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HEAT ISLAND PUBLICATIONS

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UNDOING UNCOMFORTABLE SUMMER HEAT ISLANDS CAN SAVE GIGAWATTS OF PEAK POWER*

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Abstract

Man has created summer heat islands of daily average intensity of 3-5 °C, adding to discomfort and increasing in air conditioning loads. (For example the Los Angeles basin uses 5 GW of air conditioning, thus tying up \$10 billion of power plants and another \$5-10 billion in HVAC equipment). We have been studying how to mitigate this heat, with increasing the amount of urban vegetation as an example.

We first discuss the major factors that create the heat island, its magnitude and impact on residential cooling energy use, and mitigation techniques. We then simulate building cooling demand as a function of the heat island intensity. Simple heat island energy balance models are used to predict the changes in dry bulb temperatures that are then used as input to DOE-2 hourly simulations. The DOE-2 results enable us to rank measures for preventing the urban heat island.

Our preliminary results indicate that planting trees can save as much as 34, 18, and 44% of residential cooling demand on a hot summer day in Sacramento CA, Phoenix AZ, and Los Angeles CA, respectively. The cooling energy savings are 53, 33, and ~ 0%†. Direct shading of a house itself yields only 11, 8, and 12% savings in peak power in the same locations.

I. INTRODUCTION

The urban heat island is a well documented urban phenomenon [Landsberg 1981, Lowry 1967]. The larger the city, the more intense is the summer heat island [Oke 1973] and hence the magnitude of discomfort and air conditioning load. For instance for St. Louis, Missouri, the summer heat island intensity is 4 °C during nighttime and 1 °C at noon [Vukovich et al. 1979].

Researchers have started to look at the causes and implications of the heat island, and have correlated its magnitude to the activities within and physical

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† Study of the air conditioning control strategies for Los Angeles have yielded in a saving of 7% in peak power and 88% in the annual cooling energy by simply switching from the present indoor temperature control to "smart" dual outdoor/indoor temperature control.

reflection and scattering, but the urban surface albedo ($\sim 15\%$) is lower than the

characteristics of the city, such as its rate of anthropogenic heat release [Torrance and Shum 1975], concentration of pollutants [Bennett and Saab 1982, Bornstein 1968, Vukovich et al. 1979], and thermal storage capacity [Myrup 1969, Atwater 1972]. The urban energy balance has been related to the canyon geometry of city streets [Nunez and Oke 1976] and to urban physical characteristics [Ojima and Moriyama 1982]; its nocturnal intensity has been related to the sky view factor [Barring and Mattsson 1985].

In fact, all the above variables work together to create the urban heat island, which makes it desirable to closely investigate their interactions so as to isolate the important causes and, if at all possible, to avoid them. In the last two decades researchers have attempted to simulate the urban heat island with one, two and three dimensional models. For an overview of the heat island history and models, the reader is referred to [Landsberg 1981 and Bornstein 1984b].

On a qualitative level, traditional and scientific observations indicate there are simple tools to alleviate the microclimate problems associated with cities. Traditional urban architects in hot climates have used whitewashed exterior walls, central courtyards, fountains, plants, windtowers, air scoops, masonry and heavy materials to control the quality of the indoor and outdoor micro-climates. The effects of these simple techniques, however, have never been quantified, nor do they specifically address changing the microclimate of an entire urban area.

The objective of our work is to quantify the potential of strategies such as evapotranspiration and shading to mitigate the summer heat island and reduce cooling energy use. We have used the DOE-2.1C program to simulate the reduction in cooling energies due to the application of these strategies.

II. THE HEAT ISLAND PHENOMENON

The best way to understand the formation of urban heat island is to look at the basic surface energy balance equation:

$$A + R_s - R_L = A + R_a = LE + H + G$$

III. MODELING

A. Shade

Two shading scenarios are modeled, the addition of one tree or three trees near each house. We have placed the trees on the west and south sides of the house so as to maximize shading effects and to minimize the peak power consumption of the house. The tree shading model is restricted to the reduction of the solar radiation on the building envelope, while in actuality, trees will also affect the ambient temperatures, wind speeds and humidity ratios. Those changes are simulated in other models we have developed that will be explained later.

We have assumed that each mature tree has a top view projection area of 50 m^2 , and that the suburban housing density is one house per 500 m^2 of land. Therefore, an increase of one tree per house is equivalent to a 10% increase in the urban tree canopy.

We have modeled the location of the trees relative to the prototype house such that the canopy does not overlap the roof and extends from 3 to 10 meters above ground surface (see Figure 1). This location maximizes window shading without seriously reducing night sky radiation from the roof.

B. Wind Modification

Depending on its position upwind of a reference point, a barrier might increase or reduce the wind speed and turbulence. In our work, we have assumed that the trees are close enough to the building envelope so that their effect is to retard the wind flow. At the city scale, the effect of the increased roughness is to decrease the wind speed at the surface. In both cases we have used a wind speed reduction formula derived by McGinn in his study of the vegetation and canopy effects at Davis, California [McGinn 1982].

C. Evapotranspiration

Estimating the effect of evapotranspiration of trees on the ambient conditions requires the solution of the transport equation in three dimensions. The authors are not aware of a verified model to analyze moisture migration and its effect on ambient conditions. To get an early estimate of this effect, we have devised a simplified model which assumes adiabatic evaporation. Given the unperturbed ambient condition as available from weather tapes and the added amount of tree cover, we use agricultural data to estimate the evapotranspiration rate as a function of insolation and dry-bulb temperature. The heat of evaporation is assumed to be extracted from the ambient air. The air volume (per unit width) contributing to this process is estimated as the product of the wind speed and the urban mixing height which is calculated for each hour. The mixing height is a function of many ambient variables including wind speed, anthropogenic heat release, heat

$$\text{Cost of Avoided Peak Power (CAPP)} = \frac{\text{Total Investment (\$)}}{\text{Avoided Peak Power (kW)}} \text{ normalized for life of a nominal power plant (normally 20 years).}$$

island intensity, rural lapse rate upwind of city and surface roughness. We have assumed a complete mixing of ambient air in this volume. Details of this model are described in [Huang 1986a]. An example of the original and modified dry bulb temperature for some trees covers for Sacramento is shown in Figure 2.

D. Prototypical House

To estimate the energy savings due to increased tree canopy, we used DOE-2.1C to calculate the air conditioning usage for a prototypical house in three cities under varying canopy conditions. The prototypical house is a one story house with 143 m² of floor area and a window-to-floor ratio of 10%. A 0.6 m roof overhang is assumed on the south. Construction details are standard U.S. building practices and the operating conditions as well as the infiltration rates are based on statistical surveys of current typical houses [NAHB 1979]. The house has $R=3.34$ W/(m²K) roof insulation, $R=1.95$ wall insulation, and single-pane windows. The assumed equipment is an air conditioner of SEER 9.2 and capacity dependent on the climate. For peak air conditioning demands see Tables 1 and 2. Thermostat is set at 25.5 °C for cooling and it is assumed that the occupants or a "smart" control system turns off the air conditioner and open the windows whenever the temperature and enthalpy of the outside air is lower than that of the indoors, and cooling loads can be met by ambient air at 10 air changes per hour. To account for venetian blinds, curtains, etc, a shading coefficient of 0.63 is assumed for all windows. The shading on the south and west windows due to trees is calculated automatically by the DOE-2.1C program. This house has been used in many previous studies to simulate energy performance of houses in different climates. The details of this prototype house are fully explained in [Huang 1986b].

IV. RESULTS AND DISCUSSIONS

Two sets of analyses were performed for one tree or three trees per house. The addition of three trees per house will probably cancel out the urban heat island, restore the original rural climate, and perhaps even introduce an "oasis" effect. A preliminary parametric analysis performed for Los Angeles confirmed that trees shading the west window produced the largest peak power savings.*

The simulation results for both the one-tree and three-trees cases in the three locations are presented in Table 1. It may be surprising that Table 1 shows only 65 cooling hours per year for the base case house with no additional trees in Los Angeles (all of which, incidentally, occur on only 10 days). This low number is due to our assumption of diligent occupants or a "smart control" that opens windows

* The impact of tree location on the peak power of a typical house in Los Angeles with "smart" air-conditioning control is as follows:

Tree location	none	west	south	east
Peak kW	4.48	4.03	4.41	4.32

The peak power reduction due to trees on the south is relatively small because it is assumed that a south overhang already exists.

to allow natural venting whenever the outside conditions are suitable. If we had assumed air conditioning control without natural ventilation, the number of cooling hours would have been increased more than tenfold (see Appendix; a more detailed description of air conditioning control strategies and their effects on energy and power consumption is the subject of a forthcoming paper).

The following observations are made from Table 1 :

- Percentage power savings potential is highest for Los Angeles with 44%, followed by Sacramento with 34%, and Phoenix with only 18%. In terms of absolute power saved, the potential is highest in Sacramento with 2.44 kW, second in Los Angeles with 1.96 kW, and finally Phoenix with 1.57 kW.
- Percentage energy savings potential is highest for Sacramento with 53% followed by Phoenix with 33%. Potential energy savings in Los Angeles is negligible. As we discussed earlier, most of cooling energy use in Los Angeles can be overcome by ventilation cooling.
- In all cases the effect of having two trees to the south and one to the west (=30% cover) is about twice as effective as a single tree on the west (10% cover), thus clearly showing the importance of orientation in trees placement.
- In Los Angeles, 30% cover reduces the number of cooling hours by 84% , bringing them down to only 10 hours, or one day during the whole cooling season. In Sacramento, the curtailment is of the order of 56%, down to 390 hours from an original of 904 cooling hours. In Phoenix, the reduction is 17%, down to 3028 hours.
- The net effect of wind reduction on the cooling load (both peak and energy) is negligible 1%.

The Present Value (PV) of the power and energy saved by planting trees for two scenarios are shown in Table 2. These two scenarios are based on the age of trees and their prices; we expect these two cases provide upper and lower limits for cost of conserved energy and power. For the first case we assume planting seedlings at a price of \$5 per tree [McPherson 1984, p. 173]; it takes 10 years for the seedling to mature [McPherson 1984, p. 159]. For the second case, we assume planting 5-ft trees at a price of \$60 per tree including labor costs [McPherson 1984, page 173]; we estimate that it would take 7 years for the 5-ft tree to grow to full size. We add this cost to the water cost in order to obtain the total cost of each tree.

The water consumption of a beech tree is estimated to be ~ 1 kg/h [Berustzky, 1982]. This would translate to an annual consumption of ~ 2000 gal/year. Current prices of water varies between 7-10 cent per hundred gallons*. Therefore, total water consumption of a tree is about \$2/yr. In addition to the above, we have made the following assumptions:

*The current price of water from the San Francisco East Bay Municipal Utility District is 83.5 cents per one hundred cubic feet.

- The energy and power conservation potential of trees during the growing period is neglected.
- As trees mature, their roots grow deep in the ground and for most parts of the country they will become self-sufficient in absorbing water from ground; they do not need further watering.
- Even though the average life span of a tree is high (100 years) we have assumed here a time horizon of 20 years, same as an average power plant.
- Interest rate is assumed to be 7% real.

The results from this table are encouraging. The cost of conserved energy (CCE) and avoided peak power (CAPP) is between 0.3 to 4.3 ¢/kWh and 19 to 217 \$/kW for all three locations studied. The present value of conserved energy is much higher in Phoenix and Sacramento than Los Angeles. The high but indeterminate values of conserved cooling energy in Los Angeles is due to use of "smart" control algorithm where the initial annual air conditioning energy use is only 359 kWh. It is interesting to note that the average price of electricity is about 8 ¢/kWh, and major utilities in California offer a rebate of \$100-\$300 for each kW of peak power avoided. Therefore, even with the upper limit cost of trees the CCE and CAPP seem extremely appealing.

To obtain the actual power savings in each of these locations, three essential data are required. This data include the number of households that may undergo tree planting project, the saturation and average size of actual air conditioning units used in houses, and the coincident factors for use of air conditioning units for each location. Presently, we do not have enough data to make a detailed calculation. Alternatively, we assume that one million air-conditioned houses in Los Angeles, and 250,000 each in Sacramento and Phoenix will plant trees. Table 1 can then be transformed into Table 3. The results obtained for power and energy savings in each location is encouraging; in Los Angeles ~ 2 GW (equivalent to 2 standard GW power plants) could be unloaded. Peak power savings in Sacramento and Phoenix are about 0.6 GW and 0.4 GW, respectively. These encouraging results warrants further investigation of this subject.

V. SUMMARY AND RECOMMENDATIONS

The major factors that create the heat island, its magnitude and impact on residential cooling energy use, and mitigation techniques are discussed. We have correlated the effect of planting trees on residential cooling energy and power, with specific case studies for three U.S. cities. The effects of two selected strategies (evapotranspiration and shading) and their potential in reducing the heat-island induced cooling load have been simulated.

Simulations were performed using DOE-2 building energy analysis program, in conjunction with some simple models to predict the effect of planting trees on the atmospheric dry-bulb temperature and humidity ratio. These simulations were done for three locations: Sacramento CA, Los Angeles CA, and Phoenix AZ. The location of trees is optimized with respect to the house so as to maximize the effects of shading and evaporative cooling.

Our work suggests potential energy and power savings can be realized by use the simple strategy of planting trees.* In the cities studied, the effect of planting three trees around the house can save 18%-44% of the peak power, and up to 53% of the total annual cooling electricity use. The present value of the saved peak power and the saved electricity are 29-217 \$/kW and 0.3-4.3 ¢/kWh for three seedling or three trees. Planting three trees for the approximately one million houses in the Los Angeles area can save up to 2 GW peak power. For the other two cities, 250,000 trees can save ~ 1 GW.

At this stage, we believe the following topics deserve further investigation:

1. Study the effect of changing the thermal mass of building materials.
2. Study the effect of changing the city albedo by substituting concrete pavements for asphalts, and by painting roofs and city surfaces in light colors.
3. Refine the evapotranspiration model used in this work and analyze its effect on temperature depression.
4. Refine the evapotranspiration model to consider differences between local and global effects. Although shading is modeled on a local level, evapotranspiration has been modeled assuming that the city is uniformly vegetated at the given cover percentage. We need to know the effect of spatial variations in vegetation canopy on the overall global as well as the local distribution of temperature and humidity ratio.
5. Gather observational data to validate various aspects of the heat island model. This data should include quantification of urban and neighborhood variations in surface conditions, including amounts of vegetative cover, albedo, etc., along with recorded variations in microclimate conditions.

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* A byproduct of our simulations are data showing that additional savings are possible by improving our habits or air conditioner control; i.e. opening windows ("smart" control) instead of turning on or leaving on the air conditioner ("dumb" control) when the outdoor conditions are suitable and pleasant.



south tree representation
in DOE-2 simulations.

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Knowles R., 1982, *Sun, Rhythm, Form*, MIT Press, Cambridge Mass.

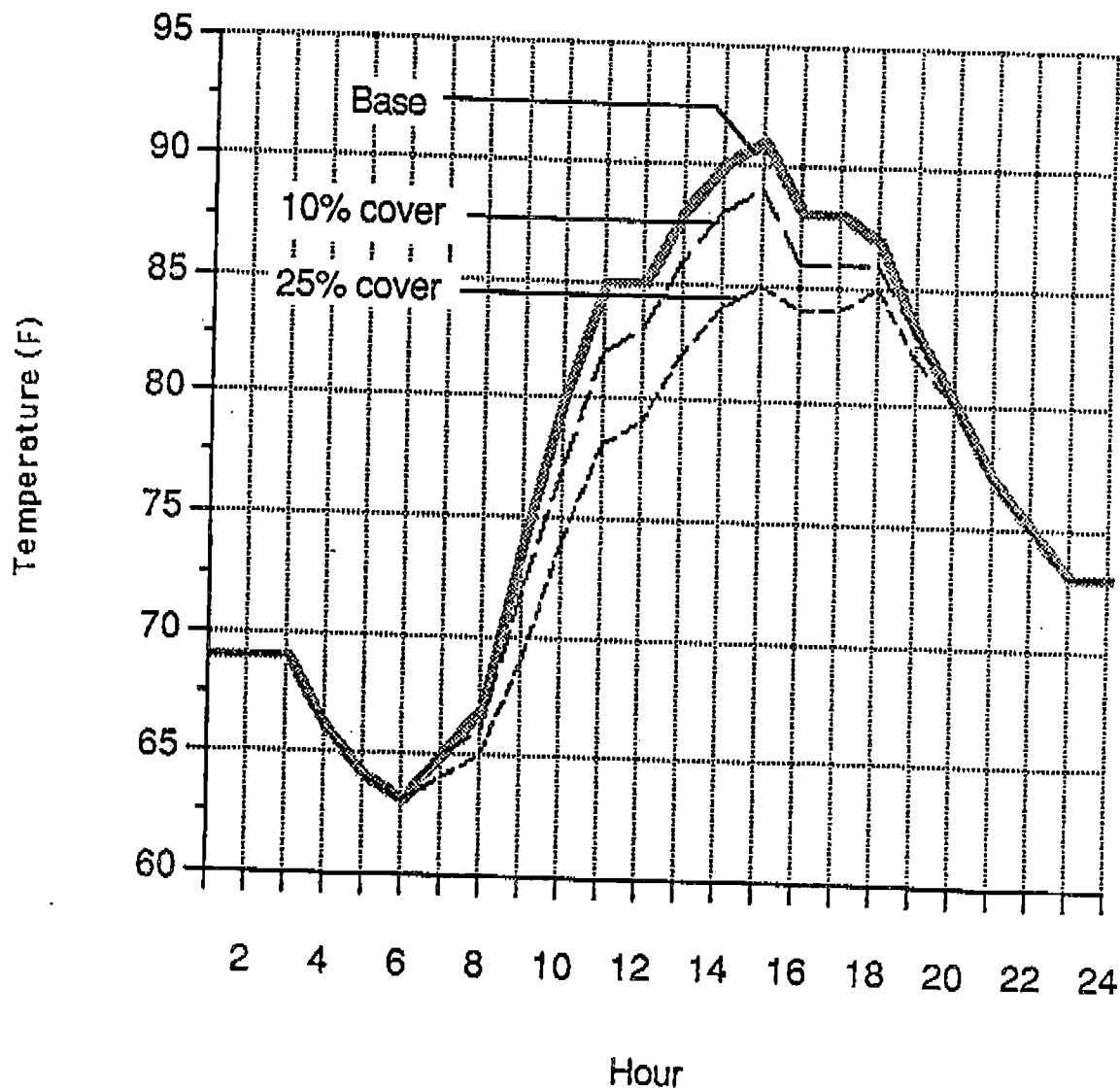


Figure 2. Outdoor dry-bulb temperatures for Sacramento, as simulated for July 27, 1980. The "base" curve shows the original temperature at the present level of vegetation. The subsequent curves show the new temperatures resulting from the evaporative cooling effect of trees, as produced by the evapotranspiration model.

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Table 1. Peak power and energy savings per house resulting from planting trees. All entries except the base-case column are savings compared to that column. Note that wind modification contributes little, and evapotranspiration overshadows direct shading. Note that the macro-effect of 10% coverage (1 tree/house) is to avoid about 1 kW/tree; for 3 trees/house we can avoid 2/3 kW/tree.

Location	Number of additional trees								
	None	1 tree = 10% cover				3 trees = 30% cover			
	Base case energy use (not savings)	Energy savings				Energy savings			
		shade only (Δ)	shade +wind (Δ)	shade+wind +evapotrans. (Δ)	(% Δ)	shade only (Δ)	shade +wind (Δ)	shade+wind +evapotrans. (Δ)	(% Δ)
Sacramento									
kW	7.10	0.66	0.72	1.24	17.5	0.76	0.81	2.44	34.4
Cooling hrs	904	36	29	165	18.3	64	95	514	56.9
kWh/yr	1420	122	114	343	24.2	225	218	757	53.3
Phoenix									
kW	8.87	0.47	0.53	0.80	9.0	0.53	0.57	1.57	17.7
Cooling hrs	3647	18	16	157	4.3	86	79	619	17.0
kWh/yr	6911	208	208	873	12.6	417	418	2289	33.1
Los Angeles									
kW	4.48	0.43	0.45	0.90	20.2	0.53	0.55	1.98	43.9
Cooling hrs	65	12	8	43	66.2	18	17	55	84.6
kWh/yr	359	~0	~0	~0	~0	~0	~0	~0	~0

Note

Table 2. Present value of saved peak power and cooling energy in 1986 dollar for savings of Table 1. Each entry shows two value corresponding to planting seedlings or 5-ft trees at \$5 and \$60, respectively. Water consumption for a growing tree is estimated to average to ~ \$2/yr for 10 years for the seedling and 7 years for the 5-ft tree. A time horizon (n) of 20 years for trees and a discount rate (d) of 7% real is assumed for these calculations.

Location	None Base case power use (kW)	Number of additional trees					
		1 tree = 10% coverage			3 trees = 30% coverage		
		Present Value			Present Value		
		shade only	shade +wind	shade+wind +evapotrans	shade only	shade +wind	shade+wind +evapotrans
Sacramento	7.10						
CAPP† (\$/kW)		36-172	33-158	19-92	93-449	88-421	29-140
CCE† (¢/kWh)		1.9-8.8	2.0-9.4	0.7-3.1	3.1-14.3	3.2-14.8	0.9-4.3
Phoenix	8.87						
CAPP (\$/kW)		50-242	45-214	30-142	134-643	124-598	45-217
CCE (¢/kWh)		1.1-5.2	1.1-5.2	0.3-1.2	1.7-7.7	1.7-7.7	0.3-1.4
Los Angeles	4.46						
CAPP (\$/kW)		55-264	53-253	26-126	134-643	129-620	36-174
CCE (¢/kWh)		N/A	N/A	N/A	N/A	N/A	N/A

†Cost of Avoided Peak Power (CAPP) = $\frac{\text{Total Investment (\$)}}{\text{Saved Power (kW)}}$ normalized for life of a nominal power plant (normally 20 years).

