Assessment of Land Use Change in Support of Sustainable Communities

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Contents

1. Abstract

The primary driver of carbon emissions reductions in California is Assembly Bill 32, the Global Warming Solutions Act passed by the California Legislature in 2006, which states that California will reduce its greenhouse gas (GHG) emissions to 1990 levels by 2020 (and target a reduction to 80% below that by 2050). Transportation accounted for 37% of the total GHG emissions in 2012, the largest of any contributing sector. Under SB 375: Sustainable Communities and Climate Protection Act, the regional transportation plan for regions of the state with a metropolitan planning organization (MPO) must adopt sustainable communities strategies designed to reduce greenhouse gas emissions from automobiles and light trucks. Reduction targets are set by ARB in consultation with the MPOs, who must submit technical methodology for their measurement. The objective of this project is to support the evaluation of progress toward meeting these goals.

A survey of the MPO's Sustainable Communities Strategies (SCS) will be conducted to determine the strategies proposed, timelines and methods of implementation, and performance metrics for GHG reductions. Strategies generally address improvements in public transit, reduction in urban sprawl, infill development, an increase in multi-family over single family housing, mixed use development, transit improvements, and the co-location of jobs and housing close to transit. In order to assess the degree to which such changes are taking place, a variety of land use and urban sprawl indicators will be employed. These include measures of residential density, land use mix, land use conversion, and street, transit and employment accessibility. In addition to these indicators, some of the most common SCSs can be determined directly, such as the mix of new housing, distance to transit, the location of new commercial, industrial and residential construction, housing affordability etc., from available data.

Data that will be explored to assess the indicators will include land use and zoning maps, land parcels and assessors' rolls, building permits, housing prices, business licenses, employment data, TAZ (Transportation Analysis Zone) maps and data, public transit maps and schedules, Census and American Community Surveys, Landsat and National Agriculture Imagery Program (NAIP) imagery. Data will be mapped in a GIS and scripts programmed within the GIS to generate the indicators of interest. A subset of all indicators proposed and tested will be recommended for employment Statewide based on data access, cost (ideally free) and availability, ability to directly measure SCS goals, usefulness and applicability across all regions of the State, degree of commonality in MPO plans, relevance to the goals of ARB and the program, simplicity of execution, and appropriateness for future determination by ARB or MPOs.

The proposing team comprises experts in sustainability, climate action planning and remote sensing; urban planning, transportation and land use indicators; Geographic Information Systems, city planning and statewide mapping. Their combined expertise will be utilized in developing a GIS system which incorporates a wealth of planning, land use, parcel, business, and economic data to derive a set of urban land use indicators that are readily employable across California by all MPOs, and will provide a useful set of metrics to inform and guide MPOs and ARB as they move forward in meeting the State's greenhouse gas reduction goals.

2. Introduction

2.1 Policy

Under Assembly Bill 32, the Global Warming Solutions Act passed by the California Legislature in 2006, California will reduce its greenhouse gas (GHG) emissions to 1990 levels by 2020, and continue with further reductions thereafter. The California Air Resources Board (ARB) is leading this effort through the development and implementation of a scoping plan[1], updated every five years, which lays out the strategies for meeting these targets. The most significant greenhouse gas emission reductions will come from changes in power generation and transportation. Under California's Renewable Energy Portfolio Standard[2], investor-owned utilities, electric service providers, and community choice aggregators are required to procure 33% of their electricity from renewable energy resources by 2020. Other key bills target the reduction of emissions from transportation, which accounts for 37% of the total, the largest of any contributing sector[3]. These bills include AB 1493, which addresses greater fuel efficiency from new vehicles; low-carbon fuel standards, established through a Governor's Executive Order; and changes in the State's growth patterns that will result in a reduction in overall driving, addressed by SB 375.

SB 375, the Sustainable Communities and Climate Protection Act, requires each of California's Metropolitan Planning Organizations[4] (MPOs) to prepare a Sustainable Communities Strategy (SCS) as part of its regional transportation plan. The key regional transportation planning entities in California are the RTPAs and MPOs. Every county in California is served by an RTPA, and every county with at least one urbanized area is also served by a MPO. The minimum size for a MPO to be formed is an urbanized area over 50,000 in population, but a single MPO may serve more than one urbanized area and may include multiple counties. There are 18 MPOs in the State.

Under the SCSs, future development in the region, when integrated with the transportation plan, are designed to reduce greenhouse gas (GHG) emissions from passenger vehicles and light trucks as part of the California Air Resources Board's (ARB) implementation strategy for GHG emissions reductions under AB 32. Under ARB's 2008 scoping plan, changes in the State's growth patterns should reduce CO_2e emissions by approximately 5 million tonnes by 2020[5], though actual targets are set by agreement between ARB and each MPO. Seventy-eight million tonnes of CO_2e are currently targeted for GHG emission reductions from all sectors[6]. Under SCS, ARB has established targets for each of the MPOs for 2020 and 2035. It is the responsibility of the MPOs to develop strategies, laid out in their SCSs, to meet these targets, and to document the technical methodology for quantifying regional GHG emissions. ARB reviews these plans for compliance and technical merit before acceptance. Although the SCS lays out the measures designed to reduce greenhouse gas emissions, if the target is not met, the MPO must

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[1] http://www.arb.ca.gov/cc/scopingplan/2013_update/discussion_draft.pdf
[2] http://www.cpuc.ca.gov/PUC/energy/Renewables/
[3] http://www.arb.ca.gov/cc/inventory/pubs/reports/ghg_inventory_00-12_report.pdf
[4] generally known in California as Councils of Government (COG) or Associations of Government (AG)
[5] http://www.arb.ca.gov/cc/scopingplan/document/adopted_scoping_plan.pdf
[6] http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf

develop an Alternative Planning Strategy to meet the target. The future land use and transportation scenario presented in the SCS must accommodate forecast population, employment, and housing sufficient to meet the needs of all economic segments of the population, including the State-mandated Regional Housing Needs Assessment (RHNA).

In and of themselves, the MPOs have no land use authority, but rather act as coordinating agencies for the jurisdictions of which they are comprised. Land use decisions rest with cities and for unincorporated areas, with counties. Thus the MPO must incorporate the General Plans of each constituent agency into their SCS and RTP. Under SB 375, some development projects consistent with SCS are exempted or gain streamlined review from the California Environmental Quality Act (CEQA). The reduced CEQA review for residential/mixed use projects will not have to address growth-inducing impacts or project-specific impacts associated with climate change, and transit projects must meet certain criteria for CEQA exemption. This does not however, prevent CEQA challenges that can delay or prevent development from going ahead.

2.2 Approach

Under this proposal, a survey of the MPOs' Sustainable Communities Strategies (SCS) will be conducted to determine the proposed approaches, timelines and methods of implementation. The MPOs' technical methodologies for GHG reductions will be reviewed to ascertain the performance metrics for GHG reductions. Included will be qualitative methods (telephone interviews and surveys) to explore the MPO's sense that strategies are being employed, which strategies are most common, and which are presenting challenges. These interviews will also help to understand the extent to which regional and local planning efforts are resulting in changes in actual land development, and help to inform the optimal choice of land use metrics to be employed in the study.

An initial examination of SCSs shows that strategies generally address improvements in public transit, reduction in urban sprawl, infill development, an increase in multi-family over single family housing, mixed use development, and the co-location of jobs and housing close to transit, with examples such as: "half of all new development on three percent of the region's land area"[7] and "significant investments in new light rail and bus rapid transit services"[8]. In order to assess the degree to which such changes are taking place, a variety of land use and urban sprawl indicators will be employed. These include measures of residential density, land use mix, the degree of centering, street accessibility and transportation measures[9]. In addition many of the most common SCSs will be determined directly, such as the mix of new housing, distance to transit, the location of new commercial, industrial and residential construction, housing affordability etc., to the extent that pertinent data are available. The plan for developing and assessing these indicators is presented in Section 4: Technical Plan.

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[7] http://www.arb.ca.gov/cc/sb375/scag_fact_sheet.pdf
[8] http://www.arb.ca.gov/cc/sb375/sandag_fact_sheet.pdf
[9] Ewing,R.,et al. (2003) Measuring sprawl and its transportation impacts. *Transportation Research Record: Journal of the Transportation Research Board*, *1831*(1), 175-183.

Data to be employed in assessing the indicators will include land use and zoning maps, land parcels and assessors' rolls, building permits, housing prices, business licenses, employment, TAZ (Transportation Analysis Zone) maps and data, public transit maps and schedules, Census and American Community Surveys, Landsat and National Agriculture Imagery Program (NAIP) imagery. Data will be mapped in a GIS and scripts programmed within the GIS to determine the indicators of interest. A subset of all indicators proposed and tested will be recommended for employment Statewide based on data access, cost (ideally free) and availability, ability to directly measure SCS goals, usefulness and applicability across all regions, degree of commonality in MPO plans, relevance to the goals of ARB and the program, simplicity of execution, appropriateness for future determination by ARB or MPOs. The data management plan is presented in Section 4.6: Data and Data Management.

2.3 Experience

The proposing team comprises experts in (i) sustainability and climate action planning, greenhouse gas accounting, and remote sensing; (ii) urban planning, transportation and land use indicators; (iii) Geographic Information Systems, city planning and statewide mapping. Previous experience of the P.I.s includes climate action and sustainability planning for the California State University (CSU) system and CSU Northridge (CSUN), GHG inventorying, development of remote sensing techniques and case studies for NASA, and theoretical land use modeling. The Centers in which the proposed work will be carried out, The Institute for Sustainability (IS) and the Center for Geographical Studies (CGS), have a wealth of project experience in sustainability-related projects and GIS including a statewide project for the State Water Resources Control Board to integrate water quality goals and guidelines, an extensive multi-year project for the California Department of Transportation (Caltrans) to update their roads layer for California and develop a linear referencing system, and change analysis of Southern California wetland habitat. Personnel and Center qualifications can be found in Sections 4.7: Previous Related Experience, and Attachments: Curriculum Vitae. Their combined expertise will be utilized in developing a GIS system which incorporates a host of planning, land use, parcel, business, and economic data to derive a set of urban land use indicators that are readily employable across California by all MPOs, and will provide a useful set of metrics to inform and guide MPOs and ARB as they move forward in meeting the State's GHG reduction goal.

