


Trees and Power Lines:

Minimizing Conflicts between Electric Power Infrastructure and the Urban Forest

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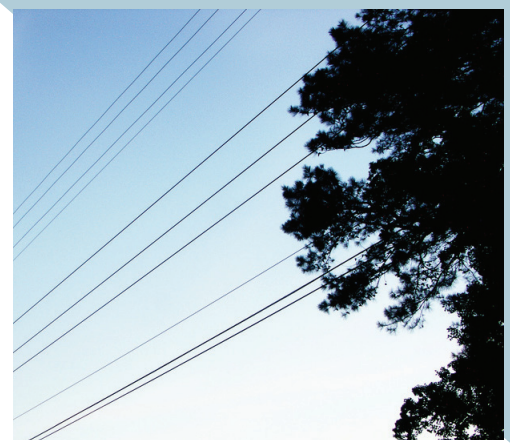


1. Executive Summary

Trees and overhead power lines are not easy companions in the urban landscape. Cities and their inhabitants plant trees in order to provide safe and pleasant pedestrian environments, cool the urban landscape, improve storm water management, provide wildlife habitat, and mitigate climate change. At the same time, electric utilities spend billions annually on trimming and (often) removing those same trees to enhance reliability and public safety related to electric service.

When trees and power lines share space too closely, the result can be power outages and fire. Large trees planted too close to power lines inevitably require expensive trimming or removal. Urban forests have the potential to be useful tools in dealing with climate change mitigation and adaptation, but widespread tree pruning and removal prevents urban forests from fulfilling this potential.

Trees and overhead power lines are not easy companions in the urban landscape. Cities and their inhabitants plant trees in order to provide safe and pleasant pedestrian environments, cool the urban landscape, improve storm water management, provide wildlife habitat, and mitigate climate change.

In many cities, the vast majority of street trees and a significant portion of trees on private property are located beneath utility lines. Many of those trees require pruning, and about one in ten of those trees have to be 'topped.' Topping involves removing the tree's crown, damaging it and leaving it open to insect infestation and disease. Such trimming reduces the positive benefits of an urban forest and slows its growth. The result is a serious conflict between the spatial needs of a valuable urban forest and the needs of the city's electrical infrastructure.

Conflicts between trees and power lines arise for a number of reasons, but most fundamentally trees continue to be planted under power lines that will grow into the wires overhead. This continues despite enormous efforts at public education. The problem may be that private property owners do not have an incentive to consider power lines when planting new trees. They do not bear the costs of pruning or tree removal, which are spread instead among all of the utility's electrical consumers. Existing city tree ordinances address many issues, but rarely deal with interactions with power lines – and when they do, they only cover street trees. The complete absence of rules guiding planting decisions on private property is a substantial gap, considering that trees on private residential property comprise nearly half of some major California cities' urban forests.

Proposed Solutions

1. ***Revision of Municipal Tree Ordinances***

   In most of California, there is no law stopping a private property owner from planting a tree of any type directly under power lines, and almost no law that allows a city or utility to remove newly planted, potentially problematic trees. Revising municipal tree ordinances to define tall-growing trees planted under powerlines as 'nuisance trees' would allow cities and utilities to replace problem trees with species more appropriate for the location, and possibly shift the cost of replacement to the person who caused the problem.

2. ***Cooperation Between Utilities and Local Governments:***

   Utilities and local governments collaborate only minimally on vegetation management. Cities that have developed programs to coordinate with utilities have had great success and can be used as a model.

3. ***Tree and Utility Inventories***

   Inventories of trees and utility infrastructure in urban areas could help assess the scope of the problem and allow for targeting of replanting efforts. Additionally, a more precise quantification of the ecosystem service values of urban forests would help local governments and utilities with cost-benefit analysis for decisions such as when and where to move power lines underground.

4. ***Tree Replacement or Preemptive Planting by Utilities and Government***

   Replacement of potentially problematic trees with more appropriate species pays for itself. A utility can recover tree replacement costs in as little as five years and then produce more than $18,000 in pruning savings per thousand trees per year plus savings from fewer power outages and repairs.

5. ***Planning Power Line Placement Around the Urban Forest***

   Cities and utilities planning out the location of new transmission lines should take into account the shape of the urban forest, especially when deciding where to place underground power lines.

2. Introduction

Trees and overhead power lines are not easy companions in the urban landscape. Cities and their inhabitants plant trees in order to provide safe and pleasant pedestrian environments, cool the urban landscape, improve storm water management, provide habitat for birds and squirrels, and mitigate climate change. At the same time, local electric utilities spend millions on trimming and (often) removing those same trees to enhance reliability and public safety related to electric service. When trees and power lines share space, the result can be power outages and fire. Large trees planted too close to power lines inevitably require expensive trimming or removal. Urban forests have the potential to be useful tools in dealing with climate change mitigation and adaptation, but widespread tree pruning and removal prevents urban forests from fulfilling this potential. This paper looks at the costs of conflict between California's urban forests and its electrical infrastructure, and possible solutions to mitigate that conflict.

California is a particularly good place to look for solutions to negative interactions between trees and power lines because of the state's focus on addressing climate change. The last decade in California has seen increasing attention on climate change issues. In June 2005, Governor Schwarzenegger established state greenhouse gas emissions reduction targets in Executive Order S-3-05. The Executive Order aims for greenhouse gas emissions reductions to 2000 levels by 2010; 1990 levels by 2020; and 80 percent below 1990 levels by 2050. The executive order was followed by AB 32, the California Global Warming Solutions Act of 2006, the first enforceable statewide program to limit greenhouse gas emissions from all major industries. These were followed by SB 97 in 2007 and SB 375 in 2008, which further seek to mitigate the state's contributions to global climate change. California recognized in its Climate Adaptation Strategy that urban forests can aid in both climate change mitigation and adaptation.[3] Urban forests are not merely a sideshow when it comes to addressing climate change. Nearly a quarter of the contiguous United States' tree canopy cover is found in urban forests, which are made up of more than 74 billion trees.[4]

California's growing urban area encompasses about 5% of its land and 94% of its citizens.[5] Those urban areas are subject to environmental problems aside from climate change that can be mitigated by a healthy urban forest: 36 of its 58 counties received a failing grade for high ozone levels under EPA standards and 28% of the state's population live in high threat areas for air pollution and urban heat.[6] California's cities do not come close to American Forests' recommended average of 25% tree canopy for the dry west.[7] Despite the wide ranging benefits of a healthy urban forest, urban forestry is an emerging discipline and is just starting to be recognized for its public benefits.[8] Among other purposes, this paper seeks to create a wider recognition of those benefits.

