 57% of students did not pursue loans, so to create an average award amount for all students I pro-rated the loan amount,  $L = (19816 \cdot .57)/365$ , to get an average package of \$31.03 of added daily income.

To help define whether a student is food secure or insecure, the boundary will be placed on their profit line. If the student has a profit in their budget constraint, greater than \$0, after income and expenditures are calibrated, the student will be identified as financially secure. On the other hand, if a student has a deficit in their budget constraint, less than \$0, the student will be identified as financially insecure. Although financial (in)security cannot determine actual food insecurity and the student's level of food security (high, marginal, low, very low) because food insecurity depends on more than just economic factors, it can act as a stand-in for food insecurity. The dimensions within food insecurity indicate that financial insecurity can be an

identifier for food insecurity, and therefore to simplify, that is the indicator used in this model and its interpretation.

By compiling all of these different aid packages into the respective budget constraints for need-based residents, students would be able to achieve financial security with their financial aid package and loans but not only with their loans. For the optimal level of food intake, 2250 calories, students with loans and aid would have \$25.07 left in their overall budget whereas students with only aid packages will have a (\$5.96) deficit to their budget. Students with only aid packages are also able to afford the optimal level food intake, and thereby, by definition, are financially insecure.

**Figure 2:**

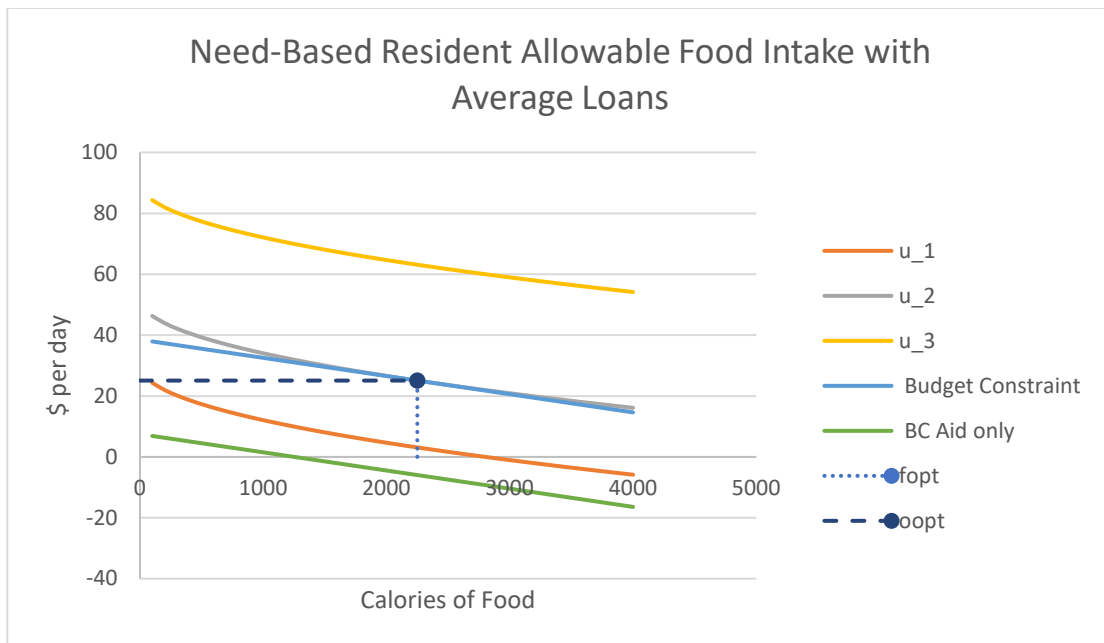


Figure 2 shows the situation if the loan amount,  $L$ , is calculated differently. Instead of pro-rating the average loan amount for all students, the average loan given to the 43% of students was used as the loan amount.  $L$ , in this calculation, was given the value of \$19,816, in accordance with the Common Data Set. This higher average loan amount for in-state residents is

used to plot the budget constraint in Figure 2. Since there was no change in the aid package awarded to students, those who received only aid packages were still deemed financially insecure. However, students receiving the full average loan amount for in-state residents are financially secure, with even more left in their budget. Instead of the \$25.07 left in their budget, these students had \$48.48 that could be used on other expenses.

### Need-Based Non-Resident

The need-based non-resident data was similarly compiled from the University of Wyoming Common Data Set and only included out-of-state residents who were determined to have financial need. Figures 3 and 4, show how students within this demographic are affected by financial insecurity.

**Figure 3:**

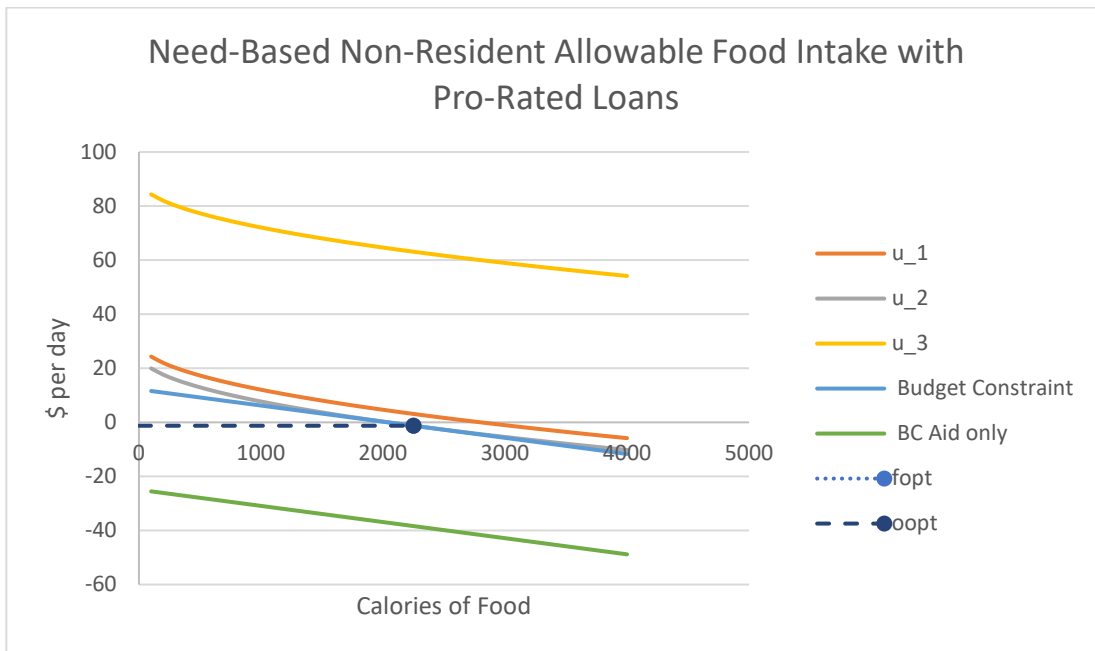


Figure 3 shows the average need-based non-resident's allowable food intake given their budget constraint from pro-rated loans. The differences in the graphs are evident due to the changes in the  $A$  variable, the average scholarship, financial, or grant aid the student received,  $c$ ,

