

# Getting the Most Out of Trees

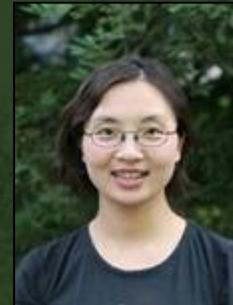
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Maximizing Energy, Air Quality, and Carbon Benefits

Kelaine Vargas, Urban Ecologist

Center for Urban Forest Research, US Forest Service

Center for Urban Forest Research  
USDA Forest Service  
PSW Research Station  
Davis, CA



# Conserving Energy





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## How California's Power Crisis Works

by [Kevin Bonsor](#)

California's power woes are worsening as power demands in the supplies. Even with the help from out-of-state sources, millions a outages. In the first few months of 2001, residents of California f of stage 3 alerts, which almost always precede rolling blackouts

The scene on the streets and in buildings in California is becom news. The lack of power paralyzes normal activity, with dead tra schools and businesses grinding to a halt. This crisis has been been building for years.

With the hottest months of the year ahead, the power crisis in C expects rolling blackouts to continue until utilities can increase th outside sources. In this edition of [HowStuffWorks](#), we will take a American history, what caused it and how it might spill over into country.

### The Roots of the Crisis

As you can imagine, there is a lot of finger-pointing going on in this most recent energy shortage. This crisis isn't something that that has been building for years. Here are a few of the factors th situation:

**CNN.com**  
**IN-DEPTH SPECIAL** In-depth Archive  CNN.com Sections

# Power Crisis

California's struggle to solve its energy crisis in the wake of the 1996 deregulation of its utilities market has nationwide implications, with 25 other states also moving toward deregulation



**California power crisis sends shock waves nationwide**

As rolling blackouts swept through parts of California, Energy Secretary Spencer Abraham warned the country that it faces its "most serious shortage" since the 1970s. In California, the crisis may have already begun. Wholesale electricity prices have risen dramatically in the past year.

[FULL STORY](#)  
[RECENT NEWS](#)

**FEATURES**

- [California power crisis sends shock waves nationwide](#)
- [The California power quagmire](#)
- [FAQ: What California's crisis means to the rest of the U.S.](#)
- [Deregulating California's electric utilities](#)

**STATISTICS**

- [U.S. home heating sources](#)
- [U.S. power generation](#)
- [U.S. residential gas prices](#)
- [World energy consumption](#)
- [Global electricity consumption](#)

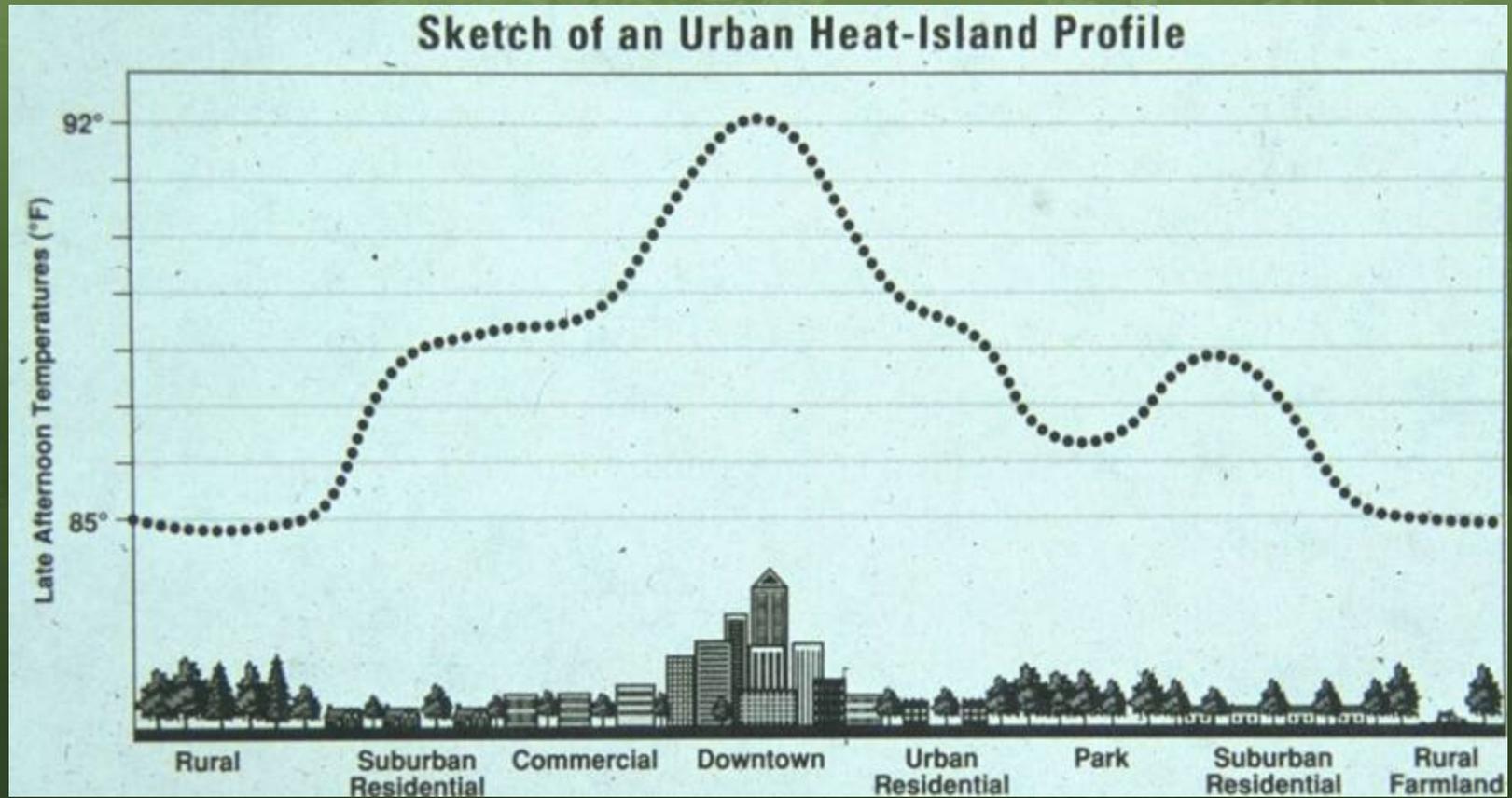
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# Conserving Energy

