Final Analysis and Recommendations: Feasibility Study of Urban Forest's Economic Value

Part I: Air Pollution Emission Reduction Credits
Part II: Carbon Credits or Offsets

Presented to
National Urban and Community Forestry Advisory Council

Submitted by
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July 25, 1996

ACKNOWLEDGMENTS

ACRT, Inc. wishes to thank the National Urban and Community Forestry Advisory Council and USDA Forest Service for their support of this project. We gratefully acknowledge the information, discussion and review of the ERC concept by the following people:

Dr. David Nowak, USDA Forest Service, Syracuse, New York
Dr. Mark C. Trexler, Trexler and Associates, Seattle, Washington
Dr. Gregory McPherson, USDA Forest Service, Davis, California
Ms. Nancy Mayer, United States Environmental Protection Agency, Research Triangle Park, North Carolina

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ACRT, Inc., with support from a National Urban and Community Forestry Advisory Council (NUCFAC) grant, investigated the feasibility of funding urban forest management through the sale of air pollution emission-reduction credits (ERCs). ERCs are created when an air pollution source, such as a utility company or industrial factory, reduces its pollution emission more than is required by regulation (Figure 1).

We proposed creating ERCs based on the amount of air pollutants removed from the air by the trees a community plants or maintains. We envisioned that these urban forestry ERCs could be marketed to industrial air polluters in existing pollution trading markets. Four tasks were proposed in the project, however, funding was requested only for information gathering on the feasibility of establishing and selling ERCs.

Our investigations found that the key legislative, regulatory, and market elements needed for urban forestry to initiate ERCs as proposed in this project are in place. The specific legislative, regulatory and market factors affecting creation of urban forestry ERCs are discussed in detail. Despite existence of these key elements, urban forestry ERCs are not feasible based on the findings of this investigation and the recommendation of the scientific review committee.

Urban forestry ERCs are not feasible because of inadequate technical and research data to meet EPA's minimum requirements for ERC creation. Specific concerns related to EPA's minimum requirement that ERCs are quantifiable, surplus, enforceable and permanent are discussed. For urban forestry ERCs to be considered in the future, the EPA will require evidence that their mandated air quality goals will not be compromised. More importantly, the EPA will not jeopardize the environmental and health issues it is charged with protecting without sufficient evidence that urban forestry ERCs are real and verifiable.

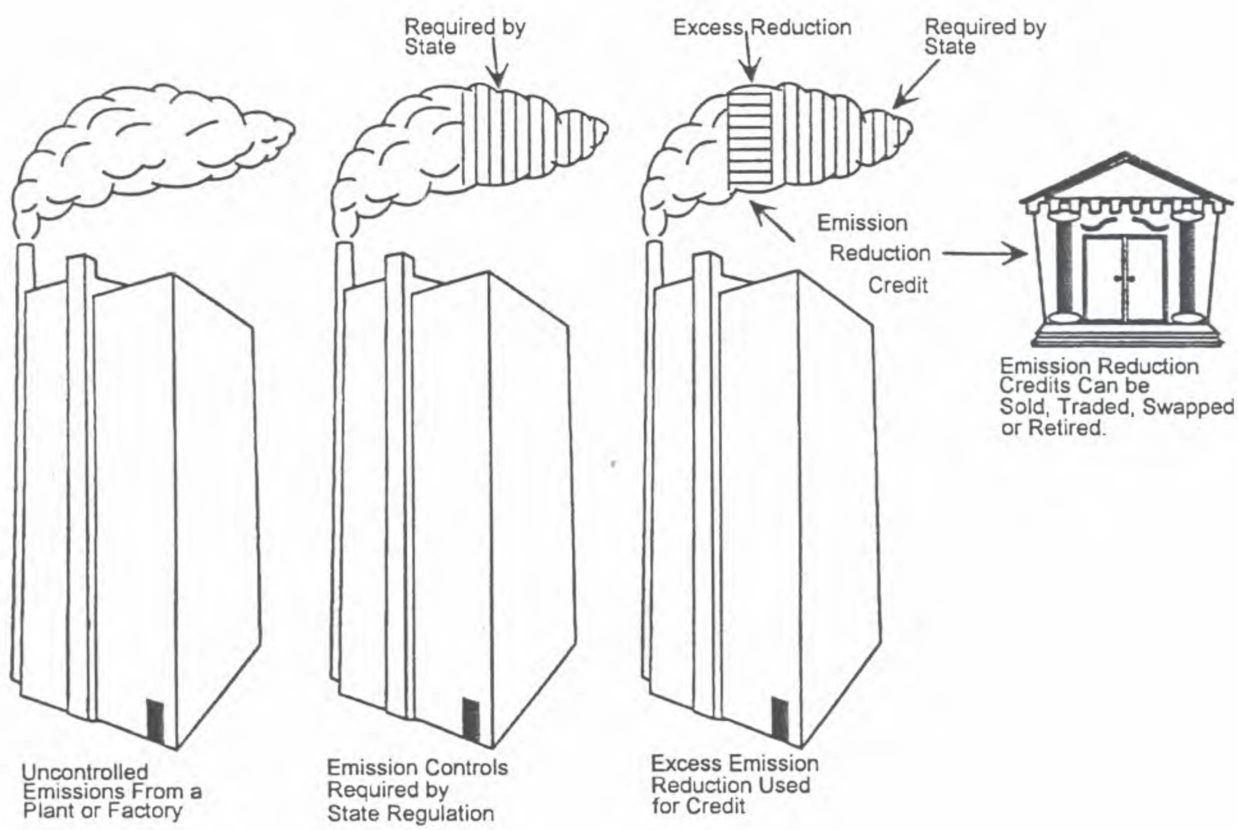
Quantification of the removal or air pollutants by the urban forest is one of the most important issues limiting ERC program development. However, quantification of air pollutants removed by urban trees is but one of many hurdles. Other basic requirements of ERC programs may be equally limiting even if adequate methodology were present to quantify air pollution removal by urban trees.

The economics of urban forestry ERCs are also sobering. Although the urban forest as a whole removes significant amounts of pollutants, the publicly maintained portion of this forest will not remove enough pollutants to make ERCs worthwhile. The dollar value of the pollutants removed by public trees does not warrant the time and effort that would be needed to obtain regulatory and market approval for urban forestry ERCs.

The scientific review team acknowledged the positive effect of trees on air quality in urban areas. The team recommended that with additional research, the EPA would reconsider use of urban trees in directionally sound strategies to improve air quality. Ozone was identified as the air pollutant most likely to be included in an air quality improvement program. Obtaining a directionally sound designation could be a defining step for integration of urban forestry into state and federal air quality improvement efforts. A directionally sound program would most likely need to include the entire urban forest to be effective.

Based on this feasibility investigation, we recommend no further effort be made to develop urban forestry ERCs. Alternatively, we recommend that efforts should be directed toward conducting research needed to obtain a directionally sound program designation. A proposal to obtain data to justify a directionally sound strategy was developed and funded by NUCFAC in 1995. Achieving a directionally sound program designation would be the first step toward attempting to justify specific funding for using urban forestry to clean the air.

Figure 1. ERCs are created when an air pollution source, such as a utility company or industrial factory, reduces its pollution emission more than is required by regulation.



INTRODUCTION

Cleansing air of pollutants by urban trees is frequently cited as a benefit of the urban forest. However, even though the urban forest can help improve air quality (Nowak, 1994) and the overall environmental quality of our cities (Dwyer et al., 1992), funding for urban forest management is declining (TCI, 1995). Apparently, simple recognition of the environmental and economic contribution of the urban forest alone has not been sufficient even to maintain historic funding levels for urban forest management.

Devising new and innovative ways to fund urban forest management may be essential to maintain the benefits provided by the urban forest. With this as a goal, ACRT, Inc., with support from a National Urban and Community Forestry Advisory Council (NUCFAC) grant, investigated the feasibility of funding urban forest management through the sale of air pollution emission-reduction credits (ERCs).

ERCs are created when an air pollution source, such as a utility company or industrial factory, reduces its pollution emission more than is required by law (Figure 1). The ERCs are usually sold to companies wanting to cost effectively meet their mandated air quality goals (Lents, 1993).

We proposed creating ERCs based on the amount of air pollutants removed from the air by the trees a community plants or maintains.

In this project, we proposed creating ERCs based on the amount of air pollutants removed from the air by the trees a community plants or maintains. We envisioned that these urban forestry ERCs could then be marketed to industrial air polluters in existing pollution trading markets. Ideally, the funds produced in the sale of these ERCs would be returned to manage the urban forest.

This idea of selling an environmental benefit of urban trees stemmed from a request made by the City of Santa Maria, California to the United States Environmental Protection Agency (EPA) in 1992 (Appendix A). Mr. Bailey Hudson of the City of Santa Maria suggested that local industrial sources of the pollutants were profiting from the maintenance of Santa Maria's urban trees. Mr. Hudson contended that without removal of air pollutants by the urban forest that local industry would have to increase their mandated air pollution mitigation measures.

Mr. Hudson proposed that the sale of the air pollutants removed by municipal trees, or possibly "renting" the city's tree canopy to local air polluters, could be a source of funding for urban forest management in Santa Maria. Based on Mr. Hudson's air pollution removal estimates for Santa Maria's public trees, the city asked permission of the EPA to sell the air pollutants to industry.

The EPA denied the city's air pollution sale request (Appendix A). However, the current project developed as a result of Santa Maria's initial request to sell urban forestry ERCs. Four tasks were proposed in the project, however, funding was requested only for the first of the tasks outlined below.

Task 1. Information gathering on the feasibility of establishing and selling ERCs.
Task 2. Development of a model ERC program for one or more pollutants.
Task 3. Presentation, justification and possible acceptance by the EPA.
Task 4. Establishment of free market trade of urban forestry ERCs.

Initiation of the remaining tasks and any new request for funding would be based on the findings of Task 1.

PROJECT METHODOLOGY

Methodology for Task 1, information gathering on the feasibility of establishing and selling ERCs, was accomplished primarily by:

1. Review of the literature on urban tree air pollution removal, historical and current information on ERC trading programs, and federal legislation and regulatory rulings on air pollution economic incentive programs.

2. Preliminary interview and discussion with EPA scientists and regulatory staff to gain insight on their view of the feasibility of urban trees ability to produce saleable ERCs.

3. Initial analysis of information gathered in the literature review and EPA discussions with project cooperators (also members of the scientific review team), namely Drs. Dave Nowak and Greg McPherson of the USDA Forest Service and Mr. Bailey Hudson.

