The Social Cost-Benefit Policy Tool in an Ecological Economic Framework: *UC Berkeley's OTRF Case Study*

Allegra Saggese
University of California, Berkeley
Undergraduate Dissertation for Environmental Policy, Science, and Management
Haas Scholars Undergraduate Thesis

May 11, 2018

Advisor: Professor Alastair Iles

Abstract:

The Cost-Benefit Analysis (CBA) is a policy tool provides a quantitative framework to comparing two potential scenarios. But, its use within the context of climate change introduces new obstacles to its accuracy and ability to perform under uncertain climate and behavioral conditions. This research uses an ecological economic framework to approach the question of whether CBA can be effectively salvaged given fundamental assumptions that imply a normative framework of behavior and resource availability that other academic disciplines have disproven. The application of ecological economic remodels of CBA is rarely applied in practice, and requires institutional buy-in and paradigm shifts in policy generation to be full realized. This research outlines the differences between a traditional welfare economic approach to CBA and an ecological economic approach, emphasizing the need to (1) increase democratic process for CBA (2) contextualize decisions in resource constraints, and (3) deploy more robust methodology on utility and welfare across generations in the face of uncertainty due to climate change. This study analyzes the University of California, Berkeley in its deliberation over converting agriculture research facilities to student housing. Because both housing and agriculture are becoming increasingly valuable in a resource constrained environment, this research focuses on shifting from the framework of competing interests to interconnected issues which require economic analysis of a higher complexity, participation level, and consideration of continually growing resource constraints.

Table of Contents

3: Towards an Expanded CBA Approach

(IV) DISCUSSION

1: Integration of Parametric Changes
- Improving Methodology: Sustainability and Democracy
- Normative Approach: Discounting, EUT, Intergenerational welfare

2. Hypothesis Re-evaluation

(V) CONCLUSION

1: Recommendations

2: Further research

(VI) WORK CITED

Introduction

Research Question: The Economic Case Study of the OTRF

The economic case study of the OTRF started from the simple necessity to do a financial policy analysis of the site of a potential housing development. Sitting on the crux of basic needs for students: housing, food, research, and experiential learning, there was a necessity to perform a financial analysis of the project in order to provide some insight for decision making. While any political decision is not made solely on financial viability, the CBA (CBA) is a unique policy tool that focuses on both quantitative and qualitative factors of the policy decision and its impact on social welfare, specifically of afflicted communities and society in general. While a political economic explanation of the CBA will come later in this paper, I will now give an overview of the research question.

This case study begins as a much larger question, one that asks how we will use economic decision making tools in the application of policy, given the growing uncertainty in future valuation that results from the onset of climate change. While climate change is a massive topic and will have a variety of impacts on our day to day lives, thinking specifically about how the effects of climate change will alter our economic valuation of goods require a perspective that capture our understanding of the impacts of climate change. Because climate scenarios are probabilistic, uncertainty is present in many components of economic analysis. But, for economics to apply itself to the most pressing issues of today and become accessible to policymakers so effective policy can be rendered using complex tools, we must begin to merge economic theory, climate change solution and practical models that integrate nuanced notions of sustainability.

Given this need, my research will describe the sociopolitical context of the decision making process at the University of California and the University of California, Berkeley level. It will set the stage for the factors of the policy scenarios given the UC performed a CBA to decide between developing the OTRF for housing space and maintain the property as agriculture research and urban gardening

facilities. Although the University has chosen to not conduct a formal economic analysis at this time, I apply the CBA tool as the most flexible and standard for investigating the potential future states.

Next, I aggregate many of the existing arguments that exist within economic, ecological, and environmental policy literature today which question both assumptions and methodologies of the CBA structure and its augmentations to lay out the general shortcomings of the modeling exercise. I emphasize the inability to capture certain ecological, environmental, and social benefits. Although limited in my economic ability currently, I will attempt to make original suggestions which build off the existing literature, both established and more experimental, which argue for ways to improve the approach to bridging economic and monetary analyses of policy decision making through integrating concerns of democracy, equity, and resource scarcity across generations impacted by this policy.

Motivation for the Question

Moving forward, understanding this tool's nonpartisan and universal acceptance given neoclassical assumptions of rationality, preference, and future utility are questionable in the future state of our world. I invite the reader to consider is duality of economics as both explaining human behavior and influencing it. Neoclassical economics holds general assumptions to be true, and as it does, these assumptions become influential in the way people make decisions. This is a necessary component of deconstructing the existing framework and moving towards a new ideological regime of economics. I argue our reliance on economics, referred to as economism, as the main informant of many of our decisions ignores new science and knowledge in favor of reinforcing a mode of thought for the sake of standardization and comparability (Norgaard).

This has of course been addressed, and the overall goal in applying economics is not to explain and predict each moment of human exchange and choice. But, the CBA differs in it holds great influence in public decision making while the information included varies across application. This makes the accounting model for the CBA appear sturdy and rigorous, while each layer of the foundation could be

made from different modes of thoughts, influenced by the clients and decision makers and not the decision's situation in a geopolitical, environmental, or long-term context.

In the earlier part of this paper, I track and recreate the decision making process within the University to first understand: who are the concerned parties in this case? Every CBA, specifically those applied in the social welfare context, have a primary purpose of serving the needs of the constituents or afflicted parties. How are these stakeholders alerted of potential policy changes and how do they remain engaged in the policy process? To dig deeper, and because the University is not undergoing a formal CBA for this proposal, I evaluate the extent to which formality exists in the analysis performed by those tasked in evaluating costs and benefits of certain aspects of the land. This formality, you could ask, is the same formality critiqued in earlier paragraphs as being too rigid in form and not in quality control or robustness. But, my case here is to say: if the University is using parsed together analyses on costs and benefits of the land to then present information formally to influence a public decision, isn't this following within the category of what the cost benefit essentially is? And if it does fall into this category, are they able to mask potentially ill-supported, cherry-picked, and narrow economic analysis under the guise of the hearty and quantitative methodology? The fault here lies again within the unique form of economism that has developed in the world, and more specifically the United States. If we are unwilling to apply a more formal and intensive review to analytical models of a potential policy decision, why be satisfied with our reliance on the neoclassical assumptions that do not hold? Many applications of CBA have been susceptible to political manipulation and ignorance, so why not develop something better? Something further away from a foundation that is no longer supported by behavioral economics, political theory, or environmental science?

The goal of this paper is to develop an alternative to CBA and in the interim, identify solutions that provide the statistical foundation for more nuanced applications of CBA under uncertainty and with respect to equity and the environment. We can develop an improved framework, but still within the same process of evaluating costs and benefits of different scenarios. To keep this paper truthful to core concepts

in psychology, economics, and philosophy, we attach ourselves to the cost benefit framework but look to develop a more integrative and considerate approach of economic analysis, both by altering some underlying assumptions and shifting the overall process for developing CBA models.

We live in a technocratic society where technical expertise informs policy generation; especially economics as expertise when it comes to land, development, and agriculture policy. The technical nature of the social science often gives more weight to the argument due to mathematical verification that many qualitative arguments do not hold up well against. But many non-technical individuals living under this political regime question the ethical implications of this dominant economic paradigm (CBA, Enviro Perspectives). To avoid this type of division and growing distrust between economics and the actors implicated most heavily in environmental, development, and land decisions, we must make technical recommendations which include methods for capturing a greater input from actors in our social world. We need to use information as economists to think more like a social planner. With a continual push towards driving stronger policy making apparatuses across subnational levels of government, a commitment to advancing and evolving assumptions of economics to prepare for future changes of value is necessary today and moving forward in decision making.

The University is currently positioned at an unprecedented place in its history. With more students than ever being admitted every year, to a growing number of buildings and departments that continue to sprawl throughout the City of Berkeley, the University is facing immense population pressure as it suffers from some of the most severe housing concerns compared to other major areas in California that continue to grow (Housing Initiative). This pressure, met with the University's desire and requirement to uphold research and policies that effectively limit consumption, reduce energy use and waste generation, and develop innovative solutions to resource constraints makes the case of the OTRF Research Facility (OTRF) critical moving forward. The short term, politically appealing decision to make would be breaking ground on OTRF as soon as possible in order to avoid major delays in what will become a series of housing developments as Berkeley struggles to bridge the massive gap between

housing provided and student admittance. Even housing for graduate students and faculty is necessary to retain these critical members of campus as they continue to be pushed away because of high rent and increasing population density. On the other hand, UC Berkeley has the opportunity to apply many of their lofty and commendable goals of climate change mitigation by incorporating the value of the existence of these policy goals and long term needs into the cost benefit framework. It is not often we have the opportunity to apply a shift in behavior to an economic model and allow for a new policy to develop from changed assumptions because of a real changes in ideology by decision making institutions.

Political Context

Archival Research and Background on the OTRF

The OTRF in its current use consists of an insectary, greenhouses, an agricultural field, and a student organic garden. The tract has undergone phases of development, including the construction of Warren Hall in 1955[1] on the southern side of the tract, as well as the East Bay Municipal District pumping station in the late 1990s. The land, as it currently exists, is owned by the University of California Regents and is managed by the College of Natural Resources. All of the research space is overseen by the Facilities Manager, Tina Winstrom. The student organic garden currently is held by the student employees of the garden and is not maintained by any University entity, although the land has the common proprietor; UC regents. The OTRF was formerly known as the Percy Tract as far back as 1888 (Oakland Map) and was sold in blocks to different private individuals in May 1894 (SF Call). Parts of the Percy Tract were again sold in August 1895 to another private individual. It is unknown when the University claimed ownership or purchased the Percy Tract for its use, but by 1953 research facilities were built on the land and the space was given for agriculture research.

The student organic garden is a ¼ acre plot of land. It has gone through a multiplicity of degrees of maintenance, but in its current operation hosts the largest student run class, deCal, five undergraduate

[1] https://capitalstrategies.berkeley.edu/sites/default/files/warrenhall_and_2223fulton_historic_2000.pdf

courses, one graduate course, high school volunteer programs, independent and professor-lead research, as well as community workshops. Currently the space promotes agriculture experiential learning, independent research, and food justice and urban agriculture education. The space is supported financially by the Global Food Initiative, Berkeley Food Institute, The Green Initiative Fund (a student funded sustainability program), the Basic Needs Coalition, and the Bank of the West.

The Agricultural Research station at the OTRF, a part of the UC Agricultural Experiment Station of the University of California system, is comprised of the growing field, insectary and greenhouses. The space that is used for agriculture research includes three glasshouses for plant propagation, totalling 37,500 ft.², 2,611 ft.2 head house space for research and planting operations, 10,663 ft.2 of storage and support space, and 5,520 ft2 of laboratory space that is used by nine faculty members in College of Natural Resources. The insectory is two separate structures for plants and insect experiments that have both temperature controlled rooms and outdoor temperature rooms for experiments and growing of insect colonies. The Agricultural Research Field Space totals 66,860 ft.² in growing lands. This part of the OTRF is one of two outdoor growing spaces capable of housing outdoor plant propagation research for UC Berkeley researchers and UC extension personnel in the Bay Area. The other facility that has similar capability is the UC Gill Tract, located in Albany, California and is not adjacent to the campus. UC Gill Tract now stands at 6.98 acres, split between approximately five acres of agriculture productivity research and two acres dedicated to urban agriculture research (Gill Tract Website).

UC Berkeley as a campus has historical significance as the first land grant public university in the state of California. California College was founded in 1860 in Oakland, California, and later merged in 1862 with the newly land granted College of Agriculture and Mechanical Arts funded by the Morrison Act. The 1868 Organic Act of California officially established the first public land grant university in California, the University of California, on the site where Berkeley is now today for the purpose of "practical education in agriculture and landscape gardening" (Historical Significance). The Agriculture Experiment Station (AES) was formally established in 1872, as required by state and federal level, by

developing 40 acres of space dedicated to learning and experimentation on plants for ornamental, agricultural, or forestry purposes (Historical Significance). Where this 40 acre plot was in 1872 is still unclear but it was established either at or adjacent to what is now the UC Berkeley campus.[2] The AES now spans three campuses: Berkeley, Davis, and Riverside. The University's Division of Agriculture and Natural Resources was established in 1878. Under the 1887 Hatch Act, states were provided additional funds for research conducted on AES given matching payment, which helped expand activities on AES which at the time was exclusively at present day Berkeley campus.

After the initial establishment of agriculture research space in 1872, an economic garden and the Botanical Garden was established as part of the AES. This was developed and encouraged under the Picturesque Era, one of three critical eras in landscape architecture and design that holds historical significance to the campus and American history due to the designers of the landscape and the attributes of campus that are significant to this part of American history. Parts of UC Berkeley are nationally recognized as historically significant places. This determination is fueled by three requirements, one of which is having an AES. These criterion are part of the National Park's standards for the National Register for Historic Places (Historic Significance). UC Berkeley's agriculture buildings including Hilgard Hall, Giannini Hall, and Morgan Hall are currently on the National Register for Historic Places. But, the campus has undergone significant changes in the architecture and yet still holds many critical components of the historical landmark, including the architects who designed the major layouts of campus through its three critical eras: pictureseque, beaunoveau, and modern. In 1956, with the anticipated jump in enrollment to 25,000 students, the campus demolished research greenhouses, the original glasshouse of the botanical garden, and planned to intensify the density of the campus (Historical Significance). From 1908 to 1958, the University Farm served as a large area of instruction for students of agriculture and related disciplines until the University Farm became its own campus, UC Davis in 1958.

[2] https://capitalstrategies.berkeley.edu/sites/default/files/gill_tract_experiment_station_history.pdf

While the OTRF exists currently outside the campus core--the historically significant area of campus for landscape architecture--the 40 acres designated as land grant status also existed outside of the campus core and were not significant to the actual landscape design of the campus but the research initiatives and funding eligibility of the campus. The establishment of twenty-two buildings for AES between 1940 and 1963 included insectary, lath houses, bioclimatic chambers, eight greenhouses and six headhouses were likely established between both the Gill Tract location and OTRF location. The 104 acre Gill Tract was purchased from the Gill family in 1928 by the University of California. Knowing which buildings were built at what sites is unclear, although the architect was H. Thomsen and the station was funded by state appropriations and likely fell under the domain of the College of Agriculture.[3] In 1939, sixteen acres of the Gill Tract was determined to be agriculture research space by a United States Department of Agriculture Grant. In 1945, UC Berkeley was granted thirty six acres in land on the northeast section of the Gill Tract for research related to biological control, making UC Berkeley a leader in this field of study due to favorable climates. Both of these land grants took place during the time of the above facilities construction, making it likely they were built on the Gill Tract. But, before these were built in 1927, thirteen greenhouses, two glasshouses, and seven headhouses were funded privately through a gift raising campaign and also through state appropriations for construction at a site directly adjacent to campus, which is now Tolman Hall and the Biochemistry Building.

The insectary at the OTRF was built in 1953, funded by state appropriations, designed by Ira Belas and Donald Macky. In 1955, Warren Hall was constructed through state appropriations for the School of Public Health and Cancer Research Genetics Library on the site adjacent to the OTRF at the corner of Hearst and Oxford.[4] The rest of the OTRF units as they exist today were built in 1960 by Donald Macky and funded by state appropriations. An addition to the OTRF was built in 1962 at a cost of $1,054,000. SOGA was founded as a student research space in 1971, during a time when the University was under the 1962 LRDP goals. Under the 1962 LRDP, an expansion of 121,000 square feet of

[3] http://berkeleyheritage.com/1967_UC_Berkeley_Buildings.html
[4] http://berkeleyheritage.com/1967_UC_Berkeley_Buildings.html

remodelled and new space at both the Oxford and Gill Tracts was projected for the purpose of agriculture research.

After the loss of the University farm in 1958, agricultural education was still prioritized and UC Berkeley strived to "emphasize teaching and Experiment Station research in the basic physical, biological and social sciences, taking advantage of the vast array of scientific resources on that campus to add to the pool of fundamental knowledge upon which advances in agricultural technology depend."[5] It was also a goal of the LRDP of 1962 to prioritize housing department research together and clustering facilities of shared disciplines for the sake of student and faculty convenience, as well as aesthetic uniformity. The OTRF at this time was a six and two tenths acre plot of land under the control of the College of Agriculture. It was one of two remaining research plots including the Gill Tract and was one resource in conjunction with the Giannini Foundation, specialized libraries, lab equipment, and a distinguished collection of source material for agriculture and agricultural economics.[6] 130 AES faculty and 50 auxiliary researchers, field managers, and specialist were budgeted to work in the College of Agriculture's AES. At the same time, the LRDP of 1962 did emphasize the need to move heavy research activities to more remote areas including the Richmond Field Station, purchased in 1950 and Gill Tract. With this relocation of activities away from central campus, the importance was to keep services unfragmented to better serve the departments' faculty and students.

The OTRF was maintained because of its importance to the agriculture research and programs being conducted at adjacent halls Giannini, Hilgard, Mulford, and Agriculture. A northern portion of the OTRF was reserved for potentially necessary buildings, but the core function of the tract was to remain for agriculture research. In 1974, the College of Agriculture merged with the School of Forestry and Conservation to form the College of Natural Resources. Today, AES remains under the direction of the UC system and particular departments on the three campuses which comprise the AES. The Dean of the College of Natural Resources at Berkeley, in addition to the Deans of UC Davis' and UC Riverside's

[5] http://www.lib.berkeley.edu/uchistory/general_history/campuses/ucb/colleges.html#agriculture
[6] http://www.lib.berkeley.edu/uchistory/general_history/campuses/ucb/colleges.html#agriculture

complimentary agriculture colleges serve as the Associate Directors of the AES.[7] Glenda Humiston was appointed the Vice President of the Division of Natural Resources for the University of California in 2015 and is the central administrator for AES.[8] The purpose of AES is three fold: (1) to aid in the production of cost effective, nutritious food, (2) to ensure the physical environment remains of high quality for enjoyment, and (3) contribute to the public health and economic health of surrounding areas.[9] The majority of faculty who are in the respective colleges hold joint appointments between campus teaching and research at the AES. A majority of funding for AES research comes from state funds.[10] Funding for research conducted specifically on the OTRF comes from both state or federal grants in amounts that are currently unclear and difficult to determine exact amounts. Overall, the OTRF and the Gill Tract have served as the centerpieces of current agricultural experimentation and research activities at UC Berkeley while also being the expansions of what was once a much more robust and central program at UC Berkeley and is central to understanding UC Berkeley's historical significance.

Today, approximately twenty-eight trips are made to the OTRF daily. Forty-four faculty members are either jointly employed with AES or conduct research at the OTRF. Between fifty and one hundred graduate students take part in research at the facilities and demand for grow space is increasing due to biological advancements such as Crispr-9.[11] The OTRF totals approximately 2.71 acres in research facilities today, while SOGA is .25 acres. Again, the Gill Tract has about five acres of land dedicated to agriculture research and two acres for urban gardening, used in a similar style and function as SOGA. These areas constitute what remains of Berkeley's AES. From when agriculture research buildings and facilities were built, the OTRF has shrunk to 43% of its original size. The Gill Tract similarly, although not all exclusively dedicated to agriculture research, has shrunk to only 6.7% of its original size.