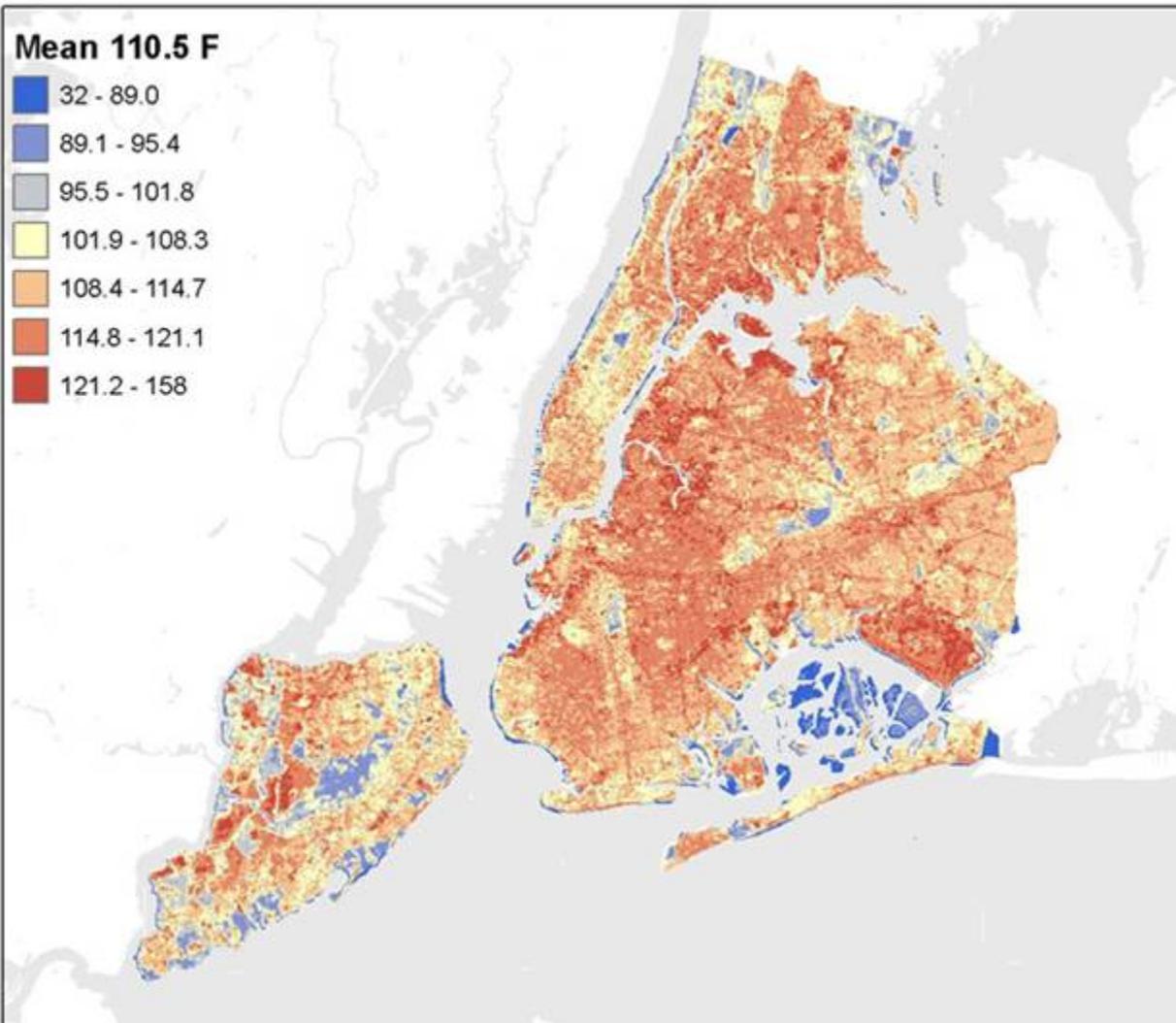


# Trees lower air temperature



# Mitigating NYC's Heat Island

**Landsat Surface Temperature August 14 2002 10:30am**



“Street trees...have the largest cooling potential per unit area...”

# Trees Conserve Energy

## Modesto's Municipal Trees

- Electricity saved: 12,700 MWh
  - Total savings: \$1 million
- Natural gas increase: 152 Mbtu
  - Cost: \$-1,233
- Total energy benefit: \$1,000,560



## Large tree (40 years old) in the San Joaquin Valley

- Electricity saved:
  - W: \$29.23
  - E: \$ 21.64
  - S: \$ 17.23
- Natural gas saved:
  - W: \$ 0.11
  - E: \$ 0.68
  - S: \$ -1.09
- Total:
  - W: \$ 29.34
  - E: \$ 22.32
  - S: \$ 16.14