‡Cost of Conserved Energy (CCE) = $\frac{\text{Annualized Investment (\$/yr)}}{\text{Saved Annual Energy (kWh/yr)}}$

Annualized Investment = $\text{Total Investment} \times \frac{d}{1 - (1 + d)^{-n}}$

Table 3. Peak power and energy savings resulting from planting trees near 1,000,000 houses in Los Angeles and 250,000 houses in Sacramento and Phoenix. All entries except the base-case column are savings compared to that column.

No. of trees per house Location	Base-case (not Savings)	1 tree = 10% cov. Savings				3 trees = 30% cov. Savings			
		shade	shade+wind	shade+wind+evap.		shade	shade+wind	shade+wind+evap.	
SACRAMENTO		$\Delta =$	$\Delta =$	$\Delta =$	$\Delta = (\%)$	$\Delta =$	$\Delta =$	$\Delta =$	$\Delta = (\%)$
MW	1775	165	180	310	17.5	190	202	610	34.4
GWh/yr	355	30.5	28.5	85.8	24.2	56.3	54.5	189.3	53.3
PHOENIX									
MW	2,218	118	133	200	9.0	133	143	393	17.7
GWh/yr	1,728	52	52	218	12.6	104	104	572	33.1
LOS ANGELES									
MW	4460	430	450	900	20.2	530	550	1960	43.9
GWh/yr	359	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0	~ 0

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Our work suggests potential energy and power savings can be realized by use the simple strategy of planting trees.* In the cities studied, the effect of planting three trees around the house can save 18%-44% of the peak power, and up to 53% of the total annual cooling electricity use. The present value of the saved peak power and the saved electricity are 29-217 \$/kW and 0.3-4.3 ¢/kWh for three seedling or three trees. Planting three trees for the approximately one million houses in the Los Angeles area can save up to 2 GW peak power. For the other two cities, 250,000 trees can save ~ 1 GW.

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3. Refine the evapotranspiration model used in this work and analyze its effect on temperature depression.
4. Refine the evapotranspiration model to consider differences between local and global effects. Although shading is modeled on a local level, evapotranspiration has been modeled assuming that the city is uniformly vegetated at the given cover percentage. We need to know the effect of spatial variations in vegetation canopy on the overall global as well as the local distribution of temperature and humidity ratio.
5. Gather observational data to validate various aspects of the heat island model. This data should include quantification of urban and neighborhood variations in surface conditions, including amounts of vegetative cover, albedo, etc., along with recorded variations in microclimate conditions.

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* A byproduct of our simulations are data showing that additional savings are possible by improving our habits or air conditioner control; i.e. opening windows ("smart" control) instead of turning on or leaving on the air conditioner ("dumb" control) when the outdoor conditions are suitable and pleasant.

Akbari et al.

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APPENDIX. THE ENERGY SAVING POTENTIALS OF "SMART" WINDOW VENTILATION

For most places in the U.S., ventilation cooling is practical during much of the cooling season. The energy savings can be observed in Table A.1 where two algorithms, mechanical cooling "dumb" and a combination of ventilation and mechanical cooling "smart" are compared. Use of the "smart" algorithm has resulted in savings of 375 watts of peak power. The reason for this saving is that the building is pre-cooled as its mass exposed to the cool ventilation air. Therefore, although the loads are similar in both "smart" and "dumb" modes, the former requires less cooling power. In our simulations, we have assumed the "smart" option to avoid overpredicting the energy savings for vegetation, although we realize that windows in most homes would not be operated in this optimal fashion.

This preliminary result on the savings of "smart" window ventilation is of great importance to utilities in Los Angeles area. It shows that by changing the control of the air conditioning unit from only the indoor temperature ("dumb" control) to the dual control by both indoor and outdoor temperature ("smart" control) the peak power and annual cooling energy use will be reduced by 7% and 88%, respectively.

Akbari et al.

Table A.1 Comparison of air conditioning without ventilation ("dumb") to combined air conditioning and ventilation with "smart" controls in Los Angeles.

Control strategy	Peak kW	Hours Cooling (annual)	kWh/year
"dumb"	4.83	752	886
"smart"	4.46	65	108

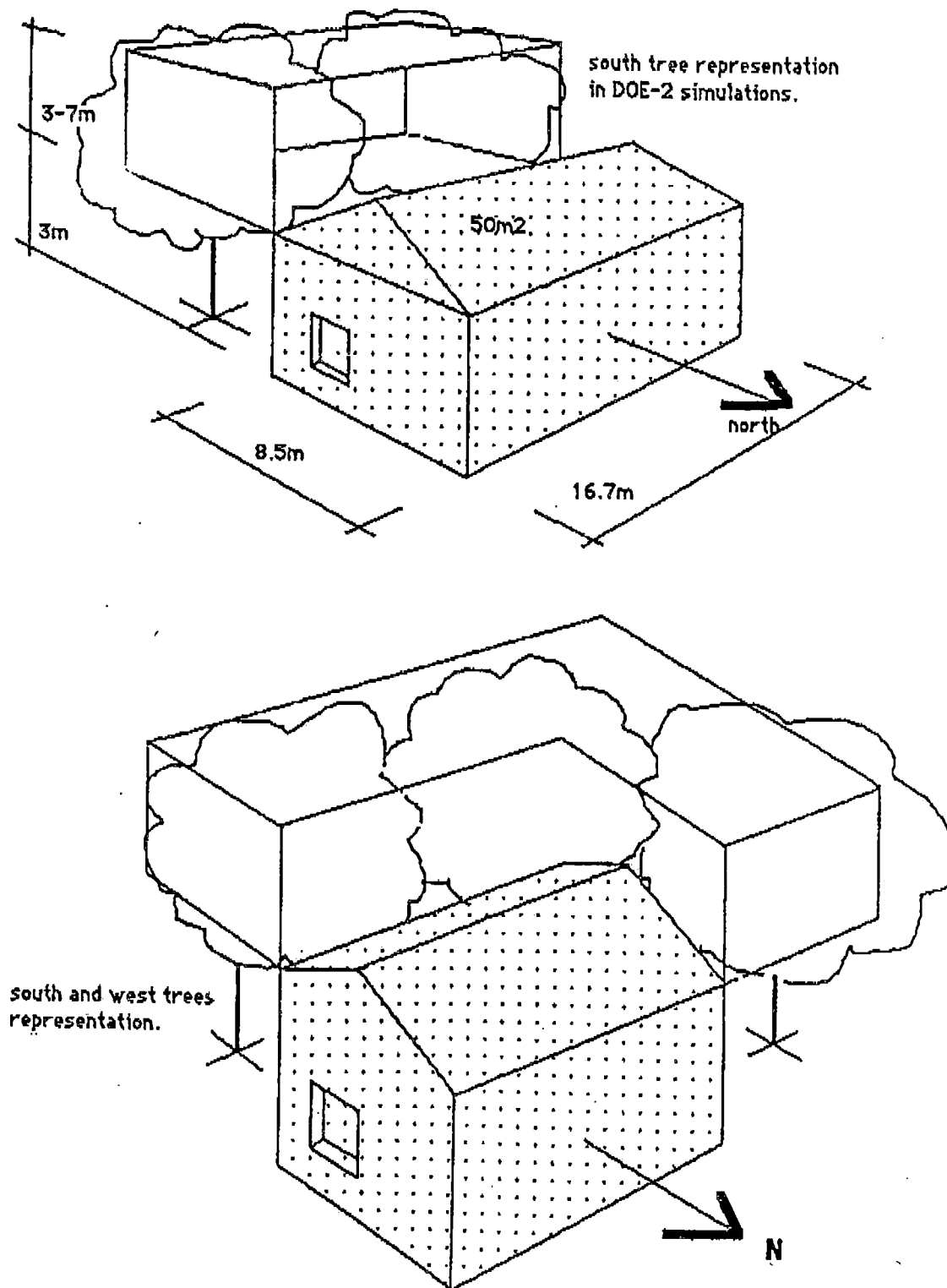


Figure 1. Schematic sketch of the simulated tree canopy. It is simulated by means of planar surfaces that approximate the tree effect.



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HEAT ISLAND PUBLICATIONS
(Rev. Date: December 1989)

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6218 - Canell

March 15, 1990

MEMORANDUM FOR ~~DAN MCGROARTY~~
PEGGY DOOLEY

FROM: STEPHANIE BLESSEY

SUBJECT: ARBOR DAY TREE PLANTING

The following is information I gathered on the pre-advance to Indianapolis:

BACKGROUND:

Attendance: 10-15,000 people (hopefully)
3-4,000 school children
Remainder of audience will be downtowners since event is in a downtown park.

Setting: Park in front of Dan Quayle's law school. Skyline would be backdrop. Banner with "Trees for Tomorrow" and school children standing directly behind him.

Time: 11:00 a.m.

Event: Give remarks

?Give 50 trees to students on behalf of the city.
Plant tree

PROGRAM: TREES FOREst TOMORROW

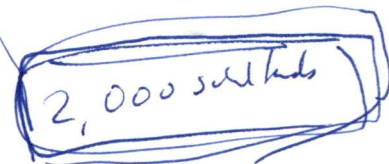
A citywide campaign to plant 30,000 trees during 1990 -- the program stresses tomorrow i.e. children. The program also wants to involve the entire community.

April is "Clean and Green Month," and they plan to give away 1,000 trees.

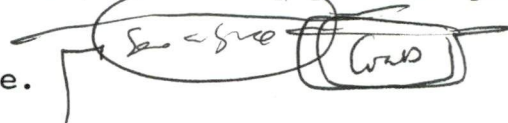
Attached is program brochure.

NOTE: Although this is Mayor Hudnut's project, he will be in Jerusalem during the event. The W.H. political office isn't concerned that he appear because he has publicly criticized the President. Their fear is that he will decide to show up.

CONTACT: Mark Goff
Mayor Hudnut's office
(317) 236-3600



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The second has my clean air
or it's size -
Keep the standard
incentive
program
W.H. - Re: tree
Program



March 5, 1990

INFORMATION

MEMORANDUM TO THE PRESIDENT

THROUGH: CHRISS WINSTON

FROM: MARK LANGE

SUBJECT: Remarks to the American Electronics Association

I. SUMMARY

On Wednesday, March 7, at 11:30 a.m. you will speak to the American Electronics Association. Your remarks are brief (10-12 minutes) and will be TelePrompted. The audience will be made up of approximately 400 senior high-tech industry executives.

Your remarks applaud the work of the electronics industry, especially the diversity of what the industry offers America. The remarks briefly outline steps taken by the Administration which will help the electronics industry, suc

FROM THE OFFICE OF THE MAYOR
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CONTACT:
Mark J. Goff
Special Assistant for Public Affairs
(317) 236-3610
(317) 236-3980 FAX

TO: CURT SMITH
White House Communications
202-456-2772

Curt:

Attached pls. find the news release you requested. Please call if you need additional assistance.

MJG

FROM THE OFFICE OF THE MAYOR
2501 City-County Building
Indianapolis, Indiana 46204

FOR IMMEDIATE RELEASE, CONTACT:

Mark J. Goff
Office: (317) 236-3610
Mark Bowell
Office: (317) 924-7037

March 22, 1990

HUDNUT ANNOUNCES PRESIDENT BUSH TO HELP PLANT "TREES FOR TOMORROW"
Nation's chief executive to visit Indianapolis on April 3

Culminating nearly a year of discussions, Mayor William H. Hudnut, III today confirmed that President George Bush will visit Indianapolis on April 3, 1990, to help the City's Department of Parks and Recreation launch its urban forestry program, "Trees for Tomorrow." Hudnut, a member of the Environmental Protection Agency's Environmental Financial Advisory Board, first initiated discussions on the possible Bush visit when he met with EPA Director William K. Reilly at the United States Conference of Mayors convention last June in Charleston, South Carolina.

"We're delighted that the President has officially accepted our invitation to come to Indianapolis to participate in this monumental program that is destined to improve air quality in our City," said Hudnut. "We've been working on this program for some time, and are pleased that the President has endorsed it and is willing to participate in its debut. Statistics show that one mature tree can generate enough oxygen for one person to breathe for one year, but for every one tree we plant we're losing four trees. 'Trees for Tomorrow' represents a positive step forward toward reforesting the urban landscape. I believe that if every person were to plant one tree, we could cut our air pollution problem in half."

The "Trees for Tomorrow" program includes a goal of planting 30,000 trees by the end of the year. Funding for 5,000 of the trees will come from the existing Department of Parks and Recreation revenues, and DPR is working to identify corporate sponsors and other interested individuals to assist in funding the remaining 25,000 trees.

The White House announced yesterday that Bush has officially agreed to participate in the program's kickoff here in Indianapolis, the "Trees for Tomorrow Celebration." Bush and Hudnut will plant the first tree near the intersection of Washington and Maryland streets in the late morning on April 3, 1990.

- more

TREES

PAGE TWO

3-22-90

Featured entertainment at the celebration includes performances by Sandi Patti, The Marlins, and the Jimmy Coe Band. Corporate sponsors for the event are AT & T, Methodist Hospital of Indianapolis, and Marsh Supermarkets.

For more information on Trees for Tomorrow, contact the Parks Department at 924-7037.

- 30 -



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LBL Account Number: 4712-01

SUMMER HEAT ISLANDS, URBAN TREES, AND WHITE SURFACES

Dear Stephanie,
It was a pleasure
to talk to you
Harham

H. Akbari, Ph.D.

A.H. Rosenfeld, Ph.D.
Member ASHRAE

H. Taha
Member ASHRAE

ABSTRACT

Temperature trends for the last 100 years in several U.S. cities were analyzed. Since ~1940 there has been a steady overall increase in urban temperatures. Summer monthly averages have increased by 0.25-1°F per decade (~1°F for larger cities like Los Angeles and 0.25°F for smaller cities). There is no evidence that this rise is moderating, and of course global greenhouse warming will add a comparable rise. Typical electric demand of cities increases by 1% to 2% of the peak for each °F, and most major cities are now ~5°F warmer than they were in the early 1900s. Hence, we estimate that about 5% to 10% of the current urban electric demand is spent to cool buildings just to compensate for the heat island effect. For example, downtown Los Angeles is now 5°F hotter than in 1940 and so the L.A. basin demand is up by 1500 MW, worth \$150,000 per hour on a hot afternoon (the equivalent national bill is ~\$1M/hour). In major cities, smog episodes are absent below about 70°F, but they become unacceptable by 90°F, so a rise of 10°F because of past and future heat island effects is very significant.

There are some strategies that can alleviate the heat island effect. Computer simulations and field studies have quantified the potential of trees and lighter surfaces for reducing summer heat islands. Results indicate that the cost of saved energy and avoided CO₂ through greening and whitening of urban areas is less than 1¢/kWh and 2¢/kg of carbon, respectively.

INTRODUCTION

Cities are getting warmer than their suburban and rural surroundings (Karl et al. 1988; Kukla et al. 1986), and this long-term warming is responsible for an increase of 1% to 2% in cooling loads (with respect to the peak) for each °F raise. As temperature rises, so does the severity of smog and the production of other airborne pollutants.

Before mechanical air conditioning, people cooled their homes by planting trees around them and painting the walls and roofs white. The disappearance of such simple practices in many urban areas contributes to summer "heat islands" with typical daily average intensities of 3° to 5°C. However, there are

ways to mitigate this negative effect on both micro- and meso-scales (Landsberg 1978; Thurnow, 1983).

Urban trees and light-colored surfaces are effective and inexpensive measures to reduce heat islands and create summer oases. Trees can improve the urban climate by shading, wind-shielding, and evapotranspiration and thus reduce summer cooling energy use in buildings at about 1% of the capital cost of the avoided power plants and air-conditioning equipment. Light colors decrease surface absorption of short-wave radiation, thereby reducing surface temperatures and convective heating of near-surface air. On the urban scale, this results in cooler cities. External surfaces of buildings can be painted white (or a light color) and streets and parking lots resurfaced with white sand (which is necessary anyway), thereby reducing cooling energy needs at relatively low costs.

In addition to saving energy, urban trees and light-colored surfaces are the most cost-effective ways to slow the growth of atmospheric CO₂. By reducing the need to burn fossil fuels for generating electricity, urban trees are many times more efficient at limiting atmospheric CO₂ than is rural forestation.

Our calculations indicate that heat island mitigation strategies such as urban trees and light-colored surfaces can save 0.5 quad per year at a cost of less than 1¢/kWh and decrease CO₂ emissions by about 17 million tons of carbon per year.

HEAT ISLAND EFFECTS AND CONSEQUENCES

Long-Term Urban Temperature Trends

Temperature data for the analysis were obtained from the Carbon Dioxide Information Analysis Center (CDIAC 1987) and Goodridge (1987, 1989). The data have been adjusted for station moves (relocation), change of height, time of observation bias, change in type of instruments, and discontinuity in record (Karl et al. 1986, 1987). They have not been corrected for urban growth (population) effects.

For example, Los Angeles is a large metropolis with a mild to warm climate. Figure 1a depicts the annual temperature highs between 1877 and 1984. It clearly indicates that downtown Los Angeles was

H. Akbari is a staff scientist at Lawrence Berkeley Laboratory, A.H. Rosenfeld is a professor of physics at the University of California and director of the Center for Building Science, and H. Taha is a Ph.D. candidate at the University of California. All are members of the Heat Island Project at the Applied Science Division, Lawrence Berkeley Laboratory, Berkeley, CA.

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cooling at a rate of 0.05°F/yr up to 1930 and then started a steady warming of 0.13°F/yr ($1.3^{\circ}\text{F/decade}$) afterwards. In other words, downtown Los Angeles's annual high temperatures are now $\sim 6^{\circ}\text{F}$ higher than they were in 1940. Figure 1b shows the post-'40s warming trend in further detail. One can see that average temperature slopes of the summer months are in the range of 0.11 to 0.13 (± 0.02) $^{\circ}\text{F/yr}$. Table 1 summarizes some related statistics:

TABLE 1
Summary Statistics for the
Monthly Average Temperature Trends
(ϵ is standard error of the slope, and α is significance).

Month	Fit	r^2	ϵ	α
June	$T=65.71(1940)+0.1307^{\circ}\text{yr}$	0.348	0.027	0.00
July	$T=70.83(1940)+0.1142^{\circ}\text{yr}$	0.346	0.023	0.00
August	$T=71.47(1940)+0.1173^{\circ}\text{yr}$	0.369	0.022	0.00
September	$T=70.46(1940)+0.1108^{\circ}\text{yr}$	0.278	0.026	0.00

Figure 2 depicts the long-term trend in annual mean temperatures in Washington, DC, between 1871 and 1987. One can see that since 1900 there has been a steady rise of $0.5^{\circ}\text{F/decade}$ and that the total rise over 80 years is about 4°F . Contrary to Los Angeles, whose temperatures were all urban (Figure 1), Washington, DC's urban stations moved to airport locations in 1942.¹

The data indicate that this recent warming trend is typical of most U.S. metropolitan areas. As an example, consider some California cities. Figure 3 (Goodridge 1989) shows that before 1940, the average urban-rural temperature differences for 31 urban and 31 rural stations in California were always negative, i.e., cities were cooler than their surroundings (both annual and 10-year averages show this). We speculate that this is a result of oasis effects in the relatively more vegetated city centers. After 1940, when built-up areas took over the vegetated ones, the urban centers became as warm as or warmer than the suburbs, and the trend becomes quite obvious after 1965, with a slope of about $0.7^{\circ}\text{F/decade}$. The heat island effect has thus become dominant in these urban areas.

Goodridge (1989) shows that San Diego, Los Angeles, San Francisco, and Sacramento have warming trends exceeding $0.4^{\circ}\text{F/decade}$. Our data support his findings and indicate that the August warming trends in San Diego, CA, and San Bernardino, CA, are, respectively, $0.8^{\circ}\text{F/decade}$ and $0.6^{\circ}\text{F/decade}$. They also indicate that the maximum temperatures in Davis and Pasadena, CA, have increased by ~ 0.8 and $\sim 0.9^{\circ}\text{F}$, respectively.

¹ Up to 1942, the Washington data are for urban weather stations, but after 1942, the stations moved to airports. Figure 2 thus depicts data from different locations. So while urban heat island information is needed, the last 40 years provide mostly airport data (adjusted or unadjusted) that may underestimate the urban effects, because cities warm up faster than their suburbs where airports are usually located. This is not only the case with Washington, DC, but also with most major cities in the U.S. The authors are not aware, at this time, of any continuous urban temperature data base for the last 100 years (except for Los Angeles and San Francisco, CA), and we believe that monitoring of this kind should be undertaken, if city-wide energy use is to be better understood and mitigation strategies properly applied.

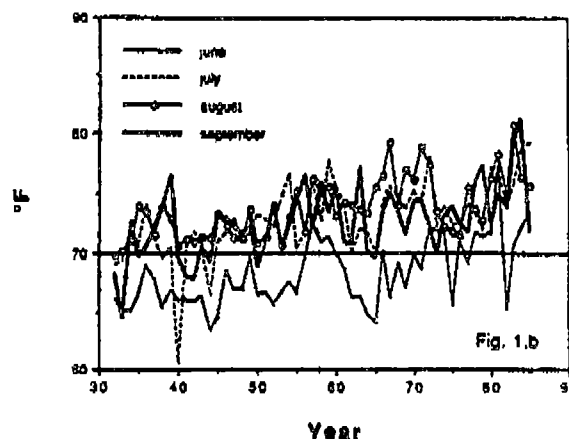
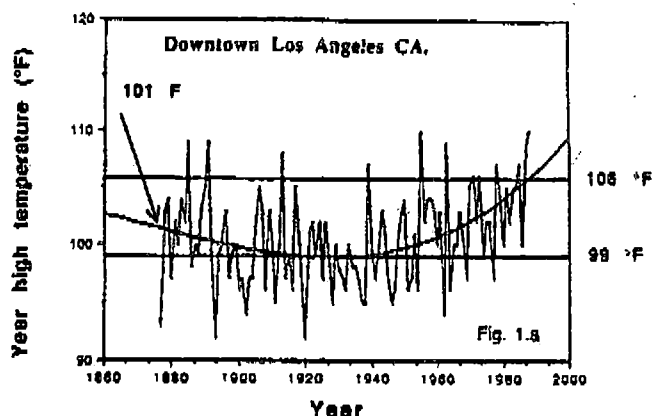


Figure 1 Long-term annual high temperatures (a), and monthly averages (b) in Los Angeles, CA

Heat Islands and Cooling Loads

Figures 4a and b depict the dependence of system-wide utility load on dry-bulb temperature for the portion of the city of Los Angeles served by the Los Angeles Department of Water and Power (LADWP). In Figure 4a, the 4 p.m. load is plotted against the 4 p.m. temperature for 365 days in 1986.² One can distinguish some weekend scatter, base load scatter, and temperature-dependent cooling load. The upper boundary of the peak demand "envelope" slopes at ~ 72 MW/ $^{\circ}\text{F}$ ($2^{\circ}\text{F/}^{\circ}\text{F}$). In Figure 4b, the same procedure is repeated by plotting peak load (at 4 p.m.) vs. average daily temperature for 365 days in 1986; the slope is 75 MW/ $^{\circ}\text{F}$, about $2^{\circ}\text{F/}^{\circ}\text{F}$ of the peak. Recalling that the city of Los Angeles has warmed by $\sim 5^{\circ}\text{F}$ since 1940 (Figure 1), one can see that we have incurred an increase of 375 MW or 10% of the current peak load.

