INTEGRATING FOOD SYSTEMS INTO REGIONAL CLIMATE ACTION PLANS:

a food security, climate resiliency and adaptation strategy for San Diego, California

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June 2022

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ACKNOWLEDGEMENTS

I would like to thank my advisory committee for their time and guidance throughout this process. Thank you to Brenda Garcia Millan for the continuous support, guidance, phenomenal stakeholder connections, as well as your trust and excitement in my motivation to bring food systems into San Diego's Climate Action Plans. Thank you to Heidi Bachelor for keeping me focused on steady progress throughout my analysis and for sharing your abundant knowledge. Thank you to Consuelo Martinez for your kind support, interest in my project, and your helpful feedback.

I would like to warmly thank the Climate Science and Policy program Executive Director, Dr. Corey Gabriel, for your continued guidance, thoughtful insights, and mentorship. You are a remarkable source of motivation for countless people, as your knowledge and fiery passion propagates throughout communities, and you deserve the utmost recognition for dedicating your whole being to the most important and urgent threat we collectively face. Thank you for all you do.

To my cohort colleagues, and now dear friends – thank you for the everlasting motivation to fight for the future of humanity with everything we have. I'm so proud to be on your team.

To my mom, Deborah Goodman – thank you for instilling the value of resilience in me, demonstrating compassion for humanity, and your unwavering support.

The Luiseno, Cahuilla, Cupeno, Kumeyaay, and Northern Diegueño indigenous people have been connected with the land we now call San Diego County for several millennia. This land once existed in harmonious balance – before European colonizers set out to explore the Americas' west coast, before the forceful incorporation of Spanish rule, before the Mayflower arrived in the "New World," and before California became a part of the United States of America.

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ABSTRACT

The global food system is failing to address food insecurity and malnutrition in a way that aligns with the urgent need to decarbonize and mitigate the release of short-lived climate pollutants. In response, mitigation of the system's CO_2 sources, supporting CO_2 sinks, and increasing access to resilient crop yields, especially among disadvantaged communities, must be prioritized. San Diego County is uniquely positioned to multi-solve this dynamic problem at hand and serve as a model for building an equitable, climate resilient food system that actively mitigates and sequesters CO_2 while alleviating food insecurity on a large scale.

This paper assesses the food security and carbon sequestration potential of converting publicly owned open space to regenerative agricultural sites among San Diego County's 15 municipalities routinely evaluated by the Climate Action Campaign's Annual Report Card, including Carlsbad, the City of San Diego, Chula Vista, Coronado, Del Mar, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, San Marcos, Solana Beach, and Vista. To conduct this analysis, a modifiable, replicable, geospatial model was built in ArcGIS Pro to identify eligible open space with key criteria to prioritize equity and suitable environmental features. As identified by this model, if 5,652 acres of eligible open space were converted to productive regenerative agricultural sites across the aforementioned 15 municipalities, an estimated annual 182.75 million pounds of crops could directly provide 152.29 million meals, closing San Diego County's meal gap by 94%, while sequestering approximately 4,060 $MTCO_2$ each year. This paper offers scaled-down food security and carbon sequestration benefits by municipality and concludes with project implementation strategy recommendations.

Keywords: food systems, climate change, regenerative agriculture, food security, carbon sequestration, climate action, urban agriculture, urban food, urban farm, human health, climate justice, food sovereignty

EXECUTIVE SUMMARY

Motivation

The effects of human-caused climate change are becoming increasingly apparent as rising temperatures test the limits of human survival, extreme events continuously break records, droughts intensify, rainfall patterns become erratic and untimely, and tornado paths shift. These changes impact every part of the food system and will have existential impacts on global and domestic food security if GHGs are not drastically cut and maximum deployment of carbon sequestration does not occur. Meanwhile, the global food system is failing to address food insecurity and malnutrition in a way that aligns with the need to rapidly decarbonize and mitigate the release of short-lived climate pollutants. In addition to current rates of food insecurity prompted by geopolitical conflict, poverty, and price spikes to name a few, the current food system contributes approximately 33 percent of global greenhouse gas emissions.[1] In response, mitigation of the system's CO_2 sources, supporting CO_2 sinks, and increasing crop yield output where possible in a changing climate must be prioritized. This multi-solving requires shifting agricultural practices, addressing food waste and diets, converting degraded land to sinks, and protecting and restoring ecosystems. Simultaneously, climate change touches every part of the food system and the associated risks are too substantial to ignore. Food availability will be increasingly challenged, nutrients are expected to deplete with an increase in CO_2,[2,3,4] access will be jeopardized as price spikes unfold, all chipping away at stability in the global food system. The four pillars of food security, 1) availability, 2) access, 3) utilization, and 4) stability,[5] should be used to design and establish a locally attuned, adaptive, responsive, and safe system that colinearly reduces sources and supports sinks.

Over one-third of San Diegans are nutrition insecure, 39% of which are children, and systemically disadvantaged communities are disproportionately impacted.[6] San Diego County has a collective opportunity and responsibility to build a resilient and equitable

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[1] Crippa et al., "Food Systems Are Responsible for a Third of Global Anthropogenic GHG Emissions."
[2] Danielle E. Medek, "Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region."
[3] Myers et al., "Effect of Increased Concentrations of Atmospheric Carbon Dioxide on the Global Threat of Zinc Deficiency."
[4] Smith, Golden, and Myers, "Potential Rise in Iron Deficiency Due to Future Anthropogenic Carbon Dioxide Emissions."
[5] Gebeyehu, "Impact of COVID-19 on the Food Security and Identifying the Compromised Food Security Dimension: A Systematic Review Protocol."
[6] San Diego Hunger Coalition, "The State of Nutrition Security in San Diego County."

regional food system that actively supports mitigation efforts and improves food security. Establishing climate-resilient food systems should be a unified priority action across all Climate Action Plans.

Analysis Objectives

The primary objective of this analysis was to assess the food security and carbon sequestration potential of converting publicly owned open space to regenerative agricultural sites among 15 municipalities within San Diego County: Carlsbad, the City of San Diego, Chula Vista, Coronado, Del Mar, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, San Marcos, Solana Beach, and Vista. To conduct this analysis, a modifiable, replicable, geospatial model was built to identify eligible open space with key criteria to prioritize equity and suitable environmental features.

Key Findings

This analysis identified 1,461 acres of Priority 1 eligible open space (EOS) within priority populations (as deemed by CalEnviroScreen4.0) that should be of priority deployment of regenerative agricultural sites and if fully converted, annually, could provide an annual benefit of 47.25 million pounds of staple crops (equivalent to 39.3 million meals) and 1,050 MT CO_2 sequestration. If distributed equitably, conversion of Priority 1 EOS or an equivalent acreage could close San Diego County's meal gap by 24%.

Further, this analysis identified 3,485 acres of Priority 2 EOS, which lies within a two-mile buffer of priority populations, and could provide an annual benefit of 112.7 million pounds of staple crops (equivalent to 93.9 million meals) and 2,504 MT CO_2 sequestration. Conversion of Priority 2 EOS or an equivalent acreage could close San Diego County's meal gap by 58%.

Lastly, full conversion deployment of Priority 3 EOS, which did not have a priority population specification, but lies within municipal boundaries, could provide an annual benefit of 182.75 million pounds of staple crops (equivalent to 152.2 million meals) and 4,060 MT CO_2 sequestration. Conversion of Priority 3 EOS or an equivalent acreage could close San Diego County's meal gap by 94%.

PART I: INTRODUCTION

Climate Change: Global Context

Stability in Earth's climate has allowed human beings to develop the systems and infrastructure we rely on every day. Our food system inherently relies on such stability. Simultaneously, the global food system emits greenhouse gases (GHG's) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) that cause an overall warming trend and contributes to destabilization of Earth's climate. Climate change refers to long-term shifts in temperatures and weather patterns. Climate change *can* be a natural part of Earth systems; however, warming since the industrial revolution is unequivocally due to human activity and will have catastrophic effects on human beings and countless ecosystems on a global scale. Atmospheric CO_2 concentrations are higher today than they have been in the past 2 million years.[7] Without rapid decarbonization and under the highest emissions pathway, the Intergovernmental Panel on Climate Change (IPCC) temperature projections indicate a *very likely* increase from pre-industrial temperatures of between 2.34°F (1.3℃) and 3.42°F (1.9℃) in the near term (2021-2040) and 5.94°F (3.3℃) and 10.26°F (5.7℃) in the long term (2081-2100).[8]

An increase in global average temperature prompts feedback mechanisms throughout Earth's dynamic climate systems that amplify the risks of destabilizing the climate. For example, an increase in global average temperature leads to permafrost melt. When this ice, that by definition should be "permanently frozen," melts due to human-caused global warming, CH_4 is released into the atmosphere. CH_4 is a potent GHG that leads to further warming, and in response, further melt. This cycle is considered a feedback loop. In summary, triggering an initial increase in warming causes tremendous global risks by destabilizing the climate through amplifying feedback loops. Immediate, deep decarbonization is essential to avoid the worst effects of climate change.

If we stopped emitting all GHGs today — abandoning every system that emits GHGs with the snap of our fingers — we would continue to see an increase in global average temperatures for decades to come due to a lag between GHGs being released to the atmosphere and the following temperature rise. Even if we implemented emergency carbon capture systems in tandem with mitigation of emissions, we likely still would exceed 2.3℃ warming from pre-

[7] IPCC, "Climate Change 2022: Mitigation of Climate Change."
[8] IPCC.

industrial average temperatures (nearly 1℃ higher than the 1.5℃ threshold adopted by the Paris Agreement). Despite the non-negotiable temperature rising that would be expected due to the lag between GHG release into the atmosphere and subsequent temperature increases, decarbonizing could prevent the *worst* catastrophic damages that are beyond repair.

Given that we cannot abandon every system that emits GHGs overnight, warming is written into our future. The degree of warming and the feedback loops that result from continued emissions, however, are up to us to write by means of effective, equitable, and actionable policy initiatives in tandem with decarbonization innovation. Many moving pieces have to come together at a large scale and rapidly to decarbonize. In the meantime, and in tandem with decarbonization efforts, effective adaptation and resiliency planning is necessary to protect communities and avoid unnecessary loss. In summary, the threats of climate change are tremendous for communities on a global scale. Given the gravity of what is at stake, safety threats due to the climate crisis must be taken seriously and integrated into planning efforts to avoid unnecessary damages to living beings.

Climate Change Impacts on Food Systems

Climate change touches every component of the food system: availability, access, utilization, and stability. Availability refers to the existence of food in a given place at a given time. Access refers to the ability of a person or a group to obtain food. Utilization refers to the ability to get nourishment from food and includes the nutritional value of the food and how the body assimilates the nutrients. Stability refers to the steady supply or absence in availability, access, and utilization.[9]

Food availability is particularly threatened by increased temperatures, extreme events (droughts, floods, cyclones), and precipitation (untimely, erratic, decreased or increased). NASA projections indicate maize yield losses as early as 2030 and will amplify to a loss of up to 24% by the century's end without immediate mitigation.[10] Access is jeopardized by price spikes, disproportionately impacting low-income communities and countries. Utilization is threatened by increased CO_2 concentrations, as key nutrients such as zinc, iron, and protein

[9] Mbow et al., "IPCC Food Security Special Report."
[10] Molar-Candanosa, "NASA at Your Table."

are anticipated to decline.[11,12,13,14] Climate change disrupts stability in all of the aforementioned food security components by changing where food is grown, causing unreliability in distribution systems, worsening the nutrient content of crops, and causes amplified disparities in food access.