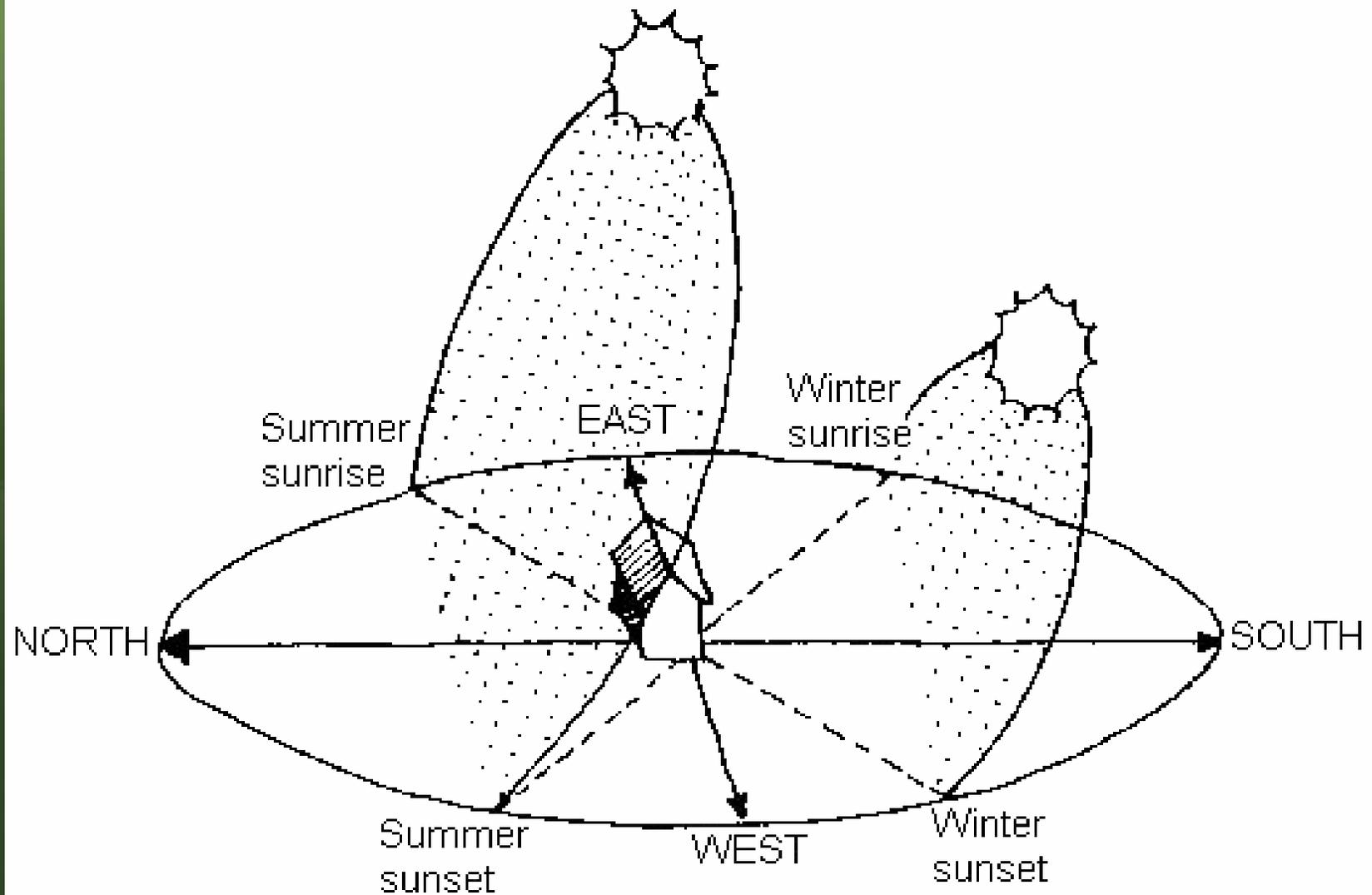
Plant lots of trees



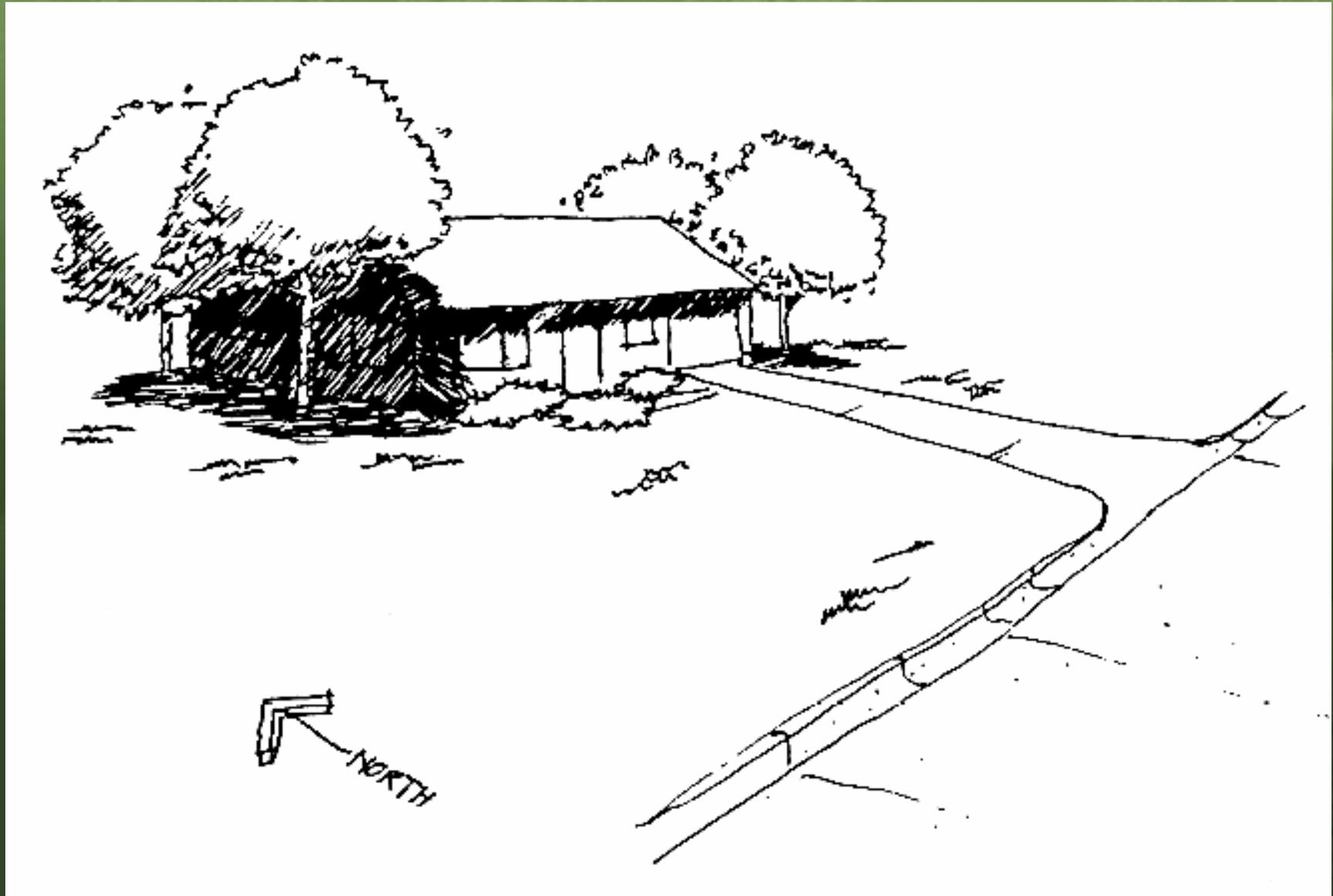
# Shade paved surfaces



# Plan for the sun



# Plan for the sun, pt. 2

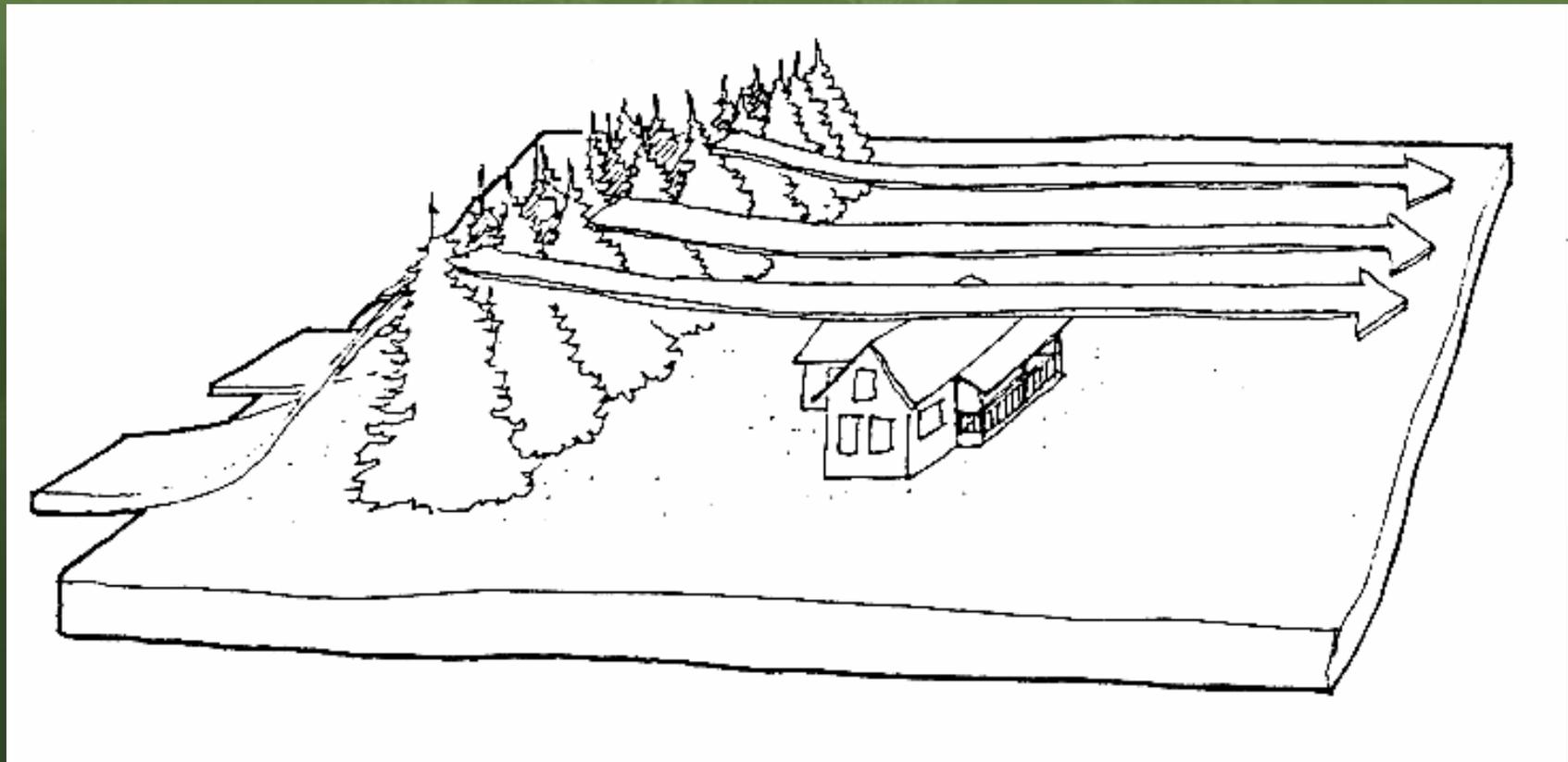




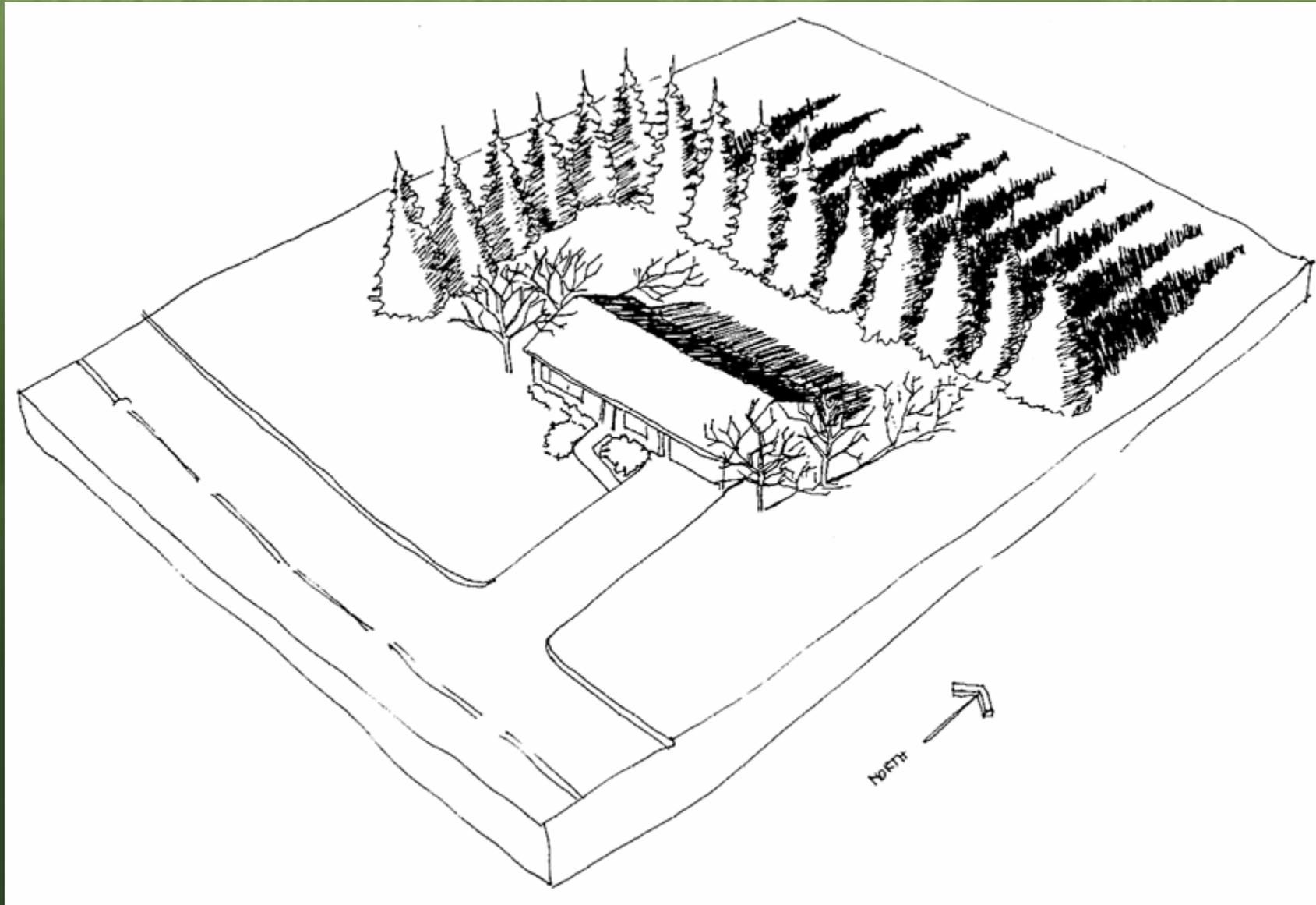
Plan for the sun, pt 3:  
Pruning on the south side



# Plan for the wind



# Plan for the wind and sun



# Choose species wisely



Evergreen



Solar-friendly



Solar-unfriendly

Choose species wisely, pt 2:  
Bigger is better



# Planting trees to save energy

- Plant lots of trees
- Shade paved surfaces and buildings
- Plan for the sun
  - West > east > south
- Choose species wisely
  - Bigger is better
  - Evergreen vs deciduous
  - Branching pattern



# For more information

## Save Dollars With Shade

A Community Tree Planting Solution to Conserve Energy

### Just Plant Trees

Imagine a solution to rising energy prices as simple as planting trees. We've all grown up with trees, climbed in them, and probably even planted a few. But how many of us know that they significantly contribute to cooling our homes, businesses and communities?

### Millions of Trees Still Needed

Studies in various parts of the West show that many communities have trees that produce shade and summer time cooling. However, Dr. Greg McPherson, Director, Center for Urban Forest Research, Pacific Southwest Research Station in Davis, California, points out that "over 100 million tree planting sites exist on the east and west side of buildings in the western U.S. with high energy saving potential. These sites need to be filled. Planting these sites will save billions of energy dollars and should be a high priority for all communities."

### Trees Conserve Energy By:

- Shading, which reduces the amount of radiant energy absorbed and stored by built surfaces.
- Evapotranspiration, which converts liquid water in leaves to vapor, thereby cooling the air.
- Reducing the velocity of wind, which slows the infiltration of outside air into inside spaces.

*Where would you rather live?*



*Strategically Placed Trees Save Energy Dollars*



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Telephone: 530-752-7636  
<http://cufsr.fs.fed.us/>



## GREEN PLANTS OR POWER PLANTS?



### What is the best solution for California?

#### Build more power plants or plant more trees?

Researchers at the Center for Urban Forest Research in Davis, California found that planting shade trees can reduce the need for power plants. The study shows that 50 million shade trees planted in strategic, energy-saving locations could eliminate the need for seven 100-megawatt (MW) power plants.

#### Are Trees Really the Answer?

According to the Center Director, Dr. Greg McPherson, "A tree must grow at least 5 to 15 years before it can fully contribute to the energy conservation process. However, if we don't invest in energy-conserving trees now, they will not be available in 15 years when the demand for energy will be even greater."