4. Presentation of the urban forestry ERC concept and our findings to an EPA scientific and regulatory review team at Research Triangle Park, North Carolina in October 1994, and

5. Final analysis and presentation of results and recommendations to conclude the project.

This report presents ACRT's final analysis for the ERC feasibility study. The report will summarize the result of our investigation on the federal legislation and regulatory guidelines affecting urban forestry ERC, marketing issues affecting sale of ERCs, and review of the urban forestry ERC concept by

This report will summarize the result of our investigation on the federal legislation, regulatory guidelines and marketing issues affecting urban forestry ERCs.

the scientific review team and the EPA. ACRT's final recommendations for the air pollutant most likely to be used to create ERCs and the future of urban forestry ERCs conclude this report.

LEGISLATIVE FINDINGS

I. Legislation Affecting Urban Forestry ERCs

The Clean Air Act (CAA) of 1970 (P.L. 91-604) established a new era of goals and guidelines for air quality improvement by providing for economic incentive programs to clean the air. Comprehensive amendments to the Clean Air Act were enacted on November 15, 1990 (P.L. 101-549). The amendments, which are known as the Clean Air Act Amendments of 1990 (CAAA), contained additional provisions for marketable reductions (ERCs) for air pollutants.

Title I of the CAAA deals with economic incentive programs for achieving National Ambient Air Quality Standards (NAAQS) for criteria pollutants including carbon monoxide and the ozone forming air pollutants nitrogen dioxide and volatile organic compounds. Title IV of the CAAA deals with economic incentive programs for the acid rain forming pollutants including sulfur dioxide and nitrogen dioxide.

A. Importance of Legislation to Urban Forestry ERCs

The legislative framework to create and sell ERCs, as proposed in this project, has been established by the CAA and CAAA. Within this framework, urban forestry ERCs would be considered under the general regulatory grouping known as economic incentive programs.

The legislative framework to create and sell ERCs, as proposed in this project, has been established by the CAA and CAAA.

The intent of the CAAA legislation was to develop new and innovative economic incentive programs that would allow industry to identify least-cost methods to clean the air (USEPA, 1994). Urban forestry ERCs could be considered new and innovative, although the economics of cleaning the air with urban trees in comparison to traditional methods requires investigation.

The legislative provisions that allow market-based trading of ERCS (and, if feasible, urban forestry ERCs) is a new occurrence provided for by the 1990 CAAA (Lents, 1993). Prior to the 1990 amendments, it is unlikely that urban forestry ERCs could have been considered.

Title IV economic incentive programs to reduce acid rain forming pollutants were well defined in the CAAA. Title IV economic programs to reduce sulfur dioxide have progressed relatively rapidly. However, Title I legislation in the CAAA encompasses a wider range of air pollutants and types of economic incentive programs. Urban forestry ERCs would best fit under regulations that were developed from the Title I legislation.

Market-based trading of ERCs, emissions offsets (where new sources of emissions are offset by increasing air pollution removal elsewhere), emissions banking and other similar programs are specific categories of economic incentive programs allowable under the CAA and CAAA. The EPA is charged with developing the regulations to guide these programs. The economic incentive programs and regulations affecting urban forestry ERCs are discussed below.

B. Regulations and Guidelines Affecting Urban Forestry ERCs

The EPA is responsible for creating specific rules and setting guidelines for economic incentive programs from the CAA and CAAA legislation. Proposed and final rulings, and regulatory guidelines for economic incentive programs, including the creation of trading of ERCs, are published periodically in the Federal Register.

The rules governing the various economic incentive programs have evolved significantly since these programs were first initiated in the 1970s (Lents, 1993). Economic incentive programs rulings have dealt mainly with the air pollutants carbon monoxide, sulfur dioxide, nitrogen dioxide, and volatile organic compounds.

The rulings are provided by the EPA to assist states in meeting air quality goals by adopting incentive-based, innovative programs. The programs are intended to benefit both the environment and regulated entities and to allow for less costly control strategies (USEPA, 1994).

C. Identification of EPA Guidelines Affecting Urban Forestry ERCs

Regulations developed under Title IV for acid rain forming pollutants will not be discussed in detail for the following reasons. The EPA responded to ACRT's presentation of urban forestry ERCs for sulfur dioxide by indicating that reduction of sulfur dioxide is best achieved through traditional emission-limiting techniques (Appendix B). Title IV market-based programs are accomplishing targeted reductions of sulfur dioxide (USEPA,1995) making urban forestry ERCs for sulfur dioxide less attractive. Further, ERCs as proposed for urban forestry may be allowable for sulfur dioxide under Title I regulations.

EPA rulings for economic incentive programs under Title I of the CAAA for ozone forming air pollutants (volatile organic compounds and nitrogen dioxide), carbon monoxide and other criteria pollutants (sulfur dioxide and particles) were published April 7, 1994 in the Federal Register (USEPA, 1994). Although this ruling was conclusive, it was intended by the EPA to act as guidance and not final action. Final action occurs when the EPA approves the economic incentive programs within a state's air quality implementation program (USEPA, 1994).

Rule making by the EPA classified economic incentive programs into three broad categories: market response, emission limiting, and directionally sound (USEPA, 1994).

Trading of ERCs, as proposed in this project, would probably fall under the category of market response because program action depends on marketplace decisions. Urban forestry ERCs could also be considered as emission limiting if they were developed by a state as part of an emission-reduction program. Directionally sound programs are strategies that do not yield quantifiable or creditable ERCs. However, directionally sound programs can be included by a State as part of their strategy to attain or maintain National Ambient Air Quality Standards (NAAQS) (USEPA, 1994). Directionally sound programs can eventually produce tradeable credits once the EPA gains experience with the program (USEPA, 1994).

Rule making by the EPA classified economic incentive programs into three broad categories: market response, emission limiting and directionally sound (EPA, 1994).

Presently, any market-based trading of ERCs has to be approved within an individual state's State Implementation Plan (SIP). SIPS are required annually by the EPA to show how mandated air quality goals for specific air pollutants will be attained.

The EPA also recently proposed a model rule that would alter the manner in which ERCs can be created and traded (USEPA, 1995). This proposed ruling could significantly streamline the regulatory process. If accepted, the ruling would allow trading of ERCs without the SIP revisions required previously. SIP revisions are technically difficult and bureaucratically cumbersome.

Market-based trading of ERCs has to be approved within an individual state's SIP.

The new credits created by the proposal are called Directed Emission Reduction Credits (DERs). If approved, this new ruling would bring faster, less expensive methods to create open markets for trading emission reduction credits. The DERs could also be created by smaller stationary and mobile sources of ozone forming air pollutants.

D. Importance of General Regulatory Guidelines to Urban Forestry ERCs

The EPA clearly intends the rules governing ERCs as presented in the Federal Register to act as general guidelines. Individual state use these guidelines in their development of air pollution trading programs. The general rulings appear flexible enough to allow urban forestry ERCs to be created if EPA guidelines could be met. However,

The general EPA rulings appear flexible enough to allow urban forestry ERCs to be created if EPA guidelines could be met.

urban forestry ERCs would have to be approved, at a minimum, at the state level before any trading occurred.

It is highly unlikely that any state would attempt to approve urban forestry ERCs. Each state is only interpreting EPA guidelines for economic incentive programs. A state attempting to use urban forestry ERCs would undoubtedly pass the initial approval process on to the EPA. In essence, EPA approval will be necessary for urban forestry ERCs.

E. Specific EPA Guidelines Affecting Urban Forestry ERCs

By any account, the EPA guidelines for economic incentive programs are complex and highly technical. Although the overall guidelines for economic incentive programs are flexible, minimum requirements must be met to create ERCs. By definition, ERCs and DERs must be surplus, quantifiable, permanent, enforceable, (USEPA, 1982) and certifiable.

By definition, ERCs and DERs must be surplus, quantifiable, permanent, enforceable, (EPA, 1982) and certifiable. These minimum requirements would apply to urban forestry ERCs.

These minimum requirements, which would definitely apply to urban forestry ERCs, are briefly outlined below.

1. Surplus - For an ERC to be created, removal of the air pollutant on which an ERC is based must be more than mandated levels or what is currently required by law. Essentially, the ERC must be in excess of existing requirements (Figure 1).

   The EPA is unlikely to grant urban forestry ERCs based on the air pollutants presently being removed by the urban forest. A baseline, from which additional reduction of air pollutants could be determined, will have to be defined to create urban forestry ERCs. Presently, there is no theoretical or technical basis to identify or determine what an urban forestry air pollution baseline is or could be.

Urban forestry would technically be creating air pollution offsets. Offsets are used to indicate that pollution emitted in one location is reduced by removing or "offsetting" pollution in another location.

   Further, urban forestry cannot create emission reductions or a surplus because it has no mandate to reduce air pollution. Urban forestry would technically be creating air pollution offsets. ERCs usually are created at the source of the emission. Offsets are used to indicate that pollution emitted in one location is reduced by removing or "offsetting" pollution in another location.

2. Quantifiable – Emission reductions must be quantifiable both in terms of measuring the amount of the reduction and characterizing that reduction for future use (USEPA, 1982). The program must specify the minimum required credible, workable and replicable procedures for quantifying emission reductions (USEPA, 1994).

   Clearly, in order to justify any type of ERC, the EPA requires accurate measurement of the amount of air pollutants on which the ERC is based. Minimal methods and monitoring procedures are outlined for industrial sources in the EPA ruling. Methods of identifying, monitoring and quantifying air pollutant reductions on which ERCs are based have been a substantial part of economic incentive program rulings.

   The effects of the urban trees on air pollution have come from a limited number of laboratory studies (Roberts et al., 1986; Roberts, 1980; Roberts, 1974) and from extrapolation of data collected from studies on forest stands to urban areas (see Nowak, 1994). These studies will not provide the methods or data that is needed to meet the EPA's requirement of "credible, workable and replicable procedures."

3. Permanent - the EPA requires that the improvement in air quality be maintained for the life of the program. In addition, the ultimate fate of the air pollutant after it is removed will need to be identified.

   The permanency of urban forestry ERCs raises a number of important questions. These questions are related to the contingencies needed to cover any shortfall in air quality improvement due to unforeseen tree mortality or impact by insect, diseases or environmental catastrophe.

4. Enforceable - relates to the ability to take action against the credit-generating source in case of air pollution reduction short falls or other problems with the program. Enforcement currently can take place through federally-granted permits or through SIPS. Statutory maximum penalties under the CAA may be as high as $25,000 per day per source violation (USEPA, 1982).