In Figure 5, a similar plot is constructed for a southern California utility (SCE)³ whereby the 4 p.m. loads are plotted against the daily average temperatures for 365 days in 1986. Although representative temperatures for the SCE service area were available, we decided to plot the SCE load data against the LADWP temperatures, so

² We chose 1986 because weather and load data were already available.

³ The system area surrounds Los Angeles but does not include the city itself, which is served by LADWP.

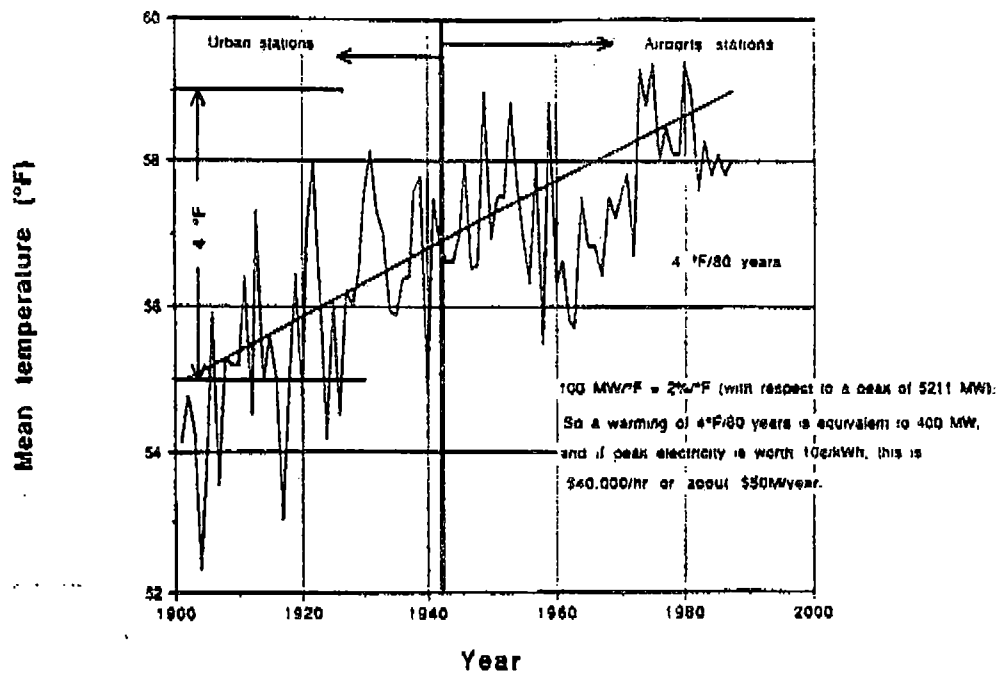


Figure 2 Annual mean temperatures in Washington, DC (1871-1987).
Data source: Mayberry, E. Potomac Electric Power Company, Washington, DC.

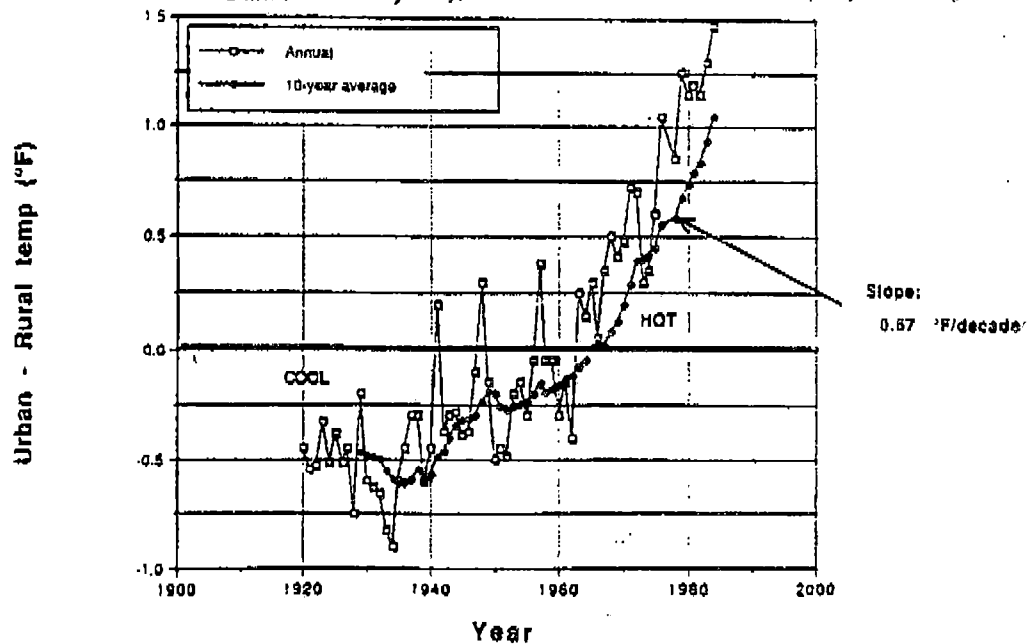


Figure 3 Urban-rural temperature differences in California. Based on 31 urban and 31 rural stations.
Data Source: Goodridge (1989)

we can consistently use them⁴ for comparison with the long-term trend shown in Figure 1.

⁴ To study peak load/temperature dependence, an appropriate method is to use 4 p.m. (peak) temperatures over the period of interest, as was the case in Figure 4a. But hourly data are not always available for long-term periods, i.e., the last 100 years, and only daily or monthly averages can be found. The use of the average temperature is thus justified, and we have shown that in Figure 4b. We saw that there was no major change in the slope, compared to Figure 4a. When the SCE load was plotted against LADWP temperatures (Figure 5), it resulted in a similar pattern. We will use temperature averages in our analysis of load/temperature data for other locations, as well.

Figure 5 shows an envelope's upper boundary slopes at 225 MW/°F, or about 1.6%/°F. If we add this to the LADWP slope (75 MW/°F), the total reaches 300 MW/°F, and for a 5°F rise since 1940, that means ~1.5 GW of heat island-dependent load. If peak electricity is worth 10¢/kWh, then this represents \$150,000/°F for each hour. For Washington, DC (Figure 2), the slope is 100 MW/°F (2%/°F of the 5200 MW peak). So for an increase of 4°F over 80 years, this is an additional 400 MW costing ~\$40,000/hr. There are about 1300 hours of air-conditioning in Washington, DC, resulting in ~\$50M annually. We estimate that the hourly cost of all the heat islands in the U.S. is of an order of magnitude of \$1 million.

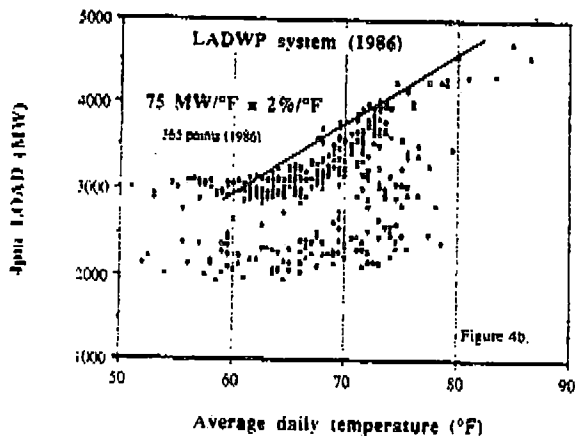
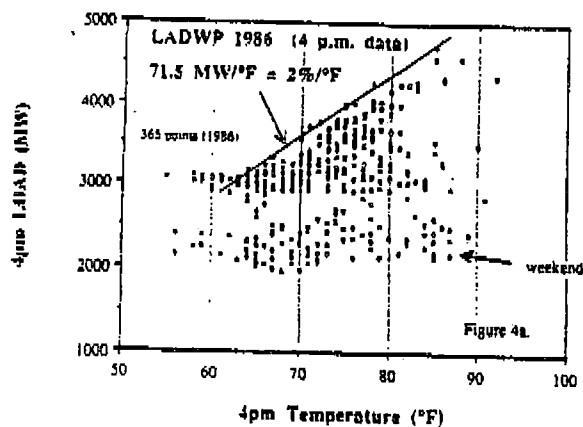


Figure 4 Load vs. temperature in downtown Los Angeles (1986)

Heat Islands and Smog

Not only do summer heat islands increase system-wide cooling loads, but they also increase the amount of smog, brought on by higher urban temperatures. For example, Figure 6 shows the daily maxima in ozone (O_3) levels for Los Angeles. Below 74°F, smog never exceeds the National Atmospheric Air Quality Standard (NAAQS), but by 94°F, smog levels are too high (≈ 26 pphm). Restated, smog is very sensitive to this 20°F increase of which one-fourth is already attributable to the heat island effect. Argento (1988) reports similar results for 13 cities throughout the state of Texas.

HEAT ISLAND MITIGATION

Light-colored urban surfaces and trees are proven and inexpensive measures to reduce heat islands and create summer oases. The effects of modifying the urban environment by planting trees and increasing albedos are best quantified in terms of direct and indirect contributions. The direct effect of planting trees around a building or painting the building surfaces with a light color is to alter the energy balance and cooling requirements of that particular building. However, when trees are planted and albedos are modified throughout an entire city, the energy balance of the whole city is modified, producing city-wide changes in climate. Phenomena associated with the city-wide changes in climate are referred to as indirect effects, because they indirectly affect the energy use in an individual building.

An important reason for making a distinction between direct and indirect effects is that, while direct

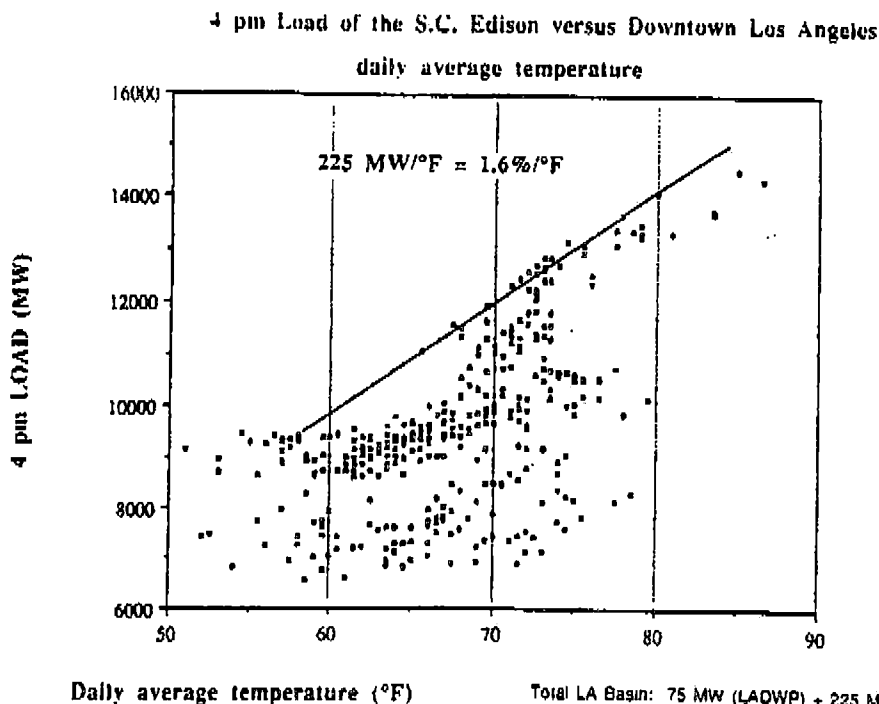


Figure 5 Load vs. temperature for the SCE system (1986)

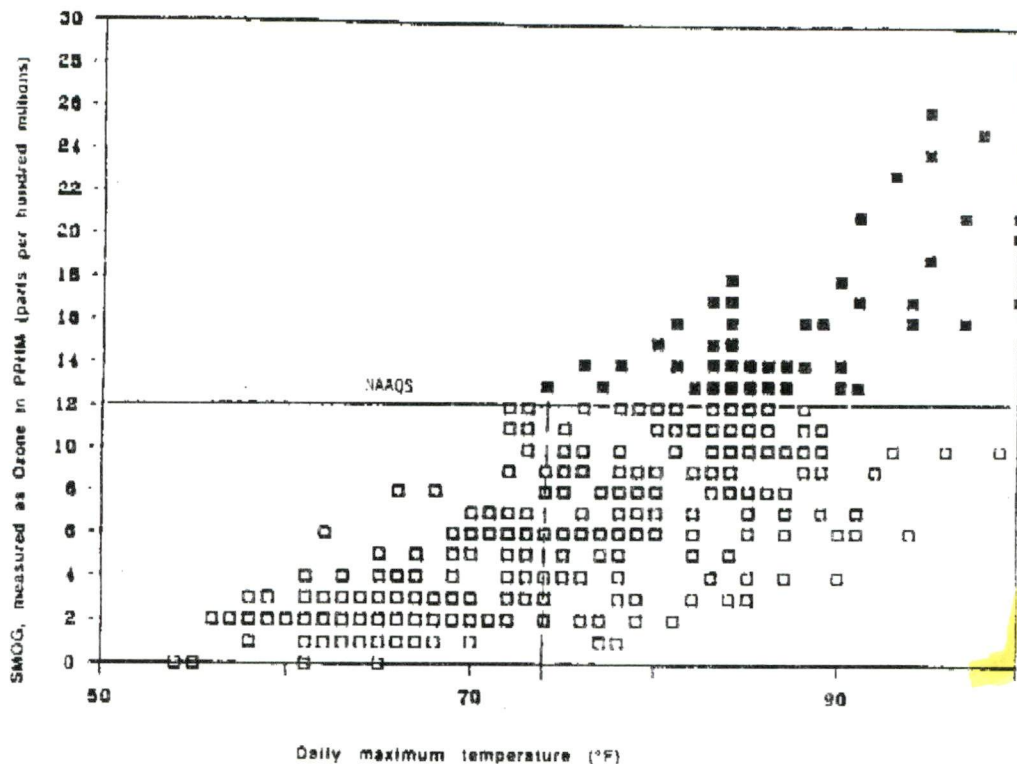


Figure 6 Ozone level vs. temperature in Los Angeles, CA (1985)

effects are well recognized and accounted for in present models of building energy use, indirect effects have received much less recognition. Methods of accounting for indirect effects have not been as well developed and remain comparatively less certain. Understanding these effects and incorporating them into accounts of building energy use is the focus of our current research. It is worth noting that the phenomenon of summer urban heat islands is itself the consequence of indirect effects of the built environment. We are proposing to use the same principles to cool hot cities.

The issue of direct and indirect effects also enters into our discussion of atmospheric CO₂. Planting trees has the direct effect of reducing atmospheric CO₂ because each individual tree directly sequesters carbon from the atmosphere through photosynthesis. However, planting trees in cities also has an indirect effect on CO₂. By reducing the demand for cooling energy, urban trees indirectly reduce emission of CO₂ from power plants. As will be seen, the amount of CO₂ avoided via the indirect effect is considerably greater than the amount sequestered directly.

Urban Trees

Case studies have documented dramatic differences in cooling energy use between houses on landscaped and unlandscaped sites. Parker (1981) measured cooling savings resulting from well-planned landscaping and found that properly located trees and shrubs reduced daily air-conditioning electricity use by as much as 50%.

Trees affect energy use in buildings through direct processes such as (1) reducing solar heat gain through windows, walls, and roofs by shading, (2) reducing the radiant heat gain from surroundings by shading and view factor reduction; and (3) reducing infiltration by shielding a particular building from wind. Deciduous trees are beneficial because they allow solar gain in buildings during wintertime.

On the other hand, the indirect effects of trees include (1) reducing the rate of outside air infiltration by increasing surface roughness and decreasing urban wind speeds and (2) reducing the heat gain of buildings by lowering ambient air temperatures through evapotranspiration (the evaporation of water from soil-vegetation systems). On hot summer days, trees act as natural "evaporative coolers," using up to 100 gallons of water a day each, thus lowering the ambient temperature. A significant increase in urban trees leads to increased evapotranspiration, thus producing an "oasis effect" and significantly lowering urban ambient temperatures. Buildings in these cooler environments will require less cooling power and energy. The effect of evapotranspiration is minimal in winter because of lower ambient temperatures and the absence of leaves on deciduous trees.

Urban Albedo

The energy balance of a building or an entire city depends on the net solar radiation at its surface. To describe the relative amounts of reflected vs. absorbed radiation, the term "albedo" is used. An albedo of 1.0 corresponds to a surface that completely reflects, while

Note

TABLE 2
Simulated Direct Savings in Cooling Energy and Peak Power Resulting from Planting Trees and Whitewashing Buildings¹

Location	1973 Houses (leaky and low insulation)		1980 Houses (tight and high insulation)	
	Savings		Savings	
	Base	(Δ%)	Base	(Δ%)
Chicago, IL	1400 ft ²		2000 ft ²	
Peak kW	3.60	23.6	3.20	29.1
Annual kWh	2584.0	19.9	1888.0	21.8
Miami, FL	1400 ft ²		1600 ft ²	
Peak kW	5.42	25.3	3.29	23.4
Annual kWh	13623.0	22.5	8730.0	16.5
Minneapolis, MN	1400 ft ²		2000 ft ²	
Peak kW	3.14	27.1	2.65	31.7
Annual kWh	1916.0	20.2	1325.0	22.6
Phoenix, AZ	1400 ft ²		1600 ft ²	
Peak kW	7.56	26.2	5.18	31.1
Annual kWh	13117.0	19.8	7789.0	17.3
Pittsburgh, PA	1600 ft ²		1600 ft ²	
Peak kW	3.50	24.9	2.38	23.3
Annual kWh	1821.0	23.3	1177.0	20.1
Sacramento, CA	1400 ft ²		1600 ft ²	
Peak kW	5.40	25.4	3.85	28.0
Annual kWh	3767.0	28.3	2372.0	23.8
Washington, DC	2000 ft ²		2200 ft ²	
Peak kW	5.80	30.3	3.98	29.4
Annual kWh	4358.0	22.7	2790.0	20.0
Average				
Peak kW	25.3		28.0	
Annual kWh	21.9		18.8	

¹ Tree cover was increased by 30% with respect to the base case, whereas albedo was increased from 30% to 70%. We have used these estimates for calculating the national savings.

an albedo of 0.0 refers to one that completely absorbs all incident solar radiation. The albedo of an individual building can be modified to achieve direct savings: a lighter building reflects more solar radiation and therefore stays cooler. The albedo of an entire city can be modified to achieve indirect savings by lowering urban temperatures.

Most buildings and cities have albedos in the range of 0.20 to 0.35. Traditional cities of white-washed buildings found in hot areas have albedos in the range of 0.30 to 0.45 (Taha et al. 1988). Reflective roof membranes and popular "solar control" glazings of commercial buildings both have albedos of up to 0.8. There is a practical constraint in the maximum achievable urban albedo if this strategy is used in conjunction with increased urban vegetation, since a dense urban tree canopy will cover a large amount of the surface area (the albedo of green trees is ~0.25). We have estimated an upper limit of 0.40 for the albedo of a highly vegetated city with light-colored surfaces.

Energy Savings

Table 2 shows the simulated direct savings in cooling energy and peak power resulting from the direct effects of increased urban tree cover and albedo. The results are shown for both the 1973 housing stocks and newer 1980 prototypical houses. The

TABLE 3
Simulated Indirect Savings in Cooling Energy Use and Peak Cooling Power for Single-Story 1980-Prototype Houses¹

Location	Urban canopy density increased by 3 trees/house ¹		Albedo of house and surroundings increased ²	
	Percent energy savings		Percent energy savings	
Sacramento, CA	23		21	
Peak kW	37		45 ³	
Annual kWh	12		—	
Phoenix, AZ	27		—	
Peak kW	15		—	
Annual kWh	31		—	
Lake Charles, LA	—		—	
Peak kW	—		—	
Annual kWh	—		—	

¹ Canopy savings are annual figures. Albedo savings are for the period from July 9 to July 12 only. (All entries are indirect effects.)

² Data from Huang et al. (1987). Assumes an increase of three trees per house.

³ Data estimated from Taha et al. (1988). Assumes an increase from 0.25 to 0.40 in the albedo of the surroundings.

⁴ Canopy savings are annual savings. Albedo savings for the period from July 9 to July 12.

1973 stock is representative of leaky and poorly insulated housing, while the 1980 homes are tight and well insulated. The savings are calculated for an increase in tree cover of 30% (three trees per house) and an increase in a building's albedo from 30% to 70% over that of a base case.

Table 3 shows the simulated indirect savings in cooling energy and peak power. For the cities modeled, the effect of an additional three trees per building results in approximately 30% savings in annual cooling energy and approximately 15% to 20% annual savings in peak cooling power. The indirect effects of albedo were quantified for Sacramento, CA, for only four days in July. Simulations showed that increasing the albedo of the surroundings from 0.25 to 0.40 reduced the cooling energy by 45% and peak power by 21%. This suggests that for residential buildings the potential savings from albedo and vegetation are roughly equivalent.