Planting trees  
can reduce the need  
for power plants



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# Improving Air Quality



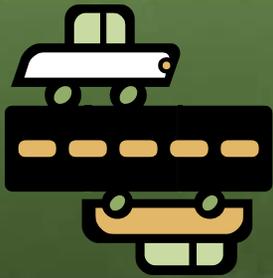
### 50 Worst Cities

Rank	Metro Statistical Area	Rank	Metro Statistical Area
1	<a href="#">Los Angeles, CA</a>	26	<a href="#">Hartford, CT</a>
2	<a href="#">Riverside-San Bernardino, CA</a>	27	<a href="#">Middlesex-Hunterdon, NJ</a>
3	<a href="#">New York City, NY</a>	28	<a href="#">Columbus, OH</a>
4	<a href="#">Philadelphia, PA</a>	29	<a href="#">Raleigh, NC</a>
5	<a href="#">Houston, TX</a>	30	<a href="#">Grand Rapids, MI</a>
6	<a href="#">Washington, DC</a>	31	<a href="#">Buffalo-Niagara Falls, NY</a>
7	<a href="#">Chicago, IL</a>	32	<a href="#">Richmond, VA</a>
8	<a href="#">Baltimore, MD</a>	33	<a href="#">Greensboro-High Point, NC</a>
9	<a href="#">Atlanta, GA</a>	34	<a href="#">Providence, RI</a>
10	<a href="#">Detroit, MI</a>	35	<a href="#">Denver, CO</a>
11	<a href="#">Fresno, CA</a>	36	<a href="#">New Haven, CT</a>
12	<a href="#">Sacramento, CA</a>	37	<a href="#">Salt Lake City, UT</a>
13	<a href="#">Bakersfield, CA</a>	38	<a href="#">Louisville, KY</a>
14	<a href="#">Dallas, TX</a>	39	<a href="#">Wilmington, DE</a>
15	<a href="#">Boston, MA</a>	40	<a href="#">Ventura, CA</a>
16	<a href="#">St. Louis, MO-IL</a>	41	<a href="#">Dayton-Springfield, OH</a>
17	<a href="#">Cleveland, OH</a>	42	<a href="#">Akron, OH</a>
18	<a href="#">Pittsburgh, PA</a>	43	<a href="#">Kansas City, KS/MO</a>
19	<a href="#">Fort Worth-Arlington, TX</a>	44	<a href="#">Allentown, PA</a>
20	<a href="#">Charlotte, NC</a>	45	<a href="#">San Antonio, TX</a>
21	<a href="#">Newark, NJ</a>	46	<a href="#">Birmingham, AL</a>
22	<a href="#">Memphis, TN</a>	47	<a href="#">Knoxville, TN</a>
23	<a href="#">Monmouth-Ocean, NJ</a>	48	<a href="#">Bridgeport, CT</a>
24	<a href="#">Indianapolis, IN</a>	49	<a href="#">Harrisburg, PA</a>
25	<a href="#">Cincinnati, OH</a>	50	<a href="#">San Diego, CA</a>

### 25 Most Ozone-Polluted Cities

2005 Rank	Metropolitan Area
1	<a href="#">Los Angeles-Long Beach-Riverside, CA</a>
2	<a href="#">Bakersfield, CA</a>
3	<a href="#">Fresno-Madera, CA</a>
4	<a href="#">Visalia-Porterville, CA</a>
5	<a href="#">Merced, CA</a>
6	<a href="#">Houston-Baytown-Huntsville, TX</a>
7	<a href="#">Sacramento-Arden-Arcade-Truckee, CA-NV</a>
8	<a href="#">Dallas-Fort Worth, TX</a>
9	<a href="#">New York-Newark-Bridgeport, NY-NJ-CT-PA</a>
10	<a href="#">Philadelphia-Camden-Vineland, PA-NJ-DE-MD</a>
11	<a href="#">Washington-Baltimore-Northern Virginia, DC-MD-VA-WV</a>
12	<a href="#">Charlotte-Gastonia-Salisbury, NC-SC</a>
13	<a href="#">Hanford-Corcoran, CA</a>
13	<a href="#">Cleveland-Akron-Elyria, OH</a>
15	<a href="#">Knoxville-Sevierville-La Follette, TN</a>
15	<a href="#">Modesto, CA</a>
17	<a href="#">Pittsburgh-New Castle, PA</a>
18	<a href="#">Youngstown-Warren-East Liverpool, OH-PA</a>
19	<a href="#">Columbus-Marion-Chillicothe, OH</a>
20	<a href="#">Detroit-Warren-Flint, MI</a>
20	<a href="#">Buffalo-Niagara-Cattaraugus, NY</a>
22	<a href="#">Sheboygan, WI 113,376</a>
23	<a href="#">Chicago-Naperville-Michigan City, IL-IN-WI</a>
24	<a href="#">El Centro, CA</a>
25	<a href="#">Lancaster, PA</a>

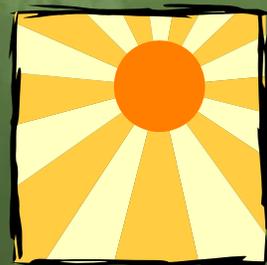
# Pollution



+



+



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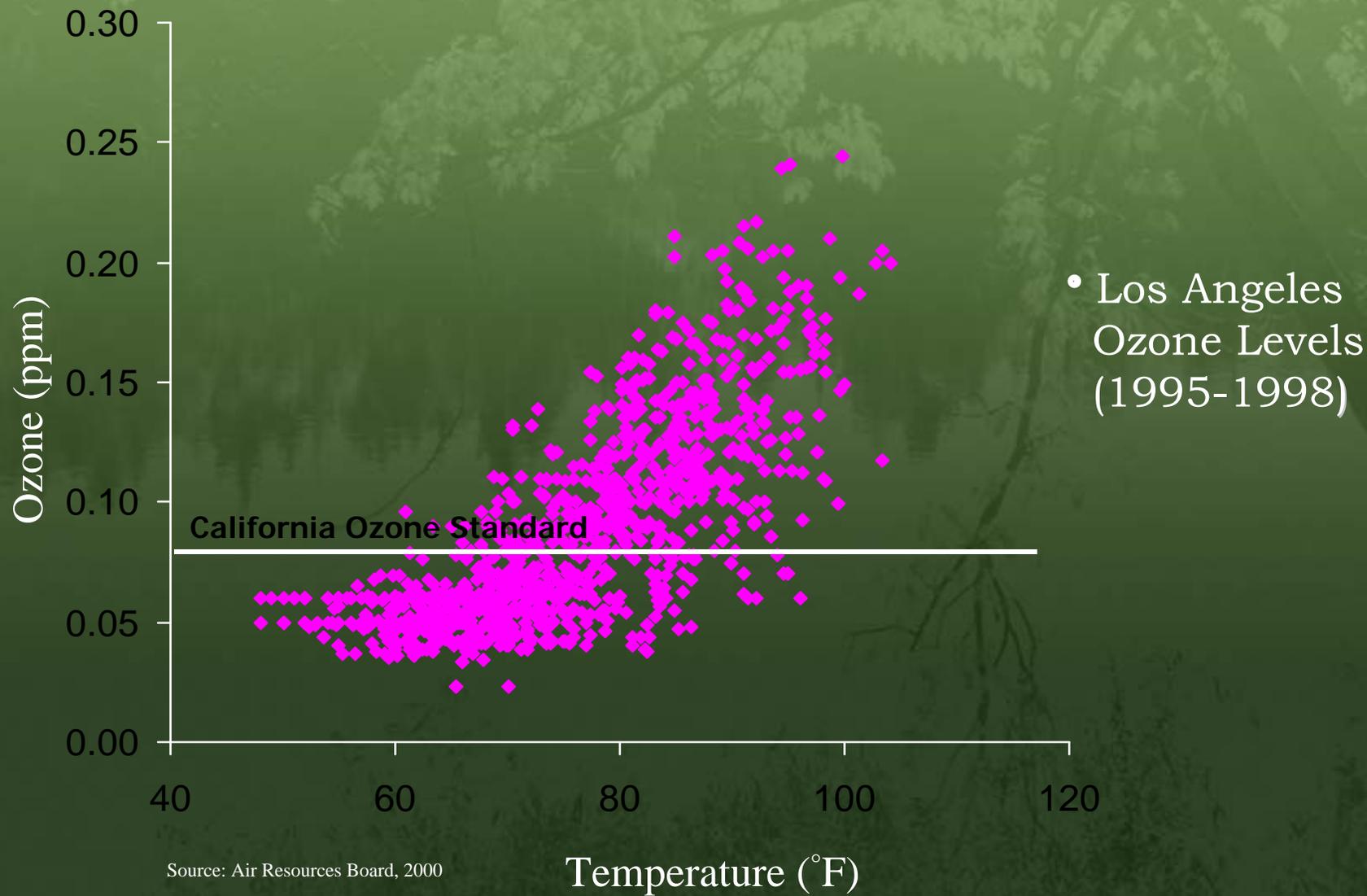
VOCs  
115 tons per day