Regional Overview

San Diego has already experienced consistent warming average temperatures and more is to come as the climate crisis progresses. Figure 1 depicts the historical rise in mean temperature with standard 30-year averages from 1895 to 2020. The most recent 1991-2020 mean shows a substantial jump in warming compared to years prior. Climate change is projected to increase annual average temperatures in San Diego by 4 to 6°F (~2.2 to 3.3°C) by 2100 under the RCP 4.5 scenario or 7 to 9°F (3.6 to 5°C) under the RCP 8.5 scenario.[15]

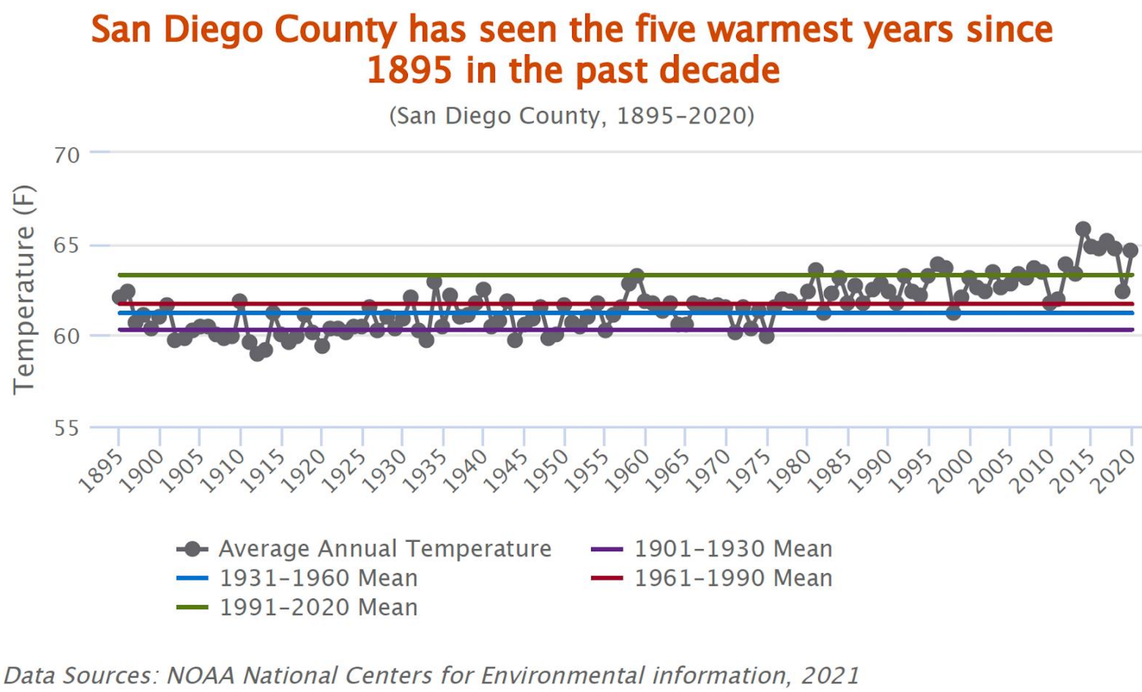
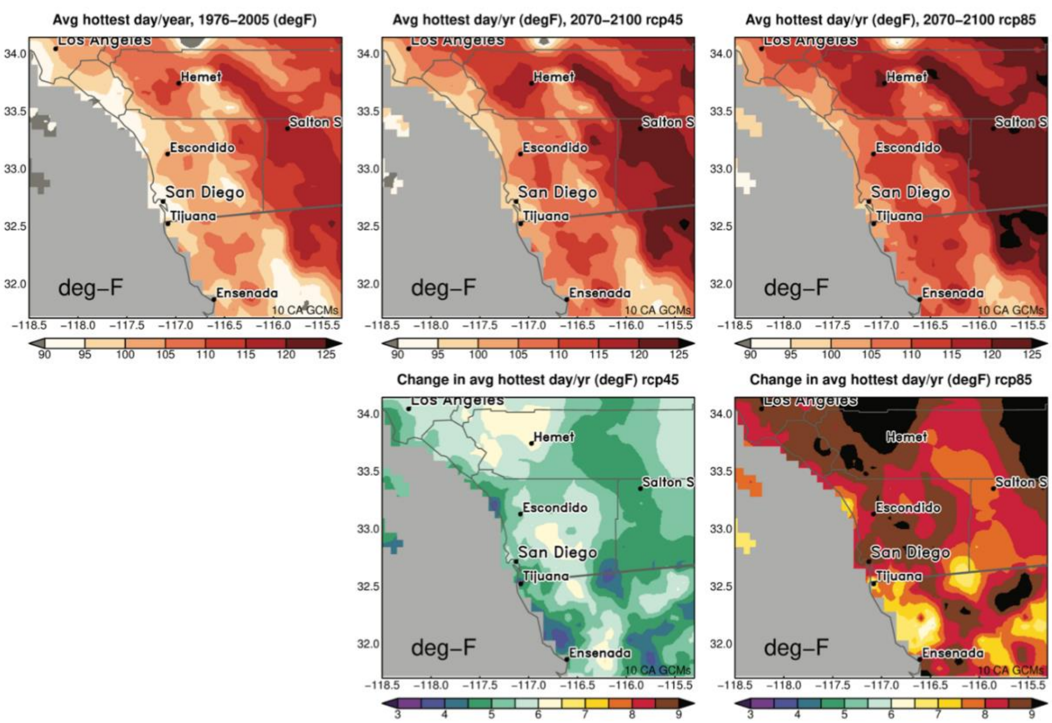


Figure 1. San Diego's Average Annual Temperature Over Time (1895-2020).[16]

[11] Mbow et al., "IPCC Food Security Special Report."
[12] Smith, Golden, and Myers, "Potential Rise in Iron Deficiency Due to Future Anthropogenic Carbon Dioxide Emissions."
[13] Danielle E. Medek, "Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region."
[14] Myers et al., "Effect of Increased Concentrations of Atmospheric Carbon Dioxide on the Global Threat of Zinc Deficiency."
[15] Pierce, Kalansky, and Cayan, "Climate, Drought, and Sea Level Rise Scenarios for California's Fourth Climate Change Assessment."
[16] Pierce, Kalansky, and Cayan.

To further visualize this increase in temperature over time and space, Figure 2 displays the region’s average hottest day per year under RCP scenarios 4.5 and 8.5 geospatially. As shown, even coastal areas throughout the San Diego region under both scenarios see substantial warming. Notably, San Diego’s neighboring county of Imperial Valley will increase substantially as well from a comparatively higher temperature baseline to San Diego due to its desert climate, which will have drastic impacts on their agricultural outputs. San Diego’s temperatures remain much lower than Imperial Valley’s by century’s end under both RCP 4.5 and 8.5 scenarios. As such, further research regarding San Diego and Imperial Valley’s agricultural production as the climate crisis progresses is critical to assess and plan for potential volatility due to a change in resource inputs and corresponding yield outputs.



Top panels show the average hottest day per year for 1976-2005 (top left) and 2070-2100 for RCP 4.5 (top center) and RCP 8.5 (top right). The bottom panels show the degree change for RCP 4.5 (bottom left) and RCP 8.5 (bottom right).

Figure 2. Regional Warming Changes with RCP 4.5 and RCP 8.5 Projection.[17]

[17] Pierce, Kalansky, and Cayan.

PART II: METHODOLOGY

Study Area

The Climate Action Campaign's 5th Edition Report Card included the key recommendation to "Create Healthy Food Systems." In response, this project aims to provide recommendations for municipalities to guide which have the opportunity to incorporate agricultural projects to their conversations as a mitigation, resiliency, and food security project. Figure 3 outlines the municipalities evaluated in this analysis.

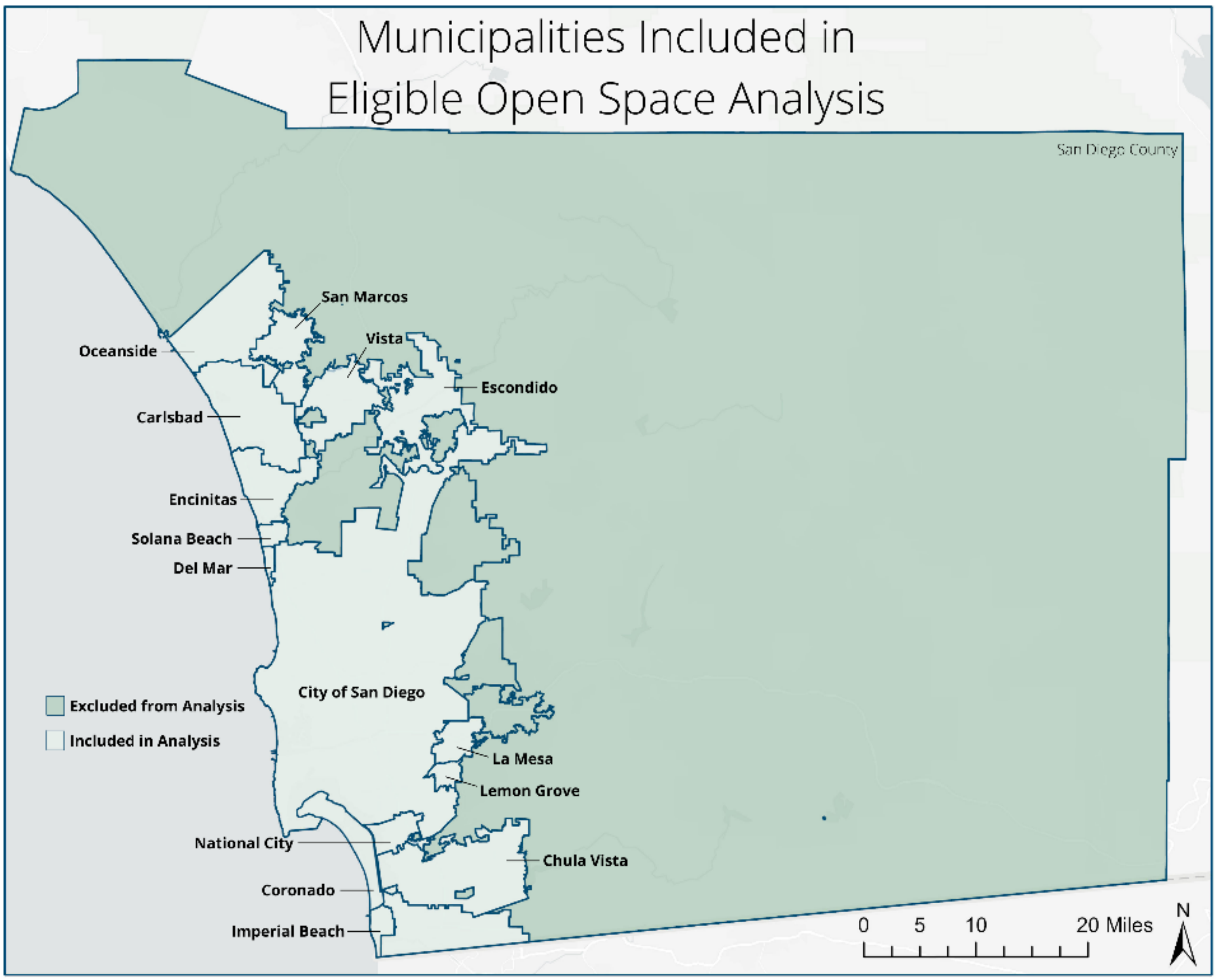


Figure 3. Municipalities Included in Eligible Open Space Analysis. The municipalities in this analysis include Carlsbad, City of San Diego, Chula Vista, Coronado, Del Mar, Encinitas, Escondido, Imperial Beach, La Mesa, Lemon Grove, National City, Oceanside, San Marcos, Solana Beach, Vista.

GIS Analysis Inputs, Processing, and Output Model

This section details the methods used to 1) identify potential eligible open space (EOS) within the study area, 2) delineate suitability criteria for each priority level for the collective study area by building a replicable, modifiable model to inform further analyses, 3) iterate the tool for site identification within each municipality, and 4) present analysis findings in a user-friendly manner (accessible to policy-makers, urban planners, climate and food security organizations, environmentalists, and residents) via interactive web-map tools.

The analysis conducted to identify EOS for regenerative urban agricultural sites and the corresponding priority levels for project deployment consists of four main phases:

- Phase One: Identify Analysis Inputs
- Phase Two: Build Model at Regional Scale
- Phase Three: Run Model at Municipal Scale
- Phase Four: Generate Interactive Web-Map Tools

Phase One: Identify Analysis Inputs

Identification of relevant suitability conditions were evaluated in this phase. All objectives, data sources, datasets, strategies, and justification are described in Table 1.