3. Objectives

The objectives of this project are as follows:

1. Assess land use change indicators that will serve as proxies for land use change in support of SB 375: The Sustainable Communities and Climate Protection Act.
2. Select appropriate land use change indicators based on the usefulness, reliability and availability of required data both now and anticipated to be so in the future.
3. Document indicators, data and methodology for utilization in generating the indices for ARB's future use.
4. Define and develop an appropriate baseline to allow for future comparison.
5. Map baseline indicator data using Geographical Information Systems (GIS).

6. Develop and deliver databases and scripts used to generate baseline for future use by ARB.
7. Develop and employ qualitative methods to explore the extent to which regional and local planning efforts are resulting in changes in actual land development
8. Document feedback from MPOs and their jurisdictions on successes and challenges to successful implementation of their SCSs.
9. Conduct sample assessments of cities' General Plan and zoning ordinance updates, to examine the extent which land use changes are taking place.

The proposed work will benefit ARB in the following ways:

1. Provide a methodology for ARB to use in making periodic assessments as to whether the MPOs are meeting their goals as set forth under SB 375.
2. Provide land use indicators that ARB can distribute to MPOs to aid them in their planning, monitoring and assessment efforts.
3. Provide baseline data and a GIS as a starting point against which to compare future growth.
4. Provide feedback to ARB on the successes and challenges encountered under the SCSs, to be utilized in informing future policy.

4. Technical Plan

4.1 Major Tasks

The following major tasks will be performed under this contract.

1. Review Sustainable Community Strategies of (18) MPOs in California in order to identify the common objectives and goals, the methods employed for determining GHG emission estimates, and to help develop relevant land use indicators. Survey a sample of 8 – 12 MPOs to inform this process.
2. Examine cities' General Plans for representative cities (some built-out, some edge cities, and some Smart Growth) as identified by MPOs. Interview city planners to determine the kinds of changes made under SB 375, to discuss zoning changes, the use of overlays, and successes and challenges.
3. Identify initial indicators for development, finalize methodology, and coordinate with ARB on a geographic unit for baseline mapping.
4. Collect and process data.
5. Develop models and conduct analysis within a GIS.
6. Evaluate indicator success through mapping samples of a number of cities.
7. Select a final set of indicators and conduct baseline GIS mapping for chosen year and region.
8. Document final indicator set and GIS methods.
9. Draft report for submission to ARB.
10. Revise report as requested, prepare final report, and present a seminar to ARB.

4.2 Research Methods

The Sustainable Community Strategies of all 18 MPOs will be reviewed to identify common objectives and goals, methods to determine GHG emission estimates, and identify relevant land use indicators. While doing this research, interviews will be conducted with personnel from 8 to 12 MPOs to ascertain the effects that regional and local planning efforts are having on actual land development. A standardized open-ended question interview will be performed to identify indices that would measure sustainability success, and to determine areas within their MPO that they consider sustainability successes. From these interviews, more usable indices will be identified that can be tested against perceived successful areas.

A sample of city plans identified by the MPO interviews will be reviewed to determine their influence in increasing sustainable land use. The sample will include plans from a mix of city types including built-out, suburban edge, and Smart Growth focused. Different city types will address sustainability in different ways, which will be identified from the plans. Built-out cities will focus more on in-fill development and mass transit infrastructure. Suburban edge cities will address developing higher densities, protecting the undeveloped land, and improving the job-housing balance. Smart Growth focused cities will usually have increased concentration areas identified that will reduce the need to increase infrastructure. Strategies used to increase land use sustainability will be identified through the plans. Based on these initial findings, a sample of city planners will be interviewed to determine perceived success of the plan and the city's efforts to increase sustainability. Part of the interviews will ask if zoning was changed based on the plan, how the city has helped incentivize sustainable land use changes, and if how zoning overlays were used. The plan reviews and interview will help create a better suite of indices to understand sustainability and provide insight as to policies that create more sustainable cities.

4.3 Land Use Change Indicators

Planning has focused on Transit-Oriented Development, Smart Growth and New Urbanism leading to a culmination towards increased sustainability over the last decade providing the benefits of reduced GHG emissions, more active and healthy cities, reduced infrastructure capital and maintenance costs, and increased access to jobs and recreation[10]. Good planning design should lead to an increased quality of life as infill development and transit-oriented development replace greenfield development and continued suburban sprawl. The planning literature has developed measures to estimate urban sprawl and has recognized that density is not the sole measure of a successful sustainable city[11,12,13,14]. The

[10] Frank, L. et al. (2006) Many pathways from land use to health. *Journal of the American Planning Association, 72*(1), 75-87.

[11] Ewing, R., and Hamidi, S. (2014). *Measuring sprawl 2014*.

[12] Ewing, R. et al. (2003) Measuring sprawl and its transportation impacts. *Transportation Research Record: Journal of the Transportation Research Board*, *1831*(1), 175-183.

[13] Galster, et al. (2001) Wrestling sprawl to the ground: Defining and measuring an elusive concept. *Housing Policy Debate, 12*(4), 681-717.

following are possible indicators that will be assessed in the development of the final project. They are grouped according to types of indicators.

- Residential Density. Residential density can simply be measure as the number of residents per square mile. However, a measure of households per square mile is also important, because an area can densify but possibly lose population. Lot sizes of new single-family development and overall development density can help determine if greenfield development is more sustainable than past forms of similar development. On a large metropolitan scale, the measure of the percent of the population living in densities above 12,500 per square mile and in densities below 1,500 per square mile can be an indicator of whether the region is gaining residential density. More units developed in previously used land (typically infill or brownfield development) versus units built in greenfields will be monitored. The percent vacant parcels identified as priority development sites by the Housing Elements of cities will help determine the level of infill.
- Land Use Mix. While a significant portion of the urban fabric is dedicated to residential use, a city also has industrial, commercial, transportation, and civic uses. Planning has focused on increasing the mix of these uses to increase the ability of residents to live close to where they work, shop, and recreate. With large zones of single use land, transportation consumption increases. Employment density allows for usage of the city to be assessed outside residential areas. As more residents gain access to employment, shopping, mass transit, and schools, the need to drive decreases. This can be measures as the percent of the population within a set distance of those areas (usually ½ mile or 1 mile). A job/residence balance is important because a perfect balance would mean that everyone living in a given area can also work there. Retail floor area ratio can help measure the amount of strip and big box shopping centers with large amounts of parking versus more walkable traditional city forms with limited parking.
- Socioeconomic Mix. Mixed use areas ideally allow all workers to live close-by, reducing commuting distances and increasing diversity. Many infill developments have an affordable housing component which is necessary as gentrification frequently follows redevelopment. Monitoring for gentrification (new upper-income residents displacing low-income residents) is important in understanding the dynamics of the plans and change in land use. Changes in incomes, housing costs, and household types can be assessed to determine land use effects.
- Centering of the City. A monocentric city allows for an efficient mass transit system to be developed as everyone is trying to get to the Central Business District (CBD). However, cities have become polycentric with multiple job centers in a region. This has increased the ability of the city to sprawl and led to reduced densities. A more centered city will have higher variances in population density, a steeper population and job density gradient, and a higher percent of jobs close to the CBD and fewer jobs far away from the CBD.
- Street Connectivity. When the street system has shorter blocks that are more interconnected it increases the ability to create walkable human-scale cities that promote mixed use and sustainability. Measures frequently used to find sustainable cities are shorter average block lengths, the smaller average block sizes, a larger percentage of small sized blocks, a higher density of street intersections and a higher percentage of four-way intersections. An in-fill

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[14] Shen, L-Y. et al. (2011) The application of urban sustainability indicators – A comparison between various practices. *Habitat International, 35*, 17-29.

project is likely to create or restore dense road networks of the surrounding area and cause an increase in all of these measures.

- Transportation Measures. Many of the urban land use plans are meant to decrease the amount of travel residents make as they travel to work, shopping, and recreation. Although vehicle miles traveled (VMT) are not directly targeted in this Request for Proposal, a more sustainable city will have fewer vehicles per household, a larger percentage of commuters using public transportation, a larger percent of commuters walking or biking to work, a reduced travel time to work, fewer hours spent delayed in traffic, decreased VMT, fewer highway fatalities, and lower ozone levels.
- Green Infrastructure. While many of the above measures are used to describe sprawl, they do not necessarily indicate benefits of green infrastructure. Cities are covered in concrete and asphalt, which leads to the Urban Heat Island (UHI) effect when the concrete absorbs the solar energy and later releases the energy as heat. This causes higher energy loads with increased use of air conditioning. Also more concrete and asphalt leads to higher rainwater runoff instead of infiltrating into the ground and the aquifer. This causes increased flooding and less future water availability. Determining indicators to monitor for increased green coverage and roofs, higher albedo levels (more reflective surfaces), increased solar panels, and less impermeable surface area will help determine how sustainability is being promoted, although these indicators are not explicitly addressed in this RFP.
- Environmental Indicators. Increased protection of the environment should occur with more sustainable urban development. The following measures can help analyze how green space is changing: increased number of parks, increased acreage of protected undeveloped natural lands, and conversion of urban uses into parks or naturalized open space.

These indicators will be explored and further developed during the project.

4.4 GIS Methodology

A Geographic Information System (GIS) is a powerful tool for creating, using, displaying and analyzing spatial data and information. As a substantial amount of relevant land use information can be associated with spatial features, this tool can be leveraged to more effectively and accurately evaluate progress towards meeting GHG emission reduction targets via the assessment of indicators (Section 4.3: Land Use Change Indicators). In order to assess indicators, key geospatial datasets will be processed and analyzed using the following tools and methodologies to produce metrics for evaluation. The datasets identified in Section 4.6: Data & Data Management Plan provide the basis for the proposed analysis described below.

Proximity Analysis: Proximity analysis provides the means to determine how close a feature is to other features. ArcGIS proximity tools identify features that are closest to other features or can calculate distances between features. This type of analysis can be useful in determining, for example, the percent of residents with either workplaces or resources (schools, shopping centers, etc.) within a specific distance (i.e. 1 mile) of their residences. Combined with spatial queries (described below), a detailed analysis of land use mix and transportation needs can be assessed. Producing a distance buffer can also assist in determining the percent of metro employment less than a specified distance (e.g. 3 miles) from the CBD. A convenience of proximity analysis is it allows analysis of different types of datasets: points (schools), polylines (streets) and polygons (parcels).

Density Analysis: When performing density analysis, the user can calculate the density of input features with a given neighborhood or area. The area can be a census unit (such as tract or block group), or a polygon generated using a buffer proximity tool (e.g. 1 mile radius from center of downtown). For example, to determine the density of houses (and potentially, population) within a given metro area, polygon parcel addresses may be converted to points, and then the point density tool can be run to better integrate multi-family parcels such as condo units and apartments into the analysis. Ewing, Pendall and Chen[15] estimated density at the center of a metro area derived from a negative exponential density function, another way to estimate density using GIS toolsets.

