PROTECTING VISIBILITY

AN EPA REPORT TO CONGRESS

CHAPTER 7

7 PROGRESS TOWARDS THE NATIONAL VISIBILITY GOAL: CONTROL STRATEGIES PERSPECTIVES

Drawing from information and discussion in previous Chapters of this report, and from a preliminary analysis of class I area visibility conducted by the Federal Land Managers, this chapter provides some initial perspectives on technological and regulatory control strategies for making progress toward the national visibility goal. The chapter summarizes the preliminary class I area visibility assessment, discusses important implications of the assessment, and outlines key components of visibility protection programs, together with alternative control approaches.

7.1 PRELIMINARY ASSESSMENT OF VISIBILITY IN CLASS I AREAS

7.1.1 Nature of the Preliminary Analysis

A fundamental process in conducting programs for protecting class I areas visibility is to evaluate existing visibility, to identify sources of perceptible impairment, and to establish visibility management objectives on a national, regional, or area specific basis. (Such objectives could take the form of criteria for incorporating visibility value judgments in case-by-case control decisions. See 7.2.3) A comprehensive evaluation might involve a year or more of monitoring, source identification and modeling, and judgments on the nature, frequency, and extent of significant or adverse visibility impacts. Clearly, it will be some time before complete assessments are available for the 156 class I areas.

Therefore, in order to develop guidance in the interim for control programs, EPA requested that the Federal Land Managers (National Park Service, Fish and Wildlife Service, Forest Service) perform a preliminary national assessment of visibility values in their respective class I areas. In conducting their assessments, the Land Managers relied on the collective expertise of individual park managers and field and regional office personnel. Visibility analysis "workbooks " were developed and distributed for completion by managers representing each of the 156 areas. Although the format developed by the three land management agencies differed in specifics, each requested the same basic information. An example of one of the workbooks is included as Appendix B.

The workbooks generally called for the following kinds of information:

1. General information on the current status of visibility, including:

    a) Man-made sources of air pollution which may significantly affect visibility,

    b) Sources and significance of natural visibility degradation (e.g., fog, dust),

    c) Impact of area management practices which may significantly affect visibility (e.g., prescribed burning, campfires, traffic),

2. An assessment of the individual scenic resources in the area, including:

a) Identification of the important vistas in the area,

b) An assessment of current visibility conditions specifying degree and extent of impairment,

c) A judgment as to whether or not the view at each vista represents desirable or undesirable visibility;

3. Formulation of visibility management objectives for each area, considering both the national visibility goal and the management responsibilities assigned to the Federal land managing agencies by enabling legislation;

4. Photographic documentation; to supplement the written analysis and to provide a baseline for further assessments, each of the land managing agencies instituted a program to photograph the most critical vistas and document desirable visibility conditions for important vistas.

The visibility workbooks were completed by field personnel for 150 of the 156 areas during the summer and fall of 1978 and transmitted to their respective headquarters for summary and analysis (NPS, 1979; USFS, 1979; FWS, 1979). The information contained in these workbooks is, in effect, as assessment of visibility in class I areas based on human observations made over a period of one to many years. Evaluation of the sources of impairment, the desirability of current conditions, and articulation of visibility management objectives represent the subjective judgment of the individual Land Managers. Because factors such as the time of service, understanding of pollutant/visibility relationships, and criteria for specifying "desirable " visibility all may be expected to vary among these managers, the results of the preliminary analysis for any individual class I area must be evaluated with caution. Nevertheless, as long as these limitations are understood, the personal observations, experiences, and judgments of the individuals managing the class I areas in question can be extremely valuable.

All 150 workbooks have been reviewed and summarized for this report. When viewed in the context of information available from other sources on regional visibility patterns (Chapters 1,4) and location of existing and projected major sources of visibility-impairing pollutants (Chapter 6), the Land Managers' assessments provide important perspectives for developing visibility control strategies. A preliminary synthesis of the workbook summary with this additional information is presented in Figure 7-1 and Table 7-1. For convenience, the airport visibility isopleth map for the summer months is reproduced as Figure 7-2. To avoid placing undue significance on the results of any single workbook, the class I areas are grouped into regions according to similarities in both the nature of visibility impairment reported and regional visual range patterns. For each region, Table 7-1, summarizes 1) subjective judgments on the status of visibility impairment as reported in the workbooks, 2) observed phenomena affecting visibility, 3) a listing of potential manmade and natural sources reported in the workbooks and, in some cases from other studies, and 4) an indication of the potential for future impairment within each general region.

7.1.2 Implications of the Preliminary Analysis

The preliminary analysis suggests a number of implications for developing control strategies and for approaching some of the major issues, which have arisen in structuring visibility regulations. Some of these implications are summarized below.

7.1.2.1 Definition of Visibility Impairment - Approximately one-third of the individual class I area managers reported "undesirable" visibility conditions and/or the need to evaluate suspected anthropogenic impacts. The remaining two-thirds of the areas were reported as having "desirable " or "acceptable " visibility conditions for all or most of their vista. Although more detailed analyses and later judgments by Land Managers and other interested parties might alter this estimate, the preliminary results suggest that, for a fair percentage of the class I areas, anthropogenic pollution is not currently causing frequent significant or adverse influences on visitor enjoyment of the area. On the other hand the analysis suggests that virtually none of the class I areas are free from at least some measurable or potentially observable anthropogenic visibility influence.

These findings indicate that, if impairment is defined as any perceptible difference from natural visibility conditions, it appears likely that few, if any, of the class I areas will be able to achieve the national goal in the foreseeable future. Moreover, little impetus may exist for improving current visibility in areas that have "desirable " visibility, but perceptible impairment.