---

[7] https://capitalstrategies.berkeley.edu/sites/default/files/gill_tract_experiment_station_history.pdf
[8] http://ucanr.edu/sites/anrstaff/Administration/Vice_President/
[9]https://www.ucop.edu/academic-personnel-programs/programs-and-initiatives/faculty-resources-advancement/faculty-handbook-sections/agricultural-experiment-station.html
[10] http://www.caes.ucdavis.edu/admin/resources/aes/overview
[11] OTRF Report 2018

UC Initiatives

At the UC level, there are multiple policy objectives with respect to the management and development of the resources that are considered in the OTRF Development. In January 2016, President Janet Napolitano of the University of California created a Student Housing Initiative looking to build more affordable housing for students across the UC systems. There is a projected 14,000 new beds that could be built for students.[12] The goals of the housing initiative include building housing that is affordable and can accommodate a growing number of students which are predicted to be let in. I will later address the 2016 Budget Act which requires an increase in bachelor's degrees of 250,000 produced by the UC system by 2030 as mandated by the California legislature. Each campus has been working with UCOP to develop individual strategies for housing to meet the unique needs of each campus. Berkeley has already begun its investigation into further development of student housing, with a new Chancellor, Carol Christ, stepping into the role in July 2017 from her interim role as Executive Vice Provost.

Previous to the Housing Initiative set out by President Napolitano, The UC Global Food Initiative (GFI) was begun in 2014 to leverage ACNR, LBNL, and other UC research in agriculture, biology, medicine, public health, and a multitude of disciplines to create more sustainable food solutions for UCs, California, and the world. A variety of working groups and smaller initiatives drive the groundwork of the larger picture, looking at Curriculum, Operations, Policy, Research, and Service.[13] The goals for the GFI are more developed, and address a comprehensive range of food system challenges.

At the level of the Berkeley campus, there are additional initiatives under the umbrella of UC initiatives which support and maintain these goals. The Long Range Development Plan (LRDP) of 2005 outlined housing goals for creating bedspace for all incoming freshman for two years, transfer students for one year, and graduate and postdoc students for one year. The Capital Strategies department is responsible for developing new infrastructure, but no formal plan to achieve this specific portion of the LRDP exists

[12] http://ucop.edu/student-housing-initiative/
[13] http://www.ucop.edu/global-food-initiative/organization/working-groups/index.html

today. In 2017, Chancellor Carol Christ assembled a Housing Master Plan Task Force to begin creating a Housing Master Plan for the campus under the LRDP goals and the UC Student Housing Initiative. The Housing Master Plan is still within its initial strategy phases as of 2017, almost a year after its announcement. As of March 2018, a real estate advisory firm has been employed by UC Berkeley to conduct a housing market report.

The Housing Initiative promotes a 3P strategy to create bed spaces at a speed fast enough to provide relief for the housing crisis. The political goal is to mitigate potential backlash or distrust against the University system and deliver immediate relief to the growing issue of student homelessness, housing insecurity, and swelling market rates around major campuses like UC Berkeley and Los Angeles. But, 3Ps for the University are designed to be auxiliary, according to a 2013 budget report by UCOP.[14] In a March 2018 email from the Co-Chairs of the newly formed Housing Master Plan Advisory group, they advocate for private-public partnerships "between the University and experienced developers [to] deliver the facilities critically needed by our students and faculty." Overall, the purpose of the facilities to be built in tandem with a developer at the OTRF would be to provide students with the needed housing that UC Berkeley has promised and not delivered given an inability to do so in a cost effective and timely manner. Another consideration is that the University's deployment of 3P is a strategy to gain additional revenue for the University. This is not the sole purpose of the project, but implicates the underlying assumption of social welfare maximization if revenue generation is an intent of the public institution.

But, the University of California has been explicit in advocating for 3P projects as an increasingly viable solution to housing development under budget constraints. Projects most successful under 3P as supported by UC Capital Strategies are ones which generate income, are situated off-campus with land not owned by the UC, and for which private development of these projects is common. General concerns with the strategy of 3P when the University does own the land is whether committing long term to the developer is a positive choice, whether UC will have enough control over the operations and facility

[14] http://www.ucop.edu/real-estate-services/_files/documents/ppp_at_uc.pdf

maintenance of the project and whether the UC will be able fully commit to the terms of the agreement with the 3P partner (PPP Doc). An example sited is the development of mixed-unit housing for graduate and undergraduate students at UC Irvine, financed through a 3P partnership as a ground lease, where UC leased the land to a developer to build the student housing development at a rate lower than comparable housing development projects at the same time. The project's excess cash flow was distributed to campus as revenue and the requirements on the owner of the property was to price the units at or below current UC housing costs while the UC's requirement was to ensure full occupancy for the first three years (PPP Doc). This is one example of the type of 3P developments that would most accurately reflect what the OTRF development would look like.

While there are short term gains politically for governments and an increased access to resources with lower risk for private partners, the long term sustainability of 3P agreements is unlikely due to conflicting interests and deferred costs for future governments (Shambaugh, Matthew). When evaluating the long term sustainability of 3P agreements, they are most successful in the case of providing a good or service that is commercially viable, but often the power imbalance and asymmetry of knowledge on costs and benefits of projects between public and private partners lead to 3P projects serving an elite subgroup of the public and the underprovision of resources to public (Shambaugh, Matthew). While housing is a commercially viable project that could benefit from expertise of private industry, the UC's heavy push towards using an increasing amount of 3Ps for campus development has the potential to affect either price, quantity, or quality of goods and services provided to campus members in the long run.

UC Berkeley Policy Making Structure

The policy making organization is a breakdown of process of engagement for development plans and lists of stakeholders/involved parties. The policy makers at UC Berkeley and specifically the University of California constituents are vital to a case study of a CBA because they are the individuals which are appealed to by economist in a CBA. They represent the public of California as well as the

students, faculty, staff, and administration of UC Berkeley. Because they make decisions on behalf of a massive referent group, I have drawn up the political organization in a diagram below. It is arranged in a way to also translate the hierarchy of decision making around land use decisions within the University of California system.

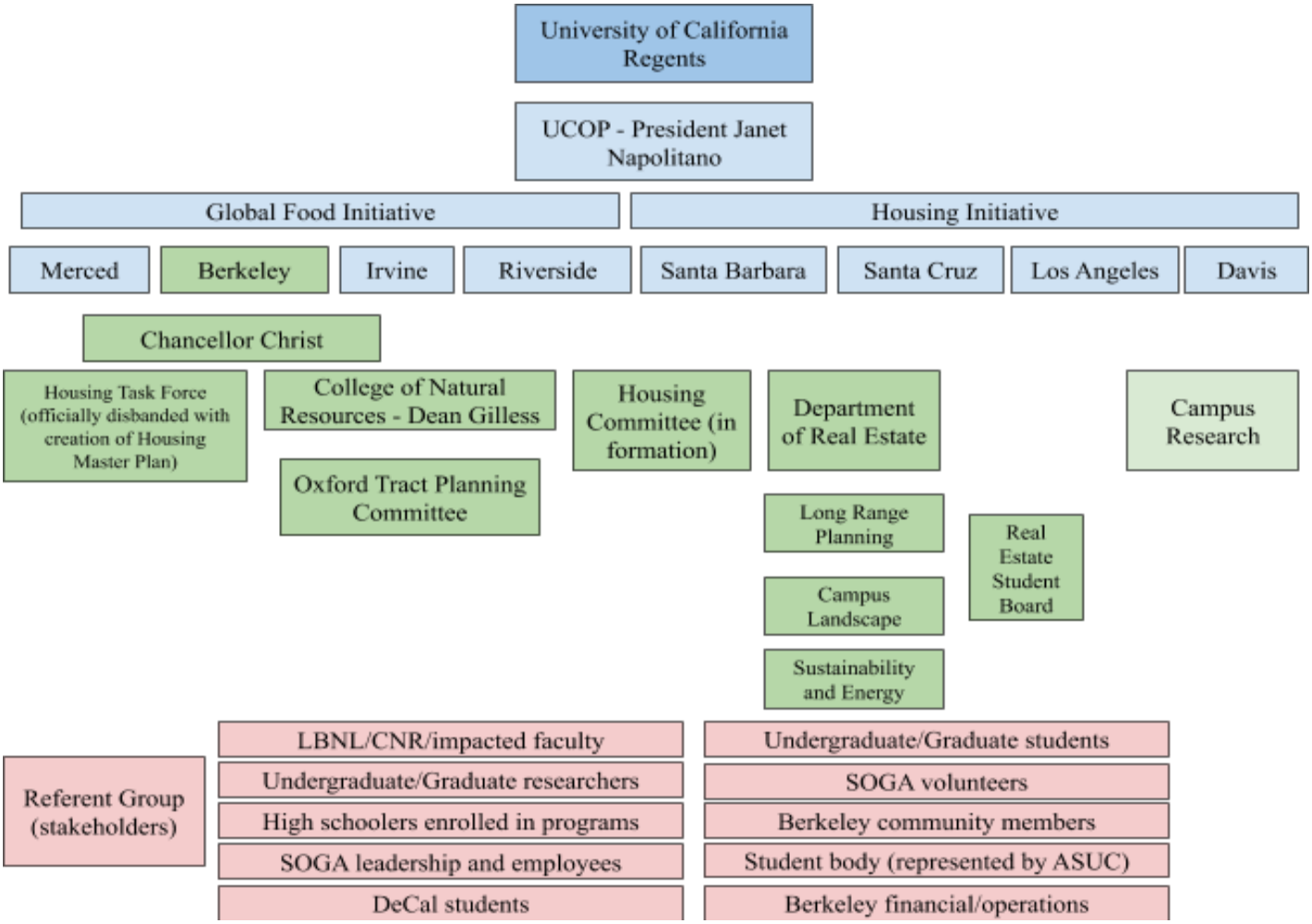

Figure 1: Policy Decision Hierarchy and Referent Group

Currently, strategy involves the structuring and development of committees to be tasked with recommendations for the Chancellor. The Chancellor makes recommendations to the Regents who must approve the actual development of any piece of land. These committees are comprised of administrators, faculty, and students. The majority of the committee is administrators who work in relevant departments

including Real Estate, Campus Planning, Residential Services, and afflicted campus departments. A financial advisor is often present, in addition to one undergraduate and one graduate student, if lobbied for. Faculty are also from afflicted communities. But, resources such as Center for Ecosystem Measurement, Monitoring and Modeling in the College of Natural Resources, the Terner Center for Housing Innovation in the College of Environmental Design, Precision Urban Agriculture Initiative at Lawrence Berkeley Laboratory, and the Fisher Center for Real Estate and Urban Economics are not utilized for generating proposals.

In the pink highlighted boxes in Figure 1, the referent group, or stakeholders, are identified. All stakeholders come from a different position on campus and have different desires, capacities, and power within the decision making process. Within this political hierarchy, it is important to note the interests that are being catered to in the process of decision making. These interests include (1) capital strategies and real estate, (2) academic and research, (3) political approval, and (4) student welfare. Each of these interests is its own political community, but each community shares some relationship and power structure with one another. In traditional pluralistic policy, we see that incremental change in policy comes from the result of competing interests in state agencies and departments that heed to the requests of different interest groups among constituents (Atkinson, Coleman). While there is an appearance of plurality in the designation of the referent group as isolated communities with competing unique interests, a more complex analysis can be used to identify the networks among different communities and can therefore identify the magnitude of power imbalances, shared beliefs, or dependence in ideology. Policy networks, which consist of both private and public organizations, serve as the mechanism of debate and decision making for policy (Park). Because of this, actors--usually political communities-- in a policy network have either social resources derived from their interaction with other members of the network or material resources that are necessary for all in the network to survive and achieve goals (Park).

In the example of the OTRF, more central actors or those higher in the hierarchy of decision making possess the most material resources and groups within the hierarchy that have more connections

to those more central in the network have an increased amount of social resources, tilting the balance of power in their favor. In a case where resources are constrained, resource distributors have more influence in the network (Park). So for this case where one parcel of land has competing uses and both agriculture and housing are facing physical and monetary constraints, I infer the executive administrator at UC Berkeley, Chancellor Christ and the University of California Regents as the land proprietors have an increasing amount of influence in the decision for the policy as proprietors of the resource. This shift in influence is important when considering how public decisions are made under resource constraints given the reality of UC Berkeley facing massive constraints on finances, physical space, and employees. How to recognize and mitigate the existing structure of power created by the unequal distribution of both material and social resources across actors in the network will be returned to in the Discussions section.

In our current political decision making process, there is a clear division between the referent group (afflicted parties) and policy designers and administrators. Where a representative from a referent group is occasionally given participatory privilege, consistent engagement can be restricted and is mediated by a more central actor like Chancellor Christ. In an example, Chancellor Christ formed the Housing Task force and determines the number of seats open to different individuals and the frequency of meeting for the task force. This separation of policy communities from other communities in a network where a decision afflicts all parties limits democratic participation and disadvantages certain communities as their access to other parts of the network is stifled by a more central node. Therefore, value and preference of referent groups are extrapolated and not aggregated, leading to inconclusive, variable, or incorrect estimates of value and willingness to pay.

Social-Political Dynamics of Berkeley Decision Making

In respect to the sociopolitical dynamics between the University and the city of Berkeley, the growing demand for housing is in part due to the University's expansion without clear planning for accomodation. Berkeley as a community has had a history of tension with the University with respect to

development of land within the City. Because UC Berkeley is a public entity, it is exempt from zoning regulations which means all the land it owns is not subject to the City's zoning laws. Despite this, University officials claim to engage with the City on different issues, and have once for OTRF.

The issue of access and promotion to environmental resources and education has now become pitted against housing in a framework of 'one or the other'. Much of the work to protect the agriculture resource space of the OTRF has been to decouple the question of one or the other in an effort to better explain the policy making landscape of UC Berkeley. The administration of UC Berkeley as a political institution highlights the issue of housing as an imminent threat to the wellbeing of students and leverages the crises status of the housing shortage to focus attention on public preference for housing. Under public economic theory, a decision that is more important to constituents should be chosen as the optimal policy. But, constituents rarely choose one policy at a time, and the points of preference for constituents is rarely single peaked, meaning there are multiple levels of optimal policy that can be chosen from without an existence of of a true median for policy decision preferences from constituents. When the University frames housing as a crisis, it isolates the issue from consideration in tandem with other policies, diverting preference identification to a single issue.

Within economics literature, individuals value choices that impact their well being today more so than decisions that impact their future wellbeing, for a variety of reasons. Neoclassical economic theory confirms this through discounting, pricing in the future based on decaying returns to utility. Because of this standard assumption about constituents' utility curve as a product of welfare over time, we can infer the political decision to focus on the imminent threat of student housing opposed to the long term and variable impact of climate change aligns with consumer preference theory and discounting. Because we assume utility curves are the same for individuals in the future, but their utility is discounted, they have less concern for future states of the world where climate science has shown us resources may become scarce or more costly to use. Therefore, when policy is normally made on short term timescales, discounting provides insight into intertemporal preference and political actors choose to eradicate issues

determined to be immediate crises over longer term issues which produce less social welfare in the immediate because benefits cannot be realized the same way short term ones can.

Because of the nature of UC Berkeley policy makers as public officials, making decisions that should promote the University's mission to produce research to enhance the public good of California is often superseded by the need to satisfy constituents immediately affected by internal campus policies. This balance of priorities as agents of a public entity often leads to conflicting decisions at the campus level and the UC level. Where the UC Office of the President is able to develop long term strategy and public missions, individual campuses, including Berkeley, are often left to make short term policy that often serves to remediate popular issues. Policy communities, entities or groups with shared ideological systems, which have access to significant technical knowledge and procedure also have increased participatory power (Atkinson, Coleman). Because of this, different departments and divisions within UC Berkeley and UCOP develop anticipatory policy targets and strive to reach them over time via internal expertise. Because of the fragmentation of stakeholders into communities, when political communities prioritize an issue, they lobby for short-term, reactive policy (Atkinson, Coleman). Overall, this balance between reactive and proactive policy development at a state institution is a common struggle, but large policy change can be realized by disturbances to existing political communities and networks.

When disruptions occur, priorities may change as different policy actors restructure networks or advocate different on different ideological platforms. Although difficult to place in a specific case study, we can frame the issue of Berkeley's decision making entity as one of a political institution in which certain policies are prioritized through influence of engaged actors and the result is often short term resolutions. There is still potential for a public institution to undergo policy shifts, not due to just sheer will or naive assumptions that ideology changes, but an evolution in the policy and power structures of a institution. With UC Berkeley, there is difficulty in enacting change given the isolated and highly technical nature of decision making that does not involve much democratic process because of stakeholder limitations. If increased community development and influence by members aligned behind

long term growth prevention and climate change mitigation strategy had more influence, there could be some reconciliation of existing crises like housing with these long term goals for environmental and resource conservation. There is a need then for policy communities who have limited influence to strengthen their connections in the network and build centrality and proximity to more central decision makers to influence institutional goal setting.

Political Economic Context

Climate Change Economics and Uncertainty

This case study requires a background understanding of the social and political context for the analysis, but also exposure to the topics addressed. This section gives additional insight into the field of economics and climate change. Climate change economics is a newer discipline which focuses on the integration of climate change models and scenarios into existing analytical literature. Within climate change economics, risk and uncertainty become important factors in deploying common economic models for decision making choices. Specific to CBA, there are a few major concerns that reappear in the literature: (1) discounting and the time considerations for decision making, (2) changing utility and preferences given knowledge of climate change, (3) intergenerational distribution of benefits, (4) risk and uncertainty in calculating benefits of environmental services. These specific issues will be addressed in the Analysis section of this paper. Understanding the principles and tools for evaluation of uncertainty is a critical question in the political economy of climate change. How our current political and governance system approaches the question of climate change through the lense of economics can provide us with insights into the existing shortcomings of the methodology.

Discounting is a main focus of the climate change economic literature and will be addressed more extensively in this paper. But for an introduction, discount rate for projects are selected through two approaches: prescriptive and descriptive. Descriptive takes the existing market fundamentals for future

predictions of growth, consumption, and cash flows to make an estimate for the discount rate. The prescriptive approach, which has been much of the focus of climate change economics literature as it relates to discounting, is an ethical approach to the question of assessing future values and deriving future utility functions as a function of these discounts. This paper, while an example of a descriptive analysis, is working to merge the two concepts together in an effort to force economic and financial decision making to be fundamentally interconnected to our social and political goals established in public institutions.

Measures of uncertainty are reflective of common beliefs about time preference and risk. Under existing theorem, individuals today can be concerned with outcomes tomorrow and in subsequent periods of the future, for themselves only. Assumptions about individuals' risk preferences are based on today, and do not update for future periods in which propensity towards risk could change given the introduction of new technology or information becoming available. But, major issues with these assumptions appear in the context of climate change. First being, can we extrapolate future utility curves from today given what makes up utility curves today may not be available tomorrow due to resource scarcity? Also, can and will today's generation properly account for the utility of future generations given that it may require a sacrifice on the part of individuals today? With concerns to equity, demanding today's generation give up some portion of utility is not justified without further analysis into how much today's generation should give up and why. Under the conceptual basis for economic decision making across generation, we can introduce an element of uncertainty to capture this unknown. But focusing on the last question of intergenerational welfare, it goes against economic assumptions that individual's today would maximize utility against anyone else's besides their own. This issue pervades the topic of climate change economics and will be discussed further in the paper.