We have comparatively few simulations of indirect effects. Since our urban climate models are still under development, we conservatively interpret these results as maximum effects. When extrapolating to determine national savings (Table 4), we typically assume smaller effects.

Table 4 shows savings of primary energy use for air conditioning in the U.S. The total residential electricity use for air conditioning (room and central) is about 100 billion kWh or 1.2 quads of primary energy per year (Akbari et al. 1988). In the U.S. in 1987, commercial buildings used 670 billion kWh of electricity (EIA 1987) of which approximately 20% was used for cooling, corresponding to about 130 billion kWh or 1.5 quads of source energy per year. Together, residential and commercial cooling uses 2.7 quads of source energy per year, worth \$20 to \$25 billion.⁵

In our calculations, we have assumed that tree planting and albedo modification can be applied to

⁵ Most residential electricity is still sold at an average price of ~7.5¢/kWh, but air-conditioning power is mainly on-peak and the cost of new peak power is closer to 10¢/kWh.

*Indirect
Evaporative
cooling*

*peak ~15%
energy ~30%*

*+ Direct effect
peak ~26%
energy ~20%*

*Total
peak ~30%
Energy ~40%*

Note trees and white surfaces: 50% savings are trees!

TABLE 4
Annual Cooling Energy Savings and Reductions in Released Carbon from
Heat Island Mitigation Using Trees and White Surfaces 5.1

	Residential		Small Commercial		Large Commercial		Total	
	Energy (%)	Carbon (M Tons)	Energy (%)	Carbon (M Tons)	Energy (%)	Carbon (M Tons)	Energy (10 ¹⁵ Btu)	Carbon (M Tons)
Cooling Energy Use	1.2	36	0.75	24	0.75	24	2.7	84
Heat Island Portion ²	15	0.18	10	0.08	3	0.02	0.27	8
Direct Savings	10 ³	0.12	4 ⁴	0.03	0	0.0	0.15	5
Indirect Savings	20	0.23	12	0.09	55	0.04	0.36	12
Total Savings	30	0.35	16	0.12	5	0.03	0.51	17

⁵ We assumed 100 million trees, white-colored homes, streets, and parking lots.

¹ Production of carbon (as CO₂) from a peak power plant assumes 11,600 Btu/kWh sold, and = 14,500 Btu/lb of carbon.

² We assumed that the overall heat island effect on the cooling energy use is 10%. We estimate that the effect of heat islands to be largest (15%) on residential, moderate (10%) on small commercial, and small (3%) on large commercial buildings.

³ Residential. We assumed 3 trees (plus light surfaces) for 50% of our 50 million air-conditioned homes, so 75 million trees (plus light surfaces).

⁴ Small Commercial. We assumed 30% coverage by trees (25 million more trees).

⁵ Large Commercial. We assumed no additional trees.

only 50% of the 51 million air-conditioned houses in the U.S. Tree density may already be high (especially in older cities) and increasing tree cover and/or albedo may not be acceptable to all municipalities, and some areas may not have a significant cooling load. We have also assumed that half of the commercial building stock of 4 million buildings is small enough to be directly affected by shading and albedo increase.

The analysis shows that the direct effect of planting three trees per house and changing the building albedo from 30% to 70% is equivalent to an average of 20% cooling energy savings (see Table 2). Applying this to the 25 million available houses, using 75 million trees, would result in energy savings of 0.12 quad. The corresponding direct savings due to the planting of a 30% tree cover around small commercial buildings is about 8% (Akbari et al. 1987). When this is applied to 50% of the 2 million small commercial buildings, using another 25 million trees, this would save an additional 0.03 quad. Conservatively, a direct savings of 0.15 quad would be achieved if 100 million trees were planted.

Data presented in Table 3 suggest that the indirect effects of tree planting and albedo modification alone can save at least 20% of the 1.2 quad of residential cooling energy use (thus 0.23 quad). Because small commercial buildings are less sensitive to outdoor temperature than houses, we expect indirect savings of only about 12% of the 0.75 quad of small commercial cooling energy use (thus 0.09 quad). By reducing urban temperatures, these measures also decrease cooling energy use in large commercial buildings by increasing system efficiency and economizer operating hours. We estimate this would save an additional 5% or 0.04 quad.

CO₂ Savings

Carbon, produced in the form of CO₂ from electricity generation, varies from about 0.5 lb carbon/kWh

for natural-gas-fired power plants to about 1 lb carbon/kWh for coal-fired power plants. Because cooling energy is almost always used during periods of peak demand (except in the case of thermal storage), the electric utility must meet this demand using a combination of coal-, oil-, and gas-fired power plants. The fraction of each fuel type used varies greatly, depending on the region of the country, and can vary from all coal in some parts of the East to all oil and gas in Texas. However, the national average is approximately half coal and half oil and gas (DOE 1988). This results in an average emission of 0.8 lb carbon/kWh generated for peak power.

About half the savings from the combination of direct and indirect effects shown in Table 4 would result from planting 100 million urban trees. This savings of 0.25 quads (22 billion kWh) corresponds to a savings of 9 million tons of carbon. A fast-growing forest tree sequesters carbon at the rate of =13 lb carbon per year. Therefore, 100 million trees could directly sequester 0.65 million tons of carbon, or only one-fifteenth of the energy saved through their reduction in cooling energy use. To directly sequester the amount of carbon saved by the planting of 100 million urban trees would require planting 1.5 billion forest trees corresponding to 1.5 million hectares of forest (by comparison, the total area of Connecticut is about 1.3 million hectares).

THE COST OF HEAT ISLAND MITIGATION MEASURES

Table 5 gives the cost-effectiveness, energy savings, and carbon reduction of urban trees/light surfaces compared to other conservation and generation strategies. All energy conservation measures that reduce fossil fuel use also reduce carbon emissions. For example, the trend to more efficient electric appliances yields a cost of conserved energy (CCE) of about 2¢/kWh, equivalent to a cost of conserved carbon (CCC) of

TABLE 5
Cost-Effectiveness, Energy Savings, and Carbon Reduction of Urban Trees/Light Surfaces Compared to Other Conservation and Generation Strategies

Strategy	CCE ¹ (¢/kWh)	CCC ¹ (¢/lb C)	ΔE (Quad/yr)	ΔC (M Tons/yr)
Conservation (Direct + Indirect Effect)				
Urban Trees/ Light Surfaces (direct CO ₂ sequestered)	0.2-1.0	0.25-1.25	0.5	17 (0.65)
Efficient Electric Appliances ²	2	2.5	0.6	21
Efficient Cars ³	4.2 (50¢/gal)	8.3	2.8	60
New Generation				
Coal Power	8	Base Case	—	Base Case
Nuclear Power	114	—	60	

¹ (Source: Akbari et al. 1988)

² CCE is Cost of Conserved Energy and CCC is Cost of Conserved Carbon.
³ Improved standards as defined by National Appliance Energy Conservation Act (NAECA).

⁴ Improved car efficiency from 26 mpg to 36 mpg.

2.5¢/lb carbon. Another conservation strategy is to improve efficiency in automobiles. The cost of conserved carbon in going from a 26 mpg to a 36 mpg automobile is 10¢/lb carbon. Both these measures are effective, but they are much more expensive than urban trees and light-colored cities.

Urban trees and light surfaces have a CCE of about 0.2 to 1.0¢/kWh and a CCC of about 0.3 to 1.3¢/lb of carbon. This is as much as 10 times less expensive than either of the alternative strategies just cited. The point of the comparison is not to discredit the other conservation strategies but to suggest that planting urban trees and modifying urban albedos seems attractive and definitely worth investigating.

There are still many things to learn about summer heat islands. A multi-year effort in research, modeling, and data gathering is required to further investigate the energy-saving potentials and ways for controlling summer heat islands. Table 6 shows some elements of a multi-year research program, including quantifying the heat island effect, verifying the mitigation savings, developing implementation guidelines, and quantifying the heat island effect on pollution and global warming.

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TABLE 6
Elements of a Multi-Year Research Program for Control of Summer Heat Islands

- (1) Quantify the heat island effect
 - gather, benchmark, develop, and test heat island simulation models
 - collect data and make experimental measurements to validate the models
 - evaluate other ways of obtaining heat island data (e.g. satellite and aircraft data)
 - integrate all simulated and measured data into a single data base
 - develop simplified tools to extract heat island data for major urban areas in the U. S. from the integrated data base
- (2) Verify the mitigation savings
 - model the peak power and energy savings of the heat island mitigation measures
 - design and develop wind-tunnel and full-scale experiments to compare and improve simulation results
 - perform field monitoring of energy savings to verify estimated savings
- (3) Develop implementation guidelines
 - evaluate the cost-benefits of heat island mitigation measures and compare savings in energy, equipment, and avoided generation to the costs of implementation
 - develop implementation strategies and guidelines
- (4) Quantify the heat island effect on pollution and global warming
 - develop algorithms to correct for heat island contamination of temperature data used to estimate the severity of global warming
 - estimate the fossil energy saved by the mitigation measures and hence the delay in global warming
 - measure the relation between heat islands, smog, and creation of smog feedstocks

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Observational Constraints on the Global Atmospheric CO₂ Budget

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Observed atmospheric concentrations of CO₂ and data on the partial pressures of CO₂ in surface ocean waters are combined to identify globally significant sources and sinks of CO₂. The atmospheric data are compared with boundary layer concentrations calculated with the transport fields generated by a general circulation model (GCM) for specified source-sink distributions. In the model the observed north-south atmospheric concentration gradient can be maintained only if sinks for CO₂ are greater in the Northern than in the Southern Hemisphere. The observed differences between the partial pressure of CO₂ in the surface waters of the Northern Hemisphere and the atmosphere are too small for the oceans to be the major sink of fossil fuel CO₂. Therefore, a large amount of the CO₂ is apparently absorbed on the continents by terrestrial ecosystems.

RISING ATMOSPHERIC CO₂ CONCENTRATIONS ARE EXPECTED to lead to significant global climatic changes during the coming decades (1). After 30 years of measurements in the atmosphere and the oceans, the global atmospheric CO₂ budget is still surprisingly uncertain. An improved understanding of the CO₂ cycle is essential to predict the future rate of atmospheric CO₂ increase and to plan eventually for an international CO₂ management strategy.

Combustion of fossil fuels, the amount of which is well documented (2), is a major contributor to the observed concentration increase of CO₂ in the atmosphere. The measured rise was about 57% of the fossil fuel input from 1981 to 1987. Other sources may have also contributed to the rise, but the amount of CO₂ released by changes in land use remains uncertain (3, 4), as is the response of terrestrial ecosystems to higher CO₂ levels and to other climatic and environmental perturbations (5). Estimates of the uptake of CO₂ by the oceans have been based entirely on computational schemes of varying complexity (6), from "box" models to three-dimensional ocean circulation models (7). The "consensus" among these studies is that the oceans might be absorbing between 26 and 44% of the fossil CO₂. This would leave no room for any significant net loss of C from terrestrial ecosystems, but instead would require net C

uptake on the land (except for the highest ocean uptake estimates) to balance the atmospheric CO₂ budget (6, 7).

The inorganic carbon chemistry that describes the ultimate uptake capacity of the oceans is well understood; however, the capacity of the oceans for uptake of CO₂ also depends sensitively on their circulation dynamics and the biological processes in them. The atmosphere exchanges CO₂ with the ocean surface layer, in which biological processes keep the partial pressure of CO₂ (*p*CO₂) much lower than in deeper waters. High-latitude areas, where deep water outcrops at the sea surface during winter, are an exception. The high *p*CO₂ in waters below about 300 m depth is attributed mainly to the downward transport of C, via gravitational settling of biogenic debris produced in the photic zone, and the slow vertical mixing rate of deep water. The models that have been used to estimate the uptake of CO₂ by the oceans incorporate these oceanic features in varying degrees and have been validated with observed distributions of tracers such as ²²²Rn, ¹⁴C, ³H, chlorofluorocarbons (CFCs), nutrient salts, and O₂. However, none of these tracers behaves exactly like CO₂. Furthermore, in all models the circulation is assumed to be in steady state, and in many of them changes in biological processes and the seasonal nature of C uptake are not included.

Measurements of *p*CO₂ in the surface waters and of total inorganic carbon (TCO₂) dissolved in the oceans have not yet led to a direct confirmation of the amount of fossil CO₂ removed from the atmosphere by the oceans (8), in part because the expected increases are small compared to the natural variation. For example, if half of the cumulative fossil fuel CO₂ emitted since 1850 were distributed uniformly in the upper 1000 m of the oceans, TCO₂ would have increased by only 1%.

Any geographical distribution of CO₂ sources and sinks is reflected in the spatial and temporal variations of CO₂ concentration patterns in the atmosphere. Numerical models of atmospheric transport can simulate these patterns; they thereby allow us to test hypotheses of the atmospheric CO₂ budget (9, 10). With the use of two-dimensional models (latitude, height) the observed concentration gradients in the atmospheric boundary layer can be inverted directly to yield the net surface source as a function of latitude and time (11). In this article, we use three-dimensional (3-D) transport fields to simulate the global distribution of CO₂ in response to specific assumptions about the strength and location of surface fluxes of CO₂. Global CO₂ budgets are constructed as linear combinations of separate sources and sinks, including new estimates for the oceanic fluxes. The mean annual meridional gradient observed from 1981 to 1987 is then compared with the model values, calculated as the corresponding linear combinations of the distributions generated separately for each source or sink, and thus used to select acceptable CO₂ source-sink scenarios.

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Atmospheric Observations

The Geophysical Monitoring for Climatic Change (GMCC) division of the National Oceanic and Atmospheric Administration (NOAA) has been collecting air samples in flasks for CO₂ analysis from more than 20 sites since 1980 (Table 1) (12). All flasks have been analyzed on the same nondispersive infrared analyzer in Boulder, Colorado, and referenced to the international manometric mole fraction scale (13) adopted for CO₂ monitoring. The seasonal cycles of CO₂ concentration observed at these sites have been used to estimate the seasonal net ecosystem production of the major terrestrial biomes of the world (10, 14). In this study we have used the average of the annual mean concentrations for 1981 to 1987 (Table 1 and Fig. 1). We have not used the data from all of the GMCC sites. Records from Niwot Ridge, Colorado, as well as Mauna Loa Observatory, Hawaii, were not used because mountainous terrain is not resolved well in the transport model. Specifically, we do not know what effective model height to assign to these sites. At some other sites, such as Cape Meares, Oregon, the data are too noisy to extract annual averages with sufficient confidence. The data yield a large-scale meridional gradient that corresponds closely to those obtained by other atmospheric CO₂ monitoring programs (14, 15).

Oceanic Observations and CO₂ Flux Estimates

The observed pCO₂ difference ($\Delta p\text{CO}_2$) between the surface ocean and the atmosphere represents the thermodynamic driving potential for transfer of CO₂ gas across the sea surface and includes implicitly the combined effects of all the processes that influence the CO₂ distribution in the oceans and atmosphere. We have analyzed measurements of $\Delta p\text{CO}_2$ obtained from 1972 to 1989 (16) (Fig. 2). El Niño events, occurring irregularly every few years, reduce the CO₂ flux from the Eastern and Central Equatorial Pacific waters to virtually zero (17), but the equatorial measurements during the 1982–1983 and 1986–1987 events have been excluded. The oceans

were divided into 2° by 2° "pixels", and the mean $\Delta p\text{CO}_2$ value for each pixel was computed separately for two seasonal periods, January through April and July through October (18) (Fig. 3). To estimate the global distribution of $\Delta p\text{CO}_2$ during each of the two seasonal periods, we extrapolated the observed values into regions where observations were lacking using relations between water temperature and surface water pCO₂ observed in various oceanographic regimes (19).

The net CO₂ flux (F) across the air-sea interface was computed from

$$F = E\Delta p\text{CO}_2 = V_p S \Delta p\text{CO}_2 \quad (1)$$

where E is the gas transfer coefficient, V_p is the gas transfer piston velocity, and S is the solubility of CO₂ in seawater; V_p depends on turbulence in both media and hence on the wind speed, W . Because the effects of temperature on V_p and S nearly cancel each other, E is mainly a function of wind speed alone. Measurements of V_p made under various wind regimes in the field and in wind tunnels show that V_p is nearly zero for $W < 3 \text{ m s}^{-1}$. They also show a wide range of variation (about a factor of 2) in V_p for $W > 3 \text{ m s}^{-1}$, the cause of which is not clearly understood. For $W > 3 \text{ m s}^{-1}$ (the wind speed at 10 m above the sea surface), we adopted the relation (20)

$$E(\text{moles of CO}_2 \text{ m}^{-2} \text{ year}^{-1} \mu\text{atm}^{-1}) = 0.016 [W(\text{m s}^{-1}) - 3] \quad (2)$$

whereas E is taken to be zero for $W < 3 \text{ m s}^{-1}$. This relation yields V_p values slightly lower than the upper limit of the wind-tunnel data (21). For comparison, Liss and Merlivat [(22), see also (23)], using results of experiments in wind tunnels and in the field (24), chose values about one half of our values. If their values are adopted, the resulting CO₂ transfer flux would be halved for a given value of $\Delta p\text{CO}_2$.

We calculated monthly values of E for every 2° by 2° pixel using Eq. 2 and monthly climatological wind speeds compiled by Esbensen and Kushnir (25). The resulting annual mean global value for E

Table 1. Annual average concentrations of CO₂ above 300 ppmv (by volume) in dry air. Years for which the data quality was deemed insufficient have been omitted (dashes), and the lack of an ongoing program is indicated by blanks. For the calculation of the 1981 to 1987 average, all years were first normalized to 1987 by adding the globally averaged difference between

1987 and that year. In order to avoid biasing the global averages by the addition or omission of stations, the averages were calculated from third-degree polynomial curve fits to the available yearly data. The reported SD is a measure of the variability of the annual averages at each station after normalization to 1987.

Name	Code	Location	1981	1982	1983	1984	1985	1986	1987	Average	SD
South Pole	SPO	90°S	38.5	39.3	40.7	42.2	43.6	44.6	46.8	46.59	.17
Halley Bay	HBA	76°S, 26°W			41.2	—	—	45.0	47.2	47.11	.23
Palmer Station	PSA	65°S, 64°W		39.5	40.9	42.7	43.9	—	47.0	46.91	.13
Cape Grim	CGO	41°S, 145°E			42.5	43.7	44.6	46.6	—	46.54	.11
Amsterdam Island	AMS	38°S, 78°E		39.3	41.1	42.4	43.9	45.0	—	46.82	.20
Santoa	SMO	14°S, 171°W	39.3	40.3	41.4	43.5	44.7	45.2	47.1	47.44	.27
Ascension Island	ASC	8°S, 14°W	39.8	40.7	42.6	43.9	45.0	45.8	48.1	48.07	.33
Seychelles	SEY	5°S, 55°E	40.2	40.5	41.1	44.1	45.2	46.1	—	47.93	.41
Christmas Island	CHR	2°N, 157°W			44.7	45.9	46.3	48.5	—	48.56	.32
Guam	GMI	13°N, 146°E		41.0	42.7	44.4	46.0	—	—	48.64	.19
Virgin Island	AVI	18°N, 65°W	40.3	40.9	42.0	43.4	45.4	46.4	48.2	48.13	.28
Cape Kumukahi	KUM	20°N, 155°W	40.6	41.2	42.6	44.3	45.6	46.5	48.5	48.32	.14
Key Biscayne	KEY	26°N, 80°W				45.2	46.7	47.6	49.5	49.47	.06
Midway	MID	28°N, 177°W					47.6	49.7	49.7	49.61	.21
Azores	AZR	39°N, 27°W		41.2	43.0	44.5	—	—	—	48.77	.21
Shemya Island	SHM	53°N, 174°E					48.9	50.0	50.39	50.39	.52
Cold Bay	CBA	55°N, 163°W	41.0	41.8	43.3	45.5	47.2	48.1	49.7	49.58	.34
Station "M"	STM	66°N, 2°E	41.8	42.1	43.1	45.5	46.5	48.2	48.8	49.49	.42
Point Barrow	BRW	71°N, 157°W	41.4	42.6	43.7	45.4	46.4	48.6	49.5	49.73	.39
Mould Bay	MBC	76°N, 119°W	41.8	42.4	43.6	45.6	46.7	48.0	49.3	49.85	.28
Alert	ALT	83°N, 62°W						48.0	49.5	49.68	.25
Global average			40.00	40.65	42.03	43.91	45.27	46.26	48.10	48.10	

Table 2. Estimates of sea-to-air CO₂ flux (Gt of C per year) based on the compilation of $\Delta p\text{CO}_2$ in micromospheres in various oceans (Fig. 3) and transfer coefficients depending on wind speeds (see text). The seasonality of

the $\Delta p\text{CO}_2$ and the winds has been taken into account. The north Indian Ocean is included in the equatorial oceans. Extrapolation of $\Delta p\text{CO}_2$ into ocean areas with no measurements is based on water temperatures (19).

Ocean	Location	January to April		July to October		Annual mean	
		$\Delta p\text{CO}_2$	Flux	$\Delta p\text{CO}_2$	Flux	$\Delta p\text{CO}_2$	Flux
Atlantic subarctic	>50°N; 90°W to 20°E	-22	-0.15	-53	-0.31	-37	-0.23
Atlantic gyre	15°N to 50°N; 90°W to 20°E	-29	-0.58	-1	-0.02	-15	-0.30
North Pacific	>15°N; 110°E to 90°W	-11	-0.44	14	0.33	2	-0.06
Equatorial	15°S to 15°N; 180°W to 180°E	37	1.56	28	1.69	33	1.62
Southern gyres	50°S to 15°S; 180°W to 180°E	-9	-1.46	-25	-3.31	-17	-2.39
Antarctic	>50°S	-23	-0.38	-10	-0.03	-17	-0.20
Global		3	-1.5	-1	-1.7	1	-1.6

is 0.067 mol of CO₂ m⁻² year⁻¹ μatm^{-1} , which is consistent with the global mean CO₂ gas exchange rate of 20 ± 3 mol of CO₂ m⁻² year⁻¹, based on the distribution of ¹⁴CO₂ in the atmosphere and oceans (21) (hence Eq. 2 is "empirical"). The ocean fluxes were calculated from the seasonal $\Delta p\text{CO}_2$ maps (Fig. 3), Eq. 2, and the monthly climatological winds (25) (Table 2). This analysis gave a net CO₂ uptake of 1.6 Gt of C per year (1 Gt equals 10¹¹ g), which corresponds to about 30% of the current rate of fossil fuel emissions.