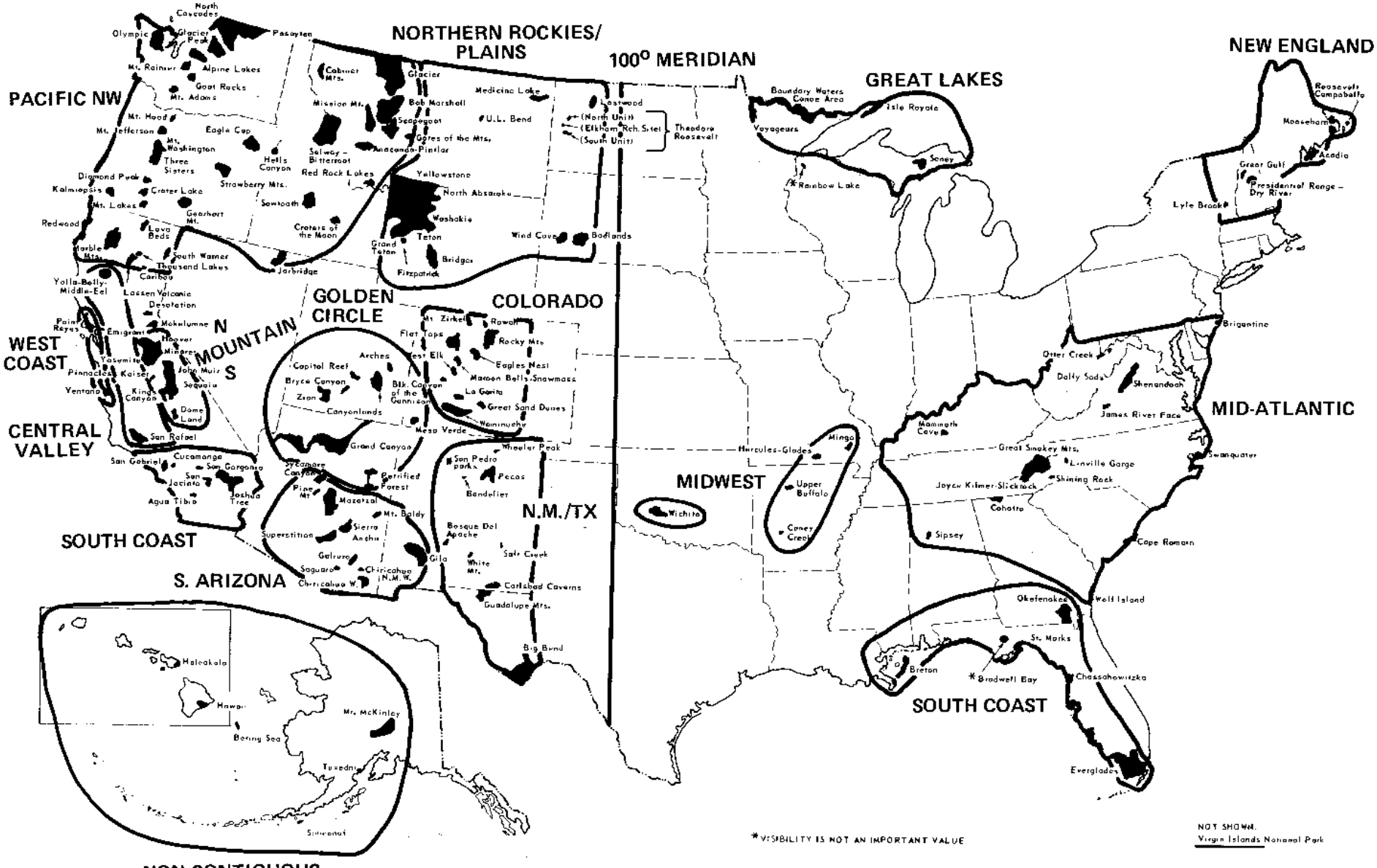

Figure 7-1. Class I area regions.

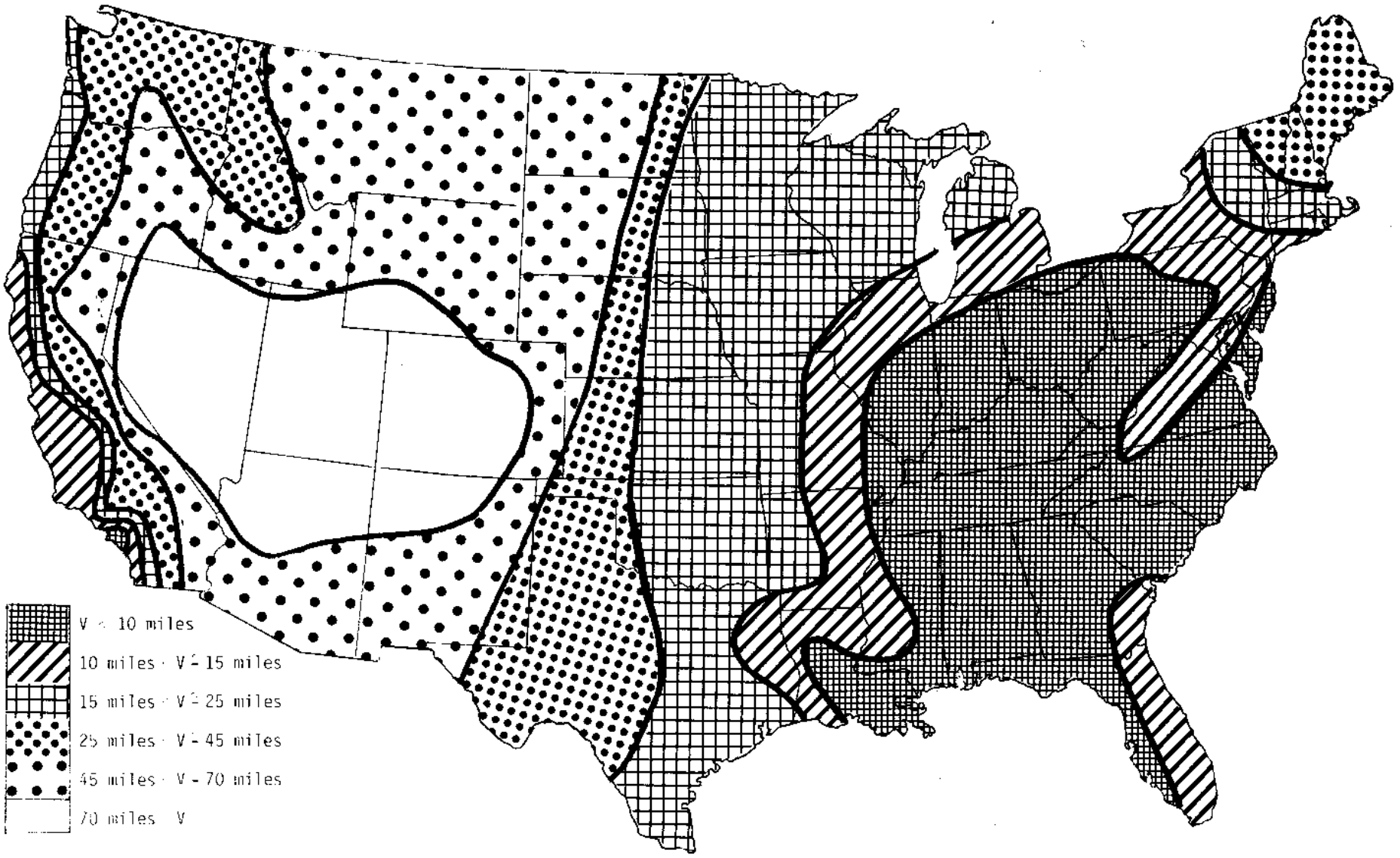

Figure 7-2. Visual Range Isopleths—Summer 1974-76 (Trijonis and Shapland, 1978).