Uncertainty has been measured alongside irreversibility to calculate the option value of a project i.e. the value of delaying making a decision by t units of time in an effort to wait and see whether a cost or benefit measurement can be more accurately assessed (Arrow, Fisher 1974). This economic methodology, while making room for alternative present values--often in the case of environmental resources--lacks

accounting of the cost of deferring preservation in the case of natural resources. If one scenario were to involve active preservation, restoration, or mitigation of effects of climate change and they were to be delayed, option value is not currently used to absorb and articulate that cost. Option value, while designed to protect natural resources and give proper valuation to resources based on additional information, still perpetuates the issue that resource evaluation can be improved within a certain time frame and with enough accuracy to be critical to decision making in CBA. This measurement of uncertainty, while strong in its intent to better realize environmental service benefits, still promotes using undetermined data for decision making which could continue to grow in variability after the project's delay. This is one example of an uncertainty metric that is not ideal under the world of climate change, and must be improved upon.

Understanding the uncertainty principle given the context of climate change creates many barriers and opportunities in the policy making space. To begin, the presence of uncertainty can lead to undervaluation or ignorance of the good or service because it does not have a clearly defined value. Without a certain understanding of the future state of the world, creating climate mitigation and adaptation policies becomes difficult politically and harder to ground into economic policy. But, opportunities include changing assumptions to meet the value of risk aversion individuals would take to avoid certain outcomes. Despite these individual's not facing the same state of the world as future generations will and therefore not as informed to have a risk aversion that is properly aligned, it is this consideration that could sway policy makers to generate solutions based on future societal needs.

Economism and Technocracy

In introducing the interdisciplinary question of the compatibility between climate change scenarios and economics, the political economic history and evolution is necessary to understand the weight of this question. Economism is a term that originated under Marxist theory and was used to describe capitalist's public propagation of the method of public and social structure of capitalism. This

political and ideological regime of capitalism, one that functions on, very broadly, principles of rational consumerism and individual utility, came about as a result not of providing mathematical proofs for these assumptions to the public, but through a combination of quantitative assessment aligning with political shifts in power. While economic models do offer predictive power for market behavior and a deeper understanding of the casual or determinant parameters in choice for different scenarios, economic theory either requires or affects individual behavior that cannot be disassociated from the model. This implicit linkage between what economics describes and how society functions is a result of societal buy-in or unanimity in belief to an extent that economics may be operationalized.

While I do not dispute that many assumptions of behaviors hold under described conditions or that creating scenarios to understand how behavior changes given a set of constraints, to ignore the foundational social theory which informed the development of economics as a quantitative discipline would be insufficient in providing sufficient context for this question. Knowing that economics results from the social sciences, the sociopolitical regime where this knowledge was defined can explain the philosophical basis for neoclassical assumptions. In order for economics to become a foundational component for governing society through interaction, exchange, and policy, the era in which economics merged into its own discipline was characterized by a number of important social factors.

Economism, while it operates a common, socially accepted belief, functions critically at the individual level. Economism is a system of beliefs held by individuals which commits us to operating within a market that both maintains us while we maintain it (Norgaard, Goddard, Sager). This two-part acceptance and promotion of a belief in the power of consumption, labor, and investment has come to replace much faith in other larger operating concepts - such as religion or differing social philosophies. Where other social philosophies exist, economics prevailed as a dominating offshoot discipline of moral philosophy, gaining traction under the changing conditions of the world that demanded a more all-encompassing understanding of the world while engaging modernist approaches to the principles of scientific process. Economism has flourished under the last century by maintaining its hierarichal place as

scientific discipline. Economics legitimizes an ideological approach of quantitative analysis to government. This results in the technocratic nature of economics and perpetuates the acceptance of belief in economic theories by society.

Economists operate under a philosophical theory of modernism, where the dichotomy between normative and positive keep ethical assumptions separate from observed behavior, deriving all truth value from observability and objectivity (McCloskey). This operationalization of the discipline aligns it with more traditional hard sciences in their knowledge production power while still operating on fundamental assumptions that are truly normative in nature. The issue here is that quantitative assessments stand upon conceptual theory that does not properly align with our current belief of scientific practice, and is instead backlogged in modernist principles of numerical justification, observation, and prediction (McClosky). This misalignment in methodology and current structures of society by economists reinforce the divide between the social science and mathematical components of economics. It also requires the rhetoric of economics be self-reinforcing: economic theory must be described in a way that helps substantiate the conceptual claims proposed. The rhetoric of economics therefore is articulated as a science of conviction when used in arguing or deciding on an outcome or decision, despite the violation of the many common claims within the discipline. Economics, as a science, requires a rhetorical component in order to brave a rigorous review through a scientific lense. But, the rhetoric is therefore not derived from the discipline's mathematical or objective space of knowledge, rhetoric is its own unbounded and purely qualitative and persuasive practice. Economics is a leader in the technocratic influence of policy and society that is common today, where technological actors are considered experts in knowledge that is applied to social decision making and public choices, despite the duality in the strength of economics in qualitative and quantitative science.

Technocracy, while developed during the 1930s under the auspice of informing policy and business with increased data and rigorous methodology has become an underlying philosophy in policy making in the United States as well as the rest of the world. Coinciding with the increased mathematically

application of economics post-Keynesian, the timing of these two ideological developments created a solid foundation for scientific methodology to inform policy, capturing economics within the realm of scientific discourse. While the increased technical nature of the economics does develop the discipline within reasonable closeness to other scientific disciplines, its early grouping with other scientific procedures allowed many of the uncertain beliefs in economics to be taken as observed in the physical world and therefore strong enough to use as a basis for policy decision. But, the economist often infers what she does not believe in order to demonstrate an isolated relationship or prove a consequence of a behavior without transmitting that leap of understanding to those who do make policy. This leap of understanding is often derived from the economist ideology - the ethical or moral belief that guides assumptions, despite strength of methodology (Soderbaum). There is nothing about holding an ideology that makes economists inherently bad or unfit to continue to perform economics work. But, without realizing this forced relationship, economics is allowed to operate under the same standards for scientific methodology as other sciences.

Within technocracy, the econocrat informs much policy, particularly through the framework of the CBA. While sympathetic to the struggle of the social planner in capturing all relevant data and best distributing benefits and maximizing the welfare of society, by adhering to the same economic principles we stay grounded within the same ideological era or belief, and the progression of social philosophy and transformations of institutions is blocked (Self). Institutions, when reliant on the scientific and technical experts to inform policy, limit their opportunity to shift economic paradigms and their own ideological orientations (Soderbaum). Deploying the same economic paradigm across rapidly shifting social philosophies stunts our ability to adapt public institutions to the needs of society. CBA generates a strong assumptions for the social planner's end goal of social welfare maximization based on consumption through utility. This reigning paradigm goes unquestioned because it is nested within the technical nature of the procedure. But a technocratic form of policy making decision requires no update to ideological principles and no procedure to democratically advocate for shifts in existing ideology, only small changes

in weighting or what is included endogenous to what has already been laid out. Therefore, using expert analysts to create definitive prices reinforces technocracy and stands in contradiction to democracy (Soderbaum).

Technocracy and Economism stand together as pillars in public decision making, specifically for the United States. Economism is a result of the adaptation of modernist principles to the social science that transformed it from philosophy to methodical science under emerging technocratic beliefs. Through their co-development, economism has become a core framework in which we develop policy and make decisions. For change, institutions through disruption by policy communities must separate the practical value of economics and many existing ideological assumptions. The practical nature of economics is derived from its constantly improving scientific processes. But this process affirms the ideology nested within it. There must be a separation in the two, and a further method of engaging the latter. By knowing the gaps where scientific rigour is filled with ideological beliefs of the economist is not enough (Sebberson). These gaps must be left open for examination by others involved in the social planning decision. For laying out the rhetoric that economists deploy is not enough to generate institutional change, but it is a starting point. Identifying the rhetoric used helps deconstruct the relationship between Economism and Technocracy, providing an entrance for policy communities to engage the institution they wish to change.

Ecological Economics: The Steady State and De-Growth

The largest barrier which prevents policy generation from properly adapting to and mitigating future issues climate change is the rooted assumption of the growth principle within economics. This principle determines many welfare, trade, and other economic policies across the world and is uniquely vague in proof. Parting from the assumption of continuous growth is almost completely infeasible given our existing tie of economics in the technocracy that informs much of policy. One major consideration in

evaluating policy structures for public institutions include addressing the political feasibility of a policy. While cost-effectiveness and general welfare distribution are other important considerations, evaluating the likelihood a policy will be adhered to and enforced based on existing economic and political structures is a necessary component of CBA (NBER). Policies that fit within the dominating economic framework have a higher likelihood of political feasibility because they require less redistribution of power in a political network to shift ideological beliefs which would adapt the policy. In discussing the steady state and de-growth, it is important to address initial limitations in the deployment of these theories but more importantly to outline strategies that would enable the underlying concept to become practically deployed.

I will begin by outlining the general theories of steady state economics and degrowth with why they are critical to understanding the question of deciding to develop in a resource constrained institution and era, given the knowledge we have of climate change impacts on resource availability, quality, and usability. The consideration of natural resources in economics is fundamentally lacking in that it does not view scarcity as a constraint on an immediate scale. More recent offshoot disciplines of economics have become large advocates on reforming the way economics approaches democracy, welfare, and the environment in order to accomodate an understanding of the limitations of growth. Specifically ecological economics and institutional economics advocate differently but both together against traditional welfare economics. Both recognize the interdependence of natural resources and environmental factors on the ability of other facets of the economy to function. Interdependence therefore recognizes that compensation or penalty to adjust for the size of the externality is not enough as certain economic functions are interdependent on the same resource and cannot be compensated or (Paavola). In addition to a more fundamental interpretation of environmental resources and pollutants in economic models to show the dependence the economy has on the its resource usage, developing a model for low growth or degrowth scenarios are practical approaches using economics designed to limit the anthropogenic effects of climate change.

Degrowth is the initial policy that would allow humans to structure a planet not dependent on increasing resource consumption and could potentially lead us to a steady state economy in which a constant stock of capital is maintained through low throughput and regeneration in the economy (Cosme, Santos, O'Neil). These complementary ideas--degrowth and the steady state--are not policy objectives in themselves but means to achieving a more politically and socially just and responsible society in which growth is not a default objective or the only solution to inequality. Ecological economics advocates for degrowth policies because the underlying issue of resource use is not that it is improperly allocated in the market resulting in failures, but that it is an issue of resource use to scale that does not push boundaries of the planet (Cosme, Santos, O'Neil). The science which underpins this theory is largely climate change science and the modelling of future scenarios given human beings' exponential effect on the ecological systems globally. While we do not necessarily know a planetary bound for pollution and extraction of resources, attempts at limiting production and consumption through agreements like the 2015 Paris Accords are examples of global awareness and political action to do just so. Recognizing production caps seems initially like a crisis-driven policy goal that when achieved will allow things to shift back to normal (a state contingent on growth), but fundamental paradigm shifts are occurring at levels of the individual and private and public institutions.

This paradigm shift is supported by the degrowth and steady state literature. Efficiency can no longer be viewed as a primary objective in policy generation, but efficiency within exogenous biophysical and socially conscious bounds must be adhered to. Overall degrowth has the following three goals: (1) reduce human impact on the environment, (2) redistribute wealth, and (3) transition from consumption based to participatory society (Cosme, Santos, O'Neil). These goals permeate through all levels of society in order to strengthen democratic processes through engaging stakeholders more broadly, distribute regenerated wealth through society, and limit our untethered consumption of resources. Under degrowth, there are many strategies at the local level for achieving a society more focused on the commons and the individual, in which participation and community are more important than preference and consumption.

Strategies include higher density cities, promotion of localized economies, local food production, tax consumption, and infrastructure moratoriums. While these range in political feasibility, cost, and effectiveness in reducing human impact on environmental assets, a question on the fairness of distribution of resources intergenerationally warrants more attention in the literature (Muraca 2012). Overall, the desire to redistribute limited resources across diverse populations while maintaining a usable stock of resources is the overall goal of degrowth policies and the literature provides current approaches in adapting these types of policies, without assessment of their feasibility or potential outcomes for certain case studies or actual experiments in alternative economies or ways of living.

Given the more conceptual and socially oriented policy generation that degrowth theory demands, the deployment of a CBA is likely an unreasonable place to approach degrowth methodology. Although a rigid and neoclassical tool of economics, it has become a staple in policy analysis and decision making, and therefore holds much of the influence in generating policies where resources are scare or being bid on for competing uses. I will later discuss how ecological economics and specifically the steady state literature address the underlying economic assumptions in CBA and how I believe some remediation between the tool and the concepts is possible.

Project Goals

Hypothesis

Overall, I anticipated a social CBA to yield a high value for agricultural research and experimentation as the growing demand for food production and efficiency continues to be unmet in a global world. I also project the opportunity cost of not using the parcel of high value city real estate for revenue generation on housing that is projected to continue to increase could also initially be high. While my estimates of the standard cost benefit are important and necessary, the remainder of my research can be summarized in critique of the CBA methodology as it is applied today given its extreme lack of

consideration for long term changes in future expected values due to the uncertainty from climate change and inability to fit changes preferences and constraints due to the change in climate into the CBA.

I hypothesize that given alterations to the CBA tool, we should not continue to widen the discrepancy between the environmental and social activist movements and economics, but instead should find a way to bridge opposite spectrums of policy drivers in order to allocate resources more fairly and make social planning decisions informed by extensive climate and environmental research. Although this paper will contain a more formal discussion of the actual strategies for implementing a type of feasible economic and policy tool, the goal is to figure out how to both broaden the scope and complexity of an economic analysis which weighs costs and benefits of a policy for the future allocation of resources.

Justification of Research

Although necessary to investigate the moral components of policy decisions, by skewering the cost benefit methodology, another tool that wields power is removed from the fight to integrate environmental and ecological perspectives into mainstream economics. Although many environmentalists make a strong argument for the out of touch nature and moral dissonance of the CBA as a quantitative tool that further dissassociates and undervalues natural resource and environmental impacts from their value, the tool will continue to be applied with or without the support of ecological economic concepts. Without the attempt to bridge the complex nature of vastly integrated ecosystems with our network of exchange--economy--our justified concerns for preservation and efficient use will go on ignored as the technical discipline gets reapplied without input of environmental and natural resource considerations. We should feel obliged to be a part of the process of generating public policies which immediately begin to address massive and long term shifts in our environment due to global climate change.

By framing institutions as interdependent on social welfare and environmental resources we can improve the structure of decision making to prioritize natural resources, environmental services, and

social welfare instead of treating these results as externalities (Paavola). Restructuring and in turn applying in practice economics to focus on the functional form of constituents' utility and preference in connection with other individuals across time--future generations--and geography enhances our predictions of policy preferences and allows us to align them with institutional decision making. While these issues are largely conceptual, these theories are assessed for feasibility to transfer theory to practice. Both a cause of major bias and great triumph of economics is its applicability across different institutional functions. This is why this study focuses particularly on a case study of a two scenario decision, in order to fulfill the underlying driver of economics and support the discipline, while also restricting its untethered influence on all aspects of policy generation in relation to long term decision making.

This paper will continue to argue that economic tools have served to benefit our world in making exchange more clear, efficient, and predictive. Providing individuals more information and synthesizing massive amounts of data to make highly quantitative judgements is a product of our strongest minds and most intensely invested resources. That being said, we have simultaneously invested similarly in our climate scientists, geologists, and biologists who have much more powerful and accurate predictions on the potential impacts and scenarios we will likely face due to anthropogenic climate change. How to re-assign value and restructure an economic framework by pulling equally from these disciplines and matching them to existing socio-political structures is the pursuit of this research. Both of these disciplines map out complex systems which are modelled over enormous periods of time. Therefore, the CBA should not be completely scrapped until it is proven virtually antiquated against a more advanced or powerful way of understanding and interpreting the value of our future on this planet and given our resources. As an interdisciplinary student within academia, it is our purpose to cross-motivate, inspire, and collaborate in developing sophisticated theories on our most pressing issues that can dually be applied to better society. This is why my research is both timely and beneficial to the field, as I am working to make the case study as applied as possible.

Methodology

Concepts of CBA

History of Economic Application

The goal of the CBA is to convert every tangible and intangible good into a monetary amount with respect to an encompassing, binding constraint (Brent 34). This technical procedure takes all benefits derived from willingness to pay (WTP) estimates and actual returns to individuals, and the costs are calculated as the price of compensation for the losing party to give up their access to the resource. The social price of capital and the social discount rate are used in order to account for well being of future generations (Brent 28). This technique is sufficient to the extent the tools of economics can be applied to derive a demand curve for WTP and compute the ratios of two (or more) policy scenarios under the same methodology. The most accurate CBAs involve survey data collection of all impacted individuals and may involve weighting techniques to prioritize disadvantaged or more grossly afflicted individuals' preferences. The overall goal of society is reflected in the welfare optimization function, and therefore CBA are based on the policy maker's aggregation of welfare concerns. CBA weighs the consumer and producer welfare gains against losses on an aggregate for society.

The distinct assumptions in CBA make it both a flexible and informative tool that allows the policy maker to select the traits of the referent group, the time period of the analysis, and other subjective assumptions within the model to mold to the specific policy scenario at hand. It is important in a cost benefit procedure to explain these assumptions, any value judgements made, technical choices within the model, potential biases, error margins, and additional qualitative assessments. (Fuiguitt, Wilcox 19). The inclusions of this information better contextualizes the analysis and allows for policy makers to still grapple with the complex, social and political system in which they are making decisions.

As above, the CBA can range from a one-off decision to very complex legislation that requires more advanced techniques. To begin, WTP is not always easy to collect nor accurate in individuals' actual assessment of their willingness to pay. WTP is often taken through direct surveys of affected population through a method called contingent valuation, in order to recreate a demand curve that is based on actual preferences as stated by individuals. But often, individuals' own assessment of their WTP is inaccurate and not priced in the way it would be given market evaluation. Therefore, other methods of deriving WTP are taken such as surrogate markets and revealed preferences (Fuguitt). Both of these methods extrapolate the prices of a nonmarket good. Surrogate markets extract the price through looking at the price of a good that generates the same form of utility or provides the same consumer benefit. Revealed preferences extract prices through tracking the change in the price of a market good dependent on the qualities or services that the good provides at a different price. By seeing how people change their price point given changes to the good i.e. travel time or entrance fees in the case of recreational goods, WTP can be derived. In the case where WTP can be proxied from a similar sample, it is taken from an existing study or survey where sample population shares similar factors.

