University of British Columbia

Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Advancing Biodiversity Conservation & Eco-Human Health

Enhancing Food Ingredient Diversity through Meal Planning at the University of British Columbia

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LFS 450

Advancing Biodiversity Conservation & Eco-Human Health

OUR GOAL

Assess current food ingredient diversity within UBC Food Services Open Kitchen (OK) and inform future menu planning and procurement by promoting Food Ingredient Biodiversity, nutrition, and food sustainability

KEY FINDINGS

- UBCFS doesn't measure ingredient diversity
- Provided a new way to measure biodiversity

UBC aims to reduce food system GHG emissions by 50% by 2030. Reaching this goal, while promoting student health, will require the procurement of biodiverse, climate-friendly foods at UBCFS outlets

METHODS

1. Acquired data from UBCFS and conducted ingredient audit
2. Interviewed 3 stakeholders to understand ingredient substitution feasibility
3. Collected data on pesticide & fertilizer use, climate impact and nutritional value to form comparison framework

INGREDIENT AUDIT RESULTS

- Garlic (1): used in **136** menu items
- Onion (2): used in **114** menu items
- Cilantro (3): used in **92** menu items

Additional Ingredient Categories

- Top 10 Used Ingredients at Open Kitchen (Frequency)
- Top 5 GHG Emitters
- Top 3 Most Frequently Used Grains

18 key ingredients

Analyzed >100 ingredients

Ingredient Comparative Framework (ICF)

Categories

- **Nutiriton** — Measured: Ingredient Menu Prevalence
- **Climate** — Measured: Emissions, Nitrogen, Water & Land Use
- **Biodiversity** — Measured: Pesticide & Fertilizer Usage

Recommendations:

Future Iniatives:

Short term (<1 year):

1. Increase ingredient diversity on OK's menu by adding 5 new ingredients:
   a. Opt for ingredients that use less pesticide and herbicide usage
   b. Choose ingredients with a lower climate impact
2. Procure 5 Seasonal Ingredients Locally - UBCFS Culinary Team

Mid-Term (1-2 years):

1. Create a Labeling/Ranking system for BFA - UBC SEEDS Team

Long term:

1. Re-evaluate CAP 2030 goals and CFFS Procurement Guidelines to specify biodiversity factors - UBC CAP 2030 Stakeholders

Alternatives

Current Ingredients:	Recommended Alternatives:
Brown Rice	Barley
Penne Pasta	Spaghetti Squash
Cilantro	Celery Leaves
Oats	Buckwheat Groats
Lime/ Lemon Juice	Apple Cider Vinegar

Future Research

1. Pesticide and fertilizer usage impact for biodiversity
2. Water usage
3. Farming practices

Practitioner Summary

This century has seen the accelerated deterioration of the environment, climate, and agricultural and species diversity. These complications are interconnected, as damages to biodiversity are linked with a heavy reliance on the same few crops (e.g. monocultures) on a local and global level (Secretariat of the Convention on Biological Diversity, 2012; Durazzo, 2019). In British Columbia, recent effects from climate change have also gravely impacted local food supply chains, highlighting the importance of creating a resilient food system that simultaneously minimizes greenhouse gas (GHG) emissions. The interrelationship between species diversity, the environment, and climate highlight the importance of applying a systems-based approach to our aim of enhancing biodiversity and nutrition at UBC.

As a result of growing concerns about these environmental problems, especially among youth who stand to be most affected, many actions are being initiated around the world to raise the quality of our ecosystems and diets while reducing GHG emissions. At the University of British Columbia (UBC) Vancouver, food systems already contribute to over 21% of GHG emissions on campus and over 31% for extended/indirect emissions related to commutes, business air travel, embodied carbon, waste, paper, and other materials/processes (UBC, 2021). Therefore, according to the Campus Action Plan (CAP) 2030, UBC is working through multiple strategies – such as creating Climate-Friendly Food System (CFFS) Procurement Guidelines and a Food Resilience and Climate Action Strategy – to reduce its emissions by 85% by 2030 (UBC, 2021).

To support UBC in achieving these strategies, this project assessed the current ingredient variability within Open Kitchen (OK), a UBC first-year residence dining hall, and provided a data analysis of viable ingredient substitutions to enhance ingredient diversity, diet quality, and food system sustainability. The substitutes recommended prioritized foods that are grown in ways that prioritize food system sustainability, reduction of GHG emissions as well as water and land use footprint, human health, and a wider variety of food options for UBC's diverse population.

By working with UBC Food Services (UBCFS), UBC CFFS Action Team, the CAP 2030 team, and the Social Ecological Economic Development Studies (SEEDS) Sustainability Program, this project seeks to contribute to a resilient food system within UBC Vancouver by conducting a Community-Based Action Research (CBAR) project. CBAR principles are important to this project as we conducted interviews with UBCFS staff recognizing them as "equal partners in identifying the problem to be investigated, undertaking the research itself, developing and implementing the intervention, and measuring the outcomes" (Gullion & Tilton, 2020), which ensures that the changes we suggest are sustainable and achievable for UBCFS.

We first collected data from UBCFS regarding menu items and ingredients used in OK. We focused our data collection efforts on a single food provider (OK) to streamline the process of identifying and analyzing information, allowing us to have more comprehensive insights and specific data analyses. Based on our findings and informed by interviews conducted with culinary staff, data was analyzed to identify the ten most commonly used ingredients, the 5 largest GHG emitters, and the top 3 most commonly used grains that can be replaced to promote biodiversity conservation, sustainable food systems, and nutritious diets for the UBC community.

Our project outcomes include [1] an Ingredient Comparative Framework (ICF) of the commonly used ingredients in OK menus and [2] a Biodiverse Menu and Procurement Strategy with food menu alternatives and other project-related recommendations for the UBCFS. Based on our findings, we recommend that [1] in the short term, the OK menu can be diversified by incorporating ingredients we found to have low biodiversity and climate impact and/or can be easily substituted in the menu (e.g. grains) and [2] in the long term, the ICF can be continually used as a reference for UBC food menu choices in the coming years. We hope our study informs the creation of future procurement strategies within UBC that support the environment/biodiversity and nutrition of communities. By basing our methodologies on CBAR principles, we collaborated to understand the perspectives of key stakeholders, ensuring any proposed suggestions are sustainable and community-generated.

Executive Summary

Food biodiversity is the absolute number of species present in a diet or food supply, and has steadily decreased in the recent century (Hanley-Cook et al., 2022). A new report supported by the United Nations Environment Programme (UNEP, 2021) has identified the global food system as the primary driver of biodiversity loss. For instance, only nine out of the 6000 plant species cultivated or foraged for food comprise 66% of the total global crop production (Secretariat of the CBD, n.d.; FAO, 2019). As the trend of food biodiversity loss impacts diet quality, climate risk, and ecosystem services (Durazzo, 2019), the report calls for the reform of food systems. This reformation would require changing global dietary patterns, preserving land for nature, farming in a way that supports biodiversity, and reducing carbon emissions (UNEP, 2021).

One of the ways to improve food biodiversity is through diversifying diets by adding to the number and amount of vegetables, fruits, animal-source foods, and other food groups to the diet (Fanzo et al., 2019). Within the University of British Columbia (UBC) Vancouver, this project utilized an integrated approach in the form of a Community-Based Action Research (CBAR) toward a just and resilient campus-wide food system. In collaboration with UBC Food Services (UBCFS), UBC Climate-Friendly Food System (CFFS) Action Team, the Climate Action Plan (CAP) 2030 team, and the Social Ecological Economic Development Studies (SEEDS) Sustainability Program, this initiative aligns with the CFFS Action Team and its Draft Procurement Strategy target to “develop and implement mandatory campus-wide Climate-Friendly Food System Procurement Guidelines applicable to all food providers” (UBC, 2021). To further the goal of sustainability, this metric should take into account and prioritize purchases from biodiverse and regenerative food systems.

This project provided UBCFS with insight to increase the diversity of food ingredients in Open Kitchen (OK), a first-year residence dining hall. Our project aims to support biodiversity conservation and GHG emission reduction on a local and global scale by providing diverse, nutritious, and more plant-based options for students and staff on campus. Dietary (bio)diversity is an important component in promoting human health, as well as the productivity, resiliency, and long-term sustainability of food systems and the environment as a whole (Isbell et al., 2015).

By collaborating with UBCFS, we aimed to promote greater diversity in food procurement strategies through data analysis of OK’s food ingredients and a literature review. Data was provided by the UBCFS team containing ingredient lists of all the menu items at OK, as well as data on ingredients, prices, and retailers. This data was tabulated to find the 10 most commonly used ingredients, the top 3 most commonly used grains, and the top 5 GHG emitters in OK. Secondary data was obtained from a literature review to select evidence-based recommendations that aim to increase ingredient richness. Our literature review also defined biodiversity within the context of our project, and identified and evaluated any similar projects in the past. Thereafter, we conducted our primary research through interviews with the UBCFS team, procurement staff, and other individuals working in large kitchens to understand their perspectives relevant to the project and to determine common themes and critical points. We found that this project was extremely novel in quantifying biodiversity through pesticide and fertilizer use. Further, we presented several possible alternatives for each of the 18 ingredients in addition to providing measures of ecological harm that we investigated presenting the data into an easy-to-navigate table.

The primary research results were chosen to shape the research process, validate our comparative framework, and compared with our secondary research to validate the feasibility of the 18 chosen ingredients and their ability to leave lasting positive impacts on OK’S food use. Project deliverables consist, firstly, of an Ingredient Comparative Framework (ICF) that collates information on the common ingredients in the OK food menus. Secondly, a Food Diversity Action Plan synthesized the research results on food menu alternatives, as well as other recommended actions for the UBCFS based on the project findings.

This project found that there are ingredients that OK can implement to support biodiversity and climate based on menu prevalence, pesticide and fertilizer usage, and climate. For immediate actions, we recommend barley, spaghetti squash, celery leaves, buckwheat groats, apple cider vinegar to be added into the menu, especially grain products as these may be more easily substituted than the frequently used ingredients. Future plans for this project include annually implementing the ICF or biodiversity factors into procurement strategies of food distributors at UBC. Biodiversity factors that can be explored in future projects include the impacts of pesticide and fertilizer, water usage, and farming practices.

TABLE OF CONTENTS

List of Figures

Link to Ingredient Comparative Framework Google Spreadsheet:
https://docs.google.com/spreadsheets/d/1OQeyA6xg367emmdEAdpnD2slOvq5qhW5uqgBDz04VZs/edit?usp=sharing

List of abbreviations

BFA: Biodiversity for Food and Agriculture

BMaPS: Biodiverse Menu and Procurement Strategy

BASF: Badische Anilin und Sodafabrik

CAP 2030: The Climate Action Plan 2030 is

CBAR: Community-Based Action Research

CFFS: Climate-Friendly Food System

FIB: Food Ingredient Biodiversity

GHG: Greenhouse Gas

ICF: Ingredient Comparative Framework

OECD: Organization for Economic Co-operation and Development

OK: Open Kitchen

SEEDS: Social Ecological Economic Development Studies

UBC: University of British Columbia

UBCFS: University of British Columbia Food Service

WA: Weighted Average

1. Introduction

1.1 Research topic

Biodiversity refers to the variety of life at the genetic, species, and ecosystems level. For this project, we are focusing on "*biodiversity for food and agriculture*" (BFA), which refers to the biodiversity that contributes to food systems (FAO, 2019). This definition includes the variety of domesticated and wild plants and animals that humans directly harvest and consume, in addition to the "*associated biodiversity*" that encompasses a wide range of organisms living around food production systems and supporting these systems' growth and productivity (FAO, 2019). To narrow our research, we studied the biodiversity of food within UBCFS, which we will refer to as "*Food Ingredient Biodiversity*" (FIB), or the number of individual ingredients within a menu. In this regard, altering food consumption in UBCFS food outlets by increasing FIB has the potential of benefitting both BFA and nutrition.

Currently, the global food system is experiencing a food diversity crisis, becoming more and more homogenized; this has negative effects on human health because of intensive agricultural practices and reduced nutritional value among monoculture crops (Nicholson et al., 2021). The global food system is one of the biggest drivers of ecological biodiversity loss in ecosystems today (FAO, 2019). Reductions to ecological biodiversity further result in the loss of the associated biodiversity that agricultural systems need to remain productive, which highlights the importance of creating a more biodiverse, sustainable, and resilient food system.