the average cost of attendance, and  $L$ , the pro-rated loan amount. These changes are due to the categorical differences between in-state and out-of-state residents and the corresponding aid and loan packages, and costs. The average amount of aid received by need-based non-residents is also summarized in the University of Wyoming Common Data Set by Residency in section H2j). The average financial aid package for all out-of-state students,  $A$ , who were determined to have financial need was \$11,643. For the  $c$  variable, the daily cost of attendance was calculated using the same resource as before. The total cost of attendance for UW students, not including room and board and varying personal expenses, was \$28,256.01 yearly or \$77.38 daily. The pro-rated loan amount,  $L$ , also changed since 52% of out-of-state students took out a loan with the average loan award amount of \$28,150. With the pro-rating system that was mentioned earlier, the loan amounts were pro-rated to assume an average loan rate for all out-of-state need-based students. The Common Data Set shares that 48% of students do not pursue loans, so to create an average award amount for all students I pro-rated the loan amount,  $L = (19816 \cdot .48)/365$ , to get an average package of \$37.12 of additional daily income. Unlike the need-based residents' graph, after compiling all of these different aid packages into the respective budget constraints, students that use both aid and loans and just loans are financially insecure. For the optimal level of food intake, 2250 calories, students with loans and aid have a (\$1.24) deficit and students with only aid have a (\$38.36) deficit. Therefore, by these metrics, all need-based non-resident students are financially insecure.

**Figure 4:**

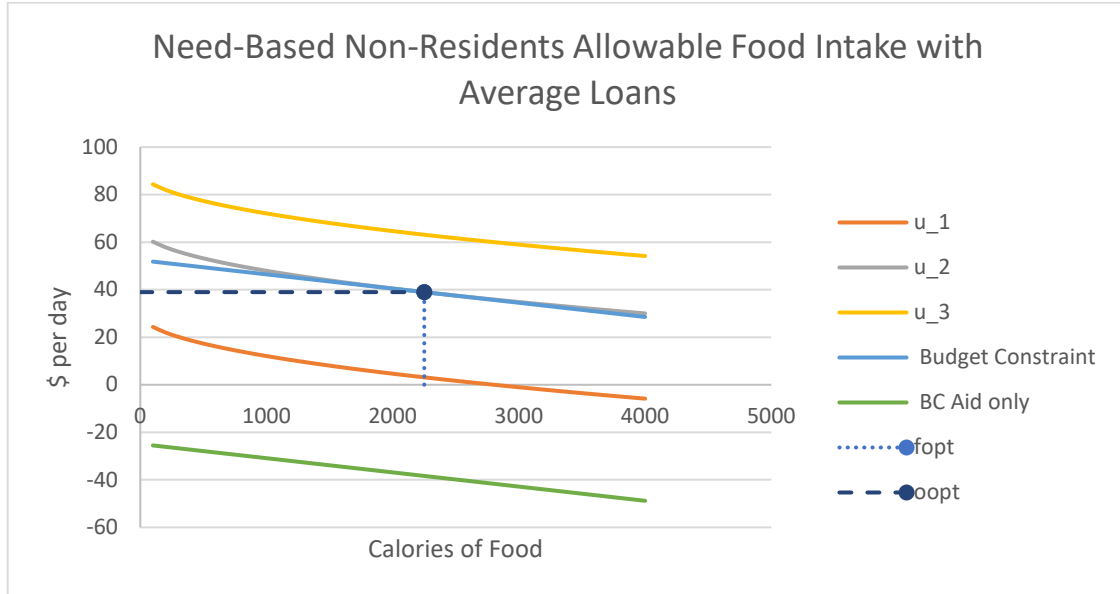


Figure 4 shows the use of the average loan amount for all non-resident students instead of using pro-rated measures for  $L$  the loan amount. This average awarded loan was based on the number provided by the Common Data Set; for the 52% of non-resident students that were awarded loans, the average was \$28,150 and therefore, that was the value given for  $L$ . There was no change in the budget constraint aid only line because there was no change in the aid package awarded to students, but the budget constraint did change. The students who received the full average loan amount for non-residents,  $L$ , were no longer considered to be financially insecure. Instead of having a deficit of (\$1.24), the students now had a surplus of \$38.97.

### **Non-need Resident**

Similar to before, the non-need resident data was compiled using the University of Wyoming Common Data Set, but contrary to earlier, only included in-state residents who were determined to have no financial need. The following graphs show how students within this demographic are financially affected (\$ per day) by differing levels of food consumption



(calories of food). This creates a better picture of how students may be affected by food insecurity and how their financial (in)security contributes to the problem.

**Figure 5:**

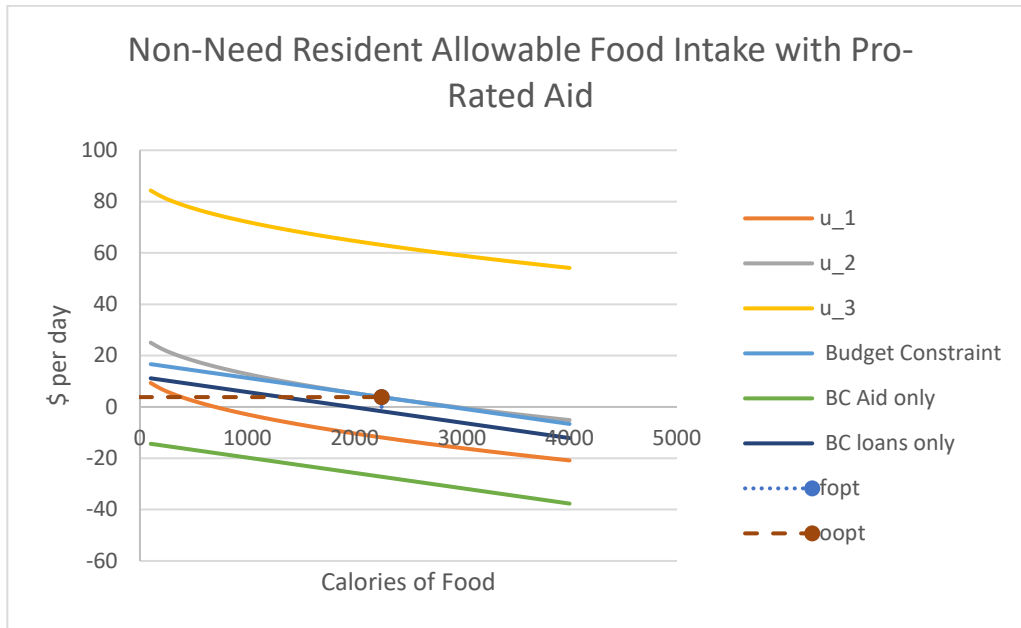
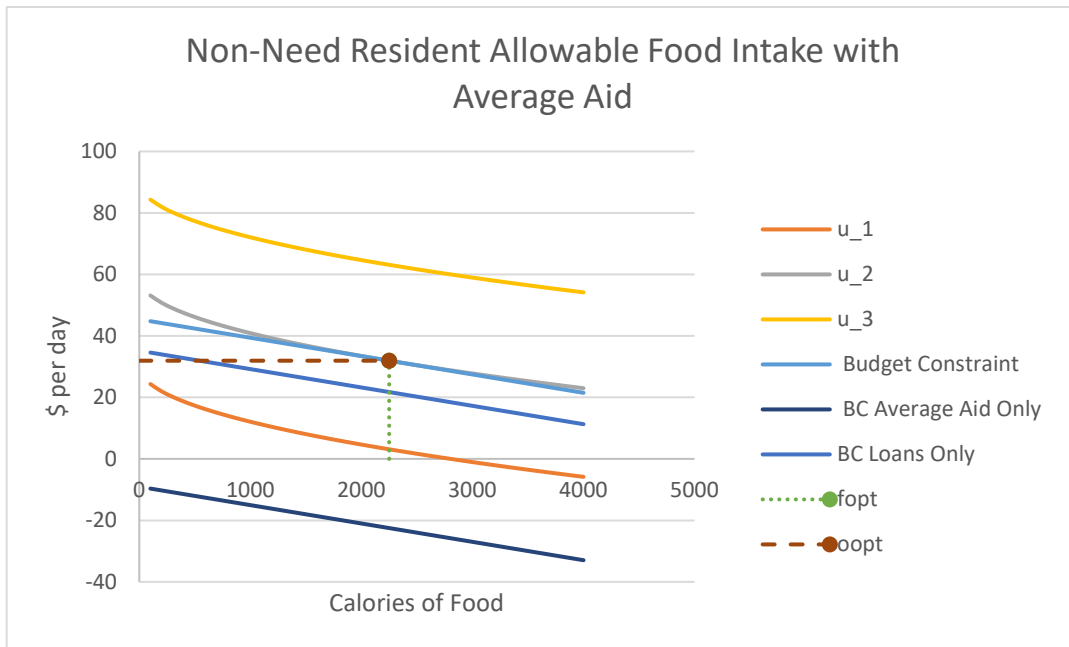