This WTP estimate is then used to price all non-market goods and services alongside market goods and services as the basic inputs into the CBA model. In addition to using WTP for nonmarket goods, environmental and ecosystem services have a unique process of being priced as their benefits are often indirect and variable given the interdependence of ecosystem functions on one another and our brief understanding of evaluating the indirect benefits. Ecosystem services are rarely studied in tandem with their productivity yields (Garbach, Milder). Because of this, the value of existing ecosystem services is estimated without particularity to a certain ecosystem but often with aggregate benefits. Other nonmarket goods are included that produce consumer or producer surplus. Where consumer or producer surplus is generated, there exists a welfare benefit. If consumer or producer loss is incurred, welfare loss results. These are the two aggregate values used in evaluating policy scenarios in a CBA.

The CBA also operates under an improved Pareto efficiency clause. Where Pareto efficiency is achieved when at least one person is made better without making anyone else worse, the modified--or improved--Pareto efficiency constraint requires that one person could be made better off while compensation to those made worse off is possible. This modified Pareto efficiency clause, also called the Kaldor-Hicks theorem, serves as a critical component of the basis for CBA methodology. It emphasizes that neither policy should be chosen just because the benefits exceed the cost, but that the policy where the difference between the benefits and costs is minimized (Revenz, Stavins 4). In deciding which policy to choose, the policy where benefits to cost ratio is minimized provides the the condition for optimality by minimizing the amount of compensation that is necessary to be transferred to the losing party. But the Kaldor Hicks criterion does not recommend a cash transfer for compensation, it models the possibility to compensate losers without any obligation.

History of Benefit-Cost Analysis in Policy

CBA have been used in practice since the early 1800s, with the implementation of the River and Harbor Acts of 1927 and 1928 becoming the first establishment of mandatory evaluation and reporting of potential projects to be completed by the government.[15] But, the Flood Control Act of 1936 is credited with the official stipulation that large infrastructure projects for flood control be "in the interest of general welfare" as conceived through a report of the benefits and costs of the project.[16] The precedent was set for comparative evaluation and culminated in cost-benefit serving as a decision making tool for policy makers on large projects, normally infrastructure projects, conducted by the government. From then on, CBA methodology continued to grow and institutionalize as more entities adapted the economic evaluation strategy and its efficiency benefited many large projects. With the help of academia, "existing economic concepts [were used] to provide a comprehensive rationale and theoretical base for the analysis" in decision making (Fuguitt, Wilcox 34). In the 1960s, the growth of the CBA can be attributed to the ability

[15] Fuiguitt and Wilcox (page 4)
[16] Fuiguitt and Wilcox (page 4)

to price non-market goods and input/output prices in a systematic and technical way (Fuguitt, Wilcox 13). President Ford in 1970 had agencies formally conduct CBA while President Carter and then President Reagan broadened the application of CBA in two separate Executive Orders to a larger number of rule proposals.[17] Finally, under President Clinton in 1993, existing mandatory CBA executive orders were consolidated and amended, requiring the agency to conduct a regulatory impact assessments for any rules that before they are reviewed by the Office of Management and Budget, then implemented in most efficient proposed form.[18] This rule was designed to increase efficiency, make the process of oversight standardized, and engage the public further. Because federal policies have encompassing impacts and their overall purpose is to create policy that bridges the gap between the current equilibrium and social equilibrium. This sophisticated and highly analytical tool has become standard for all federal decision making because it provides (Fugiliti, Wilcox 13).

CBA and Welfare Economics

The rise of welfare economics in the 1960s was, again, a large contributor to how CBA became a standard practice. Today, welfare economics is the basis for CBA in its application to public policy (Brent 1). In tandem with the increasing reliance on CBA, the development and dissemination of the Chicago school of thought helped bring technical and economic analysis into the center of policy decision making. Given the Chicago School's emphasis on market fundamentalism, the reapplication of these concepts to government decision making was almost inevitable because of the strong ideological role market fundamentalism and rationality played in economics and eventually business, consumer, and policy decisions (Samuels 364). Its dominance in the public policy sphere is due to its simplicity, independence, and objectivity. Its main objective as a tool is to provide comprehensive information in monetized form to policy makers to assist in the decision making process. It is not a functional decision maker but instead an additional piece of information that is added to the testimony.

[17] Fuguitt and Wilcox (page 10)
[18] https://www.foreffectivegov.org/node/2560

For the purposes of this paper, I will be conducting a CBA under the standard assumptions of the federally mandated CBA because the policy decision being analyzed is determined by a state institution and using this procedure clearly establishes the goal of the decision as welfare maximizing.

Ecological Economic Consideration of Cost-Benefit Analysis

Overall, CBAs of environmental regulation and decisions of natural resource management have been highly subjective areas in the economic literature and policy application. A few issues face environmental regulation and resource management including ecosystem evaluation, social and cultural benefits, and long term valuation of 'sustainability.' These issues are critical to the debates within the environmental literature and the ecological economic literature. Environmental criticism often falls on the inability to monetize ecosystem services, their interactions, and natural resources for human enjoyment through society or culture. While ecological economics confronts the technical challenges that using economics for natural resource management faces. Ecological economics is concerned mainly with the underlying growth assumption implicit in using a discount rate for future costs and benefits, as well as the role institutions who inform, design, and enforce policy play in the creation of valuation for a cost benefit.

Environmental Perspectives on Cost Benefit

Because all goods and services on the planet are necessarily derived from environmental resources, the argument that environmental goods and services cannot be fully captured is often invoked by environmentalists who see the CBA structure bias against the complexity of these services. Ackerman and Heinzerling discuss this in their book, *Priceless*, because they argue prices cannot be put onto natural systems and services (18). Ackerman and Heinzerling refute the concept of monetization, and therefore do not believe a CBA methodology could properly evaluate natural systems and ecosystem services. In addition to opposing pricing on natural resource services, another opposition to the deployment of CBA in public policy decisions is the absence of a equity measurement.

Economic does not itself promote issues of environmental injustice and resource mismanagement, but CBA does reinforce and rationalize the theories which are incompatible with environmental and ecological considerations (Ackerman 151). The distribution of costs and benefits is absent from the conception of CBA specifically when applied to resource use. This issue arises because under the modified Pareto constraint, if the losers can be compensated through cash transfers, than the policy is still efficient, which exacerbates the underestimation of environmental damages and reparation to communities who are traditionally underserved or lack access to natural resources. The extensive nature of costs that could accrue from environmental destruction or removal of ecosystem services is generally not quantifiable, and the effects are often minimized. Theorists argue the precautionary principle be deployed, creating a policy environment in which we study all potential effects and deliberate over a decision opposed to siding with quantitative results (Ackerman 118-119, Lee). This idea while widely supported is under-investigated in economics.

Next, there is an extensive body of literature on ecosystem service modeling and how to best evaluate green space given its geography, proximity to sea water, urban or rural setting, temperature, geology, and more. Although the body of literature is growing to be extremely advanced and curated for these specific constraints, the question of understanding the value of an ecosystem service or goods within that system is not fully captured by a CBA. This body of literature is a result of the need to provide conservation incentives within the market and bring resources into the domain of economics. The concepts particular to ecosystem services will be addressed later in the Analysis portion of this paper.

Ecological Economics Perspectives on Cost Benefit

Within the National Bureau of Economic working paper series on environmental policy and CBA, they address that CBA should by no means replace the decision making process but should aid in the decision maker's evaluation of a proposed set of policies (NBER). This view, while generally accepted by economists, is not always applied with policy makers. The crutch of technical calculation

often alleviates policy makers' integration of viewpoints and perspectives. This leads to institutions that rely heavily on economic analysis for decision making while claiming to integrate point of views. The ecological economic application of CBA is often not conducted because it claims (1) indefinite growth as inferred by the use of a positive discount rate is unsustainable, (2) the value of environmental resources will only grow as entropy increases and our efficiency of energy use decreases, and (3) the uncertainty due to climate change create massive larger probability valuations of potential costs and benefits of the policy scenarios in the future.

These critiques, result from the fundamental principles of ecological economics, which are primarily based on constraining economic models by the planet's entropic energy system. Herman Daly, one of the founders of the discipline of ecological economics, dubbed society's overdependence on growth, growthmania. Growthmania is the assumption that orthodox economics holds in which scarcity is relative and desire is insatiable (Daly 23). But, in the steady state, by holding stock constant, pure growth would have to curtail and society would function under a constraint of increasing entropy (Daly 37). The steady state assumption for all resources across the world is a drastic shift from current mainstream economic doctrine, and would require a total rework of the economic methodology for evaluating future costs and benefits.

An additional critique of CBA through ecological economics stresses the importance of the institutions and the role the actors of the referent group and decision making entity play within generating the analysis. The CBA is greatly impacted by its social and institutional setting, and this context often takes a backseat in importance to the technical and statistical methodology of the CBA. As addressed earlier in this paper, changes to institutions will be a strategy in transforming the CBA.

Methods

To conduct the CBA, the two policy scenarios I selected were given as the following: Policy 1 is the policy where the existing facilities at the OTRF remain in place as the current state and Policy 2 is the

policy where all existing agricultural research facilities at the OTRF are relocated permanently elsewhere on campus and the land is used to maximize undergraduate student housing. These two policy scenarios were derived from the current state of the land and the Housing Master Plan Taskforce Report, as released in April 2017 which outlined an estimate of the number of beds. Although, as of February 2018 a new proposal was developed which featured a multi-use reimagining of the OTRF. The new proposals are (a) 1.75 acres of new student housing, repurposed greenhouse facilities, agriculture grow space, and SOGA and (b) 2.5 acres of new student housing, elimination of agriculture grow space, repurposed greenhouse facilities, and SOGA (OTFR 2018). Due to the time limitations of this study, I will not be evaluating these policy options and will remain evaluating the scenarios as maintaining the existing space and relocating all facilities elsewhere as this baseline policy decision was the baseline proposal for development.

The discount rate assumed is pulled from UC Berkeley's most recent financial report which deploys a 6.1% which is chosen as the interest rate on structured debt financing that is most secure and used by the University in investment decisions. This discount rate best reflects a social rate of time preference estimate by basing the discount on the estimate for returns on secure public bonds. This use of the discount rate is the social rate of time preference approach because we assume that by being government-backed, the investment is risk free. We also assume the interest on the bond to be the discount rate as it represents a baseline, economy-wide assumption of how individuals discount their future consumption. This discount rate is considered in other public financial models for the University and I am therefore deploying this rate in my traditional CBA.

The time frame I have selected is a 33 year period because that is the time of amoritization of building or capital assets as done in University financial accounting. This is taken initially as CBA can run for predictions until infinity, but the assumption here holds that CBA, while assessing the lifetime of a project, often constrains its time horizon to a period within reasonable parameters to predict costs and benefits. It's function as a short term policy decision making tool is sound economically, as we can also

uphold the assumption that societal preferences will not shift dramatically from today's societal preference. Therefore discounting under a short time horizon is conducted for the traditional CBA.

The benefit to cost ratio was conducted for both Policy Scenario 1 and Policy Scenario 2. The Net Present Value (NPV) of both projects were calculated under the same general assumptions. The internal rate of return (IRR) was also estimated for both projects. All three of these estimations from the CBA provide different ways of comparing the outcomes of the project. For simplicity, the benefit to cost ratio reduces benefits and costs to display the effect on a 1:1 scale. The NPV gives us the project's aggregate value in today's terms. This is good for understanding the project's worth today and for eliminating either of the projects in the case of a negative NPV. If we compare both projects by their respective IRR calculations, we can compare the rate of return on the investment. The IRR is the discount rate by which the NPV of the project would equal zero. Therefore, the higher the IRR the better the project is as it makes larger returns on investment. For this research, given the availability of information on returns to productivity of agriculture research, I focus on the IRR found in Jin et. al 2016 for Policy Scenario 1.

Inputs

Inputs considered in the first CBA were financial by nature and organized by type of investment. All inputs were factors that contribute to total social welfare either through providing a public good or service, resulting in consumer surplus or loss, or resulting in producer surplus or loss. All data inputs into the CBA model are outlined in Table 1 below.

Policy Scenario 1:

Costs under the first policy scenario, where OTRF would remain exactly as it functions now include operational costs and the opportunity cost of the space itself. Opportunity cost is the value of the land if it were sold today. While this necessarily would not provide direct additional welfare, it would provide additional revenue to UC Berkeley that can be reinvested in the public good.

Understanding the returns to the agriculture investment related to productivity were determined by a meta analysis conducted in Jin et. al 2016 as a comprehensive estimate for the social welfare returns on investment in agriculture research. Public research is designed to generate benefits that are then reflected in increased productivity of agriculture and decreased costs for consumers and producers.

Current use of the space for agricultural research oriented towards productivity and use the IRR derived in an existing 2016 study by Jin et. al which found the social benefits of agricultural research given by the dollar invested in public agricultural research. For every $1 of state funds invested into agricultural research for increasing productivity of farming and ranching, there was a return of 66.8% a year across the US in aggregate which is remarkably high for public investment benefits. It was chosen because it was an aggregate study built on a 2013 study that separated extension and public research benefits and costs, and it has the most up to date data on returns to productivity in agricultural research. In addition to this finding, total factor productivity is expected to increase in California when controlling for weather variability, and irrigation around 1% per year, predicting an increase in the returns to agriculture productivity as inputs become more efficient. This calculation of the IRR is used in Policy Scenario 1 to describe the returns to investment. Essentially, even at a discount rate of 66.7%, by maintaining the space as the OTRF, the project still produces benefits greater than the cost.

While this IRR was used as the key estimator in Policy Scenario 1, benefit and cost values were still found for the tract in the case of better laying out the value of the space. Beginning with the benefits, an environmental evaluation of the habitat at the student organic garden was evaluated. Using Bay Area Greenprint, a collaborative ecosystem service evaluation tool specifically for the Bay Area, it was found that the Student Organic Garden did not possess critical habitat or biodiversity at a scale of significance. The recreational value of urban green space at this size was also not formally evaluated. Metrics for evaluating the intangible social benefits of food production at SOGA were evaluated by taking the estimated 400 pounds of fresh produce donated by SOGA to the UC Berkeley Food Pantry and averaging the cost of California vegetables grown seasonally in fall and spring at market price, according to USDA

estimated market prices. The average price of the produce from SOGA was found to be $1.71 a pound, and this was used to result in $684 of annual benefits from food production. In tandem with the actual cost savings of free food was a calculation of food security relief. According to a 2010 study, food security costs in the United States fall to $54 per capita per year.[19] Given approximately 12,841 UC Berkeley students suffer from food insecurity as found in said report. Because of this, we infer approximately 10% of the of this social cost is relieved by the active efforts of SOGA to provide produce to suffering population and provide educational workshops that attract 2,000 unique individuals annually. This 10% figure is a conservative estimate, but is used as actual benefits provided are possibly indirect and difficult to resolve. Next, the price premium on organic produce was also calculated to demonstrate additional value to consumers through the production of organic produce. Given USDA estimates of 57.62% average price increase of California organic agriculture, the additional benefits would be $387.96 annually.

In addition to the value of the food production and security reliefs, the value of SOGA as a community space of knowledge sharing was evaluated. SOGA holds approximately 20 workshops for year open to students and the public community. These workshops are typically two hours long. Given workshops are normally held by two to three facilitators who hold specialized knowledge, I approximate hourly pay for the facilitators as the benefit, as this teaching value is provided at no cost. Using a surrogate market for workshop facilitation cost, I can predict the benefit of an hour of teaching to be $50. With approximately 37.6 hours of facilitated workshops, total benefit results in $1,880 per year. Next, a large source of provided benefits are the deCals, student lead courses, facilitated at SOGA. These courses enroll approximately 185-265 students per year (Appendix D - OTFR). Given an estimated cost of a two unit course at $64.36 a week when dividing tuition costs by average number of semester units taken by a UC Berkeley undergraduate, the value of the deCal courses equates to $489,650.80 per year in free education for students towards their degree requirements. This educational value does not include the

[19] http://www.bread.org/sites/default/files/downloads/cost_of_hunger_study.pdf

value derived from additional students who access the space through other forms of programming including capstone projects for Food System Minors, educational events for specific student groups or on-campus programs, and high school students who gain experience at the garden through educational programs (Appendix D - OTFR).

Finally, the value of the courses that are taught on the OTFR and in SOGA are calculated by finding the wage premium of undergraduates to high school graduates and graduate students to undergraduate students. For the five undergraduate courses, the wage premium between high school and a bachelor's degree is $22,500.[20] The number of units required to graduate is 120, and each of the courses taught are an average of three units each, given one is a freshman seminar and others are lab intensive, leading to a value of about $562.50 for each course taken in undergraduate towards a bachelor's. This value, given five courses and an average of 75 students per class result in a net benefit of $210,937.05 (OTFR Report). For PhD students the wage differential is $17,704 and because PhDs take an average of six years to complete, the value of one PhD course and access to research facilities to perform active research contributing to the completion of the graduate program stands at $1,475 a person.[21] With seven students in the particular graduate level introductory course, the value of the course stands at $10,325. Again, this assumption is purely the additional wage per year graduate students can expect as a result of receiving their PhD through the resources necessary to complete their degree at the OTRF.

Given these factors, the indirect benefits of the OTRF are quantified at a total of $783,201 per year. These benefits, most strikingly do not include the monetary benefit of agriculture productivity research and the actual social returns to the investment in research. Without this information, we cannot properly calculate a NPV of the project and therefore cannot evaluate the two projects side by side using NPV comparison or benefits to cost ratio as we lack the monetary value of the research benefits.

---

[20] https://www.newyorkfed.org/medialibrary/media/research/current_issues/ci20-3.pdf

[21] http://www.sheeo.org/sites/default/files/publications/Econ%20Benefit%20of%20Degrees%20Report%20with%20Appendices.pdf

Next, to calculate the costs of Policy Scenario 1, we find the operational and opportunity costs of the land. In period 0 we find the opportunity cost to be $14,575,500 given an estimation of SF-Oakland urban lot prices per acre.[22] Including in these costs is also the operational costs of the facilities and programs, including three full time employees at OTRF, inputs and maintenance of facilities, compensation to the SOGA managers who are paid to maintain the space and the programs, and UC Berkeley research expenditures. These costs come out to be $15,097,934 for research, given 44 faculty use the space out of 1,525 total faculty who share a research budget of $523,289,000.[23] Costs of employees are $373,690 annually while costs of student leadership for SOGA is $15,036 where 3-4 students are compensated $15/hour salary at five hours a week over the course of each semester. Funding from the College of Natural Resources to upkeep the space is $503,100 and $141,900 come from campus recharge to pay for supplies within the OTRF. The costs of professor salaries and graduate student research costs per lab were calculated at $7,168,718.72 and $11,250,000, respectively but it was found this information did not properly constitute a social cost. Due to a disruption or relocation in the facilities, we cannot assume professors and graduate students will cease to be employees and students of the University and that this cost will not be present given Policy Scenario 2. Therefore, these amounts were not included in the CBA but is informative on the expenditures related to the OTRF regardless,

The only potential way to calculate this is to use insert the IRR found into the existing NPV calculation where NPV = 0 and IRR = .667. This would then yield a result for the returns to agriculture productivity where we separate indirect benefits as calculated above from agriculture research benefits, and solve for such.

