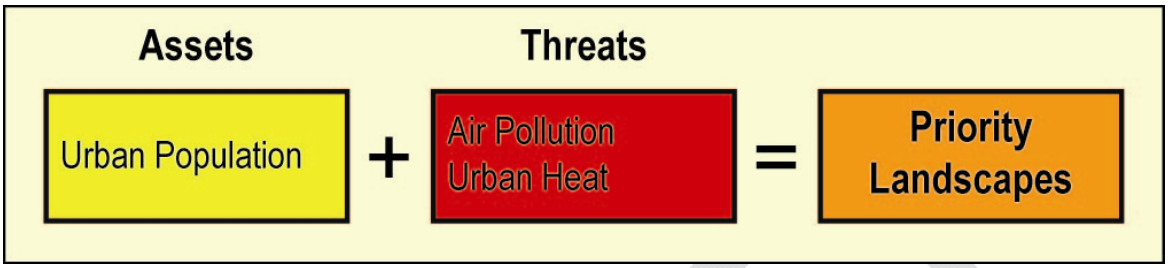
Urban Forestry for Energy Conservation and Air Quality

Methodology

Analysis #1- Urban Tree Planting for Energy Conservation and Air Quality



Threats: Urban Heat

The urban heat threat includes two components. First, we created a ranked "urban heat island" layer by combining data for impervious surface with tree canopy, both from USGS National Land Cover Dataset (NLCD). Areas with high impervious surface and low tree canopy were ranked highest, while low impervious with high tree canopy were ranked lowest. The heat island data was ranked as follows:

	% Tree Canopy Cover		
% Impervious	**L (Trees< 10%)**	**M (10-20%)**	**H (>20%)**
H(>70%)	H	M	L
M (30 – 70%)	H	M	L
L (<30%)	M	L	L

Second, the ranked urban heat island data were merged with weather data from California Climate Action Team research for number days over 90°F (Hidalgo, et al., 2008) to create the urban heat threat, which is an indicator for energy use. The higher threat ranks represent more demand for energy (days requiring air conditioning). The final threat ranks were assigned as follows from the two component inputs;

	Urban Heat Island Rank		
% of days > 90°F	**H**	**M**	**L**
L (<8%)	M	M	L
M (9-20%)	H	M	L
H (>20%)	H	H	L

Threat: Air Pollution

For air pollution, California Air Resource Board PM2.5 and ozone health data by county, non-attainment days PM10 by air basin, were merged into one data layer. Health data (PM2.5 and Ozone) has a greater overall influence on the final rank as it presents

greater health risks. To account for the increased risks, county health data was ranked using two state average standards; does the county exceed the state county average? And does the county exceed the state average per capita? Data was ranked as follows:

	PM2.5 and Ozone Health Data (overall &/or per capita)		
Air Basin N-A days PM10	**H (Exceeds Ca Avg per capita or overall)**	**M (Does not exceed CA Avg, mid values)**	**L (Does not exceed CA Avg, low values)**
L (<25 days)	M	M	L
M (26-60 days)	H	M	L
H (>61 days)	H	M	L

In addition, air pollution can be elevated in areas adjacent to major roads. Thus, areas within 300 meters of an interstate, freeway, or expressway were ranked high. Areas within 150 meters of an urban principal arterial road were ranked medium. The air pollution ranks from above was merged with urban roads to create the final air pollution threat ranks as follows:

	Air Pollution index		
Urban Roads	**H**	**M**	**L**
L	H	M	L
M	H	H	M
H	H	H	M

Composite Threat

The urban heat and air pollution threat layers were merged into a single composite threat using equal weights. All urban areas were categorically ranked by high, medium, or low vulnerability to the composite threat. Areas with high threats in both pollution and energy consumption were given the highest threat rank. The ranking was as follows:

	Urban Heat Threat		
Air Pollution Threat	**H**	**M**	**L**
L	L	L	0
M	M	L	L
H	H	M	L

Asset: Urban Population

To support our goal of enhancing public benefit our asset is “urban population” representing public health and energy conservation, which is measured by the proxy variable housing density. This asset allows us to identify where densely populated residential areas are located. Commercial development is also an urban component where people may spend much time working or conducting business. Commercial areas (NLCD class 24) use a considerable amount of energy, and are ranked high. Housing density was ranked as follows:

	Urban Housing Density[1]		
	L	**M**	**H**
Residential	L	M	H
Commercial	H	H	H

1 Housing density classes are defined as;
L = 1 housing unit/5 acres to 1 unit/acre
M = 1 housing unit/acre to 5 units/acre
H = over 5 housing units/acre

The urban population asset was clipped to only include the urban area as defined by the 2000 U.S. Census Urbanized Areas

Priority Landscape

Priority areas were identified by merging the composite threat and the urban population asset, and assigning ranks as follows;

	Urban Population Asset		
Composite Threat	**H**	**M**	**L**
L	L	L	0
M	M	L	L
H	H	H	L

To allow the consideration of impacts and opportunities across community sizes, and distribute resources equitably, urban communities were sorted into 5 size class categories based on population. Community population size classes are as follows; 1≥250,000, 2=100,000-249,999, 3=50,000-99,999, 4= 10,000-49,999, and 5<10,000. Areas in the highest ranks in each size class are considered "priority landscapes." To show another ranking option, the top 50 communities by population living in a high priority landscape are also depicted.

High-priority planting areas in California are densely populated areas with considerable air pollution and urban heat islands (low tree canopy, high percent impervious surface, and many days over 90 degrees). Planting efforts can reduce the amount of energy consumption due to cooling needs and filter air pollutants.

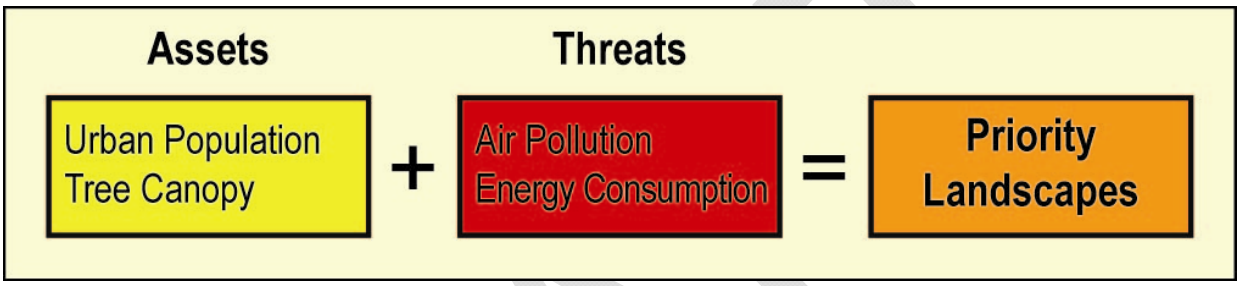
Data Used in the Analysis

The datasets used in this analysis are available at http://frap.fire.ca.gov/assessment2010/3.2_urban_forestry.html. These are provided to document the analysis, and to provide the potential to replicate results. Updated versions of these datasets may be available from the various data providers.

ANALYSIS: Urban Tree Planting for Energy Conservation and Air Quality			
Data theme		**Dataset name**	**Purpose**
THREATS			
THREAT1: Air Pollution		thr_airpollution09_1.gdb	Ranks areas by combining data for PM2.5, ozone, PM 10, and urban road buffers.
Inputs	Air pollution rank	input_airpollution09_1.gdb	Ranks from combining PM2.5, ozone, and PM10 data
	Urban roads rank	input_urbRoads04_1.gdb	Ranks from buffering urban roads
THREAT2: Urban Heat		thr_urbheat09_1.gdb	Ranks areas based on impervious surfaces, tree canopy, and days over 90°F
Inputs	Impervious surface ranks	input_impervious09_1.gdb	Impervious surface ranks, derived from NLCD
	NLCD impervious surfaces	NLCD_Impervious09_1.gdb	NLCD data for percent impervious surfaces
	Canopy cover ranks	input_canopy09_1.gdb	Tree canopy ranks, derived from NLCD data
	Percent Canopy Cover	NLCD_Percent_Canopy.gdb	NLCD data for percent tree canopy
	Days over 90	input_90deg09_1.gdb	Ranks for days over 90°F
ASSETS			
ASSET1: Urban Population		ast_urbPopulation09_1.gdb	Ranks urban areas based on housing density and commercial areas.
Inputs	Housing density class (derived from 2000 census block data)	input_denclass09_2.gdb	Input dataset for defining housing density
	Urban areas (2000 census)	input_UrbanRuralPop.gdb	Used to exclude non-urban areas
	Commercial areas (NLCD)	input_NLCD24commercial09_1.gdb	Commercial areas ranked high based on energy use
PRIORITY LANDSCAPE			
PL: Urban Tree Planting for Energy Conservation and Air Quality		pl_t32_a109_1.gdb	Priority landscape for urban tree planting for energy conservation and air quality