Figure 5 shows the average non-need resident’s allowable food intake, given their budget constraint from pro-rated aid. The process for configuring this graph was the exact same as the method for producing Figure 1, except that the aid package, *A*, for Figure 5 is also pro-rated. Since the non-need resident data is not summarized in a package by the Common Data, like the need-based resident data, it was necessary to pro-rate the aid package so that the average could be found for all non-need residents. The Common Data Set records that 79% of in-state residents receive non-need-based scholarships or grant aid. However, according to the Common Data Set definitions, “non-need-based aid that is used to meet need should be counted as need-based aid.” Therefore, students that qualify for need-based aid and receive non-need-based aid are not considered to be part of the non-need-based awardees. So, since there were 1,982 in-state students who were deemed to have financial need out of the total, 5,094, in-state undergraduate

students, that means that 39% of the 79% aid receivers were considered need-based awardees. If we pro-rate the actual number of awardees according to the average award amount,  $A = (0.79 - \left(\frac{1982}{5094}\right)) \cdot 5003$ , that equates to \$5.51 in additional daily income. The other difference is that pro-rated loans were also included because non-need-based students are more unlikely to have their needs met by aid. Through compilation of the different variables, it is determined that students are only financially secure through a combination of the pro-rated loan and aid packages. With only the pro-rated loan amounts and pro-rated aid packages, students are viewed as financially insecure. With the optimal level of food intake being 2250 calories, students with pro-rated loans and aid, have \$3.84 left in their overall budget, putting them at the brink of financial insecurity. Students with only pro-rated loans or aid packages have a deficit of, (\$1.68) and (\$27.20), respectively

**Figure 6:**



In Figure 6, the average loan amount awarded to non-need, in-state residents,  $L$ , and the average aid package for non-need, in-state residents,  $A$ , is not pro-rated. The associated loan

amount for *L* is the same as in previous graphs, \$19,816. The aid package for *A*, however, is not the same because there is a specific average award amount that the Common Data Set records for all non-need aid recipients. That award average is \$3,714. When viewing the impact of the changes in aid and loan amounts, it is apparent that students who receive the average amounts fair better. Students that receive both the average aid and loan amounts are financially secure with a \$31.94 surplus in their budget after meeting their optimal food consumption. Similarly, those students who are awarded the average loan amount have a \$21.74 after optimal food consumption and are financially secure. Only those students who receive only the average aid packages are financially insecure, as they face a (\$22.50) deficit if they try to consume the optimal, 2250 calories, of food.

### **Non-need Non-Resident**

As before, non-need, non-resident data was compiled using the University of Wyoming Common Data Set. This only includes out-of-state residents who were determined to have no financial need. The following graphs show how students within this demographic are financially affected (\$ per day) by differing levels of food consumption (calories of food). This creates a better picture of how students may be affected by food insecurity and how their financial (in)security contributes to the problem.