   Any community attempting to create urban forestry ERCs would most likely be subject to these enforcement penalties. The EPA or state could require a bonding or other enforcement mechanism be established before any ERCs are traded. Some mechanism of enforcement would be required to ensure that adequate means existed to account for any shortfalls in projected emissions reduction by the urban forest.

5. Certifiable - Certification is primarily a state regulatory function and occurs when the ERC actually becomes property and is allowed to be traded.

Certification is important because even if all other requirements for creation of ERCs are fulfilled and the EPA is willing to accept urban forestry ERCs, state certification will still be required. This means that ERCs would have to be approved, certified, and integrated into SIPS by each state where the ERCs were created.

F. Importance of Specific Guidelines for Urban Forestry ERCs

Although additional regulatory guidelines exist, the minimum requirements that define an ERC as being surplus, quantifiable, enforceable, permanent, and certifiable, are most important to urban forestry. If urban forestry is to develop ERCs or DERs, then these basic defining requirements must be met. It is very unlikely that the EPA will consider reducing its minimum requirements or will create new guidelines for urban forestry ERCs.

Based on ACRT's and the scientific review committee's analysis (see below), and the EPA's response, urban forestry will not be able to satisfy the minimum requirements for creating an ERC. In fact, urban forestry may not be able to satisfy any of the criteria that define an ERC. Additional concerns identified for minimum requirements for creating ERCs are discussed in Appendix C.

> **Based on ACRT's and the scientific review committee's analysis, and the EPA's response, urban forestry will not be able to satisfy the minimum requirements for creating an ERC.**

II. Economics and Markets for Sale of Urban Forestry ERCs

A. Economic Potential for Urban Forestry ERCs

Nowak (1994) estimated that in Chicago the annual air pollution removal by large trees (30 inches diameter at breast height and greater) was 0.12 lbs for carbon monoxide, 0.39 lbs for sulfur dioxide, 0.45 lbs for nitrogen dioxide, 1.0 lb for particles less than 10 microns, and 1.11 lbs for ozone. These removal estimates were based on canopy level calculations from the entire Chicago area urban forest. The canopy level estimates were then scaled down to individual trees of varying size classes. These estimates should be considered as near maximum removal rates for urban trees for a year because they are taken from the largest trees in the study.

Sulfur dioxide has been trading at around $150 per ton (Hahn and May, 1994) but recent trades at $100 per ton have been reported (Rodda, 1996). Assuming that other air pollutants will trade in this range, individual large diameter urban trees would produce around $0.25 worth of ERCs a year, if all pollutants removed by the tree were added together.

The value of the urban forest in removing air pollutants is larger if the cost of current emissions control strategies at the smokestack is used rather than current market trading prices. Using these values provided by Nowak (1994) from a 1992 California Energy Commission report and pollution removal rates estimated by Nowak (1994), the value of the an individual large tree for each pollutant would be $0.06 for carbon monoxide, $0.35 for sulfur dioxide, $1.09 for nitrogen dioxide, $0.72 for particles, and $0.29 for ozone. Even with these increased emission control costs, the value of air pollution removal an urban tree in Chicago is only slightly more than $2.00 per large tree for all air pollutants combined.

Based on recent trading prices of air pollutants on open markets, individual large diameter urban trees would produce around $0.25 worth of ERCs a year, if all pollutants removed by the tree were added together.

B. Importance of Economics to Urban Forestry ERCs

The low dollar value associated with air pollution removal by individual large trees would require that a city would have to have an extremely large number of mature trees on public property to even consider selling ERCs. Even with a large number of mature trees, it is very doubtful that the cost to the city and state associated with setting up an urban forestry ERC program could be justified. Revenues from the creation of ERCs, even without monitoring and brokerage costs, would make minimal contribution to a city's urban forestry program.

Economic incentive programs are based on cost-effective measures to reduce air pollution. Based on the estimates of Nowak (1994) in Chicago, it would take more than 5,000 large trees to remove a ton of sulfur dioxide in a year. The costs of maintaining these trees would be considerably more than the traditional control costs for reducing sulfur dioxide and other pollutants. Based on recent trading prices for sulfur dioxide of around $150 per ton, reduction of sulfur dioxide by urban trees could not be considered cost-effective.

The urban forest's effect on air quality is significant only when the entire urban forest is considered over large areas. Initial estimates of the potential of urban forestry to create ERCs were based on a large area of urban forest cover (Appendix A). Publicly maintained trees, although an important part of the urban forest, cannot remove enough air pollutants to make pursuing urban forestry ERCs worthwhile.

The urban forest's effect on air quality is significant only when the entire urban forest is considered over large areas.

C. Markets for Urban Forestry ERCs

Before any market-based trading of ERCs is approved, the effect of the economic incentive program on air quality must be included in a SIP revision. The revision is submitted annually to the EPA. Apparently, the submission of this revision has considerably slowed the development of markets. However, the proposed creation of DERs will allow the marketing of credits without cumbersome SIP revisions (USEPA, 1995).

The incentive for emissions trading develops when polluters reduce emissions below established requirements and earn credits or ERCs. The ERCs can be sold to other air polluters wanting to buy credits to comply with air quality laws (Lents, 1993). The first markets for emission trading were based on Title IV of the 1990 CAAA and dealt specifically with the sale of sulfur dioxide (Lents, 1993). ERC trading publicized in the media have involved primarily Title IV trading of sulfur dioxide. Trading of nitrogen dioxide between utilities is just beginning.

Title IV sulfur dioxide credits are sold in one-ton increments. These credits are often termed "offsets" to denote that emissions in one location are being offset by reducing emissions in a separate location. Sulfur dioxide credits have traded in the $122 to $450 range with an average of $157/ton for Phase I trades (Hahn and May, 1994).

Trades involving sulfur dioxide have occurred on the Chicago Board of Trade (Taylor, 1993) and through auctions established by private brokers. Private companies such as Canter Fitzgerald have created centralized trading centers for trading sulfur dioxide emissions allowances (Bartels, 1993). Trading or "swapping" of sulfur dioxide may also occur voluntarily between utilities with relatively few restrictions or through annual EPA allowance auctions (Hahn and May, 1994).

A recent "swap" of sulfur dioxide credits for carbon credits gained significant media attention. The sulfur dioxide credits were created under Title IV of the CAAA. However, the carbon credits were not under EPA or any federal or state regulation. The trade was conducted primarily for tax write-offs and public relations (ENR, 1994).

Markets for trading ERCs under Title I of the CAA are in development. For example, Illinois is proposing to establish a market for the trading of volatile organic compounds (ENR, 1995). A region-wide market to trade nitrogen dioxide, volatile organic compounds and sulfur dioxide is being developed in southern California (Lents, 1993). This market is known as RECLAIM (Regional Clean Air Incentives Market) and is easily the largest scale attempt at trading a range of air pollutants in one market under Title I.

Satisfying EPA regulatory requirements under Title I will take considerable cooperation between industry, state regulatory officials and the EPA. For example, The RECLAIM program took a 50-member advisory board more than a year just to develop a broad-based conceptual framework for this ERC market (Lents, 1993). The RECLAIM markets are still not operating despite three years of intense development.

Markets for trading nitrogen, sulfur dioxides and volatile organic compounds are likely to become more common in the future. Many states are establishing regulatory guidelines for ERC trading and determining how market-based trading of air pollutants will affect air quality attainment goals in their state. Once these initial hurdles are overcome, trading air pollutants will become operationally more practical.

The RECLAIM program took a 50-member advisory board more than a year just to develop a broad-based conceptual framework for this ERC market (Lents, 1993).

D. Importance of Markets to Urban Forestry ERCs

Presently, markets are well established to trade sulfur dioxide ERCs if urban forestry could create the ERCs to trade in this market. However, the EPA has stated that ERCs for sulfur dioxide reduction using urban trees are unlikely (Appendix B). Urban forestry ERCs would need to be integrated into markets that are developing for trading Title I program pollutants (nitrogen dioxide, volatile organic compounds and carbon monoxide).

Based on the low dollar value of air pollutants removed by urban trees, urban forestry could not justify the effort needed to create a new market system for trading urban forestry ERCs.

The effort involved in forming the RECLAIM market demonstrates the potential magnitude of the air quality, social, and economic issues surrounding creation of new markets for air pollutants. Based on the low dollar value of air pollutants removed by urban trees, urban forestry could not justify the effort needed to create a new market system for trading urban forestry ERCs.

The economics and regulatory issues surrounding urban forestry ERCs are likely to preclude any private interest becoming involved in urban forestry ERC market development. Therefore, if urban forestry ERCs could be developed under current EPA guidelines, sale of ERCs in markets developed by other groups would be necessary. This would require a revision of the air quality and market issues that were addressed when these markets were developed.

An important concern is that the proceeds from urban forest ERCs will not be of sufficient size to justify their trading. When considered in context of monitoring, administrating and brokerage trading costs, urban forestry ERCs may have minimal, or possibly no value.

III. Results of the Scientific Review Committee

During the course of this investigation, selected members of the scientific review team were periodically consulted for technical reference and guidance on the feasibility of creating urban forestry ERCs. After initial discussions and review with scientific review team members, a formal meeting convened in October 1994 to discuss the urban forestry ERC project with the EPA. Results of the scientific review teams analysis are discussed below.

Members of the EPA (all staff members located at Research Triangle Park, NC)/scientific review team included:

Ms. Vicki Atwell, USEPA, Air Quality Strategy and Standards Division-Ozone NAAQS
Mr. John Bachman, USEPA, Office of Director
Mr. Allen C. Basala, USEPA, Innovative Strategies and Economics
Mr. Bailey Hudson, City Forester, City of Santa Maria, CA
Dr. Christopher J. Luley, ACRT, Inc., Project Manager
Ms. Nancy Mayer, USEPA, Environmental Engineer
Dr. Dave Nowak, USDA Forest Service, Urban Air Quality Researcher
Ms. Rosalina Rodriguez, USEPA, Visibility and Ecosystem Protection
Mr. David Stonefield, USEPA, Ozone Policy and Strategy

The urban forestry scientific review team unanimously agreed that urban forestry does not have the technical information to meet EPA regulatory guidelines necessary to create marketable ERCs. In essence, the review team upheld the initial analysis of the City of Santa Maria's ERC request by Region IX of the EPA (Appendix A). Both reviews contended that urban forestry has insufficient technical data and research documentation to meet the minimum requirements for creating ERCs.