Attribute Queries: Attribute queries are not spatial in nature, but can be leveraged to extract subsets of data from datasets in order to more accurately perform other spatial queries and analysis. For example, in order to estimate total acres of open space polygons from a land use layer, one could perform an attribute query for features that are coded as open space. Additionally, one can perform the same query during a later time period to assess percent change in total acreage of open space. Generalized census data contains population density values averaged by square mile of census block area. Data values can be queried and symbolized to display light versus heavy levels of density in a region.

Spatial Queries: Spatial queries can take many forms, although common tools utilized that are most applicable to analyzing indices would be in conjunction with the proximity tools described previously. For example, after a 1 mile buffer is generated around public schools, one could overlay/intersect the buffer polygon with parcels to view how many parcels are selected in a given area or region.

Algebraic Functions: Complex indices, such as “urban entropy” scores (measures of distribution of land use categories across a Census tract)[16], are best calculated using the algebra function and spatial statistics tools, especially to allow application throughout large regions.

Data Summarization Tools: There are many different methods to summarize data in a given dataset. For example, to find the average house sale cost using parcel data within a predetermined census tract or TAZ, one could utilize the intersect tool with the TAZ polygon to select the subset of parcels from the parcel layer, then run the summarize tool on the appropriate field to determine the average value of house prices. The Summary Statistics tool can also be run on an entire table of information to summarize values and fields as needed by statistics type such as sum, median, average, etc. Data summarization can also be valuable in terms of land use change analysis to determine if infill is occurring or a given region is converting from mixed use to primarily residential use. Parcel data for an area (e.g. downtown) can be selected (using attribute selection to query for a residential zoning designation) and

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[15] Ewing, R. et al. (2003) Measuring sprawl and its transportation impacts. *Transportation Research Record: Journal of the Transportation Research Board*, *1831*(1), 175-183.

[16] Manaugh, K., & Kreider, T. (2013) What is mixed use? Presenting an interaction method for measuring land use mix. *The Journal of Transport and Land Use, 6*(1), 63-72.

summarized to see the percentage of residential properties in the area. The same analysis can be run 5 years or a decade later to observe percent change and assess what type conversion might be occurring.

4.5 Remote Sensing

Aerial and satellite imagery can be used to quantify land cover and land cover change and their feasibility for use in this project will be explored. Specific challenges to using remote sensing data include data availability and cost, temporal, spatial and spectral resolution. Whereas some cities and jurisdictions have procured high resolution aerial imagery (including in some cases, LIDAR), many have not. Also the frequency of acquisition can vary greatly. This makes the use of commercial or commissioned aerial imagery undesirable for this project, where readily available and consistent data sources are required. On the other hand, there are two other sources of remotely sensed data that have the potential to be useful in this project. Landsat satellite imagery is available over more than three decades and provides raster data at a 30 meter spatial resolution throughout the visible, near infrared and mid-infrared spectral regions. Data is available to download freely from a number of portals, and is available in scenes of 170 x 183 km with a temporal resolution of 16 days. There are sufficient bands to generate a wide range of indices including the Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Normalized Difference Built-Up Index (NDBI) which are useful in land cover and land use mapping. Other potential land use characterization methods to be explored include classification and principal component analysis (see below). The other potentially useful source of imagery is the National Agriculture Imagery Program (NAIP), from which higher spatial resolution data (presently 1 meter) is available in 4 bands (3 visible plus 1 near-infrared) since 2005. It is available with a 2-year temporal resolution. The higher spatial resolution makes the data potentially more useful for urban mapping but the limited spectral resolution limits the number and kind of spectral indices that can be generated. Its applicability and usefulness in this application will be explored. Other satellite data such as MODIS, MISR, ASTER etc. have limited applicability due to their spatial resolution and/or availability.

4.5.1 Satellite Imagery

Landsat 5 Thematic Mapper, Landsat 7 Enhanced Thematic Mapper Plus and Landsat 8 Operational Land Imager and Thermal Infrared Sensor imagery are best suited for land cover change assessment due to the availability of data over a long time span. These data sets also include comparable bands in the green, red, near infrared, and short wave infrared portions of the electromagnetic spectrum necessary for the identification and extraction of urban land cover types. This imagery is openly available at 30 meter resolution through the United States Geological Survey[17]. NAIP 4-band imagery is available for 2005, 2009, 2010, 2012 and 2014 from a number of online portals including the California Geoportal[18], and the California Department of Fish and Game provides a zip file with ArcGIS layers for all versions and years of the California imagery[19].

[17] http://glovis.usgs.gov/
[18] http://www.atlas.ca.gov/download.htm
[19] http://www.dfg.ca.gov/biogeodata/gis/map_services.asp

Radiometric correction and normalization will be applied to imagery acquired at different times, or from different sensors, to remove radiometric variation. This variation is often caused by differences in atmospheric and illumination conditions at the time of collection. This will help ensure that observed changes in pixel values represent actual changes on the ground. Potential methods for correction and normalization use pseudo-invariant features (PIFs), histogram matching, or image regression.

4.5.2 Normalized Difference Built-Up Index

A simple method for evaluating change in land cover over time involves the classification and comparison of multi-temporal images using various remote sensing indices. The Normalized Difference Vegetation Index (NDVI) was originally developed by Rouse et al., 1974[20] to monitor vegetation systems in the Great Plains using remotely sensed data from the Earth Resources Technology Satellite (Landsat 1). It has since become the most widely used index for identifying the location and health of vegetated areas. The Normalized Difference Water Index (NDWI) was first used to enhance the presence of open water features in remotely sensed data and delineate their boundaries[21]. It has since been applied to monitor fuel moisture levels[22], and vegetation water content in crops such as corn and soybeans[23]. Finally, the Normalized Difference Built-Up Index (NDBI), developed by Zha et al., 2003[24], is often combined with NDVI to quickly identify and extract built-up urban land cover from satellite imagery and has been used to evaluate land cover change in places such as China[25], and to explore the relationship between land cover changes and the urban "heat island" effect[26]. In general, these three remote sensing indices can be combined to extract built-up areas, specifically concrete and asphalt features such as buildings, roads, sidewalks, parking lots, etc. Each index is calculated for the area of interest and the values are compared in a logical operation which reclassifies each pixel in the image that represents built-up land cover.

4.5.3 Normalized Difference Bareness Index & Enhanced Built-Up and Bareness Index

Distinguishing between urban features and bare land or dry soils is often difficult using NDBI alone. In dry climates, or areas with exposed dry soils, modified indices such as the normalized difference

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[20] Rouse et al. (1974) Monitoring Vegetation Systems in the Great Plains with Erts. *NASA Special Publication, 351*, 309.

[21] McFeeters, S. K. (1996) The Use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing, 17,* 1425–1432.

[22] Dennison, P. E. (2005) Use of Normalized Difference Water Index for Monitoring Live Fuel Moisture. *International Journal of Remote Sensing, 26,* 1035–1042.

[23] Jackson et al. (2004) Vegetation Water Content Mapping Using Landsat Data Derived Normalized Difference Water Index for Corn and Soybeans. *Remote Sensing of the Environment, 92,* 475–482.

[24] Zha, Y. et al. (2003) Use of Normalized Difference Built-up Index in Automatically Mapping Urban Areas from TM Imagery. *International Journal of Remote Sensing, 24,* 583–594.

[25] Xu, H. (2007) Extraction of Urban Built-up Land Features from Landsat Imagery Using a Thematic-oriented Index Combination Technique. *Photogrammetric Engineering & Remote Sensing, 73,* 1381–1391.

[26] Chen, X. et al. (2006) Remote Sensing Image-based Analysis of the Relationship Between Urban Heat Island and Land Use/Cover Changes. *Remote Sensing of the Environment, 104*, 133–146.

bareness index[27], and the enhanced built-up and bareness index[28] can be used to identify dry land covers and soils so they can be excluded from the classification of built-up or urban features. Once images of an area at two different points in time have been classified, a comparison can be carried out to evaluate and quantify changes in built-up land cover.

4.5.4 Unsupervised and Supervised Classification

A second method for assessing land cover change without the use of remote sensing indices involves the spectral classification and comparison of multi-temporal images. Classes are defined by identifying the spectral properties of pixels representing different land cover types in the image. During the classification process, pixels are assigned to a class based on the similarity of their individual signatures to the class signature[29]. This method allows for complete control over the number of land cover types included in the analysis and their spectral definitions, which often vary geographically[30].

In unsupervised classification the spectral properties of each class are not defined by the investigator, only the number of classes. The computer then examines the spectral properties of pixels in the image and attempts to find natural groupings of similar pixels.

These different methods of land cover categorization and classification will be evaluate for use is measuring urban expansion, greenfield and infill development.

4.6 Data & Data Management Plan

4.6.1 Data Sources

The following data sources will be evaluated in the development and calculation of the indices:

- Parcel data: Parcel level data is accurately maintained by county auditors for tax collection efforts. The data that is frequently associated with parcels include building type and size, year built, last year sold, last sales value, units associated with a parcel or building, and building/housing attributes. This is an excellent source for evaluating location of residents and determining a more accurate distribution of the population across the city. It will also permit analysis of infill or conversion of existing buildings to residential uses. The PIs are in the process of completing an agreement with the California Department of Technology for free data access to all statewide parcel data with over 230 attributes for each parcel[31]. It is anticipated that these data will facilitate the calculation of many of the relevant indicators for this project.

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[27] Li, S. and Chen, X. (2014) A New Bare-soil Index for Rapid Mapping Developing Areas Using Landsat 8 Data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 139–144.

[28] As-syakur et al. (2012) Enhanced Built-up and Bareness Index (EBBI) for Mapping Built-up and Bare Land in an Urban Area. *Remote Sensing, 4*, 2957–2970.

[29] Jensen, J. (1996) *Introductory Digital Image Processing: A Remote Sensing Perspective*. Englewood Cliffs, NJ: Prentice-Hall.

[30] Sabins, F. (1997) *Remote Sensing: Principles and Interpretation*. 3rd edition. New York: Freeman.