A rigorous error analysis for this estimate cannot be made at this time, but most of the uncertainty is attributed to the sparsity of data in the South Pacific and South Indian oceans. In the North Pacific Ocean, where 26 trans-Pacific transects have been made during various seasons from 1984 to 1989, the uncertainty in $\Delta p\text{CO}_2$ due to the finite number of samples can be estimated. We removed an east-west transect data set (about 40 values) and computed pixel values using the remaining data (about 260 values for a seasonal map), after which we compared the values on the computed map with the removed transect. This comparison was made for three separate data sets, representing transects across the northern high-latitude areas in summer and winter, respectively, and one across the mid-latitudes during the winter. The root-mean-square difference between individual computed and measured values was 8 μatm , whereas the mean difference was about 1 μatm . This result suggests good consistency between the transects and only minor statistical sampling errors in this ocean basin, but does not address possible systematic errors. A systematic error of 1 μatm in the annual average $\Delta p\text{CO}_2$ would lead to a total flux error of about 0.07 Gt of C per year for the Arctic, North Atlantic, and North Pacific oceans combined. On the other hand, the same error in $\Delta p\text{CO}_2$ for the Southern Hemisphere oceans (south of 10°S) would cause an error in the net flux of about 0.15 Gt of C per year, mainly because of the greater area.

Transport Modeling with Surface Sources and Sinks

We used a global 3-D atmospheric tracer model derived from the general circulation model (GCM) developed at Goddard Institute for Space Studies (GISS) of the National Aeronautics and Space Administration (26) to model the distribution of CO₂ in the atmosphere. The 3-D model is fully seasonal in terms of its transport and mixing characteristics (including parameterized diffusion) as well as in the sources and sinks of CO₂. The parent GCM has diurnal and seasonal cycles, and four hourly mass fluxes, as well as monthly averaged convective frequencies, were saved for the tracer transport model. In addition to producing realistic simulations of the large-scale features of the general circulation of the atmosphere, the GCM

transport fields have been validated by the simulation of inert tracers (27). For tracers with Northern Hemisphere mid-latitude sources, the interhemispheric exchange time has been adjusted via a subgrid diffusion parameterization to 1.0 year, intermediate between what is needed to match the observed north-south distributions of CFCs and ⁸⁵Kr (exchange times of 0.9 and 1.1 years, respectively).

Two-dimensional models based on transport coefficients derived (28) from the GCM developed at the Geophysical Fluid Dynamics Laboratory (GFDL) have an interhemispheric exchange time for ⁸⁵Kr (11) nearly identical to that in the GISS model. An independent 3-D transport model based on analyzed winds, as obtained by the European Center for Medium Range Weather Forecasting, together with a convective vertical mixing scheme, gives an interhemispheric transport time for ⁸⁵Kr of 1.39 years (29). The calculated vertically and hemispherically averaged difference between the hemispheres for the fossil fuel source by the GISS model is the same as that derived for a simple atmospheric two-box model with an

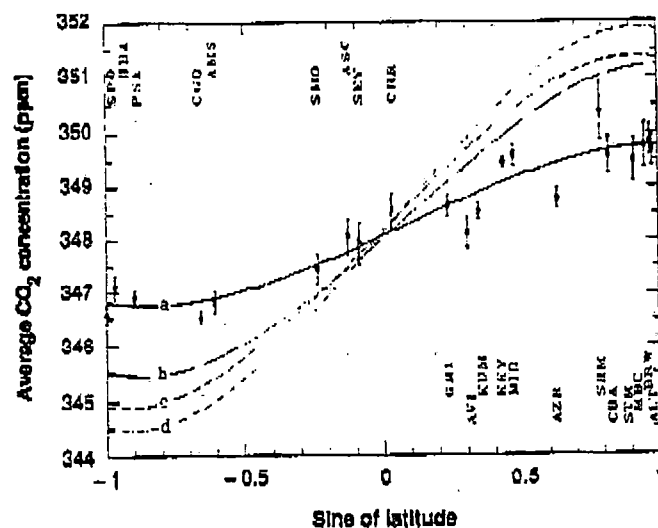


Fig. 1. Observed atmospheric CO₂ concentrations at the sites of the NOAA/GMCC flask network. The three-letter station codes are explained in Table 1. The error bars represent 1 SD of the annual averages at each site after adjustment to 1987. Curve (a) is a least-squares cubic polynomial fit to the data. The residual SD of the points with respect to the curve is 0.39 ppm. The concentration distributions at the NOAA/GMCC sites have also been calculated with the NASA/GISS GCM transport fields. Other curves are polynomial fits to the calculated CO₂ distributions (not shown) with fossil fuel emissions, seasonal vegetation (no net annual source or sink), tropical deforestation of 0.3 Gt of C per year, and three different cases of ocean uptake: (c), the compilation of CO₂ uptake based on the $\Delta p\text{CO}_2$ data (Table 2) and our empirical transfer coefficients; (b), CO₂ uptake based on the same $\Delta p\text{CO}_2$ map, but calculated with the Liss-Merlivat (22) relation for air-sea exchange; (d), an earlier estimate of ocean uptake (21) totaling 2.6 Gt of C per year.

interhemispheric exchange time of 1 year. Also, our two-dimensional model based on the transport derived from the GFDL GCM gave a virtually identical result.

The GISS transport model has been used to simulate the effects of seasonal CO_2 exchange with the terrestrial biosphere (30). The

modeled annual oscillations are similar to those observed at the surface sampling sites, as well as to those found in aircraft data from Scandinavia, Japan, Australia (Fig. 4), and from various latitudes in the Northern Hemisphere at 500 and 700 mbar (31).

The covariance of seasonal transport and seasonal CO_2 sources and sinks may lead to annually averaged concentration differences between different sites, both in the model and in the atmosphere, even in the absence of net annual sources: If transport is less vigorous during the season when a surface region is a source rather than when it is a sink, a positive net annual concentration anomaly will result. With purely seasonal annually balanced sources, the GISS 3-D model calculates annual mean concentrations for the GMCC sites in the Northern Hemisphere that are on average 0.25 ppm higher than for the sites in the Southern Hemisphere, whereas a 2-D model (11) gives a difference of only 0.05 ppm. There are no independent tracers to validate this aspect of the models. The most important reason for the difference is the summer-to-winter variability of vertical convective mixing at high latitudes. The greater vertical stability in winter would tend to keep the respired CO_2 closer to the ground, which would result in higher annual average surface CO_2 concentrations in the Northern Hemisphere.

We used the 3-D model to test hypotheses about global CO_2 budgets, constructed as linear combinations of separate source-sink



Fig. 2. The distribution of measurements of $\Delta p\text{CO}_2$ since 1972. Where observations were made quasi-continuously, the values have been averaged over 2° intervals in longitude and latitude, and each of these intervals is represented by a single dot on the map.



Fig. 3. Observed $\Delta p\text{CO}_2$ (in microatmospheres) between surface waters of the oceans and the atmosphere during two seasonal periods, (A) January through April and (B) July through October. These maps have been compiled from direct observations made since 1972 (Fig. 2) and represent the mean distributions during the past 16 years, excluding the El Niño conditions in the equatorial Pacific. Areas of ice cover are indicated in light gray.

patterns. We first calculated the CO_2 distribution for each source separately by running the model with that source for 3 years, during which the annual average concentration gradients became stabilized. The CO_2 distributions computed for the last year of the simulations were used in our analyses. As a sign convention, fluxes into the atmosphere (sources) are positive, fluxes from the atmosphere (sinks) negative. For any hypothesized global budget to be acceptable, it must satisfy two observational criteria: first, the total atmospheric inventory must increase by 3.0 Gt of C per year (corresponding to 1.4 ppm per year), and second, the corresponding linear combination of the modeled response distributions must reasonably resemble the observed atmospheric concentration differences at the stations.

The residuals, departures of the modeled annual average CO_2 concentrations from those observed at the GMCC sites, were fit with a third-order polynomial and with a straight line. In this way we were looking for consistent patterns of disagreement between the model and the data, because we did not want to adjust sources solely on the basis of discrepancies at single points. A source scenario is considered not plausible if the slope of the linear fit or any structure in the polynomial fit is statistically significant. The linear slope constraint requires that the strength of extratropical sources and sinks in the Northern relative to those in the Southern Hemisphere be determined to within about 0.2 Gt of C per year.

A Test of Some Current Views of the CO_2 Budget

The geographical distribution of fossil fuel combustion (32) was combined with several global compilations of CO_2 exchange with the oceans and the terrestrial biosphere. The fossil fuel source was 5.3 Gt of C per year, typical of that from 1980 to 1987, when the global fossil fuel consumption remained fairly constant. Seasonal exchange with the terrestrial biosphere (30) was included although it does not affect the global budget. Tropical deforestation was assumed to be a source of 0.3 Gt of C per year, at the low end of the release estimates. Three ocean estimates were tested. In the first, our ocean data analysis presented above (Table 2) was used, and in this case an additional CO_2 sink of 1 Gt of C per year is required to balance the budget because the observed atmospheric increase is 3.0 Gt of C per year. In the second, the $\Delta p\text{CO}_2$ values were combined with the air-sea transfer coefficients proposed by Liss and Merlivat

(22); this scenario results in a total ocean uptake of only 0.8 Gt of C per year, in which case an extra sink of 1.8 Gt of C per year is required. In the third, we set the global net ocean sink to 2.6 Gt of C per year (21), thus balancing the budget.

The simulated difference in atmospheric CO_2 between the north and south poles resulting exclusively from fossil fuel combustion without any CO_2 sinks was 4.4 ppm. The uncertainty in the CO_2 production from fossil fuel combustion is estimated to be between 6 and 10% (33), and about 5% (34) of the fuel carbon is only partially oxidized to CO during combustion. This CO is oxidized in the atmosphere by reaction with OH radicals, which are concentrated at lower latitudes. This effect is neglected in the scenario, so that the calculated pole-to-pole gradient for fossil fuel combustion alone could be between 3.8 to 4.6 ppm. The seasonal terrestrial CO_2 exchange and tropical deforestation together are calculated to add another 0.6 ppm to the pole-to-pole gradient. The inclusion of the oceanic sink, acting strongly in the Southern Hemisphere, resulted in a meridional gradient between both poles of 5.7 to 7.3 ppm, depending on the ocean scenario. These values are contradicted in all

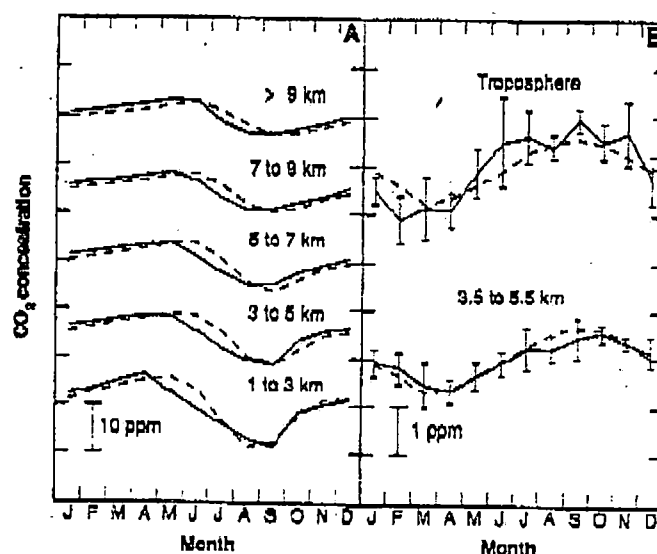


Fig. 4. Comparison of the observed (31) (solid line) and GISS-model calculated (30) (dashed line) annual cycle of CO_2 at different altitudes in the troposphere over (A) Scandinavia (67°N , 20°E) and (B) Bass Strait (40°S , 150°E).

Table 2. Four modeled scenarios of the global atmospheric cycle. Fluxes are in units of gigatons of C per year and $\Delta p\text{CO}_2$ is in microatmospheres. The terrestrial sources and sinks correspond to the basis functions: (i) tropical deforestation, (ii) carbon sequestering by temperate ecosystems, and (iii) CO_2 fertilization (see text). Fossil fuel combustion and the seasonality of the terrestrial biosphere is included in all cases. After fluxes to and from the

terrestrial biosphere have been postulated, uptake by the oceans is adjusted to minimize the SD (in parts per million, last line) of the residual differences between the observed and calculated atmospheric CO_2 concentrations. The required annual average $\Delta p\text{CO}_2$ is estimated for ocean basins with empirical air-sea gas transfer coefficients.

Source or sink	Scenario 1, flux $\Delta p\text{CO}_2$	Scenario 2, flux $\Delta p\text{CO}_2$	Scenario 3, flux $\Delta p\text{CO}_2$	Scenario 4, flux $\Delta p\text{CO}_2$
Tropical deforestation	0.3	0.3	2.0	2.0
Temperate ecosystem uptake	0.0	0.0	0.0	-1.0
CO_2 fertilization	0.0	-1.0	0.0	0.0
Total terrestrial	0.3	-0.7	2.0	1.0
North Atlantic ($>50^\circ\text{N}$)	-0.7 -72	-0.5 -52	-0.7 -72	-0.5 -52
North Atlantic gyre (15° to 50°N)	-1.0 -52	-0.8 -42	-1.4 -73	-1.0 -52
North Pacific gyre ($>15^\circ\text{N}$)	-1.0 -24	-0.7 -17	-1.4 -34	-1.0 -24
Equatorial (15°S to 15°N)	1.0 22	1.0 22	1.0 22	1.0 22
Combined southern gyres (15° to 50°S)	-1.4 -14	-1.1 -11	-2.3 -23	-2.3 -23
Antarctic ($>50^\circ\text{S}$)	0.5 9	0.5 9	0.5 9	0.5 9
Total oceans	-2.6	-1.6	-4.3	-3.3
SD of residuals	0.25	0.24	0.26	0.25

cases by the atmospheric data (Fig. 1) which exhibit a difference of only 3.0 ppm. What is wrong? In order to decrease the modeled gradient due to the fossil fuel source alone, either the extratropical net sink in the Northern Hemisphere must be larger than in the Southern Hemisphere, or there is a serious problem with the simulations of atmospheric transport in the GCM.

The annually averaged interhemispheric transport in the GCM is constrained by the ^{85}Kr and CFC calibrations, and we estimate that this part of the uncertainty in the calculated pole-to-pole concentration gradient is 10% or less. The behavior of the seasonal cycle of CO_2 as a function of altitude is well represented by the model (30, 31) in the few places where data are available. Inverse calculations with two-dimensional transport models (11) have similarly shown that the sink of CO_2 needs to be substantially larger in the Northern Hemisphere than in the Southern Hemisphere. As the peak-to-trough amplitude of the mean Northern Hemisphere CO_2 annual cycle is about 8 ppm, it is unlikely that covariation of this seasonal source and seasonal transport could produce a north-south counter-gradient as large as 3 to 4 ppm to allow the southern oceans to be the dominant sink of fossil fuel CO_2 . Therefore, the presence of a large sink of C in the Northern Hemisphere is a more likely cause for the discrepancy than problems with the model transport.

CO_2 Patterns from Single Source Regions

Before we discuss CO_2 source-sink scenarios, that is, linear combinations of sources and sinks that satisfy the two constraints, we describe the series of "basis" sources and simulations of the corresponding CO_2 response distributions made with the 3-D model. Atmospheric CO_2 patterns were calculated separately for eight oceanic source regions: the equatorial oceans between 15°N and 15°S , the North Pacific gyre north of 15°N , the North Atlantic north of 50°N , the North Atlantic gyre between 15°N and 50°N , the South Atlantic, South Pacific and Indian ocean gyres each between 15°S and 50°S , and the Antarctic Ocean south of 50°S . In each of these cases the source was assumed, as a first approximation, to be constant in time and uniformly distributed in its respective area. The resulting concentration patterns were as expected: for example, if there is a CO_2 source of 1 Gt of C per year in the North Atlantic gyre, the CO_2 concentrations at AZR, KEY, and AVI (Table 1) stand out from values at Pacific stations at similar latitudes by about 0.6 ppm. To reduce the number of independent variables, we assumed that the fluxes were proportional to area in the three southern ocean gyres, and we held the equatorial ocean source fixed at 1 Gt of C per year (21). We then had five ocean areas left as variables, the North Atlantic, the two north temperate gyres, the combined southern gyres, and the waters around Antarctica.

We considered four "basis functions" of net annual CO_2 exchange with the terrestrial biosphere: (i) net release due to deforestation in the tropics (3); (ii) C sequestering by temperate ecosystems; (iii) storage of C by high latitude boreal ecosystems; (iv) and a hypothetical sink due to enhanced net photosynthesis, which is referred to as CO_2 fertilization. For the second basis function, the C sink was uniformly distributed among locations associated with cold-deciduous forests ($13 \times 10^6 \text{ km}^2$); similarly for the third, the sink was distributed among evergreen needle-leaved forests and woodlands ($12 \times 10^6 \text{ km}^2$) and tundra ($7 \times 10^6 \text{ km}^2$). Carbon sequestering in these regions may be through processes such as reforestation (35) or accumulation of organic matter in soils. For the fourth sink, we assumed that the net fertilization is proportional to net primary productivity (NPP); thus, this sink is intense in tropical regions because of their high NPP (36). A global fertilization effect of 1 Gt of C per year, for example, would represent an increase of only 2%

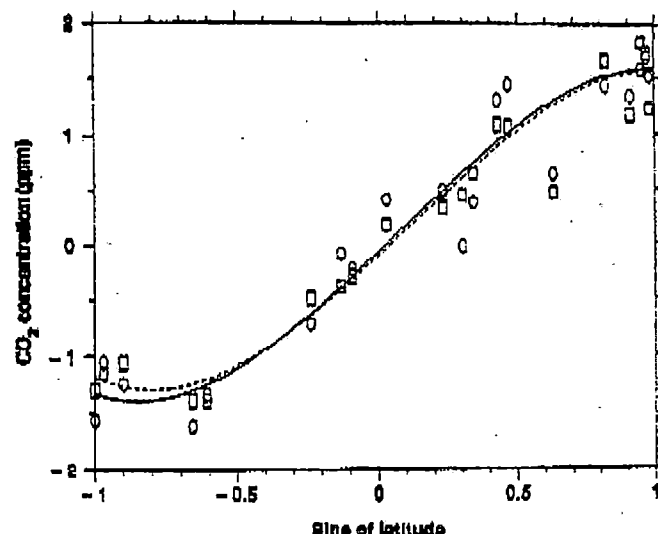


Fig. 5. Results of model calculations (scenario 1, Table 3) of the atmospheric CO_2 concentrations at the GMCC sites (squares and dashed curve) are compared with the observed concentrations (circles and solid curve). All values are relative to the global mean. The curves are least-squares cubic polynomial fits; the differences between the curves are not statistically significant.

of NPP if ecosystem respiration remained the same. This amount is easily within the uncertainties of global NPP estimates (36).

In the simulations we took into account the covariance of the annually balanced seasonal CO_2 exchange (30) with terrestrial plants (no net annual flux) and the seasonality of the transport as a separate "basis" source scenario. The inclusion of this scenario significantly improved the comparison between the modeled and the observed concentrations with respect to the longitudinal variability.

Adjustment of Oceanic Uptake to Terrestrial Scenarios

After we specified a priori certain combinations of gain and loss of C on the continents, uptake by the oceans was adjusted in each case until satisfactory agreement with the atmospheric observations was obtained. The four scenarios (Table 3 and Fig. 5) all fit the atmospheric observations equally well; these data by themselves do not permit us to determine whether any one is more likely. In fitting the data, we could, to a limited extent, trade off uptake of C by terrestrial ecosystems against uptake by the oceans, for example, boreal forest and tundra ecosystems against the North Atlantic. Monitoring techniques need to be developed for and extended to the continental interiors to preclude such freedom in modeling and to pinpoint the source-sink distributions much more definitively.

The disagreement with Table 2 for the uptake of CO_2 by the southern oceans stems mainly from the limited number of $\Delta p\text{CO}_2$ observations in the high-latitude waters near Antarctica. The atmospheric data seem to indicate that there is a CO_2 source in the waters around Antarctica. This estimate for the Antarctic waters rests on the concentration difference between HBA and PSA on the one hand and SPO, CGO, and AMS on the other hand (Fig. 1). Recent oceanographic measurements (37) appear to have provided some confirmation for the presence of a CO_2 source (Fig. 3B).

Atmospheric CO_2 concentrations at AVI, KEY, and AZR (Table 1) in the Atlantic relative to KUM and MID in the Pacific suggest that the average $p\text{CO}_2$ of the North Pacific should be higher than the North Atlantic. The $\Delta p\text{CO}_2$ observations confirm this (Fig. 3).

All of the scenarios (Table 3), however, are equally unrealistic because the mean annual $\Delta p\text{CO}_2$ required for the Northern Hemisphere oceans is much greater than observed (Fig. 3). The discrepancy is much larger than can be explained by the uncertainty in the $\Delta p\text{CO}_2$ data. Use of the gas exchange rates of Liss and Merlivat (22) would double this discrepancy.

Adjustment of Terrestrial Exchange to Observed $\Delta p\text{CO}_2$

Because of the conflict of the $\Delta p\text{CO}_2$ required by the foregoing scenarios and the observed $\Delta p\text{CO}_2$ of the northern oceans, we constructed several scenarios in which CO_2 fluxes in better known oceanic regions were kept fixed (with linear interpolation for the intervening months), namely uptake by the northern oceans and CO_2 outgassing from the equatorial oceans (Table 2). Exchange with the terrestrial ecosystems and with the southern oceans was varied to produce agreement with the atmospheric data.