NOx  
86 tons per day

Lots of sun

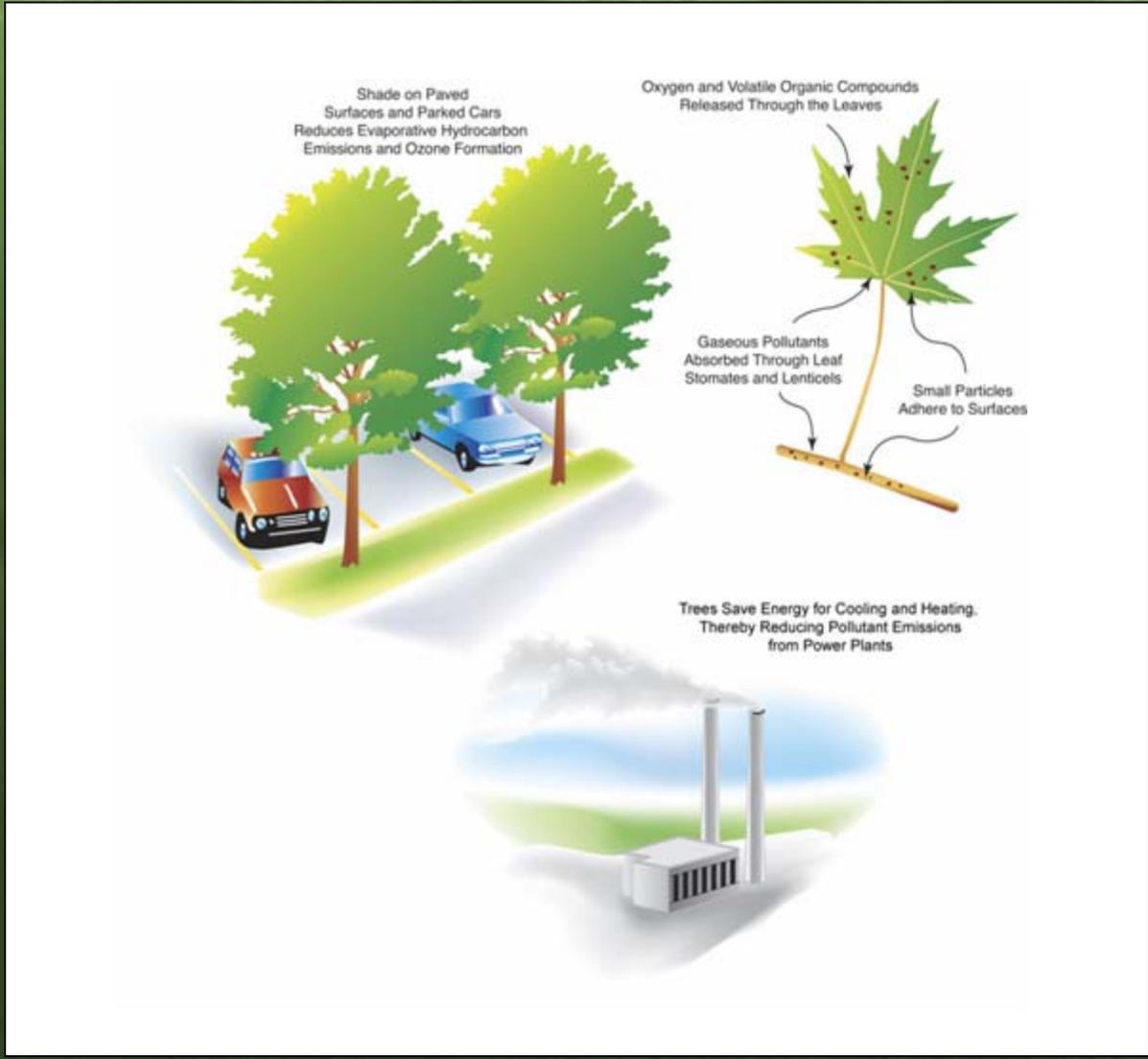
7<sup>th</sup> worst smog  
in the country

# Hotter Days Lead to Higher Emissions and More Smog



Source: Air Resources Board, 2000

# Improving Air Quality



# Trees Improve Air Quality

## Sacramento's urban canopy

- Ozone, 665 tons = \$16 million
- NO<sub>2</sub>, 163 tons = \$4 million
- PM<sub>10</sub>, 750 tons = \$8 million
- SO<sub>2</sub>, 30 tons = \$541,000
- Total, 1600 tons = \$29 million

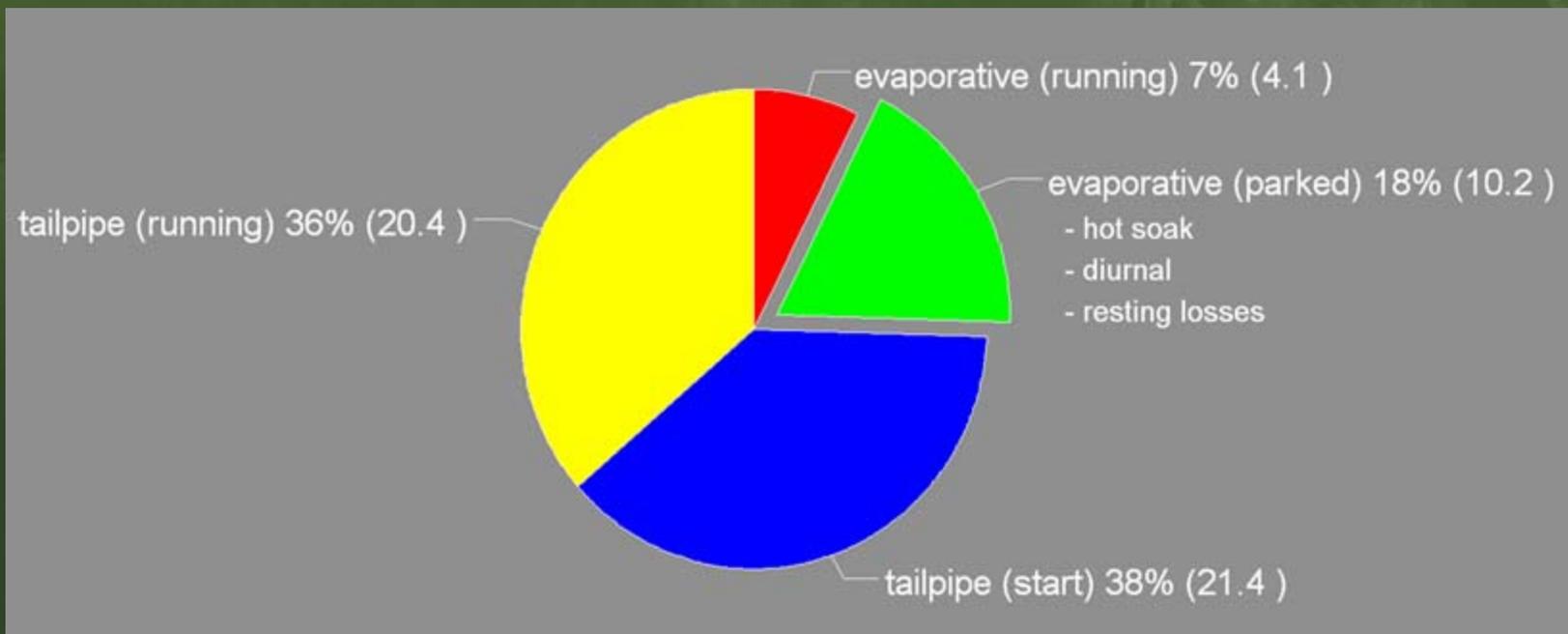
## Modesto's Municipal Trees

- Pear = \$2.98
- Chinese pistache = \$10.27
- London plane = \$25.76
- Modesto ash = \$52.61