The urban forestry scientific review team unanimously agreed that urban forestry does not have the technical information to meet EPA regulatory guidelines necessary to create marketable ERCs.

The review team indicated that a significant hurdle for urban forestry ERCs is absence of technical methods needed to quantify the reduction of an air pollutant by urban trees. The EPA stipulates that any economic incentive program must specify "credible, workable, replicable procedures for quantifying emissions" reductions (USEPA, 1994). Nearly all the remaining basic ERC requirements (surplus, enforceable, permanent and certifiable) cannot be met without accurate quantification procedures.

Members of the scientific review team were unwilling to risk the important environmental and health issues associated with upholding air quality standards on an unproven, undocumented technology such as urban forestry ERCs. The review team was adamant that the burden of proof will be on urban forestry to demonstrate that the ERCs being claimed actually exist and can be verified through replicable procedures.

Further, the EPA has openly questioned whether air pollution reductions by urban trees would be adequate to offset the cost of monitoring, accounting and trading urban forestry ERCs. These costs could represent a substantial portion of any projected revenues from an urban forestry ERC program.

The review team acknowledged that research is present to suggest that urban trees improve air quality. An active discussion took place on how the urban forest could be used in air quality improvement efforts. The review team suggested that a directionally sound program designation was obtainable with additional research. A discussion of the type of research that would be needed to allow the EPA to make an informed decision on a directionally sound program designation took place.

The review team suggested that a directionally sound program designation was obtainable with additional research.

Directionally sound programs are used in SIPS for strategies that are known to improve air quality (Appendix D). Directionally sound programs cannot be taken credit for because the improvement in air quality cannot be measured adequately to be included in state air quality attainment goals. Directionally sound programs can be reclassified into a credit producing economic incentive once experience with such programs makes it possible (USEPA, 1994).

The review team suggested that ozone reduction by urban trees has the greatest chance of being included in a directionally sound program. However, credits for ozone reduction cannot be sold on open markets as originally proposed, because ozone is not emitted by any single source. The scientific review team discussed the potential of creating credits for ozone precursors (volatile organic compounds and nitrogen dioxide) based on levels of ozone reduction by urban trees.

When contacting numerous members of the scientific community involved in air quality policy and research, it became apparent that there was a common and widespread notion that urban vegetation increases ozone pollution. This belief is based on the fact that biogenic hydrocarbon emissions from trees and other plants are the source of more than 58 percent of the total nonmethane hydrocarbon emissions in the U.S. (Novak and Pierce, 1993). Natural and anthropogenic sources of hydrocarbons play an important role in ozone formation (Rao and Sistal, 1993; Possiel and Cox, 1993). However, as discussed below, the net effect of trees may be to lower ground level ozone (Cardelino and Chamedies, 1990), although the net effect of urban trees on ozone is unknown.

A. Importance of Scientific Review to Urban Forestry

From a scientific and regulatory standpoint, the scientific review team clearly indicated that urban forestry ERCs are not feasible. The scientific and regulatory hurdles identified by the review team can only be addressed with additional research.

Based on the review team's analysis, urban forestry ERCs should not be pursued beyond this initial feasibility study. However, the review team identified an alternative approach that could promote the use of urban trees in air quality programs. The scientific review team appeared willing to support using urban trees in a directionally sound program if additional research was presented on the effect of the urban forest on air quality. Even with the minimal regulatory requirements for a directionally sound program, urban forestry would not be approved for this program based on existing research data.

The analysis of the scientific review team may be invaluable to urban forestry in the future. The team clearly indicated that from a scientific standpoint data to support the use of urban forest management in state and federal air quality goals does not exist. If urban forestry desires to promote this as a benefit of urban forest management, then it should pursue research to include urban trees in state air quality attainment goals. The review teams analysis should help focus research efforts on obtaining the data to include urban forestry in directionally sound strategies to improve air quality.

The review team's analysis shows that if urban forestry is interested in integrating urban trees in air quality programs, then it needs to provide the EPA with the research data to make an informed decision.

The review team's analysis shows that if urban forestry is interested in integrating urban trees in air quality programs, then it needs to provide the EPA with the research data to make an informed decision. Without this research, further attempts to create ERCs or develop directionally sound programs will be unsuccessful.

IV. Pollutant Most Likely to be Granted Approval for an ERC

The air pollutants in Table 1 were considered for urban forestry ERCs. Of these pollutants, ozone appears to have the greatest chance of being included in an economic incentive program. As is evident from Table 1, ozone is the most pervasive of all air pollutants.

Table 1. Air pollutants considered for use in urban forestry ERCs.

Pollutant	Source	Health Impact	Number of People Affected[1]
Carbon monoxide	Transportation	Reduces oxygen delivery to body organs	11.63
Nitrogen dioxide	Fuel combustion, transportation	Lung irritant, ozone precursor	0
Ozone	Atmospheric Chemical reactions	Lung irritant and lung tissue damage	51.3
Particulate matter[2]	Diesel vehicles, fugitive sources	Respiratory and cardiovascular effects	9.4
Sulfur dioxide	Coal and fossil fuel	Respiratory and cardiovascular effects	1.4
Volatile organic compounds	Industrial solvents, vegetation	Precursor for ozone formation	Not reported

1 *Number of persons (in millions) living in counties with air quality levels not meeting the primary NAAQS in 1992 (USEPA, 1993).*

2 *Airborne particulate matter that is less than 10 microns in diameter.*

After discussions with the EPA, urban forestry air quality researchers and the scientific review team, urban forestry has the greatest potential to be used in ozone mitigation strategies.

Initially we envisioned that urban trees could be used in market-based programs for an array of air pollutants. After discussions with the EPA, urban forestry air quality researchers and the scientific review team, urban forestry has the greatest potential to be used in ozone mitigation strategies. However, ERCs cannot be granted for ozone because no source emits this pollutant.

Ozone is formed through atmospheric chemical reactions by precursors, such as nitrogen dioxide and volatile organic compounds, in the presence of sunlight. Control of ozone pollution is achieved through reduction of these precursors.

Ozone mitigation using urban trees could be used at the state level in directionally sound programs (Appendix D). Directionally sound programs can eventually lead to credits within SIPS. However, the credits could not be sold on open markets as with other air pollutants. The credits have economic value to the state, however, because they could be applied toward reducing ozone pollution that might be created during additional industrial or commercial development.

Interest in using urban trees to reduce ozone stems from the difficulty in managing this pollutant. In the coming decades, ozone is likely to be the most important air pollutant affecting cities and ecosystems near major metropolitan areas. Additional discussion of the effects of urban trees on ozone is presented in Appendix E and a proposed study to evaluate the potential to use urban forest management in ozone mitigation strategies is provided in Appendix F.

V. Summary and Recommendations

The key legislative, regulatory, and market elements needed for urban forestry to initiate ERCs as proposed in this project are in place. Further, the markets for trading sulfur dioxide ERCs exist and markets for a broader range of EPA regulated pollutants are developing. However, despite existence of these key elements, based on the findings of this investigation and the recommendation of the scientific review committee, urban forestry ERCs are not feasible. Urban forestry is not in a position to further pursue developing an ERC trading program.

> **Urban forestry ERCs are not feasible based on the findings of this investigation and the recommendation of the scientific review committee.**

Clearly, urban forestry does not have adequate technical and research data to meet EPA's minimum requirements for ERC creation. Given the current amount of knowledge and the level of on-going research on urban trees and air quality, it is unlikely that the ERC requirements can be fulfilled in the near future. For urban forestry ERCs to be feasible, the EPA will require evidence that their mandated air quality goals will not be compromised. More importantly, the EPA will not jeopardize the environmental and health issues it is charged with protecting without sufficient evidence that urban forestry ERCs are real and verifiable.

> **The EPA will not jeopardize the environmental and health issues it is charged with protecting without sufficient evidence that urban forestry ERCs are real and verifiable.**

Quantification of the removal or air pollutants by the urban forest is one of the most important issues limiting ERC program development. However, quantification of air pollutants removed by urban trees is but one of many hurdles. Other basic requirements of ERC programs may be equally limiting even if adequate methodology were present to quantify air pollution removal by urban trees.

The economics of urban forestry ERCs are also sobering. Although the urban forest as a whole removes significant amounts of pollutants, the publicly maintained portion of this forest will not remove enough pollutants to make ERCs worthwhile. The dollar value of the pollutants removed by public trees does not warrant the time and effort that would be needed to obtain regulatory and market approval for urban forestry ERCs. It is unlikely that any single city would be interested in the creation of ERCs given the low dollar value of ERCs in comparison to, costs associated with monitoring and verifying air pollution removal, risks associated with Federal non-compliance, and cost of setting up a trading program.

The scientific review team recommended that urban forestry ERCs are impractical from a technical and regulatory standpoint. However, they acknowledged the positive effect of trees on air quality in urban areas. The team recommended that with additional research, the EPA would consider use of urban trees in directionally sound strategies to improve air quality. Obtaining a directionally sound designation could be a defining step for integration of urban forestry into state and federal air quality improvement programs.

Based on this feasibility investigation, we recommend no further effort be made to develop urban forestry ERCs. Alternatively, we recommend that efforts should be directed toward conducting research needed to obtain a directionally sound program designation. Achieving a directionally sound program designation would be the first step toward attempting to justify specific funding for using urban forestry to clean the air.

Obtaining a directionally sound designation could be a defining step for integration of urban forestry into state and federal air quality improvement programs.

VI. Recommend Budgets and Procedure to Include Urban Trees in the Next Step for ERC Development:

Appendix E outlines budgets and methodology necessary to initially obtain data needed to include urban forestry in directionally sound strategies to reduce ozone in SIPs.

A. Specific Recommendations

The following recommendations are presented as a result of this study:

1. Urban forestry no longer pursues creation and sale of ERCs.

2. Support be continued for additional air quality research, in relation to urban trees, with the goal of obtaining directionally sound program designation for ozone in areas with chronic ozone problems.

3. Support be provided for additional basic research on the effect of urban trees on air quality before any significant emphasis is placed promoting the use of urban forestry to clean the air.

4. Educational materials be developed that clearly relay the effect of urban trees on air quality. These materials should be based on existing research knowledge and should attempt to dispel the fairly widespread belief in the air quality regulatory community that urban trees contribute to ozone and other air quality problems.