TABLE 7-1. STATUS OF CLASS I AREA VISIBILITY IMPAIRMENT[a]

Region (see map)	Number of class I areas	Reported visibility status[a]	Observed visibility[a] phenomena	Potential sources[a] Man-made	Potential sources[a] Natural	Potential for future impairment[a-e]
West of 100° Meridian						
Pacific Northwest	39	Generally desirable visibility, intermittant undesirable conditions	1. Smoke, haze 2. Visible plumes	1,2. Agricultural burning; slash burning; forest products industry; pulp, paper mills; saw mills; Al, Cu smelters; urban plumes; prescribed burning	1,2. Wildfires; fog	Small increase in utility, industrial coal use;[b,c] population growth[d]
California (excluding North): West Coast Central Valley	7	Generally impaired outside areas, some impairment in areas	1. Haze 2. Smoke 3. Dust	1,2,3. Agricultural activity, burning; urban plumes; prescribed burning	1,2. Wildfires 3. Windblown dust	Small increase in utility, industrial coal use;[b,c]
East Mountain	2 North	Impairment outside areas, intermittent in areas	1. Haze 2. Smoke	1. Lake Tahoe, urban plume 2. Prescribed burning	2. Wildfires	Some improvement, with progress toward meeting air quality standards
	7 South	Generally desirable visibility, some impairment out in areas	1. Haze 2. Smoke	1. Agricultural activity, San Joquin Valley sources	2. Wildfires	
South Coast (W)	6	Generally impaired	1. Haze, smog	1. Los Angeles; other urban plume intrusions; some prescribed burning		
Northern Rockies/Plains	12	Generally desirable visibility Some impairment outside areas	1. Smoke 2. Visible plumes 3. Dust	1,2. Slash, agricultural burning; prescribed burning	1,2. Wildfires 3. Windblown dust; fog	Increased utility coal use;[b] increased industrial coal use;[c] possible decrease in smelter emissions in attaining air quality standards;[e] increased mining energy production activities;[c] associated population growth.[c,d]
Colorado	11	Generally desirable visibility	1. Smoke	1. Agricultural burning; saw mills; prescribed burning 2. Urban plumes	1. Wildfires 2. Windblown dust 3. Fog	Significant population growth in CO, UT;[d] associated urban, other development.
"Golden Circle"	9	Some impairment; need to assess noted	1. Haze (intermittent) 2. Visible plumes 3. Discoloration (brown, yellow bands)	1. Power plants; smelters; urban plumes 2. Power plants; miscellaneous small sources	1. Natural haze 2. Wildfires	Possible decrease in smelter impacts from air quality standard attainment[e]
Southern Arizona	11	Generally impaired	1. Regional haze 2. Dust 3. Smoke 4. Discoloration	1. Smelters; urban plumes (Phoenix, Tucson) 2. Agricultural activities; burning 3. Prescribed burning	1. Natural haze 2. Windblown dust	Possible further decrease in smelters emissions to attain air quality standards;[e] major population growth;[d] increased general development
New Mexico/Texas	10	Generally desirable visibility Need to assess noted	1. Haze 2. Dust 3. Smoke	1. Smelters 2. Agricultural activities 3. Prescribed burning	1. Natural haze 2. Windblown dust	Possible decrease in smelter impacts;[e] increased general development[a]

TABLE 7-1. (continued) STATUS OF CLASS I AREA VISIBILITY IMPAIRMENT[a]

Region (see map)	Number of class I areas	Reported visibility status[a]	Observed visibility[a] phenomena	Potential sources[a] Man-made	Potential sources[a] Natural	Potential for future impairment[a-e]
East of 100° Meridian						
New England	6	Generally desirable visibility	1. Episodic regional haze 2. Visible plumes outside some areas	1. Regional sulfur oxide; fine particle emissions 2. Pulp mills; open dump	1. Fog; Natural haze	Anticipated growth in regional coal use;[c] planned utility growth;[a] oil refinery;[a] significant population growth[d]
Mid-Atlantic	15	Some impairment, need to assess visibility noted	1. Regional haze, more intense in summer 2. Visible plumes 3. Discoloration (grey haze, brown plumes)	1. Regional sulfur oxide; fine particle emissions; urban plumes 2,3. Miscellaneous industrial sources; prescribed burning	1. Fog; natural haze 2. Wildfire	Some decrease in regional SO_x emissions through air quality Standards, NSPS replacement of older power plants;[b] significant population growth[d]
South Coast (E)	6	Generally desirable visibility	1. Regional haze, more intensive in summer	1. Regional sulfur oxide; fine particle emissions	1. Fog; natural haze 2. Wildfire; prescribed burning	Planned utility growth;[a] increase in utility coal use;[b] significant population growth[d]
Great Lakes	4	Generally desirable visibility	1. Fog 2. Smoke, visible plume	2. Pulp mills (1 area)	1. Fog 2. Wildfire; prescribed burning	Planned Canadian power plant;[a] increased regional utility coal use[b,c]
Midwest	5	Generally desirable visibility	1. Smoke, visible plume 2. Dust	1. Charcoal kiln (1 area)	1. Prescribed burning; wildfires 2. Fugitive dust	Significant increase in utility, industrial coal use, SO_x emissions[b,c]
Noncontiguous U.S.						
Alaska/Hawaii	7	Generally desirable visibility	1. Fog 2. Smoke	2. Agricultural burning[a]	1. Fog 2. Volcanic emissions	Planned power plant siting[a]

[a]Federal Land Manager Workbooks (NPS, 1979; USFS, 1979a; USFWS, 1979).
[b]Utility Emission Projections (ICF, 1979); see Figure 6-18.
[c]Industrial Coal Use Projections (DOE, 1979); see Figure 6-19.
[d]Population Projections (DOC, 1977); see Figure 6-29.
[e]Smelter Emission Projections (Trijonis, 1979); see Figure 6-22.

As a practical matter, it may not make much difference whether impairment is defined as a measurable, perceptible, or undesirable visibility impact. Given competing demands on available resources and lack of adequate information on impairment in most areas, the areas with current or projected undesirable visibility impacts should, in any case, receive highest priority in control programs. Section 169A of the Clean Air Act provides for consideration of the degree or significance of visibility improvement, costs, energy, and other factors in applying retrofit controls to major sources and in making "reasonable " progress toward the national goal. These provisions indicate that some flexibility can be allowed in implementing control programs for remedying existing impairment and that priorities can be established. Similarly, under Section 165 (PSD), the Federal Land Manager must determine whether construction of a major new source would result in "no *adverse* impact on the air quality related values (including visibility)" of an impacted class I area (emphasis added). This provision suggests that in making progress towards the national goal, priority is to be given to situations where impairment by a new source is projected to be perceptible *and* undesirable or adverse. Defining visibility impairment in the literal sense, (as a perceptible impact) and permitting flexibility in implementation appears to be consistent with Congressional intent.

7.1.2.2 Need for Protecting Vistas Extending Out of Class I Areas -The preliminary analysis confirms the notion that it is important to consider the impact of air pollution on visibility for vistas that extend beyond class I boundaries. Land Managers in over 90 percent of the class I areas, who provided detailed information on vistas, reported that one or more views from within the area looking outside the area may be, to some extent, important. Moreover, in some areas, these external views appear to be an integral part of the visibility experience in the area. For example, the view from Mesa Verde of Shiprock (New Mexico), a unique natural feature, is reportedly impaired regularly by power plant plumes. To exclude consideration of visibility impairment of this kind of vista appears contrary to the national goal.