There is also a lack of emphasis on food-related biodiversity in both menu planning and procurement strategies. This presents an opportunity for UBC to further promote greater food system sustainability through the implementation of more climate-friendly, biodiverse food service menus.

1.2 Research relevance

There has been about a 70% reduction in food supply variation between countries around the world over the past 50 years (Hanley-Cook et al., 2022). The increased homogenization of diets throughout the globe presents a threat to food biodiversity, which is defined as "'the diversity of plants, animals, and other organisms used for food, both cultivated and from the wild'" (Hanley-Cook et al., 2022). Agricultural practices used within the food system, such as monocropping and animal agriculture, influence biodiversity loss through "habitat loss, degradation, and encroachment" (Hanley-Cook et al., 2022). Loss in species diversity is not only a concern for planetary health but also influences human nutrition as well as the sustainability of the food system (Lachat et al., 2017).

The industrialized food system nowadays is not only a contributor to biodiversity loss but is also a known driver of climate change (Fanzo et al., 2018). However, the relationship between food and climate change is bi-directional in that climate change places further stress on the food system through precipitation changes, higher temperatures, and increased chances of extreme weather events. (Fanzo et al., 2018). The result of these changes is lower crop yields leading to reduced food availability and increased food prices. The impacts of climate change highlight the need for greater food system sustainability. BFA has been identified as a means of improving food system resilience in comparison to monocultures, which are more prone to crop failure and food shortages if the single crop being cultivated is exposed to diseases, pathogens, and other climate/ecological factors (Johns et al., 2013; Lachat et al., 2017).

Biodiversity loss and reduced food availability due to climate change also pose a threat to human nutrition. Diet species richness, or the "count of the number of different species consumed per day" is associated with high diet quality and nutritional adequacy (Lachat et al., 2017). Diet trends towards the increased consumption of processed foods and decreased food richness have come as an outcome of dominant food system practices, which may lead to health implications (Lachat et al., 2017). On a global scale, lower access to diverse food is a concern, potentially contributing to poor nutritional status among people and risks of illness, undernutrition, and child stunting (Fanzo et al., 2018). On a university level, the UBC FoodHub (n.d.) reports that research consistently shows that 30-40% of UBC students are facing food insecurity (i.e. not having a secure source of nutritious food). The consequences of climate change and biodiversity loss highlight the importance of creating greater food system sustainability to protect both human and planetary health.

Given this, diversifying food sources can provide nutritious varieties and alternatives to ubiquitous foods, most of which are unsustainably grown in monocultures and industrial factories (Durazzo, 2019). Within the UBC community, supporting biodiversity helps to work towards improved student nutrition, exposure to different ingredients, the inclusion of different cultural needs, and meeting the Climate Action Plan (CAP) 2030 target to reduce food system GHG emissions by 50% (UBC, 2021). Currently at UBC, CFFS Procurement Guidelines do not place a large emphasis on biodiversity loss (UBC, 2021). Widespread plans to reform and manage food systems are commonly based on climate action but have been incomplete without considering biodiversity loss as it is a measure of ecological stability, indicating possibility for improvements.

1.3 Project context

UBC has pledged to significantly reduce greenhouse gas emissions from both Vancouver and Okanagan campuses by 2030. Actions to reduce emissions are outlined in UBC's CAP 2030, aiming to reduce overall emissions by 85% by 2030. Within the Vancouver campus, the food system contributes to "over 21% of UBC's emissions and 31% of GHG emissions for extended emissions (UBC, n.d.a). Extended emissions are the emissions occurring from activities that are not fully controlled by UBC, and can be reduced directly and indirectly through changes in policies, procurement strategies, and other behaviors on campus. In order to reduce extended emissions, UBC has set a target to achieve a 50% reduction in food systems emissions by 2030 (UBC, 2021).

One of the methods UBC hopes to enact to reduce its food system emissions is changing its approach to food procurement and consumption (UBC, 2021). Our project then coincides with UBC CAP 2030 and UBCFS goals by assessing the ingredient variability (or FIB) within the UBC dining hall Open Kitchen (OK) and providing a research-based analysis of viable ingredient substitutions to increase ingredient diversity. Open Kitchen, one of three student dining halls, currently serves around 3,000 meals a day, thus UBC has a large opportunity to create change and promote greater food system sustainability (UBC, n.d.a). Previous student research has already helped achieve some of CAP 2030's food system actions to "advanc[e] climate-friendly foods'' – or food that "generates less GHG emissions, water, and nitrogen per 100 grams of food produced than the other items on the menu" on campus – through projects like "Climate-Friendly Food Labeling" (Huang, 2022; UBC, n.d.a). The aims of these previous LFS 450 projects was to categorize menu items within UBCFS outlets based on climatic impact via GHG emissions, nitrogen loss, and water usage. Biodiversity, however, has not been factored in with regards to UBCFS menu planning, in addition to procurement strategies.

Moreover, UBCFS' mission statement includes the provision of nutritious food to students which can be done through increasing dietary diversity (UBCFS, 2022). Dietary diversity, which is "measured through the number of food groups and the number of nutritious vegetables, fruits, and animal source foods (ASF) consumed", is associated with greater diet quality and nutritional adequacy (Lachat et al., 2017). Achieving greater ingredient diversity at the UBC campus works to satisfy UBCFS' mission to provide a "diverse selection of fresh, healthy, delicious, and memorable food experiences" (UBCFS, 2022). Lastly, actions to address climate and nutritional issues on campus are also interlinked with preserving biodiversity conservation, thereby allowing us to target all three of these focal points of our research project through ingredient assessment.

1.4 Project purpose, goals and objectives

RESEARCH PURPOSE

To increase the diversity of food ingredients within Open Kitchen or OK (a UBCFS first-year residence dining hall) to support biodiversity conservation enhancement and student nutrition.

RESEARCH GOALS

To assess current food ingredient diversity within UBFCS OK and inform future menu planning and procurement, thereby promoting greater FIB, nutrition enhancement, and food sustainability.

RESEARCH OBJECTIVES

- To conduct a data analysis to identify target ingredients for substitution on OK's 2022-2023 menu.
- To provide 5 alternatives to each of the 10 most frequently used ingredients, 5 highest GHG emitters, and 3 most commonly used grains on OK's 2022-2023 menu, and apply an Ingredient Comparative Framework (ICF) looking at measures that signal impact on climate, biodiversity, and menu diversity (FIB) to determine which ones are likely the best for the environment and biodiversity conservation.
- To inform future procurement strategies and menu planning carried out by UBC by establishing goals and actions that aim to support biodiversity, climate, and human health.

2. Methodology and methods

2.1 Research methodology

Principles drawn from Community-Based Action Research (CBAR) informed and guided the methodology for our project. This methodology involved exploring issues on a smaller scale within a community (Gullion & Tilton, 2020). CBAR emphasizes community involvement throughout the entire research process and views community members as "equal partners in identifying the problem to be investigated, undertaking the research itself, developing and implementing the intervention, and measuring the outcomes" (Gullion & Tilton, 2020). Thus, we worked to engage in open communication and to collaborate with our clients by keeping them informed and involved in our research progress. We accomplished this by sending our clients bi-weekly emails containing project updates and seeking feedback upon reaching key milestones including: completion of our project proposal, completion of our ingredient analysis, a summary of our interviews, and our main findings from our literature review. Subsequently, we conducted primary research in the form of semi-structured interviews with the UBCFS team, seeing that we understand and integrate the perspectives shared by these key stakeholders.

Primary data, completed in the form of semi-structured interviews and meetings, played an instrumental role in how we applied CBAR principles and our secondary data collection approach. This project occurred between January 2023 and April 2023, our primary data was collected in the second week of March, with advertising commencing the week prior. Ongoing discussions with our clients and UBCFS stakeholders involved in food and climate policy (i.e. primary data) aided the decision as to which ingredients we would analyze utilizing our ICF (i.e. secondary data). Feedback was further sought out from key stakeholders to discuss ways to improve our comparative framework as well as areas of future research to build off of our data findings. Once the final collection of our secondary data was complete, final meetings were held with our clients to brainstorm how our findings could be applied within UBCFS to best promote food ingredient diversity and student nutrition.

The utilization of mixed research methods and emphasis on CBAR principles, allowed us to provide insight and offer appropriate strategies that best support biodiversity enhancement efforts within the UBC community. Discussions with our clients and other key stakeholders was vital in creating community-generated solutions that are sustainable for UBCFS. We provided insight to inform interventions implemented by UBCFS to promote food biodiversity in their procurement strategies and enhance student nutrition on the UBC campus.

2.2 Research methods

We took a mixed methods approach to our research process to meet project aims and provide well evidenced recommendations. Secondary research was conducted through analysis of Open Kitchen menu data, a literature review, and formulation of our Ingredient Comparison Framework (ICF). Primary research was collected in the form of semi-structured interviews with varying backgrounds to gain insight on our ICF approach and ensure suitability of provided alternatives. These interviews also deepened our understanding of menu creation processes and informed factors analyzed in our ICF.

2.2.1 Secondary data collection research methods

Our secondary data review spanned three stages: 1) an initial review and assessment of the different ingredients and menu items used by UBCFS at Open Kitchen (OK) during the academic school year (August 2022 - April 2023), 2) a literature review of peer-reviewed articles relating to biodiversity, and 3) the formulation and analysis of our Ingredient Comparison Framework (ICF).

2.2.1a Stage 1: Menu Ingredient Analysis at Open Kitchen

The first objective of our secondary data collection was to analyze the present diversity of food items procured at OK and to identify its 10 most frequently used ingredients according to how frequently the ingredients appear on the menu. Food ingredient diversity was assessed through menu frequency or the amount of times an individual ingredient was present on the Open Kitchen menu. We later expanded this list to include a total of 18 ingredients based on interview findings regarding UBCFS menu conduction and concerns in replacing fundamental ingredients. Current menu diversity was based on how many menu items a single ingredient could be found in. Information gathered in this preliminary stage was used to propose opportunities to introduce menu alternatives for each of the target ingredients that better support both biodiversity and student nutrition. To compute food ingredient diversity within OK, menu item data was taken from the 2022/2023 Nutrislice database, an online platform allowing students to view dining hall menu offerings. The dataset from Nutrislice allowed us to conduct an ingredient audit of the 621 ingredients (Spreadsheet Tab “Frequency Ordered”) used at OK on the 2022/2023 menu. A shortlist of the 50 most frequently used ingredients can be seen in Appendix A.

2.2.1B Stage 2: Literature Review

The objective of conducting a literature review was to ensure our suggested alternatives help to meet the UBC CAP 2030 goal to "achieve a 50% reduction in food systems emissions by 2030" and inform the creation of CFFS Procurement Guidelines for more sustainable consumption patterns on campus (UBC, 2021). We developed specific criteria through a review of 11 peer-reviewed articles and reports from global organizations. The papers were chosen based on their applicability to the Canadian context and to define key terms such as food ingredient biodiversity (FIB), nutrition, and biodiversity conservation and enhancement in both local and global ecosystems. All of these definitions aided us in creating a conceptual model to compare and contrast ingredients and alternatives using chosen indicators. The comparative framework helped to ensure that the suggested ingredient alternatives meet the project purpose of increasing ingredient diversity and biodiversity. An additional section was later added to this model containing constraint factors (e.g. price, supplier) to ascertain the substitutions we suggest are viable options.

2.2.1C Stage 3: Ingredient Comparison Framework (ICF) analysis

We designed our conceptual framework for ingredient diversity management and to inform efforts towards greater sustainability and biodiversity conservation through menu planning. The Ingredient Comparison Framework (ICF) was used as a standard to organize and analyze data on the different ingredients and alternatives. The ICF focused on 3 aspects: biodiversity, nutrition, and climate (Tables 1A-2C). Data regarding biodiversity was acquired through the use of proxies and the Cool Food Calculator to estimate land use and inputs used to grow each food item as these variables are likely causes of biodiversity loss. For climate stability, we looked into the climatic impact/climate footprint of growing one pound of the food item. Lastly, for nutrition, we measured each food item's prevalence in the Open Kitchen menu to see which foods could possibly expand menu FIB.