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Appendix A:
U.S. EPA's Response to the City of Santa Maria, California's Request for the Sale of Air Pollution Credits

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

Post-It™ brand fax transmittal memo 7671	# of pages ▸
To Michael Thomas	From Bailey Hudson
Co. ARCT	Co. City of Santa Maria
Dept.	Phone #
Fax # 916 397 6060	Fax # 805 925 4508

REFER TO
A-5-1

19 April 1993

Ms. Wendy Stockton
Senior Deputy City Attorney
City of Santa Maria
110 East Cook Street
Santa Maria, CA 93454-5190

Dear Ms. Stockton:

On 15 December 1992 you wrote to ask me how to best work with me and my staff to gain "specific regulatory recognition" of the air quality benefits of Biomass Pollution Sheds (BPS). Communications with Bailey Hudson, Park Superintendent for the City of Santa Maria, and with the Santa Barbara County Air Pollution Control District (SBCAPCD), has further informed us that your idea is to use public vegetation to generate Emission Reduction Credits (ERCs) for businesses in your jurisdiction. This letter is our attempt to provide a comprehensive, constructive reply to your questions.

We regret to inform you that we have concluded that we can not approve of any ERCs generated from a BPS program now or in the near future. Our analysis further indicates that there is very little the Regional Office can do at this point to directly foster BPS ERC development. However, a recent policy proposal at the EPA may allow us to recognize a BPS program as being "directionally sound", albeit without attributing any quantifiable air quality benefit to it. While we realize that this will fall short of your wishes, we hope this alternative may provide an agreeable interim solution.

Region IX agrees that vegetation has beneficial effects on the environment in general and on air quality in particular, the latter by providing sites for deposition of particulates and non-organic gases and by possible mitigation by shade trees of the "urban heat island" effect. We are glad to see that the City of Santa Maria is taking concrete steps to plant additional vegetation, and we are further gladdened by the efforts of the City to assign to facilities under its jurisdiction realistic costs of mitigating the air pollution they create. We encourage you to continue your dialogue with BPS scientists to further develop this potentially promising concept and to consider adopting the BPS concept into a "directionally sound economic incentive program" in your State Implementation Plan (SIP). Unfortunately, we are unable to approve the concept of using BPS to generate ERCs at this time.

Relevant EPA policy on the generation of ERCs includes, but is not limited to, the Emissions Trading Policy Statement (ETPS; 51 FR 43814, 4 December 1986) and the proposed Economic Incentive Program Rules (EIP; 58 FR 11110, 23 February 1993). Both documents require ERCs to be quantifiable, surplus to existing requirements, permanent for the life of the program, and federally enforceable. In addition, all ERC trades are required to produce a net air quality benefit. The BPS concept was evaluated for its conformity to these guidelines.

The biggest problem with approving any BPS program is that the reductions are not quantifiable; there are not yet "creditable, workable, and replicable " quantification methods, as required by the EIP. While some BPS-related work has undergone scientific peer review, theory and data pivotal to quantifying emission reductions has not yet undergone this process. At this point it seems that emission reductions from vegetation is strongly dependant on site-specific factors, including wind, temperature, climate, local geography, and pollutant concentration. We are also aware that there are complex feedback loops, both positive and negative, between these and other factors.

Assuring that reductions would be surplus to those already relied upon in previous air quality progress demonstrations would also be problematic. Only vegetation planted after 1990 would be available for credit generation under this requirement, and some sort of on-going biomass inventory, required for all other credit-generating sources, would be needed to confirm the integrity of the credits. We must also point out that most plants emit some VOCs (volatile organic compounds), a smog precursor. To be consistent with sound economic and air quality management principles, these emissions would need to be quantified and mitigated.

Taken together, these uncertainties could cause a trading program involving BPS ERCs to lead to a deterioration of air quality, rather than to a benefit. These three issues are perhaps the most significant issues preventing us from approving BPS ERCs; other issues exist as well, and they are addressed in our letter to Mr. Hudson. We have also informed him of a scientist at EPA's Office of Research and Development who is willing to discuss the scientific needs of the BPS concept from EPA's point of view. Your letter speculated that fulfilling those and other regulatory needs "may take years"; we regret to inform you that this will most probably be true.

On the other hand, we feel that the City is already hastening the arrival of the day when such programs can be approved to generate ERCs, by giving the concept serious thought and by communicating with researchers in this field. It is possible that the City may be able to grant them experimental or even monetary assistance. The City of Santa Maria may also attempt to include BPS as a "directionally sound EIP" in the SIP, by listing the program without claiming any quantifiable air quality benefit. With the help of BPS scientists and the guidelines in the EIP, you may be able to develop a program to quantify the benefits from a BPS program. This could help your program gain national attention and facilitate its eventual transition from a directionally sound program into an emission-limiting program. Our letter to Mr. Hudson elaborates on this idea in greater depth, and we ask you to refer to the EIP for further guidance on this matter.

Once again, we sincerely would like to commend your innovation and dedication. We at the United States Environmental Protection Agency are committed to using the most cost-effective methods whenever prudent to protect and improve the nation's air quality, and we believe that your idea may one day find application in our national "toolbox" of air quality management techniques. Although we are not yet able to approve of ERCs generated from a BPS program, we applaud, and encourage you to continue, your research efforts. We thank you for this opportunity to review your proposal and to perform a cursory review of national policy for you. If you have further questions regarding national air quality management, please do not hesitate to contact Gene Lin of my staff at (415) 744-1238.

Sincerely,

Matt Haber
Chief, New Source Section

cc: James M. Ryerson, SBCAPCD
Bailey Hudson, City of Santa Maria

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

IN REPLY: A-5-1
REFER TO: NSE1 EIP/ETPS BPS

OPTIONAL FORM 99 (7-90)
FAX TRANSMITTAL # of pages ▶ 5
To Bailey Hudson | From Gene Lin
Dept/Agency City Santa Maria Parks/Rec | Phone # 415-744-1238
Fax # 805-925-4508 | Fax # 415-744-1076
NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

Thursday 22 April 1993

Mr. Bailey Hudson
Park Superintendent
Recreation and Parks Department
City of Santa Maria
110 East Cook Street
Santa Maria, CA 93454-5190

Dear Mr. Hudson:

Since January 1993 we have been in communication with the City of Santa Maria, regarding a proposal to gain "specific regulatory recognition" for the air quality benefits of Biomass Pollution Sheds (BPS's); in particular, to approve of the use of BPS's to generate emission reduction credits (ERCs). We have received the following documents from the City:

1. a letter to me from Wendy Stockton, Senior Deputy City Attorney of Santa Maria, dated 15 December 1993, with accompanying documents, including

2. the document "Biomass Pollution Sheds", pp. A-1 to A-4, file BIOMASS.BH; and

3. a letter to Gene Lin, of my staff, from you, dated 23 February 1993, accompanied by

4. the document "Meeting 12/23/92: Biomass Pollution Shed Applied in Santa Maria", file BIOMASS.BH, and also

5. the document "Biomass Pollution Sheds: Park Superintendent: Biogenic Hydrocarbons -- Air Quality", file BIOMASS2.BH.

The purpose of this letter is to supplement another sent to Ms. Stockton. Together, the letters explain why we cannot approve of any BPS-generated ERCs, and they describe one possible course of action that the City of Santa Maria can take.

Relevant EPA policy on the generation of ERCs includes, but is not limited to, the Emissions Trading Policy Statement (ETPS; 51 FR 43814, 4 December 1986) and the proposed Economic Incentive Rules (EIP: 58 FR 11110, 23 February 1993). Both documents require

ERCs to be quantifiable, surplus to existing requirements, permanent for the life of the program, and federally enforceable. In addition, all BRC trades are required to produce a net air quality benefit. This letter will elaborate on those issues, to the extent that they are not addressed in the letter to Ms. Stockton.

"Quantifiable"

There is considerable variability in the amount of pollution that trees and other vegetation remove from the air. While some data has been published in trade and scientific journals, our understanding is that these numbers are very site-dependant, due to factors such as local wind speed and wind patterns, air humidity, soil moisture content, albedo, solar incidence, temperature, plant density, plant species, age and health of plants, and length of growing season. We further understand that there are complex feedback mechanisms among many of these factors as well.

One example is the effect of trees on atmospheric mixing height. By contributing to surface roughness, trees can reduce the mixing that occurs between the air close to the earth's surface and the air farther above it. By itself, this effect increases pollutant concentration in the air near the ground. Part of the demonstration of net air quality benefit from involves computer simulation of the emissions increases and reductions.

"Surplus"

This criteria was adequately addressed in the letter to Ms. Stockton.

"Permanent"

At this time we see two requirements the "permanent" criteria will impose on any BPS ERC-generating scheme. The first is that some provision will need to be made for the maintenance of the vegetation. Not only will this include routine upkeep, it will also have to prepare for contingencies such as disease, parasites, weather, and fire.

The ultimate fate of pollutants deposited will also need to be determined. Deposited pollutants may be incorporated into the plants, fixed into the soil, or washed into the local watershed. EPA has previously treated the destruction of pollutants in the environment as a "black box", but if credit is to be granted for augmenting some of the activities in the "box", there needs to be a deeper understanding of the other activities in the box as well, to ensure that such a program does in fact benefit the environment.

"Enforceable"

Typically, a credit-generating source is already subject to a federally-enforceable permit. Enforcing though a permit allows quick and proper action to be taken, whereas enforcing through a SIP, EPA's other course of action, is slower and unwieldy. If the City is to be the credit generator, some viable enforcement mechanism should be in place should the BPS program not generate all the credit that it is relied upon to generate.

Other Air Quality Concerns

1. Amount of Credit Available. On p. A-2 of document 2, above, you cite the Chicago Lincoln Park Study as finding a reduction of 24 lb/day of NOx, over 122 acres. At this rate, the reduction over 2180 acres for one year is 39 tpy. (Annual figures assume an in-leaf season of 180 days.) However, this figure was calculated assuming an ambient concentration at the NAAQS level. If we assume that the City of Santa Maria has an ambient concentration similar to Lincoln Park's, the reduction becomes 14.5 tpy. If we further assume that the Lincoln Park study numbers depend on factors inappropriate to assume for Santa Maria and therefore use figures from a Lawrence Berkeley Laboratory study focusing on the South Coast Air Basin, the amount of available reduction drops to 0.24 tpy[1]. This calculation illustrates not only the great uncertainty in credit determination, but also raises the issue of uncertainty in overall capacity as well.