OTHER DATA		
Bioregions	INACCBioreg04_1.gdb	Reporting unit for summarizing results
Counties	cty24k09_1.gdb	Reporting unit for summarizing results
Communities	community09_3.gdb	Reporting unit for summarizing results

Analysis #2- Urban Tree Maintenance for Energy Conservation and Air Quality



Threat: Energy Consumption

Energy consumption was derived using a combination of housing density and days over 90°. Areas with high housing density and many days over 90° were ranked highest, while low housing density with fewer days over 90° were ranked lower as follows:

	Urban Housing Density[1]			
% of days > 90°	**H**	**M**	**L**	**0**
L (<30d)	2	1	1	0
M (30-72d)	3	2	1	0
H (< 72d)	3	3	1	0

1 Housing density classes are defined as;
L = 1 housing unit/5 acres to 1 unit/acre
M = 1 housing unit/acre to 5 units/acre
H = over 5 housing units/acre
H = commercial (NLCD class 24)

Threats: Air Pollution

The air pollution threat is the same as used in the first analysis.

Composite Threat

Air pollution and energy consumption were merged into a single composite threat using equal weights. All urban areas were categorically ranked by high, medium, or low vulnerability to the composite threat as follows:

	Energy Consumption Threat		
Air Pollution Threat	**H (3)**	**M (2)**	**L (1)**
L=1	1	0	0
M=2	2	1	0
H=3	3	2	1

Asset: Urban Population

This asset is identical to the asset for the first analysis.

Asset: Tree Canopy

For this analysis, existing tree canopy coverage from NLCD data is an asset and is ranked as follows;

% canopy cover	Rank
< 2%	-
< 10%	L
10-20%	M
> 20%	H

Composite Asset

The two assets were combined into the composite asset using equal weights, and ranks were assigned as follows;

	Tree Canopy Coverage			
Density Class	**0 (Trees< 2%)**	**L (Trees< 10%)**	**M (10-20%)**	**H (>20%)**
L=1	0	1	1	2
M=2	0	1	3	3
H=3	0	2	3	3

Priority Landscape

Priority areas were identified by merging the composite threat and asset and assigning ranks as follows:

	Composite Asset		
Composite Threat	**H (3)**	**M (2)**	**L (1)**
L=1	1	1	0
M=2	3	2	1
H=3	3	3	2

Data Used in the Analysis

The datasets used in this analysis are available at http://frap.fire.ca.gov/assessment2010/3.2_urban_forestry.html. These are provided to document the analysis, and to provide the potential to replicate results. Updated versions of these datasets may be available from the various data providers.

ANALYSIS: Urban Tree Maintenance for Energy Conservation and Air Quality			
Data theme		**Dataset name**	**Purpose**
THREATS			
THREAT1: Air Pollution		thr_airpollution09_1.gdb	Ranks areas by combining data for PM2.5, ozone, PM 10, and urban road buffers.
Inputs	Air pollution rank	input_airpollution09_1.gdb	Ranks from combining PM2.5, ozone, and PM10 data
	Urban roads rank	input_urbRoads04_1.gdb	Ranks from buffering urban roads
THREAT2: Energy Consumption		thr_energy09_1.gdb	Ranks areas based on urban housing density, commercial development, and days over 90°
Inputs	Housing density class (derived from 2000 census block data)	input_denclass09_2.gdb	Input dataset for defining housing density
	Commercial areas (NLCD)	input_NLCD24commercial09_1.gdb	Commercial areas ranked high based on energy use
	Days over 90	input_90deg09_1.gdb	Ranks for days over 90 degrees
ASSETS			
ASSET1: Urban Population		ast_urbPopulation09_1.gdb	Ranks urban areas based on housing density and commercial areas.
Inputs	Housing density class (derived from 2000 census block data)	input_denclass09_2.gdb	Input dataset for defining housing density
	Urban areas (2000 census)	input_UrbanRuralPop.gdb	Used to exclude non-urban areas
	Commercial areas (NLCD)	input_NLCD24commercial09_1.gdb	Commercial areas ranked high based on energy use
PRIORITY LANDSCAPE			
PL: Urban Tree Maintenance for Energy Conservation and Air Quality		pl_t32_a209_2.gdb	Priority landscape for urban tree maintenance for energy conservation and air quality
OTHER DATA			
Bioregions		INACCBioreg04_1.gdb	Reporting unit for summarizing results
Counties		cty24k09_1.gdb	Reporting unit for summarizing results
Communities		community09_3.gdb	Reporting unit for summarizing results