Where agriculture research benefits = X
Other benefits = $783,201
Costs (period 0) = $15,609,226
Costs (period 1-33) = $16,131,660
Time = 33
NPV = 0

[22] http://davidalbouy.net/landvalue_index.pdf
[23] UC BERKELEY ACCOUNTING

IRR = .667

NPV = 0 = sum, t=1 to 33(783201 + X)-(costs)/(1+.667)^33)

This calculation yields a value of agriculture productivity in year 1 through year 33 of $15,348,459.46. But, there are many issues in modeling the monetary value of the agriculture productivity research as a function of the input costs in the facility. To begin with, the IRR reveals the break even point for the project, and while it is a good indicator of the returns of the project, it cannot be used to reveal the monetary benefits of the function as it is already an estimation. Therefore, in evaluating Policy Scenario 1, we use the IRR to demonstrate the returns to the project overall, and have the monetized value of the benefits of the OTRF's other functions for future discussion in this paper.

Policy Scenario 2:

For Policy Scenario 2, in the case of the undergraduate student housing being built where land use is maximized and OTRF are relocated, costs and benefits were fewer to generate. To begin, in Policy Scenario 1, no amoritization or depreciation costs were factored in to the existing costs of the OTFR as Berkeley does not depreciate any capital goods that are directly research space (UC Berkeley Financial doc). Because of this, the land for agriculture use does not depreciate and neither do OTFR facilities despite some of the facilities being in possible need of repair. For the costs and benefits of this scenario, amoritization was factored in and will be discussed more below.

Benefit estimation in Policy Scenario 2 include only the additional revenue from housing 3,000 students as considering the UC Berkeley 2017 Housing Master Plan (Housing Master Plan). With 3,000 students paying $16,160 on average for on-campus housing, the additional revenue generation will be $48,480,000. This is the calculated benefit as additional revenue generation is a benefit in the same way tax revenue is for it serves the public by being reinvested in a public institution that provides benefits to constituents. The benefits here do not include market relief of the increasingly competitive East Bay housing market, relief for homeless students, or increased student welfare through retention of students in

secure housing with a diverse makeup of students living together. These intangible benefits could not be quantified and will be discussed more at length in the next section.

Costs of Policy Scenario 2 were driven mainly by relocation costs of the facilities, amounting to an estimation of $15,000,000 for main glasshouse facilities and another $4,000,000 for remaining 30,000 square feet of glasshouse. Costs of relocating insectary, additional storage and lab space was not fully assessed. Other costs include the actual construction costs of building student housing. Using the existing per bed cost of the Blackwell Residence hall on Bancroft street and finding the costs of building 3,000 beds, working capital required to build on the OTRF is estimated at $8,555,515.63. Given the Blackwell Residence and future housing projects are built under a Private-Public Partnership (3P) model of investment, we can assume the University requires less up front capital in its arrangement with a private developer. Additional costs include the same full time employees and operational maintenance at $373,690 and $645,000. Although given the spread of the facilities if relocated, full time employees are expected to increase and therefore costs associated with these employees will increase (OTRF Report). Depreciation cost of the building that would supply student housing are equivalent to 100% amoritization over the course of 33 years. Therefore, annual depreciation would result in $259,258.05 annually for lifetime of building (UC Finance Report).

Overall, Policy Scenario 2 had multiple barriers to understanding appropriate costs and benefits of the project, including the lack of operational cost for a housing development, including utilities, maintenance, employees, and janitorial services that incur regular costs. The 3P revenue model is not clearly defined and is project by project, making costs and benefits of this type of partnership difficult to evaluate in economic terms of welfare. It is unclear how the environmental impacts of increased traffic flow, noise pollution, and sound pollution will affect overall welfare in the surrounding area.

Outputs

The IRR on this net measure of public agricultural research is 66.8% per year, as found by Jin et al 2016 which is 6–10 percentage points larger than in Huffman and Evenson (2006a). This finding better encompasses demand for agricultural research and the growing benefits to society productivity related research provides through the form of consumer surplus. This IRR, compared to the IRR of Policy Scenario 2 is actually smaller. In Policy Scenario 2, an IRR of 91% with a benefits to cost ratio of 2.19. This high return to the project is also supplemented by its high NPV amount at 370,376,963. Therefore, Policy Scenario 2 generates a higher return to investment than Policy Scenario 1. Despite initial beliefs that 67% IRR was high for a public investment, we can see 91% trumps this estimate.

Concerns with the functionality of this argument are valid considering many costs associated with ongoing, annual costs of the maintaining and operating a student housing facility are highly extrapolated and non-specific to UC Berkeley services and student life offerings. Additionally, the potential project size was determined to be 3,000 which is the maximum predicted bed space for the OTRF and is not necessarily representative of actual construction or funding benefits. These concerns will be addressed further in my analysis, but given these results, we can conclude to build the maximum amount of student housing in place of the existing research facilities does generate additional utility beyond the social welfare generated from maintaining the space as an agricultural research facility. The tables below give more clear view of the costs versus benefits in both policy scenarios. Additional information on the calculations of values given in the Appendix.

Interpreting Results

Overall, my results from this CBA framework produce a recommendation of pursuing development of student housing on the OTRF as outlined in Policy Scenario 2. We can also infer when facilities are relocated, the returns to agriculture productivity still yield the same return on investment and therefore although a smaller amount of research is being conducted given physical or travel constraints, the fact that research space is preserved on campus still produces net benefits for the state of California.

Given the rough estimations of some cost and benefit factors, it is likely my model needs further development and more specific analysis attune to the Berkeley community and the UC system as a whole.

As a provider of an economic assessment that which can be used to assist a policy maker in decision making, I have worked to make it clear the technical choices in my analysis, value judgements, and possible errors which may have occurred in the analysis (Fuguitt). Given an efficiency analysis, without respect to distributional impacts of the costs and benefits between the project, the aggregate provider of more social benefits is Policy Scenario 2. Overall, this economic analysis attempts to address the Housing Task Force's requirements of assessing alternative sites including sales and relocation or replacement costs of existing services (UCOP Meeting Notes). As an independent analysis, this study should be contextualized and understood as one facet of a larger plan to develop housing at UC Berkeley within the goals outlined in the Long Range Development Plan and under the Housing Initiative of the University of California.

On the contrary, consideration of the increasing productivity of agriculture given the declining trend in investment in public agriculture research in California since 2006 is critical to this study. The need for investment in public agricultural research will only grow as developing countries continue to heavily invest and customers need declining real costs of food in order to not create a burden in consumption of these staple goods. This need is not necessarily reflected in the comparison of the results from the CBA between Policy Scenario 1 and 2 given I select static benefits for the returns to agriculture research and do not deploy a dynamic consideration of increasing value of agriculture-related research, education, and extension services.

Finally, when evaluating this policy under the Kaldor-Hicks criterion, the difference between benefits and costs of Policy Scenario 2 are larger than Policy Scenario 1. If we were to select the policy which minimizes this benefit in an effort to distribute costs and benefits more evenly, then we would consider Policy Scenario 1 as it still produces net welfare benefits while reducing the amount 'winners' would have to compensate 'losers'.

Policy Recommendations Under Traditional Cost-Benefit Analysis

Given the economic outcome of this analysis and the uncertainty in valuation of Policy Scenario 2, I would advise the University to propose a maximized development of housing on this land. But, given that costs related to the actual building and operations of the housing facility are not accurate and have different distributional outcomes given the structure of 3P agreements, I cannot fairly recommend this without consideration to other qualitative concerns and mission-oriented concerns for the University. Considerations in comparison of policy scenarios for public institutions should include cost-effectiveness, distributional effects, and political feasibility (NBER). The issue presented in this CBA is not necessarily the question of the best way to complete a policy objective, but how to balance two, competing objectives. While the framework of CBA infers a dichotomy in the possibility of these two policy goals, as a public institution which balances policy objectives, this analysis should only serve as a explanation of certain costs, benefits, and the methodologies which are used to evaluate these criterion. Explicit attention should be paid to the policy objectives of the University.

The existing policy objectives of the University of California include environmental, food systems, and housing goals. Under UC Berkeley's Long Range Development Plan from 2005, housing goals include "providing two years of University housing for entering freshmen; providing one year of University housing for entering transfers; providing one year of University housing for graduate students; maintain the number of University housing units suitable for students with children; and providing up to three years of University housing to new untenured ladder-rank faculty" (UCOP Meeting Notes). This goal, while applaudable, has been in place since 2005 and continues to be unmet.

At the University of California level, the Student Housing Initiative has a two-part goal that is less well defined, particularly the assumptions which underline 'growing' and 'affordability'. Growing is not clearly defined as expected admission for each UC campus has not been projected. With 10,000 new enrollees in 2018-2019 to UC schools, campus specific projections for enrollment has not been predicted.

[24] SB 826, the Budget Act of 2016 requires the UC system to award an additional 250,000 Bachelor's degrees by 2030, increasing enrollment from 2-55% of baseline enrollment by 2024.[25] Given the state mandate to increase enrollment and UC goals of generating student housing to meet this growing number of students, a lack of a formally developed approach and no predictions on accommodation capacity make valuing student welfare unclear. A Housing Master Plan for UC Berkeley has not yet been written, and will likely be proposed after a housing market demand study is conducted by Jones Lang LaSalle (JLL), a real estate advisory service UC Berkeley has obtained for services.[26] Affordability is still undefined in that market rate housing has proven to be both difficult to find and out of the price range for many undergraduate, graduate and postdoc students.[27] The issue of affordability in housing options near campus has lead to students living further from campus, in less habitable conditions, or experiencing homelessness because of this. Therefore, affordability is both a vague goal and subjective to each campus.

In terms of environmental initiatives, the UC GFI is both an internal and external facing policy goal. Externally, the UC system wishing to leverage its research capability to help sustainably and healthily feed a growing global population while internally reassessing its own practices around food procurement and education in order to "create desirable policy outcomes" at UC campuses.[28] Under the GFI, different working groups exist, including one dedicated to Research. This team also has a subgroup that focuses on Urban Agriculture and Disparities in Food Access, where the growing of food and development of farming skills in urban areas provides equitable access to food in communities that experience food insecurity. These goals around food production and research, in addition to our campus goal of achieving Zero Waste by 2020 would be hindered by further development and campus growth.

---

[24]https://www.ucop.edu/operating-budget/_files/legreports/16-17/EnrollmentandBudgetaryScenariosforIncreasingDegreesatUC-3-10-17.pdf
[25]https://www.ucop.edu/operating-budget/_files/legreports/16-17/EnrollmentandBudgetaryScenariosforIncreasingDegreesatUC-3-10-17.pdf
[26] https://chancellor.berkeley.edu/housing-master-plan-advisory-group-progress-update
[27] https://housing.berkeley.edu/sites/default/files/pdf/HousingSurvey_03022018.pdf
[28] https://www.ucop.edu/global-food-initiative/

While growth necessarily does not imply increased waste, it requires additional costs and precautionary measures be made to offset the increase in resource consumption. Under this zero waste goal, the built environment policy consideration includes basing capital investments on life cycle costs and minimizing overall water and utility functions. With this as a policy goal, the co-development of a project with a private partner that seeks to maximize cost-effectiveness of development will likely increase upfront costs. This type of capital project strategy is not required when an outside developer is chosen as the construction firm, and UC Berkeley may sacrifice policy goals of sustainability in an effort to meet housing goals. In consideration of the 2020 Zero Waste goal, UC Berkeley was at 54% diversion in 2015 and has since not updated its annual diversion rate.[29] When considering the environmental goals of the organization, further expansion of campus space will require a large amount of upfront investment for the following reasons: (1) building and facility design must be made with respect to low emissions, water usage, and utility usage standards, (2) increased education for on-campus residents to encourage proper sorting of waste and decreased consumption of common waste materials, (3) waste services must be managed internally to maintain records of waste diversion for overall policy goals, (4) a replacement or equivalent support of food systems education and food security relief.

When evaluating the two Policy Scenarios in tandem with existing policy goals related to housing and the environment, I do not recommend viewing the two policies in contrast with one another. Instead, I propose evaluating the different timescales of the policies. While housing is an immediate concern, it has been prioritized by the University since 2005 as outlined in the LRDP. While changes to enrollment for the UCs became effective in 2016, a tightening state budget has led UC campuses to admit more students than they have the capacity for. An increasing constraint on resources is a common economic scenario. Because this constraint on space for students and funding to provide proper services, including housing, coincides with an increasing integration of environmental principles at institutional goals. There appears to be tension between which institutional goal will warrant allocation of more resources. But, the

[29] https://sustainability.berkeley.edu/metrics

University has an obligation consider adaptive ways to meet both criteria of policy goals or resolving immediate goals unfairly discriminates against the welfare of future students who experience higher costs of climate change left unmitigated.

This will be explored more in the Analysis portion of the paper. To set up a brief understanding of how potential competing demands on resources should be considered in tandem, the University's holistic approach to student housing should encourage lower growth rates and redirection of incoming UC students to alternative campus sites that face less resource constraints. The student housing development should be high density, maximize currently unproductive lots, be purchased in the case where land is already zoned for high density residential housing, and require green space offset for areas where development effects any existing natural resource. While environmental considerations are often secondary to immediate political crises in respect to how policy generation occurs, it is necessary for high impact land development projects to be built within a framework of a resource scarcity.

Analysis

Limitations of Analysis

The deployment of the CBA in a traditional methodology is used to demonstrate how the project proposal for housing weighs against the remaining usage of the OTRF as a research facility. While it was possible for me to monetize a majority of costs and benefits of both policies scenarios in a financial framework, a few issues stand out as notable in the development of my argument. I hypothesize a few quantification errors particularly in my estimation of the costs of construction and development of student housing. Given limited access to financial data regarding 3P projects, housing projects at Berkeley, and economic assessments of the OTRF, the estimations for costs are likely overestimated while benefits are underestimated. Where the revenue of room and board was quantified as a benefit of the project as it gets reinvested in the public institution, there is no attempt to quantify consumer surplus from what might have been an agreement on the reduction in cost relative to the market rate that would therefore provide students with an increase in consumer surplus. Using the revenue generation model for social welfare also poses difficulty in that it is very likely all revenue that would be generated through student fees would actually be immediately paid towards the third party developer of the project and then surplus revenue from the project would be redistributed to campus indirectly, as the case with the ground-lease agreement at UC Irvine (3P Capital Strategies Report). Therefore, I can expect a different benefit calculation, one that ignores revenue streams and focuses on market relief for surrounding areas, increased value of homes given the proximity to high density of housing, and reduction in transportation time by housed faculty and students.

Next, a major benefit not captured in Policy Scenario 1 was resulting revenue generation or public good from particular research projects that deploy novel techniques for advanced basic research such as the Crispr-9 research and other projects conducted at the BioEnergy Institute. These projects

likely yield high benefits to the public but because of the novelty of Cripsr-9 research and the private-public nature of the Joint BioEnergy Institute. I was unable to estimate benefits of these projects. In general, estimating the returns to welfare and cost efficiency gains from 3Ps is extremely difficulty due to mixed results in the literature (Roseanu). In both developing of a service to be provided as a public good and public research that is later privatized, efficiency and welfare gains prove difficult to quantify.

Finally, within the framework of a public institution there are discrepancies in ability to account for what is actually a cost. Where taxes are a cost on constituents and take surplus generated away from individuals, it is also reinvested into the state in order to provide public goods at no (direct) cost. This accounting technicality made some of my financial estimates for operating costs and research costs inaccurate in the sense I do not know if it is a true loss to consumers or simply a reinvested or reappropriated fund that does not affect consumer welfare. Overall, I believe my attempt at estimating and accurately quantifying costs and benefits was a strong enough in order to provide an analysis for the purposes of this research.

Lack of Environmental and Social Cost Accounting

Another large limitation in my analysis was the exclusion of many social and environmental factors in weighing costs and benefits. Where social and environmental costs and benefits are necessary to achieving partial equilibrium, by not factoring them into the costs and benefits we do not achieve a full capture of all costs and benefits which affect social welfare. Welfare economics has been including social and environmental considerations for much of its application and my failure to include them absolutely will result in a misrepresentation of costs and benefits.

Particular to Policy Scenario 1, the ecosystem service benefits of a native California bee garden was not accounted for. Because these bees contribute to the urban landscape as well as the field research station at OTRF, they clearly should be considered in this analysis. Also the bee garden's proximity to an urban garden and a large, diverse landscape like the campus of Berkeley likely makes them a unique and

beneficial part of the local ecosystem. Without enough information on the bees' activity or the ecosystem service of bees, a final monetized value was not confirmed. But, in my research, I have found honey bees overall contribute significantly to social welfare and in generating consumer surplus. This benefit, while on an aggregate is significant, cannot be translated to the specific case of native bees in an urban area who do not contribute significantly to crop pollination. Also in Policy Scenario 1, the value of a green space in an urban area of the plot size of an acre was not fully estimated. While there is no critical habitat or ecosystem services that could monetized at the size of this parcel, it is important to consider the size and proximity of this urban garden to students and community members. Qualitative benefits described by having this space accessible in an urban area include a place for peace and quiet, peer learning and collaborative project space, emotional connection to nature, managerial skills, free urban gardening plot, and other recreational benefits. These environmental and social benefits are not necessarily quantified and therefore are not reflected in my benefits estimation.

In Policy Scenario 2, the absence of an evaluation of the incurred environmental costs from the housing development that would result in light pollution, noise pollution, and increased CO2 emissions was not considered. This is an important component to factor into any future CBA and should be weighed against the consumer surplus and environmental gains that results from the construction of high density residence in an urban area. In a naive analysis, one might assume the increase in housing density would cause a decrease in surrounding property value and increase overall emissions, but often high density housing actually increases surrounding property values as it generates a larger amount of economic activity within the area. Also, reducing transportation time and emissions as a result of travelling from further distances by students to campus will yield a positive externality. Therefore my inability to fully capture estimates for emissions reduction, transportation time reduction, predicted property value increase, noise pollution, light pollution, and countering CO2 emissions creates a lapse in my full ability to analyze these projects to their fullest and most robust metrics. Overall, social and and environmental

considerations in an evaluation of welfare is critical and should be considered with more scrutiny in the overall CBA.

General Critique on Cost-Benefit Theory

Given a CBA is the standard tool for creating an economic assessment of the comparison between policy scenarios, there are many assumptions which are taken as true that have become more contested in the literature recently. As discussed earlier in the History of CBA section of this research, there is a long history of development of different methodologies for CBA which provide us with some additional tools for working through the difficulties of evaluating certain components of policy decisions. To begin, I will address briefly general theoretical discord within CBA methodology that connect to the later discussed ecological economic critiques of the methodology. These include (1) the selection of the discount rate (2) equity concerns (3) the failure to recognize interdependence in ecosystem services, and (4) strategies for modeling risk.