2. Ozone Issues. In your letter to Mr. Lin, you asked if rule changes would be necessary to accommodate at BPS ERC-generating program, since EPA currently requires reductions in VOC emissions. The answer is no: it is doubtful that a BPS-based program, or any other program, would be specifically exempted from VOC reductions. As indicated in the letter to Ms. Stockton, hydrocarbon emissions would need to be duly accounted for, as is currently required. While it does make sense to control NOx emissions when the hydrocarbon/NOx ratio is high, as you pointed out in your letter, both pollutants must still be reduced to achieve the NAAQS.

One might normally expect a new rulemaking to accommodate a new air pollution control concept, but the EIP rules were written to accommodate broad categories of economic incentive programs. The BPS-based control concept as has been sketched in your letters would fall into this category. However, due to the novelty of the BPS concept, the EPA might wish to convene an internal workgroup before such a program could be approved. One possible sequence of events is outlined in the section below on the EIP.

You asked if perhaps EPA set the ozone NAAQS too tightly. EPA has just completed a periodic review of the ozone standard, and on 9 March 1993, EPA published its decision to

[1]. Lawrence Berkeley Laboratory, University of California at Los Angeles, Systems Applications International, Inc. Analysis of Energy Quality and Efficiency: Draft Interim Report, January 21, 1993, p. 3-63. A base figure of 10 kg/ha-yr NOx removed was used for urban forests, based on the reported range of "~9 to ~12 kg/ha-yr".

leave the current standards, both primary and secondary, unchanged at 0.12 ppm (58 FR 13008). Although evidence was presented suggesting that the current standards were not sufficiently stringent, EPA decided to delay tightening the standard and to accelerate the next review. This was because a large body of work published after 1988 was not included in the last review. There were few, if any, comments requesting that the standards be relaxed.

Finally, you asked a question regarding emissions of VOCs and NOx from natural sources, such as crops and lightning. While there are no indexed emissions reductions required from crops generating VOCs, those emissions are estimated and used in air quality modeling. It should be noted that the effect of crops on the VOC inventory is as difficult to quantify as that from trees and other vegetation. As for NOx, computer models at the EPA assume that there is a background concentration of NOx at about 2 ppb (0.002 ppm), well short of the relevant NAAQS. When compared to anthropogenic sources of NOx, this amount can be assumed to be negligible.

3. Economic Incentive Programs (EIPs). As mentioned above, reification of the BPS-based air pollution control concept would result in an EIP: by charging emission sources according to their amount of air emissions, an economic incentive would be created for sources to reduce those emissions. Ms. Stockton's letter listed several benefits of a BPS ERC program, including gains to air quality, emissions accountability, economic growth, and aesthetic enhancement. In fact, these reasons are why we would like to see your research on BPS continue, and they would be motivating factors for our approval of such a program as a directionally sound EIP. However, before BPS ERCs become acceptable to EPA, they would have to become much more quantifiable. This would involve the publication of peer-reviewed papers addressing, at a bare minimum, the quantity of reduction, the fate of the pollutants, the effect on the health of the plants involved, and a modeling effort to demonstrate net air quality benefit. At this point both EPA and the Clean Air Scientific Advisory Committee (CASAC) would undertake studies of the concept.

If the result of those studies were favorable, the idea would then need to be assessed for policy concerns. A national, EPA-internal workgroup would be convened to write and propose a guidance document. After comments were solicited from industry, environmental groups, and the general public, and after those comments were addresses, the proposal could then be adopted. At this point local and regional authorities, including EPA, would oversee applications for ERCs and ERC trades using BPS-generated credits, to assess conformity with national guidelines and general air quality management practices.

The obvious disadvantage of a directionally sound program is that SBCAPCD would not be able to claim any reduction in the inventory that occurred because of the program. However, proposing a BPS program in such a way would probably allow it to forego the national process, in which it would probably fail to gain approval if it were proposed now. Registering the program this way might facilitate future dealings with the district and with EPA.

The EIP preamble and rules contain much that may help you in designing your program. Help from scientists, SBCAPCD staff, and other experts such as yourself will also be essential

Help from scientists, SBCAPCD staff, and other experts such as yourself will also be essential to a good program design. Dr. Bill Hogsett of EPA's Office of Research and Development works on the ozone NAAQS reassessment and has some familiarity with the BPS concept.[1]

Dr. William Hogsett III
US EPA: Environmental Research Laboratory / ORD
200 SW 35th Street
Corvallis, OR 97333
(503) 754-4632

Please feel free to contact him with any questions you may have concerning EPA's technical assessment of the BPS concept.

Once again, we would like to commend your innovation and your dedication to this concept. Although we are not yet able to approve of ERCs generated from a BPS program, we applaud, and encourage you to continue, your research efforts. We thank you for this opportunity to review your proposal and to perform a cursory review of national policy for you. If you have further questions regarding the EIP or any other national air quality management issue, please contact Gene Lin at (415) 744-1238. In future correspondence relating to this letter or to the letter to Ms. Stockton, please refer to file "NSE1 EIP/ETPS BPS".

Sincerely,

Matt M. Haber
Chief, New Source Section

cc: James M. Ryerson, SBCAPCD

BIOMASS POLLUTION SHED

COSTS PER TREE COMPARED TO SOCIETAL VALUES

THE CASE OF SANTA MARIA, CALIFORNIA

July 1993

Meaningful methods to quantify public health values of the urban forest have consistently eluded resource managers. Quantification of what society is willing to pay for certain amounts of pollutants captured or uptaken by vegetation is now being studied. Public health values computed in dollars and cents is becoming a reality. Such values are simply calculated by comparing costs per day per tree to societal value of atmospheric pollution reduction.

Costs per day per tree

In the past, only the tree management budget was taken into account when the costs per tree where determined. To give a more realistic view of the total costs, in Santa Maria the costs for watering, liability, sidewalk curb repair and sweeping of gutters covered by tree canopies are also calculated.

Tree budget (1992-1993)

- The total tree management budget is \$355,100 per year.
- There are 24,911 public trees in the City of Santa Maria (current inventory).
- This means the tree management costs per tree per day are:
  \$355,100 / 24,911 * 1 / 365 = **\$0.039 per day per tree.**

Liability (1992-1993)

- The total costs for liability concerning the public trees (insurance, etc.) are \$35,000 per year.
- This means that the costs per tree per day are:
  \$35,000 / 24,911 * 1 / 365 = **\$0.004 per day per tree.**

Sidewalk curb repair (1992-1993)

- The total damage (caused by trees) accounts for \$40,007.50.
- This means:
  \$40,007.50 / 24,911 * 1 / 365 = **\$0.004 per tree per day.**

Water (1992-1993)

- Assumed is that all public trees are given the same amount of water. Figures are based upon average extracted from water records. The City of Santa Maria is responsible for the watering in commercial areas. Watering season is approximately 6 months per year.
- The average water consumption is assumed to be 100 gallons per tree per year. This figure is based on the fact that about 50 % of the public tree population consumes 150 gallons of water per year (deep well watering), and 50 % of the population consumes 50 gallons (surface watering / deep probe).
- Watering costs are $0.75 per 100 cubic feet.
- The water consumed per tree is:
  (100 / 7.5) * (0.75 / 100) = $0.10 per tree per year =
  $0.10 / 365 = $0.0003 per tree per day.

Gutter sweeping (1992-1993)

- In Santa Maria, there are 820 gutter miles to sweep = 4,329,000 gutter feet.
- The costs for sweeping are $18.00 per gutter mile = $0.0034 per gutter foot.
- Using a sample of 1,292 out of 24,911 trees, the average canopy diameter was 14.6 feet. This means that the total tree population covers 14.6 * 24,911 = 363,700.6 feet. This accounts for 8.4 % of the total gutter length (notice that park trees are included in the 24,911. Not all of them will cover a gutter).
- Every month, 480 miles are swept = 5,760 miles a year. This costs 5,760 * $18.00 per gutter mile = $103,680.
- The costs per tree then are:
  (0.084 * $103,680) / 24,911 * 1 / 365 = $0.001 per day per tree.

The total costs per tree per day then are:

-	Tree budget:	$0.0391
-	Liability:	$0.0038
-	Sidewalk curb repair:	$0.0044
-	Water:	$0.0003
-	Gutter sweeping:	$0.0001

-	Total costs:	$0.048 (about $0.05) per tree per day

(Note that these costs don't include the interest rate on capital lost. An interest rate of 10 % would be realistic. This means that the Net Present Value of the planting costs of a certain tree after, let's say, 30 years, would be: (planting costs * $1.1)^{30}$. So the actual costs per tree per year and per tree per day would be higher taking the interest rate on capital lost into account. But the societal values would also increase because of the interest rate.)

Societal benefits for pollution capturing

- According to a sample of 1292 out of the 24,911 public trees in Santa Maria, the tree canopies cover 95.9 acres.

- Using the data found in the Chicago-research (reduction rates), the total air pollutant reduction in Santa Maria can be calculated.

- Assumed is that the conditions in Lincoln Park, Chicago, are the same as in Santa Maria. In reality, Leaf Area Index (total leaf surface / ground surface covered by canopy), Woody Area Index (total woody area surface / ground surface covered by canopy), daytime in summer etc. will be different under Santa Maria circumstances.

- Comparison between Chicago-Lincoln Park research and Santa Maria:
  Chicago Lincoln Park tree cover = 120.75 acres
  Santa Maria tree cover = 95.9 acres

  Santa Maria particulates interception =
  (95.9 acres / 120.75 acres) * Chicago interception = 0.794 (ratio) * 170 = 135.0 lb/day

  The CO interception in Santa Maria = (95.9 / 120.75) * 5.4 [= Chicago interception] = 0.794 * 5.4 = 4.3 lb/day

  The same calculations are made for the other gaseous pollutants, NO_2 and SO_2.

  The NO_2 interception in Santa Maria = 0.794 * 24 = 19.1 lb/day.

  The SO_2 interception in Santa Maria = 0.794 * 127 = 100.8 lb/day

Now, the societal value unit values are used to calculate the societal value. In Chicago, these figures were used:

Pollutants	Societal value ($ per lb.)
Particulates	2.09
CO	0.45
NO_2	3.40
SO_2	0.78

Using the 1990 "Highest Going Rates" for particulates, CO and NO_2 of the California Air Resources Board Office of Air Quality and Planning, and adapting a higher societal value for SO_2, the values for the Santa Maria case will be:

Pollutants	Societal value ($ per lb.)
Particulates	5.0
CO	1.0
NO_2	12.0
SO_2	2.1*

• No figure was available for SO_2. So the average difference between the Chicago and Californian ratings is used. The Californian rating are 2.7 times higher (when the increase for the other pollutants is used). So the societal value for SO_2 than will be 2.7 0.78.