Data and Analysis Limitations

Data Quality

Data Element	Date	Source	Purpose	Currency[1]	Completeness	Detail	Consistency	Relevance	Limitations
Residential development	2000	US Census	Component of Urban Population asset	F	G	F	E	G	
Commercial development	2001	National Land Cover Data	Component of Urban Population asset	F	G	G	E	F	
PM10 non-attainment days by air basin	?	CA ARB	Component of Air Pollution threat	G	E	F	E	G	
Road Density	2009	CALTRANS	Component of Air Pollution threat	E	E	G	E	G	
County Health statistics (Air Pollution)	2004-6	CA ARB (Ad-hoc Report)	Component of Air Pollution threat	G	G	G	E	G	
Impervious Surfaces	2001	National Land Cover Data	Component of Urban Heat threat	F	E	G	E	E	Data often wrong for specific cells, works for prevalence of impervious over larger areas
Weather (Days over 90°)	1990-99	CA Climate Action Team	Component of Urban Heat threat	F	F	G	E	G	
Tree Canopy	2001	National Land Cover Data	Component of Urban Heat threat	F	E	G	E	E	Data often wrong for specific cells, OK for prevalence of canopy over larger areas
Tree Canopy	2001	National Land Cover Data	Tree Canopy asset	F	E	G	E	E	Data often wrong for specific cells, OK for prevalence of canopy over larger areas
Residential development	2000	US Census	Component of Energy Consumption threat	F	G	G	E	F	No adequate energy use data available, this data is a proxy for actual use
Commercial development	2001	National Land Cover Data	Component of Energy Consumption threat	F	G	G	E	F	No adequate energy use data available, this data is a proxy for actual use
Communities	2009	FRAP 2009 (incorporated cities)	Reporting unit	E	E	E	G	E	
Communities	2000	US Census (unincorporated communities)	Reporting unit	F	F	P	F	F	Census data sometimes drew huge boundaries around small communities, and missed small population centers that should have been included

Urban-Rural	2000	US Census	Identify urban area, defines the “footprint” for where urban forests may occur	F	G	G	E	E	

1. P = Poor F = Fair G = Good E = Excellent

Appropriate Use and Limitations

These analyses are designed to quantify the relative amount of priority areas over reporting units (communities, counties, bioregions), not identify specific areas for tree planting or maintenance.

Priority landscapes were identified using general ranking criteria of the most recent data available and may be constrained by the model, which may not capture all current conditions. The model does not represent all urban forestry benefits and specifically targets air pollution reduction and energy conservation only.

The model did not consider topography or changing conditions that could only be captured in a complex model. As such, the identified priority areas should be used only as a general guideline with the understanding that all priority landscapes or high value project areas may not be depicted because of data limitations.

The model calculation for canopy does not decipher if canopy is a result of tree planting efforts or because an urbanized area is built in the forest. Hence, some areas that are "urbanized forests" may be represented as a HPL maintenance community.

Energy use data was a derived ranking based on the assumption that energy use went up when the temperature was over 90°, or in the presence of urban heat islands. Additionally, the type and age of structures were not considered. Older and poorly insulated buildings can use considerably more energy than a newer energy efficient structure.

The model does not identify suitable planting spots, only areas that would benefit from such efforts. Some identified areas may offer few suitable planting sites and may require creative strategies.

Data Gaps and Data Improvements

We examined various data sources related to energy use, and could not find any sources more specific than the county level. Ideally, we would like to identify communities that are more energy efficient, for example based on local ordinances or programs that promote energy efficiency or use of "green energy" sources such as solar. Thus, we simply used housing density and commercial development as a proxy for energy use.

Data currency is an issue for numerous datasets used in the analyses, since residential and commercial development, impervious surfaces, road density, and tree canopy in reality is fairly dynamic.

We should consider an alternative way to designate and map unincorporated communities, and to maintain boundaries more frequently than once a decade.

Citations

Hidalgo, H.G., M.D. Dettinger and D.R. Cayan 2008. Downscaling with constructed analogues: Daily precipitation and temperature fields over the United States. CEC Report CEC-500-2007-123, Sacramento.