Discounting

Beginning with the discount rate, this function of the CBA serves as the main method of differing current costs into the future under the principle that humans are rational utility maximizers. This utility maximization applies to the time span of one's life. Therefore, a benefit received today is more valuable than a benefit received tomorrow. The same stands for costs. Therefore by using a discount rate, the cost of performing some task or being adversely affected by a policy decision will be greater today than tomorrow. The concept of discounting is widely used, but many social and environmental advocates have argued the discount rate is not a technical choice but a moral one (Lumey). By deploying a discount rate, the conductor of a CBA chooses at what rate they believe consumers will discount their future consumption.

There are multiple methods of selecting a discount rate including pure rate of time preference (PRTP), social cost of capital (SCC), and the Ramsey rule (Lee). PRTP is calculated to assume the rate at

which consumers discount their future consumption at no risk so it is often the rate of interest on secure government bonds. The SCC is the belief that value should be discounted at the same rate as the market and therefore the rate at which capital receives a return on investment is used to discount. Finally, Ramsey rule is a growth model that equates the consumption discount to the economy's growth rate, or capital productivity (Karp, Trager).

Despite deploying slightly different proxies for discounting, all three of these methods make the same assumptions about growth and utility. Discounting assumes that future generations will be wealthier than today and that is through an implicit recognition of growth as a strategy for poverty alleviation and increased utility (Lee). Next, discounting assumes the utility of constituents today will reflect the utility of constituents tomorrow, and the demand for the same type and quantity of resources will not shift significantly. While we can hold this true under short time frames, i.e. one generation, when using discounting for future planning that is on a longer timescale, we infer similar preferences without an explicit knowledge of future preferences. But, inferring collective discount rates for today's generation is a necessary function of how we operate in policy and finance. Strategies to reconcile the asymmetric information that exists between today and future generations has lead to ethical arguments about the rights that future generations hold to both resources and certain levels of utility. The issue of intergenerational wealth stems from our current system of discounting, and because discounting uses proxy variables from the market in which today's generation partakes, they are inherently excluded from participating and therefore do not contribute revealed preferences (Lee). I will later discuss strategies to acknowledge and accommodate for different methods of discounting and how different strategies to estimating the discount rate and changing the discount rate across different timescales of analysis attempt to reconcile philosophical issues of intergenerational wealth and concerns for future resource consumption.

Equity

Equity in CBA remains a two prong issue with equity across different constituent groups and equity across generations. Intergenerational equity as I addressed above, is an issue when long term impact of projects are considered. But, for equity across different constituent groups, CBA fails to address the distributional effects of the outcomes. While Pareto efficiency allocates resources in a way that additional allocation would make another individual more worse off than the individual it benefits, winners and losers under Pareto efficiency criterion still exist. The Pareto efficiency achievement does not take into account demographic or contextual indicators on the winning and losing population. Under the Kaldor-Hicks criterion, the reallocation of resources to those who lose is theoretically possible, and therefore some form of redistribution to generate equity exists. But, the Kaldor-Hicks criterion falls short in it does not necessitate the redistribution, only tests the feasibility.

Because of this, distributional weights have been developed in CBA which allow for those performing CBA to take into account public objectives of equity and resource allocation according to individuals' demographics or level of impact from a policy scenario. I will not address distributional weights extensively as they do provide additional ability of analysts to allocate resources to differing populations to achieve policy goals related to equity, but this research focuses mostly on equity for future generations as they will experience disproportional costs burdens of climate change.

Ecosystems as Integral and not Auxiliary Services

Another major failure of CBA is the way it approaches ecosystem services and natural environments as translated into market valuation. Contingent valuation methods including derived WTP from surveys and surrogate markets result in short-term and often undervalued evaluation of natural resources. Because most consumers do not know the extent to which ecosystem services benefit or are interconnected with other goods and services they consume in the economy, ecological resources are isolated and only partially evaluated.

The current literature approaches environmental goods as ‘ecosystem services’ that can be quantified for their contribution to public welfare. For ecosystem services that appear to be passive, i.e. a park or a mountain, a demand curve is derived by aggregating all costs that go into enjoying this passive natural good including travel time, entrance fee, and other costs associated with enabling one to enjoy this natural good (Brent). But this type of method for quantifying the benefits of a resource works exclusively in the human-centric interest of recreation. There is no acknowledgment of pollution abatement that trees provide, habitat to other species, or fire prevention. This is a narrow view of ecosystem services as recreational resources and the literature has recently pushed beyond this.

The most comprehensive analysis of ecosystem services that exists is the Millennium Ecosystem Assessment of 2005. This assessment identified key shifts availability and therefore value in different biological resources while emphasizing market solutions to conservation that advocated for better integration of ecosystem services into government and business. A more comprehensive understanding of the actual interactions and processes that occur within ecosystems which generate environmental services is needed to identify what actually provides value to humans (Montenegro, Karp). Measuring both the system of delivery of a service and the quantity of the service gives a comprehensive picture of the value of said ecosystem service (Montenegro, Karp). Within CBA, environmental services can either be accounted for as pure benefits or used to construct a standard of sustainability or ecosystem maintenance that must be maintained (Montenegro, Karp). These strategies are the more progressive and inclusive evaluations of ecosystem services in monetary decisions.

Ecosystems are interdependent on each other, and valuing one ecosystem or specific good affects the stability of another (Lumey). This interdependence has lead many to advocate for the non-substitutionality criterion for environmental goods and services. This would explicitly state ecosystem services are not transferable for manmade capital goods and therefore any impact on environmental goods should be zero or negative, meaning all projects should develop net benefits to the environment (Lumey). While this view is extreme and essentially ignores the evaluation of ecosystem

services as monetary goods, it does further emphasize the principles of ecological economics which advocate for viewing the economy as nested within the ecological systems they function. This belief will be further developed in the Discussion portion of this paper.

When it comes to evaluating ecosystem services in the CBA framework, munch of the literature is torn between 'something is better than nothing' and 'all or nothing'. Where some stand on the side of incentivizing and disincentivizing certain protections and uses of natural resources through market based incentives which require monetary conversion, others fundamentally oppose this conversion as they argue it allows for the constant undervaluation of these services. In *Priceless* the authors argue even with technical precision, evaluation of ecosystem services into monetary terms does little to promote increased concern for resource conservation (Ackerman, Heizelberg). While this general assumption may seem true, significant research has shown market based tools for environmental conservation do achieve reduced consumption or increased pollution abatement. While I disagree with Ackerman and Heizelberg's claim that nature is priceless, I do believe a more complex and related system of thought which governs how we choose to allocate, preserve, and eliminate environmental resources is needed in order to develop a better approach to our view our resources (Ackerman, Heizelberg).

Risk and Uncertainty

Lastly, CBA methodology has a great deal of improvement to do in regards to modeling risk and risk aversion in predicting future costs and benefits. Risk aversion among individuals is extremely heterogeneous and dependent on many factors including age, location, income, gender, and schooling. Because individual risk aversion varies, group risk aversion, particularly to climate change impacts, is difficult to evaluate given tradeoffs between smooth consumption over time and constant risk. Additional to this, individuals often underweight impacts of climate change given low probability of each scenario, and a lack of understanding about the risks, probability, and potential outcomes. Because of this, factoring

in risk aversion to climate change effects in CBA can lead to undervaluation of future resources benefits and costs. (Ferraro, Bernado).

Because of this, the development of option value has been used in CBA in order to evaluate the cost of waiting in the anticipation of resolving uncertainty. When both uncertainty and irreversibility exist, the option value can be derived (Arrow). In measuring irreversibility, we can reflect the cost of losing an option in order to better value the growing uncertainty in value of environmental goods and services (Arrow). This component of risk modeling in CBA provides an introduction into better emphasizing the variation in future resource value, but still lacks the ability to accommodate increased costs from inaction in decision making to conserve or abate.

General critiques of the CBA methodology as provided here will be expanded upon in the next section where the methodologies and assumptions are examined through an ecological economic perspective.

Ecological Economic Perspectives on CBA: A Deeper Analysis

Ecological economics is a discipline that strives to bridge traditional economics together with principles of democracy, environmental sustainability, and social equity. In its interdisciplinary approach, it refutes the belief that neoclassical economics alone can resolve social issues and produce optimal outcomes (Slavikova). Ecological economics strives to deploy more experimental forms of economics that depart from assumptions of well being that underlie welfare economics (Gowdy). Because CBA is nested in a Walrasian notion of general equilibrium, there is no incentive for environmental sustainability unless it increases future consumption and therefore policy makers are forced to make trade offs with environmental services as bargaining chips (Gowdy). The framework of CBA under neoclassical welfare economics continues to expand its application across longer spans of time, which moves the model further away from the purpose of providing an accurate assessment of costs and benefits (Gowdy). CBA methodology to the ecological economics discipline is considered a one-time strong framework for policy analysis, but now an overextension of neoclassical economic assumptions into the realms of social,

political, and environmental organization. CBA attempts to fragment costs and values and project them over time in an increasingly uncertain and scarce world.

Major concerns for the discipline of ecological economics also align with critical responses from other disciplines including ecology, environmental science, political economy, and institutional economics. These concerns have been present in all the above components of my research, and I have distilled them to the following topics: (1) discounting, (2) evaluation of costs and benefits independent of one another, (3) democracy, and (4) uncertainty. These major conceptual issues span across multiple disciplines, and it was surprising to find they hold similar justification for the claims they make against how these considerations are handled in traditional CBA. While existing literature attempts to model issues related to the concepts, for example uncertainty, ecological economics research argues that by including the variability in quantification due to climate change no improvement is made in the evaluation of the policy, it is just a more sophisticated model that provides less actionable information to policy makers (van den Bergh). These dissatisfactions with the existing CBA methodology and literature come from issues with the assumptions surrounding human behavior and resource scarcity. Where traditional economics argues resources are scarce, there is no fundamental limit to which economists predict resources will no longer be extractable. For human behavior, rationality assumptions in individual preference, ability to accurately price individual's WTP, and welfare generation through consumption are concepts that do not withstand the behavioral and neurological research against them (Gowdy). Because of these implicitly inaccurate assumptions on the way humans and ecosystems functions, ecological economics argue for a devaluation of CBA in policy making and a re-emphasis of qualitative considerations, democracy, and climate science.

Value judgements in CBA are made by economists who work within a framework limited to a discipline that uses disproven assumptions of environmental limitations and human behavior. Operating under this framework in an isolated and heightened position, CBA are often conducted with their own cost burdens. Where CBA is designed to account for the needs of society through welfare maximization,

it is explicitly undertaken by a subsetted individual or group that then makes value judgements based on existing economic assumptions or input from political actors who hold access to power to engage with an external analyst. The aim of the CBA should be to not satisfy welfare criterion but to engage individual preference through democratic participation in an effort to make the economic analysis more rigorous and accurate to the population affected by the policy (Nyborg). Expanding the ability to make value judgments to more actors increases democracy, rectifies the disconnect between economic rationality theory and studied human behavior, while making room for alternative methods of environmental valuation.

Overall, the literature on CBA in ecological and environmental economics differs from complete opposition (van der Bergh, Norgaard) to transformation (Gowdy, Nyborg, Mundow) to rework (Arrow). Because of this variety approaches to resolving the critical issues nested within one of the most common economic tools used to inform policy, a consensus on what to do moving forward has still not been reached. Between ecological economists, like economists in other disciplines, there are always two sides of the coin and multiple approaches to be considered. This unresolved consensus is a product of the focus on democracy and the emphasis on providing adaptive frameworks given the area of focus or project specified. As the CBA offers flexibility, the ecological economist strives to make the CBA a flexible and democratic tool, either holding less political weight than neoclassical analysis or with a process built on democracy and under resource constraints.

Towards an Expanded CBA Approach

Moving forward in this research, I will address how a CBA can be expanded to accommodate this growing and interdisciplinary approach to economics in the context of climate change. Where many critiques of the economic methodology exist and identification of the assumptions that guide them is clear, replacement methodology has been discussed but not often applied.

This research acknowledges what the present policy making environment looks like, the structures of power and exchange, and gaps of opportunity for political change to occur. Given this context, an expanded CBA methodology fundamentally requires a more democratic process. While the University currently claims an inclusive decision making process, the top down approach only includes feedback or perspective from other political communities when it is framed on how the institution benefits or fails. For example, UC Berkeley incorporates the needs of PMB, ESPM, and other AES researchers as state funding directly covers costs for these faculty, staff, and graduate students. Without that funding they would likely not be able to retain as many faculty. Without adequate facilities, faculty will also leave campus, hindering the offerings of their program to students and likely the ranking of these departments relative to other universities. The University also takes into account perspectives that must be mitigated. The advocacy of students at SOGA is reflective of the organizing that occurred before the Gill Tract development which brutally dominated UC Berkeley's public image for years, damaging components of the institution's public facing image and severing relationships with environmental and other community groups. When threats to the University's fundamental power occurs, perspectives are incorporated and quasi-democratic processes are implemented. When threats to the public mission and ideology of the University are at risk, there is surprisingly less engagement. Short term policy goals by UCOP of the Housing Initiative are brought up in all documents produced by OTRF Committee. But, UCOP's longer term, publicly driven goals of Zero Waste and Global Food programming are not discussed (OTRF Report). This response to internal threats on positionality in their political network opposed to threats on the external public mission of the University can partially be attributed to a lack of pure democratic engagement. Again, research organizations at UC Berkeley are not asked to contribute, conduct studies, or provide insight from cutting edge fields of research in urban planning, innovative housing, carbon neutral development, or environmental economics.

Increased Democratic Participation

The current model for how scholarship develops and informs public choice or policy is what is called the loading dock model. The loading dock model is the process in which information is created by scientists at their own desire without engagement by the public, which is then available 'at the loading dock' for policy makers to use when needed (Karlin et al). This model is an approach that does not allow for engagement with research or active participation in the decision to what is researched and how it is researched. Research that is engaged scholarship falls between what is pushed by scientists and what is demanded by the public (Karlin et al). Specifically the models of participatory research and interactive research are both that fall under engaged scholarship and the demand of the public.

At UC Berkeley, this type of scholarship is emphasized through American Cultures Program and other social science, humanities, and service research. But, the University does not go far enough in supporting engaged scholarship on an institutional level when looking at its own community. Where research departments, professors, and collaboratives could have the goals of reaching solutions to community-centric solutions, the demand 'push' by Universities is not sufficient. By advocating for interactive research to be done by UC's own faculty and students that engaged campus community members and Berkeley communities, a more democratic approach to determining the costs and benefits of both proposed projects could be determined.

Through an interactive framework of engaged scholarship, democratic participation in CBA could be achieved. Based on ecological economic critiques of CBA, democratization of the valuation process is a critical component of reworking the CBA to be more considerate of social and environmental realities. Interactive research is the framework that is most sufficient to meet the technical requirements of CBA but also a more accurate valuation of the community involved in the decision. Engaging with the participants in research through more feedback, knowledge sharing, articulation of process and execution, provides the community with increased transparency in the decision making process and an ability to

contribute to the research (Karlin et al). This interactive framework needs to be supported by the institution, but also advocated for by researchers, faculty, and students collectively. If those performing research actively push their research agenda to investigate scientific questions in a community that is their own, the institution should support this level of engagement and interaction between researchers, community members, and decision makers.

Change in institutions is not always driven by hierarchial shifts or incremental change advocated for my independent policy groups, but can be driven by collective efforts of individuals who exchange or work with other individuals across policy networks. When researchers work to discover and develop new forms of knowledge or answers to questions, a more equitable and sustainable solution is developed. Performing a more robust CBA demands increased democracy through interactive scholarship conducted with and by campus experts and constituents, to increase the exchange of information across different political communities in the hierarchy of political decision making at the University.

Threshold and Resource Bound Assessments

Current monetization of environmental benefits limit our ability to properly understand effects of augmenting, removing, or disrupting portions of an ecosystem on overall resource availability. Given the information available to us through climate science, ecology, and environmental science there are significant linkages between different ecosystems. These systems inherently cannot be evaluated independently for monetary benefits as they derive benefits in the interaction with other natural services and the mechanism for how resources move through them. Monetization and ecosystem service evaluation is conducted on project by project basis, assuming all else is in equilibrium which leads to an increasingly inappropriate application of analysis to a system of value (Norgaard 2009). While initially intended to bring public awareness to the ‘value’ of natural resources, ecosystem service pricing and assessment is one framework for analyzing these systems and has become an exercise in futility (Norgaard 2009).

Given ecosystem services cannot be fairly evaluated in terms of costs, the concept of natural resources as a constant stock of capital in ecological economics can still provide insight into how to properly address evaluation and allocation of resources. Ecological economics advocates for a constant stock in which the scale of extraction and energy use from production to consumption remains extremely low (Daly). This general concept provides the basis for an understanding of an intergenerational resource requirement or welfare threshold. Where existing welfare economics treats environmental goods, services, and pollutants as externalities to be incorporated into a model of welfare, the concept of maintaining a constant supply of natural resource stock as necessary to all other functioning components of the economy introduces the intergenerational threshold or resource requirement assumption.

This assumption is one that would underlie economic assessments and therefore welfare economics, implicating our current use of utility, discounting, and efficiency. An intergenerational threshold has been proposed in multiple forms, one high level explanation being a principle to guide decision making in cost benefit. This would be an intergenerational principle in which each generation produced a necessary set of conditions to allow a future generation to function in a prosperous society (Lee). This concept, despite being vague, acknowledges important components of sustainability and intergenerational wealth. This principle acknowledges that future generations' wealth, in the context of climate change, is almost impossible to sustain given the necessity of reducing consumption or suffering from adverse and increasing effects of climate change if consumption remains the same. It may be impossible to sustain given current economic wealth measurements like income and consumer surplus. But, this theorem also makes room for the idea of wealth as utility not derived exclusively from income and surplus, but possibly intangible goods and other dimensions of utility that are becoming more available to measure, like happiness, community engagement, and cultural appreciation. These components could replace utility from surplus, and therefore makes it possible for future generations to continue to experience the same 'level' of utility as individuals today. Next, this proposed concept introduces a set of conditions which can be defined as available resources that can provide that same level

of wealth. To have the resources to sustain similar levels of wealth, we can assume minimizing extraction and entropy of global energy allows for the likelihood of the achievement of wealth. This theorem provides an excellent framework for considering a transition from a current utility maximizing state that has no concern for the future by product of not being that future generation.

It is naive to assume current generations cannot infer or yield some of today's utility to future generations because they always prefer utility for themselves. In the United States, the accumulation of wealth within a small number of families of high income has grown exponentially in recent years through the saving of money for children and relatives in their after death period. While we may be able to say that children and kin are relatives and therefore 'extensions' of an individual's utility, this reasoning is not enough to say that today's society cannot sympathize or deter utility to future generations on aggregate given beliefs they hold on future states of the world. Therefore, distributing benefits across future generations at the cost of today is a possibility that needs to be considered.