[31] https://accounts.gis.ca.gov/Users/Catalog.aspx

- Census data: The Census Bureau is a significant source of data for demographics, income, population, and travel to work modes. With the American Community Survey (ACS) performed every year, using the 5-year average values for Census Tracts will provide meaningful and up-to-date information.
- Transportation Area Zone (TAZ) data: Each MPO designates a TAZ for their area of jurisdiction and then develops forecasts of population, households, and employment. The availability of employment locations provided by this dataset is an advantage over the Census data which only reports where workers live.
- Aerial photography and Satellite Imagery: Aerial photography is available from the National Agriculture Imagery Program (NAIP) and can be used to identify suburban sprawl, green spaces and infill using classification and a vegetation index such as NDVI. NAIP data has a relatively high spatial resolution (1 meter) and is available in 4 bands (3 visible plus 1 near-infrared) with a 2-year temporal resolution. Landsat satellite imagery will also be utilized to calculate NDVI, NDBI and other land cover indices, and is available twice monthly at a 30 meter spatial resolution in the visible and infrared spectral regions. Both datasets area available for free download from a number of portals.
- Permit data: Public agency permit data are especially helpful in determining conversions of existing buildings into other uses. Additions of secondary units, conversion of warehouses into residential properties, and other use changes can be investigated. Permit data is often not linked directly to parcel data or addresses, so the ability to integrate permit information into GIS analysis may be limited.
- Land Use data. Cities and MPOs generate land use maps which summarize land uses according to their General Plans. These will provide a useful set of data against which to compare indicators.
- Zoning data. Each land parcel is assigned a zone maintained by cities and MPOs. Zoning definitions will need to be generalized to be useful, but can be analyzed to assist in selecting optimal indicators.
- US Census TIGER files: The US Census creates complete maps of the Census zones (Block Groups, Census Tracts) as well as road networks. This is a freely available source of road network data.
- Census Transportation Planning Package (CTPP). The CTPP provides detailed travel behavior for a random sample of households which can provide insight into work locations and travel behavior.
- Vacant Parcel Data: Vacant parcel data identified for residential development could be a useful dataset for analysis. Each California city is required to create a Housing Element plan that identifies vacant lots that would be suitable for future residential development. The Department of Housing and Community Development collects all these housing elements from the plans once they are adopted by the city. These data can provide an indication of where future development will be promoted and is likely to occur.

4.6.2 Data Management Strategy

The following considerations will be used to ensure a successful project with quality data collection, analysis and storage:

- Data will be collected for sample MPO regions to develop and test indicators.
- Once a final set of indicators and geographic mapping unit have been agreed upon by CSUN researchers and CARB staff, all relevant data will be collected for that region.
- Researchers will use PC workstations loaded with ESRI's industry-standard ArcGIS and ERDAS Imagine software packages.
- Data will be processed and imported into an organized ArcGIS geodatabase containing metadata that identifies data sources, modification dates, projection/coordinate system information and field descriptions. The geodatabase, along with associated metadata will be delivered digitally to CARB upon completion of the project.
- Throughout the course of the project, data, maps and documentation will be archived on a regular basis by California State University, Northridge Information Technology Department.

4.7 Previous Related Experience

This project will be co-hosted by the Institute for Sustainability and the Center for Geographical Studies under the direction of their respective directors. The Institute for Sustainability[32] is a chartered university institute which serves as the umbrella organization for university activities focused on sustainability. It provides consultation services to the university administration on sustainability and sustainability planning, and on the application of sustainability practices in university operations. The Institute is responsible for climate action planning for the university, and for quantifying and reporting resource use and GHG emissions. With regard to education, the Institute supports curriculum development related to sustainability, and manages the existing sustainability programs and outreach. As a university-wide body it brings together faculty from multiple departments across campus to work on sustainability-related joint research initiatives and projects including clean technology, renewable energy, climate change education, and applied research in GHG reduction strategies. The Institute comprises its director, full-time administrative coordinator, part-time staff, student employees and faculty associates, and is housed in a suite of offices on the campus of CSUN. Previous related experience includes the development of remote sensing tutorials related to climate change and land cover in a NASA-funded initiative on climate change education[33]; a twenty year project to monitor weather on San Clemente Island for the U.S. Navy[34]; GIS mapping of campus facilities and floor plans for an online application; the development of a CSUN sustainability plan; a commuting study[35], and other studies for both university and external agencies. The director has a PhD in atmospheric sciences and is a Professor in the CSUN Geography Department (see Attachments: Curriculum Vitae).

[32] http://www.csun.edu/sustainability/
[33] http://www.csun.edu/climate/
[34] http://www.csun.edu/scisland/
[35] http://www.csun.edu/sustainability/wp-content/uploads/2012/09/CommutingReport_2010_110913.pdf

The Center for Geographical Studies (CGS) at Cal State University, Northridge is an interdisciplinary research center focused on applications, education and innovative solutions to real world problems using Geographic Information Systems (GIS). The Center has years of experience in applying geospatial technology to real world problems, has full time expert GIS staff (project managers, developers, analysts, etc.), highly motivated and educated student research assistants, and full access to numerous industry-standard GIS software packages and tools.

Over the past 10 years, the Center has deepened its involvement in a variety of focused projects as well as larger, state-wide projects in transportation (Caltrans) and water resources (State Water Resources Control Board). CGS is currently completing an extensive multi-year project for the California Department of Transportation (Caltrans) to update their roads layer for California and develop a linear referencing system to manage numerous attributes necessary to meet federal reporting requirements. The sheer amount of data and complex workflow requirements has provided CGS the opportunity to enhance skillsets related to managing statewide data and transportation datasets. The Center is also completing another statewide project for the State Water Resources Control Board to integrate water quality goals and guidelines (Beneficial Uses, Water Quality Objectives, etc.) from the California Basin Plans into a geospatial database. This project has required the synthesis of numerous pieces of information and data into a structured and transparent format that can facilitate the understanding and application of water quality policy in the State. On a regional level, the Center has participated in a variety of modeling and change analysis projects related to Southern California wetland habitat to determine changes in extent and composition over time. Through experience in these and other projects, CGS staff and students have become experts in project management, data research and collection, compilation, editing and analysis, modeling, development of automation processes, web-map development and geovisualization.

Additionally, CGS staff have been employed by municipal agencies in past years, and therefore gained knowledge in the availability, use and application of project-relevant GIS datasets such as parcel, zoning, land use, building permit, business license data and others.

5. Project Management Plan

5.1 Milestone & Deliverable List

The table below lists the major milestones and deliverables for the project, and comprises only major project milestones such as completion of a project phase or task. The project schedule is provided in Section 7. If there are any scheduling delays which may impact a milestone or delivery date, the CSUN project manager will be notified immediately so proactive measures may be taken to mitigate slips in dates. Any approved changes to these milestones or dates will be communicated to the project team and CARB sponsor by the project manager.

Task #	Milestone	Deliverable
1	Review MPO SCSs & survey sample	Documentation

	MPOs.	
2	Examine city general plans and interview planners	Documentation
3	Identify initial indicators	Data and documentation of methodology
4	Collect & process data	Geodatabase
5	Develop models & perform analysis	Documentation & model scripts
6	Evaluate indicator success	Documentation
7	Select final indicators and conduct baseline mapping	Documentation and GIS map/data
8	Document indicator set and GIS Methods	Documentation
9	Prepare Draft Report	Draft report
10	Finalize Report and Seminar at ARB	Final report and seminar

5.2 Schedule Management Plan

Upon award of the project, a detailed schedule for tasks and sub-tasks will be created using MS Project starting with the deliverables identified in the project's Milestone and Deliverable List. A draft is presented in Section 7.

Once a preliminary schedule has been developed, it will be reviewed by both CSUN and CARB team members and resources assigned to project tasks. The project teams and resources must agree to the proposed work assignments, durations, and schedule.

5.3 Communications Management Plan

This Communications Management Plan establishes the communications framework for this project. It will serve as a guide for communications throughout the life of the project and will be updated as communication requirements change. This plan identifies and defines the roles of project team members as they pertain to communications. A project team directory is included to provide contact information for all stakeholders directly involved in the project.

The Project Manager will take the lead role in ensuring effective communications. The Communications Matrix will be used as the guide for what information to communicate, who is to do the communicating, when to communicate it, and to whom to communicate.

Communication Type	Description	Frequency	Format	Participants/ Distribution	Deliverable	Owner
Quarterly Progress Reports	Project Reports and Conf Calls	Quarterly	Email and Conf Call	Project Sponsor, Team and Stakeholders	Progress Report and Meeting Minutes	Project Manager

Methodology review	Present and discuss project methodology	As Needed	In Person or Conf Call	Project Sponsor, Team and Stakeholders	Meeting Minutes	Project Manager
Project Milestone Review	Present closeout of project phases and kickoff next phase	As Needed	In Person or Conf Call	Project Sponsor, Team and Stakeholders	Phase completion report and phase kickoff	Project Manager

Meetings. The Project Manager will distribute a meeting agenda at least 2 days prior to any scheduled meeting and all participants are expected to review the agenda prior to the meeting. During all project meetings the timekeeper will ensure that the group adheres to the times stated in the agenda and the recorder will take all notes for distribution to the team upon completion of the meeting. Meeting minutes will be distributed no later than 24 hours after each meeting is completed.

Email. All email pertaining to the Project should be professional, free of errors, and provide brief communication. Email should be distributed to the correct project participants in accordance with the communication matrix above based on its content. All attachments should be in one of the organization's standard software suite programs and adhere to established company formats. If the email is to bring an issue forward then it should discuss what the issue is, provide a brief background on the issue, and provide a recommendation to correct the issue. The Project Manager should be included on any email pertaining to the Project.

Informal Communications. While informal communication is a part of every project and is necessary for successful project completion, any issues, concerns, or updates that arise from informal discussion between team members must be communicated to the Project Manager so the appropriate action may be taken.

5.4 Budget Management Plan

The Project Manager will be responsible for managing and reporting on the project's budget throughout the duration of the project. The Project Manager will present and review the project's budget performance as part of the quarterly progress reports.

5.5 Quality Management Plan

Quality assurance is essential for successful completion of the project. The following process standards will be put in place to maximize project efficiency and minimize waste. All members of the Project Team will play a role in quality management.

Standard operating procedures (SOPs) will be developed and will be used for all work to be conducted by the researchers. Adherence to these procedures will ensure that all data, maps and reports will be generated and processed with the highest level of quality control. Staff supervisors will review all 1st draft data generated by staff technicians upon completion.