Specifically looking at biodiversity, we examined the average amount of land used as well as the percentage of the land area treated with fertilizer and pesticide for each food item. Although this excludes other complex factors influencing BFA, focusing on land and the correlated chemical land inputs related to food is essential. Findings indicated that land use change is the biggest driver of biodiversity loss, thus explaining why land use change is one of the most accepted indicators of biodiversity loss inside and outside the context of food/agriculture (FAO, 2019; UNEP, 2021). Consequently, both land and the percent of cropland that is "changed" or treated with inputs per ingredient were expected to be sufficient proxies for biodiversity (LFS 450 Interviews Group 3, 2023). We retrieved the most recent data on fertilizer and pesticide use for each ingredient from the US Department of Agriculture's National Agricultural Statistics Service as this was the most comprehensive, certified database on agricultural chemical usage that is accessible online (USDA NASS, 2023).

Tables 1A-1C. ICF Categories

Table 1A. Drivers for biodiversity loss

Category	Unit
LAND USE	
Active total land use	hectares per kg food item
FERTILIZER USE	
Nitrogen	average % of total land area treated with each type of fertilizer (per food item)
Phosphorus	
Potash (Potassium)	
Sulfur	
PESTICIDE USE	
Fungicide	average % of total land area treated with each type of pesticide (per food item)
Herbicide	
Insecticide	

Table 1B. Drivers for climate change

Category	Unit
LAND USE	
Active total land use	hectares per kg food item
CARBON FOOTPRINT	
Active total supply chain emissions	kg CO2 per kg food item
NITROGEN FOOTPRINT	
N footprint	g of N lost per kg food item
WATER FOOTPRINT	
Stress-weighted water use	L per functional unit of food item

Table 1C. Nutritional diversity (FIB)

Category	Unit
MENU OCCURRENCE	
Relative abundance of the food item in the OK menu	% in menu dishes

To reiterate the value of measuring the climate impact of different foods, climate change is known to lead to biodiversity loss, making climate-friendly foods more beneficial alternatives in regard to food biodiversity and sustainability. Data for the land use and climate footprint of ingredients was based on the Cool Food Calculator, which was similarly applied in past LFS 450 projects centered around climate-friendly foods (Waite, Vennard, & Pozzi, 2019). For nutrition, calorie data was initially collected, but considering that the top 10 ingredients are all plant-based foods (Table 3A), we found that this data was not impactful due to the low quantities that these foods would be present in a final dish. Thus to analyze nutrition, we used OK menu occurrence, or the amount of dishes containing a single ingredient is found in, to quantify FIB and dietary diversity.

With the aid of the aforementioned secondary sources and databases, we created the ICF to analyze our targeted ingredients (18 in total, see Tables 3A-3C) in addition to the 5 suggested alternatives per ingredient. This totaled more than a hundred food items within our analysis. Thereafter, using the comparative analysis allowed us to select the possible best replacements according to each ICF aspect (Tables 4A-4C/Spreadsheet Tabs "Top Used Ingredient Alts", "5 GHG Alts", "Grain Alts").

2.2.2 Primary data collection research methods

Our primary data collection was executed through one-on-one semi-structured interviews with key community stakeholders. The objectives of these interviews were to gain insight into OK operations, receive feedback on our ICF, and discuss the implications of our subsequent findings. All meetings were conducted virtually via Zoom, each lasting 30-45 minutes in length. We aimed to seek out three interviewees with various areas of expertise and chose to meet with: Darren Clay, Gloria Sun, and Juan Diego Martinez. In order to suggest alternatives to UBCFS, it was important for our group to understand the current menu planning process at OK, which is why we sought out insight from Darren Clay, the Executive Sous Chef at Open Kitchen. To gain a deeper understanding of how nutrition is factored into menu planning, we met with our client, Gloria Sun, given her role as Manager of Nutrition and Wellbeing with UBCFS. Lastly, a vital factor in creating our framework was deciding how to define and quantify biodiversity within the scope of UBCFS. Our client, Georgia Stanley, recommended we seek out the insight of Juan Diego Martinez who works with SEEDS Sustainability Program, Sustainability & Engineering in the role of Climate Action and Food Systems Applied Research Coordinator. All three interviewees reviewed our ICF prior to the meeting and offered thoughts and opinions based on their respective fields. With Darren Clay and Gloria Sun, the suitability of alternatives was also discussed. These interviews opened the opportunity to present and discuss our current findings in addition to receiving outside perspectives on how to improve our ICF. These semi-structured interviews played an important role in shaping our research process and the critiques provided were used in determining categories of exploration for our ICF.

2.3 Methods of Administration

Selected interviewees were contacted directly via email and asked to participate in the interviews (Appendix F). Included in each email were a when2meet link, our ICF spreadsheet, and a document containing interview questions (Appendix E). After a meeting time was chosen, a follow-up email was sent containing the interview Zoom link. Given that the project was focused on identifying the impact different ingredients had on BFA and FIB, we chose stakeholders that could best help us understand the present-day UBC food system. Interviews were conducted one-on-one with each stakeholder to allow us to ask specific questions pertaining to each interviewee's discipline. A semi-structured format allowed for a more natural conversation that allowed space for elaboration of answers and brainstorming of the implications of our data. The number of people interviewed was intentionally kept small, owing to the limited amount of time available to conduct secondary research prior to the interview discussions. Our interviews ensured that this project provided transferable outputs to UBCFS that could inform future menu planning and procurement. Below is a list of Zoom interviews conducted and the respective dates:

Table 2. Stakeholder Interviews

Date Interviewed	Interviewee
March 30th	Darren Clay
March 7th & April 5th	Gloria Sun
April 12th	Juan Diego Martinez

3. Results

3.1 Primary data findings

3.1.1 Menu Planning at Open Kitchen

To help inform our alternative selection process, we interviewed Darren Clay and Gloria Sun to gain a deeper understanding of how menu planning is currently conducted at OK. While there are many considerations taken into account in menu planning, responses from both interviewees indicated an emphasis on creating a menu that is "50-60% plant-based". Increasing plant-based offerings on OK's menu is based on both the environmental and health benefits of greater consumption of plant-based foods (LFS 450 Group 3 Interviews, 2023). Many factors considered by Open Kitchen work towards promoting sustainability including: food GHG emissions, sustainable seafood, and supporting local suppliers like the UBC Farm. Other aspects that are taken into account in menu planning are cost, incorporation of cultural dishes, and allergies (LFS 450 Group 3 Interviews, 2023). An important finding from these discussions is that menu diversity is currently measured by the number of dishes served at Open Kitchen as opposed to ingredient diversity (LFS 450 Group 3 Interviews, 2023). These findings highlight the complexities of menu planning but demonstrate UBCFS' values for food system sustainability and health.

3.1.2 Increasing Open Kitchen (OK) Food Ingredient Biodiversity (FIB)

Each interviewee offered comments on Ingredient Comparative Framework in addition to the suitability of alternatives. In all three of these discussions, it was noted by each interviewee that commonly used ingredients, like garlic and onions, are unlikely to be replaced to increase menu food ingredient biodiversity given that they are fundamental flavor enhancers. However, animal products were identified as foods that may be more easily replaceable as this aligns with UBCFS's emphasis on a plant-forward menu. Further, Darren identified that commonly used grains at Open Kitchen provide an opportunity to increase FIB at Open Kitchen as these are more easily replaceable than flavor enhancers (LFS 450 Group 3 Interviews, 2023). The interviewees highlight that increasing FIB at Open Kitchen should focus on nutritious plant-based foods with a focus on replacing animal and grain products in addition to ingredients that are simple to work with from a culinary perspective.

3.1.3 Quantifying Biodiversity

To increase our understanding of the ways in which biodiversity can be quantified and discuss areas of improvement in our selected approach, we interviewed Juan Diego Martinez. Juan emphasized the complexity of measuring biodiversity, indicating that there are many factors that can be used to determine biodiversity loss including: land use change, number of species, production practice, and farm yields (LFS 450 Group 3 Interviews, 2023). Obtaining information on production practices and yields from suppliers is valuable information however measuring biodiversity in this way can be challenging as there is currently no consensus on the best production practice. Another limitation to collecting detailed information on production is that certain management practices may also be costly and contribute to environmental impact. Juan noted, however, that our approach of quantifying biodiversity through fertilizer and pesticide inputs is a good first step to measuring biodiversity since it hasn't been done previously (LFS 450 Group 3 Interviews, 2023). However, the ability to apply these measures to CFFS guidelines is contingent upon whether areas of data collection correspond to where food is acquired for UBC. Our interview with Juan highlighted that the concept of biodiversity is nuanced and as such, measuring it must take into account many different factors.

3.1.4 Barriers to Increasing FIB

When discussing the suitability of our alternatives with interviewees, current barriers to increasing FIB were raised in these discussions. One barrier, identified by both Darren and Gloria, is student food choice and student receptiveness to new ingredients (LFS 450 Group 3 Interviews, 2023). Currently, UBCFS is taking action to increase sustainability and lower its GHG emissions through actions such as providing more plant-based options and reducing the presence of certain animal products on its menus. For example, the frequency at which chicken fingers are served at OK has been reduced to only one day per week (LFS 450 Group 3 Interviews, 2023).

Another barrier to increasing FIB that was identified by all interviewees is the cost of proposed alternatives (LFS 450 Group 3 Interviews, 2023).

3.2 Secondary data findings

3.2.1 Literature review

We conducted a literature review to explore ways in which biodiversity can be defined and draw connections between biodiversity conservation and human health. This led to the review of 11 peer-reviewed scholarly articles as well as Food and Agriculture Organization (FAO), Organization for Economic Co-operation and Development (OECD), and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) reports covering methods of quantifying biodiversity in addition to linking biodiversity to other global concerns like climate change and global nutrition. Our literature review highlighted the complex role of biodiversity in protecting environmental and human health. This review also identified many ways in which ecological biodiversity could be measured including: land use change, farming inputs, water use, nitrogen use, and GHG emissions. Findings also uncovered ways in which agricultural biodiversity can influence nutrition and how biodiversity may be quantified within one's diet through assessing diet diversity.

Measuring Biodiversity

Firstly, we corroborated our assumptions/axioms on how land and sea use change, like harvesting natural resources, urban development, and agricultural intensification, has the largest effect on biodiversity. According to the IPBES (2019), direct exploitation of organisms, climate change, pollution, and invasive non-native species were identified as other major causes of biodiversity loss (in decreasing order). While this emphasizes the urgent need to measure biodiversity throughout agricultural fields and other environments in a practical and transferable manner, it is widely recognized in conservation research and related disciplines that biodiversity as a metric/indicator may not be fully quantifiable or generalizable as it is dependent on many emergent and dynamic factors. Therefore, a better understanding of biodiversity loss/impact of certain foods or organisms requires looking at the holistic ecological picture of the ecosystem, where it lives or grows, as well as the local and global interactions/ movements occurring within this system and with other systems (IPBES, 2019; Hanley-Cook et al., 2022; Ulrich et al., 2020).

In terms of BFA, literature on land use change is also tied into concepts and approaches on how intensive agricultural cultivation practices will be. Land sparing and land sharing are two different approaches to land use that have significant impacts on biodiversity. Land sparing involves dedicating some areas of land exclusively to intensive agriculture or other human uses while setting aside other areas for conservation purposes (Fanzo et al., 2018; Law & Wilson, 2015). This approach seeks to maximize food production on a smaller land area, allowing more land to be left untouched for pristine natural ecosystems. Alternatively, land sharing involves integrating conservation measures into agricultural practices, allowing wildlife to coexist with human activities in the same areas (Fanzo et al., 2018; Law & Wilson, 2015). This approach seeks to maintain biodiversity while still using the land for food production. Research has shown that land sparing could be more effective in preserving natural ecosystems and wildlife biodiversity by preventing the encroachment of agricultural land into pristine habitats (Phalan et al., 2011). However, land sharing can also have positive impacts on biodiversity, particularly in landscapes that are already highly fragmented (Lamb et al., 2016). However, land intensification has led to a decrease in the diversity of the average food that people eat (Fanzo et al., 2018). Ultimately, while the consensus on which farming approach is superior for BFA conservation is unclear, the context in which these strategies are utilized is important to consider in research that quantifies the biodiversity impact of crops grown in varying methods and from varying sources, such as this project.