Phase One: *Identify* Analysis Inputs				
Analysis Component	**Objective**	**Dataset**	**Strategy**	**Justification**
Baseline filter for all P 1-2-3 EOS Analyses	Identify municipalities for analysis	Municipal_Boundaries (1.5 MB, downloaded May 6, 2022)	Remove all municipal boundaries that are not monitored by report card	This analysis was targeted to find eligible open space within municipal jurisdiction. A similar analysis can (and should) be replicated for space beyond the specified municipalities within this analyais.
	Identify publicly owned land	PUBLIC_LAND_OWNER_2020 (18.3 MB, downloaded May 6, 2022)	Select for City, County, and State owned	All publicly owned space can be redesignated so long as it is not protected by a specific regulation or easement.
	Identify open space	LANDUSE_CURRENT (230 MB, downloaded May 15, 2022)	Select for landscaped open space, vacant and undeveloped, residential recreation, or parks-active	Landscaped open space is already irrigated (often with recycled water in the City of San Diego). Vacant and undeveloped space should be highly considered in tandem with affordable housing infill (adding housing without food access and within systemically disempowered communities will create lasting and perpetuated inequalities). Residential recreation spaces are optimal due to irrigation and proximity to residential homes. Parks-active should be considered for community recreation and involvement in growing food, for city and school programs, and as the climate crisis progresses, out of necessity.
	Eliminate wetlands from eligibility	Wetlands (134 MB, downloaded April 18, 2022)	Erase wetlands from publicly owned open space	Wetlands are ineligible for conversion projects due to inability to grow staple crops in soil with high salinity and due to the environmentally sensitive nature of these areas.
	Eliminate environmentally sensitive areas from eligibility	Environmentally_Sensitive_Areas (5.78 MB, downloaded May 15, 2022)	Erase environmentally sensitive areas from publicly owned open space	Environmentally sensitive areas should be preserved to maintain biodiversity and promote land conservation.
P 1-2 EOS	Identify priority populations	PriorityPopulations2022CES4 (17.6 MB, downloaded May 24, 2022)	Set the symbology for the display field to maintain consitence later on in analysis, where Display (0) = no designation, (1) = Disadvantaged = DAC, (2) = Disadvantaged and Low Income Community, (3) = Low Income Community, (4)= Low-income Community within 1/2 mile of Disadvantaged Community, (5) = Potential Low-income Households within 1/2 mile of Disadvantaged Community	California Legislature requires that at least 35 percent of all Cap-and-Trade auction proceeds in the form of California Climate Investments projects, per Senate Bill 535 (Chapter 830, Statutes of 2012) and Assembly Bill 1550 (Chapter 369, Statutes of 2016), benefit disadvantaged communities and low-income communities and households, collectively referred to as priority populations. CalEPA finalized in May 2022 the updated Designation of Disadvantaged Communities, pursuant to Senate Bill 535 (De León, 2012) and formally designated four categories of geographic areas as disadvantaged: (1) Census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0, (2) Census tracts lacking overall scores in CalEnviroScreen 4.0 due to data gaps, but receiving the highest 5 percent of CalEnviroScreen 4.0 cumulative pollution burden scores , (3) Census tracts identified in the 2017 DAC designation, regardless of their scores in CalEnviroScreen 4.0, and (4) Lands under the control of federally recognized Tribes
P 1-2-3 EOS Analyses	Identify optimal slope range for each priority level	Slopes_CN (97.5 MB, downloaded May 21, 2022)	This dataset distingueshes GRIDCODE (1) = slope less than 15%, GRIDCODE (2) = slope 15% to less than 25%, GRIDCODE (3) = slope 25% to less than 50%, GRIDCODE (4) = slop 50% or greater. Only GRIDCODE (1) and (2) included in this analysis for recommended regenerative agricultural conversion projects at this time, though terracing is commonly used throughout the world as a strategy to effectively grow on steeper slopes.	A slope of ≤15% is most suitable for growing staple crops and a slope of 3-15% is most suitable for conserving water via swaling. Slopes between 15-25% should be prioritized in municipalities with more funding for terracing spaces. This is not typically an economically viable option for municipalities, but should be considered for municipalities with low eligible open space and low priority populations. This space can be strategically used for crops that thrive on sloped environments due to drainage purposes, such as avocados).
P 1-2-3 EOS Analyses	Identify recycled water lines	Recycled_Water_Main (4.25 MB, downloaded May 6, 2022)	Locate all water lines within 10 meter buffer of eligible open space	The 10 meter buffer was included to account for any potential eligible open space unaccounted for within the specified critera neaby that has a water line.
P 1-2-3 EOS Analyses	Identify main water lines	WATER_MAIN_SD (120 MB, downloaded May 6, 2022)		
P 1 EOS Analysis	Identify developable land	Developable_Land (13.4 MB, downloaded May 6, 2022)	Eliminate developable land from top priortity tier	Land deemed undevelopable should be prioritized becuase it has minimal conflict of land use interest (comparatively). Land that is deemed developable is still viable, but could pose more restrictions and therefor, more hoops to jump through to permit a regenerative agriculture conversion project.
Further Site Suitability Exploration	Identify the potential for runoff to assess co-benefit of reducing runoff	SOILS_HYDRO_GROUP (20.1 MB, downloaded May 6, 2022)	The Hydrologic Group (A, B, C, D) indicates the potential for runoff when the soil is thoroughly wet, with A indicating the least runoff, and D indicating the most runoff. For the purpose of evaluating co-benefits of regenerative agriculture's potential to mitigate environmetnally damaging runoff, this analysis equated the following Hydrologic Group, (A) = low, (B) = low to medium, (C) = medium to high, (D) = high runoff mitigation potential.	Regenerative agricultural practices can reduce runoff and erosion, and in turn could significantly benefit neighboring communities. Healthy and biodiverse soil can absorb excess water and filter surface pollutants that would otherwise flow into communities and stormwater drainage systems.
	Display average annual rainfall at the location of eligible open space	Precipitation (224 KB, downloaded Sunday, May 15, 2022)	Display rainfall ranges for suitability exploration in online interactive web map tool.	Viewing precipitation averages can be helpful to prioritize selection of sites with greater rainfall, but should necessarily be included in strict suitability model in San Diego becuase 1) future rainfall cuold be more eratic, 2) most agricultural spaces are irrigated and not rainfed, 3) the ranges do not differ substantially. In summary, this should be used as an amplifying trait of a potential site, not an eliminating factor. Water resources should be prioritized for food production rather than irrigating landscaped space with a much lower community value.
	Display vegetation at the location of eligible open space	MSCP_Vegetation_SD (15.3 MB, downloaded May 15, 2022)	Display vegetation for suitability exploration in online interactive web map tool.	If an area's vegetation has been classified as non-native or disturbed, it would be most suitable for regenerative agriculture projects. Maintaining native vegetation is important for carbon sequestration, environmental quality, biodiversity, maintaining indigenous connection (environemental, cultural and spiritual value), flood and runoff mitigation due to long root systems, etc.

Table 1. Dataset inputs used for analysis of potential EOS for regenerative agriculture conversion projects throughout the specified 15 municipalities in San Diego, California. See Appendix A-1 for dataset descriptions and credits.

Phase Two: Build Model at Regional Scale

The entire study area was analyzed to identify EOS and rank as Priority 1, Priority 2, or Priority 3 using ArcGIS Pro's ModelBuilder tool (Figure 4). Development of a reasonable three-tiered model was designed based equity, environmental, and economic considerations to determine a recommended mode of deployment. The model first filtered for baseline criteria (see Table 2). Priority 1 EOS (P1 EOS) is optimal for prioritized deployment, as it has the narrowest parameters and identifies EOS within priority populations (see Table 3). Priority 2 EOS (P2 EOS) should follow suit in deployment prioritization due to the slight broadening of parameters (see Table 4). Priority 3 EOS (P3 EOS) should be evaluated to scale up throughout municipalities (see Table 5).

Baseline Critera Shared by Priority 1, Priority 2, and Priority 3		
Phase Two: Build Model at Regional Scale		
Dataset	**Strategy**	**Justification**
PUBLIC_LAND_OWNER_2020	Select for City, County, and State owned	All eligible open space for Priority 1, Priority 2, and Priority 3 tiers should be publicly owned. Land owned could be modified to include private land or a select grouping of publicly owned land (i.e. only City, only County, or only State owned) for future analyses.
LANDUSE_CURRENT	Select for landscaped open space, vacant and undeveloped, residential recreation, or parks-active	All eligible open space for Priority 1, Priority 2, and Priority 3 tiers should be open space. Land uses could be modified (i.e. expanded or narrowed) to adjust parameters for furture analyses.
Municipal_Boundaries	Select for all municipalities within analysis. This selection included: (1) Carlsbad, (2) City of San Diego, (3) Chula Vista, (4) Coronado, (5) Del Mar, (6) Encinitas, (7) Escondido, (8) Imperial Beach, (9) La Mesa, (10) Lemon Grove, (11) National City, (12) Oceanside, (13) San Marcos, (14) Solana Beach, and (15) Vista	All eligible open space for Priority 1, Priority 2, and Priority 3 tiers should be within the listed municipal boundaries. Municipal boundaries could be modified to include land beyond the specified municipal boundaries for future analyses.
Wetlands	Eliminate all wetlands	No eligible open space for Priority 1, Priority 2, and Priority 3 tiers should include wetlands.
Environmentally_Sensitive_Areas	Eliminate all environmentally sensitive areas	No eligible open space for Priority 1, Priority 2, and Priority 3 tiers should include environmentally sensitive areas.

Table 2. Baseline Criteria Shared by Priority 1, Priority 2, and Priority 3. See Appendix A-2 for land use descriptions.

Priority 1 Criteria		
Phase Two: Build Model at Regional Scale		
Dataset	**Strategy**	**Justification**
Developable_Land	Eliminate all land deemed 'developable' by SANDAG	No eligible open space for Priority 1 should include land deemed 'developable.' Limitation: SANDAG's dataset has limited description of how they define 'developable.' Reasonable assumptions had to be made for this analysis.
Slopes_CN	Select for land with less than 15% slope	Regenerative agricultural conversion projects would be easiest to covert on slopes of less than 15%. Slopes of 3-15% are also ideal for water conservation practices such as creating vegetative swales.
PriorityPopulations2022CES4	Only select sites within priority populations	Community-powered climate-resilient food sovereignty projects should first be prioritized within priority populations. (1) Priority populations are eligible to receive at least 35 percent of all Cap-and-Trade auction proceeds in the form of California Climate Investments projects. (2) Priority populations generally have less access to transportation; projects shold be prioritized within walking distance, then expand outward.
Recycled_Water_Main	Display recycled water lines within 10 meters of identified eligible open space	Recycled water should be prioritized. This was not included as a necessity for P2 EOS. The City of San Diego's recycled water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's recycled water line. Locating datasets for each additional municipality's recycled water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*
WATER_MAIN_SD	Display main water lines within 10 meters of identified eligible open space	The main water line was not included as a necessity for P2 EOS. The City of San Diego's main water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's main water line. Locating datasets for each additional municipality's main water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*

Table 3. Priority 1 Eligible Open Space (P1 EOS) Criteria

Priority 2 Criteria		
Phase Two: Build Model at Regional Scale		
Dataset	**Strategy**	**Justification**
Slopes_CN	Select for land with less than 15% slope	Regenerative agricultural conversion projects would be easiest to covert on slopes of less than 15%. Slopes of 3-15% are also ideal for water conservation practices such as swaling.
PriorityPopulations2022CES4	Extend site selcection to include sites within a two-mile buffer of priority populations	Food insecurity is not limited to the confines of a dataset and surely exists among communities that aren't captured by CalEnviroScreen's parameters. The two mile buffer is intended to capture communities that fall on the periphery of identified priority populations. Additionally, land within the two mile buffer could be utilized to benefit priority populations.
Recycled_Water_Main	Display recycled water lines within 10 meters of identified eligible open space	Recycled water should be prioritized. This was not included as a necessity for P2 EOS. The City of San Diego's recycled water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's recycled water line. Locating datasets for each additional municipality's recycled water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*
WATER_MAIN_SD	Display main water lines within 10 meters of identified eligible open space	The main water line was not included as a necessity for P2 EOS. The City of San Diego's main water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's main water line. Locating datasets for each additional municipality's main water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*

Table 4. Priority 2 (P2 EOS) Eligible Open Space Criteria

Priority 3 Criteria		
Phase Two: Build Model at Regional Scale		
Dataset	**Strategy**	**Justification**
Slopes_CN	Select for land with less than 25% slope	Steeper slopes can be suitable for farming if properly utilized — terraced farming is highly suitable for arid environments. This practice can effectively (1) improve rainwater harvesting, (2) retain moisture from rainfall/reduced runoff, and (3) increase food production by adjusting sloped land for farming. Though this takes more effort to create, the results are highly promising.
Recycled_Water_Main	Display recycled water lines within 10 meters of identified eligible open space	Recycled water should be prioritized. This was not included as a necessity for P3 EOS. The City of San Diego's recycled water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's recycled water line. Locating datasets for each additional municipality's recycled water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*
WATER_MAIN_SD	Display main water lines within 10 meters of identified eligible open space	The main water line was not included as a necessity for P3 EOS. The City of San Diego's main water line is displayed as a seperate layer. *Limitation: This analysis only includes the City of San Diego's main water line. Locating datasets for each additional municipality's main water lines was beyond the scope of this analysis. However, this criteria could be uesful to include in future analyses.*

Table 5. Priority 3 Eligible Open Space (P3 EOS) Criteria

P1-2-3 EOS criteria were incorporated into the full three-tiered model (see Figure 4). The model flows from left to right, beginning with the baseline filtered criteria (left), moving to the transformation of priority populations data (middle), and lastly displaying the P1 EOS output (top-right), P2 EOS output (middle-right), and P3 EOS output (bottom-right). To see close-up images of each group within the model, see Appendix A-3.