**Figure 7:**

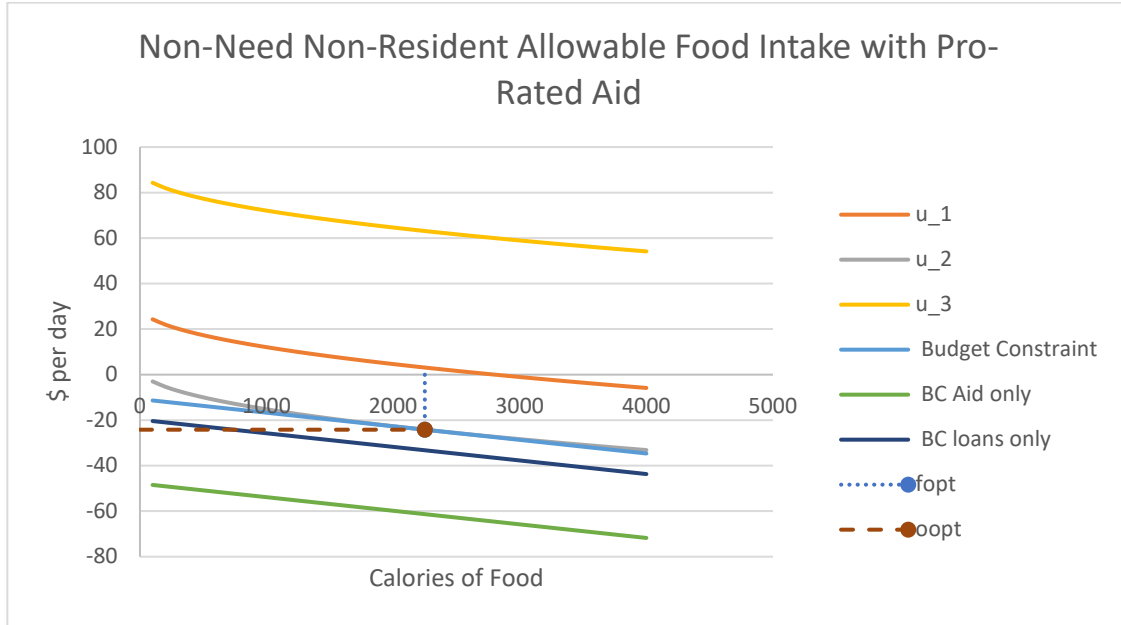


Figure 7 shows the average non-need, non-resident’s allowable food intake, given their budget constraint from pro-rated aid. The process for configuring this graph was the exact same as the method for Figure 5 except, the pro-rated aid package,  $A$ , is for out-of-state students, and likewise for the pro-rated average loan award,  $L$ . To pro-rate the average aid amount, it is recognized that 62% of non-need, non-residents, are awarded non-need-based scholarships or grant aid. Following the same Common Data Set definition for non-need-based scholarship or grant aid, students that qualify for need-based aid and receive it cannot be considered as part of the average award. Of the 3,356 total out-of-state undergraduate students, 1,018 of them were deemed to have financial need. Therefore, 30% of the total 62% receivers of aid should not be considered in the data. To pro-rate the actual number of awardees according to the average award amount,  $A = (0.62 - (\frac{1018}{3365})) \cdot 10395$ , the percent of non-need, non-residents, has to be multiplied by the average non-need-based aid. This average award amount,  $A$ , is \$13.48 in additional daily income. Adding these changes to our calculations, means that all students with

pro-rated aids and loans, whether individually or in combination, are financially insecure. For students with both, they suffer a (\$24.19) deficit, for only pro-rated aid, a (\$61.33) deficit, and for only pro-rated loans, a (\$33.23) deficit. All of these students are at high-risk for the risk factors associated with food insecurity.

**Figure 8:**

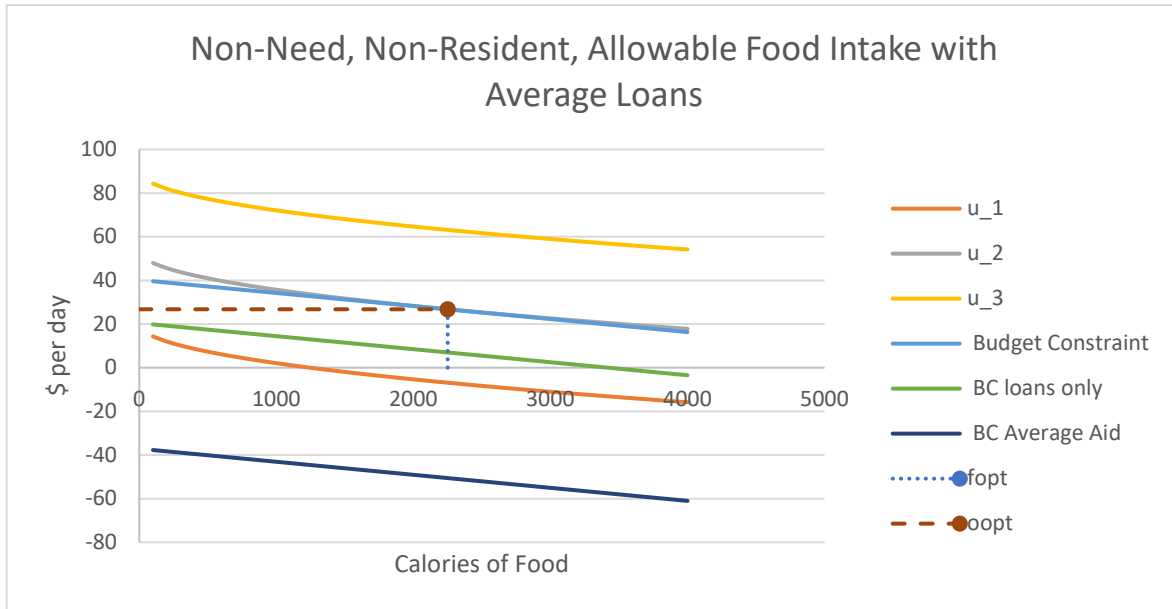


Figure 8 represents the average loan amount awarded to non-need, in-state residents,  $L$ , and the average aid package for non-need, in-state residents,  $A$ , which are not pro-rated. The associated loan amount for  $L$  is the same as in Figure 4, \$28,150. The aid package for  $A$ , however, does change because the Common Data Set offers a specific average aid package value for non-need, non-resident aid recipients. That award average is \$4,980. In comparison to the pro-rated aid and loan amounts, students with average aid and loan packages are less at risk of being food insecure. Students with both the average aid and loan awards are food secure with a \$20.47 surplus in their budget after meeting their, 2250 calorie, optimal food consumption. Students that are awarded the average loan amount are also food secure with a \$6.99 surplus, but that is putting them closer to the financial insecurity threshold. The only students from this graph

that are financially insecure are those students who only receive average aid packages; they face a (\$56.87) deficit when they try to reach the food security equilibrium.

### Average Student

The average student data was aggregated from the other categories, financial aid packages and loan amounts, consolidated into one. This category summarizes the average amount of aid across all undergraduate students based on the University of Wyoming Common Data Set. The following graphs were produced from that aggregate data.

**Figure 9:**

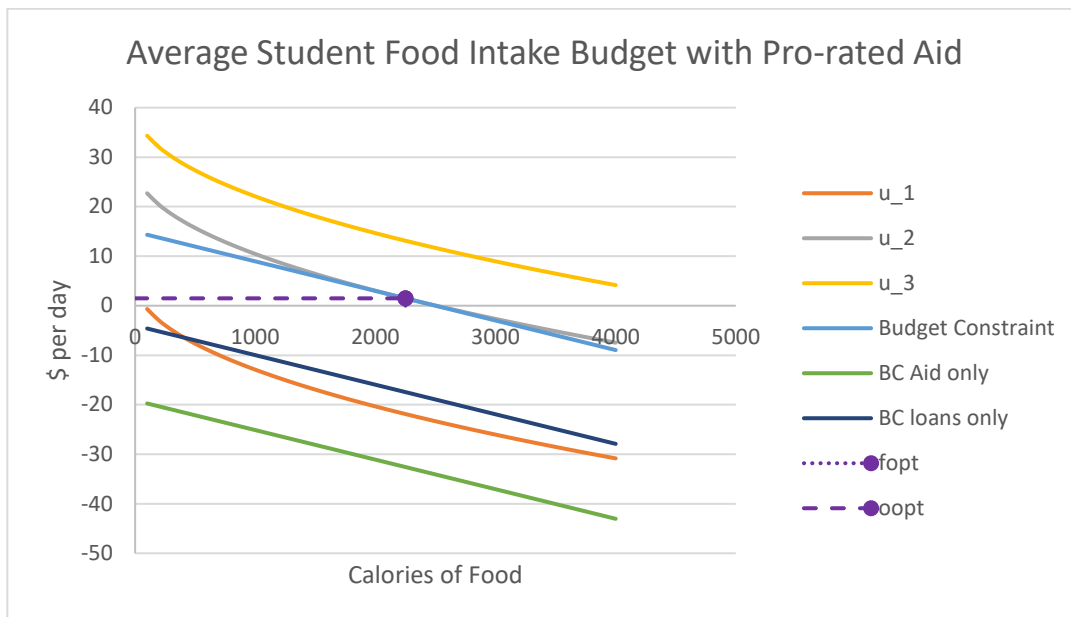


Figure 9 shows the average student’s allowable food intake given their budget constraint from pro-rated aid. The graph averages the budget constraint amounts from the previous graphs, including the average amounts for all loan and aid packages in the pro-rated loan/aid packages. To determine the average amount for pro-rated aid packages, the following equation was used:

$$A = \frac{\left( \left( \left( 0.79 - \left( \frac{1982}{5094} \right) \right) * 5003 \right) + \left( \left( 0.62 - \left( \frac{1018}{3356} \right) \right) * 10395 \right) + 10431 + 9736 \right)}{4}$$