Another approach taken by researchers to measure agricultural/food biodiversity beyond land use change is through a robust assessment of the sustainability of an agricultural product/process, namely through economic, social, and environmental dimensions (Ulrich et al., 2020). Under the Badische Anilin und Sodafabrik (BASF) organization, Ulrich and fellow colleagues (2020) created the Biodiversity Calculator to 'close the gap' wherein impact of agriculture on biodiversity could not be previously measured. As of December 2020, Ulrich et al. are still in the process of validating the Biodiversity Calculator with "real data…to check whether [its] results match the actual changes on farm[s]" (para. 4).

Given the limited time and resources in this project that restrained us from investigating the UBCFS suppliers' farm biodiversity/ecosystems, we initially encountered a fundamental problem in going about our data gathering and analysis. In response, we decided to address another gap in biodiversity data that is relatively unexplored in the literature by looking into different crops' pesticide and fertilizer usage in the US on average (USDA, 2023). We choose this data collection method due to its novelty, applicability to our project, and accessibility online. Overall, the literature shows that it is extremely useful and practical to measure biodiversity to some extent, but it is also important to acknowledge the simultaneous and context-specific effects of multiple biodiversity factors, which may not be fully reflected if biodiversity is merely represented through scales or numbers. This is why it is crucial to supplement biodiversity indices with a thoughtful and scientifically informed analysis/discussion of the results, which is what is practiced throughout the literature as well as in this report.

Measuring Climate Change

Climate change also directly affects biodiversity and agricultural practices with respect to the significant use of water, carbon, and nitrogen for crop production. High GHG emissions throughout agricultural production, from machinery to transportation, are exacerbating climate change effects and species extinctions (Habibullah et al., 2021). Nitrogen fertilizer losses into the surrounding ecosystems is a concern especially for delicate aquatic ecosystems where eutrophication takes place and negatively affects biodiversity (Yousaf et al., 2021). Water use in agriculture can lead to the depletion of aquifers and reservoirs and alter habitats (Henle et al., 2008; Sabli et al., 2017). The specific impacts of these agricultural practices on biodiversity can vary depending on local environmental conditions and farming practices.

Measuring food ingredient biodiversity (FIB)

BFA also has implications on human health, specifically diet diversity. Diet diversity, which is measured as "the number of food groups and the number of nutritious vegetables, fruits, and animal source foods (ASF) consumed" is an indicator of adequate nutrition, thus making it important to individual health (Fanzo et al., 2018). Reduced biodiversity in agriculture can then negatively impact not only the environment but also the health of the global population. Current practices of agricultural intensification can cause harm to biodiversity and have shown to be unsuccessful in addressing global nutrition, with between 720 and 811 million experiencing hunger in 2020 (Fischer et al., 2017; FAO, 2021). Enhancing crop diversity then plays a role in promoting greater food system sustainability which is important to maintaining long-term access to nutrient-dense foods. Reports from the OECD, have also highlighted that agricultural inputs, such as fertilizer and pesticide use, can impact both biodiversity and health leading to recommendations for more sustainable approaches (Sud, 2020). This is a promising development in biodiversity and health research (vis-à-vis food and nutrition), which influenced our project's framework and can similarly enrich future studies on biodiversity as well.

3.2.1 Open Kitchen Menu Data

Based on feedback from primary research, we identified the following within Open Kitchen: top 10 most commonly used ingredients based on frequency, 5 ingredients with the highest GHG emissions, and the top 3 most frequently used grains (see Tables 3A-3C). The project set out initially to determine the most commonly used ingredients at Open Kitchen, however it was found that all of these ingredients were plant-based foods with the majority of them being flavour enhancers. When presented to our interviewees, each of them commented on the fundamentality of these ingredients to many of the Open Kitchen menu items making them challenging to replace. Considering this input, we then determined the ingredients at Open Kitchen with the highest GHG emitters. We found that the greatest GHG emitters were primarily animal-based products (Table 3B), thus providing alternatives to them would support UBCFS's emphasis on promoting greater plant consumption as well as sustainability efforts. Finally, our interview with Darren Clay led to the inclusion of the top 3 most used grains as he indicated these foods are easily substituted, providing greater opportunity to enhance FIB at Open Kitchen (LFS 450 Group 3 Interviews, 2023). As a result, we ended up including 18 total ingredients to analyze and provide alternatives to. Salt and pepper were found to be the most frequently used ingredients at OK however were not included in our final 18 ingredients given their necessary culinary purpose in enhancing flavour. Raw data on the most frequently used ingredients can be found in Appendix A.

Tables 3A-3C. Final list of ingredients assessed under the Ingredient Comparative Framework (ICF), along with the number of times each ingredient appears in the OK 2022/2023 menu (Google spreadsheet "Top Ingredient" Tab)

Table 3A. Ingredients Audit Results

Top 10 ingredients (Frequency)		
	Ingredients	Frequency
1	garlic	136
2	onion (red, yellow, reg)	114
3	cilantro	92
4	tomato	86
5	sugar	81
6	lemon juice	68
7	green onion	66
8	ginger	57
9	lime juice	56
10	bell pepper (red, yellow, green)	52

Table 3B. Top GHG Emissions

Top 5 GHG Ingredients		
	Ingredients	Frequency
1	beef	20
2	cheese	123
3	pork	14
4	chicken breast / chicken	16
5	canola oil	153

Table 3C. Top 3 Grains

Top 3 Most Frequent Grains		
	Ingredients	Frequency
1	Brown Rice	35
2	Oats	8
3	Penne Pasta	7

3.2.2 ICF Results

The synthesized results based on the ICF are seen in Tables 4A-4C, which included analyzing and comparing biodiversity, climate, and nutrition data for the 18 ingredients along with each of their 5 alternatives. These results were calculated by averaging the values computed within each ICF category (see Appendix B-D for a compilation of raw data values per ingredient). A Weighted Average (WA) was created to help us determine ideal menu replacements. The WA was developed by assigning the most weight to biodiversity (0.3), followed by an equal weight assigned to menu occurrence and climate impact (0.15 each). The rationale for assigning the most weight to biodiversity is to underscore the impact and importance of novel biodiversity loss drivers (i.e. fertilizer and pesticide use) with respect to the scope of our research. After contrasting the data values among each other, the alternative(s) with the "lowest values" (i.e. lowest impact on biodiversity and climate, and had the lowest occurrence in the OK menu) were determined and chosen as the "winner" per category. For example, we assumed that lower fertilizer and pesticide use % on land in a product is less harmful to biodiversity and that products using less cropland (i.e. less land use) can preserve more natural land for biodiversity. Looking specifically at biodiversity, the data collected from the USDA NASS (2023) pesticide and herbicide usage have withheld data indicated by "D" (to not disclose data on agricultural operations) while in some cases, there is no data listed at all which is indicated by "-" on the ICF. As a result, those options were excluded and not compared within their respective categories.

Table 4A. Results of the recommended food alternatives for the top 10 most frequently used ingredients

Top 10 ingredients (Frequency)	Alternative with the lowest...				
	Fertilizer use %	Pesticide use %	Climate impact	Menu occurrence	Recommended choice
Garlic	Fennel	Garlic scapes	Celeriac	Celeriac, Garlic scapes	**Celeriac, Garlic scapes**
Onion (Red, Yellow, Regular)	Fennel	Celery	Ramps, Welsh onion, Shallots	Ramps, Welsh onion	**Ramps, Welsh onion**
Cilantro	Cilantro, Parsley, Thai basil, Caraway, Oregano	Celery leaves	Celery leaves	Celery leaves, Thai basil	**Celery leaves**
Tomato	Tamarind paste	Carrots	Mango, Tomatillo	Tomatillo, Pumpkin puree	**Tomatillo**
Sugar	Agave syrup, Maple syrup, Molasses blackstrap, Sugar	Applesauce (unsweetened)	Dates	Agave syrup, Applesauce, (unsweetened) Molasses blackstrap	**Applesauce (unsweetened)**
Lemon Juice	Apple cider vinegar	Vinegar	Apple cider vinegar	Cream of tartar, Grapefruit juice	**Apple cider vinegar**
Green Onion	Chives, Ramps, Welsh onion	Celery	Chives, Green onion, Ramps, Welsh onion	Ramps, Welsh onion, Wild garlic	**Chives, Ramps, Welsh onion**
Ginger	All equal	Missing data	All equal	Galangal, Mace	**Galangal, Mace**
Lime Juice	Apple cider vinegar	Vinegar	Apple cider vinegar	Grapefruit juice	**Apple cider vinegar**
Bell Pepper (Red, Yellow and Green)	All equal	All equal	All equal	Anaheim pepper, Banana peppers, Pimento	**Anaheim pepper, Banana peppers, Pimento**

Table 4B. Results of the recommended food alternatives for the top 5 GHG emitters

Top 5 ingredients with high GHG emissions	Alternative with the lowest...				
	Fertilizer use %	Pesticide use %	Climate impact	Menu occurrence	Recommended choice
Beef	Textured vegetable protein	Black beans, Lentils	Black beans, Lentils	B'ef Tips, Beyond Burgers, Textured vegetable protein	**Black beans, Lentils, Textured vegetable protein**
Cheese	Daiya Shreds	Missing info	Daiya Cheddar Style Sauce, Daiya Shreds, Daiya Slices	Daiya Slices, Daiya Shreds, Daiya Cheddar Style Sauce, Follow Your Heart Shreds, Vegan cheese sauce recipe	**Daiya Shreds**
Chicken Breast	Tofu, Tempeh	Seitan (vital wheat gluten)	Seitan (vital wheat gluten)	Gardein chicken strips, Seitan (vital wheat gluten), Yves Veggie Chick'n Nuggets	**Seitan (vital wheat gluten)**
Pork	Tofu	Seitan (vital wheat gluten)	Jackfruit	Gardein Sweet and Sour P'rk Bites, Gusta Sausage, Seitan	**All equal**
Canola oil	Sunflower oil	Olive oil	Sunflower Oil	Avocado oil, Grapeseed oil, Safflower oil	**Sunflower oil**

Table 4C. Results of the recommended food alternatives for the top 3 most used grains

Top 3 most frequently used grains	Alternative with the lowest...				
	Fertilizer use %	Pesticide use %	Climate impact	Menu occurrence	Recommended choice
Brown Rice	Couscous	Barley	Barley	Barley, Couscous, Farro, Wild rice	**Barley**
Penne Pasta	Chickapea Pasta	Spaghetti Squash	Spaghetti Squash	Brown rice pasta, Chickpea Pasta, Kamut Pasta, Lentil Pasta, Spaghetti Squash	**Spaghetti Squash**
Oats	Buckwheat Groats	Wheat Bran	Amaranth, Buckwheat Groats, Millet, Quinoa,	Amaranth, Buckwheat Groats, Millet, Wheat Bran	**Buckwheat Groats, Wheat Bran**

4. Discussion

4.1 Ingredient Comparison Framework (ICF)

Based on the alternatives' data, we found that there is definitely room for improvement in enhancing UBC dining halls' FIB/diet diversity, which is currently not being measured at UBC and OK (e.g. UBC currently measures FIB in terms of "menu dish diversity" rather than ingredient diversity). Our suggested alternatives have the potential to be 'better' substitutes for the target ingredients, as the majority of alternatives show improvements in biodiversity/climate categories (Appendix C-D). However, there were some data outliers due to variability in values among the ingredients and their corresponding alternatives, but it was beyond our scope to find patterns among the ingredient data.

Nevertheless, the ICF developed for UBCFS is a novel approach to quantifying biodiversity that takes into account various factors such as climate data, pesticide and herbicide usage, and FIB/ingredient diversity. This framework allows for a more comprehensive and inclusive approach to biodiversity measurement, which can help identify areas where improvements can be made in terms of sustainability and environmental impact.

The project introduced a new potential method for UBCFS to choose ingredient alternatives, which meets the need of CFFS procurement guidelines and promotes biodiversity. The ICF would allow for this data to be more easily compared as there is currently no database that compares all 3 factors (biodiversity, climate, and ingredient diversity).

4.1.1 ICF - Biodiversity: Pesticide and Fertilizer Data

The data collected from the USDA NASS (2023) pesticide and herbicide usage was chosen as a proxy because of the relevance that pesticides and herbicides have on the environment surrounding and lowering biodiversity (FAO, 2019). It was found that certain foods require more inputs than others, but there were no significant trends between the average amount of land use and the average % of land area treated with fertilizer vs. pesticides. In other words, based on our observations and estimates, there was no significant correlation between ingredients/alternatives with low fertilizer use %, low pesticide use %, and low land use. The biggest complication that we encountered when assessing the biodiversity component was the unequal availability of land use and land input data across different ingredients (e.g. missing data represented as "D" or "-").