While the above threshold argument is designed for an assumption in CBA, the ecological economic approach of a threshold falls under the planetary boundary approach. It is necessary for economic consumption to fall within the limits of resource extraction that can be regenerated by the environment and for waste to be produced at a rate lower than the absorption capacity of ecosystems (Cosme). The estimation of where the planetary boundary falls is vague and unmatched to a specific future utility scenario. Currently, our international climate goal of reducing warming to under two degrees celsius is a planetary boundary, but does not take into account all individual's future utility. Some countries' utility is prioritized while a disproportionate number of developing nations face more extreme degradation under the two degree planetary bound. Because of this, it is important to further flesh out the intergenerational resource use boundary and corresponding welfare minimum threshold. By further defining both, and possibly defining them for different states, regions, or climate zones, we may be able to better identify future states of the world in which intergenerational equity is better considered, and not stagnated by normative assumptions under utility theory.

The Role of Discounting

As addressed before, the assumption that discounting is justified in CBA is contingent on the belief that future generations will be better off (Lee). Continuous growth has been discussed before in this paper and limits to growth increase is becoming a more mainstream topic. Economic analysis still uses aggregate interest rates to determine the discount rate as it is a solid foundation for an assumption of society's shared discount. But, analysts have found interest rates to be dropping rapidly from levels predicted in the 1990s and 2000s and continue to forecast lower interest rates globally (Obama Whitehouse). Because of this, CBA over time should continue to lower the discount rate used as benchmark rates at federal banks and lending institutions continue to drop. But, in order to properly reflect the intensity of our growing resource constraints in a way that allows for the implementation of degrowth policy, a more drastic change to the way in which discounting is performed in public CBAs.

While some advocate for dissolving the discount rate because it disenfranchises future generations and cannot positively justify the distribution of benefits intergenerationally, I believe it is likely discounting will remain an active part of CBA and should not be ignored (Lee). In an effort to accommodate a variety of potential CBA modifications, methods of discounting still need to considered. The intergenerational utility theorem, which claims that we ought to be neutral between harms and benefits to generations today and in the future, a model of discounting under climate change scenarios cannot satisfy this theorem (Flanigan). While this initially seems like a strong method of ensuring that discounting does not occur in policy making decisions, we should actually consider the need to distribute less benefits to the current generation in an effort to protect future benefits to generations that will experience higher costs. This would be true given we do not expand the utility function to be one that includes less consumption based notions of utility and that the consumption baseline was dynamic across generations (Karp, Trager). But, because I will address the existing methods for how dynamic discounting is performed, I move past any discussion of intergenerational utility theorem.

Where traditional discounting is only affected by uncertainty due to catastrophic events, a discount rate that integrates more uncertainty at smaller scales is necessary (Karp, Traeger). This can be done through factoring in risk aversion, and particularly using relative intertemporal risk aversion (RIRA) opposed to constant relative risk aversion (CRRA) which is modelled in climate change discounting. But, the development of the Dismal Theorem by Weitzman argues that because of the uncertainty of climate change we can never properly model risk, consumption, or social discount as there exists an infinitely large expected loss associated with climate change scenarios (Weitz). Where Weitzman uses a CRRA, it holds that societies would be willing to pay anything for the avoidance of a zero consumption society, which is extreme when considering the probability of a zero consumption society existing (Weitz). We can consider what a low consumption society would look like, or we could create a lower bound for what consumption in society should look like in order to derive a discount rate that does not assume infinitely high costs. Because of this, modelling a utility curve that is more accurate to the way utility for future generations will consume requires changing the implicit risk aversion factor. With RIRA, utility is derived from general risk aversion and desire to smooth consumption over time, and yields a lower discount rate that can account for differences among population (Karp, Trager). These considerations of uncertainty and risk better suit CBA. While Weitzman's approach is fundamentally a strong argument, normative adjustments to utility can allow for discounting with more precision given risk and smoothing propensity as proposed by Wetiz, Karp, and Traeger separately. These approaches are strong and deserve consideration in maintaining the discount rate in CBA temporarily, but do not go far enough in changing the actual definition of what constitutes consumption, and therefore utility.

Discounting models have also been advanced by including metrics for inequality across generates, creating an adjustment for growth estimation by using median income growth as a re-parameterization of the wealth effect (Emmerling, Broom). Where average growth increases at a rate faster than median income, we can control for inequality among individuals over time (Emmerling, Broom). Integration of DICE climate models into uncertainty estimates has allowed for a stronger

quantification of uncertainty that can be applied in evaluating the discount rate for CBA under climate scenarios (Trager). This has allowed for accurate hyperbolic discounting models where predicted changes in resource stock to from one period to the next determine the rate of their worth (Karp). Hyperbolic discounting informs abatement costs for pollution which can better help achieve policy goals (Karp). By making discount rates dynamic and functions of utility, growth, consumption parameterized by uncertainty and risk, the discount rate does generally decrease.

Concluding on the efforts to expand CBA to more accurate address concerns discussed previously and theoretically in this research concerning the valuation of goods and services given uncertain future conditions, I conclude there is significant empirical work being done within the existing framework. Efforts to perform empirical analysis on theories which are more abstract and stray from foundations in neoclassical economics are lacking. The combination of different methodologies and parametric changes are considered and applied differently, yet one does not reign in the literature as the best or right way. While this is mostly a result of the literature being recent and the discipline supporting the pursuit of higher and more technical knowledge, I also support and recommend a climate change CBA approach which is based on the fundamentals of ecological economics and approaches policy decision making through technical evaluation nested within environmental constraints.

Discussion

Integration of Parametric Changes

The results of the traditional CBA prove that they are necessary adjustments to be made in order to better understand the OTRF implications of future costs and benefits for the development of housing and agriculture research at UC Berkeley. As part of the California landscape, public governance network, and a future of climate change predictions, there are factors that need to be better considered in value judging this proposal. Through CBA expansions and ecological economic policy objectives, many of the previously discussed concepts and technical changes can be instituted for a further analysis.

Improving Methodology: Sustainability and Democracy

Most important and fundamental to this decision is the political context surrounding the issue of OTFR. Generally, engagement with this project by affected individuals and communities is extremely inadequate. While UC Berkeley currently uses a system of selected committees where students are appointed either through advocacy or student government mandate, there is no internal requirement for engagement with afflicted communities in analysis of policy. UC Berkeley administrators claim to make it a goal through offering surveys and inviting or allowing for student representatives, but there is not clear transparency to aggregate affected population from the process of question to solution. LRDP do not directly engage students and housing feasibility assessments do not use student input for either perceived benefits or WTP estimates. The failure here to engage students being one of the main afflicted parties can be repaired in the following ways: (1) making housing and development meetings open to campus community with time for questions, (2) formation of working groups on different components of the decision that use an open entrance policy to those wishing to participate, (3) conduct comprehensive WTP survey for housing, urban garden resources, agriculture resources, and research space. This is necessary just for students.

There are other affected communities which require further engagement including AES employees and researchers at OTRF. These communities should also be asked to complete WTP surveys and give more accurate accounts of their research findings. Research findings at OTRF should be consolidated so past projects and research developments at UC Berkeley's AES can be attached specifically to the location of that research and a better review of the benefits of this research can be evaluated. While research is currently broken down into basic and applied, different categorizations of the research should be made that evaluate their impact in the areas of productivity and adaptability. While most basic research could be applied to either, it is important to try to distinguish between these as both are important for the future but provide different forms of benefits.

A model of engaged scholarship should be implemented for this proposed development as well as future proposals for significant changes to campus resources, land use, and expansion. A model of engaged scholarship should be interdisciplinary and encouraged by administrators actively identifying qualified or necessary disciplines to conduct research on policy question. This would include starting with using the Terner Center's Housing Development Dashboard to estimate the likelihood of Berkeley's increase in affordable housing over time.[30] This calculator should be used in determining the number of affordable units and general units that could be built in Berkeley, and developing a plan with the City of Berkeley in assuring housing is built to accommodate future growth projections of Berkeley's population and UC Berkeley's student population.[31] This data can be found provided by the Association of Bay Area Governments and can be used to better and more accurate estimate a realistic number of students that can accepted into the city given the rate and number of units being built. This, in addition to leveraging professors at the College of Environmental Design's Real Estate program which factors in both sustainability and city planning, it will be necessary for experts in this field to be undertaking UC Berkeley's own pressing issue. Their proximity to its constituents, ability to easily access design space, and work experimentally within the support of UC Berkeley is the best choice for intensive analysis for

[30] http://ternercenter2.berkeley.edu/proforma/
[31] https://abag.ca.gov/planning/research/data.html

housing and development. Empowering those affected by campus design changes to partake in research is a method of interactive research which can support and strengthen analysis as well as better obtaining the goal of democracy as outlined in the CBA literature.

In terms of increasing the methodology to take a perspective that is related to long term notions of sustainability, some changes in the CBA could be informed by additional research. Given California's climate models particular to the Bay Area, the anticipated temperature gradient for the Bay Area can be used as a function of the existing social discount rate as described by Karp, Trager. Using the California Energy Commission Climate Model Report, this information can be integrated to build more accurate models of uncertainty within a discount rate if used.[32] This information will enhance UC Berkeley's prediction of costs and inform policy makers on the long term natural effects on the city that may impact potential housing or research facilities.

Due to UCOP and Berkeley specific goals of zero waste and carbon emissions reduction, full life cycle assessments and environmental impact studies should be done for OTFR as it exists currently and a proposed housing development. The costs of making both of these projects fit within the institutional goals of waste reduction and emissions reduction should be factored into the project as it should be an obligation of the University to make decisions contingent on fitting in with the institutional goals.

The IRR on agriculture research should also be calculated as a function of the increasing productivity of agriculture and increasing demand for productive agriculture. By doing so, the CBA assumes a rate of return that displays increasing benefits to agriculture research over time. This assumption is supported by the research conducted in Jin et. al 2016 which predicts annual increasing productivity from agriculture, particular to California. This change would reflect an increasing value of benefits in Policy Scenario 1, and possibly a rate of return that is higher than 67% over the course of the project's lifetime.

[32] http://www.energy.ca.gov/2012publications/CEC-500-2012-042/CEC-500-2012-042.pdf

The considerations of both sustainability and democracy as principles in CBA for the case study of the OTRF can take many different forms. But, the more politically feasible and practical ones were chosen. These are more general changes to the protocol and value judgement process which bring to light and challenge who, how, and with what goals are CBAs conducted. Generally, CBA is accompanied with qualitative analysis that provides context to the methodology, but it is important for the state as a public institution push forward in assessing qualitative information with the same level of consideration and without appealing to policy communities for the selection of information that benefits only a specific policy community or shifts a policy network deeper in favor of decision makers. Evaluating the institutional background of the decision makers, affected communities, and those performing economic analysis needs to be described extensively to include goals, social norms, relationships, and motivations. Acknowledging information is incomplete and that institutions serve as key actors in the functional performance of CBA serve as the reasoning for expanding analysis to be more democratic and environmentally just (Slavikova).

Normative Approach: Discounting, Utility, and Intergenerational welfare

Specific recommendations on reworking the normative assumptions is necessary for the adaptation of CBA to ecological principles. But, because some fundamental normative questions are not reconcilable with existing methodologies, I recommend moving away from a traditional format of CBA and towards a format that corresponds more strongly with an institutional ecological economics analysis that still addresses both costs and benefits, projected over time, as addressed above.

For discounting, many of the issues that exist are flawed on too many axioms to be able to salvage. Issues with revealed preferences, intergenerational equity, democratic participation, and growth are too deeply ingrained in the method of deriving the discount rate. While solutions to account for uncertainty and risk have been discussed earlier in this paper, at the time I cannot recommend the continuation of discounting in models of CBA, but only acknowledge that the political feasibility of abandoning this tool is extremely low. I include the most nuanced modeling techniques which push the

discount rate lower and can provide an interim solution before a de-growth strategy is adopted. A common but critical normative stance on discounting is the continual growth assumption. This assumption rests on its own assumption of continual resource extraction with smoothed rates due to technological advancements. It is both impossible and unjust to continue on a growth trajectory while global interest rates increase at lower rates, level off, or decline and costs of emissions increase. To assume a future generation matters less to us then today's is not accurate given human behaviors including the accumulation of wealth for inheritance. Discounting therefore needs to be eliminated in the CBA and instead replaced with a more robust intertemporal threshold as discussed earlier (Lee).

What an intergenerational threshold would look like is difficult to create given what existing assumptions for utility maximizing and consumption maximizing. Research would need to be conducted that estimated Berkeley's existing resource stock. While ecological economics does not prefer methodology that parses out or isolates information and instead advocates for the interdependence of ecological systems, determining a stock of resources for a locality would be an original research endeavor and further challenges of this could be addressed. The stock would consist initially of very basic resources: available land, clean air, and water. Standards on the quality and quantity of these resources could be used to generate the threshold amount for a steady state stock of which to be met by each future generation. For water, we would look at the median consumption of water in Berkeley currently as a function predictions in snowmelt from a baseline snowmelt of a non-drought year like 2018. We use snowmelt predictions as Berkeley receives all its water from the Hetch Hetchy Watershed that is mostly snowmelt from the Sierra Nevada mountain range with a small percentage coming from surface runoff in Alameda county. The water demand curve given a steady population could be derived. We could use this curve as the threshold where the flow of snowmelt and precipitation equates the demand for water. Next, land as a stock obviously remains the same, but its current use will change. The amount of green space, commercial, residential, and industrial usage needs to be considered. Minimum requirements for green space given ecosystem services should be developed and used to better indicate a level of green space or

non-urban use of land required at minimum. Finally, a boundary of emissions and pollutants allowed in the air should be determined by looking at the level of emissions health of the median population becomes impacted. By median population, we infer the median health profile of a Berkeley resident. Concerns on equity in air pollution should be considered, where the distribution of pollutants should be as even as possible to address concerns of environmental justice.

An approach to intergenerational equity is critical in advancing the way in which policy makers decide on decisions that have long lasting effects on the population and for which are a part of a greater environmental system increasingly vulnerable to uncertainty and change. From the above standards, a resource threshold could be laid out, and waste production could not exceed the rate of absorption back into the environment while energy consumption could not exceed the rate of production. A threshold like this would hold each additional development to the standard of this flow, and its waste generation would have to be less than the rate at which it is returned to the environment while its energy consumption would have to be less than the rate of production from natural sources. This would require investment in renewable energy technology, energy efficient infrastructure, and a low flow of material goods into this proposed development. .

Re-Evaluating the Hypothesis

Under the new structure of CBA I propose, I re-evaluate my original hypothesis that the OTRF should be maintained as research space. After evaluating the ecological economic literature and discussing the normative implications of traditional CBA in the critical state of the world we are in today, I confirm my hypothesis. Though not as rigorous of a modification to CBA as a positive parametric change would be, integrating principles of sustainability, equity, and democracy in a true way yields the following results: (1) research on improving the efficiency of our use of natural resources is increasing in value, (2) accounting for the change in consumer preference and utility in the future due to changes in both perceived and real resource availability generates many unknown values that render CBA

inadequate, and (3) a lack of real stakeholder engagement further concentrates power and delegitimizes the democracy in CBA within welfare economics.

While my reworking of the CBA does not provide comparable quantitative results, the evidence for my argument that significant and possibly invaluable information is left out or left up to judgment by an analyst holds. The information on individuals' future responses to climate change is too inaccurate to properly price certain goods for the future. The dependent relationship of ecosystems on one another does not allow for an independent assessment and monetization of these resources. The use of the growth assumption has been determined to be too inaccurate and blatanly false for many scenarios to function as a key assumption. Given the evidence provided, I would argue that a housing development which replaces critical research without full relocation and grouping of facilities will yield less of a return than OTRF's current and projected use.

Also, another major element of my argument is that without proper democratization, the process of CBA is more of a pseudo-economic analysis that best supports stakeholders who are most central to the decision making process and not those who experience impact on aggregate. The political and institutional structure to UC Berkeley is critical to analyze to select projects that best fit the needs of constituents and the institutional goals which serve them.

By reevaluating under the parameters of sustainability, democracy, and equity, the process of CBA in its traditional methodology does not hold up against these inquiries. These three parameters are necessary conditions for an analysis and need to be included either quantitatively or qualitatively extensively enough where no assumptions that can be disproven exist. Working in the negative verifies that no normative approaches are taken which compromise the transition towards an economy that is rooted in de-growth. My development of a CBA-type economic analysis provides a stronger framework for considering the friction between neoclassical economics and ecological economics where necessary. It considers the transition from our institutional process that relies heavily on quantitative analysis without much questioning of normative assumptions which underlie the model. Given this research, the entire

process of evaluating the OTRF should be reconsidered with respect to democracy, long term policy goals, and equity in resource distribution across generations.

Limitations of Study

In previous chapters I address the limitation of the construction of the traditional CBA deployed for the Policy Scenario comparison. I will now address overarching limitations of this study as a whole body of research. This research was done at the undergraduate level and therefore lacked significant ponderance and development of technical analysis of greater concepts. The scope of work undertaken, both a case study, theoretical synthesis, and application of analysis was a large task that lead to a variety of research being evaluated and integrated across disciplines. This work was oriented towards assessing major flaws in existing CBA methodology that have already been discussed in the framework of ecological economics. The goal of this project was to provide an original recommendation of how the University should integrate ecological economic principles into its decision making process regarding scarce resources, but it mostly approached the topic in a summarizing fashion and provided a slightly less defined strategy for adopting these principles immediately.

While laying out the existing literature landscape and attempting to perform an original application of ecological economics to a case study was a strong intent, but given the sparse data collected on social costs and benefits, adjustments to the model were not as accurate as would have been ideal. Overall, the study was limited not in its breadth, but in its depth of the application of ecological principles. Given more time and the ability to perform original surveys, data collection, and accurate financial modeling, principles of ecological economics could be better applied to forecasted scenarios of the OTRF.

Conclusions

Recommendations

My overall recommendations are found in the Solutions portion of this paper. It is critical that policy comes from this discipline of economics in the future given the enormous impact a public institution has on adaptation of future ideologies and operational procedures. When large public institutions adapt and test more nuanced modes of analysis, either through incremental change or more network-initiated shifts, other private and social institutions follow suit. UC Berkeley is centered at the crux of a classic resource scarcity dilemma and can choose to confront this issue in a traditional framework and defer more complicated notions of intergenerational utility, development, and equity to another set of future policy makers, or administrative officials can delve deeper into analysis by leveraging the resources they have readily available.

But, it is not only administrators who need to demand this type of policy adaptation. Increased support among different policy communities need to further develop relationships with one another and align to create interdisciplinary and interdependent goals of democratic participation, engaged scholarship, and sustainability. Increasing the flow of information between separate policy communities can strengthen and recentralize them to hold a similar level of influence as policy makers within the policy network.

My recommendations are outlined above, but my research findings suggest a massive gap of opportunity between academia and application. My research is currently at the loading dock, but I hope to inspire future research that is increasingly engaged and based on democratic participation. For this research, interviews were conducted with staff, faculty, students, and administrators part of the policy network that will determine the future use of OTRF. This coupled with my position as a student, begin to break the boundaries of what traditional notions of research should look like and push to implement the

framework of engaged scholarship and institutional analysis that should be required of all major policy decisions in which resources are constrained, i.e. all of them.