This gave the average amount of pro-rated aid packages,  $A$ , which was \$6,336.12. The same was done for the average pro-rated loan packages,  $L$ . The equation for that was:

$$L = \frac{(19816*0.57)+(28150*0.48)}{2}.$$

This gave the average amount for pro-rated loan amounts,  $L$ , which was \$12,403.56. From the aggregated pro-rate data, it is clear that only the students who are awarded both the pro-rated loan and aid packages were financially secure. These students had a \$1.40 surplus after consuming their optimal, 2250 calories. Although these students had a surplus, they are at risk for being financially insecure, and it is more than likely that they are within the low food security range. The students who had only pro-rated loans and aid packages were dangerously financially insecure, with (\$17.45) and (\$32.59) deficits at the level of optimal food consumption.

**Figure 10:**

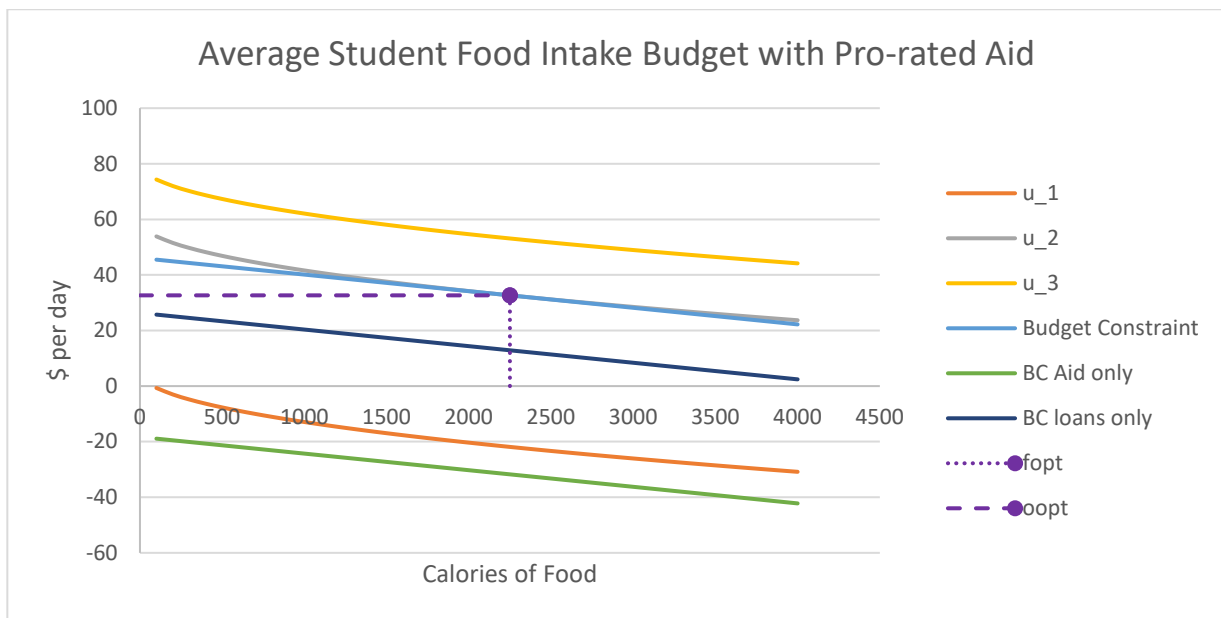


Figure 10 shows the average student's allowable food intake given their budget constraint from average aid. The graph averages the budget constraint amounts from the previous graphs,

but only includes the average amounts for aid packages,  $A$ , since the Common Data Set provides and average loan amount,  $L$ . For the average aid package,  $A$ , the following equation was used:

$$A = \frac{3714+4908+10431+9736}{4}.$$

This gave the average aid package for the average student,  $A$ , which was \$7,297.25. The value for the average loan amount,  $L$ , was given by the Common Data set as \$23,444. Using that information and the other consistent variables, budget allocations for food, for the average student was configured. The average student is financially secure when combining both the average loan amount,  $L$ , and the average aid package,  $A$ . These students have a comfortable \$32.65 daily surplus after meeting their optimal food consumption. Additionally, students who only receive loans were deemed financially secure. These students have a less comfortable surplus with \$12.88 after reaching their optimal surplus, but still enough to provide security. The only students who are not financially secure are the students that rely on aid packages only. They have a (\$31.76) deficit at the level of optimal food consumption.

## CONCLUSION

Based on the graphical modeling displayed previously, students at higher risk for financial insecurity (and, as this model assumes, food insecurity) are students that don't qualify for financial aid packaging. Specifically, out-of-state residents are more at risk than in-state students. Out of all of the different graphs presented, out-of-state, non-need students were at risk in four out of the six categories and were close to the food insecurity threshold in the "average loan only" category of the "Non-Need, Non-Resident, Allowable Food Intake with Average Loans" graph. Second to this demographic of students were the non-need, resident students, who were food insecure in the three out of six categories and approaching food insecurity in the "pro-rated loan and aid" category of the "Non-Need Resident Allowable Food Intake with Pro-Rated



Aid” graph. Although need-based students were financially or food insecure when considering only aid packages, they were deemed food secure otherwise. Similarly, for need-based students, out-of-state students have less budgetary maneuverability after consuming the optimal level of food intake. This information will be useful for the UW Food Security Taskforce moving forward, as it can help them identify specific student populations that would benefit the most from their food security strategies. Considering the previously mentioned dimensions of food security and the related underlying factors, the previous models cannot indicate levels of food security for all students. The models fail to capture systemic or institutional barriers that students may be additionally experiencing and therefore does not identify students risk levels based on ethnicity, student status, gender identification, or other factors that are often used to understand and assess food (in)security. However, these models can help indicate which students are at higher risk for experiencing food insecurity based on financial factors like time spent working, studying, financial aid packaging, and whether they are an in-state or out-of-state student. Moving forward, the taskforce should focus on non-need students and out-of-state students as targeted populations for strategy implementation. Since these populations are at high risk for food insecurity within the model, they can act as a baseline for understanding the broader food insecurity problem at UW.