FIGURE 1 . A San Francisco tree is caught among electrical lines of various kinds. Photo by author.

3. Identification of the Problem

"Trees grow up. This is a law of nature." [9]

Conflicts between trees and power lines exist because electricity is conveyed through power lines at high voltages. High voltage electric current can arc out beyond the line if grounded by something like a tree, resulting in the possible interruption of service or ignition of fire even without physical contact.[10] Power lines come in two basic types: transmission and distribution. Transmission lines are large lines on bigger utility poles and towers with larger insulators between the pole and wire. They carry large volumes of power from generation facilities to substations in local communities. Distribution lines transmit power down city streets from local substations to specific buildings. Generally, power lines are the highest lines on a utility pole and are insulated from the pole.[11] Lower down on a utility pole are telephone and cable television lines, which carry just a few volts and will only cause a problem if direct contact with tree branches rubs the protective layers off of the wire.[12]

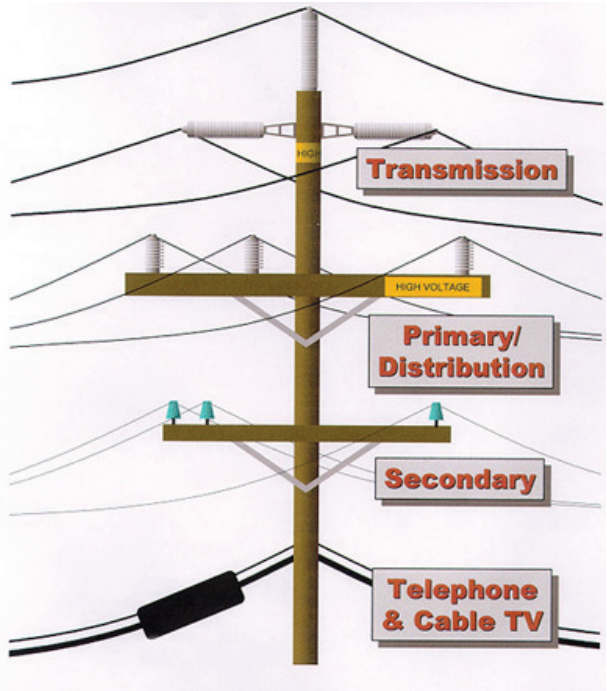
In some large cities like San Francisco, the vast majority of street trees and a significant portion of trees on private property are located beneath utility lines.[13] Many of those trees require pruning, and about one in ten of those trees have to be 'topped.' Topping involves removing the tree's crown, damaging it and leaving it open to insect infestation and disease.[14] Such trimming reduces the positive benefits of an urban forest and slows its growth. The result is a serious conflict between the spatial needs of a valuable urban forest and the needs of the city's electrical infrastructure.

This problem is not new. At the 1947 National Shade Tree Conference H.O. Drennan of the Carolina Power & Light Company said:

> This high place of importance given line clearance will be magnified in the future, since the poll also indicated trends toward higher voltages on urban distribution systems—meaning that the continuity of utility service is based on the Arborist's ability to provide an adequate right-of-way for these wires and conductors to every user, residential, commercial, or industrial. This is a real challenge to the Arborist since every one of the other items can be handled by using utility crews.[15]

This problem is also not minor. Despite extensive efforts to educate about how to choose tree species and planting sites that minimize conflict with power lines, tall trees continue to be planted below high voltage conductors. In a Phoenix tree inventory, more than 70% of trees counted where planted such that they would need to be removed.[16] In Bakersfield, CA, a developer planted 300 redwood trees directly under power lines and declined to move them when it was pointed out that they would inevitably have to be pruned back or removed.[17] Furthermore, as climate change causes extreme heat and wind events to increase in frequency, power lines are more likely to contact trees and increase the frequency of greater power outages and fires.[18]

FIGURE 2 . Diagram of Electrical Power Lines. Courtesy of PG&E.



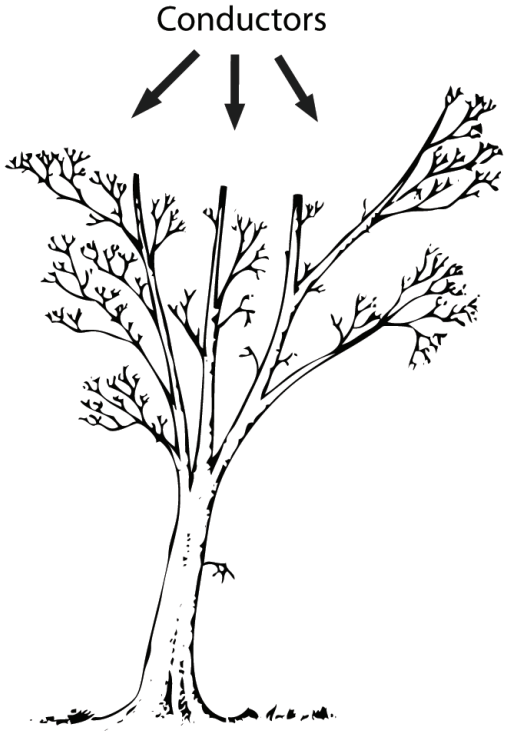
4. Costs of Conflict Between Urban Trees and Power Lines

One way to assess the scope of the problem is to look at the costs that are generated when trees and power lines exist in close proximity. The cost of pruning trees away from power lines is enormous. For example, Pacific Gas & Electric (PG&E), one of four major utilities in California, spends more than $180 million annually to trim trees.[19] PG&E's Vegetation Management Department patrols and assesses pruning needs of every part of its 132,000 miles of line every year.[20] This task requires more than 350 foresters and more than 600 tree crews.[21] Furthermore, PG&E's vegetation management budget has grown by about 20% in the last six years and is nearly triple what it was just more than a decade ago.[22]

The vegetation management process requires the pruning or removal of thousands of trees per day,[23] which has a huge effect on the health of the urban forest and returns tons of stored carbon back into the atmosphere.[24] Vegetation management also includes the use of tree growth chemical regulators to slow the growth of trees and general herbicides to clear the areas under power lines and around utility poles.[25] These chemicals could potentially harm the environment.