Several types of scenarios (four are presented in Table 4) all agreed about equally well with the atmospheric data. The constraint of the observed north-south gradient imposes two important common features. First, a large terrestrial sink at northern temperate latitudes is necessary, and second, total CO_2 uptake by the oceans is considerably less than uptake by terrestrial systems. The total terrestrial sink at high northern and temperate latitudes (including its share of the global CO_2 fertilization) varies between 2.0 and 2.7 Gt of C per year in the four scenarios. The sum of the temperate and high-latitude sources and sinks is tightly constrained, but the two can be traded off against one another to some extent. However, a large temperate sink requires a smaller high-latitude source to prevent the modeled CO_2 concentration at arctic sites from becoming too low.

The following scenarios were unsuccessful: The additional absorption of more than a few tenths of a gigaton of C by high latitude ecosystems or the Arctic Ocean resulted in predicted concentrations for the five northernmost stations that were too low. Balancing the global budget by uptake via CO_2 fertilization proportional to NPP (and no tropical deforestation) left the concentrations at equatorial latitudes too low; half of the NPP takes place in the tropics, so that the area would in that case act as a net sink for CO_2 .

The modeled CO_2 gradients are not very sensitive to the magnitude of tropical deforestation because the GMCC sites are remote from deforestation activities and the released CO_2 is dispersed rapidly via vigorous vertical mixing. If the release of CO_2 from tropical forest destruction is balanced by the fertilization effect, half of the extra CO_2 is taken up in the tropics themselves, and thus smaller amounts of carbon uptake are required at temperate latitudes in both hemispheres. A large amount of tropical deforestation (scenario 8, Table 4) can only be accommodated if CO_2 fertilization is a strong sink, so that the modeled tropical CO_2 concentrations do not become significantly larger than those observed.

We have not included in the simulations the atmospheric oxidation of CO, which produces a total of 0.85 ± 0.25 Gt of C per year of CO_2 (34). Simulations with a two-dimensional model of a latitudinal and seasonal distribution of CO oxidation totaling 1 Gt of C per year globally (38) suggest that a broad maximum in CO_2 concentrations forms at 30°N that decreases by 0.3 ppm toward the South Pole and by 0.15 ppm toward the North Pole. The inclusion of this process would have reinforced the need for a northern mid-latitude sink. As a related problem, a small part of the terrestrial sink for CO_2 that we infer will not contribute to C storage on the land because C is recycled by the biosphere into reduced volatile compounds that are oxidized, often via CO, to CO_2 in the atmosphere.

Conclusions

From 1981 to 1987 atmospheric CO_2 increased at an average rate of 3.0 Gt of C per year. The release of CO_2 from fossil fuel burning (5.3 Gt of C per year) and land use modification (0.4 to 2.6 Gt of C per year) is being partially balanced by the uptake of CO_2 by the oceans and by terrestrial ecosystems. Observations and simulations of the meridional gradient of CO_2 in the atmosphere suggest that these sinks are larger in the Northern Hemisphere than in the Southern Hemisphere.

The atmospheric gradient constrains the combined uptake by the southern ocean gyres and Antarctic waters to be from 0.6 to 1.4 Gt of C per year. In consideration of the large data base of seasonal $\Delta p\text{CO}_2$ measurements in the surface waters of the Northern Hemisphere, the uncertainties in $\Delta p\text{CO}_2$ are most likely not large enough to accommodate the values of C removal required without a large

Table 4. Four modeled scenarios of the global atmospheric C cycle in which uptake by the northern and equatorial oceans is held fixed. Fluxes are in units of Gt of C per year. Equatorial ocean outgassing is lower than in Table 2 by 0.32 Gt of C per year to take into account El Niño episodes occurring about once every 4 years. After the rate of tropical deforestation has been postulated, CO_2 exchange with terrestrial ecosystems and the southern oceans is varied (indicated by asterisk) to produce agreement with the

atmospheric observations. The estimates of uptake by the oceans are based on observed seasonal $\Delta p\text{CO}_2$ values, monthly climatological winds and two sets of air-sea gas transfer coefficients, our empirical relation (Emp), and the Liss-Merlivat (22) relation (LM). In the latter case the equatorial oceanic source is smaller, so that less uptake is required at temperate latitudes in both hemispheres to balance the budget.

Source or sink	Scenario 5		Scenario 6		Scenario 7		Scenario 8	
	Emp	LM	Emp	LM	Emp	LM	Emp	LM
Tropical deforestation	0.0	0.0	1.0	1.0	1.0	1.0	2.5	2.5
CO_2 fertilization*	0.0	0.0	0.0	0.0	-1.0	-1.0	-3.0	-3.0
Temperate uptake*	-2.0	-2.0	-3.0	-2.9	-2.3	-2.0	-1.9	-1.9
Boreal source*	0.0	0.0	0.4	0.4	0.4	0.2	0.7	0.7
Total terrestrial	-2.0	-2.0	-1.6	-1.5	-1.9	-1.8	-1.7	-1.7
Arctic and sub-arctic ($>50^\circ\text{N}$)	-0.23	-0.12	-0.23	-0.12	-0.23	-0.12	-0.23	-0.12
Combined northern gyres (15°N to 50°N)	-0.36	-0.18	-0.36	-0.18	-0.36	-0.18	-0.36	-0.18
Equatorial (15°S to 15°N)	1.30	0.65	1.30	0.65	1.30	0.65	1.30	0.65
Combined southern gyres* (50°S to 50°S)	-1.5	-1.1	-1.9	-1.6	-1.6	-1.3	-1.8	-1.4
Antarctic ($>50^\circ\text{S}$)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total oceans	-0.3	-0.3	-0.7	-0.8	-0.4	-0.5	-0.6	-0.6
SD of residuals (ppm)	0.26	0.28	0.27	0.29	0.27	0.28	0.28	0.29

terrestrial sink. We infer that the global ocean sink is at most 1 Gt of C per year. Our analysis thus suggests that there must be a terrestrial sink at temperate latitudes to balance the carbon budget and to match the north-south gradient of atmospheric CO_2 . The mechanism of this C sink is unknown; its magnitude appears to be as large as 2.0 to 3.4 Gt of C per year, depending on the sources in the tropical and the boreal and tundra regions.

The global C cycle is not well understood. Unraveling the contemporary CO_2 cycle and the development of future mitigation strategies requires a concerted measurement program to determine the seasonal fluxes of CO_2 between the atmosphere, land, and oceans. Our hypothesis suggests that annually averaged $\Delta p\text{CO}_2$ values in the combined southern oceans are small negative values. Collection of data on air-sea exchange of CO_2 in these areas in all seasons should be given high priority. Understanding the role of the land in the C budget must include a reanalysis of the contribution of mid-latitude reforestation as well as studies of the feedbacks between ecosystem functioning, climate, and atmospheric composition.

The atmosphere integrates the fluxes from all sources and sinks. It thus contains the large-scale signatures of CO_2 source areas that are often highly variable, and therefore hard to measure, on smaller scales. Data from the present international network of CO_2 monitoring sites, located almost exclusively in oceanic areas, cannot be used to resolve longitudinal gradients, and thus identification of the important source-sink areas is currently difficult. In addition, high-precision measurements of the large-scale variations of $^{13}\text{C}/^{12}\text{C}$ ratios in CO_2 and the concentration of atmospheric O_2 are needed to untangle the contributions of the land and oceans.

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19. To extrapolate $\Delta p\text{CO}_2$ values into areas where measurements were not available (black areas in Fig. 3), the seawater $p\text{CO}_2$ was assumed to be a function of temperature alone. The following temperature coefficients were determined on the basis of the measurements made during various seasons and are assumed to be independent of seasons: 1.64 °C⁻¹ in the western North Atlantic (10°N to 40°N) and the south Indian Ocean (10°S to 34°S); 2.33 °C⁻¹ in the South Atlantic (10°S to 34°S) and South Pacific (10°S to 34°S); 4.33 °C⁻¹ in the eastern North Pacific (10°N to 24°N, 84°W to 154°W); 1.23 °C⁻¹ in the Southern Ocean (34°S to 62°S). The climatological sea surface temperature data compiled by S. Levitus [Climatological Atlas of the World Ocean, NOAA Prof. Pap. 13, pp. 173 (1982)] were used. In the Pacific coastal areas along the Central and South America, where high $\Delta p\text{CO}_2$ values occur because of upwelling of deep water, the $\Delta p\text{CO}_2$ data obtained outside the two seasonal periods have been used with the assumption that the values do not change seasonally.
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$$E = 0.0083(W - 3.29) \text{ for } 3.6 \leq W \leq 13 \text{ m s}^{-1}$$

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NATIONAL TREE TRUST

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INTRODUCTION LETTER -- PRESIDENT BUSH

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TAB A

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EXECUTIVE SUMMARY

The President's Tree Planting Foundation

President Bush has a record of strong support for employing tree planting as a progressive pollution fighting method, including six presidential tree planting events. As a part of the America the Beautiful initiative, the President's budget proposal recommends a yearly \$175 million dollar tree planting program to be administered by the Department of Agriculture. In the first year only, a portion of these funds, \$35 million, will be granted to a private tree planting foundation. Proposed legislation will be submitted to authorize the President to designate a charitable nonprofit tree planting foundation to receive the funds. The foundation's purpose is to raise upwards of an additional \$500 million for the planting of trees throughout America. The funds will be used to support community based, volunteer oriented, forestation efforts. The initiative will be similar in concept to the Statue of Liberty restoration venture, with added emphasis on individual participation. Two of the President's more popular themes, reawakening the spirit of community service and improving the environment, will be melded together in a successful symbiotic alliance.

If enacted, the legislation will allow the President to choose a foundation to receive the \$35 million in Federal funds. The Office of the White House Counsel and the Department of Justice have advised that the designated foundation needs to be private, but that the White House can assist and advise the founders.

As an incorporator, the President asked for your assistance in establishing a foundation to be called the National Tree Trust and seeks your leadership, as a Director, in implementing the objectives of the Trust. The White House has prepared this briefing book containing background material, the National Tree Trust Act of 1990 as drafted, a suggested action plan, a synopsis of the Trust's mission and goals and other informational material to be used by you and the other incorporators at your discretion, in establishing and operating the Trust. As the initial board, you, with the other incorporators, will also be choosing additional Directors, with advice from the White House, creating a governing board which is non-partisan in composition.

Through Presidential remarks, participating Presidential events, and White House cooperation, this private non-profit foundation will be informally regarded by the public as the President's foundation. The National Tree Trust will provide the institutional framework for the President's efforts to encourage private tree planting at the local level.

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The National Tree Trust will begin operations, including fund-raising (individual and industry commitments are already significant), upon incorporation. With the authority provided by legislation, the President will designate the National Tree Trust as the recipient of the \$35 million in Federal funds. Should the legislation not pass, the National Tree Trust will successfully continue its mission through private donations.

_____ of the White House staff will assist you, as needed, in the weeks ahead. Please contact _____ at _____ should you have any questions or comments concerning material in the briefing book or relating to the National Tree Trust in general.

TAB B

INCORPORATORS

(To be completed)

TAB C

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NATIONAL TREE TRUST
AND
THE AMERICA THE BEAUTIFUL INITIATIVE

The President's FY 1991 America the Beautiful Initiative has been proposed to address the protection, conservation and enhancement of America's natural resources. The initiative includes three components, cutting across the Interior and Agriculture Departments. These components are (1) expanded Federal recreational land acquisition, which involves both departments; (2) a National tree planting and forest improvement initiative, to be administered by Agriculture; and (3) an Interior Department resource protection and recreation enhancement effort, called "Legacy '99".

The National Tree Planting and Forest Improvement Program at USDA is a part of the new America the Beautiful account in the Forest Service budget. The tree-planting initiative includes \$175 million to pursue the goal of planting a billion trees a year on private lands.

The initiative includes two basic components to be coordinated by USDA, a rural component to address reforestation of private, non-industrial lands and a Community Trees initiative. Within rural areas, the budget provides \$110 million to USDA for cost-sharing and technical assistance with private landowners to plant, improve and maintain trees on suitable lands. The program will be implemented through existing delivery mechanisms within USDA and through state forestry agencies. For Community Trees, the budget includes \$30 million to USDA to provide leadership, coordination and technical assistance to support tree planting and care in community and urban environments. This program also will rely on the existing technical assistance delivery system with the Forest Service working through State Foresters and other operators. Both components will be carried out under existing authorities.

In concert with the President's tree planting initiative, the budget also proposes the one-time capitalization of a private, non-profit foundation to promote public awareness, solicit financial and non-financial support and to mobilize a spirit of volunteerism to further the President's tree-planting goals.

Legislation will be submitted to authorize the President to make a grant of \$35 million to a designated foundation. Following this initial capitalization, the \$35 million would be reallocated to other components of the Tree Initiative in years 1992 through 1995 at USDA.

C 2

EXERCISING RESPONSIBLE STEWARDSHIP OF AMERICA'S NATURAL RESOURCES

America the Beautiful

President Theodore Roosevelt began this century by directing the Nation's attention to the protection of valuable public lands—America's treasure trove of parks, wildlife refuges, forests, and rangelands. It was Roosevelt who identified "the conservation of natural resources and their proper use" as a national problem of fundamental concern.

As the end of the century approaches, it is appropriate that its final decade be one in which conservation, enhancement, and protection of these irreplaceable national assets rises to the forefront of national concerns. The 1991 budget reflects the President's support for appropriate expansion and proper maintenance of the Nation's parks, refuges, forests, and other public lands; his determination to in-

volve all Americans in strengthening the Nation's natural resource heritage; and his firm commitment to providing responsible stewardship of the country's natural assets for the benefit of generations to come.

The budget contains a new initiative, "America the Beautiful", that underscores these Presidential priorities. It would finance expanded land acquisition for the national parks, wildlife refuges, forests, and other public lands. It would launch a new national program of reforestation. And it would provide substantial funds for enhanced recreation, and protection and restoration of key natural resources, under a program called "Legacy '99"—a reflection of the Administration's desire to leave behind a legacy in which these natural resource assets have been restored by the end of the century. The budget supports the America the Beautiful initiative by proposing a 75 percent increase in funding for these activities above 1990 levels.

AMERICA THE BEAUTIFUL

(Budget authority in millions of dollars)

Funding Summary	1990	1991	Proposed increase
Land Acquisition.....	215	250	+ 35
Reforestation.....	—	175	+175
Legacy '99.....	146	205	+59
Total, America the Beautiful.....	361	630	+ 269

Land Acquisition.—The President believes that America's national system of parks, wildlife refuges, forests, and other public lands should be expanded and passed on in better shape than they are now.

In 1990, the Administration proposed new funds for the first time in several years for Federal acquisition of lands with particularly high value for the environment and for recreation purposes. The \$215 million program to which the President and the Congress agreed will preserve these lands for public purposes

and increase the value of the assets passed on to future generations.

The 1991 budget proposes to expand this program of acquiring high priority lands by creating a new America the Beautiful fund. Funds for land acquisition would be provided, as in the past, through annual appropriations from the Land and Water Conservation Fund. The America the Beautiful initiative would fund the purchase of \$1 billion of key land and water resources over the next 4 years.

The America the Beautiful fund will also be able to join in partnership with private parties and State and local governments to maximize the significance of the purchases it makes and the overall value of land set aside for public purposes.

Concurrent with the submission of this budget, the Administration will propose to the Congress a priority listing of lands to be acquired by the National Park Service, the Fish and Wildlife Service, the Bureau of Land Management, and the Forest Service with the \$250 million proposed for acquisition through America the Beautiful in 1991. This list has been developed through a competitive rating system, in which particular importance was placed on the extent to which a potential acquisition parcel contains valuable wetlands, is in proximity to population centers, has the potential to offer increased recreational opportunities to the public, is important for the protection of endangered species, or possesses other characteristics which make its early acquisition for public purposes of special importance. An explanation of the rating system will be provided to the Congress with the list of priority acquisitions.

Reforestation: Planting Trees for America's Future.—Recent years have witnessed growing attention to global environmental trends, a strong upsurge in the concern of the American people about the national and international environment, and an increased willingness on the part of individual Americans to take personal responsibility for their environmental future.

The 1991 budget contains funds for a major reforestation initiative which will serve both to address emergent environmental concerns and to encourage the involvement of communities, corporations, State and local governments and individuals in creating solutions. The budget proposes \$175 million for the first year of a multi-year initiative with twin objectives: planting a billion trees a year on private land across America; and launching a community trees program, designed to plant another 30 million trees in communities across the country.

Trees are a remarkably valuable resource. In addition to their obvious value as the source of wood products and habitat for all manner of

wildlife, trees can be a "sink" for carbon dioxide emissions—and thus can help to address any effect that increases in CO₂ emissions from human activities may have.

Trees are roughly 50 percent carbon. As they grow, trees remove carbon from the air and store it as plant tissue. A single forest tree absorbs 26 pounds of carbon dioxide (CO₂) a year, and an acre of trees can remove 2½ to nine tons of CO₂.

Trees are valuable as a source of energy conservation for homes and businesses. In the summer, the shade provided by trees can greatly reduce cooling requirements. In winter, deciduous trees allow sunlight through to a home, and closely placed, dense conifers near a home can save up to 20 percent in fuel costs.

Trees can provide forest buffer strips which reduce the flow of nutrients and pesticides associated with agricultural production into the Nation's waterways. Planting timber on certain highly erodible and marginally productive croplands can produce a higher return on those lands than many other crops.

Currently, about 3½ million acres of public and private lands are planted in trees and seedlings annually. This is up from the approximately ½ million acres of 40 years ago. Nevertheless, the U.S. experiences a net loss of about 700,000 acres of forest land per year.

Much of America's 730 million acres of forests lies on Federal and State lands or on lands owned by large, commercial forest products enterprises. The Federal government currently undertakes substantial reforestation activities on lands under its jurisdiction: last year, nearly 200 million trees were planted on National Forest lands; and another 27 million trees were planted on Department of the Interior lands, principally those managed by the Bureau of Land Management. Some of the lands enrolled in the Conservation Reserve Program (CRP) since 1986 have been forested.

But almost half of America's forest land is private land that is not used by large enterprises in the forest products industry. This private, non-industrial forest land, due to low levels of management and investment, tends to be in poor condition. Thus, reforestation and stand improvement investment on these lands

can yield an especially high level of CO₂ sequestration and other benefits.

Most private landowners neither seek nor receive technical advice concerning timber management or reforestation practices; less than a third of those who actually harvest timber have a management plan before the harvest.

The budget includes \$110 million designed primarily to improve the management and encourage the reforestation of these lands. Specifically, the government will provide cost-shared assistance through the Forest Service and State forestry agencies to encourage small lot owners to plant trees and undertake other improved practices on private non-industrial lands and marginal agricultural lands. The initiative also would provide grants to State forestry agencies to allow them to provide needed materials, direct technical assistance, and seedlings to private landowners, municipal arborists, and community groups.

The goal of the program is to achieve the planting of trees on over one and one-half million acres of private land annually, and timber stand improvement and other stewardship activities on another 180,000 acres.

The Community "Plant a Tree" Initiative.—A second promising target of reforestation assistance is community trees. These include street trees, trees in local parks, community forests, and residential trees. Available information indicates that community trees are declining in number and in health. One recent survey found that in most American cities, only one tree is planted for every four removed. Moreover, because of their location in population centers, studies indicate that community trees have up to 15 times as much value in overall reduction of CO₂ as forest trees.

Thus, a second element of the President's plan to promote reforestation, provided for in the budget, will be to assist in the creation of tree planting programs in every community in America. The President is asking every town and city, every school and university, every company and indeed every citizen to join together in planting trees for America's future.

The budget contains \$30 million in funding needed to provide leadership, coordination and

technical assistance to support this massive volunteer effort. In addition, the Administration will submit legislation to the Congress to establish a private, non-profit foundation to lend further leadership and help build broad-based support for planting trees in communities across the Nation.

The Foundation will be capitalized with a one-time appropriation of \$35 million in funds from the community tree initiative, with which it will promote public awareness, solicit financial and non-financial support, and, most importantly, mobilize individuals, business, governments, and community organizations in cities and towns throughout America. The goal of the plant a tree initiative is to plant 30 million trees in various communities every year.

In total, the tree planting programs supported by the budget can have a substantial impact on sequestration of CO₂ emissions by the United States. Initial estimates are that the one billion trees a year envisioned in the President's reforestation initiatives could absorb 13 million tons of CO₂ per year, and thus sequester up to 5 percent of annual U.S. CO₂ emissions within 20 years. And they will help greatly to improve wildlife habitat and water and air quality, and to increase outdoor recreation opportunities.

Enhancing Recreation and Restoring Natural Resources: Legacy '99.—A third component of America the Beautiful, beyond land acquisition and reforestation, is designed to focus Federal funding and expertise on a wide range of threatened natural resource treasures and key recreational areas in need of improvement. The Department of the Interior is committed to accomplishing these improvements by the end of the decade—its 150th anniversary as a Department—and hence has designated the effort "Legacy '99."

The budget includes \$205 million, an increase of 40 percent above 1990, for improved resource protection and restoration (including wetlands conservation and endangered species activities) and enhanced recreational opportunities in national parks, wildlife refuges, and other public lands. Included in Legacy '99 are funds for certain resources that are of special importance:

TO THE CONGRESS OF THE UNITED STATES:

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Today I am pleased to transmit a legislative proposal entitled the "National Tree Trust Act of 1990." This proposal is a key part of my America the Beautiful initiative, and it would enhance the growing partnership between the public and private sectors to plant trees across America.