Using these figures, the societal value can be calculated for Santa Maria:

Pollutant	Calculation	Implied soc. value ($/day)
Particulates	135.0 lb/day * $5 /day	675
CO	4.3 lb/day * $1 /day	4.3
NO_2	19.1 lb/day * $12 /day	229.2
SO_2	100.8 lb/day * $2.1 /day	211.7

Appendix B:
U.S. EPA's Response to the Inquiry of the Potential for the Creation of Sulfur Dioxide ERCs

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

June 17, 1994

Mr. Chris Luley
ACRT
6050 Hicks Road
Naples, NY 14512

Dear Mr. Luley:

This is in response to your telephone call to me on May 27, 1994 asking my opinion on the use of trees as a part of a control strategy to mitigate sulfur dioxide (SO_2) ambient concentrations. As we discussed, I cannot respond to your question about the effect of trees on mitigating acid rain; you should discuss this with EPA's Acid Rain Division in Washington, DC (202-233-9150). Related to the SO_2 national ambient air quality standards, most SO_2 problems are caused by specific industrial or fuel combustion sources, and these problems are usually easily mitigated by installing the proper emission control device or by switching to a lower sulfur fuel. I am not optimistic that trees would play a significant role in SO_2 problem mitigation in most situations. Indeed, SO_2 produces foliar damage on trees and agricultural crops.

Sincerely,

Thompson G. Pace III
Acting Chief
SO_2/Particulate Matter Programs Branch

Appendix C:
Further Discussion of the EPA's Minimum Requirements for Creating Emission Reduction Credits as They Pertain to Urban Forestry

By definition, Emission Reduction Credits (ERCs) and Directed Emission Credits (DERs) must be surplus, quantifiable, permanent, enforceable, (USEPA, 1982) and certifiable. Urban forestry may have considerable trouble meeting any of these minimum requirements. Additional discussion of the requirements as they pertain to urban forestry ERC creation is presented below.

A. Surplus

One of the basic requirements for ERC creation is that the reduction level be more than mandated levels. Because the urban forest is not an air pollution producer (except for volatile organic compounds (VOCs)), it has no mandate to reduce air pollution. Therefore, it becomes problematic to define "surplus" in the creation of urban forestry ERCs. The EPA could argue that the urban forest canopy was already accounted for when National Ambient Air Quality Standards (NAAQS) were developed. Therefore, a surplus may need to be created by air pollution removal above and beyond the levels being removed after the NAAQS were established in 1990.

Another argument could be that increases in post-1990 canopy cover could be used to produce the surplus needed for ERCs. However, large documentation and verification problems are likely in an attempt to establish that canopy cover increases have actually occurred. Proof that increased canopy cover produces measurable reduction of pollutants may be impossible because levels of air pollution reduction in the past would have been virtually impossible to verify. In addition, given trends in urban forestry, reductions in canopy cover may have occurred in many areas since 1990.

In an attempt to create a surplus for an ERC, a city could try to demonstrate that a new tree-planting program will remove air pollutants beyond what is already occurring by the existing urban canopy. Demonstrating that a net increase in canopy cover has occurred because of the tree-planting program would be necessary in creating ERCs. Projecting increased canopy cover along with increases in air pollution removal over the life of the planting program would also be necessary to create the ERCs.

Creating offsets by urban forestry tree planting is the most likely way that ERCs could be produced. However, the biggest obstacle associated with this is that the tree planting could not be detrimental to the rest of the urban forestry canopy tree cover. Any real or projected decrease in canopy cover due to mortality in the existing tree population (e.g. trees not included in the planting program) could easily offset any increases in canopy from the ERC planting program. Monitoring annual changes in canopy cover levels to justify the ERC air pollution reduction may be a monumental task.

Surplus air pollution reduction by an ERC tree-planting program could easily be eliminated by unplanned or unexpected mortality in the existing tree population. Reduction in canopy cover on private property due to development or unforeseen pest or environmental problems could quickly place the ERC program in jeopardy.

B. Quantifiable

Quantification of air pollution removal by urban trees was identified by the EPA and urban forestry air quality researchers as one of the greatest hurdles that urban forestry faces in creating ERCs. Existing data to support urban forestry's claims of improved air quality from urban trees is not satisfactory to the EPA. Further, methods to practically and accurately quantify air pollution removal by urban trees do not exist. EPA, state environmental officials and industry will not and should not jeopardize air quality, environmental and health issues on air quality improvement technology that cannot be practically substantiated.

Quantification of air pollution removal by urban trees has been extrapolated from research from limited laboratory studies and forest deposition studies (see Nowak, 1994 for most recent application of methods and research for urban tree air pollution removal). Field verification of these results has never been attempted in urban areas. We have no way of practically determining if the ERC credits that might be claimed actually exist. Certainly, we do not have the scientific basis to quantify air pollution removal by urban trees that could be used to request that the EPA grant urban forestry ERCs.

Many factors that directly affect air pollution removal by urban vegetation have been virtually unstudied. These factors include leaf area index of large trees, deposition velocities of various air pollutants, individual tree species effects, effects of air turbulence and canopy level mixing in urban areas on pollution removal, feedback mechanisms due to air pollution damage to leaves, and effects of environmental factors such as drought, pest infestation, and general weather conditions. Urban forestry's technical knowledge and ability to quantify air pollution removal is clearly many years away from being adequate enough to meet EPA required standards for industry.

Monitoring techniques to adequately demonstrate that air pollution reductions projected by an ERC program would need to be extensive and intensive. Strict standards for air quality monitoring are imposed on industry (USEPA, 1994). Urban forestry has neither the basic research data nor the general methodology in place to justify or attempt creating ERCs. If the technology to quantify emissions reduction is questionable, the EPA can allow scaling factors to be applied to reflect the uncertainty of the measurements. The technology to estimate pollution removal by urban forestry is not developed enough even to use these scaling factors.

C. Permanent

To create an ERC program, considerable effort is necessary to develop contingencies to show that any pollution reduction that is granted would be permanent. Contingencies for loss of canopy cover due to mortality, temporary defoliation or loss of canopy cover would need to be in place. These contingencies would have to show how air quality would be maintained if air pollution reduction accounted for by the urban canopy did not occur.

This requirement is a difficult hurdle for urban forestry, considering the high rates of mortality of urban trees and potential impact due to unforeseen environmental events.

Replacement of lost canopy cover on a large scale is not easily achieved by planting new trees to cover the loss. As discussed below, the EPA requires the ability to enforce the implementation of the contingencies if the ERC program could not provide expected results.

Contingencies to cover losses in canopy cover might require the city creating the ERC to place monetary bonds or have the ability to cover any shortfalls in projected air pollution reduction by mechanical means. Alternatively, industry could attempt to cover the losses if they were using the ERCs. This uncertainty and added expense may inhibit any entity, private or public, from considering using urban forestry ERCs.

D. Enforceable

An obstacle facing urban forestry in creating ERCs is that the urban forest is not a regulated source of air pollution. Therefore, enforcement of ERCs through the standard federal permitting system or through State Implementation Plan (SIP) requirements would not be possible.

The EPA could stipulate that the city or state be responsible in case the ERC program does not generate all the air quality improvement expected or required. In essence, the ERC program might require a bonding mechanism or guarantor that the EPA could impose enforcement procedures against if ERC shortfalls or other problems arose. Finding the support for this bond could be difficult if not impossible given the uncertainties associated with urban forestry ERCs.

E. Certifiable

Certification is based on meeting the other requirements that define an ERC. Local, state and federal EPA officials are likely to be involved in the certification process. There has been no indication from state and EPA officials familiar with the project that urban forestry ERCs have a chance of reaching certification. Because an urban forestry ERC program has so many atypical characteristics compared to existing ERC programs, most states would likely pass initial approval by the EPA before certification was granted.

Appendix D:
Directionally Sound Program Considerations

It is important to note that a directionally sound program for ozone reduction by urban trees will not result in direct ERCs. The incentive for a state to use a directionally sound program would be in the form of an improved opportunity for the state to meet EPA's mandates for improved ozone. By meeting EPA mandates, the state would avoid regulatory consequences of being in non-attainment for ozone.

C. **Future** Credits

(USEPA, 1994, page 16699)

"Credits may not be taken for directionally sound programs until experience with such programs makes quantification possible, at which time the program could be reclassified into one of the other categories for which credit may be taken."

Realistically, tradeable ERCs developed from an urban forestry directionally sound program are very unlikely in the near future. The regulatory issues facing the creation of ERCs are a long way from resolution.

Credits of a different genre, however, may be available through urban forest management. These credits could be developed for urban forest reduction of ozone within an (SIP). The credits cannot be sold as ERCs, but they would have value as a state plans and proposes economic development that could increase ozone.

Reduction of ozone by maintaining or increasing urban forest cover in an area could be used as "credit" or justification that the economic development be allowed. These credits would therefore have value to the state and local economy where development is proposed. However, they could not be bought, sold or otherwise traded on any open markets.

A directionally sound program designation may not provide enough economic incentive for a state to adopt such an approach. The ability to eventually gain credit within state attainment goals for ozone reduction by urban forest management may provide the economic incentive needed. Accounting for and verifying that the credits from an urban forestry program taken by a state actually exist will still be complicated. However, a large ozone reduction by an urban forestry program could greatly increase states' interest in adopting such a directionally sound program.

D. Policy Implications and Future Directions

Aside from fulfilling the technical aspects of a directionally sound program, acceptance and adaptation of urban forest management into existing state air pollution reduction programs may be the greatest challenge. Success in acceptance of a directionally sound program will rely on working directly with state and federal policy makers after technical information has been acquired.

Manipulating a biological system to improve air quality is far from a typical smokestack or tailpipe air pollution reduction proposal. An inherent "softness" exists in the use of a biological system to improve air quality. Many factors, both biological and anthropogenic, will affect the reduction of air pollutants by urban trees in any given year. On the positive side, the inherent resilience of biological systems may allow the urban forest to overcome short-term negative effects of weather or other environmental factors.

A directionally sound program designation would allow air quality policy makers to evaluate the implications of using a biological system in air improvement strategies without great risk to the state. Such a program could also provide a framework to gain acceptance of a future crediting program. Without the economic incentive and future goal of a market-based program, however, we believe urban forest management will fail to gain the recognition and funding necessary to use as a tool specifically for improving air quality and the environment.