Unsurprisingly, our findings varied as farmers may be balancing between tradeoffs of using a high amount of land (i.e. large land use change) with a low amount of chemicals vs. a low amount of land with a high amount of chemicals (i.e. intensive agriculture) (LFS 450 Group 3 Interviews, 2023). Results from our interview with Martinez, as well as the literature, discussed the complicated and context-based debate regarding biodiversity preservation which raises the question: “What is the best way to conserve biodiverse ecosystems (e.g. in agriculture or nature) – through a single large undisturbed land or several small lands (i.e. the “single land or several small” or SLOSS debate)?” (Isabell et al., 2015; LFS 450 Group 3 Interviews, 2023). Through the same logic, our ICF findings provide more quantifiable information on estimated degrees to which ingredients are using up more land or are chemically treating land more severely than other ingredients; this can then help UBCFS and other food providers to visualize actual values and prioritize the “less harmful” ingredients (Isabell et al., 2015). For example, looking at the numerical findings for garlic (Appendices B-D), celeriac may be a good example of using high relative amounts of fertilizer (100% of N fertilizer treatment on celeriac cropland) and pesticide (70% of insecticide treatment on celeriac cropland) but lower relative land use (9.9 hectares per kg of celeriac harvested). On the other hand, while garlic scapes were suggested as another good alternative due to its more ideal values, compared to celeriac (92% of N fertilizer treatment on garlic scapes cropland and 63% of insecticide treatment on garlic scapes cropland), it uses up significantly more land (81.3 hectares per kg of garlic scapes harvested). These specific values greatly aid menu planning and procurement strategies, as purchasers may then prioritize using celeriac over garlic scapes because of how much more greatly garlic scapes contribute to land use change in comparison to how much celeriac contributes to chemical use on land.

4.1.2 ICF - Climate: Cool Food Calculator

The climate section also experienced a similar drawback in data availability, wherein several ingredients were classified under broad categories, resulting in them sometimes having the same values. An example of this could be bell pepper and its alternatives, which were all categorized under the "other vegetables" category provided by the Cool Food Calculator (Waite et al., 2019). These oversights hinder the validity of the climate-based substitutions. Conversely, we decided to place more emphasis (i.e. more weight on the weighted average) on pesticide and fertilizer use as indicators for biodiversity loss instead. While there were shortcomings in both the ‘biodiversity’ and ‘climate’ data that was analyzed, focusing on the ‘biodiversity’ aspect allowed us to explore the novel approach of pesticide and fertilizer use analysis, thereby bringing newer knowledge into the discipline of biodiversity/BFA and evaluating whether such knowledge is actually actionable.

4.1.3 ICF - Ingredient Diversity

Ingredient diversity at Open Kitchen was measured through both conducting an Ingredient Audit and assessing the amount of times an individual appeared on the menu. To begin to collect this data, all of the ingredients used in dishes at OK were initially recorded, then later consolidated to exclude pre-made ingredients, such as fish sauce or pasta. By focusing on individual ingredients that OK actively uses and can directly control within their own kitchen and menu plan, results from our ingredient audit can be translated into actionable items that aim to promote FIB.

The Ingredient Audit (Appendix A) provided information on ingredients with the greatest "menu occurrence" or that are present in the largest number of menu items. However, the findings on canola oil and salt and pepper were removed in the formation of Table 1A. This is due to the fact that salt and pepper are ingredients that are vital for their culinary standpoint and have no feasible alternatives. Canola oil also posed to be difficult to replace due to its low price point and versatility in a large kitchen like OK. Furthermore, they were removed from the frequency audit due to conversations with stakeholder groups. However, canola oil was later added back due to its large GHG emissions. The ingredient audit was vital to understand the inner workings of OK and allowed for menu prevalence to be calculated.

Menu diversity is a relevant indicator due to the fact that the greater diversity in a person's diet is correlated to higher nutritional adequacy and quality (Lachat et al., 2017). While calorie data was initially collected, discussions with our client, Gloria, highlighted that it is difficult to compare plant-based foods to one another and distinguish a "best option" based solely on this data. Thus, looking at the amount of dishes that an ingredient can be found in with OK's menu provided a novel approach to quantifying both diversity and nutrition at OK. Applying ICF findings, alternatives that do not occur on OK's menu provide an opportunity to introduce new ingredients to student diets and work towards increasing FIB. For example, we found that alternatives for brown rice like farro, barely, and wild rice all do not occur on the OK menu and could provide a starting point for achieving greater FIB at OK. Emphasizing FIB at UBC also aligns with biodiversity conservation efforts, as both support agricultural ecosystems/agroecosystems and climate mitigation.

4.2 ICF Application

Overall, the project has important implications for the food industry, as it promotes a more sustainable and environmentally friendly approach to food procurement at UBC and consumption. By considering various factors beyond just ingredient usage, the comparison framework developed in this project provides a more holistic view of biodiversity that can inform policy and decision-making at a larger scale.

Biodiversity within food systems is difficult to measure and even more difficult to generalize as farming practices are the more important determinant of biodiversity. Chemical inputs, such as pesticides and herbicides as well as fertilizers, have been shown to have unintended consequences on the surrounding ecosystems, such as lowering insect numbers or causing eutrophication in waterways, which negatively impact biodiversity. To add on to the reasons why we are measuring climate impact, climate change is known to lead to biodiversity loss, and climate-friendly foods would be beneficial in that regard.

The ICF is used as an overview to compare the various measures of the environmental impact of different ingredients. The framework compiles information on the estimated amount of fertilizers and pesticides used to grow the ingredient as well as the climatic footprints (carbon, nitrogen, and water) of using such an ingredient. Additionally, there exists information about whether the ingredient can be produced locally and the nutritional data (FAOSTAT, 2023; Ministry of Agriculture and Food, 2023). By using the framework and searching the ingredients someone can get a sense of the alternatives that exist and compare the different indicators to pick the most biodiverse-friendly option. The framework, however, does not currently combine the different indicators into a single value that can be determined as the best instead it gives the user several different measures all at once that can be then weighted to meet the user's priorities that align with their goals. Nonetheless by examining these various factors, such as pesticide and fertilizer usage, we aim to expand current approaches for viewing and assessing biodiverse, sustainable foods.

4.3 Limitations

While we highlighted the importance of promoting both ecological and dietary diversity, there are limitations and barriers to increasing menu diversity. Some of these barriers include the feasibility or accessibility of replacing some of the ingredients, especially the most frequently used ones, due to their superior taste, and consumer acceptance, or the possible difficulty of finding alternative ingredient suppliers. Implementing new ingredients may also be costly if suggested alternatives cost more than the ingredient they are replacing, for example, barley is more expensive than brown rice. Further, as identified in our primary research conduction, UBCFS cannot control student diet choices, whereby students may still prefer non-biodiversity-friendly options.

The study design was also not without limitations. Firstly, we chose to use proxies to fill in data for some ingredients where data did not exist online, potentially affecting the accuracy and applicability of this data. Biodiversity was especially challenging and quite improbable to quantify directly, as varying farming methods and other dynamic environmental conditions across geographical regions can result in different biodiversity outcomes in the same crop, so only indirect and generalized measurements can be realistically used. Climate data also faced limitations as some alternatives were not present on the Cool Foods Calculator causing them to be placed in an “others” category. Next, the different measurement categories made it difficult to unify ingredient effects, with some foods excelling in one category but falling short in another. Lastly, some alternatives, while helping to promote biodiversity, may not be directly applicable in a culinary sense.

5. Recommendations

Following the outcomes of our project, we have established a set of guidelines called the Biodiverse Menu and Procurement Strategy (BMaPS) that UBCFS can take to promote biodiversity and climate in their menu and procurement strategies. These guidelines are classified into short-term (changes that can be implemented before the new school year/yearly menu plan) and mid-term (1-2 years) and long-term (2 years and longer) categories, aiming to facilitate more immediate and specific modifications in food procurement and institutional and broader initiatives. Additionally, we suggested some research areas that can be explored in future projects, which we were not able to address in our study.

Short term:

1. Increase ingredient diversity by adding at least 5 different ingredients into their menu at OK that:

a. Support biodiversity through choosing ingredients that use less pesticide and herbicide usage

b. Support biodiversity through choosing ingredients with a lower climate impact

c. Increase Ingredient diversity by adding new ingredients to OK's menu

2. Procure 5 Seasonal Ingredients Locally - UBCFS Culinary Team

Mid-Term:

1. Create a Labeling/Ranking system for BFA - UBC SEEDS Team

Long term:

1. Improve the CAP 2030 goals and CFFS Procurement Guidelines, specifying biodiversity factors - UBC CAP 2030 Stakeholders

Opportunities for Future Research

1. Pesticide and fertilizer usage impact for biodiversity

2. Water usage

3. Farming practices

5.1 Recommendations for action short term

We have designed a framework that can be used to help with understanding the effects of each individual ingredient as it allows for an analysis that has not occurred at UBC before. These are recommendations that can occur using the current framework and the provided examples.

5.1.1 Increase FIB by adding at least 5 different ingredients into the OK menu

As shown in Table 2 we suggest the Open Kitchen Culinary Team increase their ingredient diversity by adding at least 5 different ingredients into their 2023-2024 menu. From the findings of the ICF we suggest the following 5 ingredients in Figure 1 to be added into OK menu as when compared to their alternatives as they follow the following principles:

a. Support biodiversity through choosing ingredients that use less pesticide and herbicide usage

b. Support biodiversity through choosing ingredients that have a lower climate impact

c. Increase Ingredient diversity by adding new ingredients to OK's menu

Figure 1: Recommended Ingredients

1. Brown Rice ---> Barley	2. Penne Pasta → Spaghetti Squash	3. Cilantro---> Celery Leaves	4. Oats→ Buckwheat Groats	5. Lime / Lemon Juice → Apple cider vinegar
• Does not appear in current menu • Lower inputs in climate section compared to other alternatives • Uses less pesticides & fertilizers	• Does not appear in current menu • Lower inputs in climate section compared to other alternatives • Uses less pesticides	• Does not appear in current menu • Lower inputs in climate section compared to other alternatives • Uses less pesticides	• Does not appear in current menu • Lower inputs in climate section compared to other alternatives • Uses less fertilizers	• Lower inputs in climate section compared to other alternatives • Uses less fertilizers

We suggest creating a menu item around these items or using these ingredients as alternatives or as an addition to their original ingredient. However, these items may not be a good alternative due to other factors such as price, availability, and consumer preference. These factors could be potentially incorporated into future comparative frameworks/formulas via customizing or adding to the weighted average formulas for the biodiversity factors.

5.1.2 Procure 5 Seasonal Ingredients Locally - UBCFS Culinary Team

We recommend that UBCFS prioritize local suppliers, local food systems, and local production methods which are assumed to have less carbon, nitrogen, and water footprint due to fewer local emissions associated with less transportation and energy use as well as higher food system resilience when compared to global processes (Cho, 2012). Procuring from local farmers provides the opportunity to build strong relations with suppliers and gain a better understanding of the production practices being used. However, it is important to note that local food production can tend to cost more than their globalized counterparts and do not always have significantly lower biodiversity loss/environmental impacts (e.g. due to variability among local food system processes) (Cho, 2012). Given this, we recommend that UBCFS implement a more robust evaluation and selection process of the best local and seasonal items. This could include checking beforehand that the suppliers of the selected items actually cause relatively lower biodiversity/environmental/health risks than the current UBCFS food suppliers. Particularly, prioritizing the usage of seasonal items in UBCFS dining hall menus throughout the academic year is found to be a potentially beneficial approach in promoting BFA and ecological/diet sustainability via prioritization of in-season vs. processed or GMO products (Macdiarmid, 2014). Thus, we recommend adding 5 seasonal ingredients from local farmers to the menu at OK in the following school year as a realistic way to promote BFA. UBCFS can then better contribute to preserving sustainable agriculture and the biodiversity conservation of agroecosystems (Durazzo, 2019).