Nevertheless, it may not be practical or necessary to require protection for all vistas extending outside of class I areas. A number of class I area managers reported that large urban areas are visible from some vantage points within the areas. In some cases, visibility impairment and discoloration within the urban or developed areas were reported. It is not clear that Congress intended to remedy this kind of visibility impairment. It is, therefore, important to develop criteria for determining which views outside class I areas constitute an integral part of the class I area experience.

7.1.2.3 Variety of Sources and Control Approaches Needed - The preliminary analysis indicates that the mix of sources that tend to dominate visibility impairment varies greatly throughout the country. The most frequent sources of impairment named by the Land Managers include (in alphabetical order):

1. Agricultural activities-burning, fugitive dust

2. Forest product development-prescription fires, pulp and paper mills, saw mills

3. Miscellaneous point sources-usually in connection with visible plumes

4. Natural sources-fog, natural haze, wind-blown dust, smoke from vegetation burning (wildfires)

5. Power plants-as single point sources and contributions through regional emissions

6. Prescription fires-supervised by Land Managers for hazard reduction, ecosystem management, etc

7. Smelters-copper and, to a lesser extent, aluminum

8. Urban pollution-mix of industrial activities, motor vehicles, space heating

The feasibility and effectiveness of remedying existing impairment from these sources vary with both the source category and the regional setting in which they are located. For example, the empirical evidence discussed in 7-7 previous chapters suggests that power plants make a significant contribution to the general regional haze, which impairs visibility throughout much of the Eastern United States. Because of the large number of power plants and the presence of significant contributions from other manmade and natural sources, however, it appears unlikely that control of any single power plant in the East will perceptibly improve visibility. On the other hand, in the Golden Circle region of the West, the Land Managers reported that the impacts of single power plants are quite noticeable; hence, control in this region could conceivably provide substantial improvements.

A totally different control approach will be needed in the Pacific Northwest and much of California to deal with the intermittent impairment caused by prescription fires and agricultural activities. Such sources are clearly not amenable to control through mechanisms requiring best available retrofit technology. Technically and economically feasible controls for these sources may, at least for the time being, be confined to attempts to minimize impacts during peak visitor periods or on days when meteorology ensures visibility impacts will be minimal. As noted in Chapter 6, prescription fires are often used in or near class I areas to protect natural ecosystems from eventual catastrophic natural wildfires.

Guidelines for the states in developing visibility regulations must recognize and take into account the diverse nature of the sources of visibility impairment.

7.1.2.4 Relative Importance of Enhancement and Protection - As discussed above, approximately one-third of the areas reported undesirable visibility conditions and/or a need to assess current visibility to determine the impact of anthropogenic pollution. Pinpointing the causes of these conditions and effecting improvements where possible are clearly important needs. Nevertheless, nearly all of the class I areas indicated the need to prevent existing conditions from deteriorating as a result of new source impacts. As Table 7 -1 indicates, many of the class I areas are likely to be influenced by increased energy development and utilization, population, and urban growth, and associated emissions increases. Once such sources are constructed, it is very difficult to mitigate their impacts. It, thus, appears that a high priority for visibility protection programs is to incorporate visibility objectives in prevention of significant deterioration (PSD) programs and to

develop long-term strategies in the state implementation plans for ensuring that increased development does not adversely affect visibility in class I areas.

EPA is developing guidance for dealing with the impacts on visibility of major emitting facilities and associated development through the preconstruction review procedures required under PSD. The PSD requirements, however, do not adequately address increases in emissions associated with population growth, such as increased urbanization, automotive emissions, and space heating. PSD also may not adequately cover the impact of activities such as agricultural growth and highway construction. Additional studies to quantify the influence of such activities on visibility are needed before adequate guidance for states can be developed.

7.2 COMPONENTS OF VISIBILITY PROTECTION STRATEGIES

A number of important activities are involved in developing programs for making progress towards the national visibility goal. A conceptual framework for this process is outlined in Figure 7-3. The remainder of this chapter focuses on the most important components illustrated in this figure and highlights significant considerations and alternative regulatory approaches for these components.

7.2.1 Regulation and Guidance

As indicated earlier, EPA must promulgate visibility regulations and guidelines under Section 169A and 165 of the Clean Air Act. These regulations will establish minimum requirements for States to follow in ensuring reasonable progress towards the national goal. In order to ensure effectiveness and coordination of regulations, the Clean Air Act requirements for State implementation plan (SIP) guidance and preconstruction review of new sources under PSD will be integrated. The regulations must also specify the roles and responsibilities of the Federal Land Managers in this process.

In promulgating these regulations, EPA must consider the issues outlined in the previous section and acknowledge the limitations in current scientific and technical knowledge. For this reason, EPA recommends a phased approach to visibility programs. Although regulations and guidelines for the State must encompass the full range of Clean Air Act requirements, they should, to the extent possible: 1) permit State control programs to focus initially on the most clearly defined cases of existing impairment and on strategies to prevent future impairment and 2) allow for the evolution of guidelines and control strategies with expected improvements in scientific understanding of source/visibility/observer relationships.

Available technical information does not permit the development of control strategies for ultimate attainment of the national goal, but enough is known to develop a series of corrective and preventive actions. An evolutionary or phased regulatory approach permits these steps to be taken while delaying actions for which the technical basis is less clear. Moreover, such an approach will allow for more effective use of the limited resources available to States, Federal Land Managers, and EPA for developing visibility control

programs. In the discussion of the remaining components of Figure 7-3, the need and potential for phasing of activities are identified.

7.2.2 Assessment of Class I Area Visibility

An essential initial step in developing visibility control strategies is an assessment of existing visibility conditions in class I areas and the identification of sources of perceptible impairment. Preliminary assessments such as Federal Land Manager workbook analyses summarized in Section 7.1 can identify significant sources of impairment, indicate the sensitivity of the area to future impairment, and form the basis for establishing priorities for control strategy development and conducting detailed visibility assessments. These detailed assessments will be necessary to provide an improved basis for control strategy decisions, especially where the impact of existing or proposed man-made sources is less obvious.

Figure 7-3 lists the essential components of an assessment of class I area visibility:

1. Review of Available Data-Airport data, preliminary Land Manager analysis, and other information should be obtained to support preliminary analyses and establish priorities.

2. Monitoring - As discussed in Chapter 3, determining the current or "baseline" visibility characteristics in a class I area will require a minimum of a year of monitoring involving human observations and several types of visibility pollutant and meteorological monitoring devices.

3. Source Identification - Sources that might impair visibility can be identified by direct observation of impacts of a visible source (empirical evidence), review of existing data bases containing emission source information, and analysis of the nature of the air pollutants detected in the monitoring program.

4. Evaluation of Source Impacts - The relative impacts of man-made and natural sources on visibility can be estimated by empirical analyses of available visibility, pollutant, meteorological monitoring data, and mathematical modeling of the impacts of various man-made sources that have been identified. Empirical assessments of visibility impairment can range from simple observations of plume blight from visible sources to the more complex data analyses summarized in Chapter 4. The resolution of empirical techniques is, however, often inadequate for evaluating the effect of control strategies. The contribution of individual major point sources can also be estimated through the use of mathematical models such as those described in Chapter 5. Such models can, within certain limits, be used to evaluate the effectiveness of controls. At the current stage of development, it is important, where possible, to supplement the results of mathematical models with empirical evidence.