Failure to sufficiently manage the interface between trees and power lines can have devastating results. It is generally accepted that trees growing into or falling onto power lines are the single largest cause of electric power outages.[26] The August 2003 blackout in the American Northeast – one of the most widespread blackouts in history – was caused in part by several transmission lines in Ohio hitting inadequately trimmed trees and going offline.[27] That blackout resulted in power outages for 50 million consumers and an economic impact estimated as high as $10 billion. In addition to electrical outages, power lines close to trees cause fires. Power lines are responsible for only about 3% of ignitions in CAL FIRE jurisdiction, but have caused four of the 20 largest fires in California history.[28] Fires caused by trees hitting power lines have resulted in settlements in the tens of millions of dollars.[29]

FIGURE 3. The Undesirable Method Of Tree Pruning Around Power Lines Called 'Topping.' Courtesy of Miller 1997.



5. Benefits of the Urban Forest

In addition to looking at the costs of mismanagement, it is important to look at the value of a healthy urban forest. According to one estimate, a single street tree returns more than $90,000 of direct benefits (not including aesthetic, social and natural) over its lifetime.[30] Many of these benefits relate to climate change. Most obviously, carbon sequestration and the reduction in urban energy consumption contribute to the mitigation of global warming. Other classes of benefits can aid with adaptation to climate change and the secondary effects of global warming. Adaptation-related benefits include temperature moderation, air quality improvement, and storm water effects,[31] as well as the necessary role urban forests play in allowing tree populations to migrate as local conditions change due to global warming.[32]

Carbon Sequestration

The most direct process linking trees to climate change mitigation is carbon sequestration. Global climate change is caused by high levels of carbon dioxide and other greenhouse gasses in the atmosphere trapping heat from the sun. As trees grow, they absorb carbon dioxide (CO_2) and release oxygen (O_2), turning the carbon into the main substance of their leaves, roots, branches, and trunk. Carbon makes up 45-50% of the dry-weight biomass of trees.[33] By this process, the growth of trees in an urban forest can reduce atmospheric levels of carbon dioxide and slow the process of global heating.

The expansion of urban forests can significantly aid California in meeting its climate change mitigation goals. The California Global Warming Solutions Act of 2006 (AB32) requires a reduction in greenhouse gas emissions to 1990 levels by 2020,[34] which amounts to a reduction of 173 Mt (million metric tons) per year from the predicted level in 2020.[35] Arial photography of California cities has found 242 million empty tree planting sites, which if filled with trees would sequester about 21.78 Mt of carbon dioxide annually.[36] This would fulfill 12.6% of the reductions necessary for the state to meet its goal.

It is true that carbon dioxide is released through the process of tree planting and maintenance through fuel consumption by vehicles and equipment, but that release is only 2-5% of the emission reductions obtained through sequestration and reduced power plant emissions.[37] The carbon sequestration benefits of trees can be lost to decay, mortality, and stress, so it is important to maximize the health of the urban forest.[38]

Property Value

One U.S. Forest Service estimate suggests that home market values are pushed upward by the presence of trees at rates from 7-20%.[39] A similar effect has been found in commercial areas, where businesses on treed streets have been found to have 20% higher income streams than those without trees, perhaps because cool, shady, attractive areas have more of a draw for customers.[40] One study showed that in tree-lined commercial districts shoppers report more frequent shopping, longer shopping trips, and willingness to spend 12% more for goods.[41]

Street Safety

Street trees buffer pedestrians from potentially hazardous traffic and provide spatial definition to the public right-of-way. By creating vertical walls and a defined edge, trees help motorists guide their movement and assess their speed.[42] Trees along street curbs have been shown to significantly affect drivers' perceptions of safety and reduce their driving speed.[43] Perhaps for these reasons, there are fewer and less severe crashes on streets with streetscape enhancements.[44]

Temperature Moderation and Reduction in Energy Consumption

Trees are ideal devices to moderate temperatures in cities – they cool urban areas when it is hot, and warm them when it is cold. Cities tend to be warmer than rural areas by 0.5-1.5º C, requiring extra use of power intensive air conditioning during summers.[45] Trees can reduce the temperature of urban areas by more than 3.5º C.[46] Trees cool their environment in several ways. First, they reduce temperatures by intercepting solar radiation (which conveniently occurs only during warm months; in the winter, deciduous trees are leafless and allow the sun through). The shade effect of trees can even lengthen the lifetime of street pavement by 40-60% by reducing the daily expansion and contraction of asphalt, requiring less frequent repair or resurfacing.[47]

Additionally, trees cool urban areas through the process of evapotranspiration, in which water is brought up through roots and evaporated off of leaves. Just as the evaporation of sweat cools the human body, evapotranspiration cools a tree and the nearby environment. A single tree can transpire approximately 88 gallons of water per day, which provides the cooling power of five average room air conditioners running 20 hours a day.[48] California's 177 million urban trees are estimated to save 6,400 GWh in annual electricity use for air conditioning, equivalent to seven 100 MW power plants.[49] A recent paper estimated that planting 100 million trees in residential locations in the U.S. could save approximately $2 billion dollars in energy costs per year.[50]

Trees also warm cities when temperatures are low. Cities primarily cool down by emitting infrared radiation into the atmosphere at night; trees reduce that heat loss.[51] Trees planted in between buildings and cold winter winds can block the wind and provide insulation that can help keep the building warm.

The U.S. Forest Service has estimated that well-positioned trees can reduce energy use in conventional houses by about 20–25% by shading houses in summer and shielding them from wind in winter.[52] This is particularly important in California, which is likely to experience significant energy shortages during future heat waves.[53]

Air Quality

California possesses three of the country's top four most polluted cities in the categories of short-term particulates, long-term particulates, and ozone, plus the top 11 most polluted counties for ozone.[54] Urban forests can mitigate all these problems.