President Theodore Roosevelt began this century by directing the Nation's attention to the protection of valuable public lands -- America's treasure trove of parks, wildlife refuges, forests, and rangelands. As the end of the century approaches, it is appropriate that this final decade be one in which conservation, enhancement, and protection of our irreplaceable national assets rise to the forefront of national concerns. With this as our goal, my FY 1991 Budget proposes a new initiative -- "America the Beautiful." Our initiative reflects my support for appropriate expansion and proper maintenance of the Nation's parks, refuges, forests, and public lands. It is also based on my determination to involve all Americans in strengthening the Nation's natural resources heritage. Finally, this initiative expresses my firm commitment to providing responsible stewardship of the country's heritage for the benefit of generations to come.

My America the Beautiful initiative includes three components. First, we propose to expand Federal recreational land acquisition, which involves activities of the Departments of the Interior and Agriculture. Second, the Department of the Interior is undertaking an effort -- "Legacy '99" -- to enhance

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resource protection and recreation. Third, we propose a national tree planting and forest improvement initiative, to be administered by the Department of Agriculture. These components will largely be implemented under existing authorities.

The proposal I am transmitting to Congress today authorizes Presidential designation of a private nonprofit Foundation to receive a one-time grant for the purpose of promoting community tree planting and cultivation projects. It also authorizes appropriations to the Secretary of Agriculture for a grant to permit the Foundation to begin its important work. The Foundation will promote public awareness and a spirit of volunteerism, solicit private sector contributions, and oversee the use of these contributions to encourage tree planting and cultivation projects throughout the United States.

The Foundation will help forge cooperation between individuals, businesses, governments, and community organizations, and provide financial assistance to grassroots volunteers to plant trees. It will help draw national attention to the need for increased planting of trees in our communities, where, on average, only one tree is now being planted for every four that die or are removed. It is a program that will reach every State, if not each and every community. All of our citizens will be encouraged to participate in this program.

Trees are one of our most valuable resources. They contribute to the environmental, economic, and social well-being of this country. They enhance biodiversity, wildlife, air and water quality, and recreational opportunities. Trees improve

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landscape esthetics and property values, reduce soil erosion, and provide many valuable wood products. They also contribute to energy conservation through the shading and cooling of buildings and by serving as windbreaks.

Enactment of this proposal will permit us to harness the efforts of individuals and organizations to undertake the nationwide planting and cultivation of invaluable trees. The prompt passage of this proposal by Congress will demonstrate our shared commitment to preserving one of our most valuable natural resources, our precious heritage of trees. Let us ensure that our descendants will be able to share our pride in referring to this land as America the Beautiful.

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To authorize the President to designate a private nonprofit Foundation as eligible to receive funds for the purpose of promoting community tree planting and cultivation projects.

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled,

SEC. 1. SHORT TITLE.

This Act may be cited as the "National Tree Trust Act of 1990".

SEC. 2. FINDINGS.

The Congress finds that --

(1) trees provide beauty and are an important part of America's heritage;

(2) trees capture and safely store greenhouse gases, and each additional tree can reduce the possibility of global warming;

(3) the shading, wind-blocking, and evaporation provided by trees, especially in urban areas, can significantly reduce energy use;

(4) trees planted adjacent to croplands filter run off and prevent erosion that threaten water quality, fish, and wildlife; and

(5) community service and service to others is an integral part of the American tradition.

SEC. 3. PURPOSES.

The intent of this Act is to provide for a grant to a private nonprofit Foundation to be used for the following purposes --

(1) to promote public awareness, education, and a spirit of volunteerism in support of community tree planting and cultivation projects nationwide;

(2) to solicit private sector contributions through the mobilization of individuals, businesses, governments and community organizations with the goal of increasing the number of trees planted in communities and urban environments;

(3) to accept and administer private gifts and make grants, including matching grants to encourage local participation, for the planting and cultivating of trees; and

(4) to ensure that our descendants will be able to share their ancestors' pride when referring to their land as America the Beautiful.

SEC. 4. AUTHORITY.

(a) The President is authorized to designate a private nonprofit organization, which for purposes of this Act shall be referred to as the Foundation, as eligible to receive funds pursuant to section 6(a), upon determining that such organization can, consistent with its charter, carry out the purposes stated in section 3, and that the officers of such organization have the experience and expertise necessary to direct the activities of the organization.

(b) Nothing in this Act shall be construed to make the Foundation an agency or instrumentality of the United States Government, or to make officers, employees, or members of the Board of directors of the Foundation officers or employees of the United States.

SEC. 5. FUNDING.

In fiscal year 1991, the Secretary of Agriculture is authorized to make a grant, from funds authorized to be appropriated under section 8 of this Act, of not to exceed \$35,000,000 to the Foundation designated pursuant to section 4.

SEC. 6. GRANT.

(a) Funds made available pursuant to section 5 shall be granted to the Foundation by the Department of Agriculture --

(1) to enable the Foundation to carry out the purposes specified in section 3; and

(2) for the administrative expenses of the Foundation.

(b) Notwithstanding any other provision of law, the Foundation may hold grant funds contributed pursuant to subsection (a) of this section in interest-bearing accounts, prior to the disbursement of such funds for purposes specified in section 3, and may retain for such program purposes any interest earned on such deposits.

SEC. 7. ELIGIBILITY OF THE FOUNDATION FOR A GRANT.

(a) A grant may be made to the Foundation under this Act only if the Foundation agrees to comply with the requirements specified in this Act.

(b) The Foundation may use funds provided by this Act only for programs and projects which are consistent with the purposes specified in section 3.

(c) Officers and employees of the Foundation may not receive any salary or other compensation for services rendered to the Foundation from any source other than the Foundation.

(d) The Foundation shall not issue any shares of stock or declare or pay any dividends.

(e) No part of the funds of the Foundation shall inure to the benefit of any board member, officer, or employee of the Foundation, except as salary or reasonable compensation for services or expenses. Compensation for board members shall be limited to reimbursement for reasonable costs of travel and expenses. No director, officer, or employee of the Foundation shall participate, directly or indirectly, in the consideration or determination of any question before the Foundation affecting his or her financial interests or the interests of any corporation, partnership, entity, or organization in which he or she is an officer, director, or trustee, or in which he or she has any direct or indirect financial interest.

(f) The Foundation shall not engage in lobbying or propaganda for the purpose of influencing legislation and shall not participate or intervene in any political campaign on behalf of any candidate for public office.

(g) For the fiscal year in which the Foundation receives the grant awarded under section 6(a), and for the succeeding five fiscal years, the accounts of the Foundation shall be audited annually in accordance with generally accepted auditing standards by independent certified public accountants or independent licensed public accountants certified or licensed by a regulatory authority of a State or other political subdivision of the United States. The report of each such independent audit shall be included in the annual report required by subsection (j) of this section.

(h) The financial transactions undertaken pursuant to this Act by the Foundation may be audited by any agency designated by the President for the fiscal year in which the Foundation receives the grant awarded under section 6(a) and for the five succeeding fiscal years.

(i) The Foundation shall ensure --

(1) that each recipient of assistance provided through the Foundation under this Act keeps, for five years after the receipt of such assistance, separate accounts with respect to such assistance and such records as may be reasonably necessary to disclose fully the amount and the disposition by such recipient of the proceeds of such assistance, the total cost of the project or undertaking in connection with which such assistance is given or used, the amount and nature

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of that portion of the cost of the project or undertaking supplied by other sources, and such other records as will facilitate an effective audit; and

(2) that the Foundation, the agency designated by the President pursuant to subsection (h) of this section, or any of the Foundation's duly authorized representatives shall have access for the purpose of audit and examination to any books, documents, papers, and records of the recipient that are pertinent to assistance provided through the Foundation under this Act.

(j) Not later than three months after the conclusion of each fiscal year, the Foundation shall publish an annual report for the preceding fiscal year. The report shall include a comprehensive and detailed report of the Foundation's operation, activities, financial condition, and accomplishments under this Act. The Foundation's obligation to publish annual reports pursuant to this subsection shall terminate after publication of the report incorporating the findings of the final audit required by subsection (g) of this section.

SEC. 8. AUTHORIZATION OF APPROPRIATIONS.

There is authorized to be appropriated for fiscal year 1991, \$35,000,000 for a one-time grant from the Secretary of Agriculture to the Foundation designated pursuant to section 4(a).

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Section-by-Section Analysis
"National Tree Trust Act of 1990"

Section 1 provides that the Act may be cited as the "National Tree Trust Act of 1990."

Section 2 sets forth five congressional findings. Four of these findings are related to the environmental and social value of trees, including adding beauty, reducing the possibility of global warming, reducing energy use, and preventing erosion. The fifth finding emphasizes community service as an integral part of the American tradition.

Section 3 outlines the purposes of the Act. The intent is to provide a grant to a private nonprofit Foundation to be used to (1) promote public awareness and volunteerism for community tree planting and cultivation nationwide, (2) solicit private contributions with the goal of increasing tree planting in communities and urban environments, (3) accept and administer gifts and make grants to encourage local participation in the planting and cultivation of trees, and (4) ensure that our descendants will be able to share the pride of their ancestors when referring to their land as America the Beautiful.

Section 4 authorizes the President to designate a private nonprofit organization, referred to as the "Foundation," to carry out the purposes of the Act. The Foundation will not be an agency or instrumentality of the United States. Officers, employees, or members of the board of directors of the Foundation will not be officers or employees of the United States.

Section 5 authorizes the Secretary of Agriculture to make a grant of up to \$35 million to the Foundation during fiscal year 1991. The grant will be funded from appropriations authorized in section 8 of the Act.

Section 6 requires the Foundation to use the grant from the Department of Agriculture to carry out the purposes specified in section 3 and for administrative expenses of the Foundation. Notwithstanding any other provision of law, the Foundation is authorized to hold grant funds in interest-bearing accounts until they are needed. Interest earned on such deposits may be retained by the Foundation and used for the purposes specified in section 3.

Section 7 directs that the Foundation must agree to comply with the requirements of the Act before a grant may be made to the Foundation. The Foundation must use funds provided by the Act only for the purposes specified in section 3. Officers and employees may not receive compensation for services rendered to the Foundation from any source other than the Foundation. The Foundation shall not issue shares of stock or declare or pay any dividends. The Foundation is prohibited from lobbying for the

purpose of influencing legislation and from intervening in any political campaign. Accounts of the Foundation will be audited for the fiscal year in which the grant is received under section 6 and for each of the succeeding five fiscal years. The results of the audit will be included in each of six required annual reports that shall include a comprehensive and detailed statement of the Foundation's operation, activities, and financial condition. The Foundation shall ensure that those who receive assistance from the Foundation under the Act keep such records as may be reasonably necessary to facilitate the annual audits.

Section 8 authorizes the appropriation of \$35 million for fiscal year 1991 to be used for a one-time grant from the Secretary of Agriculture to the Foundation.

C 4

**President Bush's Proposed
National Tree Trust Act**

Today, President Bush transmitted to Congress the National Tree Trust Act of 1990, a key part of his America the Beautiful initiative. This proposal will be the catalyst to forge new partnerships between individuals, business, governments, and community organizations with the goal of planting trees across America. It authorizes:

- o Presidential designation of a new private nonprofit Foundation to receive Federal funds through a one-time grant for the purpose of promoting community tree planting projects; and
- o the appropriation of funds to the Secretary of Agriculture for such a grant.

It is anticipated that the Foundation will:

- o promote public awareness and a spirit of volunteerism;
- o solicit private sector contributions; and
- o oversee the use of these contributions to encourage tree planting projects.

The Foundation will help draw national attention to the need for increased planting of trees in our communities, where, on the average, only one tree is now being planted for every four that die or are removed. It is a program that will reach every State, if not each and every community, by working in partnership with existing national and community organizations, businesses, State forestry agencies, and youth groups.

The President encourages all citizens to express their personal commitment to their communities and to the environment by participating in this program.

The National Tree Trust is a fitting complement to the National Tree Planting and Forest Improvement component of the President's America the Beautiful initiative. The FY 1991 Budget includes the America the Beautiful initiative to address the protection, conservation, and enhancement of America's natural resources. The initiative includes three components involving the Departments of the Interior and Agriculture. These components are (1) expanded Federal recreational land acquisition, which involves both departments; (2) an Interior Department resource protection and recreation enhancement effort, called "Legacy '99"; and (3) a National Tree Planting and Forest Improvement Program, to be administered by Agriculture.

The National Tree Planting and Forest Improvement Program includes \$175 million in fiscal year 1991 to pursue the goal of planting a billion trees a year on private lands. This program includes two basic components to be coordinated by Agriculture, a rural component to address reforestation of private, non-industrial lands and a Community Trees component:

- o Rural Areas. The FY 1991 Budget provides \$110 million to Agriculture for cost-sharing and technical assistance with private landowners to plant, improve, and maintain trees on suitable lands. The program will be implemented through existing departmental delivery mechanisms and through State forestry agencies.
- o Community Trees. The 1991 Budget also provides \$65 million to provide leadership, coordination, and technical assistance to support tree planting and care in community and urban environments. This program will rely on the U.S. Forest Service's existing technical assistance delivery system which operates through State foresters and other cooperating parties.

Both components will be carried out under existing authorities. The funds proposed for the community tree planting program include \$35 million for the one-time grant in fiscal year 1991 to the Foundation designated by the President.

Enactment of the President's "National Tree Trust Act of 1990" will permit us to harness the efforts of individuals and organizations to undertake the nationwide planting and cultivation of our Nation's precious trees. Thus, the President hopes we can ensure that our descendents will be able to share our pride in referring to this land as America the Beautiful.

TAB D

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MISSION STATEMENT

Reaching out to rekindle a spirit of volunteerism, rejuvenate community partnerships, involve America's youth and encourage an individual commitment to the environment, the Nation Tree Trust seeks to forge new partnerships with individuals, businesses, governments and community organizations with the goal of planting trees across America.

The National Tree Trust is to provide the institutional framework for the President's efforts to encourage private tree planting at the local level. Two of the President's more popular themes, reawakening the spirit of community service and improving the environment, should be melded together in a successful alliance aimed at tree-planting. The muscle of the Trust, however, will rest in its ability to leverage significant private sector contributions. These funds should be allocated at a minimum of cost through, to the extent feasible, existing delivery mechanisms in a manner that further stimulates local giving and local participation.

PURPOSE

The National Tree Trust shall be established and operated for the following purposes:

- (1) to promote public awareness and a spirit of volunteerism in support of community tree planting and cultivation projects nationwide;
- (2) to solicit private sector contributions through the mobilization of individuals, businesses, governments and community organizations with the goal of increasing the number of trees planted in community and urban environments;
- (3) to accept and administer private gifts and make grants, including matching grants to encourage local participation, for the planting and cultivating of trees; and
- (4) to ensure that our descendants will be able to share their ancestors' pride when referring to their land as America the Beautiful.

TAB E

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ORGANIZATIONAL STRATEGY

It is anticipated that the National Tree Trust's principal functions will be, 1) the solicitation of private sector contributions, and 2) the making of grants for the purpose of increasing the number of trees planted in community and urban environments. Separate advisory committees comprised of appropriate resource professionals, operating through the Board's Executive Community, may be used to advise both in the solicitation of funds and in grant-making activities.

The methods used in accomplishing tree planting are, however, as important to the President as the number of trees actually planted. The President challenges the National Tree Trust, both through its activities and as a result of its work, to:

- o rekindle a spirit of volunteerism;
- o rejuvenate community partnerships;
- o involve America's youth; and
- o encourage individual commitment to the environment.

In order to achieve these results, private sector contributions will provide the capital stock and tree planting should be the tool. In this manner, the National Tree Trust should function mainly as a conduit, ensuring a least cost allocation of resources to support principally community based, grassroots oriented projects that achieve the President's objectives.

The allocation of resources (the process of both soliciting funds and grant-making) should be achieved with the least amount of bureaucratic structure and at the lowest cost. Project implementation, the on-the-ground efforts financed by Trust grants, should, however, be carried out efficiently and by organizations worthy of support. Instead of the Trust conducting the necessary review and oversight of project implementation, it is suggested the Trust utilize existing delivery mechanisms operated through established organizations.

Global Releaf -- American Forestry Association

Though numerous national organizations currently exist with at least a partial involvement in tree planting efforts, (Tree People and the National Arbor Day Foundation for example) the American Forestry Associations (AFA) Global Releaf campaign offers the largest existing network for reaching community based needs and the ability to expand operations as resources increase.

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Through its Global Releaf strategy, AFA has worked to establish effective partnerships with State forestry agencies. Virtually every State forestry has assigned a Global Releaf State Coordinator to the Global Releaf Campaign. These coordinators represent a vital link to local programs and to other forestry specialists that serve communities under the general umbrella of the Federal-state cooperative forestry programs.

With supplemental funding, AFA could coordinate an enlarged cooperative effort with central AFA staff and new regional coordinators that would assist state coordinators and local groups to identify potential projects and oversee implementation. In this manner, the Global Releaf campaign could recommend projects for funding, coordinate local cooperation and participation and administer grants awarded by the Trust.

o Community Foundations

A community foundation is a publicly supported organization that makes grants for charitable purposes. These foundations generally receives financing from many sources and normally limits its grants to organizations within a specific region or local community. There are nationally over 300 community foundations.

The National Tree Trust could use existing community foundations by making designated donations, granting money to the community foundation for specific purposes, in this case, most probably planting trees. Appropriate guidelines could be developed to ensure that the objectives of the Trust are fully met. The Trust could seek opportunities to leverage the knowledge, experience, reputation and support inherent to existing community foundations as a means of implementing effective programs at the local level.

o Recognized Youth Organizations

The Tree Trust should take advantage of existing youth organizations as an effective delivery mechanism. Groups such as the Boy Scouts and Girl Scouts, Boys and Girls Clubs, YMCA, YWCA, Little league, and Special Olympics provide a ready source of expertise and person-power necessary to recommend projects, oversee grant awards and accomplish results.

o State Forestry Networks

State Forestry agencies have a long and established history of cooperation with Federal agencies, local communities and professional organizations relating to urban and community forestry. State urban and community forestry coordinators act as catalysts in initiating local action. Utilizing the existing

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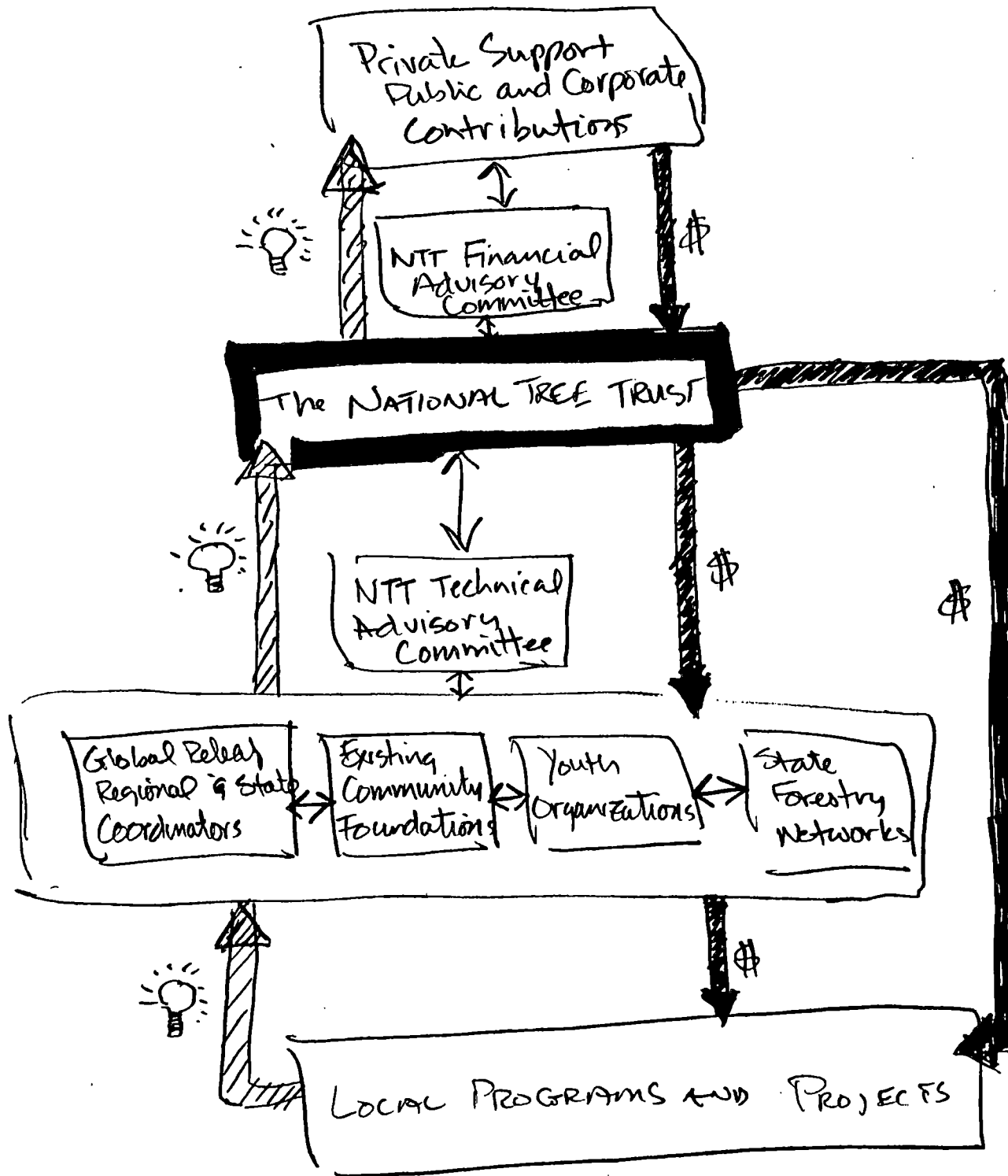
State Forestry cooperative network encompasses both professional/technical expertise and the cross section of on-going activities from the Federal to the local level.

o Limited Specific Grants

The National Tree Trust should also, on a limited basis, reach out beyond existing delivery organizations to fund specific projects identified to or by the Trust. Such grants may be used in conjunction with specific events, as part of educational campaigns, or in any manner to help focus the objectives of the Trust.