# VOC emissions

- Vehicles produce 49% (56.1 tons per day)
- 18% of vehicular emissions (10.2 tons per day; 9% of total) are produced while vehicle is not operating
- Temperature sensitive



# Emissions Modeling

- Lots 3°F cooler
- Cabin 40-50°F cooler
- Gas temp 4-8°F cooler
- VOC reductions = 0.85 ton/day (2%)
  - Greatest savings for starts (50%)
  - Diurnal and hot soak each 25%
- NOx reductions = 0.1 ton/day (0.2%)
- Reductions equivalent to greater than other SMAQMD programs:
  - VOC: Vehicle retirement program (0.15 tpd); graphic arts + waste burning, etc. (0.9 tpd)
  - NOx: Vehicle retirement program (0.065 tpd)



# Conserve energy!!!

- Plant lots of trees
- Shade paved surfaces and buildings
- Plan for the sun
  - West > east > south
- Choose species wisely
  - Bigger is better
  - Evergreen vs deciduous
  - Branching pattern

# Prioritize planting sites



Choose species wisely: Bigger is better



## Choose species wisely, pt 2



Avoid pollutant-intolerant species



More leaf surface area  
Hairy parts and long stems  
BUT watch for BVOCs

# Planting trees to clean the air

- Reduce energy use!
- Species choice
  - Size (leaf surface area)
  - Pollutant-tolerant
  - BVOC emissions
- Shade parking lots
- Plant near pollution sources



# Improving Air Quality

On a hot summer day, would you rather sit down in a nice shady spot or broil unprotected in the blazing sun? Your car feels the same way. And you know how uncomfortable it is to climb back into the driver's seat after it's been baking in the heat. But ...

**Where are all the cool parking lots?**

Center for Urban Forest Research

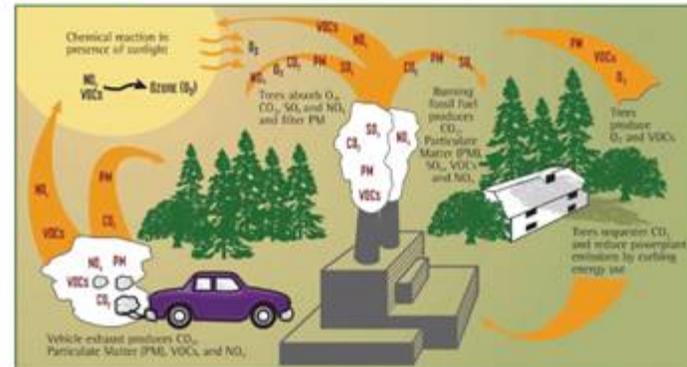
## Trees and the Clean Air Act: Strategic tree planting in Sacramento

### Trees, the EPA, and cleaner air

The Clean Air Act requires that all states with unhealthy levels of air pollutants submit a State Implementation Plan (SIP) that describes the methods that will be used to meet federal air quality standards. Until recently, SIPs have aimed mainly at reducing pollutant output at the source: power plants, factories, and vehicles. Recently, the Environmental Protection Agency (EPA) has begun to encourage new, innovative measures to fight air pollution and **trees** are being considered as **one part of the solution**.

of sunlight to produce ozone, Sacramento's biggest air quality problem. The Sacramento metropolitan area is among the ten most ozone-polluted areas in the country, exceeding the accepted levels as many as 40 days a year depending on weather conditions.

Vehicles and power plants also produce small particulate matter (PM) and carbon dioxide. Particulate matter has been linked to increased severity of asthma attacks and can have serious consequences for the elderly, children, and people suffering from lung and heart disease. Carbon dioxide contributes to global warming.



### Sacramento's air quality problem

Vehicles, including cars, trucks, buses, trains, and agricultural and construction equipment, cause the majority of Sacramento's air pollution with most of the remainder emitted by power plants. Vehicles and power plants give off nitrogen oxides ( $NO_x$ ) and volatile organic compounds ( $VOCs$ ), which combine in the presence

### How trees can help

California has long been in the forefront of the battle to fight air pollution with strict vehicle emissions laws, high fuel efficiency standards and innovative programs to reduce pollutants at the source, and important strides have been made. Still, because the population of California is growing so fast, there are more and more vehicles on the



# Reducing Carbon Dioxide





LIVE EARTH  
**THE CONCERTS FOR A CLIMATE IN CRISIS**



**an inconvenient truth**  
A GLOBAL WARNING

by far the most terrifying

**SPECIAL REPORT GLOBAL WARMING**

# TIME

**BE WORRIED. BE VERY WORRIED.**

Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

**EARTH AT THE TIPPING POINT**  
HOW IT THREATENS YOUR HEALTH  
HOW CHINA & INDIA CAN HELP  
SAVE THE WORLD—OR DESTROY IT  
THE CLIMATE CRUSADERS

The Next Big Environmental David-and-Goliath Trial by William Langewiesche

# VANITY FAIR

**EXCLUSIVE**  
SNEAK PREVIEW OF **LEONARDO DICAPRIO'S**  
NEW DOCUMENTARY FILM, *THE 11th HOUR*

THE WHITE HOUSE'S DIRTY HANDS  
BY ROBERT F. HEINZ, JR.  
THE GASPING AMAZON  
BY ALICE SAMMONS

OUR 2<sup>ND</sup> ANNUAL  
**GREEN ISSUE**

THE BATTLE FOR THE WORLD'S DRINKING WATER  
BY STEVE L. WATSON  
SOUPED-UP ELECTRIC SPORTS CARS  
BY MICHAEL L. GARDNER

**PLUS:**  
UNSEEN OSCAR PARTY PHOTOS  
THE PRIVATE EQUITY EXPLOSION  
THE KUSSINGER PRESIDENCY



by DAVID GRAY / PHOTOGRAPHS BY STEVEN KAZEMONY

## ON THIN ICE

*Struggling with pollution, oil drilling and other threats, can polar bears survive global warming's devastating effects?*

For more than an hour, the solitary polar bear traced what appeared to be a glacier toy around a smooth lagoon along the Beaufort Sea. Looking through photographs from Kaulovik's videobase bin, I watched as the seasonal plaything—a walrus flippers—came into focus. The white flippers flitted, twirled, then flipped in her mouth, tucked to either side as she waddled back a ways to watch the flippers bobbing under the target beam as across the flippers bearing only the traces of her teeth had just passed around the blue sky. Nothing, she learned, but the ground beneath, was the ice. With a last, deepening dip of strength, she took her last breath, more skilled she said she was. Heavy and white again. Her attention light shifted to a spot on the ice. She looked at the flippers some more, stared at the water and repeated the process again and again. Her connection had been possible, perhaps because what it was really for a young, well-fed polar bear playing in an unwarmed lagoon and the child's face a case in the world.