5.2 Recommendations for action long term

5.2.1 Create a Labeling/Ranking System for BFA - UBC SEEDS team

While this project was conducted for OK, we suggest first refining the framework (e.g. customizing according to dining halls' priorities and capacity to address factors in the framework) and then labeling and ranking all ingredients for all UBC dining halls and kitchens. UBC SEEDS can help organize the project and follow our system collecting and consolidating the BFA-related data to be replicated with other dining halls. Afterwards, in order for data to become available to students and consumers of UBC foods there will need to be more processing and condensation of the data and simpler measurements. Eventually, we would recommend additional icons added to the menu, like the Climate Friendly Labeling Project, to build more consumer awareness of their impacts on biodiversity.

5.2.2 Improve CAP 2030 Goals and CFFS Procurement Guidelines, Specifying Biodiversity Factors - UBC CAP 2030 Stakeholders

We hope that UBC will put a larger emphasis on BFA within its CAP 2030 goals and CFFS policy. Currently, biodiversity is vaguely defined and mainly measured through land use loss or changes, and defining this factor – particularly vis-à-vis BFA – will allow more concrete actions to be taken. Implementing these changes to increase ingredient diversity is important as these small changes in our diets can have large impacts on our environment.

5.3 Opportunities for Future Research

Biodiversity as a concept is broad and complex. Given the many ways in which biodiversity can be quantified, the current project and comparison framework is only a starting point. There are many concepts that need to be looked into to gain a better understanding of the effects of the ingredients used by UBCFS on biodiversity. There is currently no readily available database that takes land use changes and pesticide, fertilizer, and water usage to calculate the effects on biodiversity. With the creation of our framework, UBCFS has the foundations for creating BFA procurement guidelines in order to enrich UBCFS Procurement and Culinary strategies while aligning with Campus + Community Planning (via CBAR) and CAP 2030 policies (UBC, 2021).

5.3.1A Fertilizer and Pesticide Usage on Biodiversity - UBC SEEDS Team

As fertilizers and pesticides have been found to have a high impact on biodiversity and the ecosystems surrounding and within farms, conducting research specifically looking into the most commonly used fertilizers and pesticides in addition to the amount that would cause the least environmental impact could be beneficial in aiding UBCFS. This research would also allow for a ranking system to be created, which can be used to help streamline the process of quantifying and evaluating the biodiversity/ climate/nutritional impacts of food items.

5.3.1B Water Usage - UBCFS Procurement Team

Water usage is another important factor to consider when working to improve environmental sustainability and support biodiversity. The amount of water used in agriculture and food production can have detrimental effects on ecosystems, soil quality, and the availability of freshwater resources (Morison et al., 2008). Excessive water usage can lead to soil erosion, depletion of groundwater resources, and increased water pollution, all of which can have a cascading effect on biodiversity (FAO, 2019). Further, reducing water usage in agriculture and food production can have significant benefits beyond just environmental conservation. It can also lead to increased efficiency, improved crop yields, and reduced costs for farmers and producers (Morison et al., 2008).

Considering the impacts of water usage in agriculture, further research should be done on gathering data on the water usage impacts in areas where purchased ingredients are grown. Specifically, ingredients we suggest to be targeted include brown rice, oats, and olive oil, which are all water intensive crops, based on the Cool Foods Calculator (Appendix C). Locating ingredients and understanding their impacts on their local environment is essential for mitigating the negative effects of water usage on biodiversity. As UBCFS has the purchasing power that affects the global scope. Conducting research to gain a better understanding of where ingredients are farmed can aid the UBCFS Procurement team in procurement choices. We hope that from this research there can be a larger emphasis on choosing products that are grown in locations that have greater water accessibility to reduce the associated environmental impacts of water usage on the environment. The process of incorporating farm water usage into supplier selection criteria could include identifying and sourcing ingredients from regions with adequate water supply or utilizing alternative farming practices, such as rainwater harvesting and drip irrigation, that minimize water usage (Morison et al., 2008). Implementing data on farm locations and impacts of water usage to their geographical location should be added to the ICF as it will contribute to the promotion of more sustainable and environmentally friendly practices used in the food industry that bring benefit to the environment, biodiversity, and ultimately society.

5.3.2 Farming Practices - UBCFS Procurement Team

Farming practices play a critical role in shaping the biodiversity and the environmental impact of food production. In recent years, there has been increasing attention on promoting sustainable farming practices that reduce the negative impacts of agriculture on the environment. These practices include the use of natural fertilizers, crop rotation, conservation tillage, and integrated pest management. By implementing more sustainable farming practices, farmers can improve soil quality, reduce water usage, prevent soil erosion, and limit the use of harmful pesticides and fertilizers that can pollute waterways and negatively impact biodiversity (Zhang et al., 2022).

There is no conclusive consensus on whether use of intensive practice on smaller farm areas versus utilizing less intensive practice on larger farmland is better (LFS 450 Group 3 Interviews, 2023). Intensive farming discourages dietary diversity which is defined as “the number of food groups and the amount of nutritious vegetables, fruits, and animals consumed” (Fanzo et al., 2018). "Further, sustainable farming practices can also have economic benefits for farmers and the food industry as a whole. By reducing costs associated with synthetic fertilizers and pesticides, promoting crop diversification, and improving soil health (Bakker et al, 2020). Acquiring information on farming practices can be done by connecting with farmers directly and could present an opportunity to collaborate with more food system stakeholders to determine ways to further promote food system sustainability. Given the impact that production practices have on biodiversity, the UBCFS Procurement team can aim to increase the amount of produce that is bought directly from farmers to support farms that use sustainable farming practices (ie. agroecosystems) that promote biodiversity.

Overall, promoting sustainable production practices is crucial for maintaining biodiversity, reducing the environmental impact of agriculture, and supporting a more sustainable food system. Thus, a future action that can be taken by the UBCFS Procurement team is to create criteria for sustainable farming practices that consider factors such as water usage and locality. Once these criteria are established, the UBCFS Procurement team can then look into farms that satisfy identified standards to purchase ingredients from.

6. Conclusion

UBC has set the ambitious goal to reduce GHG emissions from food systems by 50% as part of CAP 2030 (UBC, 2021). Further, within CAP 2030, UBC also aims to promote more climate-friendly procurement strategies. Biodiversity in food and agriculture plays a fundamental role in achieving both of these goals as increasing biodiversity helps to achieve greater food system sustainability. Promoting food system sustainability also ties into the UBCFS Vision of providing nutritious food to all guests (UBCFS, 2022). In Open Kitchen alone, UBCFS serves around 3000 meals per day highlighting their potential to make a significant impact in promoting greater food sustainability (UBC, n.d.b). Incorporating new and climate-friendly ingredients into dining hall menus is one way to achieve both of these targets. To help UBC meet these goals, our project aimed to assess food ingredient diversity within Open Kitchen and indicate ways to increase diversity within this dining hall. Through the creation of an ICF, we analyzed the top most frequently used ingredients, top 5 GHG emitters, and top 3 frequently used grains through measures of biodiversity, climate, and nutrition impact as indicated in Tables 1A-1C. We then provided 5 climate-friendly alternatives to each of these ingredients to increase food ingredient biodiversity within Open Kitchen. In the short term, we recommend implementing more grain products given that these are more easily substituted than the top 10 most frequently used ingredients. In the long term, we suggest UBCFS utilize our framework while working to implement new ingredients within Open Kitchen's menu each year. Our framework can also help to inform climate-friendly procurement strategies given that it takes a novel approach in quantifying biodiversity through fertilizer and pesticide use which is not currently being used by UBC. Further research into fertilizer and pesticide usage, water usage, and farming practices can also be done to further UBC's impact and explore more ways to enhance food system sustainability.

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Appendices

Appendix A : Ingredient audit of the most to least commonly used and procured ingredients in the OK 2022-2023 menu (Tab Top Ingredients)

Raw data (frequency)		
	Ingredients	Amount
1	salt and pepper	182
2	canola oil	153
3	garlic	136
4	salt	120
5	cilantro	92
6	tomato	86
7	sugar	81
8	lemon juice	68
9	green onion	66
10	ginger	57
11	lime juice	56
12	red onion	53
13	jalapeno	51
14	onion	44
15	parsley	43
16	olive oil	42
17	gluten free soy sauce	38

Raw data (frequency)		
	Ingredients	Amount
18	red pepper	38
19	brown rice	35
20	carrots	35
21	arugula	34
22	butter	34
23	eggs (whole)	34
24	parmesan cheese	33
25	thyme	33
26	lettuce	32
27	avocado	30
28	mozzarella cheese	28
29	vinegar	28
30	black pepper	26
31	cheddar cheese	26
32	cucumber	25
33	corn starch	24
34	vanilla extract	24

Raw data (frequency)		
	Ingredients	Amount
35	vegetable stock	24
36	spinach	22
37	vegan mayonnaise	22
38	turmeric	21
39	water	21
40	corn	20
41	feta cheese	20
42	kale	20
43	lemon	20
44	shallots	20
45	spices	20
46	bay leaf	19
47	cinnamon	19
48	flatbread	19
49	whipped cream	19
50	milk	18

Appendix B: Nutrition Data table (Tab: Alphabetized Data)

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Agave Syrup	FALSE	0	0	0.00%	0	7129	310
Allspice	TRUE	2	2	0.56%	20	169	263
Amaranth	FALSE	0	0	0.00%	0	4409	372
Anaheim pepper	FALSE	0	0	0.00%	0	2322	40
Apple cider vinegar	TRUE	16	12	3.33%	81	13	22
Applesauce, Unsweetened	FALSE	0	0	0.00%	0	1700	42
Avocado Oil	FALSE	0	0	0.00%	0	450	126
B'ef Tips	FALSE	0	0	0.00%	0	N/A	165
Banana peppers	FALSE	0	0	0.00%	0	4857	27
Barley	FALSE	0	0	0.00%	#N/A	4485	354
Beef	TRUE	11	18	5.00%	318	2,698	317

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Bell peppers (red, green and yellow)	TRUE	52	52	**14.44%**	**663**	**2,484**	**31**
Beyond Burgers	FALSE	2	0	**0.00%**	**0**	**N/A**	**239**
Black beans	TRUE	**12**	11	**3.06%**	**216**	**3376**	**341**
Brown Rice	TRUE	35	37	**10.28%**	**543**	**4,422**	**362**
Brown rice pasta	FALSE	**0**	0	**0.00%**	**#N/A**	**N/A**	**382**
Buckwheat Groats	FALSE	**0**	0	**0.00%**	**#REF!**	**4412**	**346**
Canola oil	TRUE	153	128	**35.56%**	**1398**	**451**	**126**
Caraway	TRUE	**3**	3	**0.83%**	**36**	**173**	**333**
Carrots	TRUE	**35**	35	**9.72%**	**573**	**2380**	41
Celeriac	FALSE	**0**	0	**0.00%**	**0**	**2049**	**42**
Celery	TRUE	**12**	13	**3.61%**	**177**	**2386**	**16**
Celery Leaves	FALSE	**0**	0	**0.00%**	**0**	**2386**	**16**
Cheese	FALSE	#N/A	123	**34.17%**	**1439**	**119**	**406**
Chickapea pasta	FALSE	**0**	0	**0.00%**	**#N/A**	**N/A**	**350**

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Chicken Breast	TRUE	13	13	**3.61%**	**89**	**841**	**120**
Chives	TRUE	**5**	5	**1.39%**	**126**	**2059**	**30**
Cilantro	TRUE	**92**	**0**	**0.00%**	**734**	**2,067**	**23**
Couscous	TRUE	**2**	2	**0.56%**	**#N/A**	**4420**	**376**
Cream of Tartar	FALSE	**0**	0	**0.00%**	**0**	**4006**	**258**
Daiya Cheddar Style Sauce	FALSE	2	0	**0.00%**	**0**	**N/A**	**250**
Daiya Shreds	FALSE	0	0	**0.00%**	**0**	**N/A**	**267**
Daiya Slices	FALSE	0	0	**0.00%**	**0**	**N/A**	**273**
Dates	TRUE	**3**	3	**0.83%**	**10**	**1710**	**282**
Farro	FALSE	**0**	0	**0.00%**	**#N/A**	**N/A**	**362**
Fennel	TRUE	**2**	4	**1.11%**	**65**	**2305**	**31**
Follow Your Heart Shreds	FALSE	0	0	**0.00%**	**0**	**N/A**	**286**
Galangal	FALSE	**0**	0	**0.00%**	**0**	**N/A**	**71**
Gardein chicken strips	FALSE	0	0	**0.00%**	**0**	**N/A**	**144**