Based on my initial experience in developing this model, two main recommendations emerge for its future use and related considerations: 1) helping the taskforce to develop participation criteria or target populations for specific strategies; and 2) identifying the costs and benefits of each strategy. The model provides a structure for identifying financially insecure (food insecure) students based on generalized student profiles. These assumptions do not allow for consideration of individualized inhibiting factors that can limit student’s ability to reach food

secure status. Therefore, future work needs to delve into the multiple dimensions of food (in)security and the sociocultural factors within it. Through its own limitations, the model creates a guideline for the taskforce's future work by informing the financial factors which lead to food insecurity, further narrowing the focus for which student populations should be targeted. This financial analysis can support the taskforce in navigating how future strategies should be structured, conducted, and defined in terms of determining student qualifications needed for accessing food security resources. Furthermore, each strategy has an imposed cost for its implementation and continued performance that will (hopefully) create benefits for the student population. All of the benefits received from these strategies are not necessarily monetary gains, but they will all have impacts on a student's food (in)security level, including financial (in)security. Every strategic implementation plan will have a correlated impact on the model. For maximizing the benefits and offsetting costs, future work can use this model as an indicator of how student finances will be affected, creating a shift in their financial ability to achieve food security. This model can support all previously identified taskforce food security strategies.

Each strategy can uniquely use the financial indicators available in this model to maximize future impact while limiting costs. The meal swipe sharing strategy requires additional information to determine effectiveness; the cost of the program, student qualifications for receiving meals, the subsidy it provides for student's personal finances, and how it changes food access and food (in)security at UW. The model does not provide this information but provides an outline for factors that could be relevant in the application process, including: financial aid package amount, school-related costs, non-school-related costs, student status, student income, parental contributions, etc. In addition to questions focused on equity and food justice, the variables included in the model can help to identify a student's level of food (in)security and

create a ranking system for those students “most in need.” Further, given the financial information provided in the application, assumptions of how access to free meals would change financial (in)security for students could also be determined. This determination can create individual student profiles of the optimal level of food consumption students need to experience food security, the optimal amount of meals a student may qualify for, and what level of impact this strategy could have.

The good food recovery sharing strategy, which encompasses a campus text alert system that is sent out to indicate excess food after UW events, would also require additional information that could be embedded into the model. To determine effectiveness of the program, information would need to be found for: the average number of UW-catering events held per year, the average food availability at these events, how many students could partake in the system, and what cost offsets (if any) this program would create for student’s financial budgets. The taskforce’s future work could consider this model and create a framework for how the alert system should operate. Using a similar application or authentication process as that of the meal swipe program, which uses model variables and questions focused on equity and food justice, the alert can be designed in a way that prioritizes students who are financially insecure. The taskforce may need to determine if prioritization of students within the design of the alert is the most just process, while using this model as a resource. Additionally, the additional information needed for the good food recovery sharing program can be inserted into the model and can determine how students financial (in)security changes with the implementation and development of this program.

The installation of a campus grocery store would require considering information on student fee allocations and how they can act as a subsidy for student budgets, comparative costs

for campus grocery items compared to local grocery store items, and the degree to which transportation and time costs can benefit students. Future work on this strategy could use the model with specific consideration to the price of food, time, and cost of other good variables, to determine the financial need for healthy food access. This strategy is not solely focused on making food financially accessible, it considers other elements of food security. However, student consumer choices in food purchasing and food outlets does have a financial basis. Therefore, future use of this model in comparing campus grocery store prices and associated costs to other alternatives would help the taskforce to determine the potential level of impact of a campus grocery store. It can provide a basis for determining how students financial (in)security would change given this new option.

A central food share cabinet or pantry requires investigation into the specific food items that are offered, particularly non-perishable items, and how the no-cost delivery of these items impacts the daily cost for optimal level of food consumption. Since the food share cabinet or pantry do not impose costs on students accessing them, this strategy would only impact the model in terms of a student's ability to minimize their personal food budget. Depending on the student's ability to supply their optimal food consumption by the supplies given at the cabinet, their financial budget can increase, encouraging higher financial and food security. The other dimensions of food security affected by this strategy can also create changes in levels of student food (in)security.

All strategies that the taskforce plans to implement will need further research, using peer institutions failures, successes, and data to find relevant variables that can be inserted into this model. The model, currently based on only financial assumptions, cannot identify food (in)secure students. However, through additional future work, that provides more robust financial

profiles for students interested in the taskforce's food strategies and resources, can help to determine how individual students could benefit financially. Financial security is only one aspect of food security and, therefore additional research on how other factors are impacting student food security is needed.

Student-led economic analyses of the previously identified strategies would benefit the taskforce and provide a student perspective, furthering a focus on student voice and food justice. By building on the economic model in this paper and methods outlined above, the taskforce could examine the financial effectiveness of each strategic option. Targeted approaches that ensure equitable access for all students will help to address and reduce student food insecurity at the University of Wyoming. This model helped define the problems of food (in)security that UW undergraduate students face, different student profiles were created to determine how different income and budgetary constraints impact a student's ability to reach food security. The information shown through the mathematical and graphical representations above show that the student populations most affected by food insecurity are students who don't qualify for financial aid and non-Wyoming residents. Using this information from the model and proposed future taskforce work, these generalized student categories can be narrowed into targeted student sub-populations. By incorporating this model, the strategies already proposed by the taskforce can be delivered in a way that will create a lasting impact on UW campus, minimizing the impacts of food insecurity. Student food security is the #1 student success priority as identified by ASUW, and this model assists with the goal of ensuring that every Poke is nourished.

## APPENDIX A

To simplify the optimization problem, solve the period 1 expenditure equation (4) for  $o_1$ , set it to the side.

$$Y_1 = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1 + c \quad (3)$$

$$o_1 = Y_1 - (\bar{p} - \underline{p})f_1 - \underline{p}2250 - c$$

and use it to eliminate  $o_1$  from the rest of the problem. This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, o_2, Y_1, Y_2, t, s, W} &= u(f_1) + (Y_1 - (\bar{p} - \underline{p})f_1 \\ &\quad - \underline{p}2250 - c) + \delta[u(f_2) + o_2] \end{aligned}$$

subject to constraints

$$Y_1 = wt + L + A, \quad (4)$$

$$T = s + t, \quad (5)$$

$$W = W(s), \quad (6)$$

$$Y_2 = \bar{p}f_2 + \underline{p}(2250 - f_2) + (1 + r)L + o_2 + c \quad (7)$$

and

$$Y_2 = WT. \quad (8)$$

Next, solve the period 2 expenditure equation (7) for  $o_2$ , set it to the side

$$Y_2 = \bar{p}f_2 + \underline{p}(2250 - f_2) + (1 + r)L + o_2 - c, \quad (7)$$

$$o_2 = Y_2 - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L - c$$

and use it to eliminate  $o_2$  from the rest of the problem. This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, Y_1, Y_2, t, s, W} U = & u(f_1) + (Y_1 - (\bar{p} - \underline{p})f_1 - \underline{p}2250 - \\ & c) + \delta [u(f_2)Y_2 - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L - c], \end{aligned}$$