General quality control activities and tasks include but are not limited to:

- Coordination with senior management
- When necessary, act as liaison to settle disputes on matters of quality control or policy
- Manage organization resources designated to support quality assurance
- Maintain pertinent records
- Ensure that all changes to the guidance documents are available to all personnel using that guidance.
- Review and approve quality control documentation
- Oversee data management and storage processes for data products
- Ensure that project quality control personnel are adequately trained and qualified
- Project implementation and oversight
- Project conventions or protocol revision or development
- Data delivery oversight
- Internal reporting
- Other functions as specified by task assignment

5.6 Risk Management Plan

The Project Manager working with the project team and project sponsors will ensure that risks, if and when they occur, are actively identified, analyzed, and managed throughout the life of the project. Risks will be identified as early as possible to minimize their impact. The Project Manager will serve as the Risk Manager for this project.

Risk identification will involve the project team, project sponsor, appropriate stakeholders, and will include an evaluation of various factors including, organizational culture and the project management plan including the project scope. Careful attention will be given to the project proposal, deliverables, and other key project documents.

5.7 Staffing Management Plan

The following staffing requirements are necessary for completion of the Project.

Principal Investigators - Oversee and administer project
Project Directors – Assists in overseeing project and guiding research.
Project Manager – Manages all aspects of project
GIS Analyst – Aids in training, supervision and quality control processes

Research Assistants – Performs mapping, processing and editing tasks

6. Budget Justification

The proposed total budget for the project is $148,332 broken down as follows.

1. **Senior personnel costs - Salaries Include 3% Cost-of-living Increase per Annum**
   Total: $32,877
   - Helen Cox (Professor, Director IS)- $92,234/AY (8 month appointment): 1.0 summer months: $11,541
   - Craig Olwert (Assistant Professor, Faculty Director CGS) - $67,868/AY (8 month appointment): 2.5 summer months: $21,336

2. **Other Personnel**
   Total: $79,596
   - Danielle Bram (Director CGS) - $19,296 ($40/hr x 8 hrs/wk x 50 wks) in year 1, ($41.20/hr x 4 hrs/wk x 20 wks) in year 2
   - CGS Project Manager - $15,000 ($20/hr x 15 hrs/wk x 50 wks)
   - Graduate Students - $33,000 (2 students x $15/hr x 20 hrs/wk x 50 wks) in year 1, (1 student x $15/hr x 20 hrs/wk x 10 wks) in year 2
   - Research Assistant - $7,500 ($15/hr x 10 hrs/wk x 50 wks) in year 1
   - Administrative Assistant - $4,800 ($24/hr x 120 hrs) in year 1, ($24/hr x 80 hrs) in year 2

3. **Fringe Benefits**
   Total: $16,049. Calculated at the university's established rate of 9.1% for faculty and student salary, at 17.4% for CGS Director (retirement but no health benefits), 27.2% for CGS staff (with health benefits) and at 40.3% for administrative assistant (with health and retirement benefits).

4. **Travel**
   Total: $3,325. One roundtrip to Sacramento in each of years 1 and 2 to meet with ARB ($800 in year 1; $800 in year 2) - $500 airfare, $200 lodging, $50 per diem, $50 ground transportation. Vehicle mileage for data collection, interviews and meetings with MPOs and city staff (3000 miles x $0.575/mile).

5. **Other direct costs**
   Materials and supplies: $3,000. Includes printing and paper costs, data charges.

6. **Indirect costs**
   Total: $13,485. Calculated at 10% of total direct costs.

Total budget: $148,332

See breakdown by task in Section 8: Preliminary Cost Proposal.

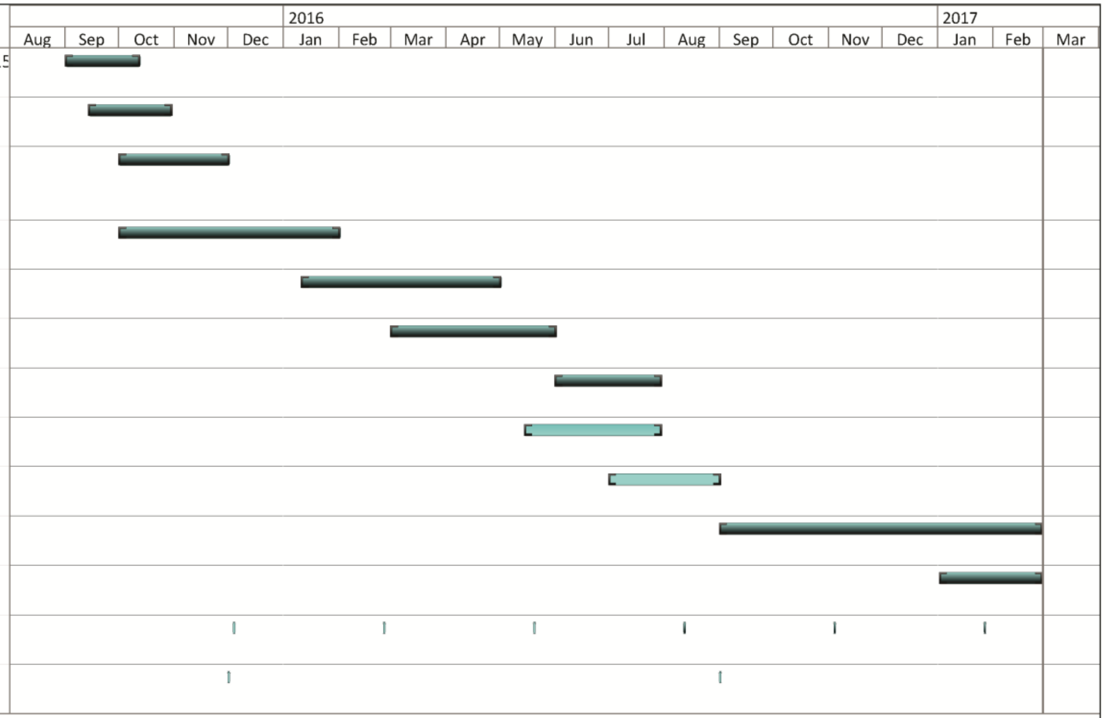
Option:

Additional mapping: $33,531

Under this proposal, a sample area of the state will be mapped; the geographical unit to be agreed upon in coordination with ARB. An additional cost of $33,531 is proposed for mapping all MPO areas in the state, broken down as follows: personnel ($25,200), fringe benefits ($3,283), data costs ($2,000), and indirect costs at 10% ($3,048).

7. Proposed Project Schedule

ID	Task Name	Duration	Start	Finish
1	Survey MPOs	30 days	Tue 9/1/15	Mon 10/12/15
2	City Review and Planner Interviews	35 days	Mon 9/14/15	Fri 10/30/15
3	Initial Indices & Methods Development	44 days	Thu 10/1/15	Tue 12/1/15
4	Data collection & Processing	88 days	Thu 10/1/15	Mon 2/1/16
5	Model Dev & Analysis	81 days	Mon 1/11/16	Sun 5/1/16
6	Evaluate & Select Indicators	67 days	Tue 3/1/16	Wed 6/1/16
7	Baseline GIS Mapping	44 days	Wed 6/1/16	Sat 7/30/16
8	Finalize Indicators & GIS Methods	57 days	Sun 5/15/16	Sat 7/30/16
9	Draft Report	45 days	Fri 7/1/16	Thu 9/1/16
10	Draft Report Review By CARB	129 days	Thu 9/1/16	Tue 2/28/17
11	Final Report	42 days	Mon 1/2/17	Tue 2/28/17
12	**Quarterly Progress Reports**	**301 days**	**Fri 12/4/15**	**Fri 1/27/17**
19	**Meetings w/ ARB Staff**	**198 days**	**Tue 12/1/15**	**Thu 9/1/16**



Project: ProjectSchedule_v2
Date: Fri 2/27/15

Task	External Tasks	Manual Task	Finish-only
Split	External Milestone	Duration-only	Deadline
Milestone	Inactive Task	Manual Summary Rollup	Progress
Summary	Inactive Milestone	Manual Summary	
Project Summary	Inactive Summary	Start-only	

8. Preliminary Cost Proposal

Task	Senior Personnel	Other Personnel	Total Labor	Fringe benefits	Travel	Material and Supplies	Overhead	Total
1. Review Sustainable Community Strategies	$6,000	$1,500	$7,500	$1,151	$600		$925	$10,176
2. Examine city General Plans	$4,000	$4,000	$8,000	$1,090	$500		$959	$10,549
3. Identify initial indicators for development	$6,000	$0	$6,000	$546	$800		$735	$8,081
4. Collect and process data	$2,000	$6,000	$8,000	$1,256	$625	$2,000	$1,188	$13,069
5. Develop models and conduct analysis	$2,000	$34,000	$36,000	$4,845			$4,085	$44,930
6. Evaluate indicator success	$2,000	$12,000	$14,000	$1,983			$1,598	$17,581
7. Select a final set of indicators	$2,000	$10,000	$12,000	$1,620			$1,362	$14,982
8. Document final indicator set	$967	$3,500	$4,467	$572			$504	$5,543
9. Draft report for submission to ARB	$4,910	$3,380	$8,290	$1,351		$500	$1,014	$11,155
10. Revise report, present seminar at ARB	$3,000	$5,216	$8,216	$1,635	$800	$500	$1,115	$12,266
TOTAL	**$32,877**	**$79,596**	**$112,473**	**$16,049**	**$3,325**	**$3,000**	**$13,485**	**$148,332**
Option for statewide mapping		$25,200	$25,200	$3,283		$2,000	$3,048	$33,531

Attachments:

Curriculum Vitae of Key Personnel

See pages following for CVs of key personnel, PIs: Helen Cox and Craig Olwert, and co-I: Danielle Bram

Helen Cox, Ph.D.