November 1, 1994

NOTE TO CHRIS LULEY:

To confirm discussion we had yesterday on the use of urban forestry, I wish to reiterate the following points:

- It is the responsibility of the organization that wishes to use "urban tree credits" to prove that trees help the ground level ozone problem.

- That a directionally sound EIP only needs to show that a program is beneficial to be approved. However, such a program would not provide credit in an attainment strategy.

- To receive credit in an attainment strategy the program must be 1) federally and practicably enforceable and 2) be quantifiable with respect to the emission/air quality benefits to within a stated confidence level.

- That a State or local agency contemplating the use of urban tree credits would be much more likely to adopt such a program if they could receive credit.

If you have any questions, please call me at 919/541-5390.

Nancy Mayer

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Appendix E:
Additional Discussion of the Effect of Urban Trees on Ground-level Ozone

Ground level ozone is the primary constituent of smog that affects many major urban areas in the United States. Ozone is not a single or point source pollutant that can be managed with reducing emissions at limited number of locations. Ozone is a large-scale regional problem with many contributing sources. Therefore, ozone reduction strategies will be based on inter-state and regional cooperation. Urban trees could be a welcome addition to these strategies if increasing urban forest cover could be shown to have an impact on the overall ozone problem.

Ozone pollution affects a large number of people, particularly in cities and urbanized areas. In 1993, an estimated 51 million people lived in counties not meeting the National Ambient Air Quality Standard (NAAQS) for ozone established by the EPA (USEPA, 1994). This figure is probably low because of difficulties projecting numbers of people affected from the location of ozone monitoring stations. Using different methodology, 140 million people were estimated to live in non-attainment areas between 1987-1989 (USEPA, 1993).

Ozone exposure is an important health concern because it affects people over broad regions of the country. Ozone causes health problems by damaging lung tissues and increasing the sensitivity of lungs to other irritants. Ambient levels of ozone can affect people with impaired respiratory systems as well as healthy adults and children (USEPA, 1994).

A. Effects of Urban Trees on Ground-level Ozone

Urban trees are biological filters of ozone (Nowak, 1994) and other air pollutants (Roberts, 1980). A recent study of the Chicago area urban forest by the U. S. Department of Agriculture Forest Service estimated the urban scale effect of trees on ozone and other air pollutants (Nowak, 1994). The Chicago area urban forest removed 6,143 tons of air pollutants in 1991 (Nowak, 1994).

Trees can reduce ozone and other pollutants through several mechanisms. First, ozone is directly removed from the air by gaseous exchange through stomata (pores in the leaf surface). Removal of gaseous air pollutants primarily occurs during the day when stomata are open to transpire water and exchange gases. Particulate matter, however, is removed by deposition directly on the leaf surface. Nowak (1994) estimated that more than 50 percent of the particles deposited on leaves are resuspended into the air.

At high concentrations, ozone, nitrogen dioxide, sulfur dioxide and other air pollutants can damage leaf tissues. Closure of stomata from ozone injury or drought can dramatically reduce the ability of trees to cleanse the air of pollutants.

A second mechanism of ozone reduction by trees is through an indirect effect on ozone production. Atmospheric generation of ozone occurs during the day usually under hot, dry, stagnant summertime conditions (USEPA, 1994). Trees lower air temperatures through transpirational cooling (releasing water through their leaves) and shading of surfaces. Cardelino and Chameides (1990) provided some of the first theoretical evidence that trees, by lowering air temperatures, may reduce ozone in urban and suburban areas. Reduction of the well known "urban heat island" effect by urban trees may be an important factor in moderating summertime ozone pollution.

Urban trees also contribute to ozone formation by the release of a class of chemical compounds known as biogenic hydrocarbons. Release of biogenic hydrocarbons has created media attention and the misleading headline that trees cause smog. What the media is missing is that urban trees are most likely to have a net positive effect on reducing ozone (Chamedies and Cardelino, 1990). However, conclusive scientific data is lacking to substantiate this point.

A third way that urban trees mitigate air pollution levels is by lowering demand-side space heating and cooling energy use. Direct shading of buildings and surfaces in conjunction with lowering air temperatures reduces air conditioning energy use. Urban trees also reduce windspeeds around buildings and this mitigates cold air infiltration into houses in the winter. By lowering heating and cooling energy demands, less fossil fuel is burned to produce electricity that is used to warm or cool spaces. Thus, fewer pollutants, such as the ozone precursor NO_x, are released into the atmosphere from power plants.

Evaluation of the overall effect of urban trees on ozone is difficult because trees both decrease and increase ozone. Measurement of the net effects of trees on ozone will require complex computer models that are applied to conditions that are specific to a particular city and region. One such model, the Urban Airshed Model (Appendix F), has been accepted by the EPA for evaluating ozone reduction strategies (Rao and Sistla, 1993). The EPA has stated that in order for urban trees to gain regulatory recognition for their effect on ozone, it will be necessary to use the Urban Airshed Model or other similar modeling techniques.

Appendix F:
Evaluating Air Quality Effects of Urban Trees: Developing Directionally Sound Programs for Use in State Ozone Attainment Goals

(A proposal presented to the National Urban and Community Forestry Advisory Council for 1995 Challenge Cost-Share Grants: Cost & Benefits of Urban Forests, April 1995)

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Executive Summary

EVALUATING AIR QUALITY EFFECTS OF URBAN TREES: DEVELOPING DIRECTIONALLY SOUND PROGRAMS FOR USE IN STATE OZONE ATTAINMENT GOALS

Drs. Christopher *J.* Luley, David J. Nowak and S. Trivikrama Rao

A previous NUCFAC cost-share project has determined that there is a significant potential for developing credits within State Implementation Plans (SIPS), based on ozone reduction due to urban forests, which can be used to fund future long-term urban forest management. Before these credits can be developed, the U.S. Environmental Protection Agency (EPA) needs evidence that the approach is directionally sound. This project proposes to produce evidence that will aid in the development of directionally sound programs for state ozone attainment goals, thereby facilitating the development of these credits. In addition, this project will quantify the effects of urban trees on numerous other air pollutants. Results of this project will have nationwide impacts, potentially affecting urban forest funding in many urban areas that have poor air quality.

Detailed analyses of urban forest cover, structure (i.e., species composition, tree size and condition) and air quality effects will be conducted for seven cities: Baltimore, MD; Baton Rouge, LA; Boston, MA; New York City, NY; Jersey City, NJ; Philadelphia, PA; and Camden, NJ. Urban forest structural information is necessary to quantify the air quality effects and will also provide good management information for the cities. Air quality effects will focus on pollution removal and volatile organic emissions by trees. Carbon sequestration by trees will also be calculated. The main focus of the project will be on the overall effects of trees on ozone in cities. Current and next generation state-of-the-science photochemical models will be used to quantitatively evaluate this overall effect. Model results will aid in developing directionally sound ozone programs, thereby creating cost-effective ozone control strategies using urban vegetation.

Funding: Requested Amount: $225,000 Matching Amount: $225,000

Partners: Arboretum Park Conservancy, Baltimore Dept. of Parks and Recreation, Baton Rouge Green, Baton Rouge Landscape and Forestry Division, Boston Parks and Recreation Dept., Center for Urban Forestry at the Morris Arboretum of the Univ. of Penn., City of Santa Maria, CA, East Baton Rouge Recreation and Parks Commission, Environmental Services, New York City Parks, Louisiana Dept. of Environ. Quality, Maryland Dept. of Environ., Mass. Dept. of Environ. Protection, NOAA, NJ Forest Service, NY State Dept. of Environ. Conservation, Philadelphia Air Management Service, Philadelphia Fairmount Park Commission, Southern Univ. and A&M College, SUNY at Albany, Trees New York, U.S. EPA, and the Yale Univ. of Forestry and Environmental Studies Urban Resources Initiative.

Key scientific staff: Dr. C.J. Luley (ACRT, Inc.), Dr. D.J. Nowak (U.S. Forest Service), and Drs. S.T. Rao, G. Sistla and S. Jin (New York State Department of Environmental Conservation). This interdisciplinary staff is unique in their ability and they are experts in assessing, through measurement and modeling, the effects of trees on air quality; particularly ozone. Never before has such a team been assembled to address this issue.

Results and Products: Numerous reports and presentations will be made to local, regional and national audiences regarding this project's results quantifying the effect of urban trees on air quality. Particular focus is on the cumulative effect of trees on ozone and the feasibility of using trees as part of directionally sound programs to decrease city ozone levels.

Introduction

Poor urban air quality is a multi-billion dollar problem in the United States. In 1985, 94 metropolitan areas, with approximately 130 million residents, were in violation of the health-based National Ambient Air Quality Standard for ozone (EPA, 1986). The U.S. Environmental Protection Agency has estimated that medical and work-loss costs from air pollution in the United States are approximately $6 billion annually. Total costs of all control strategies in non-attainment cities will be $7.7 - 8.9 billion annually by the year 2003 (OTA, 1988).

A previous NUCFAC cost-share project has determined that there is a significant potential for developing credits within SIPS, based on ozone reduction due to urban forests, which can be used to fund future long-term urban forest management (Luley et al., in review). Before these credits can be developed, the U.S. Environmental Protection Agency (EPA) needs evidence that the approach is directionally sound. This project proposes to produce evidence that will aid in the development of directionally sound programs for state ozone attainment goals, thereby facilitating the development of these credits. In addition, this project will quantify the effects of urban trees on numerous other air pollutants. Results of this project will have nationwide impacts, potentially affecting urban forest funding in many urban areas that have poor air quality. This project will also complement many existing municipal and volunteer urban tree programs, regardless of city size and air pollution levels.

Analyzing the effects of urban trees on air quality is complex, particularly for ozone, as there are many interactive factors, some of which decrease pollution, other which increase pollution. Urban trees can improve air quality through the absorption of gaseous pollutants, the interception of particulate matter, and reducing air temperatures, thus consequently reducing temperature-dependent pollution emissions and altering pollution-forming chemical reactions. However, trees also emit volatile organic compounds that can contribute to ozone formation.

Unfortunately, very little work has been conducted that quantifies the degree to which urban trees influence local air quality. This type of work and documentation are necessary before managers, planners and policy makers can begin to develop and implement necessary air quality improvement strategies involving urban vegetation. In addition, this documentation will illustrate the vital need for urban trees and appropriate urban tree management.

Final Analysis and Recommendations: Feasibility Study of Urban Forest's Economic Value

Part II: Carbon Credits or Offsets