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\$ DOLLARS \$



- IDEAS -

TAB F

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PROPOSED ACTION PLAN

ACTION ITEM

DATE

National Tree Trust Act transmitted to Congress. White House ceremony to highlight President's interest in the Tree Trust concept.

March 20

Founding members or designees meet with WH staff.

April 2

Incorporate. Prepare and file Articles of Incorporation and Bylaws; submit application for tax exempt status.

By April 10

Select additional Board members.

By April 11

Work with WH Staff to arrange for President to call to congratulate final Board members.

By April 13

Earth Day. WH Ceremony. Hold first Board meeting.

April 22-23

Organize office and staff. Develop short-term action plan.

April 22-June 1

Begin operations including active fundraising and issuance of initial grants.

June 1

TAB G

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CONTACTS

o White House

James P. Pinkerton
Deputy Assistant to the President
for Policy Planning

456-6407

Office of Policy Development

Emily Mead

456-6252

Paul Roellig

456-7173

o Department of Agriculture

Patricia M. Kearney
Acting Assistant Secretary
for Natural Resources and
Environment

447-7173

o Department of the Interior

Thomas Weimer
Chief of Staff

343-4203

Great
to hear from
you

SUBJECT: White House Ceremony for the National Tree Trust

OBJECTIVES:

- 1) Presidential transmittal of the National Tree Trust Act of 1990.
- 2) Issuance of President's challenge that Earth Day 1990 be the start of a new commitment to the environment through, in part, the planting of trees. Begin planning to plant as many trees as possible on Earth Day and let the effort grow from there.

METHODS:

- 1) Signing ceremony for transmittal (?)
- 2) Presidential remarks issuing the challenge
- 3) Tree Planting on South Lawn (?)

The President should recognize the on-going efforts of national organizations such as the American Forestry Association's Global Relief campaign (President could hold up the Global Relief Action Guide), and the expertise and technical assistance provided through State forestry agencies.

EVENT:

The significance of the President's challenge is that it gives citizens something to do now. The President will urge each of us to begin planning now as individuals, families, through existing organizations or through new groups to include a tree planting event as a part of their celebration of Earth Day and Earth Week. Efforts should be aimed at not only how and where to plant a tree, but how to care for it, why we should plant trees, and how trees benefit the environment. The goal is to plant as many trees across America as possible, as the beginning to a new commitment to the environment.

As part of the President's challenge, President Bush could present to the Association of State Foresters four (or the appropriate number) gold shovels that they, in turn, would present to the organization or individual that, through their planning efforts, best represent the President's objectives in the tree-planting initiative:

- o rekindle a spirit of volunteerism;
- o rejuvenate community partnerships;
- o involve America's youth; and
- o encourage individual commitment to the environment.

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With these gold shovels, the recipients would be asked to come to the White House during Earth Day Week and help President Bush plant a White House Tree. The National Tree Trust could finance the event.

NOTE: Rather than using the Association of State Foresters, some other national organization could be used, or the Forest Service or a combination of organizations.

(Smith/Blessey)
8 A.M.
March 26, 1990
INDY

PRESIDENTIAL REMARKS: ARBOR DAY EVENT
INDIANAPOLIS, INDIANA
TUESDAY, APRIL 3, 1990

Dan Coats, Mayor Hudnut, Director Strong, distinguished guests, ladies and gentlemen. It is indeed great to be back home again in Indiana. And as the banner says, to plant "trees for tomorrow" that will benefit our Nation and its kids. //

((Not far from here is the law school of a friend of mine. And in that context, let me tell you a story. // A guy came up to me today and said, "Mr. President, the press has been wrong about your foreign and domestic policy." // And I said to him, "That may be true -- but you left out an important fact. // They've also been wrong about Dan Quayle."

((Let me say how proud I am of the job Dan has done as Vice-President. He's served our Administration well. He's served the Nation well. // Given the choice again, I'd pick him as my Vice-President more quickly than you can say, "Indiana loves basketball."//))

Today, the Vice-President is back in Washington. // As you can see, he let me play hookie. // Nor, sadly, could Bobby Knight be with us. He's out recruiting what Dan assures me is yet another national champion. //

But on this Arbor Day, I am glad to see all of you here in a city which, unlike some, can always see the forest for the trees.

// And which intends this year to plant thirty thousand ~~of the~~ trees, that are the sanctuaries of man. Renewing and refreshing.

// And that represent the continuity of man. An inheritance passed from one generation to another. //

? Like any schoolboy, ^{thru my eyes} I grew up reading the great Hoosier poet, James Whitcomb Riley. And I recall how once he said, "Life is a cycle larger than any individual." // Well, so it is with trees. They renew and restore the natural magic of mankind. // Think of how trees enhance our atmosphere. Providing oxygen and absorbing carbon dioxide. // And how they enhance our ^{gimp} environment. Preserving the beauty of trees that is

breathtaking. And the bounty of trees that is breathgiving. //

"Trees For Tomorrow" will ensure both through a community of pride. Talk about cooperation -- individuals, private groups, your City's Department of Parks and Recreation. And results -- this month alone, you're donating 1,000 trees. // This urban forestry program will help volunteers show new volunteers not only how and where to plant trees. That's the easy part. It will also teach the difficult part -- how to care for trees -- why we need them -- and how they help the environment. //

((You know, one of my grandkids once told me he'd rather be a doctor than a tree surgeon. His reason? A doctor never falls out of his patients. // Well, the record shows that Indianapolis isn't falling down on the job of protecting the environment. And neither will our Administration.)) //

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"America the Beautiful" will help maintain and expand our parks, wildlife refuges, forests, and public lands. It's like your April "Clean and Green Month" campaign -- but on a more national scale. // It will enrich the urban landscape -- and

plant the seeds of environmental stewardship. Not only through planting trees -- but through other steps, as well. //

Clean air, for example. Our clean air proposal promises relief from the smog, acid rain, and toxic pollution that harm trees and people. Once again -- and the Vice-President joins me -- I call on the Congress to pass that bill. // I also call on them to help us improve pollution prevention and energy efficiency. // A recent study showed that if city temperatures are cut by five to ten degrees, energy used for cooling can be slashed by fifty percent. Trees can cool those temperatures. // And help realize these words of a Chinese proverb: "One generation plants the tree -- another gets the shade." //

I began by talking about two great Indiana exports -- Dan Quayle and basketball. Let me close by referring to a movie close to the Vice-President's heart. // It's called Hoosiers. You've seen it -- probably memorized it. It was filmed here and in three nearby towns. // Yes, it's about basketball. But it also portrays -- unforgettably -- the values of Indiana. //

The next time you see Hoosiers, look for kids ² -- they're everywhere -- like the 2,000 here today. And trees -- they're even more numerous than the movie's kids. // A lot of people don't know it, but Indiana is among our most heavily forested States. Look around you: Trees enhance the beauty of Indiana's cathedral of the outdoors. //

So let's help these youngsters plant trees -- nurture them -- in this State and all fifty States. And so knock Johnny

Appleseed from the Guinness Book of Records. // Let's plant the "trees for tomorrow" that will bless the children of tomorrow - the generations who will inherit our earth. //

Thank you for what you're doing. Hats off to the City of Indianapolis. God bless the land we so richly love -- the United States of America. And now, it is my great pleasure to officially plant the first tree of this magnificent campaign. ?

#

underestimating the importance

(Smith/Blessey)

8 A.M.

March 26, 1990

INDY

PRESIDENTIAL REMARKS: ARBOR DAY EVENT
INDIANAPOLIS, INDIANA
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// And which intends this year to plant thirty thousand of the ~~trees~~ ^{human kind} that are the sanctuaries of man. Renewing and refreshing.

// And that represent the continuity of man. An inheritance passed from one generation to another. //

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((You know, one of my grandkids once told me he'd rather be a doctor than a tree surgeon. His reason? A doctor never falls out of his patients. // Well, the record shows that Indianapolis isn't falling down on the job of protecting the environment. And neither will our Administration.)) //

That's why in the budget I submitted in February to the Congress, I asked for ~~\$175 million~~ to plant a billion trees a year. And why two weeks ago I asked Congress to approve another step to protect the environment. // We call it the National Tree Trust Act of 1990. An initiative that, like "Trees for Tomorrow," will foster the partnership between the public and private sectors to plant trees across America. //

Tree people
affected not using
trees. It's
not only
affecting
the environment

Under our plan, we will designate a private nonprofit Foundation to receive a one-time Federal grant to promote community tree planting and cultivation projects. // It will solicit contributions from private sources. Sound a nationwide call for each American to protect the environment. And most of all, plant the trees that clean our air, prevent erosion, consume carbon dioxide, and purify our water.

By acting as one of a Thousand Points of Light, the National Tree Trust Act of 1990 will help create Ten Billion Trees of Life. // It is a key part of our national tree planting and forest improvement initiative, to be administered by the Agriculture Department. // This two-part program involves both rural areas as well as ^{urban} local tree planting programs in cities like Indianapolis. And it, in turn, is central to my "America the Beautiful" program, which I announced ten weeks ago. //

Light
local
urban
tree
planting
programs
in cities
like
Indianapolis
And it
is central
to my
"America
the Beautiful"
program
which I
announced
ten weeks
ago.

"America the Beautiful" will help maintain and expand our parks, wildlife refuges, forests, and public lands. It's like your April "Clean and Green Month" campaign -- but on a more national scale. // It will enrich the urban landscape -- and

plant the seeds of environmental stewardship. Not only through planting trees -- but through other steps, as well. //

Clean air, for example. Our clean air proposal promises relief from the smog, acid rain, and toxic pollution that harm trees and people. Once again -- and the Vice-President joins me -- I call on the Congress to pass that bill. // I also call on them to help us improve pollution prevention and energy efficiency. // A recent study showed that if city temperatures are cut by five to ten degrees, energy used for cooling can be slashed by fifty percent. Trees can cool those temperatures. // And help realize these words of a Chinese proverb: "One generation plants the tree -- another gets the shade." //

I began by talking about two great Indiana exports -- Dan Quayle and basketball. Let me close by referring to a movie close to the Vice-President's heart. // It's called Hoosiers. You've seen it -- probably memorized it. It was filmed here and in three nearby towns. // Yes, it's about basketball. But it also portrays -- unforgettably -- the values of Indiana. //

The next time you see Hoosiers, look for kids ² -- they're everywhere -- like the 2,000 here today. And trees -- they're even more numerous than the movie's kids. // A lot of people don't know it, but Indiana is among our most heavily forested States. Look around you: Trees enhance the beauty of Indiana's cathedral of the outdoors. //

So let's help these youngsters plant trees -- nurture them -- in this State and all fifty States. And so knock Johnny

Appleseed from the Guinness Book of Records. // Let's plant the "trees for tomorrow" that will bless the children of tomorrow - the generations who will inherit our earth. //

Thank you for what you're doing. Hats off to the City of Indianapolis. God bless the land we so richly love -- the United States of America. And now, it is my great pleasure to officially plant the first tree of this magnificent campaign. ?

#

Let me just address a word to the press corps who have watched me plant trees all over the country. Many of you have scoffed at these tree plantings. There goes Bush again shovelling some more dirt. Well, it's bigger than that. It's more important. And it's not funny, silly or frivolous. We're talking about the ?environment. And planting trees is something everyone can do to keep our air clean. Communities and families can work together to _____.

Let me give you some figures to think about: A recent study has shown that if city temperatures are reduced by five to ten degrees, energy used for cooling can be reduced by fifty percent. That's a lot of energy saved by cooling things off (adding some shade).

So it's really not so funny after all. It's serious and it's ?productive, and I commend those of you who have reported on the importance of trees and I encourage the rest of you to do the same.

nurture trees

It's like buying a dog. Taking it home is easy. It's the caring that's important and at times difficult. But w/ a lot of love the dog will stick around & love you back.

Is Ronny Romney daughter or wife?

Cincinnati Staff Office
(513) 241-3591
fax

Fred Notion (317) 232-4578 Gov. Boyke's Off.

Ryan White - contracted AIDS
had hard time going to school

is dying
TV movie done about him

14 years old

Dr. Martin Cleiman
Riley Children's Hospital

New law to stop garbage importation

into Indiana

waste management

Joint Center
for Political
Studies
626-3500

Jane Elkant
626-3571

1) 636-3509 ^{← Their #?}

2) Any info. on Ctr.

3) HHS Sec. Sullivan
speech

4) ~~Q~~ Just a little
info. on South Corps

Hist. Black Colleges
in this Budget.

Gordon

Taft HS
17 Street Body
Anti-drug

THE WHITE HOUSE
WASHINGTON

Jump Master
Scout

THE WHITE HOUSE
WASHINGTON

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395-1747 Stand Guard

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Sea or air,

Arm - Stand Post
Navy Stand Watch
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THE WHITE HOUSE
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Davis/Martin
Title: jcps
March 29, 1990
Draft: Five

**PRESIDENTIAL ADDRESS: JOINT CTR. POLICY STUDIES, HILTON
7:30 p.m., Wednesday, April 4, 1990**

House quest
Wed.

6:45 Dinner

Jane Itard

((Eddie Williams, David Kearns and Robert Washington, thank you. It is also good to be out on the town with our good friends, Elsie and ~~William~~ Hillman. And I would especially like to recognize two of the elected officials among us tonight: David Dinkins -- Your Honor;\\\ and Doug Wilder -- Governor.))\\\

It's remarkable to think that in 1968, less than two years before the Joint Center was founded, there were only 200 elected black public officials in all of America. Twenty years later, there are more than 6,000 -- an amazing record.

But you know what I find most heartening of all? It's the way in which black leadership in America has become an ordinary and accepted feature of our national life. And this new leadership has a tremendous resource in the Joint Center for Policy Studies. ^{NO!} Voltaire said that no problem can stand the assault of sustained thinking. If that is true, then no problem we face today is a match for the Joint Center, truly one of the leading academies of independent thought in Washington today.

We can see for ourselves, tonight, that Washington is still a city that thrives on ideas. And as Americans from different professions and political parties, we are together on this wonderful evening to celebrate our shared ideals. We may not

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Report
Background

DAVID
MILBR
NSC

John
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agree on everything, but we agree on a few great things -- liberty, equality, opportunity and justice for all.\\

On this day, the anniversary of Dr. Martin Luther King, Jr.'s, martyrdom, the world looks to Montgomery, Alabama -- to the granite wall of the new civil rights memorial. And through a veil of flowing water we read these words from the Bible: ". . . let judgment run down as waters, and righteousness as a mighty stream."\\ Amos 5:24

Like a mighty river, justice can cut a channel through the hardest of stone. And, like a mighty river seeking the sea, justice can be impeded. But its quest is unstoppable -- in the end, justice cannot be denied.\\

Last month, a distinguished group of fifteen black publishers joined me for lunch in the White House. We discussed everything from the importance of black history in American education, to South Africa, to our struggle to rid this nation of drugs and crime.

Together, we walked outside, one of those beautiful Washington days we all live for. And, together we strolled around to the Residence, up to the Lincoln Bedroom, with its imposing high ceiling, its tall windows, lace curtains and Victorian furnishings. But you know what it is about that room that impresses Barbara and me, and impressed Vaclav Havel when he joined us there? It's not that Lincoln slept there. In fact, he didn't. It is impressive because he worked there. Because he made some of his greatest decisions there. It was his office and

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Office
Gary
Waters

Cabinet Room. It was where he signed the Emancipation Proclamation.

In a display case, along the wall, is a copy of the Gettysburg Address, written in Lincoln's dignified hand. Above it is a great painting titled "Watch Meeting, Waiting for the Hour." It's a very poignant scene, depicting slaves and their friends gathered around an elderly man, [a man who had lived in America all his life], and had never known a minute of freedom. But Lincoln had proclaimed January 1, 1863, as the first day of freedom. And so all their eyes are fixed on a watch -- waiting for the stroke of midnight, waiting to be free.

It is said that Lincoln's hand shook as he dipped his quill into the ink well before he signed the Emancipation Proclamation. Perhaps he felt the weight of history. Perhaps he was just weary. But in any event, he waited a moment to steady his hand, so that no one would think he wavered on his most important decision. And then Abraham Lincoln signed the proclamation with a firm hand. In a stroke, (millions were freed.)?

Together, we felt the greatness of the events that had taken place in that small room, and the profound consequences of a simple stroke of the pen. In moments like these, history returns as a revelation. I know that for Barbara and me, it was * certainly a very special moment, one that leads to me to reflect on the special responsibilities of the Presidency that haven't changed since that freedom midnight. Every president is

challenged to be a part of the legacy of Lincoln, the continuum of freedom.

So when Franklin and Eleanor Roosevelt asked ~~Marion~~ ^{Ave Marie} Anderson to sing ((the Battle Hymn of the Republic at the White House)), they were living up to the legacy of Lincoln.

When Ike Eisenhower acted decisively to protect a school girl in Little Rock, he was living up to the legacy of Lincoln.

When Lyndon Johnson signed the Civil Rights Act into law, he was living up to the legacy of Lincoln.

I believe that the day will come -- and it is not far off -- when the legacy of Lincoln will finally be fulfilled -- when a black man or woman will sit in the Oval Office. And when that day comes, the most remarkable thing about it will be how easily and how naturally it occurs. He or she will be another President, another traveler in the continuum of freedom, representing all the people of America, representing all that is best about America. You know, I meet a lot of school kids, many of them black, inner-city kids; and I wonder as I look at the faces of brave ten-year-olds swearing to fight drugs: **Is one of them my successor? Is this the child who will fulfill the legacy?**

But I know we aren't quite there yet. I know that prejudice and racial tensions still exist in America. So I will support, and intend to sign into law, a measure to collect as much information as we can on crimes motivated by religious, racial or ethnic animosity -- the Hate Crimes Bill.\\ And that is why I

will only appoint energetic defenders of our civil rights to the Civil Rights Commission.\\\

In my many meetings, black Americans have challenged me to live up to the highest ideals of the civil rights movement. Now let me challenge you to work with my Administration, from this day forward, to build a better America.\\

There are new missions for the civil rights movement in the 1990s. From now on, the protection of civil rights must also mean the removal of **all** barriers to opportunity, for there are forms of poverty that cannot be measured or solved by dollars alone.

First and foremost -- there is the poverty of the spirit. Government cannot teach young men and women to have faith in themselves if their mothers and fathers have lost all faith. Government cannot teach that achievement is to be found in quiet moments and subtle rewards, instead of the murderous materialism of easy drug money. But, as leaders, as parents, as communities, **we** can instill values. **We** can cultivate character.

Your own publications debunk the myth of black indifference and dependency. Black Americans have inherited a strong tradition of philanthropy and self help, from the underground railroad to the civil rights struggle of our own times.

So what we need now is a new partnership, one that draws inspiration from achievements both at home and abroad, from the civil rights and Solidarity movements, and from the new hope dawning in South Africa today. For after all, from the country

roads of Selma twenty years ago to the cobbled streets of Warsaw and Budapest today, a common refrain echoes through the history of our times: "We shall overcome." Now the winds of change have come to South Africa, **where Nelson Mandela is a free man.**\\
Where Mister Mandela and President DeKlerk are gradually moving toward negotiation, and we hope, reconciliation.\\\

((Insert on Africa to come))

Has the world known more improbable heroes than these sons of South Africa, white and black? Or Rosa Parks and Lech Walesa? But heroes they are. Let us honor them by working together, in solidarity.\\

But opportunity alone is not enough, for there is yet another form of poverty caused by fear. When people, going about the ordinary business of their lives -- waiting for a bus, walking to a corner grocery store -- must fear for their lives -- then fear has stolen our most precious possession -- freedom.

In January, in Kansas City, I saw people who had suffered from crack and crackling bursts of gunfire not heard there since the days of the Old West. In Alexandria, just across the Potomac, I saw another neighborhood where a crack-crazed addict had slain a policeman. And here in the District, I held a so-called border baby suffering the agony of withdrawal.

But everywhere I went, I also found hope. I found people who have **had had enough** of fear, **had enough** of crime, **had enough** of dope. Just as the people of East Berlin stood up for freedom, so the people of ~~this~~ ^{these} poor neighborhood are rallying together,

using people power to fight for another kind of freedom -- freedom from crime and drugs -- freedom from fear.

We must march with them in a solidarity, side by side, block by block, city by city.

Then there is yet another kind of poverty, a growing poverty of knowledge and skills.

Many young men and women in this country -- white, as well as black -- are simply not learning -- **not learning** -- the basic skills they need to hold down a job or to raise a family. **That is a national disgrace.**

We are used to thinking of unemployment as a case of too many people, too few jobs -- a game of musical chairs that leaves minorities standing when the music stops.

But in the years to come, our problem will be just the opposite: more than enough jobs -- and too few qualified people to fill them. Think about what that means. For every child growing up today -- black or white -- there will be a job waiting.\ The question is whether that child will have the education and the skills to seize that opportunity. The new service and manufacturing industries will require higher skills, more training and, at the very least, literacy. I am delighted Congress passed our youth training wage last year. But we need to do more. **After all, equal opportunity begins with equal education.**

So we must again work in a solidarity to better our schools. You know my proposals. First, I believe parents deserve choice.

They deserve the power to choose their children's child-care, whether it comes from a grandparent or a church-affiliated center. Parents also deserve one thing more -- the power to choose their children's school.

And where disadvantaged pre-schoolers are concerned, I am asking Congress to boost Head Start by half-a-billion dollars.

((I could go on. But I am reminded of the preacher who asked his congregation what he should speak about. Someone shouted from the back pew: "How about five minutes?"))\\

So let me say in conclusion, straight from the heart: This is no time for politics. This is the time for solidarity. Martin Luther King spoke of an arc of justice, a continuum of freedom. It is our legacy, our freedom legacy, that makes the sons and daughters of this American nation like no other.

I spoke earlier of the Biblical proverb that compared righteousness to a mighty stream. This same vision can be found in a poem by Langston Hughes, who compared the odyssey of black men and women to the crossing of many rivers. And with each crossing, their souls have grown deep -- deep, like the rivers.

This odyssey shaped the soul of a people, and because of black leadership, it is also shaping the soul of our nation.

Thank you, God bless you, and God bless America.

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B.
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