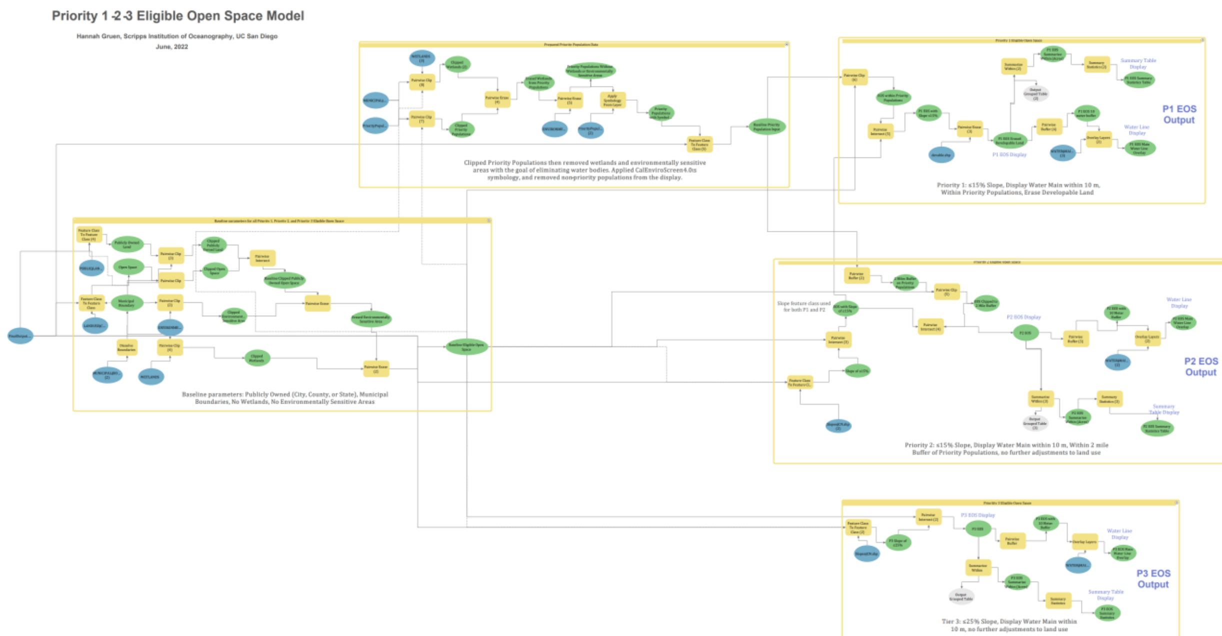


Figure 4. Regional Eligible Open Space Model

Phase Three: Run Model at Municipal Scale

This phase iterated the aforementioned ranked model for each municipality. No adjustments were made for this preliminary analysis, however future analyses (ideally replicated by each municipality), should include their city's water lines.

Phase Four: Generate Interactive Web-Map Tools

This phase exported the 16 maps generated (one for each of the 15 municipalities and one at the regional scale) via the analysis model to ArcGIS Online to embed in a Story Map. One additional map was generated outside of the model for the purpose of further exploring site suitability for users, which included vegetation type, precipitation, and runoff potential layers.

Calculating Acreage for Further Analysis Estimations

A sum of total acreage was acquired using ArcGIS Pro's 'summarize within' and 'summary statistics' geoprocessing tools. 'Summarize within' created a new attribute field that calculated the acreage of each identified parcel. 'Summary statistics' calculated the summation of acreage. These tools identified the total regional acreage among the 15 analyzed municipalities at each P 1-2-3 EOS tier. Acreage was then used to estimate 1) potential carbon sequestration (initially calculated in pounds/acre, then converted to metric tons of carbon dioxide ($MTCO_2$)/acre, 2) pounds of crop yield potential based on vegan-organic regenerative agricultural practices, and 3) number of meals this production equates to and the resulting San Diego County meal gap closure.

Carbon Sequestration Estimation Calculations

This analysis originally intended on utilizing the United States Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) COMET-Farm tool to calculate potential carbon sequestration. Upon further exploration of COMET-Farm, the online tool's maximum polygon inputs prohibited more than 40 parcels at time for the analysis. Given the abundance of several thousand parcels to analyze, this tool was not suited for this preliminary evaluation. However, COMET-Farm is a standard tool for estimating sequestration for agriculture, and it is recommended that the tool is utilized to evaluate the carbon sequestration potential for a reduced number of identified EOS if desired. For the purposes of this analysis' estimation, a simple calculation of acreage and sequestration improvement over time was sufficient.

The carbon sequestration estimations from regenerative farming practices in this analysis are based on Kenne and Kloot's 2019 publication in the American Journal of Climate Change. This study examined soil organic matter (SOM) data from 486 soil sample locations with a variety of soil textures (see Figure 6) and were compared multiple times throughout the year for four years. Study results from cover crop rotations fixed an average of 622 lbs./acre/year of atmospheric C after the first two years and fixed an average of 1,584 lbs./acre/year of atmospheric C after four years. Increases in SOM were observed across all soil textures where cover crop rotation was practiced, and the soil texture did not significantly change the soils' ability to sequester atmospheric C.[18]

[18] Gabriel Kenne and Kloot, "The Carbon Sequestration Potential of Regenerative Farming Practices in South Carolina, USA."

Soil Texture	n	Mean %OM Change/Year	lbs. OM/ac/yr
Sandy Clay Loam	1	0.35	7000
Sand	15	0.09	1800
Loamy Fine Sand	129	0.06	1200
Loamy Sand	108	0.06	1276
Sandy Loam	68	0.03	648
Fine Sandy Loam	136	0.03	600
Loam	29	0.07	1328

Table 6. Mean annual rates of change in soil OM by soil texture. The mean rates of change in soil OM/year by soil texture. No statistically significant differences were found between the textures, even when the single sandy clay loam sample was excluded from analysis due to its small sample size (n). Values are shown as %OM change and as lbs. OM/ac based on 2,000,000 lbs. of soil/ac.[19]

Based on Kenne and Kloot's findings of steady C fixation among all soil textures[20] and for the purposes of this analysis' goal of a preliminary estimation of carbon sequestration potential, each P 1-2-3 EOS acreage for the evaluated 15 municipalities was multiplied by the average C fixation after four years of cover crop rotation.

Crop Yield Estimation Calculations

Estimated crop yield outputs were based on a simple calculation of pounds of crops/acre by following regenerative agricultural practices including: (1) cover crop rotations, (2) no-till, and (3) no pesticides, herbicides, or fungicides — only plant-based fertilizers.[21] Videle, 2018's study on the production of food/acre was used to estimate potential crop yield in pounds/acre and followed the above practices. The crops studied were snap beans, dry beans, cabbage, carrots, cucumbers, kale, lettuce, onions, potatoes, summer squash and tomatoes (See Table 7).[22] Based on Videle, 2018's publication and for the purposes of a preliminary estimation of food production for this analysis, each P 1-2-3 EOS acreage for the evaluated 15 municipalities was multiplied by the average yield of 32,221 lbs./acre.

[19] Gabriel Kenne and Kloot.
[20] Gabriel Kenne and Kloot.
[21] Videle, "The Productivity of Vegan-Organic Farming."
[22] Videle, "Comparison of Farming in Production of Food Per Acre."

Crop	Lbs./acre
Snap Beans	13,129 lbs./acre
Dry Beans	2,236 lbs./acre
Cabbage	26,450 lbs./acre
Carrots	46,095 lbs./acre
Cucumbers	38,844 lbs./acre
Kale	21,275 lbs./acre
Lettuce	16,291 lbs./acre
Onions	28,654 lbs./acre
Potatoes	27,216 lbs./acre
Summer Squash	43,451 lbs./acre
Tomatoes	91,999 lbs./acre
Totals (avg.)	**32,331 lbs./acre**

Table 7. Farms practicing (1) cover crop rotations, (2) no-till, (3) no-pesticides, herbicides, or fungicides — only plant-based fertilizers. Videle, 2018's study demonstrated these practices can produce an average yield of 32,331 lbs./acre.[23]

Crop yield outputs (lbs./acre) were then divided by the average meal weight of 1.2 lbs. to estimate the potential number of meals/acres.[24] Further, to understand what percentage of San Diego County's meal gap this could mitigate, the potential number of meals/acres was then divided by San Diego County's estimated meal gap (13.5 million meals/month, or 168 million meals/year).[25]

[23] Videle.
[24] HACAP Food Reservoir, "Pounds per Person."
[25] San Diego Hunger Coalition, "The State of Nutrition Security in San Diego County."

PART III: RESULTS

Overview

Municipalities within San Diego County have the opportunity to create a resilient, healthy food system that maintains the availability and stability of nutritionally dense food in an accessible manner by actively localizing production by means of regenerative urban agriculture. The following analysis findings make the case that food insecurity could be heavily alleviated in San Diego County if food production were prioritized in publicly owned open space.

Analysis Findings

Municipalities must be willing to rethink perceived limitations of acreage to achieve local food security and must acknowledge the legitimate limitations of external solutions. One acre of regenerative agricultural production space can generate an estimated staple crop yield of 32,331 pounds/acre.[26] External solutions such as adding a grocery store to a census tract deemed a food desert can have unintended consequences of gentrification and often fails to center the needs, cultures, and aspirations of community residents. People-powered food sovereignty can be achieved by effectively converting publicly owned open space to regenerative agricultural sites. A remarkable number of climate-related food security organizations exist within San Diego. Identifying EOS amongst jurisdictions is a key step towards building a resilient local food system. The identification of eligible land will further pave the way for local organizations to cultivate food, sequester carbon, and empower food sovereignty while strengthening local economies.

Identified Priority 1-2-3 Eligible Open Space

Across the 15 municipalities monitored by the CAC annual Report Card in San Diego, approximately 1,461 acres of P1 EOS should be highly prioritized and further evaluated for conversion to regenerative urban agriculture. In addition to the baseline filtered parameters all Priority EOS include of being publicly owned (city, county, or state) open space (vacant and undeveloped, landscaped open space, residential recreational, or park-active) that is not in an environmentally sensitive area, the identified 1,461 acres of P1 EOS are within priority populations, have slopes of less than 15%, and are classified as undevelopable.

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[26] Videle, "The Productivity of Vegan-Organic Farming."

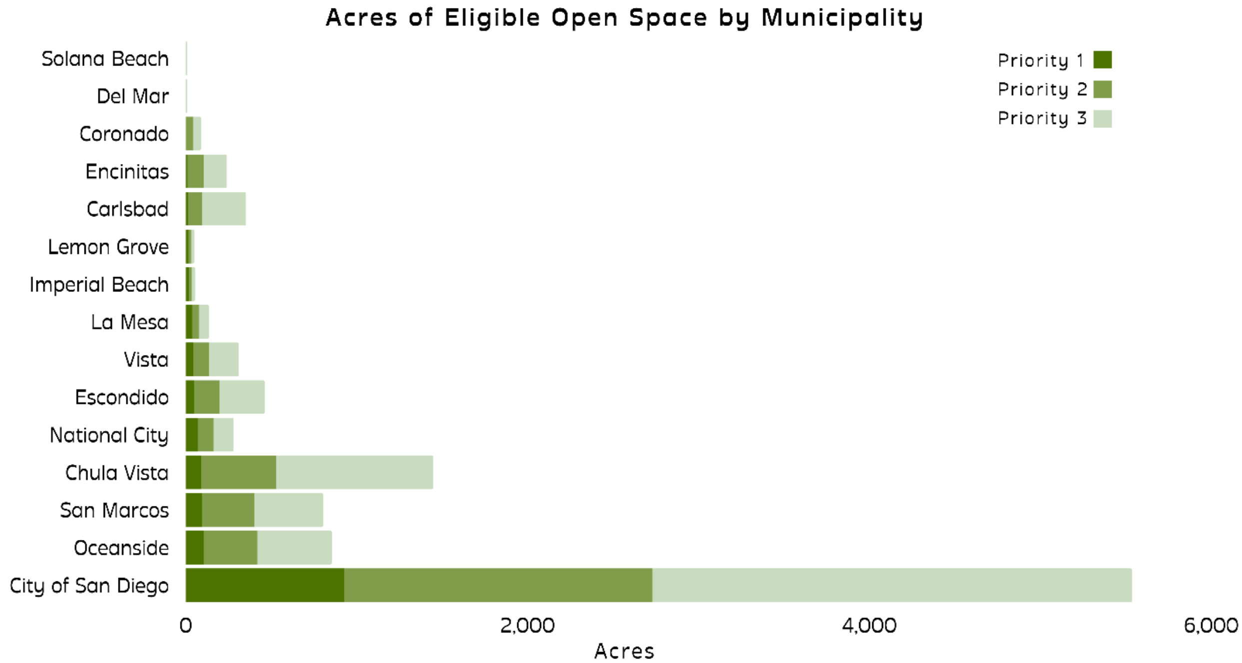


Figure 5. Acres of Eligible Open Space by Municipality

This analysis identified 3,485 acres of P2 EOS and should be prioritized as a more robust up-scale opportunity once deployment of urban agriculture within P1 EOS has been deployed. In addition to the baseline filtered parameters, P2 EOS is within a two-mile buffer of priority populations and has a slope of less than 15%. Depending on locations of P2 EOS in relation to local climate-related food security projects, it is worth exploring in tandem, especially due to the high likelihood of food insecure people within areas very nearby P2 EOS. Coronado is an exception to the recommended order of Priority 1-2-3 EOS deployment because no priority populations were identified within municipal boundaries. Coronado should begin with P2 EOS, due to close proximity to numerous priority populations.

An abundant 5,652 acres of P3 EOS should be further scaled-up and evaluated as a post-P1 EOS and P2 EOS opportunity. In addition to the baseline filtered parameters, P3 EOS is within municipal boundaries but was not filtered in this iteration for proximity to priority populations and has a slope of less than 25%. Solana Beach and Del Mar are exceptions to the order of the recommended Priority 1-2-3 EOS deployment because neither municipality has P1 or P2 EOS due to the fact that no priority populations were identified within municipal boundaries, nor are they within a two-mile buffer of priority populations. Solana Beach and Del Mar should begin with P3 EOS and prioritize alternative methods to localizing their food system. These methods are discussed in the recommendations section.