Geography Department and Institute for Sustainability
California State University, Northridge
18111 Nordhoff St, Northridge, CA 91330-8249
(818) 677-7710; helen.m.cox@csun.edu

website: http://www.csun.edu/social-behavioral-sciences/geography/helen-cox
linkedin: https://www.linkedin.com/pub/helen-cox/a/299/681
researchgate: https://www.researchgate.net/profile/Helen_Cox11

Education

University of California, Los Angeles, California	PhD MS	Atmospheric Sciences	1998 1995
University of Pennsylvania, Philadelphia, Pennsylvania	MS	Computer Information Science	1979
St. Hugh's College, Oxford University, England	MA BA Honours	Physics	1983 1978

Professional Experience

California State University, Northridge, 18111 Nordhoff Street, Northridge, CA 91330-8444
ph: (818) 677-4401; email: helen.m.cox@csun.edu

Director, CSUN Institute for Sustainability (under Provost) (2009 – present)

Responsibilities

- Lead university's sustainability efforts and serve as consultant to the university leadership on related issues
- Spearhead university strategic planning and policy development in sustainability
- Support and aid in the application of sustainability practices in university operations
- Serve as the umbrella organization for university activities focused on sustainability and increase interdisciplinary and cross-functional collaboration
- Lead, support and promote university-wide curriculum development and curriculum innovation in sustainability
- Promote and support the educational and professional growth and development of faculty, students, staff and the community in the field of sustainability and serve as an educational resource
- Aid faculty in seeking funding from private and public agencies in support of sustainability-related projects and research
- Lead research efforts in data collection, analysis and reporting of university resource use
- Coordinate and manage sustainability teaching including course scheduling, staffing and budgeting
- Manage Institute's budget and supervise and direct activities of office staff and employees

Accomplishments

- Headed/Authored university's sustainability plan (10-year CSUN Sustainability Plan)
- Led development of a campus Geographic Information System (GIS) to manage

campus facilities and resources, providing student internship opportunities (partnership with Facilities Management, and Academic Resources and Planning)
- Led CSUN feasibility study for Ecoponex (a Los Angeles Cleantech Incubator Company), including sub-contracts and interdisciplinary CSUN research team
- Led university-wide sustainability curriculum development – university minor in sustainability (2011); graduate courses and certificate program approved (2013). Developed Climate Science program with funding from NASA.
- Partnered with Associated Students to construct new university Sustainability Center
- Leading campus efforts in support of American College and University Presidents' Commitment on Climate Change (signed in 2013)
- Partnered in design and construction of bicycle paths, bicycle parking
- Led design and construction of organic food garden and composting operations for teaching purposes.
- Established public-private partnerships through Los Angeles Clean Tech Incubator (LACI)
- Developed and led series of educational workshops on energy efficiency and residential solar throughout community in partnership with cities and local council districts
- Authored/Co-authored Research reports in collaboration with faculty and students – CSUN Commuting Analysis, Tree Atlas, Bicycle Report, Energy Use Analysis: 1990-2011, CSUN Greenhouse Gas Emissions:1990-2013
- Directed outreach efforts – Annual Sustainability Day and Water Day events, workshops, seminars and student events. Published promotional, marketing and educational materials.
- Lead highly successful sustainability minor program

Professor, Geography Department
College of Social and Behavioral Sciences (2011 – present)
Associate Professor, Geography Department (2006 – 2011)
Assistant Professor, Geography Department (2000 – 2006)

- Teaching – Developed and taught undergraduate and graduate courses in Meteorology, Physical Environment, The Atmosphere, Human Impact on The Environment, Remote Sensing, Statistics, Climate Change, Spatial Analysis, Geographic Information Systems, Earth Science, Interdisciplinary Perspectives in Sustainability, Best Practices in Sustainability. Current focus in on educating students in important environmental issues such as pollution and climate change.
- Curriculum development - Developed new curriculum in Remote Sensing and Atmospheric Science; led development of undergraduate university sustainability curriculum; led design and development of interdisciplinary graduate program in sustainability; worked with faculty in mathematics and physics to develop new G.E. freshman course in understanding climate change
- Service through departmental committees – Various including Personnel, Student Recruitment, Search and Screen for new faculty hires, Curriculum, Student Awards, Geographic Information Systems
- Service at College and University level committees – Various including Personnel, Extended Learning, Green Core (and its sub-committees), curriculum, Faculty Senate. Engaged in interdisciplinary initiatives – CSUN in Africa, STEM education, Climate Change education
- Service to the Community – Member, Reviewer, Sub-committee member, Session Chair and Presenter for Association of Pacific Coast Geographers, California

Geographical Society, Association of American Geographers, American Geophysical Union

- Research – Conduct grant funded research in weather station management and climate monitoring on Channel Islands under U.S. Navy funding, climate change education under NASA funding, atmospheric remote sensing with NASA funding, energy efficiency education with funding from CSU Chancellor's Office. Many additional research projects in remote sensing, sustainability, and GIS development.

  Extensive research in atmospheric sciences focusing on retrieval of atmospheric constituent data from satellite experiments, and the role of aerosol particles in the stratosphere. Much-cited work contributed to the understanding of the formation of the Antarctic ozone hole, and on the interaction of aerosol particles with sunlight which has important implications for global warming. Presented and authored articles on inversion techniques, aerosols, stratospheric ozone depletion, climate change, carbon sequestration, energy resources and use, GIS and sustainability, and energy resources. Recent work has included planning, program evaluation, assessment of student learning and high impact practices.

Atmospheric Sciences Department, University of California, Los Angeles
and NASA Jet Propulsion Laboratory, Pasadena, California
Researcher (1999 – 2000)

- Under NASA funding, retrieved and analyzed atmospheric constituent data from infrared instruments developed by NASA's Jet Propulsion Laboratory and launched on balloons and the space shuttle. Developed algorithms to retrieve aerosol component of infrared transmission, through analysis of residuals after removal of constituent gases. Constructed models of atmospheric aerosol distributions from transmission data for use in radiative transfer studies (including climate models).

Center for Atmospheric Sciences, University of Cambridge, England
NSF-NATO Fellow (1998 – 1999)

- Under NSF-NATO Fellowship, researched the factors which influence polar stratospheric cloud formation and the formation of the Antarctic ozone hole using model-based multivariate statistics. Polar stratospheric clouds serve as the pre-cursors for stratospheric ozone depletion.

University of California, Los Angeles
Graduate Student Researcher, Atmospheric Sciences Department (1993 – 1998)

- Completed PhD course work in atmospheric physics, chemistry and dynamics, with an emphasis on remote sensing of the atmosphere.
- Recipient of NASA Global Change Fellowship. Carried out research work to retrieve and analyze remotely-sensed data from satellite sensors, including facilitating the understanding of the algorithmic bias arising in the retrieval of stratospheric ozone data as a result of separability problem with aerosols.

California Lutheran University, Thousand Oaks
Director, Math/Science Upward Bound Program (1992 – 1996)

- Wrote proposal and obtained funding from U.S. Department of Education ($500,000 for 3 years) for university's first Upward Bound Math and Science Program (an academic program for disadvantaged high school students designed to better prepare underprivileged students for college)

- Developed and directed first Math/Science Upward Bound program at CLU - Hired staff and instructors, developed outreach program, coordinated with regional schools, established policies and procedures, conducted recruitment, designed academic and residential programs, coordinated instruction. Program served fifty low-income and first-generation college students with STEM instruction throughout the academic year and in a summer residential program, preparing them for college admission and success. Under my leadership, program achieved over a 90% success rate.

Instructor in Math, Physics, Computer Science Department (1991 – 1996)

- Teaching - computer programming, software engineering, computer design and architecture, operating systems, networks, database management, discrete math, finite math, business math.
- Developed new curriculum and degree standards for computer science
- Expanded and coordinated Adult Degree Evening Program in Computer Science

Edu-Ware Services Inc.
Engineering Manager (1982-1985)

- Software manager for startup company in design and development of educational software for first-generation home computers
- Led and supervised team of programmers

<u>Selected Honors, Awards and Professional Development</u>

- Graduate of the Higher Education Resources (HERS) Denver Summer Institute, Advancing Women Leaders in Higher Education July 2014
- Member of Steering Committee of the U.S. Urban Serving Universities (Advancing Urban Sustainability) 2014 -
- Member of Advisory Board for Pick My Solar (an LACI company) 2014 -
- Member of Advisory Board for Bumuntu Peace Institute, an NGO operating in Central Africa 2012 -
- University representative for ACUPCC (American College and University Presidents' Climate Commitment), for AASHE (Association for the Advancement of Sustainability in Higher Education), and for the ARC (Alliance for Resilient Campuses) 2010 -
- Member of AGU (American Geophysical Union), AAG (Association of American Geographers), APCG (Association of Pacific Coast Geographers), CGS (California Geographical Society)
- Speaker at SCUP 2014 Pacific Regional Conference (March, 2014)
- American Council on Education (ACE) Women's Leadership Forum, San Marcos (Oct 2013)
- Credentialed by the Greenhouse Gas Management Institute (global personnel certification in support of international carbon policy) in *Greenhouse Gas (GHG) Verification for Inventories and Projects*, *Organizational GHG Accounting and Reporting to The Climate Registry* and *Project-Level GHG Accounting* 2013
- NSF-NATO Postdoctoral Fellowship to carry out research at Cambridge University (1998 - 99)
- California Institute of Technology President's Award (Co-I) (1998)
- Bjerknes Memorial Award (Graduate Student Research Award in Atmospheric Sciences) at UCLA (1997)
- NASA Global Change Fellowship (1994 - 1997)
- Edwin Pauley Foundation Fellowship for Ph.D. research, UCLA (1993 - 1996)

- Co-author of best research publication from Space Directorate at NASA Langley Research Center (1983)
- NASA Group Achievement Award as member of Nimbus 7 sensor team (1983)
- Thouron Scholarship to the University of Pennsylvania (1978-1980)
- Scholarship to Oxford University (1975-1978)

Grants

- Climate Monitoring Program on San Clemente Island (U.S. Army) (2010 – 2015)
- NASA Innovations in Climate Education Grant, awarded by NASA (2011 – 2013)
- Climate Monitoring on San Clemente Island, awarded by U.S. Navy (2004 – 2008)
- Weather and Fog-Drip Monitoring on Santa Rosa Island, awarded by US Geological Services (2011-2013)
- Student Energy Efficiency and Education (EEE) Training, CSU Chancellor's Office grant (2012)
- ACMAP (Atmospheric Chemistry Modeling and Analysis Program) grant, awarded by NASA (2001 – 2004)
- Upward Bound Math/Science Program, U.S. Dept. of Education (1992-1996)

CSUN Internal awards

- Community Service Award (2010, 2011)
- Judge Julian Beck Award (2003, 2007, 2008, 2010)
- College of Social and Behavioral Sciences Research Competition (2003, 2006,2008)
- University Research, Scholarship and Creative Activity (2003, 2006)

Selected Journal Publications and Articles (also under Steele)

Cox, Helen M., K. Kelly and L. Yetter. "Using remote sensing and geospatial technology in climate change education", *Journal of Geoscience Education,* 62, 4, 609-620, Nov 2014.

Cox, Helen M., K. Kelly and L. Yetter. "Student Activities in Climate Change using NASA Satellite Data, CSU Geospatial Review, 12 (Spring 2014).