It had already, that light had been there, she was saying the bear's mouth had always been in a subtle, but the challenge and it was not, as you see, looking around an unwarmed lagoon in a rapidly changing, unwarmed world. From the ice and pollution to oil drilling, hunting to tourism, polar bears are no longer a case in the world.

**ALONG THE ARCTIC**—meanwhile the Spring and the Arctic Sea are 30 miles off from the Arctic. It's a small polar bear pup for the first time in the Arctic.



OFFICIAL COMPANION TO THE LIVE EARTH CONCERTS

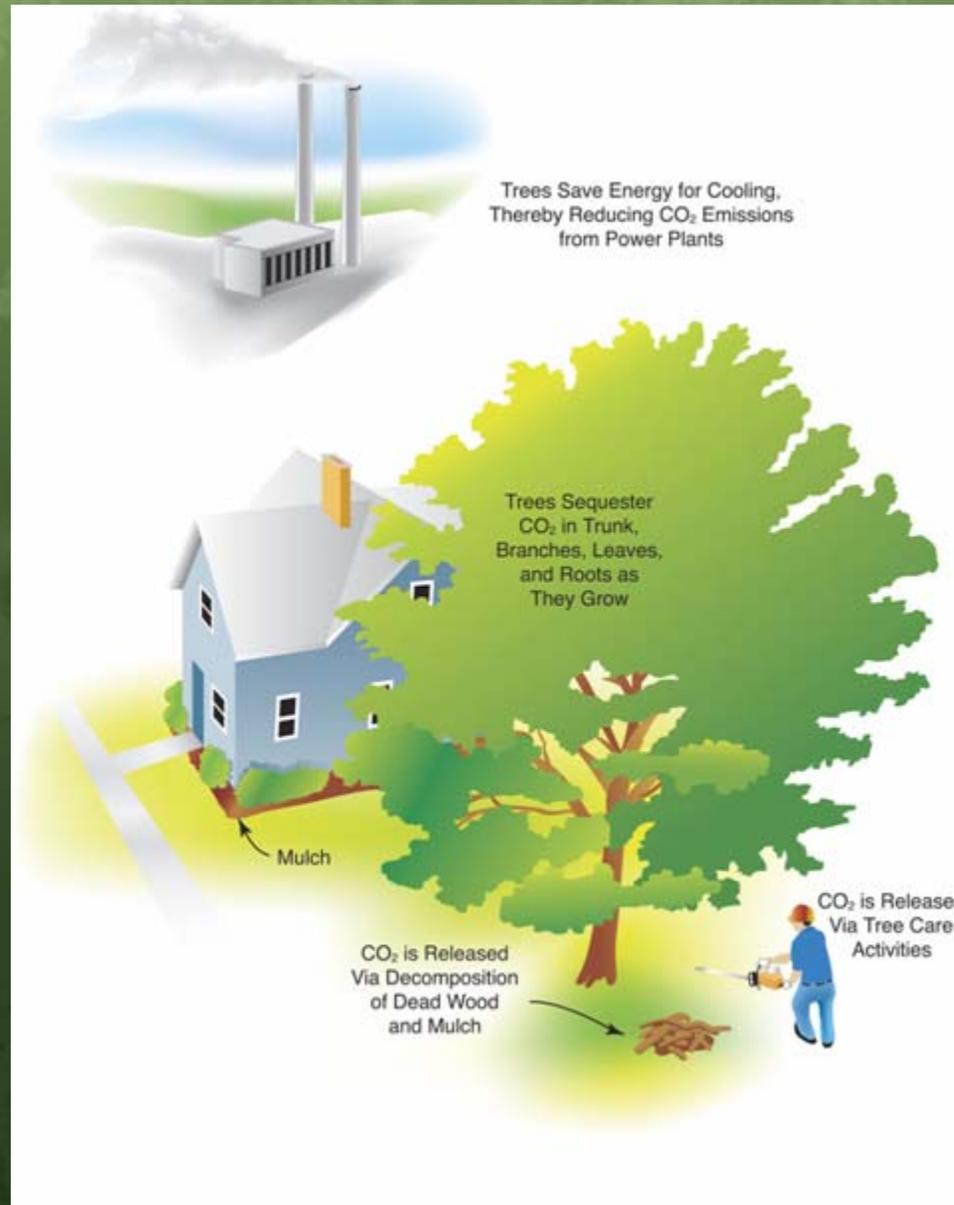
THE LIVE EARTH  
**GLOBAL WARMING SURVIVAL HANDBOOK**

DAVID DE ROTHSCHILD

77 Essential Skills to Stop Climate Change—or Live Through It



# Reducing Carbon Dioxide



# Trees Reduce CO2

## Sacramento's Urban Canopy

- Store 8.8 million tons of CO2
- Sequester 263,000 tons annually
- Reduced energy use = 83,300 tons
- Maintenance 10,000 tons
- Net annual sequestration 335,000 tons
- Estimated value \$6.7 million

## Modesto's Municipal Trees

- Pear = \$1.95
- Southern magnolia = \$2.81
- Gingko = \$5.43
- Modesto ash = \$7.67



# Conserve energy!!!

- Plant lots of trees
- Shade paved surfaces and buildings
- Plan for the sun
  - West > east > south
- Choose species wisely
  - Bigger is better
  - Evergreen vs deciduous
  - Branching pattern

Plant lots of trees



# Choose species wisely



Small and short-lived



Large and long-lived

# Make use of wood



# Planting trees to reduce CO2

- Reduce energy use!
- Choose wisely
  - Size
  - Longevity
- Use the wood



## Putting it all together

- Reduce energy use!
  - West first
- Species choice
  - Bigger is better
  - Longer-lived is better
  - Deciduous vs evergreen
  - Low emitters where possible





Urban Advantage



Urban Advantage

# Our Publications

<http://www.fs.fed.us/psw/programs/cufr/products.shtml>

The screenshot shows a Microsoft Internet Explorer browser window displaying the Pacific Southwest Research Station website. The address bar shows the URL <http://www.fs.fed.us/psw/programs/cufr/products.shtml>. The website header includes the USDA Forest Service logo and navigation links. The main content area is titled "Center for Urban Forest Research" and features a large green box with the email address [kevargas@ucdavis.edu](mailto:kevargas@ucdavis.edu) overlaid on it. The page is organized into several sections: "Programs and Projects", "Published reports", "Municipal Forest Resource Analysis", "Models", and "Center News Briefs". A sidebar on the left contains a search bar and a navigation menu with categories like "Research Topics", "Programs & Projects", "Our Products", and "Our mission".

USDA FOREST SERVICE

Pacific Southwest Research Station

(enter query) Search

Programs and Projects (RWU-4952)

## Center for Urban Forest Research

The Center for Urban Forest Research produces a wide variety of urban forestry research products, available to public managers, urban planners, city foresters, landscape designers, arborists, and other interested parties. The products are presented in the following formats and can be accessed by clicking on each category type or using the search option to the left:

**Published reports**

Our Center publishes research findings in journals, conference proceedings, and periodicals, as well as General Technical Reports and dissertations.

**Municipal Forest Resource Analysis**

Our reports provide detailed information on a particular city's tree resource. They include urban forest structure, function and value, along with resource management needs. A summary of annual benefits is provided that

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**Our mission**

Our research demonstrates new ways that trees add value to communities, converting results into financial terms to stimulate more investment in trees.

**Locations & Laboratories**

Evaluate Our Service

Pacific Southwest Research

Internet