Local Food Production and Meal Gap Closure Estimations

If all identified 1,461 acres of P1 EOS were converted to regenerative urban agricultural sites and assuming maximum utilization of the space, an estimated 47,250,096 pounds of staple crops could be grown each year. Given an average meal weight of 1.2 pounds[27] P1 EOS could provide 39,375,080 meals annually. This crop yield could close San Diego County's monthly meal gap of 13.5 million by 24.3% if distributed equitably and effectively. If all identified 3,485 acres of P2 EOS were converted to regenerative urban agricultural sites and assuming maximum utilization of the space, an estimated 112,675,178 pounds of staple crops could be grown each year. This yield could provide an estimated 93,895,981 meals each year, which would close San Diego County's meal gap by approximately 58% if distributed equitably and effectively. If all identified 5,652 acres of P3 EOS were converted to regenerative urban agricultural sites and assuming maximum utilization of the space, an estimated 182,746,839 pounds of staple crops could be grown each year. This yield could provide an estimated 152,289,032 meals each year. Full implementation of P3 EOS (or an equivalent acreage) could bridge San Diego County's meal gap by 94% if distributed equitably and effectively (see Appendix B-1).

Food Security Potential

Municipality	Priority 1 Eligible Open Space			Priority 2 Eligible Open Space			Priority 3 Eligible Open Space		
	Acreage	Yield (lbs)	Meals (#)	Acreage	Yield (lbs)	Meals (#)	Acreage	Yield (lbs)	Meals (#)
Solana Beach	0	0	0	0	0	0	4	135,334	112,779
Del Mar	0	0	0	0	0	0	4	137,524	114,603
Coronado	0	0	0	40	1,305,356	1,087,796	45	1,461,713	1,218,094
Encinitas	10	315,294	262,745	95	3,081,326	2,567,772	133	4,287,059	3,572,550
Carlsbad	12	376,398	313,665	84	2,711,371	2,259,475	254	8,203,751	6,836,459
Lemon Grove	15	478,048	398,373	15	482,268	401,890	19	625,267	521,056
Imperial Beach	17	537,529	447,941	17	552,700	460,584	20	631,654	526,379
La Mesa	36	1,151,207	959,339	40	1,278,317	1,065,264	59	1,913,513	1,594,594
Vista	42	1,360,299	1,133,583	93	2,995,555	2,496,296	174	5,624,415	4,687,012
Escondido	47	1,514,053	1,261,711	148	4,778,854	3,982,378	264	8,550,331	7,125,276
National City	71	2,300,268	1,916,890	91	2,943,697	2,453,081	116	3,745,814	3,121,512
Chula Vista	88	2,861,104	2,384,254	439	14,181,510	11,817,925	919	29,722,741	24,768,951
San Marcos	93	2,994,719	2,495,599	308	9,958,366	8,298,638	401	12,958,953	10,799,127
Oceanside	105	3,405,180	2,837,650	313	10,110,338	8,425,282	434	14,031,610	11,693,008
City of San Diego	927	29,955,998	24,963,331	1,803	58,295,519	48,579,599	2,806	90,717,159	75,597,633
Regional (Total)	1,461	47,250,096	39,375,080	3,485	112,675,178	93,895,981	5,652	182,746,839	152,289,032

Table 8. Food security potential for each priority level by municipality. Municipalities are sorted by acreage of P1 EOS (lowest to highest); Coronado, Del Mar, and Solana beach are further sorted by P 1-2 EOS (lowest to highest). The green color gradient displays acreage, yield, and meals from high (darkest shade of green) to low (white). Acreage was calculated in ArcGIS Pro. Yield calculated based on 32,331 lbs./acre.[28] Number of meals based on average meal size (1.2 lbs./meal).[29]

[27] HACAP Food Reservoir, "Pounds per Person."
[28] Videle, "Comparison of Farming in Production of Food Per Acre."
[29] HACAP Food Reservoir, "Pounds per Person."

Carbon Sequestration Estimations

In addition to food security benefits, conversion of P1 EOS (or an equivalent acreage) to regenerative agriculture could annually sequester an average of 1,050 $MTCO_2$ from the atmosphere and retain it as soil organic matter (SOM) after four years of cover crop rotation.[30] 2,504 $MTCO_2$ could be sequestered annually given the identified acreage of P2 EOS, while P3 EOS could sequester 4,060 $MTCO_2$ of atmospheric CO_2 as SOM. Distribution of potential is shown in Table 9.

Annual Carbon Sequestration Potential						
Municipality	Priority 1 Eligible Open Space		Priority 2 Eligible Open Space		Priority 3 Eligible Open Space	
	Acreage	MTCO2	Acreage	MTCO2	Acreage	MTCO2
Solana Beach	0	0	0	0	4	3
Del Mar	0	0	0	0	4	3
Coronado	0	0	40	29	45	32
Encinitas	10	7	95	68	133	95
Carlsbad	12	8	84	60	254	182
Lemon Grove	15	11	15	11	19	14
Imperial Beach	17	12	17	12	20	14
La Mesa	36	26	40	28	59	43
Vista	42	30	93	67	174	125
Escondido	47	34	148	106	264	190
National City	71	51	91	65	116	83
Chula Vista	88	64	439	315	919	660
San Marcos	93	67	308	221	401	288
Oceanside	105	76	313	225	434	312
City of San Diego	927	666	1,803	1,295	2,806	2,016
Regional (Total)	1,461	1,050	3,485	2,504	5,652	4,060

Table 9. Carbon sequestration potential ($MTCO_2$) for each priority level by municipality. Municipalities are sorted by acreage of P1 EOS (lowest to highest); Coronado, Del Mar, and Solana beach are further sorted by P 1-2 EOS (lowest to highest). The green color gradient displays acreage and sequestration potential from high (darkest shade of green) to low (white). Acreage was calculated in ArcGIS Pro. $MTCO_2$ sequestration calculated based on 1,584 lbs. of CO_2 sequestration/acre, then adjusted to $MTCO_2$ using conversion of 2,205 lbs./ton.[31]

Discussion: Additional Anticipated Food System Emission Reductions

A future that avoids the worst consequences of human-caused climate change integrates all available strategies to sequester CO_2 while meeting the needs of an increasing population. In addition to direct retention of CO_2 as SOM, localizing food production through regenerative urban agriculture would reduce GHG emissions associated with land use (deforestation, peatland degradation and fires, and cultivated soils), the supply chain (retail, packaging,

[30] Videle, "Comparison of Farming in Production of Food Per Acre."
[31] Gabriel Kenne and Kloot, "The Carbon Sequestration Potential of Regenerative Farming Practices in South Carolina, USA."

transportation, processing, and food waste improperly disposed of before making it to the market), agricultural production (synthetic fertilizers, the associated energy used to make/distribute fertilizers, and on-site heavy machinery), and post-retail (food waste and refrigeration).[32] Project Drawdown's table of solutions identified reducing food waste as the leading solution to reduce heat-trapping gases under a warming scenario of 2°C, reducing/sequestering 90.7-101.71 gigatons of CO_2 equivalents between 2020 and 2050.[33] A key strategy of reducing food waste is addressing waste from farm to household, and localization is a promising strategy. Plant-rich diets were identified as the third leading solution, and could reduce/sequester 65.01-91.72 gigatons of CO_2 equivalents between 2020 and 2050.[34] Urban agriculture has the potential to shift food consumption towards low carbon diets — up to 205.1 kg CO_2e/year/person (12.1%) — due to urban farming's powerful ability to be a social catalyst for reducing animal sourced foods.[35]

[32] "How Much of Global Greenhouse Gas Emissions Come from Food?"
[33] Project Drawdown, "The Drawdown Review."
[34] Project Drawdown.
[35] Puigdueta et al., "Urban Agriculture May Change Food Consumption towards Low Carbon Diets | Elsevier Enhanced Reader."

PART IV: RECOMMENDATIONS

Overview

Despite the regional potential for urban agricultural sites and effective localized distribution, over one million people lack access to healthy, nutritious, affordable food in San Diego County. In response, the Climate Action Campaign's 5th Edition Report Card included a key recommendation to Create Healthy Food Systems. Multi-solving food system challenges (i.e., allocation of water resources, agricultural-induced environmental degradation, GHG emissions from food waste, worker rights, etc.) is central to building resiliency while mitigating the crisis at large. Food systems that are locally attuned, responsive, adaptive, and safe must be designed and established in the immediate future with collinearity to mitigate GHGs within this sector while addressing present and future food insecurity.

Across the 15 municipalities annually monitored by the Climate Action Campaign's Report Card (City of San Diego, Oceanside, San Marcos, Chula Vista, National City, Escondido, Vista, La Mesa, Imperial Beach, Lemon Grove, Carlsbad, Encinitas, Solana Beach, Del Mar, and Coronado), there is a tremendous collective opportunity to build a resilient regional food system that addresses today's food systems' shortcomings while preparing for what is to come. In addition to ongoing local organizations' remarkable research and groundwork within this sector, identifying EOS aims to encourage community-powered solutions. The listed municipalities have a cumulative 1,461 acres of P1 EOS (within priority populations and deemed undevelopable) that should be highly considered for conversion to regenerative urban agriculture. The identified 3,485 acres of P2 EOS (within two miles of priority populations) should be subsequently considered for conversion to regenerative urban agriculture. To scale up, the identified 5,652 acres of P3 EOS (no priority population specifications, but within municipal boundaries) should be considered for conversion to regenerative urban agriculture.

Focusing on external solutions such as bringing businesses into neighborhoods rather than investing in internal community-powered solutions is a lead contributor to gentrification. Municipalities within San Diego County can cultivate a community-powered healthy food system that is equitable, stable, and profitable by actively localizing food production by means of urban agriculture within EOS. The process of building climate-related local resilience to food insecurity into regional CAPs should be thoughtfully combined with gender equity and social justice.

Given the importance of integrating social justice with climate-resilient food security, this analysis developed four groups of municipalities based on their current EOS and presence of or proximity to priority populations:

❶ **High** EOS and **high** priority populations

- City of San Diego
- Chula Vista
- Oceanside
- San Marcos
- Escondido

❷ **Low** EOS and **high** priority populations

- Vista
- National City
- La Mesa
- Imperial Beach
- Lemon Grove

❸ **High** EOS and **low** priority populations

- Carlsbad
- Encinitas

❹ **Low** EOS and **low** priority populations

- Coronado — within two-mile buffer of priority populations, comparatively significant EOS within this group.
- Del Mar — no priority populations.
- Solana Beach — no priority populations.

To indicate which strategies each municipality should prioritize, their corresponding group icon — ❶❷❸❹ — will be listed. Though some municipal groups may be better suited than others to prioritize the recommended strategy, all municipalities should consider how the action could be integrated into their Climate Action Plan and how it could directly target their community's needs. To highlight strategies particularly geared towards supporting or developed by existing community-powered organizations, the — ○ — icon will be listed.

Recommended Action Items

Intentional identification of EOS and the development of strong incentives for local community-powered organizations to repurpose publicly owned open space to regenerative urban agriculture should be a unified priority action across all Climate Action Plans.

Objective 1. Protect, improve, and invest in existing local agricultural spaces to shift towards a resilient regenerative food system.

Protect: Ensure the protection and preservation of existing agricultural space, to encourage the continued production of local crops.

- Strategy 1: Lock in agricultural space that exists within municipalities via incentivizing agricultural conservation easements. ❶❷❸
    - Consider expansion of the County of San Diego's Purchase of Agricultural Conservation Easement (PACE) Program among regional municipalities — Balancing mindful steering of affordable housing development efforts toward urban areas in tandem with agricultural conservation easements is essential to avoid exacerbating food insecurity.

Improve: Advocate for the adoption of carbon farming among existing local farms.

- Strategy 1: Develop economic incentives that encourage carbon farming practices and match grant funding to support local carbon farming pilot programs. ❶❷❸❹○
    - Foodshed's climate-smart incentive pilot is a phenomenal example of an implementation strategy to encourage farmers to adopt carbon farming practices in a socially, economically, and environmentally equitable way. Their model incentivizes adoption of carbon sink practices at the point of purchase from their network of 44 local farms (67% BIPoC owned, 50% woman owned). Local farms would receive higher premium payments for their produce with a higher tier of carbon sink participation.

Invest: Invest in decentralized and diverse food system infrastructure that prioritizes carbon sink practices.

- Strategy 1: Increase consistent, stable, and adequate funding for on-site research to enable deployment of carbon-sink pilot projects that will make the case for climate-related local resilience. ❶❸❹○
- Strategy 2: Incentivize partnerships between local businesses and regenerative farms. ❶❸❹○

- Strategy 3: Incentivize creative partnerships between food security distribution organizations and regenerative farms. ❶❷○

Objective 2. Allow, support, and advocate for the expansion of urban agricultural projects on public land.

Allow: Eliminate food sovereignty barriers within jurisdictions such as zoning regulations that have historically been used to segregate communities based on race, ethnicity, or income status.