subject to constraints

$$Y_1 = wt + L + A, \quad (4)$$

$$T = s + t, \quad (5)$$

$$W = W(s), \quad (6)$$

and

$$Y_2 = WT. \quad (8)$$

Next, treat the period 1 income equation (3) as already solved for  $Y_1$ , set it aside

$$Y_1 = wt + L + A \quad (4)$$

and use it to eliminate  $Y_1$  from the rest of the problem. This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, Y_2, t, s, W} U = & u(f_1) + (wt + L + A - (\bar{p} - \underline{p})f_1 - \underline{p}2250 + c) + \\ & \delta [u(f_2)o_2 + Y_2 - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L + c], \end{aligned}$$

subject to constraints

$$T = s + t, \quad (5)$$

$$W = W(s), \quad (6)$$

and

$$Y_2 = WT. \quad (8)$$

Next, treat the period 2 income equation, (8), as already solved for  $Y_2$ , set it aside

$$Y_2 = WT \quad (8)$$

and use it to eliminate  $Y_2$  from the rest of the problem. This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, t, s, W} U = & u(f_1) + (wt + L + A - (\bar{p} - \underline{p})f_1 - \underline{p}2250 + c) + \\ & \delta [u(f_2) + WT - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L + c], \end{aligned}$$



subject to constraints

$$T = s + t, \quad (5)$$

and

$$W = W(s). \quad (6)$$

Next, treat the period 2 wage equation (6) as already solved for  $W$ , set it aside

$$W = W(s) \quad (6)$$

and use it to eliminate  $W$  from the rest of the problem. This reduces the optimization problem to

$$\begin{aligned} \max_{f_1, f_2, t, s} U = & u(f_1) + (wt + L + A - (\bar{p} - \underline{p})f_1 - \underline{p}2250 + c) + \\ & \delta [u(f_2) + W(s)T - (\bar{p} - \underline{p})f_2 - \underline{p}2250 - (1 + r)L + c], \end{aligned}$$

subject to constraint:

$$T = s + t, \quad (5)$$

Finally, solve the time ( $t$ ) equation (7) for  $s$ , set it to the side

$$T = s + t \quad (5)$$

$$s = T - t$$

## APPENDIX B

I use a specific, square root “form” for the generic  $u(f_1)$  function, namely

$$u(f_1) = \alpha\sqrt{f_1},$$

where  $\alpha$  is a constant coefficient. Indifference curves in period 1 are defined as combinations of  $f_1$  and  $o_1$  that give the student a given level of utility  $\bar{u}$ , so the equation for any given indifference curve is

$$u(f_1) + o_1 = \bar{u}.$$

Solving that equation for  $o_1$  gives

$$o_1 = \bar{u} - u(f_1).$$

As for the budget constraint, with the expenditure side being

$$Y_1 = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1 + c$$

and the income side being

$$Y_1 = wt + L,$$

if  $Y_1$  is eliminated, the equation is

$$wt + L = \bar{p}f_1 + \underline{p}(2250 - f_1) + o_1.$$

Solving that constraint for  $o_1$  gives

$$o_1 = wt + L - \bar{p}f_1 - \underline{p}(2250 - f_1),$$

which then becomes

$$o_1 = wt + L - (\bar{p} - \underline{p})f_1 - \underline{p}2250,$$

with  $\tilde{p}$  representing  $(\bar{p} - \underline{p})$  for the purpose of simplification.

Period two follows the same process as period one, showing what income is spent on through

$$Y_2 = \bar{p}f_2 + \underline{p}(2250 - f_1) + (1 + r)L + o_2,$$

and the income side being

$$Y_2 = WT,$$

if  $Y_2$  is eliminated, what is left over is

$$WT = \bar{p}f_2 + \underline{p}(2250 - f_1) + (1 + r)L + o_2.$$

Solving that constraint for  $o_2$  gives

$$o_2 = WT - \bar{p}f_2 - p(2250 - f_1) - (1 + r)L.$$

For period two, to implement the mathematical model, I use a specific, square root “form” for the generic  $W(s)$  function, namely

$$W(s) = \underline{W} + (\bar{W} - \underline{W}) \left[ 1 - \left( 1 - \left( \frac{s}{T} \right) \right)^\gamma \right],$$

which, when expanded is written as

$$W(s) = \underline{W} + (\bar{W} - \underline{W}) - (\bar{W} - \underline{W}) \left( 1 - \frac{s}{T} \right)^\gamma.$$

After substituting  $s = T - t$ , this becomes

$$W(T - t) = \underline{W} + (\bar{W} - \underline{W}) - (\bar{W} - \underline{W}) \left( 1 - \frac{T - t}{T} \right)^\gamma.$$

After simplification it becomes

$$W(T - t) = \underline{W} + (\bar{W} - \underline{W}) - (\bar{W} - \underline{W}) \left( \frac{T - (T - t)}{T} \right)^\gamma,$$

and can be rewritten as

$$= \underline{W} + (\bar{W} - \underline{W}) - (\bar{W} - \underline{W}) \left( \frac{t}{T} \right)^\gamma.$$

With these specific functional forms, the student’s optimization problem,

$$\max_{f_1, f_2, t} U = u(f_1) + wt + L - pf_1 + \delta[u(f_2) + W(T - t)T],$$

becomes

$$\begin{aligned} \max_{f_1, f_2, t} U = & \alpha \sqrt{f_1} + wt + L + A - \tilde{p} f_1 - \underline{p}2250 - c + \delta \left[ \alpha \sqrt{f_2} + \right. \\ & \left. [\underline{W} + (\overline{W} - \underline{W}) - (\overline{W} - \underline{W}) \left(\frac{t}{T}\right)^\gamma] T - \tilde{p} f_2 - \underline{p}2250 - (1+r)L - c \right]. \end{aligned}$$

After distribution of the  $T$  term, the equation becomes

$$\begin{aligned} \max_{f_1, f_2, t} U = & \alpha \sqrt{f_1} + wt + L - \tilde{p} f_1 - \underline{p}2250 + \delta \left[ \alpha \sqrt{f_2} + \underline{W}T + (\overline{W}T - \underline{W}T) - \right. \\ & \left. (\overline{W} - \underline{W}) \left(\frac{t}{T}\right)^\gamma \cdot T - \tilde{p} f_2 - \underline{p}2250 - (1+r)L \right]. \end{aligned}$$

After more simplification, the problem becomes

$$\begin{aligned} \max_{f_1, f_2, t} U = & \alpha \sqrt{f_1} + wt + L - \tilde{p} f_1 - \underline{p}2250 + \delta \left[ \alpha \sqrt{f_2} + \underline{W}T - (\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot t^\gamma - \right. \\ & \left. \tilde{p} f_2 - \underline{p}2250 - (1+r)L \right], \end{aligned}$$

with first-order condition for  $f_1$

$$\frac{\partial U}{\partial f_1} = \frac{\alpha}{2\sqrt{f_1}} - \tilde{p} = 0.$$