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Gardein Sweet and Sour P'rk Bites	FALSE	2	0	0.00%	0	N/A	150
Garlic	TRUE	136	129	35.83%	1640	2,394	149
Garlic Scapes	FALSE	0	0	0.00%	0	2394	149
Ginger	TRUE	57	56	15.56%	645	2,091	80
Grapefruit juice	FALSE	0	0	0.00%	0	6440	39
Grapeseed Oil	FALSE	0	0	0.00%	0	436	122
Green Onion	TRUE	66	64	17.78%	604	2,144	32
Gusta Sausage	FALSE	0	0	0.00%	0	N/A	250
Jackfruit	TRUE	1	1	0.28%	15	1581	95
Jalapeno	TRUE	51	41	11.39%	525	4860	29
Kamut Pasta	FALSE	0	0	0.00%	#N/A	N/A	382
Leeks	TRUE	2	2	0.56%	6	2,396	61
Lemon juice	TRUE	68	59	16.39%	835	1,589	22
Lemongrass	TRUE	4	4	1.11%	8	4853	99

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Lentil Pasta	FALSE	**0**	0	**0.00%**	**#N/A**	**N/A**	**334**
Lentils	TRUE	**3**	5	**1.39%**	**27**	**3392**	**352**
Lime Juice	TRUE	56	48	**13.33%**	**684**	**1594**	**25**
Mace	FALSE	**0**	0	**0.00%**	**0**	**190**	**475**
Mango	TRUE	**2**	6	**1.67%**	**106**	**1603**	**60**
Maple syrup	TRUE	**16**	17	**4.72%**	**62**	**4326**	**260**
Millet	FALSE	**0**	4	**1.11%**	**#REF!**	**4491**	**378**
Molasses Blackstrap	FALSE	**0**	0	**0.00%**	**0**	**4300**	**235**
Oats	FALSE	#REF!	**unknown**	**#VALUE!**	**243**	**4,421**	**389**
Olive Oil	TRUE	**42**	38	**10.56%**	**413**	**422**	**121**
Onion	TRUE	114	0	**0.00%**	**1459**	**2,401**	40
Orange juice	TRUE	**9**	9	**2.50%**	**105**	**1619**	**45**
Oregano	TRUE	**16**	16	**4.44%**	**144**	**195**	**265**
Parsley	TRUE	**43**	41	**11.39%**	**507**	**2405**	**36**

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Penne pasta	FALSE	7	0	0.00%	40	4,524	371
Pimento	FALSE	0	0	0.00%	0	2496	23
Poblano peppers	TRUE	2	2	0.56%	20	2322	40
Pork	TRUE	6	14	3.89%	187	6,119	221
Pumpkin puree	FALSE	0	0	0.00%	0	2192	34
Quinoa	TRUE	9	9	2.50%	172	4495	368
Ramps	FALSE	0	0	0.00%	0	N/A	30
Safflower Oil	FALSE	0	0	0.00%	0	432	122
Seitan	FALSE	0	0	0.00%	0	6591	370
Seitan (vital wheat gluten)	FALSE	0	0	0.00%	0	6591	370
Shallots	TRUE	20	20	5.56%	159	2326	72
Spaghetti Squash	FALSE	0	0	0.00%	#N/A	2458	31
sugar	TRUE	81	72	20.00%	996	4,318	387
Sunflower Oil	FALSE	0	1	0.28%	5	453	126

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Tamarind paste	TRUE	2	2	0.56%	0	1689	239
Tempeh	TRUE	3	3	0.83%	17	4986	197
Textured vegetable protein	FALSE	0	0	0.00%	0	N/A	360
Thai Basil	FALSE	0	0	0.00%	0	212	22
Tofu	TRUE	16	24	6.67%	348	3404	70
Tomatillo	FALSE	0	1	0.28%	107	2347	32
Tomato	TRUE	86	1	0.28%	1737	2,460	18
Turmeric	TRUE	21	22	6.11%	372	211	312
Vegan cheese sauce recipe	TRUE	0	0	0.00%	0	N/A	206
Vinegar	TRUE	28	26	7.22%	681	14	18
Welsh Onion	FALSE	0	0	0.00%	0	2145	34
Wheat Bran	FALSE	0	0	0.00%	0	4442	216
Wild garlic	FALSE	0	0	0.00%	0	2394	149
Wild rice	FALSE	0	0	0.00%	0	4449	357

Ingredient	Is it currently being used in OK?	Menu Occurrence	How many menu items contain it? (out of 360)	Prevalence (%) among all menu items	Amount it appears on the menu in a year	CNF #	Kcal per 100g
Yves Veggie Chick'n Nuggets	FALSE	2	0	**0.00%**	**0**	**N/A**	**243**

Appendix C: Climate Data table (Tab: Alphabetized Data)

Ingredient	Active Total Supply Chain Emissions (kg CO2 / kg food)	Nitrogen footprint (g N lost/ Kg of product	Water use (Litres/Functional Units)	Active total land use (hectares)
Agave Syrup	1.641	0	65.200	10.1
Allspice	9.370	6.75	220.300	24.9
Amaranth	1.479	5.9	10,563.300	677.1
Anaheim pepper	0.503	7.9	2,939.500	81.3
Apple cider vinegar	0.358	2.7	1,024.700	114.5
Applesauce, Unsweetened	0.358	2.7	1,024.700	114.5
Avocado Oil	3.151	0.2	4,937.72	67.5
B'ef Tips	1.91769	9.21	7408.114	225.08
Banana peppers	0.503	7.9	2,939.500	81.3
Barley	0.954	9.32	27.3	7.0
Beef	41.3463	329.5	61,309.000	1,677.200
Bell peppers (red, green and yellow)	0.5029	7.9	2,939.500	81.3
Beyond Burgers	1.93553	9.21	6423.29	211.86
Black beans	1.678	5.9	0.000	0.000
Brown Rice	2.5345	5.3	4,625.6	1,574.9
Brown rice pasta	1.479	5.9	10,563.3	677.1
Buckwheat Groats	1.479	5.9	10,563.300	677.1
Canola oil	3.2401	0.2	13.60	1.4
Caraway	9.370	6.75	220.3	24.9
Carrots	0.306	7.9	37.900	9.9

Ingredient	Active Total Supply Chain Emissions (kg CO2 / kg food)	Nitrogen footprint (g N lost/ Kg of product	Water use (Litres/Functional Units)	Active total land use (hectares)
Celeriac	0.306	7.9	37.9	9.9
Celery	0.503	7.9	2,939.500	81.3
Celery Leaves	0.503	7.9	2,939.5	81.3
Cheese	8.9104	93.3	80,463.100	1,559.300
Chickapea pasta	1.678	5.9	0.0	0.0
Chicken Breast	4.3996	116.8	333.500	370.3
Chives	0.302	7.9	57.000	1.9
Cilantro	9.3703	6.75	220.3	24.9
Couscous	1.523	14.8	12,821.7	419.2
Cream of Tartar	9.370	6.75	220.300	24.9
Daiya Cheddar Style Sauce	1.77395	2.6	2487.81	38.7
Daiya Shreds	1.77395	2.6	2487.81	38.7
Daiya Slices	1.77395	2.6	2508.01	35.05
Dates	0.431	2.7	4.700	3.5
Farro	1.523	14.8	12,821.7	419.2
Fennel	0.503	7.9	2,939.5	81.3
Follow Your Heart Shreds	2.51549	2.165	2576.46	47.2
Galangal	9.370	6.75	220.300	24.9
Gardein chicken strips	1.64	10.35	3,865.43	129.34
Gardein Sweet and Sour P'rk Bites	2.15363	5.97	2584.62	87.56
Garlic	0.5029	7.9	2,939.5	81.3

Ingredient	Active Total Supply Chain Emissions (kg CO2 / kg food)	Nitrogen footprint (g N lost/ Kg of product	Water use (Litres/Functional Units)	Active total land use (hectares)
Garlic Scapes	0.503	7.9	2,939.5	81.3
Ginger	9.3703	6.75	220.300	24.9
Grapefruit juice	0.394	2.7	1,345.500	37.4
Grapeseed Oil	3.151	0.2	4,937.72	67.5
Green Onion	0.3015	7.9	57.000	1.9
Gusta Sausage	1.8049	8	6619.87	232.92
Jackfruit	0.431	2.7	4.700	3.500
Jalapeno	0.503	7.9	2,939.500	81.3
Kamut Pasta	1.523	14.8	12,821.7	419.2
Leeks	0.302	7.9	57.0	1.9
Lemon juice	0.3942	2.7	1,345.500	37.4
Lemongrass	9.370	6.75	220.300	24.9
Lentil Pasta	1.678	5.9	0.0	0.0
Lentils	1.678	5.9	0.000	0.000
Lime Juice	0.3942	2.7	1,345.500	37.4
Mace	9.370	6.75	220.300	24.9
Mango	0.431	2.7	4.700	3.5
Maple syrup	1.641	0	65.200	10.1
Millet	1.479	5.9	10,563.300	677.1
Molasses Blackstrap	1.641	0	65.200	10.1
Oats	2.3017	6.75	24,456.300	670.3

Ingredient	Active Total Supply Chain Emissions (kg CO2 / kg food)	Nitrogen footprint (g N lost/ Kg of product	Water use (Litres/Functional Units)	Active total land use (hectares)
Olive Oil	5.638	0.2	24,395.70	317.9
Onion	0.3015	7.9	57.0	1.9
Orange juice	0.394	2.7	1,345.500	37.4
Oregano	9.370	6.75	220.3	24.9
Parsley	9.370	6.75	220.3	24.9
Penne pasta	1.5225	14.8	12,821.7	419.2
Pimento	0.503	7.9	2,939.500	81.3
Poblano peppers	0.503	7.9	2,939.500	81.3
Pork	9.8315	132.8	54,242.7	1,810.3
Pumpkin puree	0.503	7.9	2,939.500	81.3
Quinoa	1.479	5.9	10,563.3	677.1
Ramps	0.302	7.9	57.000	1.9
Safflower Oil	3.151	0.2	4,937.72	67.5
Seitan	1.523	14.8	12,821.7	419.2
Seitan (vital wheat gluten)	1.52	14.80	12,821.70	419.20
Shallots	0.302	7.9	57.0	1.9
Spaghetti Squash	0.503	7.9	2,939.5	81.3
sugar	1.6414	0	65.200	10.1
Sunflower Oil	3.023	0.2	236.70	10.2
Tamarind paste	9.370	6.75	220.300	24.9
Tempeh	1.75	5.90	32.40	6.60

Ingredient	Active Total Supply Chain Emissions (kg CO2 / kg food)	Nitrogen footprint (g N lost/ Kg of product	Water use (Litres/Functional Units)	Active total land use (hectares)
Textured vegetable protein	1.754	5.9	32.400	6.600
Thai Basil	9.370	6.75	220.3	24.9
Tofu	1.75	5.90	32.40	6.60
Tomatillo	0.431	2.7	4.700	3.5
Tomato	0.6932	7.9	4,480.700	77.0
Turmeric	9.370	6.75	220.300	24.9
Vegan cheese sauce recipe	1.99905	4.56	5044.57	120.56
Vinegar	0.954	9.32	27.300	7.0
Welsh Onion	0.302	7.9	57.000	1.9
Wheat Bran	1.523	14.8	12,821.700	419.2
Wild garlic	0.503	7.9	2,939.500	81.3
Wild rice	2.535	5.3	4,625.6	1,574.9
Yves Veggie Chick'n Nuggets	2.50	3.05	2,584.62	87.56

Appendix D: Ingredient Fertilizer and Pesticide Data (Tab: Alphabetized Data)