By reducing urban temperatures tress also reduce the formation of ozone and smog.[55] They remove airborne particles by trapping them and by increasing humidity (which washes particulates out of the air).[56] Moreover, trees directly absorb air pollutants like ozone, carbon monoxide, nitric oxide, and sulfur dioxide.[57] Annually, trees in Sacramento County alone remove about 665 tons of ozone and 748 tons of particulate matter smaller than 10 micrometers.[58] Tree cover in urban areas can help reduce the incidence of respiratory diseases, which means fewer workdays lost and a lower burden on the health care system.[59] Trees can even mask unpleasant odors associated with city life via direct absorption or by producing more agreeable foliar or floral scents.[60]

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Water Quality, Stormwater, and Erosion

Urbanization increases the environment's impermeable surfaces, creating significant storm water management challenges that the urban forest can ameliorate. Trees absorb the first 30% of most precipitation through their leaf systems and up to another 30% of precipitation is absorbed into the ground and captured by the roots, which brings it back into the air through transpiration.[61] Studies show that tree canopies intercepting rain in Salt Lake City reduce surface water runoff in a 12-hour, one-inch rainstorm by about 11.3 million gallons, or 17%.[62] This stormwater retention capacity is of great value. For example, creating stormwater management infrastructure to replace San Diego's urban forest would cost an estimated $164 million.[63]

Electric and Magnetic Field Shielding

Operation of electric power transmission lines introduces electric and magnetic fields into the urban environment. Electric and magnetic fields underneath overhead transmission lines may be as high as 12 kV/m. The health impacts of electric and magnetic fields are not fully understood, but analysis by the National Academy of Sciences in 1996 suggested that

residence near power lines was associated with an elevated risk of childhood leukemia.[64] Similarly, a 1998 panel of the National Institute of Environmental Health Sciences concluded that some types of fields should be considered a "possible human carcinogen,"[65] but later scientific reviews in 1999 and 2001 used more moderate language.[66]

Whatever the eventual consensus on the risk of electric and magnetic fields, trees can provide shielding against electrical fields. They are not, however, effective shielding against magnetic fields.[67] Electrical field shielding is one of the few benefits of an urban forest that actually arises from the proximity of trees and power lines.

Other General Benefits

There are other, less tangible benefits to living around trees. Hospital patients who have a view of trees heal faster and require less pain-killing drugs than those without such a view.[68] Spending time around trees simply can reduce stress,[69] and trees can create a distinctive sense of place. Trees can soften and screen necessary street features such as utility poles, light poles and other needed street furniture.[70]

The urban forest contributes to a positive image of a community and is viewed as a factor in the quality of life of a city. "Harmony with nature" and "livable built environments" are two of the core values of sustainable development reflected in successfully local development regimes.[71] There are even suggestions that tree-filled neighborhoods experience lower levels of domestic violence and crime.[72]

Trees also provide wildlife shelter,[73] glare reduction,[74] and noise reduction of upwards of 8-12 dB, when comparing tree-shrub-grass combinations to hard surfaces.[75] [76] Trees can even make a commute seem shorter – a trip through a treed environment is perceived to take less time than an equivalent trip without trees.[77]

The urban forest also creates jobs. Preliminary data indicates that total output associated with the urban forestry industry in California was almost $5.4 billion in 2008, the result of nearly 52,000 jobs and associated labor income and tax revenue.[78]

6. History of the Urban Forest in America

Recognition that an urban forest is a desirable thing in American cities dates back to the turn of the 19th century. Prior to that, some cities had no street trees because insurance companies would not insure houses with trees in front of them.[79] Changing values resulted in 1807 legislation for the Territory of Michigan requiring tree planting on Detroit squares and boulevards.[80] Similarly, the commission charged with selecting the Mississippi capital in 1821 recommended that the new capital have every other block filled with native vegetation or a grove of trees.[81] The first Arbor Day was sponsored in 1872 by the Nebraska Board of Agriculture and involved the planting of more than a million trees.[82] During the early twentieth century most large cities and many medium sized communities initiated city forestry programs to plant and care for street and park trees. Smaller cities and towns engaged in tree planting projects, but many did not establish city forestry programs until Dutch elm disease attacked their tree populations in the 1950s, 60s, and 70s.[83]

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However, as mass housing became the norm beginning in the 1930s, trees were removed to accommodate construction and not replaced. This trend didn't begin to reverse until the late 1960s when home buyers started placing higher premiums on wooded parcels.[84] Federal investment in urban forests began in the early 1970s, with federally funded programs in urban forestry at the Pinchot Institute of Environmental Forestry Studies and U.S. Forest Service.[85] The Cooperative Forestry Assistance Act of 1978[86] authorized the Department of Agriculture to provide financial and technical assistance to state urban foresters, a commitment that was expanded as part of the 1990 Farm Bill.[87] More recently, the 2008 Farm Bill tweaked federal involvement in urban forestry by requiring each state to complete Statewide Forest Resource Assessment and Strategy that delineates priority urban forest areas and issues.[88] As the result of state and federal mandates, California performed forest resource assessments in 1979, 1988, 1996, 2003, and 2010.[89]

Currently, tree planting programs across the country are sponsored by governments at all levels – local, state, and federal. In California, CAL FIRE provides grants of up to $100,000 for urban tree planting projects through its Green Trees for the Golden State program[90] and smaller grants through the ReLeaf Urban Forestry Grant Program.[91] CAL FIRE's program specifically declares ineligible any project that will eventually conflict with overhead or underground utilities.[92] In Chicago, the Bureau of Forestry plants up to several thousand trees a year along public parkways.[93] The program was so successful that in 2009 nearly all the available locations had been covered.[94] Even more ambitiously, the Conservation Trees for Nebraska Initiative – a program seeking to plant more than a million trees per year – has partners among local, state, and federal agencies: local Natural Resource Districts, the Nebraska Forest Service and Department of Agriculture, and the federal USDA Natural Resources Conservation and Forest Services.[95]