5. Estimation of Natural Baseline - Ideally, a comprehensive assessment of visibility in a class I area would permit estimation of the distribution of visual parameters expected over the course of a meteorologically typical year in the absence of any anthropogenic air pollution impacts. Although this

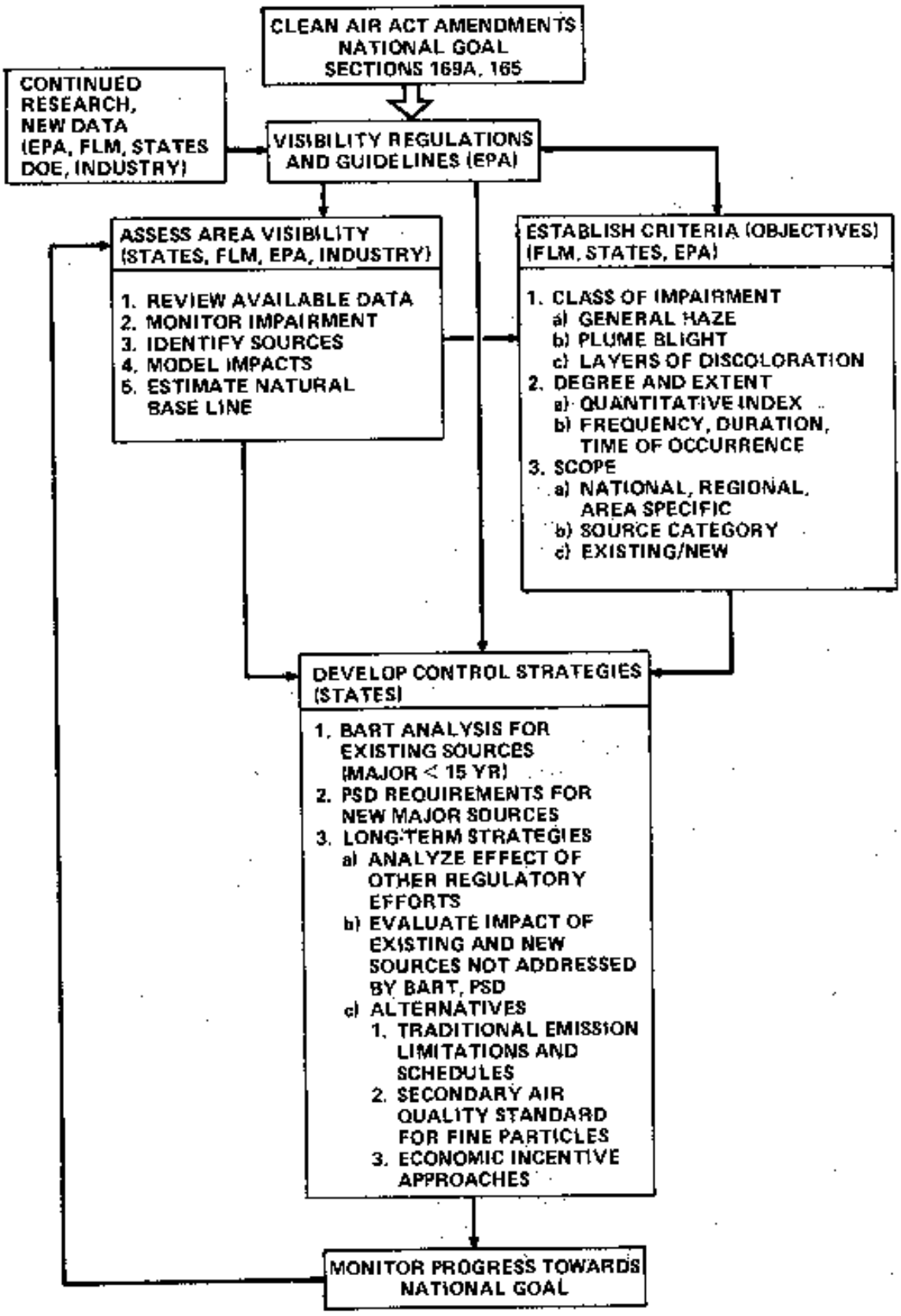

Figure 7-3. Conceptual framework for visibility protection programs.

objective is a desirable one, even with years of monitoring, the precision of available visibility assessment tools and the variability of natural impacts will probably preclude anything more than a very rough approximation of natural visibility conditions.

The principal purpose of assessing visibility in class I areas is to assist the States and Federal Land Managers in implementing Clean Air Act requirements. Therefore, the primary responsibility for assuring that these assessments are conducted must lie with the States and Land Managers. As indicated above, however, these assessments can be costly and time-consuming. Since visibility protection represents a major new regulatory program, it is unlikely that the States and Federal Land Managers possess sufficient funding, manpower, or expertise to conduct the full range of activities needed for comprehensive assessments. Although the Land Managers and EPA are acquiring additional funding for support of such assessments, it would be neither wise nor cost-effective to attempt detailed assessments and analyses of visibility in all 156 class I areas at once. Federal and State programs should attempt to establish priorities for conducting assessments in areas already reporting significant anthropogenic visibility impairment or in those areas where construction of new sources poses the greatest threat to future visibility. Where available resources are inadequate, EPA or the states might require proposed sources to conduct visibility assessments in class I areas as part of the preconstruction review process.

7.2.3 Establishing Visibility Objectives

Development of control strategies for meeting the national goal will require a number of judgments concerning priorities for assessments and controls, the meaning of "perceptible," "adverse," and "significant" impairment, and criteria for measuring "reasonable" progress. Such judgments will involve coordination among the Federal Land Managing, Agencies, States, EPA, and the public. Although many such judgments must be made on a case-by-base basis, it is desirable to establish, where possible, a consensus among interested parties in advance of control strategy decisions. For this purpose, it may be useful to establish series of visibility objectives as general guidelines for control strategy development. The term "objective," is used here to distinguish desirable/acceptable visibility conditions or control strategies, which may vary for class I areas, from the national goal, which is, in principle, the same for all class I areas where visibility is an important value. These objectives would represent the visibility characteristics and values, which are to be restored and protected, or, in some cases, tolerated on a temporary basis. Although ultimate visibility objectives must be consistent with the national goal, interim or preliminary objectives reflecting the range of judgments noted above will be useful in making reasonable progress towards the goal.

Visibility objectives should, where possible, be articulated in such a form as to permit eventual measurement or estimation by models. The objectives also must take into account the various kinds of visibility impairment and incorporate the results of studies of human perception and visibility values. Significant aspects to be considered are outlined in Figure 7-3. The objectives should express qualitative judgments concerning desired visibility in quantifiable terms, which can be related to source emissions. For example,

the general objective "maintain good visibility" might be expressed in several ways: a) maintain a median visual range ofx kilometers, b) ensure no new source emissions result in a change of contrast of greater than y percent on any day at the most sensitive viewing distance, or c) limit total anthropogenic fine particulate concentration at any point in the area to zμg/m^3 annual average.