- Strategy 1: Expand zones that currently permit urban agriculture. This should be updated in General Plans. ❶❷❸❹○
- Strategy 2: Actively connect urban farmers with private landowners who have the space to grow crops. ❷❸❹○
  - Encourage collective efforts among neighborhoods to share resources to ensure healthy food access, as effectively demonstrated by Good Neighbor Gardens CSA program.
  - The Urban Agriculture Incentive Zone should be revitalized, expanded, and effectively communicated to local grassroots organizations, community members, and schools.

Support: Encourage coordination between municipalities and amongst local climate-related food sovereignty organizations.

- Strategy 1: Streamline food planning between municipalities to develop strong networks of food production ❶❸ and equitable distribution ❷❹.
- Strategy 2: Inform organizations of clear, collectively beneficial policy advocacy efforts, funding opportunities (especially those that exist or serve within or around identified priority populations). ❶❷❸❹○
- Strategy 3: Actively identify potential urban agricultural sites and directly inform organizations of their locations. ❶❷❸❹○
- Strategy 4: Direct more resources to climate-related and/or food sovereignty organizations. ❹

Advocate: Develop economic incentives that encourage equitable local food production and consumption.

- Strategy 1: Incentivize repurposing space to improve food security. ❶❸○
  - As described by the San Diego Food System Alliance's Food Vision 2030 report: "In Los Angeles, a Good Food Zone policy was passed in 2020 to encourage food-centered community economic development initiatives. The

Good Food Zone policy provides incentives, business services, and technical assistance to stores and restaurants to increase healthy food options. Similar incentives are worth exploring in San Diego County, especially in combination with the Live Well Community Market Program and BrightSide Produce."[36]

- Strategy 2: Limit unhealthy food retail by considering an 'unhealthy foods tax.' ❶❷❸❹
  - Consider a similar tax on the sale of sugary and highly processed foods the City of Berkeley passed in 2014[37] and the Navajo Nation reauthorized in 2021 (initial authorization in 2014).[38] The accumulated funds should then be redistributed to local climate-centered food security projects.
- Strategy 3: Create targets for annually increasing purchases from local regenerative farmers and underserved producers. ❶❷❸❹○
  - Targets can be achieved by setting quotas in addition to distance and density requirements for local food businesses.

As articulated by Elle Mari at UC San Diego's Center for Community Health, "We must be willing to rethink the perceived limitations of square footage needed for success in grocery and acreage needed to produce food." There are extensive methods of integrating food systems into local climate planning, whether a municipality has a tremendous amount of publicly owned open space or not. In addition, cities should prioritize food production in its allocation of available water resources as regional drought conditions persist and average temperatures intensify. Communities need ensured availability and access to a stable supply of nutritionally dense food, more than homeowners need year-round grass lawns. Lastly, climate resiliency and adaptation planning does not discount the urgency of aggressive and prompt mitigation. As short-sighted global governance systems and heavily polluting industries fail to protect humanity from the existential threat of climate change, local leaders must double down on building resilient communities while mitigating emissions.

[36] San Diego Food System Alliance, "San Diego County Food Vision 2030."
[37] Price, "Do Soda Taxes Work?"
[38] Smith, "Navajo Nation Leaders Reauthorize Sales Tax on Unhealthy Foods, Beverages."

CONCLUSION

The global food system is failing to address food insecurity and malnutrition in an environmentally sustainable way. In response, mitigation of the system's CO_2 sources, supporting CO_2 sinks, and increasing crop yield output where possible in a changing climate must be prioritized. This multi-solving requires shifting agricultural practices, addressing food waste and diets, converting degraded land to sinks, and protecting and restoring ecosystems. Simultaneously, climate change touches every part of the food system and the associated risks are too substantial to ignore.

Converting publicly owned open space to small scale regenerative agricultural sites could play a key role in establishing resilient local food systems. To better understand how much eligible open space exists among the 15 municipalities reviewed by the Climate Action Campaign Report Card, this paper provides an analysis of a modifiable, replicable, geospatial model that was used to identify eligible open space with key criteria to prioritize equity and suitable environmental features. To begin identifying eligible space, baseline criteria that all potential conversion sites would be filtered for were established: publicly owned open space that is not an environmentally sensitive area. From there, three tiers based on project deployment priority that promotes access were created. P1 EOS had to be within priority populations, was deemed undevelopable by the County, and had minimal slope of less than 15%. P2 EOS was within a two-mile buffer of priority populations and maintained the same slope requirements. P3 EOS was further expanded with no priority population specification within municipalities and an increased slope parameter up to 25%.

This model identified 1,461 acres of P1EOS, 3,485 acres of P2 EOS, and 5,652 acres of P3 EOS. If converted to productive regenerative agricultural space, annually, P1 EOS could produce an estimated 47 million pounds of crops and provide 39 million meals, closing the San Diego County meal gap by 24%, while sequestering approximately 1,050MT CO_2. Annually, P2 EOS could produce an estimated 112.7 million pounds of crops and provide 93.9 million meals, closing San Diego County's meal gap by 58%, while sequestering approximately 2,504MT CO_2. Annually, P3 EOS could produce an estimated annual 182.75 million pounds of crops and provide 152.29 million meals, closing San Diego County's meal gap by 94%, while sequestering approximately 4,060 MTCO_2.

Given the importance of integrating social justice with climate-resilient food security, this analysis developed four groups of municipalities based on their current EOS and presence of or proximity to priority populations, which guided municipal recommendations. Group one was characterized by high EOS and high priority populations, and include the City of San Diego, Chula Vista, Oceanside, San Marcos, and Escondido. Group two was characterized by low EOS and high priority populations, and include Vista, National City, La Mesa, Imperial Beach, and Lemon Grove. Group three was characterized by high EOS and low priority populations, and include Carlsbad and Encinitas. Group four was characterized by low EOS and low priority populations, and include Coronado, Del Mar, and Solana Beach.

San Diego County has a collective opportunity and responsibility to build a resilient and equitable regional food system that actively supports mitigation efforts and improves food security. Establishing climate-resilient food systems should be a unified priority action across all Climate Action Plans, and should be a major point of discussion for Counties beyond San Diego immediately and increasingly as the climate crisis progresses. We must be willing to rethink the perceived limitations of the square footage needed to sustain ourselves. The climate is changing. Our systems must, too.

APPENDIX

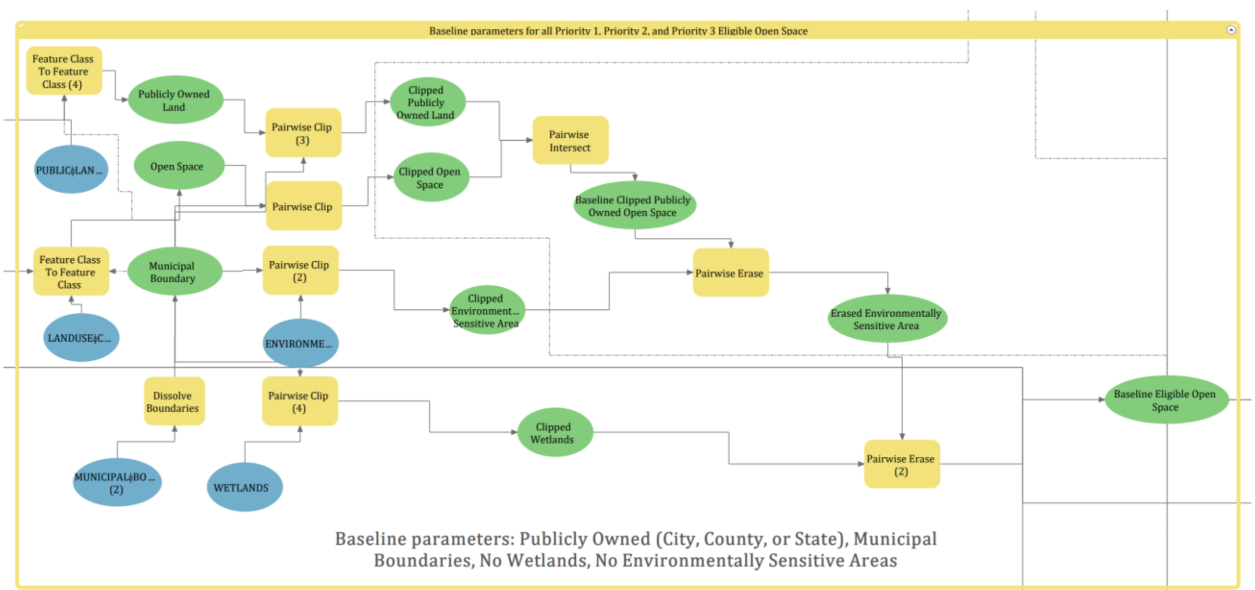
Appendix A-1: Dataset Descriptions

Dataset Credits and Descriptions		
Dataset	**Credits**	**Description**
CalEnviroScreen4.0 Priority Populations	Office of Environmental Health Hazard Assessment (OEHHA)	The PriorityPopulations2022CES4.gdb file contains spatial data identifying disadvantaged communities and low-income communities for the purposes of California Climate Investments, consistent with the release of CalEnviroScreen 4.0 and CalEPA Disadvantaged Communities designations. This update contains new and categorical changes and uses a new dataset to update the existing methodology.
Developable Land	There are no credits for this item. Hosted by SANDAG.	N/A
Environmentally Sensitive Areas	County of San Diego Land Use and Environment Group GIS	This dataset is a combination of six elements of environmentally sensitive areas. Those elements are:1. County of San Diego South County Multiple Species Conservation Program (MSCP) Hardline Preserve designation,2. Preserved land within County of San Diego South County MSCP,3. County of San Diego South County MSCP Pre-Approved Mitigation Area (PAMA) designation,4. Clean Water Act section 303(d) water bodies listed by the California Water Resources Control Board in 2016 with a 200-foot buffer,5. Waters that support habitats necessary for the survival and successful maintenance of plant or animal species established under state and/or federal law as rare, threatened, or endangered from 2007,6. Areas of Significant Biological Concern (ASBC).
Land Use (Current)	SANDAG, Data Solutions Division Data, Analytics and Modeling Department	Existing (2021) SANDAG land use. Used for mapping and analysis. Used to support SANDAG Regional Growth Forecasts. SANDAG performs an annual land use and housing unit inventory in the interest of maintaining a robust and accurate catalog of the existing conditions for any given year. This catalog of snapshots are the base year inputs to SANDAG's Regional Demographic, Economic, and Land Use Models.
MSCP Vegetation SD	There are no credits for this item. Hosted by SANDAG.	This dataset maps the MSCP areas of vegetation and land cover throughout the City of San Diego. It includes sensitive and non-sensitive vegetation. The Multiple Species Conservation Program (MSCP) is a comprehensive habitat conservation planning program for southwestern San Diego County.
Municipal Boundaries	County Assessor, SanGIS, San Diego Local Agency Formation Commission (LAFCO)	This layer is used as an overlay to locate and identify municipal jurisdictions for parcels, roads, addresses, and other data layers. The dataset is updated when SanGIS is notified by the San Diego Local Agency Formation Commission (LAFCO) of a recorded annexation or detachment and as a result of ongoing landbase maintenance activities.
Precipitation	County of San Diego, Planning & Development Services, LUEG-GIS Service	This layer exists to illustrate average precipitation zones for any area, County wide, and assist in planning and management of within, but not limited to flood and erosion control, infrastructure material choices, roadway maintenance frequencies, etc.
Public Land Owner	SANDAG Data Solutions Division: Data, Analytics, and Modeling Department	Existing public ownership. SANDAG's Land Layers are created for use in the Regional Growth Forecast to distribute projected growth for the San Diego region to suitable subareas in the region. These land layers include existing land use, planned land use, land ownership, constraints to development, land available for development, known sitespecific developments, and lands available for redevelopment and infill. The land layers inventory is updated when new information is available. Many of these data sets are built from the San Diego Geographic Information Source (SanGIS) landbase. The land use information has been updated continuously since 2000 using aerial photography, the County Assessor Master Property Records file, and other ancillary information. The land use information was reviewed by each of the local jurisdictions and the County of San Diego to ensure its accuracy. Although this inventory contains more categorical detail and has better positional accuracy than previous land use inventories, users should be aware that this data may be too generalized for some local planning projects. Road right-of-way polygons and privately owned land are not part of this ownership layer.Adjacent parcel polygons with the same ownership have been aggregated (dissolved) into a single feature.
Recycled Water Main	This data is routinely maintained by City of San Diego, Public Utilities Department; Asset Management-GIS section.	Recycled Water Distribution and Transmission System for the City of San Diego. The recycled water system includes recycled water pipes that can run parallel to potable water pipes. Recycled water is for non-potable use, typically irrigation or industrial processes and can be identified by purple pipe, tape, or signs. Potable water is used for human consumption such as drinking, cooking bathing or washing clothes.
Slope	Ross Martin with County of San Diego, Planning and Development Services, LUEG GIS Service.	This layer was generated to show County-wide relief representation, expressed as 'percent slope' and aggregated in four classifications, based on their percentages and their increase in slope severity. Aggregation into the classifications was performed to assist in increased readability and simplification of map symbolization tasks.
Soils Hydro Group	U.S. Department of Agriculture, Natural Resources Conservation Service	This data set is a digital soil survey and generally is the most detailed level of soil geographic data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric correct base and digitizing, or by revising digitized maps using remotely sensed and other information.Original SSURGO digital files include many various attributes. For this layer, only SOIL HYDROLGIC GROUP has been joined to the spatial data. The Hydrologic Group (A, B, C, D) indicates the potential for runoff when the soil is thoroughly wet, with A indiciating the least runoff, and D indicating the most runoff. This layer has been dissolved on the soil hydrologic group.
Water Main San Diego	City of San Diego, Public Utilities Department; Asset Management-GIS section	This dataset is a geographical representation of water main lines for the City of San Diego and is intended to be used for analysis and mapping. Assets are only included if they do not reside in a spatial buffer within specific asset types: o Within 100 feet of any dam, outlet tower, or pump stations. o Within 500 feet of any treatment plants.
Wetlands	US Fish and Wildlife Service	This California dataset was downloaded in FGDB from https://www.fws.gov/wetlands/Data/Mapper.html and clipped to the SanGISHYD_WATERSHEDs layer. This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the United States and its Territories.