7. Summary of California Law Affecting Urban Forests

Basic State Law Provisions

The California Civil Code outlines the most basic elements of the state's tree law, such as defining who owns a tree[96] and how a tree can be bought or sold.[97] The Civil Code also provides that if an owner's tree is wrongfully injured, they are owed three times the actual cost of damage to the tree.[98] The penal code classifies harming another's tree as a misdemeanor, but exempts trimming for the purpose of protecting or maintaining an electric power line.[99] In California, a homeowner has a right to cut back encroaching branches and roots from a neighbor's tree, but as of a 1994 court ruling that right is no longer absolute: the homeowner must consider the health of the tree and act reasonably when pruning.[100] The legislature has also expressed its support generally for aggressive tree planting and methods of pruning that promote the health of the trees, requesting that CAL FIRE distribute information about safe pruning methods.[101]

Power Line Clearances by Utilities

Prior to 1997, utilities were only required to maintain a "reasonable clearance" between power lines and foliage. However, large wildfires and two major blackouts caused by vegetation intersecting electrical lines caused the California Public Utilities Commission (CPUC) to tighten standards under General Order 95. Under Rule 35 of the General Order, utilities must maintain specific minimum clearances of tree branches and vegetation around overhead wires in all areas. Minimum clearances range from 18 inches to 15 feet in most situations, depending on the voltage of the power line, exposure to weather, and fire risk in the surrounding area.[102] Utilities are exempted from meeting clearance requirements if they cannot get permission to access the area around a power line to trim. Typically utilities require a right to access power lines as a condition of service to the consumer, and often they possess an easement for the purpose of maintaining the lines. Consumers have strong incentives to allow access: utilities do shut off power if a property owner keeps them out[103] and the property owner also faces liability for a fire if they prevent the utility from clearing a hazard.[104] Only 1-3% of property owners initially refuse to allow utilities access to trim trees, and the majority of those refusals are resolved through negotiation.[105]

General Order 95 provides a bare minimum clearance for all areas throughout California for which local fire fighters are responsible. Areas that are outside city boundaries fall within the CalFire or U.S. Forest Service jurisdiction and are more strictly regulated by state law and have minimum clearance requirements for high voltage lines ranging from 4-10 feet, depending on voltage.[106] Clearance must be sufficient to prevent vegetation from intersecting the power line considering foreseeable wind velocities, temperatures up to 120 degrees Fahrenheit, and character of the vegetation.[107] Within city boundaries, municipal tree ordinances can require additional clearance of power lines, but typically do not. Utilities are required to keep primary and secondary power lines clear, but the consumer is responsible for maintaining service wires – the power lines that bring electricity from a pole to the individual building.[108] Failure to make a power line safe from "all exigencies" can expose a utility to liability for a subsequent fire,[109] even if a tree that falls on the power line stands on private property or is outside of the utility's right of way.[110] As a result, many utilities have internal policies that require greater minimum clearances than the General Order, some ranging from 10-25 feet.[111] California regulation of power lines interaction with trees is substantially stricter than the rest of the nation – as of 2002, the California Public Utility Commission was the only utility regulatory body in the U.S. to have adopted mandatory clearance requirements.[112]

In addition to line clearance laws, the California Occupational Safety and Health Administration requires that employees trimming trees near power

lines be qualified and trained properly.[113] Further, the Federal Energy Regulatory Commission (FERC) requires utilities to have Transmission Vegetation Management Plans addressing vegetation inspections, clearances, qualifications of workers; mitigation plans, and an imminent threat process.[114] This standard has been problematic and is currently under revision. The standard requires that vegetation management "ensure" system reliability.[115] Since only tree removal and not tree trimming can truly ensure that branches will never intersect power lines, utilities have been more aggressive with their removal activities.[116]

California Urban Forestry Act of 1978

The Urban Forestry Act of 1978[117] guides the state to create and maintain sustainable urban forests. The act is implemented primarily through the California Department of Forestry and Fire Protection's (CAL FIRE) Urban and Community Forestry Program, which aims to "develop a regional and statewide cooperative effort to advance the development of sustainable urban and community forests."[118] Under amendments to the Act, a direct link is drawn between urban forestry projects and the mitigation of climate change.[119]

Pursuant to the Act, CAL FIRE provides technical assistance from seven Urban Forestry Field Specialists and gives out grants of between $2,500 and $500,000 for innovative urban forestry or greening projects. Projects that can be funded involve tree planting, tree inventories, urban forest policy and ordinance development, education, or any advances in urban forestry, urban greening, or the management of urban natural resources.[120]

Propositions 40 and 84[121] provide funding for projects under the Act. In the 2009/2010 fiscal year, CAL FIRE issued a total of $5,971,453.86 in grants to groups ranging from Adelante High School to the USFS Center for Urban Forest Research.[122] All projects must meet certain standards for nursery tree quality, planting procedure, and minimum maintenance, but the standards do not include any reference to considering the location of utility lines when planting.[123]

Urban Forest Protocols

In 2008, California approved Urban Forest Protocols developed by the non-profit Climate Action Reserve, under which local governments can account for, report, and verify greenhouse gas emission reductions associated with a planned set of tree planting and maintenance activities.[124] The goal of the protocols is to allow local governments to obtain offset carbon credits for planting trees in urban settings under AB 32's cap-and-trade system.[125] In February 2010 the Air Resources Board (CARB) rescinded its previous adoption of the first version of the Protocols in order to transition to a regulatory offset compliance system in which the Protocols will be incorporated by reference. CARB's staff subsequently recommended adoption of a revised version of the Protocols, but the board has yet to formally adopt them.[126]

The Urban Forest Project Protocol does make reference to negative interactions between trees and power lines, but only spends a few words on the subject. The Protocol recommends planting only small trees under power lines and that planters contact utilities for advice.[127]

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California Solar Shade Control Acts

The California Solar Shade Control Act of 1979 was enacted to protect solar panels from encroaching vegetation that would block access to sunlight.[128] It required that no plant may be placed or allowed to grow such that it shades a solar collector, excepting previously existing plants or their replacements. The result was that applications to install solar panels in residential homes were often denied because city street trees would need to be trimmed annually at the city's expense.[129]

In response to national attention surrounding a case in which two homeowners were criminally prosecuted under the Act for letting their redwood trees cast shade on a neighbor's solar panels,[130] the Legislature amended law through the Solar Shade Control Act of 2009 (Pub. Res. Code §§ 25981-25985). The 2009 Act exempts trees and replacements of trees that were planted prior to the solar panel. Trees are also exempted that are publically owned, protected by ordinance, or required as part of a landscape plan for the purpose of receiving an entitlement. However, the