Cox, Helen M. "A Sustainability Initiative to Quantify Carbon Sequestration by Campus Trees", *Journal of Geography, 111:5, 173-183*, 2012.

Cox, Helen M., "How Clean Is Your Power?", Sierra Club Newsletter, Jan 2011.

Cox, Helen M., "What are we doing about climate change?", *Human Geography, 3, 2, 1- 20*, 2010.

Kurland, Nancy B., Kristy Michaud, M. Best, E. Wohldmann, Helen Cox, K. Pontikis, A. Vasishth, "Overcoming Silos: The role of an interdisciplinary course in shaping a sustainability network", *Acad. Mgmt. Learn. Educ., 9, 3*, Sept 2010.

Cox, Helen M., "Old Diesel Trucks: So. Cal's Top Air Pollution Problem.", Sierra Club Newsletter, May 2010.

Cox, H. M, "Studying Climate Change: A New Tool Mixes Weather Data and GIS", *GeoWorld, 22, 9, 24-27*, 2009.

Yong, A., S.E. Hough, M.J. Abrams, H. M. Cox, C.J. Wills and G.W. Simila, "Site Characterization Using Integrated Imaging Analysis Methods on Satellite Data of the Islamabad, Pakistan, Region", *Bulletin of the Seismological Society of America, 98, 6, 2679–2693,*doi:0.1785/0120080930, 2008.

Cox, H. M.,"Current Issues in Global Warming and Mitigation Efforts: Focus on California", *APCG Yearbook*, 69, 115 – 132, 2007.

Steele, H. M., A. Eldering, J. D. Lumpe, "Simulations of the accuracy in retrieving aerosol

effective radius, composition and loading from high-resolution spectral transmission measurements”, *Applied Optics*, 45, 9, 2014-2027, 2006.

Steele, H. M., J. D. Lumpe, and R. M. Bevilacqua, "The climatology of the polar aerosol from the POAM instruments", *Physical Geography, 26, 1*, pp1-22, Jan-Feb 2005.

Polyakov. A. V., Yu. M. Timofeyev, D. V. Ionov, Ya. A. Virolainen, H. M. Steele and M. J. Newchurch, “Retrieval of ozone and nitrogen dioxide concentrations from SAGE III measurements using a new algorithm”, *J. Geophys. Res.*, *110, No. 6, doi: 2004JD005060,* 2005.

Virolainen, Ya A., Yu. M. Timofeyev, A. V. Polyakov, H. M. Steele, K. Drdla, and M. J. Newchurch, “Simulation of polar stratospheric clouds: 1. Microphysical characteristics”, *Atmos. Oceanic Opt., 18, 3*, 243-247, 2005.

Virolainen, Ya A., Yu. M. Timofeyev, A. V. Polyakov, H. M. Steele, K. Drdla, and M. J. Newchurch, “Simulation of polar stratospheric clouds: 2. Spectral aerosol extinction coefficient and PSC remote sensing possibilities”, *Atmos. Oceanic Opt., 18, 7*, 526-530, 2005.

Eldering, A., B. H. Kahn, F. P. Mills, F.W. Irion, H. M. Steele and M. R. Gunson, "Vertical profiles of aerosol volume from high-spectral-resolution infrared transmission measurements: Results", *J. Geophys. Res., 109,D20201, doi:10.1029/2004JD004623,* 2004.

Timofeyev, Yu. M., A. V. Polyakov, H. M. Steele and M. J. Newchurch, “Optimal eigenanalysis for the treatment of aerosols in the retrieval of atmospheric composition from transmission measurements.” *Applied Optics, 42, 15,* 2635-2646, 2003.

Steele, H. M., A. Eldering, B. Sen, G. C. Toon, F. P. Mills and B. H. Kahn, "Retrieval of stratospheric aerosol size and composition information from solar infrared transmission spectra", *Applied Optics,42, 12,* 2140-2154, 2003.

Steele, H. M., J. D. Lumpe, R. M. Bevilacqua, K. W. Hoppel and R. P. Turco, "The role of temperature history in polar stratospheric cloud sightings." *J. Geophys. Res., 107, AAC2-1 – AAC2-15,* 2002.

Eldering, A., F.W. Irion, A. Y. Chang, M. R. Gunson, F. P. Mills and H. M. Steele, "Vertical profiles of aerosol volume from high-spectral-resolution infrared transmission measurements. I. Methodology", *Applied Optics, 40, 18,* 3082-3091, 2001.

Steele, H. M., J. Lumpe, R. P. Turco, R. Bevilacqua, and S. T. Massie, "Retrieval of aerosol surface area and volume densities from extinction measurements: Application to POAM II and SAGE II", *J. Geophys. Res., 104,* 9325-9336, 1999.

Steele, H. M., K. Drdla, R. P. Turco, J. D. Lumpe, R. M. Bevilacqua, "Tracking polar stratospheric cloud development with Polar Ozone and Aerosol Measurement II and a microphysical model", *Geophys. Res. Lett., 26*, 287-290, 1999.

Steele, H. M. and R. P. Turco, "Separation of aerosol and gas components in the Halogen Occultation Experiment and the Stratospheric Aerosol and Gas Experiment (SAGE) II extinction measurements: Implications for SAGE II ozone concentrations and trends", *J. Geophys. Res., 102,* 19665-19681, 1997.

Steele, H. M. and R. P. Turco, "Retrieval of aerosol size distributions from satellite extinction spectra using constrained linear inversion", *J. Geophys. Res., 102,* 16737-16748, 1997.

Steele, H. M., P. Hamill and R. P. Turco, "Tropospheric Aerosols: Humidity Dependence of Light Extinction", in Hygroscopic Aerosols in the Planetary Boundary Layer, *p229-246*, Ed. L. H. Ruhnke and A. Deepak, A. Deepak Publishing, 1984.

Craig T. Olwert, PhD

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Northridge, California 91330-8259
craig.olwert@csun.edu

Education

The Ohio State University, Columbus, Ohio

PhD in City and Regional Planning, June 2010
Dissertation: "A Computable General Equilibrium Model of the City with Optimization of its Transportation Network: Impacts of Changes in Technology, Preferences, and Policy"

Committee: Dr. Jean-Michel Guldmann, Advisor; Dr. Philip Viton; Dr. Burkhard von Rabenau
GPA: 3.9

Masters in City and Regional Planning, June 2008

Bachelor of Science in Chemical Engineering, September 1994. Summa Cum Laude

Academic Appointments

2011 – present Assistant Professor
Department of Urban Studies and Planning
California State University, Northridge

2010 – 2011 Visiting Assistant Professor
City and Regional Planning
The Ohio State University

2003 – 2010 Teaching Assistant
Department of Mathematics
The Ohio State University

Teaching Experience

Assistant Professor – Urban Studies and Planning, California State University Northridge

Spring 2014, 2013, 2012 URBS 300: The Planning Idea.

Spring 2014 URBS 310OL: Growth and Sustainable Development of Cities.

Fall 2014, 2013, 2012, 2011	URBS 340A: Research Methods.
Spring 2014, 2012	URBS 490C: Fieldwork.
Spring 2014, 2013, 2012	MPA 620: Research Methods for Public Administration.
Summer 2012, Fall 2011	URBS 150: Urban Scene.
Fall 2013, 2012	URBS 400: Planning for the Natural and Built Environment.
Spring 2013, Fall 2011	URBS 450: Urban Problems Seminar.
Fall 2013	MPA 642D: Community and Economic Development.
Summer 2012	MPP 645: Urban Economic Policy.

Visiting Assistant Professor – City & Regional Planning Section, The Ohio State University

Spring 2011	Theory of City and Regional Planning. Graduate level theory course.
Spring 2011	Service Learning in City Planning. Studio to evaluate the Columbus High Five organization.
Winter 2011	City Planning in the Contemporary World. Senior capstone course for planning and non-planning students. Includes a group project, a written paper, and several tests.
Winter 2011	Service Learning in City Planning. Studio to evaluate the effectiveness of Campus Partner's programs in the Ohio State University neighborhoods.
Autumn 2010	Planning for Sustainable Economic Development. New course offering for the undergraduate program. Included field trip, guest speakers, and student presentations.
Autumn 2010	Municipal Infrastructure. Graduate level course highlighting interactions of different providers of municipal services. Included field trips, guest speakers, and web site design.

Instructor – Department of City & Regional Planning

Spring 2009	City Planning in the Contemporary World. Senior capstone course for planning and non-planning students.

Graduate Teaching Assistant – Department of City & Regional Planning

Winter 2009	Physical Elements of Urban Development

Graduate Teaching Assistant – Department of Mathematics

Winter 2010 - Autumn 2003	Mathematical Analysis for Business; Basic College Mathematics and Elementary Functions; and Algebra and Trigonometry and their Applications.

Work Experience

Senior Biological Technician – US Forest Service, Gardiner Ranger District
Summers of 2002 to 2010

- Wrote internal documentation on campsite use for developing a new wilderness plan, highlighting high impact areas that have since been treated, and recommended areas for campfire restrictions.
- Developed Access and Excel databases to store and analyze wildlife study data, used in annual reports as well as for technical papers.
- Assisted four master degree students with data analysis, data collection forms and GIS analysis as well as training three employees in GIS use.

Intern – Public Utilities Commission of Ohio
October 2001 to June 2002 and October 2002 to June 2003

- Developed an Access database to track stock market performance of utility companies.

Internal Auditor – Exxon Mobil
March 1999 to August 2001

- Developed consensus-building skills in identifying risks to the corporation with clients.
- Streamlined API measurement standards for non-engineering auditors.
- Taught accountants basic engineering to increase effective communication with clients.
- Audited facilities in Benicia, CA (Bay Area); Torrance, CA (Los Angeles); Billings, MT; New Orleans, LA; Baton Rouge, LA; Beaumont, TX; Fairfax, VA (Washington, DC); Managua, Nicaragua; San Salvador and Acajutla, El Salvador

Business Analyst – Exxon
January 1998 to March 1999

- Developed an Access database standardizing the Baton Rouge refinery's personnel (1500 employees) into industry categories
- Prepared a 5 Year Strategic Plan for Technical Services and Operations Salaries
- Prepared a Depreciation Forecast using SAP/Excel models
- Initiated SAP training manual for refinery users.

Environmental Air Quality Engineer – Exxon
January 1997 to January 1998

- Wrote a Vapor Pressure Study increasing the accuracy of permitting and reporting to governmental agencies
- Prepared Title V Air Permits
- Reported environmental releases to appropriate authorities

Process Contact Engineer – Exxon
September 1994 to January 1997

- Wrote a Safety Valve Study identifying 12 scenarios affecting the entire system of over 26 vessels and 8 pumps.