There has been some debate over what single indicator might best be used to characterize visibility objectives. Prominent examples include extinction coefficient, contrast (between sky and target plume and background), visual range, fine particulate concentration, and chromaticity. As discussed in Chapter 3, the basic visibility indices are contrast and extinction. With the exception of chromaticity, however, all of these indices of visibility can be directly monitored or estimated from monitoring data, although simplifying assumptions and approximations are often necessary. No single indicator will be clearly useful for characterizing general haze, plume blight, and discoloration in all areas. It is, however, advisable to tie visibility objectives to indices that are directly measured in class I areas.

Frequency, duration, and time of occurrence should be taken into account in establishing visibility objectives. These factors are important because meteorological conditions can cause natural and anthropogenic visibility impacts to vary widely throughout the course of a year. Moreover, all else being equal, impairment from anthropogenic sources is considerably more objectionable during times of the year with greatest visitor attendance (e.g., summer). Visibility objectives might, therefore, be stated in terms of acceptable frequency distributions of visibility (e.g., contrast) over the course of a year. A comprehensive visibility assessment would be necessary before such an objective could be articulated. Frequency might also be considered by expressing the visibility objective as an allowable increment (e.g., an x percent increase in contrast) over an estimated or assumed baseline for any day in the year.

Conceptually, the scope of visibility objectives might be national, regional, or area-specific and might distinguish among source categories and existing and new sources. National objectives must be articulated in such a way as to account for prevailing differences in regional visibility. A national visual range objective would have no meaning. A hypothetical visual range within x percent of natural background might, however, be a useful long-term objective. Several qualitative examples of interim visibility objectives include:

1. National or regional objectives regarding the seasonality, frequency, and intensity of prescribed burning activities.

2. A national objective with respect to visible coherent plumes.

3. Area-specific objectives with respect to vistas extending outside class I areas.

4. National or regional objectives concerning allowable increments from new sources.

5. Regional or area-specific objectives calling for maintenance of current visibility or improvement to specific levels.

Providing a mechanism for the development and articulation of visibility objectives is a key problem. The process must include affected States and Land Managers and opportunity must be provided for direct public comment. EPA could call for formal procedures in guidelines for implementing Section 169A or allow individual states and Land Managers to develop ad hoc mechanisms. The Forest Service has recently proposed regulations that incorporate air quality considerations (including visibility) in their overall land management planning process (USFS, 1979b).

7.2.4 Development of Control Strategies

The development of control strategies is guided and limited by the regulations, assessments, and judgments discussed above. The essential control programs required by the Clean Air Act are outlined in Figure 7-3. Each of these components is discussed below.

7.2.4.1 Best Available Retrofit Technology (BART) Analysis -State visibility strategies must require that certain major stationary sources install and operate BART. These requirements apply to major stationary sources that (a) may reasonably be anticipated to impair visibility in a class I area, (b) began operation during the period from August 1962 to August 1977, (c) are not exempted from BART requirements by the Administrator of EPA. The Administrator can exempt on a case-by-case basis major sources that do not by themselves, or in combination with other sources, cause or contribute to significant impairment of visibility in a class I area. Furthermore, in determining BART, the State must evaluate the degree of improvement in visibility, economics, energy, and other factors, as well as availability of controls.

In essence then, application of BART will be restricted to those major sources a) for which the preliminary or detailed visibility assessment provide reasonably good evidence for noticeable visibility impacts, b) which meet the age requirements and c) the control of which can be expected to result in a perceptible improvement in visibility. The applicability of BART to those 28 source categories named in Section 169 will depend upon such factors as the type and amount of emissions and the location of each individual source. The potential applicability of the BART mechanism to man-made visibility impairment identified by the Land Managers, workbooks is summarized in Table 7-2.

It appears likely that in the early stages of visibility protection programs, application of BART will be quite limited. Improvements in understanding source/visibility relationships and developments in control technology could expand, to some extent, the application of BART.

The preliminary Land Manager analysis indicates that a number of significant sources of visibility impairment identified in the preliminary analysis will not be covered under BART requirements. However, states must ultimately consider such sources in

developing long-term strategies for making progress toward the national goal. This requirement is discussed in 7.3.

7.2.4.2 Prevention of Significant Deterioration - Issues in making progress towards the national visibility goal with respect to new major emitting facilities must be resolved within the procedures established for the prevention of significant deterioration (PSD). Therefore, the preconstruction review procedures established by the state under PSD must incorporate mechanisms for a) evaluating visibility impacts, and b) involving Federal Land Managers in judgments as to whether permitting construction of a proposed new source would adversely affect current visibility or be inconsistent with long-term programs for making reasonable progress toward the national goal. As discussed in the previous section, one mechanism for formalizing such value judgments is the establishment of regional or area-specific visibility objectives to guide the implementation of procedures for granting new source permits.

A visibility analysis for a proposed new source must consider whether the new source impact is consistent with applicable visibility objectives with respect to general haze conditions, perceptible plumes, and atmospheric discoloration. The analysis must rely heavily on predictive models as supported by empirical data. As discussed in previous chapters, there are a number of uncertainties, which must be recognized in applying these procedures. Areas of important uncertainty include the difficulty in predicting the formation of secondary aerosols (sulfates) under varying meteorological conditions, estimation of transport and dispersion parameters in areas of complex terrain, predictions of the impact of single or multiple sources on a regional (200 to 500 kilometer) scale, and theoretical limitations in predicting whether incremental changes in contrast or color will be perceptible. Although major efforts to reduce these uncertainties are of high priority, the available tools can, and must, be used in evaluating new source impacts. The alternative, allowing construction of new sources as long as prescribed class I increments are met, is not acceptable. Analyses of available scientific information by Charlson et al. (1978), Latimer et al. (1978), and others support the contention of the House Commerce Committee that "mandatory class I increments do not protect adequately visibility in class I areas" in all cases.

These preliminary analyses also suggest that the areas most sensitive to these effects lie in or near the "Golden Circle " region of the Southwest, the region with the best visual range and a number of heavily visited class I areas. Initial modeling of alternative power-plant configurations suggests that potential problems in this region include plume bright from NO2 and sulfate-derived haze. As discussed in Chapter 5, brown NO_2 plumes might occur at distances of up to 80 km from the source and be perceptible for plants larger than a capacity of 500 megawatts. Under most meteorological conditions, maximum impacts of sulfate haze derived from SO_2 emissions would be expected at distances from 100 to 200 km from the source. Preliminary analyses suggest these impacts will likely not be significant for single well-controlled plants of less than 2000 MW capacity, although the cumulative effect of several sources may be of concern.