Example: Purposes of the San Francisco Urban Forestry Ordinance

(San Francisco Public Works Code, Article 16, § 801)

- Optimizing public benefits of trees, including climate, abatement of air and noise pollution, reduction of soil erosion and runoff, enhancement of the visual environment, and promotion of community pride;
- To integrate street planting and maintenance with other urban elements and amenities;
- To promote efficient, cost effective management of the City's urban forest;
- To reduce the public hazard, nuisance, and expense occasioned by improper tree selection, planting, and maintenance;
- Equitable, sustained, and reliable means of funding urban-forest management;
- Enhancing the City's overall character and sense of place;
- Recognizing that trees are an essential part of the City's aesthetic environment;
- Promoting public participation and dialogue about tree removal;
- Recognizing that green spaces are vital to San Francisco's quality of life;
- Ensuring that landscaping in sidewalk areas maximizes environmental benefits, protect public safety, and limit conflicts with infrastructure.

2009 Act also increases the potential for legal conflict between trees and solar panels by expanding the definition of solar collectors to include panels installed at ground level.

Municipal Tree Ordinances

Approximately 80% of California cities have municipal tree ordinances.[131] There is an enormous diversity among tree ordinances in California. For example, the town of Mill Valley declares redwoods to be "heritage trees," giving them legal protection, while nearby Sausalito chooses to place a higher value on views, designating the quick growing and tall redwoods as undesirable.[132] Some cities regulate all kinds of trees, while others regulate only a single tree (e.g. the city of Thousand Oaks' tree ordinance only applies to oak trees).[133] [134] Most cities require that their employees and contractors follow pruning standards and avoid harmful 'topping' when trimming trees, but as of 2003 only a small minority required utility companies or private individuals to follow the same standards.[135]

Tree ordinances cover a variety of topics, including requiring tree planting in new development, dealing with hazardous or nuisance causing trees, protecting desirable trees, and protecting the urban forest during development. In a survey conducted in 2003, most of the responding city officials stated that requiring tree planting in new residential development is the most effective ordinance provision.[136] Tree ordinances also often regulate pruning by utility companies, requiring them to observe good arboricultural practices or notify the city before working on trees.[137]

Many cities' tree ordinances require permits to plant trees on streets or other publicly owned areas. Some cities require clearance from power lines in their ordinances or implementing regulations.[138] While some cities require that a planter consider conflicts with power lines when planting street trees, the authors of this paper do not know of any cities that have a similar requirement for planting on private property.

8. The Search for Solutions

Restating the Problem

Conflicts between trees and power lines arise for a number of reasons, but most fundamentally trees continue to be planted under power lines that will grow into the wires overhead. This continues despite enormous efforts at public education. Many utilities and cities have extensive 'Right Tree, Right Place' education programs that include mass mailing of information to consumers.[139] Detailed guidelines exist to help consumers make planting decisions,[140] including an extremely impressive and usable online software package called SelecTree produced by the Urban Forest Ecosystems Institute.[141] While these programs may have helped somewhat, some members of the vegetation management community believe they have been largely ineffective,[142] and major utilities like PG&E have not developed any process for evaluating their effectiveness.[143] The general population has a limited sense of how hazardous power lines are and how unsafe it is to have trees near high voltage conductors. Perhaps more importantly, few people recognize the difference between a telephone line and a power line.[144]

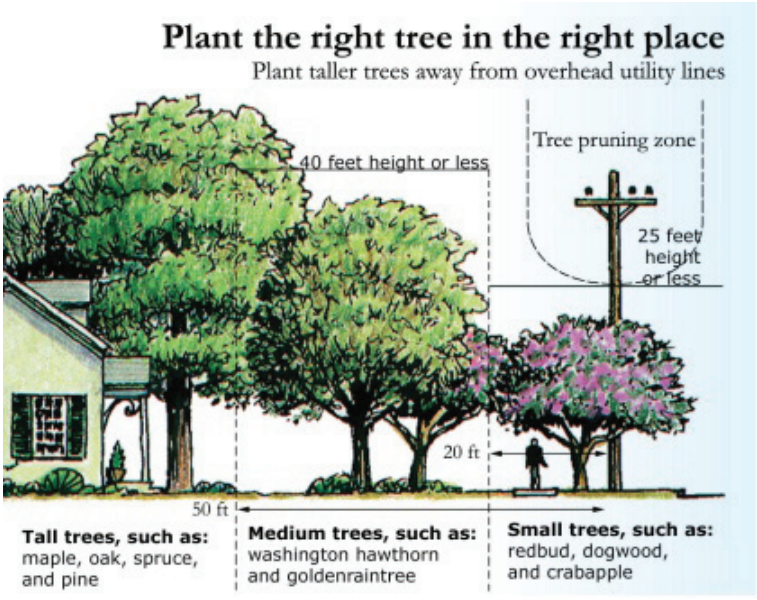
The problem may be that private property owners do not have an incentive to consider power lines when planting new trees. They do not bear the costs of pruning or tree removal, which are spread instead among all of the utility's electrical consumers. Existing city tree ordinances address many issues, but rarely deal with interactions with power lines – and when they do, they only cover street trees. The complete absence of rules guiding planting decisions on private property is a substantial gap, considering that trees on private residential property comprise nearly half of some major California cities' urban forests.[145] Generally, when cities themselves plant trees they are required to consider utility infrastructure when selecting location and tree type. More than ninety percent of the time, however, it is the developer rather than the city or homeowner who pays for and plants trees in new residential subdivisions.[146]

Documents more influential than public education guidelines tend to ignore or gloss over negative interactions between trees and power lines. California's Forest and Rangelands 2010 Strategy Report, while dealing with a number of urban forestry issues, does not address conflict with utilities.[147] The state's Urban Forest Project Protocol does make reference to negative interactions between trees and power lines, but only spends a few words on it, recommending to plant only small trees under power lines and contact utilities for advice.[148] Even model tree ordinances do not handle these issues.[149]

SOLUTION: *Revision of Municipal Tree Ordinances*

In most of California, there is no law stopping a private property owner from planting a tree of any type directly under power lines, despite the eventual consequences. There is also almost no law that allows a city or utility to