Publications

Published Papers

Olwert, C., Guldman, J-M. (2012). A computable general equilibrium model of the city: Impacts of technology, zoning, and trade. *Environment and Planning A*, 44:1, 237-253.

Engelhardt-Bergsjo, H., Tyers, D. B., Swenson, J.E. ,Irby, L. R., Zimmer, J. P., Olwert, C. T., Engelhardt-Bergsjo, K. (2009). Monitoring ungulate carcasses and grizzly-bear scavenging on the Northern Yellowstone Winter Range. *Intermountain Journal of Sciences*, 15, 7-17.

Olwert, C. (2002). Photovoltaic Peaker Plants. http://knowlton.osu.edu/files/studentwork/craig.pdf.

Papers Accepted for Publication

Olwert, C., Tchopourian, J., Arellano, V., Woldeamanuel, M. (accepted for publication). Stranding cycling transit users on Los Angeles' Orange Line Bus Rapid Transit. *Journal of Public Transportation.*

Research in Progress

Olwert, C., Guldmann, J-M (in progress). Effects of air pollution on city form: Impacts of pollution and abatement.

Woldeamanuel, M., Olwert, C. (in progress). Multimodality and active living: Connectivity of the Bus Rapid Transit with pedestrian and bicycle facitlities.

Olwert, C., Arellano, V. (in progress). Retailers in and around Transit Oriented Development.

Presentations

Association of Collegiate Schools of Planning. Stranding cycling transit users on Bus Rapid Transit: On-vehicle bicycle storage utilization on the Los Angeles Orange Line. November 2, 2014.

CSUN MPS Alumni Chapter. How to Use Census Data. May 31, 2014.

Association of Collegiate Schools of Planning. A Computable General Equilibrium Model of the City: Impacts of Locational Restrictions and Zoning. October 7, 2010.

PennDesign. Spring 2010 PhD Lecture Series. A Computable General Equilibrium Model of the City with Optimization of its Transportation Network: Impacts of Changes in Technology, Preferences, and Policy, University of Pennsylvania, School of Design. April 5, 2010.

Knowlton School of Architecture. City and Regional Planning Lectures. A Computable General Equilibrium Model of the City with Optimization of its Transportation Network: Impacts of Changes in Technology, Preferences, and Policy. March 8, 2010.

Knowlton School of Architecture. City and Regional Planning Lectures. Campsite Determinants that Effect Wilderness Planning. November 14, 2008

John Carroll University. Use of Two Stage Least Squares in Determining Policies to Protect Ohio's Farmland. December 8, 2007.

Knowlton School of Architecture. PhD Student Discussion Panel. February 16, 2007.

Honors and Awards

2014	City of Los Angeles Certificate of Commendation for URBS 490C Field Work Project for Northridge South Neighborhood Council
2013	Hagman Conference Scholar at 27th Annual Land Use Law and Planning Conference
2012	Polished Apple Award from University Ambassadors
2010	Gallatin Forest Supervisor's Award for Wilderness Excellence
2007	Ohio Planning Commission Cleveland Section Scholarship
2003	Planning Student Award, American Institute of Certified Planners
2002	City and Regional Planning Faculty Award for Outstanding Scholastic Achievement

Professional Preparation

California Planning Conference. American Planning Association California. September 16, 2014.

U.S. Cluster Mapping Presentation. Santa Clarita Valley Economic Development Corporation and Harvard Business School. July 31, 2014.

Sustainable Zoning and Development Controls: An Intensive Two-Day Seminar. American Planning Association, Seattle, Washington. June 13-14, 2013.

Successful CEQA Compliance: An Intensive Two-Day Seminar. University of California Davis. June 6-7, 2012.

Preparing Future Faculty, The Ohio State University. Workshop and mentoring to develop an understanding of academia and experiences working at a liberal arts institution. 2007-2008.

Participant in Study Abroad Program with Technical University of Dresden. 2002.

Danielle Bram
Center for Geographical Studies
Department of Geography
California State University, Northridge
Northridge, CA, 91330
818-677-3527
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Education:

Master of Arts — May 2007
California State University, Northridge, CA.
Major: Geography

Bachelor of Arts — June 1998
University of California, Davis, CA.
Major: Nature and Culture
Minor: Geographic Information Systems

Publications:

*Weintraub, D. 1998. *California's Vanishing Forests: Two Decades of Destruction*. California Wilderness Coalition. Report GIS Manager.

*Weintraub, D. 1998. What's left after all these years? California Roadless Area Report takes stock of potential wilderness. *The Wilderness Record* 23(9):1

Dark, S.J. and **D. Bram**. 2007. The Modifiable Areal Unit Problem (MAUP) in Physical Geography. *Progress in Physical Geography* 31(5):471-479

S. Dark**, D. Bram**, M. Quinones, L. Duong, J. Patanaan, J. Dooley, M. Antos, S. Sutula, and E. Blok. 2006. Wetland and riparian mapping within the Rivers and Mountains Conservancy territory: a landscape profile. Technical Report 519. Southern California Coastal Water Reserach Project, Coasta Mesa, CA.

Dark, S., E.D. Stein, **D. Bram,** J. Oscuna, J. Monteferante, T. Longcore, R. Grossinger, and E. Beller. 2011. Historical Ecology of the Ballona Creek Watershed. Technical Report 671. Southern California Coastal Water Research project. Costa Mesa, CA.

Dark, S., E.D. Stein, **D. Bram**, and J. Osuna. 2012. Historical Ecology as a Living Resource for Informing Urban Wetland Restoration. Urban Coast 3:54-60.

*Maiden name.

Thesis:

D. Bram. A Predictive Model of Fennel Occurrence in the Santa Monica Mountains. M.A. Thesis. California State University, Northridge.

Posters and Presentations:

D. Bram and Most, M. The heuristic and economic values associated with vegetation mapping in California using the national vegetation classification. 2015. California Native Plant Society Conference, San Jose, CA.

D. Bram and Most, M. The heuristic and economic values associated with vegetation mapping in California using the national vegetation classification. 2014. Ecological Society of America Conference, Sacramento, CA.

D. Bram and Osuna, J**.** Using GIS to Create Efficiencies in Statewide Water Policy: California Basin Plan Project. 2014. ESRI User Conference, San Diego, CA.

D. Bram and Dark, S**.** Using GIS to Create Efficiencies in Statewide Water Policy: California Basin Plan Project. 2012. CalGIS, Sacramento, CA.

Dark S., Danielle Bram, Dr. Martha Sutula, and Dr. Eric Stein. 2008. "The Southern California Wetlands Mapping Project." ESRI User Conference, San Diego, CA.

Dark S., Danielle Bram, Dr. Martha Sutula, and Dr. Eric Stein. 2008. "The Southern California Wetlands Mapping Project." H20 Conference, San Diego, CA.

D.Bram. April, 2007. A Spatial Analysis of fennel (*Foeniculum vulgare*) in the Santa Monica Mountains. AAG Conference, San Francisco, CA.

D. Bram. 2007. Mapping Wetland and Riparian Areas in Southern California Coastal Watersheds. CGS Conference, Borrego Springs, CA.

D. Bram. 2000. Delivering an Application that Requires no End-User Training, CalGIS Conference, Palm Springs, CA.

D. Bram. 2000. Santa Monica's Internet GIS. ESRI Annual Users Conference**,** San Diego, CA.

Research and Related Experience:

Director. Center for Geographical Studies. Cal State University, Northridge, Geography Dept. (Dec 2014 – Present). Responsible for managing all aspects of the Center for Geographical Studies. Supervises staff, performs outreach to potential clients and develops project proposals. Performs administrative tasks such as managing Center budget and administering contracts and agreements.

GIS Project Manager. Center for Geographical Studies. Cal State University, Northridge, Geography Dept. (January 2007 – Present). GIS project management and analysis for projects such as water resource/water quality, wetland and riparian mapping, historical ecology and municipal GIS projects. Manages projects, produces maps and documentation, engages in administrative/outreach tasks, generates customized projects and tools, and trains and supervisors student assistants.

GIS Specialist. San Gabriel Watershed Wetland and Riparian Mapping Project. Cal State University, Northridge, Geography Dept. (February 2006 – January 2007). Engaged in research, data collection and GIS project design for the San Gabriel Watershed mapping project. Identified, mapped and classified wetland and riparian areas using remotely sensed imagery and additional collateral data. Generated new tools, procedures and documentation for the project. Trained other student mapping assistants. Performed QA/QC work.

GIS Coordinator/Analyst. City of Culver City, Culver City, California. (February 2001 – June 2006). Managed all GIS-related projects, program budget, data, contract staff and interns. Developed new internal ArcGIS and web-based (ArcIMS) GIS applications. Generated maps; gave presentations to and was the GIS liaison for city staff and officials. Trained and supported end-users; created (and supervised the creation of) multiple GIS datasets and associated documentation for City departments.

GIS Technician. City of Santa Monica, Santa Monica, California (December 1999 – February 2001). Designed and produced GIS projects and maps for City departments, primarily the Engineering Division. Created, managed and updated numerous GIS datasets and associated documentation. Generated maps and gave presentations to City staff and officials. Trained and supported end-users of ArcView.

GIS Project Manager. California Wilderness Coalition, Davis, California (June – October 1998). Coordinated GIS aspect of a project that inventoried US Forest Service designated roadless areas in California to determine impact of human activity and development. Compiled data, input into digital format and analyzed using ArcView software. Assisted with associated text and made group presentations concerning project status and goals.

Teaching Experience:

Lecturer (Introductory, Intermediate and Advanced GIS). CSU, Northridge, Geography Dept. (August 2007 – June 2010).

Lecturer (GIS and Local Government - Extension Course). CSU, Long Beach, Geography Dept. (April 2003).

Instructor (Introductory and Advanced GIS, Internet GIS). City of Santa Monica and Culver City. (February 2000 – January 2006).

Courses Taught:

Introductory GIS (CSU Northridge, City of Santa Monica, City of Culver City)
Intermediate GIS (CSU Northridge)
Advanced GIS (CSU Northridge, City of Culver City)
Internet GIS (City of Culver City)
GIS and Local Government (CSULB)

Research Interests:

GIS, Environmental Geography, Biogeography, Spatial Analysis, Historical Ecology, Municipal GIS, Wetland and Riparian Mapping and Remote Sensing