If preconstruction analysis for a proposed new source suggests an unacceptable visibility effect, the available options for the sources include reduced emissions through improved controls or "downscaling" of the project and alternative siting in locations where meteorology and/or the terrain reduce or eliminate the expected impacts. Specification of visibility objectives and detailed analyses of visual air quality will be needed to determine the extent to which such alternative sites can accommodate regional power-plant growth

TABLE 7-2. POTENTIAL APPLICABILITY OF BART MECHANISM TO PRINCIPAL SOURCE CATEGORIES NAMED BY FLM

Source category	BART applicability
Agricultural activities	
Burning	Not applicable
Fugitive dust	Not applicable
Forest product development	
Slash burning	Not applicable
Pulp and paper mills	Varies with age, controls, impairment
Saw mills	Not applicable
Miscellaneous point sources	Varies with age, controls, impairment
Prescription fires	Not applicable
Power plants	
Single identifiable sources	Varies with age, controls, impairment
Regional emissions	Probably not applicable (evaluation of improvement not possible)
Smelters	
Copper	Not applicable to most (too old)
Aluminum	Varies with age, controls, impairment
Urban pollution	
Industrial activities	Varies with age, controls, impairment (probably limited)
Motor vehicles	Not applicable
Space heating	Not applicable

in the Southwest. Initial analyses, however, suggest that, with proper siting, application of NSPS controls, and expected reductions in smelter emissions, planned growth in Southwestern utility generation through the year 2000 should not be unduly constrained by visibility requirements (Latimer, 1979).

The analysis of the impact of proposed new sources also encompasses the impacts of other growth associated with the proposed facility. The Federal Land Managers' workbooks underscore a need for evaluating the impacts of general urban development, since these impacts are often reported to be substantial. As noted earlier, PSD mechanisms do not provide for an explicit analysis of visibility impacts for growth in smaller or urban scale source emissions not associated with a major facility. Moreover, PSD guidance to date does not provide for assessing the cumulative impact of issuing permits for a large number of new sources on a regional scale. Again, such issues must eventually be considered by the States in developing long-term strategies.

7.3 LONG-TERM STRATEGIES

As indicated in the previous discussion, development and implementation of long-term strategies are central to making progress towards the national visibility goal. These strategies should provide for integration of visibility objectives into ongoing air management efforts, to take into account sources not adequately covered by other mechanisms and to explore innovative approaches for making cost-effective progress toward visibility protection. Important considerations and alternatives are outlined below.

7.3.1 Analysis of the Effect of Other Regulatory Efforts

An essential starting point in developing long-range strategies for visibility protection is to assess the impact of other air pollution related control programs. These control programs include: 1) State implementation plan emission limits and compliance schedules for attainment and maintenance of the ambient air quality standards, 2) new source performance emission standards for power plants, industrial boilers, and other major sources of visibility impairing pollutants, 3) motor vehicle emission standards, and 4) PSD increments for class II, as well as class I areas. These regulatory programs can be expected to provide significant benefits in meeting interim objectives and making progress toward the national visibility goal.

The potential impact of existing programs on some of the more difficult visibility-impairment problems identified in the workbook analysis is outlined below.

1. Southwestern regional impairment from smelters -The Southwestern smelters have significantly reduced emissions in response to state programs for attaining the national ambient air quality standards and because of reduced production. The smelters are under compliance schedules that should provide further significant reductions in emissions by 1990 (see Figure 6-22). Preliminary analyses (Marians and Trijonis, 1979; Latimer et al., 1978), suggest that the reductions in smelter emissions to date have resulted in improved regional visibility in the Southwest

since 1972. Therefore, the exemption of most smelters from BART requirements (due to their age) will not materially affect progress toward the visibility goal.

2. Regional visibility impairment in the East - As discussed in Chapters 4 and 5, regional trends in visibility are strongly associated with regional sulfur oxide emissions, especially from power plants. Additional contributions come from direct fine particulate emissions and photochemically produced organic particles. Strategies for attaining the air quality standards for particulate matter, sulfur oxides, and ozone in the East have already stopped the general trend toward increased emissions of these pollutants. In addition, the recently announced new source performance standard for power plants represents an important long-term strategy that will ultimately reduce Eastern sulfur oxides emission levels, because the eventual replacement of older, poorly controlled power plants will be with cleaner new plants. This strategy however, will not begin to significantly reduce emissions until after 1995 (see Figure 6-18).

3. Impairment from urban plumes -A number of the class I areas are impaired by urban plumes from cities where one or more of the current ambient air quality standards are not met; for example, the South Coast Air Basin of California. Such urban areas are already moving as rapidly as practical towards meeting the air quality standards.

These efforts should, at least, limit any increased impairment and in some cases improve visibility conditions.

Once the impact of other regulatory programs is evaluated, the need for additional control approaches for meeting the national goal can be assessed. For example, in the cases of impairment caused by smelters or the South Coast Air Basin urban plume, it does not appear reasonable or necessary to develop major new strategies for visibility improvement at this time. Such strategies would not significantly affect the rate, or extent, of control application. Long-term strategies must focus on those situations and source categories that can not meet interim visibility objectives or make reasonable progress toward the national goal.

7.3.2 Analysis of Existing Sources not Covered by BART

As discussed above, long-term strategies must consider the problem of existing sources of visibility impairment that are not covered by BART requirements and that are inadequately handled by other programs. Significant examples are sources that began operations after August 1977 or before August 1962, certain non-major point source categories, such as agricultural and other prescribed burning, and area wide emissions from populated areas. In many cases, the age of the source and existing controls may preclude any action for major stationary sources. Control of many categories of area sources for visibility protection will be difficult to justify and defend. However, the preliminary workbook results indicate a significant need to consider the impact of prescription fires in a manner that minimizes visibility impacts. This task will not be an easy one. In the area with the most significant problem (the Pacific Northwest), current

fire management practices are designed to avoid effects on populated areas. Because of geography, this practice often results in increased burning impacts on class I areas. Clearly, in such situations public health protection must be paramount. However, it is likely that current programs have not attempted to deal with the question of minimizing visibility impacts.

7.3.3 Growth of Sources not Adequately Considered by PSD

As indicated above, general urban development and increased dispersion of smaller population centers in the vicinity of class I areas pose a significant threat to visibility in these areas. Long-term strategies must give some consideration to the impact on class I areas of new population growth, residential development, and increased agricultural activities. Historically, efforts to control the impact of generalized small sources have been controversial. Nevertheless, without some consideration of these sources, generalized growth could thwart attempts at preserving and attaining pristine conditions in class I areas.

7.3.4 Innovative or Supplemental Long-Term Strategies

Over the next several years, State visibility control programs will focus on controlling existing sources that have a demonstrable impact on visibility, evaluating visibility impacts of major new point sources located within about 150 kilometers of class I areas, and assessing the impact of other regulatory programs on improving and maintaining visibility in class I areas. Continued study of the various aspects of the visibility problem will permit evaluation of the effectiveness and necessity of additional control approaches for making progress toward the national goal. Examples of visibility problems that must ultimately be faced when improved technical information is available are given in Table 7-3. Potentially desirable technical control approaches are also listed. Although traditional emission limitations and control strategies may be useful, implementation of these and other necessary long-term technical control approaches may also require the use of innovative or supplemental regulatory strategies. Technical control approaches include applying control technology, conservation or other actions, which reduce emissions. Regulatory strategies include means of implementing desirable technical controls.