This condition can be solved explicitly for  $f_1$  to get optimal output,  $f_1^*$ , by first adding the  $\tilde{p}$  to both sides

$$\frac{\alpha}{2\sqrt{f_1}} = \tilde{p}.$$

Next, multiply both sides by  $\sqrt{f_1}$ , to get

$$\frac{\alpha}{2} = \tilde{p} \sqrt{f_1}.$$

Then, isolate the  $\sqrt{f_1}$  term by dividing both sides by  $\tilde{p}$ , giving

$$\frac{a}{2\tilde{p}} = \sqrt{f_1}.$$

Finally, we can determine the optimal food consumption in period one  $f_1^*$  by squaring each side, giving

$$\frac{a^2}{4} \cdot \tilde{p}^{-2} = f_1^*.$$

Since we have an explicit solution, we can directly differentiate this expression to find comparative static expression

$$\frac{\partial f_1^*}{\partial \tilde{p}} = -2 \cdot \frac{a^2}{4} \cdot \tilde{p}^{-3} < 0.$$

Simplified, this expression becomes

$$\frac{\partial f_1^*}{\partial \tilde{p}} = -\frac{a^2}{2} \cdot \tilde{p}^{-3} < 0.$$

Considering the student uses the same utility function for period one and period two, the steps for period two are the same.

Recall that the student faces optimization problem

$$\begin{aligned} \max_{f_1, f_2, t} U = & \alpha \sqrt{f_1} + wt + L - \tilde{p} f_1 - \underline{p}2250 + \delta \left[ \alpha \sqrt{f_2} + \overline{WT} - (\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \right. \\ & \left. t^\gamma - \tilde{p} f_2 - \underline{p}2250 - (1+r)L \right], \end{aligned}$$

From this, we find that the student's first-order condition for  $t$  is

$$\frac{\partial U}{\partial t} = w + \delta[-(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma t^{\gamma-1}] = 0$$

This condition can be solved explicitly for  $t$  to get optimal output of  $t$  by subtracting  $w$  from both sides, to get other side

$$\delta[-(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma t^{\gamma-1}] = -w.$$

Next, divide  $\delta$  to the other side, simplifying the problem to

$$-(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma t^{\gamma-1} = -\frac{w}{\delta}.$$

Next, multiply both sides by  $-1$ , giving

$$(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma t^{\gamma-1} = \frac{w}{\delta}.$$

Then, divide through by  $(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma$ , giving

$$t^{\gamma-1} = \frac{w}{\delta(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma}.$$

Next, raise both sides of the equation to the power  $\frac{1}{\gamma-1}$ , giving

$$t = \left( \frac{w}{\delta(\overline{W} - \underline{W}) \cdot T^{1-\gamma} \cdot \gamma} \right)^{\frac{1}{\gamma-1}}.$$

Then, use that  $\frac{1}{T^{1-\gamma}} = T^{1-\gamma}$  to simplify, giving

$$t = \left( \frac{w \cdot T^{\gamma-1}}{\delta(\overline{W} - \underline{W}) \cdot \gamma} \right)^{\frac{1}{\gamma-1}}.$$

Finally, take the  $T$  variable and multiply it by the  $\frac{1}{\gamma-1}$  exponent, giving the final solution of



$$t = \left( \frac{w}{\delta(\overline{w} - \underline{w}) \cdot \gamma} \right)^{\frac{1}{\gamma-1}} \cdot T.$$

## APPENDIX C

Characteristics of 1387 foods from the Food and Nutrient Database for Dietary Studies and the Center for Nutrition Policy and Promotion food prices database by 9 major food groups as defined by the US Department of Agriculture (USDA)<sup>29,30</sup>

Major USDA food groups	No. of foods	Food characteristics		
		Energy density <i>kcal/100 g</i>	Water content <i>g/100 g</i>	Serving size (RACC) <i>g</i>
Milk and milk products	134	182 ± 112 <sup>2,a</sup>	66 ± 17 <sup>a</sup>	112 ± 89 <sup>a,b</sup>
Meat, poultry, and fish	196	224 ± 98 <sup>a,b</sup>	60 ± 14 <sup>a</sup>	89 ± 51 <sup>a,c</sup>
Eggs	8	171 ± 74 <sup>a,c,d</sup>	72 ± 10 <sup>a,b,c</sup>	65 ± 28 <sup>a,d,e,f</sup>
Dry beans, legumes, nuts, and seeds	62	330 ± 217 <sup>e</sup>	40 ± 33 <sup>d</sup>	76 ± 62 <sup>c,d</sup>
Grain products	435	337 ± 110 <sup>e</sup>	24 ± 23 <sup>e</sup>	63 ± 53 <sup>d</sup>
Fruit	93	67 ± 56 <sup>c</sup>	82 ± 15 <sup>b</sup>	157 ± 77 <sup>g</sup>
Vegetables	257	83 ± 80 <sup>c</sup>	80 ± 17 <sup>b</sup>	102 ± 59 <sup>a,c,h</sup>
Fats, oils, and salad dressings	51	390 ± 226 <sup>e</sup>	47 ± 23 <sup>c,d</sup>	22 ± 9 <sup>e</sup>
Sugars, sweets, and beverages	151	242 ± 190 <sup>b,d</sup>	45 ± 39 <sup>c,d</sup>	119 ± 102 <sup>b,f,h</sup>
<i>P</i> values (one-factor ANOVA)	—	<0.001	<0.001	<0.001

<sup>29</sup> Data are from references 9 and 10. RACC, Reference Amounts Customarily Consumed. Statistical tests are based on post hoc comparisons after one-factor ANOVA and by using Bonferroni correction. Values with different superscript letters are significantly different from each other.

<sup>30</sup> Mean ± SD (all such values).

## APPENDIX D

2015-2020 Dietary Guidelines for Americans. 8<sup>th</sup> Edition. Table 1-1. “Healthy U.S.-Style Eating Pattern at the 2,000-Calorie Level, With Daily or Weekly Amounts From Food Groups, Subgroups, and Components.”

<b>Food Group<sup>a</sup></b>	<b>Amount<sup>(b)</sup> in the 2,000-Calorie-Level Pattern</b>
<b>Vegetables</b>	<b>2½ c-eq/day</b>
Dark Green	1½ c-eq/wk
Red & Orange	5½ c-eq/wk
Legumes (Beans & Peas)	1½ c-eq/wk
Starchy	5 c-eq/wk
Other	4 c-eq/wk
<b>Fruits</b>	<b>2 c-eq/day</b>
<b>Grains</b>	<b>6 oz-eq/day</b>
Whole Grains	≥ 3 oz-eq/day
Refined Grains	≤ 3 oz-eq/day
<b>Dairy</b>	<b>3 c-eq/day</b>
<b>Protein Foods</b>	<b>5½ oz-eq/day</b>
Seafood	8 oz-eq/wk
Meats, Poultry, Eggs	26 oz-eq/wk
Nuts, Seeds, Soy Products	5 oz-eq/wk
<b>Oils</b>	<b>27 g/day</b>
<b>Limit on Calories for Other Uses (% of Calories)<sup>c</sup></b>	<b>270 kcal/day (14%)</b>