The University as a decision maker not only sits between two resource constraints, but also two timescales, two social issues, and two major constituent groups. Housing and agriculture, short term and long term, basic needs and environmentalism, students and faculty/researchers. While the CBA forces these into dichotomies, my analysis explores their relationship, interconnectedness, and dependence on one another in advancing UC Berkeley's public research mission.

Further Research

This study would benefit from a stronger analysis in the following areas: (1) network analysis of the political communities in the University of California network, (2) resource stock measurements, (3) decoupling consumption from utility in economic modeling, and (4) case studies of participatory and democratic environmental policy generation. These four areas of research while different from one another are all areas of interest that my paper addressed in a limited way. Developing these topics further and using applied methodology to determine effectiveness of ecological economic solutions to reducing emissions, increasing democracy, and distributing wealth are essential in the advancement of the field. These areas could benefit from a deeper explanation and have limited bodies of research attached to each topic, which is why they have been identified for areas of further explanation. They all involve rigorous and nuanced techniques of modeling that further prove economic analysis can provide insight into developing strong and sound policy. Often these economic tools can be refined by environmental principles or made increasingly more nuanced by the inclusion of climate change effects and environmental constraints.

Overall, knowing how Universities make decisions in an increasingly privatized public sector can inform decision making at different levels of government for the future to come. Next, estimating the actual stock of resources and how this stock needs to be preserved in a steady state can have a stronger

built foundation. Understanding the way in which consumer utility will change in the context of climate change and whether we believe the components of utility could consist of units measured not in consumption of material or physical goods but intellectual or cultural goods is a consideration that should be researched further for the application to ecological economic concepts. Finally, a larger body of applied ecological economic studies can help strengthen and legitimize this discipline for the purpose of integration into mainstream economics. Although the intent is not to overthrow neoclassical methodology with a new, although more equitable, ideology, providing more space to ecological economics to be recognized, debated, and tested should be the overall goal of every academic discipline.

Future research should be done in an interdisciplinary approach, merging complex conceptual ideas with strong quantitative skills while still remaining rooted in social welfare and policy application.

BIBLIOGRAPHY

Barnett Morse 1963001 a.

"Cost-Benefit Analysis: Environmental and Ecological Perspectives." 2002. Chap. s. 1, 2, and 3. New Brunswick, N.J. and London: Transaction, 2002, In *Indian Journal of Applied Economics, Volume 7, Nos. 1, 2, and 3. New Brunswick, N.J. and London: Transaction, 2002, Pp. Xxiii, 430*, edited by K. Puttaswamaiah ed, xxiii.

"Economics, Sustainability, and Democracy : Economics in the Era of Climate Change." b. http://eds.b.ebscohost.com/eds/ebookviewer/ebook/bmxlYmtfXzQ4MTczOF9fQU41?sid=e120462a-916f-4fd6-b8ce-5f7ad870ade0@sessionmgr101&vid=2&format=EB&rid=3.

M. ATKINSON, MICHAEL & Coleman, William. (2005). Policy Networks, Policy Communities and the Problems of Governance. Governance. 5. 154 - 180. 10.1111/j.1468-0491.1992.tb00034.x.

Lrdp 2020 c.

NBER Working Paper Series d. Cambridge, MA:.

"Paying for Biodiversity." OECD Publishing.

"Research & Occasional Paper Series: CSHE.3.17." 2017.University of California, Berkeley.

A Bill in Support of the Real Estate Student Board. *Senate Bill No. 2014/2015081*.

Ackerman, Frank and Lisa Heinzerling. 2004. *Priceless*. New York: The New Press.

and. *Intergenerational Transfers*. doi:10.1007/BF00418816.

and Land Value Recapture. *Inclusionary Housing, Incentives,*.

As a basis for determining the primary areas of inquiry, we used the ANR Strategic Vision 2025 (UC ANR 2009), and the supporting document entitled The Evolution of California Agriculture: An Outlook for 2029 (Alston 2008). Five teams contributed to development of Strategic Vision 2025 focusing on the. a. *Authors: SFS Advisory Panel (Roberta Cook, Joe DiTomaso, Bob Hutmacher, Steve Koike, Terry Lehenbauer, Tom Tomich, Alison Van Eenennaam)*.

———. b. *Authors: SFS Advisory Panel (Roberta Cook, Joe DiTomaso, Bob Hutmacher, Steve Koike, Terry Lehenbauer, Tom Tomich, Alison Van Eenennaam)*.

Batabyal, Amitrajeet A. 1999. "On some Aspects of Land Development when the Decision to Develop is Divisible." *Resources Policy* 25 (3): 173-177. doi:10.1016/S0301-4207(99)00024-0. http://www.sciencedirect.com/science/article/pii/S0301420799000240.

Brent and Robert. 2006. *Applied Cost-Benefit Analysis*. 2nd ed. Massachusetts, USA:.

Cavicchi, Joseph. 2017. *Rethinking Government Subsidies for Renewable Electricity Generation Resources*. Vol. 30. doi://dx.doi.org/10.1016/j.tej.2017.06.003. http://www.sciencedirect.com/science/article/pii/S1040619017301173.

Chopra, Kanchan Ratna. 2005. *Ecosystems and Human Well-Being*. Washington, D.C: Island Press.

Cosme, Inês, Rui Santos, and Daniel W. O'Neill. 2017. "Assessing the Degrowth Discourse: A Review and Analysis of Academic Degrowth Policy Proposals." *Journal of Cleaner Production* 149: 321-334. doi:10.1016/j.jclepro.2017.02.016.

Edited by Dip Kapoor, Aziz Choudry. 2010. *Learning from the Ground Up* Palgrave Macmillan. http://www.palgraveconnect.com/doifinder/10.1057/9780230112650.

Fuguitt, Diana and Shanton J. Wilcox. 1999. *Cost-Benefit Analysis for Public Sector Decision Makers*. Westport, Conn. [u.a.]: Quorum.

Gardiner, Stephen, Simon Caney, Dale Jamieson, Caney, Professor Tutorial Fellow Simon, Jamieson, Professor Director of Environmental Studies Dale, Shue, Senior Research Fellow Henry, Rajendra Kumar Pachauri, and Rajendra Kumar Pachauri. 2010. *Climate Ethics*. US: Oxford University Press. http://replace-me/ebraryid=10399387.

Gruen and Associates. 1974. *Southside Student Housing Project*. San Francisco, CA.

Harvey, James W. 1958. *The University and the City; a Study of Economic Relationships between the University of California and the City of Berkeley*. United States:. http://catalog.hathitrust.org/Record/000964966.

Henriques, Adrian and Julie Richardson. 2004. *The Triple Bottom Line*. London: Routledge Ltd. doi:10.4324/9781849773348. http://www.tandfebooks.com/isbn/9781849773348.

Howard T. Odum. 1988. "Self-Organization, Transformity, and Information." *Science* 242 (4882): 1132-1139. doi:10.1126/science.242.4882.1132. http://www.sciencemag.org/content/242/4882/1132.abstract.

Kallis, Giorgos. 2011. "In Defence of Degrowth." *Ecological Economics* 70 (5): 873-880. doi:10.1016/j.ecolecon.2010.12.007. http://www.sciencedirect.com/science/article/pii/S0921800910005021.

Kniesner, Thomas J. and W. Kip Viscusi. 2003. "Why Relative Economic Position does Not Matter: A Cost-Benefit Analysis." *Yale Journal on Regulation* 20 (1): 1. https://search.proquest.com/docview/235750498.

Laura Moreno, Alastair Iles, Christine Rosen. Last Updated: January, 2 5, and 2015. *Case Study 4: The Psychological, Social, and Organizational Challenges of Green Design.*

Livermore, Michael A. and Richard L. Revesz. 2013. *The Globalization of Cost-Benefit Analysis in Environmental Policy*. US: Oxford University Press.

Martinez-Alier, Joan. 2011. "The EROI of Agriculture and its use by the Via Campesina." *The Journal of Peasant Studies* 38 (1): 145-160. doi:10.1080/03066150.2010.538582. http://www.tandfonline.com/doi/abs/10.1080/03066150.2010.538582.

Milder, JC, FAJ DeClerck, M. Montenegro, K. Garbach, and DS Karp. 2014a. *Biodiversity and Ecosystem Services in Agroecosystems*. Vol. 2.

———. 2014b. *Biodiversity and Ecosystem Services in Agroecosystems*. Vol. 2.

Miller, John H. and Page, Scott E. "Complex Adaptive Systems." Princeton Univ. Press.

Norgaard, Richard B. 2010. "Ecosystem Services: From Eye-Opening Metaphor to Complexity Blinder." *Ecological Economics* 69 (6): 1219-1227. doi:10.1016/j.ecolecon.2009.11.009. http://www.sciencedirect.com/science/article/pii/S0921800909004583.

on Gentrification and Displacement in the San Francisco Bay Area. *On Gentrification and Displacement in the San Francisco Bay Area*.

Paavola, Jouni. 2007. "Institutions and Environmental Governance: A Reconceptualization." *Ecological Economics* 63 (1): 93-103. doi:10.1016/j.ecolecon.2006.09.026. http://www.sciencedirect.com/science/article/pii/S092180090600526X.

Paavola, Jouni and W. Neil Adger. 2005. "Institutional Ecological Economics." *Ecological Economics* 53 (3): 353-368. doi:10.1016/j.ecolecon.2004.09.017. http://www.sciencedirect.com/science/article/pii/S0921800904003854.

Pimentel, David, L. E. Hurd, A. C. Bellotti, M. J. Forster, I. N. Oka, O. D. Sholes, and R. J. Whitman. 1973. "Food Production and the Energy Crisis." *Science* 182 (4111): 443-449. doi:10.1126/science.182.4111.443. http://www.sciencemag.org/cgi/content/abstract/182/4111/443.

Prepared Gordon Schanck and Tara Lamont Capital Resources Management. *Private Public Partnerships at the University of California*.

Pritchett, Lant. 2002. "It Pays to be Ignorant: A Simple Political Economy of Rigorous Program Evaluation." *The Journal of Policy Reform* 5 (4): 251-269. doi:10.1080/1384128032000096832. http://www.tandfonline.com/doi/abs/10.1080/1384128032000096832.

Slavikova, Lenka. 2013. "From Cost-Benefit to Institutional Analysis in the Economics of the Environment." *Contemporary Economics* 7 (2): 67-75. doi:10.5709/ce.1897-9254.83. http://www.econis.eu/PPNSET?PPN=755765036.

Speth, James Gustave. 2012. "American Passage: Towards a New Economy and a New Politics." *Ecological Economics* 84 (1): 181-186. doi:10.1016/j.ecolecon.2011.01.018. http://www.sciencedirect.com/science/article/pii/S0921800911000462.

Steffen, Will, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs, et al. 2015. "Sustainability. Planetary Boundaries: Guiding Human Development on a Changing Planet." *Science (New York, N.Y.)* 347 (6223): 1259855. http://www.ncbi.nlm.nih.gov/pubmed/25592418.

To: EVCP Carol Christ. *9/25/2016*.

Traeger, C. and L. Karp. 2013. *Discounting*. Vol. 2.

Troy, Austin and Matthew A. Wilson. 2006. "Mapping Ecosystem Services: Practical Challenges and Opportunities in Linking GIS and Value Transfer." *Ecological Economics* 60 (2): 435-449. doi:10.1016/j.ecolecon.2006.04.007. http://www.sciencedirect.com/science/article/pii/S0921800906002357.

UNIVERSITY OF CALIFORNIA and BERKELEY http://cshe.berkeley.edu/. 2017. *Research & Occasional Paper Series: CSHE.3.17*.

The Intergenerational Ethics of Climate Change: The Failure of Cost-Benefit Analysis as a Normative Framework 2014.

February, 1. and 2018. *Oxford Tract Planning Committee Report*.

Kallis, Giorgos, Christian Kerschner, and Joan Martinez-Alier. 2012. "The Economics of Degrowth." *Ecological Economics* 84 (1): 172-180. doi:10.1016/j.ecolecon.2012.08.017.

University of California, Berkeley 2018.

Nordhaus, William D. 2007. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature* 45 (3): 686-702. doi:10.1257/jel.45.3.686. https://search.proquest.com/docview/213297644.

Chapter 3 2012. http://search.credoreference.com/content/entry/ccltdepistle/chapter_3/0.

Chapter 6 2013.*Institutionalecon* a. *Lrdp 2020* b. *Real Estate Student Board.* Committee, UC Berkeley. *Tregub I.Inequality. D3* d. *University of California, Berkeley* 2018.

Broome, John Counting the cost of global warming 1. Title 551.6 ISBN: 1-874267-01-4

Land Value Recapture. *Inclusionary Housing, Incentives,*.

Arrow, K. J., & Fisher, A. C. (1974). Environmental preservation, uncertainty and irreversibility. *The quarterly journal of economics, 88*(2), 312-319. Retrieved from http://www.econis.eu/PPNSET?PPN=376656735.

The Evolution of California Agriculture: An Outlook for 2029 (Alston 2008). Five teams contributed to development of Strategic Vision 2025 focusing on the. *Authors: SFS Advisory Panel (Roberta Cook, Joe DiTomaso, Bob Hutmacher, Steve Koike, Terry Lehenbauer, Tom Tomich, Alison Van Eenennaam)*.

Batabyal, Amitrajeet A. 1999. "On some Aspects of Land Development when the Decision to Develop is Divisible." *Resources Policy* 25 (3): 173-177. doi:10.1016/S0301-4207(99)00024-0. https://www.sciencedirect.com/science/article/pii/S0301420799000240.

Cosme, Inês, Rui Santos, and Daniel W. O'Neill. 2017. "Assessing the Degrowth Discourse: A Review and Analysis of Academic Degrowth Policy Proposals." *Journal of Cleaner Production*149: 321-334. doi:10.1016/j.jclepro.2017.02.016.

Coyner, Theresa. 2017a. "Chapter 7." *Journal of the Dermatology Nurses' Association* 9 (5): 273-277. doi:10.1097/JDN.0000000000000342.

. 2017b. "Chapter 7." *Journal of the Dermatology Nurses' Association* 9 (5): 273-277. doi:10.1097/JDN.0000000000000342.

Dietz, Simon and Cameron Hepburn. 2013. "Benefit-Cost Analysis of Non-Marginal Climate and Energy Projects." *Energy Economics* 40: 61-71. doi:10.1016/j.eneco.2013.05.023. https://search.proquest.com/docview/1464789614.

Edited by Dip Kapoor, Aziz Choudry. 2010. *Learning from the Ground Up* Palgrave Macmillan. http://www.palgraveconnect.com/doifinder/10.1057/9780230112650.

Fulginiti, Lilyan E. and Alejandro Plastina. 2009. *Rates of Return to Public Agricultural Research in 48 U.S. States*. http://econpapers.repec.org/paper/agsiaae09/51709.htm.

Groom, Ben and Cameron Hepburn. 2017. "Looking Back at Social Discounting Policy: The Influence of Papers, Presentations, Political Preconditions, and Personalities." *Review of Environmental Economics and Policy* 11 (2): 336-356.

Harvey, James W. 1958. *The University and the City; a Study of Economic Relationships between the University of California and the City of Berkeley*. http://hdl.handle.net/2027/mdp.39015078180844.

Hassan, Rashid M. 2005. *Ecosystems and Human Well-Being*. Washington, D.C: Island Press.

Jin, Yu and Wallace E. Huffman. 2016. "Measuring Public Agricultural Research and Extension and Estimating their Impacts on Agricultural Productivity: New Insights from U.S. Evidence." *Agricultural Economics* 47 (1): 15-31. doi:10.1111/agec.12206. https://onlinelibrary.wiley.com/doi/abs/10.1111/agec.12206.

Karp, DS, M. Montenegro, K. Garbach, JC Milder, and FAJ DeClerck. 2014a. *Biodiversity and Ecosystem Services in Agroecosystems*. Vol. 2.

———. 2014b. *Biodiversity and Ecosystem Services in Agroecosystems*. Vol. 2.

Kniesner, Thomas J. and W. Kip Viscusi. 2003. "Why Relative Economic Position does Not Matter: A Cost-Benefit Analysis." *Yale Journal on Regulation* 20 (1): 1. https://search.proquest.com/docview/235750498.

Laura Moreno, Alastair Iles, Christine Rosen. Last Updated: January, 2 5, and 2015. *Case Study 4: The Psychological, Social, and Organizational Challenges of Green Design.*

Lees, Loretta, Tom Slater, and Elvin K. Wyly. 2008. *Gentrification*. New York [u.a.]: Routledge.

Lynn Hamilton Cal Poly and San Luis Obispo lhamilto@calpoly.edu. 2013. *The Value of Undergraduate Research: A Pilot Study of Agribusiness Alumni Perceptions*.

Nordhaus, William D. 2009. *An Analysis of the Dismal Theorem*.

OECD. 2010. *Paying for Biodiversity: Enhancing the Cost-Effectiveness of Payments for Ecosystem Services*. 1. Aufl. ed. Paris: OECD Paris. http://ebooks.ciando.com/book/index.cfm/bok_id/60183.

Paavola, Jouni. 2007. "Institutions and Environmental Governance: A Reconceptualization." *Ecological Economics* 63 (1): 93-103. doi:10.1016/j.ecolecon.2006.09.026. https://www.sciencedirect.com/science/article/pii/S092180090600526X.

Paavola, Jouni and W. Neil Adger. 2005. "Institutional Ecological Economics." *Ecological Economics* 53 (3): 353-368. doi:10.1016/j.ecolecon.2004.09.017. https://www.sciencedirect.com/science/article/pii/S0921800904003854.

Prepared Gordon Schanck and Tara Lamont Capital Resources Management. *Private Public Partnerships at the University of California*.

Pritchett, Lant. 2002. "It Pays to be Ignorant: A Simple Political Economy of Rigorous Program Evaluation." *The Journal of Policy Reform* 5 (4): 251-269.

doi:10.1080/1384128032000096832.
http://www.tandfonline.com/doi/abs/10.1080/1384128032000096832.

Revesz, Richard L. and Robert N. Stavins. 2007. *Environmental Law and Policy*. Vol. 13575. Cambridge, Mass: National Bureau of Economic Research.

Slavikova, Lenka. 2013. "From Cost-Benefit to Institutional Analysis in the Economics of the Environment." *Contemporary Economics* 7 (2): 67-75. doi:10.5709/ce.1897-9254.83. http://www.econis.eu/PPNSET?PPN=755765036.

To: EVCP Carol Christ. *9/25/2016*.

Traeger, C. and L. Karp. 2013. *Discounting*. Vol. 2.

Troy, Austin and Matthew A. Wilson. 2006. "Mapping Ecosystem Services: Practical Challenges and Opportunities in Linking GIS and Value Transfer." *Ecological Economics* 60 (2): 435-449. doi:10.1016/j.ecolecon.2006.04.007. https://www.sciencedirect.com/science/article/pii/S0921800906002357.

Underinvestment in agricultural, R. and D. 2002. *A New Perspective On*.