TABLE 7-3. EXAMPLES OF POTENTIAL LONG-TERM STRATEGIES

Visibility problem	Major sources	Desirable technical control approach
Reduce regional haze in East (more rapidly than NSPS approach)	Regional sulfur oxide emissions/power plants, other fossil fuel combustion	Reduce regional sulfur oxide emissions/emphasis on reduction during summer months of peak sulfate levels
Maintain regional visibility in Southwest	Regional sulfur oxide emissions/smelters, power plants, urban plumes	Maintain or reduce current regional sulfur oxides emissions - regional "offset" approach
Reduce smoke impacts from burning in Northwest	Prescribed burning to maintain ecosystem, slash burning of forestry, agricultural wastes	Limit times of necessary burning to minimize impacts/ encourage alternative disposal, energy recovery of slash

Several alternative regulatory approaches that may prove useful are outlined below, with some discussed in greater detail elsewhere (Fiorino, 1979). Because of the regional character of the visibility problems and the nature of the approaches, some of the alternatives discussed below are beyond the capability of individual States without further guidance from EPA and, in some cases, are not without additional legislative mandates. Considerable analysis of the feasibility, effectiveness, and desirability of these and other approaches is needed before they can be seriously considered.

7.3.4.1 Secondary Air Quality Standard for Fine Particles - Current understanding of the regional visibility problem in the Eastern United States suggests that any attempt to make improvements significantly faster than projected under current new source performance standards and air quality standard implementation would be extremely costly. There is some question as to whether possible enhancement of visibility in the 35 Eastern Class I areas provides sufficient justification for an accelerated cleanup effort. A general reduction in sulfur oxide emissions would, however, probably improve visibility throughout the East. Depending on the extent to which the public views this objective as a desirable one, sufficient reason may exist for establishment of a secondary ambient air quality standard for fine particles. Besides mandating regional visibility improvements, a standard that reduces regional sulfur oxide emissions could provide other benefits, such as a reduction in acid rain.

No national ambient air quality standard could be established which would protect visibility in all class I areas and at the same time be attainable throughout the nation. This is true because of generally higher natural and man-made concentrations of fine particles in the East. Nevertheless, such a standard would accelerate progress toward improved visibility throughout the Eastern United States and might also increase the efforts for visibility improvements in major urban areas of the Western United States. Thus, a secondary air quality standard for fine particles could effectively complement visibility protection programs in class I areas.

Recently initiated research efforts in monitoring of fine-particles, transformation and transport studies, and progress in evaluating visibility values could provide support for a

decision on the desirability of such an air quality standard by 1982 or 1983. Implementation is required under the Act within "a reasonable time". The consequences of such a standard for State programs are, however, far-reaching, and significant additional resources at the Federal and state level may be necessary to handle the additional load and to deal with multi-state emission control strategies.

7.3.4.2 Economic Incentives for Cost - Efficient Implementation -The problem of reducing existing impairment caused by regional haze, such as that found in the East and in the Los Angeles Basin, may well be more economically solved by means other than traditional air pollution control programs. Unlike plume blight, where the source of the plume can be identified by direct observation, pollutants that cause haze come from a multitude of sources and are so well mixed together that even the most sophisticated tracer studies are not reliable for identifying individual sources. Consequently, it may be necessary to consider polluting sources as a group rather than individually.

Macro-scale approaches such as marketable permits and fees may be suitable instruments for implementing a long-term strategy that must deal with such a group of sources. Such strategies define ways of allocating control burdens among sources that impair visibility; they differ from ambient standards that traditionally prescribe the total level of pollutants desired rather than the distribution of control requirements. Economic incentives distribute control requirements in a way that is different from and potentially more cost-effective than traditional air pollution control regulations.

1. Controlled Trading (Marketable Permits)

Under a controlled trading approach, EPA or the States would allocate pollution privileges among sources in a defined area and establish conditions for future exchanges of these privileges. The process would be implemented in several stages:

1. Draw boundaries around groups of sources that contribute to a common visibility problem; this action defines each "market" for allocating and exchanging pollution privileges.

2. Establish maximum loadings for each pollutant (or precursor) that impairs visibility in each area, or market, on the basis of the definition of visibility goals, air quality modeling data, and economic and energy considerations.

3. Allocate or auction off pollution privileges to sources in each market, to the point where total allocations equal the maximum loading of each pollutant consistent with visibility goals. The number of permits each source has would determine its allowable emissions.

4. Establish conditions for the purchase and sale of pollution privileges among sources that are part of the same market.

The advantage of a marketable permit system is that it produces the desired level of visibility protection at the lowest achievable cost by giving incentives to the sources with the lowest abatement costs to reduce emissions the most. Those sources with low

abatement costs would find it more economical to install controls than to buy permits, and those sources with high abatement costs would find it more economical to buy permits than to install controls. As the permits are traded among sources, the total cleanup cost lessens while the burden of paying for it remains spread among all sources responsible for visibility impairment.

A disadvantage of this system is that the equilibrium price of the permits is unknown until the auction has stabilized. This price factor is crucial to businesses making investment decisions, and its uncertainty might lead to less than optimal decisions on the part of the regulated industries. Coordinating the system on a multi-state basis presents additional difficulties.

2. Emission Fees

Under a fees approach, firms face a fixed charge for each unit of waste emitted (e.g. $X/lb sulfur). To control visibility, charges would be levied on sulfur oxides, nitrogen oxides, and all other constituents that can be shown to impair visibility. If the fees are set high enough, it will be cheaper for sources to reduce emissions than pay the charge. Ideally, sources would minimize their pollution control costs by abating their wastes up to the point where the incremental cleanup cost equals the level of the fee. The next increment of pollution reduction would cost more than the fees. The proper fee should be set so that the sum of residual discharges from all sources does not exceed the maximum amount of each pollutant that is consistent with the visibility goal. In theory, the amount of waste reduction from each firm will vary as a function of the firm's marginal abatement cost.

Unlike a marketable permits approach, a fees approach results in a known price for pollutants emitted but an unknown level of pollutant loading and, therefore, an unknown level of visibility protection. Consequently, several iterations of fee levels would be necessary before an optimal level is reached.

3. Supplemental Economic Approaches

Government cost-sharing, through tax incentives or direct subsidies, can be used along with visibility control strategies. Accelerated depreciation allowances, direct grants, interest-free loans, and guaranteed financing might be used selectively. Such cost-sharing schemes have proven to be most desirable in promoting control technology development. Incentives may be particularly useful in encouraging alternative means of disposing of forest debris, which is currently burned on site.

Noncompliance penalties, provided for in the Clean Air Act, can be imposed for violations of BART requirements. Such penalties remove the incentive to avoid compliance by assessing firms an amount equal to the economic benefits they receive from noncompliance.

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