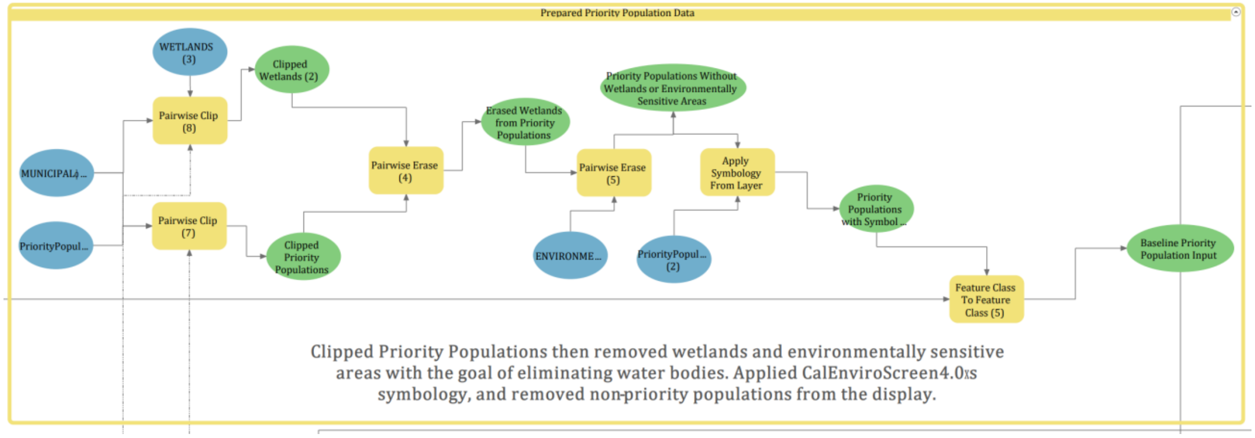
Appendix A-2: SANDAG Land Use Descriptions

SANDAG Land Use Definitions		
LU Code	**Description**	**Definition**
7606	Landscape Open Space	Actively landscaped areas within residential neighborhoods such as greenbelt areas and hillsides with planted vegetation (trees/shrubs), among others.
9100	Vacant and Undeveloped Land	Existing vacant and undeveloped land.
7607	Residential Recreation	Active neighborhood parks that are for the use of residents only such as fenced in areas that may contain pools, tennis and basketball courts, barbecues, and a community meeting room.
7601	Park - Active	Recreation areas and centers containing one or more of the following activities: tennis or basketball courts, baseball diamonds, soccer fields, or swings. Examples are Robb Field, Morley Field, Diamond Street Recreation Center, and Presidio Park. Smaller neighborhood parks with a high level of use are also included as active parks.

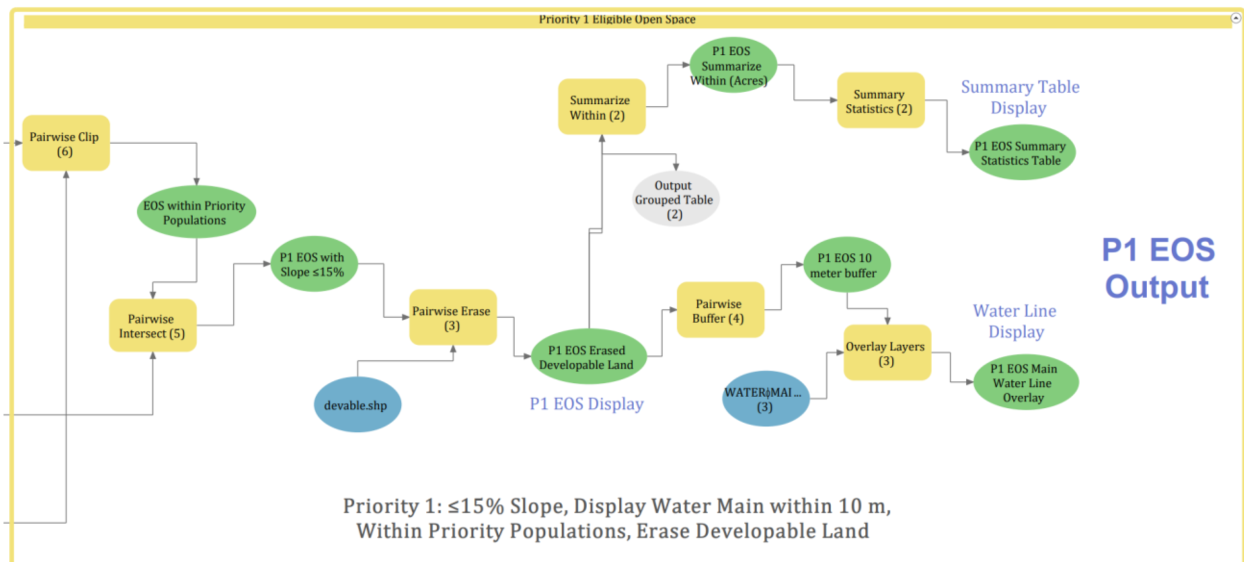
Appendix A-3: Three-Tiered Eligibility Model



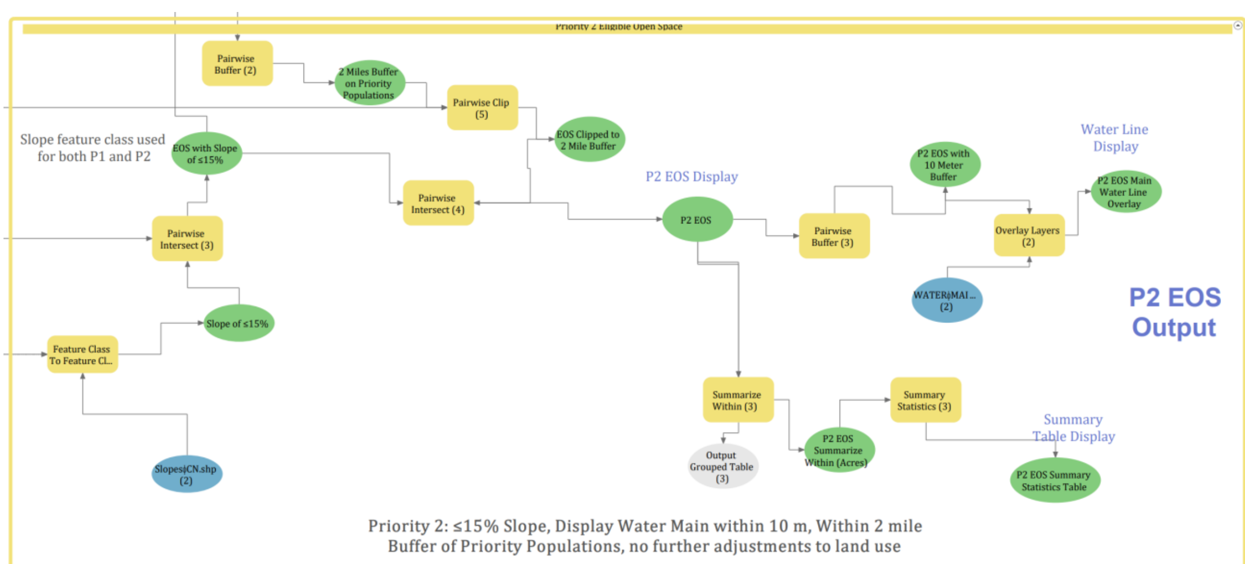
Baseline parameters: Publicly Owned (City, County, or State), Municipal Boundaries, No Wetlands, No Environmentally Sensitive Areas



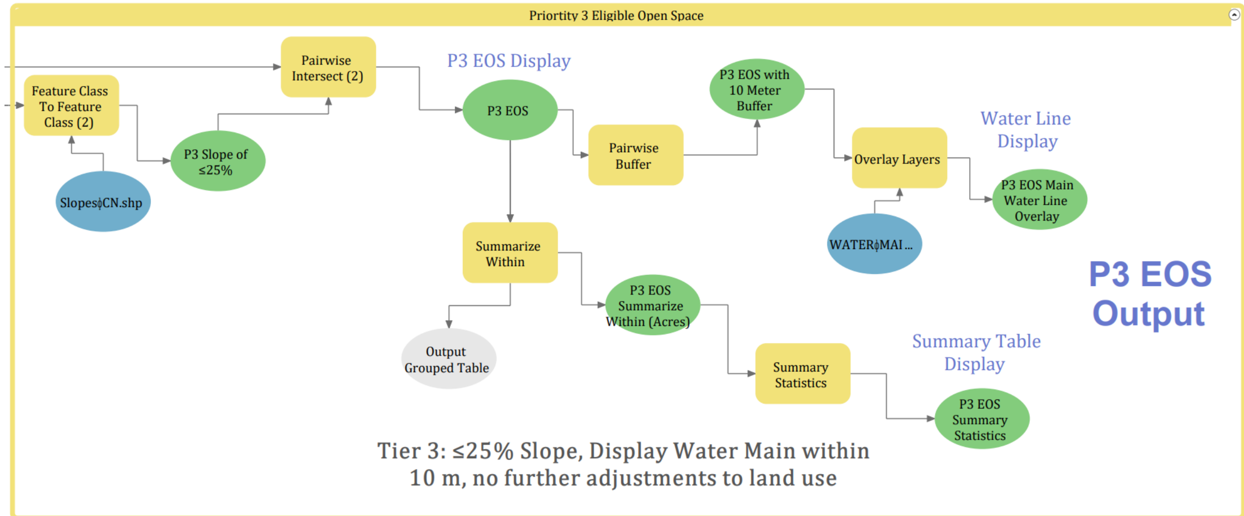
Prepared Priority Population Data
WETLANDS (3)
Clipped Wetlands (2)
Pairwise Clip (8)
MUNICIPAL...
PriorityPopul...
Pairwise Clip (7)
Clipped Priority Populations
Pairwise Erase (4)
Erased Wetlands from Priority Populations
Priority Populations Without Wetlands or Environmentally Sensitive Areas
Pairwise Erase (5)
ENVIRONME...
PriorityPopul... (2)
Apply Symbology From Layer
Priority Populations with Symbol...
Feature Class To Feature Class (5)
Baseline Priority Population Input
Clipped Priority Populations then removed wetlands and environmentally sensitive areas with the goal of eliminating water bodies. Applied CalEnviroScreen4.0's symbology, and removed non-priority populations from the display.