FIGURE 4. **An Example Of 'Right Tree, Right Place' Public Information Material Published By The City Of Riverside.**



remove newly planted trees when it is cheap to do so in anticipation of a problem. They typically must wait until the tree is an imminent danger– but by that point it is far more expensive to remove it. However, many cities regulate 'nuisance trees', and require that they be trimmed or removed at the owner's expense. Only one California city was found to have a nuisance tree ordinance that *explicitly* covers trees that may grow into power lines. The City of Fowler's municipal code provides that:

> Any tree or shrub growing in a public parking strip, public place, or on private property, which tree or shrub is endangering, **or which in any way may endanger**, the security or usefulness of any public street, sewer, or sidewalk or **the full and safe operation of public utility wires**, is hereby declared to be a public nuisance...and the City Superintendent may then remove or trim such tree and assess the costs thereof against the property.[150]

Any tree or shrub growing in a public parking strip, public place, or on private property, which tree or shrub is endangering, **or which in any way may endanger**, the security or usefulness of any public street, sewer, or sidewalk or **the full and safe operation of public utility wires**, is hereby declared to be a public nuisance...

The advantage of this ordinance, if enforced, is that the costs of dealing with a problematic tree are borne by the person most able to avoid them – the property owner who is most likely to have planted the tree. As one commenter said, "we have laws that forbid people from maintaining unsafe conditions on their property. We need legislation that makes it unlawful to maintain or cultivate any tree that is hazardous or which may come in contact with a power line and grants authority for utilities to remove unsafe trees without fear of lawsuits or reprisals."[151] Others have suggested charging private property owners if repeated pruning is needed for a certain tree, thus giving them the choice of keeping the tree or replacing it with a smaller species that would not require expensive pruning.[152]

Some cities have tree ordinances that could *plausibly* be used to remove trees before they become a problem. The City of Lakewood's code provides that:

> [A]ny tree or shrub growing wholly on private property but which, because of its physical condition, height, angle or lean, or other factor, is endangering or may in any way endanger the security or usefulness of any public street, sewer or sidewalk, **or adjoining private property,** is hereby declared to be a public nuisance.

Since power lines are presumably the private property of the utility that operates them, this ordinance might authorize the city to remove trees that will grow up to intersect lines.[153]

Most other cities reviewed with tree nuisance ordinances define a nuisance tree in such a way that it could not be used to deal with power line-tree conflicts before they become expensive. San Francisco, for example, requires that the tree pose "an imminent hazard to person or property."[154] Other cities require that the nuisance tree endanger the security or usefulness of a public sewer, street, public right of way, sidewalk or public place.[155] If more cities were to model their nuisance tree ordinances after Fowler and enforce them, private property owners would have a much greater incentive to not plant trees directly under power lines or plant shorter trees that are less likely to cause problems. This would be of great benefit to the efficient and healthy growth of the urban forest.[156] Greater city involvement in urban forest management on private land may have some support. As one commenter pointed out: "trees are large, long-lived organisms in urban areas – why wouldn't the city regulate that?"[157]

There are other related municipal ordinance changes that might achieve similar goals. Cities could move citizens towards efficient tree planting by requiring a permit to plant trees on private property, just as planting a street tree requires a permit. While the city could require that the private property owner demonstrate appropriate planting plans as a condition for receiving the permit, a system that sets up procedural roadblocks to tree planting would likely be detrimental to the urban forest.

SOLUTION: *Cooperation between Utilities and Local Governments*

There is currently minimal direct collaboration between utilities' vegetation management programs and local governments,[158] although such efforts may be increasing.[159] Utility/city direct cooperation typically occurs only when a problem arises, while it is local nonprofits that usual address forward-looking concerns.[160] The most common form of interaction

involves a local ordinance requiring utilities to obtain a permit to trim within city limits, allowing the city to exercise quality control.[161]

This regime of minimal cooperation creates significant inefficiencies. For example, often cities patrol their trees and cut branches off of the bottom to keep the streets clear, while utilities separately patrol the same trees and cut branches off of the top to keep lines clear. PG&E reports that it has attempted to combine these activities more than once, without success.[162]

PG&E's experience does not mean that efforts at cooperation are futile; other cities, notably Chattanooga, have had better results. Chattanooga hired a utility forester and a vegetation manager, and implemented a cooperative plan with the electrical utility that included: combining use of pruning and removal contractors; coordination of activities between the utility and the Public Works Department such as wood removal; joint arborist training; and GIS data sharing.[163]

Cities could approach improving cooperation by choosing from a diverse range of actions that include:

- A request that the city manager provide a report to the city council on the possible ways to incorporate utility knowledge and improve cooperation.
- Joint training programs or temporary staff exchanges.
- Periodic meetings between utility and city staff counterparts.
- Requirements that city planning departments incorporate utility knowledge into approval processes.[164]
- Allowing contractors and engineers to sit through 'pre-submittal' conferences with permit review teams.[165]
- Direction to the city manager to negotiate sharing of tree crews with utilities.
- An ordinance requiring that all tree planting meets utility 'right tree, right place guidelines.

SOLUTION: ***Tree and Utility Inventories***

Inventories of trees and utility infrastructure in urban areas could help address conflicts in several ways. First, they could help assess the scope of the problem. For example, while PG&E foresters assess every mile of every line every year to ensure that lines are clear,[166] they do not consistently count how many newly planted trees are likely to grow into power lines in the future.[167] Understanding the scope of the problem might encourage cities to take action.

Second, a more precise quantification of the ecosystem service values of urban forests would help local governments and utilities with cost-benefit analysis for decisions such as when and where to move power lines underground. The non-profit American Forests has pioneered a 'green data layer' accessible through a GIS software product called CITYgreen to help local elected officials make decisions that connect nature with growth.[168]

Third, urban forest inventories are often a necessary prerequisite to a program of planting or of replanting existing problem trees with smaller replacements. Some cities have carried out large scale inventories for this purpose in collaboration with electrical utilities.[169] Inventories of urban utility infrastructure would also be helpful for this purpose. A lack of such data in the past has prevented models from taking all tree-planting factors into account when identifying potential planting sites.[170]

Urban forest inventories are typically of two types: field surveys and remote sensing. Field studies involve either staff, volunteers, or consultants (usually costing about $3-5 per tree) locating trees with GPS and collecting data. Remote sensing involves assessing the urban forest via imagery from a plane or satellite, and can provide a more limited set of data at substantially less cost than field studies. High resolution infrared imagery can provide information on tree crown size and even species,[171] and can be used to identify potential planting sites.[172] The U.S.D.A. Aerial Photography Field Office acquires and distributes high resolution imagery on a seven-year cycle at no cost. Also, the U.S.G.S. office in Sacramento has very high resolution imagery for many cities and counties in California. Although there is no cost to local governments for use of this imagery, processing and distribution may take more than a year.