Ingredient	Fertilizer				Pesticides		
	Nitrogen	Phosphate	Potash	Sulfur	Fungicide	Herbicide	Insecticide
Agave Syrup	34.89				-	34.03	17.81
Allspice	60				-	55.2	41.04
Amaranth	94	94	-	-	85	57	87
Anaheim pepper	92	76	72	5	68	56	74
Apple cider vinegar	62	38	56	34	89	42	85
Applesauce, Unsweetened	62	38	56	34	89	42	85
Avocado Oil	77	54	67	28	3	44	48
B'ef Tips	70.96	66.13	36.90	31.93	28.17	86.79	24.08
Banana peppers	92	76	72	5	68	56	74
Barley	86	72	26	48	21	84	6
Beef	57.905				-	54.262	10.38
Bell peppers (red, green and yellow)	92	76	72	5	68	56	74
Beyond Burgers	70.85	66.01	36.78	31.81	-	89.96	16.28
Black beans	34.89				-	34.03	17.81
Brown Rice	92	74	54	22	23	96	18
Brown rice pasta	92	74	54	22	23	96	18
Buckwheat Groats	34.887				-	34.03	17.81
Canola oil	70.399				-	86.99	31.3767
Caraway	74.5655				-	76.9	65.56
Carrots	83	64	46	30	75	80	42

Ingredient	Fertilizer				Pesticides		
	Nitrogen	Phosphate	Potash	Sulfur	Fungicide	Herbicide	Insecticide
Celeriac	100				70	50	71
Celery	100				70	50	71
Celery Leaves	100	70	68	74	70	50	71
Cheese	63.54				-	57.93	22.17
Chickapea pasta	34.887				-	34.03	17.81
Chicken Breast	56.25				-	72.99	30.94
Chives	87.750				90	91	73
Cilantro	74.5655				-	76.9	65.56
Couscous	98	84	11	24	35	96	D
Cream of Tartar	82	29	69	D	95	64	66
Daiya Cheddar Style Sauce	52.76				-	57.33	32.40
Daiya Shreds	52.82				-	55.74	36.30
Daiya Slices	84.38	81.38	81.38	81.38	-	85.73	68.40
Dates	37	-	-	-	-	15	14
Farro	94.33	78.67	19.00	27.67	34.33	86.33	8.00
Fennel	83	64	46	30	75	80	42
Follow Your Heart Shreds	78.07	72.07	69.07	59.77	-	81.75	45.68
Galangal	60				-	55	41
Gardein chicken strips	58.38	58.68	41.78	28.88	-	92.30	18.68
Gardein Sweet and Sour P'rk Bites	55.99	57.85	46.92	33.15	-	92.36	21.01
Garlic	92.000				63	59	31

Ingredient	Fertilizer				Pesticides		
	Nitrogen	Phosphate	Potash	Sulfur	Fungicide	Herbicide	Insecticide
Garlic Scapes	92.000				63	59	31
Ginger	35				-	34.03	17.81
Grapefruit juice	72.000				57	50	69
Grapeseed Oil	82	29	69	D	95	64	66
Green Onion	100	100	100	-	-	52	63
Gusta Sausage	80.69	68.05	41.82	41.75	-	77.66	30.41
Jackfruit	72.00	D	39.00	-	-	86.00	41.00
Jalapeno	92.000	75.500	72	5	68	56	74
Kamut Pasta	74.5655				-	76.9	65.56
Leeks	88	73	54	53	90	91	73
Lemon juice	80	57	66	44	51	58	84
Lemongrass	60.40				-	55.2	41.04
Lentil Pasta	34.887				-	34.03	17.81
Lentils	34.89				-	34.03	17.81
Lime Juice	100	100	100	-	90	42	95
Mace	60.400				-	55.2	41.04
Mango	70.99				-	71.1	70.41
Maple syrup	35				-	34.03	17.81
Millet	89	58	10	21	-	89	9
Molasses Blackstrap	34.887				-	34.03	17.81
Oats	76	62	40	24	9	51	4

Ingredient	Fertilizer				Pesticides		
	Nitrogen	Phosphate	Potash	Sulfur	Fungicide	Herbicide	Insecticide
Olive Oil	71	22	57	D	37	34	39
Onion	87.75	73.25	53.5	53	90	91	73
Orange juice	39	64	74	38	49	79	89
Oregano	74.5655				-	76.9	65.56
Parsley	74.5655				-	76.9	65.56
Penne pasta	94.33	78.67	19.00	27.67	34.33	86.33	8.00
Pimento	92.000				68	56	74
Poblano peppers	92.00				68	56	74
Pork	67.6778				-	88.447	35.0254
Pumpkin puree	92.286	85.143	82	16	75	79	54
Quinoa	94	94	-	-	85	57	87
Ramps	88	73	54	53	90	91	73
Safflower Oil	70.399				-	86.99	31.38
Seitan	94.33	78.67	19.00	27.67	34.33	86.33	8.00
Seitan (vital wheat gluten)	94.33	78.67	19.00	27.67	34.33	86.33	8.00
Shallots	87.75	73.25	53.5	53	90	91	73
Spaghetti Squash	89	82	85	24	50	41	45
sugar	35				-	34.03	17.81
Sunflower Oil	90	43	8	-	-	95	33
Tamarind paste	34.89				-	34.03	17.81
Tempeh	32.00	42.00	44.00	13.00	22.00	98.00	20.00

Ingredient	Fertilizer				Pesticides		
	Nitrogen	Phosphate	Potash	Sulfur	Fungicide	Herbicide	Insecticide
Textured vegetable protein	32.00	42.00	44.00	13.00	22	98	20
Thai Basil	74.5655				-	76.9	65.56
Tofu	32.00	42.00	44.00	13.00	22.00	98.00	20.00
Tomatillo	99	73	49	-	83	65	88
Tomato	99	73	49	-	83	65	88
Turmeric	60.400				-	55	41
Vegan cheese sauce recipe	64.83	61.69	49.76	51.49	-	63.03	42.15
Vinegar	86.000	72.000	26	48	21	84	6
Welsh Onion	87.750	73.250	54	53	90	91	73
Wheat Bran	94.33	78.67	19.00	27.67	34.33	86.33	8.00
Wild garlic	92	46	3	-	63	59	31
Wild rice	92	74	54	22	23	96	18
Yves Veggie Chick'n Nuggets	55.99	57.85	46.92	33.15	-	92.36	21.01

Appendix E: Interview Questions & Answers

Interview Question	Response
How is menu planning conducted at Open Kitchen?	Darren: "Considerations taken into account when creating menus include: ● Making menus 50-60% plant-based or dishes that can be easily adapted to be plant-based ● Cost ● Cultural dishes ● Currently we don't look at ingredient diversity, however we measure diet diversity through the amount of dishes we serve and we never really considered "ingredient diversity" ● Food GHG emissions (ie. reducing beef) ● Sustainable seafood ● Supporting UBC Farm"
Are the alternatives applicable in a culinary sense?	Darren: No, not for seasonings. Honey has already been switched to maple syrup to make dishes vegan-friendly. We switched our garlic distributor to be more local: we used to source it from China but now it comes from California. We also only used peeled garlic." [With regards to top 5 GHG emitter alternatives]: "Guests still want animal proteins and it takes time to transition traditional protein to plant-based alternatives. Cheese alternatives work in the culinary sense however a concern is if guests will consume it as it has a different taste profile and has a lower chance of working in Open Kitchen. Open Kitchen this year switched to all access dining which means that students can come in and eat whatever they want without having to worry about the cost. We have seen more students eat and try new things that they have not tried before. Chicken strips are currently served one day a week, changes to menu planning to increase ingredient diversity"
Do you think the alternatives would be practically enjoyed by the students eating in Open Kitchen?	Darren: "Perhaps some however it would be good to look into cost of alternatives as well as flavor profile"

Are there alternatives that could be included to our list that we didn't consider? Are there any that should be removed?	Darren: No definite answer
Is there any additional information that would be helpful in comparing and deciding on ingredients?	Darren: "More about grains, like brown rice, and legumes, fruits and vegetables. Look into GHG inputs and buying locally within North America"
What is prioritized in the process of creating nutritious dishes for dining halls?	Gloria: "Menu planning is done primarily done by chefs within Open Kitchen, like Darren Clay, however some factors taken into account would include: ● Making 50-60% of the menu plant-based considering the health benefits of plants ● Allergies and food intolerances"
Are the alternatives applicable in a nutritional sense?	Gloria: "It's hard to say what is better than the other nutritionally when it comes for plant-based foods like garlic versus fennel; you can't really say which is nutritionally better. Nutrition is a very subjective term, healthy is as well. What is healthy is more than nutrients, it is also what makes sense for us mentally, culturally, traditionally, etc. too… I think no matter what we choose, [all the garlic alternatives] provide nutritional benefits… Let's take a look at your [sugar] alternatives. At the end of the day sugar is just sugar, all forms of sugar will be converted to sugar at the end so it's difficult to say that regular table sugar would be not as great as maple syrup, for example, because they are all sugar… but dates, for example, are a plant-based food and contain components other than sugar and would provide some nutritional benefit. Applesauce too… so they would provide some benefit as opposed to just using table sugar… There are alternatives for sugar here that give us more opportunities to use in seeking more nutrition." "If we (UBCFS) were able to add different types of alternatives it can definitely increase the nutrient biodiversity of what we offer. It could also have other benefits as well like being more sustainable and offering different palettes, different tastes to dishes."

Looking specifically at nutrition data, is there any additional information or data that is missing from our framework or could be explored further in future projects?	Gloria: "The nutrition information is enough for the scope of this project... Looking at menu prevalence for nutrition is a good approach"
What are your thoughts on how we chose to quantify biodiversity?	Juan: "It's hard to quantify, the concept and measuring is more difficult then compared to GHG. Biodiversity could be quantified by: ● # of species ● Land use is usually used as a proxy ie. forest turned into farmland Chemical input is great! It also has a strong impact, the choice you made is really comprehensive"
We used USDA data for our biodiversity data and ended up using many proxies as data was lacking. Do you know of other databases we could've explored to collect this data?	Juan: "I'm not sure what the 'best source' would be, this is something I would have to follow up with colleagues… If regulation in the USA is similar to Canada, this data can be relevant otherwise it may be a bit off, it's hard to say"
How would you approach biodiversity in the context of this assignment?	Juan: "I'd also look at land use change and footprint. Looking at pesticide use is new and hasn't been done before and is a good first step to quantifying biodiversity."
Are there other ways we could have quantified biodiversity that UBCFS could explore in the future?	Juan: "No, not that I can think of, what you've done is good. Gold standard would be to know production practice and the measurements from the supplier but this is costly. Certain management practices can contribute to GHG as well. Having detailed information from every supplier has an environmental impact as well… Land use and yield are important metrics too. The type of production practice is a big debate: use intensive practices or grow in a more ecological sustainable way, such as agroecology, that may result in decreased yields but is more biodiverse on site. There's no consensus on which production practice is better."
Currently, the CFFS is really broad for biodiversity. Do you think that this method of measuring biodiversity will continue to be implemented?	Juan: "Not sure, it depends on where they acquire their food (location of where food is grown). Pesticide data can be applicable to UBCFS, unless they only order local food. Safe levels of pesticide use could be considered but it is hard to determine how to meaningfully include these values."

Final thoughts or additional comments on our Comparative Framework	Darren: "We don't use horizon often, we use a lot from UBC Farm. From August to November we get a lot of produce from the [UBC] farm, we even offer to buy any products they produce and we put them in our menu. We are their largest buyer however the items listed as the top 10 are not bought from UBC Farm. The only thing would be bell peppers which are sourced from the Horticulture greenhouse at UBC." Gloria: "Great work! Dish examples of how alternatives could be implemented would be helpful." Juan: "There's a lot to factor in. You could add composite indicators to make it visually easier to comprehend or highlight lowest values, use bidirectional colour coding or normalize values. This also depends on what data is prioritized by your clients as there will tradeoffs"

Appendix F: Interview Initial Contact Email

Hi ______,

I hope this email finds you well. I am writing on behalf of my team to request your valuable opinion and feedback on our comparison model for our LFS 450 project.

As a quick background, our project is centered around assessing food ingredient diversity at Open Kitchen by creating a comparison model [hyperlinked], that provided possible substitutions for the 10 most commonly used food items. We aim to compare and contrast the 5 potential substitutions based on key categories such as biodiversity, climate, and nutrition. Within the spreadsheet linked above, there are more details about the comparison criteria.

We would love to meet with you and hear your thoughts on comparative framework. Specifically, receiving feedback on the factors we chose to look at [interviewee area of expertise: nutrition, menu suitability, or climate]. If you are able to meet with us, please fill out the when to meet: [when2meet link]

Thank you for taking the time to consider our request. Please let us know if you have any questions.

Kind regards,

Celina Chan/Julianne Unick

Appendix G: Ingredient Comparative Framework Spreadsheet Link