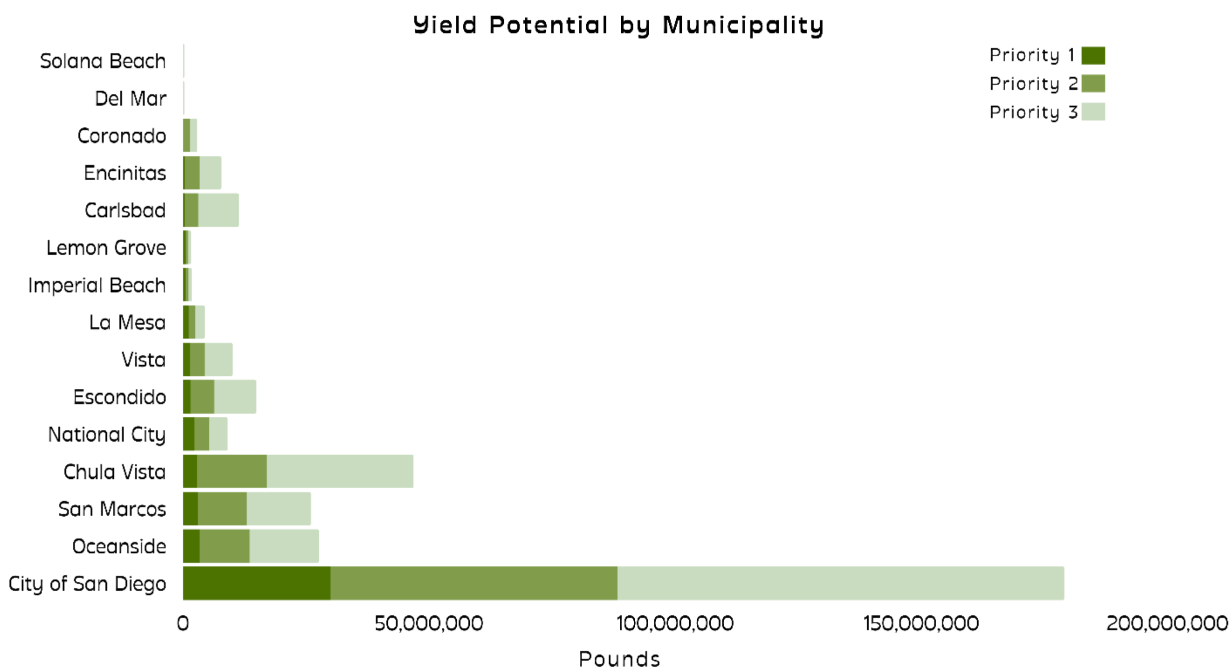
Priority 1 Eligible Open Space
Pairwise Clip (6)
EOS within Priority Populations
Pairwise Intersect (5)
P1 EOS with Slope ≤15%
Pairwise Erase (3)
devable.shp
P1 EOS Erased Developable Land
P1 EOS Display
Summarize Within (2)
P1 EOS Summarize Within (Acres)
Output Grouped Table (2)
Summary Statistics (2)
Summary Table Display
P1 EOS Summary Statistics Table
Pairwise Buffer (4)
P1 EOS 10 meter buffer
Overlay Layers (3)
WATER_MAI... (3)
Water Line Display
P1 EOS Main Water Line Overlay
P1 EOS Output
Priority 1: ≤15% Slope, Display Water Main within 10 m, Within Priority Populations, Erase Developable Land



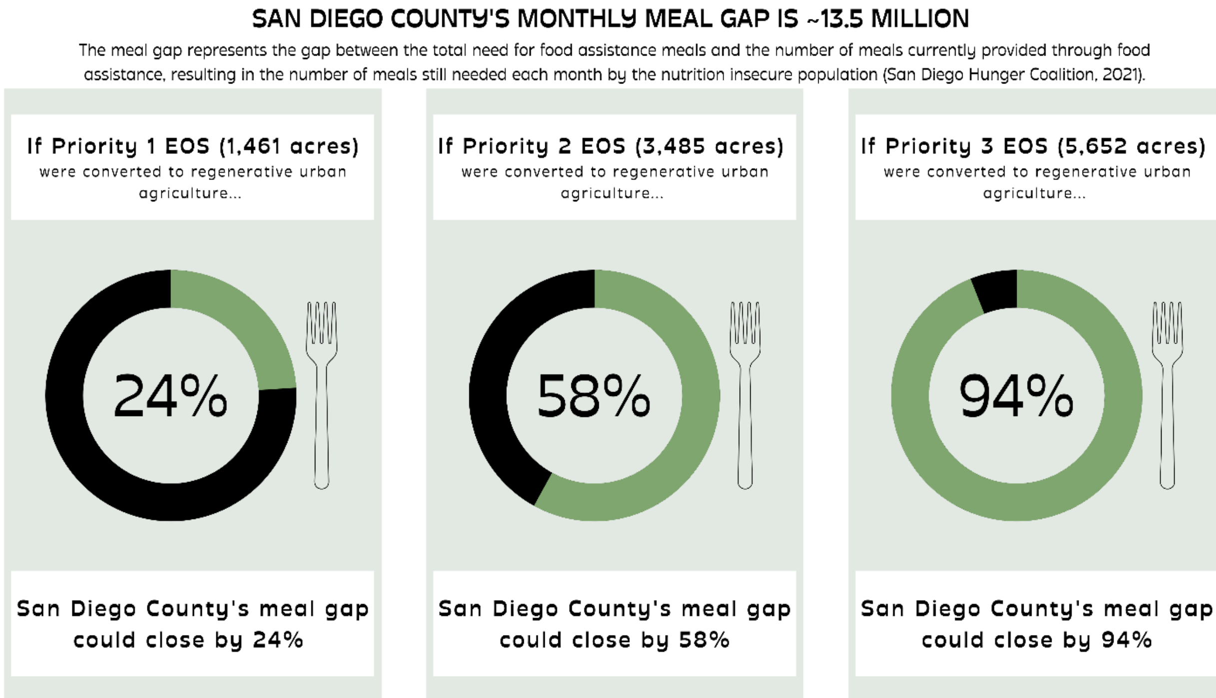
Priority 2 Eligible Open Space
Pairwise Buffer (2)
2 Miles Buffer on Priority Populations
Pairwise Clip (5)
EOS Clipped to 2 Mile Buffer
Slope feature class used for both P1 and P2
EOS with Slope of ≤15%
Pairwise Intersect (4)
Pairwise Intersect (3)
Slope of ≤15%
Feature Class To Feature Cl...
Slopes_CN.shp (2)
P2 EOS Display
P2 EOS
Pairwise Buffer (3)
P2 EOS with 10 Meter Buffer
Overlay Layers (2)
WATER_MAI... (2)
Water Line Display
P2 EOS Main Water Line Overlay
P2 EOS Output
Summarize Within (3)
Output Grouped Table (3)
P2 EOS Summarize Within (Acres)
Summary Statistics (3)
Summary Table Display
P2 EOS Summary Statistics Table
Priority 2: ≤15% Slope, Display Water Main within 10 m, Within 2 mile Buffer of Priority Populations, no further adjustments to land use



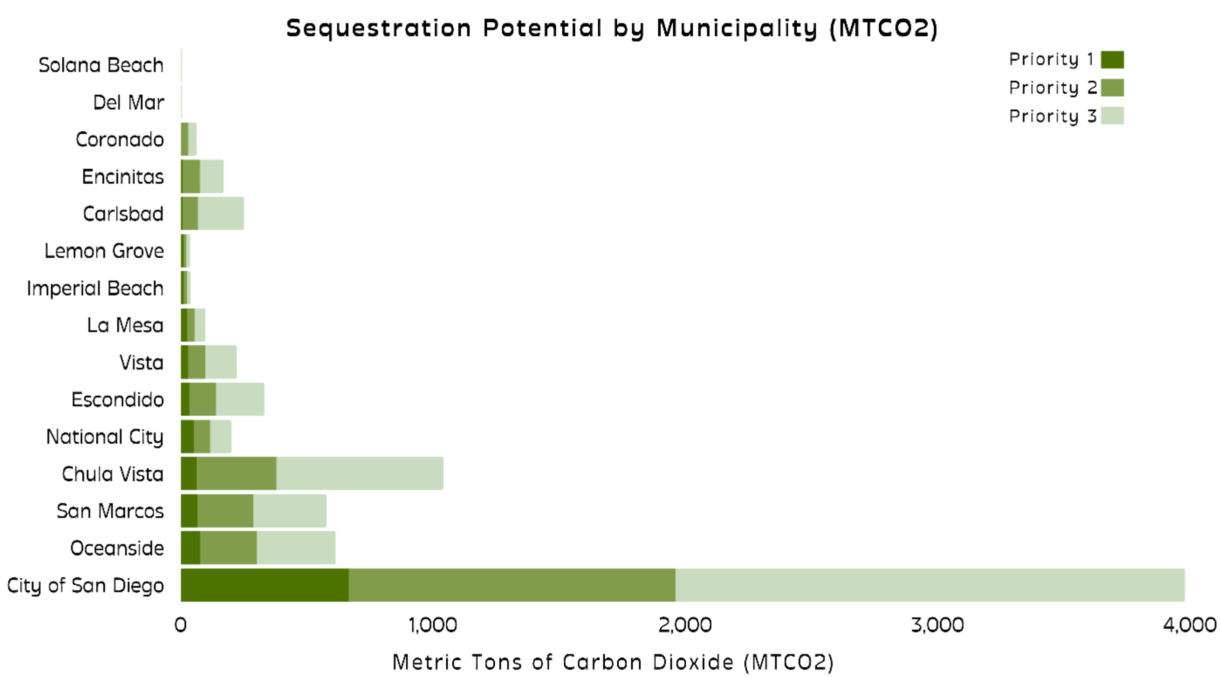
Appendix B-1: Yield potential of converting Priority 1-2-3 EOS by municipality



Appendix B-2: Regional meal gap closure potential of converting Priority 1-2-3 EOS



Appendix B-3: MTCO2 sequestration potential of converting Priority 1-2-3 EOS



REFERENCE LIST

Crippa, M., E. Solazzo, D. Guizzardi, F. Monforti-Ferrario, F. N. Tubiello, and A. Leip. “Food Systems Are Responsible for a Third of Global Anthropogenic GHG Emissions.” *Nature Food* 2, no. 3 (March 2021): 198–209. https://doi.org/10.1038/s43016-021-00225-9.

Danielle E. Medek. “Estimated Effects of Future Atmospheric CO2 Concentrations on Protein Intake and the Risk of Protein Deficiency by Country and Region.” Accessed May 14, 2022. https://doi.org/10.1289/EHP41.

Gabriel Kenne, and Robin Kloot. “The Carbon Sequestration Potential of Regenerative Farming Practices in South Carolina, USA.” *American Journal of Climate Change* Vol.8, no. No.2 (2019): 157–72. https://doi.org/10.4236/ajcc.2019.82009.

Gebeyehu, Daniel Teshome. “Impact of COVID-19 on the Food Security and Identifying the Compromised Food Security Dimension: A Systematic Review Protocol.” *National Library of Medicine*, August 9, 2022. https://doi.org/10.1371/journal.pone.0272859.

HACAP Food Reservoir. “Pounds per Person,” n.d. https://www.hacap.org/application/files/3516/0280/6327/Pounds_Per_Person.docx.pdf.

Our World in Data. “How Much of Global Greenhouse Gas Emissions Come from Food?” Accessed May 25, 2022. https://ourworldindata.org/greenhouse-gas-emissions-food.

IPCC. “Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge, UK and New York, NY, USA: Cambridge University Press, 2022. https://doi.org/10.1017/9781009157926.

Mbow, C., C. Rosenzweig, L.G. Barioni, T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, et al. “Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems,” 2019. https://www.ipcc.ch/srccl/chapter/chapter-5/.

Molar-Candanosa, Roberto. “NASA at Your Table: Climate Change Impacts on Crop Growth.” Text. NASA, September 1, 2021. http://www.nasa.gov/feature/goddard/esnt/2021/nasa-at-your-table-climate-change-and-its-environmental-impacts-on-crop-growth.

Myers, Samuel S, K Ryan Wessells, Itai Kloog, Antonella Zanobetti, and Joel Schwartz. “Effect of Increased Concentrations of Atmospheric Carbon Dioxide on the Global Threat of Zinc Deficiency: A Modelling Study.” *The Lancet Global Health* 3, no. 10 (October 1, 2015): e639–45. https://doi.org/10.1016/S2214-109X(15)00093-5.

Pierce, David, Julie Kalansky, and Daniel Cayan. “Climate, Drought, and Sea Level Rise Scenarios for California’s Fourth Climate Change Assessment,” 2018, 78.

Price, Austin. “Do Soda Taxes Work?” UC Berkeley Public Health, August 25, 2019. https://publichealth.berkeley.edu/news-media/research-highlights/do-soda-taxes-work/.

Project Drawdown. “The Drawdown Review: Climate Solutions for a New Decase,” 2020. https://drawdown.org/sites/default/files/pdfs/TheDrawdownReview%E2%80%932020%E2%80%93Download.pdf?_ga=2.30259199.1772456134.1653866218-330030167.1653196672.

Puigdueta, Ivanka, Eduardo Aguilera, Jose Luis Cruz, Ana Iglesias, and Alberto Sanz-Cobena. “Urban Agriculture May Change Food Consumption towards Low Carbon Diets | Elsevier Enhanced Reader,” March2021. https://doi.org/10.1016/j.gfs.2021.100507.

San Diego Food System Alliance. “San Diego County Food Vision 2030.” San Diego Food System Alliance, July 2021. https://sdfoodvision2030.org/download-the-plan/.

San Diego Hunger Coalition. “The State of Nutrition Security in San Diego County: Before, during and beyond the COVID-19 Crisis,” 2021. https://www.sandiegohungercoalition.org/sdhc-research-reports.

Smith, M. R., C. D. Golden, and S. S. Myers. “Potential Rise in Iron Deficiency Due to Future Anthropogenic Carbon Dioxide Emissions.” *GeoHealth* 1, no. 6 (2017): 248–57. https://doi.org/10.1002/2016GH000018.

Smith, Noel Lyn. “Navajo Nation Leaders Reauthorize Sales Tax on Unhealthy Foods, Beverages.” The Daily Times. Accessed May 25, 2022. https://www.daily-times.com/story/news/local/navajo-nation/2021/01/09/navajo-nation-reauthorizes-sales-tax-unhealthy-foods-beverages/6606210002/.

Videle, James. “Comparison of Farming in Production of Food Per Acre,” n.d., 12. “The Productivity of Vegan-Organic Farming,” n.d., 20.