SOLUTION: ***Tree Replacement or Preemptive Planting by Utilities and Government***

One solution to the problem of tall trees interacting with power lines is to remove the trees and replace them with smaller ones or to preemptively plant small trees below power lines when the lines are first installed. Cities often use cultivated varieties of trees that have predictable growth patterns. These cultivars are sold by brand name and are clones of the parent, and so their shape and size can be largely known before

planting.[173] Cities and utilities can plant on publicly-owned land or on privately-owned land with the owner's consent – something that is not hard to get when the city or utility is paying for the planting.

SB 427, a 1999 bill in the California Legislature, sought a solution along these lines, but did not make it into law. The bill would have given utilities the power to remove trees that might potentially cause conflict with power lines, but required the utility to plant at least three trees for every inch of diameter of the removed trees.[174]

SB 427 would have allowed for a utility to recover its costs from consumers, a provision that was grounded in the idea that tree replacement would lead to a more-than-compensating reduction in long-term pruning costs and energy efficiency from shade trees. This proposition holds up in the real world. The review of one 2006 replacement program found that a utility can recover tree replacement costs in as little as five years and then produce more than $18,000 in savings per thousand trees per year from pruning alone, not to mention the savings from fewer power outages and repairs.[175] Tree replacement programs can have lasting benefits, as well. In 1960, the Pennsylvania utility company Penelec planted 3,000 compatible tree species under power lines. A survey 25 years later found 39% of the trees still present and in good condition – and none of them had required pruning since planting![176]

Tree replacement and preemptive planning could be a way to reduce conflicts between power lines and trees and grow the urban forest at the same time. An initial source of financial support in California might be the obtained from the $220 million in electrical efficiency grant money funded by AB1890 and disbursed by the CPUC.[177]

SOLUTION: *Planning Power Line Placement around the Urban Forest*

Greater undergrounding of electrical power lines is frequently suggested as a solution to tree-power line conflict.[178] Certainly that is the case in some areas, but there are drawbacks as well. Undergrounding power lines can cost in the millions of dollars per mile[179] and can delay restoring power in an outage. Even if not undergrounded, best management practices recommend that planning out the location of new transmission lines should take into account the shape of the urban forest.[180] This could even include creative ideas like criss-crossing power lines across streets so as to minimize contact with trees.[181]

9. Conclusion

Urban trees are infrastructure. In a time when strategies and solutions are badly needed to address climate change mitigation and adaptation, the urban forest becomes increasingly valuable. In order to grow capacity for this important urban infrastructure, all levels of government should look for solutions to minimize conflict between trees and power lines. These solutions may not always be cheap or politically popular, but the myriad positive impacts that trees have on the human existence make action worth the cost.

Appendix A: Legal Authority for Further Municipal Tree Ordinance Provisions

Several of the solutions suggested in this white paper involve instituting or extending municipal tree ordinances. Traditionally, tree ordinances that regulated private trees were based on the police power or the common law of nuisance and applied only to trees that posed a risk such as those that were dead or diseased. If the drafter of a tree ordinance seeks to mitigate conflict between trees and power lines, he or she may need to ground the ordinance on legal authority beyond traditional sources in order to avoid successful legal challenge. Some localities, like Fairfax County, Virginia, have based their ordinance on broader state environmental law. Fairfax County adopted an erosion and sediment control ordinance which it used to support an extensive tree protection program.[182]

Drafters of tree ordinances must consider four main legal issues that can affect tree conservation efforts on private property: (1) legislative authority; (2) vagueness; (3) takings; and (4) rational nexus.[183]

Legislative Authority

In addition to the general police power of cities and the law of nuisance, California state law allows any city to adopt ordinances that are necessary to meet local conditions of weather, vegetation, or other fire hazards, even if more restrictive than state statute.[184] Furthermore, nearly a quarter of California cities are 'charter cities', which gives them greater authority under the California constitution to regulate their own municipal affairs.[185] Charter city status may provide more latitude in passing tree ordinances that are founded on local benefits. If the purpose is for something broader like addressing climate change, however, it is likely that court would find that the ordinance is outside of the sphere of 'municipal affairs.'[186] This does not mean that the city cannot pass the ordinance – it just means that the ordinance cannot conflict with state law.

Vagueness

In order to survive a constitutional challenge for "vagueness," a tree ordinance must be clear enough such that a person of reasonable intelligence could understand what it means. Courts have historically been supportive of local governments' authority to set and apply environmental regulatory standards. Still, terms should be defined with as much precision as possible to avoid challenges – terms such as "minimal disturbance to the natural topography," "protection of the maximum number of mature trees," and "minimized to the greatest degree possible under the particular circumstances" have been struck down for vagueness.[187]

Takings

The Fifth Amendment of the U.S. Constitution and Art. 1, § 19 of the California Constitution prohibit the taking of private property for public use without just compensation. Unless tree ordinances deprive the owner of all or virtually all of the property value and leave no economically viable use, or prevent an investment-backed use, they are unlikely to be struck down.[188] However, there may be limits to the constitutionality of municipal tree ordinances that require action by private property owners. The Supreme Court held in 1994 that:

[t]he city's goal of...providing for public greenways, [is] laudable, but there are outer limits to how this may be done. 'A strong public desire to improve the public condition [will not] warrant achieving the desire by a shorter cut than the constitutional way of paying for the change.'[189]

The Rational Nexus Test

Ordinances that require tree replacement or other exactions can be challenged on whether the conditions imposed are reasonably related to the need created by the regulated party's actions. In order to avoid such challenges, on-site or off-site replacement or in-lieu-fee requirements should be linked to the number, type, and size of the trees removed. Any funds should be set aside in an exclusive fund and used in a timely manner.[190]

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